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ASSESSMENT OF PHENOTYPIC VARIABILITY IN RICE (*ORYZA SATIVA* L.) CULTIVARS USING MULTIVARIATE ANALYSIS

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Abstract

Sixty-eight commercial and primitive cultivars belonging to aromatic (basmati), non-aromatic (coarse) and japonica type were used during present investigation. A considerable level of polymorphism was observed among aromatic, non-aromatic and japonica cultivars for the majority of the morphological characters measured. Cluster and principal component analyses were used to classify rice cultivars on the basis of phenotypic traits. Dendrogram was generated for the Euclidean distance and phenotypically all the cultivars were classified into three major groups corresponding to the forms of indica rice cultivated in Pakistan, i.e., aromatic (Basmati) and non-aromatic (Non-basmati) with few exceptions. Clustering of the cultivars did not show any pattern of association between the morphological characters and the origin of the cultivars. Instead cultivar groups were associated with their morphological similarities and type of indica rice cultivated in various regions of Pakistan. Regardless of the limitation in estimating total genetic variation, the current study indicated that agro-morphological traits were helpful for preliminary characterization and can be used as a broad-spectrum approach to assess genetic diversity among morphologically distinguishable rice cultivars.

Introduction

Rice is one of the most important crops that provides food for about half of the world population and occupies almost one-fifth of the total land area covered under cereals (Sasaki, 1999; 2002; Vaughan *et al.*, 2003). Approximately 11% of the world's arable land is planted to rice annually, and it ranks next to wheat (Chakravarthi & Naravaneni, 2006; Bashir *et al*., 2010). Furthermore rice is also an ideal model plant for studying grass genetics and genome organization owing to its diploid genetics, comparatively small genome size 430 Mb (Causse *et al*., 1994; Kurata *et al*., 1994), considerable level of genetic polymorphism (Tanksley, 1989; Wang *et al*., 1992; McCouch *et al*., 1998), large amount of well conserved genetically diverse material, ease of use of widely collected and well-matched wild species (Pervaiz *et al*., 2010; Rabbani *et al*., 2010). Although world rice production has doubled in the past 30 years due to the introduction of superior varieties and better cultivation practices, but it is still unsatisfactory to meet ever-increasing global demands (Fischer *et al*., 2000; Sasaki & Burr, 2000). From 2001 to 2025, it is estimated that the demand for rice in the world would increase at about 1% per annum, so the present average yield has to be increased considerably in order to meet up the rising needs (Maclean *et al*., 2002).

Among Asian rice growing countries, Pakistan is a major producer of many rice varieties such as aromatic rice and old landraces. Varieties of basmati rice, sub-species of indica, are cost-effectively important due to high quality of the grain and comprise an important source of revenue. Pakistan ranks 14th in terms of rice production and 6th in rice export in the world. Rice occupies 2.96 million hectares that is 12% of the total cultivated area. Its production was 6.95 million tones and 2347kg yield per hectares (Anon., 2009). In the perspective of global biodiversity loss, Pakistan missed several rice varieties. Out of seven basmati varieties presently under cultivation, five have 'Basmati-370' as one of the parents (Pervaiz *et al*., 2010; Rabbani *et al*., 2010). Therefore, it is essential not only to conserve the landrace genotypes but also to explore the gene-pool of aromatic rice for breeding purposes of well adapted, better quality and high yielding varieties in the country (Rabbani *et al*., 2008; Pervaiz *et al*., 2009).

In favour of this reason, estimates of genetic diversity and the relationships among cultivars are very practical for facilitating the resourceful germplasm collection and management. Several tools are now on hand for studying the variability and relationships between cultivars including isozymes, storage protein study and molecular markers linked to particular traits. Moreover for the classification and estimation of the germplasm, morphological evaluation is preliminary step (Smith & Smith, 1989; Smith *et al*., 1991). The identification of genetic variability in any character concerned with yield synthesis provides scope for improvement and breeding of aromatic rice. The hereditary differentiation among the populations is also helpful for breeding new aromatic rice cultivars with desire traits. Keeping in view present study was established to estimate genetic diversity in rice cultivars using multivariate techniques on the basis of agronomic characters and to identify the best parent lines for use in future breeding programmes.

Materials and Methods

Plant material: A set of 68 commercial varieties and primitive cultivars of rice were used for evaluation under field conditions for different morphological traits from seedling up to the maturity and harvest of the crop. Traits selection and measurement techniques were based on IRRI standard evaluation system of rice. Quantitative parameters included days to 50% flowering, leaf length, leaf width, days to maturity, productive tillers per plant, plant height, panicle length, number of spikelets per panicle, seed setting (%), grain yield per plant, straw yield per plant, harvest index, 100-seed weight, paddy grain length, paddy grain breadth, grain length/breadth ratio.

Data analysis: All recorded agro-morphological traits were analyzed by numerical taxonomic techniques using two complementary procedures: cluster and principal component analyses (Sneath & Sokal, 1973). To avoid effects due to scaling differences, means of each trait were standardized prior to cluster and principal component analyses using Z-scores. Estimates of Euclidean distance coefficients were produced for all pairs of cultivars. The consequential Euclidean dissimilarity coefficient matrices were used to estimate the relationships between the cultivars with a cluster analysis using complete linkage method (NTSys, version 2.1). Principal component analysis was also performed with the same data matrix. Scatter plots of first three principal components were formed to provide a graphical representation of the pattern of variation among all the cultivars of rice. (Statistica, version 6.0).

Results

Phenotypic variation: Basic statistics for 18 quantitative traits is presented in Table 1. A reasonable amount of genetic variation was displayed for the traits evaluated. Grain length was the only character with coefficient of variance less than 10%. However the majority traits showed above 10% coefficient of variance and the highest 53.36% was recorded for the straw yield per plant. Plant height had a wide range of 74.60-179.40 cm with mean height of 124.97±26.07, and 20.86% co-efficient of variance. Maximum plant height was observed in Mahlar-346, whereas Nipponbare is a dwarf variety, having the plant height of 74.60cm. Days to heading exhibited high range (51-121 days) and coefficient of variation for this trait was 23.88%. Ranbir-basmati had the minimum value for days to heading (i.e. 51 days). Days to maturity exhibited high range (72-161 days) with a mean value of 113.24±22.9 days, and co-efficient of variance was observed as 19.50%. Analysis of sample variance and standard deviation for this trait showed that variation was highly significant so it was concluded that a lot of variation existed among the cultivars. Maximum days to maturity (161) were attained by Dehradun-Basmati, while minimum value (72 days) was shown by Sonahri-Kangni.

Table 1. Descriptive statistics for 18 quantitative agronomic traits of commercial and primitive rice cultivars.

Traits	Mean	Minimum	Maximum	Variance	SD	CV(%)	SE
Days to flowering (DF)	80.19	51.00	121.00	366.69	19.15	23.88	2.32
Days to maturity (DM)	113.24	72.00	161.00	487.76	22.09	19.50	2.68
Leaf length (LL)	36.05	18.28	56.80	51.50	7.18	19.91	0.87
Leaf width (LW)	1.52	1.08	2.04	0.06	0.24	15.60	0.03
Leaf area (LA)	41.80	21.39	75.20	130.47	11.42	27.32	1.39
Plant height (PH)	124.97	74.60	179.40	679.43	26.07	20.86	3.16
Total tillers/plant (TT/P)	13.03	6.80	27.60	13.65	3.70	28.35	0.45
Productive tillers/plant (PT/P)	12.75	6.60	27.60	12.26	3.50	27.45	0.42
Panicle length (PL)	26.31	19.54	34.00	14.06	3.75	14.25	0.45
Branches/panicle (Br/P)	11.15	5.20	17.00	5.56	2.36	21.16	0.29
Seed setting %age (SS%)	78.43	47.20	94.60	97.39	9.87	12.58	1.20
Grain yield/plant (GY/P)	25.84	11.65	57.10	71.61	8.46	32.75	1.03
Straw yield/plant (SY/P)	210.10	77.00	561.00	12569.83	112.12	53.36	13.60
Harvest index (HI)	0.15	0.03	0.34	0.00	0.07	46.10	0.01
100-grain weight (100GW)	2.31	1.20	2.98	0.11	0.33	14.46	0.04
Grain length (GL)	9.69	7.31	11.12	0.69	0.83	8.60	0.10
Grain breadth (GB)	2.79	2.28	3.82	0.09	0.29	10.57	0.04
Grain length/breadth ratio (GL/B)	3.52	2.00	4.48	0.27	0.52	14.68	0.06

Flag leaf area with its angle is the most important growth character in which maximum photosynthesis is occurred. Maximum leaf area of 75.20 cm^2 was recorded in Jajai-77, while minimum leaf area of 21.39 cm^2 was exhibited by Pak23710. Standard deviation was 11.42 for leaf area with 27.32% coefficient of variance and 41.80 cm^2 mean value. Maximum panicle length of 34.00 cm was observed in Basmati-370-d, whereas minimum value of 19.54 cm in Kinmaze. A vast variability with high range (6.60-27.60) was exhibited for number of productive tillers per plant. The highest coefficient of variability (27.60%) was observed for NIAB IR9 for this trait. The harvest index varied from 0.03 to 0.34 with mean value 0.15, standard deviation 0.07and co-efficient of variance 46.10% which revealed maximum variation in this trait. Maximum harvest index of 0.34 was calculated in Fakhre-Malakand, while minimum value of 0.03 was observed in Dehradun-Basmati (2), Punjab-Basmati and Super-Basmati (L). Grain size is an important quality parameter. Rice grain can be categorized as extra long, long, medium and short (Akram *et al*., 1995). The coefficient of variation for this trait was 8.60% with low standard deviation value of 0.83. NIAB-IR9 was observed with maximum grain length (11.12 mm). Grain breadth ranged from 2.28 to 3.82 mm with mean value 2.79 mm, standard deviation 0.29 and co-efficient of variance 10.57% which revealed that moderate amount of diversity in grain breadth of cultivars. Maximum value 3.82 mm of grain breadth was observed in JP5, while minimum value 2.35 mm was observed in Basmati-370-P. Grain length to breadth ratio ranged from 2.00 to 4.48 with mean value of 3.52, standard deviation 0.52 and co-efficient of variance 14.68% which showed moderate amount of variability in this character. Maximum value of grain length to breadth ratio of 4.48 was observed in Lateefy, while minimum value of 2.00 was observed in JP5.

Cluster analysis: Agro-morphological data was also analyzed by multivariate tools using cluster and principal component analyses. Dandrogram based on Euclidean distance coefficients using 18 quantitative traits placed 68 cultivars into four main lineages and eight clusters (Fig. 1). Table 2 gives the description of number and names of cultivars grouped in an individual cluster. The mean values for each character in cluster are presented in Table 3. The first lineage consisted of three clusters accumulating 48 cultivars; 12 in cluster I which are all basmati type, five cultivars in cluster II and 31 cultivars in cluster III which were mixed type. These cultivars were characterized by the taller plants, large sized leaves, the longest panicle, lower grain yield, moderate straw yield and harvest index, longer grains with high grain length-breadth ratio and were late in flowering and maturity. Second lineage is composed of a total of six cultivars falling in single cluster IV. All six cultivars in this cluster were coarse type. These cultivars were characterized by the shortest days to heading and maturity, the smallest plant height, the highest harvest index, small bold seeds and the shortest panicle length. Lineage-III also consisted of a single cluster V comprising one coarse type variety NIAB-1R9 with the smallest leaves, maximum number of productive tillers per plant, maximum grain yield and higher grain length. Lineage-IV comprised of three clusters VI, VII and VIII consisting of eight, one and four cultivars, respectively. These were generally characterized by taller plants, taking maximum days to heading and maturity, minimum panicle length with lower grain yield per plant and harvest index.

Table 2. Commercial and primitive rice cultivars in different clusters.

Lineage	Cluster	Number of cultivars	Cultivars names
I	Cluster-I	12	Basmati 370(Pak), Basmati 370a (India), Basmati 370 b(Pak), Basmati 370c (India), Mahlar 346 (Pak), Dokri Basmati (Pak), Palman suffaid (Pak), Kahmir Basmati (Pak), Shaheen Basmati (Pak), Kasalath (India), Deradhun Basmati1(N), Ranbir Basmati (India)
	Cluster-II	5	Muskhan (Pak), Jajai-77 (Pak), Basmati-370d (Pak), Rachna Basmati (Pak), Basmati 217 (India)
	Cluster-III	31	Sathra(Pak), Basmati C622 (Pak), Basmati 385 (Pak), Lateefy (Pak), Pusa Basmati1(India), KS282 (Pak), PK386 (Pak), DR83 (Pak), Kangni /Torh (Pak), Sonahri Kangni (Pak), IR8(Pak), IR6(Pak), Shua 92 (Pak), KSK-133 (Pak), Purple marker (Pak), Swat1 (Pak), Swat 2 (Pak), Azucena (phillip), Basmati 2000 (Pak), Khushboo-95 (Pak), Sada hayat (Pak), Pakhal (Pak), Dr-92 (Pak), Dr-82 (Pak), Kharai Ganga (Pak), IR36 (Phillip), Shadab (Pak), Shhandar (Pak), Shahkar (Pak), Sarshar (Pak)
II	Cluster-IV	6	Pak23710 (Pak), JP5 (Pak), Kinmaze (J), Nipponbare (J), Dilrosh 97 (Pak), Fakhre malaknd (Pak)
III	Cluster-V	1	NIAB-IR9 (Pak)
IV	Cluster-VI	8	Jhona 349 (Pak), Basmati Pak (Pak), Basmati-198 (Pak), Super Basmati (Pak), Kanwal-95 (Pak), Punjab Basmati 1 (India), Mahak (Pak), Super Basmati (India)
	Cluster-VII	1	Deradhun Basmati 2 (India)
	Cluster-VIII	4	Sugdesi Ratrera (Pak), Sonahri Sugdesi (Pak), Sugdesi Bengalo (Pak), Sugdesi Sadagulab (Pak)

Table 3. Cluster means for quantitative traits in commercial and primitive rice cultivars.

Traits	Cluster-I	Cluster-II	Cluster-III	Cluster-IV	Cluster-V	Cluster-VI	Cluster-VII	Cluster-VIII
DF	79.4	78	76.3	64.8	87	104.5	121	94.2
DM	107.1	113.2	110.1	95.8	119	145.5	161	131.4
LL	39.1	47.4	35.0	31.3	27.1	31.3	56.8	36.7
LW	1.3	1.8	1.6	1.3	1.3	1.4	1.3	1.7
LA	39.5	65.4	42.8	30.3	26.0	33.7	54.4	44.9
PH	143.6	154.7	114.6	93.7	99.2	120	176	151
TT/P	12.5	14.0	13.2	10.8	27.6	15.1	9.8	11.2
PT/P	11.7	14.0	13.1	10.7	27.6	14.9	9.0	10.8
PL	28.7	33.3	25.6	22.8	23.1	24.0	24.4	28.1
Br/P	9.9	11.6	11.1	12.7	11.6	10.9	17.0	12.0
SS%	79.9	83.3	81.1	85.0	88.8	61.8	66.4	69.1
GY/P	23.5	28.9	29.5	25.4	57.1	15.2	15.6	19.0
SY/P	213.0	257.1	217.1	133.7	396.1	356.2	576.6	371.2
HI	11.5	11.4	15.1	19.3	14.4	4.5	2.7	7.5
100GW	2.0	2.0	2.4	2.6	2.4	2.1	1.20	2.2
GL	9.5	9.4	9.9	8.1	11.1	10.1	10.3	10.2
GB	2.6	2.6	2.8	3.5	2.7	2.6	2.6	2.8
GL/B	3.7	3.6	3.6	2.3	4.1	3.9	3.9	3.6

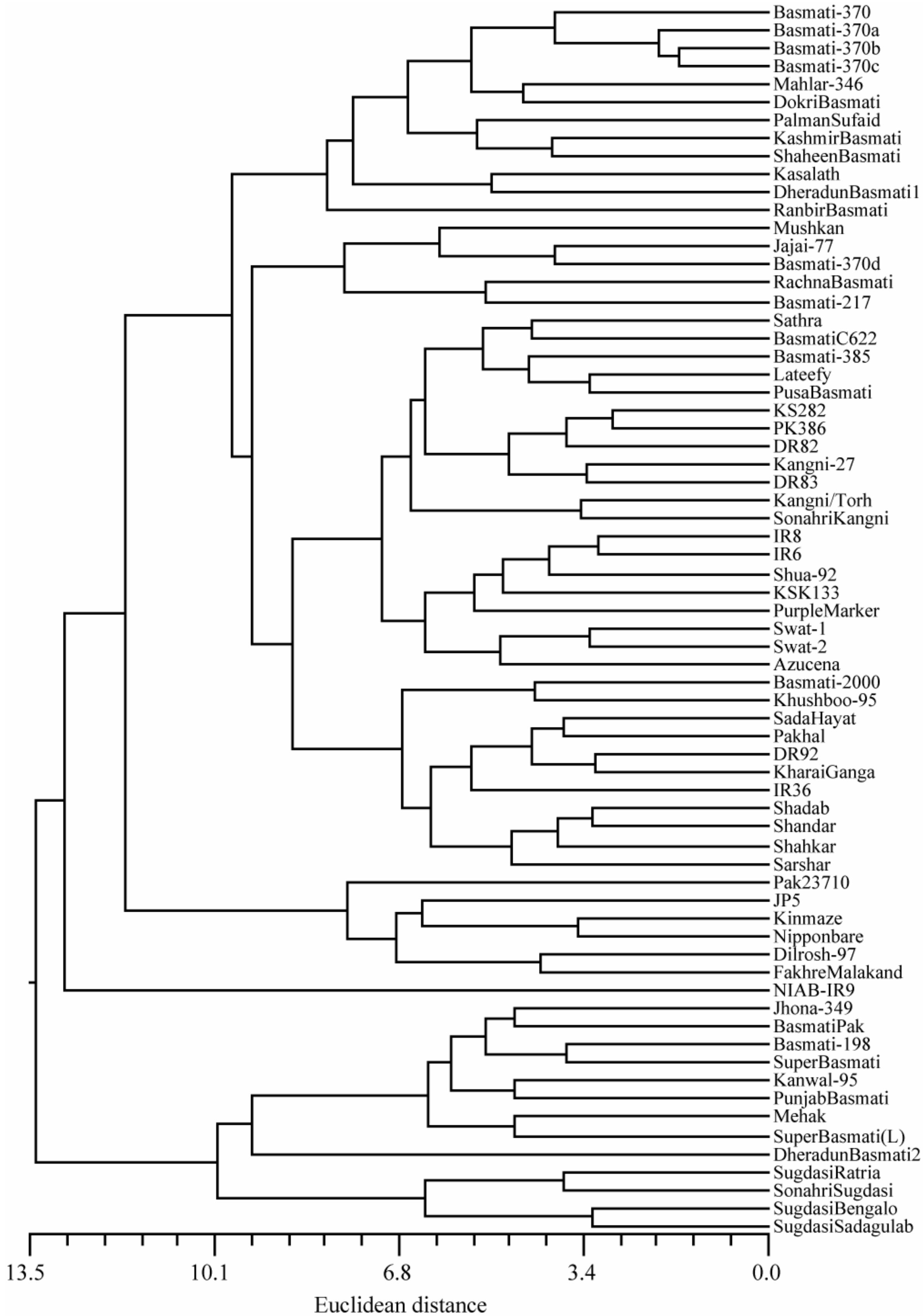

Fig. 1. Dendrogram based on 18 quantitative traits of 68 commercial and primitive cultivars of rice.

Principal component analysis: Principal component analysis showed that the first five principal components having eigenvalues greater than 1 accounted for 79.91% of the total variation. The combination of the first and second principal component explained 50.21% of the total variation covered by all cultivars (Table 4). The characters that contributed more positively to PC1, were days to flowering, days to maturity, plant height , total tillers per plant, productive tillers per plant, panicle length, straw yield per plant, grain length and grain length/breadth ratio. In contrast leaf length, leaf width, leaf area, branches per panicle, seed setting (%), grain yield per plant, harvest index, 100-grain weight and grain breadth contributed negatively to principal component-1. Principle component-2 had 20.44% of the total morphological variability and was negatively weighted by leaf length, leaf width, leaf area, plant height, panicle length, branches per panicle and grain length/breadth ratio. Whereas days to flowering, days to maturity, total and productive tillers per plant, seed setting (%), grain and straw yield per plant, harvest index, 100-grain weight and grain length and breadth were positively associated with PC2. Figure 2(a) shows the plot obtained from the first two vectors of PCA. A total of 13.38% of the variation was explained by the third principal component and was highly negatively characterized by leaf length, leaf width, leaf area, plant height , total tillers per plant, productive tillers per plant, panicle length, seed setting (%), grain yield per plant, harvest index, grain length and grain length/breadth ratio. While, days to flowering and maturity, branches per panicle, straw yield per plant, 100-grain weight and grain breadth contributed positively to PC3. Figure 2(b) shows the plot obtained from the first and third vectors of PCA.

Table 4. Variation among rice cultivars accounted for first five principal components.

Trait	PC1	PC2	PC3	PC4	PC5
Eigenvalues	5.36	3.68	2.41	1.69	1.25
Cumulative eigenvalues	5.36	9.04	11.45	13.13	14.38
Proportion of variance	29.77	20.44	13.38	9.37	6.94
Cumulative variance	29.77	50.21	63.59	72.97	79.91
			Eigenvectors		
Days to flowering (DF)	0.341	0.006	0.196	0.209	-0.210
Days to maturity (DM)	0.340	0.051	0.189	0.236	-0.235
Leaf length (LL)	-0.057	-0.401	-0.205	-0.090	-0.254
Leaf width (LW)	-0.035	-0.199	-0.108	0.592	0.205
Leaf area (LA)	-0.066	-0.405	-0.224	0.275	-0.077
Plant height (PH)	0.183	-0.381	-0.057	0.027	-0.152
Total tillers/plant (TT/P)	0.170	0.347	-0.309	-0.043	-0.243
Productive tillers/plant (PT/P)	0.173	0.352	-0.305	0.019	-0.259
Panicle length (PL)	0.069	-0.355	-0.195	-0.049	-0.100
Branches/panicle (Br/P)	-0.011	-0.099	0.210	0.184	-0.211
Seed setting percentage (SS%)	-0.283	0.078	-0.292	0.053	-0.234
Grain yield/plant (GY/P)	-0.110	0.182	-0.414	0.294	-0.244
Straw yield/plant (SY/P)	0.355	0.038	0.126	0.161	-0.252
Harvest index (HI)	-0.375	0.059	-0.182	0.032	0.006
100-grain weight (100-GW)	-0.182	0.186	0.150	0.502	0.200
Grain length (GL)	0.252	0.106	-0.242	0.175	0.449
Grain breadth (GB)	-0.312	0.131	0.282	0.164	-0.200
Grain length/breadth ratio (GL/B)	0.331	-0.013	-0.286	-0.038	0.354

Correlation study: Of different combinations of quantitative traits within the cultivars, some of the characters exhibited positive correlations, while other showed negative associations with one another (Table 5). Days to flowering was highly significant positively associated with days to maturity (r = 0.92**) and straw yield per plant (r = 0.79**). However days to flowering showed highly significant negative association with seed setting percentage (r = -0.55**) and harvest index (r = -0.74**). Days to maturity were highly positive and significant associated with straw yield per plant (r = 0.80**) and had highly significant negative correlation with seed setting percentage (r = -0.54**) and harvest index (r = -0.71**). There was highly positive significant correlation of leaf length with leaf area (r = 0.76**) and plant height (r =0.51**). With panicle length, leaf length had positively significant association (r = 0.37*). Similarly highly significant negative correlation was seen between leaf area and total tillers per plant (r = -0.66**), and productive tillers per plant (r = - 0.67**). Plant height had positive association with panicle length (r = 0.65**) and has negative correlation with grain yield per plant. Total tillers per plant were highly significant positively correlated with productive tillers per plant (r = 0.95**). Harvest index showed highly significant positive correlation with 100-grain weight (r = 0.47**) and grain breadth (r = 0.54**). However highly significant negative correlation was displayed with grain length-breadth ratio (r = - 0.54**). Hundred-grain weight was highly significant positively correlated with grain breadth (r = 0.69**) but highly significant negative association with grain length-breadth ratio (r = - 0.49**). Grain length displayed highly significant positive correlation with grain length-breadth ratio (r = 0.84**), while highly significant negative association with grain breadth (r = -0.50**). On the other hand grain breadth revealed highly significant negative correlation with grain length-breadth ratio (r = - 0.88**).

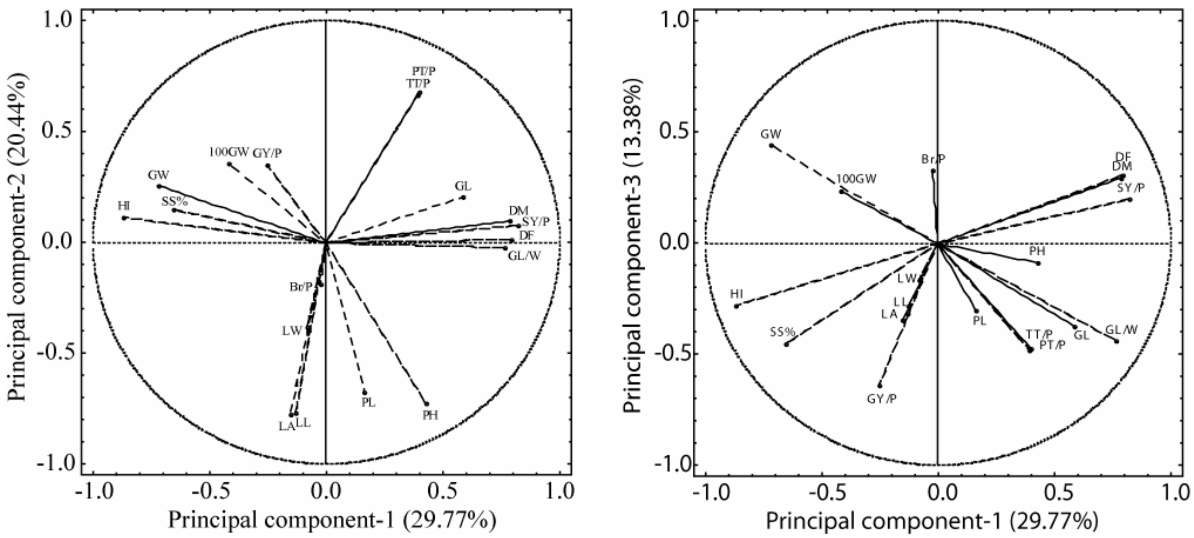

Fig. 2. Scattered diagrams of first three principal components based on mean values of 18 quantitative characters in rice cultivars.

Table 5. Correlation coefficients for quantitative traits among rice varieties.

Traits	DF	DM	LL	LW	LA	PH	TT/P	PT/P	PL	Br/P	SS%	GY/P	SY/P	HI	100GW	GL	GB	GL/B
DF	1.00																	
DM	**0.92**	1.00																
LL	-0.15	-0.10	1.00															
LW	-0.16	-0.22	0.06	1.00														
LA	-0.25	-0.25	**0.76**	**0.68**	1.00													
PH	0.30	0.14	**0.51**	-0.03	0.35	1.00												
TT/P	0.11	0.25	-0.41	**-0.58**	**-0.66**	-0.25	1.00											
PT/P	0.22	0.34	-0.44	**-0.55**	**-0.67**	-0.31	**0.95**	1.00										
PL	-0.04	-0.13	0.37	0.12	0.35	**0.65**	-0.29	-0.33	1.00									
Br/P	0.37	0.35	0.33	0.19	0.34	0.33	-0.40	-0.39	0.07	1.00								
SS%	**-0.55**	**-0.54**	0.05	-0.09	-0.01	-0.26	0.10	0.08	-0.18	-0.10	1.00							
GY/P	-0.33	-0.30	0.14	0.12	0.18	-0.13	0.10	0.17	0.03	-0.14	**0.69**	1.00						
SY/P	**0.79**	**0.80**	0.12	-0.37	-0.18	0.44	0.22	0.22	0.03	0.40	**-0.54**	-0.43	1.00					
HI	**-0.74**	**-0.71**	0.14	0.31	0.32	-0.44	-0.22	-0.19	-0.11	-0.26	**0.67**	**0.61**	**-0.88**	1.00				
100GW	-0.25	-0.28	-0.44	**0.53**	0.03	-0.39	-0.23	-0.20	-0.25	0.08	0.29	0.35	**-0.54**	**0.47**	1.00			
GL	0.28	0.25	-0.02	0.17	0.09	0.20	0.19	0.17	0.11	0.02	**-0.47**	0.03	0.35	-0.33	-0.07	1.00		
GB	-0.32	-0.34	-0.21	0.20	-0.02	-0.43	-0.25	-0.25	-0.41	0.12	**0.48**	0.17	-0.45	**0.54**	**0.69**	**-0.50**	1.00	
GL/B	0.37	0.36	0.10	-0.09	0.01	0.37	0.27	0.26	0.30	-0.04	**-0.56**	-0.12	**0.49**	**-0.54**	**-0.49**	**0.84**	**-0.88**	1.00

Discussion

Generally our findings showed that rice cultivars from Pakistan harbor a wide range of genetic variation. From the present study, a number of promising lines have been identified for specific traits that may have some potential value in future rice breeding programs for further improvement. Majority of traits showed above 10% coefficient of variance and the highest 53.36% for the straw yield per plant. Mahlar-346, coarse type cultivar had the highest plant height (179.40cm), whereas Nipponbare is a dwarf variety having the plant height of 74.60cm. Ali *et al*., (2000) had also observed relatively greater range in plant height than the other characters. Plant height in rice is a multifaceted character and the end product of a number of genetically controlled factors called internodes (Cheema *et al*., 1987). Reduction in plant height may develop their resistance to lodging and reduce substantial yield losses associated with this trait (Abbasi *et al*., 1995). Hien *et al*., (2007) reported that improvement of aromatic rice cultivars also should focus on both decreasing the plant height and increasing the culm strength. In our study, Ranbir-basmati was the one which had the minimum value for days to heading i.e., 51 days. Similar results were reported by Shah *et al*., (1999) who tested eight rice genotypes and found KS282 with 57 days to 50% flowering. He further stated that the existing atmospheric temperature, light intensity and other climatic conditions played important role in opening of the spikelets. Maximum value (34.00 cm) of panicle length was observed in Basmati-370d and minimum value 19.54 cm in Kinmaze. Although it contributes positively that maximum panicle length is not the only factor responsible for higher yield. Abbasi *et al*. (1995) reported that DR39 had maximum panicle length but due to lower grain fertility exhibited lower grain yield. Productive tillers per plant are another yield attributing trait (Abbasi *et al*., 1995). The highest coefficient of variability (27.60% for NIAB IR9) was detected for this trait. Ali *et al*., (2000) also observed high coefficient of variability for number of productive tillers per plant. Shah *et al*., (1999) also observed that DR82 and NIAB-6 were found to have higher tillers per plant i.e., 26.1 and 25.80, respectively. Maximum grain length (11.12 mm) and grain breadth (3.82 mm) was observed in NIAB-IR9 and JP5, respectively.

Cluster analysis based on Euclidean distance coefficients using 18 quantitative traits placed cultivars into four main lineages and eight clusters. Cultivars groups were primarily associated with morphological differences among them and secondly with cultivar type. Although, cultivars belonged to different research institutes in the country, however, no association was observed between the morphological traits and origin of the cultivars. Our results were in conformity with Dias *et al*., (1993); Amurrio *et al*., (1995); and Hien *et al*., (2007), who also reported that in cluster analysis cultivars grouped together with greater morphological similarity but the clusters did not essentially include all the cultivars from the same origin and no association was established between morphological characters and geographical origin.

In correlation coefficient study some of the characters exhibited positive correlations, while other showed negative associations with one another. Days to flowering was highly significant positively associated with days to maturity (r = 0.92**) and straw yield plant-1 (r = 0.79**). Zafar *et al*., (2004) also reported positive correlation between days to heading and days to maturity among landrace genotypes of Pakistani rice. Plant height had positive association (r = 0.65**) with panicle length signifying the importance of plant height in improving panicle length in rice. The results of this study were in agreement with Aly (1977) and Zafar *et al*., (2004) who observed that plant height had highly significant and positive association with panicle length. On the other hand in our study plant height had negative correlation with grain yield per plant. These results were in accordance with the findings of Dogan (2009) who also reported negative correlation between plant height and grain yield. The negative associations of some significant character as plant height vs. grain yield may lead to some undesirable selection depending on either negative correlation was because of linkage or pleiotropic effect. The negative correlations of these character-pairs impose problems in combining important yield components in one genotype. For improvement of yield components with negative association with each other, appropriate recombination may be obtained through mutation breeding, biparental mating or diallel selective mating by breaking unnecessary linkages.

The current study indicated that the amounts of variability were distributed in agro-ecological zones and highlighted the difference among the cultivars. Due to interaction between genotype and environment and the unidentified genetic control of polygenic agronomic traits, agro-morphological variation does not constantly reveal actual genetic variation (Smith & Smith, 1992; Beyene *et al*., 2005). Regardless of this limitation, agro-morphological traits are still practical for preliminary evaluation because these are easy and can be employed as a common approach for assessing genetic variability among phenotypic ally distinguishable cultivars. Additional ample study comprising markers such as isozyme, protein and molecular markers will most likely provide a comprehensive view about the genetic variation of rice cultivars. In addition for high quality food, quality parameters such as cooking and eating quality, grain appearance and nutrient contents must have to be improved to deal with the correlation between quality characteristics and phenotypic variations.

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