Original Research Article
Yield Contributing Characterization of 18 F_5 Lines of Aus Rice

ABSTRACT

Aims: The investigation was carried out under field conditions to characterize eighteen (18) advanced Aus rice lines (F_5).

Study Design: The experiment was conducted in a randomized complete block design (RCBD). The field was divided into three blocks; the blocks were sub-divided into 9 plots (lines) where genotypes were randomly assigned.

Place and Duration of Study: The experiment was conducted during the period of transplanting Aus season (April 2015 to August 2015) at the genetics and plant breeding experimental field of Sher-e-Bangla Agricultural University, Bangladesh.

Methodology: The eighteen genotypes of rice were characterized by yield contributing traits. All the genotypes were characterized and categorized as per the descriptors developed by Biodiversity International, IRRI and WARDA-2007 for DUS test of inbred rice.

Results: Among the yield contributing characteristics, traits like panicle length, thousand-grain weight, number of effective tillers per plant, culm length, time of maturity and grain length provided better agronomic performance which resulted in an ultimate higher yield per plant. The average days to maturity was 111 days and the average culm length of the tested genotypes was 79.57 cm and most of the genotypes resulted in early maturity and lodging resistance. Most of the genotypes showed average panicle length 24.33 cm and an average thousand-grain weight 22.67 gm resulted in a higher yield per plant.

Conclusion: These G1, G3, G6, G8, G9, G10, G12, G16 and G18 are the most promising lines in respect of yield which can be released as a variety in the future.

Keywords: Aus rice, Agro-morphology, Bangladesh, Paddy, Yield characterization.

1. INTRODUCTION

Rice (*Oryza sativa* L., 2n = 24) is one of the most broadly cultivated cereal crops in the world spreading across a wide range of geographical, ecological and climatic regions. It belongs to the family Poaceae and subfamily Oryzoidea is the staple food for more than half of the world's population and occupies almost one-fifth of the total land area covered by cereals. High genotypic and phenotypic diversity exists and about 1,20,000 different accessions are reported in rice globally as a consequence of various adaptations [1]. Most of the world's rice is cultivated and consumed in Asia which constitutes more than half of the world population. It provides 75% of the calories consumed by more than three billion Asians. Approximately 11% of the world's arable land is under rice cultivation and it ranks next to wheat [2].

Rice belongs to the genus *Oryza* and has two cultivated and twenty-two wild species. The two cultivated species are *Oryza sativa* and *Oryza glaberrima*. *Oryza sativa* is grown

all over the world while *Oryza glaberrima* has been cultivated in West Africa for the last ~3500 years [3]. Rice is grown under many different conditions and production systems, but submerged in water is the most common method used worldwide. Rice is the only cereal crop that can grow for long periods in standing water [4]. About 57% of rice is grown on irrigated land, 25% on rainfed lowland, 10% on the uplands, 6% in deep water, and 2% in tidal wetlands [5].

Asia can be considered as 'Rice Basket' of the world, as more than 90 percent of the rice is produced and consumed in Asia. World paddy production area was 163.3 million hectares and production were 749.7 million tons [6]. Bangladesh is the 4th largest rice producer in the world with the annual production of 345.81 lac metric tons [7]. During Aus season in Financial Year (FY) 2015-16, total cultivated area, production and yield rate of rice was 10,17,969 hectares, 22,88,642 metric tons and 2.248 metric ton respectively. During T. Aman season in Financial Year (FY) 2015-16, total cultivated area, production and yield rate of rice was 55,90,340 hectares, 1,12,39,943 metric tons and 2.412 ton respectively. During Boro season in Financial Year (FY) 2015-16, total cultivated area, production and yield rate of rice was 47,72,576 hectares, 1,89,37,581 metric tons and 3.968 ton respectively [8].

Several morphological characters are the major determining factors of rice grain yield. Genetic diversity probably serves as an insurance against crop failure [9]. Landraces and wild species possess the immense potential of most valuable genes which can be effectively utilized in the present-day breeding programs to evolve miracle varieties in rice that possess not only high yield potential and quality but also resistant to biotic and abiotic stresses [10].

The total cultivable land is decreasing at a rate of more than 1% per year due to urbanization. The population growth rate is 2 million per year and if the population increases at this rate, the total population will reach 238 million by 2050 [11]. An increase in total rice production is required to feed this ever-increasing population. Aus, Aman, and Boro rice were recently reported to account for 7%, 38%, and 55%, respectively, of the total rice production in Bangladesh [11]. Now, modern high yielding varieties in Aus season are essential to increase the total rice production of Bangladesh. The high yielding varieties of Aus rice are developed through crossing between Aus rice and Boro rice with the intention to increase the yield of Aus rice having genes from Boro rice without much affecting the days to maturity. Eighteen F_4 lines were selected previously which would be used in the present study. The study was undertaken to characterize the F_5 lines which are the prerequisite to release rice variety. It will pave the ways for selection of high yielding and short duration T. Aus rice genotypes from eighteen (18) genotypes. The objective of this study to find out high yielding genotypes with their different yield contributing characters and also select the short duration and high yielding T. Aus materials for further trial.

2. MATERIALS AND METHODS

2.1 Experimental location

The experiment was conducted at the genetics and plant breeding experimental farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from April 2015 to August 2015. The location of the site was situated at 23°77' N latitude and 90°38' E longitude. Geographically the experimental field is located at 8.4 m above the mean sea level [12].

2.2 Climate and Soil

The experimental site was medium high land belonging of Old Madhupur Tract (AEZ-28) and the soil series was Tejgaon [13]. The soil of the research field was clay loam in texture having pH around 6.5 and organic carbon content is 0.84%. Physical and chemical composition of the experimental field are presented in Table 1. The experiment area was above flood level and having available irrigation and drainage system. The research area was under the subtropical climate. It is characterized by three distinct

seasons, winter season from November to February and the pre-monsoon or summer season from March to April and the monsoon period from May to October [14]. Details of the metrological data at the time of experiment were collected from the Bangladesh Meteorological Department (Climate & Weather Division), Agargoan, Dhaka are presented in Table 2 [15].

Table 1. Physical and chemical characteristics of initial soil (0-15 cm depth) of the experimental site

Physical composition		Chemical composition	
Soil separates	**Percent (%)**	**Soil characteristics**	**Analytical data**
Sand	36.90	Organic carbon (%)	0.84
Silt	26.40	Total N (kg/ha)	1790.00
Clay	36.66	Total S (ppm)	225.00
Texture class	Clay loam	Total P (ppm)	840.00
		Available N (kg/ha)	54.00
		Available P (kg/ha)	69.00
		Exchangeable K (kg/ha)	89.50
		Available S (ppm)	16.00
		pH (1:2.5 soil to water)	5.55
		CEC	11.23

Table 2. Monthly average Temperature, Relative Humidity and Total Rainfall of the experimental site during the period from April 2015 to September 2015

Month	Air temperature (ºc)		Relative humidity (%)	Total Rainfall (mm)
	Maximum	Minimum		
April, 2015	38.0	28.0	79.80	293
May, 2015	37.5	27.0	80.20	307
June, 2015	37.70	27.80	81.08	315
July, 2015	35.45	26.50	83.43	327
August, 2015	34.50	26.00	85.82	338
September, 2015	34.60	25.80	78.08	251

2.3 Planting Materials (Genotypes)

Eighteen (18) genotypes of F_5 generation including three check varieties (BR 24, BRRI dhan 48 and BRRI dhan 55) were used as experimental materials in the study. Descriptions of the genotypes are given in Table 3.

Table 3. List of materials used for the experiment (**G=**Genotypes**)**

Genotypes	Populations	Source
G1	BR 21× BRRI dhan 29, F_5, S_7 P_5	SAU
G2	BR 24× BRRI dhan 28, F_5, S_{10} P_{10}	SAU
G3	BR 21× BRRI dhan 29, F_5, S_6P_3	SAU
G4	BR 21× BRRI dhan 29, F_5, S_7 P_2	SAU
G5	BR 24× BR 26, F_5, S_6 P_4	SAU
G6	BR 21× BRRI dhan 29, F_5, S_6 P_{10}	SAU
G7	BR 21× BRRI dhan 29, F_5, S_7P_1	SAU
G8	BR 21× BRRI dhan 29, F_5, S_6 P_9	SAU
G9	BR 21× BRRI dhan 29, F_5, S_7 P_4	SAU
G10	BR 24× BRRI dhan 28, F_5, S_{10} P_8	SAU
G11	BR 21× BRRI dhan 36, F_5, S_1 P_9	SAU
G12	BR 21× BRRI dhan 29, F_5, S_6 P_3(a)	SAU
G13	BR 24× BRRI dhan 29, F_5, S_5 P_{10}	SAU
G14	BR 21× BRRI dhan 29, F_5, S_6P_{10}	SAU
G15	BR 21× BRRI dhan 29, F_5, S_6 P_2	SAU
G16	BR 21× BRRI dhan 29, F_5, S_1 P_2	SAU
G17	BR 21× BRRI dhan 29, F_5, S_6 P_3(b)	SAU
G18	BR 21× BRRI dhan 29, F_5, S_6 P_5	SAU
G19*	BRRI dhan 48	BRRI
G20*	BRRI dhan 55	BRRI
G21*	BR 24	BRRI

2.4 Experimental Design and Layout

The research was laid out in a randomized complete block design (RCBD). The field was divided into three blocks; the blocks were sub-divided into 9 plots (lines) where genotypes were randomly assigned. The experimental field size was 27 m x 14 m where 1 m border was maintained surrounding the field and every block. The same size of crop field was used for another nine lines. The experimental field was designed in such a way where row to row distance was 25 cm and plant to plant distance was 25 cm. The 18 genotypes including three check varieties were distributed to each plot within each block randomly.

2.5 Collection of Seed

The seeds of 18 Aus lines were collected from germplasm center of Sher-e-Bangla Agricultural University (SAU), Bangladesh. Three check varieties (BR 24, BRRI dhan 48 and BRRI dhan 55) were collected from Bangladesh Rice Research Institute (BRRI).

2.6 Application of Fertilizers

The fertilizers N, P, K, S and B in the form of Urea, TSP, MP, Gypsum and Borax respectively were applied. The entire amount of TSP, MP, Gypsum, Zinc Sulphate and Borax were applied during final preparation of the field. Urea was applied in three equal installments during ploughing, vegetative stage and before flowering. The dose and method of application of fertilizer are sown in Table 4 [16].

Table 4. Dose and method of application of fertilizers in rice field

Fertilizers	Dose (kg/ha)	Application (%)		
		Basal	1st installment	2nd installment
Urea	127	33.33	33.33	33.33
TSP	52	100	--	--
MP	60	100	--	--
Gypsum	0	100	--	--
Borax	0	100	--	--

2.7 Transplanting of Seedling

The seed of all collected rice genotypes soaked separately for 24 hours in a clothes bag. Soaked seeds were picked out from the water and wrapped with straw and gunny bag to increase the temperature for facilitating germination. After 72 hours seeds were sprouted properly. Sprouted seeds were sown separately in the wet seedbed. Proper care was taken so that there was no infestation of pest and diseases and no damage by birds. Healthy seedlings of 25 days old were transplanted in a separate strip of experimental field. Water level was maintained properly after transplanting.

2.8 Intercultural Operation and After Care

After the establishment of seedlings, various intercultural operations (irrigation and drainage, gap filling, weeding, top dressing, plant protection measure) were done as per when needed for better growth and development of the rice seedlings.

2.9 Harvesting, Threshing and Cleaning

The rice was harvested depending upon the maturity of the plant. Harvesting was done manually from each plot and bundled separately. Properly tagged and brought to the threshing floor. Enough care was taken for threshing and also cleaning of rice seed. Fresh weight of grain was recorded. The grains were cleaned and weight was adjusted to moisture content 14% through drying.

2.10 Methods of Recording of Observations

To study the stable diagnostic characteristics data and morphological characters were collected from ten randomly selected hills from each replicated plot. The plants were selected from the middle of each plot to avoid border effect and portion of the plot. The mean was estimated. Yield contributing traits were recorded using the descriptors developed by BIOVERSITY INTERNATIONAL, IRRI and WARDA-2007 [17]. In addition to the descriptors, the observed genotypes were classified according to Panse and Sukhatme [18]. The observations for characterization were recorded under field condition.

2.10.1 Flag Leaf: Attitude of the blade
The attitude of the blade of the flag leaf is angle of attachment between the flag leaf blade and the main panicle axis. It was just visually observed at anthesis period and classified into the following four groups.

Erect ($<30^0$)-1, Intermediate or Semi-erect (30^0-45^0)-3, Horizontal (46^0-90^0)-5 and Reflexed or descending ($>90^0$)-7.

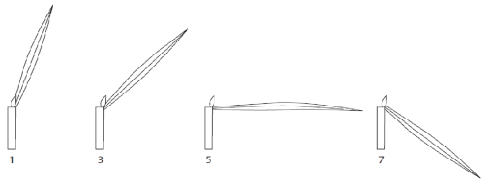

Figure 1. Flag leaf attitude

2.10.2 Male Sterility
It was observed at anthesis period of rice and grouped as per descriptors.

Absent-1, CMS-3, TGMS-5, PGMS-7 and P(T) GMS-9.

2.10.3 Microscopic Observation of Pollen with I_2-KI solution
It was observed at anthesis period of rice using a microscope and the rice genotypes were classified into eight groups with codes according to guided descriptors as per follow.

Completely sterile with TA pollen-1, Completely sterile with 80% TA pollen-2, Completely sterile with 50% TA pollen-3, Sterile (91-99%)-4, Partial sterile (31-70%)-5, Partial fertile (31-70%)-6, Fertile (21-30%)-7 and Fully fertile (0-20%)-8.

2.10.4 Stigma Exertion
Data was observed at anthesis period using a hand lens or magnifying glass and the rice genotypes were classified into five groups with codes according to guided descriptors as per follow.

No or a few (>5%)-1, Low (5-20%)-3, Medium (21-40%)-5, High (41-60%)-7 and Very high (>61%)-9.

2.10.5 Panicle Curvature of Main Axis (i.e. recurrent main axis)
Data was collected at near maturity stage and the rice genotypes were classified into four groups with codes according to guided descriptors as per follow.

Absent or very weak (upright)-1, Weak (semi-upright)-3, Medium (slightly drooping)-5 and Strong (strongly dropping)-7.

2.10.6 Panicle: Attitude of branches
The compactness of the panicle was classified according to its mode of branching, the angle of primary branches, and spikelet density by the following groups.

Erect (compact panicle)-1, Semi-erect (semi-compact panicle)-3, Spreading (open panicle)-5, Horizontal-7 and Drooping-9.

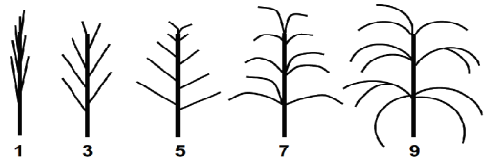

Figure 2. Attitude of panicle branches

2.10.7 Panicle: Exertion
The extent to which the panicle is exerted above the flag leaf sheath is known as panicle exertion. Data was collected at near maturity stage and the rice genotypes were classified into five groups with codes according to guided descriptors as per follow.

Enclosed-1, Partly exerted-3, Just exerted-5, Moderately exerted-7 and Well exerted-9.

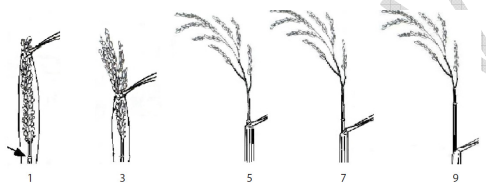

Figure 3. Panicle exertion

2.10.8 Leaf Senescence: Penultimate leaves are observed at the time of harvest
Data was collected at the time of harvest and the rice genotypes were classified into three groups with codes according to guided descriptors as per follows.

Late and slow (2 or more leaves retain green color at maturity)-1, Intermediate-5 and Early and fast (leaves are dead at maturity)-9.

2.10.9 Decorticated Grain: Shape (length-width ratio of de-hulled grain)
Data was collected at the time of harvest and the rice genotypes were classified into five groups with codes according to guided descriptors as per follows.

Round (L: W<1.5)-1, Bold (L: W=1.5-2.0)-3, Medium (L: W=2.1-2.5)-5, Medium slender (L: W=2.6-3.0)-7 and Slender (L: W>3.0)-9.

2.10.10 Stem: Culm diameter (from 5 mother tillers in the lowest internode)
Culm diameter of the stem was measured in millimeter scale at the lowest internode of the stem during flowering or late reproductive stage by using a digital caliper and categorized as per descriptors.

Small (<5.0 mm)-1, Medium (5.1-6.0 mm)-3, Large (6.1-7.0 mm)-5 and Very Large (>7.0 mm)-7

2.10.11 Stem Length (culm length): Measure from the base of the plants to the neck of the panicles
Stem length (culm length) was measured in centimeter from the base of the plants to the neck of the panicles after flowering to maturity stage and categorized as per descriptors.

Very short (<40 cm)-1, Short (41–60 cm)-3, Medium (61–80 cm)-5, Long (81-110 cm)-7 and Very long (>110 cm)-9.

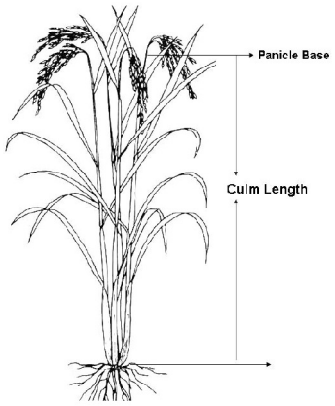

Figure 4. Culm length

2.10.12 Panicle Length: Measured from the neck to the tip of the panicle of main tillers without awns

The mean length often randomly selected panicles of main tillers from ten hills was measured from neck to the tip of the panicle of the main tiller without awn in centimeters. Data was collected at 7 days after anthesis or full panicle exertion stage According to their length, the observed rice genotypes were classified into four groups with codes.

Short (<20 cm)-3, Medium (21-25 cm)-5, Long (26-30 cm)-7 and Very long (>30 cm)-9.

2.10.13 Panicle: Number of the effective tillers per plant

Effective tillers are the tillers which bear panicle and the total number of tillers were counted from each of the sample plants and the average was taken. Based on this character, all the genotypes were grouped into the following groups.

Few (>6)-3, Medium (6-10)-5 and Many (>10)-7.

2.10.14 Time of Maturity

The total number of days from the date of sowing until 80% seeds became matured considering each replication was recorded on each individual plot and the genotypes were classified as per the guided descriptors.

Very early (>100 days)-1, Early (101-115 days)-3, Medium (116-135 days)-5, Late (136-150 days)-7 and Very late (>150 days)-9.

2.10.15 Grain: Weight of 1000 fully developed grains (adjusted of 12% of moisture)

After threshing and recording the net yield, a random sample of fully grown 1000 seeds were counted and weighed at 12% moisture content to record the test weight. According to test weight, the genotypes were categorized into five different groups as follows.

Very low (<15 gm)-1, Low (16-19 gm)-3, Medium (20-23 gm)-5, High (24-27 gm)-7 and Very high (>27 gm) – 9.

2.10.16 Grain: Length (without dehulling)

Grain length was measured in mm and a digital caliper was used for clear visualization. Ten grains from every genotype were measured and the mean value was recorded. The genotypes were classified as per the guided descriptors.

Very short (<6.0 mm)-1, Short (6.1-7.0 mm)-3, Medium (7.1-8.0 mm)-5, Long (8.1-9.0 mm)-7 and Very Long (>9.0 mm)-9.

2.10.17 Sterile Lemma Length: Measure at post-harvest stage
Sterile lemma length was measured in mm and a digital caliper was used for clear visualization. Ten grains from every genotype were measured and the mean value was recorded. The genotypes were classified as per the guided descriptors.

Short (<1.5 mm)-1, Medium (1.5-2.5 mm)-3, Long (2.6-3.0 mm)-5 and Very Long (>3.0 mm)-7.

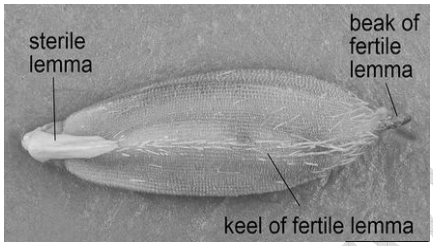

Figure 5. Rice grain with sterile lemma.

2.10.18 Decorticated Grain: Length (After dehulling, before milling)
Decorticated grain length was measured in mm and a digital caliper was used for clear visualization. Ten grains from every genotype were measured and the mean value was recorded. The genotypes were classified as per the guided descriptors.

Short (<5.5 mm)-1, Medium (5.6-6.5 mm)-3, Long (6.6-7.5 mm)-5 and Very Long (>7.5 mm)-7.

2.11 Statistical Application
The yield contributing data are presented in tabular form for easier description according to the descriptors developed by BIOVERSITY INTERNATIONAL, IRRI AND WARDA-**2007**. The data were arranged as per IBPGR-IRRI formulation with the help of the Microsoft Excel program.

3. RESULTS AND DISCUSSION
3.1 Flag Leaf: Attitude of the blade
From the study, 15 genotypes (G1, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G17, G19 and G20) showed erect type flag leaf, 5 genotypes (G2, G3, G4, G16 and G18) showed intermediate or semi-erect type and rest one genotype (G21) showed horizontal type flag leaf.

3.2 Male Sterility
Male sterility was absent in all genotypes (G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G19, G20 and G21).

3.3 Microscopic Observation of Pollen with I_2-KI solution
From the study, all genotypes (G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G19, G20 and G21) were fertile (21-30%).

3.4 Stigma Exertion
In this case 6 genotypes (G6, G7, G9, G14, G16 and G18) were no or few types, 4 genotypes (G2, G4, G5 and G12) were low type, 6 genotypes (G3, G8, G15, G17, G19

and G20) were medium type and rest 5 genotypes (G1, G10, G11, G13 and G21) were high type for exertion of stigma.

3.5 Panicle Curvature of Main Axis (i.e. recurrent main axis)
One genotype (G11) was observed weak type, 8 genotypes (G2, G4, G6, G7, G9, G10, G18 and G20) were observed medium type and 12 genotypes (G1, G3, G5, G8, G12, G13, G14, G15, G16, G17, G19 and G21) were observed strong type of panicle curvature of the main axis.

3.6 Panicle: Attitude of branches
Where 20 genotypes (G1, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G19, G20 and G21) showed semi-erect type and rest 1 genotype (G2) showed spreading type panicle. Erect typed panicles were not found among the genotypes**.**

3.7 Panicle: Exertion
One genotype (G9) was observed partly exerted type, 7 genotypes (G4, G6, G8, G12, G13, G16 and G18) were observed just exerted type, 4 genotypes (G1, G3, G14 and G20) were observed moderately exerted type and 9 genotypes (G2, G5, G7, G10, G11, G15, G17, G19 and G21) were observed well-exerted type of the panicle exertion. Enclosed type of panicle exertion was not found.

3.8 Leaf Senescence: Penultimate leaves are observed at the time of harvest.
Where 16 genotypes (G1, G3, G4, G5, G7, G9, G10, G11, G12, G13, G14, G15, G16, G17and G20) showed 2 or more leaves retain green color at maturity level and rest 5 genotypes (G6, G8, G18, G19 and G21) showed intermediate type of leaf senescence. Early and fast (leaves are dead at maturity) type of leaf senescence was not found among the genotypes**.**

3.9 Decorticated Grain: Shape (length-width ratio of de-hulled grain)
Where 16 genotypes (G1, G2, G4, G5, G7, G8, G9, G11, G13, G15, G16, G17, G18, G19, G20 and G21) showed slender type and rest 5 genotype (G3, G6, G10, G12 and G14) showed medium slender type decorticated grain shape. Round, bold and medium type decorticated grain were not found among the genotypes**.**

3.10 Stem: Culm diameter (from 5 mother tillers in the lowest internode)
Culm diameter of observed genotypes ranged from 7.93 mm to 5.18 mm with a mean value of 6.38 mm. As the guided descriptors where there were no small type genotypes on the other hand, six medium type genotypes (G2, G10, G11, G12, G13 and G18), 13 large type genotypes (G1, G3, G4, G6, G7, G8, G9, G14, G15, G16, G19, G20 and G21) and 2 very large type genotypes (G5 and G17) were found (Table 5).

3.11 Stem Length (culm length): Measure from the base of the plants to the neck of the panicles
Culm length means the length of a stem from ground level to panicle base. Culm lengths of observed genotypes ranged from 99.46 cm to 57.43 cm with a mean value of 79.57 cm. As the guided descriptors where there were no very short type and very long type genotypes on the other hand, only one short type genotypes (G11), 15 medium type genotypes (G1, G2, G3, G4, G6, G7, G8, G9, G10, G12, G14, G16, G18, G19 and G20) and 5 long type genotypes (G5, G13, G15, G17 and G21) were found (Table 5).

3.12 Panicle Length: Measured from the neck to the tip of the panicle of main tillers without awns
Panicle length of observed genotypes ranged from 26.40 cm to 20.21 cm with a mean value of 24.33 cm. Data were collected at 7 days after anthesis or full panicle exertion stage. As the guided descriptors where there were no short type and very long type genotypes, on the other hand 13 medium type genotypes (G4, G5, G10, G11, G12, G13,

G14, G15, G16, G17, G19, G20 and G21) and 8 long type genotypes (G1, G2, G3, G6, G7, G8, G9 and G18) were found (Table 5).

3.13 Panicle: Number of the effective tillers per plant

The number of effective tillers per plant of the observed genotypes ranged from 15.03 to 9.80 with a mean value of 12.55. There was no genotype showed few types of effective tillers per plant. On the other hand, only two genotypes (G14 and G18) had medium type of effective tillers per plant and rest genotypes (G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G15, G16, G17, G19, G20 and G21) showed many types of effective tillers per plant.

3.14 Time of Maturity

Time of maturity was calculated as days required from sowing to maturity. Time of maturity of the observed genotypes ranged from 130.33 days to 103 days with a mean value of 110.98 days. There was no genotype showed very early, late and very late maturity of the plant. On the other hand, 17 genotypes (G1, G2, G3, G4, G6, G7, G8, G9, G10, G11, G12, G14, G16, G18, G19, G20 and G21) showed early type maturity of plants and rest genotypes (G5, G13, G15 and G17) showed medium type maturity of plants (Table 5).

3.15 Grain: Weight of 1000 fully developed grains (adjusted of 12% of moisture)

Thousand-grain weight of the observed genotypes ranged from 26.27 gm to 19.67 gm with a mean value of 22.67 gm. In this situation, there was no genotype showed a very low and very high type of 1000 grain weight. On the other hand, 2 genotypes (G5 and G11) showed a low type of 1000 grain weight, 13 genotypes (G1, G2, G3, G4, G6, G7, G8, G9, G12, G13, G14, G18 and G21) showed medium type of 1000 grain weight and rest genotypes (G10, G15, G16, G17, G19 and G20) showed high type of 1000 grain weight (Table 5).

3.16 Grain: Length (without dehulling)

Grain length of 21 rice genotypes ranged from 10.63 mm to 7.81 mm with a mean value of 8.49 mm. Two genotypes (G17 and G20) were recorded as very long, 16 genotypes (G1, G2, G3, G4, G5, G8, G9, G10, G11, G13, G14, G15, G16, G18, G19 and G21) as long and rest 3 genotypes (G6, G7 and G12) as medium. No genotypes were found as very short and short type.

3.17 Sterile Lemma Length: Measure at post-harvest stage

Sterile lemma length of 21 rice genotypes ranged from 2.66 mm to 1.71 mm with a mean value of 1.89 mm. Twenty genotypes (G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G19 and G21) were recorded as medium and rest one genotype (G20) as long. No genotypes were found as short and very long type.

3.18 Decorticated Grain: Length (After dehulling, before milling)

Decorticated grain length of 21 rice genotypes ranged from 8.19 mm to 6.05 mm with a mean value of 6.43 mm. Fifteen genotypes (G1, G2, G3, G4, G6, G7, G8, G9, G10, G11, G12, G14, G16, G18, G19 and G21) were recorded as medium, four genotypes (G5, G13, G15 and G17) as long and rest one genotype (G20) as very long. No genotypes were found as short type.

Table 5. Observed genotypes based on culm diameter, culm length, panicle length, time of maturity and thousand grain weight

Genotypes	Culm diameter (mm)	Culm length (cm)	Panicle length (cm)	Time of maturity (days)	1000 Grain weight (g)
G1	6.28	78.52	25.71	103	21.27
G2	5.95	77.64	25.57	109	22.57
G3	6.12	78.08	25.52	106	21.92

G4	6.12	78.08	22.03	106	21.92
G5	7.93	92.89	23.58	127.33	19.70
G6	6.89	75.79	25.73	105.33	22.27
G7	6.66	78.35	25.44	105.33	21.73
G8	6.32	78.35	25.85	103.67	22.20
G9	6.72	69	26.40	106	21.07
G10	5.18	78.79	24.67	110	23.83
G11	5.84	57.43	20.21	107	19.67
G12	5.86	75.88	22.91	105	21.23
G13	5.71	92.50	24.66	130.33	23.20
G14	6.17	78.66	23.90	108	23.03
G15	6.95	95.81	24.45	130.33	26.27
G16	6.26	69.15	24.30	106.33	23.67
G17	7.03	99.46	24.12	125	27.47
G18	5.67	78.55	25.25	106	23.33
G19*	6.90	78.61	23.95	112	24.03
G20*	6.66	73.51	24.25	111	24.17
G21*	6.75	85.96	22.43	108	21.60
Highest	**7.93**	**99.46**	**26.40**	**130.33**	**27.47**
Lowest	**5.18**	**57.43**	**20.21**	**103**	**19.67**
Mean	**6.38**	**79.57**	**24.33**	**110.98**	**22.67**

4. CONCLUSION

A wide range of variation was observed in all the genotypes for yield contributing characteristics. The following characters such as attitude of the flag leaf blade, number of effective tillers per plant, panicle length, panicle curvature, panicle attitude of branches, panicle exertion, time of maturity, thousand grain weight, culm length, culm diameter, decorticated grain length, decorticated grain shape are vital characteristics for selection of better rice genotypes. The most promising lines such as G1, G3, G6, G8, G9, G10, G12, G16 and G18 were selected in respect of yield.

REFERENCES

1. Das B, Sengupta S, Parida S, Roy B, Ghosh M, Prasad M, Ghos TK. Genetic diversity and population structure of rice landraces from Eastern and North Eastern States of India. BMC Genetics. 2013;14(1):71.
Available from: http://dx.doi.org/10.1186/1471-2156-14-71

2. Chakravarthi BK, Naravaneni R. SSR marker based DNA finger printing and diversity study in rice (*Oryza sativa. L.*). African J Biotechnol. 2006;5(9): 684-688.

3. IRRI (International Rice Research Institute). Rice Research and Production in the 21st Century. (Gramene Reference ID 8380). 2001.

4. IYR (International Year of Rice). Rice and water: a long and diversified story. (Gramene Reference ID 8372). 2004.

5. Forster B. Evolution and Adaptation of Cereal Crops. Edited by V. L. Chopra and S. Prekash. Enfield, NH, USA: Science Publishers Inc (2003), pp. 295. Experimental Agriculture. Cambridge University Press (CUP). 2003;40(1):141–142.
Available from: http://dx.doi.org/10.1017/s0014479703281527

6. FAO (Food and Agricultural Organization). Statistical database. 2016.
Available: https://www.fao.org/economic/RMM

7. USDA (United States Department of Agriculture). Statistical database. 2016.
Available: https://www.world rice production.com

8. BBS (Bangladesh Bureau of Statistics). Agriculture crop cutting. Estimation of Aus, T. Aman and Boro rice 2015-2016. Government of the people's Republic of Bangladesh. 2016.
Available: http://www.bbs.gov.bd.

9. Subba Rao LV, Prasad GSV, Prasada Rao U, Rama Prasad A, Acharyulu TL, Rama Krishna S. Collection, Characterization and evaluation of rice germplasm from Bastar Region. Indian J Plant Genet Resour. 2001;14: 222-224.

10. Saxena RK, Chang TT, Sapra RL, Paroda RS. Evaluation studies in indigenous rice (*Oryza sativa L.*) germplasm at IRRI. Philippines. Published in NBPGR manual. 1988:1-3.

11. Shelley IJ, Takahashi-Nosaka M, Kano-Nakata M, Haque MS, Inukai Y. Rice cultivation in Bangladesh: present scenario, problems, and prospects. J Int Coop Agric Dev. 2016;14(4):20-29.

12. Mostofa M, Roy TS, Chakraborty R, Modak S, Kundu PK, Zaman MS, Rahman M, Shamsuzzoha M. Effect of Vermicompost and Tuber Size on Processing Quality of Potato during Ambient Storage Condition. Int J Plant Soil Sci. 2019;26(3):1-18.
Available from: http://dx.doi.org/10.9734/ijpss/2018/46554

13. UNDP (United Nations Development Programme). Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2. Agroecological Regions of Bangladesh. United Nations Development Programme and Food and Agriculture Organization. 1988:212-221.

14. Edris KM, Islam ATMT, Chowdhury MS, Haque AKMM. Detailed Soil Survey of Bangladesh, Dept. Soil Survey and Govt. People's Republic of Bangladesh. 1979:118.

15. Meteorological Department, Dhaka, Bangladesh. 2015. Accessed 13 September 2016.
Available: http://www.bmd.gov.bd/

16. BRRI (Bangladesh Rice Research Institute). Adhunik Dhaner Chash (In Bangoli). Bangladesh Rice Research Institute, Joydebpur, Gazipur. 2015:5-10.

17. Biodiversity International, IRRI and WARDA. Descriptors for wild and cultivated rice (*Oryza* spp.). Bioversity International, Rome, Italy; International Rice Research Institute, Los Banos, Philippines; WARDA, Africa Rice Center, Cotonou, Benin. 2007.

18. Panse V G, Sukhatme PV. Statistical Methods for Agricultural Workers, Rev Edn. ICAR, New Delhi. 1995.