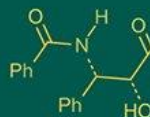


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Effect of organic and inorganic fertilizers on the growth, yield, nutrient uptake and economics in rice (*Oryza sativa* L.)

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Abstract

The present investigation entitled Effect of Organic and Inorganic Fertilizers on the Growth, Yield, Nutrient Uptake and Economics in Rice (*Oryza sativa* L.) was conducted at the Agriculture and Development Centre, Sakatpura, Vikrant University, Gwalior (Madhya Pradesh) was during the winter of Kharif season of 2025-26. The experiment was laid out into Randomized Block Design (RBD) with 3 replications and following treatments viz., T₁ = Control, T₂ = 100% RDF (NPK), T₃ = Vermicompost @ 5.0 t ha⁻¹, T₄ = FYM @ 10.0 t ha⁻¹ T₅ = Compost @ 10.0 t ha⁻¹, T₆ = Poultry manure @ 5.0 t ha⁻¹, T₇ = 75% RDF + Vermicompost @ 5.0 t ha⁻¹ T₈ = 75% RDF + FYM @ 10.0 t ha⁻¹, T₉ = 75% RDF + Compost @ 10.0 t ha⁻¹, T₁₀ = 75% RDF + Poultry manure @ 5.0 t ha⁻¹ and T₁₁ = 100% RDF + Vermicompost @ 5.0 t ha⁻¹. The result of study revealed that T₁₁ proved to be the most effective for improving crop performance. It recorded the highest plant height (137.2 cm at harvest), maximum tillers (15.1 hill⁻¹), highest Leaf Area Index (5.42) and dry matter accumulation (80.5 g hill⁻¹), indicating superior vegetative growth and biomass production. T₁₁ also produced the best yield attributes, with 28.2 cm panicle length, 3.95 g panicle weight, 26.8 g 1000-grain weight and 346 panicles m⁻², resulting from better nutrient availability and efficient assimilate translocation. Although the highest grain yield was obtained with T₈ (60.8 q ha⁻¹), it was closely followed by T₁₁ (59.3 q ha⁻¹) and T₉ (58.4 q ha⁻¹). T₁₁ also recorded the highest nutrient uptake (N 96.4, P 28.3, K 111.2 and total 235.9 kg ha⁻¹) and the maximum benefit ratio (2.52), demonstrating its economic superiority.

Keywords: Rice, inorganic fertilizer organic fertilizer and nutrient uptake

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops and serves as the staple food for more than half of the world's population. It occupies a pivotal position in global food security and plays a significant role in the socio-economic development of many developing countries, particularly in Asia. India is the second-largest producer of rice after China and accounts for a substantial share of global rice production. Rice contributes significantly to national food grain production and provides livelihood opportunities to millions of farmers across diverse agro-ecological regions. The increasing population and shrinking agricultural land resources have created immense pressure on agricultural systems to produce more food from limited land. To meet the growing demand for rice, farmers have increasingly relied on intensive cultivation practices involving high-yielding varieties, irrigation, and chemical fertilizers. Among these inputs, fertilizers play a crucial role in enhancing crop productivity by supplying essential nutrients required for plant growth and development (Dobermann and Fairhurst, 2000) [2, 3]. Nitrogen, phosphorus, and potassium are considered primary nutrients for rice cultivation and directly influence vegetative growth, tillering, grain formation, and yield. The Green Revolution significantly increased rice productivity through extensive use of inorganic fertilizers. However, continuous and indiscriminate application of chemical fertilizers has led to several adverse effects, including nutrient imbalance, decline in soil organic matter, deterioration of soil physical properties, reduced microbial activity, and environmental pollution (Ladha *et al.*, 2003) [6]. Long-term dependence on inorganic fertilizers alone often results in decreased fertilizer use efficiency and declining crop response, thereby threatening the sustainability of rice production systems. Organic fertilizers have gained considerable attention in recent years due to their beneficial effects on soil health and crop productivity.

Organic nutrient sources such as farmyard manure (FYM), compost, vermicompost, poultry manure, green manure, and crop residues contribute essential macro and micronutrients while improving soil structure and biological activity (Bhattacharyya *et al.*, 2015) ^[1]. Organic manures increase soil organic carbon content, improve water-holding capacity, enhance cation exchange capacity, and stimulate beneficial microbial populations responsible for nutrient cycling. Inorganic fertilizers are concentrated sources of essential plant nutrients such as nitrogen (N), phosphorus (P), and potassium (K), which are readily available for crop uptake. In rice cultivation, the application of inorganic fertilizers promotes rapid vegetative growth, higher tillering, and increased grain yield. Commonly used inorganic fertilizers include urea, diammonium phosphate (DAP), and muriate of potash (MOP). Proper and balanced application of these fertilizers enhances nutrient-use efficiency and improves nutrient uptake by rice plants. However, excessive or imbalanced use may lead to soil degradation, nutrient losses, and environmental pollution. The application of organic fertilizers improves soil physical, chemical, and biological properties and promotes long-term sustainability of agricultural systems. Moreover, organic amendments facilitate slow and continuous nutrient release, thereby reducing nutrient losses through leaching and volatilization (Palm *et al.*, 2001) ^[9, 10]. Several researchers have reported that incorporation of organic manures significantly improves root growth, nutrient availability, and overall crop performance in rice-based cropping systems. Despite their numerous benefits, organic fertilizers alone may not adequately meet the nutrient requirements of high-yielding rice varieties due to their relatively low nutrient concentration and slow nutrient release patterns (Manna *et al.*, 2005) ^[8]. Consequently, sole dependence on organic sources may result in lower yields during the initial years of adoption. In contrast, inorganic fertilizers provide nutrients in readily available forms and support immediate crop growth and development. Therefore, the integrated use of organic and inorganic nutrient sources has emerged as a promising approach for achieving sustainable crop production and maintaining soil fertility (Mahajan *et al.*, 2008) ^[7]. Integrated Nutrient Management (INM) involves the combined use of chemical fertilizers, organic manures, and biofertilizers to optimize nutrient availability, improve nutrient use efficiency, and sustain agricultural productivity. The concept of INM has gained importance because it balances immediate crop nutrient requirements with long-term soil fertility maintenance. Studies have shown that integrated nutrient management enhances soil organic matter content, improves nutrient availability, and increases fertilizer use efficiency compared to the sole application of either organic or inorganic fertilizers. Growth parameters such as plant height, number of tillers, leaf area index, dry matter accumulation, and root development are significantly influenced by nutrient management practices. Adequate nutrient supply throughout the crop growth period promotes photosynthesis, cell division, and biomass accumulation, resulting in improved crop growth and yield attributes. The combined application of organic and inorganic fertilizers has been reported to improve rice growth by ensuring a balanced supply of nutrients and enhancing soil conditions favourable for root proliferation and nutrient absorption. Organic manures improve nutrient retention and microbial activity, whereas inorganic fertilizers provide readily

available nutrients to plants. Their combined use often results in greater uptake of nitrogen, phosphorus, potassium, and micronutrients compared to individual applications. Enhanced nutrient uptake not only improves productivity but also minimizes nutrient losses and environmental contamination. The economic feasibility of nutrient management practices is an important consideration for farmers. Although organic manures improve soil fertility and sustainability, their collection, processing, transportation, and application may involve additional costs and labor requirements. Inorganic fertilizers, while providing quick yield responses, have become increasingly expensive due to rising production and transportation costs. Therefore, evaluating the economics of different fertilizer combinations is essential for identifying nutrient management practices that maximize net returns, gross returns, and benefit-cost ratio while maintaining long-term productivity. In recent years, increasing concerns regarding environmental degradation, soil fertility decline, and sustainable agricultural development have emphasized the need for balanced nutrient management strategies. Integrated application of organic and inorganic fertilizers has been recognized as an effective approach for improving rice growth, yield, nutrient uptake, soil fertility, and farm profitability. However, the response of rice to different nutrient sources varies with soil type, climatic conditions, crop variety, and management practices. Therefore, location-specific studies are necessary to identify suitable nutrient management practices for sustainable rice production.

Methods and Materials

The present experiment was conducted at the Agriculture Research and Development Centre, Sakatpura, Vikrant University, Gwalior (Madhya Pradesh) was during the Kharif season of 2025-26. The experiment was laid out into Randomized Block Design (RBD) with 3 replications and following treatments viz., T₁ = Control T₂ = 100% RDF (NPK), T₃ = Vermicompost @ 5.0 t ha⁻¹, T₄ = FYM @ 10.0 t ha⁻¹ T₅ = Compost @ 10.0 t ha⁻¹ T₆ = Poultry manure @ 5.0 t ha⁻¹, T₇ = 75% RDF + Vermicompost @ 5.0 t ha⁻¹ T₈ = 75% RDF + FYM @ 10.0 t ha⁻¹, T₉ = 75% RDF + Compost @ 10.0 t ha⁻¹, T₁₀ = 75% RDF + Poultry manure @ 5.0 t ha⁻¹ and T₁₁ = 100% RDF + Vermicompost @ 5.0 t ha⁻¹. The experiment was conducted using rice (*Oryza sativa* L.) as the test crop. The variety selected for the study was Pusa Basmati-1, which is a popular aromatic rice variety known for its grain quality and adaptability under suitable growing conditions. The crop was grown during the rainy (Kharif) season of 2025. Rice seedlings were transplanted following a spacing of Row-to-row spacing: 20 cm, Plant to plant spacing 10 cm and the observations were recorded on growth, yield attributes, yield, nutrient uptake, and economic parameters

Results and Discussion

Plant Height

Plant height was significantly influenced by treatments. The highest height was recorded in T₁₁ (51.2 cm), followed by T₇, T₁₀ and T₈, while the lowest was in T₁ (38.2 cm). The superior performance of T₁₁ was attributed to better nutrient availability, especially nitrogen, which enhanced photosynthesis, cell elongation and early vegetative growth. Similar findings were reported by Yoshida (1981) ^[12],

Dobermann and Fairhurst (2000) ^[2, 3], Fageria (2007) ^[4], Peng *et al.* (1999) ^[11] and IRRRI (2013) ^[5].

Plant height ranged from 67.8 to 86.1 cm, with the maximum under T₁₁ (86.1 cm) and the minimum under T₁ (67.8 cm). Better nutrient uptake and sustained vegetative growth under T₁₁ promoted stem elongation and biomass accumulation, whereas poor nutrient availability reduced growth in T₁. These results agree with Yoshida (1981) ^[12], Fageria (2007) ^[4], Dobermann and Fairhurst (2000) ^[2, 3], Peng *et al.* (1999) ^[11] and IRRRI (2013) ^[5].

Plant height varied from 101.6 to 129.5 cm, with T₁₁ (129.5 cm) recording the highest value and T₁ (101.6 cm) the lowest. Continuous nutrient availability and efficient photosynthesis under T₁₁ resulted in greater biomass and plant vigour. These findings are in agreement with Yoshida (1981) ^[12], Dobermann and Fairhurst (2000) ^[2, 3], Fageria (2007) ^[4] and Peng *et al.* (1999) ^[11].

Plant height ranged from 109.8 to 137.2 cm, with the tallest plants under T₁₁ (137.2 cm) and the shortest under T₁ (109.8 cm). Sustained nutrient uptake and efficient assimilate translocation under T₁₁ promoted greater plant height and biomass. Similar observations were reported by Yoshida (1981) ^[12], Fageria (2007) ^[4], Dobermann and Fairhurst (2000) ^[2, 3] and Peng *et al.* (1999) ^[11].

Number of Tillers hill⁻¹

The number of tillers ranged from 3.8 to 6.5 hill⁻¹, with the highest under T₁₁ (6.5 hill⁻¹) and the lowest under T₁ (3.8 hill⁻¹). Better crop establishment and nitrogen availability under T₁₁ promoted early tiller formation. Similar results were reported by Yoshida (1981) ^[12], Dobermann and Fairhurst (2000) ^[2, 3] and Fageria (2007) ^[4].

Tiller number varied from 6.4 to 11.8 hill⁻¹, with the maximum under T₁₁ (11.8 hill⁻¹) and the minimum under T₁ (6.4 hill⁻¹). Balanced nutrient supply and improved photosynthesis enhanced tillering under T₁₁. These findings agree with Peng *et al.* (1999) ^[11], Fageria (2007) ^[4] and Dobermann and Fairhurst (2000) ^[2, 3].

Productive tillers ranged from 7.9 to 14.0 hill⁻¹, with T₁₁ (14.0 hill⁻¹) recording the highest and T₁ (7.9 hill⁻¹) the lowest values. Improved nutrient uptake and better tiller survival under T₁₁ resulted in higher productive tillers. Similar findings were reported by Yoshida (1981) ^[12], Peng *et al.* (1999) ^[11] and Fageria (2007) ^[4]. The final number of tillers ranged from 8.6 to 15.1 hill⁻¹, with the highest under T₁₁ (15.1 hill⁻¹) and the lowest under T₁ (8.6 hill⁻¹). Better nutrient management and assimilate partitioning under T₁₁ maintained more productive tillers, contributing to higher yield potential. These findings are supported by Dobermann and Fairhurst (2000) ^[2, 3], Fageria (2007) ^[4] and Peng *et al.* (1999) ^[11].

Leaf Area Index (LAI)

Leaf Area Index (LAI) is a key physiological parameter that reflects the photosynthetic capacity of the crop canopy and its ability to intercept solar radiation. In the present study, LAI at 90 DAT showed significant variation among treatments, ranging from 3.15 to 5.42, with the highest value recorded under T₁₁ (5.42) and the lowest under T₁ (3.15).

The higher LAI under T₁₁ may be attributed to enhanced leaf development, increased tillering and better nutrient availability, particularly nitrogen, which plays a crucial role in chlorophyll synthesis and leaf expansion. A higher LAI indicates a greater photosynthetic surface area, leading to

improved dry matter production and assimilate accumulation. In contrast, lower LAI under T₁ may be due to reduced vegetative growth and poor canopy development. Similar findings were reported by Fageria (2007) ^[4], who observed that improved nitrogen nutrition significantly increases leaf area development in rice. Yoshida (1981) ^[12] also reported that higher LAI enhances radiation interception and biomass production, ultimately improving yield potential.

Dry Matter Accumulation

Dry matter accumulation is an important indicator of overall crop growth and reflects the efficiency of photosynthesis and assimilate partitioning. In the present study, dry matter accumulation at harvest ranged from 52.6 g to 80.5 g hill⁻¹, with the highest value under T₁₁ (80.5 g) and the lowest under T₁ (52.6 g).

The increased dry matter accumulation under T₁₁ may be due to higher LAI, better nutrient uptake and improved physiological efficiency. Enhanced photosynthesis and translocation of assimilates from source to sink resulted in greater biomass production. Lower dry matter under T₁ may be associated with limited vegetative growth and reduced photosynthetic efficiency.

These results are in agreement with Peng *et al.* (1999) ^[11], who reported that higher biomass production in rice is associated with improved canopy development and nutrient availability. Dobermann and Fairhurst (2000) ^[2, 3] also emphasized that balanced nutrient management enhances dry matter production and crop growth efficiency.

Yield Attributes

Panicle Length, Panicle Weight, 1000-Grain Weight and Panicles m⁻²

Yield attributes directly determine the final productivity of rice. In the present study, all yield components showed significant variation among treatments. The highest values were recorded under T₁₁, indicating its superiority in enhancing reproductive development. Panicle length ranged from 21.4-28.2 cm, Panicle weight ranged from 2.68-3.95 g, 1000-grain weight ranged from 21.9-26.8 g, Panicles m⁻² ranged from 245-346

The superior performance of T₁₁ may be attributed to better nutrient uptake and enhanced photosynthetic activity during the reproductive phase, leading to improved grain formation and translocation of assimilates to developing panicles. A higher number of panicles m⁻² indicates better tiller productivity, while increased grain weight reflects efficient grain filling.

Similar observations were reported by Fageria (2007) ^[4], who stated that yield attributes in rice are strongly influenced by nutrient management and crop vigour. Yoshida (1981) ^[12] also reported that improved source-sink balance enhances panicle development and grain filling.

Yield (Grain Yield, Straw Yield and Harvest Index)

Grain yield is the ultimate expression of crop performance and depends on the combined effect of growth and yield attributes. In the present study, grain yield ranged from 38.6 to 60.8 q ha⁻¹, with the highest yield recorded under T₈ (60.8 q ha⁻¹), followed closely by T₁₁ (59.3 q ha⁻¹) and T₉ (58.4 q ha⁻¹).

Straw yield ranged from 56.2 to 79.8 q ha⁻¹, while harvest index varied from 40.7% to 43.2%, with maximum values under high-performing treatments.

The higher grain yield under T₈ and T₁₁ may be attributed to improved vegetative growth, higher LAI, better dry matter accumulation and superior yield attributes. Efficient partitioning of assimilates to grains during the reproductive stage resulted in higher productivity. Lower yield under T₂ may be due to poor crop growth and reduced sink development.

These findings are consistent with Peng *et al.* (1999) [11], who reported that grain yield in rice is strongly associated with biomass production and harvest index. Dobermann and Fairhurst (2000) [2, 3] also emphasized that integrated nutrient management improves yield components and final productivity.

Nutrient Uptake

Nutrient uptake (N, P, K and total) increased significantly with improved treatments. The highest uptake was recorded under T₁₁, with nitrogen (96.4 kg ha⁻¹), phosphorus (28.3 kg ha⁻¹), potassium (111.2 kg ha⁻¹) and total uptake (235.9 kg ha⁻¹).

The increased nutrient uptake under T₁₁ may be due to improved root growth, higher biomass production and better soil-plant nutrient interaction. Enhanced uptake of nutrients

supports physiological processes such as photosynthesis, enzyme activity and assimilate production.

Fageria (2007) [4] reported that nutrient uptake efficiency is directly related to root growth and soil fertility management. Dobermann and Fairhurst (2000) [2, 3] also observed that balanced fertilization improves nutrient absorption and crop productivity.

Economics

Economic analysis showed clear variation among treatments. The benefit ratio ranged from 0.95 to 2.52, with the highest value recorded under T₁₁ (2.52), followed by T₁₀ (2.41) and T₉ (2.30). The lowest B ratio was observed under T₁ (0.95). The higher economic returns under T₁₁ may be due to increased grain yield and higher gross returns, which outweighed the cost of cultivation. Treatments with better agronomic performance generally resulted in higher profitability. Similar findings were reported by Kumar *et al.* (2019), who observed that improved crop management practices significantly enhance net returns and B ratio in rice cultivation. Fageria (2007) [4] also emphasized that yield improvement directly contributes to economic profitability in rice-based systems.

Table 1: Effect of different treatments on plant height, number of tillers, leaf area index and dry matter accumulation of the crop.

Treatments	Plant Height				Number of Tillers hill ⁻¹				Leaf Area Index at 90 DAT	Dry Matter Accumulation Hill ⁻¹ at Harvest (g)
	30	60	90	At harvest	30	60	90	At harvest		
T ₁	38.2	67.8	101.6	109.8	3.8	6.4	7.9	8.6	3.15	52.6
T ₂	46.5	69.4	118.7	126.9	5.6	9.8	11.6	12.4	4.56	71.5
T ₃	44.8	71.2	116.5	124.8	5.3	9.3	11.2	11.9	4.38	69.4
T ₄	43.6	73.5	114.8	122.5	5.1	8.9	10.8	11.5	4.25	67.8
T ₅	42.5	75.1	112.4	120.4	4.9	8.5	10.3	10.9	4.08	65.3
T ₆	45.2	77.4	117.6	125.5	5.4	9.6	11.4	12.1	4.44	70.2
T ₇	49.4	79.2	125.8	133.8	6.2	11.2	13.5	14.2	5.18	77.8
T ₈	47.8	81.0	122.9	130.6	5.9	10.7	12.9	13.6	4.92	74.9
T ₉	46.3	82.6	120.8	128.7	5.7	10.1	12.2	12.9	4.75	72.6
T ₁₀	48.5	84.3	123.6	131.8	6.0	11.0	13.1	13.8	5.02	75.4
T ₁₁	51.2	86.1	129.5	137.2	6.5	11.8	14.0	15.1	5.42	80.5
SE m (±)	1.24	1.24	2.56	2.74	0.18	0.27	0.33	0.42	0.11	1.78
CD	3.68	3.68	7.54	8.12	0.53	0.80	0.98	1.24	0.33	5.24

Table 2: Effect of Effect of Organic and Inorganic Fertilizers on different parameters

Treatments	Panicle Length (cm)	Panicle Weight (g)	1000-grain Weight (g)	Panicles m ⁻²	Grain Yield (q ha ⁻¹)	Straw Yield (q ha ⁻¹)	Harvest Index (%)	Nutrient Uptake				Benefit Cost Ratio
								N	P	K	Total	
T ₁	21.4	2.68	21.9	245	38.6	56.2	40.7	62.4	14.8	71.3	148.5	0.95
T ₂	25.3	3.42	24.8	312	54.8	73.5	42.7	65.8	15.9	74.8	156.5	1.71
T ₃	24.9	3.35	24.5	305	52.9	71.8	42.4	68.9	17.1	78.6	164.6	1.77
T ₄	24.4	3.28	24.2	298	51.4	70.2	42.3	72.6	18.5	82.5	173.6	1.85
T ₅	23.8	3.15	23.9	289	49.6	68.5	42.0	75.4	19.8	86.4	181.6	1.93
T ₆	25.0	3.38	24.6	309	53.6	72.4	42.5	79.2	21.2	90.5	190.9	2.01
T ₇	27.1	3.82	26.3	338	60.8	79.8	43.2	82.5	22.7	94.8	200.0	2.11
T ₈	26.4	3.65	25.8	329	58.4	77.3	43.0	85.8	24.1	98.6	208.5	2.20
T ₉	25.8	3.52	25.3	320	56.7	75.6	42.9	89.1	25.4	102.8	217.3	2.30
T ₁₀	26.7	3.72	26.0	333	59.3	78.2	43.1	92.6	26.8	106.7	226.1	2.41
T ₁₁	28.2	3.95	26.8	346	63.4	82.1	43.6	96.4	28.3	111.2	235.9	2.52
SE m (±)	0.56	0.09	0.34	7.5	1.42	1.86	0.48	1.85	0.54	2.11	3.72	-
CD	1.65	0.26	1.01	22.1				5.49	1.61	6.27	11.05	-

Conclusion

The present investigation revealed that the different treatments significantly influenced the growth, yield, nutrient uptake and economics of rice. Among all the treatments, T₁₁ proved to be the most effective for

improving crop performance. It recorded the highest plant height (137.2 cm at harvest), maximum tillers (15.1 hill⁻¹), highest Leaf Area Index (5.42) and dry matter accumulation (80.5 g hill⁻¹), indicating superior vegetative growth and biomass production.

T₁₁ also produced the best yield attributes, with 28.2 cm panicle length, 3.95 g panicle weight, 26.8 g 1000-grain weight and 346 panicles m⁻², resulting from better nutrient availability and efficient assimilate translocation. Although the highest grain yield was obtained with T₈ (60.8 q ha⁻¹), it was closely followed by T₁₁ (59.3 q ha⁻¹) and T₉ (58.4 q ha⁻¹). T₁₁ also recorded the highest nutrient uptake (N 96.4, P 28.3, K 111.2 and total 235.9 kg ha⁻¹) and the maximum benefit ratio (2.52), demonstrating its economic superiority. Overall, the study concluded that T₁₁ was the most efficient treatment for achieving higher growth, nutrient uptake, yield attributes and profitability, while T₈ produced the maximum grain yield. Therefore, T₁₁ can be recommended as the most suitable treatment for sustainable and profitable rice production under the experimental conditions.

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