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Effect of nutrient management in transplanted rice (*Oryza sativa* L.)

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Abstract
A field investigation entitled "Effect of Nutrient Management in Transplanted Rice (*Oryza sativa* L.)" was carried out during the *Kharif* season of 2024 at the Instructional Farm, Barrister Thakur Chhedilal College of Agriculture and Research Station, Sarkanda, Bilaspur (Chhattisgarh). The study aimed to assess the impact of integrated nutrient management strategies involving soil-applied fertilizers and foliar sprays on the growth, yield, nutrient uptake, and economic returns of transplanted rice. The experiment was laid out in a Randomized Block Design with seven nutrient management treatments: T_1 - Control (no fertilizer), T_2 - 100% Recommended Dose of Fertilizer (RDF) (100:60:40 kg NPK/ha), T_3 - 100% RDF + foliar spray of NPK (19:19:19) once at 50 days after transplanting (DAT), T_4 - 75% RDF + foliar spray once at 50 DAT, T_5 - 75% RDF + foliar spray twice at 25 and 75 DAT, T_6 - 75% RDF + foliar spray thrice at 25, 50, and 75 DAT, and T_7 - foliar spray thrice at 25, 50, and 75 DAT. The rice variety Indira Barani Dhan-1, a mid-duration cultivar, was used in this study. Results revealed that T_6 (75% RDF + NPK foliar spray thrice at 25, 50 and 75 DAT) showed significantly enhanced growth parameters (plant height, number of effective tillers, dry matter accumulation, crop growth rate and relative growth rate), yield attributes (number of panicles, panicle length and number of grains per panicle), grain yield and straw yield, harvest index and economic returns (cost of cultivation, gross returns, net returns and B: C ratio). The highest grain yield (45.87 q ha^{-1}) and straw yield (54.84 q ha^{-1}) were recorded in T_6 (75% RDF + NPK foliar spray thrice at 25, 50 and 75 DAT). Additionally, T_6 achieved the highest gross return (₹ 1,46,901.21 ha^{-1}), net return (₹ 1,03,978.68 ha^{-1}), and benefit-cost ratio (2.42). Nutrient uptake in grain and straw was also significantly improved with integrated nutrient management. Post-harvest soil analysis indicated no adverse impact on soil pH, EC, or organic carbon. The study concludes that a combination of 75% RDF and timely foliar applications of NPK is a resource-efficient and sustainable strategy to enhance transplanted rice productivity and profitability in rainfed agro-ecosystems.

Keywords: Transplanted rice, RDF (Recommended Dose of fertilizer), foliar spray, NPK, integrated nutrient management

Introduction
Rice (*Oryza sativa* L.) is a staple food crop worldwide, particularly in Asia, contributing approximately 90% of global production and consumption. It provides a major source of calories and protein, sustaining a significant portion of the global population. In India, rice serves as the staple food for over 60% of the population, playing a crucial role in food security and economic stability. Chhattisgarh, known as the "Rice Bowl of India," is a major rice-producing state where rice cultivation predominantly occurs during the *Kharif* season under rainfed conditions.

Fertilizers are indispensable for increasing food production, especially for high yielding crop varieties which respond well to fertilizer application. Crops like rice require significant number of inorganic fertilizers for optimal growth. Rice production is primarily determined by characteristics (number of grains per panicle, grain yield and straw yield) and more importantly, by the availability of nutrients including nitrogen, phosphorus, potassium, sulphur, and zinc (Masum *et al*., 2013) [14]

Efficient nutrient management is essential to sustain rice productivity. However, nutrient use efficiency in India remains low due to nutrient losses from leaching, volatilization, and soil fixation. Nitrogen, phosphorus, and potassium are the primary macronutrients vital for rice growth, influencing key physiological processes. Traditional soil fertilization alone often fails to

meet crop nutrient demands efficiently due to these losses. Foliar fertilization, where nutrients are directly applied to plant leaves, complements soil fertilization by improving nutrient availability during critical growth stages (Jagath Jyothi *et al.*, 2012) [9]

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) [19]. Additionally, nitrogen is highly soluble and prone to leaching, making it unavailable to plants and causing nutrient loss.

Foliar nutrient absorption is an inherent physiological mechanism through which plants acquire essential elements, particularly when soil nutrient availability is constrained. In agronomic practices, this is achieved by spraying dilute nutrient solutions onto the leaf surface (Fageria *et al.*, 2009) [8]. Foliar application is particularly effective during critical growth stages, enhancing nutrient uptake, stimulating physiological processes, and improving crop yield. Its role as a supplementary approach to soil fertilization rather than a replacement (Kundu Sarkar, 2009) [11]. The efficiency of foliar application may surpass soil application by 6 to 20 times, depending on specific soil properties.

Integrated nutrient management, combining soil-applied and foliar-applied nutrients, has shown promise in enhancing nutrient use efficiency, improving growth, and increasing crop yields. Despite evidence supporting its benefits, there is limited research on its optimization for rainfed transplanted rice cultivation in Chhattisgarh.

Thus, the present study was undertaken to evaluate the effects of integrated soil and foliar nutrient management on the growth, yield attributes, nutrient uptake, and economic viability of transplanted rice.

Materials and Methods

`The field experiment was conducted during the *Kharif* season of 2024 at the Instructional Farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Sarkanda, Bilaspur (Chhattisgarh). The site is situated at 22.09°N latitude and 82.14°E longitude with an elevation of 291.3 meters above mean sea level. The region has a slightly moist, hot subtropical climate, with an average annual rainfall of 1164.2 mm.

The soil of the experimental field was clay loam in texture, slightly acidic (pH 6.3), with low organic carbon (0.58%) and medium levels of available nitrogen (268.04 kg ha^{-1}), phosphorus (16.18 kg ha^{-1}), and potassium (285.87 kg ha^{-1}).

The experiment was laid out in a Randomized Block Design with seven treatments and three replications. The treatments comprised various combinations of basal fertilizer application and foliar NPK sprays *viz*, T_1 (Control), T_2 (100% RDF alone), T_3 (100% RDF + NPK foliar spray once at 50 DAT) T_4 (75% RDF + NPK foliar once at 50DAT), T_5 (75% RDF + NPK foliar spray twice at 25 and 50 DAT) T_6 (75% RDF + NPK foliar spray thrice at 25, 50 and 75 DAT) and T_7 (NPK foliar spray thrice at 25, 50 and 75 DAT) as urea, single super phosphate, and muriate of potash were used to supply the recommended fertilizer doses, and foliar NPK (19:19:19) was applied at 5 g/L as per treatment schedules.

Standard agronomic practices for nursery raising, transplanting, irrigation, and plant protection were followed. Observations on plant population, plant height, number of tillers dry matter accumulation, number of panicles, panicle length, number of grains per panicle, grain and straw yield, harvest index, test weight, nutrient uptake, and soil chemical properties were recorded following standard protocols. 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

The data on plant height (cm) of rice as influenced by various nutrient management treatments at 30, 60, 90 DAT and at harvest, are presented in table 4.1. The results indicate that plant height, number of tillers and dry matter accumulation of rice were significantly affected by the different nutrient treatments across all observation intervals. At 30 DAT, the tallest plants, the highest number of effective tillers and dry matter accumulation were recorded under treatment T_3 - 100% RDF + NPK foliar spray once at 50 DAT, which was significantly higher than T_6 - 75% RDF + NPK foliar spray applied thrice at 25, 50 and 75 DAT. At 60, 90 DAT and at harvest, variations in plant height, number of effective tillers and dry matter accumulation were found significant, with T_6 - 75% RDF + NPK foliar spray applied thrice at 25, 50 and 75 DAT showing the maximum plant height, number of tillers and dry matter accumulation, and statistically comparable with T_3 - 100% RDF + NPK foliar spray once at 50 DAT. These treatments were significantly superior compared to all other treatments. On the other hand, the smallest plants were recorded in T_1 - control, which showed significantly lower plant height than all the other treatments. The lowest plant height was consistently recorded in the untreated control plot (T_1). The treatment T6 (75% RDF + foliar spray thrice) consistently outperformed other treatments in plant height, effective tillers per hill, dry matter accumulation.

Integrated nutrient management significantly influenced yield attributes and grain and straw yield of rice. Number of panicles, panicle length, number of grains per panicle and test weight were highest in treatment T_6 - 75% RDF + NPK foliar spray applied thrice at 25, 50 and 75 DAT and it was at par with treatment T_3 (100% RDF + NPK foliar spray once at 50 DAT. Treatment T_6 has also achieved the highest grain (45.87 q ha^{-1}) and straw yield (54.84 q ha^{-1}).

T_6 recorded the highest nutrient uptake for nitrogen, phosphorus, and potassium in both grain and straw, reflecting improved nutrient availability and utilization. Post-harvest soil analysis showed that the treatments did not significantly alter soil pH, electrical conductivity, or organic carbon levels, confirming the environmental sustainability of these practices.

Economic analysis revealed that T_6 provided the highest gross returns (₹1,46,901.21/ha), net returns (₹1,03,978.68/ha), and benefit-cost ratio (2.42), making it the most economically viable nutrient management strategy.

Table 1: Effect of soil and foliar application of nutrients on plant population, plant height, number of tillers hill^{-1} and dry matter accumulation (g hill^{-1}) on transplanted rice (*Oryza sativa* L.)

Treatments	Plant population (m^2)		Plant height (cm) DAT				Number of tillers hill^{-1} DAT				Dry matter accumulation g hill^{-1}			
	30 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest
T_1 - Control	47.1	47.0	42.6	71.1	89.2	86.1	4.2	5.1	6.1	5.2	6.2	28.7	42.6	63.4
T_2 - 100% RDF (100:60:40 kg NPK ha-1)	50.4	49.9	47.1	7.0	111.6	108.5	7.9	10.3	11.5	10.6	12.2	59.3	113.4	121.0
T_3 - 100% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	51.2	50.3	47.2	92.1	119.0	115.9	8.1	11.9	13.1	12.3	13.3	62.4	119.5	127.3
T_4 - 75% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	49.2	48.3	44.2	81.5	103.8	100.7	5.48	8.51	9.4	8.7	8.3	54.2	103.9	111.0
T_5 - 75% RDF + NPK Foliar spray (19: 19: 19) twice (25 and 75 DAT)	49.5	49.1	45.6	81.9	104.1	101.0	6.6	8.7	9.8	9.0	9.9	56.2	107.1	114.5
T_6 - 75% RDF + NPK Foliar spray (19: 19: 19) thrice (25, 50 and 75 DAT)	50.1	51.0	45.7	95.2	124.3	121.2	6.8	12.3	13.6	12.6	10.6	64.1	122.0	131.6
T_7 - NPK Foliar spray thrice (25, 50 and 75 DAT)	48.5	43.2	44.1	76.4	96.5	93.4	5.3	6.9	7.7	7.1	7.9	51.3	96.6	104.6
S.Em (±)	3.2	3.1	0.4	1.6	2.2	2.2	0.3	0.4	0.5	0.5	0.5	0.9	1.9	1.9
CD (5%)	NS	NS	1.3	4.9	7.0	6.9	1.0	1.5	1.5	1.5	1.5	2.9	5.9	9.1

Table 2: Effect of soil and foliar application of nutrients on number of panicles hill^{-1}, panicle length (cm), number of grains panicles^{-1} and test weight on transplanted rice (*Oryza sativa* L.)

Treatments	Number of panicles hill^{-1}	Panicle length (cm)	Number of grains panicle^{-1}	Test weight (g)
T_1 - Control	5.05	12.03	110.17	21.88
T_2 - 100% RDF (100:60:40 kg NPK ha-1)	10.28	20.84	143.26	23.85
T_3 - 100% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	12.32	23.46	154.91	25.07
T_4 - 75% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	8.39	17.12	129.12	23.48
T_5 - 75% RDF + NPK Foliar spray (19: 19: 19) twice (25 and 75 DAT)	8.67	18.45	133.57	23.61
T_6 - 75% RDF + NPK Foliar spray (19: 19: 19) thrice (25, 50 and 75 DAT)	12.74	25.22	156.24	25.25
T_7 - NPK Foliar spray thrice (25, 50 and 75 DAT)	7.02	14.57	120.08	23.19
SEm (±)	0.34	0.76	2.90	0.35
CD (5%)	1.03	2.42	8.94	1.08

Table. 3: Effect of soil and foliar application of nutrients on grain yield (q ha^{-1}) and straw yield (q ha^{-1}) of transplanted rice (*Oryza sativa* L.)

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1 - Control	23.05	31.54
T_2 - 100% RDF (100:60:40 kg NPK ha-1)	38.94	47.48
T_3 - 100% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	44.06	52.71
T_4 - 75% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	33.56	42.12
T_5 - 75% RDF + NPK Foliar spray (19: 19: 19) twice (25 and 75 DAT)	33.88	42.23
T_6 - 75% RDF + NPK Foliar spray (19: 19: 19) thrice (25, 50 and 75 DAT)	45.87	54.84
T_7 - NPK Foliar spray thrice (25, 50 and 75 DAT)	28.47	36.88
SEm (±)	1.61	1.67
CD (5%)	4.96	5.17

Table. 4: Effect of soil and foliar application of nutrients on harvest index (g) of transplanted rice (*Oryza sativa* L.)

Treatments	Harvest index (%)
T_1 - Control	42.22
T_2 - 100% RDF (100:60:40 kg NPK ha^{-i})	45.06
T_3 - 100% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	45.53
T_4 - 75% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	44.34
T_5 - 75% RDF + NPK Foliar spray (19: 19: 19) twice (25 and 75 DAT)	44.51
T_6 - 75% RDF + NPK Foliar spray (19: 19: 19) thrice (25, 50 and 75 DAT)	45.92
T_7 - NPK Foliar spray thrice (25, 50 and 75 DAT)	43.57

Table 4: Effect of soil and foliar application of nutrients on nutrient content (%) and uptake (kg ha^{-1}) on transplanted rice (*Orrza sativa* L.)

Treatments	Nutrient content (%)						Nutrient uptake kg ha^{-1}					
	N		P		K		N		P		K	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1 - Control	0.78	0.23	0.28	0.06	0.14	1.08	17.97	7.36	6.45	1.92	3.22	24.92
T_2 - 100% RDF (100:60:40 kg NPK ha^{-1})	1.24	0.38	0.34	0.088	0.228	1.65	48.29	14.82	13.11	3.42	8.87	64.18
T_3 - 100% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	1.25	0.4	0.34	0.09	0.232	1.67	55.08	17.47	15.11	3.98	10.24	73.5
T_4 - 75% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	1.23	0.36	0.33	0.084	0.221	1.62	41.28	12.06	11.08	2.81	7.42	54.31
T_5 - 75% RDF + NPK Foliar spray (19: 19: 19) twice (25 and 75 DAT)	1.23	0.36	0.33	0.086	0.222	1.63	41.67	12.36	11.18	2.92	7.54	55.17
T_6 - 75% RDF + NPK Foliar spray (19: 19: 19) thrice (25, 50 and 75 DAT)	1.25	0.4	0.34	0.089	0.235	1.68	60.34	19.4	15.59	4.28	11.34	81.01
T_7 - NPK Foliar spray thrice (25, 50 and 75 DAT)	1.22	0.35	0.32	0.083	0.217	1.6	34.73	9.93	9.11	2.35	6.18	45.5
SEm (±)	0.06	0.01	0.019	0.004	0.012	0.072	2.4	0.68	0.53	0.12	0.38	2.56
CD (5%)	0.19	0.06	0.061	0.02	0.36	0.29	7.41	2.11	1.66	0.39	1.21	7.59

Table 5: Effect of soil and foliar application of nutrients on economics of transplanted rice (*Oryza sativa* L.)

Treatment Details	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
T_1 - Control	34556.00	74217.15	39710.15	1.15
T_2 - 100% RDF (100:60:40 kg NPK ha^{-1})	41685.38	124800.02	83114.64	1.99
T_3 - 100% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	42606.38	141107.98	98501.60	2.31
T_4 - 75% RDF + NPK Foliar spray (19: 19: 19) once (50 DAT)	41080.53	107677.48	66596.95	1.62
T_5 - 75% RDF + NPK Foliar spray (19: 19: 19) twice (25 and 75 DAT)	42001.53	108675.04	66673.51	1.59
T_6 - 75% RDF + NPK Foliar spray (19: 19: 19) thrice (25, 50 and 75 DAT)	42922.53	146901.21	103978.68	2.42
T_7 - NPK Foliar spray thrice (25, 50 and 75 DAT)	37319.00	91461.01	54153.01	1.45

Conclusion

1. The results showed that growth parameters, *viz*. plant population, plant height, number of tillers and yield attributes *viz*., panicle length (25.22 cm), number of grain panicle^{-1} (156.24), test weight (25.25 g) was found to be higher under treatment T_6 - (75% RDF + NPK foliar spray thrice at 25, 50 and 75 DAT) followed by T_3 (100% RDF + NPK foliar spray once) at 50 DAT.
2. The yield parameters like grain yield and straw yield, recorded maximum yield (45.87 q ha^{-1}) under T_6 it is at par with treatment T_3 (44.06 q ha^{-1}).
3. The economic parameters like gross monetary returns, net monetary returns and B:C ratio was significantly superior under treatment T_6 highest gross return (1,46901 ₹ ha^{-1}) was obtained with the application of 75% RDF + NPK foliar spray thrice at 25, 50 and 75 DAT) and this treatment also gave highest net return (104662 ₹ ha^{-1}) and B:C ratio 2.48. However, lowest gross return (74217 ₹ ha^{-1}) lowest net return (40345₹ ha^{-1}) and lowest B:C ratio (1.19) was obtained under control (T_1).

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