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Study on effect of nutrient management on growth, yield and profitability of transplanted rice (*Oryza sativa* L.) in south-eastern Rajasthan

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Abstract
A field experiment was carried out during *kharif* season of 2024 at Agricultural Research Station, Kota to assess the effects of nutrient management treatments on the growth, productivity and economic returns on transplanted rice. The experiment comprised of eight nutrient management treatments *viz*., 100% RDF (NPK @ 120: 60: 40 kg/ha), RDF+FYM @ 5.0 t/ha, 125% RDF, 125% RDF+FYM @ 5.0 t/ha, RDF+soil application of Zn @ 5.25 kg/ha, RDF+foliar application of $ZnSO_4$ @ 0.5%, RDF+foliar application of "Sampoorna KAU Multimax" @ 1.0% and RDF+foliar application of NPK 19:19:19 @ 0.5%. The treatments were tested in a RBD with three replications. Results revealed that maximum improvements in plant growth parameters *viz*., plant height, number of tillers, chlorophyll content, DMA and CGR at various growth stages were recorded with 125% RDF+FYM @ 5 t/ha. The application of 125% RDF+FYM significantly improved yield attributes *viz*., number of panicles/m^2, panicle length, number of filled grains/panicle, panicle weight and test weight over 100% RDF alone. The highest grain, straw and biological yield were observed with the application of 125% RDF+FYM. The economic analysis indicated that the application of 125% RDF+FYM fetched maximum net return (₹135844/ha). The highest B:C ratio was observed with 125% RDF (2.91), closely followed by 125% RDF+FYM, RDF+FYM, RDF+foliar NPK, RDF+soil Zn, RDF+foliar zinc and RDF+foliar sampoorna.

Keywords: Crop growth rate, dry matter accumulation, economic returns, grain yield, transplanted rice

Introduction
Rice (*Oryza sativa* L.) is the second most important cereal crop in the world after wheat. It is the staple food for the people of South-east Asia including India. India is the second largest producer of rice after China. The area of rice cultivation in India is 47.83 million hectares with a total production of 137.82 million tonnes and the average productivity of the country is 2882 kg/ha (GOI, 2025) [2]. In Rajasthan, it occupies an area of 2.67 Lakh hectare with an annual production of 7.46 Lakh tonnes and average productivity 2786 kg/ha (GOR, 2024) [3]. Despite of high production growth rate that has been achieved over the years, the rice productivity in the country remains low as compared to other rice producing countries like China and Japan. The estimated demand of rice in India is expected to be 197.40 million tonnes for consumption alone by 2050-51 with projected population of 1.65 billion (Pathak *et al.*, 2020) [1]. Therefore, especial efforts are needed to enhance the rice productivity through improved production technology and efficient management of agricultural inputs.

The nutrient management is one of the most important factors that determine the crop productivity. Among various essential plant nutrients, the macro nutrients NPK are crucial for determining the yield and quality. The recommended doses of NPK fertilizers have become suboptimal as the same doses are being used since long time. Hence, the field crops exhibiting substantial yield response on high fertility levels. The productivity may be further enhanced by increase in doses of NPK fertilizers (Singh, 2016) [4]. Thus, revalidating the doses of NPK fertilizers is essential to optimize rice yield. FYM is a good source of nutrients and contributed towards build-up of organic matter in soil (Kamaleshwaran and Elayaraja, 2021) [5] and it not only supply macro and micronutrients but also improve the soil physical, chemical, and biological properties of the soil (Sanwal *et al.*, 2023) [6]. Deficiencies of micronutrients are

increasing day-by-day under varying soil and crop situations. (Sucharita *et al.*, 2023) [7]. Therefore, application of zinc either as soil application or foliar in deficient soils may enhance paddy productivity. "Sampoorna KAU multimix" micronutrient formulation was developed to deal with micronutrient deficiencies such as zinc, copper, boron and molybdenum etc.

Soil application is the most common method of fertilizing crops, supplying essential nutrients directly to the root zone for easy absorption during early growth stages. However, nutrients like phosphorus, potassium, and micronutrients often become fixed in the soil as insoluble compounds, reducing their availability (Rani *et al.*, 2014) [9]. Foliar application is particularly effective during critical growth stages, enhancing growth and yield. Its role as a supplementary approach to soil fertilization rather than a replacement (Chopkar *et al.* 2024) [10]. Integrated nutrient management, combining soil-applied and foliar-applied nutrients, has shown promise in enhancing nutrient use efficiency, improving growth and increasing crop yields. Thus, the present study was undertaken to evaluate the varying nutrient levels for enhancing yield and profitability of transplanted paddy in South-eastern Rajasthan.

Materials and Methods

The field experiment was conducted during the *kharif* season of 2024 at ARS of Agriculture University, Kota, Rajasthan. The soil of the experimental field was clay in texture, slightly alkaline in reaction (pH 7.5), low in organic carbon (0.41%) and nitrogen (210.3 kg/ha), medium in phosphorus (23.6 kg/ha) and high in potassium (350.2 kg/ha) and zinc content was found below the critical threshold. The experiment was laid out in a RBD with eight treatments and three replications. The treatments comprised of various nutrient management combinations *viz*, T_1-RDF (NPK @ 120-60-40 kg/ha), T_2-RDF + FYM @ 5 t/ha, T_3-125% RDF (150-75-50 kg NPK /ha), T_4-125% RDF + FYM @ 5 t/ha, T_5-RDF + soil application of Zn @ 5.25 kg/ha, T_6-RDF + foliar spray of $ZnSO_4$ @ 0.5% at maximum tillering and panicle initiation stages, T_7-RDF + foliar sprays of Sampoorna (KAU multimix) @ 1.0% at one week prior to maximum tillering and panicle initiation stages and T_8-RDF + foliar sprays of NPK 19:19:19 @ 0.5% at maximum tillering and panicle initiation stages. Nutrients were applied in the form of urea, di-ammonium phosphate, muriate of potash and zinc sulphate monohydrate as per treatments. FYM was applied as per treatment at the time of layout preparation. Standard agronomic practices for nursery raising, transplanting, irrigation and plant protection were followed. The growth and yield parameters as well as the yield of transplanted paddy were recorded. Economic analysis was conducted to calculate gross returns, net returns and the benefit cost ratio. Statistical analysis was performed using ANOVA at a 5% significance level.

Results and Discussion

Growth parameters

The results (Table 1) showed that various nutrient management treatments had a significant effect on growth parameters *viz*., plant height, number of tillers at 60 DAT and at harvest stage, DMA at 30, 60 and 90 DAT and CGR between 30 to 60 DAT and 60 to 90 DAT and chlorophyll content at 60 DAT.

At 30 DAT and 60 DAT, the maximum plant height was recorded with the application of 125% RDF + FYM. which was significantly higher than heights observed under RDF+soil Zn, RDF+foliar sampoorna, RDF+foliar zinc, RDF+foliar NPK and 100% RDF. However, the height observed with 125% RDF+FYM was statistically at par with 125% RDF and RDF+FYM. At 90 DAT, all the nutrient management treatments were significantly enhanced the plant height over 100% RDF except RDF+foliar zinc and RDF+foliar sampoorna. The maximum plant height was observed with 125% RDF+FYM, which indicate a significant increment over RDF+foliar zinc, RDF+foliar sampoorna and 100% RDF. At harvest stage, 125% RDF+FYM treatment continued to show the maximum plant height, which was significantly higher over RDF+FYM, RDF+soil Zn, RDF+foliar zinc, RDF+foliar sampoorna and 100% RDF. However, 125% RDF and RDF+foliar NPK treatments were statistically at par with 125% RDF+FYM.

The maximum numbers of tillers/m^2 at 60 DAT and at harvest stage was recorded with the application of 125% RDF+FYM, which was significantly higher over RDF+soil Zn, RDF+foliar zinc, RDF+foliar NPK, RDF+foliar sampoorna and 100% RDF. However, 125% RDF and RDF+FYM were found statistically at par with it.

A critical analysis of the data shows that chlorophyll content in paddy leaves was significantly influenced by all treatments over 100% RDF except RDF+foliar zinc and RDF+foliar sampoorna. The maximum chlorophyll content was recorded with 125% RDF+FYM (2.58 mg/g) closely followed by treatments 125% RDF and RDF+FYM.

At 30, 60 and 90 DAT, the maximum DMA was recorded with the application of 125% RDF+FYM, which was significantly superior to treatments including RDF+soil Zn, RDF+foliar zinc, RDF+foliar sampoorna, RDF+foliar NPK and 100% RDF. However, 125% RDF and RDF+FYM were statistically at par with 125% RDF+FYM.

An evaluation of the data indicates that various nutrient management treatments significantly enhanced the CGR from 30 to 60 DAT and 60 to 90 DAT as compared to the application of 100% RDF. The highest CGR both the stages were recorded with 125% RDF+FYM, followed by 125% RDF, RDF+foliar NPK, RDF+FYM.

These positive increment in growth parameter, might be due to supply of higher nutrients through inorganic fertilizers easily available to plants adequately providing congenial growth which improve the metabolic activity and photosynthesis efficiency and finally improve the dry matter production in sink. The results of study are in close agreement with the results of Kumar *et al.* (2020) [25] and Kumar *et al.* (2022) [11].

The application of RDF+FYM @ 5t/ha also improved growth parameters of paddy over sole 100% RDF. The superior performance under RDF+FYM might have led to improved availability of all essential plant nutrients and enhanced microbial activity, which together increased nutrient mineralization and ensured a more sustained nutrient release. This balanced nutrient supply had resulted in a significant improvement in growth parameters. The findings align closely with those reported by Arunkumar *et al.* (2019) [12] confirming the synergistic effect of FYM with chemical fertilizer. The addition of Zn along with RDF as a soil application might have facilitated the distribution of Zn within paddy plant, which increased vegetative tissue formation, improved photosynthetic activity and consequently enhanced the growth of plant parts. The results also get support from the findings of Dewedi *et al.* (2024) [13].

Foliar sprays of NPK (19:19:19) showed significant improvement in plant height and CGR as compared to RDF

only. It might have supported increased leaf expansion and photosynthetic efficiency, enabling better nutrient uptake and utilization, as also reported by Upadhyaya *et al.* (2025) [8]. Since soil- applied, fertilizers are subjected to losses through leaching or fixation, foliar nutrition becomes crucial during critical growth stages when crop demand exceeded soil supply. Growth improvement due to the foliar NPK application were also reported by Geeta *et al*. (2020) [14] and Palanisamy *et al*. (2025) [15].

Yield and Yield attributes

The findings (Table 2) indicated that different nutrient management treatments had a significant effect on yield parameters *viz*., number of panicle/m^2, panicle length, panicle weight, filled grain, unfilled grain and test weight, however, significant impact on harvest index was not recorded. The maximum number of panicles was recorded under 125% RDF+FYM, which was significantly superior over RDF+ Soil Zn, RDF+ foliar NPK, RDF+ foliar Zn, RDF+ foliar sampoorna and 100% RDF. However, 125% RDF and RDF+FYM treatments remained at par with 125% RDF+FYM.

The filled grains/panicle was significantly improved by the application of all the treatments as compared to 100% RDF except RDF+foliar zinc and RDF+foliar sampoorna. The highest number of filled grains/panicle was recorded with the application of 125% RDF+FYM, which was significantly higher over RDF+foliar sampoorna, RDF+foliar Zn and 100% RDF. However, it remained statistically at par with RDF+FYM, 125% RDF, RDF+soil Zn and RDF+ NPK.

Maximum panicle weight was recorded with the application of 125% RDF+FYM treatment, which was statistically at par with the 125% RDF, RDF+FYM and RDF+foliar NPK.

The highest test weight was observed with 125% RDF+FYM treatment; however, it was at par with RDF+foliar NPK, RDF+FYM, 125% RDF, RDF+ foliar sampoorna and RDF+soil Zn treatments. All these treatments were found significantly superior over 100% RDF.

All the treatments exhibited significant positive influence on panicle length as compared to 100% RDF except RDF+soil zinc and RDF+foliar zinc. The maximum panicle length was observed with the application of 125% RDF+FYM, followed by 125% RDF alone, RDF+foliar NPK and RDF+FYM. These treatments were statistically at par among them.

The increment in yield attributes with higher fertility levels could be ascribed to overall improvement in crop growth as indicated from higher CGR and manifested in terms of dry matter accumulation. Similar positive effect on yield attributes in paddy were reported by several researchers, including Shende *et al.* (2022) [16] and Singh *et al.* (2022) [17].

The results (Table 3) showed that maximum grain yield was recorded under the application of 125% RDF+FYM (6108 kg/ha); however, it remained at par with 125% RDF and RDF+FYM. The application of 125% RDF+FYM, 125% RDF, RDF+FYM, RDF+foliar NPK, RDF+soil Zn, RDF+foliar sampoorna and RDF+foliar zinc treatments increased the grain yield by 18.41, 13.41, 11.70, 10.67, 9.87, 8.67 and 8.14 per cent; respectively as compared to 100% RDF (5158 kg/ha). This increment might be due to improvement in yield attributes and cumulative interaction between vegetative and reproductive growth of the crop plants. Further all the treatments significantly increased the straw yield over 100% RDF except RDF+foliar NPK, RDF+foliar sampoorna and RDF+foliar zinc. The highest straw yield (7792 kg/ha) was recorded with the application of 125% RDF+FYM, which was statistically superior over RDF+FYM, RDF+soil Zn, RDF+foliar NPK, RDF+foliar sampoorna and RDF+foliar zinc 100%. However, 125% RDF was found at par with 125% RDF+FYM. The highest biological yield (13900 kg/ha) was recorded under 125% RDF+FYM treatment which was found to be significantly superior to all the other treatments. The increment in biological yield under 125% RDF+FYM, 125% RDF, RDF+FYM, RDF+foliar NPK, RDF+soil Zn, RDF+foliar sampoorna, RDF+foliar zinc was to extent of 17.97, 12.38, 10.14, 8.49, 8.49, 6.70 and 6.40 per cent; respectively over 100% RDF (11783 kg/ha). Significant improvement in yield of paddy due to higher level of NPK were also reported by Kalyanasundaram *et al.* (2020) [18] and Indira *et al.* (2023) [19]. The application of FYM combined with RDF resulted in significantly higher grain, straw and biological yields compared to 100% RDF alone. This improvement could be attributed to better nutrient availability, improved soil structure and enhanced microbial activity from the addition of FYM as reported by Muthukumararaja *et al.* (2019) [20]. Similar yield enhancements with RDF+FYM integration were also reported by Behera and Pany (2021) [21].

The application of soil Zn along with RDF and foliar spray of $ZnSO_4$ along with RDF significantly increased paddy yield over 100% RDF alone. This yield improvement could be attributed to Zn role in key metabolic processes, enhancing plant growth and grain filling. Similar findings were reported by Wahane *et al.* (2022) [22]. The application foliar Sampoorna along with RDF improved grain and biological yields over 100% RDF, likely due to enhanced tillering, better panicle development, and improved grain filling from efficient nutrient uptake. Similar improvements in paddy yield were reported by Devi *et al.* (2025) [24]. Foliar application of NPK 19:19:19 along with RDF significantly improved paddy yield and yield attributes over 100% RDF alone. This improvement might be due to enhanced photosynthesis and efficient nutrient uptake during critical growth stages. Similar results were reported by Denesh *et al.* (2022) [23].

Economics

The economic analysis (Table 3) revealed that the highest net return was recorded with the application of 125% RDF along with FYM, (₹135844/ha). This enhanced profitability due to the increased crop yield achieved under this treatment. However, the difference in net return was not statistically significant as compared to the treatments of 125% RDF, RDF + FYM, RDF + soil Zn and RDF + foliar NPK during the present study. In contrast, the highest B:C ratio was fetched under the 125% RDF treatment (2.91), which was statistically at par with all other nutrient management treatments evaluated. Further, treatments including 125% RDF, RDF + FYM, RDF + foliar NPK, and RDF+soil Zn also recorded significantly higher net returns as compared to RDF alone.

Table 1: Effect of nutrient management on various growth parameters of transplanted paddy

Treatments	No. of tillers/m²		Plant height (cm)				Chlorophyll content (mg/g)	DMA (g/m²)			CGR (g/m²/day)	
	60 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest	60 DAT	30 DAT	60 DAT	90 DAT	30- 60 DAT	60- 90 DAT
T_1 - 100% RDF	308	293	59.2	91.2	110.6	113.5	2.35	245.0	652.5	966.3	13.58	10.46
T_2 - RDF+FYM	332	324	62.9	95.5	115.9	119.2	2.50	269.9	692.0	1044.7	14.07	11.76
T_3 - 125% RDF	336	319	64.5	96.2	117.7	121.5	2.52	276.3	708.0	1062.9	14.39	11.83
T_4 - 125% RDF+FYM	344	338	66.1	98.4	121.6	124.8	2.58	287.3	720.3	1078.2	14.43	11.93
T_5 - RDF+Soil Zn	319	316	58.5	94.5	115.4	118.6	2.46	263.7	664.0	1002.5	13.34	11.28
T_6 - RDF+Foliar Zn	313	304	57.7	92.5	115.0	117.2	2.43	255.1	658.4	981.6	13.44	10.77
T_7 - RDF+Foliar sampoorna	311	297	59.1	91.8	114.0	116.5	2.39	252.9	655.0	971.1	13.40	10.54
T_8 - RDF+Foliar NPK	313	302	60.4	94.1	117.4	120.4	2.47	250.0	662.3	1002.8	13.74	11.35
SEm±	7.53	7	1.11	1.15	1.46	1.56	0.03	5.76	12.30	13.81	0.25	0.27
CD (p = 0.05)	22.84	21	3.35	3.47	4.42	4.72	0.10	17.46	37.32	41.90	0.76	0.81

Table 2: Effect of nutrient management on yield attributes of transplanted paddy

Treatments	Panicle/m²	Panicle weight (g)	Panicle length (cm)	No. of filled grain/panicle	No. of unfilled grains/panicle	Test weight (g)
T_1 - 100% RDF	263	3.32	24.3	131.4	20.7	25.33
T_2 - RDF+FYM	287	3.80	26.3	150.1	21.9	26.06
T_3 - 125% RDF	290	3.88	26.8	147.7	22.4	25.93
T_4 - 125% RDF+FYM	298	3.95	27.8	155.0	24.6	26.14
T_5 - RDF+Soil Zn	280	3.66	25.7	145.2	19.8	25.76
T_6 - RDF+Foliar Zn	276	3.55	25.1	139.5	19.2	25.66
T_7 - RDF+Foliar sampoorna	272	3.63	25.3	142.3	19.4	25.88
T_8 - RDF+Foliar NPK	277	3.74	26.8	144.9	18.7	26.08
SEm±	5.31	0.086	0.5	3.36	1.06	0.15
CD (p = 0.05)	16.09	0.260	1.4	10.2	3.22	0.45

Table 3: Effect of nutrient management on yield and economics of transplanted paddy

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Net return (₹/ha)	B:C ratio
T_1 - 100% RDF	5158	6625	11783	43.77	109151	2.64
T_2 - RDF+FYM	5762	7320	12979	44.41	125355	2.78
T_3 - 125% RDF	5850	7392	13242	44.18	130700	2.91
T_4 - 125% RDF+FYM	6108	7792	13900	43.95	135844	2.88
T_5 - RDF+Soil Zn	5667	7117	12784	44.33	124032	2.80
T_6 - RDF+Foliar Zn	5578	6958	12536	44.50	120495	2.74
T_7 - RDF+Foliar sampoorna	5605	6967	12572	44.58	120581	2.73
T_8 - RDF+Foliar NPK	5708	7075	12783	44.65	124286	2.79
SEm±	131.17	155.88	208.69	0.773	4046.2	0.06
CD (p = 0.05)	397.81	472.75	632.89	NS	12270.9	NS

Conclusion

Based on present study, it may be concluded that recommended doses of fertilizers should be reconsidered in transplanted paddy, as crop exhibited substantial economic response on high fertility levels. As the application of 125% RDF+FYM significantly enhanced the grain yield and fetched higher net return (₹135844/ha), however, it was at par with 125% RDF and RDF+FYM and significantly higher over 100% RDF. If FYM not applied than use 125% RDF for higher yield and economic returns. Foliar sprays of water soluble NPK 19:19:19 @ 0.5% at tillering and panicle initiation as supplementary to the RDF also found economically viable and yield remunerative. Further soil application of zinc @ 5.25 kg/ha at the time of last ploughing is advisable for Zn deficient soils to improve crop performance.

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