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RESEARCH ARTICLE

EFFECT OF VARIOUS DOSES OF FERTILIZER ON GROWTH AND YIELD OF SPRING RICE AT SHREENAGAR, SALYAN

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ABSTRACT

At Shreenagar, Salyan, Nepal, a study was done to see how different amounts of NPK fertilizer affected the growth and yield of spring rice (Oryza sativa). The experiment followed a simple randomized complete block design with five treatments (control, RDF, 50% of RDF, 75% of RDF, and 125% of RDF) and four replications. Data related to growth and yield attributes and yield are collected. MS Excel was used for data entry, tabulation, and graphing, and the results were analyzed using R (version 4.4.1) with mean comparisons performed via the LSD test at a 5% significance level. The significantly highest plant height and tiller numbers per hill were observed with 125% of RDF (RDF: 100:30:30 NPK kg/ha). A twenty-five percent increase in the recommended dose of fertilizer consistently outperformed the other treatments in terms of flag leaf length, panicle characteristics, grain yield, and thousand-grain weight, and the control exhibited the significantly lowest values for these parameters. A twenty-five percent increase in RDF resulted in a significantly higher grain yield per hectare (4488.88 kg) and thousand-grain weight (22.10 g). The benefit-cost ratio was also significantly higher in 125% of RDF (1.41), showing its superior economic performance, while the control had the significantly lowest benefit-cost ratio of 0.80. Rice cultivation by adopting 125% of fertilizer will be more profitable than other fertilizer management practices. These findings highlight the importance of optimizing fertilizer doses to improve rice growth, yield, and profitability.

KEYWORDS

NPK fertilizer, Plant height, thousand grain weight, fertilizer management practices

1. INTRODUCTION

Rice (*Oryza sativa*) is a significant edible starchy cereal grain grown around the world in different habitats such as lowland, irrigated land, and upland (Herve et al., 2017). Rice can be cultivated at a wide range of altitudes ranging from 60 m to 3050 m above sea level. It requires a large amount of water and a warm temperature. Rice is an annual, self-pollinated, and semi-aquatic plant. Generally, it is 1-5 m in height and has a fibrous root system (Poudel et al., 2021). It was derived from China and India and later spread to different parts of the world and was regarded as a third cereal after maize and wheat (FAO, 2011). It belongs to the Poaceae family, and there are two species: *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice*). Oryza sativa* is the common commercial rice, having three subspecies: Indica is a long and aromatic rice grown in tropical and subtropical regions of the Indian subcontinent of South Asia and in Southeast Asia and Southern China; *Japonica* is grown in temperate areas of Japan, China, and Korea with short and medium grain; and *Javanica* is grown in Indonesia with large grain and poor shattering (Wang et al., 2013).

Rice alone covers 50% of total cereal crop production in Nepal (MoALD, 2022). Rice is mainly concentrated in the Terai region of Nepal; about 73% of total rice is produced in Terai. This crop contributes significantly to 4% of Nepal's GDP and 13.6% to AGDP (MoALD, 2023). Productivity of spring rice in Nepal is 4.98 mt/ha, which is higher than main season rice (3.79 mt/ha) (MoALD, 2024). Spring rice occupies 8% of total land under rice in Nepal (MoALD, 2023). The government of Nepal endorsed a fertilizer recommendation (100:30:30 N:P_2O_5:K_2O kg/ha) for hills to cultivate rice (MoALD, 2024). The major varieties for the spring season include Chaite-2, Chaite-6, Hardinath-1, Chaite-5, and CH-45, while Sabitri, Ram Dhan, Janaki, Masuli, Ghaiya 2, Radha 7, Sukha Dhan-4 and Sukha Dhan-5 are commonly grown during the main season. In the 2019–20 fiscal year, Salyan district recorded a total food production of 97,664 metric tons, with a food surplus of 8,743 metric tons (MoALD, 2022). In 2020/21, paddy was cultivated on 7,059 ha, yielding 28,642 metric tons, with an average productivity of 4.06 metric tons per hectares.

A huge amount of N and P fertilizer is applied for hybrid varieties that are inbred in irrigated conditions compared to rainfed conditions (Joshi et al., 2011). Fertilizer replenishes soil fertility, maintains soil chemical, physical, and biological properties, plant growth, soil health, and yield production (Mahmud et al., 2016). The cultivation of rice is influenced by inorganic fertilizer, which increases yield by 59%-69% (Naher et al., 2019). National productivity of spring rice in Nepal is 4.98 mt/ha, whereas in Salyan it is 4.24 mt/ha (MoALD, 2023). Inadequate and inappropriate doses of fertilizer reduce the growth and yield of rice (Adhikari et al., 2021; Herve et al., 2017; Manni and Sharma, 2023; Shrestha et al., 2020). Fertilizer dose recommendations by government bodies and research stations are based on blanket recommendations, i.e., the same dose of fertilizer for the whole country without considering the site-specific soil and weather conditions. However, Nepal is a country with diverse soil and climatic conditions, which brings forward the need for site-specific recommendations. Very few site-specific studies have been conducted regarding the different doses of nutrients for the production of rice in Nepal (Marahatta, 2017). This research helps in applying adequate fertilizers required for rice plants to increase nutrient uptake and

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ultimately increase yield and also avoid nutrient loss. And this study also helps in improving the livelihood of farmers by increasing the production of rice.

2. Materials And Methods

2.1 Research site

Research was conducted at the Shreenagar rice zone area under PMAMP, PIU, Salyan. It is located at 28°22'31"N latitude and 82°9'42"E longitude at 970 meters elevation. Salyan has dry, humid winters in a subtropical climate. Soil was clay with acidity at Shreenagr. Salyan district is a part of Karnali province. It covers a 1462 km^2 area and has a population of 238,515.

2.2 Treatment details

The following treatments were used in experiment.

T1= Control

T2 = RDF (100:30:30 N:P_2O_5:K_2O kg/ha)

T3= Half of RDF (50:15:15 N:P_2O_5:K_2O kg/ha)

T4 = 75% of RDF (75:22.5:22.5 N:P_2O_5:K_2O kg/ha)

T5 = 125% of RDF (125:37.5:37.5 N:P_2O_5:K_2O kg/ha)

2.3. Design of experiment

The experimental field trial used a simple randomized complete block design (RCBD) with five treatments, each with four replications. The individual plot was 3 m in length and 3 m in breadth. Spacing per hill was 25 cm × 25 cm, in which plot consisted of 12 rows and 12 columns. The net experimental plot area was 9 m2, having plot–plot spacing of 50cm and 1m between each block. Each plot contained 144 no. of hills, and each hill contained 2-3 seedlings. The total experimental area of the field was 291 m^2. For all treatments there were 4 replications.

0.5m	R1		R2		R3		R4	
0.5m	T1	1m	T2	1m	T5	1m	T1	0.5m
	0.5m							
0.5m	T2	1m	T4	1m	T1	1m	T4	0.5m
			0.5m					
0.5m	T3	1m	T1	1m	T4	1m	T5	0.5m
			0.5m					
0.5m	T4	1m	T5	1m	T3	1m	T2	0.5m
			0.5m					
0.5m	T5	1m	T3	1m	T2	1m	T3	0.5m
				0.5m				

Figure 1: Layout of field

2.4 Sample and sampling techniques

Each plot contained 144 hills, which was a sampling frame, and 10 hills were selected randomly from each plot as a sample.

2.5 Date of transplanting

Seedling was transplanted on the 11th of Chaitra 2080 at 25 cm*25 cm spacing. The seedlings were directly transplanted manually.

2.6 Activities performed

During field preparation, well-decomposed FYM was applied on each plot by weighing the required FYM for each plot. Before transplanting, half a dose of NPK fertilizer was broadcast in each respective plot in each replication. We replanted in intervals of 10-15 days after transplantation. Twice manual weeding was done, once at 25-30 DAT and another at 55-60 DAT. Bispyribac sodium 10% SC was applied in the field at 20 DAT. 10-15 ml of chemical was mixed with 15 liters of water and sprayed in the field. Bispyribac sodium is a selective herbicide that controls sedges, grasses, and broadleaf weeds.

Half a dose of fertilizer was split in two halves. One half was applied at 30 DAT and another half at 60 DAT. Timely irrigation was done with the help of a pump from the water channel. 1 ml of Fighter insecticide (Chlorpyrifos 55EC + Cypermethrin 5EC) was mixed with 1 L of water and applied in the field to control different insects with the help of a knapsack sprayer.

2.7 Data collection

The following data was collected from the field.

- Plant height: Plant height was measured at 30 DAT, 50 DAT, 90 DAT, and harvest time from 10 random plants from each plot.
- Tillers number per hill: Tiller numbers per hill was counted at 30 DAT, 50 DAT, 90 DAT, and harvest days from 10 random plants from each plot.
- Flag leaf length: Flag leaf length was measured at 90 DAT and harvest time from 10 random plants from each plot.
- Panicle number: Panicle number was counted at harvest time from 10 random plants from each plot.
- Panicle length: Panicle length was measured at harvest day from 10 random plants from each plot.
- Thousand grain weight: Thousand grains were counted from the randomly selected grain yield of net plot and weigh with the help of electronic balance.
- Yield of grain per hectare: It was measured at harvest time from each plot and converted into hectare.

2.8 Data analysis

According to the principles of experimental design, the data obtained from the experimental plots were subjected to MS EXCEL 2010 and analyzed by using R (version 4.4.1). All the analyzed data were subjected to Least Significant Difference (LSD) for mean comparison at a 5% level of significance.

3. Results And Discussion

3.1 Plant height

The effect of different doses of fertilizers on plant height at different growth stages of spring rice is presented in Table 1. The plant height of spring rice was recorded as significantly higher with a twenty-five percent increase in RDF at 30 DAT, 50 DAT, 90 DAT, and harvest time, which were 28.05 cm, 43.21 cm, 84.74 cm, and 100.04 cm, respectively. The significantly lower plant height was recorded in the control, which was 74.80 cm at harvest time but statistically on par with 75% of RDF (81.00) and 50% of RDF (78.02).

Table 1: Effect of different doses of fertilizer on plant height at 30 DAT, 50 DAT, 90 DAT and at harvest time of spring rice at Shreenagar, Salyan

Treatments	30 DAT	50 DAT	90 DAT	At harvest time
125% of RDF	28.05^{a}	43.21^{a}	84.74^{a}	88.30^{a}
RDF	25.84^{b}	38.03^{b}	79.69^{ab}	83.40^{ab}
75% of RDF	24.24^{bc}	37.28^{b}	76.84^{bc}	81.00^{bc}
50% of RDF	23.46^{c}	35.85^{bc}	75.16^{bc}	78.02^{bc}
Control	22.13^{c}	33.14^{c}	71.30^{c}	74.80^{c}
SEm(±)	0.15	0.44	0.35	0.59
LSD(0.05)	2.19	3.50	5.32	6.84
F-probability	***	***	****	***
CV%	5.89	6.20	4.55	5.59
Grand mean	24.74	37.30	77.55	81.10

Note: SEm= Standard error of mean, LSD= least significant difference, CV= coefficient of variation, Same letter: Non-significant difference, Different letter: Significant difference at 5% level of significance, '***' significant at 0.1% level of significance.

The increased plant height is because nitrogen has a very stimulating influence on several physiological stages, such as cell division and cell elongation, photosynthesis, assimilation, and metabolism (Guan et al., 2025; Luo et al., 2020; Mrudhula et al., 2021). The shortest plant height can be caused by a lack of fertilizer, which significantly reduces plant growth and development due to the nutrient deficiency (Shrestha et al., 2020). Similar results of the maximum plant height in rice were recorded by increasing doses of NPK fertilizers (Adhikari et al., 2021; Jo et al., 2024; Herve et al., 2017; Multafu et al., 2024).

3.2 Number of tillers per hill

The effect of different doses of fertilizers on the number of tillers per hill at different growth stages of spring rice is presented in Table 2. The tiller numbers per hill were recorded significantly as higher in 125% of RDF (22.45) at harvest time. The lowest tiller numbers per hill were found in the control (16.62), which is significantly lower than 125% of RDF, RDF, and 75% of RDF but statistically similar to 50% of RDF. Nitrogen plays a significant role in cell division and cell elongation to produce more tillers and increase flag leaf length (Adhikari et al., 2021). An increase in the tillers per hill was observed as the nitrogen level increased (Herve et al., 2017; Kumar et al., 2022; Manni and Sharma, 2023).

Table 2: Effect of different doses of fertilizer on tillers per hill at 30 DAT, 50 DAT, 90 DAT and at harvest time of spring rice at Shreenagar, Salyan

Treatments	30 DAT	50 DAT	90 DAT	At harvest time
125% of RDF	7.97^{a}	17.20^{a}	21.90^{a}	22.45^{a}
RDF	6.07^{ab}	14.25^{b}	19.50^{b}	20.25^{b}
75% of RDF	5.02^{b}	12.72^{bc}	18.32^{bc}	19.15^{b}
50% of RDF	4.40^{b}	11.42^{c}	17.52^{bc}	18.35^{bc}
Control	4.20^{b}	10.12^{c}	16.05^{c}	16.62^{c}
SEm(±)	0.15	0.30	0.22	0.20
LSD(0.05)	2.13	2.62	2.18	2.0
F-probability	***	***	***	***
CV%	25.57	13.27	7.76	6.90
Grand mean	5.53	13.14	18.66	19.36

Note: SEm= Standard error of mean, LSD= least significant difference, CV= coefficient of variation, Same letter: Non-significant difference, Different letter: Significant difference at 5% level of significance, '***' significant at 0.1% level of significance.

3.3 Flag leaf length

The effect of different doses of fertilizers on flag leaf length at different growth stages of spring rice is presented in Table 3. The effect of different doses of fertilizers on flag leaf length was found to be highly significant. The significantly highest flag leaf length was observed in 125% of RDF and the lowest in control on all days after transplanting and at harvest time. Nitrogen plays a significant role in cell division and cell elongation to increase flag leaf length (Adhikari et al., 2021). The study reported related findings that increased flag leaf length with higher application of N fertilizer (Herve et al., 2017).

Table 3: Effect of different doses of fertilizer on flag leaf length at 90 DAT and at harvest time of spring rice at Shreenagar, Salyan

Treatments	90 DAT	Harvest time
125% of RDF	28.06^{a}	31.40^{a}
RDF	25.86^{ab}	27.80^{ab}
75% of RDF	24.59^{abc}	27.77^{ab}
50% of RDF	2310^{bc}	25.87^{b}
Control	20.76^{c}	25.45^{b}
SEm(±)	0.27	0.24
LSD(0.05)	4.44	4.40
F-probability	***	***
CV%	12.06	10.57
Grand mean	24.47	27.66

Note: SEm= Standard error of mean, LSD= least significant difference, CV= coefficient of variation, Same letter: Non-significant difference, Different letter: Significant difference at 5% level of significance, '***' significant at 0.1% level of significance.

3.4 Panicle numbers per hill and panicle length

The effect of different doses of fertilizers on panicle numbers per hill and panicle length at harvest time of spring rice are presented in Table 4. The significantly higher panicle length was obtained in 125% of RDF (22.64 cm) at harvest time, which was statistically similar to RDF. Statistically similar panicle length was recorded between RDF, 75% of RDF, and 50% of RDF at harvest time. The lowest panicle length was recorded in the control (15.99 cm) at harvest time, which was significantly lower than other treatments but statistically similar to 50% of RDF. While the highest number of panicles per hill was recorded in 125% of RDF (18.20) at harvest time, which was significantly higher than in the control and 50% of RDF but statistically similar to RDF and 75% of RDF. The lowest numbers of panicles per hill was recorded in the control at harvest time, which was 11.65, and it was statistically similar to 50% of RDF and 75% of RDF.

Table 4: Effect of different doses of fertilizer on panicle numbers per hill and panicle length at harvest spring rice at Shreenagar, Salyan

Treatments	Panicle numbers per hill	Panicle length
125% of RDF	18.20^{a}	22.64^{a}
RDF	15.35^{ab}	20.42^{ab}
75% of RDF	14.77^{abc}	19.15^{b}
50% of RDF	12.92^{bc}	18.09^{bc}
Control	11.65^{c}	15.99^{c}
SEm(±)	0.30	0.18
LSD(0.05)	3.37	2.82
F-probability	***	***
CV%	15.38	9.74
Grand mean	14.58	19.26

Note: SEm= Standard error of mean, LSD= least significant difference, CV= coefficient of variation, Same letter: Non-significant difference, Different letter: Significant difference at 5% level of significance, '***' significant at 0.1% level of significance.

Nitrogen increases the number of flowers per panicle by increasing cytokinin synthesis (Ding et al., 2014). N is crucial for the development of panicles (Adhikari et al., 2021). NPK fertilizer promotes cell division and elongation to increase panicle length, and higher absorption of different fertilizers by plants is favored to produce longer panicle length (Hasanuzzaman et al., 2010; Yogi et al., 2024; Heluf and Mulugeta, 2006; Shrestha et al., 2020). A related consequence of the maximum panicle length in rice is found by increasing doses of NPK (Adhikari et al., 2021; Joshi et al., 2011; Manni and Sharma, 2023).

3.5 Thousand grain weight, yield of grain per hectare and B/C ratio

The effect of different doses of fertilizers on thousand-grain weight, yield of grain per hectare, and B/C ratio of spring rice are presented in Table 5. The significantly highest and lowest thousand grain wt. was recorded in 125% of RDF (22.10 g) and control (16.10 g), respectively. A statistically similar thousand-grain weight was recorded in RDF (19.75 g) and 75% of RDF (18.65 g). Similarly, a statistically similar thousand-grain weight was found in 75% of RDF (18.65 g) and 50% of RDF (17.80 g). In the case of yield of grain per hectare, the highest and lowest yields per hectare were recorded in 125% of RDF (4488.88 kg) and control (1683.88 kg), respectively. While statistically similar yield per hectare was found in RDF (3487.49 kg) and 75% of RDF (2885.27 kg). The benefit-cost ratio was found to be significantly maximum in 125% of RDF, which was 1.41.The significantly lowest B/C found in the control was 0.80, and it was statistically similar to 50% of RDF. Numerous investigations have

demonstrated that maximum grain yield per hectare, thousand grain weight, and B/C ratio were reported in rice by applying a high dose of NPK fertilizer (Herve et al., 2017; Manni and Sharma, 2023; Masni and Wasli, 2019; Shrestha et al., 2020).

Table 5: Effect of different doses of fertilizer on thousand grain wt., yield of grain per hectare and B/C ratio of spring rice at Shreenagar, Salyan

Treatments	Thousand grain wt.(g)	Yield of grain(kg/ha)	B/C ratio
125% of RDF	22.10[a]	4888.88[a]	1.41[a]
RDF	19.75[b]	3487.49[b]	1.25[b]
75% of RDF	18.65[bc]	2885.27[bc]	1.11[c]
50% of RDF	17.80[c]	2529.71[c]	0.86[d]
Control	16.10[d]	1683.88[d]	0.80[d]
SEm(±)	0.09	84.99	0.01
LSD(0.05)	1.43	694.14	0.08
F-probability	***	***	***
CV%	5.03	15.27	5.00
Grand mean	18.88	3015.05	1.10

Note: SEm= Standard error of mean, LSD= least significant difference, CV= coefficient of variation, Same letter: Non-significant difference, Different letter: Significant difference at 5% level of significance, '***' significant at 0.1% level of significance.

4. Conclusion

This research, conducted to evaluate the impact of varying fertilizer doses on the growth and yield of spring rice, revealed that all levels of NPK fertilizer application significantly enhanced rice production compared to the control. The findings underscore the positive influence of nutrient supplementation on crop performance, with notable improvements observed across different treatment levels. Among all the treatments evaluated, the application of 125% of the recommended fertilizer dose demonstrated superior performance in terms of both growth and yield. Nevertheless, the treatment with the standard recommended dose of fertilizers also produced commendable results, indicating its effectiveness under standard cultivation practices. Therefore, the application of 125% of RDF emerges as a highly effective strategy for enhancing both growth and yield in rice cultivation. This elevated nutrient input appears to provide optimal conditions for maximizing plant development and productivity.

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Author Contributions Statement

Conceptualization:Sagar Tamang, Toran Devkota; Data curation: Sagar Tamang, Toran Devkota, Prajala Badal, Pratiksha Tumbapo, Monika Thapa, Nawaraj Neupane ; Formal analysis: Sagar Tamang; Investigation: Sagar Tamang, Toran Devkota, Prajala Badal, Pratiksha Tumbapo, Monika Thapa, Nawaraj Neupane ; Methodology: Sagar Tamang, Toran Devkota, Prajala Badal, Pratiksha Tumbapo, Monika Thapa, Nawaraj Neupane; Resources: Sagar Tamang, Prajala Badal, Toran Devkota; Software: Sagar Tamang, Toran Devkota; Supervision: Sagar Tamang, Toran Devkota, Prajala Badal, Pratiksha Tumbapo, Monika Thapa, Nawaraj Neupane; Validation: Sagar Tamang, Toran Devkota; Visualization: Sagar Tamang, Toran Devkota, Prajala Badal, Pratiksha Tumbapo, Monika Thapa, Nawaraj Neupane; Writing – Original Draft Preparation: Sagar Tamang, Toran Devkota; Writing – Review and Editing: Toran Devkota

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Conflict Of Interest Statement

The authors have no relevant financial and non-financial interests to disclose. The authors declare that they have no competing interests.

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