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Response of Kharif Transplanted Rice (*Oryza sativa* L.) under Different Nitrogen Management Practices

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at the Siksha "O" Anusandhan University Bhubaneswar during *kharif* season 2022 in a well-drained sandy loam soil to study the effect of nutrient management practices on growth, yield, nutrient uptake and economics of rice under different organic and inorganic nutrient management practices. The experiment was laid out in a factorial randomized block design with ten set of treatments viz. T_1: 75%RDN, T_2: 100% RDN, T_3: 125%RDN ,T_4: 50% N of T_1 as urea+50% N through FYM,T_5:50%N of T_1 as urea+50% N through NOC, T_6: 50%N of T_2 as urea+50% N through FYM, T_7:50%N of T_2 as urea+50% N through NOC, T_8: 50%N of T_3 as urea+50% N through FYM, T9:50%N of T_3 as urea+50% N through NOC, and T_{10}: Farmer's

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Practice (80:40:40 kg NPK/ha+ FYM 5 t/ha) and replicated thrice. Results revealed that maximum plant height, number of tillers per m^2 and dry matter production/m^2 was recorded with treatment T_6 (50% N of T_2 as urea+50% N through FYM) at harvest. The highest grain yield along with high yield attributing characters like panicle/m^2 filled grains/panicle and test weight was recorded with application of T_6 (50% N of T_2 as urea +50% N through FYM) than all other treatments. Nitrogen, phosphorus and potassium uptake was recorded highest under the treatment T_6 (Application of 50% N of T_2 as urea + 50 % N through FYM.

Keywords: Inorganic nutrient management practices; transplanted rice; chemical farming; poultry manure.

1. INTRODUCTION

Fertilizers are the major source of nutrients for rice under intensive cultivation. However, continuous and extensive use mainly attributed to macronutrient imbalance, micro-nutrients deficiency and fertilizer related environmental pollution [1,2]. Further, the produce of chemical farming is poor in quality that affects the market acceptability. Under such situation, the restoration of soil fertility and improvement in rice yield and its quality could only be achieved through integrated use of chemical fertilizers in combination with organic manures [3,4]. Application of organics like farm yard manure, poultry manure, vermicompost, bio-fertilizers, and recycling of crop residues play a vital role in nutrients cycling, improves physical, chemical and biological properties of soil [5]. Nitrogen (N) is a yield-limiting nutrient for rice in India and its efficient use is crucial for economic and environmental sustainability. A synchrony of fertilizer application with crop demand along various nitrogen losses in Eastern India leads to low fertilizer efficiency in *kharif* rice. Inefficient utilization of nitrogen is considered to be the most critical one among various reasons for this low productivity. Blanket application of N fertilizer is the prime cause of low nitrogen use efficiency, increased cost of cultivation, and environmental degradation. Due to substantial temporal and plot-to-plot unevenness in indigenous nitrogen supply of soil, broad-based N recommendations like state -recommended N application for rice cannot be helpful. Real-time nitrogen management and site-specific nitrogen management (SSNM) are recent scientific approaches that ensure both increases in rice productivity and sustainability of the rice ecosystem. Given the value and significance of rice as a crop for human consumption, it is imperative to limit the usage of chemical fertilizers by implementing management measures such the combined use of organic and inorganic sources of nutrients. Combining the application of organic and inorganic fertilizers is one of the fertilizer management practices for successful rice culture, and it is not only a reliable method of increasing yields but also a concept that is ecologically sound for sustainable agriculture. Therefore, a balanced blend of chemical fertilizers and organic manures enhances soil health and increases sustainable production. The utilization of Farm Yard Manures (FYM), Neem oilcake (NOC), bio fertilizers, and inorganic fertilizers is contemplated by an integrated nutrient management system. Research result in recent past has shown that substituting a part of N through FYM and NOC has helped in increasing the nitrogen efficiency and yield to the extent of 25-30%. Information on integration of inorganic N with either FYM or NOC in East and South Eastern Coastal plain zone of Odisha is meagre. Hence the present experiment was conducted to study the growth, yield attributes and yield of rice under different nitrogen management practices.

2. MATERIALS AND METHODS

A field experiment was conducted during *kharif,* 2022 at Agricultural Research Station, Faculty of Agricultural Science, SOADU, Odisha, India. The experiment was laid in a randomized block design with three replications. The experiment was laid out in a factorial randomized block design with ten set of treatments viz. T_1: 75%RDN, T_2: 100% RDN, T_3: 125%RDN ,T_4: 50% N of T_1 as urea+50% N through FYM,T_5:50%N of T_1 as urea+50% N through NOC, T_6: 50%N of T_2 as urea+50% N through FYM, T_7:50%N of T_2 as urea+50% N through NOC, T_8: 50%N of T_3 as urea+50% N through FYM, T9:50%N of T_3 as urea+50% N through NOC, and T_{10}: Farmer’s Practice (80:40:40 kg NPK/ha+ FYM 5 t/ha) and replicated thrice. The soil of the experimental field was sandy loam in texture with acidic in reaction (pH 5.80), low in organic C (0.44%). Rice was sown manually in line with a spacing of 20 cm x 10 cm. The seed rate was taken 60 kg/ha. The rice variety CR Dhan 314 was used in this experiment. Fertilizerwasappliedinaccordancewiththeprescrib edcourseoftreatment.At the time of the last puddling, a full dose of $P_2O_5$and 50% K_2O were added togetherwith 25% N. The first top dressing of 50% N was applied 21 days after planting, andthe remaining top dressing of 25% N and 50% K_2O was applied during the panicle initiation stage. During the trial year, sources of N, P_2O_5, and K_2O included urea, sulphur-free phosphatic fertilizer (DAP), and muriate of potash. Sulfur and zinc were treated as $ZnSO_4$ at a rate of 25 kg per hectare, and borax at a rate of 10 kg per hectare, according to the treatment. Plant protection measures were implemented based on necessity and all other suggested agronomic procedures were followed properly. The growth and yield components and yield of rice were also recorded and statistically analysed at 5% level of significance. For nutrient uptake tests of N, P, K and B, composite plant samples from each treatment for three replications were obtained at the time the crop was harvested. For the purpose of conducting a chemical analysis on plant samples, the samples were oven dried, appropriately ground by a Willey mill grinder, and passed through a 2 mm screen.

3. RESULTS AND DISCUSSION

Results revealed that maximum plant height, number of tillers per m^2 and dry matter production/m^2 was recorded with treatment T_6 (50% N of T_2 as urea+50% N through FYM) at harvest. This is due to the positive effect of FYM over NOC in manipulating the soil physical condition and making availability of more nutrients. This findings are in conformity with the observation of Mankotia [6] and Roul et al. [7].

Table 1. Effect of nutrient management practices on growth attributes of rice

Treatment	Plant height (cm)	Tillers/ hill	Dry matter production /plant
T1: 75%RDN	124.5	13.29	24.76
T2: 100%RDN	127 .1	13.93	25.54
T3: 125%RDN	134.6	13.88	25.85
T4: 50% N of T1 as urea+50% N through FYM	131.5	13.46	25.83
T5:50%N of T1 as urea+50% N through NOC	133.7	13.89	25.19
T6: 50%N of T2 as urea+50% N through FYM	140.7	14.97	27.44
T7:50%N of T2 as urea+50% N through NOC	138.1	14.64	26.86
T8: 50%N of T3 as urea+50% N through FYM	136.8	14.39	25.44
T9: 50%N of T3 as urea+50% N through NOC	134.3	14.63	25.08
T10: Farmer’s Practice (80:40:40 kg NPK/ha + FYM 5 t/ha)	131.3	14.03	26.04
SE (m)±	**2.29**	**0.25**	**0.81**
LSD (P=0.05)	**6.82**	**0.73**	**1.99**

Table 2. Effect of nutrient management practices on yield attributes and yield of rice

Treatment	Panicle length (cm)	Panicle/ m2	Filled grains / panicle	Test weight (g)	Grain yield (t/ha)
T1: 75%RDN	24.17	220	130	20.26	3.45
T2: 100%RDN	24.30	236	142	21.23	3.68
T3: 125%RDN	25.33	242	146	23.78	3.78
T4: 50% N of T1 as urea+50% N through FYM	24.47	223	138	23.12	3.62
T5:50%N of T1 as urea+50% N through NOC	24.88	241	140	22.93	3.62
T6: 50%N of T2 as urea+50% N through FYM	26.00	263	165	25.58	3.95
T7:50%N of T2 as urea+50% N through NOC	26.00	260	157	24.21	3.82
T8: 50%N of T3 as urea+50% N through FYM	25.70	266	160	24.93	3.72
T9: 50%N of T3 as urea+50% N through NOC	25.13	264	165	23.82	3.82
T10: Farmer’s Practice (80:40:40 kg NPK/ha+ FYM 5 t/ha)	25.20	248	146	23.11	3.58
SE (m)±	**0.24**	**3.8**	**4.5**	**0.38**	**0.02**
LSD (P=0.05)	**0.71**	**11**	**17**	**1.11**	

Table 3. Nutrient uptake by plants in accordance to the nutrient management practices

Treatment	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potassium (kg/ha)		
	Grain	**Straw**	**Total**	**Grain**	**Straw**	**Total**	**Grain**	**Straw**	**Total**
T1: 75%RDN	40.66	26.89	67.55	10.16	10.66	20.82	22.45	50,33	72.78
T2: 100%RDN	55.38	29.26	84.64	13.62	12.60	26.22	22.4	55.62	78.02
T3: 125%RDN	56.35	39.42	95.77	16.2	12.22	28.42	23.42	67.87	91.29
T4: 50% N of T1 as urea+50% N through FYM	54.32	36.77	91.09	14.22	14.44	28.66	25.33	75.45	100.78
T5:50%N of T1 as urea+50% N through NOC	48.51	34.76	83.27	14.4	13.67	28.07	26.5	66.66	93.16
T6: 50%N of T2 as urea+50% N through FYM	68.67	43.71	112.38	16.30	17.19	3.49	27.9	127.54	155.44
T7:50%N of T2 as urea+50% N through NOC	45.77	34.87	80.64	16.25	16.34	32.59	26.8	110.76	137.56
T8:50%N of T3 as urea+50%N through FYM	45.88	32.45	78.33	16.2	16.43	32.63	24.4	78.54	102.94
T9:50%N of T3 as urea+50% N through NOC	44.56	30.56	75.12	14.64	13.54	28.16	23.80	77.45	101.25
T10:Farmer's Practice (80:40:40 kg NPK/ha+ FYM 5 t/ha)	42.54	34.56	77.1	12.05	12.56	24.6	22.20	67.65	89.85
SE(m)±	**5.12**	**5.55**		**1.47**	**1.11**		**5.41**	**1.84**	
LSD (P=0.05)	**12.56**	**13.60**		**3.61**	**2.45**		**2.1**	**4.51**	

Table 4. Residual soil fertility

Treatment	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available k (kg/ha)
T1: 75%RDN	0.53	227.87	21.80	237.23
T2: 100%RDN	0.54	242.37	22.67	239.50
T3: 125%RDN	0.54	242.47	23.87	240.23
T4: 50% N of T1 as urea+50% N through FYM	0.55	230.27	23.17	247.17
T5:50%N of T1 as urea+50% N through NOC	0.55	236.07	23.00	240.87
T6: 50%N of T2 as urea+50% N through FYM	0.56	247.20	23.48	262.43
T7:50%N of T2 as urea+50% N through NOC	0.51	234.27	23.05	247.93
T8: 50%N of T3 as urea+50% N through FYM	0.56	244.40	23.47	240.53
T9:50%N of T3 as urea+50% N through NOC	0.52	239.40	23.76	233.13
T10: Farmer's Practice (80:40:40 kg NPK/ha+ FYM 5 t/ha)	0.53	243.43	22.16	218.17
SE(m)±	**0.01**	**7.11**	**0.89**	**9.36**
LSD (P=0.05)	**0.04**	**17.43**	**2.18**	**22.94**
Initial values	0.54%	245	23.58	185.50

The highest filled grains /panicle, test weight and panicle/ m^2 was recorded with application of 50%N of T_2 as urea+50% N through FYM over other treatments T_7 (50%N of T_2 as urea+50% N through NOC), T_8 (50%N of T_3 as urea+50% N through FYM) and T_9 (50%N of T_3 as urea+50% N through NOC) had similar results. Conversely, using 75% of the recommended nitrogen dose (RDN) resulted in the lowest number of filled grains /panicle, test weight and panicle/ m^2. Replacing 50% of RDN with FYM and the rest with urea led to the highest number of filled grains, test weight and panicle/ m^2 compared to using urea and neem oil cake at different RDN levels. This difference is attributed to FYM's positive impact on soil conditions and nutrient availability compared to neem oil cake (NOC). This findings are in confirmity with the observation of Singh et al. [8]. Panicle length varied significantly due to different nutrient management practices. Among the nutrient management practices maximum panicle length was observed with application of 50% N of T_2 as urea+50% N through FYM (T_6).

The highest grain yield was recorded with application of T_6 (50%N of T_2 as urea+50% N through FYM) than all other treatments. T_7 (50%N of T2 as urea+50% N through NOC) T_8 (50%N of T_3 as urea + 50% N through FYM) and T_9 (50%N of T3 as urea+50% N through NOC) recorded at par value of grain and straw yield of rice. However, application of 75% of the recommended nitrogen dose (RDN) resulted in the lowest grain and straw yield. The grain yield was increased by 14.49% under treatment T_6 as compared to treatment T_1.

Similar trend was followed in harvest index. Highest harvest index was recorded with application of T_6 (50 % N of T_2 as urea + 50% N through FYM) than all other treatments. Singh et al. (2018) reported that the integrated nutrient management approach increased grain yield in rice, contributing to higher overall production.

3.1 Nutrient Uptake

The highest nitrogen, phosphorus and potassium uptake was recorded under T_6 (50%N of T2 as urea+50% N through FYM) resulted compared to all other treatments. Pandey et al. [9] stated that the combined use of compost, crop residues with chemical fertilizers significantly increased the availability of N, P and K in soil over chemical fertilizer alone.

3.2 Residual Soil Fertility

Table 4 serves as a repository of rich data concerning the residual soil fertility outcomes stemming from a multitude of treatment approaches. Among these varied treatments, T_6 (50%N of T_2 as urea+50% N through FYM), consistently emerged as the frontrunner in terms of nitrogen uptake across all growth stages. Notably, its performance surpassed that of all other treatments, making it a noteworthy standout in the study's findings. In contrast, treatments T_7 (50% urea + 50% neem oil cake or NOC), T_8 (50% urea + 50% FYM), and T_9 (50% urea + 50% NOC) showed relatively comparable levels of residual soil fertility, thus presenting a more homogeneous group in terms of outcomes.

An intriguing discovery throughout the study was that the application of only 75% of the recommended nitrogen dose (RDN) consistently led to the lowest plant height across all growth stages. This consistent pattern suggests that a lower nitrogen dosage can have detrimental effects on plant height, reinforcing the importance of adhering to recommended nitrogen levels. A particularly noteworthy observation was that substituting 50% of the RDN with FYM and allocating the remaining 50% to urea consistently resulted in the highest levels of residual soil fertility. This trend held true even when compared to the use of urea and neem oil cake at varying RDN levels. This fascinating discrepancy in outcomes can be attributed to FYM's ability to positively influence soil conditions and enhance nutrient availability, setting it apart from neem oil cake (NOC) in terms of its impact on soil fertility. These findings robustly affirm the trends and observations that have been consistently documented throughout our study by Singh et al. [10].

4. CONCLUSION

The utilization of Farm Yard Manures (FYM), Neem oilcake (NOC), bio fertilizers, and inorganic fertilizers is contemplated by an integrated nutrient management system. From this study, it can be concluded that application of 50% N of T_2 as urea+50% N through FYM was found to be superior in respect to growth, yield attributes and yield of rice.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models

(ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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