Original Article

Growth, Yield and Proximate Composition of Aromatic Rice as Influenced by Inorganic and Organic Fertilizer Management

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Abstract

Integrated use of organic and inorganic fertilizers can improve crop productivity and sustain soil health and fertility. To gain insights into the response of green manure and chemical fertilizer, the present study was conducted to evaluate the growth, yield and proximate composition of aromatic rice varieties in *Aman* season at the research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July to December 2014. The experiment was set up in split-plot design with three aromatic rice varieties in main plots and six fertilizer levels in subplots. 'Raniselute' variety produced the highest plant height, dry matter weight hill^{-1}, straw yield (7.81 t ha^{-1}), biological yield (9.05 t ha^{-1}), ash (1.59%), and fat content (2.81%). 'BRRI dhan34' gave the maximum number of effective tillers hill^{-1} (12.74), panicle length (27.93 cm), number of filled grains panicle^{-1} (192.5), 1,000-grain weight (17.22 g), grain yield (2.26 t ha^{-1}), harvest index (29.99%), and carbohydrate content (77.63%). Application of 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} showed better performance for getting the maximum growth, yield components and yield compared to other treatments. Recommended doses of NPKSZn showed the highest carbohydrate content (77.63%) and lowest moisture (8.75%) and ash content (1.29%). The maximum fat content (3.07%) and minimum carbohydrate content (76.53%) was obtained from 60% recommended doses of NPKSZn + green manure 7 t ha^{-1}. Application of 20 and 40% recommended doses of NPKSZn + green manure 14 and 10.5 t ha^{-1} produced the highest moisture content (10.43%) and lowest protein content (8.26%) in rice grain. Green manure 17.5 t ha^{-1} produced the highest ash (1.79%), protein content (9.06%) and lowest fat content (2.51%).

Keywords: fine rice; Integrated Nutrient Management; *Oryza sativa* L.; proximate composition; transplant *Aman*; 2-Acetyl-1-pyrroline

Introduction

Rice (*Oryza sativa* L.) is one of the major food crops grown in South Asia. It is mostly grown in lowlands under fully irrigated or rain-fed conditions. The people in Bangladesh depend on rice as staple food and have a tremendous influence on the agrarian economy of Bangladesh. Rice alone constitutes 97% of the food grain production in Bangladesh (BBS, 2013). Among different groups of rice, transplant *Aman* (T. *Aman*) rice cover about 49.11% of total rice area, and it contributes to 38.11% of the total rice production in the country (BBS, 2013). In Bangladesh, rice dominates over all other crops and covers 75% of the total cropped area (Rekabdar, 2004) of which

around 27% is occupied by fine rice varieties (BBS, 2003). Although the nutritional values of rice vary with different varieties, soil fertility, fertilizer application and other environmental conditions, the following trend still exists by comparison with other cereals: low-fat content after the removal of the bran, low protein content (about 7-10%), and higher digestibility of protein. Rice is considered as the queen among cereals due to its nutritional quality and higher digestibility (Anjum *et al.*, 2007). Freshly harvested rice grains contain about 80% carbohydrate which includes starch, glucose, sucrose, and dextrin (Verma and Srivastav, 2017).

Rice can be classified as aromatic and non-aromatic rice by aroma. Aromatic rice emits a unique aroma with cooking. Indian sub-continent is a habitat for aromatic rice

diversity (Bisne and Sarawgi, 2008). In aromatic rice, the flavor is expended as one of the most significant factors in market business, which distinguishes aromatic rice from ordinary rice (Laohakunjit and Kerdchoechuen, 2007; Fitzgerald *et al.*, 2009). This flavor compound is stemming primarily from its 2-Acetyl-1-pyrroline content (Bhattacharjee *et al.*, 2002), which generally plays a role in consumer acceptability of rice (Bergman *et al.*, 2000). Consumers have become more quality conscious about the rice cultivars they consume. Therefore, it needs to be focused on the quality of rice along with production. When farmers become conscious of their rice quality, they were driven to produce better quality rice (Dela Cruz and Khush, 2000; Yoshihashi *et al.*, 2004). Nowadays, scientists and breeders are more and more focused on improving the quality of rice for different purposes and markets. For instance, consumers from developed countries ask mainly for grain with good cooking quality and eating characteristics, but in many developing regions, nutritional value is crucial as rice is the most consumed staple food. Grain quality is a general concept which covers many characteristics ranging from physical to biochemical and physiological properties. The traits and parameters used to evaluate grain quality in rice vary across countries. However, four main quality traits (Yu *et al.*, 2008) are widely used to assess quality, namely milling properties, appearance, nutritional value, and cooking quality. Besides that, grain quality has been shown to be affected significantly by growing and environmental conditions, such as water availability, temperature, fertilizer application, drought, and salinity stresses (Chen *et al.*, 2012).

Rice farmers have traditionally used organic materials particularly farmyard manure and green manures in the pre-industrial age. Green manuring can improve soil physical, chemical, and biological properties and consequently crop yields (Fageria, 2007). Importance of this soil ameliorating practice is increasing in recent years because of increasing prices and low efficiency of chemical N fertilizer and low organic matter content of our soils, inclusion of green manuring crops in the rice-based cropping systems, deserves priority consideration (Bhuiyan and Zaman, 1996). But with the present day high yielding cultivars, which have higher nutrient requirements, the use of inorganic fertilizers has increased considerably leading to declining in the use of organic materials (Hossain and Singh, 2000). It is well known that sustainable production of crops cannot be maintained by using only chemical fertilizers and similarly it is not possible to obtain higher crop yield by using organic manure alone (Bair, 1990). For sustainable agriculture and to ensure the food production with high quality it is necessary to combined use of organic and inorganic sources of nutrients (Mahmud *et al.*, 2016).

Though rice is one of the most vital crops of the world but enough information regarding the varieties of fine rice and their response to green manure and chemical fertilizers are scarce in the world literature. In view of limited information on the problems mentioned above, this present study was therefore, undertaken to compare the growth, yield and quality performance of three aromatic *Aman* rice varieties using the different combination of green manure and chemical fertilizers.

Materials and Methods

Experimental location and climate

The study was carried out at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh situated at 23°46′ N latitude and 90°23′ E longitude at an altitude of 8.45 m above the sea level during the period from July to December 2014. The experimental site is under sub-tropical humid climatic conditions with a total annual rainfall was 24.23 mm with average monthly maximum and minimum temperature of 29.64°C and 14.91°C, respectively. The soil of the experimental soil was silty clay in texture under Tejgaon series with sand (26%), silt (45%), clay (29%), soil pH (5.60), organic carbon (0.45%), organic matter (0.78%), total N (0.03%), available P (20.54 mg kg^{-1} soil) and exchangeable K (0.10 meq/100 g soil).

Planting material

Rice cvs. 'Katáribhog', 'Raniselute' and 'BRRI dhan34' were used as a test crop. These varieties are recommended for *Aman* season. All the variety had photo-sensitivity and well known for their characteristic aroma.

Raising and transplanting of seedling

The seedlings of rice were raised in the wet bed methods. Hand spade was used to open the selected seed-bed on 11th June 2014. Initially seed soaking was done in water for 24 hours, and afterwards, they were kept tightly in jute sack for 3 days. When about 90% of the seeds were sprouted, they were sown uniformly in well prepared wet nursery bed on 5th July 2014. Seed-bed size was 10 m long and 1.5 m wide. 25 days old seedlings were carefully uprooted from the seedling nursery and transplanted on 1st August 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.

Land preparation

First, the land was ploughed with a power tiller at 15 days before transplanting. The soil was saturated with an 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 levelled and the experimental plot was partitioned into unit plots by experimental design.

Experimental treatments and design

The experiment consisted of two factors *i.e.*, 3 varieties of aromatic rice *viz.*, V$_1$ = Katáribhog, V$_2$ = Raniselute, V$_3$ = BRRI dhan34 and 6 levels of fertilizer management *viz.*, T$_1$ = Recommended doses of NPKSZn, T$_2$ = 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1}, T$_3$ = 60% recommended doses of NPKSZn + Green Manure 7 t ha^{-1}, T$_4$ = 40% recommended doses of NPKSZn + green manure 10.5 t ha^{-1}, T$_5$ = 20% recommended doses of NPKSZn + green manure 14 t ha^{-1}, T$_6$ = Green manure 17.5 t ha^{-1}. The two factors experiment was arranged in a split-plot design with three replications. The three varieties were assigned in the main plot and six levels of fertilizer

management treatments in sub-plot. The size of each unit plot was 3 m × 2 m (6 m²). The space between two blocks and two plots were 1.0 m and 0.5 m, respectively.

Green manure and fertilizer application

The green manures (dhaincha) are uprooted before flowering and chopped into small parts and then directly incorporated into the soil of the field before transplanting. The field was fertilized with nitrogen, phosphate, potash, sulfur and zinc at the rate of 120, 100, 70, 60 and 10 kg ha⁻¹, respectively in the form of urea, triple super-phosphate, muriate of potash, gypsum and zinc sulfate. The whole amount of all the fertilizers except urea were applied at the time of final land preparation and thoroughly incorporated with soil with the help of a spade. Urea was top dressed in three equal splits on 15, 30, and 45 DAT.

Harvesting

The maturity of crop was determined when 85% to 90% of the grains become golden yellow in color. BRRI dhan34 and Kataribhog varieties were harvested at 15th November 2014 and Raniselute at 29th November 2014. From the centre of each plot 1 m² area was harvested to determine yield of individual treatment and converted into t ha⁻¹. The harvested crop of each plot was bundled separately and tagged properly.

Biological yield (t ha⁻¹)

The biological yield was calculated by using the following formula:

Biological yield= Grain yield + Straw yield

Harvest index (%)

The harvest index is the relationship between grain yield and biological yield (Gardner *et al.*, 1985). It was calculated by using the following formula:

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

Moisture content of rice seed (%)

The moisture content was calculated by using the following formula:

Moisture (%) =

$$\frac{Sample\ weight - Constant\ dry\ weight\ of\ sample}{Sample\ weight} \times 100$$

Ash content of rice seed (%)

The ash content of rice seed was determined by following AOAC method (AOAC, 1975).

Fat content of rice seed (%)

The fat content of rice seed was determined by the Soxhlet Oxidation procedure (AOAC, 1975) using 10 g of samples and petroleum ether extraction is done continuously for 8 hours.

Protein content of rice seed (%)

The protein content of rice seed was determined by the Micro-Kjeldahl method using automated nitrogen determination system (AOAC, 1990).

Carbohydrate content of rice seed (%)

The carbohydrate content of rice seed was determined by following AOAC method (AOAC, 1990).

Statistical analysis

The data were subjected to analysis of variance (ANOVA), and the mean differences were compared by Least Significant Difference (LSD) test using MSTAT-C (Gomez and Gomez, 1984). Differences at $P \leq 0.05$ were considered significant.

Results and Discussion

Growth contributing characters
Plant height

Aman rice variety exhibited significant difference in plant height at different growth stages except for 90 DAT (Table 1). Among the varieties, Raniselute significantly showed the tallest plant and the shortest plant was found in BRRI dhan34. Plant height is dependent on the number of internodes and their length. It represents the varietal characteristics of a variety. The differences in plant height of different varieties might have resulted from the genetic makeup of the cultivars, but the environmental factors also influence a little. The results were in agreement with Bisne *et al.* (2006); Islam *et al.* (2013); Roy *et al.* (2014) who observed plant height differed significantly among the varieties.

Effect of green manure and chemical fertilizer showed a significant variation on plant height for all growth stages (Table 1). The tallest plant was recorded from 80% recommended doses of NPKSZn + green manure 3.5 t ha⁻¹ which was statistically similar with recommended doses of NPKSZn and 60% recommended doses of NPKSZn + green manure 7 t ha⁻¹, while the shortest plant was recorded from green manure 17.5 t ha⁻¹ which was statistically similar with 20% recommended doses of NPKSZn + green manure 14 t ha⁻¹ except 15 DAT. The increase in plant height due to the application of 80% recommended doses of NPKSZn + green manure 3.5 t ha⁻¹ might be associated with stimulating effect on various physiological processes including cell division and cell elongation of the plant. These results are agreed with that of Kohayashi *et al.* (1989) who observed increasing plant height with FYM + fertilizer N applied plots.

Dry matter content hill⁻¹

Significant variation was observed on dry matter content hill⁻¹ at different growth stages of *Aman* rice variety except for 15 DAT (Table 2). Among the varieties, Raniselute showed the maximum and BRRI dhan34 gave the minimum dry matter content hill⁻¹.

Effect of green manure and chemical fertilizer showed a significant variation on dry matter weight hill⁻¹ for all growth stages (Table 2). The maximum dry matter weight hill⁻¹ was recorded in 80% recommended doses of NPKSZn along with green manure 3.5 t ha⁻¹ which was statistically similar with recommended doses of NPKSZn, while the minimum was recorded in green manure 17.5 t ha⁻¹.

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Table 1. Effect of varietal variation and fertilizer management on plant height of rice at different days after transplanting (DAT)

Variety	Plant height (cm) at						
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	Harvest
V_1	45.50 b	72.50 b	106.6 b	116.2 b	126.0 b	134.5	143.2 ab
V_2	59.05 a	95.72 a	122.2 a	127.0 a	134.6 a	142.3	148.1 a
V_3	43.02 b	71.70 b	105.4 b	110.7 b	120.7 c	132.2	139.7 b
LSD$_{(0.05)}$	5.332	3.257	4.533	7.737	4.249	ns	7.172
Fertilizer management							
T_1	48.21 b	83.52 ab	115.4 ab	123.2 a	131.1 a	142.4 a	147.4 a
T_2	48.42 b	86.04 a	117.3 a	122.5 a	132.1 a	142.0 a	148.7 a
T_3	50.92 ab	80.48 a-c	112.6 a-c	121.0 a	129.9 ab	137.5 ab	144.3 ab
T_4	47.22 b	78.00 bc	110.4 b-d	117.4 ab	126.3 bc	135.2 ab	142.2 ab
T_5	47.53 b	77.45 bc	107.7 cd	113.0 b	122.4 cd	132.3 ab	142.1 ab
T_6	52.85 a	74.37 c	105.0 d	110.8 b	120.9 d	128.6 b	137.6 b
LSD$_{(0.05)}$	3.858	7.355	5.649	6.921	3.991	12.51	8.380

Figures not sharing the same letters differ significantly at $P \leq 0.05$
V_1: Kataribhog, V_2: Raniselute, V_3: BRRI dhan34
T_1 = Recommended doses of NPKSZn, T_2 = 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1}, T_3 = 60% recommended doses of NPKSZn + green manure 7 t ha^{-1}, T_4 = 40% recommended doses of NPKSZn + green manure 10.5 t ha^{-1}, T_5 = 20% recommended doses of NPKSZn + green manure 14 t ha^{-1}, T_6 = green manure 17.5 t ha^{-1}

Table 2. Effect of varietal variation and fertilizer management on dry matter weight hill^{-1} of rice at different DAT

Variety	Dry matter weight hill^{-1} (g) at						
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	Harvest
V_1	3.61	15.25 a	29.30 a	43.83 b	46.50 b	45.17 b	44.17 b
V_2	3.53	15.78 a	30.51 a	51.62 a	54.40 a	53.03 a	52.03 a
V_3	3.15	10.95 b	23.62 b	35.42 c	38.08 c	36.75 c	35.58 c
LSD$_{(0.05)}$	ns	2.714	3.323	3.953	4.478	3.968	3.980
Fertilizer management							
T_1	5.21 a	16.17 ab	33.40 a	49.44 a	52.11 a	50.78 a	49.78 a
T_2	3.83 b	16.52 a	32.93 a	50.19 a	53.08 a	51.67 a	50.67 a
T_3	3.05 c	15.08 bc	29.02 b	44.33 b	47.00 b	45.67 b	44.33 b
T_4	2.62 d	14.62 c	26.80 b	43.00 b	45.67 b	44.33 bc	43.33 bc
T_5	3.38 c	11.09 d	22.86 c	40.39 b	43.06 b	41.72 c	40.72 c
T_6	2.14 e	10.49 d	21.84 c	34.39 c	37.06 c	35.72 d	34.72 d
LSD$_{(0.05)}$	0.356	1.239	2.698	4.206	4.005	3.602	3.418

Figures not sharing the same letters differ significantly at $P \leq 0.05$
V_1: Kataribhog, V_2: Raniselute, V_3: BRRI dhan34
T_1 = Recommended doses of NPKSZn, T_2 = 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1}, T_3 = 60% recommended doses of NPKSZn + green manure 7 t ha^{-1}, T_4 = 40% recommended doses of NPKSZn + green manure 10.5 t ha^{-1}, T_5 = 20% recommended doses of NPKSZn + green manure 14 t ha^{-1}, T_6 = green manure 17.5 t ha^{-1}

Yield contributing characters
Number of effective tillers hill^{-1}

Significant variation was observed on the number of effective tillers hill^{-1} among the varieties in *Aman* rice (Table 3). The result showed that highest number of effective tillers hill^{-1} (12.74) was found in BRRI dhan34 followed by Kataribhog (11.86). The lowest number of effective tillers hill^{-1} was obtained in Raniselute (9.04). The result indicated that BRRI dhan34 produced 40.92% higher effective tillers hill^{-1} than Raniselute. The probable reason for the differences in producing the number of effective tillers hill^{-1} may be the genetic make-up of the variety which is primarily influenced by heredity. These findings collaborate with those reported by Bhowmick and Nayak (2000); Roy *et al.* (2014); Shiyam *et al.* (2014) who stated that number of effective tillers hill^{-1} was varied with variety.

The number of effective tillers hill^{-1} was significantly affected due to different fertilizer management (Table 3). The highest number of effective tillers hill^{-1} (13.39) was

obtained due to the application of 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} which was statistically similar with recommended doses of NPKSZn. The lowest number of effective tillers (8.83) hill^{-1} was obtained in green manure 17.5 t ha^{-1} which was statistically similar with 20% recommended doses of NPKSZn + green manure 14 t ha^{-1}. Variations in the number of effective tillers among the organic and inorganic sources were mainly due to their variations in the availability of necessary nutrients. Adequacy of nutrients probably favoured the cellular activities during panicle formation and development that led to increased number of effective tillers hill^{-1}. Gosh *et al.* (1991); Manzoor *et al.* (2006); Kandil *et al.* (2010) also agreed with this view.

Panicle length

Significant variation was observed on panicle length among the varieties in *aman* rice (Table 3). Results showed that the maximum panicle length (27.93 cm) was found in

Table 3. Effect of varietal variation and fertilizer management on yield contributing characters of rice

Variety	Number of effective tillers hill[-1]	Panicle length (cm)	Number of filled grains panicle[-1]	1000-grain weight (g)
V$_1$	11.86 a	26.24 b	144.4 b	11.66 b
V$_2$	9.04 b	25.62 c	76.11 c	11.43 b
V$_3$	12.74 a	27.93 a	192.5 a	17.22 a
LSD$_{(0.05)}$	1.234	0.137	11.84	0.793
Fertilizer management				
T$_1$	12.94 a	26.52 c	150.5 ab	14.22 ab
T$_2$	13.39 a	27.38 a	161.7 a	14.30 a
T$_3$	11.48 b	26.99 b	140.5 bc	13.29 bc
T$_4$	10.98 b	26.30 d	136.6 cd	13.46 a-c
T$_5$	9.64 c	26.58 c	126.6 d	13.05 cd
T$_6$	8.83 c	25.79 e	110.1 e	12.30 d
LSD$_{(0.05)}$	0.918	0.195	12.32	0.949

Figures not sharing the same letters differ significantly at $P \leq 0.05$
V$_1$: Kataribhog, V$_2$: Raniselute, V$_3$: BRRI dhan34
T$_1$ = Recommended doses of NPKSZn, T$_2$ = 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1}, T$_3$ = 60% recommended doses of NPKSZn + green manure 7 t ha^{-1}, T$_4$ = 40% recommended doses of NPKSZn + green manure 10.5 t ha^{-1}, T$_5$ = 20% recommended doses of NPKSZn + green manure 14 t ha^{-1}, T$_6$ = green manure 17.5 t ha^{-1}

BRRI dhan34 and the minimum (25.62 cm) was obtained in Raniselute. The variation as assessed might be due to genetic characters of the varieties primarily influenced by the heredity. Sarker *et al.* (2013) and Hossain *et al.* (2014) also reported that panicle length varied among varieties.

Panicle length was significantly affected due to different fertilizer management (Table 3). The maximum panicle length (27.38 cm) was obtained due to the application of 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} which was statistically different from others. The minimum panicle length (25.79 cm) was obtained in green manure 17.5 t ha^{-1}. 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} took part in panicle formation as well as elongation and for this panicle length increased. Islam *et al.* (2008); Kandil *et al.* (2010); Mannan *et al.* (2010) reported similar results.

Number of filled grain panicle[-1]

Variety differed significantly in the production of the number of filled grains panicle[-1] (Table 3). The highest number of filled grains panicle[-1] (192.50) was observed in BRRI dhan34, and the lowest number of filled grains panicle[-1] (76.11) was obtained in Raniselute. The result showed that BRRI dhan34 produced 152.92 % higher filled grains panicle[-1] than Raniselute. Varietal variation regarding the number of filled grains panicle[-1] might be due to their variation in genetic constitutions and also due to variation in photosynthetic assimilate accumulation especially after heading. Sarker *et al.* (2013); Hossain *et al.* (2014); Shiyam *et al.* (2014) reported the variable number of filled grains panicle[-1].

Different fertilizer management showed significant variation on production of filled grains panicle[-1] (Table 3). The highest number of filled grains panicle[-1] (161.70) was obtained by the application of 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} which is statistically similar with recommended doses of NPKSZn whereas the lowest (110.10) was obtained from green manure 17.5 t ha^{-1}. 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} produced 46.87% higher number of filled grains panicle[-1] than green manure 17.5 t ha^{-1}. An adequate supply of

nutrients contributed to grain formation, which probably increased the number of grains panicle[-1].

1000-grain weight

Variety had significant effect on the weight of 1,000-grains. The highest 1,000 grain weight (17.22 g) was observed in BRRI dhan34 and the lowest weight (11.43 g) was observed in Raniselute (Table 3). The result showed that BRRI dhan34 produced 50.65% heavier seed than Raniselute. The variation in 1,000-grain weight might be due to differences in length and breadth of the grains that were partly controlled by the genetic makeup of the variety under study. Chowdhury and Ghosh (1978) stated that 1,000-grain weight highly varied due to variety ranged from 9.00 g to 23.00 g fine and scented rice varieties. The results agreed with the findings of Sarker *et al.* (2013); Shiyam *et al.* (2014)

The weight of 1,000-grain was significantly influenced by the different levels of fertilizer (Table 3). The highest weight (14.30 g) of 1,000-grains was recorded due to the application of 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} which was followed by recommended doses of NPKSZn (14.22 g) and 40% recommended doses of NPKSZn + green manure 10.5 t ha^{-1} (13.46 g). The lowest weight (12.30 g) of 1000-grain was recorded from the green manure 17.5 t ha^{-1}. The results agreed with the findings of Manzoor *et al.* (2006); Mannan *et al.* (2010).

Yield and harvest index

Varieties differed significantly in producing grain, straw, biological yield and harvest index of aromatic *Aman* rice (Table 4). Among the varieties, BRRI dhan34 showed its superiority in producing highest grain yield (2.26 t ha^{-1}) and harvest index (29.99%) while the inferiority in producing lowest straw yield (5.31 t ha^{-1}) and biological yield (7.57 t ha^{-1}). Maximum straw yield (7.81 t ha^{-1}) and biological yield (9.05 t ha^{-1}) with minimum grain yield (1.24 t ha^{-1}) and harvest index (13.56 %) were obtained from the variety Raniselute. The yield of rice mainly depends on the yield contributing characters like the number of effective tillers

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hill[-1], length of panicle, number of filled grains panicle[-1] and 1,000-grain weight. Improvement of yield components increased the yield of grains agreed with the findings of Manzoor *et al.* (2006); Islam *et al.* (2008); Kandil *et al.* (2010); Mannan *et al.* (2010). Physiological parameters also play an important role in rice yield, which was supported by Cui-Jing *et al.* (2000). They obtained that higher rice yield possible by increasing total dry matter and harvest index. Grain yield differences due to varieties were also reported by Biswas *et al.* (1998). The results agreed with the findings of Sarker *et al.* (2013); Hossain *et al.* (2014); Shiyam *et al.* (2014). The differences in straw yield among the varieties might be attributed to the genetic makeup of the varieties. Several researchers also obtained variable straw yield among the varieties (Chowdhury *et al.*, 1993; Kumar *et al.*, 1995; Patel, 2000). Sokoto and Muhammad (2014) also found the similar results in case of harvest index due to varietal variations.

The significant difference was observed for grain, straw, biological yield and exerted non-significant variation on harvest index due to different levels of fertilizer (Table 4). The maximum grain yield (2.17 t ha^{-1}), straw yield (7.64 t ha^{-1}), biological yield (9.80 t ha^{-1}) was obtained due to the application of 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} which did not differ significantly with recommended doses of NPKSZn. The minimum grain yield (1.53 t ha^{-1}), straw yield (6.00 t ha^{-1}) and biological yield (7.53 t ha^{-1}) were found from green manure 17.5 t ha^{-1}. Results revealed that a combination of organic and inorganic fertilizer sources resulted in comparable better rice yields. It might be due to the presence of organic manure that increased the availability of nutrients in soil as a result of the mineralization of manures leading to the increased uptake by rice plants. Also the organic acids produced during decomposition solubilise the P and micronutrients present in the soil. The increase in yield might be due to the contribution of more number of effective tillers hill[-1], panicle length, number of filled grains panicle[-1] and 1,000-grain weight.

Proximate composition of rice grain

Moisture content invariably affects the quality and palatability of rice grains (Oko and Onyekwere, 2010), which plays a significant role in determining the shelf life (Webb, 1985). Ash content plays an important role to reflect the mineral elements of a food sample (Bhat and Sridhar, 2008; Mbatchou and Dawda, 2013) and gives an idea to determine the levels of essential minerals present in the food (Edeogu *et al.*, 2007). Fat in rice is a good source of linoleic and other essential fatty acids but does not contain cholesterol (Eggum *et al.*, 1982). Fat content influences the taste of cooked rice because rice with high-fat content tends to be tastier and have less starch (Hirokadzu *et al.*, 1979). Protein in rice is essential as proteins to form the basic building blocks for cells and tissue repairs in the body (Mbatchou and Dawda, 2013). Protein content influences the nutritional quality of rice (Sompong *et al.*, 2011). Rice protein content comprises up to 8% of the grain (Juliano, 1985), which is low but of high nutritional value (FAO, 1970; Chaudhary and Tran, 2001). Nevertheless, much research mentioned protein content up to 15% in different rice varieties (Sotelo *et al.*, 1990; Kennedy and Burlingame, 2003). Resurrection *et al.* (1979) classified protein content more than 10% as high content. Rice is the starchy staple food and a major source of carbohydrates. In present study ash, fat, protein, and carbohydrate content showed significant variation and the non-significant result was found on moisture content in rice grain due to varietal variations (Table 5). The highest protein content (8.85%), lowest fat content (2.71%) was recorded from variety Kataribhog. Raniselute variety gave the highest ash, fat content (1.59, 2.81%, respectively) and lowest carbohydrate content (77.12%). Highest carbohydrate content (77.63%), lowest ash and protein content (1.40, 8.52%, respectively) was obtained from the rice grain of BRRI dhan34. The difference in moisture content among the rice accessions might be due to the variation in moisture content in paddy after harvesting (Asaduzzaman *et al.*, 2013). The differences of ash content in all aromatic and non-aromatic rice accessions may occur due to the differences in the mineral

Table 4. Effect of varietal variation and fertilizer management on yield and harvest index of rice

Variety	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1	1.96 b	7.02 b	8.98 a	21.91 b
V_2	1.24 c	7.81 a	9.05 a	13.56 c
V_3	2.26 a	5.31 c	7.57 b	29.99 a
LSD$_{(0.05)}$	0.168	0.474	0.633	0.598
Fertilizer management				
T_1	2.04 ab	7.25 ab	9.29 ab	22.35
T_2	2.17 a	7.64 a	9.80 a	22.38
T_3	1.90 b	6.80 bc	8.70 b	22.52
T_4	1.69 c	6.37 cd	8.06 c	21.53
T_5	1.60 c	6.22 cd	7.82 c	20.94
T_6	1.53 c	6.00 d	7.53 c	21.18
LSD$_{(0.05)}$	0.161	0.622	0.614	ns

Figures not sharing the same letters differ significantly at $P \leq 0.05$
V_1: Kataribhog, V_2: Raniselute, V_3: BRRI dhan34
T_1 = Recommended doses of NPKSZn, T_2 = 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1}, T_3 = 60% recommended doses of NPKSZn + green manure 7 t ha^{-1}, T_4 = 40% recommended doses of NPKSZn + green manure 10.5 t ha^{-1}, T_5 = 20% recommended doses of NPKSZn + green manure 14 t ha^{-1}, T_6 = green manure 17.5 t ha^{-1}

Table 5. Effect of varietal variation and fertilizer management on proximate composition of rice

Variety	Moisture content (%)	Ash content (%)	Fat content (%)	Protein content (%)	Carbohydrate content (%)
V_1	9.74	1.49 ab	2.71 b	8.85 a	77.21 b
V_2	9.78	1.59 a	2.81 a	8.70 b	77.12 b
V_3	9.72	1.40 b	2.73 b	8.52 c	77.63 a
LSD$_{(0.05)}$	ns	0.117	0.051	0.106	0.319
Fertilizer management					
T_1	8.75 d	1.29 d	2.60 c	8.81 a	78.56 a
T_2	9.61 c	1.57 b	2.81 b	8.85 a	77.17 bc
T_3	10.16 ab	1.48 c	3.07 a	8.77 a	76.53 c
T_4	10.43 a	1.51 bc	2.62 c	8.40 b	77.04 bc
T_5	10.11 b	1.34 d	2.89 b	8.26 b	77.40 b
T_6	9.42 c	1.79 a	2.51 c	9.06 a	77.21 bc
LSD$_{(0.05)}$	0.295	0.075	0.118	0.297	0.794

Figures not sharing the same letters differ significantly at $P \leq 0.05$
V_1: Kataribhog, V_2: Raniselute, V_3: BRRI dhan34
T_1 = Recommended doses of NPKSZn, T_2 = 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1}, T_3 = 60% recommended doses of NPKSZn + green manure 7 t ha^{-1}, T_4 = 40% recommended doses of NPKSZn + green manure 10.5 t ha^{-1}, T_5 = 20% recommended doses of NPKSZn + green manure 14 t ha^{-1}, T_6 = green manure 17.5 t ha^{-1}

content of the soils and the water used for irrigation (Shayo et al., 2006). The differences in fat content among the aromatic and non-aromatic rice accessions could be accounted for by the differences in the degree of milling since most of the fat in rice is concentrated in the aleurone layer of the kernel (Wang et al., 2006). The variations in fat value in rice accessions may be due to oxidation of fat because most of the fat in rice grains is unsaturated which undergoes oxidation easily by atmospheric oxygen (Hirokadzu et al., 1979). The variations of protein content in different rice accessions might be due to several factors such as water supply, handling, application of fertilizer (soil nitrogen availability), environmental stress (such as salinity and alkalinity, temperatures and diseases), location of growing areas, growing conditions and time which tend to increase the grain protein content (Buresova et al., 2010). The high percentage carbohydrate contents of the rice varieties showed that rice is a good source of energy. This low carbohydrate content may be attributed to its high moisture content which also affects the milling quality and other environmental factors. The variation of the carbohydrate content of different rice accessions has also been reported by Oko and Ugwu (2011); Saikia et al. (2012); Thomas et al. (2013); Rohman et al. (2014), but neither higher nor within the range of reported values of Shayo et al. (2006); Subudhi et al. (2013).

Significant variation was observed on proximate composition of rice grain due to different levels of fertilizer (Table 5). The highest ash and protein, moisture, fat, carbohydrate content (1.79, 9.06, 10.43, 3.07, 78.56%, respectively) was observed in green manure 17.5 t ha^{-1}, 40 and 60% recommended doses of NPKSZn + green manure 7 and 10.5 t ha^{-1}, recommended doses of NPKSZn, respectively. The lowest moisture, ash, fat, protein and carbohydrate content (8.75, 1.29, 2.51, 8.26, 76.53%, respectively) was observed at Recommended doses of NPKSZn, green manure 17.5 t ha^{-1}, 20 and 60% recommended doses of NPKSZn + green manure 7 and 14 t ha^{-1}, respectively.

Conclusions

Reviewing the results of the present study, it might be concluded that BRRI dhan34 and 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} showed the best results compared to other treatments.

Acknowledgements

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