Bangladesh J. Soil Sci. 2024, 40 (1): 55-63

INFLUENCE OF INTEGRATED APPLICATION OF ORGANIC AND INORGANIC SOURCES OF NUTRIENTS ON THE YIELD OF BRRI DHAN84 RICE

M.R. Nasim, S. Rumman, S. Rahaman, K.K. Keya, H. Afroz, T.S. Hoque, M.R. Islam*

Department of Soil Science, Bangladesh Agricultural University (BAU), Mymensingh. Bangladesh.

**Corresponding author: rafiqss69@bau.edu.bd*

Abstract

Sustenance of soil fertility relies on using both inorganic and organic sources of nutrients. Although integrated nutrient management (INM) is much studied, finding the best combination and amounts to use is still unclear in Bangladesh. A study was undertaken to evaluate the combined effect of various manure and fertilizers on the growth and yield of BRRI dhan84 rice. The experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University (BAU), Mymensingh. There were seven treatments: T_1 = Control, T_2 = 100% Recommended Fertilizer Dose (RFD), T_3 = 70% RFD, T_4 = 70% RFD + Cowdung (CD) @ 5 t ha^{-1}, T_5 = 70% RFD + Poultry Manure (PM) @ 3 t ha^{-1}, T_6 = 70% RFD + Rice Straw (RS) @ 5 t ha^{-1}, and T_7 = 70% RFD + Household Ash @ 3 t ha^{-1}. Fertilizers such as urea, triple superphosphate (TSP), muriate of potash (MoP), and gypsum as sources of N, P, K and S, respectively were considered. The treatments were arranged in a Randomized Complete Block Design (RCBD) with three replications. The results revealed that treatment T_5 produced 9.42% increased grain yield and 10.2% increased straw yield compared to treatment T_2 containing sole chemical fertilizers. Additionally, T_5 demonstrated the highest NPKS uptake by plant, outperforming the other treatments with equal nutrient amounts. This study suggests that integrating PM with 30% reduced rate of chemical fertilizers provides an effective strategy for optimizing the yield and nutrient uptake of rice in Bangladesh.

Keywords: Cowdung, BRRI dhan84, Household ash, Integrated Nutrient Management, Poultry manure, Rice yield

1. Introduction

Boro rice (Oryza sativa L.) cultivated during winter season, plays a pivotal role contributing 55% of total rice production in Bangladesh. Securing the best growth and yield of Boro rice is vital for food security and economic stability in this country (Mainuddin *et al.,* 2021). Fertilizers, whether organic or inorganic, are essential for enhancing soil fertility and crop yields. Organic fertilizers such as farmyard manure, compost, and green manure enhance soil structure, increase water retention, and promote microbial activity. In contrast, chemical fertilizers supply nutrients rapidly, facilitating fast plant growth and development (Avery, 2022; Titirmare *et al.,* 2023).

However, overusing and improperly balancing inorganic fertilizers can cause soil degradation, environmental pollution, and a decline in crop yields over time (Rahman and Zhang, 2018). The Integrated Plant Nutrient System (IPNS), which blends organic and inorganic fertilizers, has become a sustainable method for enhancing soil health and increasing crop productivity (Sohel *et al.,* 2016). INM practices strive to maximize nutrient availability, improve nutrient utilization, and minimize the negative environmental impacts of using only inorganic fertilizers (Yadav *et al.,* 2017). Recent research has demonstrated that the simultaneous use of natural and chemical fertilizers can produce synergistic effects, leading to enhanced plant growth, higher yields, and improved grain quality in rice (Islam *et al.,* 2021; Liu *et al.,* 2021; Rahman *et al.,* 2022). Despite these known benefits, the optimal combination and application rates of manure and fertilizers remain elusive. By examining the interactions between different types and rates of fertilizer applications, this study attempts to identify the most effective nutrient management strategies for enhancing the productivity and sustainability of BRRI dhan84 rice.

2. Materials and Methods

2.1 Experimental location and soil

The experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University (BAU), Mymensingh, located at 24.0°N, 90.0°E, during Boro season of 2022. The soil is classified under the Sonatala series of Non-Calcareous Dark Grey Flood plain soils within the agro-ecological zone (AEZ) of the Old Brahmaputra Floodplain. The soil was characterized as silt loam having 6.47 pH (1:2.5 soil-water ratio), 1.82% organic carbon, 0.147% total N, 3.46 ppm Olsen-P, 0.097 me% NH_4OAc extractable exchangeable K, and 11.6 ppm $CaCl_2$ extractable S. Soil samples were analyzed following the methods as outlined by Page *et al.* (1982).

2.2 Treatments and experimental design

The study utilized the modern, high-yielding Boro rice variety BRRI dhan84. The experiment was carried out following a Randomized Complete Block Design (RCBD), with three replications; unit plot size was 4 m x 2.5 m. Total seven treatments were applied including: T_1: Control, T_2: 100% Recommended Fertilizer Dose (RFD), T_3: 70% RFD, T_4: 70% RFD + CD @ 5 t ha^{-1}, T_5: 70% RFD + PM @ 3 t ha^{-1}, T_6: 70% RFD + rice straw @ 5 t ha^{-1}, and T_7: 70% RFD + Household ash @ 3 t ha^{-1}. Cowdung contained 0.97% N, 0.3% P, 0.35% K and 0.12% S, such values for poultry manure being 1.34% N, 0.66% P, 0.84% K and 0.17% S, for rice straw being 0.28% N, 0.12% P, 1.45% K and 0.05% S and that for household ash were 0.01% N, 0.12% P, 1.15% K and 0.05% S.

2.3 Crop management

For cultivating Boro rice, the endorsed rates of N, P, K, S and Zn were 150, 20, 65, 18, and 2 kg ha^{-1}, respectively, with adjustments made based on different treatments. those nutrients were supplied in the form of urea, triple superphosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate, respectively. Organic sources of nutrients were incorporated into the soil a week prior to transplanting. All chemical fertilizers, except for urea, were applied as basal before transplanting across all experimental plots. Organic amendments such as CD, PM, rice straw, and household ash were added during final land preparation. Urea was top-dressed in three equal portions: the first at 12 days after transplanting (DAT), the second at 35 DAT during the maximum tillering stage, and the third at 55 DAT at the booting stage of the crop. Thirty five-day old healthy rice seedlings were transplanted into the plots at three seedlings per hill, with a spacing of 20 cm x 20 cm. Intercultural practices such as irrigation and weeding, were performed to ensure optimal growing conditions. The crop did not suffer from any pest or disease issues during growing period. Plant measurements were taken from four hills in each plot and averaged.

Yield measurements included plant height, panicle length, number of tillers $hill^{-1}$, grains per panicle, and 1000-grain weight, grain yield adjusted to a 14% moisture basis and straw yield on sun-dry conditions. The grain and straw samples were analyzed for N, P, K, and S concentrations adhering to standard laboratory procedures. The grain and straw nutrient uptake was calculated from the value of nutrient concentration and yield data.

2.4 Statistical analysis

The statistical analysis of the data involved ANOVA following F-test to assess the treatment effects. Subsequently, the Tukey HSD Test at a 5% level was employed to determine mean differences, with rankings indicated by letters (Gomez and Gomez, 1984). The data analysis was conducted using the 'R' programming language.

3. Results

3.1 Effects on plant growth and some yield components

Co-application of organic and chemical fertilizers significantly influenced the plant parameters of rice as presented in Table 1. Notably, T_5 had the tallest plant of 96.7 cm and T_4 exhibited statistically similar performance; the control showed the shortest plants (74.9 cm). Panicle length ranged from 19.0 cm in the control to 23.8 cm in T_5, and tillers per hill increased from 11.0 in the control to 15.6 in T_5. Like other parameters, T_5 produced the highest number of grains $panicle^{-1}$ (121), whereas the control had the lowest value (89.2). Furthermore, the 1000-grain weight was the highest in T_5 (24.5 g) compared to the control (19.2 g).

Table 1. Yield contributing characters of BRRI dhan84 as influenced by different treatments

Treatment	Plant height (cm)	Effective tillers hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	1000-grain wt. (g)
T_1	74.93g	10.98e	18.95f	89.2g	19.2f
T_2	81.94e	11.22e	20.6d	112.2d	20.3e
T_3	80.66f	10.33f	19.63e	106.6f	19.3f
T_4	94.06b	14.45b	22.23b	116.2b	22.5c
T_5	96.73a	15.56a	23.82a	121.0a	24.5a
T_6	86.74c	13.11d	21.38c	110.5e	21.5d
T_7	86d	13.5c	21.5c	113.9c	23.9b
CV%	0.078	0.76	0.39	0.07	0.4
SE (±)	0.04	0.06	0.05	0.05	0.05

The figure(s) having common letter(s) in a column do not differ significantly at 5% level of significance.

3.2 Effects on grain and straw yields of rice

The grain and straw yields of rice exhibited substantial variation across the fertilizer combinations ($p \leq 0.01$), as illustrated in Fig. 1. Notably, T_5 (70% RFD + PM @ 3 t ha^{-1}) produced the maximum grain yield of 6.62 t ha^{-1} and straw yield of 7.79 t ha^{-1}. Treatment T_1 (control) yielded the lowest. For straw yield, T_5 was statistically similar to T_7. However, T_5 exhibited a 9.42% increase in grain yield and 10.2% increase in straw yield over T_2, where only chemical fertilizers were applied.

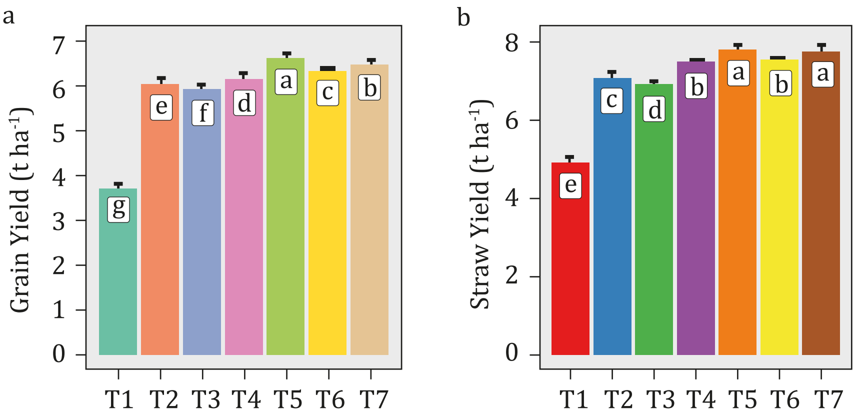

Fig. 1 *Effects of co-application of manure and fertilizers on the yield of BRRI dhan84 (a. grain yield, b. straw yield; data are mean±SE, n=3).*

3.3 Nutrient content in grain and straw

Significant differences were noticed in NPKS concentrations in rice grain among various treatments (Table 2). Notably, T_5 produced the highest N content in grains, 1.18%, while the lowest value was found in T_1 (0.73%). This difference was significant compared to T_4, T_5, and T_7, where the same quantity of fertilizers was applied. For P, the range in grain content varied from 0.18% in T_1 to 0.24% in T_5, which was significant over T_2 (where only chemical fertilizers were used). The grain K content varied from 0.17% in the control to 0.26% in T_5, which was significant over the other treatments. Additionally, T_5 exhibited the highest S content in grain at 0.15%, while the lowest value was in T_1 (0.06%).

Like grain nutrients, the straw concentrations of different nutrients (N, P, K & S) varied among the treatments. Notably, T_5, where PM was combined with NPKS fertilizers, had the highest total N content of 0.69% and the control plots had the lowest total N content (0.57%). The straw P content ranged from 0.07% in T_1 to 0.21% in T_5, which was statistically notable versus T_4, T_6, and T_7 (where the fertilizer amount was the same). The K content was 1.12% in T_1 and 1.36% in T_7 which statistically similar to T_5 (1.31%). The straw-S content varied from 0.04% in T_1 to 0.1% in T_5, showing a significant difference across the treatments.

Table 2. Nutrient contents in of BRRI dhan84 as influenced by integrated use of manures and fertilizers

Treatment	N content (%)		P content (%)		K content (%)		S content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	0.73d	0.57b	0.18c	0.07b	0.17c	1.12d	0.06b	0.04b
T_2	1.08bc	0.61b	0.19c	0.09b	0.19abc	1.22bc	0.07b	0.06ab
T_3	1.02c	0.59b	0.16c	0.08b	0.19bc	1.19cd	0.07b	0.05ab
T_4	1.11ab	0.62ab	0.21b	0.19a	0.21abc	1.3a	0.09ab	0.09ab
T_5	1.18a	0.69a	0.24a	0.21a	0.26a	1.31a	0.15a	0.10a
T_6	1.14ab	0.63ab	0.19bc	0.12b	0.22abc	1.29ab	0.10ab	0.05ab
T_7	1.16ab	0.62ab	0.17c	0.11b	0.25ab	1.36a	0.10ab	0.06ab
CV%	2.49	4.28	3.72	6.87	3.85	1.97	8.3	9.44
SE (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

The figure(s) having common letter(s) in a column do not differ significantly at 5% level of significance.

3.4 NPKS uptake by rice plant

Different treatments significantly influenced N, P, K and S uptake by grain and straw. Notably, T_5 exhibited the highest total N uptake of 106.79 kg ha^{-1}, while T_1 had the lowest value of 39.8 kg ha^{-1}. For P, T_5 led the way with 20.49 kg ha^{-1}, statistically similar to T_4, which showed a 35.6% increase over T_2 (where only chemical fertilizers were applied). K uptake ranged from 38.01 kg ha^{-1} in T_1 to 86.46 kg ha^{-1} in T_5, representing a 27.65% increase over T_2. Additionally, S uptake varied from 5.4 kg ha^{-1} in T_1 to 11.9 kg ha^{-1} in T_5, demonstrating a 37.67% increase over T_2 (Table 3).

Table 3. Effect of manures and fertilizers on total N, P, K, and S uptake by BRRI dhan84 (Mean±SE)

Treatments	Nutrient uptake (kg ha^{-1})			
	N	P	K	S
T_1	39.80g ± 0.06	9.01f ± 0.13	38.01g ± 0.08	5.4e ± 0.05
T_2	82.50f ± 0.05	15.11e ± 0.11	67.73e ± 0.02	8.66d ± 0.03
T_3	81.36e ± 0.08	14.93e ± 0.05	66.5f ± 0.03	8.49d ± 0.07
T^4	91.82d ± 0.07	19.97b ± 0.03	77.98b ± 0.04	10.26b ± 0.07
T5	106.79a ± 0.08	20.49a ± 0.06	86.46a ± 0.04	11.9a ± 0.04
T_6	92.71c ± 0.02	17.16c ± 0.03	76.23c ± 0.02	9.92c ± 0.05
T_7	101.72b ± 0.02	16.67d ± 0.07	74.42d ± 0.04	10.22b ± 0.02
CV (%)	0.92	0.18	0.12	`0.93

The figure(s) having common letter(s) in a column do not differ significantly at 5% level of significance.

4. Discussion

The results of the experiment demonstrated that the yield and yield components of rice were significantly influenced by the application of CD, PM, rice straw, household ash, with NPKS fertilizers. Yield attributes were always higher in T_5 treatment, where poultry manure was applied in combination with fertilizers on an IPNS basis, compared to those observed in other treatments. These findings are in align with previous studies (Islam *et al.,* 2014; Anisuzzaman *et al.,* 2022; Moe *et al.,* 2019). The superior performance of PM is likely due to its higher nutrient level and its slow release (Babu *et al.,* 2021; Prasai *et al.,* 2018).

The T_5 treatment, which combined PM with chemical fertilizers, yielded the highest grain

(77.5% over control) and straw output (58.3% over control), supporting findings reported by Anisuzzaman *et al.* (2022). This may be due to PM enhances yield by improving nutrient uptake, reducing sterile spikelets, and increasing grain weight although not significant due to its rich nutrient content (Schmidt & Knoblauch, 2020; Ismael *et al.,* 2021). Its high uric acid content accelerates decomposition, further boosting nutrient availability and vegetative growth (Anisuzzaman *et al.,* 2022; Islam *et al.,* 2016). Application of manures and fertilizers significantly influenced the nutrient concentration and absorption by plants. The highest N, P, K, and S uptake was observed in the T_5 treatment, and the lowest value was found in T_1 (control), which corroborates findings by Hoque *et al.* (2014); Schmidt & Knoblauch (2020); Moe *et al.* (2019). The same explanation applies to both yield and nutrient uptake (Anisuzzaman *et al.,* 2022; Tarafder *et al.,* 2020).

5. Conclusions

Co-application of organic and inorganic fertilizers improved nutrient availability and uptake, leading to better growth and yield attributes of rice. Application of T_5 (70% RFD + PM @ 3 t ha^{-1}) resulted in the maximum rice yield during Boro season. Based on the study, applying poultry manure with chemical fertilizers on IPNS basis can be recommended for maximizing the yield of BRRI dhan84 during Boro season. However, further research in various regions of Bangladesh is needed to validate these findings before widespread recommendation.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Anisuzzaman, M., Rafii, M.Y., Ramlee, S.I., Jaafar, N.M., Ikbal, M.F., and Haque, M.A. 2022. The Nutrient Content, Growth, Yield, and Yield Attribute Traits of Rice (Oryza sativa L.) Genotypes as Influenced by Organic Fertilizer in Malaysia. Sustainability. 14(9):9. https://doi.org/10.3390/su14095692

Avery, H. 2022. The Role of Organic Fertilizers in Transition to Sustainable Agriculture in the MENA Region. In M. Turan and E. Yildirim (Eds.), New Generation of Organic Fertilizers. Intech Open. https://doi.org/10.5772/intechopen.101411

Babu, A., Singh, U., Meena, R., Dadarwal, B., Jakhar, R., and Magazine, T. 2021. Use of Poultry Manure as Organic Fertilizer in Different Crops. 1, 14–15.

Gomez, K.A., Gomez, A.A. 1984. Statistical Procedures for Agricultural Research, John Wiley & Sons, New York.

Hoque, A., Islam, M.R., Siddique, A.B., Afroz, H., and Yeasmen, N. 2014. Integrated use of manures and fertilizers for maximizing the growth and yield of Boro rice (cv. BRRI dhan28). J. Soil Nature. 7(2):7-11.

Islam, M.R., Hoque, T.S., Islam, S., Ahmed, M. and Hoque, M.M. 2021. Performance of different organic manures with chemical fertilizers in increasing growth, yield and nutritional quality of potato (*Solanum tuberosum* L.). Bangladesh J. Bot. 50(3):651-657. https://doi.org/10.3329/bjb.v50i3.55845.

Islam, M.R., Shawon, A.K.S., Begum, M.L.N., and Huda, A. 2016. Effects of organic and inorganic fertilizers on the growth, yield and nitrogen uptake by BRRI dhan28. Res. Agric. Lives. Fish. 3(1):99–104. https://doi.org/10.3329/ralf.v3i1.27863.

Islam, M., Rashid, M., Siddique, A., and Afroz, H. 2014. Integrated effects of manures and fertilizers on the yield and nutrient uptake by BRRI dhan49. J. Bangladesh Agricul. Univ. 12(1):67–72. https://doi.org/10.3329/jbau.v12i1.21240.

Ismael, F., Ndayiragije, A., and Fangueiro, D. 2021. New Fertilizer Strategies Combining Manure and Urea for Improved Rice Growth in Mozambique. Agron. 11(4):4. https://doi.org/10.3390/agronomy11040783

Liu, J., Shu, A., Song, W., Shi, W., Li, M., Zhang, W., Li, Z., Liu, G., Yuan, F., Zhang, S., Liu, Z., Gao, Z. 2021. Long-term organic fertilizer substitution increases rice yield by improving soil properties and regulating soil bacteria. Geoderma. 404:15287. https://doi.org/10.1016/j.geoderma.2021.115287

Mainuddin, M., Alam, Md.M., Maniruzzaman, Md., Kabir, Md. J., Mojid, M.A., Hasan, Md.M., Schmidt, E.J., and Islam, Md. T. 2021. Yield, profitability, and prospects of irrigated Boro rice cultivation in the North-West region of Bangladesh. PLOS ONE. 16(4):e0250897. https://doi.org/10.1371/journal.pone.0250897.

Moe, K., Htwe, A.Z., Thu, T.T.P., Kajihara, Y., and Yamakawa, T. 2019. Effects on NPK Status, Growth, Dry Matter and Yield of Rice (Oryza sativa) by Organic Fertilizers Applied in Field Condition. Agric. 9(5):5. https://doi.org/10.3390/agriculture9050109.

Page, A.L, Miller, R.H., Keeney, D.R. 1982. Methods of Soil Analysis. 2nd Edn, Amer. Soc. Agron. Madison, WI., USA.

Prasai, T.P., Walsh, K.B., Midmore, D.J., Jones, B.E.H., and Bhattarai, S.P. 2018. Manure from biochar, bentonite and zeolite feed supplemented poultry: Moisture retention and granulation properties. J. Environ. Manage. 216:82–88. https://doi.org/10.1016/j.jenvman.2017.08.040.

Rahman, M.M., Islam, M.R., Uddin, S., Rahman, M.M., Gaber, A., Abdelhadi, A.A. and Jahangir, M.M.R. 2022. Biochar and Compost-Based Integrated Nutrient Management: Potential for Carbon and Microbial Enrichment in Degraded Acidic and Charland Soils. Front. Environ. Sci. 9:798729. doi: 10.3389/fenvs.2021.798729.

Rahman, K., and Zhang, D. 2018. Effects of Fertilizer Broadcasting on the Excessive Use of Inorganic

Fertilizers and Environmental Sustainability. Sustainability. 10(3):759. https://doi.org/10.3390/su10030759

Schmidt, F., and Knoblauch, R. 2020. Extended use of poultry manure as a nutrient source for flood-irrigated rice crop. Pesquisa Agropecuária Brasileira. 55:e00708. https://doi.org/10.1590/S1678-3921.pab2020.v55.00708

Sohel, M.H., Sarker, A., Razzak, Md.A., and Hashem, Md.A. 2016. Integrated use of organic and inorganic fertilizers on the growth and yield of Boro rice (cv. BRRI dhan 29). J. Biosci. Agric. Res. 10(1):857-865. https://doi.org/10.18801/jbar.100116.104

Tarafder, S., Rahman, M., Hossain, M., and Chowdhury, M. 2020. Yield of Vigna radiata L. and Post-harvest Soil Fertility in Response to Integrated Nutrient Management. 6:32–43.

Titirmare, Nihal and Ranshur, N. and Patil, Amrutrao and Patil, S. and Margal, Prasad. 2023. Effect of Inorganic Fertilizers and Organic Manures on Physical Properties of Soil: A Review. International J. Plant Soil Sci. 35:1015-1023. 10.9734/ijpss/2023/v35i193638.

Yadav, G.S., Singh, D., and Kumar, R 2017. Effect of Integrated Use of Organic Manures and Inorganic Fertilizers in Rice (Oryza sativa L.). J Pharmacogn Phytochem. 6(6S):296-298.