ISSN: 2961- 1571(Print), 2961-158X (Online)

THE LUMBINI AGRICULTURE JOURNAL

Volume: 01 June 2022

Government of Province
Lumbini Province
Ministry of Agriculture, Food Technology and Land Management, Butwal
June 2022

THE LUMBINI AGRICULTURE JOURNAL

EDITORIAL

Food security and agribusiness promotion division of Ministry of Agriculture, Food Technology and Land Management, Butwal is publishing this journal (Lumbini Agriculture Journal) in order to inform about the findings of researches related to agriculture, livestock and fishery. The journal essentially includes value chain and supply chain of agriculture products, impacts of global warming and climate change in agriculture, agriculture mechanization and other local and global issues of agriculture.

The Editor-in-Chief acknowledges the valuable contributions from authors, reviewers, editors and the editorial management team and hopes that readers find this journal informative and contribute to increase in the production and productivity of agriculture of Nepal. The editorial board will be glad to receive valuable suggestion and feedback from readers to improve quality of journal in forthcoming issues.

Editor-in-Chief

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MANAGEMENT OF STEMPHYLIUM BLIGHT OF LENTIL THROUGH HOST RESISTANCE AND CHEMICAL FUNGICIDES

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ABSTRACT

Experiments were carried out to search for resistant source(s) and chemical fungicide(s) for controlling stemphylium blight of lentil in RCB Design at NMRP and AFU, Rampur, Chitwan respectively during November to April, 2018/19. Twenty lentil genotypes were screened against stemphylium blight disease. Among the tested genotypes RL- 44 & RL-60 were identified as tolerant and RL-71, RL-68, RL-67, RL-28 & RL-83 genotypes were identified as moderate resistance with higher degree compared to others genotypes that were grouped under moderate resistance category. In case of chemical treatment, efficacy of ten different fungicides viz., tebuconazole 18.3% + azoxystrobin 11% @0.05, hexaconazole 75%WG@0.1, dimethomorph 50% WDG@0.1, carbendazim 50% WP @0.25, mancozeb 63% + carbendazim 12% WP@0.3, propiconazole 25%SL@0.1, iprodione 80WP@0.2, cholrothalonil 75% WP@0.2, tricyclazole 75% WP@0.1, and mancozeb 64% +cymoxanil 8%WP@0.1 along with control plot were tested in the field to control stemphylium blight of lentil. The minimum disease severity was obtained from tebuconazole 18.3% + azoxystrobin 11%SC treated plot followed by iprodione 80WP. Among the ten fungicides, iprodione 80WP gave the best performance in respect of plant height (50.6 cm) and number of pod per plant (102.56) while tebuconazole 18.3%+ azoxystrobin 11%SC gave best performance in thousand seed weight (20.02 gm) and grain yield (1651 kg/ha) compared to plant height (43.06 cm), no. of pod per plant (62.53), thousand seed weight (16.92 gm) and grain yield (1150 kg/ha) in no fungicide treated plot.

Key words: Fungicide, lentil, resistance, severity, stemphylium

अध्ययनको सार

मुसुरोको आनुवांशिक रुपहरु र ढुसिनासक विषादिहरुलाइ स्टेम्फिलियम ब्लाइट रोग विरुद्ध छान्नका लागि सिम्पल रेण्डोमाइज्ड कम्प्लिट ब्लक ढाँचामा तिन वटा प्रकृतीमा राष्ट्रिय मकैबाली अनुसन्धान कार्यक्रम र ए.एफ.यू, रामपुर चितवनमा क्रमश सन् २०१८ को नोभेम्बर देखि २०१९ को अप्रेलसम्म अनुसन्धान गरियो। स्टेम्फिलियम बोट्राइयोसम द्धारा लाग्ने स्टेम्फिलियम डढुवा रोग बिरुद्ध छान्नका लागि २० वटा मुसुरोको जातहरु प्रयोग गरिएका थिए। अनुसन्धान फिल्डको क्षेत्रफल ४७२.५ वर्ग मी. रहेको थियो जसमा प्लटको क्षेत्रफल ४ वर्ग मी. रहेको थियो र हरेक आनुवांशिक रुपको चारवटा पंक्ति प्रति प्लट कायम गरिएको थियो। तिनीहरुको रोग स्कोरिङ (०-९ स्केल), रोग संक्रमण, ए.यु.डि.पि.सी., उत्पादन र सय दाना तौलको मुल्यांकन गरियो।अध्ययन गरिएका बिस वटा आनुवांशिक रुपहरु मध्ये रोग संक्रमण, ए.यु.डि.पि.सी., उत्पादन र सय दाना तौलमा सघन फरक देखियो। रोगको संक्रमण र ए.यु.डि.पि.सी. सगुन मा सबैभन्दा बढी र आर.एल-७१ मा सबैभन्दा कम रहेको पाईयो। रोगको तिव्रता र उत्पादनको बीचमा नकारात्मक पारस्पारिक सम्बन्ध पाइएको थियो। दानाको उत्पादन सबैभन्दा बढी आर.एल-४४ (११२९ के.जी / हे) र सय दानाको तौल सबैभन्दा बढी आर.एल-८३ (२.९२ ग्राम) मा पाइएको थियो भने सबैभन्दा कम उत्पादन आइ.एल.एल.-८०१० (५७७ के.जी / हे) र सय दानाको तौल सबैभन्दा कम आइ.एल.एल.-२४३७ (१.७८ ग्राम) पाइएको थियो। रसायनिक उपचारको मामलामा, दस वटा विषादी र एउटा नियन्त्रण प्लट को प्रभावकारिता हेर्न ३५२.५ वर्ग मी. क्षेत्रफलमा रेण्डोमाइज्ड कम्प्लिट ब्लक ढाँचामा तिन वटा प्रकृतीमा ६ वर्ग मी भएको एउटा प्लटमा बनाएर अनुसन्धान गरियो। न्युनतम रोगको तिब्रता टेबुकोनाजोल १८.३% + एजोक्सीस्ट्रोबिन ११% एस.सि उपचार गरिएको प्लटबाट प्राप्त भयो त्यसपछि इप्रोडाइन ८०% डब्ल.पि र अधिकतम रोग नियन्त्रण प्लटबाट रिपोर्ट गरिएको थियो। दशवटा ढुसिनासक विषादि मध्ये, इप्रोडाइन ८०% डब्ल.पि ले बोटको उचाई (५०.६ से.मी) र कोसाको संख्या प्रति बोट (१०२.५६) को क्षेत्रमा उत्कृष्ट प्रदर्शन दिए जबकि टेब्यूकोनाजोल १८.३% + एजोक्सीस्ट्रोबिनले ११% एस.सि ले हजार दानाको तौल (२०.०२ ग्राम) र दाना उत्पादन (१६५१ के.जी / हे) मा उत्कृष्ट प्रदर्शन दियो।

INTRODUCTION

Lentil (Lens culinarisMedik) is one of the oldest known protein rich legumes, which has been domesticated 10,000 years ago (Cubero, Perez &Fratini, 2009). Lentil is a worthwhile food consumed as dhal (dry, dehulled, split seed used for cooking), snacks or soup preparations by human discarding the outer skin and separation of cotyledon. Lentil is a major grain and widely distributed legume crop grown under a broad range of climates in many developing countries (Turk, Rahman, Tawaha& Lee, 2004; Abd-Allah &Hashem, 2006). Main lentil growing countries around the globe are Canada, India,Turkey, Bangladesh, Iran, China, Nepal and Syria (Ahlawat, 2012). This crop has been grown mainly as an inexpensive source of high quality protein in human diets (Salehpour, Ebadi, Izadi&Jamaati-e-Somarin, 2009; Rahman, Ahmed, Islam & Hosen, 2010). In Nepal, lentil is the most important and highly commercialized pulse among the grain legumes in terms of area (2,08,766 ha), production (2,51,185 mt) and productivity (1203 kg/ha) which shares almost 62.9% of total area and 65.7 % of total production of pulses and rates the highest consumer preference (MoALD, 2020). In Chitwan also, lentil is the most important and highly commercialized pulse among the grain legumes in terms of area (4100 ha), production (5043 mt) and productivity (1230 kg/ha) which shares almost 77% of total area and 81 % of total production of pulses (MoALD, 2020). Lentil has also emerged as an important agricultural export commodity (Gharti, Darai, Subedi, Sarkar & Kumar, 2014). The revised Nepal Trade Integration Strategy (NTIS) 2016 has prioritized lentil as one of the 12 commodities with high export potential in Nepal (Prasain, 2016).

Despite high export potential, there are many constraints that are limiting the production and export of lentil. At present, the yield of lentil at national level is far below than its yield potential. Production is decreasing every year due to biotic and abiotic yield limiting factors like susceptibility to disease, low acreage and delay in sowing by the farmers (Subedi et al., 2014). Among the constraints, biotic is major one at all over the world (Bayaa& Erskine, 1998). Lentil crop is affected by a wide range of pathogens. Fungal diseases decrease in productivity through infection and damage to leaves, stems, roots and pods as well as reduce marketability by discoloring seeds (Taylor, Lindbeck, Chen & Ford, 2007). Lentil production seems adequate but current status of lentil is prone to a number of pathological threats including lentil wilt, stemphylium blight, collar rot and root rot in Nepal (Yadav, 2013). Stemphylium blight (SB) that associated with StemphyliumbotryosumWalr is the most important disease of lentil in Nepal (Joshi, 2006; Gharti et al., 2008) and estimated yield losses of about 60-90% and sometime total crop collapsed have been reported (GLRP, 2018). In Nepal, it was first reported during 1993(Bayaa& Erskine, 1998). This disease has become widespread throughout major lentil growing areas of the country (Bayaa et al., 1998). Stemphyliumbotryosum causes leaf blight that can result in large scale defoliation of plants. Preliminary studies in Bangladesh and India estimated yield losses of 62% and total crop failure have been reported in some cases where the disease defoliated the crop in the early pod setting stage (Bakr, 1991; Erksine&Sarker, 1997). In recent years, stemphyliumblight has been observed increasing in lentil fields in Banke, Bardiya, Rupandehi, Chitwan, Nepalgunj, Makwanpur, Bara, Parsa and Rautahat districts (Subedi et al., 2014).

In recent years stemphylium blight is very commonly occurring disease of lentil in Nepal. The severity is increasing gradually. It may appear in severe form in future. Thus, attention needs to be paid to combat stemphylium blight of lentil. Management strategies for this disease include use of resistant cultivars and fungicidal sprays. Chemical management is a quick, easy and effective option against plant diseases. Development of fungicide resistant biotypes of the pathogen is a major constraint. Use of resistant varieties/genotypes is simple, effective, safe and economical means of controlling disease as they do not incur additional cost for disease management and also stabilize yield.

In this study, an attempt has been made to assess the level of resistance of lentil genotypes and efficacy of chemical fungicides against SB disease thereby predicting the effect of disease on yield if disease occurs in epidemic form.

MATERIALS AND METHODS

2.1 Experimental site

Experiments were carried out to search for resistant source(s) and chemical fungicide(s) for controlling stemphylium blight of lentil in RCB Design at National Maize Research Program (NMRP) and Agriculture and Forestry University (AFU), Rampur, Chitwan respectively during November to April, 2018/19.The site was located at 27°37'N latitude and 84°25'E longitude (Thapa&Dangol, 1998) with an elevation of 228 m above the mean sea level. The soil type of the field was sandy loam and received average annual rainfall of 2000 mm.

2.2 Screening of lentil genotypes for stemphylium blight resistance

The experiment was conducted in a randomized complete block design (RCBD) with 3 replications. Individual plot size was 4 m^2 (4 m x 1 m) and the area of research field was 472.5 m^2. There were 4 rows of 4 m length/plot and 25cm apart. Lentil were sown at the spacing of 25 cm x continuous i.e. Row to Row 25 cm/Plant to Plant continuous(R-R/P-P).

Altogether twenty different lentil genotypes were brought from Grain Legumes Research Program(GLRP), Khajura to test against the stemphylium blight under Rampur, Chitwan, Nepal condition.

For the study of disease severity, 25 plants were randomly selected from each plot and tagging was done for disease scoring. Disease scoring was done after appearance of disease i.e. 75 days after sowing at 7 days interval. A total of 4 scorings were done during February 8 – March 6, 2019. The disease data were recorded from 25 randomly tagged plants/plot on the basis of 1-9 scoring scale (Morrall&Mckenzie, 1974).

1= No lesion visible (Highly resistant)

3= Few scattered lesions, usually visible after careful searching (Resistant)

5= Lesions common on plants and easily observed but defoliation and/ or damage not great, or in only one or two patches in plot (Moderately resistant)

7= Lesions very common and damaging (Susceptible)

9= Lesions extensive on all plants, defoliation and drying branches, and killing of some plants (Highly susceptible) Percent Disease Index (PDI) was computed on the basis of recorded data according to the formula (Wheeler, 1969). Data was recorded on yield and yield attributes after sun drying.

2.3 Efficacy of fungicides against stemphylium blight of lentil under field condition

The experiment to test the fungicides was conducted under natural epiphytotic condition and laid out in RCB design with 3 replications. The unit plot size was 4m x 1.5m with 25 cm row to row spacing and the area of research field was 352.5 m². The treatments were assigned through a random selection of plots in each replication. Efficacy of ten different fungicides such as tebuconazole 18.3% + azoxystrobin 11%@0.05, hexaconazole 75%WG@0.1, dimethomorph50% WDG@0.1, carbendazim 50% WP @0.25, mancozeb 63% + carbendazim 12% WP@0.3, propiconazole 25%SL@0.1, iprodione 80WP@0.2, cholrothalonil 75% WP@0.2, tricyclazole 75% WP@0.1, and mancozeb 64% +cymoxanil 8%WP@0.1 along with control plot were tested in the field to control stemphylium blight of lentil.

The experiment was monitored regularly to observe the on-set of stemphylium blight from 75 days to 120 days. First spray was done just after the appearance of disease symptom in the field. Altogether three sprays were applied at 15 days interval beginning from 75 days after sowing when the symptoms of the disease first appeared in the experimental plots. Spraying was done with the help of a Knapsack type sprayer and 3 liter of suspension of fungicide was used to spray in each unit plot. For the study of disease severity, 25 plants were randomly selected from each plot and tagging was done for disease scoring. Disease scoring was done after appearance of disease i.e. 70 days after sowing in a weekly interval twice in between the intervals of fungicide spray. A total of 6 scorings were done during February 12 – March 24, 2019.The disease data were recorded from 25 randomly tagged plants/plot on the basis of 1-9 scoring scale (Morrall&Mckenzie, 1974).Percent Disease Index (PDI) was computed on the basis of recorded data according to the formula (Wheeler, 1969).Percent Disease Control (PDC) was calculated on the basis of the formula developed by Shivankar&Wangikar (1993).

Disease severity was calculated/plant and mean severity was computed/plot. AUDPC values were calculated. Yield increase over the control was calculated. Data was recorded on yield and yield attributes after sun drying. All data were analyzed statistically using MSTAT-C. Treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5% levels of significance.

RESULT AND DISCUSSION

1.1 Screening of lentil genotypes for stemphylium blight resistance

Out of 20 genotypes including Sagun as check, 18 genotypes were moderately resistant to the disease and rest were susceptible (Table 1). RL-71, RL-68, RL-67 RL-28 & RL-83 genotypes were found statistically least affected by disease i.e. low PDI. RL-44 & RL-60 were found to have relatively higher yield despite considerable disease severity and thus exhibited appreciable degree of tolerance to SLB. The findings of the study is closely related with the study of Rashid et al.(2009), Podder (2012) and Sarkar et al.(1998). They also reported that the lentil genotypes differed significantly in respect of agronomic traits and yield parameters. The variation in yield of lentil was mainly due to Stemphylium blight disease.This variation may be due to variations in genetic makeup among lentil genotypes. Bakr(1991) and Mwakutuya et al.(2004) reported yield reduction of lentil due to Stemphylium blight. They described that yield reduction of lentil increased with the increasing of Stemphylium blight disease severity.

Table 1: PDI, AUDPC, Plant height, Number of pod per plant, Hundred seed weight and Grain yield Kg/ha of lentil genotypes

S.N.	Genotypes	PDI	Disease Reaction	AUDPC	PHT (cm)	Pod/Plant	HSWt (g)	GY (Kg/ha)
1	RL 68	† 33.33	MR	†63.56	† 45.07	† 40.51	2.89	764
2	RL 67	33.56	MR	64.12	45.73	43.23	2.71	776
3	RL 71	32.44	MR	61.51	54.87	79.37	2.60	818
4	RL 45	43.26	MR	82.32	48.87	55.20	2.57	869
5	RL 83	35.78	MR	66.64	53.33	43.44	2.92	957
6	RL 28	35.11	MR	66.64	60.87	55.14	2.80	947

7	ILL 6458	41.41	MR	78.59	51.00	39.33	2.01	752
8	ILL 9924	45.48	MR	86.43	52.67	37.61	1.98	820
9	NR 2001-71-3	40.96	MR	77.84	47.07	46.96	1.91	751
10	RL 44	42.15	MR	80.08	53.33	44.00	2.60	1129
11	ILL 10068	45.56	MR	86.89	42.20	40.09	2.19	796
12	ILL 10853	44.67	MR	85.49	47.40	57.57	2.34	737
13	ILL 2437	42.59	MR	81.57	44.93	51.71	1.78	609
14	ILL 10045	49.48	MR	94.08	49.87	38.31	2.11	618
15	ILL 10065	48.22	MR	91.93	38.47	47.69	2.45	792
16	RL 60	51.33	S	97.53	50.40	44.84	2.68	849
17	ILL 8010	48.81	MR	93.33	51.00	47.89	1.92	577
18	ILL 10856	47.26	MR	90.72	50.60	38.32	1.94	799
19	RL 55	48.00	MR	91.75	45.47	35.97	1.93	784
20	SAGUN	53.41	S	100.61	45.87	41.87	2.32	760
	Grand mean	**43.13**		**82.07**	**48.95**	**46.45**	**2.33**	**795**
	SEm(+)	1.41		2.70	1.11	2.23	0.08	27.79
	P-value	<0.001**		<0.001**	0.001	<0.001	0.001	<0.001
	LSD (0.05)	4.36		8.56	9.44	2.41	9.44	0.25
	CV,%	6.12		6.31	7.10	3.00	7.10	6.40

† Means of 3 replications, PDI- percent disease index, MR- Moderately Resistant, S- Susceptible, AUDPC- Area under disease progress curve, PHT- Plant height, cm-centimeter, GY- grain yield, HSWt- hundred seed weight, kg/ha- kilogram/hectare, g- gram, CV: Coefficient of variation, LSD: Least significant difference at 5% level of significance, SEM (±) represents Standard Error of Mean

3.2 Efficacy of fungicides against stemphylium blight of lentil under field condition

Among ten different fungicides tested in the field to control stemphylium blight of lentil, low disease severity and AUDPC values were found in the plot treated by tebuconazole 18.3% + azoxystrobin 11% followed by Iprodione 80WP. Highest plant height and number of pods per plant are found in Iprodione 80WP followed by tebuconazole 18.3% + azoxystrobin 11%. Highest thousand seed weight (gm) and grain yield (kg/ha) was found in tebuconazole 18.3% + azoxystrobin 11% followed by Iprodione 80WP. Tebuconazole 18.3% + azoxystrobin 11% is newly tested fungicide to Stemphylium botryosum but Basallote-Ureba,Prados-Ligero&Melero-Vara (1998) found triazole fungicide tebuconazole effective against garlic leaf spot caused by Stemphylium Vesicarium. Savitha&Ajithkumar,(2016) reported tebuconazole 18.3% + azoxystrobin 11% highly effective against the purple blotch of onion. Bakr& Ahmed (1992); Shahiduzzaman, Hossain &Kundu (2015) found Rovral 80 WP at 0.2% as effective foliar spray in controlling the stemphylium blight disease of lentil.

Table 2. Effect of fungicides in controlling stemphylium blight and plant growth parameters of lentil

Treatment	**PDI**	**PDC %**	**AUDPC**	**Plant height(cm)**	**No. of pods/plant**	**TSW(gm)**	**Yield/ ha (kg/ha)**	**PYI**
Tebuconazole 18.3% + azoxystrobin 11%	28.00^{g†}	28.95	87.64^{g}	49.06^{ab}	99.83^{a}	20.02^{a}	1651^{a}	43.57
Hexaconazole 75%	29.63^{ef}	24.81	92.58^{ef}	48.86^{ab}	93.66^{b}	19.67^{ab}	1599^{ab}	39.03
Dimethomorph 50%	32.79^{bc}	16.79	102.66^{bc}	45.66^{cd}	78.20^{c}	17.95^{de}	1321^{d}	14.83
Carbendazim50%	31.21^{d}	20.80	97.62^{d}	46.90^{bc}	82.36^{c}	18.23^{cd}	1400^{cd}	21.73

Mancozeb 63% + carbendazim 12%	30.27^{de}	23.19	94.54^{def}	47.66^{abc}	92.53^{b}	18.94^{bc}	1504^{bc}	30.77
Propiconazole 25%	30.66^{de}	22.20	95.76^{de}	48.00^{abc}	91.60^{b}	19.03^{bc}	1498^{bc}	30.28
Iprodione80%	29.18^{f}	25.95	91.28^{f}	50.60^{a}	102.56^{a}	19.87^{a}	1642^{a}	42.80
Chlorothalonil 75%	32.44^{c}	17.68	101.45^{c}	45.06^{cd}	77.93^{c}	17.85^{de}	1314^{d}	14.25
Tricyclazole 75%	33.63^{b}	14.66	105.56^{b}	45.46^{cd}	70.67^{d}	17.42^{ef}	1274^{d}	10.82
Mancozeb 64% + cymoxanil 8%	31.11^{d}	21.06	96.88^{d}	46.60^{bc}	83.73^{c}	18.29^{cd}	1389^{cd}	20.77
Control	39.41^{a}	-	123.85^{a}	43.06^{d}	62.53^{e}	16.92^{f}	1150^{e}	
Grand mean	**31.668**		**99.078**	**46.997**	**85.058**	**18.565**	**1431**	
SEm(+)	**0.92**		**2.93**	**0.64**	**3.72**	**0.31**	**48.92**	
P-value	**<0.001****		**<0.001****	**0.0007****	**<0.001****	**<0.001**	**<0.001**	
LSD(0.05)	**1.022**		**3.329**	**2.706**	**5.578**	**0.7404**	**116.9**	
Coefficient of Variation (CV%)	**1.89**		**1.97**	**3.38**	**3.85**	**2.34**	**4.79**	

† Means of 3 replication. Means denoted by same letter does not differ significantly by DMRT ($P<0.05$).PDI=Percent Disease Index, TSW = Thousand Seed Weight, PDC = Percent Disease Control, PYI = Percent Yield Increase

3.2.1 Relationship between Percent Disease Index (PDI) and grain yield

The crop yield of lentil was found to have significant negative correlation (r=-0.910) with the severity of stemphylium blight disease. Finding of this experiment is supported by Islam &Ariful (2014) who found that the crop yield of lentil was found to have significant negative correlation (r= - 0.974) with the severity of Stemphylium blight disease.

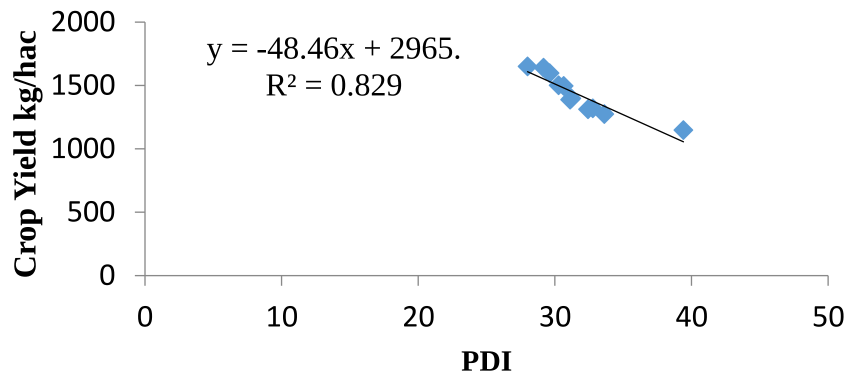

Fig 1. Relationship between crop yield (y) and PDI (x) of stemphylium blight of lentil.

3.2.2 Relationship between Percent Disease Control (PDC) &Percent Yield Increase (PYI)

A positive linear correlation between PDC and PYI was observed and Equation Y=1.661x-8.1878 and R^2 = 0.8294 gave the best fit. Subedi et al., (2014) found that the yield obtained was correlated positively with PDC which was linear and could be shown by the equation y = 1.224x + 5.645 and coefficient of regression R^2 = 0.909 which is in line with the finding of this experiment

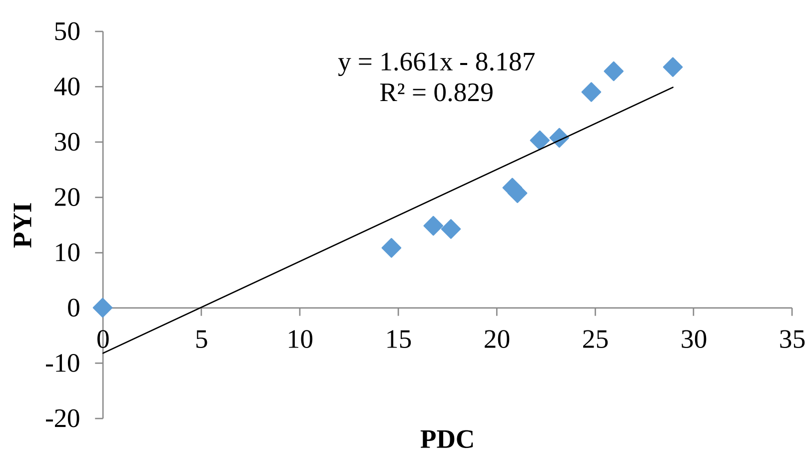

Fig 2. Relationship between PDC and PYI of chemical fungicides used in stemphylium blight management experiment at Rampur, Chitwan

CONCLUSION

Tebuconazole 18.3% + azoxystrobin 11% was found to be the most effective fungicide in managing stemphylium blight of lentil. Iprodione 80WP can also be used as an alternative to tebuconazole 18.3% + azoxystrobin 11%SC. Tolerant genotypes viz., RL- 44 & RL-60 and Genotypes viz.,RL-71, RL-68, RL-67, RL-28 & RL-83 genotypes with higher degree of resistance were identified which could be utilized in SB resistance breeding program in lentil. The information generated from the present study are useful in devising sound integrated management strategies for SB of lentil in Nepal

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ADAPTATION OF CHINESE COMBINE RICE MILL FOR DE-HUSKING PROSO MILLET AND FOXTAIL MILLET

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ABSTRACT

The Proso millet and Foxtail millet are cereal grains grown from time immemorial in the Himalayan regions of Nepal. Traditionally millets (Proso millet and foxtail millet) are de-husked by women by pounding in wooden mortar. This is tedious, labor- intensive, time-consuming and low output practice causing more drudgery to the women in this region. The commercially available small sized Chinese combine rice mill powered by a 3HP electric motor was used for de-husking of Proso millet and foxtail millet. Existing sieve used for paddy milling as well as modification with sieve has been evaluated for this study. This mill was evaluated for the de-husking Proso millet and Foxtail millet at NAERC, Khumaltar in 2020 and 2021 AD. The performance indices considered for the evaluation of the machine were de-husking efficiency, percentage of broken, head grain yield, unmilled grain, grain loss in husk and milling capacity at moisture content of 12%. Based on this study, result showed that the combine mill with modified screen has a milling capacity of 56.31 kg/hr Proso millet at 12% moisture content. Similarly, it has a grain De-Husking capacity of 74.58 kg/hr foxtail millet at 12% moisture content. This mill with existing screen/sieve needs modification to reduce the milled grain losses in husk. Overall, finding of this evaluation study shows that Chinese combine rice mill with modification is suitable for de-husking Proso millet (chino) and Foxtail millet (kaguno). It has possibility of becoming a one of the suitable milling and de-husking technology with work load reduction characteristics for hilly and mountainous areas of Nepal. Government of Nepal and province government as well as local government need to promote this multifunction processing machine having work load reduction characteristics as a milling and de-husking technology for hilly and mountainous areas of Nepal.

Key words: Proso Millet, Foxtail Millet, Moisture Content, De-Husking, Mortar, Drudgery

अध्ययनको सार

चिनो तथा कागुनो वालीहरु नेपालको हिमाली क्षेत्रमा परापूर्वकालदेखि खेति गर्दै आइरहेको छ । उच्च पहाडी क्षेत्रमा खाध्य तथा पोषण सुरक्षा र स्थानीय जैविक बिबिधता संरक्षणमा यी वालीहरुलाई मुख्य सम्भाव्य वालीको रुपमा लिन सकिन्छ । परम्परागत रुपमा चिनो तथा कागुनोको प्रशोधन कार्य महिलाहरुले काठको ओखलमा गर्ने गर्दछन । यसरी काठको ओखलमा चिनो/कागुनो कुट्न एकदमै गार्हो, बढी श्रम लाग्ने र झन्झटिलो हुनाले त्यस क्षेत्रका महिलाहरुको लागी चिनो/कागुनो कुट्ने काम एकदमै कष्टप्रद पनि छ । हाल नेपाली बाजारमा उपलब्ध ३ अश्व शक्तिको चिनिया बिधुतिय कम्बाइन मिललाई चिनो/कागुनो प्रशोधन परिक्षणमा उपयोग गरिएको हो । यस कम्बाइन मिलमा हुने पुरानै जाली (जुन धान कुट्नको लागि प्रयोग हुन्थ्यो) र परिमार्जन गरिएको जालीलाइ परीक्षणको क्रममा प्रयोग गरिएको थियो । यो मेशिनलाइ सन् २०२० र २०२१ को अबधिमा नेपाल कृषि अनुसन्धान परिषद् अन्तर्गत राष्ट्रिय कृषि इन्जिनियरिङ्ग अनुसन्धान केन्द्रमा चिनो तथा कागुनो प्रशोधनको लागि परिक्षण कार्य गरिएको थियो । परिक्षण गर्ने क्रममा १२% चिस्यान भएको चिनो/कागुनो लाइ प्रशोधन गर्दा मेशिनको प्रशोधन दक्षता, टुक्रेको प्रतिशत, सग्लो दाना, नकुटिएको दाना (वियाँ) र भुसमा गएको दाना इत्यादी सूचकांकहरु मापन गारिएको थियो । यस परिक्षणको नतिजा अनुरुप १२ प्रतिशत चिस्यान भएको चिनोलाई परिमार्जन गरिएको जाली राखेर प्रशोधन गर्दा ५६.३१ किलो प्रतिघन्टा पाइएको छ भने १२ प्रतिशत नै चिस्यान भएको कागुनो ७४.५८ किलो प्रतिघन्टा कुटेको पाइएको थियो । खासगरी कागुनोको दाना सानो भएकोले भुसमा जाने दाना कम गर्न परिमार्जित जालीनै उपर्युक्त देखिएको छ । यस परिक्षण अध्ययनको निष्कर्ष के रहेको छ भने सानो आकारको चिनिया बिधुतिय कम्बाइन मिल (संशोधित जाली युक्त) ले चिनो/कागुनो प्रशोधन गर्नसक्ने र उच्च पहाडी क्षेत्रमा कार्यबोझ कामगर्न सक्ने बिशेषता सहित एक उपर्युक्त प्रशोधन प्रबिधि हुने सम्भावना रहेको छ ।

INTRODUCTION

Grains are small hard dry seeds with or without attached hulls or fruit layers, harvested for human and/or animal consumption (FAO, 2011). Among grain crops the Pros millet (Panicum miliaceum L.) commonly known as chino is a cereal crop cultivated as a grain crop in the Himalayas up to the altitude 3500 meter. Foxtail millet [Setariaitalica (L.) P. Beauv.] is among the oldest cereal grains grown from time immemorial in the Himalayan regions of Nepal (Ghimire, K.H., Joshi, B.K., Gurung, R. et al. 2018).These are potential crop for ensuring food and nutrition security and conservation of local crop biodiversity in high mountain region. The Pros millet grains are very small and oval in shape up to 3 mm long x 2 mm width, smooth, Seed color is wide ranging and can be white, cream, yellow, orange, red, and black through to brown. It is completely gluten-free and is packed with a variety of essential minerals, potassium in particular, which contributes to nervous system health. The important popular local varieties of Proso millet in Humla are black, red, milky and hardy varieties often locally named askalo chino, rato chino, Dudhe chino, haande chino in Nepali language (Joshi and Ghimire 2016). Similarly Foxtail millet grains are about 2 mm in length and the glumes can be white, red, yellow, brown, or black (John R.N. Taylor, M. Naushad Emmambux 2008).

The removal of the husk layer thus becomes the primary task of processing of these grains for obtaining grain-rice (naked grain) and for further processing of grains for consumption. Once removed, we get the Proso millet rice. Proso millet seeds are enclosed in the hulls, and difficult to remove by conventional milling processes (Matz, 1969 quoted by Hulse, et al., 1980). The de-husking of Proso millet has been considered as a tedious and time-consuming work for people. However, currently, appropriate de-husking machines are not available. Traditionally millets (Proso millet and foxtail millet) are de-husked by women by pounding in wooden mortar. This is tedious, labor- intensive, time-consuming and low output practice causing more drudgery to the women in this region. The power levels that can be produced by an average healthy athlete are 75W maximum (Modak and Bapat, 1987). The major challenges in processing Proso millet are: 1) The small size of the grains and irregular shape of grain 2) Variations in the raw materials due to variation in varieties across production regions 3) Low shelf life of the processed rice and grits due to pest infestation and rancidity 4) Hard, slippery outer coat of seed (husk) than found in other millets. (DHAN Foundation 2016).

The motorized grain milling machine will do the work in a little time and will require less man power when compared to the manually operated systems of milling available in rural areas. The performance evaluation of the machine is therefore important so as to determine its ability to de-husk grains effectively and recommend it for use by farmers and entrepreneurs. The objective of this work was therefore, to carry out the performance evaluation (milling efficiency, de-husking efficiency and de-husking rate) of the small sized combine mill with screen modification and different moisture content range. The multiple application combined mill will be increased.

MATERIALS AND METHODS

Description of the Machine

Since the electrical Chinese combine rice mill has both grain crushing and rice milling compartment, we test the rice milling (huller) for our experiment. Major parts includes feed hopper, protective cover, rice feed hopper, feed adjuster plate, roller, screw adjust nut, adjustable handle, rice discharge port, discharge port for broken rice and husk, electric motor, frame, rice huller belt, on/off knob for milling and grinding option, feed adjustable plate, adjustable handle, blower port. On/off knob is used to transmit motor power in needed compartment. It has existing sieve size 166 X 72 mm and thickness 1.2 mm with aperture size 1.2mm. Modified screen with aperture size of 0.9mm has been fabricated at NAERC Khumaltar.

Table 1. General features of Chinese combine rice mill.

Particulars	**Technical parameters**	
	Existing	**Modified**
Matched Power	3HP(2.2-3kw)	
Operation	Manual feeding and motor drive	
Material	Mild steel (MS)	
Weight	Approx 65 kg with motor	
Power source	3HP single phase electric motor	
Voltage	220±10V	
Frequency	50Hz	
Overall dimensions(mm)	1250×530×1125	
Rotor speed(r/min)	1400-1600	
Rice sieve(mm)	Size166 X 72	Size166 X 72
	Thickness:1.2	Thickness:1.22
	Aperture:1.2	Aperture:0.9

Working Principle of Machine:

Rice milling machine consists of feed hopper, propeller, rice milling, rice sieve, roller, discharge port etc. grains feed into the milling chamber through the feed hopper manually, after then grinding process occurs inside under the joint action of the knife, sieve and rice roll, and then rice discharge by the discharging outlet. Firstly, material (in experiment millet) is feed into the de-husking chamber slowly from the feed hopper. Immediately after grain reached chamber, de-husking process started under the action of high speed blow and strong bump rub from the tooth claw and grains sheared between the rotating disk and fixed casing.

Performance Evaluation Procedure

The Performance Evaluation Experiment was performed at National Agricultural Engineering Research Centre (NAERC), Nepal Agricultural Research Council, Khumaltar Lalitpur, Nepal in 2020 and 2021 AD. The commercially available small sized Chinese combine rice mill powered by a 3HP electric motor was used for de-husking of Proso millet and foxtail millet. Existing sieve used for paddy milling as well as modification with sieve has been evaluated for this study. This mill was evaluated for the de-husking Proso millet and Foxtail millet using market available millets which are mixture of multiple varieties of millets. The performance indices considered for the evaluation of the machine were milling efficiency, percentage of broken machine efficiency, head rice recovery, machine capacity, unmilled grain, milling losses, grinding efficiency and milling rate at moisture content of 12%. Grain moisture meter (Wile 78 Crusher) was used to measure moisture content of paddy. After sun drying grains are stored and next day de-husking is carried out. Initial moisture content of millet was about12% (wet basis). Vernier caliper (accuracy of ± 0.05 mm) was used to measure the diameter of sieve holes and dimensions of millets. Digital balance was used during the experimental period. Time taken was noted using Stopwatch. During the test 10kg of samples was fed into the milling chamber through hopper and time to complete the de-husking was noted. Husk was collected separately and blown grain into the husk was recovered with winnowing. With Existing sieve test was carried out then modified sieve has been placed and performance evaluation was carried out. Field verification and traditional de-husking data has been collected with farmer's view survey and demonstration program.

Determination of milling/de-husking parameters of mill

Tests were conducted for the evaluation of following parameters of the machine: milling efficiency, percentage of broken machine efficiency, head rice recovery, machine capacity, unmilled grain, milling losses, grinding efficiency and milling rate at moisture content of 12 %.

a) Rough grain: grains as it come from the field. Rice kernels are still enclosed in their inedible protective husk
b) Milled rice: grain after removing the husk, bran and germ from rough grain
c) Brokenkernel:Thisstudyconsideredgrainshavingsizelessthan75% of the whole kernel size as broken kernel
d) Unmilled grain % $= \frac{\text{Weight of unmilled grains (g)}}{\text{Weight of milled grains (g)}} \times 100$

e) Blown grain in husk % $= \frac{\text{Weight of grains in husk outlet (g)}}{\text{Weight of grains fed to the machine (g)}} \times 100$

f) Milling/ de-husking efficiency: Dehusking efficiency % =

$$\frac{\text{Weight of milled grains (head grain and broken garain) (g)}}{\text{Weight of grains fed to the machine (g)}} \times 100$$

g) Broken % $= \frac{\text{Weight of broken grains (g)}}{\text{Weight of milled grains (head grain and broken garain) (g)}} \times 100$

h) Head grain yield % $= \frac{\text{Weight of head grains (g)(dehusked grain)}}{\text{Weight of milled grains (head grain and broken garain) (g)}} \times 100$

i) Milling capacity based on rough grain (kg/hr) $= \frac{\text{Weight of head grains (kg)}}{\text{total time taken in mill (hr)}} \times 100$

RESULT AND DISCUSSION

Tables 2 depict the parameters of combine rice mill on proso millet and foxtail millet with modified screen. Based on this study, result showed that the combine mill with modified screen has a milling capacity of 56.31 kg/hr Proso millet at 12% moisture content. Similarly, it has a grain De-Husking capacity of 74.58 kg/hr foxtail millet at 12% moisture content. The milling efficiency or recovery of 73.15% and 76.23 % was obtained for Proso millet and foxtail millet. The head rice(grain) recovery based on total milled grain, unmilled grain percentages, broken grain and grain in husk from the combine mill for Proso millet were 81.18%, 0.41%,11.79%, and 6.63%, respectively. Similarly the head rice(grain) recovery based on total milled grain, un milled grain percentages, broken grain and grain in husk from the combine mill for foxtail millet were 66.91%, 0.55 %,13.12%, and 19.11 %, respectively. Due to small grain/kernel size there is more grain loss in husk which needs recovery of processed grain from husk. This mill with existing screen/sieve needs modification to reduce the milled grain losses in husk. Overall, finding of this evaluation study shows that Chinese combine rice mill with modification is suitable for de-husking Proso millet (chino) and Foxtail millet (kaguno).

Table 2. **Performance parameters of combine rice mill on proso millet and foxtail millet at 12% MC.**

Performances indices	Proso millet	foxtail millet

Total milling recovery or efficiency (%)	73.15±0.62	76.23±0.57
Head rice recovery based on total milled grain (%)	81.18±1.32	66.91±1.37
Milling capacity based on rough rice (kg/hr) -	56.31±3.60	74.58±4.04
Broken grain (%)	11.79±0.70	13.12±1.04
Un milled grain (%)	0.41±0.42	0.55±0.45
Grain in husk (%)	6.63±0.31	19.11±3.31
Output capacity based on milled grain (kg/hr)	41.2±2.73	56.84±2.96

All values are expressed as means ± standard deviation of four replicate readings

Table 3. Descriptive statistics of performance parameters of combine mill for Proso millet

Parameters	**Replicates**	**Maximum**	**Minimum**	**Mean**	**St. dev.**	**Std error**
Weight of rough grain(kg)	4	10.00	10.00	10.00		
Operating time, minutes	4	11.50	10.00	10.69	0.69	0.34
Head rice -based on total milled rice (%)	4	82.87	79.84	81.18	1.32	0.66
Broken rice (%)	4	12.33	10.83	11.79	0.70	0.35
Milling efficiency or recovery (%)	4	73.90	72.40	73.15	0.62	0.31
Milling capacity based on rough grain (kg/hr)	4	60.00	52.17	56.31	3.60	1.80
Output capacity based on milled grain (kg/hr)	4	44.34	38.09	41.20	2.73	1.37

Table 4. Descriptive statistics of performance parameters of combine mill for Foxtail millet

Parameters	**Replicates**	**Maximum**	**Minimum**	**Mean**	**St. dev.**	**Std error**

Weight of rough grain(kg)	4	10.00	10.00	10.00		
Operating time, minutes	4	8.50	7.50	8.06	0.43	0.21
Head rice -based on total milled rice (%)	4	68.69	65.53	66.91	1.37	0.68
Broken rice (%)	4	14.42	11.89	13.12	1.04	0.52
Milling efficiency or recovery (%)	4	77.00	75.70	76.23	0.57	0.29
Milling capacity based on rough grain (kg/hr)	4	80.00	70.59	74.58	4.04	2.02
Output capacity based on milled grain (kg/hr)	4	60.56	53.86	56.84	2.96	1.48

Development of Millet De-Husking Machine, Patil et al (2018) reported that; the de-husking efficiency of minor millet de-husker was affected by moisture content of feed, feed rate, speed of rotating cone and the clearance between de-husking cones. The maximum de-husking efficiency for kodo millet was 48.5 and for little millet 52.0 per cent obtained at 167 and 150 rpm respectively at the feed rate of 12 kg/h. At the feed rate of 9 kg/h for kodo millet and 12 kg/h for little millet the maximum de-husking efficiencies were 48.74 and 52.21 per cent respectively. The de-husking efficiency was also affected by moisture content of feed and clearance between de-husking cones. At 12 per cent moisture content and 1.5 mm clearance the de-husking efficiency was maximum (50.0%) at the feed rate of 12 kg/h. But the Proso millet had the different biological properties and very hard outer shell. It was very difficult to de-husk because of smooth slippery as well as hard outer shell. The oval shape of grain created the problem to separate the unhulled grain through screen separation method from hulled rice. Gravity separation also didn’t work. GR Bhandari et al (2020) reported that GEF UNEP Local Crop Project in collaboration with Agricultural Engineering Division of NARC designed, fabricated and tested model-1 and Model-2. The Model-2 higher capacity up to 52.5 kg/hr. this machine has more broken percentage in other varieties of Proso millet except Dudhe chino.

This machine seems potential machine to change minor millet the processing behavior in the hilly areas. Electricity facility with not less than 10A and less fluctuation in voltage is essential. Since the grain loss in the husk in case of foxtail millet but it can be recovered with winnowing. Other millet like finger millet can also be pearled with this machine.

CONCLUSIONS

The combine mill with existing screen has more losses in husk and with modified screen has less loss in husk. So especially for foxtail millet screen aperture of about 0.9 mm is essential. With modified screen both Proso millet and foxtail millet will result satisfactory result. It can reduce the work load and time for processing of Proso mille. Same machine can be used for de husking rice, Proso millet, and foxtail millet and grinding maize and producing flour. It is economically sound with respect to traditional method of de husking. Proso Millet de-husker save time and reduce women's drudgery significantly, in most remote marginal region of Nepal such as Humla, where farmers have no access to improved machinery for mechanical processing and women are most vulnerable in terms of food insecurity and high drudgery. The machine has provided a potential opportunity to save time, reduce drudgery and cost of processing and thereby promoting conservation, production and improving the value chain of Proso millet and foxtail millet.

Overall, from the findings, this study suggest that combine mill could be one of the beneficial and efficient milling and grinding options for small communities and farmer's cooperatives in the hills and mountain regions of Nepal where majority of rice processing is done with traditional methods. The combine rice mill can be used by farmers' cooperatives and local entrepreneurs that are interested to engage in custom milling business that will provide additional business opportunities in the rural areas. However, further investigations of the combine mill under a wide range of grain moisture content and different millet varieties is recommended because the milling machine performance depends on the grain conditions, milling duration, operator's skill and millet grain varieties.

ACKNOWLEDGMENTS

This work was supported by grants from Nepal government, Nepal Agricultural Research Council (NARC). The author are grateful to entire family of National Agricultural Engineering Research

Centre, Nepal Agricultural Research Council Khumaltar, Lalitpur, Udhaav khadka and Hari Bahadur Lama, for their valuable assistance in the experiment.

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DESIGN AND EVALUATION OF RICE-WHEAT PEDAL THRESHER DEVELOPED AT NAERC, KHUMALTAR

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ABSTRACT

Threshing of rice and wheat is one of the tedious jobs in the hilly area. To sort out this issue, National Agricultural Engineering Research Centre has modified the existing pedal thresher so that it can be used both in rice and wheat threshing. The design is such that the rpm of the threshing cylinder is adjustable by adding extra gear to get 430 rpm for rice threshing and 860 rpm for wheat threshing. A performance study was carried out with different varieties of rice and Gautam variety of wheat. The moisture content of Rice and Wheat varies from 17% to 19% and 13% to 15% respectively. Three-year data shows the average capacity of thresher is 58 Kg/hr. at 15.2 % average moisture content in rice while in wheat the average capacity was found to be 46 Kg/hr. at 12.7 % moisture content. The threshing efficiencies in both cases were found around 99% with negligible damage. The ergonomic study indicates that there is no significant impact on the operator's health if 20 minutes of continuous operation followed by 20 minutes of rest was given to the operator.

Keywords: Threshing Capacity, Threshing Efficiency, Threshing Drum

अध्ययनको सार

धान-गहुँ नेपालको प्रमुख खेती प्रणाली हो ।खास गरी पहाडका टेरेसहरुमा गरिने धान र गहुँ खेतीको थ्रेशिंगमा यान्त्रिकरण एकदम चुनौतीपूर्ण कार्य हुन् । राष्ट्रिय कृषि इन्जिनियरिङ अनुसन्धान केन्द्र (NAERC), खुमलटारले विकास गरेको खुट्टाले चलाईने पेडल थ्रेसर पनि अभ्यासमा छ तर पहाडी क्षेत्रका साना किसानका लागि गहुँ थ्रेसिङ गर्ने समस्या अझै पनि विद्यमान रहेको सन्दर्भमा यस समस्यालाई समाधान गर्न NAERC ले धान र गहुँ दुवै थ्रेसिङमा प्रयोग गर्न सकिने गरी अवस्थित पेडल थ्रेसरलाई परिमार्जन गरेको छ।यस मेशिनको डिजाइनको कुरा गर्दा थ्रेसिङ सिलिन्डरको आरपीएम धान थ्रेसिङका लागि ४३० आरपीएम र गहुँ थ्रेसिङका लागि ८६० आरपीएम हुने गरी गेयर परिवर्तन हुने प्रणाली राखिएको छ । थ्रेसिङ सिलिन्डरको आरपीएममा सजिलै परिवर्तनको लागि गियर स्लाइडिङ लिभर जोडिएको छ।यस मेशिनको परिक्षण विभिन्न जातका धान र गौतम जातका गहुँको थ्रेशिंग गरी अध्ययन गरिएको थियो । थ्रेशिंग गरिएको धान र गहुँको चिस्यान क्रमशः

१७% देखि १९% र १३% देखि १५% सम्मको थियो । तीन वर्षको तथ्याङ्कले धानमा १५.२% औसत चिस्यानमामा थ्रेसरको औसत क्षमता ५८ केजी/घन्टा रहेको देखाएको छ भने गहुँमा १२.७% चिस्यानमा ४६ केजी/घण्टा औसत क्षमता रहेको पाइएको छ। दुबै परिस्थितिमा थ्रेसिङ दक्षता लगभग ९९ % नगण्य क्षतिको साथ परिणाम पाईयो । मेसिनको कूल तौल २३.५ किलोग्राम रहेकोले यसलाई म्यानुअल रूपमा फिल्डमा लैजान सकिन्छ। यसलाई स्थानीय रूपमा उपलब्ध सामग्रीको साथ स्थानीय कार्यशालाहरूमा बनाइएको थियो। चामल र गहुँका लागि गियरको सहज सिफ्टिङ यस मेसिनको प्रमुख विशेषता हो। थ्रेसर सञ्चालन गर्नको लागि शक्तिको स्रोत एक व्यक्ति हो तर मेसिनलाई घुमाउनको लागि सामान्यतया दुई व्यक्ति आवश्यक पर्दछ। थ्रेसिङ ड्रमको लम्बाइ ३५ सेन्टिमिटर र व्यास २६.० सेन्टीमिटर हुन्छ जसमा अवतल आकारको स्पाइक हुन्छ। थ्रेसिङ कार्य प्यानिकलमा स्पाइकद्वारा प्रभावहरूको सिद्धान्तमा हुन्छ।ईरगोनोमिक अध्ययनले सञ्चालकलाई २० मिनेट निरन्तर सञ्चालन र २० मिनेट विश्राम दिएमा सञ्चालकको स्वास्थ्यमा खासै असर नपर्ने देखाएको छ ।

INTRODUCTION

Nepal is a hilly landlocked country having 65.6% population actively engaged in agriculture and is divided into three physiographic regions namely the mountain region, hill region, and the Terai region which occupy 35%, 42%, and 23% of the total line area of 147,181 sq. km. Rice (1,491,744 ha), Maize (956,447ha), and Wheat (703,992ha) are the three major cereal crops in terms of area of cultivation and production. Rice has a significant impact on the country's agricultural economy (27% of GDP) to which rice alone contributes 20%.). The average landholding per family across Nepal is found to be less than 0.8 hectares and the value drops to 0.68 on the hill. Rice Wheat is one of the major cropping systems in the hills farming system with terrace cultivation. The production cost has been a serious matter of concern as the net income is of the order of Rs.2000/ha, which is not encouraging. The land productivity per ha is $3278. Animate power is the main source of power, in Nepalese agriculture. Human power and animal power occupy 36.3 and 40.5 per cent of the total farm power available in the country respectively. The available mechanical power in the country is only 23 per cent. Most of the mechanical power is concentrated in Terai, the share of available mechanical power in terai is 92.28% of that of the total available mechanical power in Nepal. (FBC, 2006).

The traditional wooden tools and implements have continued to remain in use in the hills and mountains. There has been some improvement in their design and performance over time. Due to the lack of physical facilities (viz. road networks and electricity) and cultivation on narrow terraces in hilly areas; hill agriculture is mainly dependent upon human and animal power. Indigenous wooden plough, local hoes, and sickle are the major implements/tools used for agricultural operations. Animal power is also widely used for threshing through tramping action. The major factor associated with the high cost of production is the traditional way of cultivation practices where a large number of laborer's are needed in different operations. Threshing is one of them. Still, the manual way of threshing is common in hilly areas for both rice and wheat. The productivity of farms depends greatly on the availability and judicious use of farm power by the farmers. Agricultural implements and machines enable the farmers to employ the power judiciously for production purposes. Agricultural machines increase the productivity of land and labour by meeting the timeliness of farm operations and increasing work output per unit of time. Over the last few years, there has been considerable progress in agriculture mechanization. It is generally believed that the benefits of modern technology have been restricted to farmers with large land-holdings. Yet the fact remains that even small farmers are adopting and utilizing selected farm equipment for efficient farm management through custom hiring.

As there is no appropriate wheat thresher available in the hills, it is manually performed. Concerning rice thresher, pedal paddy thresher is found to be popular in the mid-hills of Nepal. In this context, the National Agricultural Engineering Research Centre has improved the pedal thresher. A pedal-operated rice thresher is commonly used in the central hills to thresh rice. There is a lack of technology for wheat threshing in the hills of Nepal.

Looking to the aforementioned, the present study has been planned with the specific objective of developing a hybrid type pedal thresher that can be used for threshing rice as well as wheat.

Study Locations

The design of the R-W pedal thresher was done at National Agricultural Engineering Research Centre, Khumaltar, and evaluated at various locations of NARC and farmers filed.

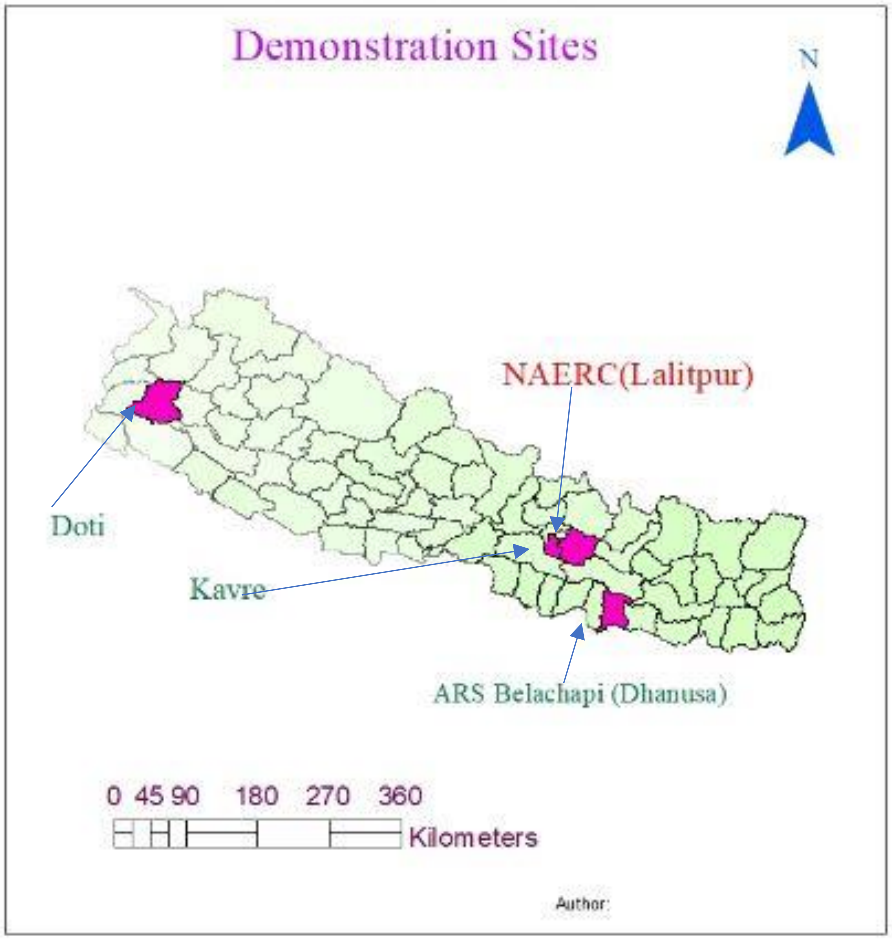

Figure 1: Study Area

MATERIALS AND METHODS

The approach of this study includes design, fabrication, and evaluation of station and validation in the field. The design includes an analysis of different parts. The evaluation includes threshing capacity, damages analysis, and ease of operation.

Machine Design

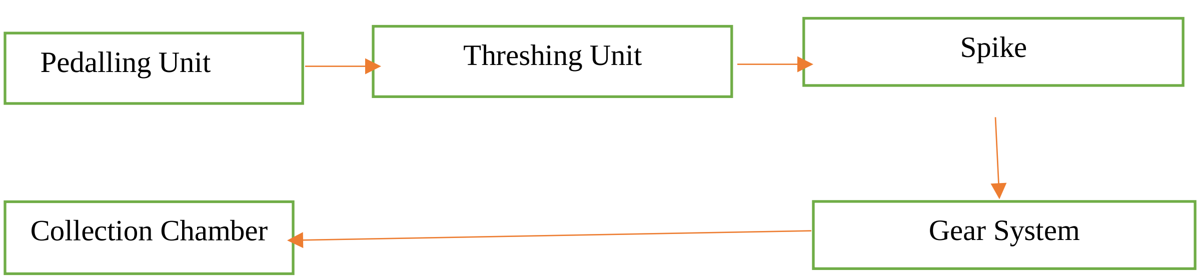

Figure 2: Machine Component

The rice-wheat pedal thresher contains a threshing drum, pedal, gear system, spike, and body frame.

Threshing Unit

It is the most important component of the machine as here the separation of grains occurs. Hence proper design is required for better efficiency and minimum breakage loss. It consists of the following components:

Threshing Drum

It is the part that holds the teeth responsible for separating the grains as well as the shaft that rotates the drum. For ease in operation and lighter in weight, the threshing drum has been made of lighter material. Its diameter should be able to hold all the straw containing grains.

Threshing Teeth

This is the part that separates the grains (Rice/Wheat) from the stalk. It is made of steel bars of 120mm in length.

Shaft

The shaft provides power to all the moving components. Hence it is designed in such a manner that it can withstand the weight of a threshing drum, threshing teeth, and the overall weight of the machine.

Hopper

This is the component where the rice/wheat stalks are fed. It should be designed in such a way that no escaping of rice/wheat takes place.

Casing

The casing of this machine should enclose the whole threshing unit and should separate the unit from the pedalling unit.

Working Principle

Threshing is a key part of agriculture that involves removing the seeds or grain from plants (for example rice or wheat) from the plant stalk. In the case of small farms, threshing is done by beating or crushing the grain by hand or foot and requires a large amount of hard physical labor. A simple thresher with a crank can be used to make this work much easier for the farmer. In most cases it takes two people to work these: one person to turn the crank and the other to feed the grain through the machine. These threshers can be built using simple materials and can improve the efficiency of grain threshing. Pedal threshers are commonly used for threshing of paddy crops by small and marginal farmers. It consists of a wire loop type threshing cylinder, power transmission system, foot pedal, and frame. Smaller gear from pair of spur gear is mounted in the shaft of the threshing cylinder and the larger gear is mounted on the frame of the thresher, which is connected to the foot pedal with a bar. For threshing of paddy, the paddy bundle is held in hands and the ear head portion of the crop is placed on the rotating cylinder. The wire loops of the rotating cylinder hit the ear heads and due to impact force, the grain is detached from the stalk of the crop.

Performance Evaluation

The performance of the machine can be evaluated on the following parameters: Threshing time, Moisture content, Threshing Capacity, Losses, and Threshing efficiency.

Threshing Capacity

Threshing capacity is the weight of grains (whole and damaged) threshed and received per hour at the main grain outlet. It is also termed as machine productivity and expressed as Kg/hr.

$$P = \frac{W}{T} \ (\text{kg/h}) \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

P = Machine productivity, Kg/hr

W = The mass of total yield, Kg

T = The time consumed in threshing operation, hr

Threshing Efficiency

The threshing efficiency is defined as the net threshed grain received at the main outlet. It is expressed as the percentage of the threshed grain of total grain.

$$£=\frac{T-U}{T}\times 100\ \%\text{..............................}(2)$$

Where,

£= Threshing Efficiency

T= Total grain threshed

U=Unthreshed grain

Broken/damaged grain

It is given in terms of the percentage of broken grain in a sample. For damage analysis, a certain weight of the sample is taken from the threshed grain, and this physically damaged grain is separated, and based on that percentage of damage is estimated. It can be expressed mathematically in eqn.3.

$$\text{Damage}=\frac{\text{Broken grain}}{\text{Sample weight}}\times 100\ \%\text{...................................}(3)$$

RPM Measurement

The revolution per minute of the shaft was estimated using a digital tachometer. The permission range of RPM for rice and wheat is different. The RPM of the machine should be adjusted based on the moisture content of the threshing crops. Generally, an rpm of 400-500 for paddy and 800-900 for wheat is required for the pedal thresher.

RESULTS AND DISCUSSION

Components Design

The different unit of pedal thresher has been designed on the principle of force analysis.

Pedalling Unit

The pedalling unit is made up of a 2mm metal sheet. The length and width of the pedal have been reduced in comparison to the traditional rice thresher. The length and widths are 46cm and 30cm respectively.

Table 1: Dimensions

Dimension	Pedal Rice-Thresher	R-W pedal Thresher
Length	58 Cm	46 Cm
Width	50 Cm	30 Cm

The reduction in the pedal dimension has reduced the overall weight of the machine thereby making it easier to transport.

Threshing Unit

It is the heart of the machine. All the components of this unit have been designed to thresh both rice and wheat efficiently with minimum breakage loss.

Drum Shaft & Threshing Drum

It supports the drum and transfers the rotary motion developed from the gearbox by connecting the two pulleys found in the gearbox and the threshing drum. The designed diameter of the shaft is 1.5 cm and the length is 45 cm. 10 numbers of the blade have been designed in the drum having 10 pegs in each blade.

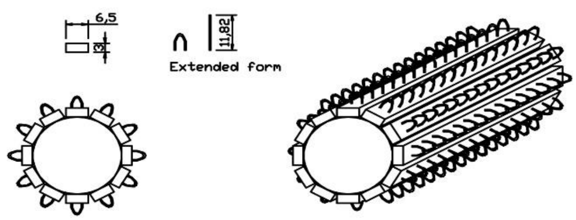

Figure 3: Machine parts

The designed width and height of the peg are 3 and 3.5 cm respectively while the distance between pegs is 3cm. The fabricated drum has been shown in the figure below.

Performance Evaluation

The performance of the machine has been studied on three parameters viz: threshing capacity, threshing efficiency, and broken percentage for both paddy and wheat.

The machine has been tested for paddy and wheat threshing on the station and various locations from 2013/14 to 2015/16 and its performances have been analyzed as shown in the table below:

Threshing Capacity

The threshing capacity of the machine has been calculated using eqn.1. The three-year data shows the average threshing capacity of the machine for paddy threshing as 57.96 Kg/hr at an average moisture content of 16.8 %. The threshing capacity has been found to increase with a decrease in moisture content. The average threshing capacities over the year have been shown in the table below. During the analysis period, no significant modifications have been done. However, welding in the pedalling unit has been done.

Table 2: Threshing Capacity for paddy

Test	Threshing Capacity (Kg/hr.)		
	2013/14	**2014/15**	**2015/16**
Test 1	48.79	60.00	56.81
Test 2	58.97	56.54	61.71
Test 3	58.43	59.50	60.92
Average	**55.39**	**58.68**	**59.81**
Three Year Avg.	**57.96**		

While the average threshing capacity of this machine for wheat threshing is 46.06 Kg/hr at an average moisture content of 13.6% as shown in the table below.

Table 3: Threshing Capacity for wheat

Test	Threshing Capacity (Kg/hr.)		
	2013/14	**2014/15**	**2015/16**
Test 1	48.55	37.92	51.25
Test 2	41.20	45.60	48.00
Test 3	54.73	41.50	45.80
Average	**48.16**	**41.67**	**48.35**
Three Year Avg.	**46.06**		

Threshing Efficiency

The threshing efficiency of the machine has been calculated using equation 2 above in both commodities i.e., paddy and wheat. The threshing efficiency of the machine has been found nearly 100% for both rice and wheat at an average moisture content of 16.8% and 13.6% for paddy and wheat respectively.

Table 4: Threshing Efficiency

Year	Threshing Efficiency (%)	
	Paddy	Wheat
2013/14	99.99	99.82
2014/15	99.93	99.94
2015/16	99.98	100.00
Avg. Threshing Efficiency	**99.97**	**99.92**

Threshing Capacity vs Moisture Content

The machine works well in the optimum moisture range of 15-17 % for paddy and 12-15% for wheat. The threshing capacity of the machine was found to be 56 Kg/hr at a moisture content of 16.0% with negligible breakage loss in the paddy as shown in the table below. The result indicates that there has not been a significant change in the threshing capacity of the machine for paddy threshing where the moisture content varies from 15-17.5%.

Table 5: Threshing vs Moisture Content (Paddy)

Year	MC (%)	Avg.Threshing Capacity(kg/hr)
2013/14	17.5	55.4
2014/15	16.0	56.0
2015/16	17.2	55.0

While the data indicates that the threshing capacity of the machine in wheat threshing drops significantly at moisture above 15%.

Table 6: Threshing vs Moisture Content (Wheat)

Year	MC (%)	Avg.Threshing Capacity(kg/hr)
2013/14	12.5	48.16
2014/15	13.0	48.35
2015/16	15.2	41.67

Weight of the Machine

The gross weight of the machine is found to be 24 Kg which is significantly lighter in comparison to the pedal thresher developed at NAERC earlier. This resulted in an easier transportation option for the farmers in the hilly area to the cropping field.

Overall Anatomy of the Machine

Table 7: Machine Information

Parameters		**Existing Rice Pedal Thresher**	**Rice-Wheat Pedal Thresher**
Frame	Height	70 cm	68 cm
	Width	66.5 cm	38 cm
	Base	52 cm	52 cm
Drum Shape	Length	53.5 cm	29 cm
	Diameter	32 cm	29 cm
Drum Shaft	Total length	72 cm	45 cm
	Diameter	2 cm	1.5 cm
	Blade/shaft	12	10
	Peg/shaft	14	10
	Clearance between drum & frame	3.5 cm	2 cm
Loop	Width	3 cm	3.5 cm
	Height	4 cm	5 cm
	Peg-Peg Distance	4 cm	3 cm
Pedal	Length	58 cm	46 cm
	Width	50 cm	30 cm
	Thickness		
Gear	Number of gear	2	4
Large gear	Number of gear	1	1
	Diameter	22 cm	17 cm

	Thickness	2 cm	1.5 cm
	Teeth width	4 mm	2 mm
	Number of teeth	72	80
Medium gear	Number of gear	Not available	1
	Diameter		9 cm
	Thickness		1.5 cm
	Teeth width		2 mm
	Number of teeth		40
Small Gear	Number of gear	1	2
	Diameter	6 cm	4 cm
	Thickness	2 cm	3.5 cm & 1.5 cm
	Teeth Width	4 mm	2 mm
	Number of teeth	18	20

Ergonomical status

The ergonomic study indicates that there is no significant impact on the operator's health if 20 minutes of continuous operation followed by 20 minutes of rest is given to the operator. The drudgery and capacity are directly associated with the moisture content of the threshing material.

CONCLUSION

The design and fabrication of the rice-wheat pedal thresher are appropriate for small farmers and can easily be transported even to the smaller parcel of land in the hilly area manually. Analyzing the performance of this machine, it can be said that the machine is efficient for both paddy and wheat threshing. The gear shift mechanism imparted enhancement in the utility of this machine. It can be a new innovation in the field of rice-wheat threshing especially for small farmers in hilly areas if promoted.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to NARC/NAERC for all the technical and financial support thought-out the conduction of this research. They are extremely thankful to all the technical and non-technical manpower of NAERC Khumaltar for their continuous effort. This wouldn't have been possible without the kind support & feedback of farmers, our deepest gratitude to them. Last but not least authors are extremely grateful to AGD Khumaltar, ARS Belachapi & AIRC Ranighat for providing samples along with feedback and candid views throughout this work.

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VARIETAL IMPROVEMENT ON RAINFED LOWLAND EARLY RICE GENOTYPES FOR CENTRAL TERAI REGION OF NEPAL

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ABSTRACT

Field experiments were carried out to identify high yielding, disease and insest-pest resistant, and early maturing rice genotypes for rainfed lowland ecosystem. Initial evaluation trial, coordinated varietal trial and coordinated farmers filed trial were conducted in rainy season of consecutive years 2017 and 2018 at National Rice Research Program, Hardinath, Dhanusha. The genotypes were tested using randomized complete block design with three replications for initial evaluation trial (IET) and coordinated varietal trial (cvt) and in single replication in coordinated farmers' field trial (CFFT). Altogether, 61 and 55 genotypes including checks were studied in 2017 and 2018 respectively. Various agronomical and morphological traits such as days to heading, days to maturity, plant height, panicle length, tillers per meter square, filled and unfilled grain per panicle, thousand grain weight and grain yield were taken in all the experiments. Statistical test revealed significance difference for most of traits except panicle length, filled grains per panicle and thousand grain weight in IET during 2017 whereas, non-significant difference for unfilled grain per panicle and thousand grains weight was found in CVT. Likewise all other traits were found statistically significant difference in IET during 2018 except unfilled grain per panicle and thousand grain weight while, non-significant difference was observed for unfilled grains per panicle and grain yield in CVT during 2018. The genotype IR95781-15-1-1-4 (3.56 t ha^{-1}) was highest yielder in IET during 2017, genotypes IR08L151, HHZ10-DT7-Y1 and HHZ1-DT3-Y1-Y1 produced highest grain yield (>4.0 t ha^{-1}) in CVT during 2017. Similarly, genotypes TP12715 produced highest yield of 5.28 t ha^{-1} in IET and genotypes GSR310, IR14L363, IR14L576, IR103588-77-1-2-B and Radha-4 were highest yielder (>4.5 t ha^{-1}) in CVT during 2018. During 2017 under CFFT, genotype IR10L151 was found early in maturity (111 days) while, IR82635-B-B-25-4 (112 days) and IR86515-19-1-2-1-1-1-1 (113 days) matured earlier than check Hardinath-3 (114 days) and were highest yielder with grain yield of 3.95 t ha^{-1} and 3.98 t ha^{-1} respectively. The genotypes HHZ1-DT3-Y1-Y1 was found earliest (107 days) while, highest grain yield of 5.49 t ha^{-1} was recorded in HHZ12-SAL2-Y3-Y3 in CFFT during 2018. From the two years' findings we could conclude that outstanding genotypes in each experiment are the candidate for the subsequent year's varietal evaluation and for variety release based on the overall performance.

Keywords: Coordinated varietal trial, genotypes, rainfed lowland, rice, varietal improvement

अध्ययनको सार

वर्षामा आधारित तल्लो भूभागको पारिस्थितिक प्रणालीको लागि उच्च उत्पादन क्षमता भएको, रोगकिरा प्रतिरोधी र छिटो पाक्ने धानको जीनोटाइपहरू पहिचान गर्न धानखेतमा प्रयोगहरू गरियो। राष्ट्रिय धानबाली अनुसन्धान कार्यक्रम, हर्दिनाथ, धनुषामा सन् २०१७ र २०१८ को वर्षायाममा प्रारम्भिक मूल्याङ्कन परीक्षण, समन्वित जातीय परीक्षण र समन्वित कृषक खेति परीक्षण गरिएको थियो। प्रारम्भिक मूल्याङ्कन परीक्षण र समन्वित जातीय परीक्षणको लागि जीनोटाइपहरू अनियमित पूर्ण ब्लक डिजाइन प्रयोग गरि तीन प्रतिकृतिमा र समन्वित कृषक खेति परीक्षणमा एकल प्रतिकृतिमा अन—स्टेशन परीक्षणहरु गरिएको थियो। सन् २०१७ र २०१८ मा चेक सहित क्रमशः ६१ र ५५ जीनोटाइपहरूको अध्ययन गरियो। विभिन्न आकृतिशास्त्रीय विशेषताहरू जस्तै पसाउन लाग्ने दिन, पाक्न लाग्ने दिन, बिरुवाको उचाइ, बालाको लम्बाइ, प्रति वर्गमिटर बोटसंख्या, प्रति बाला भरिएको र नभरिएको दानासंख्या, हजार दानाको तौल र अन्नको उत्पादन सबै प्रयोगहरूमा लिइयो। सन् २०१७ को तथ्याङ्कीय परीक्षणले प्रारम्भिक मूल्याङ्कन परीक्षणमा बालाको लम्बाइ, भरिएको दाना प्रति बाला र हजार दानाको तौल बाहेक र समन्वित जातीय परीक्षणमा नभरिएको दाना प्रति बाला र हजार दानाको तौल बाहेकका सबै विशेषताहरूको लागि जिनोटाईपहरु बीच महत्त्वपूर्ण भिन्नता पाईयो। त्यस्तै गरी, २०१८ को प्रारम्भिक मूल्याङ्कन परीक्षणमा नभरिएको दाना प्रति बाला र हजार दानाको तौल बाहेक र समन्वित जातीय परीक्षणमा नभरिएको दाना प्रति बाला र अन्न उत्पादन बाहेक सबै विशेषताहरूको लागि जिनोटाइपहरु बीच महत्त्वपूर्ण भिन्नता पाईयो। सन् २०१७ को प्रारम्भिक मूल्याङ्कन परीक्षणमा जिनोटाइप आई.आर९५७८१—१५—१—१—४ (३.५६ टन प्रति हेक्टर) ले सबैभन्दा धेरै उत्पादन दियो भने समन्वित जातीय परीक्षणमा आई.आर०८एल१५१, एच्.एच्.जेड१०—डी.टि७—वाई१ र एच्.एच्.जेड१—डी.टि३—वाई१—वाई१ ले ४.० टन प्रति हेक्टर भन्दा धेरै उत्पादन दिए। तेस्तै गरि, २०१८ को प्रारम्भिक मूल्याङ्कन परीक्षणमा टी.पी१२७१५ ले उच्चतम उपज उत्पादन (५.२८ टन प्रति हेक्टर) ग¥यो भने समन्वित जातीय परीक्षणमा जी.एस्.आर३१०, आई.आर१४एल५७२, आई.आर१०३५८८—७७—१—२—बी र राधा—४ को अन्न उत्पादन उत्कृष्ट (४.५ टन प्रति हेक्टर भन्दा

बढी) रहयो। समन्वित कृषक खेति परीक्षण अन्तर्गत २०१७ मा, जीनोटाइप आई.आर१०एल१५१ चाडो पाक्ने (१११ दिन) फेला पर्यो जबकि आई.आर८२६३५—बी—बी—२५—४ (११२ दिन) र आई.आर८६५१५—१९—१—१—२—१—१—१—१ (११३ दिन), चेक हर्दीनाथ—३ (११४ दिन) भन्दा पहिले परिपक्व भए र यिनीहरुको उत्पदान पनि उच्चतम (क्रमसः ३.९५ र ३.९८ टन प्रति हेक्टर) रहेको थियो। जीनोटाइप एच्.एच्.जेड१—डी.टि३—वाई१—वाई१ ले २०१८ मा किसानहरूको खेती परीक्षणमा सबैभन्दा छिटो पाक्ने (१०७ दिन) फेला परेको थियो भने सबैभन्दा धेरै उत्पादन (५.४९ टन प्रति हेक्टर) एच्.एच्.जेड१२—एस.ए.एल—वाई३—वाई३ ले दियो। दुई वर्षको निष्कर्षबाट हामी प्रत्येक प्रयोगमा उत्कृष्ट जीनोटाइपहरू आगामी वर्षको जातीय मूल्याङ्कनका लागि उम्मेद्वार हुन् भन्ने निष्कर्षमा पुग्न सक्छौं र समग्र विशेषताको आधारमा जात उन्मोचन प्रक्रियाको लागि प्रवर्द्धन गरियो।

मुख्य शब्दहरूः समन्वित जातीय परीक्षण, जीनोटाइपहरू, धान, वर्षामा आधारित तल्लो भूमि, जातीय सुधार

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for more than half of the world's population (Ainsworth, 2008). It is third most produced cereal with an estimated production around 500 million metric tons in 2019/20 (Shahbande, 2020; Gupt et al., 2021). Rice is the most important cereal and staple meal in Nepal, providing 50 percent of the total calories required by 30 million people (Basnet, 2017). Rice was grown on 1.46 million hectare and produced 5.55 million tons, establishing 3.8 t ha^{-1} productivity (MoALD, 2020). It is grown mostly in rainy season and during spring in areas with assured irrigation. About 2000 rice landraces are assumed to be grown from 60 to 3050m altitude in Nepal (Tiwari et al., 2019). In addition, Nepal is one of the centers of diversity for rice nurturing many wild forms and relatives in various parts of the country (Joshi, 2005; Nepali Times, 2004).

Ranfed lowland produces around 19 % of the rice from 52 million ha land of the world (Almanac, 2013; Rao et al, 2017; Dhakal et al., 2021). In Nepal, it is the prevailing rice ecosystem, covers 51% of the total rice area and remaining 49% of the area stands either fully or partially irrigated (Sapkota et al., 2015). Rainfall is an important determinant for production of rainfed rice, but other factors such as topography, soil fertility, and choice of cultivars also affect grain yield (Wade et al., 1999). An optimum water availability is must to ensure timely flowering for high yield while, under rainfed ecosystem, unavailability of water for land preparation and use of old rice seedlings, lack of adequate moisture during various growth stages results delay in flowering. So, early flowering cultivars are suitable in areas where there is probability of late season drought (Fukai, 1999). Due to increasing interest of farmers to grow vegetable and other winter crops, demand of early maturing rice varieties suitable for rainfed condition is also growing in Nepal (Sah et al., 2013). Nevertheless, there are limited early maturing rice varieties for rainfed condition in Terai region of Nepal. Radha-4 (1995) and Hardinath-1 (2004) are mostly grown early maturing rice varieties, former in western and later in central and eastern Terai. Although, both are very old varieties and has also shown susceptibility to some major diseases like blast and bacterial leaf blight causing huge yield loss in farmers' field. Therefore, development and identification and adoption of new early maturing rice variety, with enhanced agronomic characters and resistant to insect-pests and diseases is essential to assure decent crop yield in rainfed environments in central Terai of Nepal.

MATERIALS AND METHODS

Various initial evaluation trials (IETs), coordinated varietal trials (CVTs) and coordinated farmers' field trials (CFFTs) were conducted at National Rice Research Program (NRRP), Hardinath during summer in 2017 and 2018 under rainfed lowland ecosystem (RLE) to identify high yielding and early maturing rice genotypes. A total of 26 entries/genotypes were included in IET under rainfed lowland early (IET-RLE) trial during 2017 and 28 entries during 2018. CVT-RLE consisted of 20 genotypes during 2017 and 22 genotypes during 2018 while, CFFT-RLE consisted of 7 entries in both years (2017 and 2018). The genotypes were received from International Rice Research Program (IRRI), Philippines under International Rice Lowland Observation Nursery (IRLON). Genotypes under both IET and CVT were replicated thrice with randomized complete block design whereas, CFFTs were single replicated in on-station. Each plot size for IET, CVT and CFFT were $10m^2$, $12m^2$ and $50m^2$ respectively. In 2017, seeding and transplanting was done in 10^{th} June and 4^{th} July respectively. Similarly, in 2018, seeding and transplanting was done in 8^{th} June and 30^{th} July respectively. Two-three seedling per hill was transplanted maintaining spacing of 20cm X 20cm. The fertilizer dose of 100:30:30 kg ha^{-1} $N:P_2O_5:K_2O$ was applied where, $1/3^{rd}$ of N and full dose of P and K was applied as basal dose and remaining $2/3^{rd}$ N was applied at 25 DAT (days after transplanting) and 50 DAT in two splits. Two weeding was done just before top dressing. Plot harvesting was done excluding border hills. Agronomical and morphological traits; days to heading, days to maturity, plant height, panicle length, tillers per meter square, filled and unfilled grains per panicle, 1000 grains weight and grain yield were recorded and GenStat 15^{th} edition was used for statistical analysis.

Screening of rice genotypes in blast nursery:

Blast, caused by *Magneporthe oryzae* is one of the major disease of rice in Nepal. The genotypes were screened against the disease in National Rice Blast Nursery (NRBN) at NRRP, Hardinath in 2017 and 2018. Each genotype was sown in two row of 1 m length in rod row design. Targeted disease friendly high humid environment was created by seeding the genotypes inside *Senbania aculeata* surrounded plot. Highly susceptible rice varieties (Musuli and Shankharika) were also sown to border the plot creating high disease pressure inside the nursery. Three scorings were done after 21 days of seeding at 7 days interval using Standard Evaluation System (0-9 scale) for rice (IRRI, 2013) and the data was averaged. The score of 0-2 was considered as resistant reaction whereas 3-4, 5-6 and 7-9 were considered as moderately resistant, moderately susceptible and highly susceptible, respectively.

Screening of rice genotypes in bacterial leaf blight (BLB) nursery:

Bacterial leaf blight (BLB) caused by *Xanthomonas oryzae* pv. *oryzae* is one of the major destructive disease of rice. Therefore, screening of the genotypes was done against BLB in National Rice Bacterial Leaf Blight Nursery (NRBBN) of NRR, Hardinath both in 2017 and 2018 for the genotypes included in the experiment. The deigned followed was simple rod row with two row per entry of 1 m length. Fresh BLB infected rice leaves were collected from the surrounding fields which were chopped into small pieces. The chopped pieces were immersed in water for 30 minutes to prepare inoculums suspension. The suspension was inoculated in all entries at 55 days after transplanting using Kauffman's clipping method. The disease scoring was done at 14 days after inoculation using standard evaluation system (0-9 scale) for rice as suggested by IRRI (2013).

Screening of rice genotypes in brown plant hopper (BPH) and stem borer (SB) nursery:

Brown plant hoper (*Nilaparvata lugens*) *and* Stem borer (*Sirpophaga incertulus*) are the foremost economically threatening insect pests of rice crop. The genotypes were transplanted in National Rice Brown Plant Hopper Nursery (NRBPHN) and National Rice Stem Borer Nursery (NRSBN) to screen against respective insects. Both the nurseries were fertilized as per recommended dose of 150:60:30 NPK/ha. One meter long two rows per entry were transplanted in rod row design. Transplanting was done at a spacing of 15x15 cm to enhance the infestation. In NRBPHN, a resurgence insecticide, Cypermethrin 10 EC@1ml/litre of water was sprayed on boarder rows of TN1 at every 10 days interval to build up BPH population. Data were recorded based on total numbers of white ears per 5 hills caused by stem borer were recorded at the dough milk stage of the crop and damage percentage of plant caused by brown plant hopper.

Resistant and susceptible checks (RC and SC) for different nurseries were as follows and were planted after each 9 entries.

For bacterial leaf blight (BLB): RC- Sabitri, SC- TN1

For foliar blast- RC- Sabitri, SC- Shankharika

For brown plant hopper (BPH) and stem borer (SB): RC- Sabitri, SC- TN1

Weather condition during experimental period of 2017 and 2018:

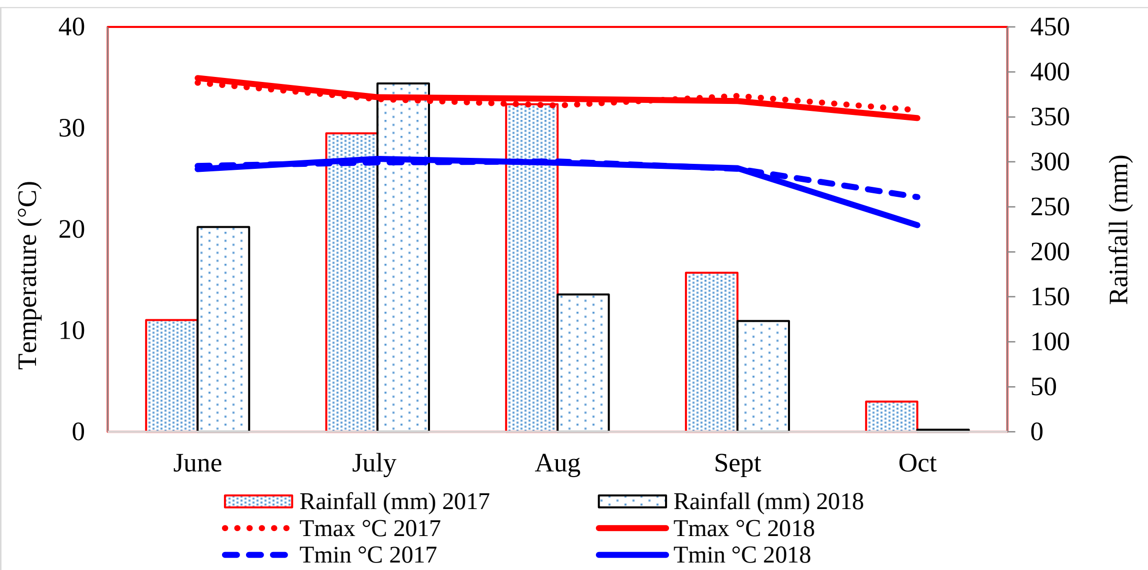

Figure 1: Meteorological condition during experimental period in 2017 and 2018 at NRRP, Hardinath, Dhanusha [where, T_{max}- Average maximum temperature (°C), T_{min}- Average minimum temperature (°C), Rainfall- Total rainfall (mm)]

Results and discussion

Initial Evaluation Trial under Rainfed Lowland for Early Rice (IET-RLE) 2017:

Under IET-RLE, genotypes were found significantly different in days to heading, days to maturity, plant height, tillers per m², unfilled grains per panicle and grain yield (table 1). The disease and insect-pests scoring is presented in table 7. The genotype IR95781-15-1-1-4 had significantly higher grain yield (3.56 t ha^{-1}) than the check, followed by IR96279-33-3-1-2 (3.42 t ha^{-1}) and IR86515-19-1-2-1-1-1-1 (3.25 t ha^{-1}). Similarly, genotype IR101465-5-25 had lowest thousand grain weight of 19 g while, IR96279-33-3-1-2 and IR14L101 had highest grain weight of 27 gram (g). Genotypes IR102607-8-B-1-3 (62 days) and IR102604-15-B-1-1 (64 days) headed earlier, however, their grain yield was among the lowest. The highest yielding genotype IR95781-15-1-1-4 also had highest no. of tillers per m² (350).

Table 1. Performance of genotypes in IET-RLE at NRRP, Hardinath during 2017

SN	Genotype	HD	MD	PH	PL	NT/m²	FG	UFG	TGW	GY
1	IR95836-14-3-1-2	85	114	116	26	274	95	41	22	2.93
2	IR14L 101	84	114	115	28	254	88	28	27	2.74
3	IR95801-6-3-1-1	85	114	117	26	258	75	45	25	2.46
4	IR96279-33-3-1-2	86	114	115	29	294	84	27	27	3.42
5	IR95809-25-1-1-1	89	117	113	27	277	112	20	26	2.66
6	IR14L160	86	115	112	26	298	71	24	25	2.50
7	IR95781-15-1-1-4	86	115	113	27	350	81	27	22	3.56
8	IR95784-21-1-1-2	105	133	109	26	337	95	42	20	1.16
9	IR93810-2-1-1-1	88	116	110	26	297	79	25	24	2.72
10	IR95804-2-1-1-2	91	119	109	26	254	103	25	22	3.17
11	IR14L158	87	116	108	25	238	109	25	26	2.19
12	IR101465-5-25	89	118	109	27	313	83	51	19	3.07
13	IR14L145	89	117	108	26	293	91	28	22	2.14
14	IR14D118	83	113	108	25	314	73	24	25	2.36
15	IR102607-8-B-1-3	62	91	98	23	345	61	41	20	1.10

16	IR102604-15-B-1-1	64	92	106	25	321	83	25	26	1.53
17	IR15L1035	82	111	99	22	289	80	22	21	2.79
18	IR14L572	87	115	114	28	241	86	26	23	2.93
19	IR14L562	83	113	114	25	252	88	35	23	2.84
20	IR14L551	86	115	119	25	272	89	39	24	2.84
21	IR14L521	86	114	110	28	271	89	44	24	2.43
22	IR86515-19-1-2-1-1-1-1	84	113	99	24	185	106	32	26	3.25
23	IR14L363	89	120	119	26	207	114	36	24	2.29
24	IR14L576	85	114	102	24	336	89	25	23	2.67
25	IR103588-77-1-2-B	83	113	111	44	225	110	40	21	3.12
26	Hardinath-3 (C)	86	114	120	27	242	94	40	22	2.57
Grand Mean		85	114	111	27	278	90	32	23	2.59
P-value		<0.01	<0.01	<0.01	0.2	0.01	0.34	<.001	0.15	<0.01
$LSD_{0.05}$		3.0	2.7	11.6	9.7	82.4	23.4	14	5	0.86
CV%		2.2	1.5	6.4	22.3	18.1	24.1	26.1	13	20.1

**Note: HD- heading days, MD- maturity days, PHT- plant height (cm), PL- panicle length (cm),NT-Number of tillers, FG- filled grain per panicle, UFG- unfilled grain per panicle, TGW- thousand grain weight in grams, GY- grain yield in ton per hectare*

Coordinated Varietal Trial under Rainfed Lowland for Early Rice (CVT-RLE) 2017:

For genotypes planted under CVT-RLE in 2017, statistical test showed high significant difference among genotypes in all observed traits except panicle length, unfilled grains, and 1000 grains weight as shown in table 2. The disease and insect-pests scoring is presented in table 8. The genotypes HHZ1-DT3-Y1-Y1 was found superior in grain yield (4.26 t ha^{-1}) and showed significant difference from check variety. The other genotypes IR08L151, and HHZ10-DT7-Y1 produced 4.22 t ha^{-1} and 4.20 t ha^{-1} of grain yield. Genotype IR14L116 (82 days) headed earlier than Hardinath-3 (84 days), while, entries HHZ1-DT3-Y1-Y1, IR86515-19-1-2-1-1-1 and B11586-FMR-11R-2-11 were as early as check. Likewise, the genotype IR09N542 had highest thousand grain weight of 28 g. while, lowest thousand grain weight was 18 g. recorded in three genotypes; IR86515-19-1-2-1-1-1, HHZ14-DT12-L11-L11 and HHZ25-DT9-Y1-Y1.

Table 2. Performance of genotypes in CVT-RLE at NRRP, Hardinath during 2017

SN	Genotype	HD	MD	PH	PL	NT/m²	FG	UFG	TGW	GY
1	B11586-FMR-11R-2-11	84	114	112	26	354	116	32	20	3.20
2	IR55423-01	92	120	110	27	267	125	36	22	3.01
3	IR88965-39-16-4	88	117	113	27	291	111	19	21	3.41
4	IR08L151	87	116	112	26	231	122	22	23	4.22
5	IR86515-19-1-2-1-1-1	84	114	96	26	215	157	48	18	3.75
6	IR09L342	85	114	105	26	338	102	29	23	3.25
7	HHZ12-SAL2-Y3-Y2	88	117	104	25	263	108	33	20	3.35
8	HHZ10-DT7-Y1	87	115	104	26	287	90	29	23	4.20
9	IR11N400	92	121	106	29	296	70	24	26	2.81
10	IR09N542	93	122	107	26	343	71	20	28	3.29
11	HHZ1-DT3-Y1-Y1	84	113	97	24	259	124	34	25	4.26
12	HHZ25-DT9-Y1-Y1	86	114	102	25	258	115	36	18	3.42
13	HHZ14-DT12-L11-L11	85	113	99	26	265	119	27	18	3.43
14	IR14L116	82	112	112	26	379	85	31	26	2.72
15	IR97096-15-1-1-3	91	119	110	26	282	97	31	22	3.52
16	IR95814-10-2-2-2	92	121	94	25	409	95	21	26	2.69
17	IR14D196	91	120	116	27	334	87	26	20	1.95
18	IR14D198	95	123	108	27	364	80	24	22	3.07
19	IR14D199	94	122	107	27	399	84	17	23	3.09
20	Hardinath-3 (C)	84	113	117	27	334	87	34	23	3.66
Grand Mean		88	117	106	26	309	102	29	22	3.31
P-value		<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.31	0.35	0.01
$LSD_{0.05}$		3	3	8.1	2.0	88	38.4	19.4	7.8	0.970

CV%	2.1	1.5	4.6	4.6	17.2	22.8	40.8	21.1	17.8

**Note: HD- heading days, MD- maturity days, PHT- plant height (cm), PL- panicle length (cm), NT-Number of tillers, FG- filled grain per panicle, UFG- unfilled grain per panicle, TGW-thousand grain weight in grams, GY- grain yield in ton per hectare*

Coordinated Farmers' Field Trial under Rainfed Lowland for Early Rice (CFFT-RLE) 2017:

All the genotypes tested under CFFT-RLE produced higher grain yield than that of check variety Hardinath-3 (table 3). The genotypes IR86515-19-1-2-1-1-1-1 and IR82635-B-B-25-4 were high yielding genotype with grain yield of 3.98 t ha^{-1} and 3.95 t ha^{-1} followed by IR09L270 with 3.9 t ha^{-1}. A highest filled grain per panicle (146) was recorded for genotype IR82635-B-B-25-4. Genotypes IR10L151 (81 days), IR82635-B-B-25-4 (82 days) and IR86515-19-1-2-1-1-1-1 (83 days), all headed earlier than check variety (85 days). The genotype IR70210-39-CPA-7-1 had finest grain with thousand grain weight of 15 g. The disease and insect-pests scoring is presented in table 9.

Table 3. Performance of genotypes in CFFT-RLE at NRRP, Hardinath during 2017

SN	Genotype	HD	MD	PH	PL	NT/m²	FG	UFG	TGW	GY
1	IR82635-B-B-25-4	82	112	107	25	175	146	28	21	3.95
2	IR70210-39-CPA-7-1	85	114	114	27	195	126	10	15	3.17
3	IR10L 151	81	111	99	26	252	85	41	23	3.53
4	IR09L 270	86	115	106	29	235	112	32	20	3.92
5	IR10L 182	85	114	111	25	147	93	36	24	1.90
6	IR86515-19-1-2-1-1-1-1	83	113	97	25	235	141	21	18	3.98
7	Hardinath-3 (C)	85	114	101	26	164	112	30	21	1.65

**Note: HD- heading days, MD- maturity days, PHT- plant height (cm), PL- panicle length (cm), NT- Number of tillers, FG- filled grain per panicle, UFG- unfilled grain per panicle, TGW-thousand grain weight in grams, GY- grain yield in ton per hectare*

Initial Evaluation Trial under Rainfed Lowland for Early Rice (IET-RLE) 2018:

The statistical analysis revealed the tested genotypes were significantly variable in days to heading, days to maturity, plant height, panicle length, tillers per m², filled grains per panicle and grain yield (table 4). The disease and insect-pests scoring is presented in table 10. Five genotype; TP12715 (5.28 t ha^{-1}), TP30524 (4.76 t ha^{-1}), TP30529 (4.48 t ha^{-1}), TP30535 (4.28 t ha^{-1}) and TP30539 (4.27 t ha^{-1}) was found best in terms of grain yield production. Two genotypes, IR103575-93-8-2-B (81 days) and TP30523 (82 days) were early flowering than Hardinath-3 (83 days). Genotype IR103587-23-2-1-B had the highest no. of filled grains per panicle (167) while, TP30524 had highest no. of tillers per m² (296) followed by IR16L1678 (285), and TP12715 (265).

Table 4. Performance of genotypes in IET-RLE at NRRP, Hardinath during 2018

SN	Genotype	HD	MD	PH	PL	NT/m²	FG	UFG	TGW	GY
1	TP30523	85	115	100	25	215	110	15	19	4.01
2	TP30524	82	113	100	24	296	95	22	26	4.76
3	TP30529	87	117	115	25	206	131	23	24	4.48
4	TP30530	84	115	107	25	233	129	22	28	4.09
5	TP30532	86	116	107	25	201	108	22	21	3.94
6	TP30533	87	118	106	26	190	96	26	25	3.66
7	TP30535	88	118	107	24	213	129	24	26	4.27
8	TP30536	89	118	109	24	218	114	35	26	3.57
9	TP30538	85	115	106	26	251	105	22	24	3.94
10	TP30539	90	116	113	25	214	128	16	25	4.28
11	TP30542	86	117	97	23	242	98	22	21	3.74
12	TP30546	86	115	99	26	230	110	24	21	3.32
13	TP30551	88	118	106	22	204	141	26	25	4.21
14	TP30555	86	116	111	22	217	112	28	24	3.91

15	TP30566	83	114	101	23	232	127	24	23	3.85
16	TP12715	104	134	94	22	265	108	22	20	5.28
17	TP30544	87	117	108	24	216	85	26	26	3.70
18	IR16L1678	86	116	112	22	285	101	20	24	4.10
19	IR16L1829	89	118	103	25	235	98	36	25	4.23
20	IR16L1723	86	116	103	24	242	105	25	19	3.95
21	IR101465-5-25	89	118	104	26	206	143	28	23	3.68
22	IR98846-2-1-4-3	84	113	98	25	215	132	22	26	3.53
23	IR103575-93-8-2-B	81	112	109	24	250	84	24	25	3.56
24	IR99739:2-1-1-2-1	82	111	109	27	249	89	25	25	2.90
25	IR103587-23-2-1-B	89	120	102	24	177	167	28	24	4.01
26	NR2169-10-4-1-1-1-1-1	83	112	119	25	156	112	22	23	4.03
27	IR103587-22-2-3-B	87	117	105	22	174	121	46	25	3.81
28	Hardinath-3 (C)	83	114	120	25	223	106	28	24	3.34
Grand Mean		87	116	106	24	223	114	25	24	3.93
P-value		<0.01	<0.01	<0.01	<0.01	0.03	0.02	0.33	0.051	0.046
$LSD_{0.05}$		5.4	5.2	6.7	1.5	64	39	16	5	1.0
CV (%)		3.8	2.7	3.9	3.7	17.6	20.7	39.4	13.0	15.5

**Note: HD- heading days, MD- maturity days, PHT- plant height (cm), PL- panicle length (cm), NT- Number of tillers, FG- filled grain per panicle, UFG- unfilled grain per panicle, TGW- thousand grain weight in grams, GY- grain yield in ton per hectare*

Coordinated Varietal Trial under Rainfed Lowland for Early Rice (CVT-RLE) 2018:

The statistical test showed that genotypes were significantly different in all traits except unfilled grains per panicle and grain yield shown in table 5. The disease and insect-pests scoring is presented in table 11. Among the tested genotypes, IR103588-77-1-2-B (4.80 t ha^{-1}), IR14L576 (4.74 t ha^{-1}), GSR310 (4.71 t ha^{-1}), and check Radha-4 (4.67 t ha^{-1}) were high yielding. Genotypes

IR86515-19-1-2-1-1-1-1 (83 days), IR15L1717 (83 days) and IR103575-76-1-1-B (83 days) headed two days earlier than Hardinath-3. Similarly, genotype IR14L198 had highest no. of tillers (317) and IR86515-19-1-2-1-1-1-1 had highest no. of filled grains per panicle (173). Among the genotypes, TP30530 had the highest thousand grain weight of 28 g.

Table 5. Performance of genotypes in CVT-RLE at NRRP, Hardinath during 2018

SN	Genotype	HD	MD	PH	PL	NT/m²	FG	UFG	TGW	GY
1	HHZ6-DT1-L11-L11	87	116	93	23	241	151	25	20	3.92
2	IR08L181	88	117	109	23	182	145	17	24	4.45
3	IR86515-19-1-2-1-1-1-1	83	114	103	23	267	173	18	19	4.34
4	HHZ25-DT9-Y1-Y1	84	114	105	24	256	141	32	19	3.13
5	IR14L198	91	120	108	24	317	71	14	25	3.85
6	GSR310	88	117	102	23	240	143	25	21	4.71
7	IR96279-33-3-1-2	87	116	110	26	251	80	20	27	3.58
8	IR95809-25-1-1-1	91	120	106	26	212	128	21	24	3.45
9	IR14L160	89	118	107	25	254	84	19	27	4.00
10	IR14L158	89	118	112	24	276	144	19	23	3.91
11	IR14L145	90	120	109	26	250	102	17	26	3.95
12	IR14L572	90	120	121	28	220	151	22	26	4.41
13	IR93810-2-1-1-1	90	120	114	25	227	92	24	26	4.49
14	IR14L363	92	122	120	25	198	131	23	25	4.60
15	IR14L576	88	117	101	23	221	129	20	27	4.74
16	IR103588-77-1-2-B	86	116	112	25	167	135	17	24	4.80
17	IR103575-76-1-1-B	83	113	121	24	250	99	22	19	3.58
18	IR98846-2-1-4-3	87	116	99	26	313	127	18	23	3.92
19	IR103587-22-2-3-B	88	118	109	23	247	100	20	26	4.17

20	IR15L1717	83	114	107	23	228	93	16	30	3.85
21	Radha-4 (C)	90	119	109	23	220	102	18	26	4.67
22	Hardinath-3 (C)	85	115	119	26	258	89	20	24	3.32
Grand Mean		88	117	109	25	241	119	20	24	4.08
P-value		0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.61	<0.01	0.14
$LSD_{0.05}$		3.074	2.9	6.2	1.5	58.3	35.2	12	3	1.16
CV (%)		2.1	1.5	3.4	3.7	14.7	18.0	34.9	7.6	17.2

**Note: HD- heading days, MD- maturity days, PHT- plant height (cm), PL- panicle length (cm), NT- Number of tillers, FG- filled grain per panicle, UFG- unfilled grain per panicle, TGW- thousand grain weight in grams, GY- grain yield in ton per hectare*

Coordinated Farmers' Field Trial under Rainfed Lowland for Early Rice (CFFT-RLE) 2018:

Among the genotypes under CFFT, all the genotypes performed better than check variety Hardinath-3 in terms of grain yield production (table 6). The highest grain yield was produced by HHZ12-SAL2-Y3-Y3 (5.49 t ha^{-1}) followed by IR82635-B-B-25-4 (5.40 t ha^{-1}), HHZ1-DT3-Y1-Y1(5.34 t ha^{-1}) and IR97096-15-1-1-3 (5.34 t ha^{-1}). Similarly, genotypes HHZ1-DT3-Y1-Y1 headed in 77 days, followed by IR86515-19-1-2-1-1-1-1 (82 days), HHZ12-SAL2-Y3-Y3 (83 days) and IR82635-B-B-25-4 (83 days) were all earlier than Hardinath-3 (86 days). The thousand grain weight ranged from 18-27 g. and HHZ1-DT3-Y1-Y1 had lowest thousand grain weight of 18 g. The disease and insect-pests scoring is presented in table 12.

Table 6. Performance of genotypes in CFFT-RLE at NRRP, Hardinath during 2018

SN	Genotype	HD	MD	PH	PL	NT/m²	FG	UFG	TGW	GY
1	IR82635-B-B-25-4	83	114	131	26	204	144	12	24	5.40
2	IR09L270	87	116	123	27	209	108	24	24	4.19
3	IR86515-19-1-2-1-1-1-1	82	113	103	25	198	147	26	20	4.20
4	HHZ12-SAL2-Y3-Y3	83	114	106	22	206	104	17	27	5.49
5	HHZ1-DT3-Y1-Y1	77	107	96	21	230	131	27	18	5.34

6	IR97096-15-1-1-3	89	119	122	25	207	104	24	24	5.34
7	Hardinath-3 (C)	86	115	118	25	233	106	20	24	3.77

**Note:* *HD- heading days, MD- maturity days, PHT- plant height (cm), PL- panicle length (cm), NT- Number of tillers,FG- filled grain per panicle, UFG- unfilled grain per panicle, TGW- thousand grain weight in grams, GY- grain yield in ton per hectare*

Table 7. Screening of rice genotypes of IET-RLE in disease and insect-pest nurseries at NRRP, Hardinath in 2017

SN	Genotype	BLAST (0-9)	BLB (0-9)	BPH (0-9)	SB (%)
1	IR95836-14-3-1-2	3.5	5	1	0
2	IR14L 101	2.5	9	3	0
3	IR95801-6-3-1-1	1.5	5	1	1.6
4	IR96279-33-3-1-2	4	5	1	1.9
5	IR95809-25-1-1-1	2.5	5	3	2.3
6	IR14L160	2.5	3	1	1.6
7	IR95781-15-1-1-4	6	7	1	0
8	IR95784-21-1-1-2	3.5	3	3	0
9	IR93810-2-1-1-1	1.5	5	1	2.6
10	IR95804-2-1-1-2	2.5	5	3	0
11	IR14L158	2.5	3	3	1.6
12	IR101465-5-25	1.5	3	0	0
13	IR14L145	1.5	3	0	0
14	IR14D118	2.5	5	0	0
15	IR102607-8-B-1-3	4	9	0	15.3
16	IR102604-15-B-1-1	5	9	1	4.2
17	IR15L1035	5	7	1	0
18	IR14L572	1.5	5	0	0
19	IR14L562	1.5	9	0	2.9
20	IR14L551	3	7	0	0
21	IR14L521	2	9	1	0
22	IR86515-19-1-2-1-1-1-1	1.5	5	3	0

23	IR14L363	4.5	3	0	0
24	IR14L576	3	5	1	0
25	IR103588-77-1-2-B	2.5	3	3	1.7
26	Hardinath-3 (C)	3.5	5	1	0
27	RC	2	3	3	0
28	SC	5	9	7	6.6
Average score		3	5.5	1.5	1.6

Table 8. Screening of rice genotypes of CVT-RLE in disease and insect-pest nurseries at NRRP, Hardinath in 2017

SN	Genotype	BLAST (0-9)	BLB (0-9)	BPH (0-9)	SB (%)
1	B11586-FMR-11R-2-11	1.5	7	3	0
2	IR55423-01	2.5	7	1	0
3	IR88965-39-16-4	3.5	3	3	0
4	IR08L151	1.5	3	3	0
5	IR86515-19-1-2-1-1-1	1.5	3	1	0
6	IR09L342	2.5	5	5	2
7	HHZ12-SAL2-Y3-Y2	3.5	7	3	2.1
8	HHZ10-DT7-Y1	2.5	3	1	0
9	IR11N400	5	3	5	0
10	IR09N542	3	3	3	0
11	HHZ1-DT3-Y1-Y1	1	3	1	0
12	HHZ25-DT9-Y1-Y1	3	3	1	0
13	HHZ14-DT12-L11-L11	1.5	3	0	0
14	IR14L116	1.5	7	3	1.5
15	IR97096-15-1-1-3	2.5	3	3	0
16	IR95814-10-2-2-2	2.5	7	5	0
17	IR14D196	2.5	3	1	9
18	IR14D198	2.5	3	5	0
19	IR14D199	2.5	5	3	0
20	Hardinath-3 (C)	1.5	7	3	0

21	RC	2.5	3	3	0
22	SC	7	7	7	9.5
Average score		2.6	4.5	2.9	1.1

Table 9. Screening of rice genotypes of CFFT-RLE in disease and insect-pest nurseries at NRRP, Hardinath in 2017

SN	Genotype	BLAST (0-9)	BLB (0-9)	BPH (0-9)	SB (%)
1	IR82635-B-B-25-4	2.5	5	1	1.7
2	IR70210-39-CPA-7-1	2.5	7	3	0
3	IR10L151	1.5	3	1	0
4	IR09L270	2.5	3	3	0
5	IR10L182	3	9	5	3.7
6	IR86515-19-1-2-1-1-1-1	2.5	3	3	0
7	Hardinath-3 (C)	3.5	7	1	0
8	RC	3.5	5	3	0
9	SC	8	9	9	4.5
Average score		3	5.3	3.4	1.6

Table 10. Screening of rice genotypes of IET-RLE in disease and insect-pest nurseries at NRRP, Hardinath in 2018

SN	Genotype	BLAST (0-9)	BLB (0-9)	BPH (0-9)	SB (%)
1	TP30523	2.5	5	5	0
2	TP30524	3	3	7	2.3
3	TP30529	3	3	3	10
4	TP30530	3	3	3	12.4
5	TP30532	3.5	3	3	7.8
6	TP30533	5.5	5	3	27.4
7	TP30535	6	5	3	0
8	TP30536	6	3	3	26

9	TP30538	1.5	3	3	10
10	TP30539	3	3	3	1.8
11	TP30542	3	3	0	5.9
12	TP30546	2	3	9	3.9
13	TP30551	3	3	3	6.6
14	TP30555	3	3	3	4.6
15	TP30566	4	5	7	8.7
16	TP12715	2.5	5	7	0
17	TP30544	5	3	3	36.5
18	IR16L1678	2	3	3	21.1
19	IR16L1829	1	3	3	11.3
20	IR16L1723	3.5	3	3	3.9
21	IR101465-5-25	2.5	3	5	16.4
22	IR98846-2-1-4-3	2.5	5	7	0
23	IR103575-93-8-2-B	4	3	3	22.7
24	IR99739:2-1-1-2-1	3.5	3	5	10.5
25	IR103587-23-2-1-B	3.5	3	3	9.2
26	NR2169-10-4-1-1-1-1-1	3	3	3	2.7
27	IR103587-22-2-3-B	5	5	3	2.5
28	Hardinath-3 (C)	3.5	3	0	14.9
29	RC	4.5	3	3	0
30	SC	7	7	9	31.2
Average score		3.3	3.5	4	10.2

Table 11. Screening of rice genotypes of CVT-RLE in disease and insect-pest nurseries at NRRP, Hardinath in 2018

SN	Genotype	BLAST (0-9)	BLB (0-9)	BPH (0-9)	SB (%)
1	HHZ6-DT1-L11-L11	3.5	3	0	6.4
2	IR08L181	5	5	0	17.4
3	IR86515-19-1-2-1-1-1-1	3.5	3	0	4.5
4	HHZ25-DT9-Y1-Y1	3	5	0	8.7
5	IR14L198	1	3	3	13
6	GSR310	3	3	0	9.2

7	IR96279-33-3-1-2	2	5	0	43.8
8	IR95809-25-1-1-1	2	3	0	18.6
9	IR14L160	3.5	3	0	14.9
10	IR14L158	2	5	0	37.8
11	IR14L145	1	3	3	5.4
12	IR14L572	0.5	3	0	19.2
13	IR93810-2-1-1-1	2	3	0	9.2
14	IR14L363	2	5	3	4.8
15	IR14L576	0	5	3	29.3
16	IR103588-77-1-2-B	1	5	0	9.3
17	IR103575-76-1-1-B	1.5	3	0	5.1
18	IR98846-2-1-4-3	2	5	3	11.2
19	IR103587-22-2-3-B	2.5	5	3	3.4
20	IR15L1717	1	3	3	8.1
21	Radha-4 (C)	2	3	5	2.3
22	Hardinath-3 (C)	1	5	0	3.6
23	RC	1	3	3	4.4
24	SC	7	7	5	19.2
Average score		2	4	1.5	13

Table 12. Screening of rice genotypes of CFFT-RLE in disease and insect-pest nurseries at NRRP, Hardinath in 2018

SN	Genotype	BLAST (0-9)	BLB (0-9)	BPH (0-9)	SB (%)
1	IR82635-B-B-25-4	1	5	3	9.2
2	IR09L270	1.5	3	3	12
3	IR86515-19-1-2-1-1-1-1	2	3	3	8.3
4	HHZ12-SAL2-Y3-Y3	1.5	3	3	0
5	HHZ1-DT3-Y1-Y1	2	3	5	7.1
6	IR97096-15-1-1-3	0.5	5	7	6.5
7	Hardinath-3 (C)	3	3	3	27.3
8	RC	2	1	3	0
9	SC	5	9	7	12.4
Average score		2.1	4.1	3.2	8.5

The genotypes under study were found significantly variable for most of agro-morphological, yield traits and disease and insect infestation. High level of phenotypic variation in grain yield is due to variation in growth and development resulting in difference for yield attributing traits such as days to heading, days to maturity, plant height, panicle length, tillers per meter square, thousand grain weight (Dhami et al., 2017). Similar finding of high genetic variation in rice under rainfed lowland condition was reported by Sah et al. (2009). To find out the superior and potentially desirable genotypes, large no. of genotypes should be considered in study so that genotypes with high phenotypic and genotypic diversity will be identified which can be used in many ways in breeding program.

CONCLUSION

Based on overall performance for each individual traits; days to heading, days to maturity, grain quality and yield performance, diseases and insect-pests resistance along with other important agro-morphological traits, genotypes were either repeated on the same trial, advanced for further evaluation or dropped. Disease and insect-pests scoring was highly emphasized during advancing of genotypes for subsequent year. Among the genotypes tested under IET during 2017, IR95809-25-1-1-1, IR14L160, IR93810-2-1-1-1, IR14L158, IR14L145, IR14L572, IR14L363, IR14L576 and IR103588-77-1-2-B were advanced to CVT in 2018. Likewise, genotypes HHZ1-DT3-Y1-Y1 and IR97096-15-1-1-3 from CVT 2017 were promoted to CFFT 2018. Under CFFT 2017, genotypes IR82635-B-B-25-4, and IR09L270 were suggested for further evaluation during 2018. Similarly, genotypes NR2169-10-4-1-1-1-1-1, IR103587-23-2-1-B, IR16L1723, IR16L1829, TP30555, TP30551, TP30530, TP30532, TP30538 and TP30539 under IET 2017 were suggested to advance in CVT. Six genotypes from CVT 2018, GSR310, IR93810-2-1-1-1, IR98846-2-1-4-3, IR103587-22-2-3-B and IR15L1717 were recommended to CFFT. The genotypes IR86515-19-1-2-1-1-1-1, HHZ12-SAL2-Y3-Y3 and IR82635-B-B-25-4 from CFFT 2018 were suggested for seed multiplication and seed kit distribution for the following year.

ACKNOWLEDGEMENT

The authors thanks to International Rice Research Institute (IRRI), Phillipines for providing advance materials. We are grateful to Nepal Agricultural Research Council management team for financially supporting this research. Authors would like to express sincere thanks to Rice Coordinators for providing every support during experiment period. Similarly, we would like to thank technical staffs of Rice Breeding unit, NRRP-Hardinath for supports to conduct this research smoothly.

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PERCEPTION OF FARMERS TOWARDS BANANA INSURANCE AND FACTORS AFFECTING THE CROP INSURANCE

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ABSTRACT

Banana farming is one of the commercial farming in Chitwan district Nepal. From the early 1940 banana was cultivated in the Chitwan district and it was developed as a potential area for banana cultivating area. This study was targeted to estimate the factor affecting purchasing insurance schemes among banana farmers. Based on banana farm size purposive random sampling method was employed to select a total sample size of 150 (50 small farmers, 50 medium farmers, and 50 large farmers) among the registered banana farmers of Chitwan district Nepal. The primary data were collected by the household survey. The result showed that disease ranks the major problem for large and small farmers while windstorm ranks the major problem for medium farmers. Similarly, crop insurance was a major tool for the transfer of risk (windstorm) on banana cultivation for large farmers. The farmers were highly satisfied with the subsidy on insurance premium of 0.83 and were highly dissatisfied with the quick payment of banana loss from the insurance companies (-0.77). The probit model was used to gauge factors influencing banana insurance in the study area. The result depicted that the factors like education, experience in banana cultivation, active membership in the organization, technical assistance, and access to loans had a significantly positive role in purchasing crop insurance schemes.

Keywords: Factors, Perception, Probit, Risk transfer, Satisfaction

अध्ययनको सार

केरा खेती चितवन जिल्लाको लागि एक व्यवसायीक कृषि खेती हो । सन १९४० देखी हुँदै आएको केराखेती चितवनमा, हाल दिनप्रतिदिन व्यवसायिक रुपमा फस्टाउँदै गएको छ । सुरुका वर्षहरुमा थौरैमात्र क्षेत्रफलमा केराखेती गर्ने कृषकहरु अहिले आफ्नो केराको क्षेत्रफल विस्तार गरेसँगै नेपाल को कृषि कुल ग्रहास्थ उत्पादनमा सहयोग पुर्‍याउँदै आएको छ । यो अध्ययन विशेषतः केरा खतिको जोखिम र यसको न्युनिकरणका लागि बिमा कमर्यक्रम साथै बिमा कार्यक्रममा सहभागीहुनका लागि के कस्ता कुराहरुले असर गर्दछन भन्नेमा रहेको छ । उद्देश्यपूर्ण केरा खेती गरेका कृषकहरुको जमिनको आधारमा गोलाप्रथा माध्ययमबाट १५० वटा केरा

कृषकलाई नमुनाको रुपमा लिईएको थियो (जसमाः ५० जना साना कृषक, ५० जना मझौला कृषक, ५० जना ठूला कृषक रकेका छन्) । प्राथमिक तथ्याङ्क घरधुरी सर्वेक्षण मार्फत गरिएको थियो । अध्ययनबाट ठूला र साना केरा कृषकहरुको नजरमा केरा को प्रमुख समस्या रोग रहेको र मझौला कृषकहरुलाई हावाहुरी प्रमुख समस्या रहेको पाइयो । यस्तै ठूला कृषकहरुलाई हावाहुरी को जोखिम न्यूनीकरणका लागि बिमा प्रकृया सबैभन्दा प्रभावकारी माध्ययम रहेको पाइयो । बिमा शुल्कमा रहेको अनुदानमा कृषकहरु एकदमै सन्तुष्ट पाइयो भने बिमा कम्पनीबाट क्षेती भएको केराको भुक्तानी रकममा हुने ढिलासुस्ती प्रति कृषकहरुको बढी असन्तुष्टी देखियो । प्रोबिट मोडल मार्फत केरा बिमालाई प्रभाव पार्न सक्ने के के हुन सक्छन भनी हेर्दा कृषकको शिक्षा, अनुभव, कृषकको सँघ सँस्थाहरुमा आवद्धता, कृषकको प्राविधिक सेवामा सहयोग र ऋणमा पहुँचले कृषि बिमा खरिदका लागि सकरात्मक असर गरेको पाइयो ।

INTRODUCTION

In Nepal, agriculture is a major source of income and forms the basis of livelihoods for the majority of the population. Agriculture is one of the important businesses in the case of Nepal which contributes 25.72% to the national GDP and provides employment to 60.4% of the population (MoALD, 2022). The above stat indicates the general development of the nation will be possible with the improvement of this agriculture sector. Despite of majority of the people were in agriculture around 50,651 Metric tons of banana with the monetary value of NRS 1,526,656,000 was imported in the year 2020 (MoALD, 2021). The importance of this sector for the nation's economy was underlined with the implementation of the Agriculture development strategy (ADS) in 2015 which supports the further commercialization of this sector. Agriculture production faces a myriad of risks. In the context of banana, production farmer faces both price risk and production risk. Agriculture risk is the negative consequences that result from imperfectly predictable variables like an outbreak of price risks, disease and pests, non-availability of inputs called resource risk, and adverse climatic elements like drought, flood, storm, etc., which are beyond the farmer's control (Mani, Chandrasekaran, & Selvanayaki, 2012). Banana fruit bears a heavy loss, and this massive loss in a banana is caused by wind/storm, Panama wilt, and the seasonal market pattern of the banana. In 2009, a heavy loss of bananas was reported in Chitwan and Nawalparasi districts (Bank, 2009). Due to this farmers were not much confident to grow bananas in the future.In January 2013, The Government of Nepal (through the Insurance Board) introduced crop and livestock insurance directives to encourage insurance companies to develop commercial agriculture under the insurance act 1992 (MoAD, 2013). The risks to be covered with the insurance are flood, landslide, drought, excess rainfall, hailstones, snowfall, frost, and earthquake. Initially, the government decided to provide a 50 percent subsidy on the insurance premium paid by the individual farmers, farmer's groups, and farmer cooperatives but later on after Nepal government decided to increase the subsidy and make it 80 percent (MoALD, 2022). Based on the cost of production premium is calculated. The insured farmer will get up to 90 percent of the compensation in case of loss. Although there was a high risk in banana cultivation, it is becoming popular among the Nepalese farmers as it was highly profitable than other commodities with having a benefit-cost ratio of 1.5 (Ghimire et al, 2019). However, the risk-minimizing benefit has not been utilized extensively by the farmers. So minimization of risk may also encourage farmers to commercially cultivate bananas. This study will help to drag out the actual cause behind the lag of this scheme and will identify the factors which govern joining the insurance. The objective of this study is to study the perception of banana farmers on banana insurance and evaluate is better the factor affecting the use of insurance schemes for banana cultivation.

METHODOLOGY

This study was conducted in the Chitwan district of Nepal. This district was purposively selected for the study because the Chitwan district ranks 3rd position with contributing 11.04% to banana production (MoALD, 2021). In Chitwan, 3,076 hectares (ha) of land is under banana cultivation with a productive land area of 2,329 ha and a production of 28,193 metric tons (MoALD, 2021).

All the banana farmers in the study area constitute the study population. On discussion with Chitwan Banana Production Association members, there were 403 banana producers. A household survey was conducted using a personal interview schedule with 150 banana producers. Samples were selected using a purposive simple random sampling technique. Producers were categorized into three based on the farm size.

Table 1. Category of farmers.

Farmer Category	Farm size	Number of samples
Small farmer	Less than 0.67 ha	50
Medium Farmer	0.67 – 2.67 ha	50
Large Farmer	More than 2.67 ha	50

Note: ha=hectare

Similarly, to know the importance of different perception on banana farming, five-point scale was used based. The index of importance was carried out using the following formula:

$I_{imp} = \frac{\Sigma (Si\ Fi)}{N}$

Where

I_{imp} = Index of Importance

Σ = Summation

S_i = i^{th} Scale value (1,2,3,4,5 and 6)

F_i = Frequency of i^{th} importance given by the respondents

N = Total number of respondents

Furthermore, in probit model, we suppose Y_i is the binary response of the farmers. $Y_i = 1$, if farmer joins crop insurance and $Y_i = 0$ if farmer does not join crop insurance.

If $Y_i = 1$; $Pr(Y_i = 1) = P_i$

If $Y_i = 0$; $Pr(Y_i = 0) = 1-P_i$

Where, $P_i = E(Y=1/X)$ represents the conditional mean of Y given certain values of X.

There might be several factors that determine farmer whether to join crop insurance or not. The determinants could be socioeconomic, demographic, institutional involvement and alike. So this model was used to identify the determinants (regressors) on the probability of joining crop insurance (regress and). The likelihood of farmers joining the crop insurance is a non-linear function of regressors (Nagler, 1994).

Table 2. Description of the variables used in probit model

Variables	Type	Description of the variables	Unit	Expected sign
Dependent variable (Y_i)	Dummy	Crop insurance status (1=insured, 0 otherwise)	-	
Independent variables				
AGE	Continuous	Age of the household head	years	+/-
GENDER	Dummy	Gender of the household head (1=Male, 0 otherwise)	-	+/-
EDUCATION	Continuous	Education of the household head	years	+/-
HHSIZE	Continuous	Household size		-

MIGRATION	Dummy	Migration status of the household member to abroad (1=yes, 0 otherwise)		+
LAND	Continuous	Land holding of household	hectare	+/-
EXPERIENCE	Continuous	Years of banana cultivation	years	+
LOG_Banana income	Continuous	Income from bananas (Rupees)	rupees	+
MEMBER	Dummy	Active membership in social organization (1=Yes, 0 otherwise)		+
TECHNICAL_ASS	Dummy	Technical assistance (1=Yes, 0 otherwise)		-
ACCESS_LOAN	Dummy	Access to loan (1=Yes 0 otherwise)		+
MEDIUM FARM	Dummy	Medium farm (1 = Yes, 0 otherwise)		+
LARGE FARM	Dummy	Large farm (1 = Yes, 0 otherwise)		+

Note: 1 hectare = 30 Kattha; 1 US$ = NRs. (as of August 2020).

RESULTS AND DISCUSSION

The average banana cultivated land by the banana insurer was 6.3 hectares, ranging from 0.25 hectares to 23.3 hectares. It was found that out of total land cultivated by banana insurers 62.5% of cultivated land was done insurance. 89.23% of the farmers who had insured their land did claim the insurance while 10.76% had not claimed it. This finding was similar to those (Snell & Atherton, 2020). It was also found that the majority of farmers (63.8%) made claims when the loss was equal to 10%, followed by 17.2 % of farmers who made claims when the loss was even small. Only 10.3% of farmers claimed when the loss was greater than 25%, followed by 8.6% of farmers who claimed when the loss was 10-25%.

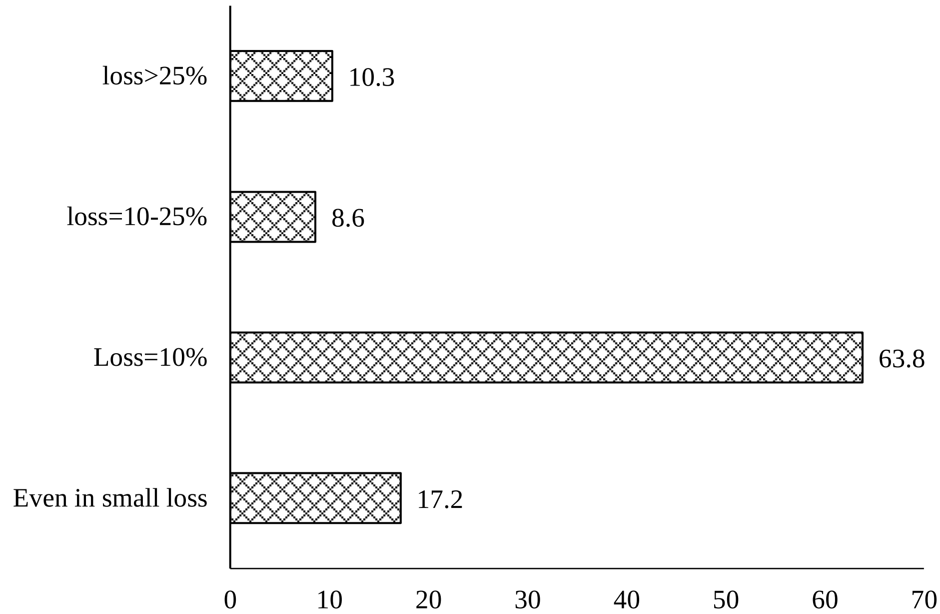

Figure 1. Diagram showing stages of the claim

Perception of banana farmers on the loss of bananas at different stages

Banana cultivation was a risky enterprise. 98.4% of the insurers had experienced the loss of bananas in the past while 83.1% of the non-insurers had experienced loss in the past. The top single cause of bananas as stated by the farmers who faced loss was the windstorm in the summer months. It had attracted the sight of every banana farmer and related stakeholders of the district. The problem of windstorms is an even higher chance of loss, majority 78.7% revealed that just after fruiting was the major stage of loss in bananas, 19.3% revealed that just the young fruit stage was the major stage of loss and only 2.0% think that mature stage was the major stage of loss. This finding was similar to (Barrueto, Nicole, & Thomas, 2017) who found that 1 to 2 windstorms have the potential to damage horticultural plants. None of the farmers have experienced heavy loss during the vegetative stage of the plant.

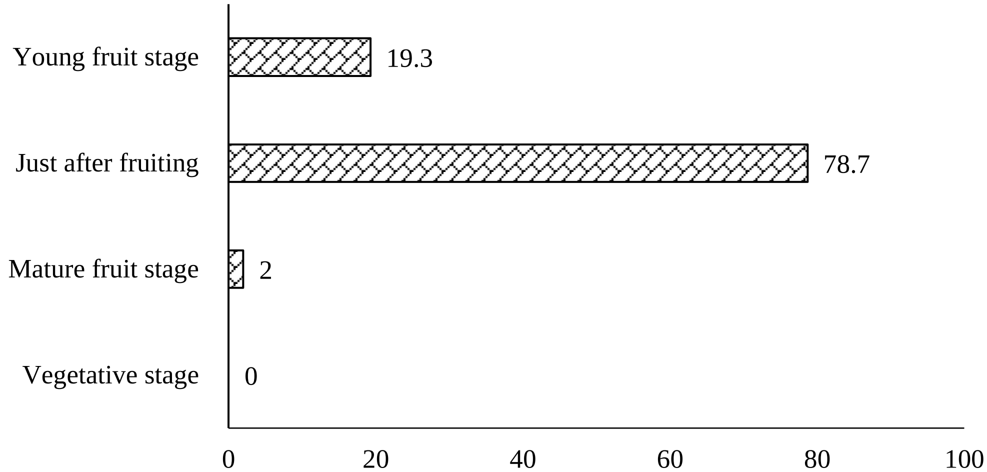

Figure 2. Diagram showing stages of major loss

Perception of banana farmers on risk minimizing tools for windstorm

The study revealed that staking rank the first risk-minimizing tool for small and medium farmers but crop insurance ranks the major risk-minimizing tool for the large farmers. This finding was similar to those (Snell & Atherton, 2020). The plant protection measures rank second followed by Earthing up, crop insurance, and land selection in small farmers. Similarly, earthing up ranks second followed by crop insurance, plant protection, and land selection in the medium farm. In the case of large farms staking ranks second followed by Earthing up, plant protection, and land selection.

Table 3. Risk minimizing tools adopted by farmer

Measures	Farm size					
	Small Farm		Medium farm		Large farm	
	Index	Rank	Index	Rank	Index	Rank
Staking	0.43	I	0.6	I	0.63	II
Earthing up	0.4	III	0.58	II	0.59	III
Crop insurance	0.26	IV	0.54	III	0.79	I
Plant protection	0.41	II	0.51	IV	0.5	IV
Land selection	0.21	V	0.23	V	0.29	V

Perception of adopters regarding their satisfaction with insurance policy

The findings for the perception of insurance adopters with insurance policies show that the farmers were highly satisfied with the subsidy on insurance premium of 0.83. Similarly, risk coverage by insurance (0.78) comes on second in satisfaction level followed by insurance premium cost (0.75) and valuation of the banana (0.47). Farmers were highly dissatisfied with the quick payment of banana loss from the insurance companies (-0.77). Similarly, farmers were dissatisfied with the claim settlement procedure (-0.6) and insurance procedure and documentation (-0.18). This finding was supported by (Nair, 2010) found that there were delays in insurance claim settlement in multi-peril crop system.

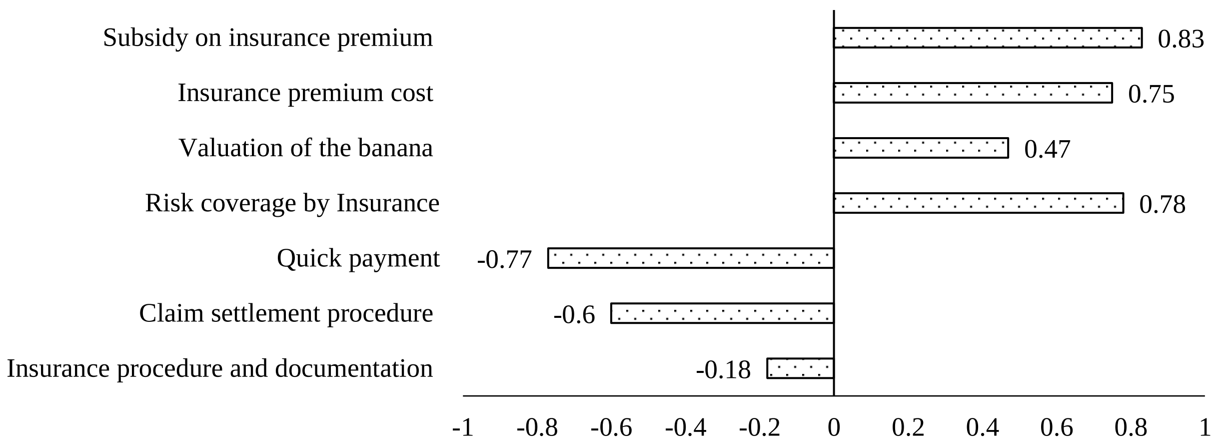

Figure 3. Diagram showing perception of adopters regarding their satisfaction with insurance scheme

Probit model for factor determining crop insurance

Table 4. Results from probit Model for factors determining crop insurance

Variables	Coeff.	Std. Err.	dy/dx
AGE	-0.023	0.023	-0.003
GENDER #	0.807	1.118	0.071
EDUCATION	0.210**	0.088	0.029
HH SIZE	-0.140	0.099	-0.019
MIGRATION #	0.280	0.611	0.043
FARM_SIZE	0.010	0.078	0.0014
EXPERIENCE	0.280***	0.093	0.039
ACTIVE_MEMBERSHIP #	1.129*	0.624	0.138
TECHNICAL_ASST #	1.181**	0.562	0.130

ACCESS TO LOAN #	1.539**	0.612	0.169
MEDIUM FARM #	0.330	0.724	0.050
LARGE_FARM #	1.314	0.959	0.255
PRODUCTIVITY	0.024	0.032	0.003
Summary statistics			
Number of observations	150		
LR Chi-square	150.76		
Prob> Chi-square	0.000		
Pseudo R^2	0.76		

Notes: dy/dx is Marginal effects after Probit. '#' indicates for discrete change of dummy variable from 0 to 1. ***, ** and * represent significance at 1%, 5% and 10% levels, respectively.

The probit model was used to gauge factors influencing banana insurance in the study area. The likelihood ratio chi-square (LR chi2) for the model was statistically significant at a 1% level which revealed that the model had a good explanatory power. The Pseudo R2 was 0.76. Among the variables eleven variables namely gender, education, migration, farm size, experience in banana farming, active membership in an organization, technical assistance, access to loan, medium farm, a large farm, and productivity per 0.03 ha had a positive relation with joining crop insurance while other variables namely age and household size had a negative relation with joining crop insurance. Five variables (education, experience in banana cultivation, active membership in an organization, technical assistance, and access to loans) were found significant. Keeping the other variables constant the probability of joining crop insurance increases by 2.9 % with the increase in the year of schooling by one year which was significant at a 5% level. Education increases one's ability to receive, decode, and understand information relevant to making innovative decisions. It reflects that the educated farmers are better informed about the insurance agencies, schemes and their characterization, and also the costs and benefits associated with the insurance (Karthick & Mani, 2013). Similarly, keeping the other variables constant the probability of joining crop insurance increased by 3.9 % with the increase in the year of experience by one unit which was found significant at a 1% level. The finding was supported by (Pant, 2016), who found that experience in banana cultivation was also a supporting factor for crop insurance. Similarly, keeping the other variables constant the probability of joining crop insurance increases by 14 % when the household head was an active member of a social organization which was found significant at a 10% level. Similarly, keeping the other variables constant probability of joining crop insurance increases by

13 % when the household head has got the technical assistance which was significant at a 10% level. Similarly, keeping the other variables constant probability of joining crop insurance increases by 17% when the household head has access to a loan which was significant at a 5% level. The finding was supported by (Boyad, Pai, Wang, Wang, & Qiao, 2011), found that active member or leader was more likely to purchase crop insurance. Similarly, keeping the other variables constant probability of joining crop insurance increases by 0.3 % when the productivity per 0.03 ha increases. Keeping the other variable constant when the household had a medium farm size, the probability of joining crop insurance increased by 5 % over that of the small farm. Similarly, when the household head had a large farm size probability of joining crop insurance increases by 25.5 % more than that of a small farm size. This result is consistent with the result of a similar study by (Fallah, Armin, & Tajabadi, 2012).

CONCLUSION

This study was carried out to explore the perception of banana farmers on their risk in banana cultivation and the strategy adopted for the minimization of risk. To compensate for the loss of bananas purchasing of crop insurance scheme was one of the risk-minimizing tools which got popular among the banana growers. The result showed that crop insurance was a major tool for risk diversion for large farmers. Just after fruiting was a major stage for crop loss and wind was a major cause for this loss. Banana farmers were highly satisfied with the subsidy on insurance premiums provided by the government but they were highly dissatisfied with the claim settlement process and the reluctant nature of insurance companies for quick payment. A standard norm with a quick payment strategy should be developed for motivating farmers for purchasing crop insurance. This study also reveals that education, experience, membership in an organization, technical assistance, and access to loans were the major factors that influence the adoption of crop insurance in banana cultivation. Grounded on the empirical findings of the study, the study recommends that agricultural support like training, access to credit, and awareness programs should be provided to farmers for inspiring farmers to purchase crop insurance schemes.

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EVALUATION OF PROMISING PRE-RELEASED VARIETIES OF CHICKPEA FOR FARMER’S PREFERENCE IN DANG, BANKE AND BARDIYA

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ABSTRACT

The trial was designed to evaluate and provide opportunity to choose the most suitable variety on their own choice under farmers' field condition. Varietal selection trials on chickpea was carried out in outreach sites Banke, Dang and Bardiya during the winter cropping seasons of 2073, 2074 and 2075. The trial was planted in 9.6 m. sq. Each location was used as one replication for statistical data analysis. Participatory trials indicated that chickpea genotype ICCV 97207 produced the highest yield 3278 and 866 kg/ha during the year 2073 and 2074 however, in 2075 check variety Tara produced the highest yield (3452 kg/ha) in Bardiya. Likewise, in Banke location during the year 2073 Tara check produced the highest yield (2363 kg/ha) while during 2074 and 2075, genotype ICCV 97207 produced the highest yield i.e. 1742 and 1951 kg/ha respectively. In Dang chickpea genotype ICCV 97207 produced the highest yield over the years. Mean yield performances indicated that the genotype ICCV 97207 produced (2138 kg/ha) yield over the years (2073-2075) and achieved Ist rank in farmers ranking and preference. So, Grain Legume Research program forwarded ICCV 97207 to variety release process.

Keywords: Chickpea,Outreach, Participatory,promising, Variety

अध्यनको सार

बिभिन्न नविनतम जातहरु विकास गर्ने क्रममा कोसेबाली अनुसन्धान कार्यक्रम बाट विकास गरिएका चनाका उदीयमान जातहरुलाई राष्ट्रिय बीउ बिजन समिति बाट सिफारिसका लागि आवश्यक डाटा प्रमाणीकरण गर्न र किसानको प्रतिक्रिया लिनका लागि किसानकै खेतमा लगाएर उनीहरूको प्रत्यक्ष सहभागीतामा आफ्नो खेतबारीका लागि ऊपयुक्त जातको छनौट गर्ने उद्देश्यले परिक्षण संचालन गरिएको थियो। वि.स. २०७३, २०७४ र २०७५ सालको हिउँदे सिजनमा बिभिन्न तीन जिल्ला दांग, बाँके र बर्दियामा परिक्षण गरिएको थियो। प्रत्येक जिल्लामा तिन-तिन कृषकलाई सहभागी गराइएको थियो र ३ कृषकको औसत लाई १ डाटा र ३ जिल्लालाई ३ रेप्लिकेसन मानी प्राप्त डाटाको विश्लेषण गरिएको थियो । परिक्षणमा प्रतिजात ९.६ वर्ग मिटर प्रयोग भएको

थियो।तीन वर्ष र तीन ठाउंको डाटालाई संयुक्त विश्लेषण गर्दा अनुजात आइ.सी.सी.भी ९७२०७ ले सबैभन्दा धेरै २१३८ केजी प्रति हे. उत्पादन गर्नुका साथै किसानको प्रतिक्रिया र न्याङ्क को आधारमा पनि पहिलो प्राथमिकतामा परेको हुनाले कोसेबाली अनुसन्धान कार्यक्रमले भविष्यमा यस जातलाई सिफारिस गर्ने प्रकृयामा रहेको छ।चनाको अनुजात आइ.सी.सी.भी ९७२०७ सिफारिस गर्ने क्रममा रहेको हुनाले बीउ उत्पादन गर्ने र कृषि प्रविधि प्रसारमा संलग्न कार्यकर्ताहरुले यस जातलाई आ-आफ्नो क्षेत्रमा प्रवर्द्धन गर्न अनुरोध छ ।

INTRODUCTION

Nepal Agriculture Research Council (NARC) has been Conducting Outreach research activities in more than 50 Outreach sites under the command areas of commodity research program, Directorate of Agricultural Research and Agricultural/Horticultural Research Station (DoAR/ARS/HRS) in various agro-ecological domains across the country. Outreach research, which is reported to be initiated during 1960's by Parwanipur Agriculture Farm by distributing minikits of maize, wheat, grain legumes and potato (Paudel, 2011), paved the long way with tremendous experiences and changes. The definition and boundary of outreach research had broadened with the present development of participatory and pluralistic model of technology development and emergence of INGO's, CBO's and private sectors in agriculture research and development (Gauchan *et al*, 2003). The activities are conducted in collaboration with extension personnel in farmer's field to verify technologies and adopt them with necessary relevant research agencies in order to make the technologies more useful to the farmers. NARSC (1987) had defined outreach research program as a combination of adoptive research and service activities conducted by researchers that assist extension personnel to disseminate technology. The present concept of outreach research is defined as a method of participatory technology development and dissemination involving interactive participation and partnership of farming communities and diverse research and development actors from public, private and civil society sectors in bringing together their knowledge and practices and research capacity (Shrestha & Kaini, 2000).

Grain Legumes Research Program(GLRP) has mandate to Conduct grain legumes research, generate appropriate technology and their promotion on the basis of priority along with Assessment of production problems of grain legumes in different agro-ecological domains in the country with the collaboration of provincial level Directorates of Agricultural Research, Agricultural Research Stations, Agriculture Knowledge Centers, Seed Company, Agri-cooperatives, farmers and other agriculture related stakeholders to prioritize the research agenda and conduct research activities. GLRP has focused to test and generate various cost effective, client oriented, socially and environmental friendly improved technologies in order to address the farmers' problem. Research results on promising crop varieties and technologies are regularly tested and validated at the farmer's field condition. In outreach since farmers are involved in every steps of the research with their remarkable participation, they acquire good knowledge and experience to select the appropriate crop varieties and technologies. They can make better decision for acceptance and rejection of promising varieties/technologies identified at on- the farm. Therefore, this participatory research approach named as "outreach research" has served as a significant bridge among researchers, extension, private sectors and farmers for dissemination of proven technologies. This research paper highlights the participatory varietal selection research executed in the command areas of GLRP, Khajura during the fiscal year 2073, 2074 and 2075 in chickpea.

Objectives

- To test and verify promising genotypes under farmers' field condition and provide an opportunity to the farmers to select most suitable variety on their own choice
- To assess researchable needs, problems or suggestion to further plan of research programs and to guide the implementation process.

METHODOLOGY

Research Sites

GLRP, Banke has its three major outreach sites where the demonstration plots have for the developing and being tested as well as proven technologies and crop varieties are maintained for the famers, extension workers and other concerned agencies through the participatory approach. The sites so mentioned are so selected and established as it would be represent various agro domain conditions of rain feeding, different altitudes of land for example, upland, low land etc, different type of irrigated conditions as well as different type of wet land (Table 1)

Table 1: Description of the outreach sites of GLRP

District	Rural/Municipality	Geographic Description

Banke	Bethani, Duduwa	Low wet-land and dry land, 180 masl
Bardiya	Joshipur, Bansgadi	Middle wet-land and dry land, 180 masl
Dang	Lalmatiya, Rapti	Irrigated and rainfed, 185 masl

The PVS trial set was distributed in all sites. Varieties were selected from the promising lines of CVTs conducted in earlier years at the GLRP, Khajura and other Coordinated NRAC stations. The trials of different crops were conducted in RCBD design consisting new promising varieties with standard check. Both crop trials were planted in 3-4 farmers field per location during the winter cropping seasons of 2073, 2074 and 2075. Each location was used as one replication for statistical data analysis.The summary of crop, packages of varieties and genotypes, plot size and respective sites of cultivation has been presented in Table 2.

Recorded data were managed in MS excel and analyzed by using statistical software R-program 4.0.5 version.

Table 2: The Summary of trial

S.No.	Name of genotypes	Planting distance	Plot size (m. sq.)	Fertilizer dose and application	Sowing time
1	KPG-59	40 × 5-10 cm (6 lines)	9.6 (4m x 2.4m)	20:40:20 – basal application	I[st] fortnight of Mangsir
	ICCV 98933				
	BG 372				
	ICCX 840508-31				
	ICCV 97207				
	Tara (Check)				

RESULTS AND DISCUSSION

Participatory trials' data from Bardiya indicated that chickpea variety Tara produced the highest yield 3452 and 1357 kg/ha during the year of 2073 and 2075 however, in 2074 genotype ICCV-

97207 produced the highest yield (806 kg/ha). Likewise, in Banke location during the year of 2073 genotype ICCX-840508-31 produced the highest yield (2495 kg/ha) while during 2074 and 2075, genotype ICCV-97207 produced the highest yield i.e. 1742 and 1951 kg/ha respectively. In Dang chickpea genotype ICCV-97207 produced the highest yield (3542, 2502 and 2008 kg/ha) over the years (Table 3). However, in all the year 2073, 2074 and 2075 genotype ICCV-97207 produced the highest yield 3037, 1703 and 1673 kg/ha, respectively. Similarly, in district wise Dang and Banke district same genotype ICCV-97207 (2684 and 1995 kg/ha) performed well while in Bardiya, Tara check variety (1838 kg/ha). In combined (genotype, year and location) analysis Mean yield performances indicated that the genotype ICCV 97207 produced (2138 kg/ha) yield over the years (2073-2075).

Table 3: Performance of chickpea genotypes at Banke, Bardiya and Dang in 2073, 2074 and 2075

Genotypes	**Yield (kg/ha)**									
	Bardiya			**Banke**			**Dang**			**Mean**
	2073	**2074**	**2075**	**2073**	**2074**	**2075**	**2073**	**2074**	**2075**	
KPG-59	2743	585	1296	2271	1316	1476	2361	2032	1263	1705
ICCV-98933	2588	614	1079	1935	1578	1533	2555	2496	1133	1723
BG-372	2291	703	1068	2050	1437	1545	2586	1359	1207	1583
ICCX -840508-31	3113	743	1257	**2495**	1344	1347	3385	1924	1240	1872
ICCV-97207	3278	**866**	1062	2292	**1742**	**1951**	**3542**	**2502**	**2008**	**2138**
Tara	**3452**	706	**1357**	2363	1525	1302	3125	2085	1805	1969
Mean	1008	703	1600	2234	1490	1526	2926	2066	1442	1832

Table 4: Combined performance of chickpea genotypes at Banke, Bardiya and Dang in 2073, 2074 and 2075

Genotypes	Yield (kg/ha) in Year			Yield (kg/ha) in District			Mean	Farmers reaction and rank
	2073	2074	2075	Dang	Banke	Bardiya		
KPG-59	2458	1311	1345	1885	1688	1541	1705	Medium bold seed(III)
ICCV-98933	2359	1563	1248	2061	1682	1427	1723	Late maturing (V)
BG-372	2309	1166	1273	1717	1677	1354	1583	Small seed(IV)
ICCX -840508-31	2998	1337	1281	2183	1729	1704	1872	Small seed (VI)
ICCV-97207	**3037**	**1703**	**1673**	**2684**	**1995**	1735	**2138**	Bold seed, disease free (I)
Tara	2980	1439	1488	2338	1730	**1838**	1969	Small seed (II)
Mean	2690	1420	1385	2145	1750	1600	1832	
CV							28	
LSD							482	
LOC							0.00	
TRT							0.05	
LOC:TRT:YR							0.8	

CONCLUSION

Based on three year and location results Chickpea genotype ICCV-97207 showed maximum mean yield than other genotypes in command areas of GLRP Khajura. Rest of the chickpea genotypes could not produce higher yield better than the check variety Tara. Based on the performance on farmers filed and their preference genotype ICCV 97207 is in variety release process.

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PROTIOMICS AND GENOMICS STUDY FOR GENE EDITING FOR COLD TOLERANCE ON RICE (*ORYZA SATIVA* L.)

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ABSTRACT

Cold water, cold weather and cold climate are expanding problems of rice growing areas. Climate change enhances more extreme events and unfavorable environment in certain areas for rice growers. Cold stress affects rice growth and yield and ultimately, limits rice productivity. The complex mechanisms affecting the molecular and physiological changes that enable adaptive response to cold stress in rice. In this complex mechanism, the cell perceives cold stress, signal transduction through the cell memebrance or channels to nucleus or chromosomes which response as transcriptional activated or deactivated genes using gene expression pathways. Multifunctional (genetics, molecular, physiological and physical) analysis and approaches solve these complex traits (cold stress) related problems. With the objective of this study was to generate and develop diverse mutants (lines/varieties) for cold tolerance on rice, we determined the possible target sites and its relation with proteins by using OPT8511 cold sensitive) sequence. About 172 proteins are affected by this gene editing system and among them, 61 proteins were found as direct or indirect relation and association with cold responsive traits or enzymes related to nine chromosomes. The collection of proteins, their position and their functions has given a good command in the future study in relation of cold response of rice and other crops, and also have new possibilities of diversity for rice breeding in future and farmers will be benefited in double or triple rice growing zones and cold sensitive areas..

Key words: gene editing, CRISPR/Cas9, cold stress, rice.

अध्ययनको सार

विश्वभर धान खेती हुने क्षेत्रहरूमा चिसो पानी, चिसो मौसम र चिसो जलबायु बढ्दो समस्याको रूपमा रहेको छ। जलबायु परिवर्तनले नेपाल, भारत, चीन, जापन, कोरिया जस्ता देशहरूमा विगतमा भन्दा तापक्रम एक्कासी बढ्ने वा घट्नेले अति अनौटा घट्नाहरू र असुहाउँदो वातावरण सिर्जना गरी धान उत्पादनमा बढी असर परेको छ। चिसोका असरहरूले धान बालीको बृद्धि अवस्था, उत्पादन तथा उत्पादकत्वमा असर पारेको छ। धान बालीको मोलकुलर तहमा र बोटमा देखिएका परिवर्तनहरूलाई असर गर्ने जटिल संयन्त्रले धानमा चिसो तनावको लागि अनुकूली प्रतिक्रिया

विकास गर्दछ। यस जटिल संयन्त्रमा, कोशिकाले चिसो तनाव, सेल झिल्ली वा च्यानलहरू मार्फत न्यूक्लियस वा क्रोमोसोमहरूमा संकेत ट्रान्सडक्सन देख्छ जुन जीन अभिव्यक्ति मार्गहरू प्रयोग गरेर ट्रान्सक्रिप्शनल सक्रिय वा निष्क्रिय जीनको रूपमा प्रतिक्रिया गर्दछ। बहु-कार्यात्मक (आनुवंशिकी, आणविक (मोलकुलर), शारीरिक र भौतिक) विश्लेषण तथा उपागमहरूले यी जटिल लक्षणहरू (चिसो तनाव) सम्बन्धित समस्याहरू समाधान गर्दछ। दक्षिण कोरियामा गरिएको यस अध्ययनको उद्देश्य धानमा चिसो सहने क्षमताका लागि विविध म्युटेन्टहरू (लाइन/विविधहरू) उत्पन्न गर्ने र विकास गर्ने थियो, हामीले (OPT8511 चिसो संवेदनशील) अनुक्रम प्रयोग गरेर सम्भावित काट्ने साइटहरू र प्रोटिनहरूसँग यसको सम्बन्ध निर्धारण गर्यौं। यस जीन सम्पादन प्रणालीबाट करिब १७२ प्रोटिनहरू प्रभावित छन् र तीमध्ये ६१ प्रोटिनहरू प्रत्यक्ष वा अप्रत्यक्ष रूपमा चिसो सहने विशेषता वा इन्जाइमसँग नौ क्रोमोजोमसँग सम्बन्धित रहेको पाइएको थियो। प्रोटिनको सङ्कलन, तिनीहरूको स्थिति र तिनीहरूको कार्यहरूले धान र अन्य बालीहरूको चिसो प्रतिक्रियाको सम्बन्धमा भविष्यको अध्ययनमा राम्रो दिशा निर्देश गरेको छ र भविष्यमा धान प्रजननका लागि विविधताको नयाँ सम्भावनाहरू थपिएका छन् र यी लाइनहरूको प्रयोग गरी धान उत्पादन क्षेत्र र चिसो संवेदनशील क्षेत्रका किसानहरू दोब्बर वा तेब्बर धान बाली लगाई लाभान्वित हुनेछन्।

INTRODUCTION

Rice (*Oryza sativa* L.) is the top most important crop and consumes more than half of the world's population (Khush, 1999). The challenges for higher production and productivity of many rice growing temperate and sub-tropical zones are facing the abiotic stresses especially the cold water and the cold weather. It was reported that more than 15 million ha of rice planted every year suffered from cold damage at one or another stage of growth throughout the world (IRRI Report, 1979, Kauffman H. E .1979.). So, this extreme environments like increment of temperature or sudden decrease in temperature has created more pronounced effects on rice production than previous. Cold stress is one of prime common environmental stress primarily in high-altitude or latitude areas of Korea, Japan, China, Nepal, India and many parts of world. Cold stress including chilling (0-15 °C), freezing (below 0 °C) and cold water irrigation affects crop growth and yield and limits rice productivity. If we could develop the cold tolerant rice varieties, farmers will be benefitted in double or triple rice growing zones and will get high productivity in cold stress suffering zones.

It has been reported that the cold sensitivity is closely linked with OPT8511 RAPD (Random Amplified Polymorphic DNA) fragments at seedling stage in rice (Kim et. al., 2000). Plant develops cold responsive mechanism by developing and producing protective structures, substances and proteins. Cold stress adapted phenotypes selection becomes fruitful on the basis of diverse genotypes (genomics), physiological adjustment and adaptation (metabolomics), molecular breeding and genetic engineering (genomics), proteomics, trasncriptomics, geographical information system (GIS) as well as phenomics studies and outputs. In many studies, the expression of many inducible genes like COR (Cold Regulated), CBF (CCAAT-binding transcription factor), DREB (Dehydration Responsive Element Binding) protein, bZip (basic leucine zipper proteins), WRKY, LEA (Late embryogenesis abundant proteins), NAC (NAM, ATAF and CUC) transcriptional factors, NAP (Nucleosome assembly/disassembly factors), iSAP (International Symposium on Antennas and Propagation) factor etc. are the effects of coordinated response pathways of ABA-dependent and independent due to below optimal temperatures (Reineri et al., 2015). The overexpression of certain cold-related transcription factors pronounced effect on the cold stress tolerance of rice (Ito et al., 2006; Wang et al., 2008; Ma et al., 2009; Su et al., 2010; Takasaki et al., 2010). Some cold-stress related genes like COLD1, OsSRFP1, and SGD1 (Fang et al., 2015) have been cloned and cold-responsive R2R3-type MYB gene OsMYB30 can bind to the promoters of β-amylase (BMY) genes as a transcription factor and OsJAZ9 function as a complex to suppress the expression of BMY genes and has a negative influence in rice cold tolerance. So, it should be given more attention for developing and finding of cold tolerance genes to cope the cold disasters and its will help in expansion of rice cultivation areas in tropical as well as subtropical zone. CRISPR/Cas9 has been widely used in genome editing in a variety of organisms including rice (Cong et al., 2013). RNA-guided genome editing (RGE) using bacterial type II CRISPR associated nuclease (Cas) has emerged as a simple and versatile tool for genome editing in many organisms including plant and crop species (Xie et al, 2014).

The objective of this study was to generate and develop diverse mutants (lines/varieties) for cold tolerance on rice. In this study, we determined the possible target sites and its relation with proteins by using OPT8511 cold sensitive) sequence. In short, we have done basic studies on cold tolerance mechanism and gene editing for cold tolerance on rice genome using the CRISPR/Cas9 system, which may offer new possibilities of diversity for rice breeding in future. However, it can be utilized for further study.

MATERIALS AND METHODS

The process for the gene editing for cold tolerance in rice using the CRISPR/Cas9 is outlined (Fig. 1). The study was conducted in Plant Molecular Breeding Lab of Kyungpook National University, South Korea.

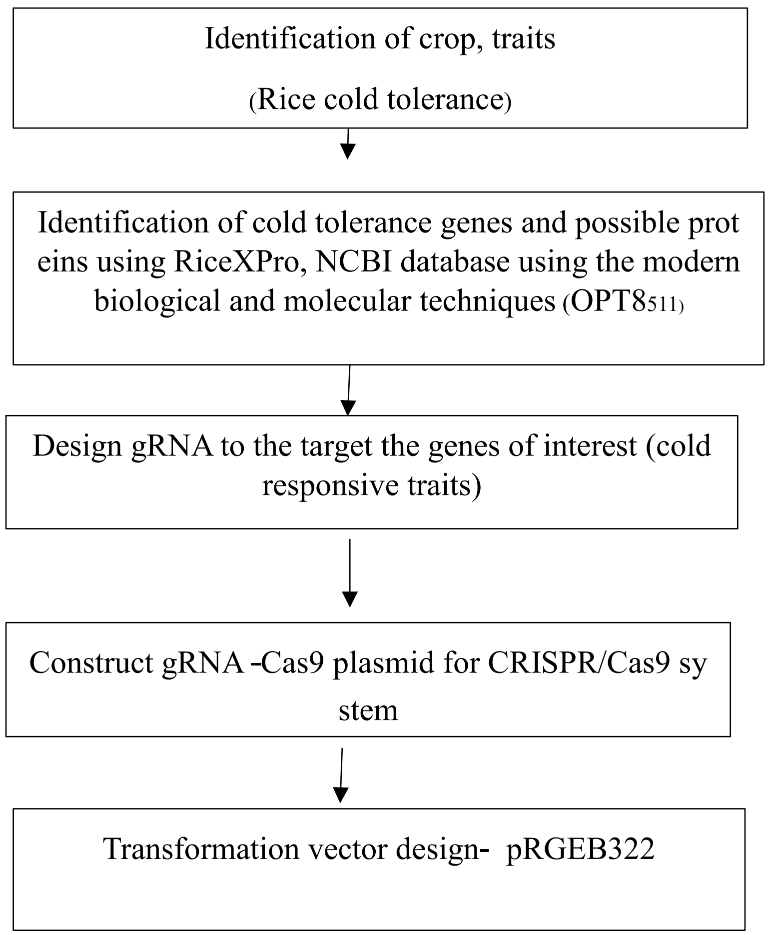

Fig. 1. Scheme for cold tolerance using CRISPR/Cas9 gene editing in rice.

Gene identification and gRNA synthesis

The sample sequence OPT8511 (511bp) was identified from rice genome located in chromosome 5. Based on this sample sequence, gRNA was designed and plasmid pGREB32 was selected as vector. The Ilmi rice variety was used for the callus culture for efficiency for *Agrobacterium* mediated transformation (Fig. 2).

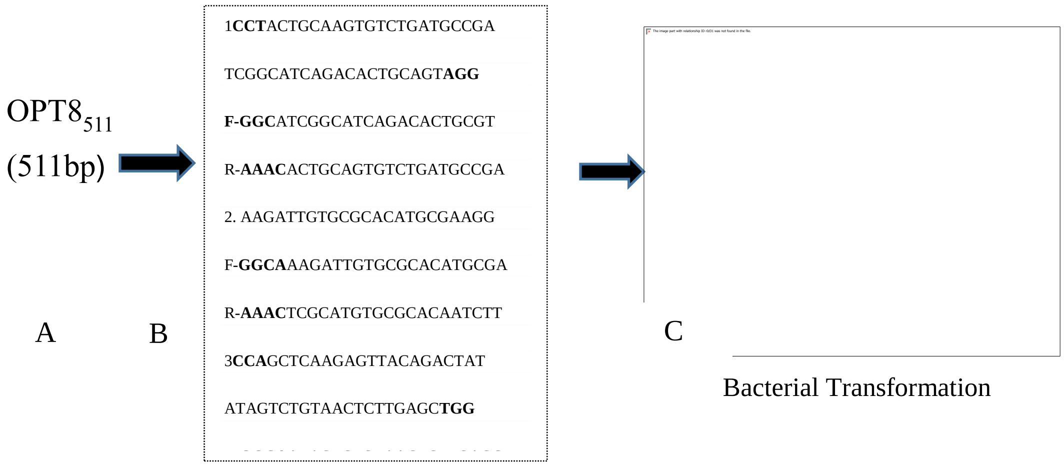

Fig. 2. Outline of gene editing system.

A. Gene identification $OPT8_{511}$ (511bp) cold sensitive sequence B. gRNA design for gene editing C. Plasmid selection and preparation, bacterial transformation

Using the CRISPRdirect web tool (http//:crispr.dbcls.jp), it was found that the possible target cutting sites of candidate gRNA target sequences in the genomic region of interest. The output window shows 23 bp genomic sites of the form 5'-N20 NGG-3' within the target region. These sites may reside on the + or - strand. 5'-NNNNNNNNNNNNNNNNNNNNNGG-3' PAM .

Table 2. sg RNA sequence and primer design.

No.	sgRNA (5‘ to 3')	Position	GC Contents (%)	Out-of-frame Score	Mismatches 0	Mismatches 1	Mismatches 2		Primer (5' to 3')
1	TCGGCATCAGACACTGCAGT**AGG**	333 – 355	60.86	69.8	1	0	0	F	**GGCA**TCGGCATCAGACACTGCAGT
								R	**AAAC**ACTGCAGTGTCTGATGCCGA
2	AAGATTGTGCGCACATGCGA**AGG**	357 - 379	52.17	71.8	1	0	0	F	**GGCA**AAGATTGTGCGCACATGCGA
								R	**AAAC**TCGCATGTGCGCACAATCTT

3	ATAGTCTGTAACT CTTGAGC**TGG**	411 - 433	43.47	75.6	1	0	0	F R	**GGCA**ATAGTCTG TAACTCTTGAGC **AAAC**GCTCAAGA GTTACAGACTAT

sgRNA-bold; PAM sequence, Primer-bold mark; *Bsa*I sequence

RESULTS AND DISCUSSION

1. Sample sequence related to cold tolerance

The sample sequence (OPT8511) was strongly associated with cold sensitivity of rice was used for gene editing and the putative open reading frame was 511 base pairs and associated with cold responsive traits.

CGACAGTACCTCACAAAGATACTACTCAAGTCGCGGACACTCATGACGTCGCTATG
ATTGAAGCCGACTGGCGAGAACCCCTCATACGATTTTTAACTTCTCAAGAACTTCCT
CAAGACAAAAATGAAGCCGAGCGGATTTCACGGCGGAGCAAACTTTATGTTATCCA
TGAAGCTGAGTTATACAAGAAAAGTCCTTCGGGAATTCTGCAACGCTGCGTATCTTT
AGAGGAAGGGAGACAACTACTGAAAGACATACATTCTGGGATATGCGGAAACCATG
CTGCCGCACGCACCATTGTCGGCAAAGCTTACCGGCAGGGTTTTTTCTGGCCTACTG
CAGTGTCTGATGCCGACAAGATTGTGCGCACATGCGAAGGTTGCCAATTTTTCGCCA
GACAAATTCATCTACCAGCTCAAGAGTTACAGACTATTCCGCTGTCTTGGCCGTTTG
CGGTTTGGGGGCTCGACATGGTTGGCCCGTTCAAAAAGGCAGTCGGCGGATACACG
CA (511 nt).

The CRISPRdirect (http://crispr.dbcls.jp/) tool was used for selection of CRISPR/Cas target sites and the reduction of numbers of potential off-target candidates. It was investigated the entire genome for perfect matches with each candidate target sequence (20 mer) and their seed sequence (12 or 8 mer) flanking the PAM. We utilized and searched based on the 20mer+PAM has one mismatch Class 0.0 and 1.0 specificity of CRISPR-direct database to avoid off-target editing.

2. Proteomics and genomics study

Using riceXPro and NCBI database, the possible affected proteins was analyzed**.** About 172 proteins might affect by gene editing using the sample sequence OPT8511**.**

Table 3 **.**The possible number of cutting sites **)**using CRISPRdirect **(**and the number of proteins may affected in rice after gene editing **)**using RiceXPro and NCBI database**(** http//:rapdb.dna.affrc.go.jp., https//:blast.ncbi.nlm.nih.gov/Blast.cgi)

Gene editing affecting chromosome no**.**	Cutting sites	Number of proteins may affected	Cold tolerance related proteins **)**direct or indirect relation**(**
02	2	12	4
03	1	2	1
04	2	15	5
05	1	18	7
06	3	34	12
07	2	19	9
09	4	25	12
11	1	19	5
12	1	28	6
Total -9	**17**	**172**	**61**

Using the sample sequence OPT8511, the possible cutting sites of whole genome of rice are 17. The highly matched sample sequence was found in chromosome 09 at four cutting sites in Table 8**.**

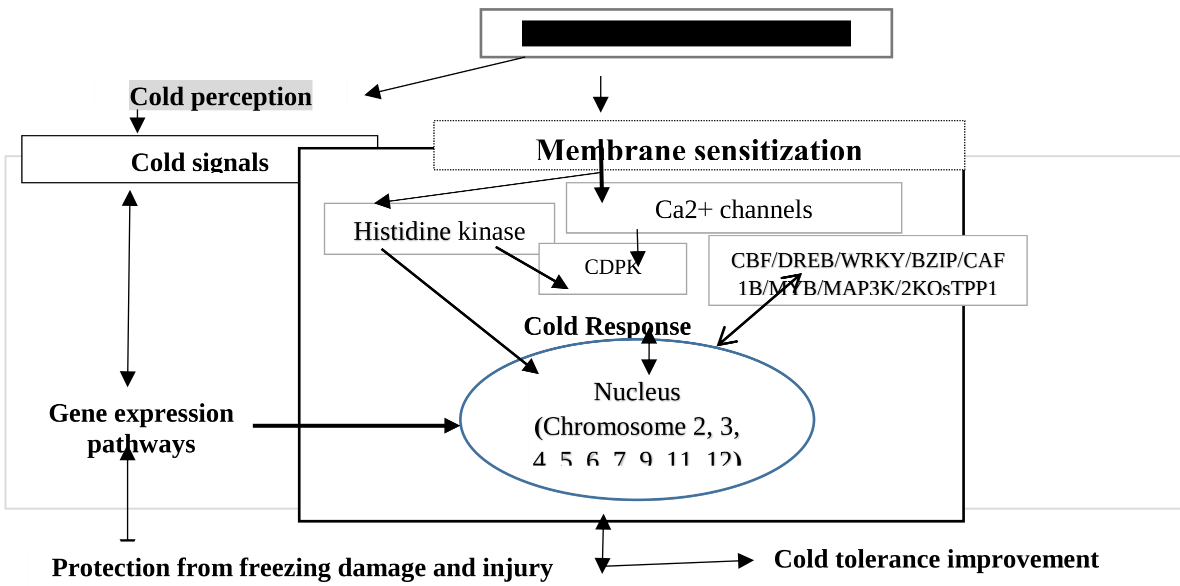

Fig.3. Cold response mechanism in rice cell in this editing system.

However, the chromosome 01, 08 and 10 has no matched sites or has not shown cutting sites on the chromosoemes. It means these chromosomes are not affected by this gene edting. It means there was no relation of cold responsive region or not associated with cold sensitive sample sequence OPT8511 in chromosome 01, 08 and 10**.** Among the 172 proteins, 61 proteins have a direct or indirect relation with cold tolerance mechanism or genetic expression of rice**.** The rice chromosomes numbers, their cutting sites, number of preoteins affected and the number of cold stess related proteins (Fig. 3) is presented in Table 3.

3. gRNA and its efficiency

The *S. pyrogens* with Cas9 was used to edit the targeted coding sequence 5’-20 nt-NGG-3’ and target region was cold sensitive sequence (OPT8511) of Chromosome 5 and this region is cold sensitive protein coding region. The pGREB322 was digested by BsaI making sticky ends and adding the adoptors as the 5’GGCANNNN……3’ and 5’……NNNNCAA3’ in Table 2 to improve the efficiency and for confirmiation of oligos. These sticky ends ligated lineared plasmid. The GC content was more than 40% and less than 60% (was 43% to 56%) in gRNA which gave the chance of heritable mutation in next generation. The the number of mismatches was kept zero to below 3 (In this experiment, only one was kept) to reduce the off target binding using CRISPRdirect. Cold tolerance is a complex trait controlled by many genes in rice and associated with complex pathway of genetic and phenotype expressions. Plant develops cold responsive mechanism by developing and producing protective structures, substances and proteins. Cold stress adapted phenotypes selection becomes fruitful on the basis of diverse genotypes (genomics), physiological adjustment and adaptation (metabolomics), molecular breeding and genetic engineering (genomics), proteomics, trasnscriptomics, geographical information system (GIS) as well as phenomics studies and outputs. IRRI scientists reported that three regions of the rice genome that have a direct link to cold tolerance at the plant's reproductive stage (irri.org/climate-smart-rice). In this study, the sample sequence (OPT8511) was utilized for gene editing using CRISPR Cas9 for cold tolerance breeding on rice because that sample sequence was strongly associated with cold sensitivity of rice proved by Random Amplified Polymorphic DNA (RAPD) analysis for the cold tolerance and the putative open reading frame was 511 base pairs (Kim et al., 1997). It is associated with cold responsive traits and it had associated with 172 proteins. It has been reported that the gene sequence (cold sensitive OPT8511) for possible target of Chromosome 5 (Kim et. al., 2000) was polymorphic. So, OPT8511 was used for studying the cold tolerance mechanism in rice and its possible target site in the different chromosomes.

Using the riceXPro and NCBI database, the possible affected proteins using sample sequence (OPT8511) were analyzed**.** The total 172 proteins affected or associated were found and we edited gene using this sample sequence OPT8511 in diffenent chromosomes of rice. In this study, we found that there are 17 the possible cutting sites of whole genome of rice and the highly matched four cutting sites were found in chromosome 09 and nine chromosomes were affected by CRISPR/Cas9 gene editing system for cold toerarnce mechanism. The chromosome 02, 03, 04, 05, 06, 07, 09, 11 and 12 are affected by gene editing. But the success rate was found the gRNA2 only. Among the 172 proteins, 61 proteins have a direct or indirect relation with cold tolerance mechanism or genetic expression of rice**.** To get more information, it should be further study and analysis of proteins, mechanism of cold tolerance with phenomics study**.** The correlation between the mutant phenotype(s) and the targeted/off-targeted mutations can determined by crossing the mutants with the parental plants followed by co-segregation analysis in the progenies in further study.

SUMMARY AND CONCLUSION

Cold stress by chilling, freezing and cold water irrigation affects rice growth and yield and limits rice productivity. So, it should be given focus on developing and searching of cold tolerance genes to cope the cold disasters and problems and it will also help in expansion of rice cultivation areas in high altitude tropical as well as subtropical zone. In this study, we determined the possible target sites and its relation with proteins using OPT8511 sequence **(**cold sensitive sequence**)**. On the basis of this target site, the gene editing was carried out on rice for cold tolerance development on rice by using CRISPR/Cas9 gene editing system**.** Among 172 proteins, 61 proteins were found as direct or indirect relation with these complex cold responsive traits. The collection of proteins, their position and their functions has given a good command in the future study in relation of cold response of rice and other crops. The study on these cold tolerance traits of rice through use of the CRISPR/Cas9 system, which has given new avenue and more chance for development of cold tolerant rice**.**

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DETERMINANTS OF PRODUCTIVITY OF GINGER (*Gingiber officinale*) IN ILAM DISTRICT OF NEPAL

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ABSTRACT

Ginger (Gingiber officinale) is highly export potential cash crop of Nepal. This study was done with the major of objective of determining the factors affecting the productivity of Ginger in Ilam district of Nepal. One hundred and sixty ginger producers were selected by a three-stage sampling procedure. Furthermore, 5 input suppliers, 15 traders and 5 consumers were randomly selected and interviewed. Intercropping, access to irrigation facilities, ownership to transportation vehicles, participation in training programs and variety were significant and positively related with productivity of ginger. Majority of ginger producers had ranked infestation of disease and pests as the major problem and high demand of ginger in domestic, regional and international market as the main motivating factor to be engaged in ginger production. This finding of the study clearly shows the need of appropriate strategies to cope with infestation of diseases and pests in ginger.

Key words: Determinants, Ginger, Ilam, Value Chain

अध्ययनको सार

अदुवा (*Gingiber officinale*) नेपालको उच्च निर्यात सम्भावित नगदे बाली हो। नेपालको इलाम जिल्लामा अदुवाको उत्पादकत्वमा असर पार्ने कारकहरू पत्ता लगाउने मुख्य उद्देश्यका साथ यो अध्ययन गरिएको हो। तीन चरणको नमूना प्रक्रियाबाट एक सय ६० अदुवा उत्पादक छनौट गरिएको थियो। यसबाहेक, ५ सामग्री आपूर्तिकर्ता, १५ व्यापारी र ५ उपभोक्ताहरूको अनियमित रूपमा छनौट गरी अन्तरवार्ता लिइएको थियो। अन्तरबाली, सिंचाई सुविधाको पहुँच, यातायात सवारी साधनको स्वामित्व, तालिम कार्यक्रममा सहभागिता, अदुवाको जात अदुवाको उत्पादकत्वसँग महत्त्वपूर्ण र सकारात्मक रूपमा सम्बन्धित पाइएको छ। अधिकांश अदुवा उत्पादकले रोग र कीराको प्रकोपलाई प्रमुख समस्या र स्वदेशी, क्षेत्रीय तथा अन्तर्राष्ट्रिय बजारमा अदुवाको उच्च मागलाई अदुवा उत्पादनमा लाग्न उत्प्रेरित गर्ने प्रमुख कारक मानेका छन्। अध्ययनको यो निष्कर्षले अदुवामा हुने रोग र कीराको प्रकोपसँग लड्न उपयुक्त रणनीतिको आवश्यकता स्पष्ट रूपमा देखाउँदछ।

INTRODUCTION

Agriculture has been the vital part of Nepalese economy which contributes about 27.10% of total GDP (MOAD, 2016). Sugarcane, tea, tobacco, potatoes, oilseeds, ginger, cardamom and jute are the principal cash crops grown in Nepal (Sedain & Aryal, 2002). About 700 spices are in use all over the world. Among twenty or more spices used, half of them are grown in Nepal (GRP, 2009). Spice crops have significant contribution in raising the social, economic, cultural and environmental status of the rural people (NSCDP, 2007). Ginger (*Gingiber officinale*) is a high value spices grown especially in mid hills of Nepal which has a large production potential (ITC, 2007). Ginger sub-sector is among five identified sub-sectors for value chain analysis in Nepal (ADS, 2015) and is the main agro based export commodity of Nepal. Dry ginger (*sutho*) processing is women dominate agribusiness sector which provides opportunities for women producers to achieve some degree of economic independence (ADS, 2015). According to Poudel (2007), Nepal has comparative advantages in resource and labor-intensive low technology agriculture products such as ginger. Despite being rich in required quality for the production of essential oils and dried ginger, ginger producers are force to sell their products as raw form (Ghimire, 2009). Despite governing the ginger trade by around 99%, the Indian importers are regularly complaining about the lack of cleaning and grading of the product (ITC, 2010).

The major objectives of this study is to assess the determinants of productivity of ginger and to identify constraints and opportunities of production of ginger.

MATERIALS AND METHODS

Value chain of ginger was studied in Ilam district of Nepal. It was selected purposively because Ilam district possess higher production potentiality of ginger cultivation. The study was conducted Ilam municipality-10, Godak and Ilam municipality-12, Sangrumba from January, 2018 to February, 2018 Eighty ginger producers from Ilam municipality-10, Godak and eighty ginger producers from Ilam municipality-12, Sangrumba were selected by using snow ball sampling technique. The primary sources of information was all actors of the value chain like input suppliers, producers, traders, service providers, key informants of related sectors. Secondary information was collected from the various published materials like journals, research articles, proceedings of various NGOs and INGOs, reports of District Agriculture Development Office (DADO). The information collected from both primary and secondary sources was analyzed by using various computer softwares like STATA version 12.1, statistical packages for social science (SPSS) version 16.0 and Microsoft office excel 2013.

ECONOMETRIC ANALYSIS

DETERMINANTS OF PRODUCTIVITY OF GINGER

Log linear regression model (Log-Lin) was used to analyze the determinants of productivity of ginger as shown below:

$LnY_i = a + b_1x_{1i} + b_2x_{2i} + b_3x_{3i} + b_4x_{4i} + b_5x_{5i} + b_6x_{6i} + b_7x_{7i} + b_8x_{8i} + b_9x_{9i} + b_{10}x_{10i} + b_{11}x_{11i} + u_i$

Where, Y_i =Productivity of ginger (Kg/Ropani)

a = regression constant

$b_1, b2_{......} b_{11}$= regression coefficient

x_{1i} = gender of households heads (male = 1 and female = 0)

x_{2i} = intercropping (yes = 1 and no = 0)

x_{3i} = economically active people (15-59 years)

x_{4i} = education (yes = 1 and no = 0)

x_{5i} = access to irrigation facilities (yes = 1 and no = 0)

x_{6i}= ownership to transportation vehicles (yes = 1 and no = 0)

x_{7i}= participation on training program (yes = 1 and no = 0)

x_{8i}= variety (1= Boshe and 0 = Nashe)

x_{9i} = experience in ginger cultivation

x_{10i} = access to credit (yes = 1 and no = 0)

x_{11i} = chemical fertilizers (yes = 1 and no = 0)

DESCRIPTION OF VARIABLES USED IN ECONOMETRIC MODEL

Table 2. Description of variables, their types and expected sign

Variables	Description of Variables	Type of variable	Expected sign
GEN_HH	Gender of household head (Male =1 and Women = 0)	Dummy	+/-
INT_C	Intercropping (Yes = 1 and No = 0)	Dummy	+
ECO_P	Economically active people (15-59 years)	Continuous	+

ED_U	Education	Continuous	+/-
IR_GTN	Access to irrigation (Yes = 1 and No = 0)	Dummy	+
TR_PORT	Ownership to transportation vehicles vehicle (Yes = 1 and No = 0)	Dummy	+
PAR_TAR	Participation in training programs (Yes = 1 and No = 0)	Dummy	+
V_TY	Variety (Boshe =1 and Nashe = 0)	Dummy	+
E_XP	Experience on ginger cultivation(years)	Continuous	+/-
AC_CR	Access to credit (Yes = 1 and No = 0)	Dummy	+
CH_FERT	Chemical fertilizers (Yes = 1 and No = 0)	Dummy	+

INDEXING

Scaling techniques provide the direction and extremity attitude of the respondent towards any proposition. The index of opportunities /constraints of ginger production was computed by using the following formula.

$$I = \sum (S_i * f_i / N)$$

Where,

I = Index of opportunities/constraints

$\sum$ = Summation

S_i = Scale value

F_i = Frequency of importance given by the respondents

N = Total number of respondents

RESULTS AND DISCUSSION

This section includes socio-demographic analysis, economic analysis of ginger value chain in the study area.

SOCIO-ECONOMIC AND DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS

The socio-economic characteristics of respondents includes age, gender, ethnicity, education level. These characteristics are described below:

GENDER OF RESPONDENTS

In case of Godak, 71.2% of the sampled ginger producers were male while 28.8 % of the sampled ginger producers were female. However in case of Sangrumba, 56.2% of sampled ginger producers were male while 43.8% of the sampled ginger producers were female. Out of the total respondents of both wards 63.8% were male ginger producers while 36.2% were found female ginger producers which is supported by Poudel, Regmi, Thapa, GC and KC (2015) who found that more women involvement in cash crops farming like ginger indicates the improvement of women economic empowerment (Table 3).

Table 3. Distribution of sample households by gender of respondents

Gender	Godhak	Sangrumba	Total
Male	57 (71.2)	45(56.2)	102(63.8)
Female	23 (28.8)	35(43.8)	58(36.2)
Total	80	80	160

Pearson chi square value is 3.895^{**} with 1 df and p value 0.048

Notes: Figure in parentheses indicate percent

AGE OF RESPONDENTS

In this study majority (40.0%) of the ginger producers were found within the age range of

Table 4. Distribution of sample households by age of respondents

Age (years)	Godak	Sangrumba	Total
< 20	8(10.0)	10(12.5)	18(11.2)
21 to 40	28(35.0)	36(45.0)	64(40.0)
41 to 60	33(41.2)	22(27.5)	55(34.4)
>60	11(13.8)	11(15.0)	23(14.4)
Total	80	80	160

21 to 40 years which is in consistent to Poudyal (2012) that younger farmer are more attracted to the ginger farming followed by age range of 41 to 60 years (34.4%) and age range of > 60 years and higher (14.4%) which is supported by Government of Nepal who has classified age of producers between 15 to 59 years as economically active group of producers. In case of Godak, majority (41.2%) of the ginger producers were found within the age range of 41 to 60 years followed by age range of 21 to 40 years (35%) and age range of > 60 years and higher (13.8%). Similarly, in case of Sangrumba, majority (45%) of the ginger producers were found within the age range of 21 to 40 years followed by age range of 41 to 60 years (27.5%) and age range of > 60 years and higher (15%) (Table 4).

Notes: Figure in parentheses indicate percent

EDUCATION LEVEL OF RESPONDENTS

The educational status of the ginger producers plays important role in increasing production and productivity of ginger. In this study, majority (32.50%) of producers were with 6th grade to SLC which is supported by Poudel, Regmi, Thapa, GC and KC (2015) who found that there is direct relation between productivity and education, productivity increases progressively as the level of education attainment by a household head increases followed by no formal education (31.90%) and less than fifth grade (18.80%). In case of Godak, majority (40.00%) of producers were with no formal education followed by sixth grade to S.L.C (28.80%) and university degree or higher (16.20%). Similarly in case of Sangrumba, majority (36.20%) of producers were with 6th grade to SLC followed by no formal education (22.50%) and university degree or higher (17.50%) (Table 5).

Table 5. Distribution of sample households by education level of respondents

Education Level	Godak	Sangrumba	Total
No formal education	32(40.00)	19(23.80)	51(31.90)
< 5th grade	12(15.00)	18(22.50)	30(18.80)
6th grade to S.L.C	23(28.80)	29(36.20)	52(32.50)
University degree or higher	13(16.20)	14(17.50)	27(16.90)
Total	80	80	160

Pearson chi square value is 5.243with 3 df and p value 0.155

Notes: Figure in parentheses indicate percent

TECHNICAL ASPECTS OF GINGER PRODUCERS

ACCESS TO IRRIGATION

Access to irrigation is one of the important aspects for increasing production and productivity of ginger. In this study 30.06% of ginger producers did not had access to irrigation while 68.94% of the ginger producers had access to irrigation facilities which is in consistent with national average (52.71 %) irrigated area (CBS, 2011) and contrast to study conducted by Poudel, Regmi, Thapa, GC and KC (2015) where they found that only 35.51% of total ginger producers in the western hills of Nepal had access to irrigation. (Figure 1).

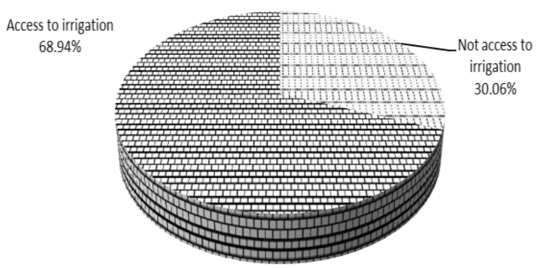

Figure 1. Access to irrigation in ginger farm

INTERCROPPING WITH GINGER

In this study, ginger producers of both Godak and Sangrumba wards were found considerably adopting intercropping with ginger. In Godak, about 90% of respondents had said that they adopt intercropping with ginger which is in consistent with HVAP (2011) which found higher yield of rain fed ginger when grown intercropping with maize that facilitate ginger with partial shade while only 10% of respondents had said they do not adopt intercropping with ginger. In case of Sangrumba about 83.8 % of respondents had said that they adopt intercropping with ginger while only 16.2 % of respondents had said they do not adopt intercropping with ginger. In the study site, it was found that most of the ginger producers cultivated maize, chili, okra as the inter crops (Table 6).

Table 6. Intercropping with ginger across wards (2018)

Intercropping with ginger	Godak	Sangrumba	Total
Yes	72(90.0)	67(83.8)	139(86.9)
No	8(10.0)	13(16.2)	21(13.1)
Total	80	80	160

Pearson chi square value is 1.370with 1 df and p value 0.242

ECONOMICS ASPECTS OF GINGER PRODUCERS

INCOME OF GINGER PRODUCERS

This study found that ginger sector contributes about 21.82% of total income of respondents. According to ADB (2010) high value crops are labor intensive and provide better return than cereal crops and they are suitable for small holder producers (<0.5 ha.). In this study, major sources of income of ginger producers were found non-farm income (36.96 %) followed by ginger production (21.82%) and other agricultural commodities (15.99 %) (Figure 2).

Based on this study the income of ginger producers can be summarized by following equation.

$$I_P = I_{GP} + I_{OAC} + I_{AHF} + I_{NFI} + I_{OS}$$

Where,

I_P = Income of Ginger Producers (NRs.)

I_{GP} = Income from Ginger Production (NRs.)

I_{OAC} = Income from other agricultural commodities (NRs.)

I_{AHF} = Income from Animal Husbandry and Fishery (NRs.)

I_{NFI} = Non-farm income (NRs.)

I_{OS} = Income from other sources (NRs.)

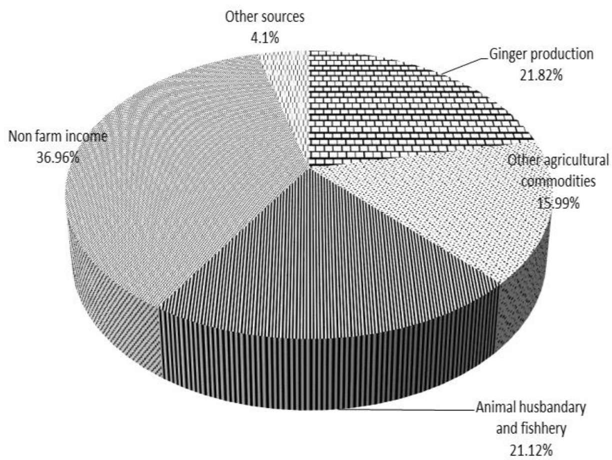

Figure 2. Income of ginger producers

COST OF PRODUCTION OF GINGER

The result form this findings shows that producers have to spend their majority of their money in rhizomes which clearly indicates lack of technical knowledge among producers for production of improved rhizomes and complete dependency of ginger producers on nursery farms for improved, adaptable and high yielding rhizomes. In this study, major cost of ginger production were found on rhizomes (36.61%) followed by labor (25.52%) and organic manures (20.88%) (Figure 3).

From this study, the average cost of production of ginger was found NRs. 18.84 per kg in study site. The average cost of production of ginger per ropani in study site was found NRs. 8556.1 while total production of ginger in study site was found 512.28 kg per ropani (Table 7). Based on this study cost of production of gingers can be summarized by following equation.

Table 7. Cost of production of ginger

	Mean ± SE	Std. Deviation
Cost per Ropani	8556.1±72.19374	6500
Production kg per Ropani	512.28 ±11.533	145.88

Cost per kg of ginger	18.84± 0.73435	9.288

Based on this study the cost of production of ginger can be summarized by following equation.

$$C_P = C_R + C_L + C_{OM} + C_T + C_p + C_C + C_O$$

Where,

C_P = Cost of production of raw ginger (NRs.)

C_R = Cost of rhizome (NRs.)

C_L = Cost of labor (NRs.)

C_{OM}= Cost of organic manures (NRs.)

C_T = Cost of transportation (NRs.)

C_p = Cost of pesticides (NRs.)

C_c = Cost of communication (NRs.)

C_O = Other cost incurred in ginger production (NRs.)

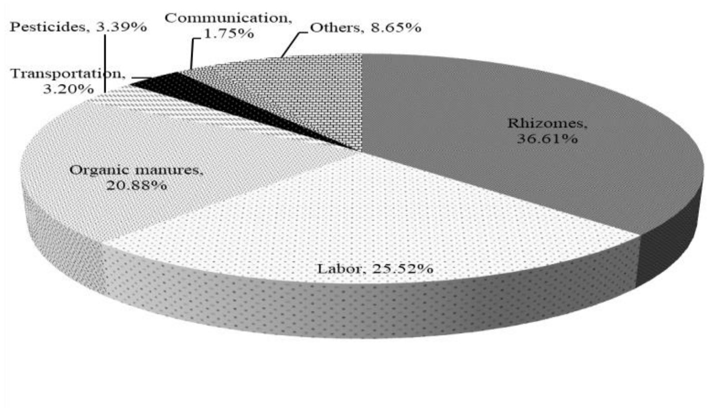

Figure 3. Production cost of ginger

MARKETING COST OF GINGER

In this study producers said that they had experienced cost of sorting, packing in Jute bag and bamboo basket, processing, loading and unloading, transportation, communication and wastage of harvested raw ginger as the marketing cost of raw ginger. This study found that major marketing cost of raw ginger were on transportation (27.14%) followed by sorting (26.33%) and wastage loss of harvested raw ginger (15.74%) (Figure 4).

Based on this study the cost of production of ginger can be summarized by following equation.

$$MC_{RG} = MC_S + MC_P + MC_{pr} + MC_{LUL} + MC_T + MC_C + MC_{WL}$$

Where,

MC_{RG} = Marketing cost of raw ginger (NRs.)

MC_S = Marketing cost of sorting (NRs.)

MC_P = Marketing cost of packing (NRs.)

MC_{pr} = Marketing cost of processing (NRs.)

MC_{LUL} = Marketing cost of loading and unloading (NRs.)

MC_T = Marketing cost of transportation (NRs.)

MC_c = Marketing cost of communication (NRs.)

MC_{WL} = Wastage loss during marketing (NRs.)

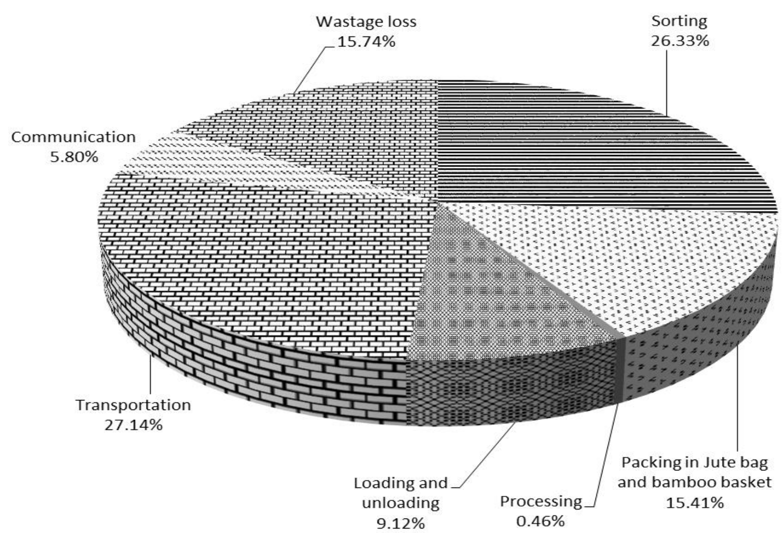

Figure 4. Marketing cost of ginger

DETERMINANTS OF PRODUCTIVITY OF GINGER

In this study log-linear regression model (Log-Lin) was adopted to analyze the determinants of productivity of ginger in study area. The result of log linear regression model was statistically significant with very small p- value associated with F value compared to the alpha level of significance (0.01), this indicates that independent variables in the regression model reliably predicted the dependent variable (productivity). The regression model had R square value of 0.596 which indicates that 59.6 % variation in productivity of ginger could be explained by regressors at 95% confidence level. The regression results showed that intercropping, access to irrigation facilities, ownership to transportation vehicles, participation in training program and variety were significant and positively related with productivity of ginger.

Adoption of intercrops with ginger (INT_C)

The intercropping of ginger with other crops was found significant at 1 % level of significance and has a positive relationship with productivity of ginger. In this study, the result showed that the productivity of ginger was 52 % higher when intercropping was done with ginger as compared to sole cropping holding other factors constant in the study area. This result is in consistent with HVAP(2011) which found higher yield of rain fed ginger when grown intercropping with maize that facilitate ginger with partial shade.

Access to irrigation facilities (IR_GTN)

The accessibility of irrigation facilities among the ginger producers was significant at 1 % level of significance and has a positive relationship with productivity of ginger. The result from this study showed that ginger producers who have access to irrigation had 17% more productivity of ginger as compared to those ginger producers without access to irrigation facilities. This finding is in support of study conducted by Acharya et al. (2013) where they found that the use of high yielding variety of ginger coupled with irrigation and fertilizer application lead to increase in productivity of ginger.

Ownership to transportation vehicles (TR_PORT)

Producers who owns their own transportation vehicles like pick up van, four wheelers was found positive and significantly related with productivity of ginger at 10% level of significance. Producers who own their own vehicles had 7% more productivity of ginger than producers without their own vehicles holding other factors constant.

Participation in training programs (PAR_TAR)

Ginger producers participation in training program was found significant at 5% level of significance and has a positive relationship with productivity of ginger. In this study, the result showed that the extension training programs was found 19% higher as compared to other programs holding other factors constant.

Variety (V_TY)

The variety of ginger was found significant at 5 % level of significance and has a positive relationship with productivity of ginger. In this study, the result showed that the productivity of Boshe variety of ginger was found 11% higher as compared to Nashe variety of ginger while other factors constant in the study area which is in consistent to (HVAP, 2011) which found that the yield and quality of Boshe variety is considered better than Nashe variety and also fetches higher prices.

Table 8. Summarization of variables used in econometrics model

Variables	Description of variables	Obs.	Mean	Min	Max
GEN_HH	Gender of household head (Male =1 and Women = 0)	160	0.73	0	1
INT_C	Adoption of Intercropping (Yes = 1 and No = 0)	160	0.87	0	1
ECO_P	Economically active people (15-59 years)	160	3.23	1	10
ED_U	Education	160	2.52	1	4
IR_GTN	Access to irrigation (Yes = 1 and No = 0)	160	0.68	0	1
TR_PORT	Ownership to transportation vehicles vehicle (Yes = 1 and No = 0)	160	0.34	0	1
PAR_TAR	Participation in training programs (Yes = 1 and No = 0)	160	0.88	0	1
V_TY	Variety (Boshe =1 and Nashe = 0)	160	0.53	0	1
E_XP	Experience on ginger cultivation (years)	160	18.25	9	30
AC_CR	Access to credit (Yes = 1 and No = 0)	160	0.55	0	1
CH_FERT	Chemical fertilizers (Yes = 1 and No = 0)	160	0.68	0	1

Table 9. Determinants of productivity of ginger

Variables	Coef.	SE	t	P>|t|
Gender of household head	0.03	0.04	0.65	0.52
Intercropping	0.52***	0.06	8.30	0.00
Economically active people	0.008	0.01	0.57	0.57
Education	-0.007	0.02	-0.45	0.65
Access to irrigation	0.17***	0.05	3.53	0.001
Ownership to transportation vehicle	0.07*	0.04	1.68	0.096
Participation in training programs	0.19**	0.06	3.08	0.002
Variety	0.11**	0.04	2.93	0.004
Experience on ginger cultivation	-0.0002	0.004	-0.06	0.953
Access to credit	0.05	0.04	1.33	0.185
Chemical fertilizers	0.05	0.04	1.20	0.23
Constant	5.35	0.12	44.54	0.00

F (11,148) = 19.88***, Prob > F = 0.0000, R-square =0.596 , Adj R-squared =0.564, Root MSE = 0.228

Dependent variable is productivity of ginger in kg/ropani. ***, ** and * indicates statistically significant at 1%, 5% and 10%, respectively.

MAJOR CONSTRAINTS OF GINGER PRODUCTION

The major constraints of market oriented ginger value chain in the study area were identified and listed from the preliminary study and later they were ranked by respondents at the time of field survey and finally tested by statistical tool. In this study, the majority of ginger producers in study area had said that they were facing problems of high infestations of diseases and pests in farm severely. Among five different problems that the producers were given to rank the majority of producers ranked high infestations of diseases and pests, meager market price of ginger, inadequate knowledge about new technologies, insufficient support from the government sectors and very high cost of inputs as first, second, third, fourth and fifth most severe problems that ginger producers are experiencing (Table 10). Rhizome rot disease may reduces 50% rhizome production. According to HVAP (2011), 70% rhizomes production will be reduced due to soft rot infestations in Nepal. If soft rot is not controlled properly it may cause complete crop failure.

Table 10. Major constraints of ginger production

Constraints	Index	Rank
High infestftions of diseases and pests	0.94	I
Meager market price of ginger	0.80	II
Inadequate knowledge about new technologies	0.56	III
Insufficient support from the government sectors	0.42	IV
Very high cost of inputs	0.28	V

MAJOR OPPORTUNITIES IN GINGER PRODUCTION

In this study the major opportunities of production of ginger in the study area were identified and listed from the preliminary study and later they were ranked by respondents at the time of field survey and finally tested by statistical tool. In this study, the majority of ginger producers said that the most appealing opportunities of ginger production to them is high demand of ginger in local, regional and international market, climatic suitability and rooted in culture, opportunities to employ women and disadvantaged group in processing activities, employment opportunities to local people, increase in number of microfinance institutions and they provide loan easily. The production of rice, wheat, maize, millet etc. in the study area is subsistence oriented while the production of ginger has commercial motive. Among five opportunities of ginger production selected from preliminary study the majority of producers ranked high demand of ginger in domestic, regional and international market, climatic suitability and rooted in culture, opportunities to employ women and disadvantaged groups in processing activities, employment opportunities to local people, increase in number of microfinance institutions and they provide loan easily as first, second, third, fourth and fifth most appealing opportunities for ginger production in the study (Table 11). Exports of high value crops like ginger to neighboring urban markets in India will increase from a base of 12700 MT in 2001, by 105 percent in 2010, and a further 188 percent to 65000 MT by 2020. Clearly, India offers Nepal huge market opportunities (ADB, 2010).

Table 11. Major opportunities of ginger production

Opportunities	Index	Rank
High demand in domestic, regional and international market	0.89	I
Climatic suitability and rooted in culture	0.80	II
Opportunities to employ women and disadvantaged groups	0.62	III
Employment opportunities to local people	0.43	IV
Increasing number of microfinance institution provide loan easily	0.25	V

CONCLUSION

This study was done with the major of objective of determining the factors affecting the productivity of Ginger in Illam district of Nepal. In this study, intercropping, access to irrigation facilities, ownership to transportation vehicles, participation in training programs and variety were found significant and positively related with productivity of ginger. Majority of ginger producers had ranked infestation of disease and pests as the major constraint and high demand of ginger in domestic, regional and international market as the main motivating factor to be engaged in ginger production. This finding of the study clearly shows the need of appropriate irrigation facilities, trainings and capacity building programs to ginger producers, technical support to cope with infestation of diseases and pests in ginger and appropriate policy instruments to strengthen ginger value chain.

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COST BENEFIT AND MARKETING OF TOMATO AND CHILLY IN BANKE AND BARDIYA DISTRICTS OF NEPAL

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ABSTRACT

The study was carried out in Banke and Bardiya districts during 2020 to assess production and market status of tomato and chilly. The study sites were purposively selected and 50 farmers growing tomato or chilly or both, 25 from each district and 25 traders (20 retailers and 5 wholesalers) were interviewed. Benefit cost ratio of tomato and chilly was found to be 2.55 and 1.80 respectively. Majority i.e., 70% of the farmers found to sell vegetables directly to wholesalers in bulk at their own farm. Lower price received by farmers, frequent price fluctuation, competition with Indian vegetables, unorganized market near production sites were the major marketing problems perceived by farmers and traders. There is an immense need to adopt market-oriented policy and programs linking with production in order to enhance production and marketing efficiency of vegetables.

Key words: benefit cost ratio, farmers, market, traders, vegetables

अध्ययनको सार

तरकारी खेती किसानका लागि थोरै जग्गामा समेत छोटो अवधिमै मनग्य आमदानी लिन सकिने एउटा भरपर्दो व्यवसाय हो । प्रायः नेपालीको भान्सामा टमाटर र खुर्सानी दिनहु जसो प्रयोग हुन्छन । यी दुई बालीको उत्पादन र बजार अवस्थाको मूल्याङ्कन गरी थप सुद्रीढ बनाउने उपाय सुझाउन सन् २०२० मा बाँके र बर्दिया जिल्लामा एक अध्ययन गरिएको थियो । टमाटर र खुर्सानीको खेती तुलनात्मक रुपमा बढी हुने ठाउँ हरु अध्ययनको लागि गरिने चयन गरिएको थियो । टमाटर वा खुर्सानी वा दुवै खेतीमा संलग्न ५० जना किसानहरू (प्रत्येक जिल्लाका २५/२५ जना) र २५ जना व्यापारी (२० खुद्रा बिक्रेता र ५ थोक बिक्रेता) सँग स्थलगत भेट गरी अन्तरवार्ता मार्फत तथ्यांक लिइएको थियो। जस अनुसार टमाटर र खुर्सानीको लाभ लागत अनुपात क्रमशः २.५५ र १.८० पाइएको थियो । जस अनुसार एक रुपिया खर्च गर्दा टमाटर खेति बाट दुई रुपिया पचपन्न पैसा र खुर्सानी खेती बाट एक रुपिया असी पैसा आम्दानी लिन सकिने देखियो ।अध्ययनमा संलग्न किसान मध्ये अधिकांश (७० प्रतिशत) ले आफ्नै फार्ममा थोक व्यापारीलाई सिधै तरकारी बेच्ने गरेको पाइयो । कृषक र व्यापारीहरूका अनुसार मुख्य समस्याको रुपमा किसानले पाउने न्यून मूल्य, बारम्बार मूल्यको उतारचढाव, भारतीय तरकारीसँगको प्रतिस्पर्धा र उत्पादन स्थल नजिकको असंगठित बजार पाईए । तसर्थ

स्थानीय तवर बाटै नीतिगत र व्यवहारिक रुपमै तरकारीको उत्पादन वृद्धि गरी न्यायोचित बजारीकरण कार्य अभिवृद्धि गर्न उत्पादनसँग जोडेर बजार उन्मुख नीति तथा कार्यक्रम अवलम्बन गर्नुपर्ने नितान्त आवश्यकता छ ।

INTRODUCTION

Vegetable farming is an evergreen business that ensures cash revenue even from small plots of land within a short period of time. The trend of vegetables area and production in Nepal during 2008/09 to 2018/19 clearly indicates that the area and production are increasing over time. Its cultivation area jumped by 31.9 % between 2008/09 and 2018/19 while production was increased by 55.01%. (MoAD, 2020). Despite the fact that vegetable production is a viable option to increase farm income and hence alleviate widespread poverty in Nepal, considerable attention has not been given for its marketing aspects. Vegetable marketing is an important mechanism to coordinate the production, distribution and consumption of vegetables in the food chain. Marketing of vegetables in particular, is more complex and risky because of the special characteristics like highly perishable nature, seasonality, bulkiness etc. and needs special care and immediate disposable (Gandhi & Namboodiri, 2002.). The marketing situation of vegetables is still in developing/rudimentary stage characterized by influences of supply and demand and price realization (Shrestha, 2008). Despite the great potential of production in the country and continuous efforts from government, vegetable farmers are facing marketing problems such as poor marketing infrastructures (marketing information, physical facilities, auction markets, marketing extension services, price uncertainty etc.), small scale of production. Moreover, producer farmers are not organized. Farmers are obliged to dispose their produce at low price due to the lack of adequate knowledge of marketing system which has affected not only the producer, but also the consumers. Involvement of large number of middlemen has decreased farmers' share. The middlemen are grabbing the economic benefits. In this light of existing marketing pattern and given the priority accorded to vegetable production and marketing as one of the instruments to uplift livelihood of community people, we conducted the market study of tomato and chilly. This research provides insights for production and marketing opportunities of tomato and chilly in the study districts and beyond assist for investment decisions. The cultivated tomato (*Lycopersicon esculentum*, Mill) is cultivated as winter crop in Terai and Inner Terai. Pungent pepper, commonly known as chilly (*Capsicum annuum L*.), is widely cultivated species from terai to mid-hills of Nepal and mostly accepted as spice crop and considered as an integral component of every Nepalese kitchen.

The overall objective of this study was to carry out production and market assessments of tomato and chilly in Banke and Bardiya districts The specific objectives of the study included: i) Assessment of present status of tomato and chilly production in study areas, ii) Identify ways and means of increasing the production and marketing of them, iii) Assessment and identify the key constraints in terms of production, collection, processing, technologies, and marketing of these commodities and value chain actors in terms of promoting marketing of those commodities.

METHODOLOGY

The study was carried out during October and November 2020 in Banke and Bardiya districts. The study sites were purposively selected by CRLGGP team in close coordination with government agencies (NARC, AKC and local bodies) as they represented major areas for tomato and chilly production in the selected districts. Both primary and secondary data collection methods and tools were used in the study. Vegetables field visits in production areas of Banke (Khajura Rural Municipality, Dudhuwa Rural Municipality, Baijanath Municipality and Nepalgunj Sub-metropolitan) and that of Bardiya (Barbardiya Municipality), and market visits beyond and nearby the production areas in Banke (Koholpur, Rajha, Khajura, Nepalgunj) and Bardiya (Basgadhi, Gulariya, Taratal, Sanoshree). Altogether 50 farmers growing tomato or chilly or both, 25 from each district and 25 traders (20 retailers and 5 wholesalers) were included. In addition, interaction with some Agrovets in vicinity of the production areas in both districts was done.

Estimation of benefit cost ratio in production

The cost-benefit ratio (B/C R) was determined by dividing the revenue generated by the costs incurred in the tomato and chilly production. Gross margin was calculated by subtracting total variable cost from total revenue.

Estimation of constraints in production and marketing

Constraints in production and marketing were estimated by using scaling technique**.** The scale value of 5, 4, 3, 2 and 1 was used to most serious, serious, moderate, a little bit and the least serious respectively. Mathematically, the index of importance of problems can be computed by the formula:

$$I_{imp} = \sum(S_i f_i / N)$$

Where, I_{imp} = Index of importance, $\sum$ = Summation, S_i= Scale value, f_i= Frequency of respondents N = Total number of respondents

Estimation of Marketing margin and producer's share

Marketing margin indicates the efficiency of marketing system as it refers to the efficiency of intermediaries between the producer and consumer in respect of the services rendered and the remuneration received by them (Sapkota, 2008). In this study, marketing margin was calculated as:

Marketing margin = Retailer's price - Farm gate price

Similarly, producer's share in this study was calculated as:

Producer's share = (farm gate price/ retailer's price) *100

Marketing margin and producer share give an indication of efficiency of existing marketing system. Lower marketing margin and higher producer share on retail price ensures efficiency of marketing system (Bastakoti, 2001).

RESULTS AND DISCUSSION

Constraints in production and marketing

Production constraints faced by vegetable growers are mentioned in table 1. Disease and pest problem was ranked as the most serious problem in both the districts followed by unavailability of quality seeds in time, lack of year-round irrigation facilities, timely unavailability of chemical fertilizers, weak technical support and services, shortage of skilled labor, and high input costs whereas difficulty to get loan was indicated as the least serious problem. Major disease and pest observed by the farmers were root and fruit rot, late blight, wilting and borer, and that in chilly were leaf spot, leaf curl and mosaic.

Table 1: Index of tomato and chilly production constraints perceived by farmers

S.N.	Problems	Districts			Rank
		Bardiya	Banke	Average	
1	Unavailability of quality seeds in time	3.5	3.6	3.55	II
2	Shortage of skilled labor	1	1.05	1.03	VI
3	Disease and pest problem	5	5	5.00	I
4	Difficulty to get loan	0.75	0.9	0.83	VIII
5	Lack of year-round irrigation facilities	2.5	3	2.75	III
6	Weak technical support and services	1.35	1.5	1.43	V
7	High input costs	0.5	0.4	0.45	VII
8	Timely unavailability of chemical fertilizers	2.2	2.5	2.35	IV

Source: Field study (2020)

Vegetable growers in the study area mentioned several constraints related to marketing of tomato and chilly as shown in table 2. The problems faced by vegetable producers are mostly similar in both the districts. Lower price of vegetables was found as the most serious problem followed by frequent price fluctuation, competition with Indian vegetables, unorganized market near production sites, high transport cost, lack of storage facilities and lack of processing facilities. Limited access to reliable market information was observed as the least serious problem in study areas. Sharma (2019) stated that on production side, vegetable producers were faced with the major problem as lack of input supply and that on marketing side, lack of storage facility, poor market access, lack of transportation, low price of output and inadequate government support for price determination. Gurung et.al. (2016) identified the similar problems as identified in this study related to both production and marketing.

Table 2: Index of tomato and chilly marketing constraints perceived by farmers and traders

S.N.	Problems	Districts			Rank
		Bardiya	Banke	Average	
1	Lower price	3.0	3.1	3.06	I
2	Unorganized market near production sites	2.8	2.5	2.63	IV
3	Frequent price fluctuation	3.0	2.8	2.85	II
4	High transport cost	2.5	2.3	2.38	V
5	Lack of storage facilities	2.3	2.4	2.31	VI
6	Lack of processing facilities	2.1	2.5	2.29	VII
7	Frequent transport obstruction	0.9	0.8	0.81	IX
8	Limited access to reliable market information	1.4	1.6	1.50	VIII
9	Competition with Indian vegetables	2.5	3.0	2.73	III

Source: Field study (2020)

Economics of production of tomato and chilly

Economics of production of tomato and chilly and gross margin have been shown in table 3. The benefit cost ratio of tomato was found to be 2.56 while that of chilly was 1.81. According to Bhandari, Bhattrai, and Aryal (2015) vegetables have a benefit-cost ratio from 1 to 3 in Nepal and similar range was found in our study. Pokharel (2021) in his study also indicated the BC ratio of tomato to be 2.15 based on study among tomato growers in Kathmandu valley. However, in the study of Paudel, Paudel and Kattel (2021), the benefit cost ratio of vegetables was found to be much higher in the range of 3-5.

Table 3: Economics of production of tomato and chilly and gross margin in the study area

Variables	Tomato	Chilly
Cost of production (Rs/kattha)	16743	7109
Average cost (Rs/kg)	9.84	16.02

Yield (kg/kattha)	1700	450
Gross revenue (Rs/kattha)	59500	20250
Gross margin (Rs/kattha)	42757	13041
Benefit cost ratio	2.56	1.81

Source: Field study (2020)

Marketing margin and producer's share

Lower marketing margin and higher producer share on retail prices indicate an efficient market system. The marketing margin of tomato was estimated to be Rs 25/kg while that of chilly was 30 Rs /kg with producer share 58.33 % and 60.0 % respectively (Table 4). Paudel (2006) also found producer share from 57 to 63 percent in marketing system of major vegetables.

Table 4: Marketing margin and value share of tomato and chilly

Commodity	Actors	Selling price (Rs/kg)	Marketing margin (Rs/kg)	Producers' share
Tomato	Farmers	35	25	58.33
	Wholesales	42	18	
	Retailers	60		
Chilly	Farmers	45	30	60.00
	Wholesales	50	25	
	Retailers	75		

Source: Field study (2020)

Major markets and marketing practices in study area

In Barbardiya Bardiya, the farmers involved in vegetable production dispose their products in nearby markets like *Bhada Bazar Samudayik Tarkari Sankalan Kendra*, Vegatables Collection Center of Gulariya and Sanoshree, Haat bazars of nearby areas. They also supply the vegetables in Koholpur Banke. Major markets in Banke within study area are vegetables collection center at

Koholpur, Ranjha, Ranitalau Nepalgunj and local *haat bazar*. The road network among the existing markets is well developed connecting with village roads, sideways, roads through local markets, *Hulaki Marga* and main East West Highway. Most of the producers used bicycle, motorbike and auto-riksaw in case to sell their vegetables by themselves. Use of plastic crates is common to transport tomato and chilly in study areas. Traders come to farmers field themselves to collect vegetables in bulk by means of pick-up van and auto-riksaw. The price fixing of vegetables is out of control of farmers and they are only price takers. Generally, farmers sell tomato, chilly and other vegetables at the price set by wholesalers, collectors, and retailers. While paying to farmers, traders reduce some percentage of volume of products to cover transport and postharvest losses, however, grading and sorting of tomato is already performed by farmers. The common means of market price information among farmers and traders is mobile phone and rarely newspaper, TV and radio.

Marketing channel

Marketing channels for vegetables vary from commodity to commodity, from producer to producer, lot to lot and time to time (Acharya & Agarwal,1999). In study areas, marketing channel of tomato and chilly was practiced in three major forms.

Channel I (C I) is the first channel disposing tomato and chilly directly to consumers. Only 10% of the farmers found to be selling their products directly to consumers. Direct selling to consumers involved selling vegetables at their own farm as well as selling door to door by farmers themselves.

Channel II (C II) is the second channel disposing to wholesalers to retailers to consumers which was found to be practiced by majority (70%). Most common practice was selling their vegetables to wholesalers in bulk at their own farm. Then retailers buy from wholesalers and then sell to consumers. Retailers stated that the producers did not agree to sell their products in small amount to retailers. So, retailers being even at nearby areas of production are buying those vegetables from wholesalers of distant markets. In second channel, the middlemen or brokers are also involved in selling of tomato and chilly in commission basis by matching up producers and buyers and help them to negotiate a price and volume of produce. They don’t buy the produce but often earn the commission, so they aren’t really traders but service providers. This type of channel was also mentioned as majorly practiced in the findings of Rai et al. (2019).

Channel III (C III) is the third channel disposing to consumers through retailers which comprised 20% in study areas.

Well organized marketing channels do not exist. In study areas, following marketing process were identified.

Farm-gate sale

In the study districts, some of the farmers sell their vegetables in their own where nearby consumers come to buy. Some of the farmers collect their vegetables in nearby collection center, and buyers purchased their produce from these collection centers. Collecting in nearby collection center was found more common in Bardiya compared to Banke. There are two types of farm gate selling: organized and unorganized farmers' collection centers.

Direct Selling

Few of farmers in the study districts found to be direct selling their products. They generally do harvest and simple grading then after brings vegetables to nearby market on foot and bicycle. In some cases, they have permanent buyers in local market, and sometimes they visit house-to-house carrying their fresh vegetables.

Selling to wholesaler and middlemen

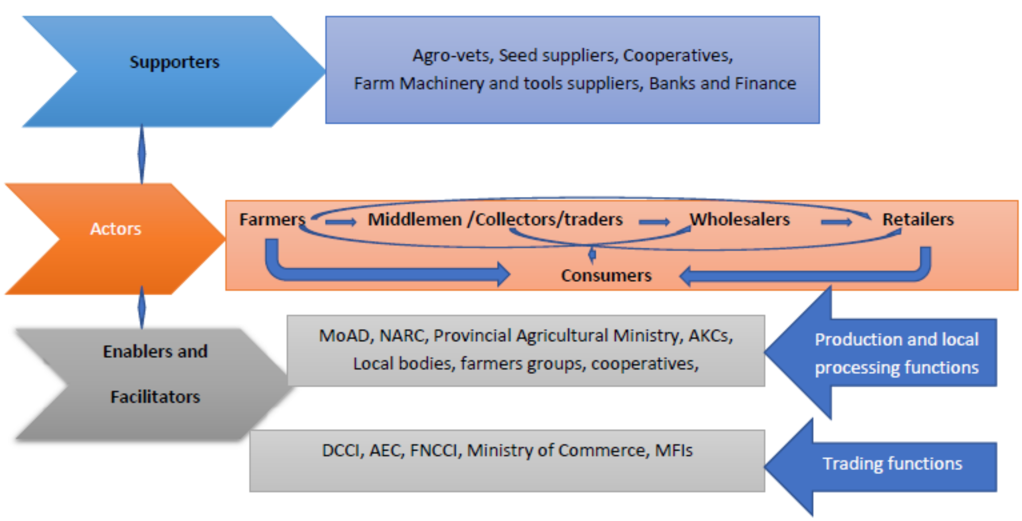

Figure 1: Value chain map of tomato and chilly in study area

The findings of this study related to marketing channel, marketing process and actors were in consistent with that of ANSAB (2011).

CONCLUSION

Tomato and chilly growing are a profitable and potential agricultural enterprise in the Banke and Bardiya. Farmers should give emphasis on growing tomato in offseason too. They should practice value addition, preservation and processing activities too to get higher price. Central, provincial and local government should focus on proper marketing of vegetables in production areas. The immense support is only focused on production so market guarantee of vegetables should be facilitated by farmers' group approach, co-operatives markets, incentives based on volume of marketing. Market oriented agricultural development programs by emphasizing more on marketing extension is must. Well-equipped agricultural marketing infrastructure (retail market, collection centers etc.) should be developed nearby production pocket and rural areas. Agricultural marketing information system needs to be improved. The present wholesale price dissemination should be accompanied with other information like information on demand and supply of vegetables, market arrivals, information on other markets. Field level agriculture extension technicians should be upgraded with technical knowhow facilitating on efficient production and marketing. Provision should be made for easy access to market, and agriculture ambulance van could be useful to be operated in major production pockets and road corridors. Interventions in short term and long-term basis are to be focused in production, marketing and policy levels.

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GENETIC DIVERSITY ASSESSMENT AND PRODUCTION PERFORMANCE OF DIFFERENT PERENNIAL FODDERS IN WESTERN TERAI REGION OF NEPAL

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ABSTRACT

A field experiment was conducted at Directorate of Agriculture Research, Lumbini Province Khajura Banke Nepal during summer season from 10th May, 2019 to 20th October 2019 to estimate genetic diversity assessment and production performance of different perennial fodders in western terai region of Nepal. Seven perennial fodder genotypes were tested in randomized complete block design with three replications to estimate for plant height, leaf length, leaf width, no of tiller per plant, no of leaf per plant and green biomass yield. There were highly significant variations among the tested genotypes for all traits but significant in biomass yield, which indicated presence of high immensity of genetic variations. The genotypes Pakchong Napier, Guinea Grass and Napier Co4 are superior over other genotypes. They had produced maximum green biomass yield (98.3 ton/ha), (91 ton/ha), (86.7 ton/ha) respectively in all four cuts. They had manifested ascendancy in genetic diversity assessment and production performance of different perennial fodders. The high amount of genotypic diversity increased the number of genotypes that may be chosen. According to the findings, superior and ideal perennial fodder genotypes could be used in future breeding programs.

Key words: Genetic diversity, Green biomass, Production performance, Perennial fodders.

अध्ययनको सार

२०७६ सालको बैशाख २७ गते देखि कार्तिक ३ गते सम्म सात ओटा विभिन्न बहुबर्से घाँसेबालीहरुको आनुवंशिक विविधता मूल्याङ्कन र हरियो घाँस उत्पादनको उत्पादन अनुमान गर्न रेन्डमाइज्ड कम्प्लिड ब्लक डीजाईन प्रयोग गरेर त्सलाई तिनपटक तेहराई कृषि अनुसन्धान निर्देशनालय, लुम्बिनी प्रदेश खजुरा बाँकेको अनुसन्धान फार्ममा मुल्यांकन परीक्षण गरियो । विभिन्न बहुबर्से घाँसहरुमा पाकचोङ नेपियर, गिनी ग्रास र नेपियर सी.ओ.४ जस्ता जातहरू सबै भन्दा उत्कृष्ट छन्। ति घाँसहरु चारै वटा कटाईमा क्रमशः (९८.३ टन/हेक्टर),

(९१ टन/हेक्टर), (८६.७ टन/हेक्टर) हरियो घाँस उत्पादन दिएका थिए। हरियो घाँस उत्पादन तथा अन्य गुणहरुको अति अर्थपूर्ण भिन्नताले गर्दा धेरै आनुवंशिक विविधता भएको पाईयो । माथिउल्लेखित बढिउत्पादन दिने बहुबर्से घाँसहरुलाई थप मुल्यांकन गर्न तथा विभिन्न चरणका परीक्षणहरुमा समाबेस गर्न आबस्यक छ । साथै किसान दाजुभाई दिदी बहिनी तथा अन्य सरोकारवालाहरुलाई घाँस उत्पादन कार्यमा प्रयोग गरि आयआर्जन गर्न आग्रह गर्दछु ।

मुख्य शब्दहरुः आनुवंशिक विविधता,हरियो घाँस, उत्पादन क्षमता, बहुबर्से घाँस।

INTRODUCTION

Livestock sector is an integral component of Nepalese economy contributing to employment and income to Nepalese farmers and sustaining the economic growth of the country. The trend of increasing population with the rapidly increasing demand has been more prominent in ruminant animals, populations of the ruminants are concentrated in the hilly areas of the country but the fodder and forest resources are depleting in a greater extent. Mahat (1987) pointed that in hill there is decline in forest and fodder supply due to steadily increasing livestock population, deforestation and uncontrolled livestock grazing. Big problem in livestock farming is inadequate supply of nutritious fodder for livestock production and maintenance (FAO, 2015). Wong et al. (1982) stated that forages are the single most important feed source for ruminants in worldwide. Perennial grasses are used to feed animal in many forms. It may be fed as pastures or fodder (cut and carry grass) or be conserved as hay, silage or haylage. Several types of forages can be used as pasture or fodder for feeding animals.

The major feed resources in Nepal are agricultural by-products and forage (DoAR, 2020). National Pasture and Fodder Research Program (NPFRP), NARC, Khumaltar, Lalitpur, Nepal. Perennial forage species (Napier, Guinea, Molasses, Guatemala Mulato, Para Grass, Signal Grass etc.) on marginal lands are increasing each year. Till now, about 0.1 percent of the cultivated land brought under forage cultivation (Pande, 1994). Perennial grass is used as a cost-effective feeding requirements for all types of animals (White and Hodgson, 1999; Romera et al., 2017). Panday & Upreti (2005) mentioned that perennial forages are major sources of green matter for animal diet. Shrestha (2005) illustrated that due to uneven production and supply of perennial fodder the production and productivity of livestock goes down. Napier grass is a full sunlight species that can still produce under partial shade but does not withstand complete shade under a dense tree canopy

(Francis, 2004). Napier grass is fast growing and has a high annual productivity that depends on the climatic conditions, especially temperature and rainfall (Aroeira et al., 1999). There is excess green forage available during the monsoon period, but for the remaining six months, over the winter and spring, there is a lack of feed. In commercialized farming situations farmers compensate for shortages of forages with supplementation of expensive concentrate feeds. As concentrates are expensive, animals are not fed to their requirement thus introducing costs without significantly increasing production The objective of this study was to accesses genetic diversity assessment and performance study of different perennial fodders in western terai region of Nepal.

METHODOLOGY

The experiment was carried out at the research farm of Directorate of Agriculture Research, Lumbini Province, Khajura Banke, Nepal during spring season from 10th May, 2018 to 20^{th} October 2018 to estimate genetic diversity assessment and production performance of different perennial fodders in western terai region of Nepal. DoAR, Khajura is located at Janaki rural municipality-4 Banke district on the way to Nepalgunj to Gulariya road. Average annual rainfall of the station is 1000-1500 mm. The maximum and minimum temperature at the station is $46^{\circ}C$. and $5.40^{\circ}C$, with relative humidity ranging between 27 to 94%. Humidity remains low for most of the duration of a year. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications consisting of seven perennial fodder genotypes (Table 1). The individual plot size was 12 m^2 (8 rows of 3m long) and spacing was 50 cm continuous. The soil texture was sandy to silty loam, poor in organic carbon and available nitrogen but medium in available phosphorus and potassium, soil pH varies from 7.2-7.5. The FYM @ 10 t/ha along with 80:60:40 kg N_2, P_2O_5 and K_2O ha^{-1} was applied in the experiments. Half nitrogen, full dose of phosphorous and potash was applied during sowing. Remaining dose of nitrogen is splitted into two parts and top dressed during 60 days after sowing and 90 days after sowing. Green biomass yield per hectare was deliberated by converting yield per plot into yield per hectare. The statistical package MSTAT-C was applied to analyze data (Russel & Eisensmith, 1983). The significant differences between treatments were determined at probability level of 0.01 or 0.05 using least significant difference (LSD) test (Gomez & Gomez, 1984).

Table 1. List of genotypes used in the experiment.

S.N	Name of Genotypes	S.N	Name of Genotypes
1	Guatemala	5	Pakchong Napier
2	Guinea	6	Para Grass
3	Mulato	7	Signal Grass
4	Napier Co4		

RESULTS AND DISCUSSION

The table 2 depicted that the Pakchong Napier produced highest green matter 98.3 mt/ha, followed by Guinea Grass (91 mt/ha) and Napier Co4 86.7 mt/ha and least green matter yield was obtained by the Signal Grass (62 mt/ha). Hare et al., (2013) indicated that appropriate cutting interval affect the yield and quality of fodder, lesser the cutting intervals higher the level of crude protein and higher level of dry matter production. Similarly, Pakchong Napier have exhibited highest Plant height (220 cm), followed by Guinea Grass (172.7 cm), Napier Co4 (160 cm) and lowest plant height found in Mulato (85 cm). Green matter production of Mombasa Guinea grass was highest than that of other cultivars (NPFRP, 2020). Guatemala have manifested highest Leaf Length (107.67 cm), followed by Pakchong Napier (96 cm), Guinea (76 cm) and lowest Leaf Length found in Para Grass (38.33 cm). Similarly, Guatemala have measured highest Leaf Width (7.43 cm), followed by Pakchong Napier (3.26 cm), Guinea (3.2 cm) and lowest Leaf Length found in Para Grass (1.5 cm). The Signal Grass have showed highest No of leaf Per Plant (2631), followed by Guinea (1967), Mulato (633) and lowest No of leaf Per Plant found in Napier Co4 (213). Argel et al., (2006) stated that high production of green leaves makes Mulato extremely attractive forage for livestock. Napier grass could only meet the digestible protein requirement for livestock species for maintenance (Francis, 2004; Goetsch et al., 2010). Napier grass requires high levels of fertilizer and regular water supply (Mannetje, 1992). Yields range about 80 mt/ha under high fertilizer inputs (Skerman et al., 1990). Similarly, Signal Grass have exhibited highest No of tiller Per Plant (395), followed by Guinea (461.7), Mulato (138.7) and lowest No of tiller Per Plant found in Guatemala (42). There was highly significant different among the tested genotypes in all traits except total green biomass yield. These genotypes were superior in other yield attributes so will be needed for further investigation.

Table 2. Summary statistics of different genotypes.

Genotypes	Plant Height (cm)	Leaf length (cm)	Leaf Width (cm)	No of leaf Per Plant	No of tiller Per Plant	Total Green biomass (ton/ha)
Guatemala	115.7	107.67	7.433	338	42	66
Guinea	172.7	76	3.2	1967	461.7	91
Mulato	85	47.33	2.633	633	138.7	64
Napier Co4	160	71	2.3	213	39.3	86.7
Pakchong Napier	220	96	3.267	376	62	98.3
Para Grass	153.3	38.33	1.5	573	90.7	65.3
Signal Grass	115	41.67	1.8	2671	395	62
Grand Mean	146	68.29	3.162	967	175.6	76.2
CV%	15.1	3.8	3.8	6.2	8.9	15.1
F Value	<.001	<.001	<.001	<.001	<.001	0.007
$LSD_{0.05}$	39.33	4.571	0.2156	107.5	27.96	20.41

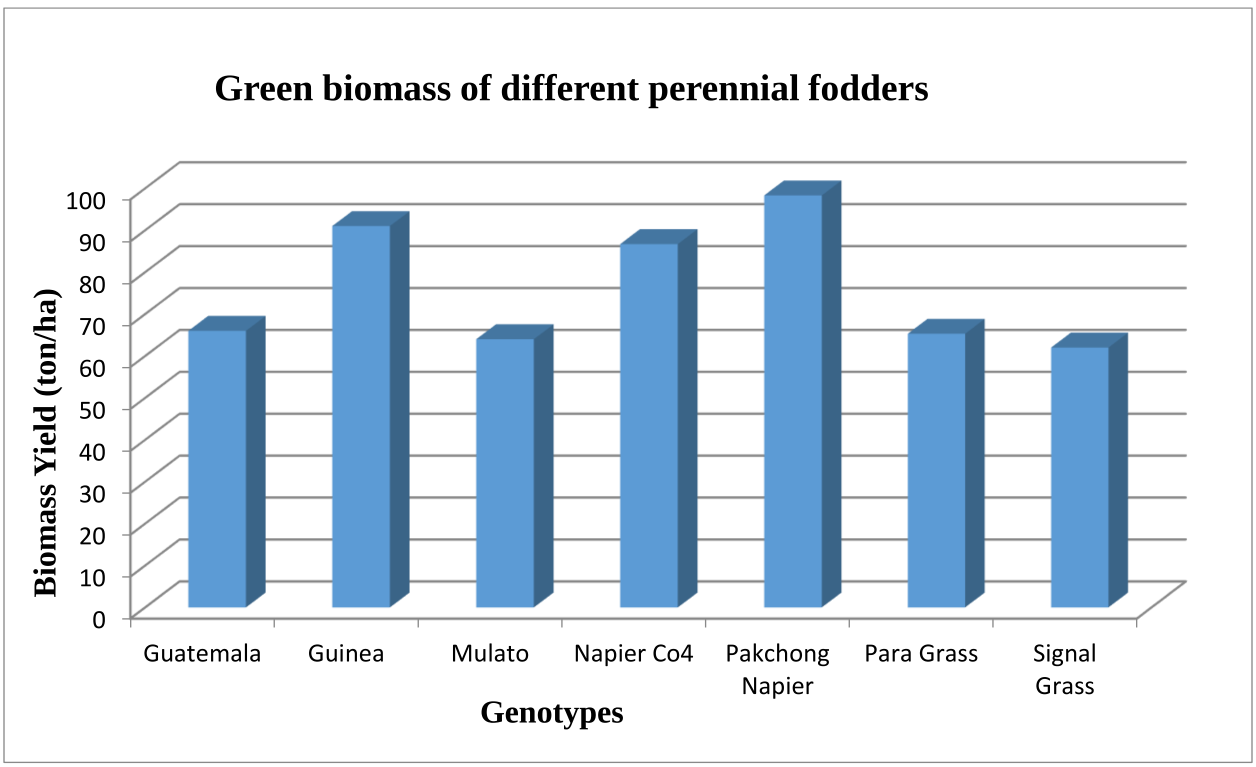

Fig 1: Total green biomass yield of different genotypes

The figure illustrated the total green biomass yield of the genotypes. The genotype Pakchong Napier produced highest green matter 98.3 mt/ha, followed by Guinea Grass (91 mt/ha) and Napier Co4 (86.7mt/ha) and least green matter yield was obtained by the Signal Grass (62 mt/ha).

CONCLUSION

There was highly significant different among the tested genotypes in all traits except total green biomass yield. Result manifested ascendancy in all traits which indicated presence of high immensity of genetic variations. The genotypes Pakchong Napier, Guinea Grass, Napier Co4 are superior over other genotypes. They produced > 86 mt/ha green biomass yield in all four cuts. Thus, they were regarded as ideal genotypes to be candidates for varieties development.

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