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Influence of integrated use of cotton seed oilcake and mustard oilcake with chemical fertilizers on growth, yield and nutritional quality of rice

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Abstract

Cotton seed oilcake and mustard oilcake are excellent and high quality organic manures enriched with essential nutrient elements. A field experiment was carried out at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during boro season of 2019 to investigate the influence of cotton seed oilcake and mustard oilcake on yield attributes, yield, nutrient content and uptake by rice cv. BRRI dhan29. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications and seven treatments viz. T_1: control, T_2: 100% Recommended Fertilizer Dose (RFD), T_3: 50% RFD, T_4: 50% nitrogen (N) from RFD + 50% N from cotton seed oilcake, T_5: 50% N from RFD + 50% N from mustard oilcake, T_6: 50% N from RFD + 25% N from cotton seed oilcake + 25% N from mustard oilcake, T_7: 50% N from cotton seed oilcake + 50% N from mustard oilcake. The maximum values of all the yield components viz. plant height, panicle length, number of effective tillers hill^{-1} and filled grains panicle^{-1} and yields (grain and straw) were found in treatment T_2. The highest content and uptake of nutrients – N, P, K and S were also recorded in T_2. The performance of T_4 and T_2 was statistically similar in producing yield parameters, grain and straw yields, nutrient contents and uptake by rice. Among the integrated approaches, the performance of T_4 was the best as it produced the second highest grain yield of 6.24 t ha^{-1} and straw yield of 8.17 t ha^{-1} with higher nutritional improvement of rice. Application of cotton seed oilcake compensated up to 50% of chemical fertilizer. Therefore, considering the significance of organic manures and soil health, cotton seed oilcake should be considered for application in association with chemical fertilizers for yield enhancement and nutritional improvement of rice.

Key words: Cotton seed oilcake, mustard oilcake, rice, organic manures, yield and nutritional improvement

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Introduction

Rice (*Oryza sativa*) is the staple food grain of about 150 million Bangladeshi people which largely contributes one-half of the agricultural GDP and one-sixth of the national income. This cereal crop provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average person in the country (BBS, 2018). Rice farming is inextricably related to households and national food security, poverty alleviation, improvement of nutrition and public health, political and economic stability, and overall growth and development of Bangladesh (Roy *et al.*, 2014). The total area and production of rice in Bangladesh are 11.62 million hectares and 36.28 million metric tons, respectively in the year 2017-18 (YAS, 2018). Although Bangladesh ranks 4th in the world in terms of both acreage and production but the yield of rice is much lower compared to that in other leading rice

growing countries such as Japan, China, Korean Republic and USA (FAO, 2014). Soil fertility deterioration has become a major limitation for better crop production in Bangladesh. The increasing cropping intensity with imbalanced use of chemical fertilizers and little or no use of organic manures have caused serious fertility deterioration problem in our soils and in some cases stagnating or even declining crop productivity. The most serious threat to sustainable agriculture is the depletion of soil organic matter which results in low fertility and productivity. Soil organic matter contributes to soil fertility and improves crop productivity through its positive effects on soil chemical, physical and biological properties. Besides, it serves as a reservoir of nutrients such as N, P and S for plant growth and also prevents leaching loss of the nutrients. A good soil should contain at least 2.5% organic matter, but most of soils in Bangladesh have less than 1.5% and even some soils have less than 1% organic matter (BARC, 2005). Losses of soil organic matter can be replenished by the application of organic manures that are cheap, friendly to our environment and are effective sources of nutrients for most crops. Maintaining organic matter in soil is the best option for sustainable crop production to ensure food security of the ever rising populations (Hossain, 2019).

Nitrogenous fertilizer is the key input for rice production and optimum dose of N fertilization plays a vital role in growth and development of rice (Esmaeilzade-Moridani *et al.,* 2013). An increase in yield by 70-80% in field rice could be obtained by the application of nitrogenous fertilizer (IFC, 1982). Excessive N fertilization causes significant environmental hazards, such as increased greenhouse gas emission, groundwater contamination, and surface water eutrophication etc. (Mahajan *et al.*, 2008; Cai *et al.*, 2018). Furthermore, long-term N fertilizer application in arable lands has increased soil acidification, degradation, and compaction resulting in inhibition of crop production (Guo *et al.*, 2017; Yue *et al.*, 2012). Therefore, the dependency on synthetic N fertilizer for crop production should be reduced and it is crucial to develop eco-friendly and sustainable management practices. Use of organic manures helps maintain soil nutrient balance, improves soil structure, and water holding capacity, and is helpful for conservation of environment in comparison to the application of chemical fertilizers alone (Mwangi, 2010). As sole application of organic manures cannot fulfill the nutrient requirement of a crop, it is wise to apply organic and inorganic sources of nutrients in combination. Among the different organic manures available in Bangladesh, cotton seed oilcake (CSOC) and mustard oilcake (MOC) are highly valued because both of them contain high amount of macro and micro nutrients that are released slowly in soil. Cotton seed in oilcakes and mustard oilcake are the residues that remain after extracting the oil from the seeds of cotton and mustard, respectively. Both CSOC and MOC are beneficial for soil health and safe for the environment. Urea in combination with cotton seed oilcake and mustard oilcake is an important aspect of N management in rice production from the view point of its efficient utilization. Combined use of organic manures and inorganic NPKS fertilizers would be quite promising not only in providing greater stability in rice production, but also in maintaining higher soil fertility status. Keeping these points in view, the present study was undertaken to evaluate the effects of integrated use of cotton seed oilcake and mustard oilcake with chemical fertilizers on the growth, yield, nutrient content and uptake of BRRI dhan29.

Materials and Methods

The research work was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University (BAU), Mymensingh during boro season from January to May, 2019. The geographical location of the field is 24°75′ N latitude and 90°50′ E longitude at the elevation of 18 m above the sea level. The site belongs to the Sonatala series under AEZ 9 (Old Brahmaputra Floodplain) having non-calcareous dark grey floodplain soils. The land was medium high in

topography, moderately well drained and sufficient sunshine was available throughout the experimental period. The soil was silt loam in texture having pH 6.69, organic matter content 1.19%, total N 0.13%, available P 11.26 ppm, exchangeable K 0.14 me% and available S 14.5 ppm.

The experiment was laid out in a randomized complete block design (RCBD), where the experimental area was divided into 4 blocks representing the replications and each block was sub-divided into 7 unit plots with raised bunds as treatments. Thus, the total number of unit plot was (4 ×7) = 28. The unit plot size was 2.5 m x 4 m and plots were separated from each other by ails (25 cm). Unit blocks were separated from one another by drains (1 m) and treatments were randomly distributed within the block. The treatments were T_1: control, T_2 : 100% RFD, T_3 : 50% RFD, T_4 : 50% N from RFD + 50% N from cotton seed oilcake, T_5 : 50% N from RFD + 50% N from mustard oilcake, T_6 : 50% N from RFD + 25% N from cotton seed oilcake + 25% N from mustard oilcake, T_7 : 50% N from cotton seed oilcake + 50% N from mustard oilcake. Thirty-day-old rice seedlings were carefully uprooted from a seedbed and transplanted into well puddled unit plots. Plant spacing was 20 cm x 20 cm and three healthy seedlings were transplanted in each hill. Cotton seed oilcake and mustard oilcake (in the form of powder) were mixed thoroughly with soil and incorporated in the plots as per the treatment at 7 days before transplanting of the rice seedlings. The doses of N, P, K, S and Zn were 144, 21, 60, 8 and 1.5 kg ha^{-1}, respectively following the Fertilizer Recommendation Guide (FRG, 2018) in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc oxide, respectively. The full doses of TSP, MoP and gypsum were applied during final land preparation to all the experimental plots. Urea was applied in three equal splits as top dressing. The first installment was applied at 15 days after transplanting (DAT) i.e. at seedling establishment stage, second installment at 30 DAT i.e. at maximum tillering stage and third installment at 50 DAT i.e. panicle initiation stage of the crop.

Various intercultural practices including irrigation, weeding, drainage, pest control etc. were performed as and when necessary. The crop was harvested at full maturity on the 15 May, 2019 and the data on the yield and yield parameters were recorded. Five hills were randomly selected from each plot and data on plant height, number of effective tillers $hill^{-1}$, panicle length, number of filled grains $panicle^{-1}$ and 1000-grain weight were recorded. The grain yield was obtained on 14% moisture basis while the straw yield was determined on sun-dry basis. The representative grain and straw samples were dried in an oven at 65°C for about 48 hours and then ground by a grinding machine. The ground samples were passed through a 20-mesh sieve, stored in paper bags and finally kept in desiccators for chemical analysis. The content of N, P, K and S in plant samples were determined following semi-micro Kjeldahl method (Bremner and Mulvaney, 1982), modified Olsen method (Olsen et al., 1954), NH_4OAc extraction method (Knudsen *et al.*, 1982), and $CaCl_2$ extraction method (Williams and Steinbergs, 1959), respectively. The nutrient uptakes were calculated from the yield (kg ha^{-1}) and nutrient content (%) data. The collected manure samples were air dried for several days under shaded condition, cleaned to remove extraneous materials, ground and mixed thoroughly. The moisture content of the manures was measured by gravimetric method according to the standard protocol (STPM, 2008). In the manures, the total N was determined by the Kjeldahl method (Bremner and Mulvaney, 1982) and for measuring total P and K, ground manure samples were digested using HNO_3-$HClO_4$ (3:1) di-acid mixture as described by Piper (1966) and the contents of P and K were measured by spectrophotometer and flame photometer, respectively according to the methods as suggested by Yamakawa (1992). The chemical composition of the organic manures is shown in Table 1.

Table 1. Chemical composition of organic manures.

Organic manures	Moisture (%)	N (%)	P %)	K (%)
Cotton seed oilcake	15	3.9	1.8	1.6
Mustard oilcake	16.5	4.5	1.5	1.2

The analysis of variance for different crop characters as well as for different nutrient concentrations of the treatments was made and the mean differences were adjudged by Duncan's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

***Effect of different treatments on the yield components of rice (BRRI dhan29)*:** Yield contributing characters such as plant height, panicle length, number of effective tiller hill^{-1} and number of filled grains panicle^{-1} of BRRI dhan29 were significantly influenced by different treatments under study while weight of 1000-grain remained statistically unaffected (Table 2). The tallest plant (84.75 cm), maximum number of effective tillers hill^{-1} (13.87), highest panicle length (25.40 cm), maximum number of filled grains panicle^{-1} (153) and highest weight of 1000-grain (23.75 g) were found in T_2 (100% RFD) which were statistically identical to those observed in T_4 (50% N from RFD + 50% N from cotton seed oilcake). The treatment T_4 produced the second highest values for plant height (84.71 cm), number of effective tillers hill^{-1} (13.83), panicle length (25.38), number of filled grains panicle^{-1} (150) and 1000-grain weight (23.71 g). On the other hand, the shortest plant (70.50 cm), minimum number of effective tillers hill^{-1} (7.60), lowest panicle length (19.75 cm), minimum number of filled grains panicle^{-1} (72) and lowest weight of 1000-grain (22.25 g) were found in T_1 (control).

Table 2. Effect of different treatments on the yield components of BRRI dhan29 rice.

Treatments	Plant height (cm)	Number of effective tillers hill^{-1}	Panicle length (cm)	Number of filled grains panicle^{-1}	1000-grain weight (g)
T_1	70.50e	7.60e	19.75e	72 e	22.25
T_2	84.75a	13.87a	25.40 a	153 a	23.75
T_3	80.80c	11.07c	23.63 c	132cd	23.62
T_4	84.71a	13.83 a	25.38a	150ab	23.71
T_5	82.63b	12.77b	24.45b	140bc	23.69
T_6	82.60b	12.80b	24.42b	144ab	23.67
T_7	78.63d	10.93d	22.53d	128d	22.64
CV%	0.04	0.37	0.20	3.51	0.10
SE (±)	0.03	0.04	0.04	3.77	0.02
Level of significance	**	**	**	**	NS

Figures in a column having common letters do not differ significantly at 1% level of significance. CV (%) = Coefficient of variation; SE (±) = Standard error of means; ** = Significant at 1% level of probability.

These results are in agreement with those of many researchers who reported significantly better yield contributing characters such as plant height, panicle length, number of effective tillers hill^{-1} and filled grains

panicle^{-1} and 1000-grain weight of rice by using organic manures with chemical fertilizers (Singh *et al.*, 2006; Satyanarayana *et al.*, 2002; Hasanuzzaman *et al.*, 2010; Siavoshi *et al.*, 2011, 2013; Arif *et al.*, 2014; Moe *et al.*, 2017, 2019; Naorem, 2018; Hoque *et al.*, 2018). Better growth under combination of concentrated organic manure and inorganic fertilizer treatments resulted in higher yield contributing characters in rice. In the early stage of plant growth, inorganic fertilizers provide readily available forms of nutrients while cotton seed oilcake releases nutrients as undergo mineralization which requires time for utilization by plants.

***Effect of different treatments on the yield of rice*:** Integrated use of organic manures and chemical fertilizers exerted significant positive effects on grain yield and straw yield of BRRI dhan29 (Table 3). The highest grain yield of 6.25 t ha^{-1} and straw yield of 8.175 t ha^{-1} were recorded in T_2 (100% RFD) and the lowest grain yield of 3.10 t ha^{-1} and straw yield of 3.48 t ha^{-1} were found in T_1 (control). The treatment T_4 (50% N from RFD + 50% N from cotton seed oilcake) showed statistically similar behavior with T_2 and it produced the second highest grain yield of 6.24 t ha^{-1} and straw yield of 8.17 t ha^{-1}. The percent increase in rice yield over control ranged from 29.89 to 50.37 for grain and 45.41 to 57.43 for straw where T_2 gave the highest yield increase over control. In case of both grain yield and straw yield, the treatments may be ranked in the order $T_2 > T_4 > T_6 > T_5 > T_3 > T_7 > T_1$. The results of the present study are also in agreement with the findings of many researchers (Asit *et al.*, 2007; Khan *et al.*, 2007; Ali *et al.*, 2009; Hasanuzzaman *et al.*, 2010; Alim, 2012; Bilkis *et al.*, 2017; Moe *et al.*, 2017, 2019; Naorem, 2018; Hoque *et al.*, 2018). Importantly, cotton seed oilcake is a nutrient-rich concentrated organic amendment that contains adequate amount of macronutrients like N, P and K for plant of which N is dominant (Chandra, 2005). The positive effect of cotton seed oilcake when applying together with chemical fertilizers may be attributed to the nutrient enrichment of the compost because most of the nutrients in the compost can be up taken by plants easily.

Table 3. Effect of different treatments on the grain and straw yield of BRRI dhan29 rice.

Treatments	Grain yield (t ha^{-1})	Increase over control (%)	Straw yield (t ha^{-1})	Increase over control (%)
T_1	3.10e	-	3.48e	-
T_2	6.25 a	50.37	8.18 a	57.43
T_3	5.16c	39.93	6.69c	47.98
T_4	6.24a	50.32	8.17 a	57.41
T_5	5.94b	47.81	7.97b	56.36
T_6	5.95b	47.87	7.98b	56.50
T_7	4.43d	29.89	6.38d	45.41
CV%	0.05	-	0.04	-
SE (±)	2.12	-	2.39	-
Level of significance	**	-	**	-

Figures in a column having common letters do not differ significantly at 1% level of significance. CV (%) = Coefficient of variation; SE (±) = Standard error of means; ** = Significant at 1% level of probability.

***Effect of different treatments on nutrients content in grain and straw of rice*:** The nutrients contents in grain and straw of BRRI dhan29 were significantly influenced by the different treatments (Table 4). In case of grain, the highest contents of N (0.98%), P (0.21%), K (0.24%) and S (0.15%) were observed in T_2 (100% RFD) which were identical to those found in T_4 (50% N from RFD + 50% N from cotton seed oilcake). Again, the lowest contents of N (0.75%), P (0.10%), K (0.15%) and S (0.08%) were noted in T_1 where no fertilizer was applied. In case of straw, the maximum contents of N (0.68%), P (0.09%), K (1.61%) and S (0.26%) were also recorded in T_2 which was identical to those observed in T_4 and the lowest contents of N (0.37%), P (0.05%), K (1.05%) and S (0.12%) were noted in T_1. Our results are partially accorded to the findings of Myint *et al.* (2010) and Hoque *et al.* (2018) who revealed increased nutrient contents in rice grain and straw due to application of organic manures and chemical fertilizers.

Table 4. Effect of different treatments on nutrients content in grain and straw of BRRI dhan29 rice.

Treatments	% N		% P		% K		% S	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	0.75 d	0.37 e	0.10 c	0.05 c	0.15 d	1.05 e	0.08 c	0.12 c
T_2	0.98 a	0.68 a	0.21 a	0.09 a	0.24 a	1.61 a	0.15 a	0.26 a
T_3	0.87 b	0.57 c	0.15 abc	0.08 b	0.18 bcd	1.48 c	0.12 b	0.19 b
T_4	0.96 a	0.66 a	0.21 a	0.09 a	0.23 a	1.58 ab	0.15 a	0.26 a
T_5	0.87 b	0.59 bc	0.18 ab	0.09 a	0.21 abc	1.52 bc	0.15 a	0.25 a
T_6	0.90 b	0.61 b	0.19 a	0.09 a	0.22 ab	1.54 bc	0.15 a	0.24 a
T_7	0.82 c	0.42 d	0.13 bc	0.08 b	0.17 cd	1.41 d	0.09 c	0.14 c
CV%	1.79	12.71	12.96	3.26	10.0	1.68	3.19	6.01
SE (±)	0.01	0.02	0.01	2.12	0.02	0.02	3.32	0.01
Level of significance	**	**	**	**	**	**	**	**

Figures in a column having common letters do not differ significantly at 1% level of significance. CV (%) = Coefficient of variation; SE (±) = Standard error of means; ** = Significant at 1% level of probability.

***Effect of different treatments on nitrogen and phosphorus uptake by grain and straw of rice*:** Application of cotton seed oilcake in association with chemical fertilizers significantly affected N and P uptake by rice grain, straw and in total (grain + straw) (Table 5). The values for N uptake in grain, straw and total varied from 223.27 to 661.25, 112.88 to 555.59 and 336.15 to 1116.84 kg ha^{-1}, respectively. On the other hand, the values for grain P uptake, straw P uptake and total P uptake ranged from 3.10 to 13.13, 1.77 to 7.36 and 4.88 to 20.49 kg ha^{-1}, respectively. For both N and P uptake (grain, straw and total), the maximum values were obtained from T_2 (100% RFD) which were identical to those found in T_4 (50% N from RFD + 50% N from cotton seed oilcake) and the minimum values were recorded in control (T_1). Increased uptake of N and P in rice was also reported by Al-Gusaibi (2004), Puli *et al.* (2017), Bilkis *et al.* (2017), Hoque *et al.* (2018) and Roy *et al.* (2018).

***Effect of different treatments on potassium and sulphur uptake by grain and straw of rice*:** Integrated use of cotton seed oilcake and chemical fertilizers showed significant influence on K and S uptake by rice grain, straw and in total (grain + straw) (Table 6). The values for K uptake in grain, straw and total ranged from 6.05 to 15, 36.54 to 131.62 and 42.59 to 146.62

kg ha^{-1}, respectively. Again, the values for grain S uptake, straw S uptake and total S uptake varied from 2.48 to 9.50, 4.18 to 21.26 and 6.66 to 30.76 kg ha^{-1}, respectively.

Table 5. Effect of different treatments on nitrogen and phosphorus uptake by grain and straw of BRRI dhan29 rice.

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total
T_1	223.27 e	112.88 e	336.15e	3.10 c	1.77 d	4.88d
T_2	661.25 a	555.59 a	1116.84a	13.13 a	7.36 a	20.49a
T_3	444.93 c	238.13 c	783.06c	7.75 b	5.29 c	13.04c
T_4	659.94 a	553.92 a	1113.86a	12.49 a	7.19 ab	19.68a
T_5	451.71 b	447.05 b	998.76b	10.70 a	6.68 b	17.56b
T_6	553.55 b	448.68 b	9102.23b	11.31 a	6.94 ab	18.25ab
T_7	336.33 d	326.78 d	763.10d	5.76 bc	4.87 c	10.63c
CV%	01.93	02.96	02.39	12.61	3.27	7.70
SE (±)	60.74	70.98	01.71	0.95	0.15	0.94
Level of significance	**	**	**	**	**	**

Figures in a column having common letters do not differ significantly at 1% level of significance. CV (%) = Coefficient of variation; SE (±) = Standard error of means; ** = Significant at 1% level of probability.

For both K and S uptake (grain, straw and total), the highest values were recorded from T_2 (100% RFD) which were identical to those noted in T_4 (50% N from RFD + 50% N from cotton seed oilcake). On the other hand, the minimum values for both K and P uptake (grain, straw and total) were observed in control (T_1).

Table 6. Effect of different treatments on potassium and sulphur uptake by grain and straw of BRRI dhan29 rice.

Treatments	K uptake (kg ha^{-1})			S uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total
T_1	6.05 c	36.54 e	42.59d	2.48e	4.18 d	6.66d
T_2	15.0 a	131.62 a	146.62a	9.50 a	21.26 a	30.76a
T_3	9.30 bc	99.01 c	108.31c	6.30 c	12.71 c	19.01bc
T_4	14.36 a	129.09 a	143.45a	9.43 a	21.24 a	30.67a
T_5	12.48 ab	121.20 b	133.68b	8.85 b	19.94 ab	28.79ab
T_6	13.09 a	122.89 b	135.98b	8.87 b	19.15 b	28.02ab
T_7	7.53 c	89.89 d	97.42	3.99 d	8.93 d	12.91c
CV%	12.13	1.83	1.26	2.57	5.31	4.22
SE (±)	1.10	1.56	1.19	0.15	0.67	0.77
Level of significance	**	**	**	**	**	**

Figures in a column having common letters do not differ significantly at 1% level of significance. CV (%) = Coefficient of variation; SE (±) = Standard error of means; ** = Significant at 1% level of probability.

These results are in line with the findings of Mhaskar and Thorat (2005), Puli *et al.* (2017), Bilkis *et al.* (2017) and Hoque *et al.* (2018) who observed higher nutrient uptake in rice with integrated use of organic manures and inorganic fertilizers. The higher nutrient uptake by the rice grain and straw may be due to increased availability of nutrients in soil through cotton seed oilcake and chemical fertilizer addition.

Conclusion

From the present study it is clear that cotton seed oilcake and mustard oil cake can be used in rice field as a good source of organic N. As an organic amendment, CSOC has the potential to increase yield components, grain and straw yields as well as nutritional quality of rice. The performance of CSOC in association with inorganic fertilizers was comparable with that of chemical fertilizers alone and this integrated approach could compensate up to 50% reduction of chemical fertilizers. This study recommends application of cotton seed oilcake with chemical fertilizers for better growth, yield and nutritional quality of rice. However, a thorough investigation with other crop species is needed to draw a reasonable conclusion on the effectiveness of this manure.

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References

Ali ME, Islam MR, Jahiruddin M (2009). Effect of integrated use of organic manures with chemical fertilizers in the rice-rice cropping system and its impact on soil health. *Bangladesh J. Agril. Res.*, 34(1): 81-90.

Alim MA (2012). Effect of organic and inorganic sources and doses of nitrogen fertilizer on the yield of boro rice. *J. Environ. Sci. Nat. Resour.*, 5(1): 273-282.

Al-Gusaibi AM (2004). Seston and nitrogen effects on yield and N, P uptake of rice (*Oryza sativa* L. cv. Hassawi). *Sci. J. King Faisal Univ.*, 5(1): 93-101.

Arif M, Tasneem M, Bashir F, Yaseen G, Iqbal RM (2014). Effect of integrated use of organic manures and inorganic fertilizers on yield and yield components of rice. *J. Agric. Res.*, 52(2): 197-206.

Asit M, Ashok K, Dhyan S, Anand S, Ebhin MR (2007). Effect of longterm application of manure and fertilizer on biological and biochemical activities in soil during crop development stages. *Bioresour. Technol.*, 98(18): 3585-3592.

BBS (Bangladesh Bureau of Statistics) (2018). 45 years Agriculture Statistics of Major Crops (Aus, Amon, Boro, Jute, Potato & Wheat). Bangladesh Bureau of Statistics, Statistics and Informatics Division (SID), Ministry of Planning, Govt. of the Peoples' Republic of Bangladesh, Dhaka. pp. 19.

Bilkis S, Islam MR, Jahiruddin M, Rahman MM (2017). Integrated use of manure and fertilizers increases rice yield, nutrient uptake and soil fertility in the boro-fallow-T.aman rice cropping pattern. *SAARC J. Agri.*, 15(2): 147-161.

Bremner JM, Mulvaney CS (1982). Nitrogen- total. In: Page, A. L., Miller, R. H., Keeney, D. R., (Eds.), Methods of Soil Analysis- Part 2. American Society of Agronomy, Inc. Publisher, Madison, pp. 595-624.

Cai A, Zhang W, Xu M, Wang B, Wen S, Atizaz S (2018). Soil fertility and crop yield after manure addition to acidic soils in South China. *Nutr. Cycl. Agroecosys*,111(1): 61-72.

Chandra K. (2005). Organic Manures. Regional Director: Regional Centre of Organic Farming, Hebbal, Banglore-24, pp. 1-46.

Esmaeilzade-Moridani M, Alami-Saeid K, Eshraghi-Nejad M (2013). Study of nitrogen split

application on yield and grain quality on native and breeded rice varieties. *Sci. Agri.*, 2(1): 3-10.

FAO (Food and Agriculture Organization). (2014). Production Yearbook, Food and Agricultural Organization of the United Nations, Rome, Italy. 57: 76-77.

FRG (Fertilizer Recommendation Guide) (2018). Fertilizer Recommendation Guide–2018. Bangladesh Agricultural Research Council, Farmgate, Dhaka.

Gomez KA, Gomez AA (1984). Statistical Procedures for Agricultural Research. John Wiley and Sons., New York.

Guo J, Hu X, Gao L, Xie K, Ling N, Shen Q, Hu S, Guo S (2017). The rice production practices of high yield and high nitrogen use efficiency in Jiangsu, China. *Sci. Rep*, 7(1): 1-10.

Hasanuzzaman M, Ahamed KU, Rahmatullah NM, Akhter N, Nahar K, Rahman ML (2010). Plant growth characters and productivity of wetland rice (*Oryza sativa* L.) as affected by application of different manures. *Emir. J. Food Agric*, 22(1): 46-58.

Hoque, TS, Jahan I, Islam MR, Ahmed M (2018). Performance of different organic fertilizers in improving growth and yield of boro rice. *SAARC J. Agri*,16(2): 153-166.

Hossain MA (2019). Need of organic amendments in intensive agriculture in Bangladesh. *Acta Sci. Agric*, 3(5): 106-109.

IFC (International Fertilizer Correspondent) (1982). FAO/FAIC working party on the economics of fertilizer use. 23(1): 7-10.

Khan MU, Qasim M, Khan IU (2007). Effect of integrated nutrient management on crop yields in rice-wheat cropping system. *Sarhad J. Agric.*, 23(4): 1019-1025.

Knudsen D, Peterson GA, Pratt PF (1982). Lithium, sodium and potassium. In: Page AL, Miller RH, Keeney DR. (Eds.), Methods of Soil Analysis-Part 2. American Society of Agronomy, Inc. Publisher, Madison, pp. 225-245.

Mahajan A, Bhagat RM, Gupta RD (2008). Integrated nutrient management (INM) in sustainable rice-wheat cropping system for food security in India-a review paper. *SAARC J. Agri*, 6(2): 29-32.

Mhaskar NV, Thorat ST (2005). Effect of nitrogen levels on NPK uptake and grain yield of scented rice varieties under Konkan condition. *J. Soils Crops*, 15(1): 206-209.

Moe K, Mg KW, Win KK, Yamakawa T (2017). Combined effect of organic manures and inorganic fertilizers on the growth and yield of hybrid rice (Palethwe-1). *Am. J. Plant Sci.*, 8: 1022-1042.

Moe K, Moh SM, Htwe AZ, Kajihara Y, Yamakawa T (2019). Effects of integrated organic and inorganic fertilizers on yield and growth parameters of rice varieties. *Rice Sci*, 26(5): 309-318.

Mwangi TJ (2010). Improving and sustaining soil fertility by use of farmyard manure and inorganic fertilizers for economical maize production in West Pokot, Kenya. *World J. Agric. Sci*, 6(3): 313-321.

Myint AK, Yamakawa T, Kajihara Y, Zenmyo T (2010). Application of different organic and mineral fertilizers on the growth, yield and nutrient accumulation of rice in a Japanese ordinary paddy field. *Sci. World J*, 5(2): 47-54.

Naorem LC (2018). Effect of organic manures and chemical fertilizers on the yield of \rice seed 'Lalat'. *Int. J. Curr. Microbiol. App. Sci*, 7(10): 2161-2166.

Olsen SR, Cole CU, Watanabe FS, Dean LA (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. Circular, U.S. Department of Agriculture, p 929.

Piper CS (1966). Soil and Plant Analysis: a laboratory manual of methods for the examination of soils and the determination of the inorganic constituents of plants. Hans Publishers, Bombay.

Puli MR, Prasad PRK, Jayalakshmi M, Rao BS (2017). Effect of organic and inorganic sources of

nutrients on NPK uptake by rice crop at Various Growth Periods. *Res. J. Agric. Sci*, 8(1): 64-69.

Roy R, Chan NW, Rainis R (2014). Rice farming sustainability assessment in Bangladesh. *Sustain. Sci*, 9: 31-44.

Roy S, Kashem MA, Osman KT (2018). The uptake of phosphorous and potassium of rice as affected by different water and organic manure management. *J. Plant Sci*, 6(2): 31-40.

Satyanarayana V, Prasad PVV, Murthy VRK, Booze KJ (2002). Influence of integrated use of farmyard manure and inorganic fertilizers on yield and yield components of irrigated lowland rice. *J. Plant Nutr*, 25(10): 2081-2090.

Siavoshi M, Dastan S, Yassari E, Laware SL (2013). Role of organic fertilizers on morphological and yield parameters in rice (*Oryza sativa* L.). *Intl. J. Agron. Plant Prod*, 4(6): 1220-1225.

Siavoshi M, Laware S, Laware SL (2011). Effect of organic fertilizer on growth and yield components in rice (*Oryza sativa* L.). *J. Agric. Sci*, 3(3): 217-224.

Singh RP, Yadav PK, Singh RK, Singh SN, Bisen MK, Singh J (2006). Effect of chemical fertilizer, FYM and biofertilizer on performance of rice and soil properties. *Crop Res.*, 32: 283-285.

STPM (Soil Testing Procedure Manual). (2008). Marathwada Agricultural University, Parbhani, p. 22.

Williams CH, Steinbergs A (1959). Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. *Aust. J. Agric. Res*, 10: 340-352.

YAS (Yearbook of Agricultural Statistics) (2018). Bangladesh Bureau of Statistics, Statistics and Informatics Division (SID), Ministry of Planning, Govt. of the Peoples' Republic of Bangladesh, Dhaka. pp. 49.

Yue S, Meng Q, Zhao R, Ye Y, Zhang F, Cui Z, Chen X (2012). Change in nitrogen requirement with increasing grain yield for winter wheat. *Agron. J*, 104(6): 1687-1693.