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Influence of organic and inorganic nutrient sources on growth attributes of rice (*Oryza sativa* L.) under the Koshi region of Bihar

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Abstract

Rice (*Oryza sativa* L.) is the principal staple food crop of India, and its sustainable production largely depends on balanced nutrient management. Continuous reliance on inorganic fertilizers has resulted in declining soil fertility, nutrient imbalance, and reduced productivity, particularly in the rice-growing ecosystems of the Koshi region of Bihar. To address this issue, a field experiment entitled “Influence of Organic and Inorganic Nutrient Sources on Growth Attributes of Rice (*Oryza sativa* L.) under the Koshi Region of Bihar” was carried out during the Kharif season of 2025 at the college farm of Dr Kalam Agricultural College, Kishanganj, Bihar. The experiment was laid out in a Randomized Block Design (RBD) with nine nutrient management treatments and replicated thrice, using the rice variety Swarna Shreya. The treatments comprised T₁ (Control i.e. No Fertilizer), T₂ (100% RDN), T₃ (75% RDN + 25% Vermicompost), T₄ (75% RDN + 25% Enriched Compost), T₅ (75% RDN + 25% Farm Yard Manure), T₆ (50% RDN + 25% VC + 25% EC), T₇ (50% RDN + 25% VC + 25% FYM), T₈ (50% RDN + 25% FYM + 25% EC) and T₉ (125% RDN). The results revealed that different treatment combinations significantly influence the growth attributes of transplanted rice. Among the different treatments, T₉ (125% RDN) consistently recorded the highest plant height (119.47 cm at harvest), number of tillers hill⁻¹ (18.75 at 90 DAT and 16.85 at harvest), leaf area index (4.71 at 90 DAT), and dry matter accumulation (1210.70 g m⁻² at harvest), reflecting the beneficial effect of higher nitrogen availability on crop growth and development. Treatments T₂ (100% RDN through inorganic fertilizer), T₄ (75% RDN + 25% N through enriched compost), and T₃ (75% RDN + 25% N through vermicompost) performed comparably and remained statistically at par with T₉ for most growth parameters. The control (T₁) recorded the lowest values throughout the crop growth period. The findings indicate that application of 75% RDN + 25% enriched compost and 75% RDN + 25% vermicompost emerged as promising alternatives to sole inorganic fertilization for achieving sustainable rice production under the agro-ecological conditions of the Koshi region of Bihar.

Keywords: Integrated nutrient management, growth attributes, FYM, enriched compost, vermicompost, rice (*Oryza sativa* L.)

Introduction

Rice (*Oryza sativa* L.) is one of the world's most important cereal crops and serves as the primary food source for more than half of the global population. In India, it contributes nearly one-third of the daily dietary energy intake and plays a vital role in ensuring national food security (FAO, 2023)^[5]. In 2025, India became the world's leading rice producer, surpassing China with an annual production of over 152 million tonnes, accounting for approximately 28% of global rice production. The crop is cultivated on nearly 52 million hectares, with an average productivity of 43.8 q ha⁻¹ (USDA-FAS, 2025)^[11]. Despite remarkable improvement in rice production, the average productivity in several eastern states, including Bihar, remains considerably lower than the national average due to poor soil fertility, imbalanced nutrient management, erratic rainfall, and low nutrient-use efficiency.

Bihar cultivates rice on 3.11 million ha, which contribute total production of 7.90 million tonnes with an average productivity of 25.41 q ha⁻¹. In Kishanganj district, rice is grown on approximately 0.081 million hectares, producing about 0.23 million tonnes with a mean productivity of 28.4 q ha⁻¹. (Agricultural Statistics at a Glance, 2024; Annual Report, Department

of Agriculture, Kishanganj, 2024) [2]. Rice productivity in the Koshi region of Bihar remains relatively low due to declining soil fertility, nutrient mining, low soil organic carbon and imbalanced use of fertilizer under intensive rice-based cropping systems. During the past several decades, continuous and excessive application of inorganic fertilizers has substantially increased crop productivity; however, their indiscriminate use has also resulted in soil degradation, nutrient imbalance, declining soil organic matter, deterioration of soil biological activity, reduced fertilizer-use efficiency and threatened the long-term sustainability of rice-based production systems. In contrast, sole application of organic manures often fails to meet the nutrient demand of rice during critical growth stages due to slow release of nutrients from organic manure (Satyanarayana *et al.*, 2002; Gaikwad *et al.*, 2022; Javier *et al.*, 2004) [12, 6, 8]. Therefore, the adoption of Integrated Nutrient Management (INM), which combines inorganic fertilizers ensure an adequate and timely supply of essential nutrients during critical crop growth stages, and organic manure like Farm Yard Manure, Enriched Compost, Vermicompost, etc. and biofertilizers, has emerged as a sustainable strategy for improving nutrient use efficiency, soil health and crop productivity (Yadav *et al.*, 2024; Chowdhury *et al.*, 2024) [13, 3]. The complementary use of these nutrient sources promotes balanced nutrition, enhances photosynthetic efficiency, stimulates root proliferation, and increases biomass production, thereby improving crop growth and productivity.

The Koshi region of Bihar is characterized by acidic alluvial soils, frequent flooding, and nutrient depletion, which adversely affect rice productivity. Although integrated nutrient management (INM) has been widely investigated under diverse agro-climatic conditions, information on the combined use of vermicompost, enriched compost, and farmyard manure with inorganic fertilizers under the agro-ecological conditions of the Koshi region is limited. Therefore, the present study was conducted to assess the impact of integrated use of organic and inorganic nutrient sources on the growth attributes of transplanted rice and to identify a sustainable nutrient management strategy for enhancing crop growth and maintaining long-term soil fertility in the Koshi region of Bihar.

Materials and Methods

The field experiment entitled “Influence of Organic and Inorganic Nutrient Sources on Growth Attributes of Rice (*Oryza sativa* L.) under the Koshi Region of Bihar” was conducted during the Kharif season of the year 2025 at the college farm of Dr. Kalam Agricultural College, Kishanganj, Bihar. The experimental site is situated in the Koshi agro-ecological region of Bihar, characterized by a humid subtropical climate with heavy rainfall, warm and humid conditions throughout the rice-growing period, making it highly suitable for transplanted rice cultivation. The soil of the experimental plot was Sandy loam with pH (1:2) 5.90, low in organic carbon (0.49%), available N (190.70 kg ha⁻¹), available P (18.90 kg ha⁻¹) and available K (148.40 kg ha⁻¹) before the start of the experiment. Nine treatments, viz. Control i.e. no fertilizer (T₁), 100% RDN (T₂), 75% RDN + 25% Vermicompost (T₃), 75% RDN + 25% Enriched Compost (T₄), 75% RDN + 25% FYM (T₅), 50% RDN + 25% VC + 25% EC (T₆), 50% RDN + 25% VC + 25% FYM (T₇), 50% RDN + 25% FYM + 25% EC (T₈), and 125% RDN (T₉) were laid out in Randomized Block Design (RBD) replicated thrice. The enriched compost was prepared using decomposed organic materials inoculated with beneficial microorganisms including *Trichoderma viride*, *Azotobacter*, and phosphate-solubilizing bacteria (*Bacillus polymyxa*), along with zinc sulphate enrichment to improve its nutrient composition and biological activity. Microbial inoculants consist a combination of

microbes like Cellulolytic fungus (*Trichoderma viride*) were inoculated at the start of composting @ 300 g ton⁻¹, Phosphate solubilizing bacteria (*Bacillus polymyxa*) and inoculants of free-living N- fixer azotobacter was applied @ 500 g ton⁻¹ were given after 30 days of initial composting in each layer to protect the microbes from direct exposure to excess heat generated from the materials and it enhances the speed of composting process. External spraying of zinc sulphate @ 200 g ton⁻¹ of compost was done at the final turning stage of composting mass for improving the micronutrient content of compost. Vermicompost and FYM were prepared as per standard procedure. Fertilizers (120:60:40 kg N-P₂O₅-K₂O ha⁻¹) were applied through urea, Single Super Phosphate and Muriate of Potash, respectively. Half of N and full dose of P and K were applied as basal before transplanting in all the treatments except the control treatment plot, and the remaining half dose of nitrogen was top-dressed in two equal splits i.e. at active tillering stage and panicle initiation stage to synchronise nutrient availability with crop demand. Different organic nutrient sources like enriched compost, vermicompost and farm yard Manure were incorporated into the soil before transplanting in respective treatments as per requirement. Twenty-three-day-old seedlings of rice variety “Swarna Shreya” were transplanted manually at a spacing of 20 cm x 15 cm, maintaining two seedlings per hill. All standard package of practices were adopted uniformly across all treatments throughout the crop-growing season to ensure optimum crop growth. Growth-attributing characters like plant height, tillers hill⁻¹ (no.), leaf area index (LAI) and Dry matter accumulation (g m⁻²) were recorded at successive crop growth stages from five randomly selected plants from each plot. The experimental data recorded for various parameters under study were statistically analysed with ANOVA to conclude.

Results and Discussion

The present investigation titled “Influence of Organic and Inorganic Nutrient Sources on Growth Attributes of Rice (*Oryza sativa* L.) under koshi region of Bihar” was carried out during the Kharif season of 2025 at the college farm of Dr. Kalam Agricultural College, Kishanganj, Bihar. This investigation aimed to assess the influence of Integrated nutrient management practices on the growth of transplanted rice in the Koshi region of Bihar.

Growth attributes

Different Growth attributes like plant height, tillers hill⁻¹, leaf area index, and dry matter accumulation m⁻² were recorded at successive growth stages (30, 60, and 90 DAT, and at harvest where applicable). The results and discussion on growth attributes are described here under as follows:

Plant Height (cm)

Plant height is one of the most important vegetative growth parameters that reflects the overall vigour of the crop and is greatly influenced by nutrient availability throughout the growing period. The experimental results indicated that different integrated nutrient management (INM) treatments exerted a significant influence on plant height at various crop growth stages, except at 30 days after transplanting (Table 1), where the differences among treatments were statistically non-significant. The result shown that plant height ranges from 46.20 cm under control (T₁) to 54.17 cm under T₉ (125% N through fertilizer) at 30 DAT. The non-significant variation during the early growth stage might be attributed to the limited nutrient uptake immediately after transplanting. Among the treatments, T₉ (125% RDN) recorded the highest plant height (104.17, 119.00, and

119.47 cm at 60 DAT, 90 DAT, and harvest, respectively), which was statistically at par with T₂ (97.87, 115.25, 115.60 cm at 60 DAT, 90 DAT, and harvest, respectively), T₄ (96.62, 112.97, 113.27 cm at 60 DAT, 90 DAT, and harvest, respectively), and T₃ (96.19, 110.93, 111.57 cm at 60 DAT, 90 DAT, and harvest, respectively) while the minimum plant height was observed under the T₁ (85.87, 96.83, 97.77 cm at 60 DAT, 90 DAT, and harvest, respectively). The superior plant height under T₉ could be attributed to an adequate and continuous supply of nitrogen throughout the crop growth period. Nitrogen is an essential constituent of chlorophyll, amino acids, nucleic acids, and proteins, thereby promoting rapid cell division, cell elongation, leaf expansion, and photosynthetic activity, which ultimately accelerates vegetative growth and stem elongation. The comparable performance of T₃ and T₄ with 100% RDN (T₂) suggests that partial substitution of inorganic nitrogen with vermicompost or enriched compost might be attributed to the balanced and continuous supply of nutrients, improved soil fertility, enhanced microbial activity, and better nutrient uptake, resulting in increased cell division and vegetative growth. In contrast, the shortest plants observed under the control treatment (T₁) were mainly due to inadequate nutrient availability, particularly nitrogen deficiency, leading to poor crop growth. Similar findings were reported by Satyanarayana *et al.* (2002) [12], Dhurve *et al.* (2023) [4], and Harikesh *et al.* (2024) [7].

Leaf Area Index (LAI)

Leaf Area Index (LAI) serves as a key physiological indicator of crop growth, reflecting the photosynthetically active surface available for solar radiation interception. The experimental results revealed (Table 3) that LAI was significantly influenced by different nutrient management treatments at successive growth stages (30, 60, and 90 DAT). Among the different nutrient management treatments, T₉ (125% Recommended Dose of Nitrogen) recorded the highest LAI values of 1.70, 2.92, and 4.24 at 30, 60, and 90 DAT, respectively. However, these values were statistically at par with T₂ (100% RDN), T₄ (75% RDN + 25% enriched compost), and T₃ (75% RDN + 25% vermicompost). In contrast, the control treatment (T₁) consistently recorded the lowest LAI values (1.13, 1.81, and 2.92 at 30, 60, and 90 DAT, respectively). Irrespective of treatments, LAI increased progressively from 30 DAT to 90 DAT owing to continuous leaf expansion and canopy development during the vegetative growth phase. The higher LAI under T₉ (125% RDN) may be attributed to greater nitrogen availability, which promoted chlorophyll synthesis, leaf expansion, canopy development and photosynthetic activity. The statistically comparable performance of T₃ and T₄ with T₉ and T₂ suggests that partial substitution of 25% inorganic nitrogen with vermicompost or enriched compost ensured balanced and sustained nutrient availability, improved soil biological activity, etc., resulting in better leaf growth,

whereas the control treatment recorded the lowest LAI due to nutrient deficiency which restricted leaf development and canopy expansion. The present findings are in close agreement with those reported by Harikesh *et al.* (2024) [7] and Yadav *et al.* (2024) [13], who reported that integrated nutrient management involving inorganic fertilizers and vermicompost improved crop growth and leaf development in rice under integrated nutrient management treatments.

Number of Tillers hill⁻¹

The number of tillers hill⁻¹ is one of the most important growth parameters as it directly influences the formation of productive panicles, which in turn play a decisive role in defining the yield potential of rice. Integrated nutrient management significantly influenced the number of tillers hill⁻¹ at different growth stages (Table 3). Tiller production increased progressively from 30 to 90 DAT and declined slightly at harvest due to senescence of non-productive tillers. Among the treatments, T₉ (125% RDN) recorded the highest number of tillers hill⁻¹ (10.50, 16.10, 18.75 and 16.85 at 30, 60, 90 DAT and harvest, respectively), which remained statistically at par with T₂ (100% RDN), T₄ (75% RDN + 25% enriched compost) and T₃ (75% RDN + 25% vermicompost). The lowest values were recorded under the control (T₁). The significantly higher number of tillers recorded under T₉ (125% N through fertilizer) at all growth stages might be due to the greater availability of nitrogen, which promoted rapid vegetative growth, enhanced cell division and stimulated the formation of new tillers. The increased tiller production under integrated nutrient management may be attributed to balanced nutrient availability, improved root growth, enhanced chlorophyll synthesis and greater photosynthetic activity, resulting in better tiller initiation and survival. Similar findings have also been reported by Rao *et al.* (2020) [10], Dhurve *et al.* (2023) [4], Harikesh *et al.* (2024) [7] and Kumar *et al.* (2025) [9].

Dry Matter Accumulation (g m⁻²)

Dry matter accumulation is an important indicator of crop growth and reflects the efficiency of photosynthesis, nutrient utilization and biomass production. Dry matter accumulation increased significantly with crop growth under all nutrient management treatments (Table 4). The highest dry matter accumulation was recorded under T₉ (248.62, 511.21, 901.80 and 1210.70 g m⁻² at 30, 60, 90 DAT and at harvest, respectively), which was significant above the other treatments but comparable to (100% RDN), T₄ (75% RDN + 25% enriched compost) and T₃ (75% RDN + 25% vermicompost). The control treatment (T₁) recorded the lowest dry matter accumulation throughout the crop growth period. These findings are in agreement with those of Satyanarayana *et al.* (2002) [12], Chowdhury *et al.* (2024) [3], Yadav *et al.* (2024) [13] and Kumar *et al.* (2025) [9].

Table 1: Influence of different nutrient management practices on plant height (cm) at various growth stages of rice

Treatment Details	Plant Height(cm)			
	30 DAT	60DAT	90 DAT	At harvest
Control (No fertilizer)	46.20	85.87	96.83	97.77
100% RDN	52.98	97.87	115.25	115.6
75% RDN + 25% Vermicompost	51.72	96.19	110.93	111.57
75% RDN + 25% Enrich Compost	52	96.62	112.97	113.27
75%RDN + 25% FYM	51.20	93.15	108.59	109.10
50% RDN + 25% VC + 25% EC	50.63	92.17	105.77	108.93
50% RDN + 25% VC + 25% FYM	49.57	89.26	101.97	102.40
50% RDN + 25% FYM + 25% EC	50.10	90.42	103.70	104.20
125% RDN	54.17	104.17	119.00	119.47
SEm (±)	1.52	2.69	2.77	2.70
CD (P=0.05)	NS	8.06	8.30	8.10

Table 2: Influence of different nutrient management practices on LAI at various growth stages of rice

Treatment Details	Leaf Area Index		
	30 DAT	60 DAT	90 DAT
Control (No fertilizer)	1.13	1.81	2.92
100% RDN	1.69	2.88	4.22
75% RDN + 25% Vermicompost	1.64	2.83	4.15
75% RDN + 25% Enrich Compost	1.66	2.84	4.19
75%RDN + 25% FYM	1.62	2.73	4.11
50% RDN + 25% VC + 25% EC	1.60	2.69	4.03
50% RDN + 25% VC + 25% FYM	1.51	2.40	3.69
50% RDN + 25% FYM + 25% EC	1.56	2.51	3.72
125% RDN	1.70	2.92	4.24
SEm ($\pm$)	0.03	0.04	0.06
CD (P=0.05)	0.08	0.12	0.16

Table 3: Influence of different nutrient management practices on tillers hill⁻¹ (no.) at various growth stages of rice

Treatment Details	Number of tillers hill ⁻¹			
	30 DAT	60 DAT	90 DAT	At harvest
Control (No fertilizer)	6.93	10.20	11.85	10.65
100% RDN	10.45	15.65	18.15	16.31
75% RDN + 25% Vermicompost	9.40	14.65	17.22	15.48
75% RDN + 25% Enrich Compost	9.90	14.95	17.72	15.7
75%RDN + 25% FYM	9.00	14.10	16.85	14.7
50% RDN + 25% VC + 25% EC	8.62	13.65	15.92	14.27
50% RDN + 25% VC + 25% FYM	7.72	12.96	14.92	13.55
50% RDN + 25% FYM + 25% EC	8.23	13.10	15.45	13.76
125% RDN	10.50	16.10	18.75	16.85
SEm ($\pm$)	0.42	0.53	0.52	0.50
CD (P=0.05)	1.27	1.60	1.56	1.49

Table 4: Influence of different nutrient management practices on dry matter accumulation (gm⁻²) at various growth stages of rice

Treatment Details	Dry Matter Accumulation (gm ⁻²)			
	30 DAT	60DAT	90 DAT	At harvest
Control (No fertilizer)	1.99.87	386.73	600.32	850.55
100% RDN	241.97	50.4.78	876.12	1184.50
75% RDN + 25% Vermicompost	235.77	494.87	852.5	1140.75
75% RDN + 25% Enrich Compost	238.84	497.57	863.56	1165.75
75%RDN + 25% FYM	230.09	484.84	841.42	1100.92
50% RDN + 25% VC + 25% EC	228.18	475.58	825.55	1080.75
50% RDN + 25% VC + 25% FYM	224.27	450.57	795.43	1000.55
50% RDN + 25% FYM + 25% EC	226.68	472.45	820.85	1060.95
125% RDN	248.62	511.21	901.8	1210.70
SEm ($\pm$)	2.56	5.75	17.79	17.53
CD (P=0.05)	7.70	17.2	53.3	52.6

Conclusion

The study revealed that different nutrient management practices significantly improved growth performance, such as plant height, LAI, number of tillers hill⁻¹, and dry matter accumulation of rice under the Koshi region of Bihar. Although plant height at 30 DAT was not significantly influenced by nutrient management, marked improvements were observed at later growth stages. Application of 125% recommended dose of nitrogen (T₉) recorded the highest values for all growth parameters, followed closely by T₂ (100% RDN), T₄ (75% RDN + 25% enriched compost), and T₃ (75% RDN + 25% vermicompost), which remained statistically at par with each other. The control (T₁) recorded the lowest growth throughout the crop growth, due to nutrient deficiency. These results indicate that partial substitution of inorganic nitrogen with organic sources like vermicompost or enriched compost can sustain crop growth comparable to higher doses of inorganic fertilizer, offering a sustainable and balanced approach to nutrient management in rice cultivation under the agro-ecological conditions of the Koshi region of Bihar.

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