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Impact of organic wastes on soil environment and yield of T-aman rice

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Abstract

Organic wastes are rich in nutrients that can improve soil fertility and enhance crop yield. A study was conducted at the experimental field of Department of Environmental Science, Bangladesh Agricultural University, Mymensingh during July-December 2014 to examine the effect of different organic wastes on soil quality and rice yield. The experiment was laid out in a randomized complete block design (RCBD) taking five treatments with three replications. The treatments were: T1 (recommended chemical fertilizers), T2 (50% farm waste + 50% poultry manure), T3 (50% poultry manure + 50% municipal solid waste), T4(50% cowdung + 50% farm waste) and T5 (50% farm waste+25% poultry manure +25% cow dung). All wastes were applied at one time after final land preparation and before 15 days of rice (BRRI dhan 49) transplanting. Minimum and maximum soil moisture content was 26.16% and 30.83% recorded at T1 and T2 treatments and that of pH values were 5.26 and 5.93 at T3and T4 treatments, respectively. Incase of soil nutrient content, organic matter, N and S content was highest in T2 treatment and P and K contents were highest in T4 treatment whereas lowest values were observed in T1 treatment. Pb and Cd contents were highest at T5 treatment and lowest at T1 treatment. However, the values of Pb and Cd were below the permissible limit for agricultural soil. The highest grain yield (4.72 t ha^{-1}) was recorded in T4 treatment and the lowest grain yield (3.87 t ha^{-1}) was observed in T1 treatment. Considering crop yield and soil properties, treatment T4 was better compared to other treatments. The present study clearly indicated that the quality of soil and yield increased due to the application of organic waste compared to chemical fertilizer.

Key words: Organic waste, soil environment, nutrients and heavy metal status, rice yield

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Introduction

Waste is an unavoidable by-product of human activities and its production maintains positive relation with increasing population that is responsible for increasing the global pollution (Rathi, 2006). Waste volumes continue to rise, which leads to loss of resources and increases environmental risks.The waste management is considered to be one of the most serious environmental problems in Bangladesh. Bangladesh has minimal waste collection coverage which forces majority of the waste to be dumped in open lands which could pose a serious environmental and health hazards (Enayetullah*et al.,* 2005). The land filling of biodegradable waste has proved to contribute to environmental degradation, mainly through the production of highly polluting leachate

and methane (CH_4) gas. Reducing the amount of CH_4 emitted from landfills is considered to be the greatest potential for reducing the overall climate change impacts of waste management.

The fertility status of soil in Bangladesh has been declining continuously due to intensive cropping and imbalanced use of chemical fertilizers. Nutrient mining, depletion of soil organic matter, reduction in soil aggregates etc. have been identified as reasons of yield stagnation or decline in the productivity of crops (Rahman and Yakupitiyage, 2006). A good soil should have at least 2.5% organic matter, but in Bangladesh most of the soils have less than 1.5%, and some soils even have less than 1% organic

matter (BARC, 2005). The addition of different types of organic wastes to soil (crop residues, MSW-compost, cow dung, poultry manure, etc.) attenuates the degradation process of soil native organic matter. On the other hand, upon its proper management waste may treat an important resource because it can reduce the costs of commercial fertilizer as well as environmental hazards.

However, there is general consensus in the scientific literature that some composted waste materials contain larger concentrations of heavy metals (e.g., Zn, Cu, Ni, Cd, Pb, Cr and Hg) than the background values present in soil. The long-term accumulations of heavy metals in the soil environment potentially have important consequences on the quality of the human food chain, toxicity to plants and soil microbial processes. Therefore, it is important to evaluate soil quality and crop yield under the application of different waste materials on agricultural land.

The agriculture of Bangladesh is governed by intensive rice cultivation. About 11.7 million hectares cultivable land is used for rice cultivation (BBS, 2012). Therefore, the present study was proposed with a view tofinding out the impacts of recycling of waste materials on soil environment as well as the yield of rice crop.

Materials and Methods

Site description: The experiment was conducted in the field of Department of Environmental Science, Bangladesh Agricultural University, Mymensingh. The experimental field is located at 24° 54″ N latitude and 90° 50″ E longitudes at a height of 18 m above the mean sea level. The soil belongs to the "Old Brahmaputra Floodplain", under Agro-Ecological Zone-9 (UNDP and FAO, 1988). The climate of the study area is characterized by high temperature, high humidity and heavy rainfall with occasional breezy winds during kharif season and low temperature and low humidity during rabi season.

Experimental design and layout: The study was carried out during *aman* season (kharif-2) from 20 July to 28 November, 2014.The experiment was laid out in a randomized complete block design (RCBD) with 5 treatments and 3 replications. Thus total unit of plots were 15. The area of each plot was 4 m^2 (2m × 2m). There were 3 blocks in the field. Between each block there was 50 cm drain. The total area of the experimental plot was 60 m^2 (15×4 m^2).The treatments were:

T1: 100% Recommended fertilizer dose (urea, TSP, MOP, Sulphur and Zinc at the rate of 195, 21, 59, 60 and 4kg ha^{-1}, respectively.)

T2: 50% Farm waste+50% Poultry waste (5.13+2.7 tha^{-1})

T3: 50% Poultry waste + 50% Municipal solid waste (2.7+6.39 tha^{-1})

T4: 50% well decomposed cowdung + 50% Farm waste (6.45+5.13 tha^{-1})

T5: 50 % Farm waste +25% Poultry waste + 25% well decomposed cowdung (5.13+1.35+3.2 tha^{-1})

In this study impact of organic waste was compared with 100% recommended fertilizer dose.

Cultivation procedure: The experimental plot was ploughed with tractor on August 01, 2014. It was ploughed and cross ploughed followed by laddering to get hold of the attractive tilth. Then it was cleaned by removing weeds, crop residues and stubbles. The total doses of organic wastes were applied at one time after final land preparation and that was before 15 days of transplanting. Thirty-day old seedlings of BRRI dhan49 were transplanted on 08 September 2014, maintaining row to row distance 20 cm; hill to hill distance 20 cm and 3 seedlings per hill. Necessary gap filling was done at 8 days after transplanting. Weeding was done when necessary. Insecticides and pesticides were applied two times in a growing season for insect and pest management.

Collection, preparation and analysis of soil and plant sample: Soil samples were collected from 0-20cm soil depth prior to application of well decomposed waste materials and after harvest for the analysis of soil physical and chemical properties such as i) soil texture, ii) soil moisture, iii) soil pH, iv) electrical conductivity (EC), v) organic matter (OM), vi) total nitrogen (N), vii) available phosphorus (P), viii) exchangeable potassium (K) ix) available sulphur (S) and x) heavy metal (lead, Pb and cadmium, Cd). Analyses weredone following standard methods.

To measure plant height and leaf area index (LAI), three hills were randomly collected from each unit plot of five treatments from tillering to mature stage. The rice was harvested at full maturity on 22 November 2014. The grains were separated and sun dried for 5 days for attaining the moisture up to 14%. The grains were kept in paper bags plot wise and weighted in kg and finally converted into t ha^{-1}.

Data analysis: Data on different parameters were statistically analyzed to find out the significance of different treatments. The means for all the treatments were calculated and analyses of variation of all the characters were performed by F-test. The significance of the difference between the pair of means was evaluated at 5% level of significance by Least Significant Difference (LSD) test using MSTAT-C computer package program (Gomez and Gomez, 1984).

Results and Discussion

Effect of organic wastes on soil texture, moisture content and soil pH: Sand, silt and clay ranged from 24-27%, 67-70% and 5-7%, respectively at different treatments and there were no significant variations in textural class among different treatments. The moisture content of the experimental plots ranged from 26.02% to 30.83% at different treatments (Fig. 1a). The highest soil moisture content (30.83%) was recorded at T2 treatment (50% poultry waste+ 50% municipal solid waste)whereas the lowest (26.02%) was recorded at T1 (100% recommended fertilizer dose) treatment. Addition of poultry waste + municipal solid waste in soil increased the moisture holding capacity and hence, the soil moisture content increased. Similar results were obtained by Ali (1994); Hussain and Jilani (1992) and Swarup (2000).

The pH values of the experimental plots ranged from 5.26 to 5.93 at different treatments (Fig. 1b). The highest pH (5.93) was observed at T4 treatment (50% cowdung + 50% farm waste) and the lowest value (5.26) observed at T3 treatment (50% poultry waste + 50% municipal waste). Soil pH decreased in all treatments relative to the initial soil (6.3). However, there were no significant variations in pH among different treatments. All the soils were slightly acidic in nature.
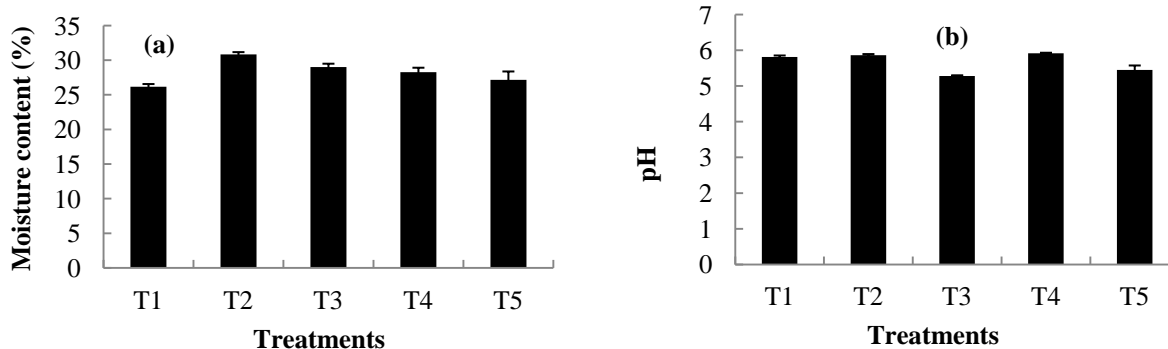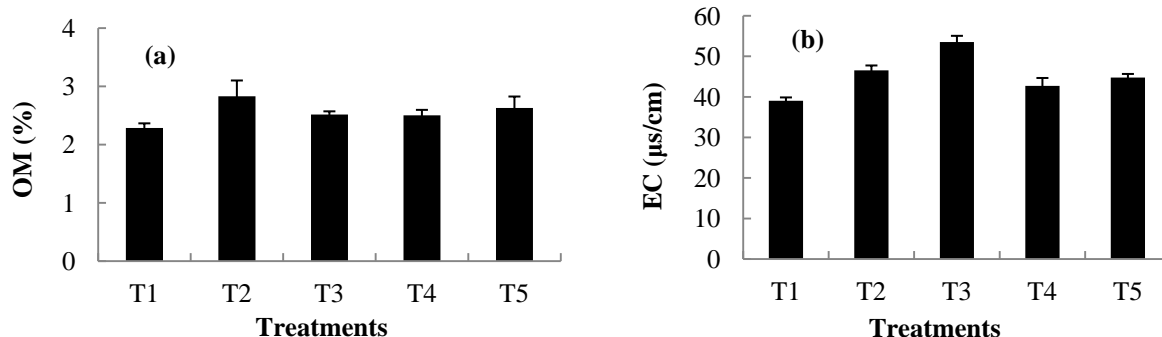

Figure. 1 Effect of organic wastes on (a) soil moisture content and (b) soil pH

Effect of organic wastes on soil organic matter (OM) content and electrical conductivity (EC): Organic matter content was significantly increased in all treatments (ranged from 2.28-2.83%) relative to the initial soil (1.53 %). The highest organic matter content (2.83%) was observed in T2 treatment and the lowest (2.28 %) was noted at T1 treatment (Fig. 2a). The variation in OM at all the treatments followed the order of T3>T2>T4>T5>T1, respectively. An increase in soil OM through the application of waste materials has also been found in previous studies (Kabirinejad and Hoodaji, 2012; Walter *et al*., 2000). Raju and Reddy (2000) reported that after five years of continuous cropping, all the organic manures plots had higher OM than that of inorganic fertilized plot. This may possibly owing to recycling of more OM from the crop stubbles in the field (Swarup and Sing, 1989).

The values of EC ranged from 38.5 to 54.7 μS/cm at different treatments (Fig. 2b). EC was highest (54.7 (μS/cm) at T3 treatment and lowest (39.03 (μS/cm) at T1 treatment. From the Fig. 2b, it is found that EC values did not differ significantly among different treatments. However, the EC values in all treatment were increased relative to the initial soil status (33.1 μS/cm). The reason for increasing EC might be due to the increased organic matter at all treatments.

Figure 2. Effect of organic wastes on soil (a) organic matter (OM) content and (b) electrical conductivity (EC)

Effect of organic wastes on nutrient status of soil: The total N content of soil was significantly influenced due to the combined effects of different organic waste treatments. The highest value of N (0.162%) was observed at T2 treatment and the lowest (0.128%) was observed at T1 treatment (Fig. 3a). The treatments can be ranked in the order of T2>T5>T4>T3>T1, respectively for total N content. An increase in N through the application of waste materials has also been found in previous studies (Kabirinejad and Hoodaji, 2012; Walter *et al.*, 2000). The P content varied from 12.09 to 17.34 ppm at different treatments (Fig. 3b). The highest value (17.34 ppm) was recorded in T4 treatment and the lowest value (12.007 ppm) was recorded in T3 treatment. In case of available P, the treatments can be ranked in the order of T4> T5> T2> T1> T3, respectively. Suwara and Kulesza (1990) reported that, application of mineral; FYM and combined mineral + FYM influenced soil pH, organic carbon, total N, available P, K and Mg content of soil.

Exchangeable K content of soil significantly influenced by different organic waste treatments (Fig. 3c). The maximum value of exchangeable K (51.34 ppm soil) was observed at T4 treatment and the lowest (34.23 ppm) was recorded at T1 treatment. The treatments may be ranked in the order of T4> T5> T3> T1> T2, respectively for K content.

Crisman (1995) reported a significant increase in K of soil with the application of organic materials.

From the Fig. 3d, it is found that available S content varied among different treatments. In all treatments, available S content was increased compared to inorganic fertilizer treatment (T1) as well as initial soil (8.02 ppm)). The highest available S (12.15 ppm) was observed in treatment T2 followed by T4 treatment and the lowest (9.68 ppm) was observed in T3 treatment which was less than T1 treatment. Golabai *et al.* (2007) and Silva *et al.* (2005) observed that concentration of P, K and S increased after application of organic matter over control due to the decomposition of organic matter.

Effect of organic wastes on heavy metal status of soil: The lead (Pb) content ranged from 9.5 to 12 ppm at different treatments (Fig. 4a). The highest Pb content (12 ppm) was recorded at treatment T5 and lowest (9.5 ppm) was recorded in T1 treatment. Cadmium (Cd) content varied from 2 to 4.17 ppm at different treatments (Fig. 4b). The Cd content was highest (4.67 ppm) in T5 treatment and the lowest value (2.0 ppm) was recorded at T1 treatment. The treatments can be ranked in the order of T5>T3> T2> T4> T1, respectively for Pb and Cd content. According to WHO (1996), the maximum permissible limits of Pb in soil is 38 ppm and the

permissible limits of Cd ranges between 0.45-4.17 ppm. The Pb and Cd contents of all the treatments were lower than the permissible limit.
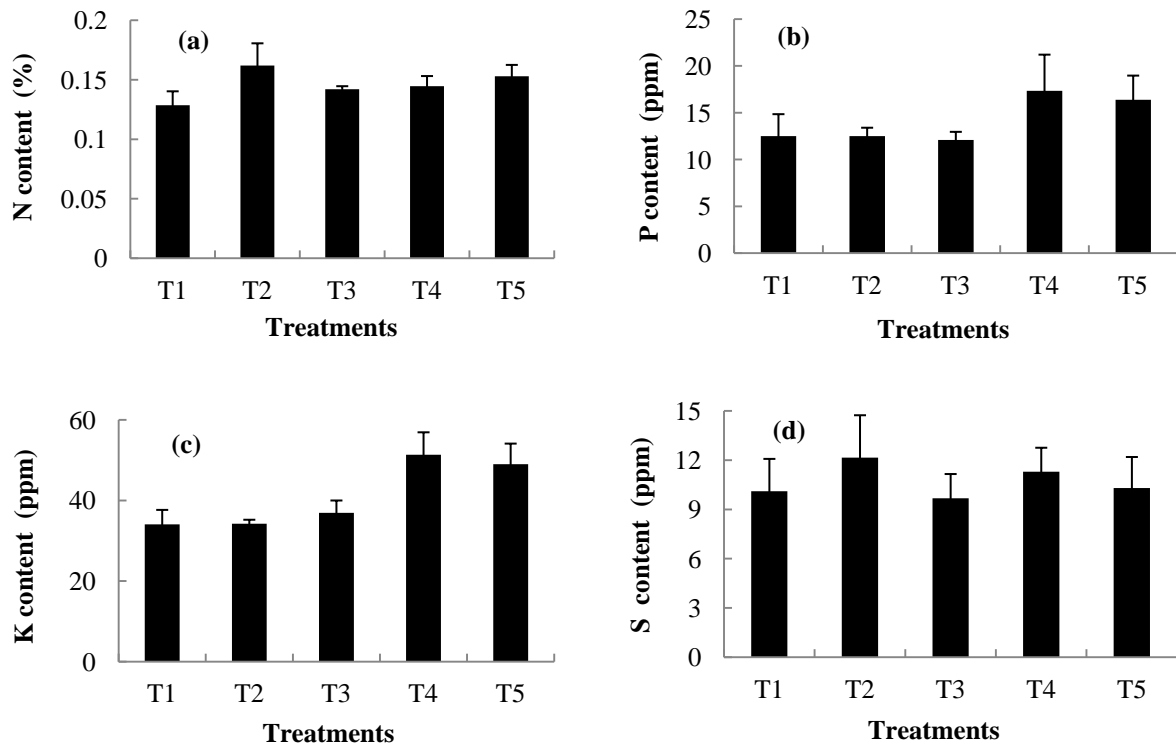
Figure 3. Effect of organic wastes on soil (a) nitrogen (N) (b) phosphorus (P) (c) potassium (K) and (d) sulphur (S) content
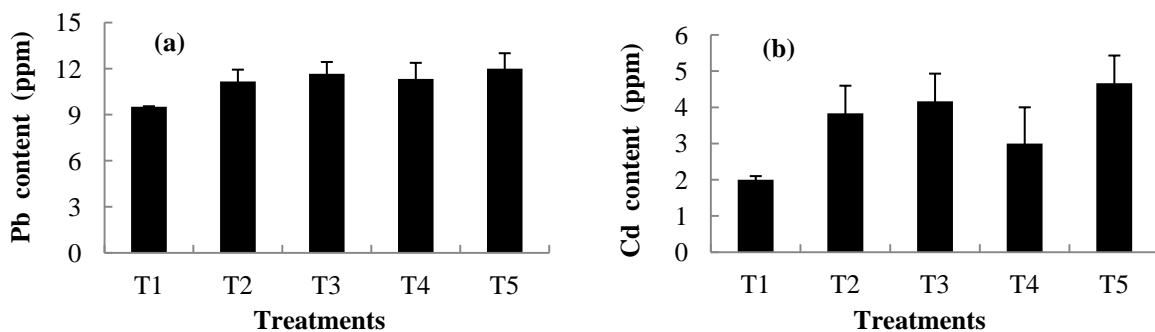
Figure 4. Effect of organic wastes on soil (a) lead (Pb) and (b) cadmium (Cd) content

***Effect of organic wastes on crop yield*:** The variation in grain yield was highly significant due to the application of different treatments of organic wastes and 100% recommended fertilizers dose (Table 1). The highest grain yield (4.72 t ha^{-1}) was found in T4 treatment and the lowest (3.870 t ha[-1)]) was obtained in T1 treatment. The treatments can be ranked in the order of T4> T3> T5> T2> T1 for grain yield. It is

important to note that, plant height and leaf area index (LAI) were also highest in T4 treatment. Most of the soil components as well as plant height and LAI were higher in T4 treatment which contributed to higher yield in T4 treatment. Application of cowdung encouraged the vegetative growth of rice in terms of plant height and number of tillers hill[-1] which ultimately resulted in the increase of grain

yield (Mishra *et al.,* 2003). It is found that proper utilization of organic wastes give more yield with maintaining soil quality compared to 100% recommended fertilizer.

Table 1. Effect of organic wastes on yield of rice

Treatment	Grain yield (t ha^{-1})
T1	3.870 c
T2	3.910 c
T3	4.290 b
T4	4.723 a
T5	4.170 bc
CV (%)	3.75
Level of significance	**

** = Significant at 1% level of probability

This study indicated that most of the nutrient contents and yield were higher at T4 treatment. On the other hand, Pb and Cd content were lower at T4 treatment. Therefore, T4 treatment i.e., uses of combination of farm waste and cowdung ismore suitable compared to other treatments.

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