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EDITORIAL

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Editor-in-Chief

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EVALUATION OF RICE GENOTYPES FOR YIELD AND YIELD COMPONENTS IN IRRIGATED LOWLAND ECOSYSTEM

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ABSTRACT

Farmers have a limited choice of rice varieties that are specifically advised for their local agro-ecological domain. With an objective of identifying high yielding rice genotypes for irrigated lowlands of Banke district, fifteen rice genotype were tested in Randomized Complete Block Design (RCBD) for two consecutive years 2020 and 2021 at Directorate of Agricultural Research, Khajura, Banke. Data on plant height (PH), panicle length (PL), panicles/hill (PPH), days to maturity (DTM), days to heading (DTH), thousand grain weight (TGW) and grain yield (GY) were taken. Combined analysis of yield traits for two years revealed that genotypes showed highly significant difference ($P<0.001$) for DTM, DTH, PH, GY, straw yield and TGW while significant difference ($P< 0.05$) for PL. DTM ($r= 0.316$), PPH ($r= 0.393$), PH ($r= 0.349$), PL ($r= 0.142$), and TGW ($r= 0.074$) showed positive correlation with GY. Among the tested genotypes, TP 30536 was the top grain yielder in both years, with an average GY of 5172 Kg ha^{-1} and a maturity of 140 days, making it the most promising genotype. Similarly, the genotype GSR 310 was the highest grain yielder (4517 Kg ha^{-1}) with early maturity days (121 days) which could be a good alternative to the farmer.

Keywords: genotypes, irrigated, lowland, rice, yield

अध्ययनको सार

नेपाल कृषि अनुसन्धान परिषद् लगायत कृषिसँग सरोकार राख्ने अन्य निकायले विगतमा थुप्रै धानका जातहरु उन्मोचन र दर्ता गरी किसानहरुलाई सिफारिस गरेतापनि ती मध्ये निकै कम जातहरुले मात्र कृषकहरु माझ लोकप्रियता हासिल गर्न सफल भएका छन्। यस्तो हुनुका थुप्रै कारणहरु मध्ये एउटा कारण स्थान/भूगोल विशेष जातहरुको विकास वा पहिचान हुन नसक्नु हो। हालसम्मको प्रचलन हेर्दा, जातहरु उन्मोचन गर्दा प्राय, एकमुष्ठ पर्यावरण/भूगोललाई सिफारिस गर्ने गरिन्छ (जस्तैः तराई तथा भित्रि मधेश, मध्य-पहाड)। यसरी समग्र भूगोललाई सिफारिस गर्दा पूर्वी तराईका जिल्लामा लोकप्रियता कमाएका जातहरुले पश्चिमी तराईमा खराब प्रतिक्रिया पाएका हुन सक्छन्। तसर्थ, स्थानीय कृषि

वातावरणलाई सुहाउँदो जातहरु पहिचान गर्नसके कृषकहरुको माग र चाहनालाई व्यावहारिक रुपमा सम्बोधन गर्न सकिन्छ भन्ने विश्वासका आधारमा कृषि अनुसन्धान निर्देशनालय, लुम्बिनी प्रदेश, खजुरा, बाँकेमा क्रमशः सन् २०२० र २०२१ मा धानको पन्ध्रवटा अनुजातहरुको जातीय परिक्षण संचालन गरिएको थियो। हर्दिनाथ-३ लाई आधार जात मानेर संचालन गरिएको उक्त परिक्षण सिंचित वातावरणमा, सिफारिस मलखाद तथा बिउ दरको प्रयोग गरी संचालन गरिएको थियो। परिक्षणमा समावेस गरिएका अनुजाताहरुको उत्पादनलाई प्रभाव पार्ने विविध पक्षहरुको आँकडा मापन तथा अध्ययन गरी यिनै पक्षका आधारमा अनुजातहरु बीचको तात्विक भिन्नता विश्लेषण गरिएको थियो। यसरी दुई बर्षको आँकडालाई समग्रमा विश्लेषण गर्दा, ब्याडमा बिउ छरेदेखि बाला पसाउन लाग्ने औसत समय, धानपाक्न लाग्ने औसत समय, बोटको औसत लम्बाई, परालको औसत तौल, हजार दानाको औसत तौल र धानको औसत उत्पादन दिने क्षमताको आधारमा परिक्षणमा समावेश गरिएका सबै अनुजातहरु एक-अर्का सँग तात्विकरुपमा भिन्न रहेको तथ्य पत्ता लाग्यो। त्यसै गरी परिक्षणले धान पाक्न लाग्ने अवधि, प्रति गाँज बालाको संख्या, बोटको उचाई, बालाको लम्बाई, र हजार दानाको तौलको कुल धान उत्पादन क्षमता सँग सकारात्मक सम्बन्ध रहेको पत्ता लग्यो। अर्थात, छिटो पाक्ने जातको भन्दा ढिलो पाक्ने जातको उत्पादन धेरै हुने, एउटा गाँजमा जति धेरै बालाको संख्या भयो त्यति धेरै उत्पादन बढ्ने, लामो बाला भएका जातको उत्पादन धेरै हुने, र मोटा धानको उत्पादन मसिनो धानको भन्दा धेरै हुने देखियो। परिक्षण गरिएका अनुजातहरु मध्ये सबै भन्दा धेरै उत्पादन (५१७२ कि.ग्रा./हे.) दिने अनुजात "टि.पी. ३०५३६" रहेको पाइयो। यस अनुजातलाई पाक्न १४० दिन लाग्ने देखियो। त्यसैगरी, यदि छिटो पाक्ने अनुजातको छनौट गर्नुपर्ने हो भने १२१ दिनमा पाक्ने र प्रति हेक्टर ४५१७ कि.ग्रा. उत्पादन दिने "जी.एस.आर ३१०" उपयुक्त देखियो।

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the Gramineae family, sub-family Oryzoideae, tribe Oryzae and has 24 (2n = 24) number of chromosomes. More than half of the world's population depend on rice as their primary food source (Prasad et al., 2017), and roughly 90% of the world's rice is produced in Asia (USDA, 2022). It is a primary food crop of Nepal, and has a substantial contribution to both the livelihood of people and the national economy. Food security of Nepal is reliant on the production of staple grains, with rice serving as the primary cereal among all (Choudhary et al., 2022). Rice contributes more than 50% of grain demand and more than 30% of calorie requirement of Nepal (Dhungel & Acharya, 2017). Rice is the first major cereal crop of Nepal in terms of production, productivity and area coverage. National statistics of 2022 shows that the rice is grown on more than 1.40-million-hectare land area with total production of about 5.4 million metric tons and productivity 3.79 Mt/ha (MOALD, 2022). Likewise, in the Lumbini Province of Nepal, rice is grown in 0.3-million-hectare land area, to produce 1.1 million Mt rice with productivity of 3.81 Mt/ha (MOALD, 2022).

Rice can be grown in a wide range of agro-ecological domain and environment. The agricultural production ecosystem of Nepal is broadly categorized into two major ecosystems, namely, irrigated and rainfed. The irrigated ecosystem comprises 49% and the rainfed ecosystem comprises 51% of the total production ecosystem (Tiwari et al., 2019). Lowland rice is cultivated in flooded fields and is either rain-fed or irrigated. Because of the lowland conditions, the soils are puddled and saturated with periodic application of irrigation. In addition to the 82 rice varieties already developed and released by the Nepal Agricultural Research Council (NARC), it has additionally recognized more than 48 multinational company hybrid rice varieties to date (Choudhary et al., 2022). However, the national average of the country is much lesser than its neighboring countries. The rice yield gap between the research and the farmer's field is still a big issue. Though a significant number of rice varieties are developed by the NARC, only few of them are getting popular among the farmers as farmers have limited choice of varieties that are recommended specifically for their agro-ecological domain. Thus, this research aims to comparing yield and yield components of rice genotypes to identify promising rice genotype suitable for irrigated lowlands of Banke district of Nepal as grain yield is considered as the artifact of all the contributing features, including plant height, days to flowering, days to maturity, panicles per hill, and panicle length (Oladosu et al., 2017).

METHODOLOGY

Experimental site

This experiment was conducted at Directorate of Agricultural Research (DoAR), Lumbini Province, Khajura, Banke in the cropping year 2020 and 2021. Geographically, it lies between 81^{o} 37" East longitudes and 28^{o} 06" North latitude. It is situated at an altitude of 181 meters above mean sea level and has sub-tropical climatic conditions. It receives an average annual rainfall of 1000-1500 mm. The site's soil is a sandy to silty loam that has a low organic carbon and nitrogen availability but a medium phosphorus and potassium availability. The soil pH ranges from 7.2 to 7.5 (DoAR, 2022).

Research material

A set of fifteen rice genotypes selected from the Coordinated Varietal Trials (CVT) of 2019 and 2018 including Hardinath-3 as a standard check variety were obtained from National Rice Research Program (NRRP), Hardinath, Dhanusha (Table 1). Seeds of all the

genotypes were treated with Bevistin @ 2gm/kg seed prior sowing in nursery. Seedlings were transplanted in the experimental field on twenty-fifth day after sowing.

Table 1: Rice genotypes name, source and origin.

SN	Genotypes	Source	Origin
1	TP29766	NRRP, Hardinath	IRRI, Philippines
2	SVIN188	NRRP, Hardinath	IRRI, Philippines
3	IR 16L 1829	NRRP, Hardinath	IRRI, Philippines
4	GSR 310	NRRP, Hardinath	IRRI, Philippines
5	TP 30529	NRRP, Hardinath	IRRI, Philippines
6	TP 30535	NRRP, Hardinath	IRRI, Philippines
7	IR 13F 402	NRRP, Hardinath	IRRI, Philippines
8	TP 30536	NRRP, Hardinath	IRRI, Philippines
9	IR 16L 1678	NRRP, Hardinath	IRRI, Philippines
10	IR 14L 363	NRRP, Hardinath	IRRI, Philippines
11	HARDINATH-3	DoAR, Khajura	n.d
12	NR2169-10-1-1-6-2-1-3-1	NRRP, Hardinath	NRRP, Nepal
13	IR103587-22-2-3-B	NRRP, Hardinath	IRRI, Philippines
14	SVIN123	NRRP, Hardinath	IRRI, Philippines
15	NR2179-82-2-4-1-1-1-1	NRRP, Hardinath	NRRP, Nepal

Experimental Design

The rice genotypes were evaluated in Randomized Complete Block Design (RCBD) with three replications in both years. The plot size was maintained 10 m^2 (10 rows of 5m length) and the planting geometry was maintained as 20cm X 20cm. The plot to plot distance was maintained at 40cm while a gap of 50cm was given between the replications.

Fertilizer and irrigation

Fertilizer was applied at the rate of 120:50:50 kg N: P_2O_5: K_2O per hectare. The full dose of P_2O_5 and K_2O and half dose of N was applied as basal dose and the remaining 50%

nitrogenous fertilizer was further split into two halves. The first half was applied at the tillering stage and the second half was applied at the booting stage. Field was inundated with water up to 4-5cm through periodic irrigation until the crop reach 80% physiological maturity.

Data collection and analysis

Visual observations were used to record morphological traits such as days to heading (DTH), days to maturity (DTM), plant height (PH). Plant height (cm) was determined by measuring the length of five sample plants from the soil's surface to the tip of the panicle. Similarly yield and yield attributing traits like tillers per square meter, the panicle length (cm), and the 1000-grain weight (g) were also measured. The amount of grain produced at each plot was calculated and expressed as kg $ha^{-1}$by adjusting the yield at 12% moisture level by following (Shrestha et al., 2021).

$$\text{Grain yield } \left(\frac{\text{Kg}}{\text{ha}}\right) \text{at 12\% moisture level} = \frac{(100 - \text{M\%}) * \text{Plot yield (kg)} * 10000\text{m}^2}{(100 - 12) * \text{Net Plot Area in m}^2}$$

Where, M% = moisture percentage of sample grain.

ADEL-R developed by International Maize and Wheat Improvement Center (CIMMYT) was used to perform analysis of variance and IBM SPSS Statistics 20 was used to do correlation analysis.

Agro-meteorological data

The agro-meteorological information of the experimental site during the crop period of both years was obtained from the meteorological station of DoAR, Lumbini Province, Khajura, Banke (Figure 1).

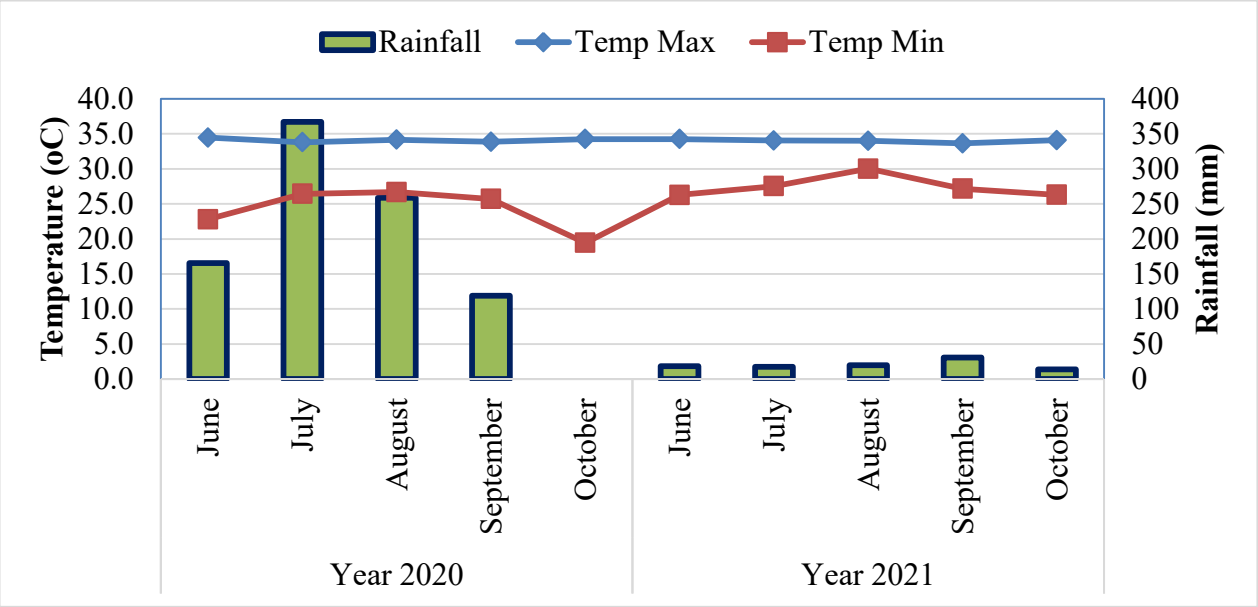

Figure 1: Temperature and rainfall of the experimental sites in 2020 and 2021.

The maximum temperature of both the years were at par, while the minimum temperature in 2021 was slightly higher than in 2020. Significantly higher amount of rainfall was recorded at early crop stage in 2020 than in 2021.

RESULT AND DISCUSSION

For 2020, the analysis of variance exhibited highly significant difference ($P< 0.001$) among the rice genotypes for traits like days to 50% heading, days to 80% maturity, plant height, panicle length, grain yield and 1000 grain weight. Significant difference ($P< 0.05$) was found for straw yield (Table 2). The highest grain yield of 5581 Kg ha^{-1} was obtained from TP 30536, followed by GSR 310 (4770 Kg ha^{-1}).

Table 2: Mean genotypic performance of fifteen rice genotypes in 2020.

SN	Genotypes	Days to 50% Heading	Days to 80% Maturity	No. of panicles per hill	Plant Height (cm)	Panicle length (cm)	Grain yield (kg ha -1)	1000 grain wt. (gm)	Straw Yield (kg ha-1)
1	TP29766	105	133	14	82	24	3497	29.0	9090
2	SVIN188	106	140	15	83	27	3543	21.3	8712
3	IR 16L 1829	101	132	15	91	25	3994	24.0	6562
4	GSR 310	93	121	13	92	23	4770	24.6	6468
5	TP 30529	103	132	14	96	23	3556	20.2	7416
6	TP 30535	104	129	14	98	29	3897	23.7	8360
7	IR 13F 402	104	120	14	80	28	2610	23.2	5515
8	TP 30536	105	138	15	80	25	5581	21.2	8038
9	1R 16L 1678	91	131	16	99	24	4176	20.9	7605
10	IR 14L 363	104	130	15	87	23	3241	14.4	8631
11	HARDINATH-3	92	121	13	84	28	3045	23.7	6951
12	NR2169-10-1-1-6-2-1-3-1	97	140	14	87	27	4248	23.0	9153

SN	Genotypes	Days to 50% Heading	Days to 80% Maturity	No. of panicles per hill	Plant Height (cm)	Panicle length (cm)	Grain yield (kg ha -1)	1000 grain wt. (gm)	Straw Yield (kg ha-1)
13	IR103587-22-2-3-B	96	130	15	85	24	4333	25.3	7346
14	SVIN123	105	141	13	81	25	1023	22.9	9207
15	NR2179-82-2-4-1-1-1-1	97	126	15	97	23	4498	24.1	7732
Grand Mean		**100.111**	**130.956**	**14.418**	**88.187**	**25.307**	**3734.141**	**22.761**	**7785.689**
CV (%)		**2.167**	**1.382**	**14.915**	**4.780**	**4.818**	**22.047**	**10.643**	**14.714**
StdMSE		**2.170**	**1.810**	**2.154**	**4.218**	**1.216**	**823.276**	**2.422**	**1145.607**
$LSD_{0.05}$		**3.629**	**3.027**	**3.603**	**7.054**	**2.034**	**1376.944**	**4.051**	**1916.047**
P-value		**<0.001**	**<0.001**	**0.8323**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.0104**

Likewise, for 2021, the analysis of variance showed the genotypes were significantly different for traits such as days to 50% heading, days to 80% maturity, plant height, grain yield, 1000 grain weight and straw yield (Table 3). The same genotype as in 2020 i.e. TP 30536 gave the highest grain yield of 4763 Kg ha^{-1} in the year 2021 as well. The earliest physiological maturity of 118 days was exhibited by SVIN 123 followed by IR 13F 402 (120 days).

Table 3: Mean genotypic performance of fifteen rice genotypes in 2021.

EN	Genotypes	Days to 50% heading	Days to 80% maturity	No. of panicles per hill	Plant Height (cm)	Panicle length (cm)	Grain yield (kg ha -1)	1000 grain wt. (gm)	Straw Yield (kg ha-1)
1	TP29766	106	131	14	83	26	3478	28.5	6701
2	SVIN188	107	140	15	83	26	3670	20.9	6322
3	IR 16L 1829	104	134	15	91	27	4020	23.5	4172
4	GSR 310	97	121	14	92	24	4263	24.1	4875
5	TP 30529	104	132	15	96	26	3475	19.8	5026
6	TP 30535	106	129	14	97	26	3869	23.2	5971
7	IR 13F 402	104	120	15	81	25	2843	22.7	3126
8	TP 30536	107	141	14	81	27	4763	20.7	5649
9	1R 16L 1678	95	132	16	98	26	4172	20.5	5215
10	IR 14L 363	105	130	15	89	25	3278	14.0	5910
11	HARDINATH-3	97	121	13	87	25	3156	23.2	4561
12	NR2169-10-1-1-6-2-1-3-1	99	140	15	86	26	3951	22.5	6764

EN	Genotypes	Days to 50% heading	Days to 80% maturity	No. of panicles per hill	Plant Height (cm)	Panicle length (cm)	Grain yield (kg ha -1)	1000 grain wt. (gm)	Straw Yield (kg ha-1)
13	IR103587-22-2-3-B	99	130	15	86	28	4191	24.8	4957
14	SVIN123	88	118	13	83	24	1665	22.4	6403
15	NR2179-82-2-4-1-1-1-1	100	125	14	96	28	4308	23.7	5342
	Grand Mean	**101.133**	**129.644**	**14.462**	**88.644**	**26.067**	**3673.58**	**22.302**	**5399.700**
	CV (%)	**2.236**	**1.288**	**13.002**	**4.981**	**7.129**	**7.262**	**10.852**	**18.772**
	StdMSE	**2.261**	**1.670**	**1.881**	**4.416**	**1.855**	**266.772**	**2.421**	**1013.701**
	$LSD_{0.05}$	**3.782**	**2.793**	**3.146**	**7.387**	**3.103**	**446.180**	**4.049**	**1695.432**
	P-value	**<0.001**	**<0.001**	**0.7945**	**<0.001**	**0.2492**	**<0.001**	**<0.001**	**0.0074**

Combined analysis of variance revealed that growing genotypes in two different years have highly significant effect only on days to maturity and straw yield, but non-significant effect on traits like plant height, grain yield and 1000 grain weight. Likewise, interaction of genotypes with years has no significant effect on number of panicles per hill, plant height, grain yield, straw yield and 1000 grain weight. Highest grain yield of 5172 Kg ha^{-1}, 4517 Kg ha^{-1}, 4403 was obtained from TP 30536, GSR 310 and NR2179-82-2-4-1-1-1-1 respectively (Table 4).

Table 4: Mean genotypic performance of genotypes over two consecutive years (2020 and 2021).

SN	Genotypes	Days to 50% heading	Days to 80% maturity	No. of panicle per hill	Plant height (cm)	panicle length (cm)	Grain yield (kg ha -1)	1000 grain wt. (gm)	Straw yield (kg ha-1)
1	TP29766	105	132	14	83	25	3487	28.8	7896
2	SVIN188	106	140	15	83	27	3606	21.1	7517
3	IR 16L 1829	103	133	15	91	26	4007	23.8	5367
4	GSR 310	95	121	14	92	24	4517	24.4	5672
5	TP 30529	104	132	15	96	25	3515	20	6221
6	TP 30535	105	129	14	98	28	3883	23.5	7166
7	IR 13F 402	104	120	14	80	27	2727	22.9	4321
8	TP 30536	106	140	14	81	26	5172	20.9	6844
9	IR 16L 1678	93	132	16	99	25	4175	20.7	6410
10	IR 14L 363	105	130	15	88	24	3260	14.2	7271
11	HARDINATH-3	95	121	13	86	27	3100	23.5	5756

SN	Genotypes	Days to 50% heading	Days to 80% maturity	No. of panicle per hill	Plant height (cm)	panicle length (cm)	Grain yield (kg ha -1)	1000 grain wt. (gm)	Straw yield (kg ha-1)
12	NR2169-10-1-1-6-2-1-3-1	98	140	14	87	27	4100	22.8	7959
13	IR103587-22-2-3-B	97	130	15	86	26	4262	25.1	6152
14	SVIN123	96	129	13	82	24	1344	22.7	7805
15	NR2179-82-2-4-1-1-1-1	98	126	14	96	25	4403	23.9	6537
Grand mean		**100.622**	**130.300**	**14.456**	**88.456**	**25.633**	**3703.867**	**22.533**	**6592.856**
CV (%)		**2.222**	**1.085**	**11.982**	**1.599**	**7.802**	**0.047**	**8.876**	**0.015**
StdMSE		**2.236**	**1.414**	**1.732**	**1.414**	**2.000**	**1.732**	**2.000**	**1.000**
$LSD_{0.05}$		**3.584**	**2.267**	**2.776**	**2.267**	**3.206**	**2.776**	**3.206**	**1.603**
P-value (G)		**<0.001**	**<0.001**	**0.334**	**<0.001**	**0.002**	**<0.001**	**<0.001**	**<0.001**
Year (Y)		**0.033**	**<0.001**	**ns**	**ns**	**0.02**	**ns**	**ns**	**<0.001**
G*Y		**<0.001**	**<0.001**	**ns**	**ns**	**<0.001**	**ns**	**ns**	**ns**

It is common practice to examine the strength and direction of correlations between different traits using correlation coefficient analysis. Significant and positive correlation (r= 0.628*) was observed between days to maturity and straw yield. Likewise, days to maturity (r= 0.316), panicles per hill (r= 0.393), plant height (r= 0.349), panicle length (r= 0.142), and thousand grain weight (r= 0.074) has positive correlation with grain yield which is in agreement with the findings of Niraula et al. (2020). The correlation of different trait is given in table 5.

Table 5: Phenotypic correlation coefficients of yield and yield attributing traits of rice genotypes.

	DtH	DtM	PPH	PH	PL	GY	TGW	SY
DtH	1	.385	.123	-.269	.279	.055	-.201	.137
DtM		1	.365	-.118	.156	.316	-.195	.628*
PPH			1	.427	-.114	.393	-.371	-.098
PH				1	-.103	.349	-.116	-.084
PL					1	.142	.204	-.123
GY						1	.074	-.093
TGW							1	-.064
SY								1

*. Correlation is significant at the 0.05 level (2-tailed).

Note: DTM= Days to maturity, DTH- Days to heading, PPH= Panicles per hill, PH= Plant height (cm), Pl= Panicle length (cm), GY= Grain yield (Kg ha^{-1}), TGW= Thousand grain weight, SY= Straw yield (Kg ha^{-1}), r= Pearson's correlation coefficient.

Fifteen rice genotypes were grouped into four clusters based on mean values of DTH, DTM, PPH, PH, PL, GY, TGW and SY for two years (Figure 2).TP29766, SVIN 188, TP 30535, IR 14L 363 and NR2169-10-1-1-6-2-1-3-1 fall in cluster one indicating they are closely related to each other. Likewise, IR 16L 1829, GSR 310, TP 30529, TP 30536, IR 16L 1678, HARDINATH-3, IR103587-22-2-3-B and NR2179-82-2-4-1-1-1-1 fall in 2nd cluster, while IR 13F 402 and SVIN123 fall on cluster 3 and 4 respectively (Table 6).Eight

genotypes in cluster 2 including Hardinath-3 is the most promising genotypes in terms of grain yield for irrigated lowland conditions of Banke District.

Table 6: Cluster membership

	Case													
	TP29766	SVIN188	IR 16L 1829	GSR 310	TP 30529	TP 30535	IR 13F 402	TP 30536	IR 16L 1678	IR 14L 363	HARDINATH-3	NR2169-10-1-1-6-2-1-3-1	IR103587-22-2-3-B	SVIN123	NR2179-82-2-4-1-1-1-1
Clusters	1	1	2	2	2	1	3	2	2	1	2	1	2	4	2

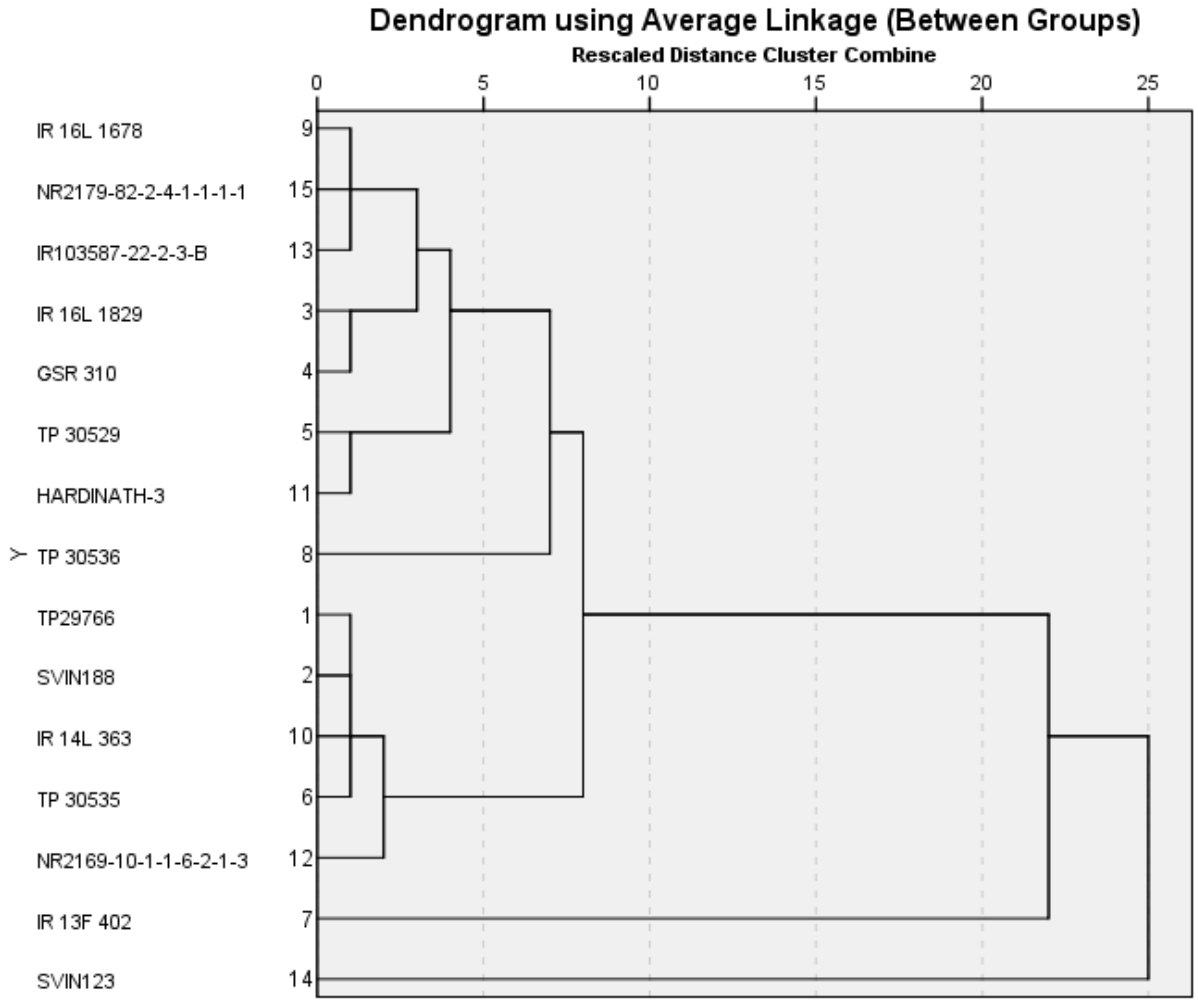

Figure 2: Clustering of rice genotypes based on yield and yield components values over 2020-2021.

CONCLUSION

Based on the results of this study, it can be concluded that the genotype TP 30536 with maturity of 140 days and 5172 Kg ha^{-1} grain yield was the most promising rice genotype in terms of grain yield for irrigated lowlands of Banke district and other similar ecology of the Lumbini Province. GSR 310 was the best option for early maturing rice (121 days) with higher grain yield (4517 Kg ha^{-1}) as it was the second highest grain yielder after TP 30536 and second earliest maturing genotype after IR 13F 402 (120 days, 2727 Kg ha^{-1}). As this research is solely focused on grain yield and a few morphological parameters, it has a restricted ability to describe overall genotypic performance. Further evaluation for economically important diseases, and quality attributes is necessary to explore the genotypes from multiple angles.

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ADOPTION STATUS OF IMPROVED RICE VARIETIES IN LUMBINI PROVINCE

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ABSTRACT

This study was carried out from January to May 2022 for adoption assessment of improved rice varieties in Lumbini Province. Rupandehi, Kapilvastu, Banke, Bardiya, and Dang districts of Lumbini Province were selected for the primary data collection. Total 373 farmers were selected through simple random sampling method and a pre-tested interview schedule was employed. For data analysis, excel and Stata12 were used for descriptive statistics and probit regression. Productivity of Nepali improved varieties (4.8mt/ha) was found slightly higher than the Indian varieties (4.56mt/ha). Probit econometric model revealed that independent variables such as age of the household head and number of economic active members have significant and negative effects, land under the irrigation facilities and membership dummy have significantly positive influence on the adoption of improved rice varieties. Major barriers to the adoption of Nepali improved rice varieties were reported to be the timely unavailability of seeds and lack of traits to fit in the cropping pattern in a specific area. It is highly advised that improved access for farmers to agricultural organizations like cooperatives, timely availability of improved seeds, hybrid variety development, and promotion of available competitive rice varieties should be done to boost productivity and decrease import of rice.

Keywords: adoption, improved varieties, membership, probit, rice productivity.

अध्ययनको सार

लुम्बिनी प्रदेशमा धानको उन्नत जातहरुको अनुग्रहण र उत्पादकत्वको अवस्था सम्बन्धि जानकारीका लागि कुल ३७३ धान कृषकहरुसंग बि.स.२०७९ मा सर्वेक्षण गरिएको थियो। यो अध्ययन लुम्बिनी प्रदेशको रुपन्देही, कपिलवस्तु, दांङ, बाँके र बर्दियामा गरिएको थियो। प्राप्त तथ्यांकहरुको विश्लेषण गर्नका लागि व्याख्यायन तथ्यांकशास्त्र र प्रोबिट रिग्रेसनका लागि एक्सेल र स्टेटा १२ को प्रयोग गरियो। प्राप्त नतिजा अनुसार ५३% प्रतिशत धान खेति गरिएको जग्गामा नेपालमै विकास अथवा दर्ता गरिएका उन्नत जात, ४५% भारतीय उन्नत जात तथा २% जति लोकल जातहरु लगाईएको थियो। कृषकहरुको अपेक्षा विपरित भारतीय उन्नत जातहरुको

उत्पादकत्व (४.५६ मे.ट.) तुलनामा नेपाली उन्नत जातहरुको उत्पादकत्व (४.८ मे.ट.) धेरै भेटिएको थियो। प्रोबिट मोडेल अनुसार उन्नत धानको जातको अनुग्रहणमा कृषकको उमेरले र घरपरिवारमा आर्थिक रुपले सक्रिय सदस्यको संख्याले नकारात्मक प्रभाव पारेको र कृषकहरुको कृषि सहकरी वा कृषक समुहमा संलग्नताले र सिंचाई सुविधामा पहुँचले उन्नत जातको अनुग्रहणमा सकारात्मक भूमिका रहेको यस अध्ययनले जनाएको छ। नेपाली उन्नत जातहरुको बीउ समयमै र चाहिने जति नपाईने र कृषकहरुको बाली चक्रमा समायोजन हुने गुण हरुको कमीको कारणले नेपाली उन्नत जातहरुको अनुग्रहण कमी भएको जनाएको छ। तसर्थ धान कृषकहरुको कृषि सहकारी वा कृषक समुहमा संलग्नता बढाउने र सिंचाईको सुविधालाई विस्तार संग संगै उन्नत बिउमा कृषकको पहुँच बढाउने, हाइब्रिड जातको उत्पादन र विकास गर्नु, उपलब्ध प्रतिस्पर्धी जातहरुको प्रवर्धनले धानको उत्पादकत्व बढाउन सक्ने र धान आयात घटाउन सहयोग गर्न सक्ने यस अध्ययनले जनाएको छ।

INTRODUCTION

Rice has been a staple nourishment and source of employment for the greater part of the population in the world as well as in Nepal. Its contribution towards the national GDP is 7% and 20% to AGDP (MoALD, 2020). Rice is grown in 1.47 million ha and has an average productivity of 3.4 mt/ha with the Terai region in the south being major producer (AITC, 2022). However, Nepal is not self-sufficient in rice production and relies on imports to meet the domestic demand (Tripathi et al., 2018). The rice sector in Nepal faces several challenges, including limited irrigation facilities, low productivity, high productivity losses, and lack of modern technology and infrastructure. Nepal Agricultural Research Council (NARC) has developed 130 (64 released varieties, 66 registered varieties with the 21 de-notified) improved rice varieties with various required traits, such as early and late varieties, drought and flood resistance, insect pest resistant that are appropriate for various agro-climatic conditions to promote the growth and development of the rice sector (AITC, 2021). MoAFW, 2016 has reported that rice productivity in Nepal is lowest (3760kg/ha) when compared to its neighbor countries, China has the highest productivity of rice (6932kg/ha) followed by Vietnam (5581kg/ha) Indonesia (5414 kg/ha) and Bangladesh (4618 kg/ha). There are various improved technologies and interventions which could be adapted to increase the productivity of rice in the country. According to (SINA, 2022) in Nepal rice is grown almost all parts of Nepal with the Madhesh pradesh leading the way in terms of production (1420436mt) followed by Koshi Pradesh (1245545mt) and Lumbini province (1185493mt). Major constraints for the low productivity of rice is rain-fed system, erratic rainfall pattern, droughts, inefficient use of

inputs poor soil fertility and some socio-economic factors like changing rice consuming pattern, consumption shifts towards the fine and aromatic rice and open border area prompts the use of Indian improved seeds with risk of crop failure. Nation should not rely on the import of seeds because of risk of the introduction of invasive species which can create a negative impact on the local and domestic seed industry.

Major objective of the study is to assess the rice productivity and area covered by the Nepali improved, Indian improved and hybrid varieties in Lumbini Province. The adoption study of rice varieties is an important aspect to study because it provides insights into how farmers are responding to new rice varieties and technology that are being introduced to increase productivity and yield. Understanding the adoption status can help in assessing the success of various interventions and policies aimed at improving the rice sector. Assessment of adoption of improved rice varieties can help in improving rice productivity, enhance food security, promote sustainability and identify constraints and opportunities for farmers in different contexts.

METHODOLOGY

According to (SINA, 2022), Lumbini province, which is part of the major terai region, has the second highest rice coverage area (608158 ha) followed by Koshi Province (750198ha). Five of the 12 districts of Lumbini Province i.e. Rupandehi, Kapilvastu, Banke, Bardiya and Dang are known as the hub of cereals and the study was carried out in these principal rice growing districts. The districts, and municipalities wards were selected purposively based on the highest area allocated for rice cultivation based on the information obtained from Statistical Information on Nepalese Agriculture (2021). The sample was constituted 373 rice growers by applying simple random sampling. Primary data were collected using a semi-structured interview schedule developed by a panel of agri-economist and agronomist. To increase validity and reliability, farmers were interviewed by researchers and experienced extension officers. The information gathered was verified by the data collected through Focus Group Discussion (FGD) and Key Informant Interview (KII). Secondary data were obtained from Agriculture Knowledge Center (AKC) annual reports, newsletters, bulletins, and relevant arts published in Department of Agriculture, Ministry of Agriculture and Livestock Development (MOALD). The survey was conducted between January to May 2022.

Probit model is used to identify the factors determining the adoption of Nepali improved rice varieties. Probit model has been used repeatedly to assess the functional relationship between adoption likelihood and its determining factors (for example age, farm size, gender of household head, availability of irrigated land, and resources). To determine the adoption decision of farmers, probit regression model has been used in several studies (Chandio & Yuansheng 2018, Subedi et al., 2019). The binary econometric models enable a more specific analysis of farmers' adoption of new technology (Mariano et al., 2012, Muzari et al., 2012,). This type of analysis provides more detailed information on the characteristics of the farmers who tend to adopt a specific technology. The probit regression model is preferred over the others because of the assumption of normal distribution (Wooldridge, 2010). The generalized equation for probit model is expressed as follows.

Pr (Adoption of improved varieties = 1, otherwise = 0) = f (β_0+ β_1X_1+ β_2X_2+β_3 X_3+ β_4 X_4 + μ)

where, β_0, is the coefficient and β_1, β_2,β_3 are the parameters to be estimated and X_1, X_2, X_3, X_4 are the value to be determined and μ stochastic error term.

RESULTS AND DISCUSSIONS

Landholding of farmers in the study site

The total and average landholding of the farmers in the study site is presented in Table 1. Being a staple crop, rice typically covers the entire cultivable region during the rainy season in the study area. The average area covered by the rice crop is 0.89ha with 0.69 ha of that land having access to irrigation.

Table 1. General features of the production system

Landholding	**Area (ha)**
Total cultivated land	345.26
Average cultivated land	0.89
Total irrigated land	266.31
Average irrigated land	0.69

Source: (Field survey 2022)

Extent of adoption

Farmer's preference for growing multiple varieties is presented in Table no 2. Most of the farmers used to grow only one variety. Adoption of more than one variety is driven by the number of plots at various locations, the farmer's decision to experiment with different varieties, and the farmer's choice either for self-consumption or for selling purposes.

Table 2. Number of varieties grown

Number of varieties grown	Numbers of farmers
Single variety grown	278
Two varieties grown	69
More than two varieties grown	26

Source: (Field survey 2022)

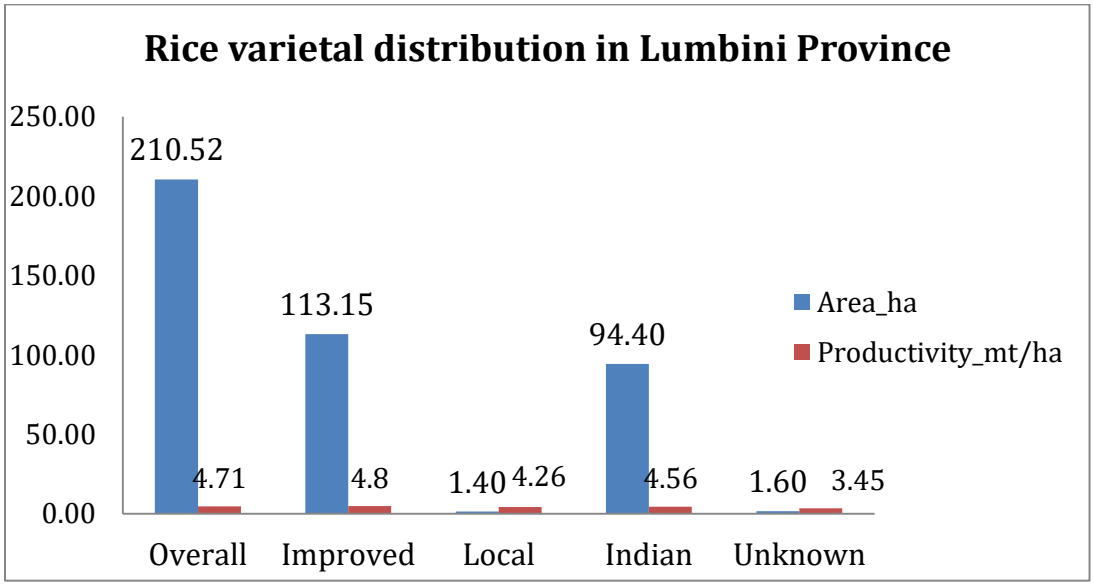

Figure 1. Varietal distribution of improved rice varieties.

The chart represents the productivity and area covered by different rice varieties. NARC developed improved varieties including the varieties released and registered by the NARC, however, sawa mansuli was taken as Indian varieties for the analysis. The study has depicted that higher rice cultivated area in Lumbini Province was covered by improved rice varieties (113.15ha) developed in Nepal followed by Indian hybrids and improved varieties

(94.40ha). Productivity of improved varieties was found slightly higher i.e 4.8 mt/ha than the Indian improved varieties (4.56mt/ha). Overall rice productivity was found 4.71mt/ha with the coverage of 210.52 ha of cultivable land.

Rice varieties adopted in Lumbini Province

Table 3 depicted the number of rice varieties adopted by the farmers. In the study site, total 38 varieties were reported to be cultivated, among them 9 varieties were NARC released, 8 were registered hybrids, 19 were Indian varieties, 1 was local and 1 variety was unidentified. About 45% of the total rice cultivated area was found covered by Indian varieties. Among Indian varieties, the most preferred varieties were Sawa mansuli, Prasanna, Sampuran and Upaj, while Radha-4, Sambha mansuli sub-1, and Sabitri, were the most adopted Nepali improved varieties.

Majority of highly adopted NARC-released varieties such as Radha-4, Sambha mansuli sub-1 and Sabitri were released 20-30 years ago indicating the ineffective coordination between the research and extension system indicating in developing rice varieties in accordance with farmer preferences and promoting the recently released ecological region specific varieties. Given this, compared to neighboring nations, the adoption of improved rice varieties has not been able to improve or boost productivity in Nepal.

Nearly half of the rice cultivated area is covered by Indian improved or hybrid seeds, most of them informally imported in Nepal increasing the risk of complete or partial crop failures, and invasion of foreign insect pests and weed species. So for Nepal, it is important to create a strengthened environment for the domestic seed industry that can produce hybrid and high quality improved seeds. The government of Nepal should also focus on strengthening the rice seed supply chain.

Table 3. Rice varieties adopted in the study site.

Variety name	Area (kattha)	Release/Registration year	Type
US-312	977	2011	Registered
Sawa mansuli	933	2019	Indian
Prasanna	652		Indian
Gorakhnath	555	2011	Registered

Variety name	Area (kattha)	Release/Registration year	Type
Sampurna	450	2018	Indian
Radha-4	410	1995	NARC
Sambha masuli sub-1	255	2011	NARC
Upaj	246		Indian
Arise 6644	251	2011	Registered
Hybrid	128		Indian
Sabitri	128	1979	NARC
Golden	111		Indian
Radhika	100		Indian
Punam	77		Indian
Mahendra 30-30	74		Indian
Mahendra 404	71		Indian
Ramdhan	54	2016	NARC
Machapalan	48		Unknown
Makkarkaddu	41		Local
Bindeshwari	40	1981	NARC
Delta	40	2015	Registered
DY-69	39	2010	Registered
Sultan	35		Indian
Nilima	32		Indian
Shanti	25	2015	Registered
Sukha	20	2011	NARC
Jeera masino	18		Indian
Pabitra	15		Indian

Variety name	**Area (kattha)**	**Release/Registration year**	**Type**
Swarna Sub-1(N)	14	2011	NARC
Supreme Sona	13		Indian
Saurabh	12		Indian
Sukha_2	12	2011	NARC
Priyanka	10		Indian
Loknath	6	2011	Registered
Bahuguni	5.4	2018	NARC
Mukabala	5	2019	Indian
Chaurasiya	4		Indian
Jamuna mansuli	3		Indian

Source: (Field survey, 2022)

Table 4. Statistical description of the variable used in Probit regression model

Summary statistics of some socioeconomic characteristics of the farmers are depicted in Table 4. Average age of the farmers was found 51 years. The average cultivated land was 26.83 kattha (0.89ha), irrigation facility was available for 20.75 kattha (0.69 ha) land. The number of average economically active family members was found 4 in studied sample.

Variables	Description	Observation	Min	Max	Mean	Standard deviation
Age	Age of household head	373	10	92	50.5	12.44
Economic active members	Number of economically active members(15-59 years old) in family	373	2	25	4.80	2.73

Variables	Description	Observation	Min	Max	Mean	Standard deviation
Total cultivated land	Total cultivated land in kattha	373	2	210	26.83	30.03
Total irrigated land	Total irrigated land in kattha	373	0	200	20.75	27.04
Membership	If family member is involved in any agricultural organization then 1,0 otherwise	373	0	1	0.51	0.50
Gender	If HH head is male than 1,0 otherwise	373	0	1	0.89	0.30
Ethnicity	If Ethnicity of HH is Brahmin/chettri1,0 otherwise	373	0	1	0.23	0.42

Source: (Field survey, 2022)

Factors determining the adoption of improved rice varieties in Lumbini Province

To identify the factors influencing the adoption of Nepali improved rice varieties, probit model was used. To run the probit model and to know the factors affecting adoption, required variables were categorized into binary responses. For the interpretation of the model, marginal effects were driven from the regression coefficients, calculated from the partial derivatives as a marginal probability. The extent to which the probit regression analysis model's independent variables used in the prediction correctly predicted the dependent variable. The Wald test (LR chi2) for the model indicated that the model had good explanatory power at the 1 percent level. The pseudo R^2 was 0.12 which means variables included in the model explain 12% of the probability of a household decision to

adopt or not to adopt the improved varieties of rice. Receiving operating characteristics (ROC) is the area under the curve that evaluates how well a binary regression model classifies positive and negative outcomes at all possible outfits. ROC curve relies on between 0-1 value close to one means higher accuracy of the test. The area under the ROC curve for the regression is 0.68 which depicts the higher accuracy of the test.

Table 5. Factors determining the adoption of improved rice varieties in Lumbini Province

Variables	Coefficients	Standard error	P>|z|	dy/dx[b]	S.E.[b]
Age of Household head	-.016504***	.0054126	0.002	-0.0066	0.002
Gender of Household head	.0515491	.2310755	0.824	0.0205	0.092
Ethnicity	-.1204884	.1606764	0.454	-0.0479	0.639
Economic active members	-.0659217**	.0312301	0.035	-0.02617	0.124
Involvement in agricultural organization	.6041743***	.1360984	0.000	0.2364	0.052
Total cultivated land(kattha)	-.0033121	.0049381	0.502	-0.0013	0.002
Total irrigated land(Kattha)	.0094845*	.0052105	0.069	0.0037	0.002

Variables	Coefficients	Standard error	P>|z|	dy/dx[b]	S.E.[b]
cons	.7835558	.318983	0.014		

*** Significant at 1% level;** Significant at 5% level;* Significant at 10% level. b= Marginal change in probability evaluated at the sample means

Summary statistics	
Number of observations	373
LR chi^2 (8)	42.60
Pseudo R^2	0.12
Log likelihood	-236.26
Area under ROC curve	0.6843

Source: (Field survey, 2022)

Adoption of improved varieties is likely to be determined by the number of socio-economic variables of a farmer. The study indicates that some of the variables had a significant effect on the probability of adoption of improved varieties and were in line with the previous studies. Age of the household head, family size, involvement in the agricultural organization, and availability of irrigated land has a significant effect on the adoption of improved rice varieties. Among the significant variables, the age of the household head, and family size has a negative effect, and membership in the agricultural organization and total irrigated land has a positive effect on the adoption of Nepali improved varieties.

The estimated marginal coefficient of the age of household head is -0.006 which means that with the increment in age of the farmers by one year, probability of adopting improved rice variety decreases by 0.6%. This result is consistent with the study of Subedi et al. (2019). However, some studies have shown the positive effect of age on the adoption of improved varieties indicating that the younger ones have higher risk capacity and are early adopters (Subedi and Dhakal, 2014).

The probability of adopting improved rice varieties reduces by 2.6% as the number of economically active family members increases compared to families with fewer

economically active members and the result is not consistent with the previous studies. Such as, Chandio et. al. (2020) reported that a larger family size is more associated with the adoption of improved technologies. Likelihhod of adoption of improved rice technologies is increased with the increment in number of family members. Possible explanation of negative realation between the larger family size and adoption of improved varieties is that demand for rice increases with family size and the notion of higher productivity of Indian variety encourages farmers to cultivate the Indian varieties over the Nepali improved varieties or Higher income produced by more economically active members provides the opportunity to purchase expensive Indian hybrid seed to meet family demand of rice.

Likelihood that farmer's will adopt the improved varieties increases by 23.64% for the farmers as the member of any agricultural organization such as cooperatives or farmer's groups as compared to farmers having no membership. The result is significant at 1% level. This result is in line with Subedi et al. (2019), Subedi & Dhakal (2014). Further, Mignouna et al. (2011) reported that being a part of a social group facilitates idea and information sharing so that farmers can be benefited from adopting new technology.

Availability of irrigated land increases the probability of improved rice varieties by 0.3% than the non-irrigated landholders. This result is consistent with the works of literature. The availability of resources like seeds and irrigation positively influences the adoption of improved technologies/varieties (Chandio et al., 2020; Kumar et al., 2020).

Farmer's perception of NARC developed improved rice varieties

The majority of farmers stated the lower yield of Nepalese varieties in contrast to Indian varieties (21%) and the timely unavailability of NARC released and developed improved varieties (44%) as the main justifications for choosing other rice varieties over Nepalese improved varieties. Eighteen percent of non-adopters in the study locations found that Nepali improved rice varieties lacked the characteristic to fit into the particular site-specific cropping pattern.

Table 6. Farmer's perception of Nepali improved rice varieties

Constraints in adoption of Nepali improved rice varieties	Response in percentage (%)
Timely unavailability of seed	44
Low yield	21
Disease pest susceptibility/infestation	6
Drought flood intolerant	5
Grain shattering problem	6
Not fit to cropping pattern	18

Source: (Field survey, 2022)

CONCLUSION

Improvement in rice productivity will certainly help to boost Nepalese economy as rice farming makes an incomparable contribution to agricultural gross domestic product, employment generation, nutrition and calorie fulfillment in food. This study analyzed the productivity of various improved rice varieties, factors influencing their adoptions along with the constraints in adoption Nepali improved rice varieties. The productivity of improved rice varieties released and developed by NARC in Nepal has been found greater than that of Indian varieties. However, farmer's perception towards Indian rice yield is more positive than the Nepali improved rice. Farmer's preference of replacing and growing Indian hybrid highlight the dire need for competitive Nepali hybrid rice seed production. To analyze the factors influencing the adoption of improved rice varieties, probit model was applied and empirical results revealed that independent variables like involvement of farmers in agricultural cooperative or farmer's group and acess to irrigation facilties positively and significantly influenced the adoption of improved rice varieties. Based on the findings this study recommend to elevate the farmers' participation in organizations like seed cooperative or farmer's cooperative because it has been discovered to be important in the increasing the adoption of improved technology. For the timely availability of seeds, seed supply system should be improvised and strenghthened. Researchers should concentrate on producing and developing breeder seeds according to farmers' needs and

preferences for particular characteristics. National and provincial government should enable the environment to develop and promote the newly released improved varieties.

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EVALUATION OF GROWTH AND YIELD CHARACTERISTICS OF VARIOUS OAT (*Avena sativa*) GENOTYPES AT KHAJURA BANKE

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ABSTRACT

A field experiment was laid at Directorate of Agriculture Research, Lumbini Province Khajura Banke Nepal during winter season from 8th November, 2019 to 30th March 2020 for the evaluation of growth and yield characteristics of various oat genotypes at Khajura Banke. Five Oat genotypes (Bundel 851, Nandini, NZA 30002, NZA 3217302 and WIX 8792) were tested in randomized complete block design with four replications for plant growth and yield parameters like plant height, leaf length, leaf width, no of tiller per plant, no of leaf per plant, green biomass yield and seed yield. There were non significant variations in all trais. The genotypes WIX 8792 and Bundel are superior over other genotypes had produced maximum green biomass yield 16.47 ton/ha and 15.10 ton/ha respectively. Similarly, the highest seed yield was observed in NZA 30002 (3.73 ton/ha) followed by Bundel 851(3.57 ton/ha) and WIX 8792 (3.57 ton/ha). They show variaions in Evaluation of growth and yield characteristics of various oat genotypes at Khajura Banke. According to the findings the genotypes WIX 8792 and Bundel 851 were superior and ideal could be used for forage production and variety release.

Keywords: evaluation, characteristics, oat, genotypes.

अध्ययनको सार

नेपालको पश्चिम तराई क्षेत्रमा पाँच ओटा जै घाँसका विभिन्न अनुजातहरुको वृद्धि र उत्पादनका विशेषताहरूको मूल्याङ्कन गर्नको लागि कार्तिक २२, २०७६ देखी चैत्र १७, २०७६ सम्म रेन्डमाइज्ड कम्प्लिट ब्लक डीजाईन प्रयोग गरेर त्सलाई चारपटक चौराई निम्न गुणहरु जस्तै बिरुवाको उचाइ, पातको लम्बाइ, पातको चौडाइ, प्रति बोट गाँजको संख्या, प्रति बोट पातको संख्या, हरियोघाँस उत्पादन र बीउ उत्पादन पत्ता लगाउनको लागि कृषि अनुसन्धान निर्देशनालय, लुम्बिनी प्रदेश खजुरा बाँकेको अनुसन्धान फार्ममा मुल्यांकन परीक्षण गरियो। सम्पूर्ण गुणहरुमा उल्लेखनीय भिन्नताहरू फेला परेनन् तथापी विभिन्न अनुजातहरु मध्ये डब्लु. आई. एक्स. ८७९२ र बुन्देल सबै भन्दा बढि बीउ तथा हरियो घाँस उत्पादनमा उत्कृष्ट छन्। माथि उल्लेखित बढि उत्पादन दिने अनुजातहरुलाई थप मुल्यांकन गर्न तथा विभिन्न चरणका परीक्षणहरुमा समावेस गर्न आबस्यक छ। साथै

किसान दाजुभाई दिदी बहिनी तथा अन्य सरोकारवालाहरुले घाँस उत्पादन कार्यमा प्रयोग गर्न तथा सम्बन्धित निकायबाट उन्मोचन को लागि सिफारिस गर्न आबस्यक छ।

INTRODUCTION

Oat (*Avena sativa* L.) is a cereal species widely used for human food and livestock feed. It is rich in primary metabolites (e.g., protein, carbohydrate, and fibre) as well as in many secondary compounds. Suttie and Reynold (2004) indicated that oat is used throughout the world for human food and animal feed, and it is frequently grown as a dual-purpose crop.

Oat is one of the major forages grown as main component of crop rotation in Mediterranean farming systems (Corleto, 1987). In recent years, its agronomic and nutritive values, as well as the increase in the popularity of organic agriculture due to its ability as a winter cover crop in no-till rotations, have led to renewed interest in this crop (NPFRP, 2020). Furthermore, the demand for oat for human consumption has increased, particularly because of the demonstrated dietary benefits of oat whole-grain products. Oat that was traditionally used as breakfast cereal and porridge in some countries, after the recognition as a healthy food has started to be used in other products like pasta, muffins, biscuits, cakes, bread, snack food, infant food, probiotic drinks (Andersson & Börjesdottir, 2011). Oat is considered to be a nutritious source of protein, carbohydrate, fibre, vitamins, and minerals as well as of compounds with beneficial effects on health (e.g., polymers of fructose, and antioxidant molecules), (FDA, 1997).

Peterson et al. (2005) illustrates that in particular, oat grain has a high concentration of fructo-oligosaccharides (FOS), soluble nonstructural carbohydrates made of short chains of fructose molecules. Redaelli et al. (2003) indicates that FOS have been termed “prebiotics”, because they can selectively stimulate growth and/or activity of a number of potentially health-stimulating intestinal bacteria, and they have essential roles in many molecular processes that impact upon eukaryotic biology and disease. Recently, a new approach in the feed supply chain has suggested that milk production and composition can be influenced by the availability and characteristics of the soluble carbohydrates in the animal diet (Saksena et al., 1099). However, little is known about the variability of FOS concentrations in the forage biomass of cereals. Singh & Singh (2019) illustrates the insufficiency of good quality seeds of fodder oat is one of the major limitations of fodder production in Nepal. Only six improved varieties of various oat crops have been released by Nepal Agricultural Research Council for the different agroecological regions (Krishi

Diary, 2022). On other hand Ahmad et al. (2014) depicts oat seed production can be promoted by selecting new varieties having better seed yield as well as green biomass. Kim et al. (2006) exhibits to overcome nutritional demand for animals to select superior fodder oat variety and to combine good management practices to produce crops with high yield and favorable quality characteristics. In our western terai region, we were evaluating different oat genotypes with the objective of identifying and screening the superior oat varieties for fodder and seed yields for the winter season.

METHODOLOGY

The experiment was carried out at the research farm of Directorate of Agriculture Research, Lumbini Province, Khajura Banke, Nepal during winter season from 8th November, 2019 to 30th March 2020 to estimate green biomass and seed production performance of different oat genotypes 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 was 1000-1500 mm. The maximum and minimum temperature at the station was 5.4^{o}C and 46 ^{o}C and 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 four replications consisting of five oat genotypes (Table 1). The individual plot size was 18 m^2 (20 rows of 3 m long) and spacing was 30 cm between rows and continuous sowing on each rows. 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 ton/ha along with 80:60:40 kg N2, 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 30 days after sowing and 45 days after sowing. The seed rate, sowing method, fertilizer application, irrigations and all other agronomic operations were provided according to recommendations of the crops. Plant height, leaf length, leaf width, no of tiller per plant, no of leaf per plant, green biomass yield and seed yield per hectare was deliberated by converting yield per plot into yield per hectare. The statistical package MSTAT-C was used 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 genoypes used in the experiment.

S.N	Name of Genotypes
1	Bundel 851
2	Nandini
3	NZA 30002
4	NZA 3217302
5	WIX 8792

RESULT AND DISCUSSION

Green biomass

Agronomical and yield attributing traits influence the green biomass and seed yields of forage crops. Among tested oat genotypes the highest green biomass was produced from WIX 8792 (16.47 ton/ha) followed by Nandini (15.37 ton/ha), Bundel (15.10 ton /ha) and the least yield was produced from NZA 30002 (14.23 ton/ha). There was non significant difference among the tesed genotypes. Burstmayer et al. (2007) expressed the influences of genotype and climate conditions are significant parameters affecting yield and quality of oat. Amanullah et al. (2004) showed that higher fodder yields in oat genotypes can be due to their bigger leaf area, which results in higher photosynthetic activities and a high ability to retain assimilative photosynthesis products.

Seed yield

The highest seed yield was produced by Nandini (4.97 ton/ha) followed by NZA 30002 (3.73 ton/ha), Bundel 851 and WIX 8792 obtained same yield (3.57 ton/ha) and least seed yield was produced by NZA 3217302 (2.80 ton/ha). Green biomass and seed yield is highly influenced by leaf area of plant (Amanullah et al., 2004). Peltonen-Sainio (1991) exhibited that seed yield was positively correlated with seed weight per panicle.

Plant height

The highest plant height was measured in Nandini (83 cm) followed by NZA 30002 (70.07 cm), WIX 8792 (63 cm) and least Plant height was measured in Bundel 851 (55.47 cm). The plant height which is largely dependent on the genetic make-up of an individual variety. Pariyar (2007) indicated that taller the plant higher the seed and green biomass yield. Plant height may be different in varieties due to genetic make-up and environmental conditions which in turn cause variations in hormonal balance and cell division rate in a particular environment (Zaman et al., 2006). Ahmad et al. (2014) reported that plant height were found a positive association with culm diameter, leaf stem ratio, number of tillers and thousand grain weight and seed length.

Leaf length

The highest leaf length was measured in Nandini (47.73 cm) followed by NZA 3217302 (43.73 cm), WIX 8792 (42.27 cm) and least leaf length was measured in Bundel 851 (40.27 cm).

Leaf width

The highest leaf width was measured in Bundel 851 (2.00 cm) followed by same leaf width in Nandini, NZA 30002 and NZA 3217302 (1.67 cm), and least leaf width was measured in WIX 8792 (1.33 cm). Sharma et al. (2021) reported similar findings.

Number of leaves per plant

The number of leaves plays an important role in plant development and growth which directly affect the yield both for cereal and fodder plants. The number of leaves per plant has a direct effect on the yield of fodder crops. Highest no of leaf per plants was found in NZA 3217302 (34.87) followed by NZA 30002 (33.80), Bundel 851 (31.20) and least no of leaf per Plants was found in Nandini (28.40).

No of tillers per plants

Highest no of tillers per plants was found in NZA 3217302 (8.93) followed by NZA 30002 (8.87), Bundel 851 (7.47) and least no of tillers per Plants was found in WIX 8792 (7.27).Sharma et al. (2021) concluded that there were variations among the evaluated genotypes for agro-morphological traits. Overall, the experiment of Oat genotypes showed that the tested traits were found non- significance difference among the evaluated genotypes.

Table 2. Summary statistics of genotypes.

Genotypes	Plant Height (cm)	Leaf Length (cm)	Leaf Width (cm)	No of leaf/ Plants	No of Tillers /Plants	Total Green biomass (ton/ha)	Total Seed Yield (ton/ha)
Bundel 851	55.47	40.27	2.00	31.20	7.47	15.10	3.57
Nandini	83.00	47.73	1.67	28.40	7.47	15.37	4.97
NZA 30002	70.07	41.20	1.67	33.80	8.87	14.23	3.73
NZA 3217302	62.27	43.73	1.67	34.87	8.93	14.80	2.80
WIX 8792	63.00	42.27	1.33	30.20	7.27	16.47	3.57
Grand Mean	66.76	43.04	1.67	31.69	8.00	15.19	3.73
CV %	15.07	11.28	33.76	22.49	25.66	16.89	27.26
F Value	0.07^{ns}	0.42^{ns}	0.72^{ns}	0.80^{ns}	0.75^{ns}	0.86^{ns}	0.23^{ns}
$LSD_{0.05}$	18.94	9.14	1.06	13.42	3.86	4.83	1.91

Significance at the level of 0.05

CONCLUSION

The results of this study indicates that there was non-significant (p=>0.5) difference exibits in all traits, there by showing the importance of selecting suitable genotypes for specific uses. Result shows the variations in all traits which indicated presence of variations. The genotypes WIX 8792 and Bunde l851 are superior over other genotypes in both green biomass and seed yield. They produced more than15 ton/ha green biomass yield in all four cuts and more than 3.5 ton/ha seed yield. Thus, they were regarded as best genotypes to be candidates for further verifications.

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ISOLATION AND ANTIBIOTIC SENSITIVITY ASSAY OF *Salmonella* IN CULTURED CARPS OF RUPANDEHI

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ABSTRACT

Fish serves as a host to a variety of pathogen including *Salmonella*. This study was done to identify the zoonotic pathogen *Salmonella* infecting cultured carps and establish antibiotic susceptibility of *Salmonella* in Rupandehi. A total of 126 fish samples were collected aseptically from 42 fish ponds from three different sites; Chapiya, Siktahan and Patkhauli of Rupandehi. Isolation of *Salmonella* was done from liver and intestine, and identified by biochemical tests. Antibiotic sensitivity of *Salmonella* was determined by the Kirby-Bauer disc diffusion method. Time period from site selection to antibiotic sensitivity test was done from June to October 2019. The overall prevalence of *Salmonella* in cultured carps was 26.2% which was statistically significant ($p<0.05$) among infected species where higher prevalence was found in grass carp (57.1%). Prevalence of *Salmonella* was found higher in pond fertilized by organic manure (50%). Out of 8 antibiotics tested, isolates were most sensitive to Levofloxacin (100%) and most resistant to Cefotaxime (100%). This observed resistance might be due to the haphazard use of antibiotics in the study area which need to be monitored. Thus, this study provides baseline information for future reference and fish disease management in Rupandehi.

Keywords: antibiotics, antibiotic sensitivity test, fish, levofloxacin, *Salmonella*

अध्ययनको सार

माछामा लाग्ने साल्मोनेला एक जुनोटिक रोग हो। संसारका विभिन्न अध्ययन अनुसन्धानबाट साल्मोनेलाले माछाको स्वास्थ्य तथा उत्पादनमा हानी नोकसानी गरेको पाइएको छैन तर ती संक्रमित माछाको सेवनबाट मानिसमा झाडापखाला, ज्वरो, सुत्केरी महिलामा स्वास्थ सम्बन्धित असर जस्ता अनेकन रोग लाग्ने संभावना प्रवल देखिएको पाइन्छ। साल्मोनेला अस्वस्च्छ पालन अभ्यासबाट माछाहरुमा संक्रमण हुने गर्दछ तथा त्यस जीवाणुले उचित हावा पानी पाएमा यो रोगको संक्रमण फैलिने अवस्था देखिन्छ। सामान्यतया पोखरीमा साल्मोनेलोको संक्रमण गर्मी मौसममा वढी भएको पाइन्छ। यस अध्ययनको मुख्य उद्देश्य रुपन्देहीमा पालन भएका कार्प माछामा संक्रमण गर्ने जुनोटिक जीवाणु साल्मोनेलाको पहिचान गरी उक्त जीवाणुमा एन्टिवायोटिकको संवेदनशिलता स्थापना गर्नु

थियो। यस अध्ययनको लागि रुपन्देहीका माछा उत्पादनमा संभाभ्यता बोकेको तीन स्थानहरु(छपिया, सिकटन तथा पटखौली)मा अध्ययन अनुसन्धान गरी जुनोटिक जीवाणु साल्मोनेलाको पहिचान तथा एन्टिवायोटिकको संवेदनशिलता स्थापनाको प्रारम्भ गरियो। रुपन्देहीमा भएको यस अध्ययनमा साल्मोनेल्लाको संक्रमण ग्रास कार्प माछामा बढि देखिएको तथा गोवर मलको प्रयोग अत्याधिक मात्रामा भएको पोखरीहरुमा पाइएको थियो। यस अध्ययनबाट अव्यवस्थित रुपमा पालन गरिएको माछामा साल्मोनेलाको संक्रमण बढ्ने सम्भावना देखियो जसको खपतबाट मानिसलाई समेत प्रभावित पार्न सक्ने सम्भावना देखियो। यसै गरी उक्त संक्रमण भएका माछाहरुमा एन्टिवायोटिकको संवेदनशिलता जाँच गर्दा Cefotaxime भन्ने एन्टिवायोटिक बिरुद्ध सालमोनेला बढि प्रतिरोधक देखियो। यो अवलोकन गरिएको अध्ययन क्षेत्रहरुमा प्रतिरोधी क्षमता स्थापित हुनुमा एन्टिवायोटिकहरुको अनियमित प्रयोगको कारण हुन सक्ने सम्भावना देखियो। त्यसैले माछा पालन क्षेत्रमा एन्टिवायोटिकको अव्यवस्थित प्रयोग हुन दिनवाट नियमित निगरानी आवश्यक भएको पाइन्छ। यस अध्ययनबाट नेपालको रुपन्देही लगायत अर्धसघनबाट सघनमाछा पालनमा रुपान्तरण हुने सम्भावना बोकेका जिल्लाहरुमारोग व्यवस्थापनको लागि आधारभूत जानकारी प्रदान गर्दछ।

INTRODUCTION

Fishes are cold blooded, aquatic vertebrates, allowing their body temperatures to vary with respect to environment, having gills for respiration and communicate through the use of acoustic communication (Carvalho et al., 1995). Fishes are abundant in nearly all aquatic environments; from high mountain streams to lowest depths of the oceans (Alheit & Pitcher, 2010). Fishes consist of nutritional and economic importance which encourages people to rear fish for commercial purpose. Intensification is creating prevalence of infectious and non-infectious diseases in all stages of life cycle of fish and results in mass mortality of fish (Pillay & Kutty, 2005).

With increasing demand in animal protein, farmers are subjected to fish intensification with less technical knowledge and lack of supply of quality fingerlings and fish feed which ultimately leads to outbreak of diseasein context to Nepal (Gurung, 2003). Similarly, application of animal manure, uncontrolled fertilization and rearing of domestic animals (pig, poultry, duck etc.) around pond vicinity have made pond highly susceptible to contagious microorganism. Among infectious pathogen, *Salmonella* tends to be a threat to health of both fish and human (Novoslavskij et al., 2015). Uncontrolled management practices, release of cow dung as fertilizer, and infection in feed ingredients could be major cause for transmission of *Salmonella* in cultured fish (Jones, 2011). Thus, consumption of raw and undercooked fish causes infection of *Salmonella* to human and causes abdominal cramps and immune system problems (Gunn etal., 2014). Infection caused by *Salmonella* in human differs within serotype (Silva et al., 2013).

Aquaculture system contains high number of diverse bacteria, which exist in combination with the current and past use of antibiotics, probiotics and other treatment regimens. The administration of antimicrobials in aquaculture provides a selective pressure creating a reservoir of multiple resistant bacteria in the cultured fish and shrimps as well as in aquatic environment (Rahimi et al., 2011). Profit oriented aquaculture production with haphazard use of antibiotics as prophylactic and curative treatment is creating threat to global human health in terms of antimicrobial resistance (Agoba et al., 2017). Prolonged use of antibiotics leads to multiple antibiotic resistance (MAR) and effect on human and environmental health (Watts et al., 2017). This study is therefore performed with intension to assess sensitivity of *Salmonella* among cultured carps.This study will also provide baseline for future research for improvement in fish health; as no approaches has been made in the field of *Salmonella* infection in Rupandehi. The objectives of study are as follows:

- To find the prevalence of *Salmonella* in cultured carps in Rupandehi district.
- To determine multiple antibiotic resistance indices of *Salmonella* isolates, study sites and individual carp species.

METHODOLOGY

2.1 Study sites

The study was conducted in Rupandehi District of Nepal from June 2019 to September 2019 which is shown in Figure 1. The live fish were collected from three different sites of Rupandehi district. The field study sites were Chapiya, Siktahan and Patkhauli. The live fish were transported to the laboratory of Institute of Agriculture and Animal Science (IAAS), Department of Aquaculture and Fisheries, Fish Disease Diagnostic Lab, Paklihawa Campus, Rupandehi, Nepal.

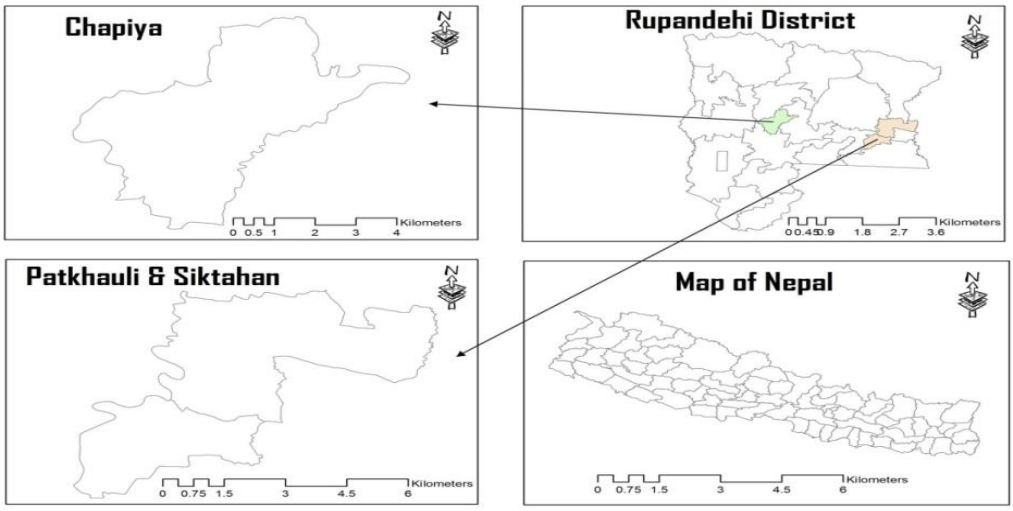


Figure1: Map of study area

Sample Size

$n = \frac{z^2 * p * q}{d^2} = 126$ = no of samples

z = 1.96 is Z statistic corresponding to 95% confidence level

p = 0.09 probability of prevalence of *Salmonella* due to infinite sample size (Kothari, 2004)

q = 0.91 probability of non-prevalence of *Salmonella*

d = 0.05 is the precision

A total of 126 fish were collected from Rupandehi district which means 42 samples were collected from each study sites.

2.2 Site selection and epidemiological survey

Impact of *Salmonella* was studied in the Rupandehi district of Nepal. Fresh raw sample of fish were collected in sterile polyethylene bag from the field sites (Chapiya, Siktahan and Patkhauli) and transported in ice box to Fish Disease Diagnostic Lab, Institute of Agriculture and Animal Science (IAAS), Paklihawa, Rupandehi. Questionnaires interview regarding epidemiological factor for growth of *Salmonella* was performed.

2.3 Study on source for *Salmonella* infection

In this study, the classical factors that could affect epidemiological condition of the pond were also considered. During the research, socio-economic and epidemiological surveys

were done among the fish farmers regarding management practices and pond fertilizationtechniques.

2.4 Sample size, sampling population and sampling procedure

Three clusters were formed consisting of 42 households in each cluster in Rupandehi fish super zone corridor for assessing the occurrence of *Salmonella* and its impact to commercial farmers and consumers. Thus, there were altogether 126 households for the study. Pond selection was done on the basis of simple random sampling. The sample fish were transported aseptically to Fish Disease Diagnostic Lab, Institute of Agriculture and Animal Science (IAAS), Paklihawa, Rupandehi.

2.5 Laboratory work

Methods of laboratory work are presented in Figure 2:

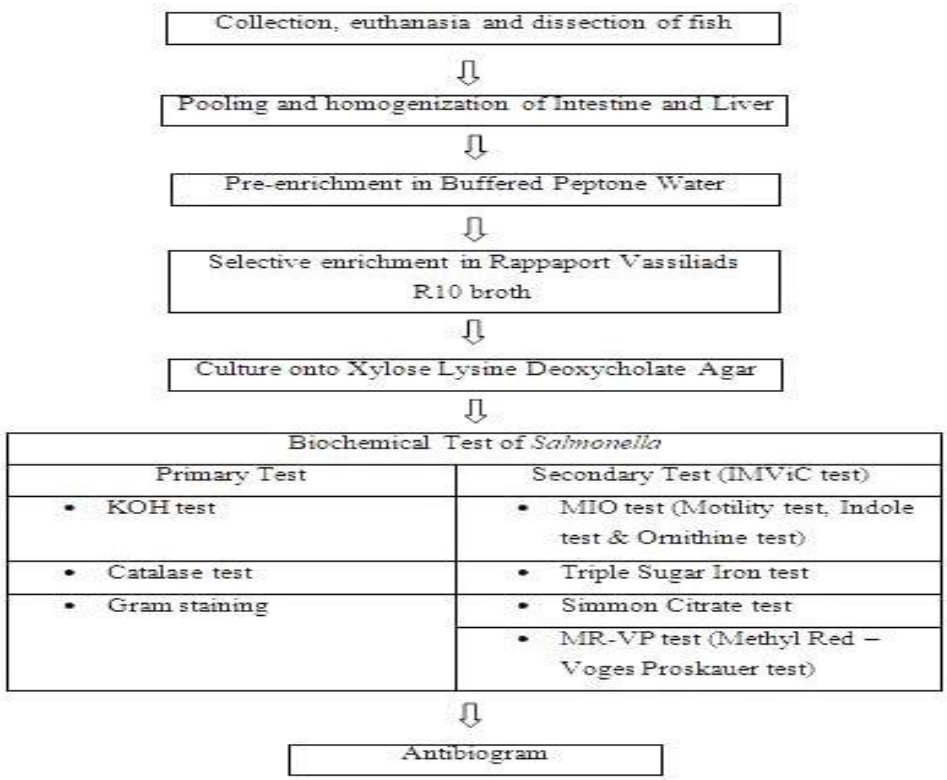


Figure 2: Flow of the Study of Lab work

Detail description about flow diagram of Figure 2 has been given below:

2.5.1 Collection, euthanasia and dissection of fish

Forty-two samples from each of study sites were collected in sterilized polythene bag where processing of the samples was done within four hours of collection. Intestine and

liver were collected aseptically with the help of a sterilized knife and then pooled using sterilized forceps.

2.5.2 Pre-enrichment in buffered peptone water

The homogenized samples were kept in Buffered peptone Water (Hi-Media, India) and were incubated at 38^{o}C for 24 hours.

2.5.3 Enrichment in rappaport vassiliads R10 broth

The incubated samples from Buffered Peptone Water (Hi-Media, India) were kept in RVR10 broth (Hi-Media, India) and incubated at 42^{o}C for 24 hours.

2.5.4 Culture on Xylose Lysine Deoxycholate Agar

A loopful of pathogen were streaked on XLD agar (Hi-Media, India) and incubated at 38^{o}C for 24 hours. After 24 hours, growth and colony characteristics of *Salmonella* was observed.

2.5.5 Primary test

Salmonella being Gram negative bacteria; primary testing was done to differentiate Gram positive and Gram negative bacteria.

2.5.5.1 KOH test

One drop of 3% KOH was placed on a microscopic slide where generous amount of bacteria was transferred and stirred with help of inoculation loop. An array of mucoid string was observed within 15 seconds as presented in Figure 4.

2.5.5.2 Catalase test

A small amount of colony growth was transferred in a clean, dry and sterile glass slide with the help of inoculating loop. A drop of 3% H_2O_2 was placed in the glass slide. Evolution of oxygen bubbles was observed as presented in Figure 4.

2.5.5.3 Gram staining

Gram staining was done done to differentiate between gram positive and gram negative bacteria. *Salmonella*, being gram negative showed pink staining during the resultand presented in Figure 4.

2.5.6 Secondary test

To differentiate *Salmonella* among gram negative bacteria, secondary test (IMViC test) was performed.

2.5.6.1 TSI (Triple Sugar Iron) test

Pure colonies were inoculated in Triple Sugar Ironmedium and incubated aerobically at 35-37^{o}C for 18-24 hours. Examining of reaction of medium was done as presented in Figure 5.

2.5.6.2 Simmon Citrate Test

Pure colonies were inoculated in Simmon Citrate medium and incubated aerobically at 35-37^{o}C for 18-24 hours. Examining of reaction of medium was done as presented in Figure 5.

2.5.6.3 MIO (Motility Indole Ornithine) test

Pure colonies were inoculated in Motility Indole Ornithine medium and incubated aerobically at 35-37^{o}C for 18-24 hours. Examining of reaction of medium was done as presented in Figure 5.

2.5.6.4 MRVP (Methyl Red Voges Proskeur) test

Pure colonies were inoculated in Methyl Red Voges Proskeur broth and incubated aerobically at 48^{o}C for 48 hours insterile test tube (Eppendorf tube).The initial test tube was marked 'methyl red' and second test tube was marked 'Voges-Proskauer'. Methyl Red Voges Proskeur test were done and color changed were observed which is presented in Figure 5.

2.5.7 Antibiogram

The confirmed pathogens after biochemical test were cultured under nutrient broth and incubated at 38^{o}C for 24 hours. *Salmonella* from nutrient broth were spread into Mueller Hinton agar and antibiotics disc were placed in infected Mueller Hinton agar and incubated at 38^{o}C for 24 hours. The antibiotics used for treatment of *Salmonella* were:

a) Ampicillin b) Cefotaxime c) Gentamicin d) Levofloxacin e) Nalidixic Acid f) Norfloxacin g) Ofloxacin h) Piperacillin

Zone of inhibition was measured by using Hi-media scale and numbers of sensitive and resistant antibiotics were recorded.

2.6 Methods and techniques of data analysis

Statistical packages for social science (SPSS) and Microsoft excel were used for data analysis. Descriptive statistics include frequency count, percentage, charts and diagrams while inferential analysis was performed through one-way ANOVA and Chi-square test.

RESULTS AND DISCUSSION

This section describes the result obtained from laboratory test and questionnaire survey. The description includes tables and figures. The results are described and discussed in regard to various parameters.

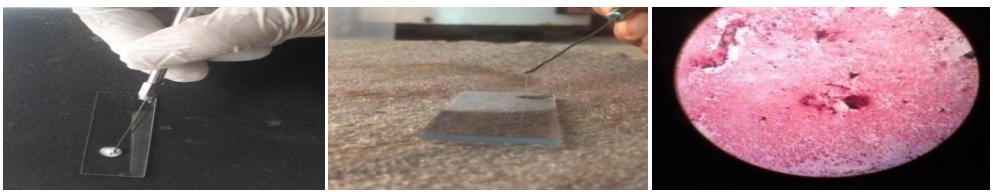
3.1 Isolation and identification of *Salmonella*

Salmonella was isolated from Chinese and Indian major carps (*Hypophthalmichthys molitrix*, *Aristichthys nobilis*, *Ctenopharyngodon idella*, *Labeo rohita*, *Cirrhinus mrigala* and *Catla catla*) after obtaining the black centered colonies on XLD agar presented in Figure 3. The colonies were confirmed to be of *Salmonella* after performing the biochemical tests which is presented in Figure 4 and Figure 5.

(Figure 3: Pure black centered colonies of *Salmonella* on XLD)

3.1.1 Result of primary testing

Salmonella was found to be catalase positive forming effervescence of gas bubble to H_2O_2 tests which ispresented in Figure 4. Similarly, *Salmonella* showed positive result on KOH test by forming viscous and mucous string within 15 second and form purple stain in gram staining test which is presented in Figure 4.

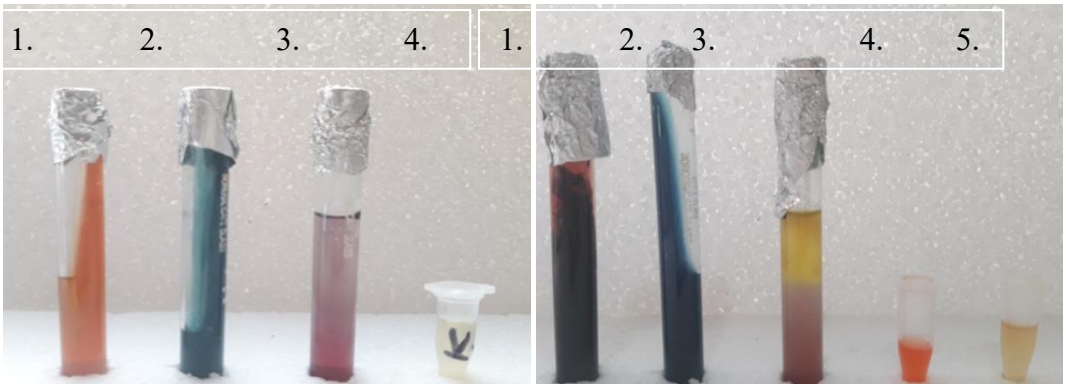


A) Catalase test B) KOH test C) Gram staining

Figure 4: Primary testing of *Salmonella* A) Catalase test after isolation of *Salmonella* B) KOH test after isolation of *Salmonella* C) Gram staining after isolation of *Salmonella*

3.1.2 Result of secondary test (IMViC test)

Salmonella showed negative result in Indole test forming yellow band of ring after addition of Kovac's reagent which is presented in Figure 5. Similarly, *Salmonella* showed positive result in Motility test forming cloudiness of stab region in MIO (*Motility Indole Ornithine)* agar which is presented in Figure 5. Straw yellow color appearance after VP (VogesProskeur) test indicated negative result of *Salmonella* and blue color appearance after Citrate utilization test showed negative result of *Salmonella* which is presented in Figure 5. The growth in Triple Sugar Iron (TSI) agar produced alkaline slant (red), acidic butt (yellow), H_2S positive and gas positive and showed positive result by forming red color appearance after addition of Methyl Red which is presented in Figure 5.



A) Before inoculation B) After inoculation and incubation

Figure 5: TSI, Simmon citrate, MIO and MRVP tests (IMViC test) for *Salmonella*. A) TSI (1), Simmon Citrate test (2), MIO (3) and MRVP (4) media before inoculation B) TSI (1), Simmon Citrate test (2), MIO (3), MR (4) and VP (4) media after inoculation and incubation

3.2 Prevalence of Salmonella in cultured carps in Rupandehi District

From the study, the overall prevalence of *Salmonella* in cultured carps (Chinese and Indian major carps) in Rupandehi, Nepal was found to be 26.2% which is presented in Figure 6. The prevalence of *Salmonella* from this research is similar to that reported in Chitwan where prevalence of *Salmonella* in fresh water fish (*Labeo rohita* and *Cirrhinus mrigala*) was 22.2% (Bastola, 2018) which might be due to similar climatic conditions, similar sampling techniques and similar selection and transportation of carps. Unscientific integration of fish farming with poultry farming and livestock farming leads to contamination of *Salmonella* in cultured fish (Moore et al., 2003). Similarly, prevalence of

Salmonella was found to be 14.25% in South India over a period of 2 years where major serovar were *Salmonella weltevreden*, *Salmonella typhi*, *Salmonella paratyphi*, *Salmonella mgulani* and *Salmonella typhimurium* (Mohamed et al., 1997).

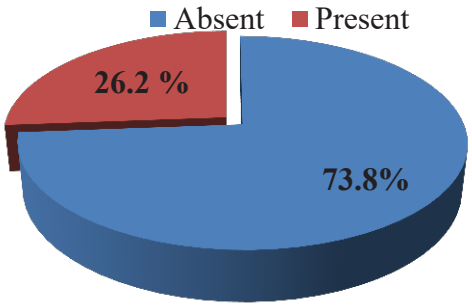


Figure 6: Prevalence of *Salmonella* in cultured carps in Rupandehi district

3.3 Prevalence of Salmonella in 3 different research sites in Rupandehi District

From the study, the prevalence of *Salmonella* was statistically non-significant to 3 different research sites of Rupandehi District (p=0.2, chi-square test). The prevalence of *Salmonella* in the cultured carps in different research sites is found as 16.6% (Chapiya), 30.9% (Patkhauli) and 30.9 % (Siktahan) which is presented in Figure 7.

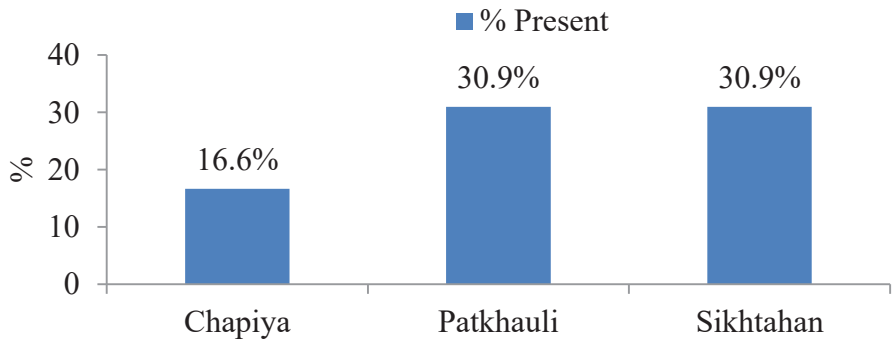


Figure 7: Prevalence of *Salmonella* in 3 different research sites in Rupandehi District

3.4 Prevalence of *Salmonella* in different species of cultured carps

From the study, the prevalence of *Salmonella* was found to be significant (p=0.001, chi-square test) between species of carps. The result showed that the prevalence of *Salmonella* is higher in Grass carp (57.1%) followed by Silver carp (33.3%), Bighead carps (33.3%), Rohu (14.3%), Naini (14.3%) and Catla (4.8%) which is presented in Figure 8. Among all the carps; grass carp showed higher prevalence of *Salmonella* which is similar to that reported in skin of grass carp (Balasubramanian et al., 2012). The prevalence of *Salmonella* in grass carp, silver carp and bighead carp was found to be 4.9 %, 1.7 % and 2.7 %

respectively (Li et al., 2017). Higher prevalence of entero-bacterial infection was observed in grass carp 82 (18.5 %) of 443 grass carp sampled (Chen and Jiang, 2014)

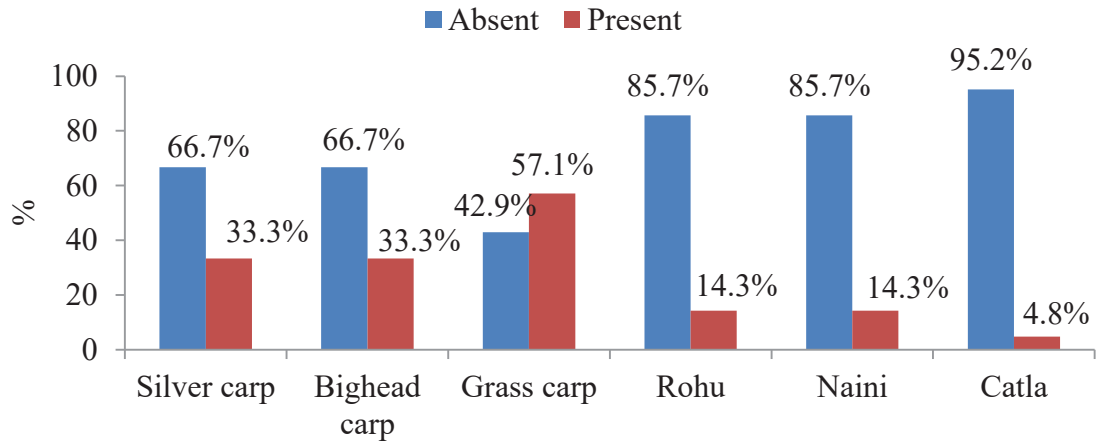


Figure 8: Prevalence of *Salmonella* in different species of cultured carps

3.5 Prevalence of *Salmonella* in cultured carps in integration of animal cum fish farm

From the study, the prevalence of *Salmonella* was found to be highly significant (p=0.00, chi-square test) between the animal cum fish farming. The result showed that the higher prevalence was observed in poultry cum fish farming (45.2%) followed by livestock cum fish farming (26.2%) and non-integrated farms (7.1%) which are presented in Figure 9.

This study reveals that the incidence of the *Salmonella* in cultured carps increased with an increase application of poultry manure which was 45.2% that agreed with Elsaidy (2015) who reported that among 19 isolates from the poultry manure, *Salmonella* represents about 9(43%), which explains the increasing incidence of *Salmonella* with an increase application of poultry manure in Nile tilapia. *Salmonella* are the common pathogenic bacteria found associated with fish from the ponds associated with integrated farming systems (Abdelhamid et al., 2006).

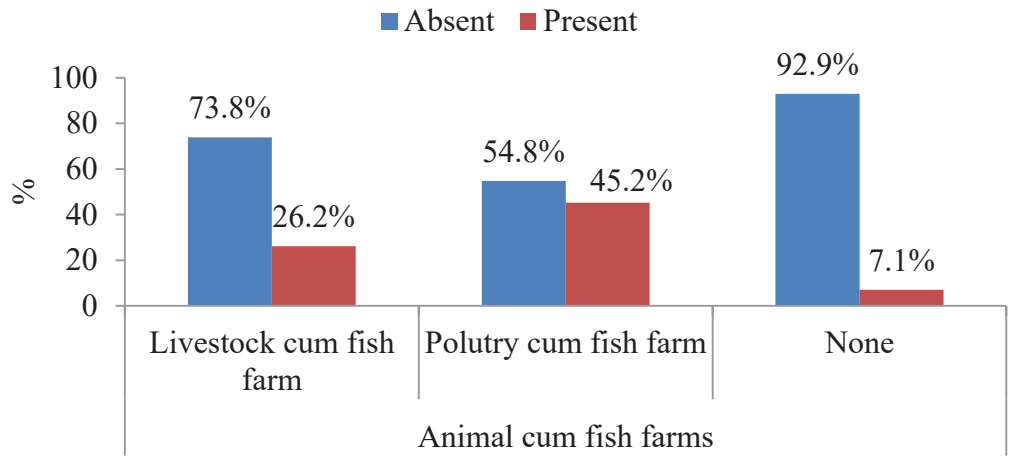


Figure 9: Prevalence of *Salmonella* in cultured carps in integration of animal cum fish farm

3.6 Prevalence of *Salmonella* in cultured carps in different fertilizers used

The study revealed that the prevalence of *Salmonella* is highly significant to different fertilizer used (p=0.00, chi-square test). The result showed that the prevalence is higher in the organic manure used (50%), followed by mixed fertilizers (23.8%) and inorganic fertilizers (4.8%) which is presented in Figure 10. This study reveals that the incidence of the *Salmonella* in cultured carps increased with an increase application of organic manure which was 50% that is near with Fagbamila et al., (2017) who reported 65.4% in chicken manure. Application of organic is usually not recommended for pond fertilization since it degrades water quality and initiate growth of pathogenic bacteria in fish pond (Watts et al., 2017).

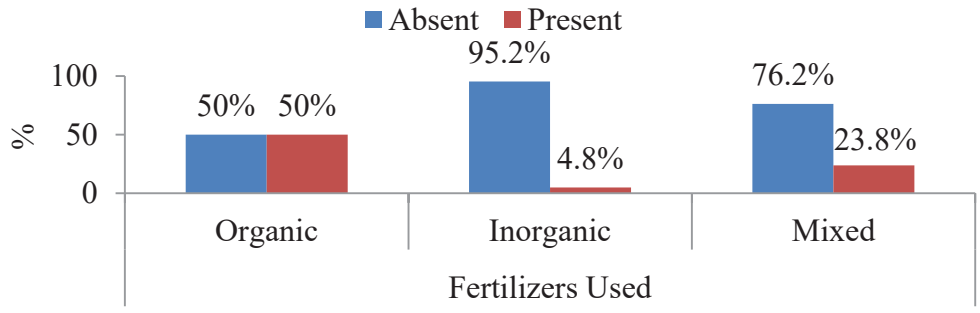


Figure10: Prevalence of *Salmonella* in cultured carps in different fertilizers used

3.7 Antibiotic Sensitivity against *Salmonella* infection

The result showed that the percentage of sensitivity was found to be 100% for Levofloxacin which was comparatively higher to Norfloxacain (96.9%) followed by

Nalidixic acid (72.7%), amoxicillin (39.4%), Gentamicin (27.2%), Ofloxacin (6%), piperacillin (3%) and Cefotaxamine (0%) which is presented in Figure 11. In this study, the bacterial isolates displayed sensitive to Levofloxacin (100%), Norfloxacin (96.9%), Nalidixic acid (72.7%), Amoxicillin (39.4%), Gentamicin (27.2%), Ofloxacin (6%) and Piperacillin (3%) and Cefotaxamine (0%). All *Salmonella* isolates were susceptible to Levofloxacin according to Karlsson et al. (2014) and Dutta et al. (2014). Isolates were more sensitive to Cefotaxime in compared to Ampicillin, Nalidixic acid, Penicillin and Tetracycline when antibiotic sensitivity test was done for *Salmonella* and *Escherichia coli* in intestine of silver carp in China (Wu *et al*., 2014). These findings are different from the present study since only 0% of the isolates were susceptible to Cefotaxime in this study. This implies that *Salmonella* in Rupandehi have developed and spread resistant genes against Cefotaxime. The scenario is quite alarming in a sense that *Salmonella* isolates are better resistant to antibiotics due to haphazard use of antibiotics in aquaculture production.

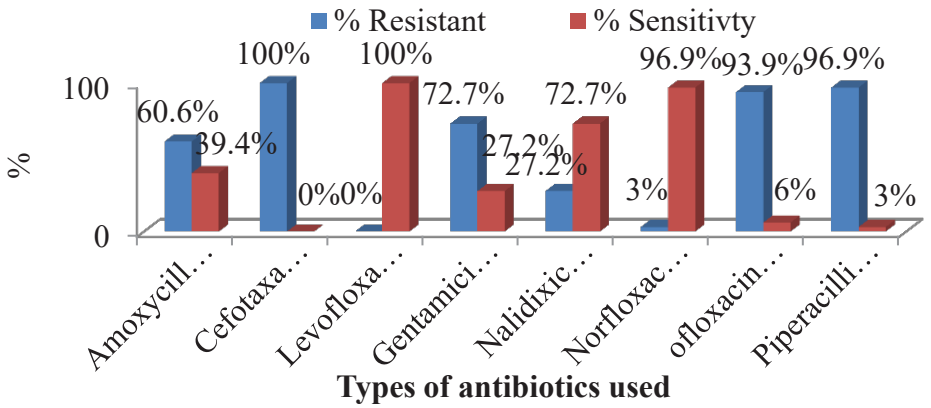


Figure 11: Antibiotic Sensitivity against *Salmonella* infection

CONCLUSION

In conclusion, prevalence of *Salmonella* was found higher in grass carp which suggested that grass carps are susceptible to *Salmonella* infection due to its sensitiveness to physical and environmental stress. Ponds infected with *Salmonella* were transferred to liver and intestine of grass carp through circulation of infected water from mouth and gills. Higher load of *Salmonella* is seen in organic manure which is being used as natural fertilizer in ponds of Rupandehi. Higher prevalence of *Salmonella* is seen in poultry integrated fish farm and livestock integrated fish farm which was being practiced in Rupandehi district. Levofloxacin was found to be best for curative treatment of *Salmonella* isolated. *Salmonella* isolate showed highest resistivity to Cefotaxime which might be due to

haphazard application of antibiotics in fish production. Antibiotic resistant *Salmonella* become untreatable, leading to dangerous infections in fish so awareness program need to be raised in Rupandehi for effective use of antibiotics in aquaculture production.

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INSURANCE SCHEME AND ITS ADOPTION DETERMINANTS AMONG LIVESTOCK FARMS IN BARDIYA, NEPAL

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ABSTRACT

Livestock insurance is the most crucial strategy to cover farm level risks. A Study was conducted to derive farm characteristics categorized by the adopters and non-adopters of livestock insurance scheme with its adoption determinants. Primary data was collected through survey in Bardiya district with randomly selected 145 households using semi-structured interview schedule in 2022. Chi-square, t-test and probit regression model was applied for the data analysis. The study resulted daily per household average milk production of 19.01 liters and average monthly income from milk was NRs. 38381.89. Almost 68.28% of farms were found rearing improved breed, 74% were practicing fodder/forage cultivation, 69% were adopting improved shed and 39% were adopting artificial insemination method of breeding and the adoption ratio is higher among the insurance adopters. The probit Model revealed with unit increase in adult livestock in the farm, rearing improved breeds, linking farmers to government subsidy and providing training, the probability of adopting insurance scheme will increase by 6.7%, 31.8%, 17.5% and 21.1% respectively. Majority of farmers were found selling their milk at dairy (50.3%). Government should highly focus and strengthen extension system and create mass level awareness regarding the insurance policy and its procedures with adequate facilitations.

Keywords**:** adoption determinants, Insurance, Livestock, Milk, Nepal, Probit

अध्ययनको सार

कृषिको जोखिम ब्यवस्थापन गर्न पशुधन बीमा सबैभन्दा महत्त्वपूर्ण रणनीति हो। पशु बीमा योजनाको ग्रहणकर्ता र गैर-ग्रहणकर्ताहरूले वर्गीकृत फर्म विशेषताहरू प्राप्त गर्न अध्ययन सञ्चालन गरिएको थियो। सन् २०२२ मा अर्ध-संरचित अन्तर्वार्ता तालिका प्रयोग गरी अनियमित रूपमा चयन गरिएका १४५ घरधुरीहरूसँग बर्दिया जिल्लामा सर्वेक्षणबाट प्राथमिक तथ्यांक सङ्कलन गरिएको थियो। काई-स्क्वायर, टी-टेस्ट र प्रोबिट मोडेलहरु अध्ययन

उद्देश्यहरू प्राप्त गर्न लागू गरिएको थियो। सर्वेक्षण गरिएका फार्महरूमध्ये दैनिक औसत दूध उत्पादन १९.०१ लिटर र दूध बिक्रीबाट मासिक आम्दानी रु. ३८३८१.८९ रहेको पाईयो। करिब ६८.२८% कृषकले उन्नत नस्ल पालन गर्दै आएका छन्, ७४% ले घाँस/डालेघाँस खेती गरिरहेका छन्, ६९% ले सुधारिएको गोठ र ३९%ले कृत्रिम गर्भाधान विधि अपनाइरहेका छन् र यो अनुपात बिमा नगर्नेहरूमाभन्दा ग्रहण गर्नेहरुमा बढी छ। प्रोबिट मोडलले फार्ममा वयस्क पशुधनको संख्यामा एकाइ वृद्धि, उन्नत जातका पशुपालन, सरकारी अनुदान कार्यक्रममा किसानलाई जोड्ने र किसानलाई तालिम प्रदान गरेमा पशु बीमा अपनाउने सम्भावना ६.७,३१.८, १७.५ र २१.१ प्रतिशतले क्रमशः बढ्ने देखाएको छ। अध्ययनमा अधिकांश किसानहरूले आफ्नो दूध डेरीमा (५०.३%) बेच्ने गरेको पाईयो। यी निष्कर्षका आधारमा सरकारले कृषि प्रसार प्रणालीलाई उच्च ध्यान दिई सुदृढीकरण गर्नुपर्छ र पर्याप्त सहजीकरणका साथ बीमा नीति र यसका प्रक्रियाहरूबारे जनस्तरमा व्यापक सचेतना जगाउनुपर्छ।

INTRODUCTION

Animal husbandry constitutes a potential and a viable agribusiness apart from food and fishery production in Nepal. Livestock sector covers approximately about 25 percent of Agricultural Gross Domestic Product (AGDP) and about 11 percent of total country Gross Domestic Product (CBS, 2021). The livestock sector in Nepal is broadly characterized by a large number of animals, but with low level of productivity (TLDP, 2002). Among various products from livestock, milk production is one of the most important which has a bulk share among livestock products (MOALD, 2021). The current cattle population is 74,66,841 and buffalo is 51,59,931 (MoALD, 2021) with total 24,79,899 mt. milk production per year in the country (DLS, 2021). Dairy is a promising sector for providing significant opportunities for livelihood management in Nepal (Banskota et al., 2020). Livestock production system is basically integrated with agriculture system and productivity of an animal depends on feeding, breeding, health, management and the marketing of the livestock products. Government has approved Dairy Development Policy, 2064;National Agriculture Policy, 2061; National Milk Marketing Strategy, 2001 and Agriculture Business Promotion Policy, 2063 to promote overall dairy sector in the country.

Government of Nepal has approved the Dairy Development Policy, 2064 for overall development of the dairy sector in accordance to the spirit of Twenty-Year Agriculture Perspective Plan; National Agriculture Policy, 2061; National Milk Marketing and Strategy, 2001; and Agriculture Business Promotion Policy, 2063.

An important risk management tool, livestock insurance scheme is becoming popular in Nepal after Crop and Livestock Insurance Directives, 2013 came in to action (Devkota et al., 2021). The livestock insurance scheme covers cattle, buffalos, yaks, sheep, goat, pig, chicken, fish farming and ducks, and the crop insurance covers bananas, coffee, tomatoes etc. and has recently added bee, ostrich and mushroom in the list. For animals, the premium payable is 5% of the sum assured. All risks are covered; in case of animals, 90% of the sum assured is paid in the event of death and for permanent total disability, 50% of the sum assured is paid. Deaths not reported within three days, missing livestock and theft are excluded (Insurance Board, 2017). The subsidy was introduced initially at 50%, and this was raised to 75% in August 2014 and currently raised to 80%. Among 32 insurance companies 15 are non-life insurance companies which are mandatorily assigned for agricultural insurance to different districts of Nepal. Crop and Livestock Insurance Directive 2013 has provision for insurance of more than 70 products such as livestock, vegetables, rice, fruits, potato etc. (Timilsina et al., 2018). Among all agricultural insurance markets livestock sector covers more than 75% (Insurance Board, 2019). As a premium, 5% of total valuation or the insured amount has to be paid by the insured farmers of which 80% will be provided by government as a subsidy and 20% should be paid by farmers. The adoption rate of agriculture insurance in Nepal is very low, only 1.1% of agriculture insurance has been done in Nepal which is lowest among Asian countries (Thapa & Adhikari, 2018). Understanding the farms characteristics and factors that influence farmers' decision to adopt livestock insurance is paramount to upscale its adoption in future. In this context, this study contributes to an increased understanding of the factors influencing adoption decisions for livestock insurance which have become quite relevant to extend its adoption through better policy actions in Nepal and help to develop a better extension strategy to increase the adoption of livestock insurance among the livestock farmers.

METHODOLOGY

Description of the study area

Bardiya district of Nepal was purposively selected for the study as it is one of the major potential districts for dairy production with 123245 cattle and 132936 buffalo with annual milk production of 56652 Mt. It lies in the western part of Lumbini Province located at 28.3102° N, 81.4279° E.

Sampling techniques and sample size

A simple random sampling technique was followed for this study covering all the local bodies in the district to make homogenous sample size within the district. Altogether, 145 farms as sample were brought under this study.

Methods of data collection

For primary data collection semi-structured interview schedule was administered using face to face interview method with randomly selected 145 farms in March 2022. Also, one focus group discussion and key informant interview with concerned stakeholders in the district was done to complement on the data collected through questionnaire.

Methods and techniques of data analysis

To fulfill the specific objectives of this study both descriptive and inferential statistical tools were applied. Results like frequency, mean, ratio, standard deviation, percentage, minimum, maximum etc were used to summarize the socio-economic characteristics of livestock farms differentiated by insurance scheme adopters and non-adopters. Most of other inferential like t-test and chi^2 tests were also performed using STATA software. The estimation of determinants affecting adoption of insurance scheme in livestock was analyzed using probit regression model using STATA software.

Empirical analysis and econometric model

In this study, a probit model was used to determine the factors determining the adoption of livestock insurance scheme by the farmers as the response dependent variable is a binary one. This model was used to identify the determinants on the probability of adoption of insurance scheme. The model is appropriate since it can resolve the problem of heteroscedasticity and satisfies the assumption of cumulative normal probability distribution (Gujarati, 2004).The probit model used is of the form Pr (Y=1) = (Xi) where Pr (Y=1) represents the probability of adopting a livestock insurance scheme with the change in X variable. A positive estimated coefficient implies an increase in the likelihood of adoption of insurance.

In the probit model, it was supposed that Yi is the binary response of the farmers, Yi = 1 if the farmer adopts livestock insurance scheme and Yi = 0 if the farmer does not adopt.

If Yi = 1; Pr (Yi = 1) = Pi If Yi = 0; Pr (Yi = 0) = 1-Pi Where, Pi = E(Y=1/X) represents the conditional mean of Y given certain values of X.

Model specification

Pr (Y=1) = f (bo + b1X1 + b2 X2 + b3 X3 + b4 X4 + b5 X5 + b6 X6 + b7 X7 + b8 X8 + b9 X9 + b10 X10)

Where, Pr (Y=1) = Probability of adopting livestock insurance scheme to X10= set of explanatory variables described in Table 1 below.

b0 =Regression coefficient and b1, b2…… b10 = Probit coefficient

Since estimates of the probit model provide only direction of effects, the marginal effects are usually calculated to interpret the actual change in probability of independent variables.

Table 1. Description of the variables (dependent and independent) used in probit model for factors affecting adoption of livestock insurance scheme

Variables	Type	Description	Value	Expected sign
Dependent variable (Yi)	Dummy	Adoption of livestock insurance	Adopter=1, Otherwise = 0	
Independent Variables (X_i)				
Age (X_1)	Continuous	Age of household held in years	Number of years	-
Education(X_2)	Continuous	Years of schooling of household head	Number of years	+
Gender(X_3)	Dummy	Gender of the household head	Male=1, Otherwise = 0	±
Number of adult cattle(X_4)	Continuous	Total number of adult cattle in the farm	Numbers	+
Breed type(X_5)	Dummy	Type of breed in the farm	Improved=1, local=0	+
Experience(X_6)	Continuous	Years of experience of	Number of years	+

Variables	Type	Description	Value	Expected sign
		household head in livestock rearing		
Received grant(X_7)	Dummy	Status of grant received by the farms	Received grant=1, Otherwise = 0	+
Training(X_8)	Dummy	Status of training received by household head related to livestock production and marketing	Received training=1, Otherwise = 0	+
Initial investment(X_9)	Continuous	The total amount of money invested initially during farm establishment	NRs. value	+
Distance to technical source(X_{10})	Continuous	Distance in Km in between farm and technical service providers	Km distance	-

RESULTS AND DISCUSSION

Socio-economic characteristics of informant farmers in the study area

Table 1 below presents the socio-economic profile of the respondents. In the study area about 62.7% of the sampled farmers found adopted livestock insurance scheme. About 51% of surveyed households were headed by female with majority of Brahmin chhettri and janajati community. About 78% farms were owned by the farmers whereas; 22% were leased in. Among the surveyed farms, 27.59% found received government subsidy and 41.38% have received training related to livestock production and the ratio is higher among the adopters.

Table 2. Socio-economic profile of livestock farmers based on adopters and non-adopters of insurance scheme in the study area

Variables	Overall (n=145)	Adopters (n=91)	Non-adopters (n=54)	Chi-square value
A. Categorical				
Gender of Farm owner				
Male	70 (48.28)	44 (48.35)	26 (48.14)	0.0006 (p=0.981 at 1 df)
Female	75 (51.72)	47 (51.64)	28 (51.85)	
Ethnicity				
Brahmin/Chhetri	70 (48.28)	53 (58.24)	17 (31.48)	11.04** (p=0.011 at 3 df)
Aadibasi/Janjati	55 (37.93)	26 (28.57)	29 (53.70)	
Dalit	9 (6.21)	6 (6.59)	3 (5.56)	
Other (Muslim etc.)	11 (7.59)	6 (6.59)	5 (9.26)	
Types of farm ownership				
Own farm	113 (77.93)	68 (74.73)	45 (83.33)	1.46* (p=0.227 at 1 df)
Leased in	32 (22.07)	23 (25.27)	9 (16.67)	
Taken subsidy (yes=1)	40 (27.59)	29 (31.87)	11 (20.37)	2.24 (p=0.134 at 1 df)
Received training (yes=1)	60(41.38)	38 (41.76)	22 (40.74)	0.014 (p=0.904 at 1 df)

B. Continuous					
Variables	Overall (n=145)	Adopters (n=91)	Non-adopters (n=54)	Mean differences	T-value
Age of farm owner	41.17 (9.30)	41.76 (9.07)	40.18 (9.68)	1.584	0.990
years of schooling of farm owner	4.13 (4.45)	4.58 (4.50)	3.37 (4.31)	1.21**	1.59

Numbers of livestock	7.38 (5.01)	6.01 (3.13)	9.77 (6.57)	-3.76***	-4.65
Number of milking animals	4.97 (2.61)	5.69 (2.76)	3.75 (1.77)	1.93***	4.60
Area under forage (kattha)	5.54 (5.85)	6.57 (6.27)	3.80 (4.61)	2.76***	2.81
Daily milk production (ltr)	19.01(14.29)	21.86(14.33)	14.19 (12.97)	7.67***	3.22
Average monthly income from milk	38381.89 (28851.92)	44151.76 (28933.07)	28658.58 (26204.78)	15493.1***	3.22
Distance to technical source from farm in km	4.74 (2.50)	4.67 (2.47)	4.85 (2.56)	-0.17	-0.40
Initial Investment in lakhs	8.55 (6.66)	9.24 (7.18)	7.38 (5.56)	1.86	1.63

Source: (Field survey, 2022)

The average age of farm owner was 41.17 years with 4.13 mean years of schooling. Most of the livestock farm owners were found illiterate. Low literacy rate, traditional farming system, lack of technical knowledge in farming system, poor management practices, poor nutrition are major cause of low animal production in Nepal (Bhatta et al., 2018).The average numbers of livestock in the farm was 7.38 and the numbers was significantly higher among the non-adopters (9.77) compared to adopters (6.01). Dhakal (2022) reported that in spite of this large population, their contribution towards food and nutritional security, income and livelihood have not been fully realized due to inefficient production system in dairy cattle in Chitwan, Nepal. Similarly, the mean area under forage was 5.54 kattha and the ratio is higher and statistically significant among the adopters. Daily average milk production and average monthly income from milk was 19.01 liter and NRs. 38381.89 among the surveyed farms. The daily milk production volume and monthly income from milk was significantly higher among the insurance adopters. Neupane et al., (2018) reported that dairy sector has its importance in reducing poverty through creating employment and income generating opportunities that is ensured through regular cash flow from urban to the rural areas. The distance between farm and technical source was found 4.74 Km. with average initial investments of around 8.55 lakhs. The detail and

differentiated figures by adopters and non-adopters about socioeconomic characteristics are presented in Table 2.

Accessibility and scope of livestock farms

Among the surveyed farms in the study area, about 49.66% of farms were found with the scope of production increment, 42.76% with scope of production increment and linkage with market. Whereas, only 7.59% of farms were found lacking of both scope on production increment and linkage with market. About 90% of farms were found having access to road, water and electricity (Table 3). The accessibility rate is higher among the adopters compared to non-adopters in the study area. This accessibility and potential scope of farms may favor adoption of insurance scheme.

Table 3. Accessibility and scope of livestock farms based on adopters and non-adopters of insurance scheme in the study area

Variables	Overall (n=145)	Adopters(n=91)	Non-adopters (n=54)	Chi^2 value
Scope of farm				
Production increment	72 (49.66)	49 (53.85)	23 (42.59)	1.76 (p=0.413 at 2 df)
Production increment and linkage with market	62 (42.76)	36 (39.56)	26 (48.15)	
Lack both production increment and linkage with market	11 (7.59)	6 (6.59)	5 (9.26)	
Farm accessibility				
Access to road only	3 (2.07)	1 (1.10)	2 (3.70)	2.13 (p=0.343 at 2 df)
Access to road and water resource only	12 (8.28)	6 (6.59)	6 (11.11)	
Access to road, water resource and electricity	130 (89.66)	84 (92.31)	46 (85.19)	

Source: (Field survey, 2022)

Technical characteristics of farms

Practice of producing forage within own farm, shed type, breed type and breeding methods were taken to analyze technical characteristics of livestock farms differentiated by adopters and non-adopter's category using chi^2 test. The study resulted that almost 68.28% of farms were rearing improved breed of livestock and the ratio is significantly higher among the insurance adopters (76.9%) compared to non-adopters (53.7%). Among the livestock farms, about 74% were practicing fodder/forage cultivation, 69% were adopting improved shed type and 39% were adopting artificial insemination method for breeding purpose. Further the study revealed that, the technical characteristics of farms found advanced and improved among the adopters than non-adopters. Percentage of farms adopting fodder/forage cultivation, improved shed, improved breed and artificial breeding method was 81.32%, 73.63%, 76.92% and 39.56% respectively among the adopters and was 62.96%, 61.11%, 53.70% and 38.89% respectively among the non-adopters of livestock insurance scheme (Table 4). No significant difference was found on shed type and breeding method between adopters and non-adopters in the study area. Implementation of breed improvement program and providing well equipped technical staffs at ward level to deliver insemination technology free of cost linking with compulsory scheme of the insurance is recommended in the study area.

Table 4. Technical characteristics of livestock farms based on adopters and non-adopters of insurance scheme in the study area

Variables	Overall (n=145)	Adopters (n=91)	Non-adopters(n=54)	Chi^2 value
Breed type				
Local	46 (31.72)	21 (23.08)	25 (46.30)	8.43**(p=0.004 at 1 df)
Improved	99 (68.28)	70 (76.92)	29 (53.70)	
Shed type				
Traditional	45 (31.03)	24 (26.37)	21 (38.89)	2.48 (p=0.115 at 1 df)
Improved	100 (68.97)	67 (73.63)	33 (61.11)	

Breeding method				
Artificial Insemination	57 (39.31)	36 (39.56)	21 (38.89)	0.006(p=0.936 at 1 df)
Natural	88 (60.69)	55 (60.44)	33 (61.11)	
Practice fodder/forage cultivation (yes=1)	108 (74.48)	74 (81.32)	34 (62.96)	6.00**(p=0.014 at 1 df)

Source: (Field survey, 2022)

Factors influencing the decision to adopt livestock insurance

The results of probit regression analysis for the estimation of determinants of adopting livestock insurance in the study area are presented in Table 5. The statistical diagnostic test showed that the estimated model had a good fit and has good explanatory power with chi-square statistics (LR chi2=46.59) significant at 1% level of significance. This means that all the explanatory variables included in the model jointly influenced probability of adoption of livestock insurance. The Pseudo R^2value is 0.24, which means the variables included in the model were able to explain about 24 percent of the probability of respondents' decision to adopt or not to adopt livestock insurance (Table 5). The regression result showed that number of adult livestock in the farm, breed type, received grant and training were significant variables that influenced livestock insurance adoption at various levels of significance. Similar to this, total adult dairy animals, extension contact of farmers, membership holding by the farmers and knowledge on premium subsidy scheme are the factor affecting the adoption of livestock insurance (Kandel & Timilsina, 2018). Breed of cattle, income from livestock, access to loan and the number of cattle reared were the factor affecting livestock insurance adoption in Nepal (Subedi et al., 2021). Other important variables like age, education, gender, experience, initial investment and distance to technical source were found insignificant in this study.

Table 5. Adoption determinants of livestock insurance scheme

Variable	**Coefficient**	**Std. error**	**P>Z**	**dy/dx[b]**	**S.E.[b]**
Age	-0.0083	0.0221	0.708	-0.0018	0.0048
Education	-0.0351	0.0522	0.501	-0.0076	0.0113

Variable	**Coefficient**	**Std. error**	**P>Z**	**dy/dx[b]**	**S.E.[b]**
Gender	0.178	0.423	0.674	0.0385	0.0916
Number of adult livestock	0.312**	0.121	0.010	0.0679	0.0254
Breed type	1.437***	0.417	0.001	0.3188	0.0904
Experience	0.0437	0.081	0.593	0.0094	0.0177
Received grant	0.860*	0.486	0.077	0.1755	0.0912
Training	0.969**	0.433	0.025	0.2110	0.0930
Initial investment	0.0233	0.037	0.535	0.0050	0.0081
Distance to technical source	0.0538	0.087	0.536	0.0116	0.0189
Constant	-2.756**	1.271	0.030	-	-
Summary Statistics					
No of observation (N)	145				
Log likelihood	-72.347				
LR Chi^2 (10)	46.59 (Prob>Chi^2=0.000)				
Pseudo R^2	0.243				
Predicted Probability	0.681				
Diagnostic tests					
Variance Inflation Factor (VIF)	1.14 (mean VIF), maximum VIF=1.40 i.e. <10 indicating no multicollinearity				
Breusch-Pagan/Cook-Weisberg test)	Chi2 (1) = 1.69, prob>chi2= 0.1934 (constant variance) (p>0.05) implying no problem of heteroscedasticity in the data.				

b Marginal change in probability (marginal effects after probit) evaluated at the sample means.

Source: (Estimation based on field survey, 2022)

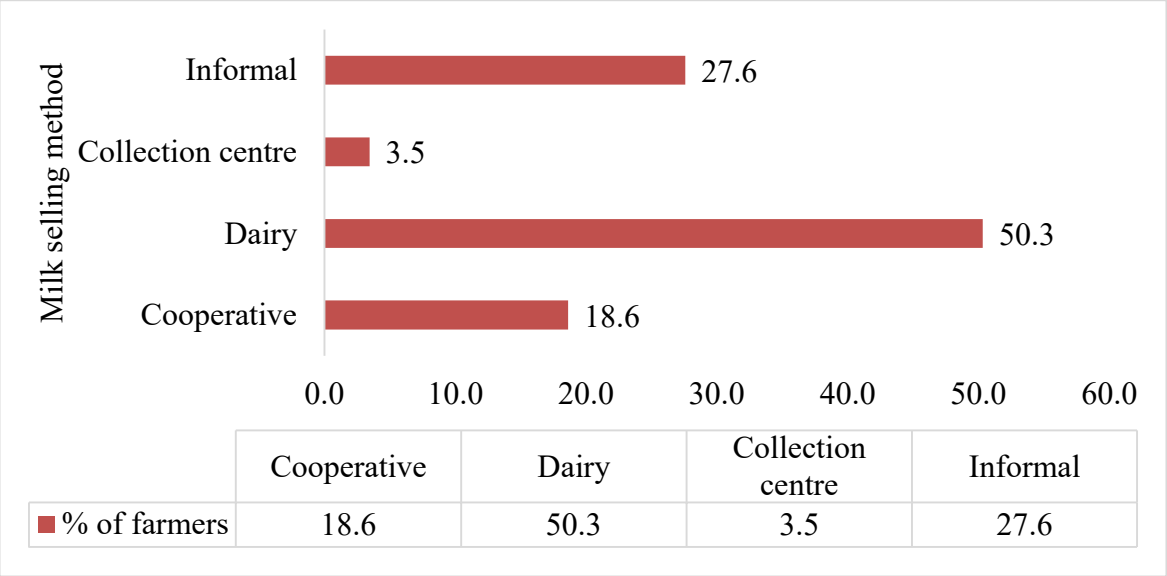
The regression result revealed that with higher number of adult livestock in the farm, the probability of adopting livestock insurance increases by 6.7%. This indicates that the adoption rate of insurance increases with the large herd size and with higher number of milking animals. The result is similar with the findings of (Kandel & Timilsina, 2018). Rearing improved breeds of the animals was another determining factor that increased the probability of adopting livestock insurance by 31.8% than those with local breeds. This result is similar to Devkota et al., (2021) reported 37% probability of adoption of insurance by livestock farmers with rearing of improved breeds in Nepal. Also, Subedi & Kattel (2022) resulted that insurance increases by around 44 percent when the cattle breed is improved in their study in Nepal.

Also, the probability of adoption of insurance scheme increases by 17.5% if the farms are linked with grant and subsidy program of government. This may be due to mandatory provision of submitting insurance documents to receive grant from the district offices. A little contradictory to this result Timsina et al., (2018) reported that Most of farmers who participated in government grant program have limited understanding of crop insurance so that they have discontinued insurance after the end of grant/subsidy program and it is necessary to revisit the existing provision of grant linked insurance and need to focus more on creating awareness on importance of agriculture insurance for its sustainability. The study further revealed that training access to farmers would increase the probability of adoption of livestock insurance by 21.1%. The training program make farmer aware about the insurance scheme. Similar to this result, Aina and Omonona (2012) reported that the probability of insurance adoption increases with the increase in awareness about the insurance. Information sources particularly from government offices and insurance companies/agents have played an important role in livestock insurance adoption by creating awareness among the farmers (Devkota et al., 2021).

Selling mode of produced milk

The selling mode of produced milk in the district is presented in figure 1. Most of the farmers in the study were used to sell their milk at dairy (50.3%) followed by informal method (27.6%), cooperative (18.6%) and at collection center (3.5%). Here, informal mode of selling milk signifies the self-selling modality of farmers wherever they get higher price and have better access. Similar to this, Shingh et al. (2020) reported that the milk is produced by the dairy farmers and the surplus milk is distributed either via formal and

informal trading methods. The farmers those were members of milk cooperative in the study area were selling their product formally to the cooperative. Higher percentage of milk sold in dairy may be due to easy access of rural dairy in the district.



	Cooperative	Dairy	Collection centre	Informal
% of farmers	18.6	50.3	3.5	27.6

Figure1. Selling mode of milk followed by farmers in the study area (Source: Field survey, 2022)

CONCLUSION

Livestock enterprises needs higher initial investments and possess higher risks than other agricultural enterprises. Farmer's opinioned weak technical assistanceship in the study area with low grant support and training opportunities. The mean area under forage was low and the ratio is higher and statistically significant among the adopters. The daily average milk production and monthly income from milk was significantly higher among the insurance adopters. Livestock farms in the study area were found potential in production increment and market linkage with access to road, water resource and electricity. Further the study revealed that, the technical characteristics of farms found advanced and improved among the adopters than non-adopters. The regression result showed that number of adult livestock in the farm, breed type, received grant and training were significant variables that influenced livestock insurance adoption at various levels of significance. The probit regression model revealed that livestock farming, rearing improved breeds, linking farmers to government subsidy programs and providing training to farmers will increase the adoption rate of insurance scheme. Most of the farmers in the study were used to sell their milk at dairy. Based upon these findings, government should highly focus and strengthen

extension system to cover large number of livestock farms, create mass level awareness regarding the insurance policy and procedures with adequate facilitations. As the adoption rate of artificial insemination was found low in the study area, this study suggests that province and local government to provide well equipped technical staffs at ward level and deliver insemination technology free of cost linking with compulsory scheme of the insurance. To cover the risks associated with farms, farmers are suggested to adopt the insurance policy for whole farms not only to the improved breed and productive animals. Progressive farmers and other representatives from farmers groups or cooperatives being formal insurance agent can act as the service provider, can extend and promote livestock insurance in rural areas.

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EFFECT OF MULCHING AND NITROGEN LEVELS ON SOIL PROPERTIES AND YIELD OF MAIZE

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ABSTRACT

A field experiment was conducted during February-May 2021 at Lamahi Dang to evaluate soil properties, nitrogen uptake, and yield of maize influenced by mulching and nitrogen. Three different mulching methods combined with four different levels of nitrogen were evaluated in a two-factor Randomized Complete Block Design with three replications. The interaction effect of both factors was found significant on cob length, stover yield, and grains yield. The highest grain yield was obtained in plastic mulching (9.64 t/ha) followed by straw mulching (9.39 t/ha). In case of nitrogen level, the highest yield was obtained in the Leaf color chart (LCC) based nitrogen application (9.11 t/ha) followed by Soil Plant Analysis Development (SPAD) based (8.92 t/ha) and recommended dose of fertilizer (8.32 t/ha). The highest nitrogen uptake (166.19 kg/ha) was recorded in plastic mulching among the mulches and LCC based (154.89 kg/ha) among the nitrogen levels. Furthermore, the lowest bulk density was observed in plastic mulching (1.20 Mg/m^3) followed by straw mulching (1.22 Mg/m^3). It is suggested that nitrogen application based on the readings of LCC combined with plastic mulching would be beneficial for increasing yield and attributing traits in hybrid maize as well as enhancing soil properties.

Keywords: hybrid maize, mulching, nitrogen, soil properties, yield

अध्ययनको सार

मकैमा उत्पादकत्त्व बढाउन नाइट्रोजन र चिस्यानको उचित व्यवस्थापन आवश्यक हुन्छ। यस अध्ययनमा वसन्ते मकैको उत्पादन र उत्पादनसंग सम्बन्धित गुणहरुको अध्ययनको लागि चार फरक स्तरको नाइट्रोजन (सिफारिस मात्रा, लिफ कलर चार्टमा आधारित, स्प्याडमा आधारित र किसान अभ्यास) र तीन फरक छापो विधिहरूको मूल्याङ्कन गरिएको थियो। लमही दाङ, नेपालमा छापो र नाइट्रोजनको मात्रा गरी दुई ओटा फ्याक्टरमा बाह्र ट्रीटमेन्ट सहित नियमित पूर्ण ब्लक डिजाइनमा तीन पटक दोहोर्याई फिल्ड ट्रायल गरिएको थियो। नतिजा अनुसार फूल फुल्ने दिन, घोगाको लम्बाइ, प्रति घोगा दानाको सङ्ख्या ,मकैको उत्पादन र हजार दानाको तौलमा छापो र विभिन्न मात्राको नाइट्रोजनको प्रभाव तथ्यांकीय रुपमा उल्लेखनिय पाईए । यद्यपि, दुवै कारकहरूको

अन्तरक्रियात्मक प्रभाव घोगाको लम्बाइ र मकैको उत्पादनमा मात्र महत्त्वपूर्ण पाइयो। सबैभन्दा बढी उत्पादन प्लाष्टिक छापो (९.६४ टन/हेक्टर) र त्यसपछि पराल छापो (९.३९ टन/हेक्टर) मा प्राप्त भयो। नाइट्रोजनको मात्रा मध्ये LCC आधारित नाइट्रोजन प्रयोग (९.११ टन/हेक्टर) मा उच्चतम उत्पादन प्राप्त भयो, त्यसपछि SPAD आधारितमा (८.९२ टन/हेक्टर) र RDF (८.३२ टन/हेक्टर) मा प्राप्त भयो। दुई कारक छापो र नाइट्रोजन बीचको अन्तरक्रिया प्रभाव मकै उत्पादनमा उल्लेखनीय रूपमा फरक पाइयो। सबैभन्दा बढी नाइट्रोजन अपटेक (१६६.१९ के.जी./हेक्टर) प्लाष्टिक छापोमा र LCC आधारित (१५४.८९ के.जी./हेक्टर) नाइट्रोजन स्तरहरूमा रेकर्ड गरिएको थियो। छापोमध्ये सबैभन्दा कम बल्क घनत्व प्लास्टिक छापो (१.२० Mg/m^3) मा र त्यसपछि पराल छापो (१.२२ Mg/m3) मा देखियो। चिस्यानको मात्रा सबैभन्दा बढी पराल छापो (२२.२९ %) र त्यसपछि प्लाष्टिक छापो (२०.३४%) मा पाईयो। छापोका कारण नाइट्रोजनको मात्रा र उपलब्ध पोटासको मात्रा उल्लेखनीय रहेको पाईयो। यस अध्ययनले प्लाष्टिक मल्चिङको साथमा LCC मा आधारित नाइट्रोजन प्रयोग गर्नाले हाइब्रिड मकै बालीको उत्पादन वृद्धिका साथै माटोका विभिन्न गुणहरुमा सकारात्मक प्रभाव पार्ने देखाएको थियो।

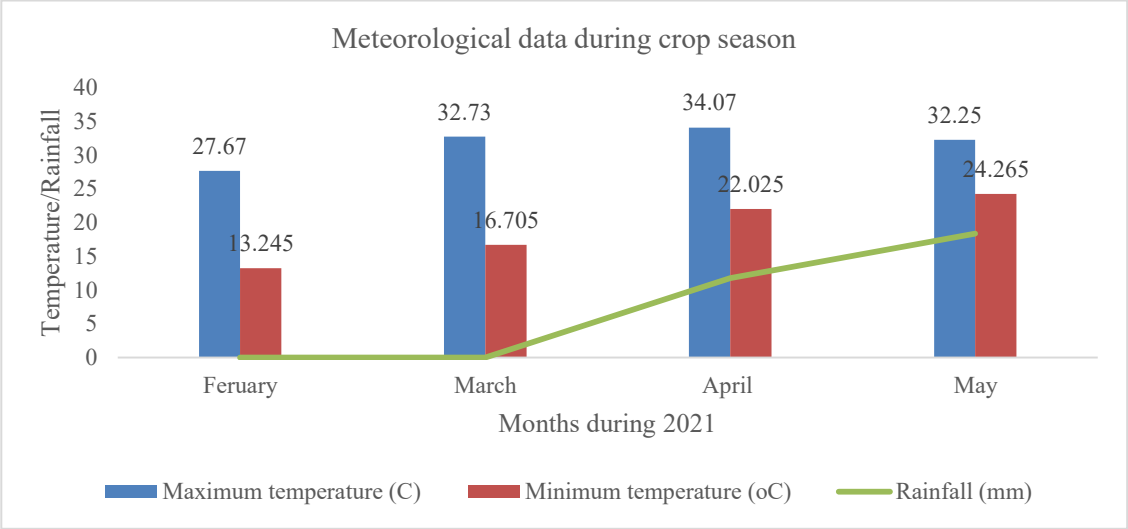
INTRODUCTION

The improvement of soil moisture and nutrient availability through soil and crop management practices are crucial in promoting growth and productivity of maize. The grain and biomass yield of maize is significantly affected by the levels of nitrogen application (Hernandez et al., 2015). Nitrogen promotes uptake of nitrogen, phosphorus and potash by increasing top and root growth, altering plant metabolism and increasing nutrient solubility and availability. The large variation in soil fertility status and improper adoption of general fertilizer recommendation by the farmers leads to excess or deficit application of fertilizers. Injudicious use and application of nutrients at wrong time is common among Nepalese farmers. When nitrogen application is not synchronized with crop demand, N losses from the soil-plant system are large leading to low N fertilizer use efficiency. Effective management of fertilizer, particularly N is a major challenge for researchers and producers. The nutrient demand and synchronization differ with local, improved and hybrid maize varieties. The blanket recommendation approach of fertilizers does not take into account the existence of large variability in soil nutrient supply and site-specific crop response to nutrients among farms (Timsina& Connor, 2001). Thus, fixed time and fixed rate fertilizer application recommendation to overall areas and all maize varieties lead farmers to apply an improper balance of nutrients for their soil or crop resulting both biological and economic yield decline. Location specific researches especially on hybrid maize varieties have been done very few on different level of nitrogenous fertilizer under local environmental and soil condition. Management of N

through Leaf Color Chart (LCC) and The Soil Plant Analysis Development (SPAD) chlorophyll meter had been reported by several studies (Duttarganvi et. al., 2014; Karthik., et al., 2021). LCC and SPAD meter are reliable tools for real-time site-specific nitrogen management (Singh et. al., 2002). The decline is further coupled with improper moisture management and related crop husbandry practices. For moisture management in maize, mulching is effective which preserves soil health and improves crop productivity through its moderating influence on soil temperature regime and enhanced moisture retention. Mulching is a common method used by farmers to cover the soil surface for the purpose of retaining moisture in the soil, reduce soil temperature to contain evaporation and to improve soil fertility or organic matter content (Li & Gong, 2002). The most common materials used as mulches are conventional organic stuff such as crop residue and crop cover and widely used plastic films (Fan et al., 2017). Recently, researchers are making efforts to replace plastic mulches with biodegradable film or spray mulches (Sartore et al., 2018). Mulch and nitrogenous fertilizer application rate not only have significant effects on improving maize grain yield and nutrient use efficiency, but also on uptake and translocation of nitrogen. It needs to explore more studies on nitrogen management combined with mulching technologies to observe sole and interaction effect on maize production as well as soil properties. Thus, in this study, it was attempted to assess the effect of mulches and nitrogen level on hybrid maize production and soil properties in field condition in Lamahi, Dang.

METHODOLOGY

The field experiment was conducted at the farmer's field in the coverage area of Prime Minister Agriculture Modernization Project, Maize Super Zone, Lamahi Dang, Nepal during spring season (from 2nd week of February, 2021 to 3rd week of May, 2021). The site was located at 27°86'N latitude and longitude 82°54'E with an elevation of 248 m above the mean sea level.



Source: Department of Hydrology and Meterology, Ghorahi, Dang

Figure 1: Meteorological condition during the research period.

The soil of the experimental site was slightly acidic in reaction (pH: 6.5) and sandy loam. The organic matter content was 1.08% and bulk density was 1.75 g/cm^3. It contained 0.04 % total N, 85 mg/kg available P_2O_5 and 165 mg/kg available K_2O. The experiment was laid out in two factor Randomized Complete Block Design (RCBD) with three replications. Three levels of mulching and four levels of nitrogen were used for factorial set up. Among two factorial treatments used in the experiment, Factor A included three mulching materials: no mulching, straw mulching and plastic mulching. Straw mulching included uncrushed rice straw which was applied at 0.3 kg/square meter, whereas plastic mulching included silver-black plastic of 45-micron thickness. Factor B included four nitrogen levels: Recommended dose of fertilizer (RDF), Soil Plant Analysis Development (SPAD) chlorophyll meter-based nitrogen, Leaf Color Chart (LCC) based nitrogen and Farmers practice (FP). Straw mulching included uncrushed rice straw which was applied at 0.3 kg/m^2, whereas plastic mulching included silver-black plastic of 45-micron thickness. In case of LCC based nitrogen application, six panel LCC was used. Basal nitrogen was applied @ 60 kg N/ha whereas top dressing nitrogen was applied based on LCC readings. The subsequent N application was carried out by matching the color of youngest fully expanded top leaf of ten randomly selected maize plants from each plot at 15 days interval, starting from 15 days after sowing of maize till initiation of silking. If the greenness of 6 or more out of ten leaves was less than LCC threshold ≤5, top-dressing of nitrogen was done @ 20 percent of recommended dose of nitrogen i.e., 36 kg N/ha. If the greenness of 5 or more out of ten leaves was more than LCC threshold, no nitrogen was applied. During

analysis, color of the leaf with LCC under shade of the body was matched visually with LCC and disease/insect free leaves of normal crop. Matching of the leaf was discontinued and no further N was applied after initiation of silking.

For SPAD based nitrogen application, SPAD 502 Plus meter was used. Basal nitrogen was applied @ 60 kg N/ha whereas top dressing nitrogen was applied based on SPAD readings. Readings were carried out in the stages of 3 to 6, 6 to 7, 10 to 11 leaves fully expanded leaves and at silking. SPAD readings were taken at two-thirds of the distance from the leaf tip towards the stem. The two upper leaves were sampled on each growth stage before maize flowering. At the silking stage, the reading was done at the index leaf (first leaf below the ear). Five plants per plot were measured on each sampling time. Nitrogen was applied if SPAD reading showed value less than 42, as top-dressing @ 20 per cent of recommended dose of nitrogen i.e., 36 kg N/ha.

In case of farmers practice, five local farmers were randomly selected and interviewed about their practice. Also, the general practice of farmers involved in the working area of Maize Super Zone under PMAMP was also analyzed. Based on these observations, fertilizer dose under farmers practice was applied at the rate of 100 N kg/ha in two equal splits: @ 50 kg N/ha at sowing and knee-high stage, whereas phosphorus @ 30 kg/ha and no potash were applied.

Table 1: Treatment combination details included in the experiment, 2021

Symbol	Treatment Combination
M_0N_1	No mulching+ RDF (180:60:40 kg NPK/ha)
M_0N_2	No mulching+ LCC based N split + basal 60:60:40 kg NPK kg/ha
M_0N_3	No mulching+ SPAD based N split + basal 60:60:40 kg NPK kg/ha
M_0N_4	No mulching+ Farmers Practice
M_1N_1	Straw mulching+ RDF (180:60:40 kg NPK/ha)
M_1N_2	Straw mulching+ LCC based N split + basal 60:60:40 kg NPK kg/ha
M_1N_3	Straw mulching+ SPAD based N split + basal 60:60:40 kg NPK kg/ha
M_1N_4	Straw mulching+ Farmers Practice
M_2N_1	Plastic mulching + RDF (180:60:40 kg NPK/ha)

Symbol	Treatment Combination
M_2N_2	Plastic mulching + LCC based N split + basal 60:60:40 kg NPK kg/ha
M_2N_3	Plastic mulching + SPAD based N split + basal 60:60:40 kg NPK kg/ha
M_2N_4	Plastic mulching + Farmers Practice

Individual plot size was 9.6 m^2 **(**4.8m×2m), net plot area was 345.6 m^2 and the total area of research field was 520.8 m^2. Maize was sown at the spacing of 60cm (row to row) x 25 cm (plant to plant) with single seed per hill. The field was prepared by plowing with a tractor mounted with a cultivator 2-3 weeks prior to sowing. Farm yard manure @ 10 ton/ha was mixed into soil two weeks before sowing. Full dose of phosphorus and potassium fertilizers (60:40 kg PK/ha) through DAP and MOP and one third dose of nitrogen (60 kg N/ha) through urea and DAP was applied as a basal dose during final plowing in all plots, except in farmers practice. Maize seeds were sown @ single seed/hill on 17th February, 2021. Two manual weeding and hoeing and one earthing up were done throughout the maize growing period. First weeding was done at knee height stage i.e., 30 DAS and second was done before flowering stage, i.e., 50 DAS. The crop was raised under irrigated condition where the irrigation was done at pre-sowing, after sowing, knee high stage, flowering stage and maturity stage. The crop was harvested manually starting from 15th May, 2021. The parameters taken in observation were plant height, flowering, thousand grain weight, cob length, number of rows per cob and grains per cob and grain yield. Soil samples were collected diagonally from three spots from each plot at a depth of 0-15 cm using a screw auger before sowing and after the crop harvest. They were air dried, ground and sieved through 2 mm sieve for analysis. Soil samples were analyzed for soil texture, organic matter, N, P_2O_5 and K_2O and pH before sowing and after the crop harvest from each plot to determine the initial and final physiochemical properties of the soil. Also, soil samples were taken for soil moisture and bulk density (by using a core sampler) determination before sowing and after harvesting the crop. Soil analysis was done in soil lab of Prithu Technical College, Lahami Dang and Soil and Fertilizer Testing Laboratory, Khajura Banke. Plant sampling and sample preparation was done for which the dried plant samples were ground, sieved through 0.5 mm sieve and analyzed in Lumbini Agro-Environment Lab, Nawalparasi-West for nitrogen content. After the chemical analysis of plant and grains

samples, the nitrogen contents were calculated. The nitrogen content on sample was calculated as: % N = reading (mg/l) x 50 / 0.150 / 10000

The formula used for the determination of nitrogen uptake was:

Nitrogen uptake (kg/ha) = Nitrogen content (%) × yield (kg/ha)/100

Microsoft excel 2010, and ADEL-R software (Pacheco et al., 2017) were used for data compilation and analysis. Two-way analysis of variance (ANOVA) of response variables was done with ADEL-R to test the significance of the treatments and mean comparison of the statistically significant variable was done by Duncan Multiple Range Test (DMRT) ($p \leq 0.05$).

RESULTS AND DISCUSSION

LCC based nitrogen application on straw and plastic mulching indicated that nitrogen was applied two times at 30 DAS and 60 DAS in 2 splits @ 36 kg N/ha, whereas it was applied three times at 15 DAS, 30 DAS and 60 DAS in 3 splits @ 36 kg N/ha in no mulched plot as guided by Leaf Color Chart. Thus, LCC based nitrogen application showed that in total, nitrogen was applied @ 132 kg N/ha in both straw and plastic mulched plot and @ 168 kg/ha in no mulched plot including basal nitrogen application. Application on straw and plastic mulching indicated that nitrogen was applied two times at 25 DAS and 55 DAS in 2 splits @ 36 kg N/ha, whereas it was applied three times at 25 DAS, 55 DAS and 67 DAS in 3 splits @ 36 kg N/ha in no mulched plot as guided by SPAD meter. Thus, SPAD based nitrogen application showed that in total nitrogen was applied @ 132 kg N/ha in both straw and plastic mulched plot and @ 168 kg/ha in no mulched plot including basal nitrogen application.

Plant height

Plant height of maize as influenced by different nitrogen levels and mulching methods are presented in table 2. The plant height at 30 DAS and 60 DAS were significantly influenced by mulching methods whereas there was no any significant difference on plant height at 90 DAS. At 30 DAS, plant height was significantly higher in straw mulching (26.76 cm) which was statistically similar with plastic mulching (24.88 cm). At 60 DAS, plant height was significantly higher in plastic mulching (106.16 cm) which was statistically similar with straw mulching (93.92 cm). However, highest and lowest plant height at 90 DAS were observed in plastic mulching (263.46 cm) and no mulching (223.11 cm) respectively. Due

to the effect of nitrogen levels, there was no significant difference on plant height at 30 DAS, 60 DAS and 90 DAS. However, highest plant height at 30 DAS, 60 DAS and 90 DAS were observed in SPAD based nitrogen application (25.50 cm), RDF (97.36 cm) and SPAD based nitrogen application (253.56 cm) respectively. The interaction effect of mulching and nitrogen for plant height at 30 DAS, 60 DAS and 90 DAS was found non-significant. The adequate supply of nitrogen at appropriate growth stages of maize could increase plant growth, the number of nodes and internodes, resulting in increased plant height (Adhikari et al., 2016). Xu et.al. (2015) also reported greater soil moisture conservation leading to higher plant height of grains corn grown with clear plastic mulch compared with bare ground.

Table 2: Effect of different nitrogen levels and mulching methods on plant height of maize (*Zea mays L.*) cv, Rampur Hybrid- 10, 2021

Treatments	Plant height(cm)		
	30 DAS	60 DAS	90 DAS
Mulching (M)			
No mulching	19.53[b]	81.32[b]	223.11[a]
Straw mulching	26.76[a]	93.92[ab]	222.23[a]
Plastic mulching	24.88[a]	106.16[a]	263.46[a]
SEm (±)	4.83	20.19	57.87
LSD	4.09**	17.10*	ns
Nitrogen level (N)			
RDF	22.35[a]	97.36[a]	232.06[a]
LCC based N application	22.60[a]	94.56[a]	218.30[a]
SPAD based N application	25.50[a]	93.11[a]	253.56[a]
Farmers Practice	24.44[a]	90.17[a]	241.13[a]
SEm (±)	4.83	20.19	57.87
LSD	ns	Ns	Ns

Treatments	Plant height(cm)		
	30 DAS	60 DAS	90 DAS
CV (%)	20.36	21.53	24.49
Interaction (M X N)	ns	ns	Ns

Similar letters on column indicates statistically non-significant at <0.05 probability level by DMRT.SEm- standard error of mean, CV- coefficient of variation.

Flowering

Days to flowering (tasseling and silking) of maize as influenced by different nitrogen levels and mulching methods are presented in table 3. Male flowering (tasseling) and female flowering (silking) both were significant among the both factors: mulching and nitrogen. Among the mulching methods, earliest days to tasseling (67 days) and silking (69 days), were found in plastic mulching. In case of nitrogen levels, the RDF resulted earliest days to tasseling (68 days) and silking (70 days). The interval between tasseling and silking was 2 days in all the treatments. The interaction effect of mulching and nitrogen levels on days to tasseling, days to silking and tasseling silking interval was found non-significant. Delayed flowering days with no mulching in our study indicated the low performance in plant growth coupled with moisture and soil temperature factors. Kuchanur et al. (2013) also reported that in maize, no mulching due to moisture stress increased significantly the days required to 50% anthesis, 50% silking and anthesissilking interval. Similarly, due to the varying level of nitrogen, RDF, LCC and SPAD based application resulted earliness in flowering compared to farmers' practice. Recommended dose of nitrogen as well as real time nitrogen application guided by LCC and SPAD value likely provided the maize crop with significantly more favorable growing condition. Other studies have also reported that clear and black plastic biodegradable mulches and polythene mulches decreased days to germination, tasseling, silking, and harvest of sweet corn compared with bare ground (Waterer, 2010; Ghimireet.al., 2020).

Table 3: Effect of different nitrogen levels and mulching methods on flowering of maize (*Zea mays L.*) cv, Rampur Hybrid- 10, 2021

Treatments	Days to tasseling (DTT)	Days to silking (DTS)	Tasseling Silking Interval
Mulching			
No mulching	73[a]	76[a]	2 [a]
Straw mulching	69[b]	71[b]	2 [a]
Plastic mulching	67[c]	69[c]	2 [a]
SEm (±)	0.80	0.89	0.34
LSD	0.68**	0.75**	Ns
Nitrogen			
RDF	68[c]	70[c]	2 [a]
LCC based N application	69[b]	71[b]	2 [a]
SPAD based N application	69[b]	71[b]	2[a]
Farmers Practice	73[a]	75[a]	2 [a]
SEm (±)	0.80	0.89	0.34
LSD	0.78**	0.87**	Ns
CV (%)	1.14	1.23	18.24
Interaction (M X N)	ns	ns	Ns

Similar letters on column indicates statistically non-significant at <0.05 probability level by DMRT.SEm- standard error of mean, CV- coefficient of variation.

Cob characters

Length of cob and number of grains per cob were found significant due to mulching as well as nitrogen level, while number of rows per cob was found non-significant in both the factors (table 4). Due to the effect of mulching, number of grains per cob was found significantly higher in plastic mulching (552.83) which was statistically similar with straw mulching (539). The cob length was significantly higher in plastic mulching (21.08 cm) which was statistically similar with straw mulching (20.58 cm). The number of grains per

cob as influenced by nitrogen levels was significantly higher in RDF (551.56) which was statistically similar with LCC based nitrogen application (535.11). Similarly, the cob length as influenced by nitrogen levels was significantly higher in LCC based nitrogen application (21.11 cm) which was statistically similar with RDF (20.67 cm) and SPAD based nitrogen application (20.44 cm). The interaction effect of mulching and nitrogen was significant on cob length. Kumar (2015) reported that dust mulch was recorded significantly maximum cob length and number of grains per cob. Majority of agronomic and yield attributing traits were positively influenced by the application of slow-release and real time-based nitrogen application, the slow and real time release of these fertilizers and the improved application method might have enhanced supply and uptake of N, and attributed to increase in photosynthesis, inter- node elongation and overall vegetative performance of the crop (Adhikari et al., 2016). However, number of rows per cob was found non-significant in our study. These traits might be genetically controlled, thus N dose could not effect on them (Dhakal et al., 2021).

Table 4: Effect of different nitrogen levels and mulching methods on cob characters of maize (*Zea mays L.*) cv, Rampur Hybrid- 10, 2021

Treatments	Number of rows per cob	Number of grains per cob	Cob length (cm)
Mulching (M)			
No mulching	14.00 [a]	431.00[b]	19.50[b]
Straw mulching	14.17 [a]	539.00[a]	20.58[a]
Plastic mulching	14.25 [a]	552.83[a]	21.08[a]
SEm (±)	0.38	38.48	57.87
LSD	ns	32.59**	48.99**
Nitrogen level (N)			
RDF	14.11[ab]	551.56[a]	20.67 [a]
LCC based N application	14.22[ab]	535.11[ab]	21.11 [a]
SPAD based N application	14.33[a]	511.44[b]	20.44 [a]
Farmers Practice	13.89[b]	432.33[c]	19.33 [b]

Treatments	Number of rows per cob	Number of grains per cob	Cob length (cm)
SEm (±)	0.38	38.48	57.87
LSD	ns	37.63**	56.58*
CV (%)	2.73	7.58	5.29
Interaction (M X N)	ns	ns	0.02 *

Similar letters on column indicates statistically non-significant at <0.05 probability level by DMRT. SEm- standard error of mean, CV- coefficient of variation.

Thousand grains weight, grain yield and stover yield

The thousand grain weight, grain yield and stover yield as influenced by different mulching methods and nitrogen levels are presented in table 5. Due to both mulching and nitrogen levels, there was significant difference on thousand grain weight, grain yield and stover yield. The effect of mulching showed that thousand grain weight was significantly higher in plastic mulching (336.83 g). Grain yield was significantly higher in plastic mulching (9.64 t/ha) which was statistically similar with straw mulching (9.39 t/ha). In case of stover yield, it was significantly higher in plastic mulching (21.08 t/ha) which was statistically similar with straw mulching (20.58 t/ha). In case of effect of nitrogen levels, thousand grain weight was significantly higher in SPAD based nitrogen application (335.44 g) which was statistically similar with RDF (334 g) and LCC based nitrogen application (324.22 g). Similarly, grain yield was significantly higher in LCC based nitrogen application (9.11 t/ha) which was statistically similar with SPAD based nitrogen application (98.92 t/ha) and RDF (8.32 t/ha). The stover yield due to nitrogen levels was significantly higher in LCC based nitrogen application (21.11 t/ha) which was statistically similar with RDF (20.67 t/ha) and SPAD based nitrogen application (20.44 t/ha). The interaction effect of mulching and nitrogen was found significant on grain yield and stover yield. Results are corroborated with research findings of Priya and Shashidhara (2016), Tang et al. (2016). The possible reason for higher yield in these mulching practices may be disturbing the capillary tube that reduce the evaporation and conserve the soil moisture as well as improved physical condition of the soil which favorably increased the uptake of nutrients by the crop and also reduced the state of crop-weed competition by lowering the weed population leading to increase in values of yield contributing characters. Liu et al.

(2002) also concluded that transplanting spring maize with plastic film mulching improved the ecological environment of the soil, increased soil temperature and soil water contents, promoted the growth and maturation of maize and increased crop yield. Higher N application could increase dry matter deposition in grains compared to lower doses, thus TKW was higher in N180 (Dhakal et al., 2021). Corroborating our results, Ding et al. (2005) and Cheetham et al. (2006) reported higher dry matter deposition in grains at higher doses of N application. These results further support the findings of previous studies which depicts that with increase in nitrogen doses, stover yield and thousands kernel weight of hybrid maize increased in Nepalese condition (Dawadi & Sah, 2012; Dhakal et al., 2020; Sapkota et al., 2017). This could be due to the fact that the LCC based N was able to synchronize the plant N demand due to the split application of N in small doses.

Table 5: Effect of different nitrogen levels and mulching methods on thousand grain weight, grain yield and stover yield of maize (*Zea mays L.*) cv, Rampur Hybrid- 10, 2021

Treatments	Thousand Grain Weight (g)	Grain Yield (t/ha)	Stover Yield (t/ha)
Mulching			
No mulching	318.92 [b]	6.18[b]	19.50[b]
Straw mulching	324.58 [b]	9.39[a]	20.58[a]
Plastic mulching	336.83 [a]	9.64[a]	21.08[a]
SEm (±)	14.34	1.08	1.08
LSD	12.14*	0.76**	0.33**
Nitrogen level			
RDF	334.00 [a]	8.32 [a]	20.67[a]
LCC based N application	324.22[ab]	9.11 [a]	21.11[a]
SPAD based N application	335.44 [a]	8.92 [a]	20.44[a]
Farmers Practice	313.44 [b]	7.22 [b]	19.33[b]

Treatments	Thousand Grain Weight (g)	Grain Yield (t/ha)	Stover Yield (t/ha)
SEm (±)	14.34	1.08	1.08
LSD	14.01*	0.87**	0.38*
CV (%)	4.39	10.62	5.29
Interaction (M X N)	ns	0.03*	0.014**

Similar letters on column indicates statistically non-significant at <0.05 probability level by DMRT. SEM- standard error of mean, CV- coefficient of variation.

Bulk density and soil moisture content

The effect of different mulching methods and nitrogen levels on bulk density and soil moisture content are presented in table 6. Due to mulching, bulk density and soil moisture content were found significantly different. The lowest bulk density was found in plastic mulching (1.20 mg/m^3) which was statistically similar with straw mulching (1.22 mg/m^3). Mulching effect showed significantly higher soil moisture content in straw mulching (22.29 %) which was statistically similar with plastic mulching (20.34 %). The effect of nitrogen levels on both bulk density and soil moisture content was found statistically non-significant. However, the lowest bulk density was found in Farmers practice (1.25 mg/m^3) and highest soil moisture content was found in Farmers practice (20.13 %) followed by RDF (19.46 %). Similar results were also reported by Jain et al. (2017)and Shah et al. (2013). Shashidhar et al. (2009) reported that soil moisture was affected by mulching showing significant result with moisture retention of 14.463% in case of mulching and 12.970% in case of no mulched.

Table 6: Effect of different nitrogen levels and mulching methods on bulk density and moisture content of soil after harvest of maize (*Zea mays L.*) cv, Rampur Hybrid- 10, 2021

Treatments	Bulk Density (mg/m^3)	Soil moisture content (%)
Mulching		
No mulching	1.35[a]	14.19[b]
Straw mulching	1.22 [b]	22.29 [a]

Plastic mulching	1.20 [b]	20.34 [a]
LSD	0.04**	2.29**
Nitrogen level		
RDF	1.25[a]	19.46[a]
LCC based N application	1.26 [a]	18.11 [a]
SPAD based N application	1.27 [a]	18.06 [a]
Farmers Practice	1.25 [a]	20.13 [a]
LSD	Ns	Ns
SEm (±)	0.06	2.70
CV (%)	4.08	14.29
Interaction (M X N)	Ns	Ns

*Similar letters on column indicates statistically non-significant at <0.05 probability level by DMRT.*SEm- standard error of mean, CV- coefficient of variation.

Soil pH, organic matter and NPK content

The effect of different mulching methods and nitrogen levels on soil pH, organic matter and NPK content are presented in table 7. Due to the effect of mulching, nitrogen content and potassium content were found statistically significant. Nitrogen content was significantly higher in straw mulching (0.053 %) which was statistically similar with plastic mulching (0.051 %). The effect of mulching on potassium content showed significantly higher in straw mulching (298 mg/kg). In case of the effect of nitrogen levels, only nitrogen content was found statistically significant. The significantly higher nitrogen content was found in LCC based N application (0.063 %). The interaction effect of mulching and nitrogen was found non-significant on pH, organic matter content and NPK content. Similar result also reported by of Zhang et al. (2013). Stagnari et al. (2014) observed that mulching significantly influenced the soil moisture content and concentration of nitrate-N, P, K, Ca and Mg in the soil.

Table 7: Effect of different nitrogen levels and mulching methods on pH, organic matter and NPK content of soil after harvest of maize (*Zea mays L.*) cv, Rampur Hybrid- 10, 2021

Treatments	pH	OM (%)	N (%)	P_2O_5(mg/kg)	K_2O (mg/kg)
Mulching					
No mulching	6.4	1.13	0.041[b]	187.23 [a]	231.05[ab]
Straw mulching	6.4	1.11	0.053 [a]	192.38 [a]	298.00[a]
Plastic mulching	6.3	1.09	0.051 [a]	196.24 [a]	260.03[b]
LSD	Ns	ns	0.005**	Ns	35.08*
Nitrogen level					
RDF	6.3	1.17	0.056[b]	184.35 [a]	258.36 [a]
LCC based N application	6.4	1.14	0.063 [a]	199.83 [a]	277.02 [a]
SPAD based N application	6.4	1.13	0.051 [b]	203.25 [a]	262.36 [a]
Farmers Practice	6.3	1.00	0.033 [c]	180.35 [a]	254.37 [a]
LSD	Ns	ns	0.006**	ns	Ns
SEm (±)	0.19	0.18	0.007	63.01	53.24
CV (%)	2.98	17	13.80	32.82	20.24
Interaction (M X N)	Ns	ns	ns	ns	Ns

*Similar letters on column indicates statistically non-significant at <0.05 probability level by DMRT.*SEm- standard error of mean, CV- coefficient of variation.

Nitrogen uptake

The effect of different mulching methods and nitrogen levels on nitrogen uptake was found significant (table 8). Due to the effect of mulching, the significantly higher nitrogen uptake was found in plastic mulching (166.19 kg/ha) which was statistically similar with straw mulching (150.25 kg/ha). In case of the effect of nitrogen levels, the significantly higher nitrogen uptake was found in LCC based N application (154.89 kg/ha) which was statistically similar with RDF (150.94 kg/ha). The interaction effect of mulching and nitrogen on nitrogen uptake was found significant. Optimum supply of moisture in general is well-known to enhance growth and dry matter production of crop directly as well as indirectly by increasing the availability and utilization of nutrient and increase the nutrients

uptake in maize was reported by Rajput et al. (2014) and Pervaiz et al. (2009). Application of rice straw mulch also significant conserved the soil moisture, provided better availability of nutrients and nutrients uptake as compared to the control. The uptake of nitrogen by grains and stover of maize improved under adequate supply of nutrients. It might be due to increased growth, nutrient influx and photosynthetic rate that resulted in more absorption and translocation of these nutrients to the grains and stover.

Table 8: Effect of different nitrogen levels and mulching methods on nitrogen uptake in maize (*Zea mays L.*) cv, Rampur Hybrid- 10, 2021

Treatments	**Nitrogen Uptake (kg/ha)**
Mulching	
No mulching	102.66[b]
Straw mulching	150.25 [a]
Plastic mulching	166.19 [a]
LSD	18.82**
Nitrogen level	
RDF	150.94 [a]
LCC based N application	154.89 [a]
SPAD based N application	149.38[ab]
Farmers Practice	103.59 [b]
LSD	21.73*
SEm (±)	22.23
CV (%)	15.91
Interaction (M X N)	0.014*

*Similar letters on column indicates statistically non-significant at <0.05 probability level by DMRT.*SEm- standard error of mean, CV- coefficient of variation.

CONCLUSION

Nitrogen application based on the readings of LCC combined with plastic mulching was found beneficial for increasing yield and attributing traits in hybrid maize crop as well as enhancing soil properties. Based on the results of experiment, nitrogen splits @ 36 kg/ha before silking matched with LCC values in plastic mulching appropriate for growing maize in similar growing condition. The highest nitrogen uptake and lowest bulk density were found in plastic mulching with LCC based nitrogen application. Straw mulching resulted the highest moisture level, nitrogen content and available potash. Thus, proper nitrogen and moisture management in maize with high soil water conservation potential is imperative that leads to increased productivity especially in spring season maize, through the site specific nitrogen management and mulching. The study represents limited geographical area and one variety of maize so the results might not be generalized in extended scale. The results are quite exciting for the farmers to use real time-based nitrogen application tool combined with mulching. The study suggests for further evaluation of more maize varieties for mulching and decision support tools at different agro-ecologies, soil types and climatic condition for the validity of its effectiveness and general recommendation to the farmers.

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EVALUATION OF GLRP DEVELOPED PROMISING GENOTYPES OF PHASEOLUS BEAN FOR FARMER'S PREFERENCE IN DANG, BANKE AND BARDIYA

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ABSTRACT

A trial was designed to evaluate and provide an opportunity to choose the most suitable variety of Rajma on their own choice under farmers' field conditions. The Varietal selection trials on Rajma were carried out in outreach sites Banke, Dang and Bardiya during the winter cropping seasons of 2017, 2018 and 2019. The trials were laid in 12 m^2 at each outreach site. This research was replicated thrice considering each location as a replication for statistical data analysis. Participatory trials indicated that Rajma genotype PDR 14 produced the highest yield 2111, 1796 and 2339 kg/ha during the year of 2017, 2018 and 2019, respectively. Likewise, PDR 14 produced the highest yield 2025, 1826 and 2396 kg/ha in Dang, Banke and Bardiya district, respectively. In combined analysis, the highest mean yield 2082 kg/ha was recorded in PDR-14 followed by Utkarsh 1522 kg/ha. It has a consistency in yield in all outreach sites along with Grain Legume Research Program (GLRP) multi-locations and resistance to bean common mosaic virus and moderate resistance to anthracnose and white mold. PDR 14 has been registered in the national seed system for farmer's cultivation in 2020.

Keywords: rajma, genotypes, outreach, participatory

अध्ययनको सार

कोसेबाली अनुसन्धान कार्यक्रमबाट विकास गरिएका राजमाका उदयीमान जातहरूलाई प्रमाणीकरण गर्न र किसानको प्रतिक्रिया लिनका लागि किसानकै खेतमा लगाएर उनीहरूको प्रत्यक्ष सहभागीतामा उनकै खेतबारीका लागि उपयुक्त जातको छनौट गर्ने उद्देश्यले यो परिक्षण संचालन गरिएको थियो। परिक्षण बि.स.२०७४,२०७५ र २०७६ सालमा हिउँदे सिजनको कार्तिक महिनामा दाङ, बाँके र बर्दिया जिल्लामा रहेका बाह्य अनुसन्धान

क्षेत्रमा संचालन गरिएको थियो। उक्त परिक्षण तीनवटै जिल्लामा १२ बर्ग मीटर क्षेत्रफलमा लगाईएको थियो। यस अध्ययनमा, अध्ययन सामग्रीलाई ३ वोटा रेप्लिकेसनमा परिक्षण गरिएको थियो जसमा एक जिल्लालाई एउटा रेप्लिकेटको रुपमा लिइएको थियो। तीनै वर्ष र तीनवटै स्थानको तथ्याङ्कलाई संयुक्तरुपमा विश्लेषण गर्दा अनुजात पिडिआर १४ ले सबैभन्दा धेरै (२०८२ कि.ग्रा. प्रति हेक्टर) उत्पादन दिएको पाइयो। यस अनुजातको तीन वटै जिल्लामा उत्पादनमा स्थिरता रहेको र कमन मोजाइक भाइरस प्रतिरोधी, एन्थ्राक्नोज र सेतो मोल्ड प्रति मध्यम प्रतिरोधी रहेको पाइयो। पिडिआर १४ अनुजातलाई खेतीका लागि राष्ट्रिय बीउ बिजन समितिमा सन् २०२० सालमा दर्ता गरिएको छ।

INTRODUCTION

Phaseolus bean (*Phaseolus vulgaris* L.) is a legume crops commonly known as Rajma, Common bean, French bean, Kidney bean and bush bean. In Nepal, it is growing during summer in mid/high hills and during winter months (post rainy) in terai. Major Rajma Growing districts are Chitwan, Nawalparasi, Makwanpur, Rupendehi, Jumla, Ramecchap, Banke, Bardiya etc.

Nepal Agriculture Research Council (NARC) has been conducting outreach research activities in more than 50 outreach sites and 3 NARC technology villages 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 mini-kits of maize, wheat, grain legumes and potato (Paudel, 2010), paved the long way with tremendous experiences and changes. The definition and boundary of outreach research had broadened with the present development of a participatory and pluralistic model of technology development and emergence of INGO's, CBO's and private sectors in agriculture research and development (Gauchan, Joshi, & Biggs, 2003). Nepal Agricultural Research Service Centre (NARSC) had defined outreach research program as a combination of adoptive research and service activities conducted by researchers that assist extension personnel to disseminate technology (NARSC, 1987). The present concept of outreach research is being 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, 2005).

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 step 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 decisions 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 the dissemination of proven technologies. This research paper highlights the participatory varietal selection research conducted at command areas of GLRP Khajura during the fiscal year 2017 to 2019. (Darai, Ghimire, Pokhrel, Poudel, & Aryal, 2017;2018;2019). The objective of this study was verify promising genotypes of Rajma under farmer's field condition and providing them opportunity to select most suitable variety to their own choice.

METHODOLOGY

GLRP, Banke has its three major outreach sites Duduwa municipality, Banke 180 masl, Bansgadhi municipality, Bardiya 180 masl and Rapti municipality, Dang 185 masl. Both Banke and Bardiya land has a rainfed while Dang has an irrigated condition.

Trials were planted in 3 farmers per location during the winter cropping seasons of 2017, 2018 and 2019. Each location was used as a replication for statistical data analysis.

Promising 5 genotypes from Coordinated Varietal Trial (CVT) were namely Amber, Utkarsh, Arun-2, NL-1 and PDR -14 used for research. The plot size per genotype was 12 m^2. The recommended dose of fertilizer 100:60:40 Kg N, P_2O_5, K_2O in which half dose of nitrogen and a full dose of phosphorus was applied as a basal dose and the remaining half dose of nitrogen was applied 25-30 days after sowing. The trial was sown on last week of October in Bardiya and on first week of November in Dang.

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

RESULTS AND DISCUSSION

Participatory trial data from Bardiya indicated that Rajma variety Arun-2 produced the highest yield 2567 kg/ha in the year 2017. However, in 2018 and 2019 PDR-14 produced

2261 and 2672 kg/ha, respectively. Similarly, in the Banke location during the year 2017 genotype Utkarsh produced the highest yield (2589 kg/ha) while during 2018 and 2019, genotype PDR-14 produced the highest yield i.e. 1453 and 2082 kg/ha, respectively. In the Dang genotype, PDR-14 produced the highest yield (2137, 1675 and 2263 kg/ha) over the years (Table 1). However, in all the years 2017, 2018, and 2019 genotype PDR-14 produced the highest yield 2111, 1796 and 2339 kg/ha, respectively. Similarly, the same genotype PDR-14 produced the highest yield in 2025, 1826 and 2396 kg/ha in Dang Banke, and Bardiya districts, respectively. In combined (genotype, year and location) analysis mean yield performances indicated that the genotype PDR-14 (2082 kg/ha) produced the highest yield in the tested years (2017 to 2019).

Table 1: Performance of Rajma genotypes at Banke, Bardiya and Dang in 2017, 2018 and 2019

Genotypes	Yield (kg/ha)									
	Bardiya			Banke			Dang			Mean
	2017	2018	2019	2017	2018	2019	2017	2018	2019	
Amber	2117	1757	1400	2076	641	1342	1131	806	804	1342
Utkarsh	2252	1979	1557	**2589**	531	1522	1274	731	1259	1522
Arun-2	**2567**	1965	1277	2009	719	1411	1131	901	721	1411
NL-1	1779	1803	1435	2176	570	1333	1161	832	907	1333
PDR-14	2254	**2261**	**2672**	1942	**1453**	**2082**	**2137**	**1675**	**2263**	2082
Mean	2194	1953	1668	2158	783	1538	1367	989	1191	1538

Table 2: Combined performance of Rajma genotypes at Banke, Bardiya and Dang in2017, 2018 and 2019

S.N	Genotypes	Yield (kg/ha) in Year			Yield (kg/ha) in District			
		2017	2018	2019	Dang	Banke	Bardiya	Mean
1	Amber	1775	1068	1182	914	1353	1758	1342^{bc}
2	Utkarsh	2038	1080	1446	1088	1547	1929	1522^{b}

3	Arun-2	1902	1195	1136	918	1380	1936	1411[b]
4	NL-1	1705	1068	1225	967	1360	1672	1333[bc]
5	PDR-14	**2111**	**1796**	**2339**	**2025**	**1826**	**2396**	**2082[a]**
	Mean	1380	1567	1934	1182	1493	1938	1538
	CV							31
	LSD							462
	LOC							0.000
	TRT							0.01
	LOC:TRT:YR							0.08

CONCLUSION

Based on three-year and location results of the trial in Rajma genotype PDR 14 produced a higher mean yield compared to other genotypes. The genotype PDR 14 performed consistently over the year in farmers' fields. The National Seed Board of Nepal registered it in the year 2020 for adoption in the farmer's field. Seed companies and cooperatives can multiply seeds of this variety and marketing. In addition, the Agriculture Knowledge Center (AKC) and Municipalities can disseminate this newly released variety among farmers.

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VALUE CHAIN ANALYSIS OF GINGER (Gingiber officinale) IN ILAM DISTRICT OF NEPAL

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ABSTRACT

Ginger (*Gingiber officinale*) is a cash crop of Nepal with high export potential. This study was conducted with the major objective to analyze the value chain of ginger in Ilam district of Nepal. A three-stage sampling procedure was adopted to select 160 ginger producers. Additionally, by employing the snow ball sampling technique, 5 input suppliers, 15 traders and 5 consumers were selected for the study. The input suppliers, producers, local processors, collectors, wholesalers, exporters, retailers and consumers were found as the major value chain actors of ginger. The producers share in consumer price was found 55%. The profit margin of processors was found highest among the value chain actors which clearly indicates that the processing upgrades the value of product. Hence, linkage between producers and processors should be improved with proper development and strengthening of ginger processing infrastructures.

Keywords: Ginger, Ilam, profit margin, value chain actors, value chain map

अध्ययनको सार

नेपालको निर्यातयोग्य बालीहरु मध्ये अदुवा एक महत्त्वपूर्ण नगदे बाली हो। नेपालको इलाम जिल्लामा अदुवाको मूल्य शृंखलाको विश्लेषण गर्ने प्रमुख उद्देश्यका साथ यो अध्ययन गरिएको हो। अध्ययनमा एक सय साठी अदुवा उत्पादक तीन चरणको नमूना प्रक्रियाद्वारा छनोट गरिएको थियो। साथै, स्नोबल नमूना विधि प्रयोग गरी अध्ययनका लागि पाँच (५) सामाग्री आपूर्तिकर्ता, पन्ध्र (१५) व्यापारी र पाँच (५) उपभोक्ता छनोट गरिएको थियो। अध्ययनमा सामाग्री आपूर्तिकर्ता, अदुवा उत्पादक, स्थानीय प्रशोधनकर्ता, अदुवा सङ्कलनकर्ता, थोक बिक्रेता, निकासीकर्ता, खुद्रा बिक्रेता र उपभोक्ताहरू अदुवाको प्रमुख मूल्य शृंखला पात्रहरुका रूपमा पाइयो। उपभोक्ता मूल्यमा उत्पादकको हिस्सा पच्पन्न (५५%) प्रतिशत रहेको पाइयो। अदुवा प्रशोधनकर्ताहरूको मुनाफा मार्जिन मूल्य श्रृंखला पात्रहरू मध्ये सबैभन्दा उच्च फेला परेकाले स्पष्ट रूपमा प्रशोधनले उत्पादनको मूल्य अभिवृद्धि गर्छ भनेर संकेत गर्दछ। तसर्थ, अदुवाको मूल्य अभिवृद्धिको लागि अदुवा उत्पादक र प्रशोधनकर्ता बीचमा समन्वय स्थापित गर्दै अदुवा प्रशोधन गर्ने संरचनाको बिकास तथा सशक्तीकरण गर्नु पर्ने आवश्यक देखिएको छ।

INTRODUCTION

According to MOAD (2021) agriculture is a crucial component of Nepal's economy which accounts 23.95 percent of the gross domestic product (GDP). Ginger is one of the principal cash crops grown in Nepal (Sedain & Aryal, 2002). ANSAB (2011) stated that Ginger is cultivated throughout the mid-hills, foothills, and in some plain areas of Nepal in which major ginger producing districts are Ilam, Salyan, Nawalparasi, Palpa, Morong, Kailali, Surkhet, Tanahu, and Kaski. ADS (2015) stated that ginger sub-sector is among five identified sub-sectors for value chain analysis in Nepal. According to MOAD (2016) the area, production and productivity of ginger was 21869 ha, 271863 MT and 12.43 MT/ha respectively. The area, production and productivity of ginger was 6534 ha, 94648 MT and 14.48 MT/ha respectively in eastern development regions (MOAD, 2016). According to MOAD (2016) the area, production and productivity of ginger was 3233 ha, 45994 MT and 14.23 MT/ha respectively in Ilam district. According to TEPEC (2017) total amount of fresh ginger neither crushed nor ground of 17303.56 MT with the value of NRs.41.26 million, other ginger crushed nor ground (*sutho*) of 4942.989 MT with the value NRs. 23.29 million and other ginger crushed or ground of 807.148 MT with the value NRs. 125.67 million was exported to different foreign countries. Total amount of fresh ginger neither crushed nor ground of 17.778 MT with the value of NRs. 1.446 millions, other ginger crushed nor ground (Sutho) of 4191.880 MT with the value NRs. 83.92 million and other ginger crushed or ground of 788.49 MT with the value NRs. 1.730 million was imported from different foreign countries (TEPEC, 2017). The value chain is the full range of activities required to bring a product or service from conception through the different phases of production, delivery to final customers and disposal after use (Kaplinsky & Morris, 2000). According to Dunne (2001) supply chain is taken to mean the physical flow of goods that are required for raw materials to be transformed into finished products. According to Poudel (2007), India is the major trading partner for spices of Nepal. The major objectives of this study was to analyze the value chain of ginger based on the data gathered from two wards of Ilam Municipality of Nepal.

MATERIALS AND METHODS

Ilam district of Nepal was selected purposively to study the value chain of ginger because it possess high production potentiality of ginger cultivation. The study was conducted in two wards of Ilam municipality (Ilam municipality-10, Godak and Ilam municipality-12,

Sangrumba) from January, 2018 to February, 2018. One hundred and sixty ginger producers were selected for study by using snow ball sampling technique whereas 5 input suppliers, 15 traders and 5 consumers were selected for study by using snow ball sampling technique.

Table 1. Distribution of ginger producers

District	Name of Selected Municipality	Ward No.	Name of Village	Number of Sample Households
Ilam	Ilam Municipality	10	Godak	80
		12	Sangrumba	80

Value chain actors like input suppliers, producers, traders, service providers, key informants of related sectors were primary sources of information. The producers were selected randomly from two wards of Ilam municipality whereas local processors, collectors, wholesalers, exporters, retailers and consumers were selected from Ilam municipality as well as Ilam District for study. Field Survey was conducted through structured and semi structured questionnaire, direct observation, focus group discussion and key informant interview. Secondary information was collected from the various published materials like journals, articles, research, 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 Statistical packages for social science (SPSS) version 16.0, STATA version 12.1 and Microsoft office excel 2013.

The profit margin is calculated by using following formula.

PM = (SP-BP)

Where, PM= Profit margin of intermediaries, SP= Selling Price and BP = Buying Price

The producers share is calculated by the following formulas.

$$P_s = (P_f/P_r) * 100$$

Where, P_s = Producers share, P_r = Retailers price, P_f = Producers price (farm gate price

The Benefit cost analysis was carried out by using formula:

B/C Ratio = Gross return/ total variable cost

RESULTS AND DISCUSSION

In this study value chain mapping was done in order to understand the characteristics of the value chain actors and the relationships among them. It was carried out in both qualitative and quantitative terms through graphs presenting the various actors of the chain, their linkages and all operations of the chain from production, processing, marketing to end consumers. In this study input suppliers, producers, local traders, collectors, wholesalers, exporters, retailers and consumers were found as the major actors involved in value chain of ginger which is supported by ANSAB (2011) based on their study of value chain of ginger in Nepal also found that input suppliers, producers, collectors, wholesalers, retailers and consumers were the major value chain actors. The enablers involved in value chain of ginger were Federation of Nepal Chamber of Commerce and Industries (FNCCI), Government Organizations (GO) and Non-Governmental Organizations (NGO). The major actors involved in the value chain of ginger are as follows:

a. Input suppliers

Input suppliers were the agro vets of the local markets. They were found supplying agricultural tools, fertilizers and pesticides to the ginger producers. However, the self-saved rhizome and homemade organic manures were found managed by producers themselves at the site of production.

b. Producers

Hundred percent of the producers involved in the study were found selling fresh ginger to collectors. Harvesting and marketing of ginger were found doing by producers themselves. Producers were found not aware about the processing of ginger. Ginger was sold directly either by packing into jute bags or transport in Pick up van or four wheelers or using bamboo basket to collectors. High infestations of diseases and pests eespecially rhizome rot, post-harvest losses, fluctuation in market prices and unavailability of proper storage facilities were found as the major problems faced by producers in the study site.

c. Collectors

The collectors were found collecting rhizomes directly from the producers in local areas.

After the collection of ginger, collectors stored ginger in their own godown (store room) where cooling facilities were usually not available. Majority (90%) of the collectors were found selling ginger to wholesalers and very few of them were found selling ginger to retailers (5%) and local processors (5%).

d. Wholesalers

Majority (90%) of wholesalers were found selling ginger to exporters and very few of them (10%) were found selling ginger to washing and drying centers in Dhulabari, Jhapa. The wholesalers were found grading rhizomes in three grades viz. mother rhizomes, baby rhizomes and seed rhizomes. The volume of sale of these grades of rhizomes was found highly demand driven. They were found selling mother rhizomes from June to September, baby rhizomes from November to January and seed rhizomes from December to January based on their demand in market.

e. Retailers

Retailers were found buying fresh ginger from collectors and selling them to consumer at local level. They were found selling ginger directly from their shop without packaging and grading. They were found not conscious about quality management of rhizomes. None of the retailers were found having storage and cooling facilities to maintain quality of ginger.

f. Local Processors

Very few collectors (5%) were found selling ginger to local processors. The local processors were found processing ginger into dry ginger (*sutho*), candy, pickles, squash, and powder using local techniques.

g. Exporters

Due to resource and time constraint exporters were not taken for this study. The wholesalers and washing drying centers in Dhulabari, Jhapa were found selling ginger to exporters.

h. Consumers

In this study, three types of consumers of ginger i.e. local consumers, domestic consumers and international consumers were found. Due to resource and time constraint domestic and international consumers were not taken in this study. The local consumers were found

consuming fresh ginger from retailers and locally processed products of ginger from local processors.

i. Enablers

Enablers were those who were not directly involved in the chain activities but they were supporting from outside of the chain. In this study, governmental organizations, non-governmental organizations and projects were found as the major enablers of ginger value chain. The District Agriculture Development Office (DADO), Ginger and cardamom development section/vegetable development directorate (VDD), National spices crop development program (NSCDP), Plant protection directorate (PPD), Nepal agricultural research council (NARC), Trade and export promotion center (TEPC), Project for agricultural commercialization and trade (PACT) and Commercial agriculture development project (CADP) are involved in supporting the ginger value chain from government sectors. The UNNATI Project, Asia network for sustainable agriculture and bio-resources (ANSAB), Agro enterprise center/federation of Nepalese chamber of commerce and industries (AEC/FNCCI), Nepal ginger producers and traders association (NGPTA), Micro-enterprise development programs (MEDEP) and Mercy Corps are involved in supporting ginger value chain from non-governmental sectors.

In this study, following different types of marketing channels of ginger were identified.

Channel I: Producers→ Collectors→ Retailers → Local consumers

Channel II: Producers→ Collectors→Wholesalers→ International consumers

Channel III: Producers→ Collectors→ Processors → Local consumers

First marketing channel (C-I)

In this study, the average cost of production of ginger including its marketing cost was found NPR.18.84 per kg of ginger while the average selling price of ginger was found NPR. 22 per kg. Hence, the profit margin of producers was found NPR. 3.16 per kg. The average purchasing price of ginger from producers by collector was found NPR. 22 per kg. The average marketing cost incurred in marketing ginger by collector was found NPR. 26.6 per kg of ginger while the average selling price of ginger was found NPR. 32 per kg.

Hence, the profit margin of collectors was found NPR. 5.4 per kg. The average purchasing price of ginger for retailers was found to be NPR. 33.0 and average selling price of ginger by retailers to the consumers was NPR. 40. Therefore, profit margin of retailers was found to be NPR. 6.95. The benefit cost ratio of producers, collectors and retailers were found 1.16, 1.20 and 1.21, respectively (Table 2).

Second marketing channel (C-II)

In this study the average marketing cost incurred in marketing ginger by wholesalers in the market was found NPR. 38.98 per kg while the average selling price of ginger was found NPR. 45 per kg. Hence, the profit margin of wholesalers was found NPR. 6.02 per kg. The second marketing channel in study area was observed starting with producers linking through collectors, wholesalers and international consumers. In this study, international consumer refers to consumers of cities of India near to Nepal India border like Naxalbari, Siligudi, and Lucknow etc. The benefit cost ratio of wholesaler was found NPR. 1.15 per kg (Table 2).

Third marketing channel (C-III)

In case of third marketing channel (C-III) the product transformation from producers to collectors was similar as that of first marketing channel (C-I). In first marketing channel (C-I), the collector sold fresh ginger to retailers and finally to consumers. But in case of third marketing channel (C-III), the collector sold ginger to local processor. The processor had processed the collected fresh ginger from collector into various products like *sutho*[1] (Dry ginger), squash, candy, pickles, powder and other forms. In process of product transformation appreciable value was added to each product. According to key informants the average marketing cost of *sutho* or dried ginger was found to be NPR. 280 per kg while the average selling price of *sutho* was found to be NPR. 590 per kg. Hence, the profit margin of processor for dried ginger or *sutho* was found to be NPR.310 per kg. Besides, the processor also sold ginger in the form of candy, squash, pickles, and powder. From the focal group discussion and key informants interview the average marketing cost of candy, squash, pickles and powder was found NPR. 1000 per kg, NPR. 150 per litre, NPR. 86 per kg and NPR. 276 per kg, respectively while the average current selling price of candy,

[1] Dried ginger or Sutho is second mostly traded product after fresh ginger which is obtained by drying of fresh ginger which can be preserved for longer time. Dried ginger is prepared from mature rhizomes which have developed full aroma, flavour and pungency and harvesting is usually carried out at between eight to nine months after planting (HVAP, 2011).

squash, pickles and powder of ginger was found NPR. 1500 per kg, NPR. 315 per litre, NPR. 160 per kg, NPR. 520 per kg, respectively. Hence, the profit margin of processor in selling candy, squash, pickles and powder was found NPR. 500 per kg, NPR. 165 per litre, NPR. 74 per kg and NPR. 244 per kg, respectively. It was observed that the profit margin and value addition of products was considerably increased with processing. The benefit cost ratio of processor for *sutho,* candy, juice, pickles and powder was found 2.14, 1.5, 2.13, 1.84 and 1.88, respectively (Table 2).

Table 2. Marketing cost/cost of production, average selling price and profit margin

Marketing Actors	Marketing cost/ Production Cost (NPR. /kg, NPR. /litre)	Average selling price (NPR. /kg, NPR. /litre)	Profit margin (NPR. /kg, NPR. /litre)	B:C ratio
Producers	18.84	22	3.16	1.16
Collectors	26.6	32	5.4	1.20
Wholesalers	38.98	45	6.02	1.15
Retailers	33.05	40	6.95	1.21
Processors				
Sutho	280	590	310	2.14
Candy	1000	1500	500	1.5
Squash/Juice	150	315	165	2.13
Pickles	86	160	74	1.84
Powders	276	520	244	1.88

Note: In case of producers the production cost of ginger including the marketing cost was found NPR 18.84 per kg.

Producer's share

In this study the average ginger producers price was found NPR. 22 per kg while the average retailers' price was found NPR. 40 per kg. Hence, the producers share in consumer price was found 55%.

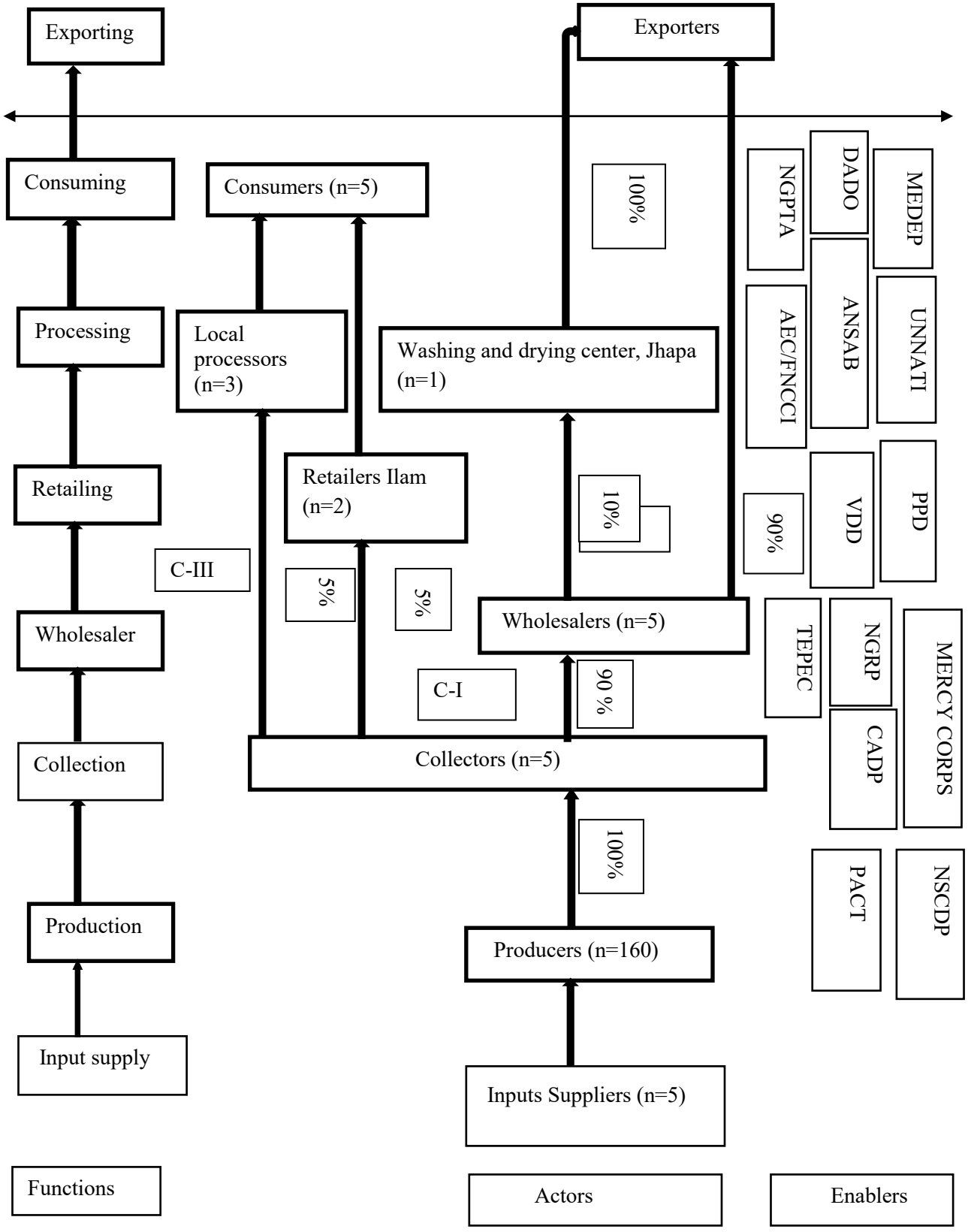

Figure 1. Value chain map of the ginger in Ilam district

CONCLUSION

This study was conducted with the major objectives to analyze the value chain of ginger in Ilam district of Nepal. The major actors involved in value chain of ginger were found input suppliers, producers, local traders, collectors, wholesalers, exporters, retailers and consumers. The profit margin of producers was found lowest among the value chain actors of ginger. The producers share in consumer price was found 55%. Among the actors involved in the value chain of ginger the profit margin of processors was found highest which clearly indicates that the processing upgrades the value of product. Hence, a strong linkage between producers and processors should be developed which eventually reduces the gap between them. In addition to that, the new processing infrastructures of ginger should be developed and strengthening of existing processing infrastructures should be to done to capture more profit for producers and promotion of ginger production and marketing.

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INFORMATION SOURCES, NEED AND SATISFACTION AMONG SMALLHOLDER VEGETABLE FARMERS IN CHITWAN DISTRICT, NEPAL

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ABSTRACT

Vegetable farming plays a vital role in sustaining the livelihood of smallholder farmers in developing countries. Adequate and context specific information through effective sources with focus on satisfaction of smallholder farmers is utmost important. An investigation was carried out during 2022 in Chitwan district to identify the information sources, need and satisfaction among smallholder farmers. Farm household survey of 100 smallholder farmers was carried out using semi-structured questionnaire while Focus Group Discussion (FGD) and Key Informant Interview (KII) was done with selected informants. Results revealed that common sources of information were agrovet shops (0.9 index value). Most needed information was about input market (0.88 index value). Moderate satisfaction (3-6 score) was reported by majority of the respondents. Hence, at the present context, capacity development of agrovet should be focused through trainings along with strengthening the government prioritized sources among farming communities. Adequate and efficient information on input and credit facilities should be delivered and further mechanisms should be developed to identify and provide need based information to smallholder farmers. Context specific information that boost the production and productivity, provide cost effective production techniques and improved farming practices should be delivered timely to ensure maximum satisfaction among smallholder farmers.

Keywords**:** information, need, satisfaction, smallholder, sources

अध्ययनको सार

नेपालजस्ता विकासोन्मुख देशहरूमा साना किसानहरूको जीविकोपार्जनमा तरकारी खेतीले महत्त्वपूर्ण भूमिका खेल्छ। प्रभावकारी स्रोतहरू मार्फत पर्याप्त र सन्दर्भ केन्द्रित जानकारी र साना किसानहरूमा सन्तुष्टि अत्यन्त महत्त्वपूर्ण छ। चितवन जिल्लामा साना किसानको जानकारीको स्रोत, आवश्यकता र सन्तुष्टि पत्ता लगाउन अनुसन्धान गरिएको थियो। अर्ध–संरचित प्रश्नावली प्रयोग गरी १०० साना किसानहरूको सर्वेक्षण गरिएको थियो।

एफजिडि र केआइआइ चयन गरिएका सूचनाकर्ताहरूद्वारा गरिएको थियो। परिणाममा जानकारीको साझा स्रोत कृषि पसलहरू (०.९ सूचकांक मान) आएको थिए । सबैभन्दा आवश्यक जानकारी आगत बजारको (०.८८ सूचकांक मान) बारेमा थियो। अधिकांश उत्तरदाताहरूद्वारा मध्यम सन्तुष्टि (३-६ प्राप्तांक) व्यक्त गरिएको थियो । तसर्थ वर्तमान परिप्रेक्ष्यमा सरकारी प्राथमिकता प्राप्त स्रोतलाई सुदृढ गर्दै तालिमको माध्यमबाट एग्रोभेटहरूको क्षमता विकासमा केन्द्रित हुनुपर्छ। आगत तथा ऋण सुविधाका बारेमा पर्याप्त र प्रभावकारी जानकारी उपलब्ध गराउनुपर्छ। साना किसानहरूका निरन्तर परिवर्तनशील आवश्यकतामा आधारित जानकारी पहिचान गर्न र उपलब्ध गराउन थप संयन्त्रहरू विकास गरिनुपर्छ। साना किसानहरूमा अधिकतम सन्तुष्टि सुनिश्चित गर्न समयमा लागत प्रभावकारी उत्पादन प्रविधिहरू र सुधारिएको खेती अभ्यासहरू प्रदान गर्न सक्ने सन्दर्भ केन्द्रित जानकारी पर्याउनुपर्छ ।

INTRODUCTION

The agriculture sector plays a vital role in the Nepalese economy, accounting for 25.8% of the country's Gross Domestic Product (GDP) (MOF, 2021). Among its components, the vegetable subsector holds significant importance, contributing significantly to the Agriculture Gross Domestic Product (AGDP) (Shrestha et al., 2022). This subsector creates ample opportunities for self-employment along the food value chain, involving input suppliers, farmers, traders, transporters, processors, and other supporting agencies, thus directly or indirectly impacts income generation, poverty reduction, food and nutritional security, and livelihoods in developing countries like Nepal (Shrestha et al., 2022). In 2019, more than 3.2 million farmers were engaged in vegetable farming, cultivating 3.96 million tons of vegetables across 0.69 million acres of land (MoALD, 2020). Despite its substantial contribution to the AGDP, the growth rate of this sector has declined from 5.98% (2007-2009) to 3.07% (2010-2019), along with low productivity (MoALD, 2020). The MoALD (2020) has reported an average yield of 5.74 tons per acre in 2019, highlighting the need to enhance productivity to achieve the potential of 7 tons per acre.

Smallholder farmers, who typically cultivate small plots of land, majority of them measuring less than 0.5 hectares (14.8 kattha), are dominant in Nepalese agriculture (CBS, 2011). These farmers rely on limited food production techniques, often lack access to advanced technology, are resource poor and mainly depend on family labor. In vegetable farming, smallholder farmers adopt integrated cropping systems i.e. growing different vegetable crops on a single farm (Shrestha et al., 2016). However, they face several common challenges, including insufficient credit, limited market access, inadequate infrastructure, and a lack of extension services (Bhatta & Mishra, 2021b). These

constraints contribute to the low productivity and inefficiency of the agricultural sector (Pokhrel, 2010; Timsina & Shivakoti, 2018). In particular, the absence of effective extension services is recognized as a significant hindrance to agricultural growth as it indirectly promotes all other constraints. Agricultural extension now plays a broader role beyond technology transfer, encompassing the improvement of farmers' management and technical skills through training, facilitation, and coaching. To achieve productivity growth, it is crucial to develop and disseminate improved agricultural information and technologies specifically tailored to the needs of these smallholder farmers (Mishra & Bhatta, 2021a). While Nepal's vegetable farming is predominantly carried out by smallholders, there is a gradual shift from subsistence to commercial farming. Enhancing productivity and profitability is essential for the long-term economic sustainability of the subsector. This necessitates a deep understanding of the information requirements of farmers.

Vegetables play a significant role in the income generation of smallholder farmers, as they offer higher returns compared to other crops (Ferdous et al., 2016). One advantage of vegetable production is its suitability for smaller land areas, which helps mitigate issues associated with fragmented land (Ferdous et al., 2016; Niroula & Thapa, 2007). Insufficient access to information often hampers production and trade in the subsector (Yaseen et al., 2017). Farmers who have better information access are able to adjust their crop choices towards high-value produce (Shepherd, 1997). Inadequate access to market information creates opportunities for intermediaries to manipulate price information, disadvantaging farmers while increasing their own profit margins (Demaine et al., 1996; Khushk, 2001; Mohtar, 1997). Minimizing information gaps and uncertainties in the agricultural sector of developing countries is crucial. This ensures that all participants in the food supply chain have equal and sufficient information regarding prices, output, and technology. This, in turn, promotes fairer trade of agricultural commodities and more evenly distributed benefits among the actors in the supply chains. Smallholder farmers acquire improved agricultural information and knowledge from various sources such as extension agents of government institutions, private companies and I/NGOs, cooperatives, Information and Communication Technology (ICT) and input dealers (Elly & Silayo, 2013; Mishra & Bhatta, 2021a). Traditionally, they obtain agricultural information and knowledge through social interactions, direct observations, and engagements with neighbors, family and friends (Mishra & Bhatta, 2021a).

The availability of agricultural information is vital for the development and sustainability of the agricultural sector (Mishra & Bhata, 2021a; Koutsouris, 2010). It serves as a key input for farmers and plays a crucial role in ensuring their success (Nzonzo & Mogambi, 2016). Smallholder farmers often seek information when they encounter challenges in their farming activities. By utilizing agricultural information effectively, farmers can adopt new and improved practices that lead to higher yields and increased incomes (Soyemi & Haliso, 2015). Furthermore, access to agricultural information can drive change and progress within the agricultural sector by empowering smallholder farmers to make informed decisions regarding value-adding agricultural production (Mwantimwa, 2019; Mtega et al., 2016; Gunasekera & Miranda, 2011). Farmers require timely, reliable, and relevant agricultural information at various stages of production (Mbwangu, 2018), including crop selection, production techniques, agricultural equipment, inputs, markets, postharvest technology, access to credit and others (Mkenda et al., 2017; Mishra & Bhatta, 2021a).

The Government of Nepal has been actively taking measures to enhance smallholder farmers' access to agricultural information in order to enhance their productivity. One notable initiative is the establishment of the PMAMP (Prime Minister Agriculture Modernization Project), which aims to transform the subsistence agricultural sector into a commercially viable one through proper access to technical information and other inputs among farming communities. Additionally, the government conducts training programs for extension officers, who are deployed nationwide to facilitate smallholder farmers' access to reliable and timely agricultural information, thereby improving their production capabilities. Government institutions are also monitoring and strengthening the functioning of ICTs, agricultural cooperatives, and agrovets to ensure the provision of dependable and up-to-date information to smallholder farmers.

Despite significant efforts to improve the availability and utilization of agricultural information among smallholder farmers, there are still major challenges in effectively delivering these resources. While the importance of agricultural information for smallholder farmers is well recognized, the majority of farmers in developing countries continue to lack access or have limited access to such information (Nyamba, 2017). This is primarily due to the limited reach of the information generated, with only a small portion actually reaching the farmers (FAO, 2017). Researchers and extension workers have

generally neglected the satisfaction of smallholder farmers regarding the agricultural information they receive (Mkenda et al., 2017; Nyamba, 2017; Msoffe & Ngulube, 2016; Mtega et al., 2016). However, the satisfaction of smallholder farmers with the agricultural information they access is crucial for enhancing agricultural production. Satisfaction with information plays a significant role in determining agricultural outcomes (Soyemi & Haliso, 2015). On the other hand, dissatisfaction with the agricultural information accessed and used can have a detrimental impact on the agricultural success of smallholder farmers (Adio et al., 2016). If dissatisfaction increases, smallholder farmers may have no choice but to migrate to urban centers in search of employment or choose alternative services and trade (Nicholas-Ere, 2017). Consequently, the agricultural sector in developing countries, which heavily relies on smallholder farmers, faces challenges in terms of its survival and growth (Mkenda et al., 2017; Elias et al., 2015). The lack of timely and context-specific information, as well as farmers' inadequate knowledge and skills regarding accessing and utilizing information, have an impact on their satisfaction (Galadima, 2014; Omar et al., 2013). Limited availability of local information centers and irregular visits by extension officers also restrict farmers' access to and utilization of information (Phiri et al., 2019).

Agriculture is governed by risk and uncertainties and is ever changing with regards to farming practices and interest; hence agricultural information need is constantly changing among farming communities. Thus, information need of farmers should be regularly identified to ensure better sustainability of farm. Sources of information and satisfaction level of provided information should be closely monitored to promote context specific - information uptake among smallholder farmers. There is lack of sufficient empirical evidence about the information need of smallholder vegetable farmers in the real-time context. Hence, this study aims to identify the information need, source of information and satisfaction level to the provided information among smallholder vegetable farmers so that we can develop policies and programs to foster the growth of this subsector.

METHODOLOGY

Study area

Chitwan district lies in the tropical plain terai of Nepal, though small portion of district experience subtropical and has abundant resources that can enhance the productivity of the vegetable subsector. It is one of the major vegetable producing districts in the country (Rijal et al., 2018; MoALD, 2020). Bharatpur metropolitan covers the significant portion

of farming land and particularly vegetable farms. PMAMP Chitwan (2022) reported 769 ha of vegetable farming through registered farms/farmers with productivity of 27.7 mt/ha in its command area. Average annual temperature lies between 10^0C to 40^0C and rainfall of 1500mm. Government led PMAMP (Prime Minister Agriculture Modernization Project), Agriculture Knowledge Center (AKC), and other government bodies and institutions together with I/NGOs (International/National Non-Governmental Organization) and private firms are working to develop vegetable farming as the means to attain food and nutritional security. Similarly, returnee migrants, marginalized and small holder farmers are seeking to improve livelihood through vegetable farming in this area. Smallholder farmers are interested in this subsector as they can get higher economic return in short time and is gender friendly and applies easy production techniques (Rijal & Bhatta, 2022). We selected Bharatpur metropolitan wards (24, 25, 26) for study as it is major hub within the district (comparatively has higher number of farmers) and lies in the command area of government led PMAMP. Smallholder farmers are cultivating multiple vegetables in their farm including likes of cauliflower, cabbage, tomato, carrot, capsicum, chillies, cucumber, gourds, potato, eggplant, radish, etc. With recurring issues of disease and pest incidence, market price fluctuation, unavailability of fertilizers and pesticides and others, vegetable farming has always been in national headline in this area. Initial Focus Group Discussion (FGD) and Key Informant Interview (KII) with farmers, extension officials and others, highlighted that smallholder farmers cultivating less than 10 kattha are not registered in PMAMP Chitwan and are provided less attention, thus promoting formation of groups. Further, information need of smallholder farmers and satisfaction are hardly fulfilled and there is wide gap in real time context between available and actual need. Hence, this study will help to identify the information need along with satisfaction and hence develop mechanism to foster the growth of this subsector in this area. This study will particularly help smallholder farmers, and other stakeholders in this area and other similar settings.

Data collection and sampling technique

We employed multistage, purposive and random sampling technique to select district, metropolitan, wards and smallholder farmers during 2022. At the first stage, we purposively selected Chitwan district, then we purposively selected Bharatpur metropolitan, then we purposively selected wards (24, 25, 26) and then randomly selected smallholder farmers (cultivating less than 0.5 ha) from these wards. We found less

smallholder farmers registered in the government bodies/institutions compared to those in agricultural cooperatives/farmers group. We could not get the clear insights on the numbers and estimated the population to be any 500 to 900 in the study wards on the basis of analysis of different data. We selected 35 smallholder farmers each from ward (24, 25) and 30 smallholder farmers from ward (26) making total sample size of 100 smallholder farmers. Sample size was taken with the aim to include more than 10% of population. We employed semi structured questionnaire for farm household survey with principal decision maker (head) and respective checklist was prepared for KII and FGD. KII was carried out with progressive smallholder farmers, cooperative officials, agrovets, extension workers of Government and Non-Government agencies. FGD was carried out with smallholder farmers (6-12 people) and key informants (6-10 people) and in combination. All the wards in study area were covered in KII and FGD. Similarly, secondary data sources like published reports from individuals, government and nongovernment institutions and body were reviewed to get insights on the subject.

Data analysis

We employed frequency and index value calculation with the help of Ms-Excel. Frequency calculation was used to present the findings of satisfaction of the information respondents have received. Satisfaction was measured with respect to parameters like adequate, accurate, and timely and context specific information that increased the production and productivity, promoted cost effective production techniques and adoption of improved farming practices. Maximum score of 9 and minimum score of 0 was assigned to each parameter. This was followed by sum of parameters divided by total number of parameters. Score less than 3 (<3) was termed as low satisfaction, score between 3 to 6 (3-6) was termed as medium satisfaction and score greater than 6(>6) was termed as high satisfaction. We applied this measurement to each of the information mentioned. Index value calculation was used to present findings of information need and sources of information to farmers. Information need was measured with ranking the most needed information, which farmers feel is necessary to farming at the present context. Sources of information were ranked accordance to higher and significant information acquisition.

Index value calculation was done using following formula;

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

I_{imp}= Index of importance

S_i= Scale value

F_i= Frequency of importance given by the respondents

N= Total number of respondent

Level of satisfaction was measured using following formula;

Satisfaction score= Adequate+Accurate+Timely+Context specific+Production and productivity+ Cost effective production technique+Adoption of improved farming practices/Total number of parameters (i.e.7)

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents in the study area

Majority of the respondents were male (57%) followed by female (43%) as shown in Table 1. Further, educational status of farmers showed that majority of the respondents (62%) were educated less than intermediate level, 26% had intermediate and above level of education, whereas 12% were still illiterate. Similarly, the majority of respondents belong to economically active age group (76%) followed by dependents (24%). We found 46% of the respondents had experience of 15-30 years in vegetable farming. Majority of the respondents (63%) claimed more than 10 kattha farm size followed by less than 5 kattha by 7% of the respondents. About 60 % of the respondent's household had income from only agriculture source whereas 40 % received both agricultural and off farm income. Similarly, 50% of the respondents earned annual NPR 3 lakhs to 6 lakhs from vegetable farming. All the respondents (100%) were practicing commercial farming. Similarly, the majority of the farmers (54%) used ICT in agriculture. All of the respondents (100%) were engaged in agricultural cooperatives. Majority of the respondents (55%) were not in regular contact with the extension agents from government and non- government institutions in the study area.

Table 1. Socio-economic characteristics of respondents in the study area

Variables	Frequency	Percentage

Variables	**Frequency**	**Percentage**
Gender		
Male	57	57
Female	43	43
Education		
Illiterate	12	12
Less than intermediate	62	62
Intermediate and above	26	26
Age group		
Economically active (15-59 years)	76	76
Dependent	24	24
Farming experience (in years)		
<15	23	23
15-30	46	46
>30	31	31
Farm size (in kattha)		
<5	7	7
5-10	30	30
>10	63	63
Source of income		
Agriculture	60	60
Agriculture + off farm	40	40
Annual income from vegetable farming (NPR)		
< 3 lakhs	30	30
3 lakhs-6 lakhs	50	50

Variables	**Frequency**	**Percentage**
>6 lakhs	20	20
Nature of production		
Commercial	100	100
Subsistence	0	0
Use of ICT in agriculture		
Yes	54	54
No	46	46
Member in agricultural cooperatives		
Yes	100	100
No	0	0
Regular contact with extension worker		
Yes	45	45
No	55	55

Source: (Field survey, 2022)

Existing Source of agriculture information to respondents in study area

We found that, minority of the respondents (46%) was not using information received from ICT in agriculture, but all of the respondents were receiving agricultural information from ICT. Similarly, majority of farmers (55%) were not having regular contact with extension worker, but they were acquiring information from this source in varying degree. We found smallholder farmers using multiples information sources in agriculture. The information sources included agrovet shops, extension workers, agricultural cooperatives, fellow farmers, and ICT as shown in Table 2. Results revealed that agrovet shops (0.9) was ranked most common source of information for farmers in study area. Similarly, the second most used source was fellow farmers (0.7). Third most used source was agricultural cooperatives (0.5). Likewise, extension workers and ICT were least used source. In relation, KII and FGD highlighted;

- Cooperatives/farmers group led agrovets or other agrovet shops provide credit in the purchase of inputs and give farmers opportunity for loan payment after product being sold. Farmers feel comfort in taking agricultural credit from these sources for input purchase as they don't need to pay monthly EMI. With occurrence of any pest and diseases or any other difficulties in farm, farmers consult with agrovets and follow the practices stated by agrovets including application of inputs prescribed by agrovets.
- Farmers feel agrovets try to sell extra inputs than required in farm. Their advices are not accurate rather they provide multiple causes and solutions advices, thus creating confusion and risk among farming communities.
- Fellow farmers share about practices and technology that they have heard or seen with each other. They consult with each other regarding agricultural information. However, they feel advice from fellow farmers are more on past experience and thus cannot solve the problems that are new in community.
- Agricultural cooperatives are more focused on credit facilities and little effort has been given on capacity building and training to its member. Many times, cooperatives were providing trainings on seeds after farmers have already started plantation for that year. Agricultural cooperatives fail to provide time specific training facilities on agricultural information.
- Extension workers are making periodic and need based visit to farms. Farmers fell extension worker are providing information on new practices. However, limited interaction with farmers was making it difficult for proper exchange of information. Extension workers pay limited attention to smallholder farmers. Farmers were contacting extension worker when the advice from fellow farmers and agrovet fails to provide solution in farm. Eventually, when extension worker reach in play, commodities are mostly destroyed by disease, pest and other causes.
- ICT lack to provide real time context and location specific information to farming communities. Similarly, digital literacy was low among farmers to search information from mobile applications and other modern technology. Radio, TV and phone call was mostly used to get information.

Agrovet shops are providing input and technical recommendation to farmers in plain terai (Thapa, 2010). Studies (Vaggi & Kamble, 2017; Mishra & Bhatta, 2021a) reported agrovet shops as most used information source by farmers. Studies (Rijal et al., 2018; Rijal et al.,

2006) reported farmers mostly rely on agrovet for information on selection, handling and use of pesticide. Similarly, majority of the farmers were dependent on overall pest and disease management and even farmers were using application dosage recommended by agrovet instead of following the product label description (Rijal et al., 2018). However, there is risk associated with dependence on agrovet likes agrovet employees have no technical background, the information is misleading in many circumstances and their focus is mainly to sell the inputs so there might be a conflict of interest in the transfer of information (Rijal et al., 2018). Studies (Adio et al., 2016; Mishra & Bhatta, 2021a) reported majority of the farmers depend on fellow farmers rather than extension workers. Fellow farmers were found to be the most effective channels for most farmers, followed by extension officers and ICT (Mkenda et al., 2017; Mishra & Bhatta, 2021a). Studies (Mtega & Ngoepe, 2018; Ndimbwa et al., 2021) reported fellow farmers as effective information sources. Several studies (Due et al., 1997; Mtega & Ngoepe, 2018; Stringfellow et al., 1997; Churi et al., 2012; Misaki et al., 2016; Msoffe & Ngulube, 2017; Mtega & Ngoepe, 2019) reported it favors convenient and easy consultation in a daily basis, and are believed to be rich in context specific information. Fellow farmers was preferred as source because of easy availability and accessibility, and the fact that no resources are needed to access agricultural information from them (Churi et al., 2012; Misaki et al., 2016; Msoffe & Ngulube, 2017; Mtega & Ngoepe, 2019; Ndimbwa et al., 2021). Similarly, studies (Ajuwon & Odeku, 2012; Mugwisi et al., 2014) reported that the most effective way of transferring agricultural information is face to face communication favoring the information transferring from agrovets, fellow farmers, extension workers and agricultural cooperatives than ICT. Mishra and Bhatta (2021b) reported farmers participate in agricultural cooperatives to get information on input, credit and market. Poulton et al. (2010) however reported cooperatives did not improved the farmer's situation. Studies (Verhofstadt & Maertens, 2014; Ahmed & Mesfin, 2017) reported that cooperatives are not suitable for land-poor or near-landless farmers. Extension agents of government and nongovernment agencies have authority in providing agricultural extension services as they are hired for same purpose and have more technical knowledge and have better understanding to meet farmers' information needs (Msoffe & Ngulube, 2017). Due to less number of extension agents, large number of areas is to be covered by single extension agent (Mishra & Bhatta, 2021a). Earlier studies (Mishra & Bhatta, 2021a; Mishra, 2021; Mishra & Bhatta, 2021b; Dhakal & Mishra, 2022) reported majority of smallholder

farmers has no regular contact with extension workers. The availability of extension agents (Churi et al., 2012; Misaki et al., 2016; Msoffe & Ngulube, 2017; Ndimbwa et al., 2021) and accessibility to extension agents influenced choice among farmers (Churi et al., 2012; Misaki et al., 2016; Msoffe & Ngulube, 2017; Ndimbwa et al., 2021). Studies (Singh & Moirangthem, 2010); Margono & Sugimoto, 2011) reported ICT method of disseminating agricultural information is inadequate. Transferring complex information like how to apply fertilizer or cultivate is ineffective through ICT hence less complex information is predominantly provided through ICT like weather, prices, etc. (Aker, 2011, Phatty-Jobe et al., 2020). Similarly, studies (Akpabio et al., 2007; Munyua et al., 2009; Maulu et al., 2021) reported expensive transmission equipment, expensive interconnectivity and the lack of electricity are preventing extension workers from utilizing ICT for information delivery. Mishra and Bhatta (2021a) reported lack of digital literacy to use ICT in agriculture, high cost of ICT (Kale et al., 2015), lack of customized ICT in accordance to specific location farming practices and capabilities of farmers to use (Gelb & Voet, 2009) has reduced use of ICT among farmers. All these factors justify the low usage of ICT as information source among farmers.

Table 2. Sources of agriculture information to respondents in the study area

Source	**Index value**	**Rank**
Fellow farmers	0.7	II
Agricultural cooperatives	0.5	III
Agrovet shops	0.9	I
Extension Workers	0.48	IV
ICT	0.36	V

Source: (Field survey, 2022)

Agricultural information need of respondents in the study area

The information needs of the respondents were identified and presented in Table 3. Results revealed that the most needed agriculture information is about input market and prices (0.88) followed by credit facilities (0.83). The least needed information was about farmer's organization (0.22). In relation, KII and FGD highlighted;

- Agricultural information on input market and prices are hardly disseminated by any information sources. Farmers are limited to the nearest agrovet from input market and prices. They feel, if they had information on alternate sources, they could choose cost effective input market and prices.
- Similarly, credit sources are not well explored as they have access to limited credit sources. Farmers interest on informal sources and agrovet are slowly fading away as they find it expensive. Hence, they want to find alternative sources that can benefit them.
- Information need is almost on different aspects of farming. Farmers are not being able to achieve cost effective production and productivity.
- Farmers are not being able to communicate properly on their information need to extension workers due to less attention by extension workers.

Studies (Phiri et al., 2018; Phiri et al., 2019; Mishra & Bhatta, 2021a) reported information on market and disease management was the more important needs. Babu et al. (2012) reported important needs were disease management, pest management, pesticide application and fertilizer application. Lokanathan and Kapugama (2012) reported fertilizers, market prices and pesticides related information held higher importance. Samarakoon and Shamil (2010) reported most needed information was about inputs and outputs prices, seeds and fertilizers. Rahman et al. (2020) reported priority was higher in information of seeds, fertilizers, credit, diseases and pest control compared to weeding and postharvest technology. Mishra and Bhatta (2021a) reported credit information as one of the important information need of smallholder farmers and information related to mulching and farmers organization as least important. Mostly resource poor smallholder farmers are depending on vegetable farming for livelihood. Credit is important to buy inputs and information on cost effective input market is thus top most priority to reduce cost of production.

Table 3. Information need of respondents in the study area

Information	**Index value**	**Rank**
Input market and prices	0.88	I
Credit facilities	0.83	II
Disease and pest control	0.76	III

Output market and prices	0.71	IV
Postharvest technology	0.68	V
Soil management	0.65	VI
Seed	0.63	VII
Weed control	0.50	VIII
Farm machinery	0.47	IX
Cropping pattern	0.45	X
Fertilizer application	0.41	XI
Water management	0.37	XII
Mulching	0.33	XIII
Farmers organization	0.22	XIV

Source: (Field survey, 2022)

Level of satisfaction among respondents to information in the study area

Table 4 shows the level of satisfaction to different information provided to the respondents. Majority of respondents (80%) were moderately satisfied with the information provided on input market and prices whereas only 7% were highly satisfied. And 13% of respondents were least satisfied with the provided information on input market and prices. Moreover, majority of the respondents (70%) were moderately satisfied having information on credit facilities. Only 23% of respondents complained about the less satisfaction on credit facilities whereas 7% of the respondents were highly satisfied with the information. Almost more than half respondents (60%) were satisfied with the information given on disease and pest control. Very few (13%) had high level of satisfaction and 27 % of respondents were still not satisfied with the disease and pest control information. Majority of respondents (81%) had medium, 9% had low and 10% had high level of satisfaction with the information served regarding water management to crops. Only 70 % of respondents were moderately satisfied to information on farmers organization and 8% were least satisfied to this. Also, 70% of respondents were satisfied moderately to mulching information whereas 15% were highly satisfied and 15% were least satisfied with the given information and so on. In relation, KII and FGD highlighted:

- Information on weed control, farmer's organization, mulching and other soil management practices were provided to farmers by extension officers of NGOs and government institutions in collaboration with agricultural cooperatives and farmers were able to acquire new practices in farm that benefited their productivity and reduced cost of production.
- Farmers feel information on seed, input and output market, credit and cropping pattern is very limited and this particular lacking information is reducing their actual potential in farming.
- Farmers are not satisfied as they were not getting timely, adequate and context specific information from sources and the information they received have not benefitted in terms of production and productivity, cost effective production techniques and improved farming practices.
- Agrovets are major information of input market whereas agents/middleman is major information source to output market, and farmers feel these sources are reducing their potential economic benefits.

Studies (Meitei & Devi, 2009; Brhane et al., 2017; Mishra & Bhatta, 2021a) reported medium and low level of satisfaction among majority of farmers as they were not getting context specific, adequate, accurate and timely information. Several studies (Agholor et al., 2013; Debnath et al., 2016; Kassem et al., 2021; Adesiji et al., 2010; Lalhmachhuana & Devarani, 2016) reported that farmers were moderately satisfied with provided agricultural information through extension services. Ndimbwa et al. (2021) reported information related to credit, market, pesticides, crop production techniques and postharvest technology was not delivered in time to majority of smallholder farmers. Most of the farmers lack access to context specific information (Nyamba, 2017). Studies (Mtega, 2017; Mwantimwa, 2019; Siyao, 2012) reported information from different sources in not being able to meet the information need of farmers. Information from agrovet and fellow farmers has limitations and in most cases is inadequate and inaccurate to meet the information need. Similarly, relevant and trustworthy sources like cooperatives, extension workers and ICT are limited; this can be major reason for medium and low satisfaction among majority of smallholder farmers.

Table 4. Level of satisfaction to information among respondents in the study area

Information	Level of satisfaction		
	High	**Medium**	**Low**
Input market and prices	7(7)	80 (80)	13(13)
Seed	5 (5)	85(85)	10(10)
Soil management	15(15)	70(70)	15(15)
Water management	9 (9)	81(81)	10(10)
Mulching	15(15)	70(70)	15(15)
Weed control	30(30)	60(60)	10(10)
Farm machinery	14(14)	47(47)	39(39)
Fertilizer application	10(10)	60(60)	30(30)
Disease and pest control	13 (13)	60 (60)	27(27)
Cropping pattern	7 (7)	63 (63)	30(30)
Postharvest technology	12 (12)	48 (48)	40 (40)
Output market and prices	5 (5)	35(35)	60(60)
Credit facilities	7 (7)	70(70)	23(23)
Farmers organization	22(22)	70 (70)	8 (8)
Note: Figure in the parenthesis indicate percentage			

Source: (Field survey, 2022)

CONCLUSION

Vegetable farming is directly related to the livelihood of resource poor smallholder farmers in developing countries like Nepal. Focus should be given to increase the production and productivity of this subsector to meet the food and nutritional security. Agricultural information need of smallholder farmers should be addressed to ensure maximum satisfaction and promote agribusiness of this subsector. Effective and real time context sources should be used to deliver the information. Results from this study revealed that agrovet shops were the most important and common information sources among farming

communities. Extension agencies of Government and Non- Government institutions were least used source for information among smallholder farmers. Government prioritized information sources like cooperatives and ICT were also least used by smallholder farmers. Hence, at the present context, agrovet should be further strengthening to ensure timely, accurate and need based information delivery to small holder farmers. This can be done by regular monitoring of working mechanisms of agrovet by government and timely training programs to agrovet on different aspects of farming practices. Further, working mechanisms of cooperatives, extension workers and ICT should be reshaped with respect to information delivery to smallholder farmers, as these means are important for sustainable and cost-effective delivery of information to smallholder farmers. Like, cooperatives should emphasis on smallholder farmers on capacity buildings and need based training/information delivery rather than just focus on credit facilities. Extension worker should initiate multiple approaching techniques like group approach to reach farmers and focus on farm visit of smallholder farmers. ICT should be customized for specific location to meet language, specific cropping pattern and capabilities of smallholder farmers. The information need of the farmers should be addressed to promote improved farming practices and reduce the existing problems in farming. Satisfaction of smallholder farmers should be increased to sustain this subsector. Timely information need of smallholder farmer and satisfaction to the provided information should be studied through cost effective and relevant means like cooperatives and ICT by extension workers. This will ensure that timely, accurate, adequate and context specific information are provided to smallholder farmers that will meet their information need, improve farming practices, reduce cost of production, increase production and productivity.

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