Asian Journal of Research in Crop Science

4(1): 1-12, 2019; Article no.AJRCS.48775
ISSN: 2581-7167

Characterization of Agro-morphological Traits of 21 F_5 Lines of Aus Rice

Md. Kamrul Islam[1], Md. Shahidur Rashid Bhuiyan[2], Md. Sarowar Hossain[2], Md. Sadiquzzaman Sarker[3], Md. Shamsuzzoha[4] and Maruf Mostofa[1*]

[1]Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.
[2]Department of Genetics and Plant Breeding, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.
[3]Ministry of Agriculture, Dhaka, Bangladesh.
[4]Bangladesh Institute of Research and Training on Applied Nutrition, Dhaka-1207, Bangladesh.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRCS/2019/v4i130061
Editor(s):
(1) Dr. Ahmet Esen Çelen, Professor, Faculty of Agriculture, Ege University, Turkey.
Reviewers:
(1) Joseph Adjebeng-Danquah, CSIR-Savanna Agriculture Research Institute, Ghana.
(2) Suelen Alves Vianna, Instituto Agronômico de Campinas, Brazil.
(3) Luc Tshilenge-Lukanda, University of Kinshasa, Republic of the Congo.
Complete Peer review History: http://www.sdiarticle3.com/review-history/48775

Original Research Article

Received 25 February 2019
Accepted 10 May 2019
Published 20 June 2019

ABSTRACT

The investigation was carried out under field conditions to characterize agro-morphological traits of twenty-one (21) advanced Aus rice lines (F_5). The experiment was conducted in a randomized complete block design (RCBD). The field was divided into three blocks; each block was sub-divided into 21 plots (lines) where genotypes were randomly assigned. 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. 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. All the genotypes were grouped and classified as well as described based on morphological characters as per descriptors so that all the observed genotypes containing described characters can be easily evaluated and identified at a glance for further studies.

**Corresponding author: E-mail: marufsau@hotmail.com;*

Keywords: Agro-morphological attributes; characterization; germplasm; phenotypic component analysis; rice.

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 more than 120,000 different accessions including landraces 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. It 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 per ha respectively. During Transplant Aman (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 per ha 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 per ha respectively [8].

Several morphological characters are the primary 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 during the year 2013-14 [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 were developed through crossing between Aus rice and Boro rice to increase the yield of Aus rice having genes from Boro rice without much affecting the days to maturity. Eighteen F_4 lines were previously selected 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 in future. It would pave the ways for selection of high yielding and a short duration Transplant Aus (T. Aus) rice genotypes from eighteen (18) genotypes. The objective of this study is to observe high promising genotypes with their different agro-morphological characteristics of T. Aus rice 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 (SAU), Dhaka-1207, 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 (Agro Ecological Zone - 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%. The 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].

2.3 Planting Materials

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.

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; each block was sub-divided into 21 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. Row to row distance was 25 cm and plant to plant distance was 25 cm.

2.5 Collection of Seed

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

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 (%)	0.82
Silt	26.40	Total N (kg ha^{-1})	1790.00
Clay	36.66	Total S (ppm)	225.00
Texture class	Clay loam	Total P (ppm)	840.00
		Available N (kg ha^{-1})	54.00
		Available P (kg ha^{-1})	69.00
		Exchangeable K (kg ha^{-1})	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	38.0	28.0	79.80	293
May	37.5	27.0	80.20	307
June	37.70	27.80	81.08	315
July	35.45	26.50	83.43	327
August	34.50	26.00	85.82	338
September	34.60	25.80	78.08	251

Table 3. List of genotypes (G) used in the experiment

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_6 P_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

F- Generation no; S-Selection no; P-Plant no

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

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

2.6 Application of Fertilizers

The fertilizers N, P, K, S and B were applied in the form of Urea, TSP, MP, Gypsum and Boron respectively. The entire amount of TSP, MP, Gypsum, Zinc Sulphate and Boron 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 presented in Table 4 [16].

2.7 Transplanting of Seedling

The seed of all collected rice genotypes soaked separately for 24 hours in cloth bags. 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 previously 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. The water level was maintained properly after transplanting.

2.8 Intercultural Operation

After the establishment of seedlings, various intercultural operations such as irrigation, 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

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 cleaning of rice seed. The grains were cleaned and weight was adjusted to moisture content 14% through drying.

2.10 Agro-morphological Traits Evaluation Methods

Agro-morphological characteristics 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. Agro-morphological 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. Morphology of rice plant is presented in Fig. 1.

2.10.1 Leaf sheath: Anthocyanin color

Data were collected at an early vegetative stage on leaf sheath anthocyanin color and the rice genotypes were classified into two groups with codes according to guided descriptors as per follow.

Absent-0 and Present-1.

2.10.2 Leaf color

Observations with respect to the green coloration of the leaf at the late vegetative stage the rice genotypes were classified into seven groups with codes according to guided descriptors as per follows.

Pale green-1, Green-2, Dark green-3, Purple tip-4, Purple margins-5, Purple blotch-6 and Purple-7.

2.10.3 Penultimate leaf pubescence

It was assessed both visually and by touch, rubbing fingers over the leaf surface from the tip to downwards at late vegetative stage and the observed genotypes were categorized into following groups as per descriptors by following way.

Absent or very weak-1, Weak or only on the margins-3, Medium hairs on the medium portion of the leaf-5, Strong hairs on the leaf blade-7 and Very strong-9.

2.10.4 Penultimate leaf: Anthocyanin coloration of auricles and collar

Data was collected at the late vegetative stage on penultimate leaf anthocyanin coloration of auricles and collar and the rice genotypes were classified into two groups with codes according to guided descriptors as per follow.

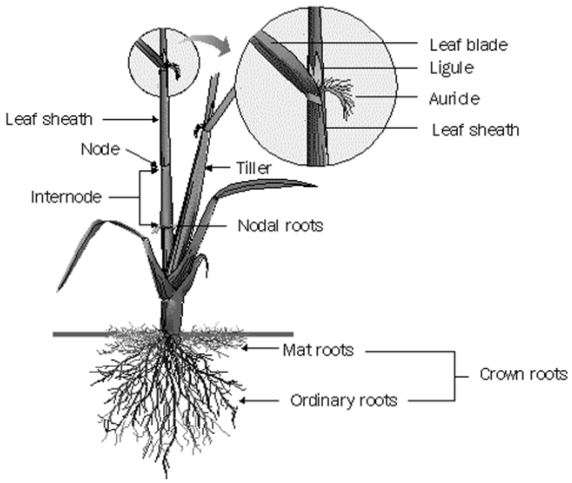

Fig. 1. Morphology of a rice plant (Vegetative stage)

Absent-0 and Present-1.

2.10.5 Penultimate leaf: Ligule

Data was collected at the late vegetative stage on penultimate leaf ligule and the rice genotypes were classified into two groups with codes according to guided descriptors as per follow.

Absent-0 and Present-1.

2.10.6 Penultimate leaf: Shape of the ligule

The shape of the penultimate leaf ligule was observed and the genotypes were categorized as following which is also shown hypothetically in Fig. 2.

Absent-0, Truncate-1, Acute to acuminate-2 and Split or two-cleft-3.

2.10.7 Lemma and palea: Anthocyanin coloration

Data were collected at the pre-ripening stage on grain anthocyanin coloration of lemma and palea and the rice genotypes were classified into five groups with codes according to guided descriptors as per follow.

Absent or very weak-1, Weak-3, Medium-5, Strong-7 and Very strong-9.

2.10.8 Lemma: Anthocyanin coloration of area below apex

Data were collected at the pre-ripening stage on grain anthocyanin coloration of the lemma and the rice genotypes were classified into five groups with codes according to guided descriptors as per follows.

Absent or very weak-1, Weak-3, Medium-5, Strong-7 and Very strong-9.

2.10.9 Lemma: Anthocyanin coloration of apex

Data were collected at the pre-ripening stage on grain anthocyanin coloration of the lemma and the rice genotypes were classified into five groups with codes according to guided descriptors as per follow.

Absent or very weak-1, Weak-3, Medium-5, Strong-7 and Very strong-9.

2.10.10 Color of stigma

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.

White -1, Light green-2, Yellow-3, Light purple-4 and Purple-5.

2.10.11 Stem: Anthocyanin coloration of nodes

Data was collected after flowering to near maturity stage on stem anthocyanin coloration of nodes and the rice genotypes were classified into two groups with codes according to guided descriptors as per follow.

Absent-0 and Present-1.

2.10.12 Stem: Intensity of anthocyanin coloration of nodes

Data was collected after flowering to near maturity stage on stem anthocyanin coloration of nodes and the rice genotypes were classified into four groups with codes according to guided descriptors as per follow.

Weak-3, Medium-5, Strong-7 and Very strong-9.

2.10.13 Stem: Anthocyanin coloration of internodes

Data was collected at near coloration maturity stage on stem anthocyanin coloration of internodes and the rice genotypes were classified into five groups with codes according to guided descriptors as per follow.

Absent or very weak-1, Weak-3, Medium-5, Strong-7 and Very strong-9.

2.10.14 Spikelet: Pubescence of lemma and palea

Data was collected after anthesis to hard dough stage or pre-ripening stage on spikelet with a pubescence of lemma and palea and the rice genotypes were classified into five groups with codes according to guided descriptors as per follow.

Absent or very weak-1, Weak-3, Medium-5, Strong-7 and Very strong-9.

2.10.15 Spikelet: Color of the tip of lemma

Data was collected after anthesis to hard dough stage or pre-ripening stage on spikelet with the color of the tip of the lemma and the rice genotypes were classified into six groups with codes according to guided descriptors as per follow.

White-1, Yellowish-2, Brownish-3, Red-4, Purple-5 and Black-6.

2.10.16 Spikelet: Awns in the spikelet

It was observed at flowering to maturity stage and normally a character of wild species of rice and grouped as per descriptors.

Absent-0 and Present-1.

2.10.17 Spikelet: Length of the longest awn

It was observed at maturity stage and normally a character of wild species of rice and grouped as per descriptors.

Very short (<2 mm)-1, Short (2-5 mm)-3, Medium (5-10 mm)-5, Long (11-20 mm)-7 and Very long (>20 mm)-9.

2.10.18 Panicle: Distribution of awns

It was observed at flowering to maturity stage and normally a character of wild species of rice and grouped as per descriptors.

Tip only-1, Upper half only-3 and Whole length-5.

2.10.19 Panicle: Color of awns

It was observed at flowering to maturity stage and normally a character of wild species of rice and grouped as per descriptors.

Yellow white-1, Brown-3, Reddish-5, Purple-7 and Black-9.

2.10.20 Decorticated grain (bran): Color

Data was collected at the time of harvest and the rice genotypes were classified into seven groups with codes according to guided descriptors as per follows.

White-1, Light brown-2, Variegated brown-3, Dark brown-4, Red-5 Variegated purple-6 and Purple-7.

2.10.21 Polished grain: Size of white core or chalkiness (% of kernel area)

Data was collected at the time of harvest and the rice genotypes were classified into four groups with codes according to guided descriptors as per follows.

Absent or very small-1, Small (<10%)-3, Medium (11-20%)-5 and Large (11-20%)-7.

2.10.22 Decorticated grain: Aroma

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.

Absent-1, Lightly present-5 and Strongly present-9.

2.10.23 Time of heading (50% of the plants with heads)

Date on which 50% of panicle emergence is done of the rice fields known as a heading. It is specified either as the number of days from seed sowing date to 50% heading date. On the basis of the time of 50% heading, rice genotypes were classified into 5 groups viz. very early (<70 days), early (70-85 days), medium (86-105 days), late (106-120 days) and very late (>120 days).

2.11 Statistical Application

The qualitative and quantitative data in relation to morphological traits are just 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 Microsoft Excel 2016 program.

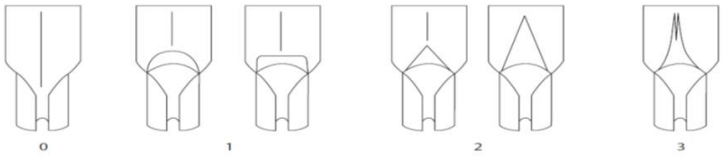

Fig. 2. Ligule shape

3. RESULTS AND DISCUSSION

3.1 Leaf Sheath: Anthocyanin Color

No coloration was found in this investigation. A pictorial view of leaf sheath anthocyanin color is present in plate 1.

Plate 1. Leaf sheath anthocyanin color

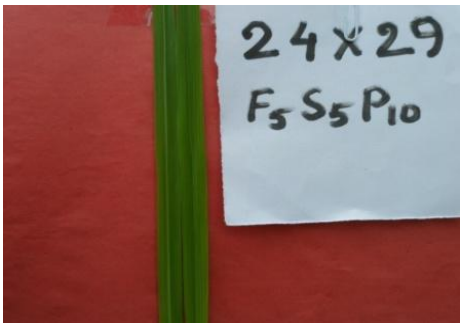

Plate 2. Pale green color leaf

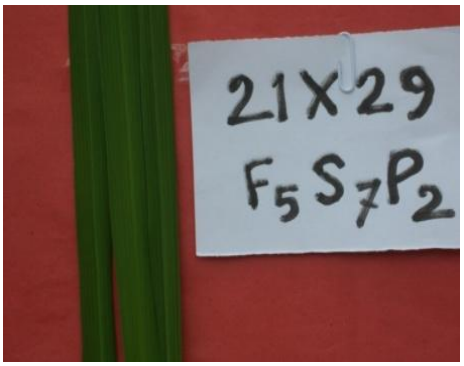

Plate 3. Green color leaf

3.2 Leaf Color

Among the genotypes, 2 genotypes (G9, and G13) showed pale green color, 15 genotypes (G1, G2, G4, G6, G7, G10, G11, G12, G14, G15, G16, G17, G18, G19 and G21) showed green color and rest 4 genotypes (G3, G5, G8 and G20) showed dark green color on leaf. Purple tip, purple margins, purple blotch and purple-green type leaf were not found in any genotypes. A pictorial view of leaf color is present in plate 2, 3 and 4.

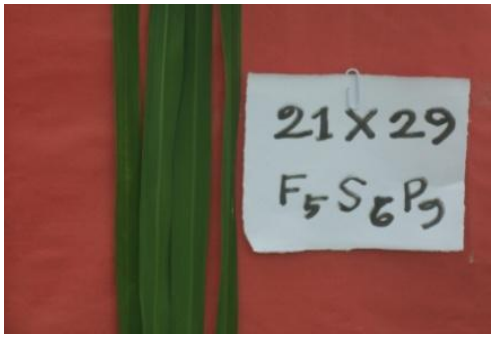

Plate 4. Dark green color leaf

3.3 Penultimate Leaf Pubescence

Nineteen genotypes (G1, G2, G3, G4, G5, G6, G7, G9, G10, G12, G13, G14, G15, G16, G17, G18, G19, G20 and G21) were strong hairs on the leaf blade type and 2 genotypes (G8 and G11) were very strong type. Absent or very weak, weak or only on the margins and medium hairs on the medium portion of the leaf were not found in any genotypes.

3.4 Penultimate Leaf: Anthocyanin Coloration of Auricles and Collar

Only one genotype (G16) absence penultimate leaf anthocyanin coloration of auricles and collar and twenty genotypes (G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G17, G18, G19, G20 and G21) presence penultimate leaf anthocyanin coloration of auricles and collar. A pictorial view of anthocyanin coloration of auricles and color of the penultimate leaf is present in plate 5.

Plate 5. Anthocyanin coloration of auricle and collar

3.5 Penultimate Leaf: Ligule

All genotypes (G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G19, G20 and G21) presence ligule of the penultimate leaf.

3.6 Penultimate Leaf: Shape of the Ligule

But our 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 two-cleft type that means there was no significant difference among the genotypes. According to IRRI most of the cultivated rice have two-cleft type ligule shape and wild type genotypes may show others type. From our observation, the two-cleft type ligule was found. A pictorial view of the shape of the ligule of the penultimate leaf is present in Plate 6.

Plate 6. Split or two-cleft type of ligule

3.7 Lemma and Palea: Anthocyanin Color

Lemma and palea combinedly indicate the seed coat color. 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 observed no anthocyanin coloration of lemma and palea or very weak anthocyanin coloration of lemma and palea for seed coat color.

3.8 Lemma: Anthocyanin Coloration of Area below Apex

Lemma indicates the seed coat color. 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 observed no anthocyanin coloration of area below apex of lemma or very weak anthocyanin coloration of area below apex of lemma for seed coat color.

3.9 Lemma: Anthocyanin Coloration of Apex

Lemma indicates the seed coat color. 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 observed no anthocyanin coloration of apex of lemma or very weak anthocyanin coloration of apex of lemma for seed coat color.

3.10 Color of Stigma

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 observed the white color of stigma. Light green, yellow, light purple and purple color of stigma were not observed.

3.11 Stem: Anthocyanin Coloration of Nodes

In this case 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 observed no anthocyanin coloration of nodes. A pictorial view of anthocyanin coloration of nodes is present in plate 7.

Plate 7. Anthocyanin coloration of nodes

3.12 Stem: Intensity of Anthocyanin Coloration of Nodes

In this case there was no anthocyanin coloration of nodes on the stem present in all the genotypes (G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G19, G20 and G21). So, the intensity of anthocyanin coloration of nodes on the stem of all genotypes was not present.

3.13 Stem: Anthocyanin Coloration of Internodes

In this case, 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 observed no anthocyanin coloration of internodes. A pictorial view of anthocyanin coloration of internodes is present in plate 8.

Plate 8. Anthocyanin coloration of internodes

3.14 Spikelet: Pubescence of Lemma and Palea

In this case all genotypes (G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G20 and G21) were observed medium type pubescence of lemma and palea of the spikelet without only one genotype (G19) which was strong type.

3.15 Spikelet: Color of the Tip of Lemma

In this case, two genotypes (G3 and G20) were observed white color type, 13 genotypes (G1, G2, G4, G5, G7, G8, G9, G11, G12, G14, G15, G17 and G18) were observed yellowish color type and 6 genotypes (G6, G10, G13, G16, G19 and G21) were observed brownish color type of the tip of lemma. Red, purple and black coloration of the tip of lemma was not observed.

3.16 Spikelet: Awns in the Spikelet

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 not observed awns in the spikelet.

3.17 Spikelet: Length of the Longest Awn

In this case, there were no awns in the spikelet present in all the genotypes (G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G19, G20 and G21). So, the length of the longest awn in the spikelet of all genotypes was not present.

3.18 Panicle: Distribution of Awns

In this case, there were no awns in the spikelet present in all the genotypes (G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G19, G20 and G21). So, the distribution of awns in the panicle of all genotypes was not present.

3.19 Panicle: Color of Awns

In this case, there were no awns in the spikelet present in all the genotypes (G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G19, G20 and G21). So, the color of awns in the panicle of all genotypes was not present.

Plate 9. White colored decorticated grain

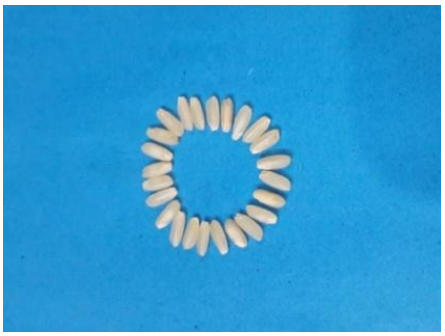

Plate 10. Light brown colored decorticated grain

3.20 Decorticated Grain (bran): Color

Where 10 genotypes (G3, G4, G7, G8, G9, G13, G17, G19, G20 and G21) showed white colored decorticated grain (bran) and rest 11 genotypes (G1, G2, G5, G6, G10, G11, G12, G14, G15,

G16 and G18) showed light brown decorticated grain (bran) color. Variegated brown, dark brown, red, variegated purple and purple decorticated grain (bran) coloration were not found among the genotypes**.** A pictorial view of decorticated grain (bran) color is present in plate 9 and 10.

3.21 Polished Grain: Size of White Core or Chalkiness (% of Kernel Area)

Where 19 genotypes (G1, G2, G3, G4, G5, G6, G8, G9, G10, G11, G12, G13, G14, G16, G17, G18, G19, G20 and G21) showed absent or very small size of white core or chalkiness (% of kernel area) of polished grain and rest 2 genotypes (G7 and G15) showed small size of white core or chalkiness (% of kernel area) of polished grain. The medium and large small size of white core or chalkiness (% of kernel area) of polished grain were not found among the genotypes.

Table 5. Mean of time of heading of twenty-one genotypes

Genotype	TH (Days)
G1	73.33
G2	73.33
G3	73.33
G4	73.33
G5	93.33
G6	73.33
G7	73.33
G8	71.66
G9	71.67
G10	76.67
G11	75.00
G12	70.67
G13	96.67
G14	75.00
G15	96.67
G16	70.67
G17	93.33
G18	75.33
G19	87.00
G20	80.00
G21	76.00
Mean	78.56
Maximum	96.67
Minimum	70.67

3.22 Decorticated Grain: Aroma

In this case, 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 observed no aroma present in the decorticated grain.

3.23 Time of Heading (50% of the Plants with Heads

Time of 50% heading of the observed genotypes ranged from 97 days to 71 days with a mean value of 79 days (Table 5). Sixteen genotypes (G1, G2, G3, G4, G6, G7, G8, G9, G10, G11, G12, G14, G16, G18, G20 and G21) showed early, five genotypes (G5, G13, G15, G17 and G19) showed medium but no genotypes were found as very early, late and very late type for 50% heading formation. A pictorial view of the time of heading (50% of the plants with heads) is present in plate 11.

Plate 11. Time of heading (50% of plants with heads)

4. CONCLUSION

Based on agro-morphological characteristics developed by Biodiversity International, IRRI and WARDA-2007 for DUS test of inbred rice, the rice germplasms were classified. All the genotypes were grouped and classified as well as described based on morphological characters as per descriptors so that all the observed genotypes containing described characters can be easily evaluated and identified at a glance for further studies as a part of variety release.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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: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 Chopra VL and Prekash S. Enfield NH, USA: Science Publishers Inc. 2003;295. Experimental Agriculture. Cambridge University Press (CUP). 2003;40(1):141–142. Available:http://dx.doi.org/10.1017/s00144 79703281527
6. FAO (Food and Agricultural Organization). Statistical database; 2016. Available:https://www.fao.org/economic/R MM
7. USDA (United States Department of Agriculture). Statistical database; 2016. Available:https://www.worldriceproduction. 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:http://dx.doi.org/10.9734/ijpss/20 18/46554
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 VG, Sukhatme PV. Statistical Methods for Agricultural Workers, Rev Edn. ICAR, New Delhi; 1995.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/48775