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RESIDUAL EFFECTS OF TWO CONSECUTIVE APPLICATIONS OF MUNICIPAL SOLID WASTE COMPOST AND FERTILIZERS ON BIOMASS PRODUCTION AND YIELD OF RICE (*ORYZA SATIVA* L.)

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Abstract

A field experiment was conducted to evaluate the residual effects of municipal solid waste (MSW) compost and inorganic fertilizer on the yield, biomass production and nutrient uptake of rice. The treatments used in the experiment were: T_0 (no fertilizer/compost), T_1 (100% recommended doses of NPKS), T_2 (compost 5.0 t/ha), T_3 (compost 5 t/ha + 100% RDF), T_4 (compost 7.5 t/ha), T_5 (compost 7.5 t/ha + 100% RDF), T_6 (compost 10 t/ha), T_7 (compost 10 t/ha + 100% RDF) and T_8 (compost 20 t/ha). Residual effects of MSW (10 t/ha) with 100% RDF (T_7) produced the highest grain (5.15 t/ha) and straw (7.21t/ha) yield. The NPKS uptake by BINAdhan7 was markedly influenced by the residual effects of MSW compost and inorganic fertilizers. Municipal solid waste compost with 100% RDF was found to exert the best residual effect for obtaining the maximum yield of rice.

Introduction

Bangladesh is an agro-based country. The total area and production of rice in Bangladesh are about 11.7 million hectares and 31.98 million metric tons, respectively (BBS 2011) which indicates that the yield of rice is very low in comparison with developed countries mainly due to the poor management and low soil fertility.

The low organic matter content is one of the reasons for the low fertility and low productivity of most soils in Bangladesh. As a result emphasis should be given to increase the rice yield through the adoption of proper management especially judicious application of fertilizers.

Continuous use of chemical fertilizers accelerates the depletion of soil organic matter and impairs physical and chemical properties of soil in addition to micronutrient deficiencies. Soil organic matter plays an important role in preserving the fertility and productivity of soil and improves the physico-chemical properties of soil, increases microbial activity and promotes crop production. The most important role of organic matter for rice production is to supply N, P and S and to regulate the immobilization and mineralization of nutrients in the soil. Compost is a good source of organic matter which improves soil fertility and supplies nutrients essential to plant growth.

Municipal solid waste compost is made up of kitchen and yard waste, and its composting has been adopted by many municipalities (Otten 2001). Composting of MSW is seen as a method of diverting organic waste materials from landfills while creating a product, at relatively low-cost, that is suitable for agricultural purposes (Wolkowski 2003). The use of organic manure e.g. municipal solid waste (MSW) compost may reduce the need for chemical fertilizers allowing the

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small farmers to save part of the cost of crop production. In addition, environmental pollution can be reduced considerably by reducing the use of chemical fertilizers and increasing the use of MSW compost. Residual effects of manure or compost application can maintain crop yield level for several years since only a fraction of the N and other nutrients in manure or compost become plant available in the first year after application (Motavalli *et al.* 1989). In view of limited information on the problems mentioned above, the present study was undertaken to evaluate the residual effects of MSW compost and inorganic fertilizers on the growth and yield of rice.

Material and Methods

The experimental area is located at 24°75´ N latitude and 90°50´ E longitudes at the elevation of 18 m above the sea level. The land of experimental field was medium high, belonging to the Sonatala soil series of non-calcareous dark grey floodplain soils under the Agro-Ecological Zone 9 (Old Brahmaputra Floodplain) and the order is Inceptisol. Soil samples from the experimental field were collected from the plough layer (0 to 15 cm). Then the samples were air-dried, well-mixed and ground to pass through a 2-mm sieve and stored in clean plastic bag for mechanical and chemical analyses. The particle-size analysis was done by hydrometer method (Black 1965) and the textural class was determined by plotting the results of sand %, silt % and clay % to the "Marshall's Triangular Co-ordinate'' following the USDA system. The soil pH was measured with the help of a glass electrode pH meter using soil- water suspension ratio of 1: 2.5 as described by Jackson (1962). Organic carbon of soil was determined by wet oxidation method described by Walkley and Black (1934). To obtain organic matter content, the amount of organic carbon was multiplied by the Van Bemmelen factor of 1.73. Cation exchange capacity of soil was determined by sodium saturated method as outlined by Jackson (1962). The nitrogen of soil was estimated by micro-Kjeldahl method (Page *et al.* 1989). Available phosphorus was extracted from the soil by shaking with 0.5 M $NaHCO_3$ solution at pH 8.5 following the method of Olsen *et al.* (1954). Exchangeable potassium (K) was determined from the soil by extraction with 1N NH_4OAc (pH 7.0). The extracted potassium was determined by using flame photometer (Black 1965). Available S content in soil was determined by extracting soil samples with 0.15% $CaCl_2$ solution as described by Page *et al.* (1989).

Table 1. Physico- chemical characteristics of initial soil.

Soil properties	Results
% sand	10.84
% silt	77.96
% clay	11.20
Textural class	Silt loam
pH (soil : water = 1 : 2.5)	6.58
CEC (me/100 g soil)	11.6
Organic carbon (%)	1.0
Total N (%)	0.17
Available P (ppm)	11.0
Exchangeable K (me/100 g soil)	0.11
Available S (ppm)	11.8

The treatment combinations used for the experiment were: T_0 = Control (no fertilizer/compost), T_1= 100% recommended dose of N, P, K, S (RDF), T_2 = MSW compost 5 t/ha, T_3 = MSW compost 5 t/ha + 100% RDF, T_4 = MSW compost 7.5 t/ha, T_5 = MSW compost 7.5 t/ha

+100% RDF, T_6 = MSW compost 10 t/ha, T_7 = MSW compost 10 t/ha +100% RDF, T_8= MSW compost 20 t/ha. Municipal solid waste compost and fertilizers were applied as per treatments in the preceding two rice crops. Recommended dose of fertilizers were applied to all the plots except control for the present cropping year. Urea, triple super phosphate, muriate of potash, and gypsum were used as sources for N, P, K and S, respectively. Three healthy seedlings were transplanted in each hill with maintaining plant spacing of 25 cm × 15 cm. The crop was harvested at full maturity. Grain and straw yields were recorded plot wise and the data were expressed as t/ha on 14% moisture basis.

One hill was randomly selected from each treatment at 45 days of planting to record the shoot and root biomass. Collected plant samples were dried in an oven at about 65^0C for 48 hrs and then dry weights were recorded. Three hills were randomly selected from each plot at maturity to record the yield contributing characters like plant height (cm), panicle length (cm), no. of tillers/hill, no. of filled grains/panicle, no. of unfilled grains/panicle and 1000-grain weight (g). Grain and straw samples were kept for chemical analysis.

The grain and straw samples were analyzed for determination of N, P, K and S. Total N, P, K and S contents of plant were determined after H_2SO_4-H_2O_2 digestion method described by Lu *et al*. (1999). Then nutrient (NPKS) uptake was calculated by the following formula: Nutrient uptake (kg/ha) = (Gy × N_{Gr})/ 100 + (Sy × N_{st})/100; where, Gy = Grain yield (kg/ha), Sy = Straw yield (kg/ha), N_{Gr} = Nutrient content in grain (%), N_{St} = Nutrient content in straw (%).

The collected data were analyzed statistically using ANOVA to examine the treatment effects and the mean differences were tested by DMRT and ranking was indicated by letters (Gomez and Gomez 1984).

Results and Discussion

Residual effects of MSW compost and fertilizers showed positive effects on the yield contributing characters of rice like plant height, panicle length, effective tillers/hill, filled grains/panicle, and 1000-grain weight (Table 2). Maximum plant height (86.38 cm), panicle length (23.05 cm), effective tillers/hill (14.78), filled grains/panicle (83.58), and 1000-grain weight (24.33 g) were recorded in the treatment T_7 (100% RDF + compost 10 t/ha. Minimum plant height of 61.00 cm was obtained in the control (T_0). The plant height, panicle length, effective tillers/ hill, filled grains/panicle, unfilled grains/panicle and 1000-grain weight effective tillers/hill due to different treatments ranged from 61.00 to 86.38 cm, 18.93 to 23.05 cm, 8.30 to 14.78, 70.52 to 83.58 and 19.50 to 24.33 g, respectively. Parvez *et al.* (2008) observed that plant height was significantly influenced by the incorporation of organic manures and fertilizers. Tamaki *et al.* (2002) found increased panicle length in organic farming.

Begum (1998) observed significant residual effect of organic manures on the number of effective tillers/hill. The findings of the present study are supported by Rahman *et al*. (2007), who found increased number of grains/panicle due to application of manures and fertilizers.

Application of MSW compost and fertilizers resulted a significant and positive residual effect on the grain, straw and biological yield of the follow-up crop (Table 3). The grain yield varied from 3.60 to 5.15 t/ha due to different treatments. The highest grain yield of 5.15 t/ha was obtained in the treatment T_7 (100% RDF + compost 10 t/ha) which was followed by the treatment T_5 (100% RDF + compost 7.5 t/ha) with the value of 4.97 t/ha. The per cent increase of grain yield ranged from 23.06 to 43.06 and the treatment T_7 gave the highest value over control.

The higher grain yield due to residual effect of organic manures was also reported by many investigators (Maskina *et al*. 1986). The straw yield due to the different treatments ranged from 5.37 to 7.21 t/ha with the increase of 15.64 to 34.26% over the control treatment (Table 3). The highest straw yield of 7.21 t/ha (34.26% increases over control) was obtained in the treatment T_7. The lowest straw yield of 5.37 t/ha was recorded in the control (T_0). These results are in agreement with Fokhrul and Eaqub (1981) who observed that the residual value of farm yard manure significantly increased straw yield of the following rice crop.

Table 2. Residual effects of MSW compost and fertilizers on the yield contributing characters of BINA dhan7.

Treatment	Plant height (cm)	Panicle length (cm)	Effective/ tillers hill	Filled grains/panicle	1000-grain weight (g)
T_0	61.00e	18.93d	8.30e	70.52c	19.50d
T_1	74.46d	21.37c	10.91d	71.28c	20.00cd
T_2	76.78cd	21.70b	11.78cd	70.18c	21.50bc
T_3	80.85b	22.50ab	13.38b	79.10ab	22.33b
T_4	78.69bc	22.15abc	12.89bc	74.87bc	21.67bc
T_5	82.03b	22.71ab	13.44b	80.22ab	22.50b
T_6	77.48cd	21.96bc	12.67bc	74.49bc	21.50bc
T_7	86.38a	23.05a	14.78a	83.58a	24.33a
T_8	78.92bc	22.43ab	12.53bc	75.34bc	21.83b
CV (%)	2.31	2.56	6.21	4.25	4.19

The value (s) having common letter(s) in a column do not differ at 1% level of significance.

Table 3. Residual effects of MSW compost and fertilizers on the yield of BINA dhan7.

Treatment	Grain		Straw		Biological	
	Yield (t/ha)	% increase over control	Yield (t/ha)	% increase over control	yield (t/ha)	% increase over control
T_0	3.60g	-	5.37g	-	8.97g	-
T_1	4.43f	23.06	6.21f	15.64	10.64f	18.62
T_2	4.52ef	25.56	6.33ef	17.88	10.85ef	20.96
T_3	4.88bc	35.56	6.84bc	27.37	11.72bc	30.66
T_4	4.75cd	31.94	6.65cd	23.84	11.40cd	27.09
T_5	4.97b	38.06	6.95b	29.42	11.92b	32.89
T_6	4.65de	29.17	6.51de	21.23	11.16de	24.41
T_7	5.15a	43.06	7.21a	34.26	12.36a	37.79
T_8	4.82bc	33.89	6.74bcd	25.51	11.56c	28.87
CV (%)	1.82	-	2.26	-	1.72	-

The value (s) having common letter(s) in a column do not differ at 1% level of significance.

The biological yield of BINAdhan7 ranged from 8.9 to 12.36 t/ha. The highest (12.36 t/ha) and lowest (8.97 t/ha) biological yield were recorded with the treatments T_7 and T_0, respectively. The percent increase of biological yield ranged from 18.62 to 37.79 and the treatment T_7 gave the highest value over control. These results are in agreement with Aga *et al.* (2004) who observed the highest biological yield of rice using compost.

The shoot and root weight and biomass production of BINAdhan7 increased significantly due to the residual effect of MSW compost and fertilizers (Table 4). All the treatments significantly increased the shoot, root and biomass weight over control. The shoot weight recorded in different treatments ranged from 183.3 to 731.0 g/m^2. The maximum shoot weight of 731.0 g/m^2 was recorded in the treatment T_7 (100% RDF+ compost 10 t/ha) which was followed by the treatment T_5 (100% RDF + compost 7.5 t/ha) and the treatment T_8 (compost 20 t/ha). The minimum shoot weight of 183.3 g/m^2 was obtained in the control (T_0). These results are in agreement with Singh *et al*. (2001) who observed the increased shoot biomass at different growth stages due to the application of compost with fertilizer in rice wheat cropping system. The root weight recorded in different treatments ranged from 40.3 to 166.3 g/m^2. The maximum root weight of 166.3 g/m^2 was recorded in the treatment T_7 which was followed by the treatments T_3 (151.3 g/m^2), T_5 (140.3 g/m^2), T_6 (136.3 g/m^2) and T_8 (160 g/m^2), respectively. The minimum root weight of 40.3 g/m^2 was obtained in treatment T_0.

Table 4. Residual effects of MSW compost and fertilizers on the biomass production of BINA dhan7.

Treatment	Shoot dry weight (g/m^2)	Root dry weight (g/m^2)	Total biomass (g/m^2)
T_0	183.3g	40.3f	223.7g
T_1	323.3f	69.0e	392.3f
T_2	511.0d	99.0d	610.0d
T_3	550.3d	151.3abc	701.7c
T_4	417.6e	99.7d	517.3e
T_5	668.6b	140.3bc	809.0b
T_6	536.3d	136.3c	672.7c
T_7	731.0a	166.3a	897.3a
T_8	613.3c	160.0ab	773.3b
CV (%)	5.2	9.7	4.5

The value(s) having common letter(s) in a column do not differ at 1% level of significance.

Total biomass production recorded in different treatments ranged from 223.7 to 897.3 g/m^2. The maximum biomass value of 897.3 g/m^2 was recorded in the treatment T_7 which was followed by the treatment T_5 with value of 809.0 g/m^2. These results are in agreement with Akter (2012) who observed the increased root biomass and total biomass production due to the application of compost with fertilizers.

Nitrogen uptake by rice grain and straw of BINA dhan7 was significantly increased due to the residual effect of MSW compost in different treatments (Fig. 1a). The N uptake in rice grains due to different treatments ranged from 26.89 to 69.25 kg/ha. The maximum N uptake by rice grain (69.25 kg/ha) was noted in the treatment T_7. The minimum N uptake (26.89 kg/ha) was recorded in the control. The second highest N uptake was recorded in T_5 (65.94 kg/ha). The N uptake of rice straw due to different treatments ranged from 20.06 to 44.52 kg/ha. The maximum N uptake by rice straw (44.52 kg/ha) was also noted in the treatment T_7. The minimum N uptake (13.06 kg/ha) was recorded in the control. Nitrogen uptake by rice grain was always higher than that by straw in all the treatments. Malika (2011) reported that the N uptake by rice grain and straw increased significantly with the combined application of organic manure and chemical fertilizers.

There was a significant variation in P uptake by BINAdhan7 due to the various treatments (Fig. 1b). Phosphorus uptake by rice grain varied from 3.56 to 9.39 kg/ha. The highest P uptake by rice grain (9.39 kg/ha) was found in the treatment T_7 with the application of compost @ 10 t/ha + 100% recommended dose of fertilizers which was statistically different from all other treatments. The lowest P uptake of 3.56 kg/ha was noted in the control treatment. The P uptake by rice straw ranged from 1.10 to 2.98 kg/ha. The maximum P uptake (2.98 kg/ha) by rice straw was obtained in the treatment T_7 which was also statistically different from the other treatments. The minimum P uptake by rice straw (1.10 kg/ha) was recorded in the control (T_0). Dongarwar *et al.* (2003) observed that the P uptake by rice grain was increased with the combined application of manures and fertilizers.

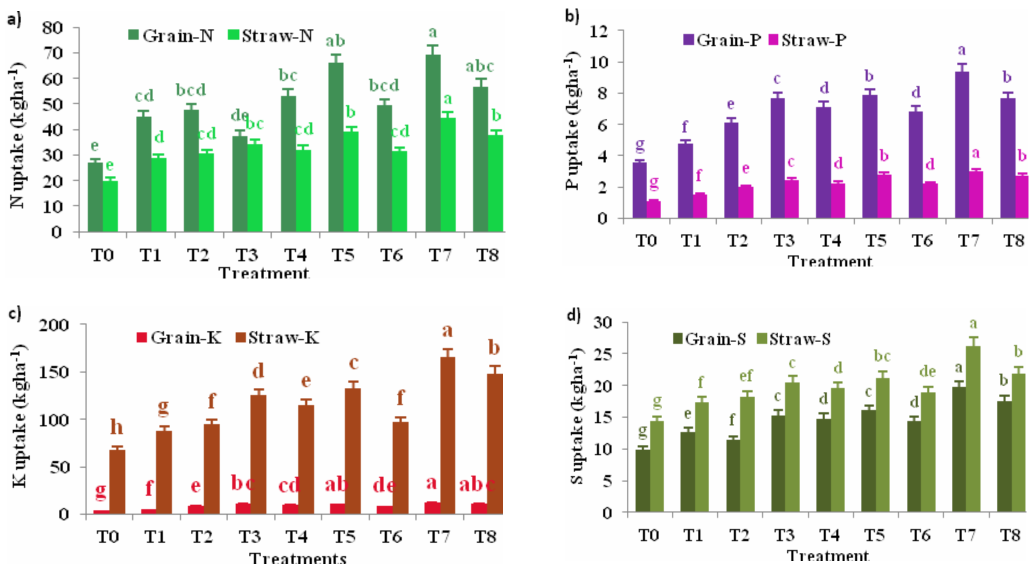

Fig. 1. Residual effects of MSW compost and fertilizers on (a) N, (b) P, (c) K and (d) S uptake by grain and straw of BINA dhan7.

Results presented in the Fig. 1c reveal that K uptake by grain of BINA dhan7 was influenced significantly due to the residual effects of MSW compost and fertilizers. The K uptake by rice grain ranged from 3.85 to 12.03 kg/ha. The maximum uptake of K by rice grain (12.03 kg/ha) was observed in the treatment T_7. The second highest value was observed in T_5 (11.25 kg/ha). The lowest K uptake (3.85 kg/ha) was recorded in the control. The K uptake by rice straw ranged from 67.92 to 165.75 kg/ha. The maximum K uptake (165.75 kg/ha) was observed in the treatment with compost @ 10 t/ha +100% RDF (T_7) which was statistically different from the other treatments. The lowest K uptake by straw of 67.92 kg/ha was noted in control. The results are in agreement with Meena *et al.* (2003) who reported that application of organic manure and chemical fertilizers significantly increased the K uptake by rice.

The uptake of S by rice grain and straw was significantly affected by different treatments (Fig. 1d). Sulphur uptake both in rice grain and straw ranged from 9.81 to 19.72 kg/ha and 14.40 to 26.27 kg/ha, respectively. The maximum uptake of S (19.72 kg/ha) by rice grain was observed in the treatment T_7 which was statistically different from the other treatments. The second highest uptake of S in rice grain recorded in treatments T_8 (compost 20 t/ha) where the value was 17.57

kg/ha. The lowest S uptake by grain (9.81 kg/ha) was recorded in the control (T_0). In case of straw, the highest S uptake of 26.27 kg/ha was observed in the treatment T_7 which was statistically different from the other treatments. The lowest S uptake by straw (14.40 kg/ha) was recorded in the control treatment (T_0). These results are in agreement with Malika (2011) who observed positive effects on S uptake by rice with application of manures and fertilizers.

The highest grain, straw and biological yield were obtained in the treatment T_7 (100% RDF+ compost 10 t/ha). The maximum shoot weight, root weight and total biomass weight was also recorded in the treatment T_7. The treatment T_7 recorded maximum N, P, K and S uptake in grain and S uptake in straw.

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