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Yield performance of Boro rice through integrated application of vermicompost, biochar and urea

Ahnaf Akif Alvi[1], Farjana Akter Tumpa[1], Kawsar Hossen[1] and Belayet Hossain[1,2]

[1]Department of Agriculture, Noakhali Science and Technology University, Noakhali-3814, Bangladesh
[2]Department of Horticulture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

✉ For any information: belayet50718@bau.edu.bd (Hossain, B)
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ABSTRACT

The present investigation was executed at Agricultural Research Field, Noakahali Science and Technology University, Noakhali, Bangladesh to access the effects of variety and integrated application of vermicompost, biochar and urea on efficiency of boro rice yield. The experiment was accomplished during the period from November 2018 to May 2019. It was completed in a randomized complete block design (RCBD) with three replications. The treatments assigned in a factorial arrangement of 2 × 4, with 2 varieties of rice (V_1-BINA dhan 8, V_2- BINA dhan 10) and 4 integration of vermicompost, biochar, and urea (T_1: Vermicompost-2.5 t ha^{-1}, T_2: Vermicompost-2 t ha^{-1}+ Biochar 0.5 t ha^{-1}, T_3: Vermicompost-1.5 t ha^{-1}+ Biochar 1 t ha^{-1} and T4: Vermicompost-1.5 t ha^{-1} + Urea-150kg ha^{-1}/0.15 t ha^{-1}). Data were collected to analyze growth and yield contributing characters of boro rice. All the parameters were not statistically significant to differ. According to variety highest grain (3.73 t ha^{-1}) and straw (2.8 t ha^{-1}) yield was found from BINA dhan 10 in comparison with BINA dhan 8. In case of integrated application of vermicompost, biochar and urea, superior grain and straw yield were obtained from T4: Vermicompost-1.5 t ha^{-1} + Urea-0.15 t ha^{-1} whereas lowest grain yield (3.01 t ha-^{1} recorded from integrated application vermicompost and biochar. In combine maximum grain (4.92 t ha-1) and straw (4.40 t ha-1) yield was noted from BINA dhan 10 alone with integrated application of vermicompost and urea whereas the lowest data (grain: 2.50 t ha-1; straw: 1.64 t ha-1) was found from BINA dhan 8 along with vermicompost and biochar.

***Key Words**: Performance, Treatments, Vermicompost, Biochar and Boro rice*

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I. Introduction

Rice (*Oryza sativa* L.) is one of the most important and staple food crops in Bangladesh. It is cultivated extensively and provides food on the earth for one of every three persons. In agricultural sector of Bangladesh approximately 74.85% of the land is occupied by rice cultivation. Aus, Aman and Boro are the three rice growing seasons. Among the rice growing season most of the growing area is taken by

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Boro rice comprising approximately 41.94% of the total rice growing area (BBS, 2018). The yield of Boro rice is 13.76% and 78.81% higher than that of Aman and Aus rice respectively. Bangladesh is the fourth largest rice producing country in the world (FAOSTAT, 2017).

In Bangladesh, the most important cropping system is the rice-rice system. Most of the irrigated fertile lands have declined soil fertility in general and soil organic carbon (SOC) content in particular due to continuous cultivation of this highly exhaustive cropping sequence. For this reason, total productivity factor greatly reduced as well as raised questions on the sustainability of this cropping system. Application of inorganic fertilizers increases yield only for few years but no longer and enhancing soil degradation, acidification of soil, adversely affecting soil microorganism as well as biogeochemical processes, which accelerate risk of environmental and reducing the production of crops (Satyanarayana et al., 2002; Pietri and Brookes, 2008).

In recent times, more emphasis has been given on the global environmental problems as well as world agricultural productivity which are greatly influenced by degradation of soil fertility due to erosion and depletion or imbalance of organic matter/nutrients (Foley et al., 2005). Many studies suggested that production of economically viable as well as least environmental pollution can be obtained through organic fertilization which improves soil organic matter content, enhances microbial biomass and activity of beneficial soil microbes, to reduce the risk of plant diseases attack, especially those pathogen which are soil-borne and increasing the resistance of soil against erosion (Bruhn et al., 2012).

Efficiency of using vermicompost, biochar with chemical fertilizer could be reduced consumption of chemical fertilizers. 50 percent amount of chemical fertilizer in field conditions can be reduced through the combined application of vermicompost with urea also the yield was 12% higher than treatments that only received fertilizer (Adhikri and Mishra, 2004). Biochar also has been considered as a probable tool for improving fertility status of soil, potential toxic element adsorption and climate change mitigation (Ennis et al., 2012). Therefore, growth and yield of boro rice varieties were greatly enhanced by different vermicompost combination with biochar and urea. Considering the points, the motive of this study was to determine the positive influence of vermicompost on growth and yield contributing characters of boro rice varieties improved by the addition of biochar and urea.

II. Materials and Methods

Location

During the period from November 2018 to May 2019, the present investigation was accomplished at the Research Field of the Department of Agriculture, Noakhali Science and Technology University (NSTU), Sonapur, Noakhali-3814.

Agro-ecological region

Young Meghna Estuarine Floodplain (AEZ-18) was the Agro-Ecological Zone of the research area. Young alluvial land and adjoining the Meghna estuary were the characteristics of that region as well as almost level with very low ridges and broad depressions.

Soil and Climate

Almost leveled land having sandy loam soil, moderately alkaline, with pH value 7.8. During dry season, the soils become saline. Low organic matter content and medium fertility status was the nature of soil. Sub-tropical climatic condition and having significant rainfall most months, whereas a short dry season was obvious characters.

Experimental Treatments

Two factors included in the experiment were as follows:

Factor A: Variety (2)	Factor B: Vermicompost combinations (4)
V_1 – BINA dhan 8	T_1 - Vermicompost (VC) 2.5 t ha^{-1}
V_2 – BINA dhan 10	T_2 - Vermicompost-2 t ha^{-1}+ Biochar 0.5 t ha^{-1}
	T_3 - Vermicompost-1.5 t ha^{-1}+ Biochar- 1 t ha^{-1}
	T_4 - Vermicompost 1.5 t ha^{-1} + Urea-150kg ha^{-1}/0.15 t ha^{-1}

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Experimental Design
The design of this experiment was randomized complete block design (RCBD). The experiment was executed with three replications. Unit plot size was 2 m × 1.5 m, having an area of 3 m^2. In the experiment, each replication indicated a block. In each replications, treatment combinations were assigned randomly. Thus the total number of unit plots was 24 (3× 8). Spacing between block and plot was 1.0 m and 0.5 m.

Materials Collection
Seeds of boro rice variety (BINA dhan 8 and BINA dhan 10) were collected from Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Vermicompost and urea were collected from the local market. Biochar was collected from Dr. Shamim Mia, Associate professor, Department of Agriculture, Potuakhali Science and Technology University (PSTU). Biochar was produced using the PSTU slow pyrolysis kiln (Shamim et al., 2015) from sawdust. The temperature of biochar production was ~400 °C while the duration of pyrolysis was 12 hrs.

Seed sprouting
After 24 hours soaked in water, the collected seeds were taken out and covered the seeds with wet gunny bags for sprouting. After 36 hours the seed started sprouting and after 72 hours almost all seeds were sprouted uniformly.

Preparation of seed bed and seed sowing
In a well prepared nursery bed, pre-germinated seeds of the variety BINA dhan 8 and BINA dhan 10 were uniformly broadcasted. After raising seedlings, urea is applied. For protecting the seed into the bed and to raise healthy seedlings proper care was maintained. Irrigation was given in the seed bed when necessary and weeds were removed.

Land preparation for transplanting
By a tractor, the main field was first opened. Then, ploughing and repeated ploughing the land was prepared and subsequently leveled by laddering. Thereafter, for obtaining good tilth condition, the land was deep ploughed which was essential for better plant growth as well as yield. After each ploughing laddering was given to break the soil clods into small pieces. The experimental land was kept clean and weeds, as well as stubbles, were rdesisted from the experimental land. Finally, according to design of the experiment the plots were laid out.

Fertilization
Fertilizers were applied at the basal with vermicompost, bichar, triple superphosphate (TSP) and muriate of potash (MP) at the specific plot according to the layout of RCBD design and urea was applied as top dressing in three equal splits at 15, 30 and 45 days after transplanting (DAT).

Uprooting and transplanting of Seedlings
From the seedbed, seedlings were carefully uprooted. Slightly irrigation was given for easier uprooting of the seedlings and maintains the health and vigour. On 25th January 2019 uprooted seedlings were transplanted into the main plots keeping spacing of 15 cm (row to row) × 10 cm (plant to plant) and per hill 2-3 seedlings were given.

Gap filling and weed control
After 5 days of transplanting died off of seedlings from some hills replaced died seedlings by gap filling. Few weeds namely durba, shama, maluncha and mutha were found in each plot after two weeks of transplanting. They were uprooted immediately by hand pulling. Hand weeding was accomplished two times during the whole growth period at 20 and 35 days after transplanting (DAT).

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.

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Crop protection

The crop was attacked by yellow stem borer and Rice bug. Mortar at the rate of 12.5 ml of 10L water was applied to control the stem borer whereas applying Carate at the rate of 12.5 ml of 10L of water for controlling rice bug. 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 normal growth. White ears disease had seen in some plots which are caused by yellow stem borer. 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.

Sampling, Harvesting, Threshing, Cleaning and Processing

BINA dhan 8 and BINA dhan 10 became mature in dissimilar times. When 90% of grains became golden yellow color, then the harvesting done. After harvesting, harvested crops are bundled separately in according to the plot, marked them properly according to the treatments and sent to threshing floor. Grains were separated by a manually operated paddle thresher. Kept the grain moisture at 14% and clean the grain properly to remove unwanted and inert materials. At last straw and grain yield were calculated and converted into t ha^{-1}.

Data collection

Data were tabulated from five hills that were selected randomly and avoiding border hills as well as marked those selected hills by bamboo sticks soon after transplanting. Data was recorded on Plant height (cm), number of tillers hill-1, grains panicle-1, 1000 grains weight, grain yield (t ha-1), straw yield (t ha-1) and harvest index (%). Data of grain and straw yield was recorded in grams and finally converted into t ha^{-1}. After sun drying the grains properly 1000 grains weight was recorded.

Statistical analysis

For proper statistical analyses data were recorded as well as tabulated accurately from different crop growth stages to find out appropriate effects of growth, yield and yield contributing characters of Boro rice. The recorded data of different parameters in this study were analyzed statistically by using MSTAT-C and Microsoft office Excel 2013 to find out the significant or non-significant within treatments and means were compared at 5% probability level.

III. Results and Discussion

Varietal effects of Boro rice on growth and yield attributes

All the growth and yield parameters under study was not statistically significant variation among the varieties (Table 01). The tallest plant (93.32 cm) was recorded from BINA dhan 8 whereas BINA dhan 10 gave 80.75 cm. Plant height was significantly varied for the variation of studied field conditions and variation of genetic characters into the varieties (Isa et al., 2015). Maximum tiller (12.47$hill^{-1}$) was attained from BINA dhan 8 and BINA dhan 10 gave 11.51 tillers $hill^{-1}$. Due to genetic variation, physiological functions and growth characters of the varieties differences might occur in the production of total tillers $hill^{-1}$. Sohel et al. (2009) reported that due to varietal differences all the yield and yield contributing character differed significantly. Statistically non-significant variation was recorded in terms of grains $panicle^{-1}$. Maximum grains $panicle^{-1}$(90.68) was attained from BINA dhan 8. Minimum data (81.63 grains $panicle^{-1}$) was found from BINA dhan 10. Similar results were attained (Isa et al., 2015). Hossain et al. (2014) reported that variation ineffective, non-effective and total tiller production among the varieties was found variation in total grains $panicle^{-1}$. Thousands grain weight was statistically varied. Superior data (30.46g) was noted from BINA dhan 10 whereas BINA dhan 8 gave 24.11g. Variation among varieties in terms of grain weight might be due to variation in genetic characters as well as size of the grain. The highest grain yield (3.73 t ha^{-1}) and straw yield (2.8 t ha^{-1}) was noted from BINA dhan 10. On the other hand lowest grain (3.43 t ha^{-1}) and straw yield (2.45 t ha^{-1}) was found from BINA dhan 8. The higher number of effective tillers $hill^{-1}$ and higher number of filled grains $panicle^{-1}$ as well as larger grains which attained higher grain yield ha^{-1} (Mondal et al., 2005). The variation in straw yield was due to varietal characteristics as well as shorter plant height and fewer no. of leaves $plant^{-1}$ and number of tillers $hill^{-1}$. Yield performance between grain and straw through Harvest index. Data was not influenced by the varieties in terms of harvest index. The highest harvest index (58.48%) was noted from BINA dhan 8 whereas the lowest (57.58%) noted from BINA dhan 10.

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Table 01. Performance of varieties on growth and yield attributes of Boro rice

Variety	Plant height (cm)	Total tillers hill^{-1} (no.)	Grains panicle^{-1} (no.)	1000 grain weight (g)	grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Bina dhan 8	93.32a	12.47	90.68	24.11b	3.43b	2.45	58.48
Bina dhan 10	80.75b	11.51	81.63	30.46a	3.73a	2.8	57.58
CV (%)	2.45	9.66	5.78	6.35	2.04	8.32	2.97
Significance	*	NS	NS	*	*	NS	NS
CD (5%)	7.50			6.09	0.258		

CV= coefficient of variation, NS= not significant, *= significant at 5% level of probability, CD= critical difference, Similar letters are not differed at 5% probability and dissimilar letters are differed at 5% probability level.

Effects of integrated application of vermicompost, biochar and urea on growth and yield attributes of boro rice

The application of vermnicompost, biochar and urea had a remarkable influence on growth and yield attributes of boro rice presented in (Table 02). The tallest plant (79.72cm) was found from application of vermicompost 1.5 t ha^{-1} along with urea 0.15 t ha^{-1} followed by only vermicompost 2.5 t ha^{-1} (77.65 cm) whereas minimum data (74.42 cm) was noted from application of vermicompost 2 t ha^{-1} and biochar 0.5 t ha^{-1}. Availability of major plant nutrients resulting in variation in plant height reported by (Muhammad, 2008). Number of tiller hill^{-1} was greatly influenced by the application of vermicompost, biochar and urea. Maximum tiller (15.54 hill^{-1}) was found from combine application of vermicompost 1.5 t ha^{-1} and urea 1.5 t ha^{-1} in comparison with only vermicompost application 2.5 t ha^{-1} (10.51 hill^{-1}) whereas lowest value (9.60 hill^{-1}) was noted from vermicompost 2 t ha^{-1} and biochar 0.5 t ha^{-1} application. Organic matter provides availability of nutrients into soil and uptake of nutrients in proper proportion in plants mainly micronutrients for this reason enhancing number of tiller production (Miller, 2007). Higher grains panicle^{-1} (91.91) was attained from application of vermicompost 1.5 t ha^{-1} and urea 1.5 t ha^{-1} meanwhile lowest grains (79.54 panicle^{-1}) were recorded from T_2 (vermicompost 2 t ha^{-1} and biochar 0.5 t ha^{-1}). In terms of thousand grains weight application of vermicompost 2 t ha^{-1} and biochar 0.5 t ha^{-1} gave higher weight (28.53g) followed by vermicompost 1.5 t ha^{-1} and urea 1.5 t ha^{-1} (26.59g) and lowest data (26.44g) was recorded from Vermicompost-1.5 t ha^{-1}+ Biochar 1 t ha^{-1}. The highest grain (4.54 t ha^{-1}) and straw yield (4.19 t ha^{-1}) were found from application of vermicompost 1.5 t ha^{-1} along with urea1.5 t ha^{-1}. The lowest grain yield (3.01 t ha^{-1}) was noted from Vermicompost-1.5 t ha^{-1}+ Biochar 1 t ha^{-1} (T_3) whereas the lowest straw yield (1.98 t ha^{-1}) was obtained from T_2 (Vermicompost-2 t ha^{-1}+ Biochar 0.5 t ha^{-1}). Khan et al. (2007) reported that significantly increased grain yield due to application of organic manure and chemical fertilizers. The application of urea in combination with organic manures increased the straw yields reported by Rahman et al., (2009). The highest harvest index was found from application of vermicompost-2 t ha^{-1}+ biochar 0.5 t ha^{-1} (T_2) whereas the lowest harvest index (52.99%) was attained from vermicompost-1.5 t ha^{-1} + urea-150kg ha^{-1} 0.15 t ha^{-1} (T_4). Variation in organic manures was lead to variation in availability of nutrients resulting in variation in plant growth. Application of vermicompost along with urea leads to fast release of nitrogen in comparison with other manure can be attributed for this superior performance.

Table 02. Effects of integrated application of vermicompost, biochar and urea on growth and yield contributing characters of Boro rice

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Grains panicle^{-1} (no.)	1000 grain weight (g)	grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
T_1	77.65	10.51b	88.67	26.49	3.18b	2.35b	58.83
T_2	74.42	9.60b	79.54	28.53	3.31b	1.98b	61.93
T_3	76.45	9.66b	82.87	26.44	3.01b	2.05b	60.64
T_4	79.72	15.54a	91.91	26.59	4.54a	4.19a	52.99
CV (%)	2.45	9.66	5.78	6.35	2.04	8.32	2.97
Significance	NS	*	NS	NS	**	**	NS
CD (5%)		3.72			0.73	0.54	
CD (1%)					1.11	0.83	

CV= coefficient of variation, NS= Not significant, *= Significant at 5% level of probability, **= Significant at 1% level of probability, CD= Critical difference, Similar letters do not differ at 5% probability and dissimilar letters differ at 5% probability level.

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Combine effects of varieties and integrated application of vermicompost, biochar and urea on growth and yield attributes of boro rice

Growth and yield attributes of boro rice were greatly influenced by combination of varieties and integrated application of vermicompost, biochar and urea presented in (Table 03). Superior plant height (80.87cm), number of tillers hill^{-1}(16.33), grain yield (4.92 t ha$^{-1)}$ and straw yield (4.40 t ha^{-1}) were attained from V_2T_4 (BINA dhan 10 along with vermicompost-1.5 t ha^{-1} and Urea-0.15 t ha^{-1}). Second highest grain yield (4.28 t ha^{-1}) was recorded from V_1T_2 meanwhile second highest straw yield was attained from V_2T_3. Maximum grain panicle^{-1} (102.42) was found V_1T_4 (BINA dhan 8 along with vermicompost-1.5 t ha^{-1} + urea-150kg ha^{-1}/0.15 t ha^{-1}) and highest thousands grain yield (30.57g) was noted from V_2T_2. Highest harvest index (70.49%) was obtained from V_1T_2 (64.59%) followed by V_1T_3 meanwhile lowest data (52.59%) was found from V_1T_4. Higher crop yield was noticed in application of organic and inorganic fertilizers combined and this experiment was a workout to identify the effects of qualitative and quantitative parameters of two rice cultivars to combine application of organic and inorganic fertilizers (Sharada and Sujathamma, 2018).

Table 03. Effects of varieties and integrated application of vermicompost, biochar and urea on growth and yield contributing character s of Boro rice

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Grains panicle^{-1} (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1T_1	77.22	10.26	96.91a	23.45c	3.26d	2.51bc	59.44bc
V_1T_2	74.37	12.49	82.50b	26.63bc	4.28b	1.76de	70.49a
V_1T_3	73.15	12.53	97.47a	23.56c	2.50e	1.64e	64.59ab
V_1T_4	80.47	13.63	102.42a	23.70c	4.03bc	3.91a	52.59c
V_2T_1	77.22	9.57	81.08b	29.16ab	3.11d	2.15bcd	58.43bc
V_2T_2	78.44	10.27	82.13b	30.57a	2.95de	2.02cde	59.54bc
V_2T_3	78.84	9.88	79.22b	29.52ab	3.57cd	2.60b	57.45bc
V_2T_4	80.87	16.33	83.44b	29.96ab	4.92a	4.40a	53.23c
CV (%)	2.45	9.66	5.78	6.35	2.04	8.32	2.97
Significance	NS	NS	**	**	**	**	**
CD (5%)			6.13	3.78	0.60	0.50	7.13
CD (1%)			8.51	5.24	0.84	0.70	10.55

V_1=BINA dhan 8, V_2=BINA dhan 10, T_1=Vermicompost-2.5 t ha^{-1}, T_2=Vermicompost-2 t ha^{-1}+ Biochar 0.5 t ha^{-1}, T_3= Vermicompost-1.5 t ha^{-1}+ Biochar 1 t ha^{-1}, T4=Vermicompost-1.5 t ha^{-1} + Urea-150kg ha^{-1}/0.15 t ha^{-1}, CV= coefficient of variation, NS= not significant, *= significant at 5% level of probability, **= significant at 1% level of probability, CD= critical difference, Similar letters are not differed at 5% probability and dissimilar letters are differed at 5% probability level.

IV. Conclusion

From the above results, it could be concluded that in terms of varieties BINA dhan 10 gave superior results 285 in comparison with BINA dhan 8. In case of application of vermicompost, biochar and urea, higher efficiency was noted from integrated application of vermicompost and urea in comparison with other treatments. In combined effects of varieties along with vermicompost, biochar and urea highest grain and straw yield was recorded from BINA dhan10 with vermicompost along with urea.

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