



RESEARCH COMMUNICATION

Influence of nitrogen levels, organic amendments and foliar nutrition on growth and yield performance of rice (*Oryza sativa* L.)

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Abstract

Nitrogen (N) is an essential macronutrient for crop growth and its efficient management is crucial for sustainable rice production and the prevention of soil nutrient depletion. Despite extensive research, knowledge gaps remain regarding root-soil interactions for efficient N uptake, root-shoot coordination for N utilization and integrated nutrient management strategies to enhance nitrogen use efficiency and yield in rice. A field experiment was conducted at the Experimental Farm, Department of Agronomy, Annamalai University in 2024, using a randomized block design with nine treatments replicated thrice. Among the treatments, T₁ (100 % recommended dose of fertilizer: 120:40:40 kg ha⁻¹) recorded the highest plant height (102.67 cm), no. of tillers (402 m⁻²), leaf area index (5.41), dry matter production (10,985 kg ha⁻¹), crop growth rate (5.74 g m⁻² day⁻¹), absolute growth rate (0.0861 g plant⁻¹ day⁻¹), grain yield (4,978 kg ha⁻¹) and straw yield (7,126 kg ha⁻¹). This was followed by T₆ (75 % RDN through urea + 25 % RDN through urban compost + 100 % P and K with foliar application of ZnSO₄ at 0.5 % and boron at 0.3 % at 25 and 50 DAT), which was on par with T₄ involving biochar-based N substitution. The results demonstrate that partial replacement of chemical nitrogen with organic amendments, coupled with targeted foliar Zn and B application, improved nutrient uptake efficiency, reduced nitrogen losses and sustained crop productivity. Such integrated nutrient management practices offer a viable pathway to reduce urea dependency, enhance soil health and ensure long-term sustainability of rice agroecosystems.

Keywords: biochar amendment; integrated nutrient management; nitrogen; urban compost and rice yield

Introduction

Rice (*Oryza sativa* L.) is globally the most important cereal crop cultivated for human consumption (1). It occupies an area of 168.58 M ha, with a total production of 532.87 Mt and an average productivity of 4.72 t ha⁻¹. In India, rice is cultivated across 50 M ha, producing 145 Mt with a productivity of 4.35 t ha⁻¹ (2) and for Tamil Nadu, cultivated across 20.20 lakh hectares, with a production of 81.81 lakh tonnes and a productivity of approximately 4.0 t ha⁻¹ (3).

The Cauvery delta, with its extensive canal networks and favourable tropical climate, has traditionally supported intensive rice farming with high productivity. However, growing concerns related to soil degradation, nutrient depletion and environmental sustainability have encouraged researchers to examine the complex interactions among nitrogen (N) inputs, organic amendments and foliar nutrition on rice growth, yield and soil health in this ecologically sensitive region (4). Nitrogen is a critical macronutrient for rice production, regulating key physiological processes such as chlorophyll synthesis, enzymatic activity and protein formation, which directly influence photosynthesis, vegetative growth and grain yield. Although conventional reliance on mineral nitrogen fertilizers through the recommended dose of fertilizers (RDF) has

effectively met crop nitrogen demand and enhanced yields, it has also resulted in reduced nitrogen use efficiency, soil nutrient imbalance, depletion of soil organic matter and environmental pollution through leaching and gaseous losses (5–6). Consequently, sustainable nitrogen management strategies integrating organic amendments such as biochar, urban compost, goat manure and farmyard manure, along with foliar nutrition, are increasingly explored to partially substitute chemical fertilizers, improve nutrient use efficiency and restore soil health.

Organic amendments play a multifaceted role by supplying nutrients through gradual mineralization, improving soil structure, enhancing microbial activity and increasing soil moisture retention, thereby promoting healthy root growth and efficient nutrient uptake (7). Among these, biochar, a carbon-rich material derived from pyrolyzed biomass, improves soil aeration, water-holding capacity and cation exchange capacity, leading to reduced nutrient losses and prolonged nutrient availability. Urban compost, produced from segregated municipal organic waste, has emerged as a valuable component of Integrated Nutrient Management (INM) systems by providing macro and micronutrients along with organic matter that enhances soil fertility and structure. Compost application improves soil aggregation, water-holding capacity and cation exchange

capacity, creating a favourable rhizosphere environment. The organic carbon present in compost also serves as an energy source for beneficial microorganisms such as nitrogen-fixing bacteria, phosphate-solubilizing microbes and decomposer fungi, which are vital for nutrient cycling and mineralization. When combined with inorganic fertilizers, urban compost improves nutrient-use efficiency, reduces dependency on chemical fertilizers and sustains rice productivity under intensive cropping systems (8). Goat manure and farmyard manure similarly contribute to long-term soil fertility and biological activity, although their nutrient release rates are relatively slower (9). Foliar nutrition through the application of soluble nutrients to leaf surfaces provides a rapid and efficient means of supplementing soil nutrient supply during critical growth stages of rice. Such as zinc and boron enhances enzyme activity, chlorophyll synthesis, carbohydrate translocation and reproductive development, thereby improving tillering, leaf area index and dry matter accumulation. This targeted approach increases nutrient use efficiency, reduces micronutrient deficiencies and contributes to improved yield and crop stability (10).

Prolonged intensive cultivation of high-yielding rice varieties supported by heavy mineral fertilizer use has accelerated soil nutrient mining and reduced soil organic carbon, threatening the sustainability of rice production systems (11). Declining soil organic carbon adversely affects nitrogen mineralization and soil fertility, emphasizing the need for organic amendments. Additionally, water availability in the Cauvery delta has become increasingly uncertain due to climate variability, upstream water disputes and groundwater overexploitation, further complicating nutrient management. Under these conditions, INM approaches integrating chemical fertilizers, organic amendments and foliar nutrition are essential for maintaining balanced nutrition, enhancing nitrogen use efficiency and achieving sustainable rice yield and quality (12).

Research studies in similar agro-ecological settings have demonstrated that the combined use of organics, inorganics and foliar nutrient sprays can significantly enhance growth parameters such as plant height, leaf area index, chlorophyll content and dry matter accumulation, culminating in improved yield attributes including number of productive tillers, panicle length, grain filling and ultimately grain and straw yield (13). Despite these benefits, the precise effects and optimal combinations of nitrogen sources, organic amendments and foliar spray remain region-specific and subject to soil type, climate, varietal response and management practices, underscoring the need for localized comprehensive studies in the Cauvery Delta region.

This study hypothesizes that integrated nitrogen management, involving partial replacement of inorganic fertilizers with organic amendments such as biochar, urban compost, farmyard manure and goat manure, in combination with foliar nutrition, enhances rice growth, yield, nutrient use efficiency and soil health compared to sole application of the recommended dose of fertilizers under the Cauvery Delta region. Accordingly, the objectives were to evaluate the effects of different nitrogen sources on rice growth and yield, to assess the role of foliar nutrient application in improving nutrient utilization efficiency at phenological stages and to determine the impact of integrated nutrient management practices on soil health and sustainability of rice cultivation.

Materials and Methods

Experimental site and soil characteristics

A field experiment was conducted during the *Kuruvai* season (June–September) of 2024 at Annamalai University, Experimental Farm, Cuddalore District, Tamil Nadu, India (Fig. 1). The experimental site falls under the Northeastern Agro-Climatic Zone of Tamil Nadu and is geographically located at 11°24' N latitude and 79°44' E longitude, with an altitude of +5.79 m above mean sea level. The soil belongs to the clay textural class (Vertisol, typical *Udic chromustert series*) with coarse sand 26.16%, fine sand 16.15%, silt 19.60% and clay 38.03%, classified as clay loam according to USDA taxonomy. The soil had a pH of 7.20, electrical conductivity (EC) of 0.17 dS m⁻¹, low available nitrogen (228 kg ha⁻¹) (14), medium available phosphorus (20.53 kg ha⁻¹) (15) and high available potassium (264 kg ha⁻¹) (16).

Weather conditions

During the cropping season, the maximum temperature ranged from 34.2 °C to 37.7 °C with a mean of 36.1 °C, while the minimum temperature ranged from 20.1 °C to 22.8 °C with a mean of 21.6 °C. Relative humidity varied from 64 to 77%. A total rainfall of 194.4 mm was recorded over 15 rainy days and the mean daily sunshine duration was 5.8 hrs day⁻¹. The compiled weather data reflect the prevailing climatic conditions during the cropping period.

Experimental design and treatment details

The experiment was laid out in a Randomized Block Design (RBD) with nine treatments and three replications.

T₁ - 100 % RDF (120:40:40 kg ha⁻¹)

T₂ - 75 % RDN through urea + 25 % RDN through FYM + 100 % RD of P and K + foliar application of zinc sulphate (ZnSO₄) at 0.5 % and boron at 0.3 % on 25 and 50 DAT

T₃ - 50 % RDN through urea + 50 % RDN through FYM + 100 % RD of P and K + foliar application of zinc sulphate (ZnSO₄) at 0.5 % and boron at 0.3 % on 25 and 50 DAT

T₄ - 75 % RDN through urea + 25 % RDN through biochar + 100 % RD of P and K + foliar application of zinc sulphate (ZnSO₄) at 0.5 % and boron at 0.3 % on 25 and 50 DAT

T₅ - 50 % RDN through urea + 50 % RDN through biochar + 100 % RD of P and K + foliar application of zinc sulphate (ZnSO₄) at 0.5 % and boron at 0.3 % on 25 and 50 DAT

T₆ - 75 % RDN through urea + 25 % RDN through urban compost + 100 % RD of P and K + foliar application of zinc sulphate (ZnSO₄) at 0.5 % and boron at 0.3 % on 25 and 50 DAT

T₇ - 50 % RDN through urea + 50 % RDN through urban compost + 100 % RD of P and K + foliar application of zinc sulphate (ZnSO₄) at 0.5 % and boron at 0.3 % on 25 and 50 DAT

T₈ - 75 % RDN through urea + 25 % RDN through goat manure + 100 % RD of P and K + foliar application of zinc sulphate (ZnSO₄) at 0.5 % and boron at 0.3 % on 25 and 50 DAT

T₉ - 50 % RDN through urea + 50 % RDN through goat manure + 100 % RD of P and K + foliar application of zinc sulphate (ZnSO₄) at 0.5 % and boron at 0.3 % on 25 and 50 DAT

The short-duration rice variety ADT 43 was chosen for this study. The recommended seed rate of 60 kg ha⁻¹ is transplanted at a spacing of 15 × 10 cm.

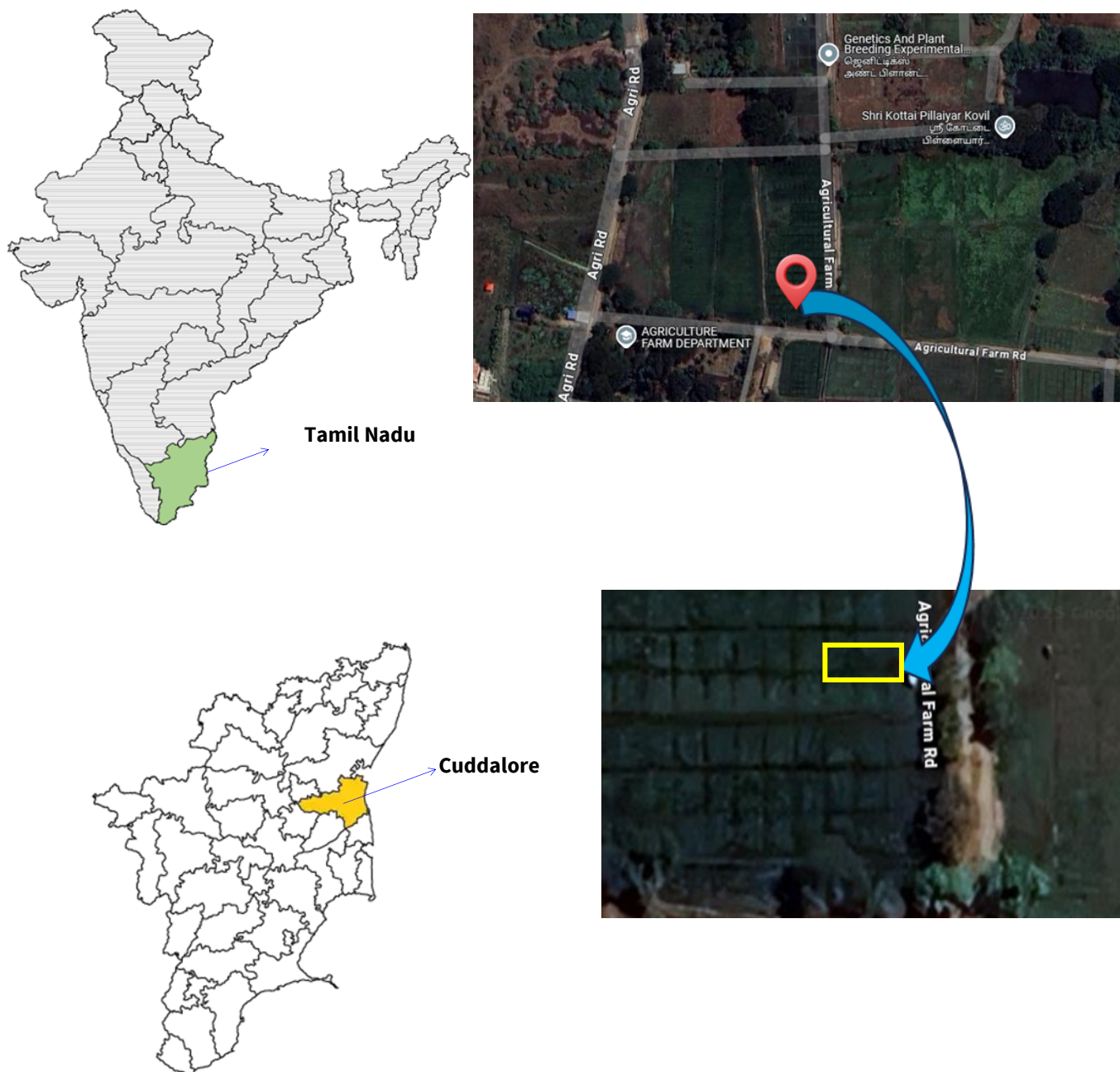


Fig 1. Location of experimental field.

Data collection

Growth attributes were systematically recorded at 30, 60 DAT and at harvest stage. Plant height was measured from the ground level to the tip of the topmost leaf on five randomly selected plants per plot and the mean values were expressed in centimetres. The number of tillers was determined by counting tillers in four quadrats of 0.25 m² per plot, with results expressed as tillers m². Leaf area index was recorded by tagging five hills per plot and measuring the third leaf without detachment. For dry matter production, 5 hills per plot were harvested, air-dried in shade and subsequently oven-dried at 80 ± 5 °C for 48 hr. The oven-dry weights were then converted to (kg ha⁻¹). Crop growth rate, representing the increase in plant dry matter per unit ground area per unit time (g m⁻² day⁻¹) and absolute growth rate, representing the increase in dry weight per plant per unit time (g plant⁻¹ day⁻¹), were calculated for the intervals 30-60 DAT and 60 DAT at harvest stage.

Statistical analysis

The recorded data were statistically analyzed using R software (version 4.2.2) with RStudio (version 2022.12.0+353), employing the “Agricole” package. Differences among treatments were tested using the “F” test of significance at the 5 % probability level ($p=0.05$) (17).

Results and Discussion

Growth parameters

The growth parameters such as, plant height, number of tillers, leaf area index (LAI) and dry matter production (DMP), differed significantly among nutrient management treatments (Table 1). The highest values were consistently recorded under a 100 % recommended dose of fertilizers (RDF) (T₁), which produced a plant height (102.67 cm), no. of tillers (402m²), LAI (5.41) and dry matter accumulation (10,985 kg ha⁻¹). The superiority of T₁ can be attributed to the immediate and balanced availability of nutrients, particularly

Table 1. Effect of integrated nutrient management strategies with organic amendments and foliar application on the growth of rice

Treatments	Plant height (cm)	No. of tillers (m ⁻²)	Leaf area index	Dry matter production (kg ha ⁻¹)
T ₁ - 100 % RDF (120:40:40 kg ha ⁻¹)	102.67	402	5.41	10985
T ₂ - 75 % RDN through urea + 25 % RDN through FYM + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	92.59	349	4.26	9532
T ₃ - 50 % RDN through urea + 50 % RDN through FYM + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	81.98	283	2.66	7904
T ₄ - 75 % RDN through urea + 25 % RDN through biochar + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	97.90	381	4.91	10258
T ₅ - 50 % RDN through urea + 50 % RDN through biochar + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	87.25	319	3.61	8707
T ₆ - 75 % RDN through urea + 25 % RDN through urban compost + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	99.94	389	5.11	10549
T ₇ - 50 % RDN through urea + 50 % RDN through urban compost + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	89.78	331	3.93	9128
T ₈ - 75 % RDN through urea + 25 % RDN through goat manure + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	95.08	366	4.60	9906
T ₉ - 50 % RDN through urea + 50 % RDN through goat manure + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	84.77	304	3.21	8298
S. Ed	1.09	4.71	0.11	148.11
CD (P=0.05)	2.32	10.00	0.24	314.00

* RDF: recommended dose of fertilizers, RDN: recommended dose of nitrogen, FYM: farmyard manure, P: phosphorus, K: potassium, DAT: days after transplanting, ZnSO₄: zinc sulphate, S. Ed: standard error deviation, CD: critical difference.

nitrogen, which enhances chlorophyll synthesis, cell division, leaf expansion and photosynthetic efficiency, ultimately resulting in greater biomass accumulation (18, 19).

The next best treatment was 75 % RDN through urea + 25 % RDN through urban compost, along 100 % recommended P and K with foliar application of ZnSO₄ (0.5 %) and boron (0.3 %) at 25 and 50 DAT (T₆). This treatment exhibited enhanced growth attributes due to the combined effect of readily available inorganic nitrogen and the gradual nutrient release from urban compost, which improves soil organic carbon, microbial activity and nutrient cycling. Improved soil structure and moisture retention under urban compost further supported root growth and nutrient uptake, leading to better plant vigour and canopy development (20-22). The foliar supply of zinc and boron complemented soil nutrition by improving enzymatic activity, leaf greenness and meristematic growth (23, 24). Treatment T₆ remained statistically on par with T₄, which received 75 % RDN through urea + 25 % RDN through biochar, along with recommended P and K and foliar ZnSO₄ and boron. Biochar application enhanced plant height, LAI and DMP by improving soil aeration, water-holding capacity and cation exchange capacity, thereby increasing nutrient availability and use efficiency. The porous nature of biochar also reduced nutrient leaching and promoted sustained nutrient uptake, resulting in growth responses comparable to urban compost (25-29). In contrast, the lowest growth performance was observed under T₃ (50 % RDN through urea + 50 % RDN through FYM and foliar application of ZnSO₄ (0.5 %) and boron (0.3 %) at 25 and 50 DAT), which recorded the least plant height (81.98 cm), tiller numbers (283 m⁻²), LAI (2.66) and DMP (7,904 kg ha⁻¹). The slower mineralization rate of farmyard manure and limited synchrony between nutrient release and crop demand may have restricted nutrient availability during critical growth stages, leading to reduced vegetative growth.

Growth-oriented indices (CGR and AGR)

Crop growth rate (CGR) and absolute growth rate (AGR) followed trends like those of growth parameters (Table 2). The highest CGR (5.74 g m⁻² day⁻¹) and AGR (0.0861 g plant⁻¹ day⁻¹) were recorded under T₁, reflecting optimized nutrient supply that enhanced photosynthetic activity, assimilate production and source-sink relationships during the active growth period. These findings corroborate earlier reports highlighting the role of balanced fertilization in accelerating biomass accumulation and crop growth dynamics (18, 19).

The second highest CGR and AGR were observed under T₆, where the integration of inorganic nitrogen with urban compost ensured better synchronization of macro and micronutrient availability throughout the crop growth cycle. The gradual nutrient release from compost, combined with foliar zinc and boron application, enhanced nutrient translocation, starch synthesis and carbon assimilation, thereby improving growth efficiency (30-34). Treatment T₄ remained on par with T₆, indicating that biochar, when integrated with inorganic fertilizers and micronutrient sprays, can effectively support crop growth rate by improving soil physical properties, nutrient retention and physiological activity of plants (35, 36). The lowest CGR (4.03 g m⁻² day⁻¹) and AGR (0.0604 g plant⁻¹ day⁻¹) were recorded under T₃, likely due to delayed nutrient availability from farmyard manure, resulting in suboptimal growth during peak demand stages.

Yield

Rice productivity was significantly influenced by nutrient management practices (Table 3). The highest grain yield (4,978 kg ha⁻¹) and straw yield (7,126 kg ha⁻¹) were obtained under T₁, owing to enhanced vegetative growth, improved photosynthetic efficiency and an efficient source-sink relationship facilitated by adequate nitrogen availability. These results agree with earlier findings emphasizing the yield advantage of balanced mineral fertilization in rice (18-19).

Table 2. Effect of integrated nutrient management strategies with organic amendments and foliar application on growth oriented indices of rice

Treatments	CGR (g m ⁻² day ⁻¹)	AGR (g plant ⁻¹ day ⁻¹)
T ₁ - 100 % RDF (120:40:40 kg ha ⁻¹)	5.74	0.0861
T ₂ - 75 % RDN through urea + 25 % RDN through FYM + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	5.06	0.0760
T ₃ - 50 % RDN through urea + 50 % RDN through FYM + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	4.03	0.0604
T ₄ - 75 % RDN through urea + 25 % RDN through biochar + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	5.39	0.0809
T ₅ - 50 % RDN through urea + 50 % RDN through biochar + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	4.60	0.0690
T ₆ - 75 % RDN through urea + 25 % RDN through urban compost + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	5.48	0.0822
T ₇ - 50 % RDN through urea + 50 % RDN through urban compost + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	4.88	0.0732
T ₈ - 75 % RDN through urea + 25 % RDN through goat manure + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	5.26	0.0790
T ₉ - 50 % RDN through urea + 50 % RDN through goat manure + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	4.31	0.0647
S. Ed	0.05	0.0007
CD (P=0.05)	0.10	0.0015

* RDF: recommended dose of fertilizers, RDN: recommended dose of nitrogen, FYM: farmyard manure, P: phosphorus, K: potassium, DAT: days after transplanting, ZnSO₄: zinc sulphate, CGR: crop growth rate, AGR: absolute growth rate, S. Ed: standard error deviation, CD: critical difference.

Table 3. Effect of integrated nutrient management strategies with organic amendments and foliar application on yield of rice

Treatments	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
T ₁ - 100 % RDF (120:40:40:40 kg ha ⁻¹)	4978	7126
T ₂ - 75 % RDN through urea + 25 % RDN through FYM + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	4261	6140
T ₃ - 50 % RDN through urea + 50 % RDN through FYM + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	3511	5099
T ₄ - 75 % RDN through urea + 25 % RDN through biochar + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	4643	6669
T ₅ - 50 % RDN through urea + 50 % RDN through biochar + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	3878	5609
T ₆ - 75 % RDN through urea + 25 % RDN through urban compost + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	4796	6872
T ₇ - 50 % RDN through urea + 50 % RDN through urban compost + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	4067	5881
T ₈ - 75 % RDN through urea + 25 % RDN through goat manure + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	4453	6408
T ₉ - 50 % RDN through urea + 50 % RDN through goat manure + 100 % of P and K + foliar application of ZnSO ₄ at 0.5 % and boron at 0.3 % on 25 and 50 DAT	3695	5352
S. Ed	85.37	117.92
CD (P=0.05)	181.00	250.00

* RDF: recommended dose of fertilizers, RDN: recommended dose of nitrogen, FYM: farmyard manure, P: phosphorus, K: potassium, DAT: days after transplanting, ZnSO₄: zinc sulphate, S. Ed: standard error deviation, CD: critical difference.

The next highest yields were recorded under T₆, where the combined application of RDF and urban compost improved nutrient availability through compost mineralization, supplying both macro and micronutrients essential for grain formation and biomass production. Enhanced vegetative growth under this treatment contributed to higher straw yield, while improved nutrient uptake supported grain filling (37–39). Treatment T₆ was statistically comparable with T₄, which involved biochar integration. The high carbon content and nutrient-retention capacity of biochar improved soil fertility, moisture availability and nutrient use efficiency, resulting

in increased grain number, grain yield and straw yield (40-43). Previous studies of (44-46) have also reported yield improvements of 13-14 % with biochar application due to enhanced soil CEC, pH regulation and nutrient translocation to economic plant parts. The lowest grain yield (3,511 kg ha⁻¹) and straw yield (5,099 kg ha⁻¹) were observed under T₃, corresponding with its inferior growth performance. Limited nutrient availability during reproductive stages under farmyard manure-based nitrogen management likely restricted assimilate production and translocation, leading to reduced yield.

Conclusion

The findings clearly indicate that while 100 % RDF produced the highest growth attributes and rice yield due to the rapid and balanced supply of nutrients, urban compost emerged as a viable and sustainable complementary nutrient source. Partial substitution of chemical nitrogen with urban compost improved soil organic carbon, nutrient availability and overall soil health, leading to stable and satisfactory grain and straw yields. The integrated application of urban compost with inorganic fertilizers enhanced nutrient use efficiency and reduced nutrient losses, thereby lowering environmental risks associated with exclusive reliance on chemical fertilizers. Although 100 % RDF remains essential for achieving maximum yield under intensive systems, integrating urban compost ensures long-term soil fertility, sustainable crop productivity and ecological resilience. Thus, recycling urban organic waste through rice cultivation represents an environmentally sound strategy for sustaining high productivity in rice-based cropping systems.

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Authors' contributions

KM contributed to conceptualization, investigation and preparation of the original draft. BG contributed to conceptualization, data curation and investigation. MS was involved in review, editing and plagiarism checking. VD contributed to review and editing. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical issues: None

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