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Evaluation of Six Aromatic Rice Varieties for Yield and Yield Contributing Characters

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ABSTRACT

A study was undertaken to evaluate the growth performance and grain quality of six aromatic rice varieties BR34, BR38, Kalizira, Chiniatop, Kataribhog and Basmati grown under rainfed conditions. The rice varieties differed significantly ($P<0.05$) with respect to leaf chlorophyll content, plant height, internode length, thousand grain weight and grain and straw yields. Varieties differed in morphological and yield and yield contributing traits. Thousand grain weight and grain yield both were highest in BR38. Basmati required shorter days to maturity and Kalizira longest days to maturity.

Key Words: Aromatic rice; Varieties; Morphology; Yield; Chlorophyll content

INTRODUCTION

Aromatic rice (*Oryza sativa* L.) is known for its characteristic fragrance when cooked. This constitutes a small but special group of rice, which is considered best in quality. Aromatic varieties fetch higher price in rice market than the non-aromatic ones. Cultivation of fine as well as aromatic rice has been gaining popularity in Bangladesh over the recent years, because of its huge demand both for internal consumption and export (Das & Baqui, 2000). Despite the generally favorable agroclimatic conditions, area of aromatic rice is less than 2% of the national rice acreage of Bangladesh. More than four thousand landraces of rice are adopted in different parts of Bangladesh. Only some of these are unique for quality traits including fineness, aroma, taste and protein contents (Kaul *et al.*, 1982). Most of high quality rice cultivars are low yielding (Shakeel *et al.*, 2005). Locally adapted varieties are Chiniatop, Kalizira and Kataribhog. BR34 and BR38 are another two high valued rice varieties released by Bangladesh Rice Research Institute (BRRI), having small grain and pleasant aroma. These varieties could be exported after meeting local demand. Aromatic rice varieties have occupied about 12.5% of the total transplant aman rice cultivation (BBS, 2005).

Production of aromatic rice in Bangladesh is becoming popular due to its high prices and export potentiality (Dutta *et al.,* 2002). It is also preferred by some consumers despite their price and yield. Farmers' net income was increased by 23% with the adoption of modern varieties (Shrestha *et al.,* 2002). Information on morpho-physiological characters play a vital role in rice breeding. It is essential to know the physiological behavior and genetic expression of the selective aromatic and modern rice cultivars for definite breeding objectives to improve those cultivars. Identifying promising morpho-physiological traits associated with quality and yield plays an important role in varietal development programs. Development of rice cultivars with a high yielding ability is one of the most fundamental approaches for dealing with the expected increase in the world demand (IRRI, 1993).

There is a lot of research information on specific rice variety, but a little is documented on comparative study of morpho-physiological characters of rice cultivars during aman season in Bangladesh. Present work gives an account of growth and yield performance of some aromatic fine rice varieties and describes the relationship between grain yield and morpho-physiological characters of the same.

MATERIALS AND METHODS

Field experiment was conducted at the field of Bangladesh Agricultural University, Mymensingh during June to December, 2007. Six aromatic rice varieties namely Kalizira, Chiniatop, Kataribhog, BR34, BR38 and Basmati were used for the study. Seeds were soaked for 24 h in gunny bag, washed thoroughly in fresh water and incubated for sprouting. Sprouted seeds were sown on raised nursery beds. The main field was fertilized with urea, triple super phosphate (TSP), muriate of potash (MOP) and gypsum at 150, 95, 70 and 60 kg ha^{-1}, respectively. One third of urea and whole of TSP, MOP and gypsum were applied during land preparation and thoroughly incorporated into the soil. The remaining urea was top dressed in two equal splits at 30

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and 52 days after transplanting (DAT). The unit plots (2 m × 2 m) in the main field were arranged in a randomized complete block design (RCBD) with three replications. Twenty six-days-old and 2 seedlings per hill were transplanted at 20 cm × 15 cm spacing on the 13th July 2007.

Determination of leaf chlorophyll. Leaf chlorophyll was measured using the method of Yoshida *et al.* (1976). Firstly, 50 mg of fresh leaf sample was weighed and placed into mortar and then crushed thoroughly with pestle. Ten mL of 80% acetone was added to allow the tissue to be thoroughly homogenized and centrifuged for 5 min at 3000 rpm and supernatant the solution. Absorbance of the chlorophyll solution was recorded at 645 and 663 nm wavelengths by Spectrophotometer. Total chlorophyll was calculated by the following formulae:

$$Chl\textit{a} = 0.0127\ D_{663}-0.00269\ D_{645}.$$
$$Chl\textit{b} = 0.0229\ D_{645}-0.00468\ D_{663}.$$

Total chlorophyll (mg g^{-1} fresh weight) =

$$(20.2\times D645+8.02\times D663) \times \frac{10}{1000 \times 0.05}$$

Data recorded. Plant height and number of tillers were recorded from randomly selected 4 hills in each plot. Number of internodes of the mother tillers and length of each internode were recorded. Diameter of the internode was measured with the help of a slide calipers. Length and breadth of flag leaf of the main culm were measured in cm and leaf area was determined by an electronic leaf area meter (Model Licor-300, Inc. Nebrasea, USA). Angle of the flag leaf with the main culm was measured in degree in each of the five randomly selected plants. Flowering date was recorded at emergence of 50% panicle. Maturity date was recorded when nearly 80% of total grains showed characteristic color of maturity. Grain length and breadth were measured with slide calipers. Thousand-grain weight was measured by an electronic balance. Harvest index was calculated as the ratio of grain yield to grain plus straw yield and expressed as percentage.

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and means were adjudged by Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986).

RESULTS AND DISCUSSION

Plant architecture. Plant height varied significantly among the studied entries from 107.90 cm to 93.40 cm (Table I). Kalizira was the tallest (107.90 cm) of all the studied varieties. It had shown no significant difference with BR38 (107.80 cm) and BR34 (106.70 cm). Chiniatop was the shortest and was insignificant to Kataribhog (95.30 cm). The shorter plant height in Chiniatop (93.40 cm) was due to shorter internode length (Table I). Taller plants produced longest internode than shorter ones. Plant height is mostly governed by the genetic makeup of the cultivar, but the environmental factors also influence it. Our results are in agreement with data presented by Mohammad *et al.* (2002).

Internodal length and diameter of internodes varied significantly in different varieties (Table I). The number of countable internodes was 5 except in BR38 and Kalizira. The thicker base internode was found in the varieties BR38 and Kalizira and they had 6th internode. BR38 and BR34 possessed the longest base internode (3.25 cm), while shortest base internode (2.25 cm), respectively. Longest top internode was found in BR38 (45.5 cm). The over lapping character of leaf sheath on internode and broader diameter might be the basis of resistance to lodging in high yielding varieties. The outer diameter of internodes varies with internode position, type of shoot (main culm or tillers) and environmental conditions (Yoshida, 1981).

Flag leaf characters. The longest flag leaf (34.45 cm) was found in Basmati, while Kalizira produced the shortest (25.28 cm) flag leaf. Chiniatop recorded the broadest flag leaf (1.64 cm) followed by Kalizira. Basmati had the narrowest (1.36 cm) flag leaf. Mean flag length-breadth ratio data are also shown in Table II. Basmati produced the largest length-breadth ratio (25.18) followed by BR38 (21.08), BR34 (19.94), Kataribhog (19.59) and lowest one is Chiniatop (18.85). The smallest flag leaf area was recorded from Kalizira (25.14 cm^2 plant^{-1}). The highest flag leaf area was recorded from Kataribhog (35.42 cm^2 plant^{-1}). The grain yield and yield related traits were positively related to flag leaf area. Flag leaf plays an important role in grain yield (Wan & Shong, 1981; Sheela *et al.,* 1990; Raj & Tripathi, 2000), spikelet fertility (Sheela *et al.,* 1990; Regina *et al.*, 1990); panicle size (Bashar *et al.*, 1990; Rao, 1992) and grain size and weight (Das *et al.*, 1981). The highest flag leaf angle (45.14°) was recorded in Basmati, which is statistically identical to Kataribhog (42.24°). The lowest flag leaf angle (16.20°) was found in BR38, which is statistically identical to BR38 (17.23°).

Leaf chlorophyll content. The variation in chlorophyll *a* content among the studied varieties was assessed at booting stages (Table III). The content of chlorophyll *a* varied from 2.81 to 2.95 mg g^{-1} fresh weight. BR38 had the highest (2.95 mg g^{-1} fresh weight) chlorophyll content. The lowest chlorophyll-a content was recorded in Chiniatop (2.61 mg g^{-1} fresh weight). The content of chlorophyll-b varied from 1.83 to 1.13 mg g^{-1} fresh weight. BR38 was highest (1.83 mg g^{-1} fresh weight) of all the studied entries. The lowest chlorophyll-b content was recorded in Basmati (1.13 mg g^{-1} fresh weight). It had shown no statistical difference with BR34 (2.92), Kalizira (2.85), Kataribhog (2.82), Basmati (2.83). Chlorophyll *b* is most important element of photosynthesis. Varieties exhibited significant differences in chlorophyll a+b. The results showed that BR38 contained highest (4.77 mg g^{-1} fresh weight) and Basmati held lowest (3.38 mg g^{-1} fresh weight) amount of chlorophyll *a+b* content.

Table I. Plant height and dimension of internodes of culm

Variety	Plant height (cm)	Length of internode (cm) 1st	2nd	3rd	4th	5th	6th
BR38	107.80	2.4	8.70	11.56	14.5	25.14	45.5
BR34	106.70	2.25	6.24	24.50	31.5	42.27	
Kalizira	107.90	2.56	6.3	12.25	20.5	25.80	40.5
Chiniatop	93.40	2.5	10.56	18.20	26.75	35.50	
Kataribhog	95.30	2.75	11.55	16.0	25.5	39.5	
Basmati	106.31	3.25	12.26	15.0	32.25	43.55	
		Diameter of internode (mm)					
BR38		6.0	6.8	6.5	6.2	5.3	4.0
BR34		4.5	5.6	5.7	3.8	3.8	
Kalizira		4.5	5.8	5.2	5.5	3.6	3.5
Chiniatop		6.5	6.8	6.5	6.9	3.9	
Kataribhog		4.4	4.6	5.0	3.6	3.1	
Basmati		4.2	4.6	5.5	3.8	2.6	

Table II. Flag leaf characteristics of some aromatic fine rice varieties

Variety	Length (cm)	Breadth (cm)	Length: breadth ratio	Area (cm^2/plant)	Angle (°)
BR38	29.15c	1.40c	21.08b	28.23d	17.23e
BR34	28.65d	1.42c	19.94c	26.12e	16.21f
Kalizira	25.28f	1.54b	16.31f	25.14f	24.25d
Chiniatop	31.28b	1.64a	18.85e	33.21b	26.05c
Kataribhog	27.32e	1.40c	19.59d	35.42a	42.24b
Basmati	34.45a	1.36c	25.18a	31.30c	45.14a
$LSD_{0.05}$	0.47	0.06	0.22	0.35	0.43
CV (%)	2.80	1.80	2.61	4.50	0.83

Means followed by a common letters are not different at 5% level of DMRT

Table III. Evaluation of leaf chlorophyll content of some aromatic fine rice

Variety	Chlorophyll-a (mg/g fresh weight)	Chlorophyll-b (mg/g fresh weight)	Chlorophyll-a+b (mg/g fresh weight)	Chlorophyll-a/b
BR38	2.95a	1.83a	4.77a	1.64c
BR34	2.92a	1.71ab	4.64a	1.60cd
Kalizira	2.85b	1.67b	4.52ab	1.73b
Chiniatop	2.81b	1.59bc	4.32b	1.83a
Kataribhog	2.82b	1.52c	4.33b	1.82a
Basmati	2.83b	1.13d	3.38c	1.55d
$LSD_{0.05}$	0.06	0.13	0.07	0.06
CV (%)	1.20	4.54	3.40	2.14

Means followed by a common letters are not different at 5% level of DMRT

Others were statistically indifferent: BR34 (4.67), Kalizira (4.52), Chiniatop (4.32) and Kataribhog (4.33). Chlorophyll-a and -b play vital role of grain filling and most important element of photosynthesis. Munshi (2005) reported that grain yield was positively correlated with chlorophyll content. In the present investigation high yielding genotypes also showed higher chlorophyll content in rice cultivars.

Phenological characters. Days required to first flowering varied significant among the studied varieties (Table IV). Chiniatop required shorter duration to flowering (71.67 days). Kalizira required 77 days representing the longest duration to flowering. Number of days required to 50% flowering differed significantly among the studied varieties. The lowest number of days required to 50% flowering was observed in Chiniatop (81.33 days), which is statistically indifferent from Kataribhog (82.33 days). The maximum number of days required to 50% flowering was for Kalizira (86.67 days). BINA (2004) reported that Chiniatop had shorter duration to maturity than other cultivars. Days to maturity also varied significantly among the varieties studied (Table IV). Basmati took the lowest duration for maturity (103.70 days), while Kalizira took the longest duration (111.00 days). Breeding efforts are underway to develop short lived varieties with high yield potential.

Grain characteristics. Data (Table V) revealed that Chiniatop had the highest (10.8 mm) grain length and BR34 had shortest length (6.8 mm), which was statistically

Table IV. Phenological characters of six fine aromatic rice varieties

Varieties	Days to fist flowering	Days to 50% flowering	Day to maturity
BR38	75.67a	86.33a	108.70b
BR34	74.00b	84.00b	104.30c
Kalizira	77.00a	86.67a	111.00a
Chiniatop	71.67d	81.33d	105.00c
Kataribhog	72.00cd	82.33c	105.30c
Basmati	73.33bc	83.00c	103.70c
$LSD_{0.05}$	1.396	0.85	2.32
CV (%)	1.04	3.56	1.20

Means followed by a common letters are not different at 5% level of DMRT

Table V. Grain morphology of some aromatic fine rice varieties

Variety	Grain length (mm)	Grain breadth (mm)	L:B ratio	Awan	Colour
BR38	9.8 a	1.3 d	4.44 a	Short	Golden
BR34	6.8 c	2.0 c	3.28 b	no	Golden
Kalizira	6.9 c	2.0 c	3.36 b	no	Black
Chiniatop	10.8 a	2.2 b	4.64 a	no	Golden
Kataribhog	10.2 a	2.3 a	4.55 a	Long	Golden
Basmati	8.5 b	2.5 a	3.39 b	no	Golden
$LSD_{0.05}$	1.2	0.3	0.29		
CV (%)	6.90	13.26	4.14		

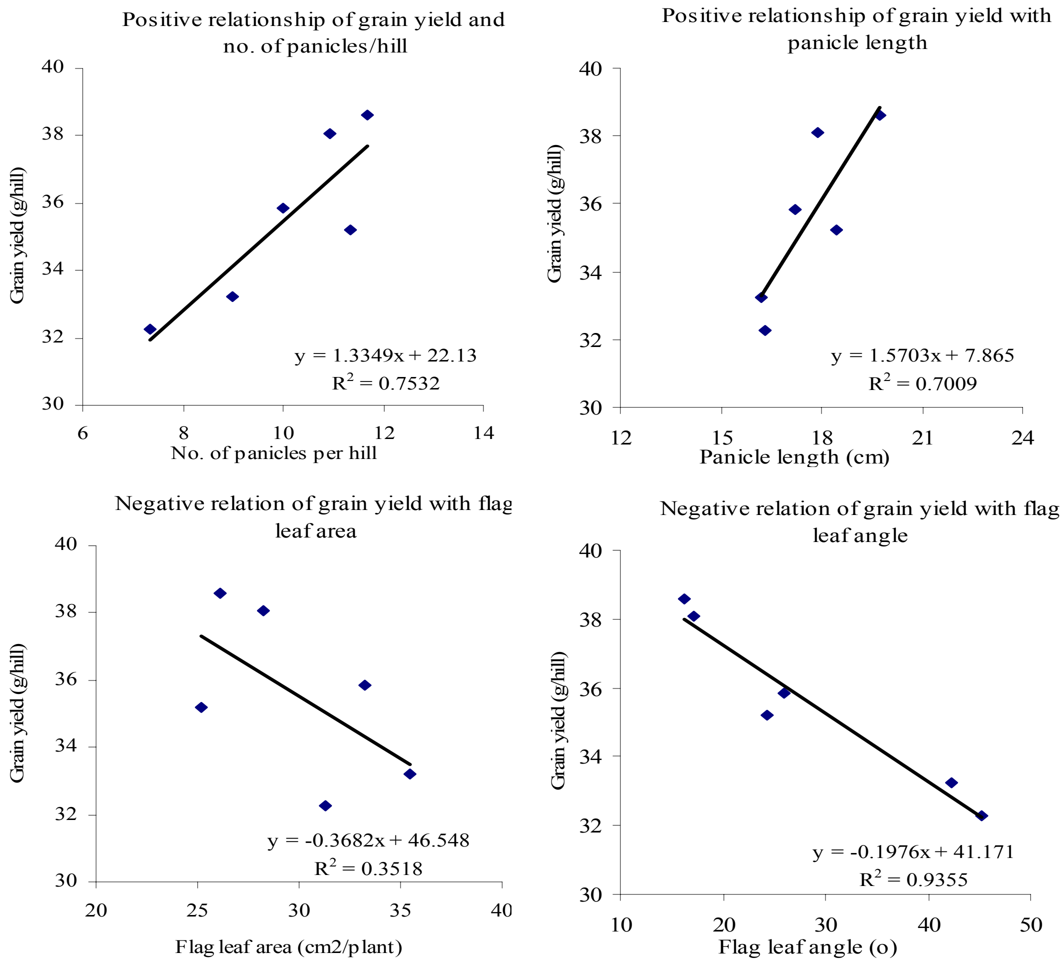
Means followed by a common letters are not different at 5% level of DMRT

Table VI. Mean values of yield and yield components of aromatic rice varieties

Variety	Panicle per hill (no.)	Panicle length (cm)	Grain yield per hill (g)	1000-grain weight (g)	Harvest index (%)
BR38	10.93ab	17.87bc	38.08a	20.13a	33.17b
BR34	11.67a	19.73a	38.60a	12.17f	34.93a
Kalizira	11.33ab	18.43b	35.21b	13.10e	33.22b
Chiniatop	10.00ab	17.20cd	35.83b	14.15b	32.28c
Kataribhog	9.00bc	16.20e	33.23c	17.51c	32.77bc
Basmati	7.33c	16.30de	32.27d	18.07b	31.51d
CV (%)	12.55	2.84	1.36	0.76	1.05
$S\bar{x}$	0.727	0.288	0.200	0.278	1.089

Means followed by a common letters are not different at 5% level of DMRT

Fig. 1. Liner regression showing the relationships among the grain yield and different characters of aromatic rices



identical with Kalizira (6.9 mm). Kataribhog (10.2 mm), BR38 (9.8 mm), BR34 (6.8 mm) and Kalizira (6.9 mm) produced intermediate and statistically identical grain length. The highest grain breadth was observed in Basmati (2.5 mm) followed by Kataribhog (2.3 mm). The lowest grain breadth was obtained in BR38 (1.3 mm) and followed by BR34 and Kalizira (2.0 mm). Rest of varieties had intermediate status. BR34 possessed the lowest length-breadth ratio. The variety Chiniatop possessed the highest length-breadth ratio (4.64) and was statistically identical with rest of the varieties. BR38 had short awn and Kataribhog have long awn. Rest of varieties were awnless. Only Kalizira was black colored and other varieties were golden.

Yield and yield attributes. There were significant differences amongst varieties in number of total panicles per hill (Table VI). BR34 showed the highest number of panicles perhill (11.67) followed by Kalizira (11.33). Basmati produced the lowest number of panicles per hill. Number of panicles was the result of the number of tillers produced and the proportion of effective tillers, which survived to produce panicle (Hossain *et al.*, 2008). BR34 possessed the longest panicle (19.73 cm) and Kataribhog had the lowest (16.20 cm). However Shrirame and Muley (2003) observed that panicle length had no significant difference among the genotypes studied. On the other hand Sharma (2002) worked with fine grain rice and reported that there had been significant variation in panicle length.

Different varieties exhibited significant differences in grain yield (Table VI). BR34 produced the maximum grain yield and Basmati produced the lowest. Varietal differences of grain yield were reported by Biswas *et al.* (1998). The genotypes, which produced higher number of effective tillers per hill and higher number of grains per panicle also showed higher grain yield in rice (Kusutani *et al.*, 2000; Dutta *et al.* 2002). There was significant difference of 1000-grain weight among the varieties (Table VI). The highest 1000-grain weight was recorded in BR38 (20.13 g) and the lowest was recorded in BR34 (12.17 g). BRRI scientists reported that 1000-grain weight differed among the cultivars (BRRI, 1997). Mondal *et al.* (2005) studied 17 modern cultivars of transplant aman rice and reported that 1000-grain weight differed significantly among the cultivars studied, which supported the present experiment results.

Variety had significant differences in harvest indices (Table VI). The highest harvest index was recorded from BR34 (34.94%) and the lowest harvest index was obtained from Basmati (31.51%). Harvest index is a vital character having physiological importance. It reflects translocation on alternatively dry matter partitioning of a given genotype to the economic parts. Kusutani *et al.* (2000) highlighted the contribution of high harvest index to yields. High yield is determined by physiological process leading to a high net accumulation of photosynthates and their partitioning (Miah *et al.,* 1991). Findings of the present study affirm the importance of relative partitioning of dry matter towards grain yield accumulation.

Relationship of yield and morphological characters. Relationship between morphological and yield contributing characters with grain yield is presented in Fig. 1. From the study it was found that grain yield had positive significant correlation with panicle length (r = 0.84*) and number of panicles per hill (r = 0.87*). On the other hand, grain yield was negatively correlated with flag leaf area (r = -0.59) and flag leaf angle (r = -0.97**).

CONCLUSION

Variety BR38 had the best agronomic performance for grain yield, while Basmati and Kataribhog showed the lowest record in grain yield However, further investigation are necessary to confirm these findings under various set of agronomic and climatic conditions.

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