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Response of Spring Rice Varieties to Different Nitrogen Management Practices in Kapilvastu, Nepal

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ABSTRACT

The study was carried out at the farmer's field in Tilkahana, Kapilvastu from February 2020 – June 2020. The objectives of the study were determining the better variety nitrogen management practices for spring rice cultivation. The study was conducted in Factorial Randomized Complete Block Design replicated thrice. Factor A includes spring rice varieties viz. Chaite-5 and Hardinath-3. Factor B includes the nitrogen management practices adopted which were: Recommended dose of N at 3 equal splits, 1/3 at basal +1/3 at 20 DAT + 1/3 at 45 DAT; Recommended dose of N at 3 splits, ¼ at basal + ½ at 20 DAT + ¼ at 45 DAT; N application using leaf color chart (LCC); Zero N, Control and Farmer's Fertilizer Practices (FFP). Rice seedlings were raised in a wet nursery bed and transplanted in experimental plots on 21st March 2020. The crop geometry was 20 x 20 cm. Growth parameters, grain yield, and yield-attributing traits of rice were recorded. The results revealed statistical differences between the treatments in terms of agronomical parameters, yield attributing characters, and grain yield. Results indicate the recommended dose of N application at 3 splits i.e., ¼ at basal+ ½ at 20DAT+ ¼ at 45 DAT contributes to the higher plant height (104.79 cm), the number of tillers (9.88), grain yield (4.9 Mt $ha^{-1)}$ and straw yield (7.44 Mt ha^{-1}). The highest LAI (2.84), flag leaf length (31.063 cm), and effective tillers/m2 (245.41) were obtained in nitrogen application using LCC. Moreover, the recommended dose of N at 3 splits, ¼ at basal + ½ at 20 DAT + ¼ at 45 DAT, and nitrogen application using LCC showed almost similar performance in most of the parameters. Among the varieties, Hardinath 3 produced the highest plant height (100.86 cm), Flag leaf length (29.509 cm), and 1000 grain weight (29.059 gm) as compared to Chaite 5 (94.613 cm), (26.355 cm) and (24.199 g) respectively. Also, there was a positive correlation between the grain yield and effective tillers per m^2 (r =0.972), grain yield and filled grains per panicle (r =0.405), and grain yield and LAI (r =0.716). Hence, the recommended dose of nitrogen application at 3 splits i.e., ¼ at basal+ ½ at 20 DAT+ ¼ at 45 DAT, and nitrogen application using LCC were found to improve yield and yield attributes of spring rice.

Keywords: Farmer's Fertilizer Practices, Leaf Color Chart (LCC), Grain yield, Split nitrogen application

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INTRODUCTION

Rice (*Oryza sativa* L.), Dhaan in Nepali, is an annual, self-pollinated, and semi-aquatic plant in the poaceae family. In the fiscal year 2079/80, rice played a significant role in Nepal's agriculture GDP, contributing 13.6%, with an expansive cultivation area spanning 1,477,000 hectares and a robust production of 5,130,000 metric tons (MOALD 2023). The national seed production status for rice showed notable figures, with breeder seed production at 10.93 metric tons, foundation seed at 462.30 metric tons, certified seed at 1709.83 metric tons, and improved seed reaching 12,354.23 metric tons, summing up to a total of 14,537.29 metric tons (MOALD 2023). Spring Rice is sown in the last week of February to the first week of March and follows the transplanting of 30-40 days old seedlings. The month of transplanting coincides with the Nepali month "Chaitra" and so is named Chaite rice.

Rice production depends on several factors: climate, physical conditions of the soil, soil fertility, water management, sowing date, cultivar, seed rate, weed control, and fertilization (Jing et al 2008). For fertilization, nitrogen is the main nutrient associated with yield (Jing et al 2008, Bouman et al 2007, Sahrawat 2006, Wilson et al 1994, Angus et al 1994). Nitrogen rate and timing are important crop management practices for improving nitrogen use efficiency and crop yields (Fageria and Baligar 2005). Problems with excess nitrogen happen when fertilizers are relatively cheap and farmers do not understand the correct amount of nitrogen required relative to their yield goals, and the right time of nitrogen application (IRRI 2020). The nitrogen application strategy, equivalent to the number and applications or fertilization splits of this nutrient, also affects crop response to applied nitrogen rates, thus allowing the increase of nitrogen use efficiency (Jing 2007, Beser 2001). Split application of N-fertilizer reduces nitrogen losses and improves the uptake efficiency of crops (Roy et al 2006).

The leaf color chart (LCC) is an easy-to-use and inexpensive diagnostic tool for monitoring the relative greenness of a rice leaf as an indicator of the plant's nitrogen status (Alam et al 2005). It measures leaf color intensity that is related to leaf nitrogen status. Plant nitrogen status is a better indicator of nitrogen availability thus Leaf Color Chart has emerged which can indirectly estimate crop N status and help in timely nitrogen application and required amount (IRRI 2020).

The haphazard and untimely use of nitrogen fertilizer in the rice field in terms of quantity and time (QT) led to the study. The objective of the study was to find out the response of nitrogen management in two spring rice varieties: Chaite -5 and Hardinath -3.

MATERIALS AND METHODS

Study site

The research was conducted at a farmer's field, Tilkahana, Banganga municipality located in the northeast part of Kapilvastu. It lies at a latitude of 27˚38'44" N and longitude of 83˚10'16'' E and an elevation 63.9 masl. The study site is a lowland plain area dominated by alluvial clay soil of about l.

Experimental materials

The major experimental materials used in the research are two varieties of rice, Chaite 5 and Hardinath 3 having 125 and 120 maturity days respectively. Urea, DAP, and MoP were used as an inorganic source of nitrogen, P_2O_5, and K. Besides this, Leaf Colour Chart (LCC) was also used to study the enhancement of nitrogen use efficiency.

Field layout

The experiment was carried out in Factorial Randomized Complete Block Design (RCBD) under 3 replications consisting of two factors; Factor A: Variety and Factor B: N management practices. The layout details are;
Total number of plots: 30
Individual plot size: 2.4 m×2.4 m
Spacing between plots: 0.4 m
Net experimental plot area: 172.8 m^2
Gross experimental plot area: 241.4m^2 (Length= 28.4 m and Breadth= 8.5 m)
Total number of rows/ plots:12
Number of treatments: 10
Number of Replications: 3
The central eight rows were considered as net plot rows for yield calculation and taking biometrical observations. Two rows on each side of the net plot rows were used to take destructive samples for growth analysis. The remaining two rows on each side of destructive rows were considered as border rows.

Treatment details

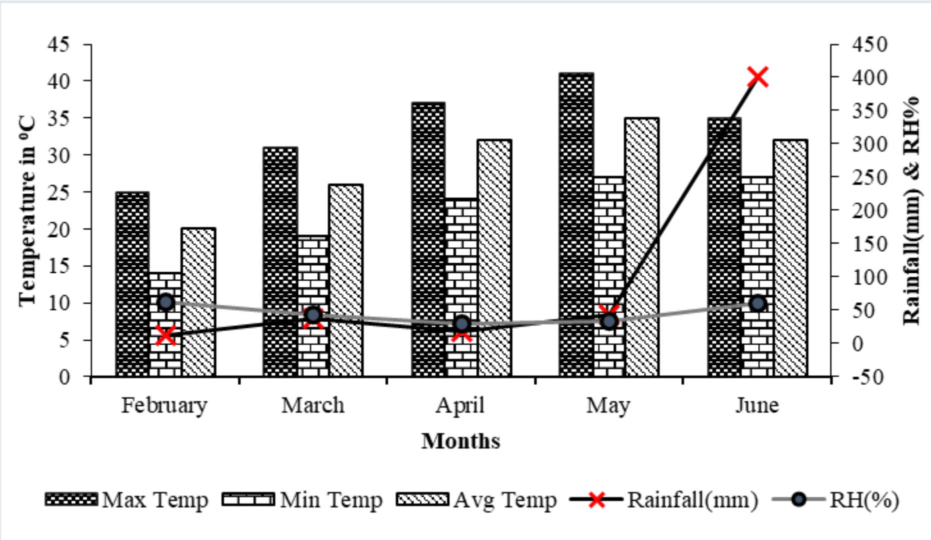
Factor A: Spring rice varieties (V)
V1 = Chaite- 5
V2 = Hardinath -3
Factor B: Nitrogen management practices Treatments (T)
T1= Recommended dose management practice (3 equal Splits of N as 1/3 at basal, 1/3 at 20DAT, 1/3 at 45 DAT)
T2 = Recommended dose management practice (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45DAT)
T3 =Nitrogen fertilizer application using LCC
T4 = Control (Zero Nitrogen)
T5 = Farmer's Fertilizer Practices (FFP) (2 Splits of N as ½ at basal, ½ at 45DAT)

Table 1: Treatment combination used during the research

S. N	Variety (V) (Factor 1)	N management practices (T) (Factor 2)	Interaction (V×T) (Factor 1×2)
1	Chaite 5 (V1)	T1	V1T1
2	Chaite 5 (V1)	T2	V1T2
3	Chaite 5 (V1)	T3	V1T3
4	Chaite 5 (V1)	T4	V1T4
5	Chaite 5 (V1)	T5	V1T5
6	Hardinath 3 (V2)	T1	V2T1
7	Hardinath 3 (V2)	T2	V2T2
8	Hardinath 3 (V2)	T3	V2T3
9	Hardinath 3 (V2)	T4	V2T4
10	Hardinath 3 (V2)	T5	V2T5

Meteorological data for cropped season

The research was conducted during the month of mid-February to last June. The maximum mean temperature was observed in May while the minimum was in February. The highest precipitation was received during the month of June i.e. up to 502 mm. The monthly mean maximum, minimum, and average temperatures during the period ranged from 25°C to 41°C, 14°C to 27°C and 20°C to 35°C respectively. The relative humidity during the period ranged from 29% to 63%.



Source: (www.worldweatheronline, 2020)

Figure 1. Weather condition during the experimental period from February 2020 to June 2020 at Kapilvastu

Adapted cultivation practices

Seedlings were raised in wet nursery beds after soaking seeds for 24 hours, with urea applied 14 days after sowing (DAS). Seedlings were ready by 28 DAS and transplanted manually into a puddled field with 20x20 cm spacing with 144 plants in each plot. Gap fillings were done 4 days after transplanting (DAT). Full dose of phosphorus and potassium fertilizers (30:30 kg ha^{-1}) were applied at the time of final land preparation, with nitrogen applied in three splits. No herbicides were used; hand weeding occurred at 25 and 45 DAT. Irrigation was provided via a solar pump. The crop was manually harvested, sundried, bundled, threshed, and cleaned by winnowing before being weighed.

Observations and data collection

To evaluate several important rice-growing parameters, including plant height, tiller count, Leaf Area Index (LAI), and yield-related attributes, a thorough agronomic study was carried out. Plant height, measured from the base to the apex of the topmost leaf or panicle, was carefully recorded every 15 days up to 75 days after

transplanting (DAT). By averaging observations from randomly selected hills at various stages of crop growth, the number of tillers per hill was calculated. The Leaf Area Index was calculated by following the formula-
Leaf Area= Length x Breadth x 0.78
LAI = Leaf Area / Ground Area

The length of the leaf was measured longitudinally by scale whereas; breadth was measured at the middle portion leaf. Similarly, the ground area was calculated as the spacing between hills (20 x 20 cm).
Characters that are associated with yields, such as the number of grains per panicle, effective tillers per square meter, panicle length, flag leaf length, thousand-grain weight, and grain sterility percentage were observed from 10 plants of each hill. Sterility % is given by

$$\text{Sterility\%} = \frac{\text{No. of unfilled grains}}{\text{Total no.of filled grains}} \text{ x } 100\%$$

Grain and straw yields from each plot were recorded taking plot area conversion factors and moisture content into account and given by

$$\text{Grain yield (Mt ha}^{-1}\text{) at 14\% moisture} = \frac{(100-MC)\, X\, plot\ yield(kg) X\, 1000(m2)}{(100-14) X\, 1000(ton)\, X\, A}$$

Where;
MC = Moisture content of grain (%) just before weighing the bulk.
Y = Net plot yield (kg)
A = Net plot area (m^2)
(100-MC)/ (100-14) = Conversion factor for grain yield at 14% moisture content.
(10000)/A = Conversion factor for the actual harvested area into a hectare basis.
Plot yield/1000 = Conversion factor for actual harvested yield into ton basis.

The straw obtained from the net plot area of each plot was sun-dried for 3-4 days, weighed, and were converted into tons per hectare.
Harvest Index (HI), indicating the efficiency of assimilate partitioning towards economically valuable components, was calculated by dividing grain yield by the sum of grain and straw yields.

$$\text{Harvest Index (HI)} = \frac{\text{Economic Yield (Grain Yield)}}{\text{Biological yield (Grain Yield + Straw Yield)}}$$

Statistical analysis
All the recorded data were arranged systematically treatment-wise under three replications based on various observed parameters. Experimental data were analyzed using R studio with R stat Software of 3.6.1th edition and treatment means were separated using Duncan's Multiple Range Test (DMRT) at a 5% level of significance. Analysis of variance (ANOVA) was used to test differences among the two factors (Gomez and Gomez 1984). A simple correlation and regression were established among the selected parameters regarding Gomez and Gomez (1984). The treatments were randomized by creating a random table in MS Excel.

RESULTS

1. Agronomic characters
1.1 Plant height
The rice varieties significantly influenced the plant height as; the plant height of Hardinath 3 (100.86 cm) was taller than the plant height of Chaite 5 (94.61 cm) at 77 DAT. This variation in plant height in rice varieties might be due to varietal characteristics (Table 2). Among the nitrogen management practices, the highest plant height (104.79 cm) was found with the Recommended Dose (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) which was followed by Nitrogen fertilizer application using LCC (103.14 cm) and Recommended dose (3 equal splits of N as 1/3 at basal, 1/3 at 20 DAT, 1/3 at 45 DAT) (101.29 cm) (Table 2). The availability of nitrogen throughout the growth stages might be responsible for better performance. The result is similar to the findings of (Budhathoki et al 2018, Salam et al 2011, Shailful et al 2009). The result indicated that three splits application of nitrogen fertilizer was found more effective in increasing plant height than 2 splits. This result was supported by Reddy et al (1987) and Akanda et al (1986).

The nitrogen management practices, and the varieties interactively affected the plant height at a significant level except for 75 days after transplanting. At 45 and 60 days after transplanting, a combination of Hardinath 3 and Nitrogen fertilizer application using LCC had the highest plant height (72.76 cm) and (93.70 cm) respectively.

1.2 Number of tillers per hill

A non-significant difference was observed in the number of tillers regarding the rice varieties except for 15 days after transplanting, where Chaite 5(4.68) was found superior to the Hardinath 3(3.86). This result is probably due to the difference in varietal performance. Regarding the nitrogen management practices, highly significant results were observed in the number of tillers. At 75 DAT, the highest number of tillers (9.88) was obtained in the recommended dose (3 splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) which was followed by nitrogen fertilizer application using LCC (9.80), Recommended dose (3 equal splits of N as 1/3 at basal, 1/3 at 20 DAT, 1/3 at 45 DAT) and Farmer's fertilizer Practices (FFP) (Table 2). The result indicated that three split applications of nitrogen fertilizer were found to be more effective in increasing the number of tillers. This result was supported by Shailful et al (2009). The interaction of rice varieties and nitrogen management practices on the number of tillers was found to be non-significant on the number of tillers except 15 days after transplanting and 45 days after transplanting.

1.3 Leaf area index (LAI)

The effect of rice varieties in LAI was found to be non-significant. Highly significant results were recorded with the effect of nitrogen management practices on LAI. Leaf Area Index (LAI) was recorded lowest in Control-Zero Nitrogen. The highest LAI (2.84) was obtained with Nitrogen fertilizer application using LCC. Nitrogen fertilization amount had an important role in improving the morpho-physiological characteristics of rice Nitrogen could increase rice leaves and roots growth to prepare appropriate LAI for obtaining the most grain yield (Barari et al 2009).

A non-significant difference was observed regarding the interaction of rice varieties with N management practices on the Leaf Area Index (LAI) except 60 days after transplanting. At 60 days after transplanting, the highest LAI (2.61) was observed with the interaction of Hardinath 3 with Nitrogen fertilizer application using LCC which was statistically similar with the interaction of Chaite 5 with Recommended dose (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) (2.39) while the lowest LAI (0.97) was observed with the interaction of Chaite 5 with (Control-Zero Nitrogen) which was statistically at par with the interaction of Hardinath 5 (1.15) with (Control-Zero Nitrogen).

Table 2: Effect of rice varieties, nitrogen management practices, and their interaction on agronomic characters of rice plant (*Oryza sativa* L.) at Kapilvastu, Nepal, 2020

Treatments	Plant height(cm)		Number of tillers/hill		Leaf Area Index (LAI)	
	60DAT	75DAT	60DAT	75DAT	60DAT	75DAT
Varieties						
Chaite 5	84.06	94.61^{b}	9.47	8.93	1.77	2.15
Hardinath 3	85.57	100.86^{a}	9.38	8.92	1.87	2.25
F test	NS	***	NS	NS	NS	NS
LSD (0.05)		2.208				
Nitrogen dose						
T1	87.41^{b}	101.29^{a}	9.70^{ab}	9.12^{a}	1.82^{b}	2.07^{b}
T2	88.97^{ab}	104.79^{a}	10.50^{a}	9.88^{a}	2.22^{a}	2.25^{b}
T3	91.03^{a}	103.14^{a}	10.23^{ab}	9.80^{a}	2.33^{a}	2.84^{a}
T4	72.89^{d}	84.53^{c}	7.32^{c}	6.73^{b}	1.06^{c}	1.44^{c}
T5	83.75^{c}	94.92^{b}	9.41^{b}	9.10^{a}	1.78^{b}	2.39^{ab}
F test	***	***	***	***	***	***
LSD (0.05)	2.93	3.49	0.81	0.86	0.27	0.47
Variety x Nitrogen dose						
Chaite 5xT1	88.24^{b}	99.34	9.57	8.83	1.68^{cd}	1.99
Chaite 5xT2	89.82^{ab}	101.01	10.67	9.76	2.39^{ab}	2.19
Chaite 5xT3	88.36^{b}	97.81	10.13	9.83	2.05^{bc}	2.83
Chaite 5xT4	68.14^{e}	81.22	6.86	6.43	0.97^{e}	1.31
Chaite 5xT5	85.72^{bc}	93.68	10.14	9.80	1.79^{cd}	2.40
Hardinath 3xT1	86.58^{b}	103.24	9.83	9.40	1.95^{cd}	2.15
Hardinath 3xT2	88.12^{b}	108.58	10.33	10.00	2.05^{bc}	2.30
Hardinath 3xT3	93.70^{a}	108.47	10.33	9.77	2.61^{a}	2.84

Treatments	Plant height(cm)		Number of tillers/hill		Leaf Area Index (LAI)	
	60DAT	75DAT	60DAT	75DAT	60DAT	75DAT
Hardinath 3xT4	77.66^{d}	87.84	7.77	7.03	1.15^{e}	1.57
Hardinath 3xT5	81.79^{cd}	96.17	8.67	8.40	1.62^{d}	2.38
F test	***	NS	NS	NS	*	NS
LSD (0.05)	4.16				0.39	
Grand mean	84.81	97.74	9.43	8.97	1.83	2.20
SEm (±)	1.98	2.35	0.55	0.58	0.18	0.32
CV (%)	2.86	2.94	7.14	7.92	12.41	17.83

Means followed by common letters within the same columns are not significantly different based on DMRT at P=0.05, * significant at 0.05 P level, ** significant at 0.01 P level, *** significant at 0.001 P level, NS= non-significant, LSD= Least Significant Difference, SEm: Standard error of the mean, CV: Coefficient of Variation.

2. Yield attributing characters

2.1 Flag leaf length

Regarding the rice varieties, the flag leaf length of Hardinath 3 (29.51 cm) was higher than the flag leaf length of Chaite 5 (26.36 cm). Regarding nitrogen management practices, the highest flag leaf length (31.06 cm) was observed with Nitrogen fertilizer application using LCC which was statistically at par with the recommended dose (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) and Recommended dose (3 equal Splits of N as 1/3 at basal, 1/3 at 20DAT, 1/3 at 45 DAT) while the lowest flag leaf length (24.47 cm) was observed with Control-Zero Nitrogen which was statistically similar with Farmer's fertilizer Practices (25.55 cm).

The effect of the interaction of rice varieties and nitrogen management practices was highly significant on flag leaf length. The highest flag leaf length (35.36 cm) was observed with the interaction of Hardinath 3 with Nitrogen fertilizer application using LCC and the lowest flag leaf length (22.49 cm) was observed with the interaction of Chaite 5 with Control-Zero Nitrogen (Table 3).

2.2 Panicle length

The mean value of panicle length in the response of rice varieties and nitrogen management practices was non-significant whereas, the significant results were obtained in panicle length due to the interaction of rice varieties with nitrogen management practices. The highest panicle length (24.76 cm) was found in the interaction of Hardinath 3 with Nitrogen fertilizer application using LCC followed by Hardinath 3 with Control-Zero Nitrogen (23.92 cm) while the lowest panicle length (20.20 cm) was found with the interaction of Hardinath 3 with Recommended dose (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) (Table 3). The panicle length in the recommended dose (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) and nitrogen fertilizer application using LCC was recorded as 21.8cm and 22.716 cm. The result is similar to the findings of Budhathoki et al (2018).

2.3 Effective tillers per square meter

A highly significant result was obtained due to nitrogen management practices. The greater number of effective tillers per m2 (245.42) was obtained in Nitrogen fertilizer application using LCC followed by Recommended dose (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) and the lowest effective tillers per m^2 (169.58) was obtained in Control-Zero Nitrogen (Table 3). The role of nitrogen available to the plant from the soil in cell division causing an increase in the number of effective tillers was reported by Haq et al (2002).

2.4 Grain per panicle

Grains per panicle were highly significantly influenced due to rice varieties. The grains per panicle were higher in Chaite 5 (223.53) than in Hardinath 3 (155.93) (Table 3). The nitrogen management practices, and the interaction had no significant effect on grain per panicle.

2.5 Sterility %

Sterility % was significantly influenced by nitrogen management practices. The highest sterility % (27.36) was found in Control-Zero Nitrogen while the lowest sterility % (21.01) was found in Farmer's fertilizer Practices (FFP) followed by the recommended dose (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) (Table 3).

2.6 1000 grain weight

The 1000 grains weight was highly significantly influenced due to rice varieties. The 1000-grain weight was observed higher in Hardinath 3 (29.06) than the 1000-grain weight of Chaite 5 (24.19) whereas, no significant difference in 1000-grain weight was obtained in response to the N management practices (Table 3).

Table 3: Different yield attributing characters of rice as affected by the rice varieties, nitrogen management practices, and their interaction at Kapilvastu, Nepal, 2020.

Treatments	Yield attributing characters					
	Flag leaf Length (cm)	Panicle Length (cm)	Effective Tillers/m^2	Grains/panicle	Sterility %	1000 grain weight (g)
Varieties						
Chaite 5	26.35^b	22.40	225.83	223.53^a	26.21	24.19^b
Hardinath 3	29.51^a	22.58	217.83	155.93^b	23.71	29.06^a
F test	**	NS	NS	***	NS	***
LSD (0.05)	1.69			34.74		1.55
Nitrogen dose						
T1	28.48^a	21.88	230.42^a	182.07	25.85^a	26.39
T2	30.09^a	21.80	242.92^a	190.13	23.44^{ab}	27.44
T3	31.06^a	22.77	245.42^a	193.20	27.13^a	26.31
T4	24.47^b	23.52	169.58^b	187.06	27.36^a	27.39
T5	25.55^b	22.54	220.83^a	196.20	21.01^b	25.60
F test	***	NS	**	NS	*	NS
LSD (0.05)	2.69		42.01		4.57	
Variety x Nitrogen dose						
Chaite 5xT1	26.25^{de}	22.28^{abc}	235.00	204.13	26.35	24.44
Chaite 5xT2	30.92^b	23.40^{abc}	239.17	243.33	25.49	23.24
Chaite 5xT3	26.76^{cd}	20.67^{bc}	244.17	200.20	27.74	25.70
Chaite 5xT4	22.47^e	23.13^{abc}	169.17	233.53	29.59	25.32
Chaite 5xT5	25.35^{de}	22.55^{abc}	241.67	236.46	21.87	22.29
Hardinath 3xT1	30.71^{bc}	21.49^{abc}	225.83	160.00	25.35	28.34
Hardinath 3xT2	29.27^{bcd}	20.20^c	246.67	136.93	21.38	31.65
Hardinath 3xT3	35.36^a	24.77^a	246.67	186.20	26.53	26.92
Hardinath 3xT4	26.46^{de}	23.92^{ab}	170.00	140.60	25.13	29.46
Hardinath 3xT5	25.75^{de}	22.54^{abc}	200.00	155.93	20.15	28.91
F test	**	*	NS	NS	NS	NS
LSD (0.05)	3.80	3.01				
Grand mean	27.93	22.49	221.83	189.73	24.958	26.63
SEm (±)	1.81	1.43	28.28	36.97	3.077	1.66
CV (%)	7.93	7.80	15.61	23.87	15.1	7.61

Means followed by common letters within the same columns are not significantly different based on DMRT at P=0.05, * significant at 0.05 P level, ** significant at 0.01 P level, *** significant at 0.001 P level, NS= non-significant, LSD= Least Significant Difference, SEm: Standard error of the mean, CV: Coefficient of Variation.

3. Measurement of Yields

3.1 Grain Yield

The rice varieties had no significant difference in grain yield. In contrast, nitrogen management practices had a statistically significant difference in grain yield. The highest grain yield (4.90 Mt ha^{-1}) was found in the recommended dose (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) and Farmer's fertilizer Practices (FFP) (4.26 Mt ha^{-1}) while the lowest grain yield (2.98 Mt ha^{-1}) was found in Control -Zero Nitrogen (Table 4). Haque et al (2003) reported that N use efficiency was much higher in LCC-based N applications. Approximately 19-37 kg N/ha was found saved in LCC and it reduces disease and insect infestation in rice.

3.2 Straw yield

The result revealed that no significant difference was obtained in straw yield due to the rice varieties whereas the N management practices significantly influenced the straw yield. The highest straw (7.44 Mt ha^{-1}) was found in the recommended dose (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) whereas the lowest straw yield (4.44 Mt ha^{-1}) was obtained in Control-Zero Nitrogen. The increased straw yield of the recommended dose (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) over Control -Zero Nitrogen is 67.71% (Table 4).

3.4 Biological yield

The N management practices had a statistically significant influence on biological yield. The highest biological yield (12.34 Mt ha^{-1}) was found with the recommended dose (3 Splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) followed by Nitrogen fertilizer application using LCC (11.38 Mt ha^{-1}) (Table 4).

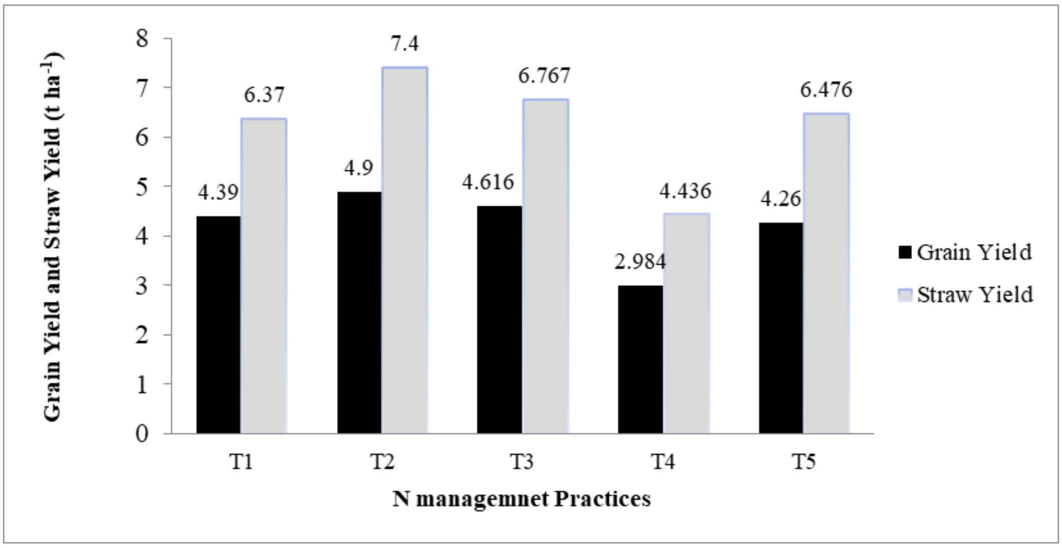


Figure 2. Comparison of grain and straw yield of spring rice varieties with different nitrogen management practices at Kapilvastu, Nepal, 2020

The effect of the interaction between rice varieties and N management practices on biological yield was non-significant.

3.5 Harvest index (HI)

The highest HI (0.41) was obtained in T3 while the lowest HI (0.39) was found in T5 (Table 4). The result was similar to the findings of (Budhathoki et al 2018). There was no significant difference in HI due to rice varieties, N management practices, and their interaction because the grain yield and biological yield varied side by side with different treatments.

Table 4: Different yield measurements of rice plant (*Oryza sativa* L.) as affected by rice varieties, nitrogen management practices, and their interaction at Kapilvastu, Nepal, 2020.

Treatments	Measurement of Yields			
	Grain Yield (Mt ha^{-1})	**Straw Yield (Mt ha^{-1})**	**Biological Yield (Mt ha^{-1})**	**Harvest Index (HI)**
Varieties				
Chaite 5	4.38	6.58	10.97	0.40
Hardinath 3	4.08	6.01	10.09	0.41
F Test	NS	NS	NS	NS
LSD (0.05)				
Nitrogen dose				
T1	4.39^{a}	6.37	10.76	0.40
T2	4.90^{a}	7.44	12.34	0.40
T3	4.62^{a}	6.77	11.38	0.41
T4	2.98^{b}	4.44	7.42	0.40
T5	4.26^{a}	6.47	10.74	0.39
F test	*	*	*	NS
LSD (0.05)	1.17	1.63	2.77	
Variety x Nitrogen dose				
Chaite 5xT1	4.38	6.08	10.45	0.42
Chaite 5xT2	5.07	8.19	13.26	0.38
Chaite 5xT3	4.61	6.74	11.35	0.40
Chaite 5xT4	2.94	4.18	7.12	0.41
Chaite 5xT5	4.92	7.73	12.65	0.39

Treatments	Measurement of Yields			
	Grain Yield (Mt ha^{-1})	Straw Yield (Mt ha^{-1})	Biological Yield (Mt ha^{-1})	Harvest Index (HI)
Hardinat 3xT1	4.40	6.67	11.06	0.39
Hardinath 3xT2	4.73	6.68	11.41	0.42
Hardinath 3xT3	4.63	6.79	11.41	0.40
Hardinath 3xT4	3.03	4.69	7.72	0.39
Hardinath 3xT5	3.60	5.22	8.82	0.41
F Test	NS	NS	NS	NS
LSD (0.05)				
Grand mean	4.23	6.29	10.53	0.40
SEm (±)	0.81	1.09	1.87	0.01
CV (%)	23.31	21.29	21.69	4.96

Mt ha-1= Metric ton per hectare

Means followed by common letters within the same columns are not significantly different based on DMRT at P=0.05, * significant at 0.05 P level, ** significant at 0.01 P level, *** significant at 0.001 P level, NS= non-significant, LSD= Least Significant Difference, SEm: Standard error of the mean, CV: Coefficient of Variation

4. Correlation Regression

To assess the relationship between growth parameters, yield attributing traits, and grain yield, simple correlation coefficients were analyzed. The positive correlation between grain yield and yield attributing characters like the number of effective tillers per square meter (r =0.972) (Figure 3), number of filled grains per panicle (r =0.405) (Figure 4), and Leaf Area Index (r =0.716) (Figure 5). The number of effective tillers/m^2 contributes approximately 94.4% of the grain yield. At the same time, the remaining 5.6% increase in grain yield may be due to variables other than the effective tillers/m^2. Similarly, approximately 16.4% contribution was given by the number of filled grains/panicle on grain yield. The remaining 83.6% part was contributed by variables other than the filled grains/panicle. Again, the Leaf Area Index (LAI) input about 3.5% share on grain yield, and the leftover 96.5% increase in grain yield was due to other variables except for the Leaf Area Index (LAI).

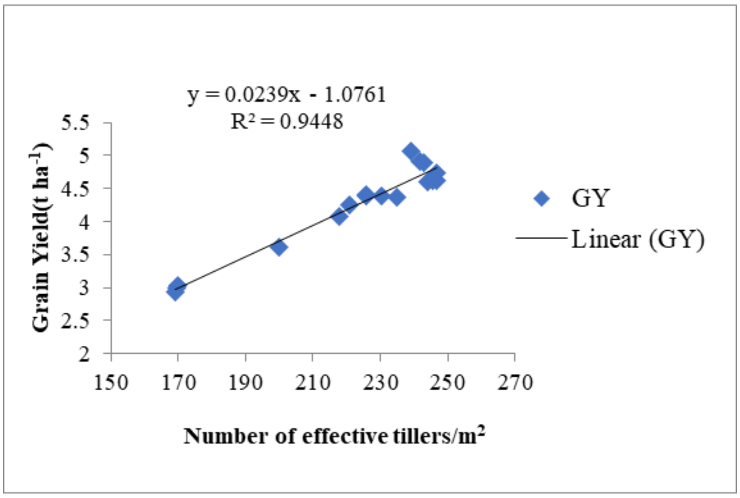


Figure 3: Relationship between grain yield and number of effective tillers per square meter of rice plant

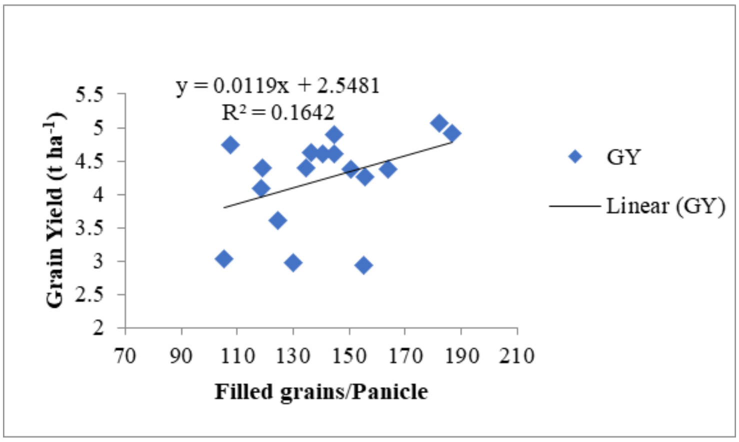


Figure 4. Relationship between grain yield and filled grains per panicle of rice plant

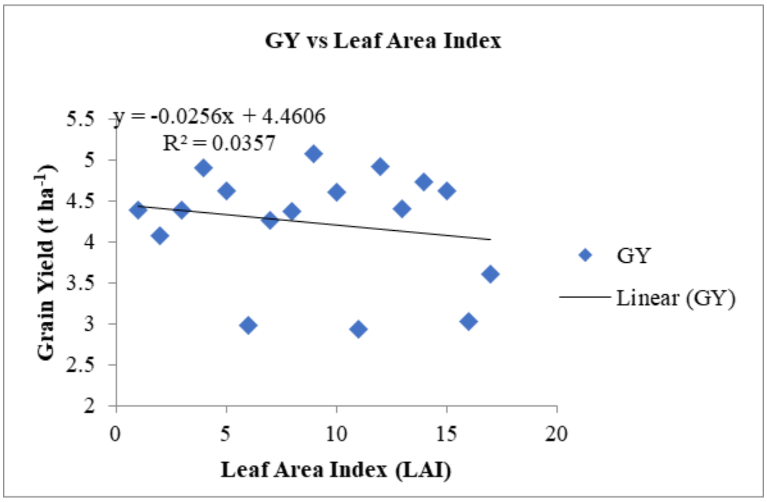


Figure 5. Correlation between grain yield and Leaf Area Index (LAI) of rice plant

The growth parameters and productivity of rice proved that the difference between the treatments was found highly significant in terms of plant height (cm), panicle length (cm), effective tillers per hill, leaf area index (LAI), grains per panicle, sterility %, test weight (g), grain yield (Mt ha^{-1}), straw yield (Mt ha^{-1}) and biomass yield (Mt ha^{-1}). Moreover, the highest grain yield was found in the recommended dose of 3 splits N (1/4 at basal+ ½ at 20DAT + ¼ at 45 DAT) followed by Nitrogen application using LCC. The nitrogen application using Leaf Color Chart is efficient as it results in satisfactory grain yield similar to the other recommended nitrogen management practices. Among varieties, Hardinath 3 performed better for most of the growth, yield, and quality parameters as compared to Chaite 5. Among nitrogen management practices, the recommended dose management practice (3 splits of N as ¼ at basal, ½ at 20 DAT, ¼ at 45 DAT) was found better for spring rice cultivation in terms of yield signifying its validity.

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AUTHORS' CONTRIBUTION

Manshi Jaiswal- Data collection, organization of experimental dataset, data visualization, literature review, data analysis and report writing.
Raju Kharel- Regular constructive comments and support during this research work; guidance during the preparation of the manuscript.
Sandesh Subedi- Data analysis and report writing.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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