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EFFECTS OF ORGANIC MATTER AMENDMENTS ON PHYSICOCHEMICAL PROPERTIES OF SOIL AND YIELD OF RAINFED RICE

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ABSTRACT

Organic matter amendments play a pivotal role in improving the soil's physiochemical properties and crop productivity. This study was conducted to examine the effects of various organic matters on soil physicochemical properties and the yield of rainfed rice in Bangladesh. The research was conducted following a randomized complete block design (RCBD) with seven treatments, viz. cow dung slurry (CDS), rice husk biochar (RHB), cow dung (CD), vermi-compost (VC) and trico-compost (TC) used @ 2 t C ha^{-1}, and bacterial inoculant (BI) @ 4 ml $plot^{-1}$. The findings indicated a reduction trend of bulk density as compared to the initial soil in all the organic matter-treated soils, where the highest reduction percent was found in the RHB (1.45%) treated plot, followed by CDS (0.74%), VC (0.74%), TC (0.74%), CD (0.73%) and BI (0.73%). Significantly higher total N was observed in inorganic matter-treated post harvested soil compared to initial soil. The highest total N was recorded in TC (0.12%) and CDS (0.12%) treated soils, followed by CD (0.11%), VC (0.11%), BI (0.11%) and RHB (0.10%). The significantly highest CEC (6.48 meq100g $soil^{-1}$) was noted in RHB-added soil, while the lowest value (5.70 meq100g $soil^{-1}$) was found in initial soil. The RHB exhibited the maximum quantity of P, S, and exchangeable K in post-harvest soils, with 12.75, 19.73 mg kg^{-1} soil, and 0.14 cmol kg^{-1}, respectively. Plant height, tiller $hill^{-1}$, panicle length, grain $panicle^{-1}$, and 1000-grain weight were greatly influenced by the various treatments. In the context of grain yields, the treatments can be rated as follows: CD>CDS>VC>RHB>TC>BI>control. Thus, it was concluded that organic amendments improves soil fertility and the yield of rice, particularly in rainfed condition.

Keywords: Nutrient, organic materials, soil, *Oryza sativa*, yield

Introduction

In Asian nations, rice (*Oryza sativa* L.) is produced on vast areas of land, having the highest levels of production and consumption (Selvarah *et al.* 2020). Over 80% of the overall irrigated regions and almost 75% of all cultivated areas in Bangladesh are intensified using a rice-based cropping technique (Hossain and Deb 2003). The area's soil acidity is rising constantly as a result of the land's extensive use, which is reducing the level of organic matter (Hossain *et al.* 2016). The demand for production of rice will endure rising in the near future due to shrinkage of cultivable land and over population growth (Alam *et al.* 2019). Soils of different areas have different requirements of inorganic and organic fertilizers for crop production and reclamation of soil acidity. Most of our farmers are not very much aware of modern cultivation techniques due to their inadequate knowledge. They use more and more inorganic fertilizers, mainly nitrogenous fertilizers to increase the crop yield. Excessive use of same fertilizer hinders the availability of other nutrients too. Several researchers expressed their concerns about the loss of organic matter in the soils resulting lower soil fertility status (Barua *et al.* 2018). The proper fertilizer use depends on nutrient status of the soils. Bangladesh spends huge amounts of natural resources and foreign exchange for making fertilizers available within the reach of the farmers. So, judicious use of fertilizers should be assured. Madhupur tract a large upland area of 4244 sq km situated at the central part of Bangladesh. Land topography of this region is overall high. The high land is known as 'Tila' and plain land known as 'Baid'. Sal is the dominant species of whole Madhupur tract. Transplant aus and aman rice are commonly cultivated in Kharif season in Baid lands while potato, sweet potato, mustard and wheat are grown in Rabi season. During the dry season, boro rice is grown in the lowlands by impounding the streams to provide irrigation. (Rahman *et al.* 2012).

During 1980 to 2016, cropping intensity increased by from 154%-191%. (Rahman 2017). Three million metric tons of nutrients are lost as a result of cultivating various crops, either with or without balanced fertilizers (Biswas *et al.* 2004). Nutrient mining and organic matter (OM) depletion put the growing crops under stress. The crop growth process passes through a series of complex nutrition translocation mechanisms. Organic materials applied exogenously can reduce the quantity of chemical fertilizer utilized and compensate for soil C losses induced by land-use changes (Salma *et al.* 2022). The nutrient release dynamics of different organic matter play a major role in fertility of natural ecosystems. Organic amendments along with mineral fertilization have a potential for acting as a nutrient reservoir, improving soil physiochemical properties, thereby maintain agricultural sustainability and enhance crop yield (Rahman *et al.* 2022). Soil OM is important for nutrient cycling and can help to improving soil structure and soil bulk density. The amount of organic matter, texture, and mineral elements of a soil have substantial impact on its bulk density. Bulk density information is critical for understanding nutrient dynamics and designing modern farming strategies (Chaudhari *et al.* 2013). However, little information is available in organic amended reduced soil system series impact on physicochemical properties motion. At the moment, it is certain that the impacts of organic and inorganic modifications on fertility of degraded wetland rice soils will be evaluated (Liu *et al.* 2017). There is a scarce information on the dissimilarity of various organic amendments and their effects on crop yield and soil properties in the rice soil. These, the current study was designed to evaluate the impacts of various organic matters on the soil physiochemical properties and yield of rainfed rice.

Materials and Methods

Study site: The study was conducted in the rainfed rice season of 2020. The research was carried out on an agricultural field in Bhaluka Upazilla of Mymensingh district in Bangladesh. The site is located at 24° 22" N and 90° 24" E.

Experiment detail: The seven treatments used in the field experiment were: control, cow dung, cow dung slurry, rice husk biochar, vermi-compost, tricocompost, and bacterial inoculant (*Agrococcus jijuensis*). The experiment was arranged in a Randomized Complete Block Design (RCBD) with four replications. Organic materials were applied at the rate of 2 tons C ha^{-1} and bacterial inoculant 4 ml $plot^{-1}$. The unit plot size was 4 m × 2.5 m. Thirty days' old seedlings of BU dhan1 were transplanted at 20 cm × 20 cm spacing at one week after puddling of the plots. Soil test-based fertilizer doses of N (60), P (11), K (43), S (9), and Zn (0.8) kilogram per hectare were applied in the forms of Urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, and zinc sulphate, respectively following BARC model (FRG, 2018). TSP, MoP, gypsum, and zinc sulphate were applied during final land preparation and urea was applied in three equal splits of 15 days after transplantation. Intercultural operations were carried out when needed.

Soil sampling and analysis: Soil samples from each plot were collected from 0-15 cm depth at initial and after harvesting of rice crop. Soil bulk density was determined at the initial and after crop harvest. Standard techniques were used to analyze the chemical properties of soil and various organic materials. Soil pH was determined using glass electrode pH meter method, total N was determined by the micro-Kjeldahl method following H_2SO_4 digestion using a mixture of $CuSO_4$ and K_2SO_4 (1:9) as a catalyst and steam distillation with 40% NaOH solution. The distillate was collected in 4% H_3BO_3 and finally titrated against 0.02N H_2SO_4, extraction for available phosphorus in the soil sample was determined by Bray and Kurtz Method, available sulphur was determined by the turbid metric method, the exchangeable potassium was determined by the ammonium acetate extraction method and CEC was determined by NH_4OAC extraction method.

Statistical analysis: Analysis of variance (ANOVA) of the experimental data was done using the statistical software Statistix 10. The least significant difference (LSD) test was used to separate the treatment means at the 5% level of significance.

Results and Discussion

Effects of different organic materials on bulk density of soil at initial and after harvest in a rain fed rice are summarized in Figure 1. Soil bulk density reduced after the application of different organic materials. The highest reduction of bulk density was observed in RHB treated plot (1.45%) followed by CDS (0.74%), VC (0.74%), TC (0.74%), CD (0.73%) and BI (0.73%), compared to the initial soil. Soil organic amendment and bulk density have a strong reciprocal connection. The bulk density and nutrient release pattern in the soil are mostly synchronized by the degrees of organic matter breakdown. Microorganisms release polysaccharides during the breakdown of organic materials. This increases aggregate stability by improving the inter-cohesion of soil particles thereby reducing bulk density (Marland *et al.* 2004). While more stable materials like lignin and cellulose-containing matter have reduced but consistent effects on aggregate stability, the organic amendment that decomposes quickly has a strong and sporadic impact. Celik *et al.* (2010) found alike information that different organic amendment reduced the bulk density at 0-15 cm soil depth.

Table 1. Physical and chemical properties of organic materials used in the experiment

Organic materials	Properties of organic materials			
	Moisture (%)	Organic Carbon (%)	Nitrogen (%)	C:N ratio
CD	14.87	28.89	1.61	17.94
CDS	17.13	30.75	2.52	12.30
RHB	9.31	40.72	0.50	81.44
VC	17.76	27.88	2.03	13.69
TC	16.94	26.19	2.01	13.02

CD=Cowdung, CDS= Cowdung slurry, RHB= Rice husk biochar, VC= Vermi-compost, TC= Trico-compost.

Effects of different organic materials on total N of soil at initial and after harvest in a rainfed rice are summarized in Figure 2. A significantly higher total N was observed in organic matter-treated post harvested soil compared to initial soil. The highest total N was observed in TC (0.12%) treated soil, followed by in CDS (0.12%), CD (0.11%), RHB (0.10%), VC (0.11%), and BI (0.11%). Added OM shows a continuous variation of releasing N in rainfed rice soil might be related with its variations in mineralization potentials. Different carbon forms have varying degrees of resistance to microbial breakdown, mineralization of various organic components differs depending on the soil and crop management techniques used. Different organic material amendments improved soil physiochemical properties, especially total nitrogen content (Cabrera *et al.* 2005).

Addition of different organic matter significantly ($p \leq 0.05$) increased the soil CEC as compared to initial soil (Figure 3). Among all the treatments, the highest CEC (6.48 meq/100g soil) was observed in RHB added soil while lowest value (5.70 meq/100g soil) was found in control soil. A previous study demonstrated that the CEC was positively associated with the OM content of soil and ranged from 9 to 45 cmol kg^{-1} (Kashem *et al.* 2007) which is in agreeent with the present finding.

Table 2 shows the effect of different organic amendment on soil pH, P, S, and K. Among the studied chemical properties, a significant ($p \leq 0.05$) enrichment was found in available P, available S, and soil pH, exchangeable K at harvest. Organic materials did not show significant effect

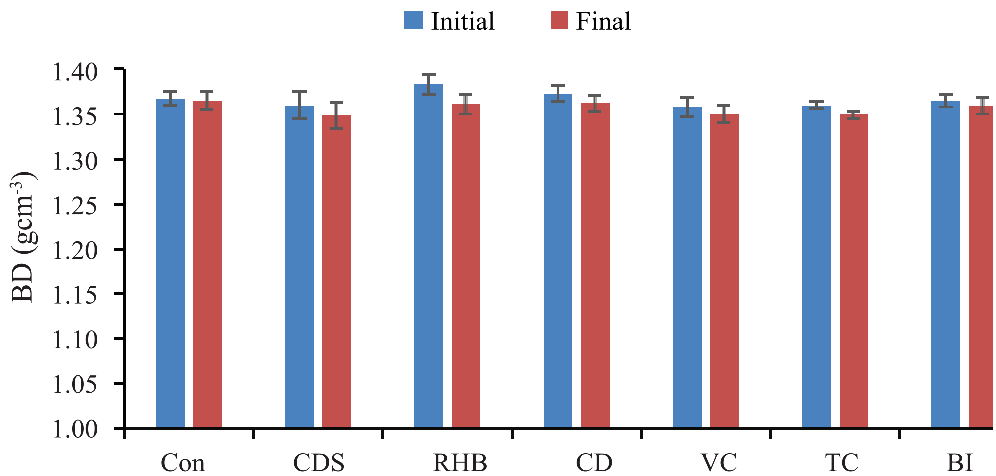

Figure 1. Effect of organic materials and bacterial inoculant on bulk density of rainfed rice soil; standard error is shown by the vertical bar in the column. CD=Cowdung, CDS= Cowdung slurry, RHB= Rice husk biochar, VC= Vermi-compost, TC= Trico-compost, BD= Bulk density, CON= Control.

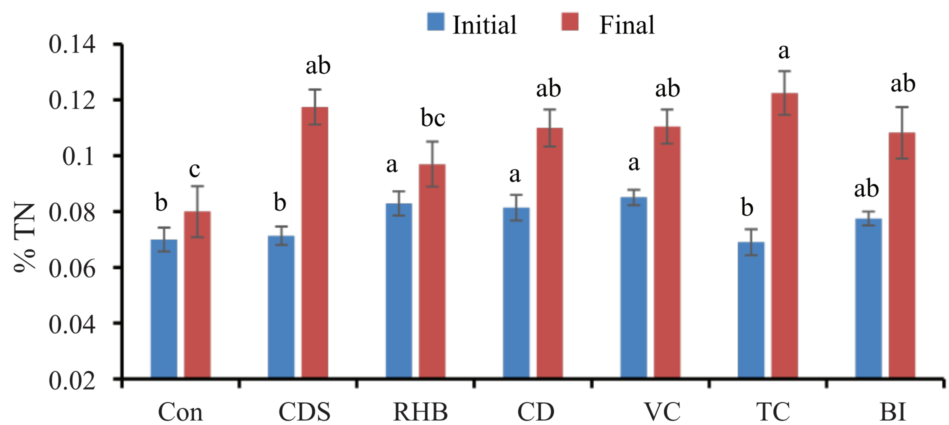

Figure 2. Effect of organic materials and bacterial inoculant on total nitrogen of rainfed rice soil; standard error is indicated by the vertical bar in the column. CD=Cowdung, CDS= Cowdung slurry, RHB= Rice husk biochar, VC= Vermi-compost, TC= Trico-compost, TN= Total Nitrogen, CON= Control.

on soil pH and exchangeable K at initial but significant effect as observed at postharvest. The highest amount of soil pH in post-harvest soils was found in CDS, RHB and CD along with 5.77, 5.81 and 5.74, respectively. The highest amount of P, S and exchangeable K in post-harvest soils was found in RHB along with 12.75 mg kg^{-1}, 19.73 mg kg^{-1} soil and 0.14 cmol kg^{-1}, respectively. Soil microbial populations become increasingly important in bio-geo-chemical processes as the organic materials are added to soils (Jenkinson *et al.* 1999). Plants can alter soil pH by releasing root exudates, such as organic acid anions, to enhance mineral nutrient solubility, as well as the liberation of H^+ and OH^- (or HCO_3^- resulting from OH^- carbonation) to counterbalance cations of anions entering the roots (Hinssinger *et al.* 2003). Organic matter showed the most favorable increase in P availability in residual soil might be attributed to an acceleration of nutrient release from different manures the enhanced mineralization process. The increase in soil P in the acidic soil is a great accomplishment for the long-term control of the scarcest plant nutrient P in the investigated soil. The addition of various organic materials increased the

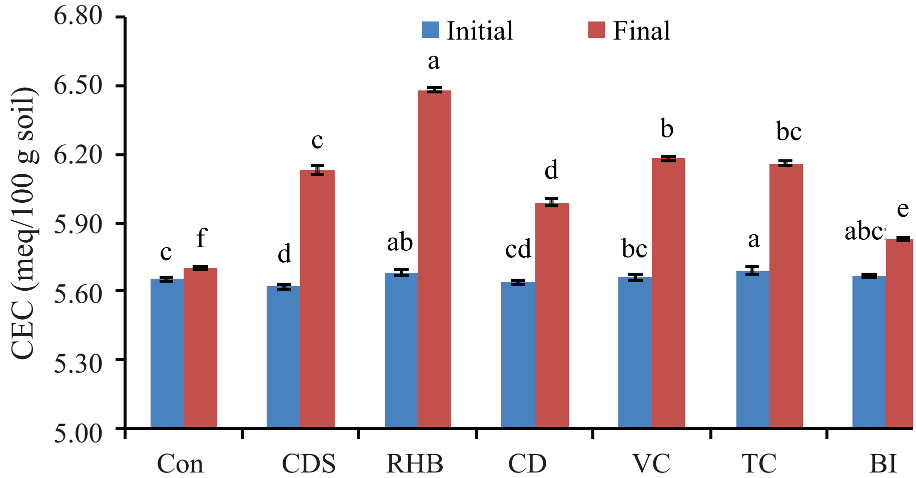

Figure 3. Impact of organic materials and bacterial inoculant on CEC of rain fed rice soil; standard error is indicated by the vertical bar in the column. CD=Cowdung, CDS= Cowdung slurry, RHB= Rice husk biochar, VC= Vermi-compost, TC= Trico-compost.

Table 2. Impact of organic materials and bacterial inoculant on different chemical properties of post-harvest soil

Treatments	Soil pH		Available P (mg kg^{-1})		Available S (mg kg^{-1})		Exchangeable K (cmol kg^{-1})	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Con	5.24	5.28c	9.53b	9.54e	14.55bcd	14.70g	0.09	0.10c
CDS	5.26	5.77a	9.60a	11.74b	14.59ab	17.65d	0.10	0.13ab
RHB	5.25	5.81a	9.62a	12.75a	14.63a	19.73a	0.10	0.14a
CD	5.22	5.74a	9.52b	11.53c	14.50e	17.30e	0.10	0.12b
VC	5.23	5.55b	9.59a	11.86b	14.58abc	18.12b	0.10	0.13ab
TC	5.24	5.52b	9.53b	11.85b	14.52de	17.83c	0.10	0.12b
BI	5.22	5.44b	9.52b	11.06d	14.54cde	16.80f	0.10	0.12b
S.E.(±)	0.043	0.059	0.018	0.076	0.024	0.071	0.008	0.007
CV (%)	1.17	1.50	0.27	0.94	0.23	0.57	12.28	7.92

In table having similar letter(s) do not differ significantly whereas dissimilar letter(s) differ significantly as per LSD at 5% level of significant. Con = control, CDS= cowdung slurry, RHB = rice husk biochar, CD = cow dung, VC = vermicompost, TC =trico-compost and BI= bacteria inoculant.

amount of microbial biomass, dehydrogenase activity, and high phosphatase activities in the soil. In addition to holding a labile pool of nutrients, microbial biomass is what propels the soil's OM and nutrient cycling (Jenkinson *et al.* 1999).

Different organic treatments resulted in a considerable increase in plant height as compared to the control treatment. The plant height varied from 99.25 to 117.75 cm (Table 3). The highest plant height (117.75 cm) was found in CDS treatment, being significantly similar to RHB (117.25 cm), VC (117 cm), TC (116.25 cm) and BI (112.50). The control treatment exhibited the lowest value (99.25 cm). Channabasavanna and Birandar (2001) found that plants height was higher when fertilized with poultry manure. Babu *et al.* (2001) reported that adding organic manures to soil had created a substantial positive impact on plant height.

The various organic materials had a major impact on the number of effective tillers hill^{-1} as well. There were 8.09 to 9.90 effective tillers hill^{-1} (Table 3). The CD treatment produced the maximum number of effective tillers hill^{-1} (9.90), being followed by CDS (9.46), RHB (9.39) and VC (9.23) treatments having no significant difference among those treatments. The lowest number of effective tillers hill^{-1} (8.09) was noted in the control treatment. The positive effects of manures combined with chemical fertilizers on effective tillers hill^{-1} were documented by Chaturvedi 2005.

The various treatments had positive impact on length of the rice panicle (Table 3). Over the control treatment, all of the treatments resulted in longer panicles. The length of the panicle ranged from 20.25 to 24.25 cm. The RHB treatment had the longest panicle length (24.25 cm), which was closely followed by the treatments CD (24.02 cm), CDS (24.0 cm) and VC (23.25 cm) having no significant difference among those. The control treatment showed the lowest panicle length (20.25 cm). The outcome additionally demonstrated that the increased dosage of organic materials in conjunction with chemical fertilizers directly contributed to the rise in panicle length. According to Singh (2006) rice panicle length rose when organic matter were applied.

Application of CD, CDS, RHB, VC and TC had created a significant impact on the number of grains panicle^{-1}. Grains pancle^{-1} varied from 111.5 to 146.5 (Table 3). The highest number of grains panicle^{-1} (146.50) was recorded in CD treatment, the lowest value (111.5) being noted in the control treatment. According to Usman (2003) and Umanah *et al.* (2003), there were more grains per panicle when organic matter was present. Satyanarayana *et al.* (2002) also asserted a similar conclusion.

The weight of the 1000 grains varied from 25.23 to 27.15 g (Table 3). The CDS treatment had the highest 1000-grain weight (27.15 g), which was statistically equivalent to the weights noted in the RHB, VC, TC, CD, and BI treatments. In the control treatment, the lowest 1000-grain weight (25.23 g) was recorded. According to Rahman (2001), using chemical fertilizers in combination with wheat straw or farmyard manure under alternating soaking and drying conditions enhanced the uptake of N, P, and K by rice plants, as well as the 1000 grains weight and yield of rice.

The highest grain yield of rice (3.83 t ha^{-1}) was obtained in the CD treatment followed by the CDS (3.81 t ha^{-1}), VC (3.71 t ha^{-1}), RHB (3.65 t ha^{-1}) and TC (3.49 t ha^{-1}). The lowest yield was observed in control (2.32 t ha^{-1}) treatment. In terms of grain yields, the treatments can be organized as follows: CD>CDS>VC>RHB>TC>BI>control. The application of organic manure along with chemical fertilizers was found to boost up rice grain and straw yields (Rahman *et al.* 2009). Our findings are also in harmony with the findings of Afrad *et al.* (2021).

Table 3. Yield and Yield contributing characters of BU dhan1 as influenced by different treatments

Treatments	Plant height (cm)	No. of effective tiller hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	1000 seed weight (g)	Grain yield (tha^{-1})
Con	99.25b	8.09d	20.25c	111.50b	25.23b	2.32c
CDS	117.75a	9.46ab	24.00a	144.25a	27.15a	3.81a
RHB	117.25a	9.29abc	24.25a	140.75a	27.13a	3.65a
CD	111.25a	9.90a	24.02a	146.50a	26.38ab	3.83a
VC	117.00a	9.23abc	23.25ab	142.75a	27.00a	3.71a
TC	116.25a	8.87bcd	22.25b	135.0 ab	26.80a	3.49ab
BI	112.50a	8.61cd	22.00b	117.25b	26.75a	3.25b
CV (%)	5.24	6.22	4.49	10.77	3.83	7.27
$LSD_{(0.05)}$	8.79	0.837	1.53	21.34	1.52	0.37
SE (±)	4.18	0.398	0.726	10.16	0.722	0.176

In table having similar letter(s) do not differ significantly whereas dissimilar letter(s) differ significantly as per LSD at 5% level of significant. Con = control, CDS= cowdung slurry, RHB = rice husk biochar, CD = cow dung, VC = vermicompost, TC =trico-compost and BI= bacteria inoculant.

Conclusion

The addition of different organic amendments had a positive effect on the physicochemical properties of rain-fed rice soil. The results showed a decreasing soil bulk density and increasing total N, CEC, soil pH, available P, available S, and exchangeable K due to the amendment. The improvement of soil properties resulted in an improvement in rice growth.

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