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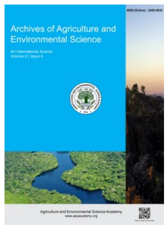

ORIGINAL RESEARCH ARTICLE

Effect of different nitrogen levels on yield and yield attributes of different rice varieties in DDSR condition at Kanchanpur, Nepal

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ABSTRACT

An experiment on the effect of different nitrogen levels on yield and yield attributes of different rice varieties was conducted in Kanchanpur, Nepal, from March 2021 to July 2021. The experiment was laid in randomized complete block design with two factors: nitrogen levels and rice varieties, each factor having three levels (Nitrogen: 60kg/ha, 120kg/ha, and 180kg/ha and rice varieties: Hardinath 1, Hardianth 3 and Chaite 5) resulting in nine treatment combinations. Rice seeds were sown directly in experimental plots under the dry condition on March 24, 2021. The plant spacing was 20x20cm^2. Growth parameters, grain yield, and yield attributing traits of rice were recorded. The statistical results revealed significant differences between the treatments regarding agronomical parameters, yield attributing characters, and grain yield. The results indicated that the 180 kg/ha level of N application contributes to the higher plant height (74.502 cm), the number of tillers (1101.667), effective tillers (577.222), filled grain per panicle (116.490), panicle length (25.241 cm), grain yield (4.7 ton/ha) and straw yield (10.564 ton/ha). Among the varieties, Hardinath 3 produced significantly higher plant height (79.68 cm), panicle length (25.68cm), sterility percentage, and 1000 grain weight (24.60g) as compared to Hardinath 1 and Chapter 5, respectively. However, yield and yield attributing characters like grain yield, straw yield, effective tillers, and filled grains per panicle were significantly higher in Chaite 5. Therefore, a nitrogen level of 180 kg/ha and variety Chaite5 may be used for better productivity in Kanchanpur, Nepal.

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INTRODUCTION

Rice (*Oryza sativa* L.) is one of the world's most important cereal crops, with more than half of the world's population relying on it for daily sustenance (Chauhan and Johnson, 2011). Nearly two-thirds of the world's population relies on rice as a staple food; of the 2500 million people who eat it, 90% live in Asia, and the remaining 10% are in America, Africa, Australia, and Europe (Dahipahle and Singh, 2018). Nepal is a country of mountains with a wide variety of rice ecologies. Rice is grown in all agroecological zones, from the Terai to the high mountains. Numerous landraces have been discovered that are suited to various climatic conditions and farmer needs. Rice is an annual, self-pollinating, semi-aquatic plant member of the Poaceae family. More than half of the total number of calories needed by Nepalese people are provided by rice, which accounts for about 20% of the country's agricultural gross domestic product (AGDP) and 50% of all edible cereal production (Basnet, 2008). Typically, seedlings are transplanted into puddles of soil to grow rice. By lowering water percolation losses, eliminating weeds, making seedling establishment simple, and fostering anaerobic conditions that increase nutrient availability, puddling is beneficial for rice. However, persistent puddling and destruction of soil aggregates decreased permeability of subsurface layers, and the development of hardpans at shallow depths all have a detrimental effect on the physical characteristics of soil (Kumar *et al.*, 2019).

Direct-seeding of rice (DSR) is the method of establishing the crop from seeds placed in the field and is a cost-effective alternative to transplanting. Rice can be planted directly, eliminating the requirement for nursery preparation, seedling, uprooting, and transplanting (Singh *et al.*, 2018). In terms of planting date, water requirements during the early stages of the crop, weed management, and control, and N fertilization rates, agronomic management in direct seeding can be different from permanent inundation (Khan *et al.*, 2012). By saving irrigation water by 12-35 percent and labor by up to 60 percent when compared to the traditional transplanting (TP) method, direct seeding (DS) is a promising cultivation technique that yields crops with almost identical or slightly lower yields (Farooq *et al.*, 2011; Kumar and Ladha, 2011). Direct seeded rice (DSR) is becoming more popular since it is less expensive, consumes less water, and needs less work than conventional crop establishment procedures (Kumar *et al.*, 2019).

One of the essential nutrients, nitrogen, is needed in sufficient amounts at the early, middle, and ripening periods for improved grain formation. Nitrogen is most frequently needed for high rice yields (Bokado *et al.*, 2020). It is well known that nitrogen fertilizers significantly increase rice yields, especially since the development of current varieties. A significant component of protoplasm, protein, and chlorophyll is the nutrient nitrogen (Karim *et al.*, 2019). The application of nitrogen fertilizer in an inefficient manner raises production costs and degrades product quality (Mahato *et al.*, 2019). Inappropriate N fertilizer application can have adverse environmental effects due to nitrate leaching into groundwater, surface runoff into water bodies, and ammonia volatilization into the atmosphere. Appropriate N fertilizer application also increases pest resistance, improves dry matter accumulation, and encourages better nutrient uptake in rice plants. Due to the soil, atmosphere, and water being enriched with reactive N from agriculture, excessive N application causes significant ecosystem problems (Ju *et al.*, 2009). It can limit grain yield: limited grain filling rate by declining post-anthesis assimilates translocation (Zhang *et al.*, 2009). Therefore, it is imperative to investigate the proper nitrogen fertilizer application amount, which may prevent not only nitrogen fertilizer loss but also reduce nitrogen fertilizer contamination of soil and the environment (Zhang *et al.*, 2020). Additionally, given the significance of nitrogen fertilization on the yield of grain from the rice plant, it is essential to understand the optimal dose for each variety as well as how it affects various yield components and other agronomic parameters like the cycle, plant height, lodging, and grain moisture content in order to gain a better understanding of said effective response (Chaturvedi, 2006). Therefore, the present study was conducted to know the appropriate nitrogen levels for increasing the productivity and profitability of spring rice varieties in the Kanchanpur district.

MATERIALS AND METHODS

The experiment was conducted in the farmers' plot of the Mahuliya village (represents Terai) of the Rice super zone implementation site of PMAMP, Kanchanpur, during the spring of 2021. The experiment was laid out in two factorial Randomized Complete Block Design (RCBD) with three replications and nine treatments. The main field was heavily plowed and tilled two times. The size of the main field was 1.5 x 1.8 m^2 with 27 different plots. The treatment consisted of three levels of Nitrogen: 60 kg/ha, 120 kg/ha, and 180 kg/ha, and three rice varieties: Hardinath 1, Hardinath 3, and Chaite 5, combined to form nine treatments. As a source of NPK, urea (46%N), DAP (46%P), and MOP (60%K) were applied. A total of P & K and half nitrogen were applied as basal doses in all treatments. Half dose of nitrogen was applied to the standing crop by top dressing into two equal splits at tillering stage and panicle initiation stage of the crop.

Physio-chemical characteristics of the experimental soil

Soil samples were collected randomly from every four corners and a center experimental plot at 20 cm depth from the surface using a Shovel to analyze the initial soil physicochemical properties. The sub-samples were mixed, air-dried under shade, grounded, and sieved through a 2 mm sieve and a 0.5 mm sieve for organic matter determination. The samples were then collected in Plastic and sent to Soil Testing Laboratory, Sundarpur, Kanchanpur, for the test.

From the analysis, the soil texture of the research plot was found to be loam. The pH of the soil was neutral (6.84) in nature. The total nitrogen content of the soil was medium (0.08%), while available phosphorus (20.06 kg ha-1) and available potassium (121.2 kg ha-1) were low, respectively. The organic matter content of the soil was medium (1.68%).

RESULTS AND DISCUSSION

Agronomic characters

Plant height: The data for plant height were collected 30 DAS, 45DAS, 60DAS, 75DAS and 90DAS. The effect of rice varieties and N levels on plant height is illustrated in Table 1. Different nitrogen levels significantly influenced the plant height of rice at all growth stages. At all growth stages, the tallest plant height was recorded at a nitrogen level of 180kg/ha, followed by 120 kg/ha. At 30 days after sowing, the highest plant height (21.117cm) was observed with 180kgN/ha, which was statistically at par with the 120kgN/ha (19.847cm). At 45 DAS, the highest plant height (33.266cm) was observed with a nitrogen level of 180kg/ha (29.93cm) followed by 120kg/ha. At 60DAS tallest plant height (44.352cm) was observed at 180kg/kg

Table 1. Effect of nitrogen levels and rice varieties on plant height of rice plant (*O. sativa*) at Kanchanpur, Nepal, 2021.

Treatments	Plant height				
	30 DAS	45 DAS	60 DAS	75DAS	90DAS
Nitrogen levels					
N1(60kg/ha)	18.791[b]	30.028[c]	39.567[b]	51.926[b]	68.662[b]
N2(120kg/ha)	19.847[b]	31.406[b]	41.793[ab]	54.192[ab]	72.031[a]
N3(180kg/ha)	21.117[a]	33.266[a]	44.352[a]	56.311[a]	74.502[a]
F-probability	<0.01	<0.001	<0.01	<0.05	<0.01
Varieties					
V1 (Hardinath1)	19.755	30.424[c]	39.590[b]	47.843[c]	64.411[c]
V2 (Hardinath 3)	20.681	33.264[a]	45.995[a]	58.733[a]	79.687[a]
V3 (Chaite 5)	19.310	31.013[b]	40.127[b]	55.857[b]	71.096[b]
F-probability	NS	<0.001	<0.001	<0.001	<0.001
LSD (0.05)	NS	0.487	2.647	2.761	2.880
SEm (±)	0.410	0.162	0.883	0.921	0.960
CV %	6.176	1.545	6.322	5.103	4.024
Grand mean	19.918	31.567	41.904	54.144	71.621

Note: Treatment means separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance, DAS: days after sowing, NS= non-significant, LSD: Least Significant Difference, SEm: Standard error of the mean deviation, CV: Coefficient of Variance.

Table 2. Interaction effect of nitrogen levels and rice varieties on plant height of rice plant (*O. sativa*) at Kanchanpur, Nepal, 2021.

Treatments	Plant height (cm)				
	30DAS	45DAS	60DAS	75DAS	90DAS
Nitrogen level × Variety					
N1×V1	18.800	28.616[f]	36.276	44.530	61.260
N1×V2	18.950	32.240[c]	43.490	56.583	76.046
N1×V3	18.623	29.230[ef]	38.936	54.667	67.620
N2×V1	19.570	29.966[e]	39.790	48.043	65.016
N2×V2	21.090	33.243[b]	46.003	59.230	79.550
N2×V3	18.883	31.010[d]	39.586	55.316	71.416
N3×V1	20.896	32.690[bc]	42.703	50.956	66.896
N3×V2	22.033	34.310[a]	48.493	60.386	82.533
N3×V3	20.423	32.800[bc]	41.860	57.590	74.253
LSD (0.05)	NS	0.844*	NS	NS	NS
SEm (±)	0.236	0.093	0.509	0.531	0.554
CV (%)	6.176	1.545	6.322	5.103	4.024
Grand mean	19.918	31.567	41.904	54.144	71.621

Note: Treatment means separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance, DAS, days after sowing.

nitrogen level, which was statistically similar to 120kg/ha (41.793 cm, respectively). Similarly, at 75 DAS, the plant height was significantly higher (56.311cm) at 180kg/ha, which was statistically similar to 120kg/ha (54.192cm). At 90 DAS, the plant height was significantly higher (74.502cm) at 180kg/ha, which was statistically similar to 120kg/ha (72.031cm). Because of the stimulation of biosynthesis cytokinin and its emission from the root to the aerial parts of the plant, nitrogen elements cause an increase in cell division and, as a result, an increase in height, the number of tillers, and leaf area in rice plant (Jalali-moridani and Amiri, 2014). Among the nitrogen levels tested, the application of 180 kg N ha-1 resulted in higher growth characteristics, followed by the application of 150 kg N ha-1 during both years of testing. This could be because increasing nitrogen levels increase plant height, which could have resulted in more cell elongation and cell division in plant meristematic tissue, which play a crucial role in increasing plant height (Dahipahle and Singh, 2018). The addition of 144 or 192 kg N/ha recorded the tallest plants (Badawi and El-shayb, 2010). The nitrogen level of 160 N/kg resulted in significantly higher plant height, dry matter accumulation/m, and total tillers/running row compared to 100 kg N/ha, 120 kg N/ha, and 140 kg N kg/ha (Singh *et al.*, 2018). Plant height increased with increasing nitrogen rates up to 200 kg/ha, which was significantly higher than at other nitrogen levels (Salahuddin *et al.*, 2009). This finding is also in conformity with Mahato *et al.* (2019), who also discovered a correlation between the rise in nitrogen level and an increase in plant height. Increased N rates significantly increased the BRRI dhan58 plant's height, with 175 kg/ha producing the highest plant height (98.20 cm) (Jahan *et al.*, 2022). Plant height increased along with the increase in N rates, and at 250 kg/ha, it was discovered to be significantly higher than the other levels (Khairunniza-Bejo *et al.*, 2017). Increased nitrogen application may have improved the crop's availability of nitrogen, enhancing cell division, photosynthesis metabolism, assimilation, and production, leading to taller plants (Bhavathi *et al.*, 2021).

Regarding rice varieties, highly significant results were obtained except at 30 DAS. At 45 days after sowing, plant height was recorded higher in Hardinath 3 (33.264cm) followed by Chaite 5 (31.013cm). At 60 days after sowing, the tallest plant height was observed in Hardinath 3 (45.995cm), followed by Chaite 5 (40.127cm). At 75 DAS tallest plant height was recorded in Hardinath 3(58.733cm), which was statistically similar to Chaite 5(55.857). Furthermore, at 90 days after sowing, the plant height of Hardinath 3 (79.687cm) was higher than the plant height of Chaite 5 and Hardinath1 (71.096 cm and 64.411cm, respectively). This variation in plant height in rice varieties might be due to varietal characteristics.

Interaction effect of nitrogen levels and rice varieties on plant height of rice

The interaction effect of nitrogen levels and rice varieties on plant height was significant only at 45DAS (Table 2). Maximum plant height (32.52cm) was produced by the treatment N3V2 (180 kg/ha & Hardinath3) which was followed by the treatment N2V2 (120 kg/ha & Hardinath 3) which was statistically similar to N3*V3 and N3V1 (32.800 and 32.690, respectively). The other treatment produced significantly lower plant height.

Number of tillers per m^2: The data were collected on 30 DAS, 45DAS, 60DAS, 75DAS, and 90DAS respectively. The N levels and rice varieties significantly influenced the number of tillers at all growth stages (Table 3). Nitrogen levels significantly influenced the number of tillers per square meter during all growth stages. At 30 days after sowing, the highest number of tillers (277.778 m-2) was recorded at 180kg/ha, followed by 120kg/ha (211.111 m-2). At 45 days after sowing, 180kg/ha nitrogen application showed the maximum number of tillers (967.222 m -2) which was statistically similar to 120 kg/ha (808.333m-2). At 60 DAS, the maximum number of tillers (1462.222 m-2) was observed at 180 kg/ha, followed by 120kg/ha (1268.333 m-2). The tiller number increased and reached the maximum at 60 DAS, and after that was a decline in tiller number per meter square due to tiller mortality. At 75 DAS, the highest number of tillers (1242 m^{-2}) were recorded when 180kg/ha of nitrogen was applied, followed by 120kg/ha (1086.67). At 90 days after sowing highest tiller number was observed with 180kg/ha (1101.667 m^{-2}), which was statistically similar to Nitrogen doses of 120kg/ha, which again produced a statistically similar number of tillers as with 60 kg/ha (928.33 m^{-2} & 810 m^{-2} respectively). The result indicated that 180kg/ha nitrogen level was found more effective in increasing the number of tillers. The highest number of tillers per square meter may be caused by increased nutrient uptake and higher nitrogen availability to crops (Dahipahle *et al.*, 2018). Additionally, the positive effects of increased N application on tiller production were seen by Ramesh *et al.* (2009). There were more tillers per square meter when N was applied (Mandana *et al.*, 2014). Since nitrogen helps plants grow vegetatively, 140 kg/ha produces more tillers per square meter (Bokado *et al.*, 2020). The higher number of effective tillers/m2 found in 160 kg N/ha and 140 kg N/ha may be due to better growth and early tiller initiation before the onset of reproductive growth (Singh *et al.*, 2018). N levels significantly affected the tiller per square meter (Jahan *et al.*, 2022). The varieties' ability to till was significantly enhanced by the addition of nitrogen (Nneke, 2016). Regarding the varieties, significant results were observed in the number of tillers. At 30 days after sowing, the maximum number of tillers (262.222 m^{-2}) was recorded with Chaite 5 followed by Hardinath 1 (195.566 m^{-2}). At 45 days after sowing, the highest tillers number was recorded with Chaite 5 (852.778 m^{-2}) which was statistically similar to Hardinath 1. (846.111 m^{-2}). And at 60 DAS, 75 DAS, and 90 DAS significantly higher number tillers (1308.333 m^{-2}, 1116.111 m$^{-2,}$ and 1007.778 m^{-2} respectively) were recorded to Chaite 5 which was statistically similar with the Hardinath 3 (1293.333 m^{-2}, 1109.444 m^{-2}, and 990.556 m^{-2} respectively). These observed results might be due to the varietal characteristics.

Table 3. Effect of nitrogen levels and rice varieties on tiller number of rice plant (*O. sativa*) at Kanchanpur, Nepal, 2021.

Treatments	Number of tillers per m^2				
	30 DAS	45 DAS	60 DAS	75DAS	90DAS
Nitrogen levels					
N1(60kg/ha)	143.333^c	650.556^c	1105.000^c	910.556^c	810.000^c
N2(120kg/ha)	211.111^b	808.333^b	1268.333^b	1086.667^b	928.333^b
N3(180kg/ha)	277.778^a	967.222^a	1462.222^a	1242.778^a	1101.667^a
F-probability	<0.001	<0.001	<0.001	<0.001	<0.001
Varieties					
V1 (Hardinath1)	195.556^b	846.111^a	1233.889^b	1014.444^b	841.667^b
V2 (Hardinath 3)	174.444^b	727.222^b	1293.333^a	1109.444^a	990.556^a
V3 (Chaite 5)	262.222^a	852.778^a	1308.333^a	1116.111^a	1007.778^a
F-probability	<0.001	<0.05	<0.01	<0.001	<0.05
LSD (0.05)	27.748	89.355	42.562	43.605	112.676
SEm (±)	9.255	29.429	14.197	14.544	37.583
CV %	13.175	11.056	3.331	4.040	11.910
Grand mean	210.740	808.703	1278.519	1080	946.667

Note: Treatment means separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance, DAS: days after sowing, NS= non-significant, LSD: Least Significant Difference, SEm: Standard error of the mean deviation, CV: Coefficient of Variance.

Table 4. Different yield attributing characters of rice plant (*O. sativa*) as affected by the nitrogen levels and rice varieties at Kanchanpur, Nepal, 2021.

Treatments	Yield attributing characters				
	PL (cm)	ET (no/m^2)	FGPP	TGW	S%
Nitrogen levels					
N1(60kg/ha)	23.011^c	435.833^c	94.461^b	22.550	42.544^a
N2(120kg/ha)	24.370^b	511.944^b	115.370^a	22.837	38.694^a
N3(180kg/ha)	25.241^a	577.222^a	116.490^a	22.378	33.806^c
F-probability	<0.001	<0.001	<0.001	-	<0.001
Varieties					
V1(Hardinath1)	22.287^c	454.722^c	101.771^b	22.065^b	31.363^c
V2 (Hardinath 3)	25.688^a	503.333^b	87.801^c	24.600^a	47.693^a
V3 (Chaite 5)	24.645^b	566.944^a	136.748^a	21.100^b	35.988^b
F-probability	<0.001	<0.001	<0.001	<0.05	<0.001
LSD (0.05)	0.265	44.095	9.016	2.211	2.347
SEm (±)	0.088	14.708	3.007	0.737	0.783
CV %	1.098	8.680	8.294	9.794	6.126
Grand mean	24.207	508.333	108.773	22.588	38.348

Note: Treatment means separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance, DAS: days after sowing, NS= non-significant, LSD: Least Significant Difference, SEm: Standard error of the mean deviation, CV: Coefficient of Variance.

Yield attributing characters of rice

The effect of rice varieties and nitrogen levels on yield attributing characters (Panicle length (PL), Effective tiller (ET), Filled grains per panicle (FGPP), Thousand grain weight (TGW), Sterility percentage (S%)) is illustrated in Table 4.

Panicle length: The mean value of panicle length in the response to nitrogen levels was highly significant. The longest panicle length (25.241cm) was recorded at 180kg/ha followed by 120kg/ha (24.370cm). Dahipahle *et al.* (2018) and Singh *et al.* (2018) came to similar results. Nitrogen applications were compared, and 160 kg N ha-1 resulted in longer panicles and more grains per panicle (Kumar *et al.*, 2019). The most extended panicle length was found at 140 kg N ha-1, which suggests that nitrogen played a role in both panicle formation and elongation. As a result, increased N-fertilization caused panicle length to increase (Bokado *et al.*, 2020). 180kg/ha was found to be the most effective for panicle length (Sah *et al.*, 2019). These results align with those attained by Bhuiyan *et al.* (2017). With higher nitrogen levels, panicle length increased noticeably (Bhavathi *et al.*, 2021). Ghoneim *et al.* (2018) also reported the longest possible panicle at the highest nitrogen application level. Panicle length was significantly influenced by varieties. The longest panicle length (25.688cm) was observed with Hardinath 3 and followed by Chaite 5 (24.645cm).

Effective tillers per square meter: A highly significant result was obtained due to nitrogen levels. The highest number of effective tillers (577.222m-2) was found in the treatment of nitrogen with 180kg/ha, which was statistically similar to the nitrogen dose of 120kg/ha with 511.944 m-2. A nitrogen level of 140 kg/ha produced the highest number of active tillers per square meter, which may be related to sufficient nitrogen favoring cellular activity during panicle formation and development, which increased the number of active tillers per square meter (Bokado *et al.*, 2020). These results agree well with those that were previously reported by Dahipahle *et al.* (2018), Singh *et al.* (2018), and Bhuiyan *et al.* (2017). With nitrogen level of 240 kg/ha, the greatest number of productive tillers was observed (Bhavathi *et al.*, 2021). Regarding the variety, the highest number of effective tiller (566.944 m^{-2}) was obtained to Chaite 5 which was statistically similar to Hardinath 3 (503.333 m^{-2}). Least number of effective tillers (454.722) was recorded with Hardinath 1.

Filled grain per panicle: Filled grain per panicle was significantly influenced nitrogen levels. Maximum filled grain per panicle (116.490) was recorded at 180kg/ha, statistically at par with 120kg/ha (115.370). The least filled grain (94.461) was observed at a 60kg/ha nitrogen level. These results are in agreement with the findings of Bokado *et al.* (2020). Panicle length and grains per panicle increased noticeably with nitrogen application of 180 kg/ha (Dahipahle *et al.*, 2018). Increases in nitrogen rate from 0 to 220 kg N ha-1 significantly increased the number of filled grains per panicle for all rice genotypes (Ghoneim *et al.*, 2018). At 320 kg N/ha, the number of grain panicles that were filled was significantly higher (Bhavathi *et al.*, 2021). A significantly higher number of filled grain (136.748) per panicle was obtained with Chaite 5, which was followed by variety Hardinath 1 (101.771). A lower number of filled grain (87.801) was recorded with variety Hardinath 3.

Thousand-grain weight: Nitrogen levels had no significant effect on the thousand-grain wight because 1000 grain weight as it is governed by varietal character rather than nitrogen levels. Kumar *et al.* (2019) observed similar outcomes in their experiment. When various N fertilizer contents were used, there was no observable difference in the weight of 1000 grain (Mandana *et al.*, 2014). Thousand-grain weights were significantly influenced by rice varieties. The 1000 grain weight was observed higher in Hardinath 3 (24.600g) followed by Hardinath 1(22.065g). The least 1000 grain weight was observed in Chaite 5 (21.100g).

Sterility%: Sterility % was significantly influenced by nitrogen levels. The highest sterility percentage (42.544%) was recorded at 60kg/ha which was followed by 120kg/ha (38.694%). Significantly lowest sterility percentage (33.860%) was found at 180kg/ha, respectively. The outcome was consistent with that of Bhuiyan *et al.* (2017). Increased nitrogen application rates resulted in measurable increases in the number of unfilled grains per panicle for all rice genotypes (Ghoneim *et al.*, 2018). Regarding variety, highest sterility was observed in Hardinath 3 (47.693%) which was statistically similar to Chaite 5 (35.988%). Least sterility % was recorded with Hardinath 1(31.363%).

Measurement of yields

The effect of rice varieties and nitrogen levels on yield parameters (Grain yield, straw yield, biological yield and harvest index) is illustrated in Table 5.

Grain yield: Grain yield is determined by function of various yield attributing characters (effective tiller $m^{-2,}$ panicle length, filled grain per panicle, thousand-grain weight, sterility percentage, etc.), environmental factors, input applied, and their management. Grain yield responded to nitrogen levels and varieties because all those parameters were influenced by both the nitrogen levels and rice varieties. The grain yield of rice was significantly affected by nitrogen levels. A significantly superior grain yield (4.732tha-1) was recorded with a higher dose of nitrogen at 180kg/ha, which was statistically par with the 120kg/ha nitrogen level (4.316tha-1). The least yield (3.704 to-1) was recorded at 60kg/ha. Table 5 showed yield increase with the increasing nitrogen level from 60 to 180kg/ha. Nitrogen level had a significant effect on yield and the highest yield at 300 kg/ha (ZHU *et al.*, 2017). These findings are similar with those reported by Badawi and El-shayb (2010), Sakarwar *et al.* (2014), Singh *et al.* (2018), and Mahajan *et al.* (2012). Higher nitrogen applications may have improved biomass accumulation through improved rice growth rates, photosynthesis, promoting internode lengthening, activities of growth hormones like gibberellins, and other physiological processes. Higher grain and straw yields were seen with the application of 160 kg N ha-1 compared to 120 kg N ha-1 for nitrogen levels (Kumar *et al.*, 2019). It is possible that the increase in nitrogen levels, which enhanced traits that contribute to yield like the Number of grains panicles per plant and test weight, contributed to the highest grain yield, which was achieved at 140 kg of nitrogen per hectare (Bokado *et al.*, 2020). The nitrogen rate increased along with the grain yield, which peaked at 180 kg N/ha (Sakarwar, 2014). According to the experiment conducted by Hirzel *et al.* (2020), significantly impacted grain yield. Grain yield increased significantly as nitrogen rates were raised from 0 to 220 kg N ha-1, with 220 kg N ha-1 showing the highest grain yield values and 165 kg/ha coming in second (Ghoneim *et al.*, 2018). The rice yield increased as N did, peaking at 10,981 kg/ha at 202 kg/ha (Harrell and Blanche, 2010). The Grain yield of rice was significantly influenced by varieties also. Maximum yield (5.31 tha^{-1}) was obtained with Chaite 5 (4.607 tha^{-1}) followed by variety Hardinath 3 (4.127 tha^{-1}) which was statistically similar to variety Hardinath 1 (4.017 tha^{-1}). The highest grain yield was obtained in Chaite 5 might be due to the highest number of effective tillers, filled grains per panicle.

Table 5. Different yield measurements of rice plant (*O. sativa*) as affected by rice varieties and nitrogen levels at Kanchanpur, Nepal, 2021.

Treatments	Measurement of yields			
	Grain yield (ton/ha)	Straw yield (ton/ha)	Biological yield (ton/ha)	Harvest index (HI)
Nitrogen level				
N1(60kg/ha)	3.704^{c}	8.260^{c}	11.965^{c}	0.309
N2(120kg/ha)	4.316^{b}	9.312^{b}	13.629^{b}	0.317
N3(180kg/ha)	4.732^{a}	10.564^{a}	15.296^{a}	0.310
F-probability	<0.001	<0.001	<0.001	-
Varieties				
V1(Hardinath 1)	4.017^{b}	8.833^{b}	12.851^{b}	0.312
V2(Hardinath 3)	4.127^{b}	9.271^{b}	13.398^{b}	0.308
V3(Chaite 5)	4.607^{a}	10.033^{a}	14.641^{a}	0.315
F-probability	<0.001	<0.01	<0.001	-
LSD (0.05)	0.243	0.629	0.615	NS
SEm (±)	0.081	0.210	0.205	0.006
CV (%)	5.730	6.717	4.516	6.599
Grand mean	4.251	9.379	13.630	0.312

Note: Treatment means separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance, DAS: days after sowing, NS= non-significant, LSD: Least Significant Difference, SEm: Standard error of the mean deviation, CV: Coefficient of Variance.

Straw yield: Rice straw was significantly influenced by nitrogen levels. At higher doses of nitrogen, the straw yield (10.564tha^{-1}) was found significantly higher, followed by 120kg/ha nitrogen level with 9.312tha^{-1}. The lowest straw yield (8.260tha^{-1}) was observed at the lower level of nitrogen of 60kg/ha. An increase in the plant height, green leaves per hill, and dry matter production are apparent with the balanced and optimum application of fertilizer: which finally results in higher straw yield. Similar conclusions were reported by Singh *et al.* (2018) and Badawi and El-shayb (2010). Higher tiller per meter square and leaf area index values at higher nitrogen applications of 180 kg/ha during the two years of the experiment increased dry matter accumulation at comparable growth stages (Dahipahle *et al.*, 2018). Higher nitrogen rates may have increased leaf area, which in turn increased photo assimilates and the accumulation of dry matter, resulting in the highest straw yield of 140 kg N kg/ha (Bokado *et al.*, 2020). The straw yield was significantly higher at 180 kg/ha (Thind *et al.*, 2018). Rice varieties significantly influenced the straw. Maximum straw yield (10.033 tha^{-1}) was recorded with variety Chaite 5, which was statistically similar to Hardinath 3 (9.271 tha-1). The least straw yield was recorded with Hardinath 1. Maximum straw yield may be due to highest tillers per square meter in Chaite 5.

Biological yield: The N levels had a statistically significant influence on biological yield. The highest biological yield (15.296 tha^{-1}) was found at 180 kg/ha, followed by nitrogen level 120kg/ha (13.629tha^{-1}), The lowest biological yield was found with 60kg/ha (11.965tha^{-1}). Nitrogen application increased biological yield by raising plant height, tiller density, photosynthesis rate, and dry matter production. Bhuiyan *et al.* (2017) came to similar results. Regarding the rice varieties, the highest biological yield was recorded with Chaite 5 (14.641tha^{-1}) which was statistically similar to Hardinath 3 (13.398tha^{-1}) which in turn was statistically similar to Hardinath 1 (12.851tha^{-1}).

Harvest index (HI): There was no significant difference in HI due to nitrogen level. Nitrogen concentrations had no discernible impact on the harvest index (Jalali-moridani and Amiri, 2014). Similar conclusions were reported by Sakarwar, (2014). Different nitrogen levels also had a negligible impact on harvest index (Kumar *et al.*, 2019). Regarding the rice varieties also, no significant influence was observed.

Conclusion

At various nitrogen levels and rice varieties, the yield and yield-attributing parameters, such as plant height, tiller number per square meter, effective tiller per square meter, panicle length, filled grains per panicle, and yield, were significantly different. The variety Chaite 5 and nitrogen level of 180 kg/ha, respectively, produced the highest yields of rice. Based on the results, it can be said that a nitrogen level of 180 kg/ha is ideal because it results in a higher yield. Additionally, variety Chaite5 outperformed Hardinath1 and Hardinath3 for most of the growth, yield, and quality parameters based on the overall performance of the varieties.

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