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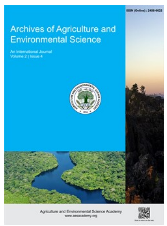

ORIGINAL RESEARCH ARTICLE

CrossMark

Effect of municipal solid waste compost and NPK fertilizer on growth, yield and protein content of rice (cv. BRRI dhan49)

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ABSTRACT

An experiment was conducted to study the effect of municipal solid waste compost (MSWC) on growth, yield and protein content as well as to know the effect of combined application of MSWC and NPK fertilizers in rice (cv. BRRI dhan49). There were six treatments including- T_0 = Control (No fertilizer or no MSWC); T_1= 100% Recommended Doses of Fertilizers (RDF) NPK; T_2 = (MSWC @ 5 t ha^{-1}+ 75% RDF); T_3= (MSWC @ 7. 5t ha^{-1}+ 50% RDF); T_4= (MSWC @ 10 t ha-1 + 25% RDF); T_5 = (MSWC @ 10 t ha^{-1}). The experiment was laid out in a randomized complete block design (RCBD) with three replications. Our results showed that the integrated application of MSWC and different RDF% had a significant impact on various plant growth and yield parameters including plant height, panicle length, number of effective tillers per hill, number of filled grains per panicle, 1000-grain weight (g), and grain and straw yield of rice. In case of T_2 treatment, highest grain yield (5.70 t ha^{-1}), straw yield (7.71 t ha^{-1}) and protein content (5.875%) were obtained. Thus, the result indicated that combined application of MSWC with NPK performed better than the single application of either MSWC or NPK fertilizer.

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INTRODUCTION

Rice (*Oriza sativa* L.) is one of the major food grains on which 50% of the world population depends on it (Sultana *et al*., 2021). According to BBS (2019), the average rice yield is about 3.01 t/ha which occupies 77% of the cultivable land and contributes 10% of the GDP. But rice production is getting decreased over years due to low organic matter in soil, improper use of inorganic fertilizers, conventional management practices, climatic hazards etc. Soil organic matter is gradually getting decreased due to low organic matter addition. Since organic matter is a key resource for strengthening soil health, managing soil organic matter has grown to be a crucial issue in Bangladesh's efforts to address the issue of low soil fertility and production. As a result, soil fertility depletion has become an important consideration regarding rice production. Use of chemical fertilizers is a crucial part of modern farming, and it accounts for around 50% of global crop production (Aktar *et al*., 2018). As a costly input, the use of long-term application of unbalanced chemical fertilizer is one of the causes of lower rice production (Moe *et al*., 2019) comprising negative impact on soil properties (both physical and chemical) and crop productivity which ultimately causes soil deterioration, pollution, etc. (Yogananda *et al*., 2019; Aktar *et al*., 2018). Application of organic amendments with chemical fertilizers significantly reduce fertilizer cost, environmental degradation and replenish soil fertility to obtain agricultural sustainability (Sultana *et al*., 2021).

On the other hand, a large quantity of municipal solid wastes

(MSW) is generated regularly posing serious disposal problems, environmental degradation, and potential health hazards. Now-a-days, MSW are effectively converted to valuable compost for its higher organic matter and mineral content to enhance soil properties including soil fertility (Rajaie and Tavakoly., 2019; Srivastava *et al*., 2016). It is an excellent source of nitrogen (N), phosphorous (P) and other vital trace elements as well as improve water holding capacity, infiltration, soil aeration, soil microbial response, etc. (Salam *et al*., 2021; Srivastava *et al*., 2016; Rajaie and Tavakoly., 2019). In addition, municipal solid waste compost alleviates different problems like groundwater contamination, air pollution and different health hazards caused by landfilling. However, the application of either manure or fertilizer is not an effective solution for maintaining soil health and crop production. So, the integrated use of organic manure with mineral fertilizers improves soil health by enhancing plant growth, quality, and productivity (Sultana *et al*., 2021; Kumar *et al*., 2019; Moe *et al*., 2019). Considering these, an experiment was done to evaluate the simultaneous effects of municipal solid waste compost with different percentage of recommended inorganic fertilizers on the growth, yield and protein content rice cv. BRRI dhan49.

MATERIALS AND METHODS

Site description and soil properties

During the Kharif season, the experiment was carried out in the Soil Science Field Laboratory, Bangladesh Agricultural University, Bangladesh (Agro-ecological zone-9). The soil of the experimental site is above the flood level, moderately drained, and taxonomically classified as a silt loam. Initial soil samples were analyzed for determining soil pH, organic carbon, total nitrogen, available P, exchangeable K and available S. The results are presented in Table 1.

Treatments and design of the experiment

The experiment was laid out in Randomized Complete Block design (RCBD) to limit the heterogenic effect of soil. There were six treatments with different combinations of MSWC and NPK, each treatment consists of three replications. A total number of plots were 18 (6×3). The study comprised of the following treatments: T_0 = Control (No fertilizer or no MSWC); T_1= 100% Recommended Doses of Fertilizers (RDF) NPK; T_2 = (MSWC @ 5 tha-1+ 75% RDF); T_3= (MSWC @ 7. 5 tha-1+ 50% RDF); T_4= (MSWC @ 10 t ha^{-1} + 25% RDF); T_5= (MSWC @ 10 t ha^{-1}. Inorganic fertilizer such as Urea, Triple superphosphate (TSP), and Muriate of potash (MoP) were used as sources of N, P, and K, respectively.

Fertilizer application and crop management

Marketable MSWC was collected from the organization Grameen Manobic Unnayan Sangstha ("GRAMAUS"). The collected MSWC was prepared from the solid wastes of Mymensingh city. The rice variety BRRI dhan49 was used as a test crop. Before 7 days of transplanting the rice seedlings, MSWC was incorporated thoroughly with the soil as per treatment. The one-third dose of urea with the full dose of TSP and MoP were applied as a basal dose. The rest 2 doses of urea were applied at 30 days after transplanting (active tillering stage) and the third split was at 60 days (panicle initiation stage) after transplanting. Intercultural operations were performed according to the requirement.

Data recording

The data on the growth and yield parameters like plant height, panicle length, number of effective tillers pot^{-1}, no of grains $panicle^{-1}$, 1000-grain weight, grain yield and straw yield were recorded at the full maturity stage. Harvested grains were dried and weighed at 14% moisture content. Straw from each plot was sun-dried and weighed. The biological yield was calculated by using the formulae- (Grain yield + Straw yield).

Chemical analysis

The total N content of plant samples was determined through Micro-Kjeldahl method described by Sultana *et al.* (2022). Protein contents of rice grain were calculated by multiplying the % nitrogen content by 6.25.

Statistical analysis

The one-way analysis of variance (ANOVA) for different plant parameters and yield was calculated using General Linear Model (GLM) and the means were compared using Fisher's method at 95% confidence level in Minitab 18 statistical package (State College, PA, USA).

Table 1. Chemical properties of soil.

Soil Properties	Values	Determination method
pH (1:2.5, soil: water)	6.31	Glass electrode pH meter method (Peech *et al*., 1965)
Organic carbon (%)	1.06	Black's wet oxidation method (Black *et al*., 1965)
Total nitrogen (%)	0.20	Micro-Kjeldahl method (Bremner *et al*., 1982)
Available P (ppm)	12.08	Olsen Method (Olsen *et al*., 1982)
Exchangeable K (me / 100 g soil)	0.15	NH_4OAc (1 N) extraction method (Knudsen *et al*., 1982)
Available S (ppm)	12.50	$CaCl_2$ turbidity method (Fox *et al*., 1964)

RESULTS AND DISCUSSION

Effect of MSWC application on the growth parameters of rice (cv. BRRI dhan49)

The application of MSWC to rice (cv. BRRI dhan49) resulted in considerable variation in different growth and yield contributing characters like plant height, panicle length, number of effective tillers per hill, number of filled grains per panicle, 1000 grains weight (Table 2). The plant height varied from 71.53- 85.18 cm, panicle length from 19.48-24.63 cm, no. of effective tillers per hill 10.29-13.82, number of filled grains per panicle 76.67-137.33, 1000 grains weight 19.91-24.53g. In the T_2 treated plots, the combined application of (MSWC @ 5 t ha^{-1}+75 % RDF) produced the highest values for the growth and yield contributing characters. Sarkar *et al.* (2021a) reported that the highest plant height, panicle length, number of effective tillers per hill, number of filled grains per panicle were obtained from the combined application of inorganic fertilizers and organic manures. Another study suggested that the integrated use of MSWC and N fertilizers effectively enhanced growth response in tomatoes as MSWC supply sufficient nutrients for plant uptake (Rajaie and Tavakoli, 2016).

Effects of MSWC application on the yield of rice (cv. BRRI dhan49)

Different combinations of MSWC and RDF or their single application considerably impacted the grain yield of rice (cv. BRRI dhan49), as shown in Table 3. The grain yield varied from 3.11 to 5.70 t ha^{-1}. The application of T_2 (MSWC@5 t ha^{-1} + 75% RDF) produced a highest grain yield of 5.70 t ha^{-1} with 83.27 % yield increase over control. The grain yield value (5.53) obtained from T_3 (MSWC @ 7. 5t ha^{-1}+ 50% RDF) was statistically identical to the value (5.52 t ha^{-1}) of T_1 (100% RDF). The lowest grain yield of 3.11 t ha^{-1} was recorded under the control (T_0) condition (Figure 1). These results suggest that the combined use of MSWC and inorganic fertilizer could exert better yield performance than the sole application of either inorganic fertilizer or MSWC. These findings were support the research of Moe *et al.* (2019) in which, the combined application of organic and inorganic fertilizers enhanced growth and yield attributes of rice. Yogananda *et al.* (2019) also reported that the complementary application of inorganic fertilizer and urban waste compost produced significantly higher maize yield. Like grain yield, the highest straw yield of (7.71 t ha^{-1}) was obtained under T_2 (MSWC @ 5 t ha^{-1} + 75 % RDF) condition with 49.41% increase over control. This result suggested that use of MSWC or RDF alone may not be effective. For that reason, supplementary inorganic fertilizer is necessary to ensure maximum crop production (Scotti *et al.*, 2016). A wide variation in the biological yield of rice was observed under the application of different combination of MSWC and RDF. The lowest value was recorded in T_0 (Control).

Table 2. Effect of MSWC application on yield of rice (cv. BRRI dhan49).

Treatment	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1} (no.)	Filled grains panicle^{-1} (no.)	1000 grains weight (g)
T_0	71.53d	19.48d	10.29d	76.67d	19.91d
T_1	83.12ab	22.74b	12.49bc	130.33b	22.38bc
T_2	85.18a	24.63a	13.82a	137.33a	24.53a
T_3	81.30b	23.26ab	11.92bc	123.63c	22.17bc
T_4	81.37b	22.46bc	13.04ab	120.67c	23.25ab
T_5	78.47c	21.15c	11.76c	118.67c	21.01cd
CV%	5.76	8.08	10.28	17.14	7.48
SE ($\bar{x}$)	1.09	0.425	0.296	4.76	0.392

Figures in a column having common letters do not differ significantly at a 5% level of significance; CV (%) = Coefficient of variation, SE (±) = Standard error of means.

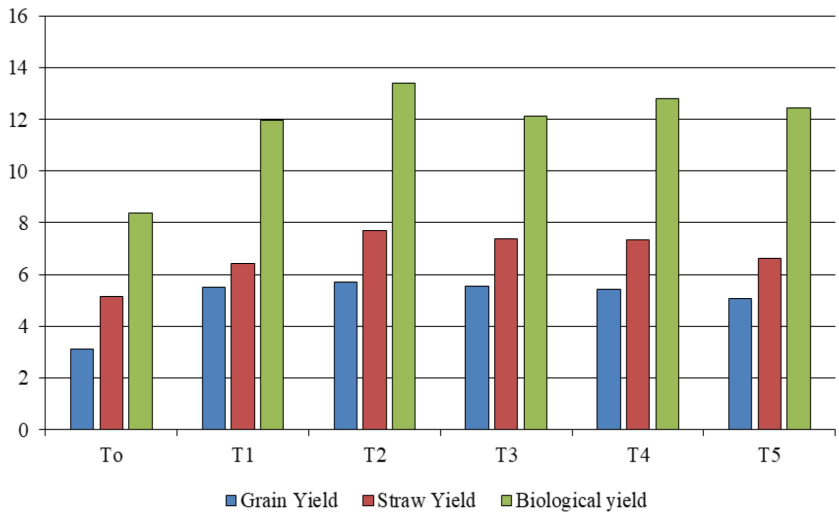

Figure 1. *Effect of municipal solid waste (MSWC) application on (grain, straw, and biological) yield of rice (cv. BRRI dhan49).*

Table 3. Effects of MSWC application on grain and straw yield of rice (cv. BRRI dhan49).

Treatment	Grain yield ($t\ ha^{-1}$)	Increase over control (%)	Straw yield ($t\ ha^{-1}$)	Increase over control (%)	Biological yield ($t\ ha^{-1}$)
T_0	3.11d	-	5.16d	-	8.37
T_1	5.52ab	77.49	6.44c	24.80	11.96
T_2	5.70a	83.27	7.71a	49.41	13.41
T_3	5.53ab	74.60	7.38ab	28.10	12.14
T_4	5.43c	74.59	7.36ab	42.64	12.79
T_5	5.06c	62.70	6.61bc	43.02	12.44
CV%	18.28		14.30		
SE ($\bar{x}$)	0.218		0.228		

Figures in a column having common letters do not differ significantly at a 5% level of significance; CV (%) = Coefficient of variation, SE (±) = Standard error of means.

Table 4. Effects of MSWC application on nitrogen and protein content of rice (cv. BRRI dhan49).

Treatments	Nitrogen (%)		Protein (%)	
	Grain	Straw	Grain	Straw
T_0	0.69 d	0.36d	4.31	2.25
T_1	0.91b	0.55b	5.68	3.43
T_2	0.94 a	0.62a	5.87	3.88
T_3	0.87c	0.45c	5.43	2.81
T_4	0.84d	0.46c	5.25	2.88
T_5	0.84d	0.41d	5.25	2.56
CV (%)	9.73	18.84		
SE(±)	0.0195	0.0212		

Figures in a column having common letters do not differ significantly at a 5% level of significance; CV (%) = Coefficient of variation, SE (±) = Standard error of means.

Effects of MSWC on protein content in rice (cv. BRRI dhan49)

Protein content in rice grain significantly affected by the application of different combinations of MSWC and RDF (Table 4). Protein content is directly proportional to the nitrogen content of rice grain and expressed as, % Protein content = 6.25 x % Nitrogen content. Among all the treatments, highest protein content (5.87%) was observed in the T_2(MSWC @ 5 t ha^{-1} + 75 % RDF). The application of T_1(100 % RDF) produced the protein content of 5.69 % and the protein content of 5.25% was noted in the single application of MSWC @ 10 t ha^{-1}. The lowest nitrogen content (0.69%) was recorded under T_0 (control). From the study it was assumed that instead of using only MSWC or mineral fertilizer, their integrated use showed increased protein percentage in rice. According to Sultana *et al.* (2022), the treatment containing 50% fertilizer +10 t ha^{-1} of amended compost containing MSWC performed better considering protein content in rice.

Conclusion

From the experiment, we have examined that the combined application of MSWC along with RDF of inorganic fertilizer exerted positive impact on growth, yield and protein content of rice. The results showed that the application of T_2 (MSWC @ 5 t ha^{-1} conjunction with 75% RDF) significantly produced the highest plant height, panicle length, number of effective tillers per hill, number of filled grains per panicle, 1000 grains weight. The grain yield and protein content also found maximum in the same treatment (T_2). Although our farmers prefer to use inorganic fertilizers, but excessive use of such fertilizers makes soil less fertile and show lower crop productivity. The integrated use of MSWC and RDF improved soil fertility as well as increased crop productivity. So, municipal solid waste compost (MSWC) mixed with NPK (75%) is strongly recommended for increased rice production and protein content in rice (cv. BRRI dhan49) than sole application of either MSWC or NPK.

AUTHORS' CONTRIBUTION

All authors have contributed equally to the preparation of this manuscript.

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Conflict of interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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