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Response of organic and inorganic fertilizer yield of transplanted rice (*Oryza sativa* L.)

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Abstract

A field experiment entitled “Response of Organic and Inorganic Fertilizers on Yield of Transplanted Rice (*Oryza sativa* L.)” was conducted during the Kharif season of 2023-24 at the Research Farm, Department of Agronomy, School of Agricultural Science, Technology & Research, Sardar Patel University, Balaghat (M.P.). The study included nine treatments comprising different combinations of organic and inorganic nutrient sources. These consisted of a control plot (T₁), 6 t/ha vermicompost + Azotobacter (T₂), 6 t/ha vermicompost + 6 t/ha FYM + PSB + Azospirillum (T₃), 50% RDF + 6 t/ha FYM (T₄), 50% RDF + 6 t/ha FYM + Azospirillum (T₅), 75% RDF + PSB + Azospirillum (T₆), 75% RDF + 6 t/ha FYM (T₇), 75% RDF + 8 t/ha FYM (T₈), and 100% RDF (T₉). The experiment was laid out in a Randomized Block Design (RBD) with three replications. Based on the experimental results, the application of 100% RDF produced the highest grain yield (54.50 q/ha), gross returns (₹101405.50/ha), net returns (₹63700.50/ha), and the maximum benefit-cost ratio (1.80:1). These findings indicate that applying the recommended dose of NPK @ 120:80:60 kg/ha is a profitable and effective nutrient management practice under integrated nutrient management systems.

Keywords: Organic, tiller, bio-fertilisers, grains, seed index, straw, yield

Introduction

Rice (*Oryza sativa* L.) serves as the staple food for more than half of the global population, with Asia accounting for over 90% of its production and consumption. Among the various agronomic practices influencing rice productivity, nutrient management plays a crucial role. However, in recent decades, a steady decline in the partial factor productivity of fertilizers has been reported. Given the growing interest in organic farming in countries like India, integrating organic and inorganic nutrient sources has emerged as the most practical and sustainable strategy for farmers.

Agriculture is fundamentally dependent on soil, and achieving the required yield levels of major crops is impossible without ensuring a balanced and adequate nutrient supply (Antil and Singh, 2007; Kumar, 2016) ^[1, 10]. For plants to fully utilize nutrients, they must be present in appropriate forms, in the right quantities and proportions, and at the correct growth stages (Chandrashekara *et al.*, 2000) ^[2]. Currently, excessive use of fertilizers poses environmental concerns mainly in developed nations and a few regions of developing countries (Kumar, 2015) ^[9]. Applying fertilizers judiciously is essential to sustain crop yields while minimizing environmental risks (Jat *et al.*, 2013; Kumar, 2015) ^[4, 9]. In many developing regions, however, fertilizer use remains so low that environmental threats are minimal, and increased application of organic and inorganic sources could both improve yields and support environmental health (Kumar and Chopra, 2016) ^[10].

Over the past several decades, heavy dependence on chemical fertilizers worldwide has promoted the view of soil as merely a physical substrate for crops, rather than a dynamic and living ecosystem. Continuous use of these chemicals has negatively impacted soil physico-chemical properties, microbial activity, and the quality of agricultural produce. Entry of chemical residues into plants and the food chain has raised concerns about food quality. Issues such as declining soil factor productivity, depletion of soil organic carbon, and diminishing nutrient reserves (Prakash *et al.*, 2008) ^[11] are direct consequences of imbalanced and

indiscriminate use of fertilizers in modern rice production systems. With limited scope to expand cropland and declining productivity trends, ensuring food security for a population projected to surpass 8.5 billion by 2022 remains a major challenge.

The principle behind integrating organic and inorganic fertilizers is to maintain, and where possible, enhance soil fertility for sustainable long-term productivity while also reducing the cost of inorganic inputs (Kumar and Chopra, 2010; Kalhapure *et al.*, 2013)^[1, 5]. Integrated nutrient management (INM) focuses on optimizing soil fertility and nutrient supply through the efficient and balanced use of all available nutrient sources, both organic and inorganic (Kannan *et al.*, 2013; Jat *et al.*, 2015)^[7, 4]. In plant nutrition, soil organic matter is a critical determinant of nutrient availability. Semi-arid regions of Madhya Pradesh commonly exhibit low soil fertility and reduced organic carbon levels, mainly due to high temperatures and rapid organic matter decomposition.

Materials and Methods

The experiment was carried out at the Research farm of the Department of Agronomy, School of Agriculture Science, Technology & Research, Sardar Patel University, Balaghat (M.P.). The experiment was conducted in a randomized complete block design with three replications. Different organic and inorganic fertilizer yield of transplanted rice will be allocated to the plots as per treatments. The seed rate used was 30 kg/ha for transplanting with a row-to-row and plant-to-plant distance of 20.0 x 15.0 cm. The study consisted of nine treatments aimed at evaluating the impact of various combinations of organic and inorganic nutrient sources. T₁ served as the control with no nutrient application. T₂ included 6 tons of vermicompost along with *Azotobacter*, while T₃ combined 6 tons each of vermicompost and farmyard manure (FYM) with phosphate-solubilizing bacteria (PSB) and *Azospirillum*. T₄ received 50% of the recommended dose of fertilizers (RDF) along with 6 tons of FYM, and T₅ included the same treatment with the addition of *Azospirillum*. T₆ involved 75% RDF along with PSB and *Azospirillum*. T₇ and T₈ were treated with 75% RDF combined with 6 and 8 tons of FYM, respectively. T₉ received the full 100% RDF. These treatment combinations were designed to assess their effects on crop yield, nutrient uptake, and soil fertility under integrated nutrient management practices. All the other agronomic practices were applied uniformly to all the treatments. The experiment will be consisting of the following factors along with their respective levels.

Results and Discussion

The application of different nutrient levels produced a significant improvement in the growth parameters of rice, including plant height, leaf number per plant, and tiller count per hill, across all observation stages during the experiment. The superior performance observed under the 100% RDF treatment may be linked to the development of a larger and more persistent photosynthetically active leaf area throughout the vegetative and reproductive phases. This likely enhanced light interception, photosynthesis, nutrient uptake, and total dry matter accumulation, ultimately resulting in improved growth. Both inorganic fertilizers alone and their combinations with vermicompost, FYM, or biofertilizers showed clear superiority over the control in enhancing growth attributes.

In the present study, plant height was consistently influenced by varied combinations of organic and inorganic nutrient sources.

These results align with the observations of Kumar *et al.* (2012)^[8], who recorded increased plant height in rice when FYM and pressmud were applied along with 75% NP, compared with 100% NP alone. The maximum plant height was achieved with the application of 100% NP + green manure. Similar findings were reported by Kumar *et al.* (2015)^[9], who noted improved wheat growth under integrated nutrient management.

Differences in leaf and tiller production among treatments were largely attributed to differences in nutrient availability. Chemical fertilizers supply nutrients in forms readily soluble in soil solution, supporting immediate plant uptake, although losses may occur through leaching or volatilization. In contrast, organic sources release nutrients gradually, maintaining steady nutrient availability throughout the crop's growth cycle. Singh *et al.* (2016)^[15] also reported similar trends. The number of tillers increased from 30 to 90 DAT, followed by a natural decline due to tiller mortality and senescence.

Treatments combining organic inputs with fertilizers produced the highest leaf and tiller counts. This may be due to the rapid decomposition of organic materials, release of organic acids, and oxidation of sulphur present in bio-organics, which collectively help in moderating soil pH. As noted by Sultana *et al.* (2015)^[17], a shift of pH toward neutrality improves the availability of several nutrients. Organic inputs also exert residual benefits in subsequent seasons owing to their slower decomposition rates (Singh *et al.*, 2015)^[16].

Yield attributes of rice responded positively to higher nutrient levels. The application of 100% RDF registered the maximum values for panicle length (34.88 cm), total grains per panicle (192.80), filled grains per panicle (164.66), chaffy grains per panicle (25.00), and 1000-grain weight (24.60 g). Although 100% RDF produced the highest values, it remained statistically comparable with slightly lower nutrient levels. These improvements are likely a consequence of higher vegetative growth, enhanced translocation of photosynthates to reproductive structures, and continuous nutrient mineralization during later growth stages.

The combined application of NPK supported vigorous early root development and rapid cell division, allowing greater extraction of nutrients from deeper soil layers. Since the experimental soil was low in nitrogen (176.6 kg/ha) and medium in phosphorus (12.5 kg/ha) and potassium (200 kg/ha), the crop responded strongly to 100% RDF. Adequate nutrient supply at the basal stage also ensured healthy crop establishment and reduced early crop-weed competition. Similar observations were reported by Ravichandran (2019) and Kalyan *et al.* (2020).

Plots receiving both organic and inorganic sources recorded the highest number of grains per panicle. The beneficial effects of organic inputs may result from rapid decomposition and organic acid production, as well as sulphur oxidation, which helps neutralize soil pH and thereby enhances nutrient availability (Singh *et al.*, 2015)^[16].

The test weight of rice increased significantly with integrated nutrient management. Organic inputs improve soil structure, aeration, and root development, allowing greater nutrient uptake. Additionally, organics help reduce nutrient losses from chemical fertilizers by minimizing volatilization, denitrification, and leaching (Sahu *et al.*, 2015)^[13]. Better root development and nutrient uptake ultimately enhance grain filling and boldness. Sultana *et al.* (2015)^[17] also reported increased 1000-grain weight when chemical fertilizers were supplemented with organic manures.

Improvements in straw yield followed a sequential process. The addition of organic sources raised soil organic matter content,

which improved soil physical properties, nutrient availability, and biological activity. The release of organic acids helped lower soil pH and enhanced nutrient dissolution, increasing uptake by plants. This enhanced nutrient uptake stimulated metabolic activities, translating into improvements in plant height and tillering—traits directly contributing to increased straw yield. Sultana *et al.* (2015)^[17] reported similar increases in straw yield with the application of FYM and other organic amendments along with mineral fertilizers. The present findings reaffirm the importance of integrating organic and inorganic nutrients to maximize rice productivity. The higher straw yield under 100% RDF likely resulted from improved growth parameters, particularly plant height and tiller number.

Economic analysis revealed that nutrient levels significantly influenced gross returns, net returns, and the benefit-cost ratio. The highest profitability was obtained with 100% RDF, yielding net returns of ₹63,700.50/ha, which marked a substantial improvement over 75% RDF + 8 t FYM (T_8) and the control (T_1). Differences in net returns were primarily due to variations in grain and straw yields, since net returns depend on total production value minus the cost of cultivation. The 100% RDF treatment recorded the highest B:C ratio (1.80:1), attributed to higher yields and relatively lower additional costs compared to other nutrient levels. These results corroborate the findings of Imade *et al.* (2017)^[3].

Table 1: Response of organic and inorganic fertilizer yield of transplanted rice (*Oryza sativa* L.)

Treat.	Treatment combinations	Plant height (cm)	Number of leaves per plant	Number of tillers per hill	Length of panicle (cm)	Test weight (g)	Grain yield per hectare (q/ha)	Straw yield per hectare (q/ha)	Harvest index (%)	Protein content (%)	B: C ratio
T ₁	Control	74.60	44.14	11.07	23.58	19.04	15.83	25.51	38.49	7.06	0.45
T ₂	6 ton Vermicompost + <i>Azotobacter</i>	86.49	48.40	13.53	27.40	20.98	20.84	29.45	40.01	7.57	0.32
T ₃	6 ton Vermicompost + 6 ton FYM + PSB + <i>Azospirillum</i>	90.55	51.20	14.54	28.71	21.25	26.33	32.34	41.38	7.69	1.25
T ₄	50% RDF + 6 ton FYM	91.34	54.53	15.34	29.66	22.39	38.17	37.45	43.10	7.83	1.76
T ₅	50% RDF + 6 ton FYM + <i>Azospirillum</i>	91.64	56.20	16.30	30.47	22.79	39.08	47.17	43.96	7.87	1.68
T ₆	75% RDF + PSB + <i>Azospirillum</i>	91.73	56.34	17.73	30.87	23.26	43.00	47.70	44.55	7.88	1.78
T ₇	75% RDF + 6 ton FYM	93.20	56.83	18.27	31.30	23.69	45.66	48.55	44.87	7.91	1.71
T ₈	75% RDF + 8 ton FYM	95.13	57.53	18.67	31.37	23.97	48.75	60.77	45.11	8.27	1.74
T ₉	100% RDF	99.45	65.53	23.62	34.88	24.60	54.50	66.08	45.37	8.61	1.80
	S. Em±	1.55	1.80	0.10	0.13	0.26	0.3	0.3	0.3	0.1	
	C.D. (P=0.05)	4.52	5.26	0.29	0.37	0.76	0.8	0.8	0.8	0.4	

RDF=100:60:60 Kg NPK ha⁻¹

Conclusion

Based on the findings of this study, the application of 100% RDF emerged as the most effective nutrient management strategy, producing the highest grain yield (54.50 q/ha), along with maximum gross returns (₹101405.50/ha), net returns (₹63700.50/ha), and the highest benefit-cost ratio (1.80:1). These results indicate that the recommended dose of fertilizers, particularly NPK @ 120:80:60 kg/ha, can serve as a profitable and efficient option within an integrated nutrient management framework.

Nevertheless, the outcomes of the present investigation should be considered preliminary. To establish more reliable and broadly applicable recommendations for farmers, further multi-location and multi-season studies are necessary.

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