Effect of Organic and Inorganic Fertilizer on the Growth and Yield of Rice (*Oryza sativa* L.)

Ashik Jamil Mahmud[1], A. T. M. Shamsuddoha[1], Md. Nazmul Haque[2]

[1.] Department of Soil Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
[2.] Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
sumon2539@gmail.com

Abstract: Combination of organic and inorganic sources of nutrients is necessary for sustainable agriculture that can ensure food production with high quality. In order to study the effect of vermicompost and chemical fertilizers on the growth and yield components in rice, an experiment was carried out during December 2013 to June 2014, in randomized block design based on 3 replications. The treatments of vermicompost were given in 4 levels (0.0, 1.0, 2.0 and 4.0 t ha^{-1}) and 4 levels of chemical fertilizers (0-0-0-0, 50-8-33-6, 100-16-66-12 and 150-24-99-18 kg N, P, K and S ha^{-1}, respectively). Different levels of vermicompost and NPKS fertilizers showed significant effect on growth, yield and yield contributing characters of BRRI dhan29. Results showed that application of medium level of chemical fertilizer with 4 t ha^{-1} vermicompost gave the maximum yield. It was observed that over dose of NPKS fertilizers from chemical source decreased rice yield. Results also revealed that the highest plant height, effective tillers $hill^{-1}$, flag leaf length, panicle length, filled grains $panicle^{-1}$, 1000-grain weight, grain yield, straw yield and biological yield were obtained from the combination of 4 t ha^{-1} vermicompost with 100 kg ha^{-1} N, 16 kg ha^{-1} P, 66 kg ha^{-1} K, 12 kg ha^{-1} S. It was observed that yield of rice can be increased substantially with the judicious application of organic fertilizer with chemical fertilizer.

[Mahmud AJ, Shamsuddoha ATM, Haque MN. **Effect of Organic and Inorganic Fertilizer on the Growth and Yield of Rice (*Oryza sativa* L).** *Nat Sci* 2016;14(2):45-54]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). http://www.sciencepub.net/nature. 7. doi:10.7537/marsnsj14021607.

Keywords: Grain yield; NPKS fertilizer; organic fertilizer; rice; vermicompost

1. Introduction

Rice (*Oryza sativa* L.) is an important cereal crop of the poaceae family and a major staple food that is widely consumed all over the world irrespective of race, religion and political association (Ohajianya and Onyenweaku, 2002). Inorganic, organic and bio-fertilizers are the main sources for replenishing plant nutrients in agricultural soils (Masarirambi et al., 2012). Continuous use of inorganic fertilizers leads to deterioration in soil chemical, physical, and biological properties, and soil health (Mahajan et al., 2008). The negative impacts of chemical fertilizers, coupled with escalating prices, have led to growing interests in the use of organic fertilizers as a source of nutrients (Satyanarayana et al., 2002; Mahajan et al., 2008).

Vermicompost has been considered as a soil additive to reduce the use of mineral fertilizers because it provides required nutrient amounts, increases cation exchange capacity and improves water holding capacity (Tejada and Gonzaler, 2009). Vermicompost not only increases yield of rice but can also substitute chemical fertilizer to some extent (Sharma et al., 2008; Guera, 2010).

Many research findings have shown that neither inorganic fertilizers nor organic sources alone can result in sustainable productivity (Satyanarayana et al., 2002; Jobe, 2003). However, the use of organic manures alone might not meet the plant requirement due to presence of relatively low content of nutrients. Application of organic manure with chemical fertilizer accelerates the microbial activity, increases nutrient use efficiency (Narwal and Chaudhary, 2006) and enhances the availability of the native nutrients to the plants resulting higher nutrient uptake. Therefore, in order to make the soil well supplied with all the plant nutrients in the readily available form and to maintain good soil health, it is necessary to use organic manures in combination with inorganic fertilizers to obtain optimum yields (Ramalakshmi et al., 2012).

Keeping these facts in mind, research has been launched to study the effect of combined application of vermicompost and chemical fertilizers on yield and yield attributes of boro rice.

2. Materials and Methods

2.1 Experimental location, soil and climate

The study was carried out at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh situated at $23^0$46´ N latitude and $90^0$23´ E longitude at an altitude of 8.45 m above the sea level during the period from December 2013 to June 2014. The soil of the experimental soil was silty clay loam in texture with sand (17.60 %), silt (47.40 %), clay (35.00 %), soil pH (5.70), organic carbon (0.89 %), total N (0.063

%), available P (14.90 mg kg^{-1} soil), exchangeable K (0.12 meq/100 g soil) and available S (11.00 mg kg^{-1}). The climate of this area is subtropical. Detail weather data of the experimental area have been presented in Table 1.

2.2 Planting Material

A rice variety called BRRI dhan29 was used as a test crop. This variety was developed at the Bangladesh Rice Research Institute (BRRI) from the cross between BG 90-2 and BR51-46-5 in 1994. It is recommended for boro season.

2.3 Raising and transplanting of seedling

The seedlings of rice were raised in the wet bed methods. The selected seed bed was opened by hand spade on 25th November 2013. Seeds (95% germinated) 5 kg ha^{-1} were soaked and incubated for 48 hours. 30 days old seedlings were carefully uprooted from the seedling nursery and transplanted on 19th January 2014. Two seedlings per hill were used following a line to line of 20 cm and hill to hill spacing of 15 cm. After one week of transplantation all plots were checked for any missing hill which was filled in with extra seedlings whenever required.

2.4 Land preparation

First the land was ploughed with a power tiller. The soil was saturated with adequate supply of irrigation water and finally prepared by successive ploughing and cross ploughing followed by laddering. The unexpected residues were removed from the experimental plot. Finally, the land was leveled and the experimental plot was partitioned into unit plots in accordance with experimental design.

2.5 Experimental design and treatment

The experiment was arranged in Randomized Complete Block Design (RCBD) with three replications. The experiment consists of two Factors i.e. 4 levels of vermicompost *viz.*, V_0=0 t ha^{-1} (control), V_1=1 t ha^{-1}, V_2=2 t ha^{-1}, V_3=4 t ha^{-1} and 4 levels of chemical fertilizers *viz.*, F_0 = control (0-0-0-0 kg N, P, K, S ha^{-1}, respectively), F_1= low level (50-8-33-6 kg N, P, K, S ha^{-1}, respectively), F_2 = medium level (100-16-66-12 kg N, P, K, S ha^{-1}, respectively), F_3 = high level (150-24-99-18 kg N, P, K, S ha^{-1}, respectively). The plants without treatments were served as control. The size of the plot was 2 m × 2 m (4 m^2). The distance maintained between two plots was 0.5 m and between blocks was 1 m. Vermicompost contains 48 % C, 2.99 % N, 0.28 % P, 1.65 % K, 0.32 % S, C:N ratio 15.

2.6 Biological yield

Biological yield was calculated by using the following formula:

Biological yield= Grain yield + straw yield

2.7 Harvest index (%)

Harvest index is the relationship between grain yield and biological yield. It was calculated by using the following formula:

$$\text{HI (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

2.8 Statistical analysis

The data were statistically analyzed by using MSTAT-C (Russell, 1994) programme. The mean differences among the treatments were compared by least significant difference (LSD) test at 5% level of significance.

Table 1. Monthly average air temperature, relative humidity and rainfall of the experimental site during the period from December 2013 to June 2014

Year	Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2013	December	25.36	5.21	54.30	0.63
2014	January	21.17	15.46	64.02	0.00
	February	24.30	19.12	53.07	2.34
	March	29.78	22.37	49.25	0.12
	April	33.87	22.91	51.08	2.19
	May	33.64	23.69	62.60	6.52
	June	32.07	23.27	71.85	9.42

3. Results and Discussion

3.1 Plant height

Significant variation was observed on the plant height of rice when the field was incorporated with different doses of vermicompost (Table 2). The tallest plant (93.89 cm) was observed from 4 t ha^{-1} vermicompost application and the smallest (90.05 cm) was observed from control treatment. Vermicompost might have increased the soil moisture content, soil porosity and other plant enhancing characters and for that reason increasing dose of vermicompost increased plant height. Agrawal et al. (2003) found that the increase in soil organic matter content through the application of FYM in wheat increased plant height. Different doses of NPKS fertilizer showed significant variation on the plant height of rice (Table 2). The longest plant (94.52 cm) was observed from 150-24-99-18 kg ha^{-1} NPKS fertilizer and the lowest (89.02

cm) was found from control where no fertilizer was applied. Song; Yao (2001) found that application of NPK fertilizer increased the height of wheat plant compared with control treatment. Increase in plant height in response to recommended dose of fertilizer might be primarily due to the improved vegetative growth and supplementary contribution of nitrogen (Awan et al., 2011). Combined application of different doses of vermicompost and fertilizer had significant effect on plant height of rice (Table 2). The highest plant height (95.78 cm) was observed from V_3F_2 and it was statistically similar with V_3F_3, V_2F_3, V_0F_3, V_2F_2, V_2F_1, V_1F_3 and V_3F_1 whereas, the lowest (86.04 cm) was found from V_0F_0. The variation in plant height due to nutrient sources was considered to be the variation in the availability of major nutrients. Chemical fertilizer offers nutrients which are readily soluble in soil solution and thereby instantaneously available to plants. Nutrient availability from organic sources is due to microbial action and improved physical condition of soil. These results were supported by Sarker et al. (2004).

3.2 Effective tillers hill^{-1}

Tillering is an important trait for grain production and is thereby an important aspect of rice growth improvement. Effective tillering depends primarily on soil physical conditions that were superior due to addition of organic manure (Usman et al., 2003). Different doses of vermicompost showed significant variation on number of effective tillers hill^{-1} of rice (Table 2). The maximum effective tillers hill^{-1} (13.65) was obtained from 2 t ha^{-1} vermicompost which was statistically similar with 4 t ha^{-1} and the minimum (12.11) was recorded in without vermicompost treatment. Organic sources offer more balanced nutrition to the plants, especially micro nutrients which has caused better affectivity of tiller in plants grown with vermicompost (Miller, 2007). This result was also supported by Rakshit et al. (2008). Variation of number of effective tillers hill^{-1} of rice at different doses of NPKS fertilizer was significant (Table 2). The maximum effective tillers hill^{-1} (14.55) was observed from 150-24-99-18 kg ha^{-1} NPKS fertilizer and the minimum (11.41) was found in the treatment that received no fertilizer. In case of control treatment there was deficiency of N and other essential nutrients which was required for tiller production while the other treatments supplied it which rendered the higher number of tillers. Hasanuzzaman et al. (2010) reported increase in number of tillers per square meter might be due to the more availability of nitrogen, which plays a vital role in cell division. Interaction effect of different doses of vermicompost and NPKS fertilizer had significant effect on effective tillers hill^{-1} of rice (Table 2). The maximum (15.30) effective tillers hill^{-1} was observed from V_3F_2 which was statistically at par with V_2F_3, V_3F_3, V_1F_3 and V_2F_2 whereas, the lowest (10.50) was counted from V_0F_0 and it was statistically identical with V_3F_0 and V_0F_1. From this study it was observed that excess application of inorganic fertilizers is not necessary to produce effective tillers if we can supplement it from organic manures, which also help in providing essential micronutrients to the plants (Miller, 2007; Rakshit et al., 2008). Nayak et al. (2007) reported a significant increase in effective tillers hill^{-1} due to application of chemical fertilizer with organic manure. Hasanuzzaman et al. (2010) also reported similar results in rice.

3.3 Non-effective tiller hill^{-1}

The significant result was found in non-effective tiller hill^{-1} of rice by the different levels of vermicompost (Table 2). The maximum non-effective tiller hill^{-1} (2.31) was obtained from without vermicompost treatment which was statistically similar with 1 t ha^{-1} vermicompost level and the minimum (1.61) was noted in 2 t ha^{-1} treatment. The significant variation was found due to the effect of fertilizers in non-effective tiller hill^{-1} of rice (Table 2). The maximum non-effective tiller hill^{-1} (2.68) was obtained from without fertilizer and the minimum (1.29) was observed from 150-24-99-18 kg ha^{-1} NPKS fertilizer treatment. These might be due to the higher number of tiller production hill^{-1} for higher nutrient absorption where the total non-effective tillers were also higher in number. Production of non-effective tiller hill^{-1} of rice was significantly affected due to the interaction effect of different doses of vermicompost and NPKS fertilizers (Table 2). The maximum non-effective tiller hill^{-1} (2.88) was obtained from V_0F_0 which was statistically similar with V_2F_0, V_1F_0, V_0F_1 and V_1F_1 whereas, the minimum (0.93) was obtained from V_3F_2 which was statistically similar with V_2F_3, V_3F_3 and V_1F_3. Hossaen et al. (2011) reported that number of non-effective tillers per hill of BRRI dhan29 varied significantly due to the application of various organic manure and inorganic fertilizers.

3.4 Flag leaf length

Different doses of vermicompost showed significant variation on flag leaf length of rice (Table 2). The longest flag leaf (25.04 cm) was obtained from 4 t ha^{-1} vermicompost application which was statistically similar with 2 t ha^{-1} and the shortest (23.23 cm) was found from control treatment. Significant variation was observed on flag leaf length of rice at different doses of NPKS fertilizer (Table 2). The maximum (25.41 cm) flag leaf length was observed from 150-24-99-18 kg ha^{-1} NPKS fertilizer which was statistically similar with 100-16-66-12 kg ha^{-1} NPKS and the lowest (22.42 cm) was observed from without chemical fertilizer treatment. Interaction effect of different doses of vermicompost and NPKS fertilizer had significant effect on flag leaf length of rice (Table 2). The maximum flag leaf length (27.27 cm) was observed from V_3F_2 which was statistically similar with V_3F_3 and V_2F_3 whereas, the lowest (21.51) was obtained from V_0F_0 and it was statistically similar with V_1F_0, V_2F_0, V_3F_0, V_1F_1 and V_0F_1. Again it was observed that organic fertilizer alone and in combination with chemical fertilizers significantly increased the flag leaf length over untreated control. Similar findings are reported by Hasanuzzaman *et al.* (2010). The increase in leaf number as well as size due to enough nutrition can be explained in terms of possible increase in nutrient absorption capacity of plant as a result of better root development and increased translocation of carbohydrates from source to growing points (Singh and Agarwal, 2001).

Table 2. Effect of vermicompost and/or NPKS fertilizer on plant height, number of effective tiller $hill^{-1}$, non effective tiller $hill^{-1}$ and flag leaf length of rice

Treatments	**Plant height (cm)**	**Effective tiller $hill^{-1}$ (no.)**	**Non-effective tiller $hill^{-1}$ (no.)**	**Flag leaf length (cm)**
Vermicompost				
V_0	90.05 b	12.11 c	2.31 a	23.23 c
V_1	90.14 b	13.01 b	2.13 ab	23.76 bc
V_2	93.74 a	13.65 a	1.61 c	24.43 ab
V_3	93.89 a	13.60 ab	1.96 b	25.04 a
$LSD_{(0.05)}$	1.275	0.614	0.236	0.869
NPKS fertilizer				
F_0	89.02 d	11.41 d	2.68 a	22.42 c
F_1	91.26 c	12.58 c	2.30 b	23.68 b
F_2	93.03 b	13.82 b	1.73 c	24.96 a
F_3	94.52 a	14.55 a	1.29 d	25.41 a
$LSD_{(0.05)}$	1.275	0.614	0.236	0.869
Vermicompost × NPKS fertilizer				
V_0F_0	86.04 h	10.50 h	2.88 a	21.51 g
V_0F_1	88.70 fg	11.50 gh	2.63 a-c	23.09 d-g
V_0F_2	90.80 d-f	12.50 e-g	2.10 d-f	23.51 d-f
V_0F_3	94.67 a	13.93 b-d	1.63 fg	24.82 b-d
V_1F_0	86.61 gh	12.10 fg	2.70 a-c	22.18 fg
V_1F_1	89.25 ef	12.10 fg	2.47 a-d	23.03 e-g
V_1F_2	91.21 c-f	13.40 c-e	2.03 d-f	24.51 b-e
V_1F_3	93.50 a-c	14.43 abc	1.30 gh	25.32 bc
V_2F_0	92.05 b-d	12.40 e-g	2.77 ab	22.95 e-g
V_2F_1	93.76 a-c	13.13 def	2.23 c-e	24.57 b-e
V_2F_2	94.33 ab	14.10 a-d	1.87 ef	24.55 b-e
V_2F_3	94.81 a	14.97 ab	0.97 h	25.67 abc
V_3F_0	91.38 c-e	10.63 h	2.37 b-d	23.02 e-g
V_3F_1	93.32 a-d	13.60 c-e	1.87 ef	24.03 c-e
V_3F_2	95.78 a	15.30 a	0.93 h	27.27 a
V_3F_3	95.10 a	14.87 ab	1.27 gh	25.82 ab
$LSD_{(0.05)}$	2.550	1.228	0.472	1.737

Distinct letters in the row indicate significant differences according to LSD ($P \leq 0.05$)
V_0=control, V_1=1 t ha^{-1}, V_2=2 t ha^{-1}, V_3=4 t ha^{-1}; F_0 = control, F_1= (50-8-33-6 kg ha^{-1} N, P, K, S, respectively), F_2 = (100-16-66-12 kg ha^{-1} N, P, K, S, respectively), F_3 = (150-24-99-18 kg ha^{-1} N, P, K, S, respectively)

3.5 Panicle length

Different doses of vermicompost had significant effect on panicle length of rice (Table 3). The highest panicle length (24.52 cm) was found from application of 4 t ha^{-1} vermicompost and the lowest (21.73 cm) was observed from without vermicompost treatment. This might be due to the balanced supply of nutrients from vermicompost which enhanced panicle length. Different doses of NPKS fertilizer showed significant variation on the panicle length of rice (Table 3). The longest panicle (25.74 cm) was observed from 150-24-99-18 kg ha^{-1} NPKS fertilizer and the shortest (21.47 cm) was recorded from control treatment where no fertilizer was applied. Hasanuzzaman et al. (2010) also reported the increased panicle length with the application of NPKS fertilizer. These might be due to higher absorption of different fertilizer by the plant that favored to produce the longer panicle. Combined application of different doses of vermicompost and fertilizer had significant effect on panicle length of rice (Table 3). The highest panicle length (27.30 cm) was observed from V_3F_2 and the lowest (19.86 cm) was recorded from V_0F_0. Increase in panicle length in response to combined use of organic and inorganic fertilizers is might be due to more availability of macro as well as micro nutrients (Awan et al., 2011). Rahman et al. (2009) also reported similar results.

Table 3. Effect of vermicompost and/or NPKS fertilizer on panicle length, number of filled grains panicle^{-1}, unfilled grains panicle^{-1} and 1000-grain weight of rice

Treatments	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (g)
Vermicompost				
V_0	21.73 d	149.8 c	21.93 a	21.89 b
V_1	22.67 c	165.9 bc	20.92 ab	22.27 ab
V_2	23.77 b	167.3 b	20.65 b	22.33 ab
V_3	24.52 a	185.2 a	18.99 c	22.88 a
LSD $_{(0.05)}$	0.469	17.020	1.108	0.921
NPKS fertilizer				
F_0	21.47 c	134.5 c	25.11 a	21.03 b
F_1	21.87 c	160.2 b	21.38 b	22.36 a
F_2	23.61 b	179.8 a	17.42 d	22.75 a
F_3	25.74 a	193.7 a	18.60 c	23.23 a
LSD $_{(0.05)}$	0.469	17.02	1.108	0.921
Vermicompost × NPKS fertilizer				
V_0F_0	19.86 i	102.7 g	26.77 a	19.70 e
V_0F_1	21.15 f-h	147.7 ef	21.57 c-e	21.67 b-d
V_0F_2	21.54 fg	161.0 c-f	20.27 d-f	22.63 a-d
V_0F_3	23.34 e	188.0 a-d	19.13 fg	23.57 a
V_1F_0	20.49 hi	142.9 f	26.90 a	21.00 de
V_1F_1	21.03 gh	146.1 ef	23.27 bc	22.17 a-d
V_1F_2	22.08 f	178.8 a-e	17.93 gh	22.87 a-c
V_1F_3	23.88 de	195.7 ab	15.60 i	23.03 a-c
V_2F_0	21.89 fg	133.9 fg	24.20 b	22.03 a-d
V_2F_1	23.45 e	162.0 b-f	21.73 cd	22.60 a-d
V_2F_2	24.17 c-e	178.9 a-e	19.37 e-g	22.20 a-c
V_2F_3	24.95 c	194.4 a-c	17.30 g-i	22.50 a-d
V_3F_0	24.67 cd	158.6 d-f	22.57 bc	21.40 c-e
V_3F_1	25.06 bc	184.9 a-d	18.93 f-h	23.00 a-c
V_3F_2	27.30 a	200.4 a	17.63 g-i	23.83 a
V_3F_3	25.91 b	196.8 a	16.83 hi	23.30 ab
LSD $_{(0.05)}$	0.937	34.030	2.217	1.843

Distinct letters in the row indicate significant differences according to LSD ($P \leq 0.05$)
V_0=control, V_1=1 t ha^{-1}, V_2=2 t ha^{-1}, V_3=4 t ha^{-1}; F_0 = control, F_1= (50-8-33-6 kg ha^{-1} N, P, K, S, respectively), F_2 = (100-16-66-12 kg ha^{-1} N, P, K, S, respectively), F_3 = (150-24-99-18 kg ha^{-1} N, P, K, S, respectively)

3.6 Filled grains panicle^{-1}

The number of filled grain is the next important component of rice yield (Kaushal et al., 2010). Filled grain panicle^{-1} of rice was significantly influenced by different doses of vermicompost (Table 3). The highest number of filled grains panicle^{-1} (185.2) was found from 4 t ha^{-1} vermicompost application and the lowest (149.8) was observed from control treatment where no vermicompost. Maximum grains panicle^{-1} in 4 t ha^{-1} treatment might be due to availability of macro as well as micro plant nutrients with the addition of organic matter to the soil (Siavoshi et al., 2011). Different doses of NPKS fertilizer had showed significant variation on filled grain panicle^{-1} of rice (Table 3). The maximum filled grains panicle^{-1} (193.70) was found from 150-24-99-18 kg ha^{-1} NPKS fertilizer which was statistically similar with 100-16-66-12 kg ha^{-1} NPKS and the minimum (134.5) was obtained in F_0 treatment where no fertilizer was applied. Hasanuzzaman et al. (2010) reported that 100% of the recommended NPK which was supplied from inorganic fertilizer produced the second highest number of fertile grains per panicle. Combined application of different doses of vermicompost and

NPKS fertilizer had significant effect on filled grains panicle^{-1} of rice (Table 3). The maximum (200.4) filled grains panicle^{-1} was observed from V_3F_2 and it was statistically similar with V_3F_3, V_1F_3, V_2F_3, V_0F_3, V_3F_1, V_2F_2 and V_1F_2 whereas, the minimum (102.70) was observed from V_0F_0 which was statistically similar with V_2F_0 (133.9). Naing et al. (2010) stated that the potential number of grains panicle^{-1} was influenced by the plants' nutritional status. They further reported that combined application of 10 t ha^{-1} FYM with 50-22 kg N-P ha^{-1} resulted in a 30.7 % increase in rice filled grains number per panicle as compared to no fertilizer application. The results were in agreement to those of Sarwar et al. (2007, 2008).

3.7 Unfilled grains panicle^{-1}

Unfilled grains panicle^{-1} of rice was significantly influenced by different doses of vermicompost (Table 3). The highest unfilled grains panicle^{-1} (21.93) was found from control treatment where no vermicompost was applied which was statistically similar with 1 tha^{-1} and the lowest (18.99) was observed from 4 t ha^{-1} treatment. Different doses of NPKS fertilizer had showed significant variation on unfilled grain panicle^{-1} of rice (Table 3). The maximum unfilled grain panicle^{-1} (25.11) was observed from control treatment (no NPKS) and the lowest (18.60) was found from 100-16-66-12 kg ha^{-1} NPKS fertilizer treatment. Combined application of different doses of vermicompost and NPKS fertilizer had significant effect on unfilled grains panicle^{-1} of rice (Table 3). The maximum (26.90) unfilled grains panicle^{-1} was observed from V_1F_0 and it was statistically similar with V_0F_0 and the minimum (15.60) was observed from V_1F_3 which was statistically at par with V_3F_3, V_2F_3 and V_3F_2 treatments. This might be due to the nitrogenous fertilizer which increases vegetative growth resulting decrease the number of filled grains.

3.8 1000-grain weight

Different levels of vermicompost had significant effect on 1000-grain weight of rice (Table 3). The highest 1000-grain weight (22.88 g) was calculated from 4 t ha^{-1} vermicompost application whereas, the lowest (21.89 g) was found from control treatment. 1000-grain weight is mostly mediated by genetic potential but in this case it declines significantly with decreased application of vermicompost as well as with control treatment due to severe deficiency of essential nutrients and hence the plants failed to produce a bold grain. 1000-grain weight of rice significantly influenced by different levels of NPKS fertilizers (Table 3). The highest 1000-grain weight (23.23 g) was calculated from 150-24-99-18 kg ha^{-1} NPKS fertilizer which was statistically similar with 100-16-66-12 kg ha^{-1} and 50-8-33-6 kg ha^{-1} NPKS fertilizer whereas, the lowest (21.03 g) was found from F_0 treatment. Interaction effect of different doses of vermicompost and NPKS fertilizer had significant effect on 1000-grain weight of rice (Table 3). The highest 1000-grain weight (23.83 g) was obtained from V_3F_2 which was statistically similar with V_0F_3, V_3F_3, V_1F_3, V_3F_1, V_1F_2, V_2F_1, V_2F_3, V_2F_2, V_1F_1 and V_2F_0 whereas, the lowest (19.70 g) was recorded from V_0F_0 and it was statistically at par with V_1F_0 and V_3F_0 treatment. Yang et al. (2004) recorded that 1000-grain weight was increased by the application of chemical fertilizer along with organic manure. The increase in grain yield components can be due to the fact that available water enhanced nutrient availability which improved nitrogen and other macro- and micro-elements absorption as well as enhancing the production and translocation of the dry matter content from source to sink (Ebaid and El-Refaee, 2007).

3.9 Grain yield

Different doses of vermicompost showed significant variation on grain yield of rice (Table 4). The highest grain yield (6.99 t ha^{-1}) was obtained from 4 t ha^{-1} vermicompost application and the lowest (5.76 t ha^{-1}) was observed from control treatment. Increase in grain yield due to application of organic matter was observed by Ram et al. (2000); Singh et al. (2001). Significant variation was observed on the grain yield of rice at different doses of NPKS fertilizer (Table 4). The maximum grain yield (7.16 t ha^{-1}) was found from 150-24-99-18 kg ha^{-1} NPKS fertilizer and the lowest (5.14 t ha^{-1}) was observed from F_0 treatment where no fertilizer was applied. Satyanarayana et al. (2002) found significant increase in rice grain yield due to application of NPK fertilizer. Combined application of different doses of vermicompost and NPKS fertilizer had significant effect on grain yield of rice (Table 4). The highest grain yield (7.89 t ha^{-1}) was observed from V_3F_2 and the lowest (4.41 t ha^{-1}) was observed from V_0F_0 and it was statistically similar with V_0F_1 treatment. The yield advantages due to integration of organic sources and inorganic fertilizers over chemical fertilizers alone might be due to the availability of nutrients for a shorter period as mineralization of nitrogen is more rapid and in turn the losses of inorganic nitrogen due to volatilization, de-nitrification and leaching etc., would be more. Sarwar et al. (2008); Ali et al. (2012) also claimed increased yields of rice with the use of organic manures alone or in combination with chemical fertilizers.

Table 4. Effect of vermicompost and/or NPKS fertilizer on grain yield, straw yield, biological yield and harvest index of rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Vermicompost				
V_0	5.76 c	6.12 d	11.88 d	48.24 a
V_1	6.33 b	7.04 c	13.37 c	47.19 ab
V_2	6.56 b	7.51 b	14.07 b	46.58 b
V_3	6.99 a	8.04 a	15.02 a	46.36 b
LSD $_{(0.05)}$	0.291	0.318	0.44	1.65
NPKS fertilizer				
F_0	5.14 d	6.48 c	11.62 d	44.15 c
F_1	6.48 c	6.72 c	13.20 c	49.14 a
F_2	6.86 b	7.39 b	14.25 b	48.22 ab
F_3	7.16 a	8.11 a	15.27 a	46.86 b
LSD $_{(0.05)}$	0.291	0.318	0.44	1.65
Vermicompost × NPKS fertilizer				
V_0F_0	4.41 e	5.42 j	9.91 j	44.52 f-h
V_0F_1	4.92 de	6.43 i	11.35 hi	43.35 h
V_0F_2	5.30 d	6.69 g-i	11.99 h	44.20 gh
V_0F_3	5.93 c	7.30 e-g	13.23 fg	44.82 f-h
V_1F_0	5.30 d	5.50 j	10.72 ij	49.47 a-c
V_1F_1	6.70 b	6.63 hi	13.33 fg	50.29 ab
V_1F_2	6.89 b	7.09 f-h	13.98 d-f	49.26 a-c
V_1F_3	7.03 b	7.75 c-e	14.79 b-d	47.55 a-f
V_2F_0	6.59 b	6.42 i	13.02 g	50.64 a
V_2F_1	6.79 b	7.09 f-h	13.89 e-g	48.91 a-d
V_2F_2	6.94 b	7.69 d-f	14.64 c-e	47.42 a-f
V_2F_3	7.09 b	8.35 a-c	15.44 bc	45.92 d-h
V_3F_0	6.73 b	7.15 e-h	13.88 e-g	48.49 a-e
V_3F_1	6.91 b	8.02 b-d	14.93 bc	46.30 c-h
V_3F_2	7.89 a	8.73 a	16.62 a	47.47 e-h
V_3F_3	7.12 b	8.54 ab	15.66 b	45.49 b-g
LSD $_{(0.05)}$	0.582	0.635	0.879	3.300

Distinct letters in the row indicate significant differences according to LSD ($P \leq 0.05$)
V_0=control, V_1=1 t ha^{-1}, V_2=2 t ha^{-1}, V_3=4 t ha^{-1}; F_0 = control, F_1= (50-8-33-6 kg ha^{-1} N, P, K, S, respectively), F_2 = (100-16-66-12 kg ha^{-1} N, P, K, S, respectively), F_3 = (150-24-99-18 kg ha^{-1} N, P, K, S, respectively)

3.10 Straw yield

Different doses of vermicompost showed significant variation on straw yield of rice (Table 4). The maximum straw yield (8.04 t ha^{-1}) was obtained from application of 4 t ha^{-1} vermicompost and the minimum (6.12 t ha^{-1}) was found from control treatment. Straw yield of rice was significantly increased by 12 %, over no farmyard manure (Satyanarayana et al., 2002). Significant variation was observed on straw yield of rice at different doses of NPKS fertilizer (Table 4). The highest (8.11 t ha^{-1}) straw yield was observed from 150-24-99-18 kg ha^{-1} NPKS fertilizer and the lowest (6.48 t ha^{-1}) was found from control treatment and it was statistically similar with 50-8-33-6 kg ha^{-1} NPKS fertilizer. Satyanarayana et al. (2002) observed a significant increase in straw yield of rice due to application of NPK fertilizer. Combined application of different doses of vermicompost and NPKS fertilizer had significant effect on straw yield of rice (Table 4). The highest straw yield (8.73 t ha^{-1}) was obtained from V_3F_2 and it was statistically similar with V_3F_3 and V_2F_3 whereas, the lowest (5.42 t ha^{-1}) was recorded from V_0F_0 which was statistically at par with V_1F_0 treatment. Organic manure in combination with inorganic fertilizers might be increased the vegetative growth of plants and thereby increased straw yield of rice. Rahman et al. (2009) reported that the application of organic manure and chemical fertilizers increased the straw yields of rice. These findings are corroborated with the work of Hasanuzzaman et al. (2010).

3.11 Biological yield

Different doses of vermicompost showed significant variation on biological yield of rice (Table

4). The highest biological yield (15.03 t ha^{-1}) was obtained from 4 t ha^{-1} vermicompost and the lowest (11.88 t ha^{-1}) was observed from control treatment. Significant variation was observed on the biological yield of rice at different doses of NPKS fertilizer (Table 4). The maximum biological yield (15.27 t ha^{-1}) was found from 150-24-99-18 kg ha^{-1} NPKS fertilizer and the minimum (11.62 t ha^{-1}) was obtained from F_0 treatment where no fertilizer was applied. Combined application of different doses of vermicompost and NPKS fertilizer had significant effect on biological yield of rice (Table 4). The highest biological yield (16.62 t ha^{-1}) was obtained from V_3F_2 and the lowest (9.83 t ha^{-1}) was observed from V_0F_0 which was statistically similar with V_1F_0 treatment. Higher biological yield might be due to the increase in growth and yield attributes (Ebaid and El-Refaee, 2007). Organic matter provided the micro nutrients and increased the cation exchange capacity of soil thus improved nutrients availability which in combinations with inorganic fertilizers enhanced the growth and yield (Rani et al., 2001).

3.12 Harvest index

Significant variation was observed on the harvest index of rice when the field was incorporated with different doses of vermicompost (Table 4). The highest harvest index (48.48 %) was obtained from control which was statistically similar with 1 t ha^{-1} whereas, the lowest (46.54 %) was observed from 4 t ha^{-1} which was statistically similar with 2 t ha^{-1} treatment. Different doses of NPKS fertilizer showed significant variation on the harvest index of rice (Table 4). The highest harvest index (49.09 %) was observed from F_1 which was statistically similar with F_2 whereas, the lowest (44.23 %) was obtained from control treatment, where no fertilizer was applied. Combined application of different doses of vermicompost and NPKS fertilizer had significant effect on harvest index of rice (Table 4). The highest harvest index (50.61 %) was found from V_2F_0 and it was statistically similar with V_1F_1, V_1F_0, V_1F_2, V_2F_1, V_3F_0, V_1F_3 and V_2F_2 whereas, the lowest (43.35 %) was observed from V_0F_1, which was statistically similar with V_0F_2, V_0F_0, V_0F_3, V_2F_3, V_3F_1 and V_3F_2 treatment. Higher yield and harvest index due to poultry manure and recommended fertilizer indicates better partitioning of photosynthetic substance to economic yield. Appreciably high harvest index shows the efficiency of converting biological yield into economic yield (Kusalkar et al., 2003).

4. Conclusion

All the treatments showed significant influence on growth and productivity of rice. Form the present study it was observed that 4 t ha^{-1} vermicompost and 100, 16, 66, 12 kg ha^{-1} NPKS fertilizers gave the best result. Our results indicated that, organic fertilizer can be a better supplement of inorganic fertilizer to roduce better growth and yield of rice.

Corresponding Author:
Md. Nazmul Haque
Department of Agronomy, Faculty of Agriculture,
Sher-e-Bangla Agricultural University,
Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh.
E-mail: sumon2539@gmail.com

References

1. Agrawal SB, Singh A, Singh GD, Dwivedi A. Effect of vermicompost, farmyard manure and chemical fertilizers on growth and yield of wheat (*Triticum aestivum* L. var. HD 2643). Plant archives 2003;3:9-14.
2. Ali RI, Awan TH, Ahmad M, Saleem MU, Akhtar M. Diversification of rice-based cropping systems to improve soil fertility, sustainable productivity and economics. Journal of Animal and Plant Sciences 2012;22(1):108-112.
3. Awan TH, Ali RI, Manzoor Z, Ahmad M, Akhtar M. Effect of different nitrogen levels and row spacing on the performance of newly evolved medium grain rice variety, KSK-133. The Journal of Animal and Plant Sciences 2011;21(2):231-34.
4. Ebaid RA, El-Refaee IS. Utilization of rice husk as an organic fertilizer to improve productivity and water use efficiency in rice fields. African Crop Science Conference Proceedings 2007;8:1923-1928.
5. Guera RD. Vermicompost production and its use for crop production in the Philippines. International Journal of Global Environmental Issues 2010;10(3-4):378-383. doi:10.1504/IJGENVI.2010.037278
6. Hasanuzzaman M, Ahamed KU, Rahmatullah NM, Akhter N, Nahar K, Rahman ML. Plant growth characters and productivity of wetland rice (*Oryza sativa* L.) as affected by application of different manures. Emirates Journal of Food and Agriculture 2010;22(1):46-58.
7. Hossaen MA, Shamsuddoha ATM, Paul AK, Bhuiyan MSI, Zobaer ASM. Efficacy of different organic manures and inorganic fertilizer on the yield and yield attributes of Boro rice. The Agriculturists 2011;9(1&2):117-125.
8. Jobe. Integrated Nutrient Management for Increased Rice Production in the Inland Valleys of The Gambia. In: Sanyang S., A. Ajayi and A. A. Sy (eds). Proc. 2nd Biennial Regional Rice Research Review. WARDA Proceedings Series No. 2003;2(1):35-41.

9. Kaushal AK, Rana NS, Singh A, Neeray S, Strivastav A. Response of levels and split application of nitrogen is green manured wetland rice (*Oryza sativa* L.). Asian Journal of Agricultural sciences 2010;2(2):42-46.
10. Kusalkar DV, Awari VR, Pawar VY, Shinde MS. Physiological parameters in relation to grain yield in rabi sorghum on medium soil. Advances in Plant Sciences 2003;16(1):119-22.
11. Mahajan A, Bhagat RM, Gupta RD. Integrated nutrient management in sustainable rice-wheat cropping system for food security in India. SAARC Journal of Agriculture 2008;6(2):149-163.
12. Masarirambi MT, Mandisodza FC, Mashingaidze AB, Bhebhe E. Influence of plant population and seed tuber size on growth and yield components of potato (*Solanum tuberosum*). International Journal of Agriculture and Biology 2012;14(4):545-549.
13. Miller HB. Poultry litter induces tillering in rice. Journal of sustainable agriculture 2007;31(1):1-12.
14. Naing A, Banterng P, Polthanee A, Trelo-Ges V. The effect of different fertilizers management strategies on growth and yield of upland black glutinous rice and soil property. Asian Journal of Plant Sciences 2010;9(7):414-422.
15. Narwal RP, Chaudhary M. Effect of long-term application of FYM and fertilizer N on available P, K and S content of soil. In: 18th world congress of soil science, 9-15 July, Philadelphia, Pennsylvania, USA, 2006.
16. Nayak DR, Babu X, Adhya TK. Long-term application of compost influences mineral biomass and enzyme activities in a tropical Aeric Endoaquept planted to rice under flooded condition. Soil Biology and Biochemistry 2007;39(8):1897-1906.
17. Ohajianya DO, Onyenweaku CE. Farm size and relative efficiency in rice production in Ebonyi State, Nigeria. Modeling Simulation Coni, D, 23, 2002;1-16.
18. Rahman MS, Islam MR, Rahman MM, Hossain MI. Effect of cowdung, poultry manure and urea-N on the yield and nutrient uptake of BRRI dhan29. Bangladesh Research Publications Journal 2009;2(2):552-558.
19. Rakshit A, Sarkar NC, Debashish S. Influence of organic manures on productivity of two varieties of rice. Journal of Central European Agriculture 2008;9(4):629-633.
20. Ram S, Chauhan RPS, Singh BB, Singh VP. Integrated use of organic and fertilizer nitrogen in rice (*Oryza sativa*) under partially reclaimed sodic soil. Indian Journal of Agricultural Science 2000;70(2):114-116.
21. Ramalakshmi ChS, Rao PC, Sreelatha T, Mahadevi M, Padmaja G, Rao PV, Sireesha A. Nitrogen use efficiency and production efficiency of rice under rice-pulse cropping system with integrated nutrient management. Journal of Rice Research 2012;5(1&2):42-51.
22. Rani R, Srivastava OP, Rani R. Effect of integration of organics with fertilizer N on rice and N uptake. Fertilizer News 2001;46:63-65.
23. Russell OF. MSTAT-C v.2.1 (a computer based data analysis software). Crop and Soil Science Department, Michigan State University, USA, 1994.
24. Sarker MAR, Pramanik MYA, Faruk GM, Ali MY. Effect of green manures and levels of nitrogen on some growth attributes of transplant aman rice. Pakistan Journal of Biological Sciences 2004;7:739-742.
25. Sarwar G, Hussain N, Mohammad S. Use of compost and environment friendly technology for enhancing rice-wheat production in Pakistan. Pakistan Journal of Botany 2007;39(5):1553-1558.
26. Sarwar G, Schmeisky H, Hussain N, Mohammad S, Safdar E. Improvement of soil physical and chemical properties with compost application in rice-wheat cropping system. Pakistan Journal of Botany 2008;40(1):275-282.
27. Satyanarayana V, Prasad PV, Murthy VRK, Boote KJ. Influence of integrated use of farmyard manure and inorganic fertilizers on yield and yield components of irrigated lowland rice. Journal of plant nutrition 2002;25(10):2081-2090.
28. Sharma DK, Prasad K, Yadav SS. Effect of integrated nutrient management on the performance of dwarf scented rice (*Oryza sativa* L.) growth in rice wheat sequence. International Journal of Agricultural Sciences 2008;4(2):660-662.
29. Siavoshi M, Nasiri A, Laware SL. Effect of organic fertilizer on growth and yield components in rice (*Oryza sativa* L.). Journal of Agricultural science 2011;3(3):217-24.
30. Singh R, Agarwal SK. Analysis of growth and productivity of wheat in relation to levels of FYM and nitrogen. Indian Journal of Plant Physiology 2001;6(3):279-283.
31. Singh SK, Varma SC, Singh RP. Effect of integrated nutrient management on yield, nutrient uptake and changes in soil fertility under rice (*Oryza sativa*) - lentil (*Lens culinaris*) cropping system. Indian Journal of Agronomy 2001;46(2):191-197.

32. Song Y, Yao Z. Effect of application of fertilizer NPK combined with organic manure on growth characteristics and yield of winter wheat. Beijing Agricultural Science 2001;19(5):15-17.
33. Tejada M, Gonzaler JL. Application of two vermicompost on a rice crop: effects on soil biological properties and rice quality and yield. Agronomy Journal 2009;101(2):336-344. doi: 10.2134/agronj2008.0211
34. Usman M, Ullah E, Warriach EA, Farooq M, Liaqat A. Effect of organic and inorganic manures on growth and yield of rice variety "Basmati-2000". International Journal of Agriculture and Biology 2003;5:481-83.
35. Yang CM, Yang L, Yang Y, Ouyang Z. Rice root growth and nutrient uptake as influenced by organic manure in continuously and alternately flooded paddy soils. Agricultural Water Management 2004;70(1):67-81.

2/1/2016