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AGRO-MORPHOLOGICAL CHARACTERIZATION, GROWTH AND YIELD PERFORMANCE OF GLUTINOUS AND AROMATIC RICE CULTIVARS OF SYLHET REGION IN BANGLADESH

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Abstract

Agro-morphological characters, growth and yield performances of 11 local cultivars and a high yielding variety (BRRI dhan34) were studied in pot culture at the experimental research field of Agronomy, Sylhet Agricultural University (SAU), Sylhet, Bangladesh for two consecutive years of Aman rice season (July to December 2017 and July to December 2018). The objective was to find out the qualitative glutinous and aromatic rice cultivars for future use. The treatments consisted of eleven local rice cultivars viz., Haitta, Lenjur, Dumai, Modonga, Maloti, Gandi, Biruy, Moyna sail, Nagra sail, Biruin, Madhumadab along with a control variety BRRI dhan34. Twenty-eight (28) agro-morphological traits, growth patterns, and yield performances were analyzed based on DUS (Distinctness, Uniformity, and Stability) guidelines, and results showed the phenological variation among the cultivars and BRRI dhan34. Among all the cultivars, Dumai and Lenjur were found as early mature (maturity days 77 and 92 days), Modonga showed lodging resistance, Biruin produced a higher grain yield than others, and Madhumadab had a finer grain with aromatic rice having lower 1000 grains weight. Association analysis also showed a positive relationship between the grain yield with length of panicle, grains per panicle, unfilled grains per panicle, and crop duration (days). So, above mentioned, cultivars were found as promising cultivars for future breeding purposes.

Key words: Agro-morphological characters; Growth & yield; Glutinous & Aromatic rice cultivars.

Introduction

In Bangladesh, rice is one of the main foods and occupies nearly 90% of the total net cropped area, as well as possesses the fourth position around the world based on production. More than 99% of the people in Bangladesh consume rice as their main food @ 416 gm/person/day (Anon., 2010). It also provides 80% of the calorie intake for Bangladeshis and is the main dietary source of essential nutrients including, selenium (Se) and zinc (Zn) (Shaban *et al.*, 2012).

In 1971, 10.59 million tons (MT) of rice was being produced for only about 70.88 million people, but now Bangladesh is producing 33.80 million tons (MT) of rice for 165.0 million people with a decreasing amount of cultivable land (Anon., 2017). This proved a higher amount of cultivation of modern rice varieties, about 73% of rice production was obtained with using modern rice varieties (Anon., 2012) for their high yielding capacity. Nevertheless, cultivating modern high yielding rice varieties due to the daily needs of food consumptions, some promising local cultivars are being extinct from the farmer's field (Hossain *et al.*, 2013). Though these cultivars are low yielding, they have some unique characteristics like as fineness, fragrance, acidity forbearances, drought tolerances, phosphorus up-taking ability having PISTOL gene, a higher concentration of Zinc and Selenium, as well as special glutinous/sticky with good flavor and aroma (Shaban *et al.*, 2012 and Wissuwa & Ae, 2001).

The genetic resources are considered as a key in breeding science. The local cultivars are the harbor of enormous genetic resources that are the wealth resources for plant breeding programs to develop any special type of rice variety for any specific area or situation like drought and salt tolerances, various types of nutrient enrichment, etc. However, due to the obliviousness of these local cultivars, plant breeding resources are decreasing day by day, which is a direct threat to the successful rice production for immense population and food security. As well as, morphological characterization of these local cultivars is also important for their identification and recognition. Therefore, collection, characterization, and preservation of local cultivars should be done for their valuable genes. Glutinous and aromatic rice is one of the unique types of rice. Glutinous rice becomes sticky after cooking due to the presence of a higher amount of starch called amylopectin. There is a lot of aromatic rice cultivars present around the whole Bangladesh, which is finely grained and scented, but glutinous rice is cultivated mainly in Chittagong, Cox's bazaar, and the Sylhet region.

Sylhet is a vast source of glutinous and aromatic rice cultivars, enriched with valuable genes. Limited work has done with these local cultivars, especially in glutinous rice. So, it is needed to characterize and evaluate these types of cultivars for enriching the breeding program to identify the valuable genes for further study and has not been conveyed yet. Therefore, this study was conducted to illustrate the agro-morphological characteristics and evaluate the growth and yield performances of aromatic and glutinous rice cultivars in order to suggest highly qualitative cultivars for future breeding purposes.

Materials and Methods

The experiment entitled "Agro-morphological characterization, growth and yield performances of

aromatic and glutinous rice cultivars of Sylhet Region in Bangladesh'' was carried out at the experimental field of Agronomy, Sylhet Agricultural University, Sylhet, Bangladesh (24°54′33.2″N latitude and 91°54′7.15″E longitude at 30m above the sea level) during two consecutive years of Aman rice seasons of Jul-Dec, 2017 and 2018. The experimental site belongs to the Khadimnagar soil series with low to medium fertility sandy loam texture under the Agro-Ecological Zone (AEZ 20) named Eastern Surma-Kushiyara Floodplain. Nearly 80% of the 4,200 millimeters (170 inches) annual average rainfall occurs between May and September.

A total of 11 local rice cultivars and BRRI dhan34 an aromatic high yielding variety were used as the checked variety to characterize through DUS descriptor as well as each of the cultivar was considered as treatment (Table 1). In the first week of June, the seedling was raised in the seedbeds. Twenty-six (26) days old seedling was transplanted in 30 cm x 20 cm pot. Each treatment or cultivar was replicated five times following in CRD design. Two seedlings per hill and three hills per pot were transplanted. Each pot was fertilized by N-P-K fertilizers @40-10-46 kg/ha. In all, 28 agro morphological traits (Table 2) were observed, and data on growth parameters viz. plant height and tillers number were also recorded on 15 days interval. Yield and yield attributes viz. effective tillers, panicle length, filled grains per panicle, unfilled grains per panicle, 1000 grains weight, grain yield per pot, and grain yield per hectare were recorded at maturity.

Table 1. List of 11 local cultivars with control HYV (High Yielding Variety) variety.

Sl. No.	Cultivars/Variety	Sl. No.	Cultivars/Variety
1.	Haitta (V1)	7.	Biruy (V7)
2.	Lenjur (V2)	8.	Moyna sail (V8)
3.	Dumai (V3)	9.	Nagra sail (V9)
4.	Modonga (V4)	10.	Biruin (V10)
5.	Maloti (V5)	11.	Madhumadab (V11) (Aromatic)
6.	Gandi (V6)	12.	BRRI dhan34 (V12)

Plant materials: High demand of food for increasing population, farmers are inclined to cultivate HYV. As a result, the production of local elite rice cultivars (aromatic and glutinous characters) are going to be extinct day by day. Some of the elite farmers are still cultivating these cultivars which are tasteful and have export potentiality. For these thematic point of view, we collected 11 local rice cultivars based on farmer's opinion from different areas of Sylhet region to establish an elite special rice germplasm and done agro-morphological characterization as well measure their growth and yield performances. Eleven aromatic and glutinous local rice cultivars along with BRRI dhan34 (check variety) are listed in Table 1.

Statistical analysis

Growth parameters, yield, and yield attributing characters were analyzed by R software. On the other hand, agro-morphological characterization was performed via the DUS (Distinctness, Uniformity, and Stability) test using IBPGR or IRRI rice descriptor. DUS testing is a way to assess whether a newly developed variety varies from existing varieties within the same species (Distinctness), whether the characteristics used to assess Distinctness are consistently expressed (Uniformity), and whether those characteristics do not alter over subsequent generations (Stability).

Data were analyzed by "R-version 3.6," and mean differences were measured at a 5% level of significance by the LSD (least significance difference) test. The correlation coefficients between the grain yield with yield and yield contributing characters, plant height at DAT (Days after transplanting) with grain yield as well as tiller numbers at DAT with grain yield according to Al-Jibouri *et al*., (1958) were determined. The significance of correlation coefficients was verified against Fisher & Yates (1963) provided 'r' values.

Data collection

Agro-morphological characters: Data was collected for agro-morphological characters on various stages of rice plant from germination to ripening and from stem to top of panicle according to DUS guidelines. Twenty-eight (28) agro-morphological data were recorded (Table 2).

Table 2. Agro morphological traits which are recorded during data collection.

Sl. No.	Morphological characters	Sl. No.	Morphological characters
1.	Coleoptile color	15.	Lemma: anthocyanin coloration of the apex
2.	Basal leaf sheath color	16.	Spikelet: the color of stigma
3.	Leaf: anthocyanin coloration	17.	Stem: length (excluding panicle)
4.	Leaf: distribution of anthocyanin coloration	18.	Stem: anthocyanin coloration of nodes
5.	Leaf: auricles	19.	Stem: anthocyanin coloration of internodes
6.	Leaf: Anthocyanin coloration of auricles	20.	Panicle: length of the main axis (cm)
7.	Leaf: collar	21.	Flag leaf: the attitude of the blade (late observation)
8.	Leaf: Anthocyanin coloration of the collar	22.	Panicle: number per plant
9.	Leaf: ligule	23.	Lemma and palea: color
10.	Leaf: the shape of ligule	24.	Panicle: awns
11.	Leaf: length of the blade	25.	Time maturity (days)
12.	Leaf: width of the blade	26.	Grain: the weight of 1000 fully developed grains (g)
13.	Time of heading (50% of plants with panicles) (days)	27.	Decorticated Grain: color
14.	Flag leaf: the attitude of the blade (early observation)	28.	Decorticated Grain: aroma

Table 3. Qualitative agro-morphological traits of collected rice cultivars/variety BY using DUS descriptor.

Cultivars	CC	BLSC	ACL	ACLA	ACLC	ACN	ACIN	CS	ACLA Lema/grain	LPC	SA	DGC	DGA
Haitta	Colorless	Green	Absent	Absent	Absent	Absent	Absent	White	Absent	Straw	Absent	Red	Absent
Lenjur	Colorless	Green	Absent	Absent	Absent	Absent	Absent	White	Absent	Straw	Absent	Red	Absent
Dumai	Colorless	Green	Absent	Absent	Absent	Absent	Absent	White	Strong	Black	Absent	Dark brown	Absent
Modonga	Colorless	Green	Absent	Absent	Absent	Absent	Absent	White	Absent	Straw	Present	White	Absent
Maloti	Purple	Uniform purple	Present	Present	Present	Present	Present	Purple	Medium	Straw	Absent	White	Absent
Gandi	Colorless	Green	Absent	Absent	Absent	Absent	Absent	White	Strong	GGSB	Absent	Dark brown	Absent
Biruy	Colorless	Green	Absent	Absent	Absent	Absent	Absent	White	Strong	GGSB	Absent	Light red	Absent
Moyna sail	Colorless	Green	Absent	Absent	Absent	Absent	Absent	White	Very strong	BFS	Absent	Dark brown	Absent
Nagra sail	Colorless	Green	Absent	Absent	Absent	Absent	Absent	White	Absent	Straw	Absent	Light red	Absent
Biruin	Purple	Uniform purple	Present	Absent	Absent	Absent	Present	White	Very strong	Straw	Absent	Light red	Absent
Madhumadab	Colorless	Green	Absent	Absent	Absent	Absent	Absent	White	Absent	Straw	Absent	White	Present
BRRI dhan34	Colorless	Green	Absent	Absent	Absent	Absent	Absent	White	Absent	Straw	Absent	White	Present

CC = Coleoptile color, BLSC= Basal Leaf Sheath Color, ACL= Anthocyanin Coloration of Leaf, ACLA= Anthocyanin Coloration of Leaf Auricles, ACLC= Anthocyanin Coloration of Leaf Collar, ACN=Anthocyanin Coloration of Nodes, ACIN =Anthocyanin Coloration of Inte modes, CS=Color of Stigma, ACLA=Anthocyanin Coloration of Lemma Apex, LPC= Lemma and Palea Color, SA= Spikelet awns, DGC=Decorticated Grain Color, DGA= Decorticated Grain Aroma, GGSB= Gold & gold furrows on straw background, BFS= Brown furrows on straw

Results and Discussion

Agro-morphological characters: Among all the 28 qualitative and quantitative agro-morphological traits, 8 were similar in all 11 cultivars and checked variety BRRI dhan34. These were the distribution of anthocyanin coloration, which was present on leaf margin only (4), leaf auricles (5), leaf collar (7), and leaf ligule (9), the shape of leaf ligule (10) which was split. Flag leaf attitude of the leaf blade in both early (14) and late observation (21), which was erect, and stem length (17) was short. The rest of the 20 traits were different qualitatively, and quantitatively from each other within all cultivars. Our observations here in agreement with those of Mohammad *et al*., (2015), who reported high significant variability among the various genotypes of rice. Also, Wang *et al*., (2006) endorsed the results under way. These qualitative and quantitative characters were categorized according to the DUS guidelines.

Qualitative traits: Qualitative traits can be categorized in leaf, culm, and grain traits. Variation was observed in different traits among all the cultivars. Mohammad *et al.*, (2015) and Nascimento *et al.*, (2011) was also found similar difference in different local cultivars. These traits were different from cultivar to cultivars, and presented in Table 3 as well as in pictorial view.

Leaf traits: Coleoptile color was purple in cultivar Maloti (V5) and Biruin (V10), the rest of the cultivars had colorless coleoptiles (Fig. 1). Cultivar Maloti and Biruin had uniform purple in basal leaf sheath color, but another cultivar was green (Fig. 2). Leaf anthocyanin color was present in leaf, leaf auricles, and leaf collar in the cultivar Maloti (V5) and absent in others except for Biruin, which had anthocyanin color in leaf only (Fig. 3).

Culm traits: Anthocyanin coloration of nodes was present only in Maloti (V5) and absent in the rest of the cultivars (Fig. 4). In the internodes, anthocyanin coloration was present in Maloti (V5) and Biruin (V10) but absent in all other cultivars (Fig. 4).

Grain traits: The color of the lemma and palea was gold and gold furrows with straw background in cultivar Gandi (V6) and Biruy (V7); brown furrows on straw only in Moyna sail (V8) and black only in Dumai (V3); rest of the cultivars had straw coloured lemma and palea (Fig. 5). Only Modonga (V4) cultivar had awns in its spike none of the cultivar possessed awns (Fig. 6). Decorticated grain color was white in Modonga (V4), Maloti (V5), Madhumadab (V11) and BRRI dhan34 (V12); dark brown in Dumai (V3), gandi (V6), moyna sail (V8); light red in Biruy (V7), Nagra sail (V9), Biruin (V10) and red in Haitta (V1), Lenjur (V2) (Fig. 7). Decorticated grain aroma was present in Madhumadab (V11), BRRI dhan34 (V12), but absent in the rest of cultivars. Color of spikelet stigma was purple only in Maloti (V5), and others had white-colored or colorless stigma (Fig. 8). Anthocyanin coloration of lemma apex (rice grain) was absent in Haitta (V1), Lenjur (V2), Modonga (V4), Nagra sail (V9), Madhumadab (V11) and BRRI dhan34 (V12), the medium was only in Maloti (V5), strong in Dumai (V3), Gandi (V6), and Biruy (V7), and very strong was in Moyna sail (V8), and Biruin (V10) (Figs. 9 and 10).

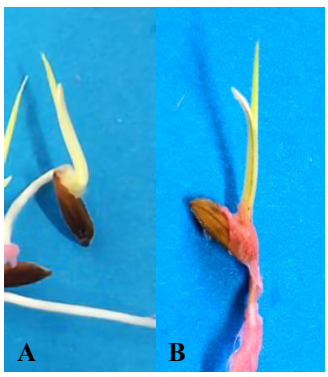
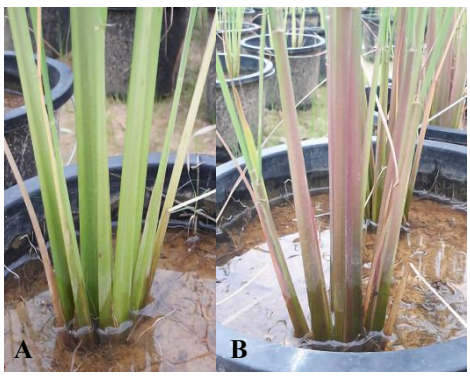


Fig. 1.



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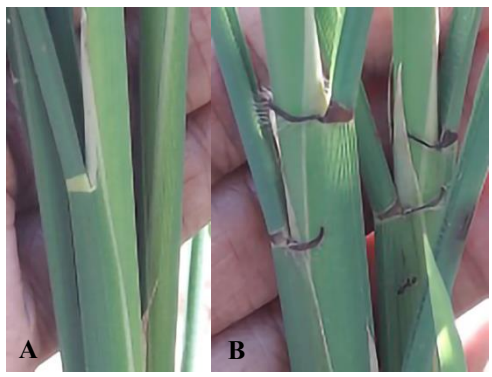

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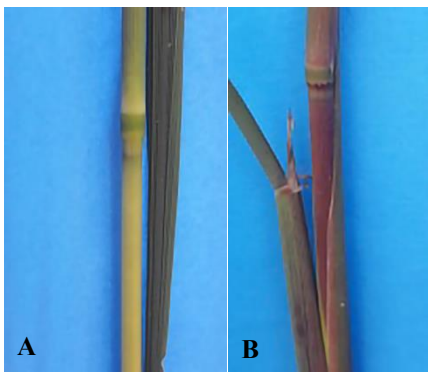

Fig. 4.

Fig. 5.

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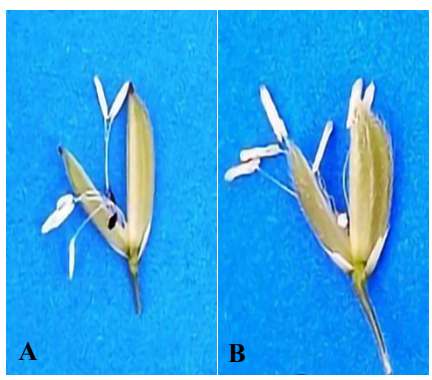

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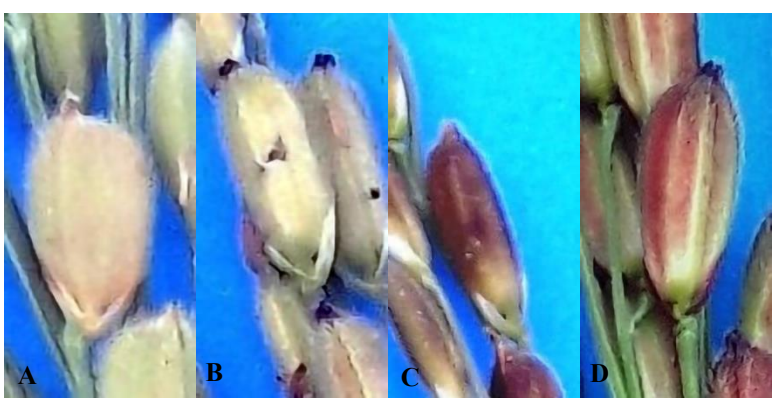

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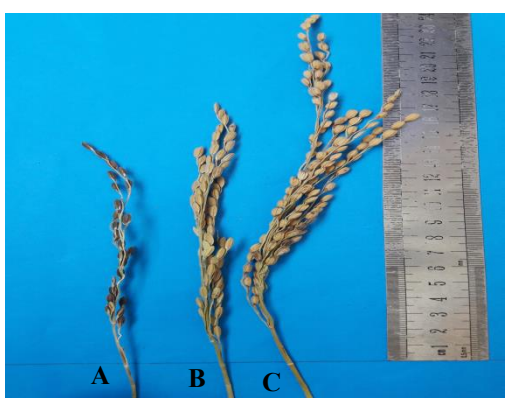

Fig. 10.

Figs. 1-10: Pictorial view of different agro-morphological characters.

[Fig. 1. Coleoptile color Picture (A-Colorless, B-Purple); Fig. 2. Different basal leaf sheath color (A-Green, B-Uniform purple); Fig. 3. Anthocyanin coloration of leaf auricles and collar (A-Absent, B-Present); Fig. 4. Anthocyanin coloration of nodes and internodes (A-Absent, B-Present); Fig. 5. Lemma and Palea color (A- Black, B-Gold and gold furrows on straw background, C-Straw, D-Brown furrows on straw); Fig. 6. Panicle: Awns (A-Absent, B-Present); Fig. 7. Decorticated grain color (A-White, B-Dark brown, C-Light red, D-Red); Fig. 8. Color of stigma (A- White, B- Purple); Fig. 9. Lemma: Anthocyanin coloration of the apex (A-Absent, B-Medium, C-Strong, D-Very strong); Fig. 10. Panicle: length of the main axis (A- Very short, B- Short, C- Medium)].

Table 4. Quantitative agro-morphological traits of rice cultivars/variety.

Cultivars	Leaf length (cm)	Leaf width (cm)	Effective panicle (No.)	Panicle length (cm)	Filled grain (No.)	50% flowering days	Harvesting days/ maturity
Haitta	45.06	0.82	10.7	18.84	58	83	129
Lenjur	39.24	0.66	10.7	18.6	41	56	92
Dumai	39.38	0.54	7.9	15.66	30	51	77
Modonga	42.48	0.84	7.4	20.84	79.6	88	129
Maloti	42.88	0.68	10.6	21.3	94.6	90	129
Gandi	39.3	0.6	11.9	18.18	67.2	90	129
Biruy	42.22	0.68	11.5	19.2	61.8	90	129
Moyna sail	40.88	0.7	12	15.66	57.4	90	129
Nagra sail	36.46	0.58	11.5	20.92	78.6	92	132
Biruin	39.0	0.72	10.2	19.28	62.6	92	127
Madhumadab	41.4	0.66	10	20.48	139.2	89	132
BRRI dhan34	20.96	0.96	13.8	18.92	127.8	92	132

Table 5. Plant height of different cultivars and variety at 15 days interval.

Cultivars \ DAT	15 DAT	30 DAT	45 DAT	60 DAT	Harvesting
Haitta (V1)	68.55 a	82.66 a	96.45 bc	107.53ab	107.08 a
Lenjur (V2)	62.72ab	82.64 a	91.36 c	91.94 c-e	91.51 bc
Dumai (V3)	61.47 a-c	65.48 b	76.29 e-g	77.65 f	75.15 d
Modonga (V4)	60.35 a-d	79.46 a	102.12 ab	98.43bc	106.92 a
Maloti (V5)	57.99 b-d	67.87 b	81.64 de	91.95 c-e	98.38 b
Gandi (V6)	54.06 c-e	63.43 b	73.20 fg	86.81 d-f	92.50 bc
Biruy (V7)	61.50 a-c	65.23 b	79.25 d-f	85.78 d-f	91.38 bc
Moyna sail (V8)	52.83 de	63.05 b	79.36 d-f	94.14 cd	97.17 b
Nagra sail (V9)	54.37 b-e	64.34 b	73.26 fg	89.11 c-e	93.35 bc
Biruin (V10)	56.58b-e	64.97 b	83.04 d	88.57 c-f	86.26 c
Madhumadab (V11)	49.11e	62.67b	70.03 g	81.26ef	88.19 c
BRRI dhan34 (V12)	57.86 b-d	69.60 b	107.56 a	110.46 a	110.0 a
LSD	8.44	7.58	6.66	11.44	7.19
CV (%)	11.42	8.60	6.20	9.78	6.07

Quantitative traits: Quantitative traits are categorically classified as leaf, flowering, panicle, and grain traits, etc. These traits differed from cultivar to cultivars, (Table 4).

Leaf traits: Length of leaf blade was short in BRRI dhan34 (V12), long in Haitta (V1), medium in rest of the cultivars; the leaf blade width was medium in BRRI dhan34 only and narrow in other cultivars.

Flowering traits: Heading time was very early (<71 days) (Table 4) in cultivar Lenjur (V2) and Dumai (V3); medium (90-110 days) in Nagra sail (V9), Biruin (V10); rest of the cultivars varied (71-90 days) in the flowering habit.

Panicle traits: Panicle length was very short (<16 cm) in Dumai (V3) and Moyna sail (V8); Medium (21-25 cm) only in Maloti (V5), and short (16-20 cm) in rest of cultivars (picture 10). Panicle number per plant was few (<11) in Haitta (V1), Lenjur (V2), Dumai (V3), Modonga (V4), Maloti (V5), Biruin (V10) and Madhumadab (V11); the medium type (11-20) was observed in Gandi (V6), Biruy (V7), Moyna sail (V8), Nagra sail (V9) and BRRI dhan34 (V12).

Grain traits: Very early maturity (<100 Days) type cultivar was found in Lenjur (V2) and Dumai (V3); Medium (121-140 days) was found in the rest of the cultivars. Thousand grains weight was very low (<15 g) in Madhumadab (V11) and, BRRI dhan34 (V12); Medium (21-25 g) was in Haitta (V1); Lenjur (V2), and Maloti (V5) and Low (15-20 g) were in rest of the cultivars. The average values for leaf traits, flowering traits, panicle traits, and grain traits are given in Table 4.

Growth characters: To observe the growth pattern of the cultivars, growth parameters viz. plant height and tillers number data were recorded at every 15 days interval from transplanting to harvesting (Tables 5 & 6).

Plant height: The plant height differed amongst the cultivars and variety (Table 5) on the same date of data collection, that is, from 15 days after transplantation (DAT). At 15 DAT, the highest plant height was recorded in cultivar Haitta (V1), which was at par with cultivar Lenjur (V2), Dumai (V3), Modonga (V4) and Biruy (V7) and the lowest in Madhumadab (V11). A similar trend was noticed in 30 DAT, but BRRI dhan34 (V12) had the highest plant height observed at 45 DAT, which was at par with cultivar Modonga (V4). At this time, the lowest height was also recorded in cultivar Madhumadab (V11). A similar trend was noticed in 60 DAT. At harvesting time, the highest plant height was recorded in variety BRRI dhan34 (V12), which was like Haitta (V1) and Modonga (V4), and the lowest in Biruin (V10) and Madhumadab (V11). Differences in plant height are due to genetic variability, which is supported by Ashrafuzzaman *et al.*, (2009). Results indicated that,

Madhumadab (V11) appeared as a short stature cultivar with aromatic and excellent grain quality.

Tillers number: According to Xiu-Mei *et al*., (2015), Tillering is a major agronomic characteristic for growing rice, which has a great impact on plant type and grain yields. Tiller numbers varied significantly in different stages of growth (Badshah *et al.*, 2014). At 15 DAT, the higher number of tillers was found in Moyna sail (V8), which was statistically like Biruin (V10), and the lower in Modonga (V4) (Table 6). At 30 DAT and 45 DAT tiller number was the higher in BRRI dhan34 (V12), and the lower in cultivar Dumai (V3). The tiller number gradually increased, and at harvest, it reached a maximum of 13.8 in number in checked variety BRRI dhan34 (V12); other cultivars showed differential trend responses from 30 DAT until harvest, and the lowest was found in Modonga (V4).

Yield and Yield contributing attributes of rice cultivars/variety: Yield and yield attributes of different rice cultivars and variety are shown in Table 7. Maximum number of effective tillers per hill was found in check variety BRRI dhan34 (13.8) at harvesting. A moderate number of effective tillers were found in Moyna sail (12), which was at par with Haitta (10.7), Lenjur (10.7), Maloti (10.6), Gandi (11.9), Biruy (11.5), Nagra sail (11.5). Both Dumai (7.9) and Modonga (7.4) had the statistically least effective tillers/hill.

The highest panicle length was recorded in local cultivar Maloti (21.3 cm) and statistically similar with variety BRRI dhan34 (18.9 cm), cultivar Madhumadab (20.5 cm), Biruin (19.3 cm), Nagra sail (20.9 cm), Biruy (19.2 cm), Modonga (20.8 cm) and Haitta (18.8 cm). Statistically, the lowest panicle length was recorded in both cultivar Dumai (15.7 cm) and Moyna sail (15.7 cm). High statistical dissimilarity was found in the case of filled grains/panicle in all cultivars and variety BRRI dhan34. Local cultivar Madhumadab produced the highest (139.2) grains followed by variety BRRI dhan34 (V12), and the lowest in Dumai (30). The lowest number of grains left unfilled were present in Lenjur (2.6), and statistically like Dumai (4.6), Gandi (4.8), and Nagra sail (4.8).

Haitta had the highest (24.6 g) 1000 grains weight and had the lowest in Madhumadab (10.5 g), which is very desirable as an excellent grained rice cultivar and almost closest to variety BRRI dhan34 (11.8 g). The highest grains yield per pot was obtained in check variety BRRI dhan34 (18 g), and statistically like to local cultivar Biruin (17.80 g). The highest yield in BRRI dhan34 can be caused due to the presence of the highest effective tillers, highest or moderate length of the panicle, and several filled grains per panicle. This result was entirely supported by Srijan *et al.*, (2016), who reported that the effective tillers (no.), grains per panicle (no.), and length of the panicle positively correlated with grain yield. Karki *et al.*, (2018) also observed a positive and significant correlation with the number of effective tillers per hill and the number of filled grains per panicle and yield per panicle.

Another critical factor in rice production is the crop duration. From the experiment, local cultivars Dumai and Lenjur had lower crop duration only 77 and 92 days, respectively, which is very much useful for the successful breeding program.

Correlation between grain yield and yield contributing characters of different cultivars and variety: Table 8 represents the correlation between grain yield and yield parameters of various glutinous and aromatic rice cultivars. Grain yield appeared to have a positive non-significant correlation with length of the panicle, grains per panicle, unfilled grains per panicle, and highly significant for the duration of the crop but negative non-significant relation to the weight of 1000 grains. Bhadru *et al*., (2011), Srijan *et al*., (2016), and Ramesh *et al*., (2018) also recorded significant positive correlation of grains/panicle with grain yield/plant, length of the panicle. The weight of 1000 grains had a negative non-significant correlation to all yield contributing traits except grains/panicle and have a high significance. Grains/panicle had a non-significant positive relationship with effective tillers/hill, length of the panicle, grain yield, and highly significant correlation with unfilled grains per panicle only except the weight of 1000-grains. Length of the panicle showed a positive correlation to the grain yield per plant, weight of the panicle, number of productive tillers/plant, grains/panicle. Bhadru *et al*., (2011), Patel *et al.*, (2014) and Srijan *et al*., (2016) also reported that, the grain yield per plant had positive phenotypic correlation with length of the panicle. Crop duration had a non-significant positive relationship with all traits and highly significant to grain yield but negative non-significant with the 1000 grains weight.

Table 6. Tillers number of different cultivars and variety at 15 days interval.

DAT / Cultivars	15 DAT	30 DAT	45 DAT	60 DAT	Harvesting
Haitta (V1)	3.4 d	6.3ef	10.6ef	10.1 de	10.7 b-d
Lenjur (V2)	4.4 b	6.5ef	9.7 f	10.7 d	10.7 b-d
Dumai (V3)	3.6 cd	5.8 f	8.0 g	9.0 de	7.9 e
Modonga (V4)	2.1 e	3.8 g	6.6 h	8.3e	7.4 e
Maloti (V5)	4.0bc	7.7 cd	14.3 b	14.4 c	10.6 b-d
Gandi (V6)	3.8 cd	7.0 de	11.4 de	13.5 c	1.9 b
Biruy (V7)	3.7 cd	8.4bc	13.5bc	14.6 c	11.5 bc
Moyna sail (V8)	5.2 a	9.2 b	13.6bc	13.8 c	12.0 b
Nagra sail (V9)	3.9 b-d	8.5bc	13.6bc	16.2a	11.5 bc
Biruin (V10)	5.0 a	7.6 cd	13.2bc	13.5 c	10.2 cd
Madhumadab (V11)	4.4 b	7.8 cd	12.6 cd	13.1 c	10.0 d
BRRI dhan34 (V12)	4.0bc	14.6 a	14.3 a	15.8 a	14.8 a
LSD	0.53	1.08	1.31	1.83	1.47
CV (%)	10.69	10.97	8.39	11.03	10.85

Table 7. Yield and yield attributes of rice cultivars/variety.

Treatments	Effective tillers/ hill	Panicle length (cm)	Grains/ panicle	Unfilled grains/ panicle	1000 grains weight	Grain yield (gms/pot)	Crop duration (days)
Haitta	10.7 bcd	18.8 abc	62.0 f	10.2 d	24.6 a	13.44 cd	129
Lenjur	10.7 bcd	18.6 bc	41.0 h	2.6 g	22.1 b	6.12 g	92
Dumai	7.9 e	15.7 d	30.0 i	4.6 fg	21.1 b	3.94 h	77
Modonga	7.4 e	20.8 ab	79.6 d	7.4 e	21.8 b	13.08 de	129
Maloti	10.6 bcd	21.3 a	94.6 c	14.6 c	19.8 cd	12.18 de	129
Gandi	11.9 b	18.2 cd	67.2 e	4.8 fg	21.0 bc	8.68 f	129
Biruy	11.5 bc	19.2 abc	61.8 f	14.0 c	18.1 ef	15.56 b	129
Moyna sail	12.0 b	15.7 d	57.4 g	6.0 ef	19.9 cd	14.10 bcd	129
Nagra sail	11.5 bc	20.9 ab	78.6 d	4.8 fg	17.6 f	14.56 bc	132
Biruin	10.2 cd	19.3 abc	62.6 f	10.6 d	19.4de	17.80 a	127
Madhumadab	10.0 d	20.5 abc	139.2 a	29.4 a	10.5 h	11.28 e	132
BRRI dhan34	13.8 a	18.9 abc	127.8 b	17.2 b	11.8 g	18.00 a	132
Lsd (0.05)	1.47	2.64	4.28	2.36	1.24	2.11	-
CV (%)	10.85	10.95	4.48	17.70	5.14	13.40	-

Table 8. Correlation between yield and yield attributes.

	Panicle length	Grains/ panicle	Unfilled grains/ panicle	Thousand grains weight	Crop duration	Grain yield/ pot
Effective tillers/hill	-0.06	0.1	0.13	-0.38	0.45	0.47
Panicle length		0.36	0.42	-0.26	0.54	0.37
Grains/panicle			0.81**	-0.84**	0.31	0.21
Unfilled grains/panicle				-0.77	0.44	0.35
Thousand grains weight					-0.34	-0.36
Crop duration						0.80**

** Significant at 1% level of probability

Table 9. Correlation between plant height with grain yield of different cultivars and variety at different DAT.

	30 DAT	45 DAT	60 DAT	Harvesting	Grain yield
15 DAT	0.77*	0.56	0.40	0.23	-0.14
30 DAT		0.73	0.58	0.50	-01.6
45 DAT			0.86**	0.75	0.31
60 DAT				0.92***	0.51
Harvesting					0.54

*Significant at 5% level of probability;
**Significant at 1% level of probability;
***Significant at 0.1% level of probability.

Table 10. Correlation between tiller numbers and grain yield of different cultivars and variety at different DAT.

	30 DAT	45 DAT	60 DAT	Harvesting	Grain yield
15 DAT	0.45	0.65	0.52	0.33	0.15
30 DAT		0.75	0.76	0.63	0.54
45 DAT			0.94***	0.51	0.61
60 DAT				0.40	0.58
Harvesting					0.54

***Significant at 0.1% level of probability

Correlation between plant height at DAT with grain yield of different cultivars and variety: A correlation between plant height at DAT with grain yield of different glutinous and aromatic rice cultivars are presented in Table 9. Grain yield had a non-significant positive correlation with 45 DAT, 60 DAT, and harvesting, and the negative correlation to 15 DAT and 30 DAT. 60 DAT has a non-significant positive correlation with different DAT and highly significant with 45 DAT and harvesting. 30 DAT had a significant positive correlation with 15 DAT. It seems that, when plant height gradually reaching the optimum level, maintain a very good relation.

Correlation between tiller numbers at DAT with grain yield of different cultivars and variety: The correlation between grain yield and tiller numbers at DAT of different glutinous and aromatic rice cultivars are presented in Table 10. Grain yield had a positive non-significant relationship to different DAT. At 45 DAT, it had a positive, highly significant correlation to 60 DAT. All other DAT had maintained a positive non-significant correlation with each other. It appeared that, when plant maturity gradually increases, the tiller number are also increase and maintain an outstanding correlation with them.

Conclusion

For the fulfillment of experimental objectives, and based on the 28 agro-morphological traits, growth patterns, and yield performances indicated that all local cultivars and checked variety BRRI dhan34 were different from each other. Dumai and Lenjur had very early maturation days of 77 and 92 days, respectively. Modonga had lodging resistance at harvest, which was observed during rice cultivation and seemed to be very much promising for breeding purposes. BRRI dhan34 had the highest yield, followed by Biruin, which had the highest grain yield among local cultivars. Madhumadab could compete with BRRI dhan34 in case of finer grain and scent. The Lenjur, Dumai, Modonga, Madhumadab can be used in breeding purposes, and Biruin can be cultivated commercially due to higher yield. On the other hand, correlation studies with grain yield versus yield contributing traits, also suggest similar patterns too.

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References

Al-Jibouri, H.A., P.A. Miller and H.F. Robinson. 1958. Genotype and environmental variances and co-variance in the upland cotton cross of interspecific origin. *Agron. J*., 50(10): 633-636.

Ashrafuzzaman, M., M.R. Islam, M.R. Ismail, S.M. Shahidullah and M.M. Hanafi. 2009. Evaluation of six aromatic rice varieties for yield and yield contributing characters. *Int. J. Agric. Biol*., 11: 616-620.

Badshah, M.A., N. Tu, Y. Zou, M. Ibrahim and K. Wang. 2014. Yield, and the tillering response of super hybrid rice Liangyoupeijiu to tillage and establishment methods. *The Crop J.*, 2(1): 79-86.

Anonymous. 2017. Bangladesh Bureau of Statistics (BBS). Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning. Government of the People's Republic of Bangladesh.

Bhadru, D., L. Reddy, D and M.S. Ramesha. 2011. Correlation and path coefficient analysis of yield and yield contributing traits in rice hybrids and their parental lines. *Elect. J. Plant Breed*., 2(1): 112-116.

Fisher, R.A. and F. Yates. 1963. Statistical tables for biological, agriculture, and medical research. oliver and boyd, edinburgh. *Biometrische Zeitschrift*, 13(4): 285-1971.

Anonymous. 2010. HIES (Household Income and Expenditure Survey). Bangladesh Bureau of Statistics. Government of Bangladesh, Dhaka.

Hossain, M., M.S. Alam and A.N.M.M. Rahman. 2013. Rice biodiversity in bangladesh: adoption, diffusion, and disappearance of varieties. dhaka, bangladesh: research and evaluation division.

Karki, S., N.S. Poudel, G. Bhusal, S. Simkhada, B.R. Regmi, B. Adhikari and S. Poudel. 2018. Growth parameters and yield attributes of Rice (*Oryza Sativa*) as influenced by a different combination of nitrogen sources. *World J. Agri. Res*., 6(2): 58-64.

Muhammad, S., A.K. Shahid, K.H. Haris, I. Javed, N.S. Ali Muhammad and A.S. Syed Mehar. 2015. Characterization of Rice (*Oryza Sativa* L.) germplasm through various agro-morphological traits. *Sci. Agri.*; 9(2): 83-88. Retrieved from www.pscipub.com (DOI: 10.15192/PSCP.SA.2015.9.2.8388).

Nascimento W.F., E.F. Silva and E.A. Veasey. 2011. Agro-morphological characterization of upland rice accessions. *Sci. Agri*., 68(6): 652-660.

Patel, J.R., M.R. Saiyad, K.N. Prajapati, R.A. Patel and R.T. Bhavani. 2014. Genetic variability and character association studies in rainfed upland rice (*Oryza sativa* L.). *Elect. J. Plant Breed*., 5(3): 531537.

Ramesh, Ch., C.D. Raju, C.S. Raju and N.R.G. Varma. 2018. Character association and path coefficient analysis for grain yield and yield components of parents and hybrids in rice *(Oryza sativa* L.). *Int. J. Curr. Microbiol. App. Sci.*, 7(04): 2692 2699.

Anonymous. 2012. Rice production in Bangladesh. Available at-http://en.wikipedia.org/wiki/.

Shaban, W.A.R., O.J. Richard, J.W. Michael and I.H. Parvez. 2012. Reducing human exposure to arsenic, and simultaneously increasing selenium and zinc intake, by substituting non-aromatic rice with aromatic rice in the diet. DOI: 10.3233/BSI-120028, Project: Food analysis. Biomedical Spectroscopy and Imaging: 365-381.

Srijan, A., S.S. Kumar, C.D. Raju and R. Jagadeeshwar. 2016. Character association and path coefficient analysis for grain yield of parents and hybrids in rice (*Oryza sativa* L.). *J. App. & Nat. Sci*., 8(1): 167-172.

Wang, J.L., Y.B. Gao and Zhao. 2006. Morphological and RAPD analysis of the dominant species Stipa krylovii Roshev. In: *Inner Mongolia steppe, Botanical Studies*, 47(1): pp. 23-35.

Wissuwa, M. and N. Ae. 2001. Genotypic variation for tolerance to phosphorus deficiency in rice and the potential for its exploitation in rice improvement. *Plant Breed*., 120(1): 43-48.

Xiu-Mei, W., L. Yue-Yang, L. Ling, G. Chang-Wei, W. Hai-Peng, H. Xiao-Xi, L. Shuang-Cheng, D. Qi-Ming, Z. Jun, Z. Ai-Ping, L. Ping and W. Shi-Quan. 2015. Identification and cloning of tillering-related genes OsMAX1 in rice. *Rice Sci.*, 22(6): 255-263.

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