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SCREENING OF ADVANCED AROMATIC RICE LINES USING MORPHOLOGICAL AND PHYSICO-CHEMICAL CHARACTERISTICS

S. Paul[1], P.K. Biswas[2], M.S. Islam[2],S.S. Siddique[3], B.J. Shirazy[3]and M.S. Kobir[3]

[1]Ex-MS Student, SAU & S.O., BARI, RARS, Jashore; [2]Professor, Dept. of Agronomy, SAU;
[3]Scientist, BARI, RARS, Jashore
Corresponding E-mail: suchanapaul.sau@gmail.com

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Abstract

Short-statured and lodging resistant rice plants with long to medium slender grain are the expected criteria for aromatic rice. However, most of the aromatic rice varieties in Bangladesh do not meet the expected criteria. Therefore, this study was undertaken to detect short-statured rice plants with aromatic and long to medium slender grain where twelve advanced rice lines (derived from the local rice germplasm) with a local check Kataribhog were evaluated. All the genotypes demonstrated significant variation for different parameters such as plant height at harvest, yield per hectare, grain length, grain size, grain shape, and aroma. At harvest, the shortest plant height was obtained from SAU ADL11 (107.09cm), and it was statistically similar to SAU ADL4 (111.68cm) and SAU ADL5 (111.89cm). However, the plant height of check variety Kataribhog was 167.17cm. The highest grain yield per hectare was found in SAU ADL5 (4.79 tha^{-1}), where it was 2.71 tha^{-1} in Kataribhog. Besides, the grain yield of shorter genotypes SAU ADL4 and SAU ADL11 was 3.47 t ha^{-1} and 3.84 t ha^{-1}, respectively. The SAU ADL1 provided the highest kernel length (7.31mm), and the lowest kernel length (4.87 mm) was recorded in the check. Kernel length of short-statured genotypes ranged from 7.01 mm to 6.57 mm. Kernel size of all evaluated genotypes was long to medium; whereas, it was short for Kataribhog. Kernel shape of these short-statured genotypes was slender to medium. In case of aroma, SAU ADL3, SAU ADL5, SAU ADL7, SAU ADL9, SAU ADL10, and SAU ADL11 were moderately aromatic, and other genotypes were non-aromatic. However, Kataribhog was strongly aromatic. Finally, SAU ADL5 and SAU ADL11 were evaluated as important germplasms in respect of different characters such as short-statured plant, long to medium slender grain, and aroma. These two lines could be potential inbreed aromatic rice genotypes for Bangladesh.

Introduction

Aromatic rice cultivars are a special group of rice genotypes (Aljumaili *et al.,* 2018), characterized by their qualities like nut-like aroma, cooking, eating and/or super-fine grained (Roy *et al.,* 2016). This group of rice is very popular throughout Asia and has gained wider acceptance in Europe, Australia, the Middle East and the United States of America (Sakthivel *et al.,* 2009). According to Giraud (2013), the international trade market is covered by two aromatic rice varieties namely Basmati (from the Indian Subcontinent), and Jasmine rice (from Thailand) because of its' premium long grain and aroma. According to Kaul (1970), the premium grain was determined by grain length (> 6.0 mm), and length: breadth ratio (L/B 2.5mm to 3mm). Therefore, rice grains with these qualities can be defined as premium quality grain. Several authors (Krishna *et al.,* 2018 and Louis *et al.,* 2005) mentioned that the consumers' demand has significantly increased for quality grain aromatic rice. Therefore, research regarding aromatic rice development increases in different rice-growing countries to fulfill the consumers' demand.

In Bangladesh, the cultivated aromatic rice genotypes are mostly traditional or native types (Islam *et al.,* 2018). The major drawback is that these native aromatic rice germplasms are low yielding per hectare (Islam *et al.,* 2018). Long-statured and lodging susceptible nature were identified as the reasons behind the low yield of native cultivars (Mia *et al.,*2012).Moreover, most of these cultivars produced short bold to medium bold grain and could not meet the criteria of premium quality grain (Islam *et al.,* 2013). Therefore, short-statured, quality grain aromatic rice is important to develop or evaluate. According to Khalid *et al.* (2010) morphological traits were considered effective in evaluation, as they were economic and feasible. Moreover, morphological traits can be easily transmitted to the next generation through conventional breeding (Islam *et al.,* 2016). Apart from morphological traits, some other qualities such as milling, cooking, and eating can also be considered for the evaluation of aromatic rice germplasm (Juliano and Bechtel, 1985).

Bangladesh has a stock of above 8,000 rice germplasm of which nearly 100 are aromatic (Khalequezzaman *et al.,* 2012). These traditional aromatic rice germplasm are great reservoirs of the valuable gene pool (Ahmed *et al.,* 2016). However, many of these germplasm have already been lost from Bangladesh and some of them are still on the verge of extinction (Ahmed *et al.,* 2010). Moreover, information regarding the characterization, genetic diversity, and quality of different local rice germplasm in Bangladesh is limited (Islam *et al.*, 2018). Thus, it is important to conserve these germplasm. Meanwhile, it is necessary to characterize and evaluate these local rice germplasm both morphologically and physico-chemically. Therefore, in this study, twelve advanced lines (derived from the local rice germplasm of Bangladesh) were evaluated to find out short-statured, quality grained aromatic rice.

Materials and Methods

Collection of seed

Seeds of local aromatic Aman rice (grown in July to December) genotypes were preserved in the Department of Agronomy of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207. Then, twelve advanced lines were selected from the local genotypes through various field observations by the Department of Agronomy of Sher-e-Bangla Agricultural University. The selected advance lines were named as SAU ADL (Sher-e-Bangla Agricultural University Agronomy Department Line) having chronological numerical as (i) SAU ADL1, (ii) SAU ADL2, (iii) SAU ADL3, (iv) SAU ADL4, (v) SAU ADL5, (vi) SAU ADL6, (vii) SAU ADL7, (viii) SAU ADL8, (ix) SAU ADL9, (x) SAU ADL10, (xi) SAU ADL11 and (xii) SAU ADL12. Kataribhog was collected from Bangladesh Rice Research Institute, Gazipur, Bangladesh and used as the check variety throughout the entire evaluation process.

Experimental design and management practice

The experiment was laid out in Randomized Completely Block Design (RCBD) with three replications and there were thirteen rice genotypes as treatment. Sprouted Seeds were sown in seedbed on and transplanted on the main field. The plot size was 6 m^2, with spacing 25 cm ×15 cm; 8 rows $plot^{-1}$, 20 hills row^{-1}, and one seedling $hill^{-1}$. The experimental area was fertilized with 120, 80, 80 and 20 kg ha^{-1} of N, P_2O_5, K_2O and S applied in the form of urea, triple super phosphate (TSP), muriate of potash (MoP) and gypsum respectively. The entire amounts of TSP, MP, and gypsum were applied as basal dose at final land preparation. The urea was top-dressed in three equal installments. All the plots were irrigated depending on rainfall to maintain the flood condition. All the plots were dried 7 days before harvesting.

Evaluation of plant growth and yield contributing characters

The crop was considered mature after 80 percent grain became yellow color. Harvesting was started manually at 106 days and continued up to 138 days according to the maturity of the individual lines. Ten hills were selected randomly per plot for evaluation of different growth parameters such as plant height (cm) at harvest, the number of tillers hill^{-1} at harvest, effective tillers hill^{-1}, panicle length (basal node of the rachis to apex), total grains panicle^{-1}, thousand grain weight (g). To determine the fertile spikelet per panicle (%), 10 panicles were harvested at maturity from five randomly chosen plants in each of the plot. The number of filled, unfilled and total grain was also counted to compute fertile spikelet percentage panicle^{-1} as Kumar (2016).

$$\text{Fertile spikelet panicle}^{-1}(\%) = \frac{\text{No.of filled grains in the panicle}}{\text{Total no.of grains in the panicle}} \times 100$$

Yield determination

To determine the yield per plot, the 3 m^2 area (from the middle portion of each plot) was separately harvested and bundled, properly tagged, and then brought to the threshing floor for recording grain and straw yield. Threshing was done using pedal thresher. Both grain and straw were sun-dried immediately after harvesting. The harvested grain was cleaned and sun-dried to a moisture content of 14% (measured by grain moisture meter). Finally, grain and straw yields per plot were determined and converted to ton per hectare (t ha^{-1}). Then Biological yield was calculated following the formula (Youshida, 1981):

Biological yield (t ha^{-1}) or total dry weight (t ha^{-1}) = Grain yield (t ha^{-1}) + Straw yield (t ha^{-1})

The harvest index was determined according to Gardner *et al.* (1985) and the formula was,

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

Grain quality parameters assessment

Milling recovery: A hundred gram sample of dried (14% moisture) paddy grain samples i. e. rough rice were dehulled to produce brown rice in a Satake Laboratory Sheller. The brown rice was milled in McGill mill number 2 (Adair, 1952). The total milled rice was calculated with the following formula (Khush*et al.,* 1979).

$$\text{Total milled rice (\%)} = \frac{\text{Weight of milled rice}}{\text{Weight of rough rice or paddy sample}} \times 100$$

Head rice recovery: The broken grains were separated from the whole grains by using a grain grader and the rice kernel length greater or equal to three quarters was also considered as whole kernel.The percentage of the head rice recovery was calculated using the following equation:

$$\text{Head rice recovery} = \frac{\text{Weight of head rice}}{\text{Weight of paddy sample}} \times 100$$

Grain Classification: Ten de-husked entire brown rice grains were measured using digital slide calipers and based on the L/B ratio, size and shape were classified according to Table 1 and Table 2.

Table 1. Classification of grain size

Scale	Size Category	Length (mm)
1	Very long	More than 7.50
3	Long	6.61 to 7.50
5	Medium or intermediate	5.51 to 6.60

7	Short	Less than 5.50 or 5.50

Source. Cruz and Khush (2000) and IRRI standards

Table2. Classification of grain shape

Scale	Shape	L/B ratio (mm)
1	Slender	Over 3.0
5	Medium	2.1 to 3.0
9	Bold	2.0 or less than 2.0

Source. Cruz and Khush (2000) and IRRI standards

Kernel length after cooking: Kernel length after cooking **(**KLAC) was measured according to Bhonsle and Krishnan (2010). Rice samples were cooked in a water bath for 20 min, followed by ten selected (intact at both ends) cooked rice placing on blotting paper. Finally, the length of the kernels was measured using graph paper for computing the KLAC.

Aroma content: The aroma content of all rice germplasm was evaluated according to IRRI (1971). One gram of freshly harvested milled rice was mixed with 20 ml of distilled water and placed into a centrifuge tube (50 ml round bottom). The tubes were then covered with aluminum foil. The samples were placed in a boiling water bath for 10 minutes. The cooked samples were allowed to cool and the presence of aroma was smelled by a panel of experts to score as strongly aromatic, moderately aromatic, slightly aromatic and non-aromatic. A strongly scented genotype (Kalizira) was used as a check for comparison.

Statistical analysis: All the data were analyzed using the R program for statistical analysis. The means were separated using the least significant difference (LSD) test at the 0.05 level.

Results and Discussion

This investigation successfully evaluated the growth, yield contributing characters, yield and physico-chemical quality of different native aromatic Aman (growing season July to December) rice genotypes.

Morphological characteristics

Plant height: Plant height is an important morphological parameter as this positively correlated to lodging (Navadi*et al.,* 2006). Additionally, lodging disturbs the ripening process, decreases crop yield, and causes poor grain quality (Kono, 1995). The plant height at harvest for all genotypes ranged from 219.08 cm to 107.09 cm and the genotypes differed significantly (Table 3). This result was supported by Hossain *et al.*(2008) stated that the popular aromatic rice cultivars in Bangladesh were local with long-statured in nature and very much prone to lodging. SAU ADL11 produced the shortest plant (107.09 cm) which was statistically similar to SAU ADL4 (111.68 cm), SAU ADL5 (111.89 cm) and did not lodge during the maturity stage. The highest plant height was obtained from SAU ADL10 (219.08 cm) where Kataribhog the popular aromatic rice cultivar provided the third highest plant height (167.17 cm) which was statistically similar with SAU ADL2 (159.57 cm), SAU ADL3 (173.26 cm) and these long-statured plant demonstrated lodging. This result indicated that the lodging of rice plants is highly associated with plant stature and short-statured genotypes could be useful for the lodging resistant genotypes. Previously Okuno *et al.* (2014) also recorded that the short height rice genotypes are resistant to lodging.

Total tiller numbers hill^{-1}: Tillering is a vital determinant of panicle production as well as yield in rice (Miller *et al.,* 1991). The current study found that the total tillers hill^{-1} at the harvesting stage varied among the evaluated genotypes. The highest total tiller numbers hill^{-1}at harvest was observed in the local aromatic rice genotype SAU ADL10 (18.75) followed by SAU ADL5 (15.58).The total tiller numbers hill^{-1} of SAU ADL1, SAU ADL3, SAU ADL4, SAU ADL6, SAU ADL8, SAU ADL11 and

Kataribhog were statistically similar with SAU ADL5. The minimum tiller numbers hill^{-1} (6.58) was obtained from SAU ADL12 (Table 3).

Table 3. Morphological characters such as plant height and total number of tillers hill^{-1} at harvest, and days to maturity of evaluated rice genotypes

Genotypes	Plant height (cm)	Total tillers hill^{-1} (no.)	Maturity duration (days)
SAU ADL1	124.16 e	15.36 b	134.67 c
SAU ADL2	159.57 d	11.83 de	124.67 g
SAU ADL3	173.26 c	14.50 bc	126.33 f
SAU ADL4	111.68 fg	14.00 bcd	131.00 e
SAU ADL5	111.89 fg	15.58 b	131.00 e
SAU ADL6	166.14 cd	11.08 e	134.67 c
SAU ADL7	119.56 ef	12.66 cde	135.67 b
SAU ADL8	119.73 ef	13.17 bcdee	135.67 b
SAU ADL9	194.72 b	11.83 de	133.33 d
SAU ADL10	219.08 a	18.75 a	134.33 c
SAU ADL11	107.09 g	13.33 bcde	136.00 b
SAU ADL12	202.25 b	6.58 f	138.67 a
Kataribhog	167.17 cd	15.00 bc	135.67 b
$LSD_{(0.05)}$	8.74	2.65	0.78
CV (%)	3.41	11.76	0.35

The means with the same letter in a column show an insignificant difference at the 5% level

Maturity duration:SAU ADL12 recorded the maximum days (138.67 days) for maturity, whereas the minimum days (124.67 days) was recorded in SAU ADL2. Local check Kataribhog recorded 135.67 days for maturity where short statured genotypes SAU ADL4, SAU ADL5 and SAU ADL11 recorded 131.00, 131.00, 136.00 days, respectively.

The variations in tillering and days to maturity might be the varietal variation. Previously several authors (Hossain *et al*., 1991 and Jisan *et al*., 2014) also identified the difference in the genetic makeup as the reason for these variations during evaluation of different lines.

Yield and yield contributing parameters

Panicle length and fertile spikelets panicle^{-1} (%): Maximum panicle length (32.63 cm) was recorded in genotype SAU ADL10 followed by SAU ADL9 (30.75 cm) which was statistically similar to SAU ADL3 (30.67), SAU AD6 (29.62) (Table 4). A minimum panicle length of 26.33 cm was recorded in SAU AD7 which was statistically similar to SAU AD1, SAU AD2, SAU AD4, SAU AD11 and Kataribhog (Table 4). The highest fertile spikelets panicle^{-1} (%) was found in SAU ADL2 (91.57%) followed by Kataribhog (83.15 %). The lowest fertile spikelets panicle^{-1} (%) was recorded from SAU ADL7 (27.44 %). Short statured genotypes SAU ADL4, SAU ADL5 and SAU ADL11 had 52.02 %, 64.50% and 69.52 % fertile spikelets panicle^{-1}, respectively (Table 4).

Effective tillers hill^{-1}: The number of panicles or effective tillers hill^{-1} is the most important component of rice yield (Shahidullah*et al.,* 2009). The maximum effective tillers hill^{-1} (16.75) was recorded from the genotype SAU ADL10 (Table 4).Kataribhog also produced second highest tillers m^{-2}, which was statistically similar to SAU ADL3, SAU ADL7, SAU ADL11, and SAU ADL5 (Table 4).

On the other hand, the least effective tillers hill^{-1}were recorded in SAU ADL12 (5.33) which was statistically similar to SAU ADL6 (7.67). This result was similar to Hossain *et al.* (2005) who found variation among the evaluated native aromatic rice cultivars in case of fertile tillers hill^{-1} which ranged from 8.6 to 11.4.

Thousand-grain weight: Thousand-grain weight is an important yield-determining component, which is also a genetic character least influenced by the environment (Ashraf *et al.,* 1999). Yoshida (1981) reported that under most conditions, 1000 grains of field crop is a very stable character. The highest thousand grain weight (31.97 g) was obtained from the genotype SAU ADL4 (31.97 g) which was statistically similar to SAU ADL1 (31.03g) and SAU ADL9 (31.03 g). On the other hand, the lowest thousand grain weight (15.03 g) was obtained from Kataribhog. Moreover the thousand grain weight of SAU ADL11 was 21.88 g which was statistically similar with SAU ADL7 (Table 4). The main cause of the highest and lowest 1000-grain weight could be the long-slender grain size and short-medium grain size of genotypes respectively. The previous study found that grain size determines grain weight and affects grain quality (Jiang *et al*., 2015).

Grain yield and harvest index (HI): Grain yield and harvest index differed significantly among the local Aman rice germplasms (Table 4). The highest grain yield (4.79 tha^{-1}) was obtained from SAU ADL5 which was statistically similar to SAU ADL2 (4.55 tha^{-1}), SAU ADL3 (4.47 tha^{-1}) and SAU ADL9 (4.48 tha^{-1}). The lowest grain yield (2.59 t ha^{-1}) was recorded from SAU ADL7 which was statistically similar to SAU ADL6 (2.86 tha^{-1}), SAU ADL12 (2.81 tha^{-1}), Kataribhog (2.71tha^{-1}). However, Hossain *et al.* (2005) observed 3.3 t ha^{-1} yield in Kataribhog and Hoque *et al.* (2013) found 2.63 t ha^{-1} yield in Kataribhog.The reasons behind this yield could be the result of number of effective tillers hill^{-1}, fertile spikelets panicle^{-1} (%) and 1000-grain weight (g). This result was also in agreement with Hassan *et al.* (2003) who stated that grain yield is a function of the interplay of various yield components such as the number of productive tillers, fertility percentage panicle^{-1} and 1000-grain weight.

Table 4. Yield and yield contributing characters of evaluated rice genotypes after harvest

Genotypes	Panicle length (cm)	Fertilespikelets panicle^{-1} (%)	Effective tillers hill^{-1} (no.)	1000-grain weight (g)	Grain yield (tha^{-1})	Harvest index (%)
SAU ADL1	26.79f	43.34 g	12.69 bc	31.03 ab	3.50 cde	37.75 b
SAU ADL2	26.95ef	91.57a	10.50 de	29.96 bc	4.55 ab	43.50 a
SAU ADL3	30.67bc	50.95fg	13.92cbc	26.02 f	4.47 ab	20.40 de
SAU ADL4	27.33ef	52.02 f	12.58 bc	31.97 a	3.46 cde	37.17 b
SAU ADL5	28.27de	64.50cd	14.34 b	29.25 cd	4.79 a	34.69 b
SAU ADL6	29.62 bcd	54.14ef	8.42 f	28.97 cd	2.86 ef	20.09 de
SAU ADL7	26.33 f	27.44h	10.67 de	22.34 g	2.59 f	19.18 de
SAU ADL8	29.33cd	61.43de	9.17 ef	28.10 de	3.10 def	36.88 b
SAU ADL9	30.75b	72.15c	9.92 ef	31.03 ab	4.48 ab	33.57 b
SAU ADL10	32.63a	68.75cd	17.08 a	27.22 ef	3.92 bc	16.84 e
SAU ADL11	26.39f	69.52c	12.08 cd	21.88 g	3.84 bcd	35.34 b
SAU ADL12	29.59bcd	54.76ef	5.33 g	27.83 de	2.81ef	23.18 cd
Kataribhog	27.47ef	83.150b	13.00 bc	15.17 h	2.71ef	27.75 c
$LSD_{(0.05)}$	1.37	8.02	1.88	1.68	0.81	5.05
CV (%)	2.84	7.8	9.7	3.68	13.20	10.07

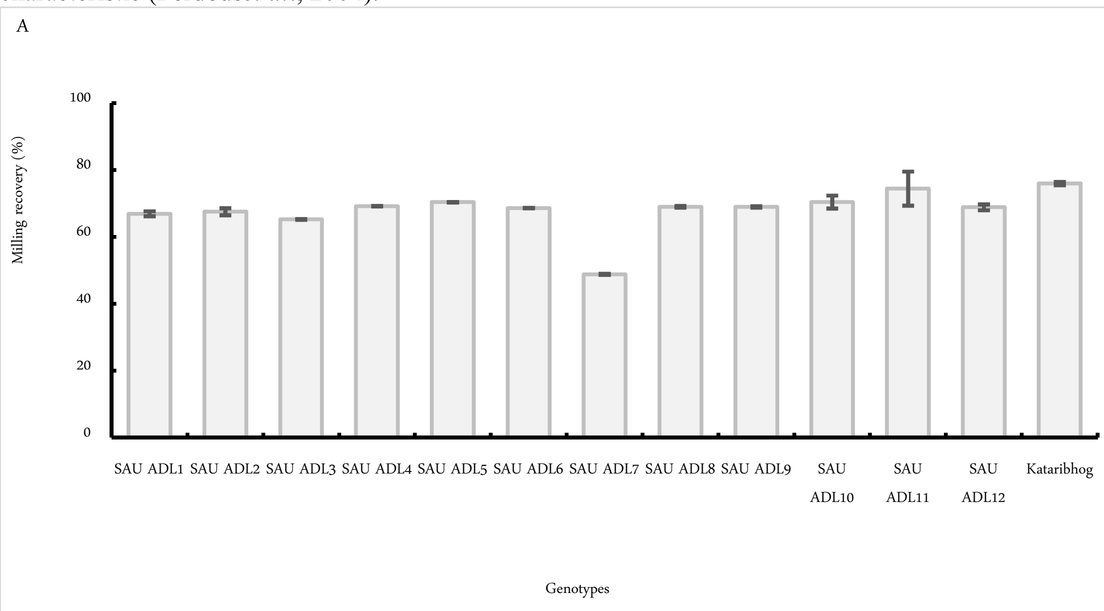
The means with the same letter in a column show an insignificant difference at the 5% level

According to Youshida (1981), the harvest index of traditional tall varieties is about 30% and for improved short varieties it is 50% and the identified reason is that dry mater partitioning to economic part is higher in short-statured varieties than the traditional one. The highest harvest index was found from the genotype SAU DL2 (43.50%). The lowest harvest index (16.84%) was found from SAU ADL10 which was statistically similar to SAU ADL6, SAU DL7, and SAU ADL3. Harvest Index of local cultivar Kataribhog was 27.75 %, where HI of short-statured genotypes SAU ADL4, SAU ADL5 and SAU ADL11 was 37.63%, 35.57%, and 35.34% respectively.

Physico-chemical parameters

Physical properties include kernel size, shape, milling recovery, degree of milling and grain appearance (Cruz and Khush, 2000) and physico-chemical properties include cooking and eating quality like Kernel length after cooking, aroma (Rebeira*et al.,* 2014).

Milling Recovery (MR) (%) and Head Rice Recovery (HRR) (%): Milling yield is an important physical property of rice especially for market value (Rosniyana *et al.,* 2006). A variety should possess a high turn-out of whole-grain (head) rice and total milled rice (Webb, 1985). This criterion is important because it expresses the actual yield of a consumable product. The typical range of milling recovery was from 68 to 72 percent (Hardke and Siebenmorgen, 2012). The highest MR (75.92%) (Figure 1A) and HRR (68.64%) (Figure 1B) were recorded in Kataribhog. Both MR (74.41%) and HRR (65.71%) of SAU ADL11 were statistically similar to Kataribhog. The lowest MR (48.82%) and HRR (35.51%) were recorded from SAU ADL7. Short-statured genotypes SAU ADL4 and SAU ADL5 had 69.19% and 70.36% milling recovery, respectively. Besides short stature genotypes SAU ADL4 and SAU ADL5 showed 58.94% and 58.41% of HRR, respectively. The MR% of rest genotypes lays 65.24% to 74.41%. Ahmed *et al*. (2016) also assessed agro-morphological, physico-chemical and molecular characters of rice germplasm in Bangladesh and found 65.3% to 69.9% milling rate. This study was also similar to Hossain *et al*.(2008) who evaluated several local aromatic rice genotypes and reported 67.3% and 67.8% HRR in Kataribhog (Philippine) and Kataribhog (deshi), respectively. The reason for this variation could be the result of different grain size and shape, moreover its a varietals characteristic (Ferdous*et al*., 2004).



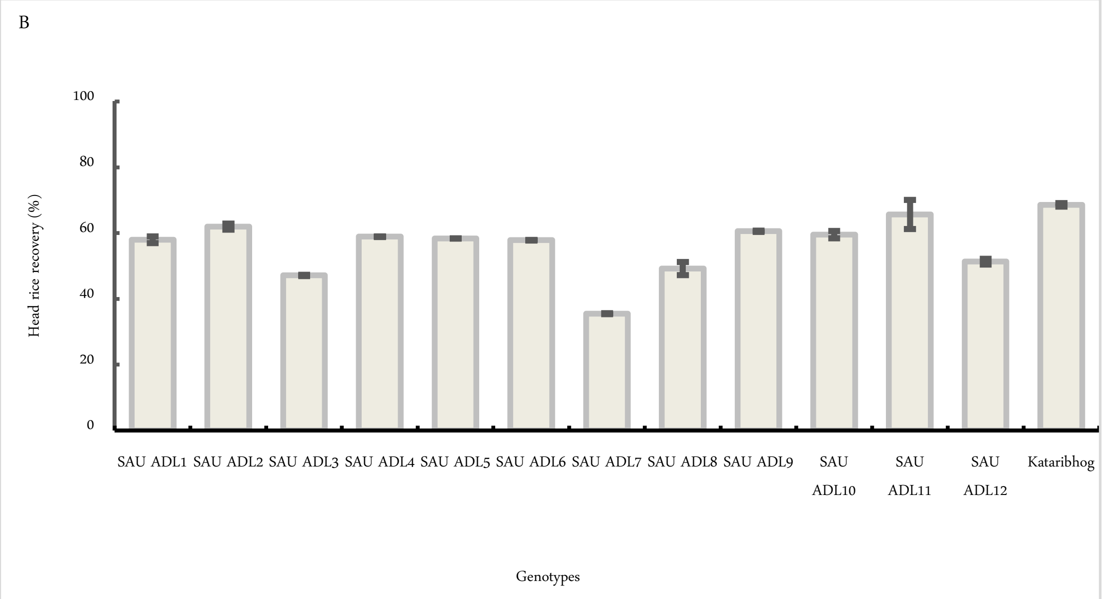


Fig. 1. Milling recovery (%) and head rice recovery (%) of evaluated local Aman rice genotypes. A) Millingrecovery (%)of evaluated local Aman rice genotypes. B) Head rice recovery (%) of evaluated local Amanrice genotypes. Vertical bars mention the $LSD_{(0.05)}$ values.

Kernel length (mm) and breath (mm): Grain size and shape are the first criteria of rice quality that breeders consider in developing new varieties for release for commercial production (Adair *et al.,* 1966). Aromatic variety with kernel length 6.0 mm and above is considered a widely acceptable size (Kaul, 1970). The highest kernel length (7.31mm) was obtained from SAU ADL1 followed by SAU ADL9 (7.22 mm) (Table 5). Meanwhile, the highest kernel breadth (2.62 mm) was obtained from SAU ADL2. The lowest kernel length (4.87 mm) and breadth (1.8 mm) was obtained from Kataribhog. Kernel length of short statured genotypes SAU ADL4, SAU ADL5, and SAU ADL11 was 7.01mm, 6.78mm, and 6.57mm respectively. In this investigation, the kernel length of all evaluated local germplasm was more than 6 mm and considered to be premium quality. However, Kataribhog does not meet the acceptable range. Islam *et al*. (2016) also reported medium bold scented grain in Kataribhog and that was similar to the study.

Kernel size and shape: Furthermore, the L/B ratio formulates the grain shape and the length and breadth ratio of all studied genotypes was also between the acceptable ranges 2.5 mm to 3mm (Kaul, 1970). Kernel length and breadth ratio of all the genotypes ranged from 3.77 mm to 2.37 mm (Table 5). The highest ratio (3.77) was obtained from SAU ADL8 followed by SAU ADL7, SAU ADL3, SAU ADL10 and SAU ADL1. However, the lowest ratio (2.37) was obtained from SAU ADL2.

The kernel size of SAU ADL1, SAU ADL3, SAU ADL4, SAU ADL7, SAU ADL8 and SAU ADL10 were long and slender; SAU ADL5 was long medium; SAU ADL6, SAU ADL9 and SAU ADL11 were medium slender and SAU ADL2 and SAU ADL12 were of medium type. On the other hand the kernel size of the check variety (Kataribhog) was of short medium type. The result was similar to Hossain *et al*. (2008) who reported 5.2 mm kernel length and 2.3 length-breadth ratios in Kataribhog (Philippines) and also 4.90 mm grain length and 2.5 length-breadth ratios in Kataribhog (Deshi). However, the result was not supported by Dutta *et al*. (1998) who analyzed seven aromatic rice and reported 5.97mm kernel length and 3.09 length-breadth ratio in Kataribhog.

Table 5. Physico-chemical characteristics and aroma content of evaluated genotypes

Treatments	Kernel length (mm)	Kernel size	Kernel breadth (mm)	L/B ratio	Kernel shape	Kernel length after cooking (mm)	Aroma content
SAU ADL1	7.31 a	Long	2.23 de	3.28 bcd	Slender	9.34 b	non-aromatic
SAU ADL2	6.27 h	Medium	2.62 a	2.37 h	Medium	8.11 f	non-aromatic
SAU ADL3	7.13 abcd	Long	2.10 f	3.40 b	Slender	9.20 bc	moderately aromatic
SAU ADL4	7.01 bcde	Long	2.25 de	3.13 cd	Slender	8.91 cd	non-aromatic
SAU ADL5	6.78 efg	Long	2.33 cd	2.92 ef	Medium	9.99 a	moderately aromatic
SAU ADL6	6.93 cde	Long	2.43 bc	2.86 fg	Medium	9.13 bcd	non-aromatic
SAU ADL7	6.62 fg	Long	1.93 g	3.43 b	Slender	8.00 f	moderately aromatic
SAU ADL8	7.19 abc	Long	1.93 g	3.77 a	Slender	8.99 bcd	non-aromatic
SAU ADL9	7.22 ab	Long	2.52 ab	2.88 fg	Medium	9.19 bc	moderately aromatic
SAU ADL10	6.89 def	Long	2.09 f	3.30 bc	Slender	9.03 bcd	moderately aromatic
SAU ADL11	6.57 g	Medium	2.13 ef	3.08 de	Slender	8.53 e	moderately aromatic
SAU ADL12	6.60 g	Medium	2.33 cd	2.87 fg	Medium	8.78 de	Slightly aromatic
Kataribhog	4.87 i	Short	1.80 h	2.70 g	Medium	6.77 g	Strongly aromatic
Acceptable range	>6 mm	-	-	>3	-	-	-
$LSD_{(0.05)}$	0.29	-	0.13	0.20	-	0.38	-
CV (%)	2.53	-	3.39	3.82	-	2.54	-

The means with the same letter in a column show an insignificant difference at the 5% level

Kernel length after cooking (**KLAC**)**:** Results revealed that KLAC of screened rice ranged from 8 mm to 9.99 mm (Table 5). The highest KLAC (9.99mm) was found in SAU ADL5 and the lowest KLAC (6.77mm) was found in Kataribhog.

Aroma: Aroma varied among the varieties (Table 5). Among the genotypes SAU ADL3, SAU ADL5, SAU ADL7, SAU ADL9, SAU ADL10, SAU ADL11 were moderately aromatic. SAU ADL12 was slightly aromatic. SAU ADL1, SAU ADL2, SAU ADL4, SAU ADL8 were non-aromatic. The check Kataribhog was strongly aromatic.Islam *et al.*(2018) also found variability among 113 aromatic rice germplasms of Bangladesh and reported that more than 58% of the germplasm were well scented, 31% germplasm were moderately scented, and 11% germplasm were non-scented. Moreover, several authors (Hossain *et al.,* 2008 and Islam *et al.,* 2016) evaluated local cultivars and reported moderate to the strong aroma in the evaluated aromatic rice cultivars.

Conclusion

The short-statured lodging resistant aromatic rice genotypes SAU ADL5 and SAU ADL11 along with the quality grain and higher yield can be evaluated at different Agro-ecological zone of Bangladesh to promote as improved genotypes for cultivation. Other genotypes could be preserved as improved breeding materials.

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