



Evaluation of agromorphological trait of rice landraces collected from *Haor* areas of the north-eastern part of Bangladesh

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ABSTRACT

Rice (*Oryza sativa* L.) is gifted with a lot of biodiversity both in the form of landraces and wild species. Rice breeders are working to evaluate genetic variability by digging out desirable characters and assessing them up to which extent they are heritable. Therefore, this study was carried out to know the presence of valuable agro-morphological traits in landraces of rice and to find out the landraces of rice having agronomic and genetic importance. The north-eastern part of Bangladesh is rich with wide range of land topography from hill, *haor* (backswamp), river and floodplain. This chorography of land renders continuous natural crossing, variation and evolution of land races of rice. In this study, different qualitative and quantitative traits of twenty promising rice landraces were evaluated. Data revealed that qualitative characters like leaf blade color and basal leaf sheath color was green until late vegetative stage in most of the cultivars which shows higher photosynthesis potentiality. Leaf angle, flag leaf angle was erect and awn was present in most of the cultivars which also reflect photosynthetic ability of the cultivar. Shattering percentage was low and seed coat color was brown in most of the cultivar indicating most of them are shattering loss resistant. On the other hand, panicle type was compact in most of the cultivars. Considering quantitative characteristics higher grain yield and yield attributes was recorded in the cultivars of *Pajam*, *Changirmora*, *Jori*, *Kakhibiroin*, *Latma*, *Chinigura*, and *Chorabiroin*. Moreover, some landraces of rice could be used as a source of potent genetic material.

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Introduction

Rice (*Oryza sativa* L.) is the main food for more than half of the world's population. It is the staple food for the 160 million population of Bangladesh and obtains more than 70% of their total calorie intake (FAO, 2014). It is grown on close to 80% of Bangladesh's arable land during three cropping seasons: *Aus* (the spring season, from March/April to June/July), *Aman* (the monsoon season, from June/July to September/October) and *Boro* (the winter season, from November/December to April/May) (BBS, 2016). Currently, Bangladesh is producing more than 34 million tons of rice, which is three times higher than the post-liberation war (BBS, 2018). Bangladesh is the world's fourth-biggest rice producer country and achieving self-sufficiency in rice production (Akhand *et al.*, 2015). But, about 48% children and 33% women of Bangladeshi are still suffering from malnutrition. So, now it is high time to develop nutritionally high valued rice those are rich in nutrients (Fe and Zn), vitamin, aroma, superfine, etc. Landraces evolved in different free-mixing and natural

crossing regions are resistance to insect, diseases, and environmental stress (Ganesh, 2004; Siddiq *et al.*, 2005; Kuroha *et al.*, 2018). They are differing in their agromorphological performances and response to various biotic and abiotic stresses. The variability in high yielding varieties of crop is limited due to homogeneity, whereas the landraces endowed with huge genetic variation, as they were evolved through natural crossing and variation, and free from artificial selection pressure. Generally, rice landraces having stress tolerance properties are grown over wide range of climatic and edaphic conditions. Landraces of rice harbor potential genetic material for improvement of traits. For instance, Kasalath, a traditional rice variety contain the phosphorus (P) uptake efficient gene with deeper root system (Wissuwa *et al.*, 1998), which can be used to develop P uptake efficient variety. This aids in the adaptation of landraces to wide agroecological niches and biotic factors. Additionally, this type of variability of landraces could be exploited to modern cultivars for developing resistance against abiotic and biotic stresses to mitigate the climate change induced problem.

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Indian center is the center of origin and diversity of cultivated crops (Vavilov, 1926). A large number of rice genotypes are believed to have originated in the Indian subcontinent (Jackson, 1995). The north-eastern part of Bangladesh is considered belongs to the Indian center of origin of crop plant. Sylhet region has many landraces and wild strain of rice with some distinct characteristics which could be an excellent natural source of rice germplasm. For instance, ethylene-gibberellin loci induced resistance to flooding of rice which is called as deep-water rice was collected from Sylhet region of Bangladesh (Kuroha et al., 2018). Similarly, rice landraces of this region like *Biron*, *Changri*, *Kalapur*, *Kalijira* and *Rata* have higher concentration of zinc (Zn) and selenium (Se) which is helpful for human diets and which also act as a counter acting agent of the arsenic problem (Al-ramalli et al., 2012). These cultivars also have some special characteristics like fineness, aromatic, acidity tolerances, drought tolerances, phosphorus uptake ability having PSTOL gene, higher concentration of Zn and Se, as well as glutinous/sticky with good flavor and aroma (Wissuwa and Ae, 2001; Al-Ramalli et al., 2012).

Agricultural production largely depends on continuing infusions of genetic resources for high yield and optimum growth environment of crop plants. Availability and wide gene pool in the form of genetic diversity is a prerequisite for crop improvement. It revealed that the landraces of rice evolved through free-mixing and crossing are rich in genetic variability. Although the genetic diversity of rice germplasm has been well characterized globally, few studies have taken an in-depth view of a large number of rice landraces on a local scale. The diverse genotypes of rice will be a good option for varietal improvement program and future utilization. Exploration, collection and evaluation of agro-morphological trait of landraces had been started to study the agromorphological variability relationship and also being exploited for rice improvement. Therefore, this study was conducted to find out the desirable genetic traits in landrace of rice, and to evaluate their agromorphological performance collected from *haor* area of the north-eastern part of Bangladesh.

Materials and Methods

This experiment was conducted at the field research site of the Department of Agronomy and *Haor* Agriculture, Sylhet Agricultural University, which belong to the Agro-Ecological Zone-22 (Northern and Eastern Hills Piedmont Floodplain), during *Aman* season (July to December) 2015. The experimental site situated at 24° 54' 33.2" N latitude and 91° 54' 7.15" E longitude at the elevation of 30m above the sea level. The soil belongs to the *Khadimnagar* soil series which is sandy loam in texture with moderate organic matter content (1.45%), N 0.80%, K 0.07 m mol/100g of soil, P was 25 µg/g of soil and S was 10 µg/g of soil with pH value 5.2.

The average temperature during the crop growing period was 26 to 31°C and rainfall was 150 mm.

Twenty landraces of rice were collected from the different parts of the *haor* region (north-eastern region) of greater Sylhet division, Bangladesh. The landraces were *Badaldhan*, *Changirmora*, *Chinigura*, *Chorabiroin*, *Choria*, *Gandi*, *Ikradai*, *Jori*, *Joria TV*, *Joria*, *Kai*, *Kalakura*, *Kakhibiroin*, *Khurabadal*, *Latma*, *Lalmoni*, *Maloti*, *Modonga*, *Nightkoli* and *Pajam*. One-month old seedlings were transplanted in a 10 m² plots with spacing of 20 cm × 12 cm following randomized complete block design (RCBD) with three replications. Fertilizer, irrigation, weeding, pest protection and all sorts of intercultural operations were given as per requirement of the crop. Harvesting was done with their respective maturity. Cultivars were characterized (31 qualitative characters and 10 quantitative characters) according to International Rice Research Institute and International Board for Plant Genetic Resources (IBPGR-IRRI, 1980). Qualitative characteristics were blade pubescence, blade color, leaf sheath anthocyanin color, basal leaf sheath color, flag leaf angle, leaf angle, ligule color, ligule shape, collar color, auricle color, culm anthocyanin, culm angle, inter node color, strength, panicle type, panicle secondary branch, panicle exertion, attitude of main axis of panicle, panicle axis, attitude of branches, shattering, thresh ability, awns in the spikelet of panicle, apiculus color, stigma color, stigma exertion, lemma and palea color, lemma and palea pubescence, sterile lemma color, seed coat color and leaf senescence. Frequency distribution for all the qualitative characters was computed. Quantitative characters were measured in terms of number of plants/m², plant height, flag leaf length, panicle length, effective tiller, total tiller, grain/panicle, 1000 grain weight, straw yield and grain yield. Collected data of quantitative traits were statistically analyzed using MSTAT.

Results and Discussion

Qualitative agro-morphological characteristics

Thirty-one qualitative agro-morphological traits of rice landraces were studied, among them twenty-three qualitative traits showed heterogeneity/polymorphism (Figs. 1-8). No polymorphisms were observed for eight traits like as blade pubescence, blade color, ligule shape, ligule color, auricle color, panicle type, panicle axis and sterile lemma color of the landraces. All the landraces possess intermediate type blade pubescence, green colour leaf blade, 2-cleft shape ligule, white color ligule, pale-green color auricle, intermediately compact panicle, droopy panicle axis, straw (yellow) color of sterile lemma. Anthocyanins are a class of flavonoid pigments synthesized by a secondary metabolic pathway from the amino acid phenylalanine, and they impart purple, red and blue coloration in plant body.

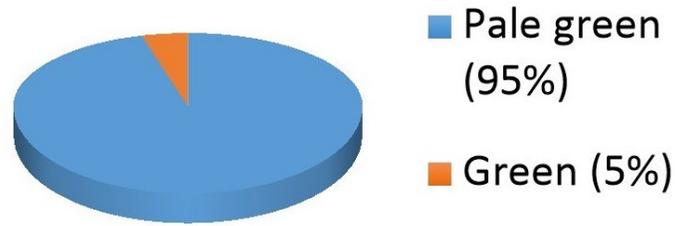


Fig. 1. Polymorphism in colour of collar

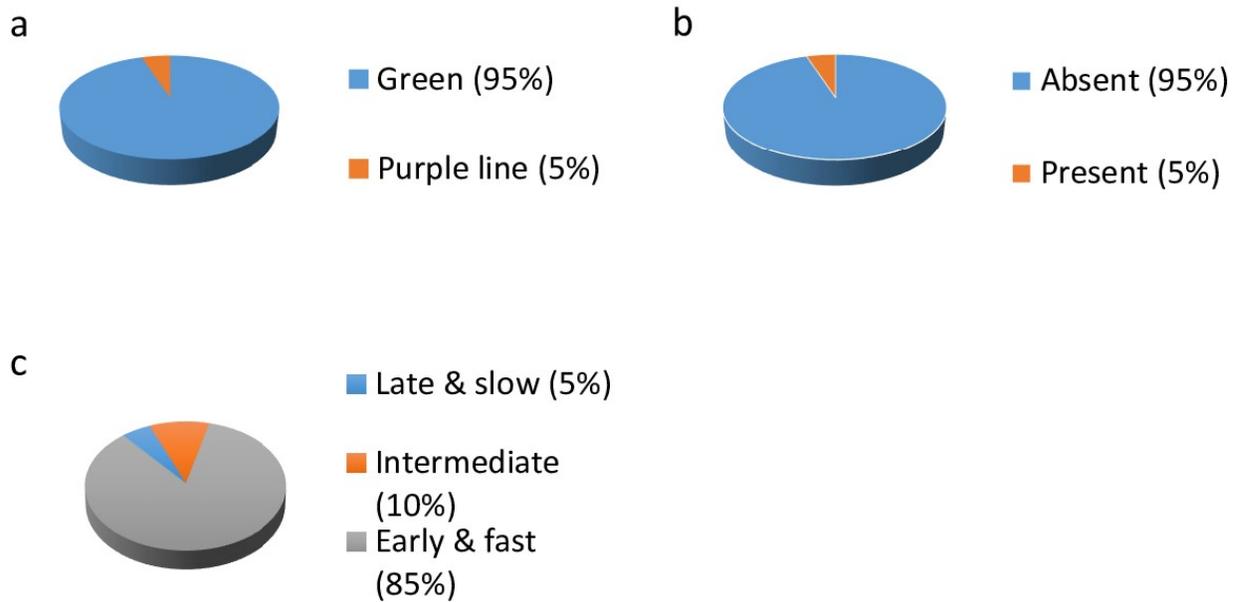


Fig. 2. Polymorphism in leaf sheath, a. Leaf sheath colour b. Presence of anthocyanin in leaf sheath c. Leaf senescence

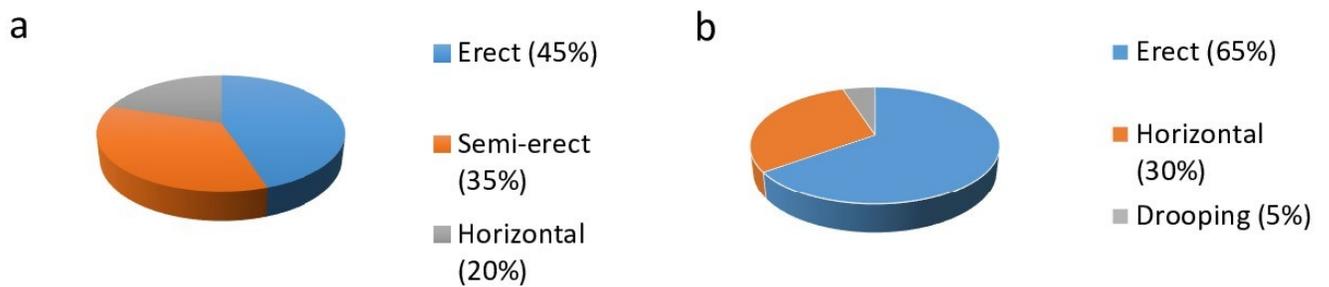


Fig. 3. Polymorphism in angel of flag-leaf and other leaf (a) Flag leaf angel, (b) Leaf angel

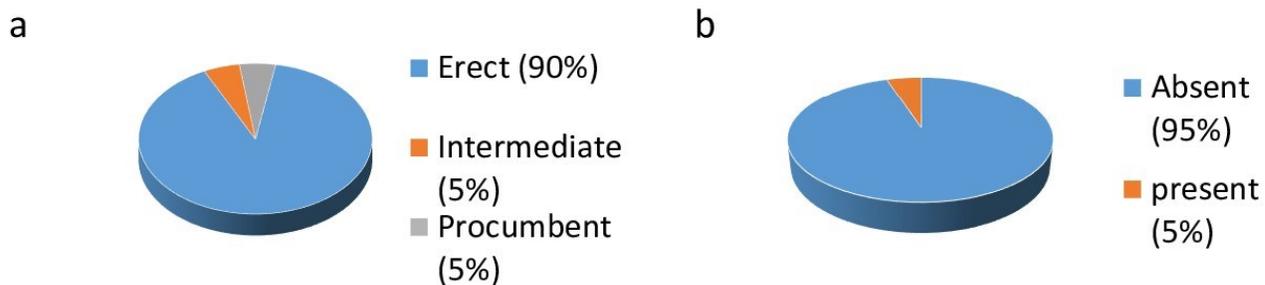


Fig. 4. Polymorphism in culm (a) Culm angle, (b) Presence of anthocyanin in culm

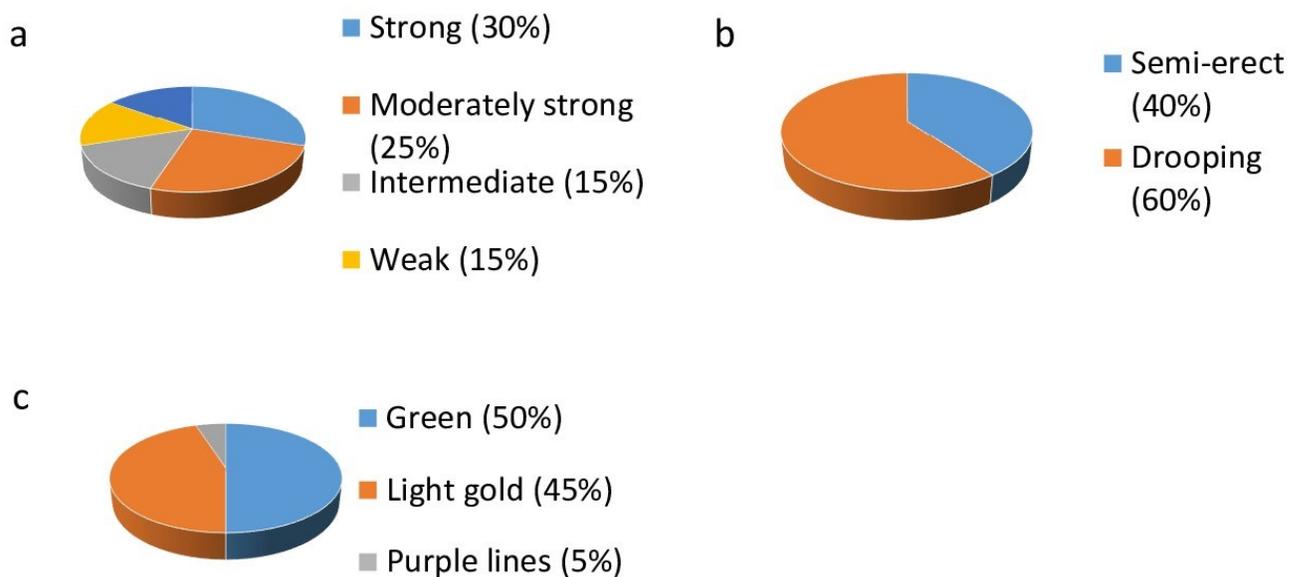


Fig. 5. Polymorphism in culm characteristics (a) Plant strength, (b) Attitude in tiller, and (c) Internode colour

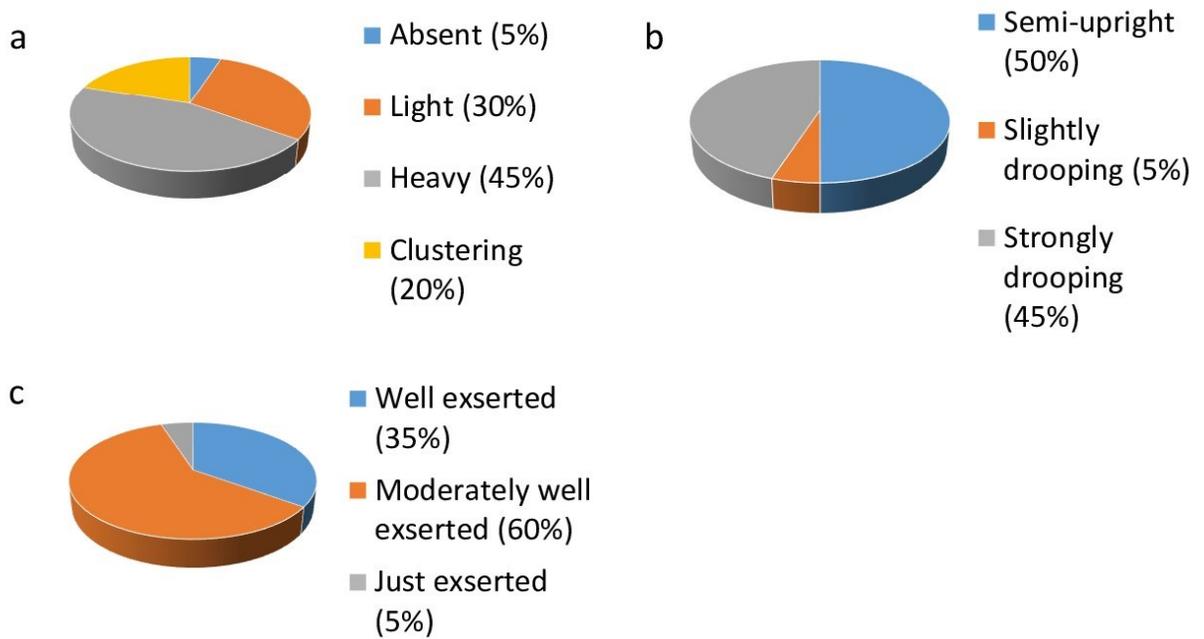


Fig. 6. Polymorphism in panicle (a) Panicle secondary branch, (b) Attitude of main axis of panicle, and (c) Pattern of panicle exertion

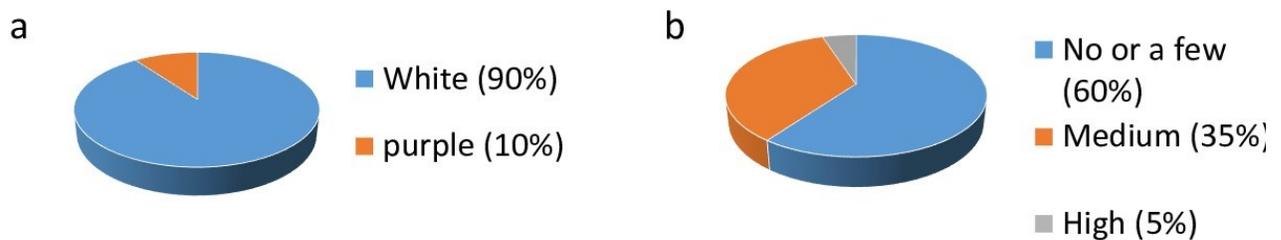


Fig. 7. Polymorphism in stigma (a) Stigma colour, (b) Stigma exertion

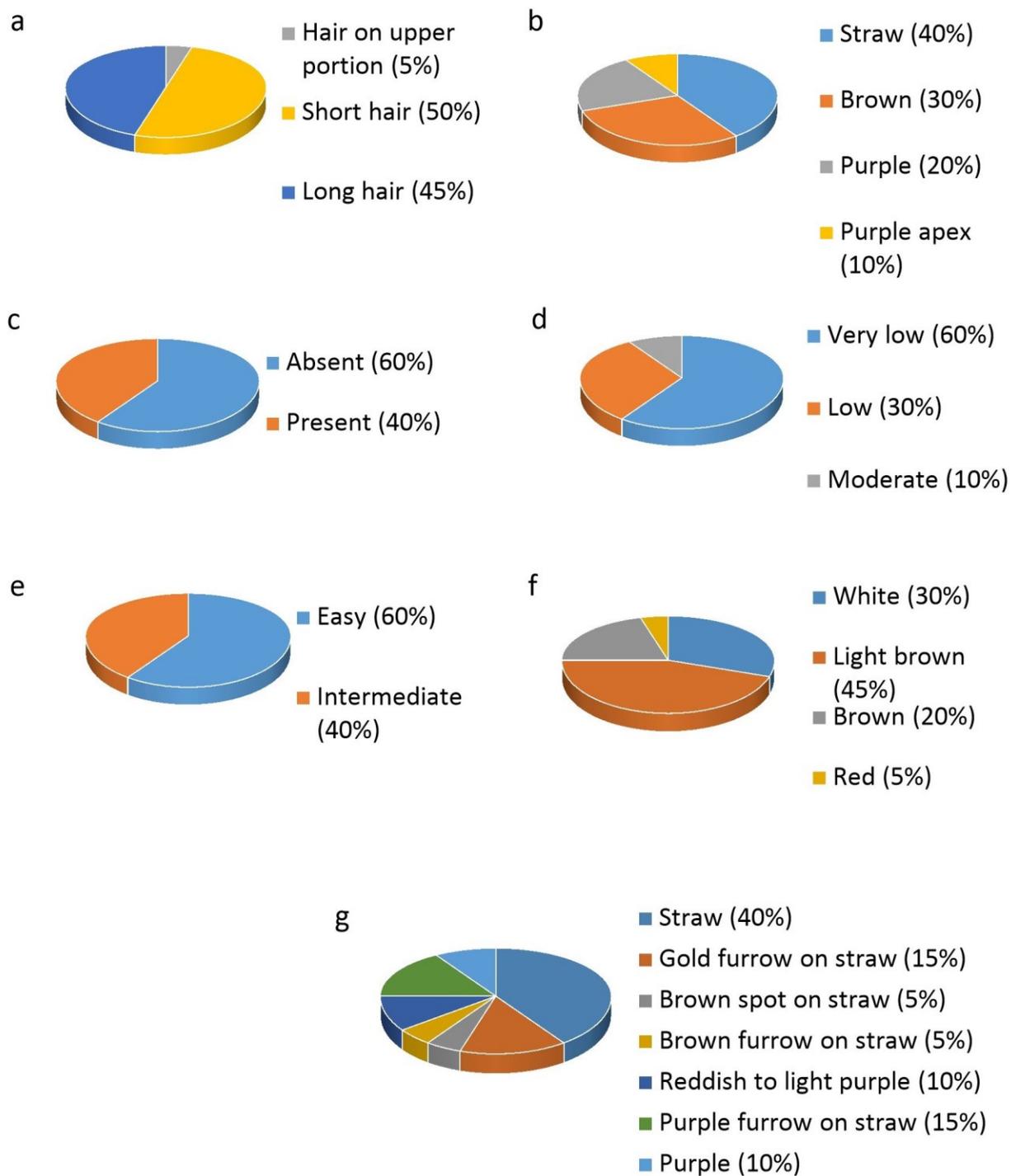


Fig. 8. Polymorphism in spikelet characteristics (a) Pubescence in lemma and palea, (b) Apiculus colour, (c) Presence of awn in spikelet, (d) Shattering behaviour, (e) Threshability, (f) Seed coat colour, and (g) Lemma and paleacolor

Collar color of rice developed for anthocyanin synthesis showed polymorphism among the landraces (Fig. 1). Pale green color collar was produced by 95% of the genotypes and only 5% of the genotypes possessed green color collar. This information is in accordance with the results of Parikh *et al.* (2012), where they observed that genotypes of rice germplasm possessed different colours collar. Green basal leaf sheath were observed in 95% genotypes of rice and 5% showed purple line in their basal leaf sheath (Fig. 2a). Sinha and Mishra (2013) reported diverse color in basal leaf sheath where green, light purple, purple line and purple color were found on basal leaf sheath of 65%, 5%, 20% and 5% genotypes of investigated 20 landraces of rice in India. The maximum number (95%) of cultivars had no anthocyanin color on the leaves, only one cultivar contains anthocyanin color in leaf (Fig. 2b). Leaf senescence is a genetically programmed process and thus requires *de novo* gene expression and protein synthesis that should be controlled in a highly coordinated manner (Hensel *et al.*, 1993; Quirino *et al.*, 2000). Early and fast leaf senescence was observed in 85% of the genotypes, whereas only 5% showed late and slow leaf senescence followed by intermediate type leaf senescence in 10% of the landraces in our study (Fig. 2c).

The angle between the main culm and leaf is called leaf angle which is one of the important plant architectures for photosynthesis and plant breeding program. Flag leaf angle characteristics showed higher variability among the cultivar. Flag leaves of the 45% genotypes were recorded erect type followed by semi-erect type in 35% of the genotypes and rest of them showed horizontal type (20%) (Fig. 3a). Different type of leaf angles viz. erect, horizontal and drooping were in the population. The maximum proportion of genotypes showed erect (65%) followed by horizontal type (30%). Only 5% landraces showed droopy type leaf (Fig. 3b). A good number of cultivars were able to produce high amount of photosynthates by intercepting more sunlight. Erect type leaf angle are desirable in rice for harvesting sunlight for photosynthesis. The erect-leaved canopy of fersa higher rate of photosynthesis than a droopy-leaved one which results in a higher grain yield (Yoshida, 1972). Matsushima *et al.*, (1964) also revealed the significance of erect leaves in optimizing the photosynthesis and higher yields of rice. Among all the cultivars, 90% cultivar showed erect type, 5% were procumbent type and rest of them showed intermediate type of culm angle (Fig. 4a). Similarly, Islam *et al.* (2017) found variation in culm angle of rice and observed 23.33% erect, 33.33% open and 43.33% intermediate type culm angel in the landraces from the hilly areas of Chattogram, Bangladesh. Production of anthocyanin in culm is a polymorphic character among the collected landraces of rice. In our study, no anthocyanin color on the culm was found in 95% cultivars of rice (Fig. 4b). The most important morphological character that has contributed high yielding rice varieties in recent years is short and

stiff culm by maintaining lodging resistance traits (Yoshida, 1972). Among the tested cultivar, 30% genotypes showed no lodging tendency, 25% were moderately strong, 15% were moderately prone to lodging, 15% were nearly flat and 15% were found very weak to lodging (Fig. 5a). Variation for lodging resistance in rice germplasm was also reported by Nascimento *et al.* (2011). They found that different degree lodging resistance phenomenon was present among 146 landraces in Brazil. Green color internodes were observed in 50% genotypes, light gold color internode in 45% genotypes and purple line color were found in 5% genotypes, whereas Nascimento *et al.* (2011) found only light gold color internode among 146 upland accessions in Brazil.

Tiller angle of rice is an important determinant of rice architecture controlled by *TAC1* locus of chromosome 9 (Yu *et al.*, 2007) which affect the photosynthesis efficiency and number of effective tiller in a certain area of land. Angle of tiller showed diversity among the cultivars: 40% was semi erect and 60% was drooping, none of the cultivars was erect, spreading or horizontal (Fig. 5b). Purple colour tillers were observed in some rice strains due to presence of anthocyanidin which is synthesized from a major pigment cyaniding and a minor pigment peonidin (Reddy *et al.*, 1995). Purple colour culm of rice tillers were observed in 5 % of the landraces and 45 % genotypes showed light gold colour culm, rest of them were shown normal green colour culm (Fig. 5c).

Panicle exertion of rice has been suggested to be an important trait for increasing grain yield especially under stress condition of plant growth. In our study, 35% landraces showed well exerted panicle, 60% were moderate, and 5% were just exerted type during (towards the) panicle exertion (Fig. 6a). Sinha and Mishra (2013) reported similar result in a study where they observed that rice germplasm showed different degree of panicle exertion: 25% of the genotypes were partially exerted, 55% exerted and 20% well exerted type panicle. Number of branches per panicle contributes to increased number of grains per panicle which ultimately contributes to high yield of rice. Secondary branch of panicle were absent, light, heavy and cluster type with the respective value of 5%, 30%, 45%, and 20% among the cultivars (Fig. 6b). Sinha and Mishra (2013) also observed strong, weak and cluster type secondary branching of panicle in 20 landraces of rice. Variation was found in mode of main axis of panicle. It was found that the main axis of panicle were semi-upright in 50% genotypes, 45% were strongly drooping and rest of them showed slightly drooping tendency (Fig. 6c). The maximum cultivars (60%) showed no or few stigma exertion characteristics, 35% showed medium characteristics and 5% had high stigma exertion characteristics (Fig. 7b). Stigma color was white in 90% of the cultivars, rest of them possessed purple color (Fig. 7a).

A higher number (50%) of lemma and palea pubescence had short hair, 45% cultivars had long hair and 5% had hairs only on upper portion (Fig. 8a). Straw colored apiculus were observed in 40% cultivars whereas 30%, 20% and 10% genotypes showed brown (tawny), purple and purple apex color, respectively (Fig. 8b). Straw, golden furrow on straw background, brown spot on straw color, brown furrow on straw color, light purple color, purple furrow on straw color and purple color on lemma-palea were observed in 40%, 15%, 5%, 5%, 10%, 15% and 10% genotypes, respectively (Fig. 8g). The seed coat color was white, light brown, brown and red in 30%, 45%, 20% and 5% genotypes of rice (Fig. 8f). Grain character of rice also showed high polymorphism in different studies conducted in India by Parikh et al. (2012) and Sinha and Mishra (2013). Polymorphism was also observed in grain characters viz. awned spikelet. Awn was present in 40% rice cultivars (Fig. 8c). Different shattering characteristics were observed among the cultivars. No high shattering characteristic cultivar was found. Only 10% cultivars were found moderately high shattering habit and less or very few shattering tendencies were observed among the 60% genotypes (Fig. 8d). Oba et al. (1995) reported that shattering rice cultivars have an abscission layer at the base of sterile lemmas and shed matured grains more easily than non-shattering cultivars which have abscission layer. On the other hand, 40% and 60% cultivars showed intermediate and easy type of thresh ability, respectively (Fig. 8e). Early and fast senescence characters were showed by 85% cultivars whereas intermediate and late senescence showed in 10 and 5% cultivars, respectively. This 5% of the cultivars might be able to produce and partitioning assimilates until full maturity. Ansari et al., (2005) reported that the gene *Osl2* is responsible for rice leaf, senescence which is specifically up regulated during leaf senescence in rice.

Quantitative characteristics of different rice cultivars

Quantitative characters contribute to yield attributes and yield of different rice landraces differed significantly. Plant height showed significant variation among landraces of rice; height was ranges from 95.2 cm to 148.7 cm among the cultivars. The landrace *Kai* showed the lowest plant height (95.2 cm) while *Badal dhan* showed the highest plant height (148.7 cm) which was followed by *Kurabadal* (139.8 cm). The short stature of rice was derived from a semi-dwarf gene (*sd1*), which gene contributed significantly to the rice “green revolution” (Ashikari et al., 2002). There is a close association between plant height and other plant characters such as leaf erectness, strength and grain-to-straw (Tanaka et al., 1966). Tillering of rice is an important agronomic trait for grain production which is formed on the unelongated basal internode. Rice tiller develop through the formation of an axillary bud at each leaf axil and its subsequent outgrowth which is controlled by *MOC1* locus (Li et al., 2003). Significant

differences were found in effective tiller number among the cultivars. Number of tiller ranges from 10.4 to 20.5. The maximum number (20.5) of tillers was produced by *Joria* which was statistically similar with *Maloti* (19.3). Average number of tillers produced by the cultivar *Badal dhan* (16.4) which was at par with cultivars *Changirmora*, *Chinigura*, *Chorabiroin*, *Gandi*, *Ikradai*, *Jori*, and *Kai*. The lowest number (10.4) of effective tillers was produced by *Kalakura* which was statistically similar with *Kakhibiroin*, *Khurabadal*, *Latma*, *Lalmoni*, *Modonga*, *Nightkoli* and *Pajam*. In rice, cultivar or variety with medium tillering capacity has been considered desirable for a high yielding variety (Beachell et al., 1964). Considering this point of view *Badal dhan*, *Changirmora*, *Chinigura*, *Chorabiroin*, *Gandi*, *Ikradai*, *Jori*, and *Kai* might be useful for future breeding program.

Effective tiller is one of the most important yield contributing characters of rice. Land races showed significant variations due to number of effective tillers. *Joria* showed the highest number of tillers where as *Joria TV* and *Lalmoni* showed the lowest number of effective tillers per hill. This is due to the genetic make up of the land races. The flag leaf length ranges from 20.6 cm to 35.4 cm which varied significantly among the cultivars. The longest flag leaf length (35.4 cm) was observed in *Kakhibiro in* where as the shortest one (20.6 cm) was observed in *Pajam*. Flag leaf in rice produces a large proportion of photosynthate and transferred to grain, the improvement of flag leaf character has led to increase in grain production (Kobayashi et al., 2003). Among leaves of the rice the flag leaf appears to be the major source of grain carbohydrate (Quinlan et al., 1962).

Significant variation was found in panicle length among the cultivars. The longest panicle (24.6 cm) was found in *Changirmora* and the lowest one (17.5 cm) in *Kai*. On the other hand *Ikradai* and *Kakhibiroin* produced medium type of panicle. Grain yield is the ultimate goal of rice production. Number of grains per panicle is one of the vital traits for determining yield. Significant differences were observed in grains per panicle of rice cultivars. *Changirmora* showed the highest number (132.2) of grains panicle⁻¹ whereas *Kai* showed the lowest grains panicle⁻¹ (55.60). In present study, the highest 1000-grain weight (26.5g) was observed in *Modonga* followed by *Lalmoni*, *Kakhibiroin*, *Chorabiroin* and those were significantly different with rest of the cultivars. The lowest 1000-grain weight (14.5 g) was found in *Chinigura*. Alike as yield attributes, grain yield differed significantly among the cultivars. The highest grain yield was recorded in cultivar *Pajam* which was statistically similar with the yield of *Jori*, *Kakhibiroin*, *Latma* and *Changirmora*. On the other hand, the lowest yield was recorded in *Kai* genotype of rice.

Table 1. Yield and different quantitative characters of twenty landraces of rice

Cultivar's name	Plant height(cm)	Effective tiller (no.)	Flag leaf length(cm)	Panicle length (cm)	Grains panicle ⁻¹ (no.)	1000-grain weight. (g)	Grain yield (tha ⁻¹)
<i>Badaldhan</i>	148.7	16.4	34.2	21.7	108.3	23.7	1.5
<i>Changirmora</i>	104.8	13.2	29.7	24.6	133.2	17.5	1.6
<i>Chinigura</i>	115.8	13.8	22.9	22.3	95.6	14.5	1.2
<i>Chorabiroin</i>	102.8	14.6	22.9	21.6	77.6	25.5	1.4
<i>Choria</i>	127.9	12.0	28.5	20.3	70.20	23.5	1.1
<i>Gandi</i>	114.4	14.0	27.2	21.9	98.2	19.5	1.4
<i>Ikradai</i>	120.7	13.6	27.2	23.8	125.0	20.5	0.85
<i>Jori</i>	116.0	13.8	29.5	19.6	65.0	22.5	1.6
<i>JoriaTV</i>	108.8	11.2	32.8	22.4	100.4	19.9	1.0
<i>Joria</i>	119.9	20.5	23.2	21.9	97.4	18.5	1.3
<i>Kai</i>	95.2	14.2	25.4	17.5	55.60	16.5	0.7
<i>Kalakura</i>	112.6	10.4	25.6	21.0	107.2	21.5	0.8
<i>Kakhibiroin</i>	125.7	13.0	35.4	23.7	97.8	25.5	1.6
<i>Khurabadal</i>	139.8	11.4	30.3	20.6	94.4	23.5	1.1
<i>Latma</i>	120.8	12.7	26.6	22.3	92.3	22.5	1.5
<i>Lalmoni</i>	106.6	11.2	28.5	21.8	99.6	26.0	1.4
<i>Maloti</i>	112.7	19.3	25.1	18.3	83.8	19.5	1.4
<i>Modonga</i>	108.6	12.6	23.4	22.2	75.6	26.5	1.0
<i>Nightkoli</i>	101.0	11.4	25.4	21.0	119.4	17.7	1.2
<i>Pajam</i>	111.4	12.5	20.6	20.9	93.1	16.6	1.8
CV (%)	4.60	7.36	2.53	3.95	4.94	3.7	3.47
LSD	15.20**	2.86**	1.98**	0.59**	13.35**	2.26**	0.92*

Conclusion

Improving global rice yield productivity under low-input conditions is the main challenge for plant breeders and molecular biologists to develop/improve appropriate rice cultivars. Rice breeders are working to evaluate genetic variability by digging out desirable characters and assessing them up to which extent they are heritable, so various morphological characters have been identified that play a pivotal role for increasing production and quality of rice. The traits directly related to yield per plant (positively and significantly) and revealing direct positive effects, could therefore, be most efficient to produce high grain yield varieties in Asia. Our study revealed that rice landraces of the north-eastern part of Bangladesh is rich with genetic variations that is important to the worlds' rice breeding program. This study also provides useful information about different agro-morphological characters contributing to grain yield and quality of rice.

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