



Effect of bio-enriched paddy straw compost on reduction of chemical fertilisers in rice (*Oryza sativa*) – wheat (*Triticum aestivum*) cropping system

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Received: 07 October 2025; Accepted: 30 January 2026

Keywords: Bio-manure, Soil nutrients, Uttar Pradesh, Yield

Rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L.) is the major cropping system in Indo-Gangetic plains of India. In India, rice and wheat production recorded was 150 and 118 million tonnes, respectively, in the year 2024–25 (PIB 2025). A huge amount of paddy and wheat straw are generated after harvest out of which, 44.5 and 24.5 million tonnes of paddy straw and wheat straw, respectively are burnt annually (Dutta *et al.* 2022). After the harvest of paddy, there is a short window (less than a month) available to the farmers to prepare the field for next crop i.e. wheat in rice–wheat cropping system, therefore, the farmers prefer to burn the paddy straw in the field itself (Zaidi 2021). A report indicated that the air quality of national capital territory and the adjoining states especially Haryana, Punjab and western parts of Uttar Pradesh is severely deteriorated during winters due to burning of paddy straw in the field itself after the harvest of paddy (Nghi *et al.* 2020). The poor air quality causes complex and severe respiratory diseases and ailments. Traditionally, a major portion of wheat straw is used as animal feed. However, paddy straw is not preferred as animal feed due to its high silica content (Singh and Brar 2021). Therefore, a viable solution for on-farm utilisation of paddy straw is need of the hour. Among the different value addition of crop residue, viz. briquettes and pellets, particle boards, pulp and paper, bio-fuel, mushroom production, etc. the bio-conversion of crop residue into bio-manure receives much attention due to its inherent property of recycling of nutrients in the soil and also avoid logistics and huge investment (Pandirwar *et al.* 2023). In the recent past, there is an increasing awareness among the different stakeholders including policy makers and farmers about the deleterious effect of chemical inputs in the soil. To overcome this, organic farming is being

promoted at different levels, wherein the application of compost is integral part of it (Raut *et al.* 2018). Rapid composting technique employs bio-decomposer which consists of lignocellulolytic microorganism's consortium to prepare the bio-enriched compost from paddy straw/ other agro-residue within a shorter period usually 60–90 days. The bio-enriched compost is 3–4 times nutrient rich and saves about 120 days compared to conventional farmyard manure (Manna *et al.* 2015, Mageshwaran *et al.* 2024a). In eastern Uttar Pradesh, the technology on rapid composting technique using bio-decomposer (Kush Bio-Fast) was disseminated to more than 6,000 farmers by which the farmers were able to produce the bio-enriched compost from paddy straw and reap the benefit through use of compost in their own field or selling the excess compost after use (Mageshwaran *et al.* 2024b). Though, much work has been done on production of bio-enriched compost from paddy straw, the literature on the effect of application of bio-enriched compost on crop yield and the soil quality is scarce. Thus, the present study was aimed to evaluate the effect of paddy straw bio-enriched compost on yield of wheat and rice on substitution with chemical fertilisers and to evaluate the soil nutrient properties.

Experimental site and treatment details: A field experiment was conducted in 2023 and 2024 at the research farm of ICAR-National Bureau of Agriculturally Important Microorganisms, Mau (25°53'54"N, 83°29'17"E; at an elevation of 70 m amsl), Uttar Pradesh in rice–wheat cropping system under low land conditions at eastern part of Uttar Pradesh. The transplanted rice was cultivated in rainy (*khariif*) season (July–October) while wheat was cultivated during winter (*rabi*) season (December–March). The experimental area was 25 m × 60 m and recommended dose of NPK was 120:60:60 kg/ha. The varieties used for the experiment were MTU7029 and HD2967 for rice and wheat, respectively. The experiment was carried out under randomised block design (RBD) with five treatments. There were four replications in each treatment and thus, a total of 20 plots of 35 m² each. The treatments were T₁, Absolute

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control (no fertilisers applied); T₂, Compost 2.5 t/ha; T₃, Compost 1.25 t/ha + 50% Recommended NPK; T₄, Compost @0.625 t/ha + 75% Recommended NPK; and T₅, 100% Recommended NPK. The bio-enriched compost was prepared from paddy straw by employing Kush Bio-Fast (a liquid bio-formulation for rapid decomposition) as described by Mageshwaran *et al.* (2024a). The mature compost was prepared in an accelerated manner within 60 days by adding and mixing 10% cattle dung, 0.1% Kush Bio-Fast bio-decomposer 0.1% jaggery and 1% urea at the start of composting. The Kush Bio-Fast bio-decomposer consists of two hyper lignocellulolytic fungi i.e. *Phanerochaete chrysosporium* V-1 and *Pleurotus flabellatus* M-1. The quality parameters of bio-enriched compost were pH- 8.5, EC- 3.38 mS/cm, total nitrogen- 1.65%, total phosphorus- 0.44%, total potassium- 1.63%, total carbon- 24.75%, CN ratio- 15.17, iron 2,135 mg/kg, and zinc- 88.3 mg/kg. The compost was applied to the field at 15 days after transplanting (rice) and sowing (wheat).

Yield analysis: After maturity, the crop was harvested from the respective plots, threshed and yield/plot was recorded and by extrapolation, yield (q/ha) was calculated for each treatment. The data were recorded for the two consecutive years (2023 and 2024).

Soil analysis: After the harvest of wheat crop, the soil samples were collected. 5 g of the sample was mixed with 25 mL distilled water and pH and EC were estimated. The samples dried, powdered and passed through 200 μ sieve, used for analysing the primary and micronutrients. The total organic carbon (TOC) content of the soil sample was evaluated as described by Walkley and Black (1934). The total nitrogen content (%) was estimated by micro-Kjeldhal method (Humphires 1956) while the total phosphorus content (%) was estimated by Vanadate-Molybdate method (Jackson 1967) and potassium content (%) by flame photometer (SYSTRONICS Flame Photometer 128) (Velmourougane *et al.* 2022).

Statistical analysis: The data were analysed in a randomised block design (RBD) using one-way analysis of variance (ANOVA) (OPSTAT, <http://opstat.somee.com/opstat/>). For all the analysis, the differences were considered to be significant at $p \leq 0.05$.

Effect of bio-enriched compost application on yield of rice and wheat: In 2023, the rice yield was higher in T₅ i.e. 100% NPK (39.48) and lower in T₁, absolute control (26.36) while the wheat yield was higher in T₄, Compost 0.625 t/ha + 75% NPK (33.74) and lower in absolute control (22.78). In 2024, the rice yield was higher in T₄ (42.22) and lower in T₁ control (17.55) while the wheat yield was higher in T₄ (37.89) and lower in absolute control (12.99) (Table 1). In a similar study, partial replacement of recommended dose of fertilisers with N-enriched and P-enriched compost has improved root parameters and water productivity in aerobic and conventional transplanted rice (Gouda *et al.* 2024). The application of compost @5 t/ha along with recommended dose of fertiliser resulted in increased yield of wheat (Kumari *et al.* 2018b). Velmourougane *et al.* (2022)

reported the modified integrated nutrient management (INM) practice of replacing 12.5 t/ha FYM with cotton stalks compost @5 t/ha in cotton cultivation, thereby, saved cost of cultivation extensively. Thus, the present study showed that 25% replacement of chemical fertilisers with only 0.625 t/ha of compost has resulted in improvement of rice and wheat yield. The savings in fertiliser cost in a season by replacement of 25% of chemical fertilisers with bio-enriched compost was 2,808.47 ₹/ha (Table 2). Considering, rice-wheat cropping system, the annual savings in cost of cultivation was estimated as 5,616.94 ₹/ha. In a similar study, the feedback analysis showed that the farmers of eastern Uttar Pradesh were able to save a sum of 7,563.01–10,100.34 ₹/ha in rice-wheat cropping system by reduction in use of chemical fertiliser and replacement of FYM with bio-enriched compost (Mageshwaran *et al.* 2024b).

Effect of compost application on soil nutrient properties: The soil sample was collected after the harvest of wheat crop each year. The soil nutrient properties such as pH, EC (mS/cm), TOC (%), and Total NPK (%) were determined to evaluate the effect of bio-enriched compost on long-term fertility of the soil. The pH of the soil was higher in

Table 1 Effect of bio-enriched compost on yield of rice and wheat in the year 2023 and 2024

Treatments	2023		2024	
	Rice yield (q/ha)	Wheat yield (q/ha)	Rice yield (q/ha)	Wheat yield (q/ha)
T ₁	26.36 ± 0.76	22.78 ± 0.88	17.55 ± 0.59	12.99 ± 0.69
T ₂	33.84 ± 1.06	28.65 ± 0.95	24.11 ± 1.60	15.99 ± 2.22
T ₃	36.33 ± 0.83	30.65 ± 1.07	27.55 ± 0.97	32.33 ± 1.35
T ₄	38.24 ± 1.29	33.74 ± 1.47	42.22 ± 1.25	37.89 ± 0.87
T ₅	39.48 ± 1.43	32.10 ± 1.21	35.44 ± 1.6	33.88 ± 1.75
CV	4.99	7.31	6.39	10.49

Refer to Methodology for treatment details.

Table 2 Savings in cost of chemical fertiliser

Description	Fertiliser cost (₹/ha)
A, Existing practice (100% NPK)	12,751.93
B, Modified practice Compost* 0.625 t/ha + 75% NPK	379.06 + 9,564.40
Net savings (A-B)	2,808.47

*The cost of compost production includes the input costs such as jaggery, decomposer culture, cow dung and urea @0.1, 0.1, 10 and 1%, respectively (Mageshwaran *et al.* 2024a).

Table 3 Effect of bio-enriched compost application on soil properties

Treatments	pH	EC (mS/cm)	Total organic carbon (%)	Total nitrogen (%)	Total phosphorus (%)	Total potassium (%)
T ₁	7.82 ±0.03	0.25 ± 0.01	0.22 ± 0.01	0.14 ± 0.01	0.076 ± 0.001	0.18 ± 0.008
T ₂	7.16 ±0.14	0.31 ± 0.02	0.57 ± 0.06	0.18 ± 0.01	0.076 ± 0.001	0.27 ± 0.012
T ₃	7.44 ±0.02	0.26 ± 0.01	0.46 ± 0.02	0.2 ± 0.01	0.073 ± 0.003	0.23 ± 0.015
T ₄	7.54 ±0.04	0.35 ± 0.04	0.34 ± 0.03	0.3 ± 0.02	0.08 ± 0.002	0.19 ± 0.012
T ₅	7.56 ±0.09	0.48 ± 0.04	0.15 ± 0.02	0.25 ± 0.01	0.084 ± 0.002	0.202 ± 0.016
CV	1.87	15.31	17.89	11.29	7.50	13.46

Refer to Methodology for treatment details.

T₁ (7.82) and lower in T₂. The EC (mS/cm) was recorded higher in T₅ (0.48) and lower in T₁ (0.25) (Table 3). The total organic carbon (%) was higher in T₂ (0.57) and lower in T₅ (0.15). The study showed that pH and EC of the soil was reduced in compost applied soil compared to the full dose of chemical fertilisers. The excess application of chemical fertilisers as in case of full dose of chemical fertilisers affects the soil property by increasing the soil pH, EC, and SAR (sodium adsorption ratio) which results in salinity and degradation of soil. This negative effect can be overcome by substitution of chemical fertilisers with bio-enriched compost. The application of compost revives the soil quality in a sustainable manner (Peng *et al.* 2023). In a similar study carried out at Pakistan, the application of compost has improved the soil nutrient properties in rice–wheat cropping system. The soil pH, EC and SAR were decreased due to acidic effect of compost, release of Ca and leaching of Na. The organic matter and soil NPK have been increased in compost applied saline-sodic soils. (Sarwar *et al.* 2008). The soil physical property specifically the soil organic matter was less degraded in compost applied soil than in chemical fertilisers applied soil in rice–wheat cropping system (Wang *et al.* 2012). A similar observation was made in our study that application of compost has improved the organic carbon content of the soil.

The total nitrogen (%) was found higher in T₄ and T₅ (0.3) while lower in T₁ (0.14). The total phosphorus (%) didn't differ between the treatments. The total potassium (%) was recorded higher in T₂ (0.27) and lower in T₁ (0.18). Thus, the results showed that the total N and K were found higher in compost applied soil than the full dose of chemical fertilisers. In a similar study, the soil nutrient properties have also improved to 0.041% N, 532 mg/kg P and 0.32% K in compost applied soil compared to 100% RDF (recommended dose of fertilisers). The NPK uptake by the wheat plants was also higher in compost applied soil compared to the recommended RDF (Kumari *et al.* 2018a). The effect of compost was evaluated in saline-sodic soils of rice–wheat cropping system in Pakistan. The results showed that the application of compost @24 t/ha along with chemical fertilisers significantly increased the yield of rice and wheat but also reduce the pH, EC and SAR. The

nutrient properties also improved in the compost-applied soil (Sarwar *et al.* 2020). Bharadwaj *et al.* (2023) had extensively studied different INM modules to reduce the use of chemical fertiliser without compromising the yield and productivity of rice–wheat cropping system in Indo–Gangetic plains. The INM practice of green manuring with *Sesbania aculeata* + rice straw compost @5 t/ha + 50% recommended RDF reduced 50% inputs of chemical fertiliser along with the improvement of soil N and plant N uptake. The authors also suggest for community scale rice–straw composting for sustainable nitrogen management in rice–wheat cropping system of Indo–Gangetic plains.

SUMMARY

Due to increasing awareness on the benefit of organic farming for sustainable ecosystem, there is an increase in area of organic cultivation and demand of organic inputs. The preparation and use of bio-enriched compost from agricultural residues cannot be avoided in organic farming practices. Therefore, an experiment was conducted for two years (2023 and 2024) at ICAR-National Bureau of Agriculturally Important Microorganisms, Mau, Uttar Pradesh to evaluate the bio-enriched compost prepared from paddy straw for yield and soil properties of rice–wheat cropping system. The replacement of 25% chemical fertilisers with 0.625 t/ha of bio-enriched compost resulted in increase in yield of rice and wheat compared to full dose of chemical fertilisers. Similarly, the soil TOC, TN and TK has been increased while pH and EC were maintained. The study recommended 25% replacement of chemical fertilisers with 0.625 t/ha of bio-enriched compost in rice–wheat cropping system of eastern Uttar Pradesh in order to reduce the dependency of chemical fertilisers, maintain the soil fertility, save the production cost, enhanced productivity and quality of the produce and overcome the problem of crop residue burning. In future, the combination of different organic inputs can be studied to further reduce the chemical fertilisers usage in rice–wheat cropping system.

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