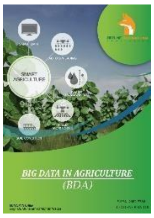
ZIBELINE INTERNATIONAL™ PUBLISHING
ISSN: 2682-7786 (Online)
CODEN: BDAIDR

Big Data in Agriculture (BDA)

DOI: http://doi.org/10.26480/bda.01.2023.36.42



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RESEARCH ARTICLE

ASSESSING THE OPTIMAL LEVEL OF NPK FERTILIZERS FOR ENHANCING PRODUCTION OF SPRING RICE IN KANCHANPUR, NEPAL

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ARTICLE DETAILS

Article History:

Received 23 September 2023
Revised 15 October 2023
Accepted 27 November 2023
Available online 05 December 2023

ABSTRACT

Spring rice plays important role in ensuring food self-sufficiency by complementing the production of main season rice in Nepal. To assess the optimal level of nitrogen, phosphorous and potassium in spring rice, a field experiment was conducted in Kanchanpur district, during Feb- June 2023. The experiment was laid out in randomized complete block design with three replications and seven treatments viz., (T1), 120:40:40 NPK kg/ha, (T2), 180:40:40 NPK kg/ha, (T3), 60:40:40 NPK kg/ha, (T4), 120:60:40 NPK kg/ha, (T5), 120:20:40 NPK kg/ha, (T6), 120:40:60 NPK kg/ha and (T7), 120:40:20 NPK kg/ha. Hardinath-1 variety of rice was transplanted at spacing of 20 cm × 15 cm in all the plots. Data for growth parameters, yield attributes, and yield were collected and analyzed. Analysis of variance for all the parameters was done and treatments were compared at 5% level of significance. The statistical analysis revealed that the treatment T2, 180:40:40 NPK kg/ha was statistically superior in terms of yielding plant height, effective tillers, panicle length, grain yield and straw yield ($P< 0.05$). An increase of 20.52%, 30.19% and 50.68% was observed in number of effective tillers, grain yield and straw yield respectively in T2 over the recommended dose of government i.e. T1 (120:40:40 NPK kg/ha). Similarly, T2; 180:40:40 NPK kg/ha, where nitrogen level was increased by 50 % on government recommendation, provided highest gross return, net return and the benefit cost ratio of 2.35. Therefore, the fertilizer dose 180:40:40 NPK kg/ha is suggested for better productivity of spring rice in Kanchanpur, Nepal.

KEYWORDS

Government recommendation, Growth parameters, Hardinath-1, Yield

1. INTRODUCTION

Nepal is the agriculture based developing country and its agrarian sector is dominated by cereal crops, primarily, rice, maize, and wheat. Rice (*Oryza sativa* L.) alone covers about 50% of total cereal crop production in Nepal (Agriculture Information & Technology Center [AITC], 2022) and hence occupies first place in terms of area (14,77,378 ha), production (51,30,625 MT) and preferences in Nepal (Dhungana et al., 2022). This crop contributes significantly to 4 % of country's GDP and 13.6% to AGDP (Ministry of Agriculture and Livestock Development (MoALD, 2023). The demand for rice is predicted to rise from 439 million MT in 2010 to 496 million MT by 2020, 553 million MT by 2035, and 623 million MT by 2050 (Timsina et al., 2023). In Nepal, rice could be grown throughout the year i.e. during rainy season, winter season and spring season. Spring rice also called "Chaite Dhan" has huge scope in complimenting the demand of rice production in Nepal. Considering its huge potential in sufficient grain production and ensuring food security in Nepal, it has been prioritized by government of Nepal in current periodic plans and policies (Regmi et al., 2023).

Currently, spring rice occupies 8 % of total land under rice in Nepal and is cultivated over 1310 ha in Sudurpashim Province. The productivity of spring rice is 4.67 t/ha, which is higher than that of main season rice (3.37 t/ha). Despite its huge potential, productivity and profitability of rice crop is low in Nepal as compared to other Asian countries. Erratic and uneven distribution of rainfall, lack of high yielding and climate smart varieties, weed infestation, increased insect pests and poor soil conditions are some of the key challenges faced by the rice growers of Nepal (Karki et al., 2018). The use of chemical fertilizers was maximum in paddy crop 76%, followed by wheat at 59%, maize at 49%, potato at 44%, and vegetables at 23% (Census Report, 2023).

The use of chemical fertilizers in Nepal has increased by 48.26 % in last decade (MoALD, 2022). The excessive use of synthetic pesticides and fertilizers can have negative impact on both the environment and human health, as reported by (Kumar and Dev, 2017). The majority of farmers apply excessive or imbalanced amounts of chemical fertilizers without proper soil test recommendations or considering the actual nutrients requirements of the crop. In absence of adequate organic manures, continuous and imbalanced application of fertilizers has been the major cause for declining soil fertility in the fertile terrain of Nepal (Tripathi, 2019). Thus, improper and haphazard use of chemical fertilizers especially in paddy field is one of the major issues demanding proper attention from all the stakeholders.

For achieving sustainable agricultural production and improving environment quality, a good fertilization strategy is needed (Devkota et al., 2019). For this, government of Nepal endorsed fertilizer recommendation (120:40:40 NPK kg/ha) for rice crop which assumed the whole country as one domain without factoring the site-specific soil, weather conditions, specific crop management practices, crop varieties, cropping pattern and growing seasons (AITC, 2022). This demands comparison of government recommended dose with different levels of macro nutrients under various growing seasons and under different cropping system for achieving optimum rice production at low cost. So, this study focused on determining the optimal combination of macro nutrients for profitable spring rice production in a Rice-Rice-Rapeseed cropping system.

Quick Response Code	Access this article online	
	Website: www.bigdatainagriculture.com.my	**DOI:** 10.26480/bda.01.2023.36.42

Cite The Article: T.B. Manni, R. Sharma (2023). Assessing the Optimal Level of NPK Fertilizers for Enhancing Production of Spring Rice in Kanchanpur Nepal. *Big Data in Agriculture, 5(1): 36-42.*

2. Materials and Methods

2.1 Description of experimental site

The field experiment was conducted during spring season of 2023 at Bedkot Municipality-01, the command area of Rice Super Zone under Prime Minister Agriculture Modernization Project in Kanchanpur district of Nepal. Located at 28° 34' North latitude and 80° 8' East longitude, the site has subtropical humid climate, receives average rainfall of 1300-2500 mm annually and has clay loam to clay soil. The experiment was conducted from 26th February 2023 in the farmer's field which had clay soil with soil pH 7.6. The soil test report revealed that the study site had poor nutrient status viz. nitrogen (0.08%), organic matter content (1.6%), potassium (98.4 kg/ha) and phosphorous (58.4 kg/ha) as shown in Table 1.

During the experimental period, highest temperature was observed during the month of June i.e. 41.56 °C i.e. at crop maturity whereas lowest temperature of 7.84 °C was observed during the month of February. The site received average precipitation of 125.07 mm during the growing period with the highest on June and the lowest on the March. The relative humidity ranged from 31.88 % to 65.94 % during the growing season.

Table 1: Physio-chemical properties of soil at study site, 2023

Description	Content	Type/level
Soil type	Clay soil	-
pH	7.6	Basic
Organic matter	1.63%	Low
Nitrogen	0.08%	Low
Phosphorus	54.36 Kg/ha	Medium
Potassium	98.40 Kg/ha	Low

(Source: Soil and Fertilizer Testing Laboratory, Sundarpur, Kanchanpur, Nepal)

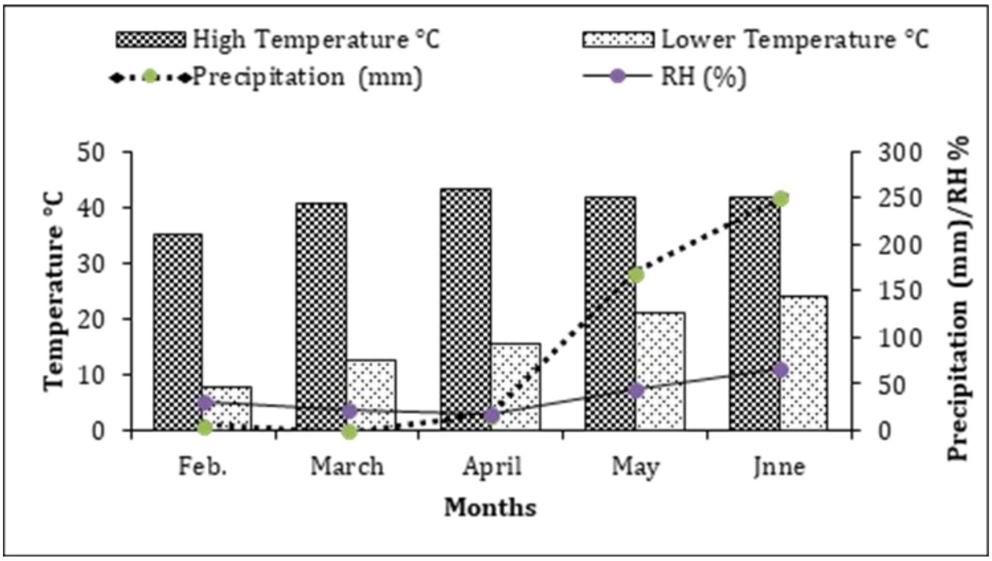

Figure 1: Weather condition of study site during study period (source: https://power.larc.nasa.gov/data-access-viewer/)

2.2 Experimental details

The experiment was set up in randomized complete block design (RCBD) with three replications and seven treatments i.e. different level of nutrient contents as shown in Table 2. For supplying the nutrient contents, fertilizers used were viz. Urea (46% N), Di-Ammonium Phosphate (18%N, 46% P2O5) and Muriate of Potash (60% K2O). For all the treatments, half dose of nitrogen and full dose of phosphorus and potash was applied as basal dose during transplanting whereas the remaining half dose of nitrogen was applied as top dressing after 40 days of transplanting. The size of plot receiving each treatment was 3m x 2m. There were altogether 21 plots, each plots were separated by 30 cm bund and each replication by 1m.

Table 2: Total treatment details, Kanchanpur, Nepal, 2023

Treatments	Remarks
T1 -120:40:40 NPK kg/ha	Recommended dose (R.D)
T2-180:40:40 NPK kg/ha	Nitrogen increased by 50% on R.D
T3-60:40:40 NPK kg/ha	Nitrogen decreased by 50% on R.D
T4-120:60:40 NPK kg/ha	Phosphorus increased by 50% on R.D
T5-120:20:40 NPK kg/ha	Phosphorus decreased by 50% on R.D
T6-120:40:60 NPK kg/ha	potassium increased by 50% on R.D
T7-120:40:20 NPK kg/ha	potassium decreased by 50% on R.D

2.3 Cultivation practices

Hardinath-1, the most common variety among spring rice growers in Far Western Province was selected for the study. Seed was sown on 26th February on plastic trays. For raising the seedlings, the medium was prepared by mixing 15 kg FYM, 200 gm Urea with fine soil, which were filled in the trays before to sowing. The main field preparation was done by 2 times with rotavator, 15 days before transplanting. FYM (84 kg i.e. @ 4 kg per plot; 6 ton/ha) was applied before puddling and chemical fertilizers Urea (46%N), Di- Ammonium Phosphate (18%N, 46% P2O5), Muriate of Potash (60%K2O) were was applied after puddling in each experimental unit as per treatment allotment. 22 days old seedlings were transplanted in each plot at spacing of 20cm × 15 cm. Two seedlings were transplanted per hill. The rice field was irrigated regularly from 3 days after transplanting to 20 days after transplanting and 3cm water level was maintained till the milking stage. For proper weed management, Pretilachlor 50 EC @ 5ml in 1 lit. water was applied two days after transplanting and manual weeding was done 50 days of transplanting. Manual harvesting was done 96 days after transplanting. Harvesting and threshing for each plot was done separately.

2.4 Data collection and observation

2.4.1 Growth parameters

2.4.1.1 Plant height

The plant height was taken from randomly selected 10 plants from different rows other than border row at 30, 50 and 75 DAT. The plant height was taken from the base of the plant to the tip of the panicle. Mean plant height was taken from the tagged main tillers of each hill in centimeters.

2.4.1.2 Number of tiller per hill

Tiller from randomly selected 10 hills was counted at 30 and 50 DAT. Main stem was also counted for calculating the total tiller number per hill. Tiller numbers were then averaged for this parameter.

2.4.2 Yield and yield attributing traits

2.4.2.1 Number of effective tiller per square meter

The number of panicle bearing tillers per m^2 were counted just before harvesting the crop.

2.4.2.2 Panicle length

The randomly selected 10 panicles from each plot were measured for panicle length from the base of the panicle to tip of the panicle and the mean value was taken as panicle length of each plot in cm.

2.4.2.3 Grain sterility %

To calculate sterility percentage total number of sterile grains per panicle and filled grains per panicle were counted manually from the panicles obtained from 10 random hills of each plot. The average value of both the parameters were taken for each plot and sterility percent was calculated using following formula.

$$Sterility\,\% = \frac{Number\ of\ unfilled\ grain}{Total\ grain\ per\ panicle} \times 100$$

2.4.2.4 Thousand grain weight

Thousand grains were counted from randomly selected panicles for each plot and weighed at 14% moisture content. The thousand grains weight was expressed in gram (g).

2.4.2.5 Grain yield

The total weight of grains from each plot was recorded immediately after threshing and was calculated in kg/ha at 14% moisture as:

$$Grain\ yield\ kg/ha\ 14\,\%\ moisture = \frac{(100 - MC) \times plot\ yield(kg) \times 1000\,m2}{(100 - 14) \times A}$$

Where, MC = Moisture content of grain (%) just before weighing the bulk

A = Net plot area (m^2)

(100-MC) / (100-14) = Conversion factor for grain yield at 14% moisture content.

(1000) / A = Conversion factor for actual harvested area into hectare basis.

2.4.2.6 Straw yield

The straw obtained from the net plot area of each plots was sun dried for 3-4 days and weighed. The yields obtained from net plot was converted into ton per hectare.

2.4.2.7 Harvest index (HI)

Harvest index was computed by dividing grain yield with total biomass yield as per following formula;

$$HI = \frac{Economic\ Yield\ (Grain\ Yield)}{Biological\ Yield\ (Grain\ Yield + Straw\ Yield)}$$

2.5 Data analysis tools and techniques

2.5.1 Statistical analysis

Data were recorded for each treatment and tabulated in MS Excel. Data were analyzed using RStudio with R 4.3.0 version and doe bioresearch package. Randomized complete block design one- way ANOVA was used to analyze data. Treatment means were compared with Duncan's multiple range tests (P ≤0.05) and the simple linear correlation and regression were also established by using MS Excel.

2.5.2 Economic analysis

For calculating cost of cultivation, all the cost incurred for each treatment and the amount obtained from selling the grain and straw were calculated for 1 ha. Calculation of the cost of cultivation, gross return, net return and benefit cost ratio of all the 7 treatments were done. The cost of cultivation and gross return was determined on the basis of local market price of study site. The monetary value of total grain and straw production were taken as gross return. The net return was calculated by subtracting total cost from gross return. The B:C ratio was computed as per following formula.

$$B{:}C\ Ratio = \frac{Gross\ Return\ (NRs.)}{Cost\ of\ cultivation\ (NRs.)}$$

3. Results and Discussion

3.1 Growth parameters of spring rice

Table 3: Impact of different levels of NPK fertilizers on growth parameters of spring rice, Kanchanpur, Nepal, 2023

Treatments	Plant Height (cm)			Tiller number per hill (count)	
	At 30 DAT	At 50 DAT	At 75 DAT	At 30 DAT	At 50 DAT
(T1), 120:40:40 NPK kg/ha	31.87^{a}	48.53^{cd}	89.1^{bc}	7.367	9.4
(T2), 180:40:40 NPK kg/ha	34.33^{a}	58.6^{a}	98.47^{a}	7.9	12.93
(T3), 60:40:40 NPK kg/ha	26.8^{b}	44.7^{d}	84.87^{c}	5.63	7.37
(T4), 120:60:40 NPK kg/ha	32.03^{a}	50.57^{bc}	91.8^{b}	7.47	10.36
(T5), 120:20:40 NPK kg/ha	33.97^{a}	54.37^{ab}	93.3^{ab}	6.23	8.63
(T6), 120:40:60 NPK kg/ha	34.20^{a}	52.13^{bc}	91.47^{b}	8.46	11.23
(T7), 120:40:20 NPK kg/ha	31.20^{a}	51.0^{bc}	90.37^{bc}	6.4	9.2
SEm (±)	1.427	1.855	1.89	0.712	1.13
LSD (0.05 %)	4.398	5.717	5.826	2.194	3.483
F-Probability	*	**	*	ns	ns
C.V (%)	7.723	6.251	3.585	17.456	19.825
Grand Mean	32.057	51.414	91.338	7.066	9.876

Description: DAT, days after Transplantation, LSD, least significance difference, SEm, standard error of mean; CV, coefficient of variation, ** represent significant at 1% level, * represent significant at 5% level, ns, Non-significant, '.' represent significant at 10% level, Treatment mean followed by same letter(s) are non-significance difference on Duncan multiple range test at 0.05 level of significance.

3.1.1 Plant height

Significant influence of different levels of NPK fertilizers were observed in plant height across all growth stages as shown in Table 3. In early growth stage i.e. at 30 days after transplanting, all the treatments showed statistically similar effect on plant height except T3 i.e. 60:40:40 kg NPK/ha, when nitrogen fertilizer was applied lesser than 120 kg/ha. The result revealed that nitrogen fertilizer alone is responsible for vigorous growth at early growth stage than other two macro nutrients. Similarly, plant height was found to be significantly taller when nitrogen was applied at greater amount i.e. 180 kg/ha as compared to 120 kg N/ha with similar level of potassium and phosphorus content. Similar results were observed in paddy by (Giri et al., 2022; Puri et al., 2021). The result showed that T2 (180:40:40 kg NPK/ha) showed the greatest plant height followed by T5 (120:20:40 kg NPK/ha), T6 (120:40:60 kg NPK/ha) and T7 (120:40:20 kg NPK/ha) and T4 (120:60:40 kg NPK/ha) respectively. The treatments T7, T6 and T4 were statistically at par in yielding the plant height.

Increase or decrease in phosphorous and potassium levels showed statistically similar effect on plant height at 50 DAT and 75 DAT at 120 kg N/ha. Higher level of nitrogen application improves the availability of nitrogen content in soil thus enhancing cell division, photosynthesis metabolism, assimilation, leading to taller plants (Bhavathi et al., 2021). Potassium when increased more than 20 kg/ha at 50 DAT did not contribute significantly to the plant height at 120 kg N/ha and 40 kg P/ha. Similarly, plant height at 50 and 75 DAT at T1 was significantly inferior to T5 and T4. It means 20 kg phosphorous showed superior effect on plant height at similar level of nitrogen and potassium than 60 kg/ha and 40 kg/ha phosphorous. This might be due to availability of phosphorus content in the soil as evident from the Table 2. Similarly, it is found that increased amount of phosphorous in the soil might have shown negative effect on plant height. As reported in a research, the solubility and plant availability of P is maximum at pH 6.5 which declines as the pH increases into the alkaline range (Hopkins and Ellsworth, 2005).

3.1.2 Tiler Number per hill

The influence of different levels of NPK fertilizers was found to be non-significant on total number of tiller per hill at 5% level of significance however, numerically the highest number of tiller per hill (8.47) were displayed in 120:40:60 NPK kg/ha and T2- 180:40:40 kg NPK/ha at 30 and 50 days after transplanting respectively whereas the lowest number of tiller per hill were observed in T3-60:40:40 kg NPK/ha. It implies that the effect of different NPK fertilizer had no any measurable effect on tiller number per hill at early growth stage of spring rice. This result is in line with the findings of which revealed non-significant effect of NPK on tiller per hill at 50 DAT but significant at other growth stages for chaite-5 variety (Adhikari et al., 2021).

3.2 Yield attributes of spring rice

Table 4: Impact of different levels of NPK fertilizers on yield attributing traits and yields of spring rice, Kanchanpur, Nepal, 2023

Treatments	Effective tiller/m^2 (count.)	Panicle Length (cm)	Grain Sterility %	Test Weight (g)	Grain Yield (ton/ha)	Straw Yield (ton/ha)	HI
(T1), 120:40:40 NPK kg/ha	357.33^{b}	22.45^{bc}	34.51	19.67	5.84^{bc}	8.05^{b}	0.42
(T2), 180:40:40 NPK kg/ha	430.67^{a}	24.38^{a}	34.79	20.67	7.72^{a}	12.13^{a}	0.39
(T3), 60:40:40 NPK kg/ha	388.33^{b}	21.29^{c}	29.09	18.67	5.06^{c}	9.22^{b}	0.36
(T4), 120:60:40 NPK kg/ha	385.67^{b}	21.67^{bc}	30.74	20.33	6.04^{bc}	9.07^{b}	0.39
(T5), 120:20:40 NPK kg/ha	370^{b}	22.9^{b}	28.69	20.67	6.89^{ab}	9.1^{b}	0.43
(T6), 120:40:60 NPK kg/ha	393.67^{ab}	22.38^{bc}	30.21	19.67	6.69^{ab}	9.22^{b}	0.42
(T7), 120:40:20 NPK kg/ha	360.67^{b}	22.45^{bc}	30.49	20	6.45^{ab}	8.34^{b}	0.44
SEm (±)	12.81	0.46	3.14	0.62	0.44	0.62	0.017
LSD (0.05 %)	39.46	1.40	9.68	1.91	1.37	1.89	0.052
F-Probability	*	*	ns	ns	*	*	ns
C.V (%)	5.78	3.50	17.42	5.34	12.08	11.45	7.19
Grand Mean	383.76	22.53	31.22	19.95	6.38	9.3	0.40

Description: DAT, days after Transplantation, LSD, least significance difference, SEm, standard error of mean; CV, coefficient of variation, * represent significant at 5% level, ns, Non-significant, Treatment mean followed by same letter(s) are non-significance difference on Duncan multiple range test at 0.05 level of significance

3.2.1 Number of effective tillers per square meter

The number of effective tillers per square meter was significantly influenced by different level of NPK fertilizers. The average number of effective tillers per square meter was found to be 383.7, which ranged from 357.3 to 430.67 for Hardinath-1 variety at different levels of NPK. The highest number of effective tillers was observed with higher dose of nitrogen in NPK fertilizer combination i.e. T2-180:40:40 NPK kg/ha which was slightly superior over T6 -120:40:60 NPK kg/ha where, potassium was increased by 50 % on government recommendation. This result aligns with the findings of who reported higher number of effective tillers at higher level of nitrogen i.e. 180 kg/ha with similar level of P and K (Giri et al., 2022). The other treatments were statistically at par in yielding total number of effective tillers per square meter at 5% level of significance and were inferior to T2 and T6 revealing that the nitrogen and potassium had significant impact in effective tillers whereas phosphorus had negligible effect on effective tillers.

3.2.2 Panicle length

The panicle length in response to different level of NPK fertilizers was found significant in Hardinath-1 variety of spring rice. The longest panicle length 24.38 cm was recorded at T2-180:40:40 NPK kg/ha followed by T5-120:20:40 NPK kg/ha and T4- 120:40:40 NPK kg/h respectively. T4 was found to be statistically at par with T1-120:40:40 NPK kg/ha, T6-120:40:60 NPK kg/ha, and T7-120:40:20 NPK kg/ha. Sah et al. (2019) also reported that 180 kg N was found most effective for panicle length along with 60 kg/ha P and 40 kg/ha K. The result showed statistically shorter panicle length of 21.28 cm in the treatment T3-60:40:40 NPK kg/ha. Higher doses of nitrogen showed greater influence on panicle length as compared to other nutrients, owing to greater vegetative growth at early stages. An increase in N-fertilization aslo increased panicle length (Bokado et al., 2020).

3.2.3 Grain sterility

The different level of NPK fertilizers had no significant effect on grain sterility percentage at 5% level of significance. But numerically the sterility percentage varied slightly among the treatments. The highest percentage of grain sterility of more than 34% was observed in T2-180:40:40 NPK kg/ha and T7-120:40:40 NPK kg/ha. However, the fertilizer dose T5-120:20:40 NPK kg/ha where phosphorus was decreased by 50 % on government recommendation showed the had lowest grain sterility 28.69 %. It implies that the higher dose of nitrogen and phosphorus were responsible for grain sterility. A group of researcher also observed similar result for Hardinath-1 variety i.e. 31.3 % grain sterility but they conclude that sterility % was significantly influenced by nitrogen levels (Giri et al., 2022). Another group of researchers also reported that the increased nitrogen application rates resulted in measurable increases in the number of unfilled grains per panicle for all rice genotypes (Ghoneim et al., 2018). Though non- significant, relatively higher percentage of grain sterility was observed when nitrogen was applied @180 kg/ha whereas only 29.09% grain sterility was observed with 60 kg N/ha at similar level of phosphorous and potassium. In line with this findings, some researchers also reported increased sterility percentage i.e. up to 22% at 180 kg N/ha as compared to lower level of 120 kg N/ha (Mahajan et al., 2012).

3.2.4 Thousand grain weight (TGW)

The thousand grains weight was not affected significantly by different levels of NPK fertilizers. The thousand grain weight is governed by varietal character rather than different level of fertilizers (Giri et al., 2022). The mean thousand grain weight was recorded 19.95 gram in this study. Some researchers also observed similar outcomes in their experiment with the value of 22.3 gm and 22 gm respectively for same variety Hardinath-1 (Adhikari et al., 2023; Giri et al., 2022).

3.3 Yield parameters of spring rice

3.3.1 Grain yield

Grain yield was significantly influenced by the application of different level of NPK fertilizers. Significantly highest grain yield was recorded when nitrogen dose was applied @180 kg/ha. The treatments T5-120:20:40 NPK Kg/ha was statistically at par with T6-120:40:60 NPK Kg/ha and T7-120:40:20 NPK kg/ha with the grain yield of more than 6.45 ton/ha. While the lowest grain yield (5.06 ton/ha) was observed with the treatment T3-60:40:40 NPK kg/ha. The result showed that the nitrogen played important role in grain yield of spring rice where 7.7 ton/ha was recorded with 180 kg N/ha, whereas only 5.06 ton/ha was recorded with 60 kg N/ha with similar level of phosphorous and potassium. But varying levels of potassium had statistically non- significant effect at 120 kg N/ha and phosphorous @40 kg/ha as observed in the treatments T6 and T7. Grain yield responded to nitrogen levels because of the higher growth of the plant accompanied by higher number of effective tillers and length of the panicle, which is in line with a research finding, which also reported increase in grain yield due to improvement in most of the yield attributes at higher level of nitrogen (Giri et al., 2022). Our result showed increase in grain yield by 32.1 % with 50 % increased nitrogen level in T2 over the recommended dose T1. Thus it can be concluded that nitrogen is the major yield limiting nutrient content for spring rice. This finding corroborates with the results from a research which observed higher grain yield with higher doses of nitrogen (Adhikari et al., 2023; Singh et al., 2018).

3.3.2 Straw yield

The straw yield was significantly influenced by the application of different level of chemical fertilizers. The highest straw yield amounting 12.13 ton/ha was found on T2-180:40:40 NPK kg/ha where nitrogen level was increased by 50 % on recommendation dose. The result showed statistically similar results for straw yield with all other treatments except T2 in this variety Hardinath -1. The fertilizer level with higher level of nitrogen (180 kg/ha) with recommended P (40 kg/ha) and K (40 kg/ha) displayed superior result in straw yield over other treatments. Sah et al. (2019) also reported the highest straw yield with 180 kg N/ha along with 60 kg/ha P and 40 kg/ha K. The higher level of nitrogen 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). But the different levels of phosphorous and potassium showed negligible effect on straw yield of spring rice. Similar outcome of higher straw yield with higher doses of nitrogenous fertilizers were also reported (Adhikari et al., 2023; Giri et al., 2022).

3.3.3 Harvest index (HI)

Harvest index ranged from 0.44 to 0.36 at varying levels of NPK fertilizers, showing non-significant differences at 5% level of significance. It was recorded relatively higher (0.438) in T7- 120:40:20 NPK kg/ha followed by T5-120:20:40 NPK Kg/ha with the value (0.429) and T6-120:40:60 NPK kg/ha (0.419). Relatively lower harvest index of 0.355 was recorded in T3-60:40:40 NPK kg/ha. Some researchers also concluded similar results where different doses of nitrogen had no significant effect on harvest index but had statistically higher effect on grain yield and biological yield (Giri et al., 2022). It showed grain and straw yield were not linearly affected by the tested treatments. This result supportive conclusions were also reported in a study (Sakarwar, 2014). Similarly, some researcher also concluded that the different nitrogen levels had a negligible impact on harvest index whereas, reported significant effect on harvest index when chemical fertilizers and organic fertilizers were combined together (Kumar et al., 2019; Adhikari et al., 2023).

3.4 Correlation and regression study

The relationship between growth parameters, yield attributing traits and grain yield were studied through simple correlation and linear regression analysis. The positive correlation was found between grain yield and plant height at 75 DAT (r = 0.732), panicle length (r = 0.613) number of filled grain per panicle (r = 0.569). Similarly, the grain yield and harvest index was also found to be positively correlated and significant at 5 % significance level with correlation coefficient r = 0.538.

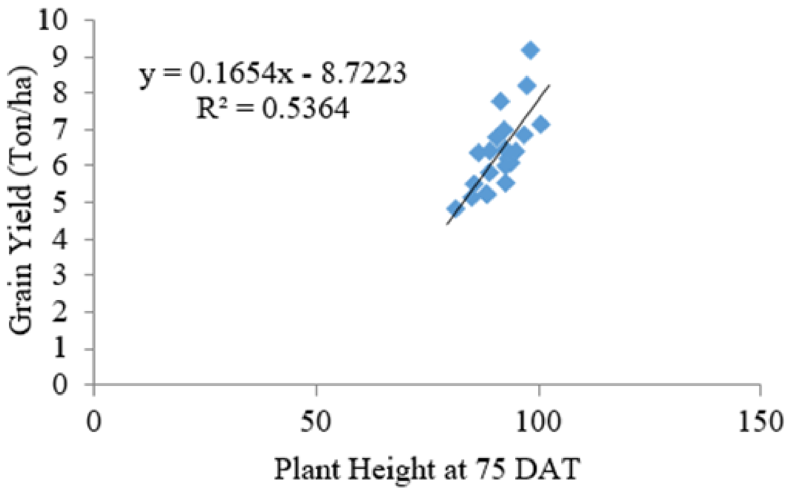

Figure 2: Relationship between grain yield and plant height 75DAT of spring rice, Kanchanpur, Nepal, 2023.

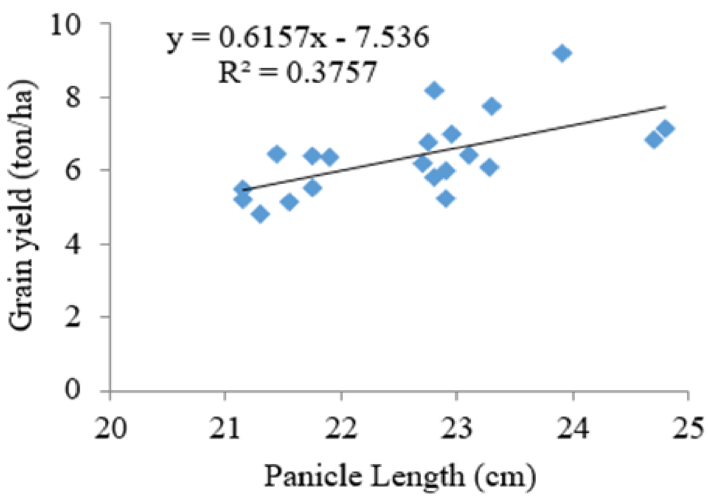

Figure 3: Relationship between grain yield and Panicle at length of spring rice, Kanchanpur, Nepal, 2023.

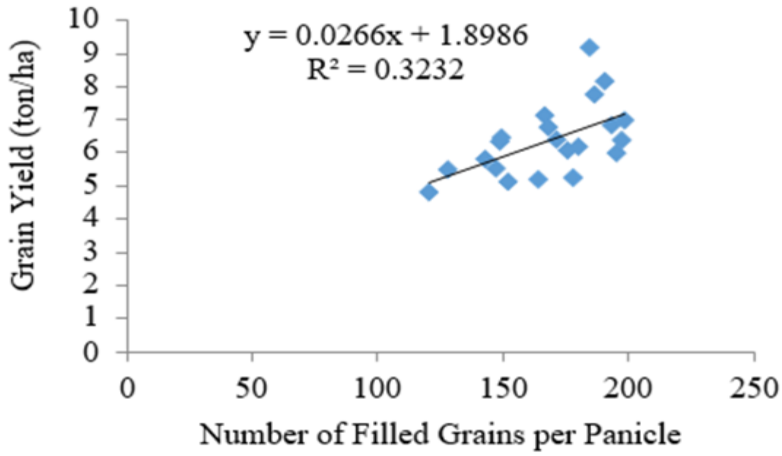

Figure 4: Relationship between grain yield and number of filled grain per panicle, Kanchanpur, Nepal, 2023

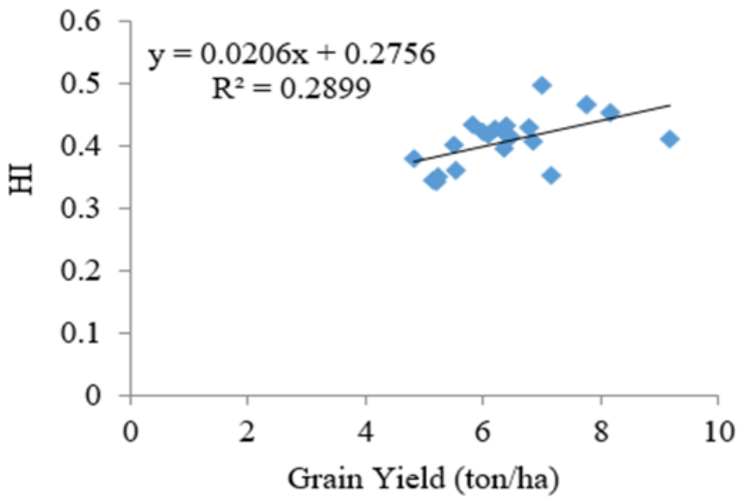

Figure 5: Relationship between harvest index and grain yield of spring rice, Kanchanpur, Nepal, 2023

The above figures (3,4,5) revealed linear relationship between grain yield and plant height at 75 DAT, panicle length and number of filled grains per panicle. The pattern of grain yield was similar to plant height and panicle length. The plant height at 75 DAT and panicle length input impact about 53.6 % (Figure 3) and 37.6 % (R2=0.376) (Figure 4) on grain yield respectively. The relation between grain yield and number of filled grain per panicle was also found to be linear with coefficient of determination (R2=0.323) (Figure 5) where, it had approximately 32.32 % share on grain yield. Thus it was concluded that the grain yield number of increased with increased plant height at 75 DAT, panicle length and total filled grain per panicle.

The relationship between harvest index and grain yield was also found linear with coefficient of determination R2=0.2899 (Figure 6) where grain yield contributed about 28.99 % towards increase in the harvest index and the remaining 71.01 % contribution for increasing yield was made by the variable other than harvest index.

3.5 Economic analysis

The cost of cultivation and gross return of each seven treatments were calculated on the basis of local market price for different agro inputs. The cost of production was the highest amounting NRs. 91,968 in the treatment T2-180:40:40 NPK kg/ha because the nitrogen level was applied 180 kg/ha which was more than three times when compared to T3 i.e., 60 kg/ha and more than all other treatments. With increase in net return of Nrs. 62,280.3 in the treatment T2 over T3, the higher net return was Nrs. 1,24,322 for T2, as shown in the Table 5. The relatively lower cost of cultivation Nrs. 84,145.8 was observed in 60:40:40 NPK kg/ha due to lower dose of nitrogen fertilizer. But the benefit cost ratio was also found higher (2.35) in T2 as compared to T6 and T7 (2.01). Despite, the higher cost of cultivation the fertilizer levels 180:40:40 NPK kg/ha provided higher net return and higher B:C ratio (2.35) as a result of higher grain yield. Thus, the fertilizer level 180:40:40 NPK kg/ha proved to be profitable over other levels of NPK fertilizers.

Table 5: Economic analysis of different levels of NPK fertilizers on spring rice, Kanchanpur, Nepal, 2023

Treatments	Cost of Cultivation (ha).	Gross Return (ha). (NRs.)	Net Return (ha). (NRs.)	Benefit Cost Ratio (B:C)
(T1), 120:40:40 NPK kg/ha	88,058.3	1,59,688	71,629.2	1.813
(T2), 180:40:40 NPK kg/ha	91,968	2,16,290	1,24,322	2.352
(T3), 60:40:40 NPK kg/ha	84,145.8	1,46,188	62,041.7	1.737
(T4), 120:60:40 NPK kg/ha	90,246.7	1,67,533	77,285.8	1.856
(T5), 120:20:40 NPK kg/ha	85,897.2	1,86,965	1,01,068	2.17
(T6), 120:40:60 NPK kg/ha	90,724	1,83,033	92,308	2.017
(T7), 120:40:20 NPK kg/ha	86,280.6	1,73,903	87621.9	2.012

Description: NRs., Nepalese rupees; B:C ration; Benefit Cost Ratio

4. Conclusion

The fertilizer combination with high nitrogen level i.e. T2- 180:40:40 NPK kg/ha outperformed in terms of growth, yield attributing traits and yield of spring rice (Hardinath-1 variety) over all the different combinations compared in the study. Grain sterility was found to be slightly higher in the treatment containing higher doses of nitrogen, though non-significant. It is suggested to study the effect of different levels of nitrogen on grain sterility under similar condition. Despite the increased cost of cultivation, the treatment T2 provided the highest net profit with 2.35 B:C ratio, among all other treatments. From this study, it is concluded that the fertilizer levels 180:40:40 NPK kg/ha could be an economically viable option for spring rice growers in Rice-Rice-Rapeseed cropping system at Kanchanpur district of Nepal. Also, it is recommended to conduct similar study across diverse cropping system in the far western regions with different varieties of spring rice for comprehending the findings of this research.

Acknowledgement

The authors acknowledge the study platform availed by Prime Minister Agriculture Modernization Project, Project Implementation Unit Kanchanpur and Faculty of Agriculture, Far-western University, Kailali, Nepal. Our special thanks goes to Ms. Sanju Rimal, PMAMP Office, for the field supervision during the experiment. We would like to thank all the supportive hands from Far Western University and PMAMP site office during the study period.

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