Morphological Characterization and Diversity of T. Aman Rice Germplasm of Bangladesh

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ABSTRACT

Fifty-four T. Aman rice landraces were studied for 11 morphological and yield contributing characters at Bangladesh Rice Research Institute during T. Aman 2016 season. The largest variation was observed for yield per hill with 53.6% CV, followed by 1000 grain weight (29.9), number of effective tillers per hill (22.8), culm diameter (18.8), leaf width (18.4), leaf length (18.1) and days to maturity (6.7) respectively. The longest leaf was recorded as 82.2 cm and that of culm diameter as 7.57 mm, grain length as 7.2 mm and LB ratio as 3.48. The shortest days to maturity (110 days) was observed in Kajal lata and plant height (86.6 cm) in Haijam. Indursail possessed the longest panicle (31.6 cm) and the highest yield per hill (24.3 g). Based on D^2 values, all the germplasm were grouped into 15 clusters using Mahalonobis D^2 statistic. The maximum numbers of germplasm (7) were grouped into the clusters IV with VI, whereas clusters III and XIII contained the minimum (1). The highest intra-cluster distance (1.0) was found in cluster II and the lowest (0.0) in clusters III and XIII, respectively. The inter-cluster D^2 values ranged from 19.2 to 0.6 indicating wide range of diversity among the germplasm. Cluster XIII showed the highest leaf length (82.2 cm) and culm diameter (6.5 mm), cluster IX the highest effective tillers per hill (13), cluster II the lowest days to maturity (117), cluster XV the highest grain length (6.1 mm) and cluster I the highest grain LB ratio (2.97), while cluster VIII showed the highest yield per hill (22.0 g), panicle length (28.8 cm) and 1000 grain weight (25.2 g), respectively. Finally, the germplasm under clusters VIII may be selected for crossing with the germplasm from clusters XIII, IX, II, XV and I for developing high yielding varieties with improved panicle length, effective tillers per hill, growth duration and grain type.

Key word: Morphology, genetic diversity, T. Aman, germplasm, Bangladesh

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of Bangladesh, as well as the half of the world's population. Rice is also a commodity of significance and the easiest food source in Bangladesh. The availability and its price are also a major determinant of the welfare of the least food-secure segment of the country. However, with an increasing global population, the demand for rice will continue to rise, which raises challenges for the breeding of high yielding rice cultivars (Zhang *et al.*, 2013).

Rice production at farmer's level is increasing day to day in Bangladesh due to the constant development of many promising varieties for different rice ecosystems. Consequently, this bridge between technology and farmer now make Bangladesh possible to achieve the self-sufficiency in food grain production.

Genetic diversity created in the farmers' fields over millennia, complemented by the diversity present in wild relatives of crops, provides the primary material for improving crop productivity through plant breeding (Upadhyaya *et al.*, 2008). The amount of genetic enrichment is reliant on the extent of genetic diversity inherent in a population (Kumbhar *et al.*, 2015). A reduction in germplasm diversity is an obstacle to plant breeding and reduce the tendency of plants to resist unfavourable environments (Xiyong *et al.*, 2012). Landraces of rice can contain some valuable alleles not common in modern germplasm (Pervaiz *et al.*, 2010).

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Genetic variation in plant material is the base for crop improvement (Iqbal *et al.*, 2014). Any crop improvement programme depends on the utilization of germplasm. Evaluation and characterization of existing landraces of rice are important due to increasing needs of varietal improvement. The pool of genetic variation within a population is the basis for selection as well as for plant improvement. Before exploiting a population for trait improvement, it is necessary to understand the magnitude of variability in the population which is fundamental for genetic improvement in all crop species. Agro-morphological characterization of germplasm accessions is fundamental criteria in order to provide information of plants (Lin, 1991) for plant breeding programmes (Das and Ghosh, 2011). Agro-morphological traits, both qualitative and quantitative have been commonly and traditionally used to estimate relationships between genotypes (Goodman, 1972). Finally, Lahkar and Tanti (2017) studied the morphological variation of 22 aromatic rice landraces of Assam using five qualitative and seven quantitative traits and reported that in rice improvement programme characterization of landraces could help breeders to utilize appropriate characters. Though a number of transplanted Aman rice germplasm have existed in different agro-climatic conditions of Bangladesh but their characterization is not sufficient. Therefore, the objectives of the present study was to characterize using morphological traits of the local transplanted Aman rice germplasm of Bangladesh for providing useful informations in rice breeding programmes.

MATERIALS AND METHOD

Fifty-four newly collected rice landraces from BRRI Genebank were studied for genetic diversity through morphological characterization (Table 1). The experiment was conducted using a single row of 5.4 m long for each entry with a spacing of 25 × 20 cm between rows and plants respectively during T. Aman 2016 season at Genetic Resources and Seed Division, BRRI, Gazipur. The thirty-five-day-old single seedling was transplanted in randomized complete block design (RCBD) with three replications. All the fertilizers except N were applied @ 60:20:40:12 kg NPKS/ha at final land preparation. All fertilizers were applied in basal, except urea. Intercultural operations and pest control measures were taken as and when necessary.

Data were collected on leaf length (cm), leaf width (mm), culm diameter (mm), effective tillers per hill, panicle length (cm), plant height (cm), days to maturity (days), grain length (mm), grain LB ratio, 1000 grain weight (TGW) and yield per hill (g). Simple statistics (means, ranges etc.) was calculated to have an idea of the level of variation. The genetic diversity was studied following Rao (1952), which was originally developed by the generalized distance (D^2) as proposed by Mahalonobis (1936). The germplasm were grouped into clusters using canonical vector analysis. All the statistical analysis regarding diversity was carried out using the GENSTAT 5.5 software.

RESULTS AND DISCUSSION

Morphological characterization. Analysis of variance revealed that the 54 germplasm showed highly significant differences for all the 11 studied morphological characters. Table 2 presents the details of the characterization results. The largest variation was observed for yield per hill with 53.6% CV, followed by TGW (29.9), number of effective tillers per hill (22.8), culm diameter (18.8), leaf width (18.4), leaf length (18.1) and the smallest in days to maturity (6.7) respectively.

Table 1. List of rice germplasm characterized during T. Aman 2016.

Variety	Code*	Upazila	District	Variety	Code*	Upazila	District
Double rice	TA1	Kaliganj	Jhenaidah	Molla digha	TA28	Shibalaya	Manikganj
Tulshi mala	TA2	Fulpur	Mymensingh	Modhu sail	TA29	Shibalaya	Manikganj
Kajal lata	TA3	Jhikorgacha	Jashore	Indursail	TA30	Ulipur	Kurigram
Subal lata	TA4	Jhikorgacha	Jashore	Jira bhog	TA31	Vurangamari	Kurigram
Hb. Aman II (Lacki)	TA5	BRRI	Habiganj	Malshira	TA32	Vurangamari	Kurigram
Depor dhan	TA6	Nagarpur	Tangail	Khirshapal	TA33	Ulipur	Kurigram
Kalo parangi	TA7	Nagarpur	Tangail	Dudh kolom	TA34	Ulipur	Kurigram
Swarna	TA8	Nagarpur	Tangail	Narikel jhupi	TA35	Ulipur	Kurigram
Lalsaina	TA9	Nagarpur	Tangail	Urichadra	TA36	Ovainagar	Jashore
Jotalaijum	TA10	Nagarpur	Tangail	Ranga gasa	TA37	Ovainagar	Jashore
Dolni	TA11	Ghatail	Tangail	Sada gosa	TA38	Ovainagar	Jashore
Barai dhan	TA12	Ghatail	Tangail	Haringa digha	TA39	Mirzapur	Tangail
Chini sugar	TA13	Ghatail	Tangail	Bagraj	TA40	Kalihati	Tangail
Kalijira	TA14	Ghatail	Tangail	Begun bichi	TA41	Sadar	Tangail
Kiron mala	TA15	Ghatail	Tangail	Chamara (Lal)	TA42	Sadar	Tangail
Apsaya	TA16	Ghatail	Tangail	Kalijira	TA43	Sadar	Tangail
Chini kutei	TA17	Ghatail	Tangail	Patjak	TA44	Sadar	Tangail
Biropa	TA18	Sakhipur	Tangail	Nizersail	TA45	Sadar	Tangail
Gobra sail	TA19	Sakhipur	Tangail	Dulai	TA46	Sadar	Tangail
Gonokrai	TA20	Basail	Tangail	Haijam	TA47	Sadar	Tangail
Soma baila	TA21	Basail	Tangail	Digha	TA48	Sadar	Tangail
Dulai boron	TA22	Basail	Tangail	Aloi	TA49	Sadar	Tangail
Hari dhan	TA23	Basail	Tangail	Vaeulu	TA50	Nagarpur	Tangail
Kartikjul	TA24	Basail	Tangail	Heringa digha	TA51	Nagarpur	Tangail
Komkamane	TA25	Sakhipur	Tangail	Hejal digha	TA52	Nagarpur	Tangail
Ganokairot	TA26	Sakhipur	Tangail	Harharia	TA53	Nagarpur	Tangail
Bela digha	TA27	Shibalaya	Manikganj	Sada vara	TA54	Nagarpur	Tangail

*New collection.

On the other hand, 26 germplasm possessed intermediate (6-10), 27 possessed many (>10) and one had few (<6) number of effective tillers (Table 2). One germplasm was found with very long (>30 cm), 11 with long (26-30), 38 with medium (21-25) and four had short (≤20) panicle length. Three germplasm were found with short (<110 cm), 11 with moderate (110-130) and 40 with long (>130) plant height. Thirteen germplasm had short (<120 days), seven had medium (120-130) and 34 had long (>130) days to maturity. Besides, 20 germplasm were found with short (<5.6 mm), 33 with medium (5.6-6.5) and one with long (6.6-7.5) types of grain. Rice grain can also be classified as extra-long, long, medium and short (Bisne et al., 2006). Considering length-breadth ratio, 12 germplasm were found with bold (1.5-2.0), 34 with medium (2.1-2.5) and four each with medium slender (2.6-3.0) and slender (>3.0) grain. TGW of 14 germplasm was found very low (<16 g), 10 with low (16-19), 19 with medium (20-23), eight with high (24-27) and three had very high (>27). Eleven germplasm possessed low (<5 g), 26 had moderate (5-10) and 17 had higher (>10) yields per hill. Maji and Shaibu (2012) reported a wider range (70-184 cm) of variation with a mean value of 151.15 cm in plant height. Plant height in rice is a complex character and is the

end product of several genetically controlled factors called internodes (Sarawgi and Rastogi, 2000). Reduction in plant height may improve their resistance to lodging and reduce substantial yield losses associated with this trait (Pachauri *et al.*, 2017a). Pachauri *et al.* (2017b) studied 124 rice germplasm accessions on the basis of 19 morphological characters and reported that a great variability with high range (5-26) and mean of 8.20 was exhibited for number of productive tillers per plant, while high range (86-130 days) with mean of 111.33 days for days to maturity.

However, the shortest growth duration (110 days) was observed in Kajal lata and the longest (143) in Ranga and Sada gasa in the present study. The shortest plant height (86.6 cm) was observed in Haijam and the longest (168) in Gobra sail. Indursail possessed the longest panicle (31.6 cm). Malshira was found with the highest number of effective tillers (18) and Harharia with the lowest (2). The highest grain length-breadth ratio (3.48) was observed in Subal lata and the lowest (1.89) in Vaeulu and Depor dhan. Komkamane had the lowest (8 g) and the Molla digha had the highest (31.2) TGW. The highest yield per hill (24.26 g) was observed in Indursail and the lowest (2.48) in Biropa. Table 3 presents the top ranking accessions for yield ancillary traits in T. Aman 2016. Abarshahr *et al.* (2011) also found valuable and highly significant and positive variability among their studied rice genotypes. Besides, Sajid *et al*. (2015) also reported that characterization of rice germplasm through different morphological traits is an important step for assessment of its genetic potential.

Principal component analysis. The first four components in principal component analysis with eigen values >1, contributed 68.78% of the total variation among the 54

germplasm for 11 morphological characters (Table 4). Chakravorty *et al.* (2013) also observed the contribution of 75.9% of the first four components to the total variation in rice.

Cluster analysis. Based on D^2 values, the germplasm were grouped into 15 clusters using Mahalonobis D^2 statistic (Table 5). Mahalingam *et al.* (2012) also observed 13 clusters in 31 Indian and exotics germplasm lines. Maximum numbers of germplasm (7) were grouped into the clusters IV and VII, followed by 6 in clusters V and II, 5 in cluster IX. However, clusters III and XIII contained the lowest (1) number of germplasm. The result revealed that all the germplasm collected from Tangail or Kurigram district were not clubbed into the same cluster. This pattern of clustering indicated that there was no association between the geographical distribution of genotypes and genetic divergence. The similar result was also reported earlier by Chandra *et al.* (2007). Considering this, Hasan *et al.* (2000) suggested that parents should be selected on the basis of genetic diversity rather than geographic diversity.

Table 6 indicates the variations among the intra and inter cluster distances. All the inter-cluster distances were larger than the intra-cluster distance indicating the homogeneous nature of the germplasm within the cluster. The highest intra-cluster distance was recorded for cluster II (1.00), followed by cluster I (0.83) and cluster XII (0.81) indicated the high genetic diversity among the germplasm belonging to the respective cluster. The germplasm belonging to the highest intra-cluster distance (cluster II) were the most heterogeneous and might develop the highest segregants by crossing between them. Again, there were marked variations in intra-cluster

Table 2. Some important features of characterized germplasm during T. Aman 2016.

	LL		LW		CD		ETPH		PL		PH		DM		GL		LBR		TGW		YPH	
	R	NE	R	NE	R	NE	R	NE	R	NE	R	NE	R	NE	R	NE	R	NE	R	NE	R	NE
	<40	4	<10	3	<4	4	<6	1	≤20	4	<110	3	<120	13	<5.6	20	<1.5	0	<16	14	<5	11
	40-59	38	10-12	26	4-5	37	6-10	26	21-25	38	110-30	11	120-30	7	5.6-6.5	33	1.5-2.0	12	16-19	10	5-10	26
	60-79	11	13-16	21	6-7	12	>10	27	26-30	11	>130	40	>130	34	6.6-7.5	1	2.1-2.5	34	20-23	19	>10	17
	>79	1	>16	4	>7	1			>30	1					>7.5	0	2.6-3.0	4	24-27	8		
																	>3.0	4	>27	3		
	Shortest (25.2)	Double rice	Lowest (7)	Kalijira	Lowest (3.05)	kajallata	Lowest (2)	Harharia	Shortest (16)	Double rice	Shortest (86.6)	Hajjam	Shortest (110)	Kajallata	Lowest (3.68)	Chini sugar	Lowest (1.89)	Vaeulu, Depor dhan	Lowest (8.0)	Komka mane	Lowest (2.5)	Biropa
	Longest (82.2)	Sada gasa	Highest (18)	Nizersail	Highest (7.57)	Dulai	Highest (18)	Malshira	Longest (31.6)	Indursail	Longest (168)	Gobra sail	Longest (143)	Ranga and Sadagasa	Highest (7.2)	Dudh kolom	Highest (3.48)	Suballata	Highest (31.2)	Molla digha	Highest (24.3)	Indur sail
Mean	52.5		12.8		5.2		10		24.3		138.9		129		5.5		2.3		19.6		8.9	
Std. Dev.	9.5		2.4		1.0		2.4		2.7		20.0		8.6		0.7		0.4		5.8		4.8	
CV	18.1		18.4		18.8		22.8		11.3		14.4		6.7		12.2		15.4		29.9		53.6	
LSD	2.5		0.6		0.3		0.6		0.7		5.3		2.3		0.2		0.1		1.5		1.3	

LL=Leaf length (cm), LW=Leaf width (mm), CD=Culm diameter (mm), ETPH=Effective tillers per hill, PL= Panicle length (cm), PH=Plant height (cm), DM=Days to maturity (days), GL=Grain length (cm), LBR=Grain LB ratio, TGW=1000 grain weight (g), YPH= Yield per hill (g), R= Range and NE= No. of entries.

Table 3. Top ten ranking germplasm for different yield ancillary traits in T. Aman 2016.

Panicle length (cm)	Plant height (cm)	Effective tillers per hill	Time of maturity (day)	Grain length breath ratio	1000 grain weight (g)	Yield per hill (g)
Indursail (TA30)-31.6*	Hajjam (TA47)-86.6	Malshira (TA32)-18.2	Kajal lata (TA3)-110	Subal lata (TA4)-3.48	Molla digha (TA28)-31.2	Indursail (TA30)-24.3
Lalsaina (IA9)-29.4	Subal lata (IA4)-88	Khirshapal (TA33)-15.8	Subal lata (TA4)-112	Kajal lata (TA3)-3.44	Sada vara (TA54)-30.3	Kartikjul (TA24)-19.9
Kartikjul (TA24)-29.0	Kajal lata (TA3)-89.8	Dudh kolom (TA34)-15.6	Harharia (TA53)-112	Kalijira (TA43)-3.21	Modhu sail (TA29)-28.9	Gobra sail (TA19)-19.7
Dolni (TA11)-28.0	Chini kutei (TA17)-115.2	Apsaya (TA16)-14.0	Hejal digha (TA52)-117	Dudh kolom (TA34)-3.08	Kartikjul (TA24)-26.9	Narikel jhupi (TA35)-19
Barai dhan (TA12)-28.0	Hari dhan (TA23)-116.4	Jira bhog (TA31)-14.0	Depor dhan (TA6)-118	Double rice (TA1)-2.87	Patjak (TA44)-26.2	Ranga gasa (TA37)-15.7
Jira bhog (TA31)-28.0	Chini sugar (TA13)-117	Chamara (Lal) (TA42)-12.6	Kalo parangi (TA7)-118	Jotalaijum (TA10)-2.67	Ranga gasa (TA37)-26.0	Hari dhan (TA23)-15.6
Sada vara (TA54)-27.8	Dolni (TA11)-163.0	Alcii (TA49)-12.6	Biropa (TA18)-118	Ranga gasa (TA37)-2.67	Depor dhan (TA6)-25.6	Barai dhan (TA12)-14.8
Begun bichi (TA41)-27.6	Sada vara (TA54)-166.0	Lalsaina (TA9)-12.4	Dulai boron (TA22)-118	Nizcrsail (TA45)-2.62	Indursail (TA30)-25.5	Malshira (TA32)-14.2
Sada gasa (TA38)-27.2	Sada gasa (TA38)-167.8	Hb. Aman II (Lacki) (TA5)-12.2	Bela digha (TA27)-118	Barai dhan (TA12)-2.60	Gobra sail (TA19)-24.9	Molla digha (TA29)-13.9
Biropa (TA18)-26.2	Gobra sail (TA19)-168.0	Somo (TA8)-12	Molla digha (TA28)-118.0	Apsaya (TA16)-2.57	Hari dhan (TA23)-24.2	Sada gasa (TA38)-12.7

*local name (code name)-value

Table 4. Latent roots (eigen value) and their variation for 11 morphological characters of 54 T. Aman rice germplasm.

Principal Component	Latent roots	Variation accounted (%)	Cumulative Variation (%)
I	2.83	25.75	25.75
II	2.22	20.21	45.96
III	1.49	13.55	59.51
IV	1.02	9.27	68.78
V	0.91	8.27	77.05
VI	0.62	5.64	82.69
VII	0.58	5.25	87.94
VIII	0.54	4.9	92.84
IX	0.46	4.18	97.02
X	0.27	2.46	99.48
XI	0.06	0.53	100.01

Table 5. Distribution of 54 T. Aman rice germplasm into 15 clusters for 11 morphological characters.

Cluster	No. of germplasm	Code name of the germplasm
I	3	TA3, TA4, TA47
II	6	TA18, TA21, TA22, TA27, TA28, TA53
III	1	TA15
IV	7	TA2, TA12, TA14, TA16, TA31, TA41, TA43
V	6	TA6, TA20, TA24, TA42, TA45, TA54
VI	7	TA5, TA7, TA26, TA48, TA50, TA51,TA52
VII	2	TA1, TA36
VIII	2	TA19, TA30
IX	5	TA13, TA17, TA25, TA32, TA33
X	3	TA10, TA35, TA46
XI	3	TA9, TA44, TA49
XII	2	TA11, TA40
XIII	1	TA38
XIV	2	TA23, TA37
XV	4	TA8, TA29, TA34, TA39

Table 6. Average intra-(bold) and inter-cluster distances (D²) for 11 morphological characters of 54 T. Aman rice germplasm.

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
I	**0.83**														
II	9.9	**1.0**													
III	12.5	8.3	**0.0**												
IV	11.4	7.1	1.3	**0.68**											
V	14.4	5.0	7.5	6.9	**0.71**										
VI	10.7	1.0	7.9	6.7	4.0	**0.57**									
VII	7.0	4.7	6.1	4.8	7.9	5.1	**0.64**								
VIII	18.3	9.4	8.3	8.3	4.6	8.5	11.3	**0.39**							
IX	7.3	8.1	5.6	4.8	10.4	8.3	3.4	12.9	**0.74**						
X	9.8	4.3	4.2	2.9	5.5	4.0	2.8	8.6	4.9	**0.75**					
XI	13.4	5.5	4.6	4.1	2.9	4.7	6.4	4.9	8.2	3.6	**0.57**				
XII	19.1	10.4	8.7	8.9	5.5	9.4	12.1	1.0	13.6	9.3	5.7	**0.81**			
XIII	19.2	11.2	7.9	8.4	6.7	10.3	12.2	2.6	13.2	9.4	6.0	1.9	**0.0**		
XIV	7.5	4.9	5.5	4.2	7.7	5.2	0.6	11.0	3.2	2.4	6.0	11.7	11.8	**0.33**	
XV	11.7	3.4	5.5	4.5	3.1	2.7	4.9	6.7	7.4	2.5	2.1	7.5	8.0	4.7	**0.68**

distances indicating the presence of wider diversity among the germplasm of different clusters. However, the lowest intra-cluster distance were observed in clusters III and XIII as zero due to the presence of single genotype in both the clusters (TA15 and TA38 respectively), followed by cluster XIV (0.33) and cluster VIII (0.39) indicating the comparatively more homogenous in nature of the germplasm. The inter-cluster D^2 values ranged from 19.2 to 0.6 indicating wide range of diversity. The highest inter-cluster distance was observed between clusters I and XIII (19.2) suggested wide diversity between these clusters, followed by between clusters I and XII (19.1), clusters I and VIII (18.3), clusters I and V (14.4) and clusters IX and XII (13.6). The lowest inter-cluster distance was observed between clusters VII and XIV (0.60), followed by clusters VI and X (2.55) and clusters II and VI (1.0) indicating the close relationship between the germplasm of these clusters and hence, may not be emphasized upon to be crossed each other in hybridization programmes. Hossain (2008) also reported intra- and inter-cluster distances ranged from 0.0 to 1.02 and 2.21 to 21.59, respectively on aromatic and fine grain landraces of rice. However, germplasm belonging to these clusters may be further used in hybridization programme for the improvement of rice. Crosses involving parents belonging to the most divergent clusters would be expected to manifest maximum heterosis and wide variability of genetic architecture (Souroush *et al.*, 2004).

Cluster means for the characters. Cluster XIII showed the highest leaf length (82.2 cm) and culm diameter (6.5 mm), cluster IX the highest number of effective tillers per hill (13), cluster II the lowest days to maturity (117), cluster XV the highest grain length (6.1 mm) and cluster I the highest grain LB ratio (2.97) respectively, while cluster VIII showed the highest yield per hill (22.0 g), panicle length (28.8 cm) and 1000 grain weight (25.2 g) (Table 7). As a result, the germplasm under cluster VIII may be selected for crossing with the germplasm from clusters XIII, IX, II, XV and I for developing high yielding T. Aman variety along with long panicle, high effective tiller numbers per hill, short growth duration and long-slender type grain. Islam *et. al.* (2017) earlier also reported the similar trend of conclusion using Mahalanobis' D^2 statistic on rice.

Canonical variate analysis. In the present study, it also appeared from the canonical analysis that 52.51% of the total variation was accounted for canonical root 1 and 19.88% by canonical root 2 (Table 8).

Contribution of characters towards divergence. Table 9 presents the coefficients pertaining to the different characters in the first two canonical roots. The canonical variate analysis revealed that the grain LB ratio, culm diameter, effective tillers per hill, panicle length and days to maturity were positive for both the vectors (I and II) and were the most responsible for both the primary and secondary differentiations and contributed maximum to the genetic divergence. Such results indicated that these characters will offer a scope for selection of parents. Similarly, Islam *et al.* (2017) also found positive contribution of both canonical vectors for culm diameter, days to flowering, days to maturity and length-breadth ratio on Jhum rice landraces collected from Rangamati district in Bangladesh.

Table 7. Cluster means of 54 T. Aman rice germplasm for 11 morphological and yield contributing characters.

Cluster	Leaf length (cm)	Leaf width (mm)	Culm diameter (mm)	Effective tillers per hill	Panicle length (cm)	Plant height (cm)	Day to maturity	Grain length (mm)	Grain LB ratio	1000 grain weight (g)	Yield per hill (g)
I	46.8	11.7	4.2	10	23.7	88.1	119	5.9	2.97	17.3	6.4
II	47.1	13.8	5.3	8	23.7	132.7	117	5.7	2.17	22.3	6.37
III	33.0	11.0	5.1	11	24.4	154.4	139	4.1	2.10	9.5	6.3
IV	52.9	10.9	4.8	12	26.0	142.4	135	4.9	2.47	12.4	8.9
V	58.2	15.8	6.0	11	25.6	156.9	125	6.0	2.23	23.9	10.9
VI	55.9	14.9	5.2	10	21.9	135.6	121	5.6	2.14	21.3	6.33
VII	30.6	10.5	4.6	9	19.2	125.7	133	5.7	2.45	21.8	7.9
VIII	61.5	13.5	4.5	10	28.8	172.3	133	5.7	2.10	25.2	22.0
IX	44.5	11.2	5.0	13	23.6	122.6	135	4.6	2.36	11.1	8.4
X	62.3	12.7	6.2	11	23.7	130.7	133	5.8	2.40	20.7	13.0
XI	65.4	11.2	5.5	12	25.7	147.1	137	6.0	2.23	23.8	8.8
XII	49.5	11.7	5.3	11	25.3	182.9	133	5.5	2.25	16.0	6.4
XIII	82.2	11.0	6.5	8	27.2	167.8	143	5.3	2.10	22.7	12.7
XIV	47.0	12.4	4.5	10	23.0	120.7	142	5.9	2.20	25.1	15.6
XV	51.1	12.8	5.2	11	24.2	144.8	133	6.1	2.40	23.7	4.7

Table 8. Values of latent roots (canonical roots) and percentage of variation of 11 morphological characters of 54 T. Aman rice germplasm.

Canonical root	Value of the canonical root	Percentage of variation absorbed by the canonical root
1	24.54	52.51
2	9.29	19.88
3	6.35	13.59
4	3.73	7.98
5	1.22	2.60
6	0.69	1.47
7	0.37	0.79
8	0.23	0.50
9	0.17	0.35
10	0.11	0.23
11	0.04	0.09
Total		100.0

Table 9. Latent vectors for 11 morphological characters of 54 T. Aman rice germplasm.

Character	Vector I	Vector II	Combined ranking*
Leaf length (cm)	-0.0851	-0.0104	8
Leaf width (mm)	0.0851	-0.2458	9
Culm diameter (mm)	0.2782	0.4546	2
Effective tillers per hill	0.183	0.0856	3
Panicle length (cm)	0.0884	0.1272	4
Plant height (cm)	-0.1961	0.0167	10
Days to maturity	0.0138	0.1515	5
Grain length (mm)	-1.2476	-2.1051	11
Grain LB ratio	1.8633	2.9192	1
1000 grain weight (g)	0.0413	-0.0153	7
Yield per hill (g)	-0.0121	0.0787	6

*Combined ranking is estimated by summing the values of vector I and II, then higher (1) is the rank with higher positive value.

CONCLUSIONS

Since the modern variety with the narrow genetic base are vulnerable to diseases and adverse climatic changes, the genetically diverse genotypes for variety development become more important. Moreover, characterization of landraces could help to utilize appropriate characters in rice improvement programme. Indursail (TA30), Kartikjul (TA24), Kajal lata (TA3) and Subal lata (TA4) are the elite germplasm promising for one or more characters. Finally, the germplasm under clusters VIII may be selected for crossing with the germplasm from clusters XIII, IX, II, XV and I for developing high yielding variety along with long panicle, high effective tiller numbers per hill, short growth duration and long-slender type grain.

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