Original Research Article

Optimizing Productivity and Nutritional Composition of *Boro* Rice (BRRI dhan97) Through Vermicompost

Application

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ABSTRACT

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| The present study was conducted at the Field Laboratory of the Department of Agriculture, Noakhali Science and Technology University (NSTU), Noakhali-3814, from December 2022 to May 2023 to investigate the effect of vermicompost on the growth, yield, and nutritional content of *boro* rice. This field experiment consisted of the BRRI dhan97 and four vermicompost (VC) treatments viz. T0 (Control), T1 (vermicompost 3 t/ha), T2 (vermicompost 4 t/ha), T3 (vermicompost 5.5 t/ha). The experiment was arranged in a randomized complete block design (RCBD). It was found that vermicompost have a significant effect on the number of grains/panicles and nutritional value (moisture %). The highest plant height (136.84cm), grain/panicle (114.04), thousand-grain weight (27.9gm), grain yield (6.32 t/ha), panicle length (27.893cm) were observed for T3 (vermicompost 5.5 t/ha) and these are 1.49 %, 31.98 %, 5.006 %, 24.17%, 0.79 % higher than control. The total number of tiller/hill (15.56), and straw yield (7.74 t/ha) were highest for T2 (vermicompost 4 t/ha) which are 10.59 %, 30.41 % higher than control. Nutritional value (protein) (3.73) was highest for T1 (vermicompost 3 t/ha) which is 26.80 % higher than control. Harvest index (46.51%) and moisture content (4.85 %) was highest for control. Vermicompost treatment (5.5 t/ha) provided 6.32 t/ha grain yield which was the highest compare to other treatments. |

*Keywords: Boro Rice, Growth, Nutritional Value, Vermicompost, Yield*

1. INTRODUCTION

Bangladesh is a primarily agriculture-dependent developing nation. Since gaining independence in 1971, agriculture has remained central to Bangladesh's economy, contributing approximately 17 % to the GDP and employing 45 % of its workforce [1]. In the early stages of a country's development, the agriculture sector takes precedence as the primary catalyst for growth, surpassing other sectors in the economy [2]. At this point, prioritizing the industrial sector over agriculture would be a significant error in strategy, highlighting the crucial influence of agriculture on economic progress [3]. Bangladesh experiences three rice-growing periods: *aus*, *aman*, and *boro*. Aus occurring before the monsoon, involves rainfed upland rice cultivation [4]. *Aus* rice is typically sown through direct or broadcast seeding between March and April after the initial pre-monsoon rains and harvested from July to August [5]. Due to the higher yield potential, certain regions previously cultivating *aus* rice have transitioned to irrigated *boro* rice [6,7]. In 2014-15 and 2023-24, the projected cultivation areas for *Aus* rice were 1041.12 and 499.31 thousand hectares, while the estimated production stood at 2059.642 and 1781.545 thousand metric tons respectively [8]. BRRI dhan97 surpasses BRRI dhan28 in lifespan by 6 days and BRRI dhan67 by 2 days. One standout trait is its sturdy stem that prevents bending and ensures the rice grains stay secured within the ear [9]. This variety boasts enhanced tolerance to salinity compared to traditional types, handling levels between 14-15 dS/m during the vegetative phase [10,11]. However, it's sensitive to salinity at key growth stages, particularly between 8-10 dS/m, differing from the salt-tolerant BRRI dhan67 [12]. Overall, BRRI dhan97 demonstrates remarkable resilience to higher salinity levels, outperforming even the Czech variety, BRRI dhan67, known for its salinity tolerance [13].

For millennia, agriculture thrived without relying on artificial chemicals until the advent of synthetic fertilizers in the mid-1800s. These artificial options proved initially advantageous due to their affordability, potency, and ease of mass transport [14]. However, their short-term benefits were countered by long-term drawbacks, including soil compaction, erosion, diminished soil fertility, and concerns over harmful chemicals infiltrating the food chain [15,16]. As early as the late 1800s and early 1900s, soil biologists endeavored to mitigate these issues while striving to maintain high yields [17]. In a similar vein, inorganic fertilizers, despite their expensive nature and potential environmental harm if mismanaged, were prevalent [18].

The nutritional value of the protein concentrated in the rice bran is exceptional and somewhat similar to that of any other cereal and legume endosperm protein [19,20]. Rice bran proteins can be utilized as components to enhance dishes since they are highly digestible and contain a lot of necessary amino acids, particularly lysine [21]. Rice bran offers the potential to be added to a range of foods to improve storage stability because of its antioxidant qualities [22]. Rice bran fiber can be utilized as a functional and nutritional component [23]. Ethiopia's agricultural sector played a pivotal role in sustaining growth and poverty reduction. Yet, challenges such as nutrient deficiencies, declining soil organic matter, and erosion remain significant impediments to ensuring continual agricultural productivity [24]. In the past years, traditional chemical farming methods, known for significantly boosting crop yields, have led to various challenges for humanity [25,26]. Groundwater contamination has been linked to these practices, and the persistent use of agricultural chemicals has raised concerns about health impacts on both humans and animals. Moreover, excessive soil erosion from these conventional farming systems has significantly diminished soil fertility and crop output [27]. Numerous studies have concluded that vermicompost continues to enhance plant growth even when the plants are already receiving an adequate amount of nutrients [28]. Vermicompost, created through the decomposition of organic waste by earthworms, has been demonstrated in earlier research to serve as a highly effective organic fertilizer [29]. Its diverse set of physical, chemical, and biological characteristics has the potential to enhance soil fertility and manage crop diseases [30]. Vermicompost possesses several advantageous qualities as a fertilizer, such as uniformity, high porosity, excellent water retention, stability, a low C:N ratio, and its environmentally friendly, nutrient-rich composition [31]. It offers a diverse array of benefits for plant growth and development, including enhanced root and shoot growth, improved seed germination, increased leaf size, root complexity, fruit production, and nutritional value [32,33]. Additionally, vermicompost promotes flowering, influences biomass, and positively impacts photosynthetic processes like pigment production, photosynthesis, and respiration rates [34].

Vermicompost significantly increase the plant height, stem diameter, fresh weight and dry weight. The effect of using vermicompost as fertilizer on *boro* rice, particularly BRRI dhan97, lacks comprehensive documentation in Bangladesh. Hence, a field trial was carried out at Noakhali Science and Technology University's (NSTU) Agriculture field laboratory during the Boro season of 2022-23, aiming to address this knowledge gap with the following objectives: To reduce the use of chemical fertilizers, to observe the effect of vermicompost on BRRI dhan97, to enhance the soil quality to enhance the *boro* paddy production, to know about the nutritional value of rice.

2. material and methods

**2.1 Experimental site and Soil**

The experiment was carried out at the Field Laboratory of the Department of Agriculture, Noakhali Science and Technology University (NSTU), Noakhali-3814, during the period from December 2022 to May 2023 to study the effect of vermicompost on the growth and yield performance of BRRI dhan 97. The experimental field belongs to the agro-ecological region of the Young Meghna Estuarine Floodplain (AEZ-18). This region occupies young alluvial land in and adjoining the Meghna estuary. It is almost level with very low ridges and broad depressions. The experiment field was almost level land having sandy loam soil, moderately alkaline, with pH value 7.5. The soils become saline in dry season. General fertility is medium but low in organic matter (Table 1).

**Table 1:** Physical characteristics and chemical composition of soil of the experimental plot.

|  |  |
| --- | --- |
| **Soil characteristics** | **Analytical result** |
| Agro-ecological Zone | Young Meghna Estuarine Floodplain (AEZ-18). This region occupies young alluvial land and adjoining the Meghna estuary. |
| pH | 7.5 |
| N and organic matter | Low |
| Electrical conductivity (EC) | >4ds/m |
| Exchangeable sodium percentage | 15 at 25°C |

**Source:** Soil Resource and Development Institute (SRDI), Noakhali.

**2.2 Experimental Climate**

The experimental area is under the tropical climate and it has significant rainfall most months, with a short dry season. The average annual temperature is 25.6 °C and the average annual rain fall is about 3,302 mm. With an average of 40.6 °C, May is the warmest month. At 19.5 °C on average, January is the coldest month of the year. The driest month is January with 8 mm of precipitation. In July, the rainfall reaches its peak, with an average of 671 mm.



**Fig. 1. Monthly average temperature, relative humidity and total rainfall of the experimental site during the crop growth period from December 2022 to April 2023.**

**2.3 Experimental Design**

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The size of the unit plot was 2.25 m2. Each of the replications represented a block in the experiment. Four treatment combinations were randomly assigned in each replication. Total number of plots was 12. A spacing of 0.5 m and 0.5 m was maintained in between the replications and unit plot, respectively.

**2.4 Experimental Treatments**

Two factors included in the experiment were as follows- Factor A Variety (01): BRRI dhan 97. Factor B Treatment (04): T0 (Control), T1 (Vermicompost 3 t/ha), T2 (Vermicompost 4 t/ha), T3 (Vermicompost 5.5 t/ha)

**2.5 Description of the variety**

BRRI dhan97 is salinity tolerant variety. The size and shape of the plant in the growing stage (organ stage) is similar to BRRI dhan67. Dig leaves are erect, broad and long and the color of the leaves is dark green. Root is dark brown in color; grain is golden in color and medium coarse. Height of fully grown plant is 100 cm. Average weight of 1000 nutritious rice is 25.5 grams. The size of the rice is medium coarse and white in color. Rice is neat. The amylose content of grains is 25.2 percent and the protein content is 8.6 percent**.**

**2.6 Conduction of the Experiment**

**2.6.1 Seed Collection**

Seeds of BRRI dhan97 variety was collected from Bangladesh Rice Research Institute (BRRI), Joydebour, dhaka. These was so tough to collect this variety but our honorable teacher Dr. Md. Kawsar Hossen sir help me to collect this variety.

**2.6.2 Raising of Seedlings**

Seedlings were raised in well prepared nursery bed at the Field Laboratory of Department of Agriculture, NSTU, Noakhali. Seeds were soaked in the water for 24 hours. Then they were taken out of water, covered with wet gunny bags and kept for sprouting. The sprouted seeds were broadcast uniformly in a well-prepared nursery bed on 3rd January 2023. Proper care was taken to protect the seeds in the bed and to raise healthy seedlings. Seedlings were ready at 45 days after sowing for transplanting in the main field.

**2.6.3 Land Preparation**

The experimental land was first opened with a power tiller. Later on, the land was prepared by ploughing and cross-ploughing with a country plough and subsequently leveled by laddering. All weeds and stubble were removed from the land. The field layout was done according to the experimental design 18 February.

**2.6.4 Fertilization**

The field was fertilized with urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate were used as the source of nitrogen, phosphorus, potassium, sulphur and zinc at the rate of 150, 60, 40, 110, 10 kg/ha respectively. The entire amounts of triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate were applied during transplanting. Urea was applied as top dressing in three equal splits at 15, 30 and 45 days after transplanting (DAT). Vermicompost and other fertilizer was collected from local market.

**2.6.5 Uprooting and Transplanting of Seedlings**

Forty-five days old seedlings were uprooted from the nursery bed carefully and then transplanted on 18 February at the rate of two seedlings/hill maintaining spacing as per experimental treatments.

**2.7 Intercultural Operations**

**2.7.1 Gap Filling**

Seedlings in some hills died off and those were replaced by gap filling after 15 days of transplanting with seedlings from the same source.

**2.7.2 Weed Control**

During the whole growth period three hand weeding were done at 20, 35 and 50 days after transplanting (DAT).

**2.7.3 Water Management**

Precipitation was not available throughout the whole cultivation period. So, we used a motorized irrigation machine for pumping water from the pond which was near the field.

**2.8 General Observation of the Experimental Field**

A regular observation was made to ensure better growth of plants for good yield. In the whole period of experiment, the field was nicely green ensuring the normal growth. Insect attack was not severe. Disease infestation was not too severe to cause damage to the crop. Lodging of any plant was not observed, so yield was not reduced for lodging.

**2.9 Sampling, Harvesting, Threshing, Cleaning and Processing**

The crop was harvested at full maturity. The date of harvesting was confirmed when 80% of the grain became golden yellow in color. Five hills (excluding border hills) were selected randomly from each unit plot and uprooted before harvesting for recording data. After sampling, a harvest area of central 1 m × 1 m was selected from each unit plot. The harvested crop of each unit area was separately bundled, properly tagged and then brought to the threshing floor. The harvested crop was threshed by pedal thrasher. Grains were then sun dried at 14 % moisture level and cleaned. Straws were also sun dried properly. Finally straw and grain yield per plot were recorded and converted to ton per hectare.

**2.10 Data collection Parameters**

The following data on yield components and yield were recorded**:** Plant height (cm)**,** Number of total tillers/ hills**,** Number of grains/panicles**,** Thousand grain weight (gm)**,** Grain yield (t/ha)**,** Straw Yield (t/ha)**,** Harvest Index (%)**,** Panicle length (cm)**,** Carbohydrate (%)**,** Protein (%)**,** Moisture (%).

**2.10.1 Harvest index (%)**

It denotes the ratio of economic yield to biological yield and was calculated with the following formula (Gardner et al., 1985).

Harvest index (%) = x 100

Where,

Economic yield = Grain yield

Biological yield = Grain yield + Straw yield

**2.10.2 Carbohydrate (%)**

Carbohydrate was estimated by phenol sulfuric acid method. This method is simple and rapid colorimetric to determine total carbohydrate in a sample. Carbohydrate was estimated from 100 gm rice sample**.**

**2.10.3 Protein (%):**

Protein was estimated by Kjeldahl method. High Precision and good reproducibility have made it the major method for the estimation of protein in food. The amount of protein was estimated from 100 gm rice sample.

**2.10.4 Moisture (%)**

Moisture content on food can have a significant impact on factors such as the product taste, texture, appearance, shape and weight. Moisture% was estimated from 100 gm rice sample.

**2.11 Data analysis**

**2.11.1 Statistical analysis**

Data recorded for growth, yield and yield contributing characters were compiled and tabulated in proper form for statistical analyses. Analysis of variance was done with the help of Minitab. The data in respect of growth, yield and nutritional value were statistically analyzed to find out the statistical significance. The significance of the difference among the treatment mean was estimated by Least Significant Difference (LSD) Test at 5 % and 1 % level of probability [35].

**2.11.2 Percent increase calculation**

The concept of percent increase is basically the amount of increase from the original number to the final number in terms of 100 parts of the original. It was calculated with the following formula:

Percent increase= (New value - Original value /Original value) ×100

When the result was negative (-), it was indicated percent decrease.

3. results and discussion

**3.1 Effect of vermicompost on crop growth component of Boro rice (BRRI dhan 97)**

**3.1.1 Plant height (cm)**

The plant height was not significantly influenced by vermicompost combinations (Appendix 3). Among the different doses of vermicompost T3 (5.5 t/ha) showed the highest plant height (136.84cm) and T1 (4 t/ha) showed the lowest plant height (127.78 cm) (Fig 2a). Here T3 (5.5 t/ha) showed highest plant height which is 1.49 % higher than control and T1 (4 t/ha) showed lowest plant height which is 5.24 % lower than control (Table 2 & Table 3).

**3.1.2 Number of total tillers /hills**

The number of total tillers/hills was not significantly influenced by vermicompost. The number of total tillers/hills was highest (15.56) in case of T2 (4 t/ha) and lowest was (12.67) obtain for T3 (Fig 2b). The number of total tillers/hillsis highest for T2 which is 10.59 % higher than control and lowest for T3 which is 9.95 % lower than control (Table 2 & Table 3). The number of tillers per hill was significantly affected by the use of vermicompost, biochar, and urea applications [36].



**Fig. 2. Effect of vermicompost on the plant height and total number of tillers/hills of *boro* rice.**

*Here, T0= Control), T1= Vermicompost 3 t/ha), T2= Vermicompost 4 t/ha), T3= Vermicompost 5.5 t/ha)*

**3.1.3 Panicle length (cm)**

Vermicompost had non-significant effect on panicle length of *boro* rice. The highest panicle length (27.89 cm) was obtained on T3 (5.5 t/ha) (Fig 3a) which is 0.79 % higher than control and the lowest panicle length (27.14 cm) was obtained from T1 (3 t/ha) which 1.92 % lower than control (Table 2 & Table 3). Siddika et al., [37] reported that panicle length was statistically similar by different residue treatments.

**3.1.4 Number of grains /panicles**

The number of grains/panicles was not significantly affected by vermicompost (VC) combinations. The number of grains/panicles was highest (114.04) in case of T3 (5.5 t/ha) which is 31.98 % higher than control. On the other hand, the lowest number of grains/panicle (68.33) was obtained in T1 (3 t/ha**)** which is 20.92 % lower than control (Table 2 & Table 3).

**3.1.5 1000 grain weight (gm)**

Weight of thousand grains was not significantly influenced by vermicompost combinations. Among the different doses of vermicompost T3 (5.5 t/ha) showed the highest thousand grains weight (27.9 gm) which is 5.01 % higher than control. On the other hand, lowest thousand grain weight (26.37) was observed in the T2 where 4 t/ha vermicompost was applied which is 0.75 % lower than control (Table 2 & Table 3). Varying levels of vermicompost showed notable impact on the 1000-grain weight of rice [38].

**3.1.6 Grain yield (t/ha)**

Grain yield was not significantly influenced by vermicompost combinations. The highest grain yield (6.32 t/ha) was recorded on T3 (5.5 t/ha) and that is 24.17 % higher than control (Fig 3b) and the lowest grain yield (4.69 t/ha) was recorded on T1 (3 t/ha) that is 7.86 % lower than control (T0) (Table 2 & Table 3). The highest grain yield of organic rice, reaching 4.29 tons per hectare, was achieved by applying 15 tons per hectare of farmyard manure (FYM) as basal fertilizer along with 2.5 tons per hectare of vermicompost as basal, and an additional 2.5 tons per hectare of vermicompost as topdressing ten days after transplanting [28].

**3.1.7 Straw yield (t/ha)**

Straw yield was not significantly influenced by vermicompost combinations. The highest straw yield (7.74 t/ha) (Fig 3c) was recorded on T2 (4 t/ha) and that is 30.41 % higher than control and lowest straw yield (5.92 t/ha) was recorded on T0 (control) (Table 2 & Table 3). Vermicompost provide highest straw yield found by [38].



**Figure 3:** Effect of vermicompost on the panicle length, grain yield and straw yield of *boro* rice.

*Here, T0= Control), T1= Vermicompost 3 t/ha), T2= Vermicompost 4 t/ha), T3= Vermicompost 5.5 t/ha)*

**3.1.8 Harvest index (%)**

Vermicompost had non-significant effect on harvest index. The highest harvest index (46.51 %) was obtained on T0 (control) and lowest harvest index (40.95 %) was obtained on T1 (3 t/ha) which is 11.95% lower than control (Table 2 & Table 3).

**3.2 Effect of vermicompost on nutritional value of Boro rice (BRRI dhan97)**

**3.2.1 Carbohydrate (%)**

Vermicompost had non-significant effect on carbohydrate (%) of *boro* rice. The highest carbohydrate (%) (85.57) was observed in control and the lowest carbohydrate (%) (84.13) (Fig 4a) was observed in T2 (4 t/ha) which is 1.68 % lower than control (Table 2 & Table 3). These results are in conformity with that obtained by Alam et al., [39].

**3.2.2 Protein (%)**

Vermicompost had non-significant effect on protein (%) of Boro rice. The highest protein (%) (4.4) was observed in T1 (3 t/ha) (Fig 4b) which is 26.80 % higher than control and the lowest protein (%) (3.47) was observed in control (Table 2 & Table 3). Similar results were supported by Nishi et al., [40].

**3.2.3 Moisture (%)**

Vermicompost had significant effect on nutritional value (moisture%) of Boro rice. The highest moisture (%) (8.49) was observed in control (Fig 4c) and the lowest moisture (%) (6.67) was observed in both T1 (3 t/ha) and T3 (5.5 t/ha) which is 21.44% lower than control (Table 2 & Table 3). Similar findings were reported by Hoque et al., [41].



**Fig. 4.** Effect of vermicompost on carbohydrate, protein and moisture of *boro* rice.

*Here, T0= Control),* *T1= Vermicompost 3 t/ha), T2= Vermicompost 4 t/ha), T3= Vermicompost 5.5 t/ha)*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Plant height (%)** | **Tillers/hill (%)** | **Grains/panicle (%)** | **1000 grain weight (%)** | **Grain yield (%)** | **Straw yield (%)** | **Harvest index (%)** | **Panicle length (%)** | **Carbohydrate (%)** | **Protein (%)** | **Moisture (%)** |
| T1 | -5.24 | -2.91 | -20.92 | 3.12 | -7.86 | 19.76 | -11.95 | -1.92 | -0.75 | 26.8 | -21.44 |
| T2 | -2.12 | 10.59 | 4.8 | -0.75 | 14.93 | 30.41 | -6.15 | -0.69 | -1.68 | 7.49 | -11.78 |
| T3 | 1.49 | -9.95 | 31.98 | 5.01 | 24.17 | 27.7 | -1.61 | 0.79 | -1.22 | 7.49 | -21.44 |

**Table 2. Rate (%) of increase or decrease of growth, yield and nutritional value of BRRI dhan97 than control through the effect of vermicompost.**

*(-) for decreasing rate /lower than control.*

*T1= Vermicompost 3 t/ha), T2= Vermicompost 4 t/ha), T3= Vermicompost 5.5 t/ha)*

**Table 3. Effect of vermicompost treatment on growth and yield and nutritional value of *boro* rice**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Plant height**  **(cm)** | **Tiller hill-1** | **Grain**  **Panicle-1** | **1000 grain weight (g)** | **Grain yield (t/ha)** | **Straw yield (t/ha)** | **Harvest index (%)** | **Panicle length (cm)** | **Carbohydrate (%)** | **Protein (%)** | **Moisture (%)** |
| T0 | 134.8333 | 14.0667 | 86.41067 | 26.5667 | 5.087667 | 5.922667 | 46.511 | 27.6667 | 85.5667 | 3.4667 | 8.48667 |
| T1 | 127.7767 | 13.6633 | 68.3333 | 27.4 | 4.694333 | 7.096 | 40.95233 | 27.14333 | 84.9333 | 4.4 | 6.67333 |
| T2 | 131.97 | 15.5567 | 90.5567 | 26.3667 | 5.85233 | 7.73933 | 43.64733 | 27.48 | 84.1333 | 3.7333 | 7.48667 |
| T3 | 136.8433 | 12.6667 | 114.0367 | 27.9 | 6.31767 | 7.56233 | 45.75833 | 27.8933 | 84.5333 | 3.7333 | 6.67 |
| Mean | 132.8558 | 13.97167 | 89.83433 | 27.05833 | 5.488 | 7.080083 | 44.21725 | 27.54583 | 84.79167 | 3.8333 | 7.329167 |
| CV | 4.61 | 12 | 20.57 | 4.48 | 22.22 | 21.36 | 19.08 | 2.52 | 3.75 | 17.06 | 12.26 |
| Level of significance | NS | NS | **\*\*** | NS | NS | NS | NS | NS | NS | NS | **\*\*** |

*\*\* = Significant at 1% level of probability, NS = Not-Significant, T0= Control), T1= Vermicompost 3 t/ha), T2= Vermicompost 4 t/ha), T3= Vermicompost 5.5 t/ha)*

4. Conclusion

From the result of this experiment, it has been concluded that the highest yield (6.32 t/ha) obtained from treatment 5.5 t/ha vermicompost. Our result indicates that vermicompost can be a better supplement for better growth and yield of rice. It will reduce the use of chemical fertilizer. However, to attain a final decision more research work on Boro rice with the same treatment should be done in different Argo-ecological Zones (AEZs) of Bangladesh.

Disclaimer (Artificial intelligence)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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