

ORGANIC AMENDMENT ON SOIL QUALITY AND YIELD PERFORMANCE OF DRY DIRECT SEEDED BORO RICE

M.M. Rahman¹ and M. Uddin²

¹Professor and ²Post-graduate student, Department of Agronomy, Bangladesh Agricultural University, Mymensingh
Corresponding Email: rahmanag63@gmail.com

(Received: 10 October, 2020, Accepted: 03 November, 2020)

Keywords: Trichocompost, vermicompost, mustard oil cake, water saving, *boro* rice, organic matter

Abstract

An experiment was conducted at Khitrokashipur, Durgapur, Rajshahi during March to June 2018 to study the effect of organic amendment on soil quality and yield performance of dry direct seeded *boro* rice var. BRRI dhan28. The treatments were Trichocompost (TC), Vermicompost (VC), mustard oil cake (MOC), Trichocompost + mustard oil cake (TC+MOC), Vermicompost + mustard oil cake (VC + MOC), and no amendment control. The experiment was laid out in a randomized complete block design with three replications. Trichocompost and Vermicompost were applied @ 3 t ha⁻¹, while mustard oil cake was used @ 0.5 t ha⁻¹. The results revealed that Trichocompost and vermicompost fertilization exerted significant influence on yield performance of BRRI dhan28 in *boro* season. The treatment trichocompost (T₁) @ 5 t ha⁻¹ produced the highest grain yield (5.95 t ha⁻¹), while the mustard oil cake (T₃) @ 0.5 t ha⁻¹ the highest effective tillers hill⁻¹ (15.33), though the highest straw yield (5.46 t ha⁻¹) was produced in the treatment VC + MOC (T₅). In case of soil properties, Trichocompost (T₁) @ 3 t ha⁻¹ and mustard oil cake (T₃) @ 0.5 t ha⁻¹ improved soil organic matter content, while Trichocompost (T₁) @ 3 t ha⁻¹ and Vermicompost (T₂) @ 0.5 t ha⁻¹ improved phosphorus and potassium content. Field capacity was greatly influenced by Trichocompost (T₁) @ 3 t ha⁻¹ and Vermicompost + mustard oil cake (T₅). Soils with Trichocompost (T₁) @ 3 t ha⁻¹ showed the highest bulk density. It was concluded that organic amendment greatly improved the yield performance of BRRI dhan28 and also soil physical and chemical properties under dry direct seeded *boro* rice cultivation system.

Introduction

Rice (*Oryza sativa* L.) contributes 95% to food production in Bangladesh. About 77% of cropped area of Bangladesh is used for rice production, with the annual production of 37.36 million tons from 11.68 million ha of land (AIS, 2020). The rice production in the country has been increased by 3.4 folds over the last four decades. In Bangladesh, more than 55.0 million tons of rice will be required by the year 2050 when population of Bangladesh will be 233.3 million (Basak, 2009). The possibility of expanding the area under rice in near future is limited. The major challenges to achieve this gain are accompanied with less water, labor shortage, and negative impact of chemicals use, especially for attaining long-term sustainability.

The rice production with less water and labor can be achieved by adopting different climate smart technologies, such as dry direct seeding, organic amendment and cropping pattern renovation. Direct seeding of rice refers to the process of establishing the rice crop from seeds directly sown in the field rather than by transplanting of seedlings from the nursery. There are three principal methods of direct seeding of rice (DSR): dry seeding (sowing dry seeds into dry soil), wet seeding (sowing pre-germinated seeds on wet puddle soils) and water seeding (seeds sown into standing water). Dry seeding

has been the principal method of rice establishment since the 1950s in developing countries (Pandey and Velasco, 2005). In the traditional transplanting system (TPR), puddling creates a hard pan below the plough-zone and reduces soil permeability. It leads to high losses of water through puddling, surface evaporation and percolation.

Water resources, both surface and underground are shrinking and water has become a limiting factor in rice production (Rahman, 2019). In practice, *boro* rice uses about 70% of total water used in agriculture. Therefore, technologies and practices need to be in place for sustaining *boro* rice production, while increasing cropping intensity with minimal water input especially in the drought prone areas. Dry seeding allows cultivation of *boro* rice with less than 50% irrigation water compared with that required in puddle transplanted method (Rahman et al., 2012; Rahman and Masood, 2014, Rahman, 2019). The adoption of a direct-seeded method for lowland rice culture would significantly decrease costs of rice production (Rahman and Masood, 2014). As this cultivation system is done in dry land, organic matter decreases rapidly and therefore, it needs to increase organic matter status in soil. Direct seeding is done after dry cultivation, and controlled irrigation is provided to keep the soil at field capacity. However, standing water is maintained for a very short period of time from panicle initiation to heading or grain filling (Rahman et al., 2020). Organic amendment through Trichocompost, Vermicompost and mustard oil cake increases organic matter content and water holding capacity of soil as well as allows more infiltration to increase water retention capacity of the soil (Minasny and Mcbratney, 2018).

T. *aman* – Mustard – DDS *boro* rice is considered as one of the most promising cropping patterns for increasing farm productivity and farmers income (Rahman, 2018). However, it is important to adopt management practices that improve the system productivity and soil health as well. Therefore, the present study was undertaken to evaluate the effect of organic amendment on soil quality and yield performance of dry seeded *boro* rice under T. *aman* rice – Mustard - DDS *boro* rice cropping pattern.

Materials and Methods

Site and soil

The experiment was conducted at farmers' field in Khitrokashipur village of Durgapur upazilla in Rajshahi district. The field is located at 24°75' N latitude, 90°50' E longitude and at an altitude of 18 m. The area falls under High Barind Tract agro-ecological zone (AEZ-26) having non-calcareous dark grey floodplain soil. The land was a medium high with moderate drainage facilities. The soil was silt loam having pH value of 6.5. The particle density and bulk density values of soil were 2.60 and 1.35 g cc⁻¹, respectively. Soil contained 1.78% organic matter, 0.14% total N, 1.98 μ g⁻¹ available P, 0.10 meq 100g⁻¹ exchangeable K and 4.56 μ g g⁻¹ available S. The experimental area falls under the sub-tropical climate characterized by its heavy rainfall during Kharif season (April to September) and scanty rainfall during Rabi season (October to March).

Experimental Treatments and Design

The study included six combinations of three organic manures viz., (i) Trichocompost (TC) @ 3 t ha⁻¹ (T₁); (ii) Vermicompost (VC) @ 3 t ha⁻¹ (T₂); (iii) Mustard oil cake (MOC) @ 0.5 t ha⁻¹ (T₃); (iv) =Trichocompost + mustard oil cake @ 0.5 t ha⁻¹ (T₄); (v) Vermicompost + mustard oil cake @ 0.5 t ha⁻¹ (T₅) and (vi) Control (no organic matter applied, T₀) in a randomized complete block design (RCBD) with three replications. The size of each unit plot was 3m x 2.5m.

Crop management

The experiment was done under T. *aman* rice – mustard - DDS *boro* cropping pattern. Twenty five days old seedling of BRRI dhan57 was transplanted in well puddled land at 25 cm x 15 cm spacing

with three seedling hill⁻¹ on 12 July 2017. The crop was cultivated with recommended agronomic management practices as and when needed. The *aman* rice was harvested on 5 November 2017. Then mustard var. BARI Sharisha14 was sown on 27 November and harvested on 20 February 2018. After harvest of mustard, rice var. BRR1 dhan28 was grown following the standard practices for dry direct seeded system. Seeds were sown in furrows with 5 seeds hill⁻¹ on 16 March 2018 under dry direct seeded system. The land was fertilized with urea, triple super phosphate, muriate of potash and gypsum at the rate of 375 kg, 60 kg, 92 kg and 70 kg ha⁻¹, respectively. The whole amount of triple super phosphate, muriate of potash and gypsum was applied at the time of final land preparation. Urea was applied in three equal splits at 21, 42 and 63 days after sowing (DAS). Pre-emergence herbicide (Panida 33EC) was applied for weed control @ 50 ml 10 L⁻¹ of water on 17 March 2018. Intercultural operations were done for maintaining the normal growth and development of the crop. Weeding was done twice by hand pulling at 21 and 41DAS. Irrigation was provided only to maintain the field at moist soil condition for successful crop growth and development. During the whole crop period, only four irrigations were given at 22, 43, 65 and 73 DAS. The crop was infested by Thrips which was controlled by applying Diazinon @ 35 ml 10 L⁻¹ of water. The crop was harvested at full maturity on 23 June 2018 from central 1.8 m × 1.5 m area of each plot for recording yields of grain and straw. Grains and straw were sun dried and cleaned. Grain yields was adjusted to 14% moisture and converted to ton per hectare.

Data recording

Data on various plant characters like plant height, tiller production and yield contributing characters were recorded from randomly collected five hills plot⁻¹ before plot harvest. After harvest of *boro* rice, soil sample was collected from 0 to 15 cm depth from the experimental field by iron core to record soil related data- soil pH, bulk density, organic matter content (%), field capacity (%), phosphorus and potassium content. After processing the soil was taken to the Humboldt Soil Lab of the Department of Soil Science, BAU. Soil pH was determined by Glass Electrode pH meter. The soil phosphorus was determined by Olsen method (Horta and Torrent, 2007). Soil organic matter content was determined by Wet oxidation method. For determining field capacity (%) collected soils with cores were soaked with water for about 48 hours. After that soil was allowed to air dry about 72 hours and weighted. The field capacity (%) was determined using the following formulae.

$$\text{Field capacity (\%)} = \frac{\text{Soil weight after 72 hour} - \text{oven dry soil weight}}{\text{Oven dry soil weight}} \times 100$$

Statistical Analysis

The collected data were compiled and tabulated in proper form and were subjected to statistical analysis with the help of a computer package programme Statistix 10 and mean differences were adjudged by Duncan's Multiple Range Test.

Results and Discussion

Crop yield and yield Parameters

Organic amendment had significant effect on grain and straw yields, number of effective and non-effective tillers hill⁻¹ but insignificant on plant height, number of total tillers hill⁻¹, panicle length, number of grains panicle⁻¹, number of sterile spikelets panicle⁻¹ and 1000-grain weight. Data presented in Table 1 revealed that the maximum plant height (107.21 cm) was observed in control treatment (T₀) and the shortest (104.58 cm) in TC + MOC @ 0.5 t ha⁻¹ treatment (T₄). The highest number of effective tillers hill⁻¹ (15.33) and non-effective tillers (3.67) was obtained with the treatment MOC @ 0.5 ton ha⁻¹ (T₃). The lowest number of effective tillers hill⁻¹ (12.33) and non-effective tillers was found in the

control treatment (Table 1). The highest number of grains plant⁻¹ (85.33) was obtained from VC @ 3 ton ha⁻¹ (T₂), and the lowest one (68.300) was observed with control. The highest number of sterile spikelet (26.66) was obtained from TC + MOC (T₄), while the lowest (23.00) in control (Table 2). Numerically, the highest 1000-grain weight (20.75 g) was obtained from VC + MOC (T₅) and the lowest weight (19.15 g) was obtained from MOC (T₃).

Table 1. Effect of organic amendment on plant height and tiller production of dry direct seeded *boro* rice Var. BRRIdhan28

Treatments	Plant height (cm)	Total tillers hill ⁻¹ (no.)	Effective tillers hill ⁻¹ (no.)	Non effective tillers hill ⁻¹ (no.)	Panicle length (cm)
T ₀	107.15	12.67	12.33b	2.33b	23.33
T ₁	105.00	14.67	13.33ab	2.33b	24.03
T ₂	105.83	15.67	13.00ab	2.67ab	23.03
T ₃	105.67	16.67	15.33a	3.67a	23.70
T ₄	104.58	16.67	15.00ab	3.00ab	27.73
T ₅	106.17	14.67	14.00ab	2.67ab	23.70
LSD _(0.05)	NS	NS	2.92	1.23	NS
CV (%)	1.63	12.10	7.47	15.65	3.81

In a column, figures with same letter(s) or without letter do not differ significantly

T₀= Control (No organic matter used), T₁=Trico-compost (TC) @ 3 t ha⁻¹ used, T₂= Vermicompost @ ha⁻¹, T₃= Mustard oil cake @ 0.5 ha⁻¹, T₄= Trichocompost + Mustard oil cake, T₅= Vermicompost + Mustard oil cake

Table 2. Effect of organic amendment on yield and related attributes of dry direct seeded *boro* rice Var. BRRIdhan28

Treatments	Grains panicle ⁻¹ (no.)	Sterile spikelet panicle ⁻¹ (no.)	Weight of 1000-grain (g)	Grain yield ha ⁻¹ (ton)	Straw yield ha ⁻¹ (ton)
T ₀	68.30	23.00	20.19	4.25b	4.68b
T ₁	72.77	26.00	19.89	5.95a	5.41a
T ₂	85.33	26.33	20.08	5.57a	5.07ab
T ₃	77.80	24.33	19.15	5.25ab	5.37a
T ₄	73.13	26.67	20.06	5.61a	5.38a
T ₅	73.07	25.00	20.75	5.48ab	5.46a
CV (%)	8.94	11.93	4.69	8.33	4.41
LSD _(0.05)	NS	NS	NS	1.26	0.65

In a column, figures with same letter(s) or without letter do not differ significantly, whereas figures with dissimilar letter(s) differ significantly

T₀= Control (No organic matter used), T₁=Trico-compost (TC) @ 3 t ha⁻¹ used, T₂= Vermicompost @ ha⁻¹, T₃=Mustard oil cake @ 0.5 ha⁻¹, T₄= Trichocompost+Mustard oil cake, T₅=Vermicompost+Mustard oil cake

The maximum grain yield (5.95 t ha⁻¹) was observed in the treatment TC @ 5 ton ha⁻¹ (T₁), while the lowest one (4.25 t ha⁻¹) in control (T₀). The result revealed that yield improvement was obtained with the organic amendment with Tricho-compost alone or in combination with mustard oil cake. The grain yield obtained with TC was similar with those of T₂ and T₄. However, the highest straw yield (5.66tha⁻¹) was observed in the treatment VC + MOC (T₅), while the lowest one (4.68 t ha⁻¹) in control treatment. Thus, the result clearly showed that the yield improvement of direct seeded *boro* rice was possible through organic amendment with trichocompost or vermicompost @ 3 t ha⁻¹. Benbi *et al.* (1998) also found that farm yard manure in combination with NPK chemical fertilizers resulted in higher soil organic carbon concentration and enhanced crop growth along with higher root biomass production.

Organic matter amendment is effective in increasing rice yield. Organic amendment with compost along with application of chemical fertilizers increased the biomass and grain yields of crops (Saleque *et al.*, 2004, Sarwar *et al.*, 2007). Several studies also reported that long – term organic amendment increased rice yield in rice – wheat system (Shamsuhddin and Fauziah, 2010; Mitran and Mani, 2017).

Mitran and Mani (2017) reported that the long-term application of inorganic fertilizer in conjunction with FYM, PS, and GM had a significant effect on maintaining positive yield trend in case of rice under such rice – wheat system over control.

Soil physical and chemical properties

Organic amendment did not have significant effect on pH, organic matter content, bulk density, field capacity, phosphorus and potassium content of soil of the experimental field after harvest of the dry direct seeded rice (Table 3). However, the lowest pH of soil (5.8) was found in control (T₀) and the highest (6.02) was observed in the treatment Tricho-compost (T₁) @ 3 t ha⁻¹. The highest OM of soil (1.08) was found with mustard oil cake (T₃) @ 0.3 t ha⁻¹ and the lowest (0.84) was with Vermicompost treatment @ 3 t ha⁻¹ (T₂). The highest BD of soil (1.43) was determined in the treatment Trichocompost @ 3 t ha⁻¹ (T₁) and the lowest (1.32) was in Vermicompost + MOC @ 0.5 t ha⁻¹ (T₅). However, the highest FC of soil (33.83) was found in Vermicompost + mustard oil cake @ 0.5 t ha⁻¹ (T₅) treatment and the lowest (31.20) in Trichocompost @ 3 t ha⁻¹ treatment (T₁). Phosphorus was the highest (24.9) in the treatment Trichocompost @ 3 t ha⁻¹ (T₁) and lowest (16.23) in Vermicompost treatment @ 0.3 t ha⁻¹ (T₂). The treatment Vermi-compost @ 3 t ha⁻¹ (T₂) had the highest K of soil (0.17), while the lowest (0.15) in Vermicompost + MOC @ 0.5 t ha⁻¹ treatment (T₅). It was noted that soil pH and soil organic matter were consistently higher in T₄ and T₅ than those in other treatments. On the other hand, soil bulk density, field capacity and soil phosphorus content were consistently higher in T₄ and T₃ than those in other treatments. However, soil potassium was consistently high in T₄ and T₁ than the other treatments. Earlier report indicated that integrated nutrient management through the combined use of inorganic and organic fertilizers increased crop yield and improved N and K use efficiency (Ryan *et al.*, 2017). It was also disclosed that the efficiency of fertilizer P use could possibly be increased by recycling of P from crop residues, and organic and mineral fertilizers (Hedge and Dwivedi, 1993). Integrated use of organic manures and fertilizers not only improved the efficiency of P (Vats *et al.*, 2001) but also significantly increased the availability of P. Mitran and Mani (2017) observed that long – term organic amendment increased P content in rice soil. Organic amendment also improved water use efficiency (WUE) of crop plants by improving soil water holding capacity as reported by Shehzadi *et al.* (2017)). A high WUE is a good indicator of a crop to cope with soil water deficit and provides a greater opportunity for increasing grain yield (Zhou *et al.*, 2017).

Table 3. Effect of organic amendment on soil physical and chemical characteristics after growing direct seeded boro rice in a rice-mustard-direct seeded rice system

Treatments	pH	Organic matter (%)	Phosphorus meq100g ⁻¹	Potassium meq100g ⁻¹	Bulk density (g cm ⁻³)	Field capacity (%)
T ₀	5.8	1.04	22.39	0.16	1.42	32.58
T ₁	6.0	1.01	24.97	0.16	1.43	31.20
T ₂	6.1	0.84	16.23	0.17	1.33	31.98
T ₃	6.2	1.08	22.43	0.16	1.36	31.85
T ₄	6.3	1.06	17.66	0.16	1.35	31.54
T ₅	6.2	0.91	10.93	0.15	1.32	33.81
CV (%)	3.68	18.14	33.04	15.46	6.26	9.52
LSD _{0.05}	NS	NS	NS	NS	NS	NS

In a column, figures with same letter(s) or without letter do not differ significantly, whereas figures with dissimilar letter(s) differ significantly; ns = non significance. [T₀= Control (No organic matter used), T₁=Trico-compost (TC) @ 3 t ha⁻¹ used, T₂= Vermicompost@ ha⁻¹, T₃=Mustard oilcake@ 0.5 ha⁻¹, T₄= Trichocompost+Mustard oil cake , T₅=Vermicompost+Mustard oil cake.]

Conclusion

Organic amendment significantly influenced the yield performance of dry direct seeded boro rice and the highest grain yield was obtained with TC @ 0.3 tha^{-1} (T_1). Thus, organic matter amendment along with recommended chemical fertilization application is an important management option for obtaining the high grain yield of dry direct seeded *boro* rice in a rice based cropping system.

Acknowledgement

We are highly grateful to the Project Implementation Unit of Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka-1215 for funding under the Competitive Research Grant (CRG) sub-project # 777 under NATP2.

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