Distinctness of 45 irrigated rice (*Oryza sativa* L.) landraces of Bangladesh through agro-morphological traits

N Akter[1*] MZ Islam[1] A Bhuiya[1] MA Siddique[2] and M Khalequzzaman[3]

Present address
[1]Scientific Officer [2]Senior Scientific Officer [3]Chief Scientific Officer, Genetic Resources and Seed Division, Bangladesh Rice Research Institute, Gazipur, Bangladesh

Correspondence*
nadia.akter21@yahoo.com

Accepted: 31 July, 2017

Abstract

The agro-morphological characterization of crop plant is fundamental in order to provide information for breeding programs. The aim of the present study was to characterize 45 landraces of irrigated rice (*Oryza sativa* L.), based on qualitative and quantitative agro-morphological descriptors in Boro, 2015-16. All the landraces were appeared morphologically distinct from others due to anthocyanin colouration of leaf sheath, presence of awn, lemma palea colour, seed colour and stigma colour. Among 45 distinct varieties 5 were distinctly different from others by four traits, 22 by three traits, 13 by two traits and 5 varieties by only single trait. This grouping was done to assess the quality traits of distinctness as major concern and was non-influenced by the environment. After this study some genotypes were found like Asami boro, Gagli boro, Boro, Soto habji, Jagli, Bhawaila dhan, Kali boro, Rushian jira those could be used for future breeding program. Evaluation of agro-morphological traits demonstrated that the rice landraces under the present study possessed a high genetic diversity.

Keywords: **Rice (*Oryza sativa* L.), Distinctness, Morphological traits**

Introduction

The staple food grain of Bangladesh, Rice, *Oryza sativa* (2n = 24) belongs to the family *Gramineae*. Rice is considered as a major crop in Bangladesh as it constitutes 90.56% of the total food grain (rice, wheat & maize) production (Anonymous, 2015). There is wide genetic variability, leaving a wide scope for future crop improvement (Chakravarthi and Naravaneni, 2006). With the increasing number of rice varieties, it has become more difficult to distinguish them on the basis of morphological and biochemical traits, mostly due to genotype-environment interaction. Distinctness is the unique character for identity and protection of any developed variety. Depending on this uniqueness, plant breeding research aimed at developing new varieties for increased crop production. Without a good method for maintaining genetic purity of such varieties, there is the danger of losing varieties' identity. The advent of plant variety protection lends urgency to the search for solutions to the conservation of plant genetic diversity. Varieties that originated in farmer's fields may be legally protected, as many of those materials have been approved in Bangladesh and elsewhere by the regulating agencies in association with the institutional breeders for protection. So, it is very much clear that characterization of Bangladeshi rice germplasm is an urgent and crucial issue considering patenting and protecting of intellectual property rights (IPRs). In this aspect, current study is emphasizing on conservation and sustainable use of landraces considering their potential. Another work on the rice variety identification through distinct qualitative and quantitative traits is part of the morphological and molecular characterization of plant varieties in Bangladesh (Rahman *et al*., 2007; 2008) where descriptors have widely been used. The aims of this study were: (i) to identify agro morphological traits to prove the distinctness of the landraces, (ii) to select suitable genotypes for breeding programme.

Materials and Methods

Plant Materials

The experiment was conducted at the farm of Bangladesh Rice Research Institute (BRRI), Gazipur in Boro, 2015-16. A total of 45 landraces were used in the experiment (Table 1). Forty five rice landraces collected from the genebank of Bangladesh Rice Research Institute (BRRI), Gazipur were grown under irrigated condition (Boro) in 2015-16 for studying morphological traits.

Rice Cultivation

Forty-day-old seedlings from each entry were

transplanted using single seedling per hill in 2.4 m^2 plot following 25 cm and 20 cm space between rows and plants, respectively. Fertilizers were applied @ 80-60-40-10 kg NPKS per hectare. All the fertilizers except N were applied at final land preparation. Nitrogen was applied in three equal splits, at 15 days after transplanting (DAT), at 35 DAT and just before flowering. Intercultural operations and pest control measures were done as and when necessary.

Methods of Data Collection

Twenty eight qualitative traits were scored based on "Germplasm Descriptors and Evaluation Form" developed by BRRI (2008). The traits were: Blade pubescence (late vegetative stage), Blade colour (late vegetative stage), Leaf sheath: anthocyanin colour (early to late vegetative stage), Basal leaf sheath colour (early to late vegetative stage), Leaf angle (prior to heading), Flag leaf angle (after heading), Ligule colour (late vegetative stage), Ligule shape (late vegetative stage), Collar colour (late vegetative stage), Auricle colour (late vegetative stage), Culm anthocyanin colouration of nodes (after flowering), Culm angle (after flowering), Internode colour (after flowering), Culm strength (after flowering to maturity), Panicle type (near maturity), Secondary branching (near maturity), Panicle exertion (near maturity), Shattering, Spikelet : awns in the spikelet (flowering to maturity), Spikelet : length of the longest awn (flowering to maturity), Distribution of awing (flowering to maturity), Awn colour (at maturity), Apiculus colour (at maturity), Stigma colour (at maturity), Lemma and palea colour (at maturity), Lemma and palea pubescence (flowering to maturity), Seed coat (bran) colour (at maturity), Leaf senescence (at maturity), Decorticated grain scent (aroma) at maturity. A few quantitative traits were studied using Plant height (cm), Days to flowering, Days to maturity, Panicle length (cm), Effective tiller, Length-breadth ratio and 1000 grain weight (g). The approved crop descriptor as given in the Volume 1 of Plant varieties of Bangladesh (Rahman *et al.*, 2007; 2008) were used for documentation of these varieties. Ten plants from each landrace were randomly selected for recording data. Recommended Breeder's descriptors codes were used for the assessment of anthocyanin colour characteristics.

Harvesting

The 45 rice landraces were harvested at different times due to their requirement of different days to reach maturity.

Data analysis

Mean, Standard deviation and Co-efficient of variation were analyzed using a total of eight parameters: Plant height (cm), Days to 50% flowering, Days to maturity, Panicle length (cm), Effective tiller, Length-breadth ratio,1000 grain weight (g) and yield (g/hill).Statistical analyses were carried out using Microsoft Excel 2010.

Results and Discussion

The quantitative results (Table 1) clearly indicate high level of variation. One of the major traits, the days to 50% flowering is considered as the types are Boro. But other consideration is important that the rice varieties selected over long years but grown under same management conditions in a single season will in fact give the expression of that trait as compared to others. This is the case where distinctness is more important.

In the present study, 45 landraces were morphologically characterized. The important traits for distinctness were anthocyanin colouration of leaf sheath, presence of awn , lemma palea colour, seed colour and stigma colour. The study includes group-wise distinction as well as overall pooled (45 landraces) distinctness of the concerned varieties of Boro season (Table 2)

Considering variation among 45 landraces, only Gagli boro was distinct from all others on the basis of four traits viz. leaf sheath anthocyanin colouration, presence of awn, stigma colour and lemma palea colour. Four varieties; Rata boro, Gocha dhan, Rushian jira and Sada boro were distinct from others on the basis of presence of awn, stigma colour, lemma palea colour and seed coat colour.

Ten varieties namely, Chini kuri, Gatu, Chini sail, Soto habji, Black vojon, Khanni dhan Abdul hai, Begun bichi, Ayla binni and Subal lata were identified by stigma colour, lemma palea colour and seed coat colour. Three varieties, Bashful, Boro habji and Jagli were distinct by presence of awn, stigma colour and lemma palea colour. On the basis of leaf sheath anthocyanin colouration,

Distinctness based on quantitative traits of groups

Table 1. Mean values of different morphological traits of 45 rice landraces

Sl.	Variety	Acc. No.	DF	DM	PL (cm)	Effective tiller	PH (cm)	Grain LB ratio and grain type	TGW (g)	Yield (g/hill)
01	Gagli boro	NC	117	147	22	15	115	2.72(MS)	24	13.5
02	Kabar balam	NC	124	156	25.2	10	112.8	3.64(S)	26.8	20.75
03	Chini kuri	NC	127	156	25.2	10	133.2	2.08(M)	17.2	12.91
04	Unknown	NC	127	156	25.6	14	116.2	3.24(S)	17.7	17.02
05	Rata boro	NC	127	156	29.2	16	131.6	2.49(M)	22.5	14.48
06	Gatu	NC	134	160	25.4	8	105.8	2.99(MS)	19.6	21.37
07	Gocha dhan	NC	134	160	30.2	9	121	2.19(M)	30.1	11.51
08	Gochi	NC	124	153	23.6	14	102.8	2.50(M)	26.8	18.1
09	Chini sail	NC	127	154	24.8	20	109	2.41(M)	16.5	13.03
10	Parbat jira	NC	127	154	28.2	7	124.4	2.11(M)	12.8	12.17
11	Bashful	NC	127	156	30.4	11	138.4	2.29(M)	23.3	14.02
12	Boro	NC	117	147	22.4	17	124	2.56(MS)	27.9	11.05
13	Boro habji	NC	124	153	26.8	11	128.6	2.50(M)	24.9	17.74
14	Soto habji	NC	117	147	23.8	6	77.6	3.51(S)	33.4	12.56
15	Bairage sail	NC	126	153	24.2	11	118.2	2.51(M)	26.7	21.66
16	Jagli	NC	120	147	22	19	110.2	2.68(MS)	27.9	18.34
17	Bhawaila dhan	NC	120	147	24.2	18	127.2	2.71(MS)	29.8	22.89
18	Kali boro	NC	120	147	25.4	20	134.4	2.74(MS)	30.6	15.03
19	Rushian jira	NC	121	147	24.8	12	88.2	4.52(S)	23.8	10.07
20	Lati boro	NC	123	153	28.6	15	120	2.41(M)	31.1	17.61
21	Khato vojon	7656	149	176	26.6	24	96	2.68(MS)	31.1	21.28
22	Kali boro	7657	144	172	26	16	124	2.28(M)	28.4	17.64
23	Lal vojon	7658	127	153	25.2	19	118.8	3.02(S)	21.4	23.46
24	Black vojon	7659	136	164	26.6	9	98	2.47(M)	27.34	15.82
25	Sada vojon	7660	131	161	26	15	72.8	2.47(M)	25.2	18.49
26	Khanni dhan	7661	133	160	29	8	113.2	2.26(M)	13.8	9.05
27	Abdul hai	7662	148	174	30.6	9	144.2	2.61(MS)	25.43	22.31
28	Kalo boro	7663	132	156	22.4	15	121	2.74(MS)	29.5	14.57
29	Begun bichi	7664	141	161	28.4	11	137	1.88(B)	13.5	18.51
30	Ayna sail	7665	144	170	30.2	10	111.6	3.74(S)	23.9	15.66
31	Ayla binni	7666	127	161	27.2	10	88.8	2.64(MS)	27.5	20.95
32	Asami boro	7667	129	153	24	16	119.2	2.79(MS)	28.74	23.87
33	Pabda for	7668	130	156	18	36	105.8	2.93(MS)	30.2	10.46
34	Amania	7669	134	164	23.6	17	134.8	2.87(MS)	22.3	15.87
35	Lakhain	7670	134	156	29	16	144.2	2.63(MS)	29.1	23.04
36	Khaiya boro	7671	124	153	24.4	13	125.4	2.71(MS)	24.6	14.76

Table 1. Mean values of different morphological traits of 45 rice landraces (Cont.....)

Sl.	Variety	Acc. No.	DF	DM	PL (cm)	Effective tiller	PH (cm)	Grain LB ratio and grain type	1000g wt(g)	Yield (g/hill)
37	Kali boro	7672	126	153	21.2	18	113.4	2.47(M)	30.9	13.19
38	Kalo boro	7673	131	153	22.8	14	112	2.78(MS)	29.4	13.77
39	Dholi boro	7674	136	164	28.6	13	133	2.76(MS)	23.6	13.8
40	Lafaia	7675	131	161	26	16	122.4	3.66(S)	17.3	15.5
41	Rata	7676	133	156	25.2	12	132	2.80(MS)	22.8	12.86
42	Kakhai beruin	7677	148	176	25	8	116	2.58(M)	33.1	11.87
43	Kala irri	7678	122	153	21.6	7	118.8	2.58(M)	33.1	13.88
44	Sada boro	7679	135	164	30	11	134	3.64(S)	25.1	22.16
45	Subal lata	7680	127	156	23.6	9	85.8	3.60(S)	18.9	17.25
	Range		117-149	147-176	18-30.6	6-36	72.8-144.2	1.88-4.52	12.8-33.4	9.05-23.87
	Mean		129.67	157.22	25.63	13.67	116.91	2.76	25.10	16.35
	StDev		8.20	7.65	2.85	5.36	16.73	0.52	5.43	4.06
	CV		6.33	4.87	11.13	39.22	14.31	18.66	21.63	24.84
	SE		1.22	1.14	0.43	0.80	2.49	0.08	0.81	0.61
	LSD		2.40	2.24	0.83	1.57	4.89	0.15	1.59	1.19

NC=New Collection, DF =Days to 50% flowering, DM =Days to maturity, PL=Panicle length, PH=Plant height, StDev=Standard deviation, SE=Standard error

presence of awn , stigma colour , five varieties, Boro, Bhawaila dhan, Khaiya boro ,Kalo boro and Rata were distinct. One variety Bairage sail was identified by the presence of awn, stigma colour and seed coat colour. According to the presence of leaf sheath anthocyanin colouration, lemma palea colour and seed coat colour , two varieties, Ayna sail and Dholi boro were distinct. Another variety, Asami boro was distinct depending on leaf sheath anthocyanin colouration, presence of awn and lemma palea colour.

Internode colour (IC) often shows variation on colour tonality depending on the age of the plants and the soil fertility conditions. Plants usually present a dark green tonality on high soil fertility and a light green one on low soil fertility (Fonseca *et al*., 2002). Veasey *et al*. (2008) reported variation within and among populations of *O. glumaepatula* for stigma colour, with three populations 100 % white, four populations 100 % purple, and the others with varying degrees for each color, while white was the only colour found on the other South American wild rice species (*O. latifolia*, *O. grandiglumis* and *O. alta*).

Three varieties, Kabar balam, Khato vojon and Kali boro were identified by the stigma colour and lemma palea colour . Based on presence of awn and stigma colour, Unknown and Gochi were found distinct. Four varieties , Parbat jira, Lati boro, Lakhain and Lafaia were distinct based on stigma colour and seed coat colour .According to the presence of of leaf sheath anthocyanin colouration and awn ,four varieties ,namely, Kali boro, Lal vojon ,Kalo boro and Kala irri were identified as distinct. In relation to distribution of awn per panicle (PDAP,) while the awn is present its length should be influenced by the soil fertilization and plant density (Fonseca *et al*., 2002). Studies conducted by Bisne and Sarawgi (2008) to characterize 32 aromatic rice accessions of Badshah Bhog group, Raipur, Chhattisgarh, germplasm found the highest variation among accessions for the traits leaf blade colour, lemma and palea colour, apiculus colour, and lemma and palea pubescence. So, after considering the above discussion it can be concluded here that, the qualiitative characters among the genotypes showed different types of variation.

Table 2. Qualitative characters of the landraces with % variation of different traits

Characters	Classification	No. of variety	% of Total	Genotype (As its serial number from list of the landraces used, Table 1)
Leaf sheath: anthocyanin colour	01. Absent	32	71.11%	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 19, 20, 21, 22, 24, 25, 26, 27, 29, 31, 33, 34, 35, 37, 40, 42, 44, 45,
	09. Present	13	28.89%	1, 12, 17, 18, 23, 28, 30, 32, 36, 38, 39, 41, 43,
Flag leaf angle	01. Erect(<30^0)	26	57.78%	1, 2, 4, 6, 7, 8, 9, 13, 14, 16, 18, 19, 20, 21, 22, 24, 27, 30, 34, 35, 36, 37, 40, 41, 44, 45,
	03.Semi erect (<30-45^0)	07	15.55%	5, 12, 17, 28, 31, 39, 42,
	05.Horizontal (<46-90^0)	09	20%	3, 10, 11, 15, 23, 26, 29, 32, 43,
	07.Descending (>90^0)	03	6.67%	25, 33, 38,
Culm strength (lodging resistance)	01. Strong	18	40%	6, 7, 10, 14, 19, 20, 21, 22, 24, 25, 28, 29, 30, 31, 37, 42, 44, 45,
	03.Moderately strong	13	28.85%	3, 4, 8, 9, 15, 23, 26, 27, 34, 35, 39, 40, 41,
	05. Intermediate	05	11.11%	11, 12, 13, 36, 38,
	07.Weak	05	11.11%	1, 2, 5, 32, 33,
	09.Very weak	04	8.89%	16, 17, 18, 43,
Shattering	01. Very low	06	13.34%	4, 5,12 ,14, 32, 36,
	03.Low	28	62.22%	1, 2, 3, 6, 7, 8, 9, 10, 11, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 31, 33, 34, 35, 39, 40, 41, 42, 45,
	05.Moderate	01	2.22%	30,
	09. High	10	22.22%	24, 25, 26, 27, 28, 29, 37, 38, 43, 44,
Spikelet: awns in the spikelet	01. Absent	22	48.89%	2, 3, 6, 9, 10, 14, 20, 21, 22, 24, 25, 26, 27,29, 30,31,34, 35, 39, 40, 42, 45,
	09.Present	23	51.11%	1, 4, 5, 7, 8, 11, 12, 13, 15, 16, 17, 18, 19, 23, 28, 32, 33, 36, 37, 38, 41, 43, 44
Lemma and palea colour	0. Straw	24	53.33%	1, 2, 3, 5, 6, 7, 9, 11,1 3, 14, 16, 19, 21, 22, 24, 26, 27, 29, 30, 31, 32, 39, 44, 45,
	01. Gold	14	31.11%	4, 8, 10, 12, 15, 17, 20, 25, 33, 34, 35, 36, 40, 41,
	03.Brown furrows on straw	02	4.45%	18, 38,
	09.Black	05	11.11%	23, 28, 37, 42, 43,
Seed coat (bran) colour	01.White	21	46.67%	3, 5, 6, 7, 9, 10, 14, 15, 19, 20, 24, 26, 27, 29, 30, 31, 35, 39,40, 44, 45,
	02.Light brown	05	11.11%	8, 11, 17, 23, 37,
	03.Speckled brown	01	2.22%	25,
	04.Brown	11	24.44%	16, 18, 21, 22, 28, 32, 33, 38, 41, 42, 43,
	05.Red	07	15.56%	1, 2, 4, 12, 13, 34, 36,
Decorticated grain: Scent (aroma)	0. Non scented	37	82.22%	1, 2, 4, 6, 7, 9, 11, 12, 13, 14, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 37, 38, 39, 40, 41, 42, 43, 45,
	01.Lightly scented	06	13.33%	3, 8, 10, 15, 36, 44,
	02.Scented	02	4.45%	5, 20,

Overall Distinctness based on qualitative traits

Irrespective of groups of rice landraces 45 varieties appeared to be distinct morphologically due to anthocyanin colouration of leaf sheath, presence of awn, lemma palea colour, seed colour and stigma colour. Among 45 distinct varieties 5 varieties were distinctly different from others by four traits, 22 by three traits, 13 by two traits and 5 varieties by only single trait (Table 3). More than 8000 rice germplasm have been registered till date in BRRI genebank (BRRI Annual Report, 2015-16). Among this huge collection of germplasms, there are huge variation of yield and yield contributing traits. Even among the varieties of same growing season, variation can be observed. This variation will help to select varieties as prospective parents for future breeding programme. Here, the variation of plant height of Sada vhojon and Lakhain is almost twice. Length-breadth ratio of the highest and lowest range is very important to consider.

Table 3. Distinctness of 45 rice landraces based on qualitative traits

Class	landraces	Distinction in respect of traits	No. of landraces
Distinction of landraces through four traits	Gagli boro	Leaf sheath anthocyanin colouration, presence of awn, stigma colour and lemma palea colour	1
	Rata boro, Gocha dhan, Rushian jira, Sada boro	Presence of awn, stigma colour, lemma palea colour and seed coat colour	4
Distinction of landraces through three traits	Chini kuri, Gatu, Chini sail, Soto habji, Black vojon, Khanni dhan, Abdul hai, Begun bichi, Ayla binni, Subal lata	Stigma colour, lemma palea colour and seed coat colour	10
	Bashful, Boro habji, Jagli	Presence of awn, stigma colour and lemma palea colour	3
	Boro, Bhawaila dhan, Khaiya boro, Kalo boro, Rata	Leaf sheath anthocyanin colouration, presence of awn and stigma colour	5
	Bairage sail	Presence of awn, stigma colour and seed coat colour	1
	Ayna sail, Dholi boro	Leaf sheath anthocyanin colouration, lemma palea colour and seed coat colour	2
	Asami boro	Leaf sheath anthocyanin colouration, presence of awn and lemma palea colour	1
Distinction of landraces through two traits	Kabar balam, Khato vojon, Kali boro	Stigma colour and lemma palea colour	3
	Unknown, Gochi	Presence of awn and stigma colour	2
	Parbat jira, Lati boro, Lakhain, Lafaia	Stigma colour and seed coat colour	4
	Kali boro, Lal vojon, Kalo boro, Kala irri	Leaf sheath anthocyanin colouration and presence of awn	4
Distinction of landraces through single trait	Pabda for, Kali boro	Presence of awn	2
	Amania, Sada vojon, Kakhai beruin	Stigma colour	3
Total			45

Table 4. Variation ranges for important characters among the landraces

Character	Minimum	Maximum	Mean
Plant height(cm)	72.8 (Sada vhojon)	144.2(Lakhain)	116.91
LB ratio	1.88(Begun bichi)	4.52(Rushian jira)	2.76
Days to maturity	147 days(Gagli boro,Boro,Soto habji,Jagli, Bhawaila dhan, Kali boro,Rushian jira)	174 days(Kakhai beruin)	157.22
Effective tiller	6(Soto habji)	36(Pabda for)	13.67
1000 gwt(g)	12.8(Parbat jira)	33.4(Soto habji)	25.10
Yield(g/hill)	9.05(Khanni dhan)	23.87(Asami boro)	16.35

Again, in case of growth duration huge variation found. Short durated variety development is one of the essential criteria for developing new variety. Short durated parent could be selected among Gagli boro, Boro, Soto habji, Jagli, Bhawaila dhan, Kali boro, Rushian jira .

Number of effective tiller hill^{-1} showed positive significant association with number of filled grains panicle^{-1} and yield plant^{-1} (Sarker *et al*., 2014). Pabdafor exhibited the potential in that response. Moreover, Soto habji produced the maximum amount of thousand grain weight. Highest yield was found in Asami boro, while Khanni dhan produced minimum yield per hill (Table.4). Therefore, these special characteristics made the landraces distinct.

Based on the study results, a number of superior agro-morphological traits can be selected from this landraces i.e. flag leaf angle, plant height and maturity, number of effective tillers, panicle length, grain size and shape, 1000 grain weight and grain yield per hill. Flag leaf angle is an important trait as it determines the efficiency of photosynthesis, and hence the grain filling and grain yield (Rabara *et al*., 2014). Plant height and maturity are two important traits in crop improvement where shorter plant and shorter duration are mostly preferred by plant breeders. Number of effective tiller, number of grain per panicle and panicle length had been reported to be positively correlated with grain yield (Ahmad *et al*., 2015).

Conclusion

Based on the results of the present study, it can be concluded as follows: (i) Boro rice landraces collected from different district of Bangladesh showed a high diversity in both qualitative and quantitative agro-morphological traits. (ii) Observed variability in qualitative data were mostly explained by flag leaf angle, culm strength, lemma- palea color, seed coat colour and awning while that in quantitative data were mostly explained by plant height, effective tiller , flowering date and harvesting date.

References

Ahmad F, Hanafi M M, Hakim A H, RafiMY, Arolu I W and Abdulla S N A. 2015. Genetic divergence and heritability of 42 coloured upland rice genotypes (*Oryza sativa*) as revealed by microsatellites marker and agro-morphological traits. PLoS One 10 (9): e0138246. DOI:10.1371/journal.

Anonymous.2015. Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Ministry of Planning, Govt. of Bangladesh. p.49,92.

Bisne R and Sarawgi A K. 2008. Agro-morphological and quality characterization of Badshah Bhog group from aromatic rice germplasm of Chhattisgarh. Bangladesh Journal of Agricultural Research 33: 479-492.

BRRI (Bangladesh Rice Research Institute). 2008. Germplasm Descriptor and Evaluation Form. BRRI, Gazipur, Bangladesh.

BRRI (Bangladesh Rice Research Institute). 2015-16. BRRI Annual Report.

Chakravarthi K B and Naravaneni R. 2006. SSR marker based DNA fingerprinting and diversity study in rice (*Oryza sativa*. L).*African J. Biotec.* 5 (9): 684-688.

Fonseca J R, Cutrim V A and Rangel P H N. 2002. Morpho-Agronomic Descriptors and Phenology of the Lowland Rice Cultivars. Embrapa, Brasília, DF, Brazil (in Portuguese).

Rahman L, Molla M R, Sultana S, Islam M N, Ahmed N U, Rahman M S and Nazim-ud-

Dowla M. 2007. PLANT VARIETIES OF BANGLADESH: Morphological and Molecular Characterization. Published by Seed Wing, Ministry of Agriculture, Government of the Peoples' Republic of Bangladesh, Vol. 1, pp.486.

Rabara R C, Ferrer M C, Diaz C L, Newingham MaCV and Romero G O. 2014. Phenotypic diversity of farmers' traditional rice arieties in the Philippines. Agronomy 4: 217-241.

Rahman L, Islam M N, Rahman M S, Islam M S, Shah-E-Alam M, Hassan L and Bashar M K. 2008 PLANT VARIETIES OF BANGLADESH: Morphological and Molecular Characterization. Published by Seed Wing, Ministry of Agriculture, Government of the Peoples' Republic of Bangladesh, Vol. 2, 300 p. [ISBN: 984-300-001120-8].

Sarker M M, Hassan L, Islam M M, Rashid M M and Seraj S . 2014. Correlation and Path Coefficient Analysis of Some Exotic Early Maturing Rice (*Oryza sativa* L.) Lines. J. of Biosci. and Agri. Res (JBAR) 01(01):01-07.

Veasey E A, Silva E F, Schammass E A ,Oliveira G C X and Ando A. 2008.Morphoagronomic genetic diversity in American wild rice. Brazilian Archives of Biology Technology 51: 99-108.