International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 7, No. 3, p. 25-37, 2015

INNSPUB

RESEARCH PAPER OPEN ACCESS

Morpho-physicochemical characterization of Kartiksail rice(*Oryza sativa* L.) land races of Bangladesh

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Article published on September 09, 2015

Key words: Morpho-physicochemical characters, Rice, Kartiksail, Bangladesh

Abstract

Twenty one land races of Kartiksail rice of Bangladesh were studied at Bangladesh Rice Research Institute during T. Aman2011. The analysis of variance of 37 morpho-physicochemical characters showed highly significant differences among the land races. The mean performances showed that wide range of variations among the genotypes was existed and there was no duplicate genotype. The seedling height varied from 53.24 (KS15) to 82.93 cm (KS1), culm height from 80.80 (KS15) to 117.0 cm (KS6), straw yield per hill from 12.34 (KS3) to 34.39 g (KS14), panicle length from 19.81 (KS13) to 27.04 cm (KS5), secondary branch number from 15.67 (KS13) to 49.0 (KS5), grain length from 44 (KS16) to 10.6 mm (KS19), 1000-grain weight from 16.52 g (KS16) to 30.06 g (KS13), protein content from 6.6% (KS10) to 10% (KS20), grain yield per panicle 1.58 (KS15) to 3.82 g (KS1) and grain yield per hill from 16.83 (KS17) to 29.84 g (KS19), respectively. Besides, high GCV and h^2_b together with high GAPM were observed in secondary branch number, LB ratio, seedling height, 1000-grain weight, protein content etc. suggested that selection may be effective for these characters in segregating generations. The correlation between different characters indicated that the higher the PBN, APBL, SBN and SBFGW possessed greater PL and PGY and these characters emerged as most important associates of grain yield in rice. Finally, the identified traditional rice germplasmof the present study can offer a valuable gene reservoir which needs to be characterized as well as mapping the QTL using molecular tools for validating useful genes.

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Introduction

Rice (*Oryza sativa* L.) is the staple food for nearly half of the global population especially in Asia, Africa and Latin America (Maclean *et al.*, 2002; FAO, 2004). Bangladesh is self-sufficient for rice production. But, the increased demand for rice will have to meet in the context of limiting rice land and irrigation water resourcesand changing climate of the country. Therefore, diverse genes governingbiotic and abiotic stresses, medicinal and nutritional values and quality traits having indigenous or traditional valuesneed to be included in future rice varieties.

The characterization of accessions allows quantification and structuring of the genetic variability and its conservation, preservation and utilization for crop improvement programs (Chiorato*et al.*, 2006). Exploring diversity in a landrace collection is very important for identifying new genes and further improvement of the germplasm (Thomson *et al.*, 2007).Rice germplasm shows not only the genetic diversity but also represents a wealth of valuable genes. However, land races of rice played a very important role in the local food security and sustainable development of agriculture, in addition to their significance as genetic resource for rice genetic improvement (Tang *et al.*, 2002).But, presently rice land races is replacing by the extensive cultivation of Modem varieties (MVs) in all over Bangladesh along with various intervention of rice habitat (Ahmed, 2010).

Again, a total of 12,487 names of rice germplasm were listed season and Thana wise with duplications. It was then identified that duplicate(s) named rice germplasm were in all over the country and many rice germplasm have different names in different regions (Hamid *et al.*, 1982). Similarly, Kisandu and Mghogho (2004) studied 275 accessions from all rice growing regions of the southern highlands of Tanzania, and reported that a large number of similar names were existed for rice cultivars. So, similar named rice germplasm need to be characterized for their effective conservation and utilization in Genebank. Singh *et al.* (1991) stated that the genetic diversity of a collection can be reflected perfectly, only if, various kinds of traits have been evaluated compositively. The present study was, therefore, undertaken to assess the variability and genetic parameters of 21Kartiksaillandraces havingduplicate or similar namesof rice in Bangladesh for identifying duplicate as well as potential genotypes through morph-physicochemical characters.

Materials and methods

*Experimental site and materials*The field experiment was conducted at the research plots of Bangladesh Rice Research Institute (BRRI), Gazipurduring T. Aman2011 season and the physico-chemical properties were estimated in the laboratory of Grain Quality and Nutrition Division (GQND)of the same in 2011.A total of 21 *Kartiksail* landracesthat collected from Genebank, BRRI, Gazipurwere used in the experiment (Table 1).

Experimental design

The thirty days old single seedling was transplanted per hill for each genotype in Randomized Complete Block Design (RCBD) with three replications using spaces within and between rows of 20 and 25 cm, respectively. The unit plot for each genotype had 4 rows each 2.7 m long. The chemical fertilizer dose of 60-50-40-10 kg NPKS per hectare was applied in the form of Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP) and Gypsum (Anonymous, 2014). Thorough hand weeding was done each time before the top dressing of urea. The experimental plots were irrigated properly following alternate wet and drying (AWD) method. Perching were also used as biological control against rice stem borer and leaf roller.

Data recording

Nine plants from each entry were randomly selected for recording data regarding seedling height, penultimate leaf length and width, flag leaf length and width, culm height, culm diameter, plant height, panicle exertion, effective tiller number per hill, straw yield per hill, days to maturity, panicle length, grain yield per panicle, grain yield per hill, harvest index, biological yield, primary branch number, average primary branch length, filled grain number per primary branch, primary branch filled grain weight, secondary branch number, average secondary branch length, filled grain number per secondary branch, secondary branch filled grain weight, grain length, LB ratio, awn length and 1000-grain weight. Besides, milling outturn, head rice outturn, cooking time, imbibition ratio, amylose and protein content were estimated according to the laboratory manual, GQND, BRRI.

Data analysis

The data of the morpho-physicochemical characters were statistically analyzed by computer using Mstat-C software. For each character, the mean, range and standard deviation were calculated and ANOVA (Analysis of Variance) was performed. The mean values were separated by Duncan's Multiple Range Test (DMRT) as suggested by Steel and Torrie (1960). The error MS was considered as error variance (σ^2e). The genotypic variance (σ^2g), phenotypic variance (σ^2p) and heritability (h^2_b %) in broad sense were estimated as suggested by Johnson *et al.* (1955), while the genotypic coefficient of variation (GCV %) and phenotypic coefficient of variation (PCV %) by the formula suggested by Burton (1952). Moreover, the genetic advance (GA) was estimated by the formula suggested by Lush (1949) and Johnson *et al.* (1955), the genetic advance in percent mean (GAPM) by Comstock and Robinson (1952) and the simple correlation coefficients by Beale (1969).

Results and discussion

Analysis of variance of morpho-physicochemical characters: The analysis of variance of studied morpho-physicochemical charactersshowed very highly significant differences (P<0.001) among the 21 land races of Kartiksail except grain yield per panicle, grain yield per hill and filled grain number per secondary branch which showed highly significant differences (P<0.01), secondary branch filled grain weight and imbibitions ratio which showed significant differences (P<0.05)indicating the existence of wide range of genetic variations among the genotypes. Previously, Chakravorty*et al.* (2013) evaluatedrice landraces of West Bengal on agro-morphological traits and found highly significant differences for all the characters under study except culm diameter. Dhananjaya*et al.* (1998) by studying genetic variability of 121 elite homozygous rice, observed maximum variations for productive tillers per plant, number of fertile spikelets and grain yield per plant among the studied traits.Whereas, Fukuoka *et al.* (2006) observed flag leaf width, culm diameter and the length width ratio of the grain as non-significant traits in aromatic rice landraces.Therefore, means of 37 morpho-physicochemical characters need to be separated to identify the potential genotypes of the land races.

Extent of variability of Kartiksail land races: The mean performance results of 21 land racesof Kartiksail for 37morpho-physiochemical characters showed wide range of genetic variations, where no duplicate was found(Table 3, 4, 5 and 6). The seedling height had the mean value of 63.14 cm with a wide range from 53.24 (KS15) to 82.93 cm (KS1). Similarly, penultimate leaf length with a mean value of 42.76 cm, varied from 35.98 (KS13) to 49.59 cm (KS5), penultimate leaf area with a mean value of 31.35 cm², varied from 23 (KS2) to 43.55 cm² (KS5), flag leaf area with a mean value of 25.87 cm², varied from 19.9 (KS12) to 36.15 cm² (KS5), culm height with mean 96.39 cm varied from 80.80 (KS15) to 117.0 cm (KS6), respectively. Again, plant height with mean 119.46 cm varied from 101.2 (KS15) to 138.7 cm (KS6), effective tiller number per hill with mean 11.80 varied from 10.7 (KS5) to 14 (KS21), straw yield per hill withmean 20.76g varied from 12.34 (KS3) to 34.39g (KS14), days to maturity with mean 142.2 varied from 129.7 (KS11) to 151.7 (KS14), respectively. On the other hand, panicle length with a mean value of 23.07 cm varied from 19.81 (KS13) to 27.04cm (KS5), grain yield per panicle with 2.77 g varied from 1.58 (KS15) to 3.82 g (KS1), grain yield per hill with 22.15 g varied from 16.83 (KS17) to 29.84 g (KS19), harvest index with 45.30% varied from 28.64 (KS1) to 56.62% (KS9) and biological yield with 45.30 g varied from 25.32 (KS15) to 54.74 g (KS14), respectively. Besides, primary branch number with mean 9.80

varied from 6.67 (KS13 and KS16) to 12 (KS21), average primary branch length with mean 10.50 cm varied from 8.60 (KS15) to 12.76cm (KS5), secondary branch number with mean 28.97 varied from 15.67 (KS13) to49.0 (KS5) and average secondary branch length with mean 24.22mm varied from 20.35 (KS6) to 26.59 mm (KS10), respectively. Last but not the least, grain length having a mean value of 8.40 mm, showed a wide range of variation from 6.44 (KS16) to 10.6 mm (KS19), 1000-grain weight with mean 22.87g varied from 16.52 g (KS16) to 30.06 g (KS13), milling outturn with mean 68.36%, varied from 63 (KS8) to 74% (KS16), head rice outturn with mean 77.95% varied from 12 (KS13) to 95% (KS6), amylose content with mean 25.49% varied from 21.81 (KS1) to 27.7% (KS13) and protein content with mean 7.90% varied from 6.6% (KS10) to 10% (KS20), respectively. Therefore, it can be said that wide range of variationswere existed among the land races for different morpho-physicochemical characters.

Table 1. Alphabetical list of the 21 Kartiksail land races of rice.

Common/ Local name	Code name	Accession* number	Place of collection		Date of collection	Growing season
			Thana	District		
Kartik Sail	KS1	3243	Balaganj	Sylhet	18/03/86	T. Aman
Kartik Sail	KS2	776	Raojan	Chittagong	14/01/74	,,
KatihShail	KS3	438	Natore	Rajshahi	12.01.74	,,
Kartik Sail	KS4	539	Panchabibe	Rangpur	18.04.74	,,
Kartik Sail	KS5	77	Lohajanj	Dhaka	18/07/74	,,
Kati Shail	KS6	170	Kotowali	Tangail	08.02.74	B. Aman
Kartik Sail	KS7	3662	Sherpur	Sherpur	27/10/86	T. Aman
Kati Shail	KS8	3631	Siagra	Rajshahi	25.10.86	,,
Kartika	KS9	4053	Jaimlapur	Sylhet	Nov.,1988	,,
Kartik Sail	KS10	4881	Haluaghat	Tangail	Nov.,1997	,,
Kartik Sail	KS11	76	ManikGonj	Dhaka	18/07/74	,,
Kati Shail	KS12	437	Natore	Rajshahi	10.01.74	,,
Kartik Sail	KS13	78	Lohajanj	Dhaka	02.02.74	,,
Kartik Sail	KS14	1882	Hossainpur	Kishorgonj	21.01.76	,,
Kartik Sail (2)	KS15	689	B.Baria	Comilla	21/03/73	,,
Kartik Sail (2)	KS16	846	Kawaighat	Sylhet	17/12/73	,,
Kartik Sail	KS17	664	Faridganj	Comilla	24/11/74	,,
Kartik Sail	KS18	1887	Nandail	Kishorgonj	05/02/76	,,
Kartik Sail	KS19	844	Ch. Ghat	Sylhet	15/12/73	,,
KatihShail	KS20	994	Phultala	Khulna	13.12.73	,,
Kartik Sail	KS21	845	Biswanalh	Sylhet	02/12/73	,,

* = BRRI Rice Genebank accession number.

Earlier, Parikh *et al.* (2012) characterized 71 aromatic rice germplasm and found the highest plant height, panicle length, hundred seed weight and head rice recovery as 146.05 cm, 26.9 cm, 2.99 g and 73.7%, respectively by evaluating 22 morphological and agronomical traits. Chakravorty*et al.* (2013) observed the highest leaf length as 61.0 cm, leaf breadth as 2.20 cm, plant height as 43.0 cm, days to maturity as 172 days, panicle length as 30.50 cm, primary branch per panicle as 16, grain length as 11.2 mm, 1000-grain weight as 29.91 g and grain per panicle as 334 etc. in 51 rice land races of West Bengal. Thus, the identified potential rice germplasm can be utilized in developing varieties for maintaining rice diversity as well as its sustainable production. Again, Biswas *et al.* (1992) evaluated 34 modern and local rice varieties for physico-chemical properties and found the highest grain length and L/B ratio as 6.9 mm and 3.6, respectively. Begum *et al.* (2001) studied on some Iranian and BRRI rice varieties and found the highest grain length as 7.83 and 6.82 mm, L/B ratio as 4.1 and 3.61 and 1000-grain weight as 28.32 and 27.02 g, respectively. Similarly, Biswas *et al.* (1992) by evaluating 34 modern and local rice varieties for physico-chemical properties and found the highest milling outturn as 72%, head rice outturn as 98%, amylose as 27% and protein content as10.5%, respectively. Biswas *et al.* (2000) by evaluating 18 aromatic and seven Balam rice for physico-chemical properties and found the highest milling outturn as 72 and 71%, head rice outturn as 98 and 95%, amylose as 27.4 and 27.9% and protein content as 10.5 and 9.7%, respectively.As a result, there are ample of scope to utilize the identified potential genotypes for the improvement of modern T. Aman rice varieties in different physico-chemical characters. The mean separations of 21 Kartiksail land racesshowed highly significant differences among the genotypes (Table 3, 4, 5 and 6).

Table 2. Mean sum of square (MSS) of 37 morpho-physicochemical characters of 21 kartiksail land races of rice.

Characters	Replication	Variety	Error
Seedling, leaf and culm characters			
Seedling height (cm)	12.37	216.51***	2.50
Penultimate leaf length (cm)	21.15	43.05***	12.40
Penultimate leaf width (mm)	0.70	5.60***	1.68
Penultimate leaf area (cm^2)	12.70	95.19***	32.19
Flag leaf length (cm)	9.73	16.03***	4.63
Flag leaf width (mm)	1.31	6.14***	1.86
Flag leaf area (cm^2)	26.55	50.01***	15.08
Culm height (cm)	79.86	228.63***	29.78
Culm diameter (mm)	0.13	0.68***	0.19
Morpho-physiological characters			
Plant height (cm)	75.47	268.51***	31.05
Panicle exertion (cm)	0.00	0.11***	0.02
Effective tiller number per hill	29.15	2.97***	3.18
Straw yield per hill (g)	35.52	87.00***	21.38
Days to maturity	2.33	12.71***	0.00
Panicle length (cm)	0.07	13.39***	0.84
Grain yield per panicle (g)	0.15	1.48**	0.53
Grain yield per hill (g)	271.11	32.42**	11.81
Harvest index (HI)(%)	20.01	116.44***	31.14
Biological yield (BY)(g)	45.75	166.40***	35.90
Primary and secondary branch characters			
Primary branch number	0.42	7.70***	0.90
Av. primary branch length (cm)	0.19	3.46***	0.38
Filled grain number per primary branch	0.23	0.36***	0.10
Primary branch filled grain weight (g)	0.00	0.31***	0.05
Secondary branch number	0.56	204.16***	20.47
Av. secondary branch length (mm)	1.98	15.49***	2.74
Filled grain number per secondary branch	0.07	0.40**	0.17
Secondary branch filled grain weight (g)	0.13	0.80*	0.48
Grain characters			
Grain length (mm)	0.00	1.66***	0.03
LB ratio	0.01	0.60***	0.01
Awn length (mm)	3.09	175.36***	2.10
1000-grain weight (g)	0.34	37.09***	1.08
Milling outturn (%)	1.64	14.73***	2.30
Head rice outturn (%)	5.50	1574.99***	3.21
Cooking time (min)	17.82	11.51***	0.18
Imbibition ratio	0.09	0.11*	0.05
Amylose content (%)	0.02	7.02***	0.09
Protein content (%)	0.01	2.99***	0.09

*, ** and *** = significant at 5%, 1% and 0.1% level of probability, respectively.

It was evident that no single duplicate genotype was found among the 21 Kartiksail land races having duplicate or similar names.But identical or similar genotypes were observed for individual characters among the genotypes. For example, the genotype KS9, KS11, KS17, KS18, KS19 and KS20 were found statistically similar for seedling height. Again, the genotype KS1, KS2, KS3, KS4, KS7, KS8, KS11, KS12, KS13, KS15, KS16 and KS20 were statistically identical for penultimate leaf length.

Table 3. Mean performance of seedling, leaf and culm characters of 21 Kartiksail landraces of rice.

Genotypes	Seedling height (cm)	Penultimate leaf length (cm)	Penultimate leaf width (mm)	Penultimate leaf area (cm^2)	Flag leaf length (cm)	Flag leaf width (mm)	Flag leaf area (cm^2)	Culm height (cm)	Culm diameter (mm)
KS1	82.93a	38.78de	9.06c-g	26.41c-f	*24.98f*	11.10d-g	20.89ef	98.43c-h	4.67d-g
KS2	56.18l	36.43e	8.50d-g	*23.0f*	25.45ef	10.67e-g	20.24f	94.67e-i	4.92c-g
KS3	59.91jk	42.79a-e	10.30a-f	33.52a-f	29.20b-f	12.77a-f	28.41b-e	87.93h-j	4.84c-g
KS4	62.93g-i	40.28c-e	8.53d-g	25.78d-f	28.55b-f	10.53e-g	22.57d-f	90.20e-j	4.55e-g
KS5	68.85b-d	49.59a	11.70ab	43.55a	34.67a	13.90ab	36.15a	109.5ab	5.97a
KS6	70.24bc	43.64a-d	10.73a-e	35.08a-e	28.11b-f	13.0a-f	27.37b-f	117.0a	5.24a-e
KS7	62.24h-j	42.32b-e	9.30b-g	29.62b-f	28.68b-f	11.50b-g	24.78b-f	97.87d-i	4.68d-g
KS8	68.02c-e	42.84a-e	11.40a-c	36.67a-d	28.97b-f	13.83a-c	30.09a-d	108.4a-c	5.35a-e
KS9	63.63f-h	44.25a-d	11.13a-c	36.95a-d	30.22b-d	13.47a-d	30.58a-c	100.7b-e	5.48a-d
KS10	57.74kl	43.53a-d	8.87c-g	28.94b-f	29.50b-e	11.07d-g	24.52b-f	88.53g-j	4.60e-g
KS11	66.29d-f	40.38c-e	11.27a-c	34.12a-f	25.92ef	13.83a-c	26.88b-f	98.70c-g	5.64a-c
KS12	60.27i-k	39.41c-e	7.77fg	23.01f	26.54d-f	*9.97g*	19.90f	93.27e-i	4.58e-g
KS13	71.54b	*35.98e*	11.03a-d	30.10b-f	25.87ef	13.03a-e	25.39b-f	88.13g-j	4.88c-g
KS14	68.85b-d	46.10a-c	9.90a-g	34.18a-f	29.45b-e	12.40a-g	27.40b-f	100.7b-e	5.24a-e
KS15	*53.24m*	40.61c-e	*7.70g*	23.53f	29.29b-e	10.03g	22.07ef	80.80j	4.38fg
KS16	58.38kl	40.67c-e	8.27e-g	25.34ef	27.0c-f6	10.33fg	20.97ef	90.87e-j	4.25g
KS17	65.35e-g	48.52ab	10.13a-g	37.12a-c	31.63ab	11.90b-g	28.26b-e	107.9a-d	5.58a-c
KS18	63.49f-h	46.06a-c	9.83b-g	34.03a-f	29.58b-e	12.03b-g	26.71b-f	99.70b-f	5.34a-e
KS19	65.99d-f	48.07ab	9.03c-g	32.61a-f	31.53ab	11.20c-g	26.49b-f	97.50e-i	5.48a-d
KS20	63.49f-h	40.56c-e	8.97c-g	27.47c-f	27.58b-f	11.23b-g	23.41c-f	89.87f-j	5.11b-f
KS21	62.29h-j	48.06ab	8.20e-g	29.57b-f	31.14a-c	10.47e-g	24.51b-f	92.40e-i	5.07b-g
BR23	37.22n	41.94b-e	12.40a	39.14ab	28.79b-f	14.73a	31.61ab	87.43ij	5.80ab
mean	63.14	42.76	9.73	31.35	28.76	11.95	25.87	96.39	5.07

In column, means followed by a common small letter are not statistically different at the 5% level by DMRT.

Table 4. Mean performance of morpho-physiological characters of 21 Kartiksail landraces of rice.

Genotypes	Plant height (cm)	Panicle exertion (cm)	Effective tiller number per hill	Straw yield per hill (g)	Days to Maturity	Panicle length (cm)	Grain yield per panicle (g)	Grain yield per hill (g)	Harvest Index (HI)	Biological yield (BY)
KS1	119.2c-g	0.68a-d	11.0	31.64ab	138.7f-h	20.79g-i	3.62ab	20.07c-e	28.64g	44.32a-d
KS2	117.8c-h	0.76a-c	11.3	20.38c-f	142.7de	23.12d-f	3.02a-f	22.56b-e	47.57a-f	38.84b-e
KS3	108.6g-i	0.36e-g	12.7	12.34f	140.7ef	20.69g-i	1.62fg	22.20b-e	51.87a-c	25.65fg
KS4	113.3d-h	0.38e-g	12.7	16.48c-f	140.7ef	23.14d-f	2.18b-g	20.76c-e	52.54ab	34.71c-g
KS5	136.5a	0.72a-c	10.7	18.82c-f	139.7fg	27.04a	3.37a-d	19.77c-e	39.32ef	30.81e-g
KS6	138.7a	0.62a-e	11.3	23.96b-d	144.7cd	21.67f-h	2.87a-g	22.76b-e	41.23c-f	40.79b-e
KS7	123.2b-d	0.58b-e	11.0	19.96c-f	142.7de	25.35bc	3.04a-f	25.01a-c	47.23a-f	37.03b-f
KS8	130.3ab	0.37e-g	11.0	18.96c-f	142.7de	21.82f-h	2.96a-g	19.89c-e	39.84d-f	31.45e-g
KS9	124.8bc	0.81ab	12.7	15.02d-f	136.7hi	24.02c-e	3.16a-e	25.46a-c	56.62a	34.68c-g
KS10	111.9e-h	0.38e-g	13.7	15.46d-f	142.7de	23.39d-f	2.67b-g	19.90c-e	47.59a-f	29.55e-g
KS11	119.6c-f	0.61a-e	11.3	18.71c-f	129.7j	20.90g-i	3.49a-c	22.41b-e	51.52a-c	38.70b-e
KS12	115.6c-h	0.54c-f	12.0	18.68c-f	138.7f-h	22.30e-g	2.11c-g	17.66de	45.35b-f	33.76d-g
KS13	107.9hi	0.60b-e	13.0	22.61c-e	134.7i	19.81i	2.27b-g	21.21b-e	41.50b-f	38.59b-e
KS14	126.2bc	0.57b-e	12.7	34.39a	151.7b	25.50a-c	2.65b-g	20.26c-e	36.97fg	54.74a
KS15	101.2i	0.17g	10.7	14.30ef	139.7fg	20.43hi	1.58g	23.76a-d	43.82b-f	25.32g
KS16	111.3f-h	0.86a	10.7	24.10b-d	137.7gh	20.42hi	1.75e-g	17.84de	39.59d-f	39.05b-e
KS17	131.0ab	0.87a	11.7	18.15c-f	149.7b	23.07d-f	3.12a-e	16.83e	47.77a-f	34.81c-g
KS18	124.7bc	0.51c-f	11.7	25.24bc	145.7c	25.04bc	2.59b-g	21.34b-e	43.30b-f	43.36b-d
KS19	122.2b-e	0.44d-f	11.3	23.30b-e	145.7c	24.69b-d	3.35a-d	29.84a	50.44a-d	47.02ab
KS20	112.6d-h	0.41d-g	10.7	16.39c-f	136.7hi	22.68ef	2.00d-g	26.01a-c	46.48a-f	30.65e-g
KS21	117.9c-h	0.29fg	14.0	24.02b-d	146.7c	25.50a-c	3.36a-d	23.93a-d	48.68a-e	46.83ab
BR23	113.5d-h	0.54c-f	12.0	23.74b-d	158.7a	26.08ab	4.23a	27.91ab	48.63a-e	46.11a-c
Mean	119.46	0.55	11.80	20.76	142.2	23.07	2.77	22.15	45.30	45.30

In column, means followed by a common small letter are not statistically different at the 5% level by DMRT.

The genotype KS1, KS2, KS3, KS4, KS6, KS7, KS8, KS11, KS12, KS13, KS16 and KS20 were statistically identical for flag leaf length. The genotype KS3, KS4, KS10, KS13, KS15, KS16 and KS20 were statistically identical for culm height. The genotype KS1, KS3, KS4, KS10, KS12, KS16, KS20 and KS21 were statistically identical for plant height. Again, the genotype KS2, KS3, KS4, KS7, KS8 and KS10 were found similar for days to maturity. Similarly, genotype KS2, KS3, KS4, KS6, KS8, KS9, KS14, KS15 and KS17 for grain length and the genotype for KS1, KS5, KS9 andKS14 1000-grain weight were found statistically similar. Finally, it was evident from the result that none of the studied land race,though has similar or duplicate name was identical to other, when concerning all the studied characters.

Table 5. Mean performance of Primary Branch (PB) and Secondary Branch (SB) characters of 21 Kartiksail landraces rice.

Genotypes	PB number	Av. PB length (cm)	Filled grain number per PB	PB filled grain weight (g)	SB number	Av. SB length (mm)	Filled grain Number per SB	SB filled grain weight (g)
KS1	9.33c-f	8.97i-k	4.86b-d	0.98e-h	22.33h-j	21.19e-g	2.35b-e	2.64a
KS2	11.33ab	9.53g-k	4.67cd	1.48a-d	33.0c-f	21.21e-g	2.33b-e	1.54a-d
KS3	9.0d-f	9.24h-k	5.08a-d	0.90g-i	21.0ij	23.30c-g	2.56a-e	0.72d
KS4	9.67b-e	10.43c-g	4.95b-d	0.95e-h	26.67f-i	26.33bc	2.76a-d	1.23b-d
KS5	11.67a	12.76a	4.46d	1.26c-h	49.0a	24.64b-d	2.14c-e	2.11a-c
KS6	11.0a-c	8.847jk	5.13a-c	1.58a-c	24.0g-j	20.35g	1.86e	1.29a-d
KS7	12.0a	10.99b-f	5.18a-c	1.34a-f	37.33bc	23.78b-e	2.16c-e	1.70a-d
KS8	9.33c-f	11.28b-d	4.61cd	1.22c-h	26.67e-i	24.31b-e	2.47b-e	1.74a-d
KS9	9.33c-f	11.21b-d	3.92e	0.92f-i	43.0ab	26.51bc	2.52b-e	2.25a-c
KS10	9.0d-f	11.18b-e	4.96b-d	1.02e-h	32.0c-g	26.59b	2.56b-e	1.65a-d
KS11	8.67ef	10.03e-i	5.06a-d	1.37a-e	27.0e-i	24.29b-e	2.85a-c	2.12a-c
KS12	7.67fg	10.79b-f	4.97b-d	0.9f-i	23.0h-j	22.65d-g	2.54b-e	1.20b-d
KS13	6.67g	9.96f-j	4.56cd	1.01e-h	15.67j	25.90b-d	3.07ab	1.27b-d
KS14	10.33a-e	11.54bc	4.84b-d	1.30b-g	28.67c-i	25.03b-d	2.42b-e	1.36a-d
KS15	9.67b-e	8.60k	4.78b-d	0.86hi	21.67h-j	20.46fg	1.99de	0.72d
KS16	6.67g	9.86f-j	4.58cd	0.52i	22.0h-j	25.13b-d	3.35a	1.24b-d
KS17	9.67b-e	10.22d-h	5.59a	1.64a-c	28.67d-i	22.85d-g	2.11c-e	1.48a-d
KS18	10.67a-d	11.33b-d	4.72b-d	1.08d-h	35.67b-d	23.56b-f	2.10c-e	1.51a-d
KS19	11.33ab	10.96b-f	5.33ab	1.71ab	30.33c-h	25.65b-d	2.07c-e	1.64a-d
KS20	8.67ef	9.93f-j	4.63cd	1.02e-h	17.67j	24.67b-d	2.70a-d	0.98cd
KS21	12.0a	11.52bc	4.96b-d	1.46a-d	35.33b-e	24.47b-d	2.78a-d	1.90a-d
BR23	12.0a	11.80ab	5.05a-d	1.75a	36.67b-d	29.97a	2.46b-e	2.49ab
Mean	9.80	10.50	4.86	1.19	28.97	24.22	2.46	1.58

In column, means followed by a common small letter are not statistically different at the 5% level by DMRT.

Table 6. Mean performance of grain characters of 21 Kartiksail landraces of rice.

Genotypes	Grain length (mm)	LB ratio	Awn length (mm)	1000-grain weight (g)	Milling outturn (%)	Head rice outturn (%)	Cooking time (min)	Elongation ratio	Amylose content (%)	Protein content (%)
KS1	8.70cd	2.99f-i	0	23.20ef	68cd	61h	19c	2.6c	21.8l	9.1cd
KS2	8.21f-i	3.17c-f	0	20.26hi	69cd	93ab	17e	2.9bc	24.5h-j	7.6e-g
KS3	8.0hi	3.05d-h	0	18.89ij	68cd	93ab	15g	2.9bc	24.0jk	8.8d
KS4	8.2f-i	3.16c-f	0	19.55h-j	70bc	95a	17e	2.9bc	24.0jk	7.7e-g
KS5	7.72j	2.41lm	0	23.77d-f	70bc	73f	19c	2.9bc	24.3ij	6.8i
KS6	7.97ij	2.66jk	20b	25.16cd	67cd	95a	18d	2.6c	24.6hi	9.7ab
KS7	8.46d-f	3.18c-f	0	21.34gh	67cd	93ab	16f	2.9bc	25.8f	8.1e
KS8	8.15g-i	2.68jk	26a	26.31bc	63e	53i	20b	2.9bc	23.5k	9.4bc
KS9	8.26f-i	2.95g-i	0	23.41d-f	68cd	77e	15g	2.9bc	26.5c-e	7.5fg
KS10	8.41e-g	3.21c-e	0	20.13hi	69cd	92a-c	16f	2.9bc	26.7b-d	6.6i
KS11	8.8c	2.83ij	0	27.56b	69cd	24j	19c	2.6c	27.6a	6.8hi
KS12	8.57c-e	3.14c-g	0	20.26hi	69cd	80d	17e	3.1ab	26.2d-f	7.6e-g
KS13	9.19b	2.9hi	19b	30.06a	66d	12k	22a	2.9bc	27.7a	7.97ef
KS14	8.23f-i	3.02e-i	0	22.55fg	70bc	93ab	19c	2.9bc	25.0gh	7.4fg
KS15	8.12g-i	3.24cd	0	18.18jk	68cd	93ab	16f	2.9bc	25.3g	7.3gh
KS16	6.44k	2.35m	0	16.52k	74a	94ab	18d	2.9bc	26.0ef	7.6e-g
KS17	8.25f-i	2.6k	0	26.55bc	66d	68g	15g	2.6c	26.9bc	8.8d
KS18	8.47d-f	3.34bc	0	20.03h-j	67d	91bc	14h	2.6c	24.9gh	6.7i
KS19	10.6a	4.49a	7c	25.02c-e	67cd	94ab	15g	3.1ab	24.3ij	6.8hi
KS20	8.3e-h	2.55kl	0	26.52bc	69cd	76ef	16f	2.9bc	26.9bc	10.0a
KS21	8.37e-g	3.28c	0	21.36gh	68cd	89c	17e	2.9bc	27.2ab	7.7e-g
BR23	9.36b	3.46b	0	26.48bc	72ab	76ef	17e	3.4a	27.0bc	7.8e-g
Mean	8.40	3.03	3.24	22.87	68.36	77.95	17.14	2.87	25.49	7.90

In column, means followed by a common small letter are not statistically different at the 5% level by DMRT.

Hossain (2008) also observed highly significant differences among the aromatic and fine grain land races of rice genotypes having duplicate names for all the studied morphological and physico-chemical characters. Nascimento*et al.* (2011) studied 146 accessions with same names of upland rice for 14 quantitative traits also found significance differences. However, Fukuoka *et al.* (2006) studied aromatic rice land races and concluded that significant variation may be found among genotypes with the same name for quantitative traits. Finally, it can be concluded that in this collection of germplasm, one can find wide range of variation and diversity and each genotype was clearly distinct from others though have similar or duplicate names.

Table 7. Genetic parameters of 37 morph-physicochemical characters of 21 Kartiksail landraces of rice.

Characters	GCV(%)	PCV(%)	H^2_b(%)	GA	GAPM(%)
Seedling, leaf and culm characters					
Seedling height (cm)	13.38	13.61	96.61	17.1	27.09
Penultimate leaf length (cm)	7.47	11.12	45.17	4.43	10.35
Penultimate leaf width (mm)	11.75	17.77	43.71	1.56	16
Penultimate leaf area (cm²)	14.62	23.26	39.48	5.93	18.92
Flag leaf length (cm)	6.78	10.09	45.11	2.7	9.38
Flag leaf width (mm)	9.99	15.16	43.46	1.62	13.57
Flag leaf area (cm²)	13.19	19.98	43.57	4.64	17.93
Culm height (cm)	8.45	10.17	69	13.93	14.45
Culm diameter (mm)	8.01	11.66	47.19	0.58	11.34
Morpho-physiological characters					
Plant height (cm)	7.45	8.79	71.82	15.53	13
Panicle exertion (cm)	31.2	40.05	60.69	0.27	50.06
Effective tiller number per hill	2.24	14.78	2.3	0.08	0.7
Straw yield per hill (g)	22.53	31.69	50.56	6.85	33
Days to maturity	1.45	1.45	99.76	4.23	2.98
Panicle length (cm)	8.87	9.72	83.33	3.85	16.68
Grain yield per panicle (g)	20.23	33.14	37.28	0.71	25.45
Grain yield per hill (g)	11.83	19.51	36.79	3.27	14.78
Harvest index (HI)(%)	11.77	17.04	47.73	7.59	16.75
Biological yield (BY)(g)	17.55	23.71	54.78	10.06	26.76
Primary and secondary branch characters					
Primary branch number	15.36	18.16	71.59	2.62	26.77
Av. primary branch length (cm)	9.65	11.31	72.83	1.78	16.97
Filled grain number per primary branch	5.98	8.88	45.26	0.4	8.28
Primary branch filled grain weight (g)	24.68	30.86	63.97	0.49	40.67
Secondary branch number	27.01	31.2	74.95	13.96	48.17
Av. secondary branch length (mm)	8.51	10.91	60.83	3.31	13.68
Filled grain number per secondary branch	11.12	20.27	30.12	0.31	12.58
Secondary branch filled grain weight (g)	20.54	48.46	17.96	0.28	17.94
Grain characters					
Grain length (mm)	8.79	8.99	95.61	1.49	17.7
LB ratio	14.64	15.04	94.7	0.89	29.34
Awn length (mm)	234.91	239.15	96.49	15.38	475.36
1000-grain weight (g)	15.15	15.81	91.78	6.84	29.9
Milling outturn (%)	2.98	3.71	64.26	3.36	4.92
Head rice outturn (%)	29.36	29.45	99.39	47.01	60.3
Cooking time (min)	11.34	11.61	95.4	3.91	22.82
Imbibition ratio	4.88	9.19	28.23	0.15	5.34
Amylose content (%)	5.96	6.08	96.29	3.07	12.05
Protein content (%)	12.43	13.01	91.29	1.93	24.47

Legend:GCV=Genotypic coefficient of variation, PCV=Phenotypic coefficient of variation, H^2_b=heritability, GA=genetic advance and GAPM=Genetic advance in percent of mean.

Statistical and genetic parameters: Heritability (h^2_b%), genetic advance and genetic advance in percent of mean (GAPM), genotypic coefficient of variation (GCV%) and phenotypic coefficient of variation (PCV%) of 21 Kartiksail landraces having duplicate or similar names are presented in Table 7. It was apparent from the table that the genotypic and phenotypic coefficient of variations were found close to each other for traits like days to maturity as 1.45 and 1.45%, head rice outturn as 29.36 and 29.45%, amylose content as 5.96 and 6.08%, grain length as 8.79 and 8.99%, seedling height as 13.38 and 13.61%, cooking time as 11.34 and 11.61% and LB ratio as 14.64 and 15.04%, respectively both of which indicated less environmental influence and additive gene action for the characters.Hossain and Haque (2003) stated that closer difference between the phenotypic and genotypic coefficients of variations indicating less environmental influences on the expression of the respective characters in rice. Ghosal*et al.* (2010) by conducting experiment on 18 advanced breeding lines for yield contributing characters during Boro season, observed the genotypic and phenotypic coefficient of variations close to each other for plant height, panicle length, 1000-grain weight, growth duration and yield, while some differences were found for effective tillers per sq. meter and spikelet sterility indicating influence of environment on the expression of these characters. Again, wide differences were observed for filled grains weight per secondary branch as 20.54% and 48.46%, followed by grain yield per panicle as 20.23 and 33.14%, effective tiller number per hill as 2.24 and 14.78%, straw yield per hill as 22.53 and 31.69%, filled grains number per secondary branch as 11.12 and 20.27%, panicle exertion 31.2 and 40.05%, penultimate leaf area as 14.62 and 23.26% and grain yield per hill as 11.83 and 19.51%, respectively. But, Higher estimates of both GCV and PCV were found for awn length (234.91 and 239.15%) followed by panicle exertion (31.2 and 40.05%), filled grains weight per secondary branch (20.54 and 48.46%), head rice outturn (29.36 and 29.45%), secondary branch number (27.01 and 31.2%), filled grain weight per primary branch (24.68 and 30.86%), straw yield per hill (22.53 and 31.69%) and grain yield per panicle (20.23 and 33.14%), respectivelywhich indicated wide degree of variability for these traits. Bisne*et al.* (2009) evaluated four CMS lines, eight testers and 32 hybrids for thirteen yield related characters and found high genotypic and phenotypic coefficient of variations for harvest index, total number of filled spikelets per panicle, 100-grain weight, and spikelet fertility percentage. Similarly, Akter*et al.* (2004) by observing the variability in rice genotypes with yield and yield contributing characters found higher genotypic coefficient of variations for flag leaf area, panicles per sq. meter, 1000-grain weight and spikelets per panicle. Thus, improvement of studied germplasm may be possible through direct selection for the characters having high GCV and PCV in segregating generations. However, very little GCV was found in days to maturity (1.45%), followed by effective tiller number per hill (2.24%), milling outturn (2.98%), imbibition ratio (4.88%), amylose content (5.96%), filled grains number per primary branch (5.98%) and flag leaf length (6.78%) indicating lack of inherent variability for these traits among the test genotypes.

Again, high h^2_b coupled with high GAPM were found for awn length (96.49 and 475.36%), followed by head rice outturn (99.39 and 60.3%), LB ratio (94.7 and 29.34%), seedling height (96.61 and 27.09%), secondary branch number (74.95 and 48.17%), 1000-grain weight (91.78 and 29.9%), cooking time (95.4 and 22.82%), panicle length (91.29 and 24.47%) and grain length (95.61 and 17.7%),respectively suggested that they were simply inherited traits governed by a few genes with additive effects. Iftekharuddaula*et al.* (2001) by studying 24 modern rice varieties of irrigated ecosystem found high heritability coupled with high genetic advance in percent of mean in plant height, 1000-grain weight, spikelets per panicle and grain yield per panicle. Ghosal*et al.* (2010) documented high h^2_b estimate with high GAPM for yield, 1000-grain weight, panicle length, spikelets sterility and plant height suggested that they were simply inherited traits governed by a few major genes or additive gene effects. Parikh *et al.* (2012) stated high heritability coupled with high genetic advance indicating preponderance of additive gene action in the expression of these characters. While high h^2_b estimates with low GAPM was found for days to maturity (99.76 and 2.98%), amylose content (96.29 and 12.05%), grain length (95.61 and 17.7%) and panicle length (83.33 and 16.68%), respectively.

Again, high GCV and h^2_b together with high GAPM were observed in awn length (234.91, 96.49 and 475.36%), head rice outturn (29.36, 99.39 and 60.3%), secondary branch number (27.01, 74.95 and 48.17%), LB ratio (14.64, 94.7 and 29.34%), seedling height (13.38, 96.61 and 27.09%), 1000-grain weight (15.15, 91.78 and 29.9%), cooking time (11.34, 95.4 and 22.82%) and protein content (12.43, 91.29 and 24.47%), respectively. Shanthakumar*et al.* (1998) found high genotypic coefficient of variability together with high heritability and genetic advance for plant height, total tillers per hill, flag leaf length panicle length, spikelet fertility, 1000-grain weight and grain yield. However, Prasad *et al.* (2001) studied eight fine rice genotypes and found that 1000-grain weight, number of effective tiller per plant, number of fertile grain per panicle and yield per plant showed high GCV and high heritability coupled with high GAPM. Therefore, selection may be effective for these characters in segregating generations.

Table 8. Estimates of simple correlation coefficients between 18 agro-morphological characters of 21 Kartiksail landraces of rice.

	PFLA	PH	ENT	DM	PL	PBN	APBL	PFGN	PFGW	SBN	ASBL	SFGN	SFGW	GL	LBR	TGW	PGY
PFLA	1																
PH	0.515***	1															
ENT	-0.011	-0.100	1														
DM	0.253*	0.222	0.127	1													
PL	0.416***	0.400***	0.087	0.562***	1												
PBN	0.191	0.345**	0.015	0.552***	0.679***	1											
APBL	0.487***	0.330**	0.075	0.339**	0.748***	0.250*	1										
PFGN	-0.004	0.057	-0.098	0.321**	0.072	0.241*	-0.022	1									
PFGW	0.283*	0.398***	0.041	0.523***	0.459***	0.646***	0.218	0.474***	1								
SBN	0.417***	0.414***	0.054	0.290*	0.766***	0.591***	0.669***	-0.105	0.286*	1							
ASBL	0.262*	-0.088	0.261*	0.226	0.364**	-0.005	0.538***	-0.126	0.053	0.221	1						
SFGN	-0.254*	-0.370**	0.243*	-0.293*	-0.263*	-0.504***	0.010	-0.194	-0.330**	-0.330**	0.491***	1					
SFGW	0.231	0.218	0.158	0.104	0.317**	0.156	0.385***	0.002	0.219	0.413***	0.281*	0.116	1				
GL	0.091	-0.031	0.075	0.207	0.205	0.248*	0.156	0.283*	0.491***	0.048	0.213	-0.202	0.165	1			
LBR	-0.099	-0.185	0.133	0.345**	0.266*	0.349**	0.129	0.264*	0.314**	0.127	0.144	-0.215	0.036	0.777***	1		
TGW	0.363**	0.290*	0.019	0.001	0.013	0.015	0.114	0.043	0.455***	-0.053	0.220	-0.019	0.219	0.489***	-0.097	1	
PGY	0.305**	0.341**	0.148	0.296*	0.448***	0.389***	0.409***	0.192	0.583***	0.459***	0.255*	-0.034	0.920***	0.333**	0.156	0.363**	1
HGY	0.093	-0.005	0.118	0.126	0.170	0.314**	0.028	-0.045	0.252*	0.207	0.210	-0.079	0.013	0.368**	0.385***	0.155	0.112

***, **, * Significant at 0.1%, 1% and 5% probability levels, respectively.

Legend: PFLA=Penultimate and flag leaf area, PH=Plant height, ENT=Effective tiller number per hill, DM=Days to Maturity, PL=Panicle length, PBN=Primary branch number, APBL=Average primary branch length, PFGN=Filled grain number per primary branch, PFGW=Primary branch filled grain weight, SBN=Secondary branch number, ASBL=Average secondary branch length, SFGN=Filled grain number per secondary branch, SFGW=Secondary branch filled grain weight, GL=Grain length, LBR=LB ratio, TGW=1000-grain weight, PGY=Grain yield per panicle, HGY=Grain yield per hill.

Correlation between different characters: Out of 34very highly significant ($P<0.001$) estimates among the total 153 correlations obtained between 18 different character pairs, 33 correlation coefficients were positive in nature and only one estimates were negative (Table 8).The simple correlation between two characters revealed that PGY had the highest very highly significant positiveassociation (0.920) with SBFGW, followed by LBRwith GL (0.777),PL with SBN (0.766),PLwith APBL (0.748), PL with PBN (0.679), APBL with SBN (0.669), PFGW with PBN (0.646)etc. Therefore, these characters emerged as most important associates of grain yield in rice. Secondly, among the 19 highly significant ($P<0.01$) estimates, 16 correlation estimates were positive in nature and 3 were negative. The HGY showed the highest highlysignificant positive association (0.3.68) with GL, followed by PL with ASBL (0.364), TGW with PFLA (0.268), PGY with TGW (0.266) etc. Besides, the SBFGN showed the highest highly significant negative association (-0.370) with PH, followed by PBFGW with SBFGN (-0.330), SBFGN with SBN (-0.330) etc. Therefore, these characters emerged as important associates of grain yield in rice.

Finally among the 21 significant (P<0.05) estimates, 18 correlation estimates were positive in nature and 3 were negative. The PGY showed the highest significant positive association (0.296) with DM, followed by SBN with DM (0.290), TGW with PH (0.290), SBN with PBFGW (0.209) etc. Besides, only SBFGN showed the highest significant negativeassociation (-0.293) with DM, followed by PL with SBFGN (-0.263), SBFGN with PFLA (-0.254) etc. The above observations of strong positive associations between yield and yield components are in agreement with the available literature in rice (Chaudhary and Motiramani, 2003; Zahid*et al.*,2006; Yadav*et al.*, 2011). Results indicated that the higher the PBN, APBL, SBN and SBFGW possessed greater PL and PGY, which appears logical. Therefore, this represents very high response for selection in improving yield and yield components in rice.

Conclusion

Highly significant differences among the land races were observed and no single duplicate was found among the genotypes having duplicate or similar names, which can otherwise offer a valuable gene reservoir. The highest potentiality (positive) were found in KS1 for seedling height, grain yield per panicle and secondary branch filled grain weight, KS5 for penultimate leaf length width and area, flag leaf length width and area, culm diameter, panicle length, average primary branch length secondary branch number, KS13 for 1000-grain weight, KS14 for straw yield per hill and biological yield, KS19 for grain yield per hill, primary branch filled grain weight, grain length, LB ratio and imbibition ratio, KS20 for protein content and KS21 for effective tiller number per hill and primary branch number, while the highest potentiality (negative) were recorded in KS11 for days to maturity and KS15 for plant height. Moreover, the correlation between different characters revealed that the higher the PBN, APBL, SBN and SBFGW possessed greater PL and PGY.Finally, molecular characterization and QTL mapping of identified genotypes needs to be done for the confirmation of validatingcandidategenes.

Acknowledgement

This study was the part of my PhD dissertation and I acknowledge the financial support and research facilities of Genetic Resources and Seed Division of Bangladesh Rice Research Institute, Gazipur, Bangladesh.

References

Ahmed MS, Khaleda A, Khalequzzaman M, Rashid ESMH, Bashar MK. 2010. Diversity analysis in Boro rice (*Oryzasativa* L.) accessions. Bangladesh Journal of Agricultural Research **35(1),** 29-36.
http://dx.doi.org/10.3329/bjar.v35i1.5864

Akter K, Iftekharuddaula KM, Bashar MK, Kabir MH, Sarker MZA. 2004. Genetic variability, correlation and path analysis in irrigated hybrid rice.Journal of Subtropical Agricultural Research and Development **2(1),** 17-23.

Anonymous. 2014. Annual research review for July 2013- June 2014. Varietal development sub-program area, Rice germplasm and seed program performing unit, Genetic Resources And Seed Division, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh.

Beale EML. 1969. Euclidean cluster analysis. A paper contributed to 37th session of the International Statistical Institute **37(3),** 324.
http://www.jstor.org/stable/1402126

Begum F, Dipti SS, Karim NH, Kabir KA. 2001. Physico-chemical characteristics of some Iranian and Bangladesh rice varieties. Bangladesh Journal of Biochemistry **7,** 11-16.

Bisne R, Sarawgi AK, Verulkar SB. 2009. Study of heritability, genetic advance and variability for yield contributing characters in rice. Bangladesh Journal of Agricultural Research **34(2),** 175-79.
http://dx.doi.org/10.3329/bjar.v34i2.5788

Biswas SK, Banu B, Kabir KA, Begum F, Choudhury NH. 1992. Physico-chemical properties of modern and local rice varieties of Bangladesh. Bangladesh Rice Journal**3,** 128-131.

Biswas SK, Kabir KA, Siddique MA, Banu B, Choudhury NH. 2000. Phsico-chemical properties of local aromatic and Balam rice varieties of Bangladesh. Annals Bangladesh Agriculture **10(1),** 93-104.

Burton GW. 1952. Quantitative inheritance in grasses. Proceedings of the Sixth International Grassland Congress **1,** 277-83.

Chakravorty A, Ghosh PD, Sahu PK. 2013. Multivariate analysis of phenotypic diversity of land races of rice of West Bengal. American Journal of Experimental Agriculture **3(1),** 110-23. http://dx.doi.org/10.9734/ajea/2013/2303

Chaudhary M, Motiramani NK. 2003. Variability and association among yield attributes and grain quality in traditional aromatic rice accessions. Crop Improvement **30(1),** 84-90.

Chiorato AF, Carbonell SAM, Dias LAS, Moura RR, Chiavegato MB, Colombo CA. 2006. Identification of common bean (*Phaseolus vulgaris*) duplicates using agro-morphological and molecular data. Genetics and Molecular Biology **29(1),** 105-111. http://dx.doi.org/10.1590/s141547572006000100020

Comstock RE, Robinson HF. 1952. Genetic parameters, their estimation and significance. Proceedings of the Sixth International Grassland Congress **1,** 284-91.

Dhananjaya MV, Rudraradhya M, Kulkarni RS, Bhushan HO. 1998. Variability and character association in elite lines of rice (*Oryza sativa* L.). Current Research University Agricultural Sciences Bangalore **27(9-10),** 166-168.

FAO. 2004. Food and Agriculture Organization of the United Nations, The state of Food and Agriculture 2003-2004. Agricultural Biotechnology:Meeting the Needs of the Poor? FAO, Rome, Italy. http://dx.doi.org/10.1111/j.0169-5150.2005.t01-7-00008.x

Fukuoka S, Suu TD, Ebanna K, Trinh LN. 2006. Diversity in phenotypic profiles in land races populations of Vietnamese rice: a case study of agronomic characters for conserving crop genetic diversity on farm. Genetic Resources and Crop Evolution **53,** 753-761. http://dx.doi.org/10.1007/s10722-004-4635-1

Ghosal S, Biswas PL, Khatun M, Khatun S. 2010. Genetic variability and character associations in irrigated rice. Bangladesh Journal of Plant Breeding and Genetics **23(2),** 23-27. http://dx.doi.org/10.3329/bjpbg.v23i2.9321

Hamid A, Nasiruddin M, Haque M, Haque E. 1982. Deshi Dhaner Jat (Local rice varieties). In: Taluckdar MHR Ed. Gazipur, Bangladesh: Bangladesh Rice Research Institute, ix-x p.

Hossain MA, Haque ME. 2003. Variability and path way analysis of rice genotypes. Bangladesh Journal of Plant Breeding and Genetics **16(1),** 33-37.

Hossain MZ. 2008. Genetic diversity study in fine grain and aromatic landraces of rice (*Oryza sativa* L.) by morpho-physico-chemical characters and micro-satellite DNA markers, PhD thesis, Department of Genetics and Plant Breeding, BSMRU, Gazipur, Bangladesh, 63-78.

Iftekharuddaula KM, Badshah MA, Hassan MS, Bashar MK, Akter K. 2001. Genetic variability, character association and path analysis in irrigated rice (*Oryza sativa* L.). Bangladesh Journal of Plant Breeding and Genetics **14,** 43-49.

Johnson HW, Robinson HF, Comstock RE. 1955. Estimates of genetic and environment variability in Soybean. Agronomy Journal **47,** 314-318.

http://dx.doi.org/10.2134/agronj1955.00021962004700070009x

Kisandu DB, Mghogho RMK. 2004. The genetic diversity of indigenous rice cultivars collected in Tanzania. Abstracts of the Conference Challenges and opportunities for sustainable rice-based production systems. 13-15 September, 2004, Torino, Italy.

Lush JL. 1949. Heritability of quantitative characters in farm animals. In: Proceedings of International Congo Genetica, Heriditas (Suppl.) **35,** 356-357. http://dx.doi.org/10.1111/j.1601-5223.1949.tb03347.x

Maclean JL, Dawe DC, Hardy B, Hettel GP. 2002. Rice Almanac: source book for the most important economic activity on Earth. 3rd Eds. Wallingford, UK: CAB International. http://dx.doi.org/10.1017/s0021859605225248

Nascimento WF, Silva EF, Veasey EA. 2011. Agro-morphological characterization of upland rice accessions. Scientia Agricola **68(6),** 652-60. http://dx.doi.org/10.1590/s01039016201100060000 8

Parikh M, Motiramani NK, Rastogi NK, Sharma B. 2012. Agro-morphological characterization and assessment of variability in aromatic rice germplasm. Bangladesh Journal of Agricultural Research **37(1),** 1-8. http://dx.doi.org/10.3329/bjar.v37i1.11168

Prasad B, Patwary AK, Biswas PS. 2001. Genetic variability and selection criteria in fine rice. Pakistan Journal of Biological Sciences **4(10),** 1188-90. http://dx.doi.org/10.3923/pjbs.2001.1188.1190

Shanthakumar G, Mahadevappa M, Rudraradhya M. 1998. Studies on genetic variability, correlation and path analysis in rice (*Oryza sativa* L.) during winter across the locations. Kamataka Journal Agricultural Sciences **11(1),** 67-72.

Singh SP, Gutierrez JA, Molina A, Urrea C, Gepts P. 1991. Genetic diversity in cultivated common bean: II. Marker-based analysis of morphological and agronomic traits. Crop Science **31,** 23-29. http://dx.doi.org/10.2135/cropsci1991.0011183x0031000010005x

Sohrabi M, Rafii MY, Hanafi MM, Akmar ASN, Latif MA. 2012. Genetic diversity of upland rice germplasm in Malaysia based on quantitative traits. The Scientific World Journal **416291,** 1-9. http://dx.doi.org/10.1100/2012/416291

Stell RGD, Torrie JH. 1960. Principles and procedures of statistics with especial reference to biological science. New York, USA: Mcgraw Hill Books Co. Inc. 187 p.

Tang SX, Jiang YZ, Wei XH, Li ZC, Yu HY. 2002. Genetic diversity of isozymes of cultivated rice in china. Acta Agronomica Sinica **28,** 203-207.

Thomson MJ, Septiningsih EM, Suwardjo F, Santoso TS, Silitonga TS, McCouch SR. 2007. Genetic diversity analysis of traditional and improved Indonesian rice (*Oryza sativa* L.) germplasm using microsatellite markers. Theoretical and Applied Genetics **114(3),** 559-568. http://dx.doi.org/10.1007/s00122-006-0457-1

Yadav SK, Pandey P, Kumar B, Suresh BG. 2011. Genetic architecture, interrelationship and selection criteria for yield improvement in rice (*Oryza sativa* L.). Pakistan Journal of Biological Sciences **14,** 540-545. http://dx.doi.org/10.3923/pjbs.2011.540.545

Zahid MA, Akhter M, Sabar M, Zaheen M, Awan T. 2006. Correlation and path analysis studies of yield and economic traits in Basmati rice (*Oryza sativa* L.). Asian Journal of Plant Sciences **5(4),** 643-645. http://dx.doi.org/10.3923/ajps.2006.643.645