RESEARCH ARTICLE

Comparative Bio-Economic Efficiencies of Different Organic Manures in Winter Rice

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ABSTRACT

The experiment was conducted to analyze comparative bio-economic efficiencies of different organic manures in winter rice (locally known as *boro* rice) of Bangladesh. This study consists of 11 treatments with different combinations of chemical fertilizers and organic manures. Vermicompost, Trico-compost, Cow dung, Poultry manure, and Co-compost at 2.5 t ha^{-1} or 5 t ha^{-1} were applied with the recommended fertilizer dose (RDF) or 75% RDF, respectively. Only RDF was considered as a control. The experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University (90°25'35.2"E, 24°43'07.3"N), following a randomized complete block design with three replications. Overall, the results indicate that the combination of RDF with 2.5 t ha^{-1} organic manure significantly enhanced the yield attributes and yield of winter rice. In contrast, 75% RDF, coupled with any of the organic manures studied, was found to be less effective than RDF in terms of yield. Poultry manure and cow dung at 2.5 t ha^{-1}, combined with RDF, resulted in a higher benefit-cost ratio (2.34 and 2.28) compared to a single application of RDF (2.05) in winter rice. This is also closely followed by co-compost application at 2.5 t ha^{-1} (2.00). The BCR was determined to be less than 1 for vermicompost and trico-compost at a rate of 5 t ha^{-1} with RDF. Considering both productivity and profitability, poultry manure appeared as the best manure to be incorporated with RDF. Based on availability and other factors, cow dung and co-compost at 2.5 t ha^{-1} with RDF could also be applied for sustainable and increased yield of winter rice.

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INTRODUCTION

Rice is the primary staple food of the most malnourished and impoverished people in Asia and Africa, providing nearly half of the world's population with essential calories (Bin Rahman & Zhang, 2023). Bangladesh ranks third in rice production and fifth in terms of cultivated area (BBS, 2022). Globally,

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an average of 3.18 t ha^{-1} rice is produced, while Bangladesh's national average is marginally higher at 3.25 t ha^{-1}, but substantially lower than China's (4.74 t ha^{-1}) and Japan's (5.00 t ha^{-1}) (FAO, 2022). The primary causes of soil fertility depletion in Bangladesh, which lower yields, include increased cropping intensity, the use of newer varieties (HYVs and hybrids), uneven fertilizer application, and little to no incorporation of organic manure. Because of the subtropical climate, Bangladesh's soil has an extremely low organic matter content and is still declining. A prerequisite for maintaining soil fertility and agricultural productivity is the augmentation of soil resources. Excessive use of chemical fertilizers may temporarily supply the required nutrients to crop plants, but it also deteriorates soil health and the environment. Using manure is an effective way to improve soil microbial biomass and nutrient availability, which can help reduce dependence on chemical fertilizers (Maitlo *et al*., 2022; Alam *et al*., 2024). Organic manures can serve as a supplement, allowing for a more than 20% reduction in chemical fertilizer usage while maintaining crop yield and quality (Wu *et al*., 2024). Organic fertilizers enhance soil fertility by increasing nutrient levels, improving microbial diversity (mainly bacteria), and altering soil physicochemical properties such as pH, EC, and NO_3-N content (Zhang *et al*., 2023). The most common organic manures are cow dung, farmyard manure, poultry manure, crop residues, vermicompost, urban waste etc. Vermicomposting is a sustainable biological treatment that converts organic solid waste into nutrient-rich fertilizer, supporting organic agriculture and environmental protection. It helps control pollutants, recover nutrients, and enhance soil health and crop production (Wang *et al*., 2024). Nitrogen nutrition provided by vermicompost helped to improve the grain quality of aromatic rice (Manir *et al*., 2025). Vermicompost strengthens plants' antioxidative defense mechanisms, helping them withstand environmental stress (Manzoor *et al*., 2024). The research findings indicated that applying 20 tons per hectare of Trichotithonia, along with 50% of the recommended NPK fertilizer dose, produced the best growth response in local Jambi red chili varieties (Eliyanti *et al*., 2024). Another excellent source of nutrients for soil is poultry manure. The application of poultry manure enhances microbial diversity, supporting the cycling of carbon, nitrogen, and sulfur, along with key enzymes such as dehydrogenases and catalase, as well as carbohydrate-active enzymes, which offers a cost-effective and sustainable way to boost soil health (Minkina *et al*., 2023). Co-compost is an excellent way for plants to obtain organic matter and vital nutrients that help them withstand drought and water stress (Manga *et al*., 2022). The results of the experiment showed that applying co-compost at a rate of 2 t ha^{-1} in addition to the recommended dosage of chemical fertilizer (RDF) increased rice grain production by 7% compared to applying RDF alone (Mahmud *et al*., 2024). Based on the explanation above, the purpose of this investigation was to ascertain the most appropriate organic manure in terms of productivity and cost-effectiveness for sustainable winter rice farming, as well as to compare the relative efficacy of various organic manures when mixed with chemical fertilizers.

MATERIALS AND METHODS

Experimental Site and Duration

The experiment was conducted at the Bangladesh Agricultural University's (BAU) Agronomy Field Laboratory. The site was situated at 90°25'35.2"E and 24°43'07.3"N (average height from sea level: >18 m). That medium-high land area was part of the Sonatola series, characterized by non-calcareous, dark grey floodplain soils, within the Old Brahmaputra Floodplain (Agroecological Zone 9). The experiment was conducted during the winter season (November to April) of 2022-23.

Experimental Soil and Climate

The field soil was nearly neutral, with a pH of 6.82, and exhibited low levels of organic matter and fertility. The land was medium-high in elevation with fairly level topography, moderate drainage, and was cropped with rice, wheat, and maize. The soil had a silt loam texture containing 67% silt, 20% sand, and 13% clay, with a bulk density of 1.35 g/cc, porosity of 46.67%, and particle density of 2.60 g/cc. Chemically, it had 1.77% organic carbon, 0.66% nitrogen, a C:N ratio of 11.06, and contained 15.67 ppm available phosphorus, 0.087 ppm exchangeable potassium, and 23.08 ppm available sulfur, making it fertile and suitable for diverse crop cultivation.

The experimental site experienced a subtropical climate, marked by high temperatures and heavy rainfall from March to October, while temperatures were moderately low and rainfall was scarce from November to February. Relative humidity was high from April to July and low during most of the months from November to February. The average air temperature (°C) throughout the experimental period ranged from 19.8 to 24.4, and the total rainfall varied from 0.00 mm to 17.7 mm. The relative humidity varied from 80.2% to 84.35%. The average total sunshine (hrs.) ranged from 164.4 to 227.2.

Experimental Treatments and Design

Eleven different chemical fertilizer and organic manure combinations made up the experimental treatments *e.g.*, (i) BRRI Recommended dose of chemical fertilizer (RDF) (T_1), (ii) 100% RDF + Vermicompost at 2.5 t ha^{-1} (T_2), (iii) 100% RDF + Trico-compost at 2.5 t ha^{-1} (T_3), (iv) 100% RDF + Cow dung at 2.5 t ha $^{-1}$ (T_4), (v) 100% RDF + Poultry Manure at 2.5 t ha^{-1} (T_5), (vi) 100% RDF + Co-compost at 2.5 t ha^{-1} (T_6), (vii) 75% RDF + Vermicompost at 5 t ha^{-1} (T_7), (viii) 75% RDF + Trico-compost at 5 t ha^{-1} (T_8), (ix) 75% RDF + Cow dung at 5 t ha^{-1} (T_9), (x) 75% RDF + Poultry Manure at 5 t ha^{-1} (T_{10}), (xi) 75% RDF + Co-compost at 5 t ha^{-1} (T_{11}). The experiment followed a randomized complete block design with three replications. The different manures used in the study were analyzed at the Plant Nutrition and Environmental Chemistry Laboratory of BAU, for their nutrient contents, which have been presented in Table 1.

Crop Husbandry

From BAU's Agronomy Field Laboratory, healthy seeds of BRRI Dhan 89 (a high-yielding Bangladesh Rice Research Institute (BRRI) released winter rice variety with an average yield potential of 9.17 t ha-1) were collected. Prepared and ready-to-use organic manure was obtained from the agronomy farm at BAU, and co-compost from the NGO Forum for Public Health, Mymensingh. A power tiller was used to plough and cross-plow the experimental field. The experimental field was cleared of all weeds and stubble, and the area was then prepared for treatment by the layout.

Urea, triple superphosphate, muriate of potash, gypsum, and zinc sulfate were sprayed at 296, 161, 210, 124, and 12 kg ha^{-1}, respectively, to meet the prescribed dose of chemical fertilizers (RDF). Following the experimental requirements, chemical fertilizers and manures were applied. Three equal portions of urea were administered at 15, 45, and 60 days following transplantation (DAT). All manures were applied in accordance with treatment guidelines and thoroughly mixed into the soil before the final stage of field preparation.

In the prepared puddled field, forty-day-old, healthy seedlings of comparable size were transplanted at a rate of three seedlings per hill, with row-row and hill-hill spacing of 25 cm and 15 cm, respectively. Where required, gap filling was carried out at seven DAT. Three hand-weeding operations were done at 15 DAT, 45 DAT, and 60 DAT. To improve maturity, the field was ultimately drained out 15 days before harvest. Infection from any disease organism or a substantial bug infestation was not observed in the field. Therefore, no steps were taken to protect the plants.

Data Collection

To document the different components of rice production, five rice hills—aside from border hills—were randomly selected from each unit plot before harvest. When 90% of the grains had turned golden yellow, they were harvested. Harvesting each plot separately allowed us to record the grain and straw yields. The crop was washed, threshed, and dried until it had a grain moisture content of 14% after

Table 1. Comparative nutrient compositions of the manures used

Manures	OC (%)	N (%)	P (%)	K (%)	S (%)	Ca (%)	Mg (%)
Vermicompost	9-18	1-2	0.4-0.8	0.5-1.2	0.2-0.3	1-3	0.2-0.5
Trico-compost	12-25	1.2-2.5	0.6-1.2	1.5-2.5	0.2-0.5	0.5-1.5	0.3-0.8
Cow dung	20-40	0.4-1	0.2-0.4	0.4-0.6	0.1-0.2	0.4-1	0.1-0.3
Poultry Manure	15-30	1.5-3.5	1.3-2.5	1.5-3	0.5-1	2-4	0.3-0.8
Co-compost	15-30	0.8-2	0.4-1.5	0.5-1.5	0.2-0.5	1-3	0.3-0.8

Source: Plant Nutrition and Environmental Chemistry Laboratory of Bangladesh Agricultural University harvest. The weight of the grain and straw was measured and transformed into tons per hectare. The growth, yield attributes, and yield of winter rice were noted. The benefit-cost ratio (BCR) of different integrated nutrient management systems for *winter* rice was also calculated.

Statistical Analysis

The data were compiled and tabulated in the appropriate format for statistical analysis. Analysis of variance was performed using the MSTAT-C software tool. Using Duncan's Multiple Range Test, the mean differences between treatments were examined at a 5% probability level.

RESULTS AND DISCUSSION

Effect on Growth Attributes

Plant Height

A combination of chemical fertilizer and organic manure exerted a significant influence on the plant height of BRRI Dhan 89 at all sampling dates (Figure 1). The combination of 75% RDF with 5 t ha^{-1} vermicompost or trico-compost resulted in statistically similar plant height at all the observations (Figure 1). They showed the lowest height at different DATs. On the other hand, the application of all manures at 2.5 t ha^{-1} with RDF, which consistently demonstrated higher plant height compared to the sole application of RDF. At 30 DAT (30.45 cm), 50DAT (51.26 cm), 70 DAT (70.16 cm) and at harvest (99.13 cm) poultry manure @ 2.5 t ha^{-1} with RDF resulted in the highest height of plants and at 90 DAT (95 cm) it occurs when cow dung @ 2.5 t ha^{-1} was applied with RDF. The differences in plant height due to the nutrient sources were attributed to the varying availability of key nutrients. Nitrogen release mostly depends on the types of manure and temperature. Poultry manure exhibits the fastest mineralization, followed by vermicompost and cow dung (Mondol *et al*., 2024).

Tillering ability

The number of tillers $hill^{-1}$ was significantly affected by the integration of RDF and different organic manures at all the growth stages (except 30 DAT) (Figure 2). The maximum and minimum number of tillers were recorded from RDF with 2.5 t ha^{-1} poultry manure and RDF with at 5 t ha^{-1} vermicompost, respectively, at different DATs. At 90 DAT, 2.5 t ha^{-1} cow dung (14.16) or poultry

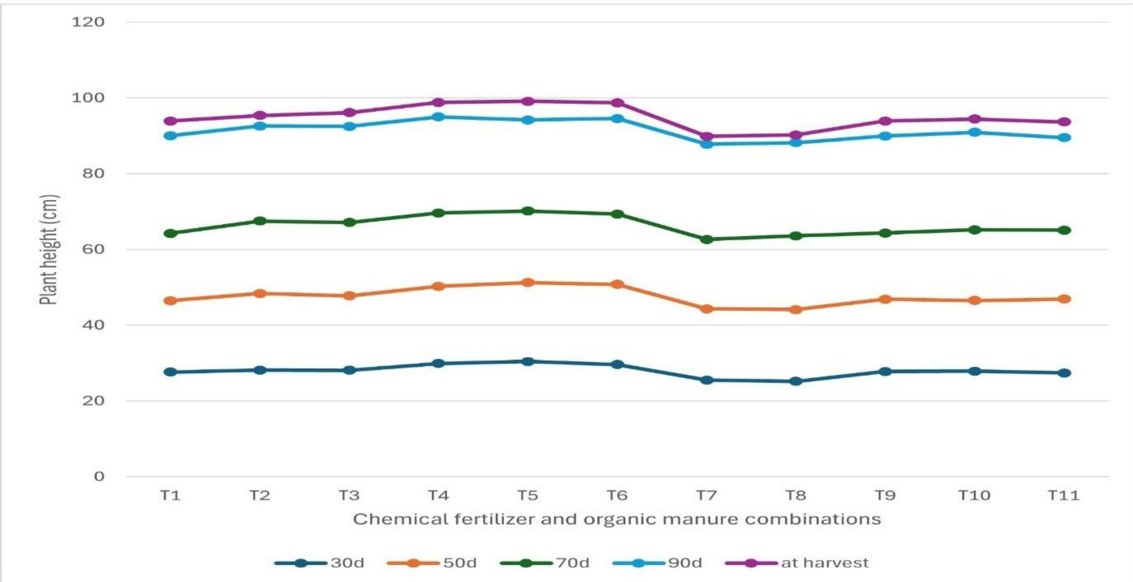

Figure 1. Effect of chemical fertilizer and various organic manure combinations on plant height at different days after transplanting of winter rice variety BRRI dhan89

T_1= Recommended dose of fertilizer (RDF), T_2= RDF + Vermicompost @2.5 t ha^{-1}, T_3 = RDF + Trico-compost @2.5 t ha^{-1}, T_4 =RDF + Cow dung @2.5 t ha^{-1}, T_5 = RDF + Poultry manure @2.5 t ha^{-1}, T_6 = RDF + Co-compost @2.5 t ha^{-1}, T_7 = 75% RDF + Vermicompost @5 t ha^{-1}, T_8 =75% RDF + Trico-compost @5 t ha^{-1}, T_9 = 75% RDF + Cow dung @5 t ha^{-1}, T_{10} = 75% RDF + Poultry manure @5 t ha^{-1}, T_{11} =75% RDF + Co-compost @5 t ha^{-1}

manure (15.10) in combination with 100% RDF provides the highest significant response for obtaining the greatest number of total tillers hill-1, which is statistically different from other treatments. This result supported the nutrient composition of poultry manure, which contains more nitrogen than other manures (Table 1) and is responsible for the vegetative growth of plants. Kader *et al*., (2025) also reported that the application of vermicompost, cow dung, and chemical fertilizers had a significant impact on the total number of tillers hill^{-1}. It was also noted that the combination of 75% chemical fertilizer with different organic manures at 5 t ha^{-1} sometimes resulted in fewer tillers compared to the application of the recommended dose of chemical fertilizer alone. This may have occurred because the amount of essential macro and micronutrients released from 5 tons of organic manure was lower than the nutrients available from 25% of the chemical fertilizer or because of the gradual nutrient release from organic manure.

Effect on Yield attributes

Number of effective tillers hill^{-1}

The analysis revealed that the number of effective tillers hill^{-1} was notably affected by the application of both organic and inorganic fertilizers (Table 2). The highest count of effective tillers hill^{-1} (12.9) was achieved with the recommended dose of chemical fertilizer combined with 2.5 t ha^{-1} poultry manure. This result is also supported by the residual impact of poultry manure and chemical fertilizers, enhancing the number of effective tillers hill^{-1} in BR11 rice (Das *et al.*, 2024).

Non-effective tillers per hill

From this experiment, we find that RDF with 2.5 t ha-1 co-compost produced the lowest number of non-effective tillers, which is statistically identical to 2.5 t ha^{-1} cow dung (Table 2). There were notable differences between the types of co-composed fecal sludge-based manures and chemical fertilizer combinations in the generation of the total tiller count hill^{-1}, which was observed by Mahmud *et al*., (2024).

Grains per panicle

A notable variation in the number of grains panicle^{-1} was found among the different combinations of chemical fertilizers and organic manures (Table 2). The maximum number of grains

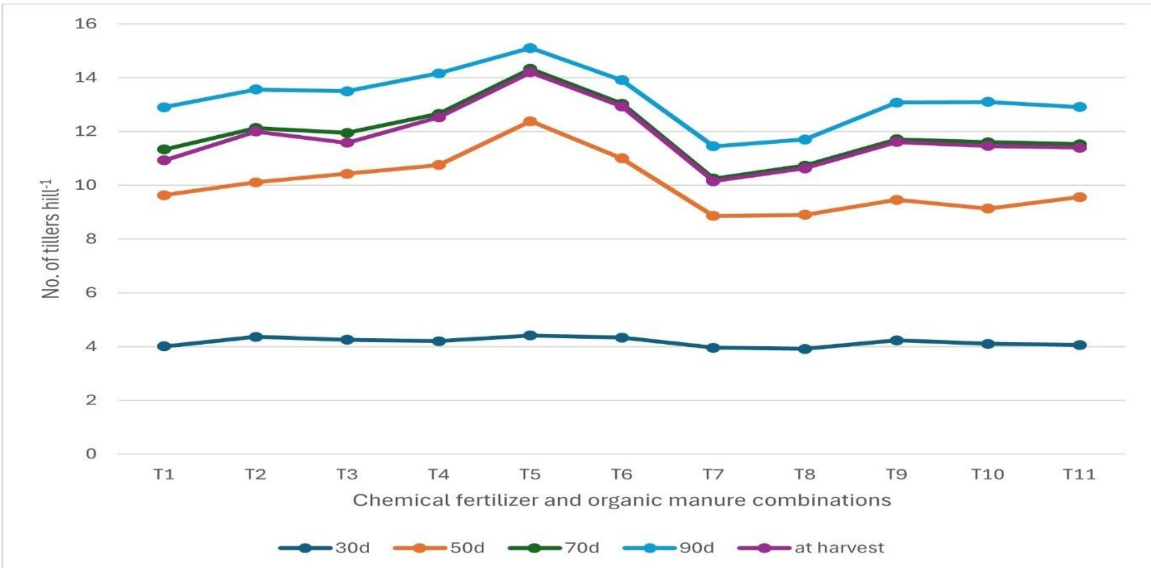

Figure 2. Effect of chemical fertilizer and various organic manure combinations on tillers number hill^{-1} at various days after transplanting of winter rice variety - BRRI dhan89

T_1= Recommended dose of fertilizer (RDF), T_2= RDF + Vermicompost at 2.5 t ha^{-1}, T_3 = RDF + Trico-compost a t2.5 t ha^{-1}, T_4 =RDF + Cow dung at 2.5 t ha^{-1}, T_5 = RDF + Poultry manure at 2.5 t ha^{-1}, T_6 = RDF + Co-compost at 2.5 t ha^{-1}, T_7 = 75% RDF + Vermicompost at t ha^{-1}, T_8 =75% RDF + Trico-compost at 5 t ha^{-1}, T_9 = 75% RDF + Cow dung at 5 t ha^{-1}, T_{10} = 75% RDF + Poultry manure at 5 t ha^{-1}, T_{11} =75% RDF + Co-compost at 5 t ha^{-1}

Table 2. Effect of treatment on yield contributing characters and yield of winter rice variety BRRI dhan89

Treatments	Effective tillers hill⁻¹ (no.)	Non -effective tillers hill⁻¹ (no.)	Grains panicle⁻¹ (no.)	Sterile spikelets panicle⁻¹ (no.)	Grain yield (t ha⁻¹)	Straw yield (t ha⁻¹)	Biological yield (t ha⁻¹)	Harvest index (%)
T_1	9.30 def	1.63ab	104.27bcd	13.22bcd	6.87bc	7.26bcde	14.14 cd	48.62ab
T_2	10.6bcd	1.33 bc	109.04abc	12.86 cd	7.64ab	8.08abc	15.72abc	48.60ab
T_3	10.2bcd	1.33 bc	106.64bcd	12.14 d	7.12ab	7.56abc	14.69abc	48.48abc
T_4	11.4abc	1.10 c	115.75a	11.99 d	8.15ab	8.52abc	16.68abc	48.88ab
T_5	12.9a	1.26 bc	111.15ab	11.97 d	8.37a	8.65ab	17.02a	49.15a
T_6	11.8ab	1.06 c	111.02ab	11.61 d	8.14ab	8.80a	16.94ab	48.04bcd
T_7	8.21 f	1.93ab	99.68d	15.60ab	5.35d	5.97 e	11.32 e	47.19 d
T_8	8.30 ef	2.33a	100.51cd	16.25a	5.47cd	6.03 de	11.50 de	47.50 cd
T_9	10.0 cd	1.60 bc	106.01bcd	13.86abcd	6.88bc	7.30bcde	14.18 bcd	48.51abc
T_{10}	10.0 cd	1.40 bc	104.01bcd	14.90abc	6.90 b	7.37bcd	14.27abcd	48.32abc
T_{11}	9.90 cde	1.50 bc	102.80bcd	14.73abc	6.73bcd	7.23 cde	13.97 cde	48.18abcd
Sx	0.80	0.34	4.36	1.23	0.68	0.67	1.34	0.49
Level of significance	**	*	*	**	**	**	**	*
CV (%)	9.49	28.07	5.02	11.13	11.79	10.88	11.27	1.24

In a column, figure having similar letter(s) do not differ significantly at p ≤ 0.05, whereas figures with dissimilar letter(s) differed significantly as per DMRT. **=significant at 1% (p≤0.01) level of probability, CV = Co-efficient of variation, NS = Not significant. T_1= Recommended dose of fertilizer (RDF), T_2= RDF + Vermicompost at 2.5 t ha⁻¹, T_3 = RDF + Trico-compost a t2.5 t ha⁻¹, T_4 =RDF + Cow dung at 2.5 t ha⁻¹, T_5 = RDF + Poultry manure at 2.5 t ha⁻¹, T_6 = RDF + Co-compost at 2.5 t ha⁻¹, T_7 = 75% RDF + Vermicompost at t ha⁻¹, T_8 =75% RDF + Trico-compost at 5 t ha⁻¹, T_9 = 75% RDF + Cow dung at 5 t ha⁻¹, T_{10} = 75% RDF + Poultry manure at 5 t ha⁻¹, T_{11} =75% RDF + Co-compost at 5 t ha⁻¹

panicle⁻¹ (115.75) was observed in rice plants treated with 100% of the recommended fertilizer dose (RDF) along with 2.5 t ha⁻¹ of cow dung. Most interestingly, only 75% of chemical fertilizer with 5 tons ha⁻¹ cow dung produced 1.67% more grains per panicle compared to the sole application of the recommended dose of fertilizer. It is also higher than other manure at 5 t ha⁻¹ with 75% chemical fertilizer. Cow dung contains a high organic matter content (Table 1), which improves soil structure, water holding capacity, and aeration, creating an optimal environment for root development and nutrient uptake. This supports the development of larger and more productive panicles. Moreover, as the nutrient release process of cow dung is slow compared to other manures and fertilizers, it may match the crop's nutrient demand during flowering and grain filling (a critical growth stage), leading to better panicle performance. (Atman *et al.*, 2018) Also observed the significant effect of cow dung on the number of grains per panicle.

Number of sterile spikelets per panicle

A notable variation in the number of sterile spikelets per panicle-1 was identified among the treatments, which included various combinations of chemical fertilizers and organic manures (Table 2). The highest count (16.25) of sterile spikelets panicle⁻¹ was observed with 75% RDF combined with 5 t ha⁻¹ trico-compost. Conversely, the lowest counts were recorded with 100% RDF paired with 2.5 t ha⁻¹ trico-compost (12.14), cow dung (11.99), poultry manure (11.97), or co-compost (11.61). A combination of RDF with 2.5 t ha⁻¹ organic manure ensures a sufficient water supply, essential for photosynthesis and nutrient transport, which affects pollen development and grain setting by increasing the water-holding capacity of the soil. In addition, macro- and micro-nutrients like N, P, K, Zn, and B, which are critical for grain filling, pollen formation, and fertilization, become more available.

Grain yield

Grain yield of rice by applying an integrated system where different organic manures were added with chemical fertilizers ranging between 5.35 t ha^{-1} to 8.37 t ha^{-1} (Table 2). It was observed that the highest grain yield (8.37 t ha^{-1}) was recorded when 2.5 t ha^{-1} poultry manure was applied alongside the 100% RDF. The benefits of poultry manure on yield and yield-contributing traits are evident from the experiment with maize varieties grown in soil amended with 50 and 75 g/pot of poultry manure (Rasool *et al*., 2023). In treatment T1, where only recommended doses of fertilizers were applied, 6.81 t ha^{-1} grain yield was observed, which was significantly lower than the higher grain yield. Numerous studies have highlighted the benefits of using co-compost (Kumar *et al*., 2025), vermicompost (Iqbal *et al*., 2024), cow dung (Pramono *et al*., 2024), poultry manure (Ding *et al*., 2025), and trico-compost in improving soil health and boosting rice yields. The adoption of INM in cropped fields resulted in yield increases ranging from 1.3% to 66.5%, compared to conventional nutrient management, across major cropping systems (Paramesh *et al.*, 2023). In this study, grain yield was increased by 11.2%, 3.64%, 18.63%, 21.83% and 18.49% respectively as a result of the integration of vermicompost, trico-compost, cow dung, poultry manure or co-compost at 2.5 t ha^{-1} with RDF compared to using the recommended dose of chemical fertilizer alone. Results from different experiments also showed that the relative performances of organic manures followed the order poultry manure > cow dung> vermicompost > trico-compost (Hasan *et al.,* 2024).

Biological Yield, and Harvest Index

The study revealed that the application of 2.5 t ha^{-1} poultry manure combined with 100% RDF resulted in the highest biological yield (17.02 t ha^{-1}) among all treatments (Table 2). It is worth noting that the combined use of organic manures and chemical fertilizers resulted in improved yield performance. Conversely, the lowest biological yield (11.32 t ha^{-1}) was observed with the combination of 75% RDF and 5 t ha^{-1} vermicompost. A statistically significant difference in the harvest index was also observed between the chemical fertilizer and organic manure treatments. The maximum harvest index (49.15%) was recorded from 100% RDF + 2.5 t ha^{-1} poultry manure. However, the lowest harvest index (47.19%) was obtained with 75% RDF + 5 t ha^{-1} vermicompost.

Economic Performance

We observed that the gross return of BRRI Dhan89 varied from 185,000 TK ha^{-1} to 285,980 TK ha^{-1} among various combinations of chemical fertilizers and organic manure (Table 3). The fertilization of BRRI Dhan 89 with 2.5 t ha^{-1} poultry manure, combined with 100% RDF, yielded the best gross return, closely followed by a 2.5 t ha^{-1} co-compost and 100% RDF combination. However, the combination of 5 t ha^{-1} vermicompost and 75% RDF had the lowest gross return, which was closely followed by the combination of 5 t ha^{-1} trico-compost and 75% RDF. The net return of BRRI Dhan89 varied from -9,923.6 TK ha^{-1} to 163,504 TK ha^{-1} across various combinations of chemical fertilizers and organic manure. When BRRI dhan89 was fertilized with 2.5 t ha^{-1} of poultry manure combined with 100% RDF, the maximum net return was determined. This was closely followed by 2.5 t ha^{-1} of cow dung combined with 100% RDF. It's noteworthy to note that the poor rice yield and high cost of vermicompost and trico-compost resulted in a negative net return when applied at a rate of 5 t ha^{-1} in conjunction with 75% RDF. Application of vermicompost or trico-compost at 5 t ha^{-1} in combination with 75% RDF resulted in a benefit-cost ratio < 1 due to the high cost of vermicompost and trico-compost, as well as the low rice yield. The application of poultry manure at 2.5 t $ha^{-1,}$ combined with 100% RDF, produced the highest benefit-cost ratio (2.34), closely followed by the combination of 2.5 t ha^{-1} cow dung and 100% RDF. The benefit-cost ratio of BRRI Dhan89 varied between 0.66 and 2.34 among the various chemical fertilizer and organic manure combination treatments.

CONCLUSION

Based on the present findings, it was deduced that the growth and yield contributing qualities of our selected winter rice, BRRI Dhan 89, could not be stimulated by the recommended dosage of chemical fertilizer alone. To maximize growth and

Table 3. Economic efficiency of application of different chemical fertilizer and organic manure combinations in winter rice variety BRRI dhan89

Chemical fertilizer and compost combinations	Variable cost ($TK\ ha^{-1}$)				Gross return ($TK\ ha^{1}$)	Net return ($TK\ ha^{1}$)	Benefit cost Ratio
	Variable cost (Except fertilizer and manures)	Fertilizer cost	Manure cost	Total variable cost			
T_1	107000	7976	-	114976	235530	120554	2.05
T_2	107000	7976	62500	177476	261960	84484	1.48
T_3	107000	7976	87500	202476	244280	41804	1.20
T_4	107000	7976	7500	122476	278950	156474	2.28
T_5	107000	7976	7500	122476	285980	163504	2.34
T_6	107000	7976	25000	139976	280060	140084	2.00
T_7	107000	6016	125000	238016	185000	-53016	0.77
T_8	107000	6016	175000	288016	188780	-99236	0.66
T_9	107000	6016	15000	128016	236020	108004	1.85
T_{10}	107000	6016	15000	128016	236950	108934	1.85
T_{11}	107000	6016	50000	163016	231320	68304	1.42

T_1= Recommended dose of fertilizer (RDF), T_2= RDF + Vermicompost at 2.5 t ha^{-1}, T_3 = RDF + Trico-compost a t2.5 t ha^{-1}, T_4 =RDF + Cow dung at 2.5 t ha^{-1}, T_5 = RDF + Poultry manure at 2.5 t ha^{-1}, T_6 = RDF + Co-compost at 2.5 t ha^{-1}, T_7 = 75% RDF + Vermicompost at t ha^{-1}, T_8 =75% RDF + Trico-compost at 5 t ha^{-1}, T_9 = 75% RDF + Cow dung at 5 t ha^{-1}, T_{10} = 75% RDF + Poultry manure at 5 t ha^{-1}, T_{11} =75% RDF + Co-compost at 5 t ha^{-1}

Labor wage =500 Tk $head^{-1}$ day^{-1}; Urea=28 Tk kg^{-1}; TSP= 28 Tk kg^{-1}; MoP= 30 Tk kg^{-1}; Gypsum= 14 Tk kg^{-1}; Zinc sulphate= 240 Tk kg^{-1}; Vermicompost = 25 Tk kg^{-1}; Trico-compost = 35 Tk kg^{-1}; Poultry manure = 3 Tk kg^{-1}; Co-compost = 10 Tk kg^{-1}; Cow dung = 3 Tk kg^{-1}; Rice grain= 29 Tk kg^{-1}

output, the results indicated that poultry manure at a rate of 2.5 t ha^{-1}, combined with the recommended dosage of chemical fertilizers, performed better. Additionally, when treated with the necessary dosage of artificial fertilizers, the other manures performed noticeably better. To ensure a more effective nutrient management system and optimal yield of winter rice, it is recommended to use organic manure in conjunction with the recommended dosage of fertilizers.

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