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Morphological diversity of 83 rice accessions for qualitative and quantitative parameters

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Abstract

This research was conducted to study indigenous rice germplasm for 15 qualitative and 8 quantitative characteristics at The University of Agriculture Peshawar-Pakistan, during 2010 rice crop growing season. Eighty three rice accessions were planted in a randomized complete block design (RCBD) using two replications. Sufficient genetic variation was displayed by the rice genotypes for most of the traits studied. Accession 006511 showed maximum panicle length (38.7 cm) whereas accession 006505 exhibited maximum grain length (10.2 mm). Maximum grain width (4.08 mm) was displayed by the accession 006702. Maximum number of spike lets panicle^{-1} (362.0) and grain yield plot^{-1} (1.8 kg) were observed for the accession 006630. Accessions 006778 and 006549 displayed maximum values for 1000-grain weight (41.4 g) and biological yield plot^{-1} (5.7 kg).. Cluster analysis for qualitative traits revealed five clusters at a dissimilarity level of 7.47. At a dissimilarity level of 6.22 six clusters were observed for quantitative traits. The genetic potential of the accessions 006630,006549, 006511, 006778, 006505 and 006702 on account of their high values for various traits of interest can be exploited in future rice breeding program.

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Introduction

Rice (*Oryza sativa* L.) is one of the most important crops that feed more than half of the world's population (Huang *et al*., 2013). It is cultivated in a wide range of ecological environments worldwide. It is a nutritious cereal crop, providing 20 per cent of the calories and 15 percent of protein consumed by world's population. Rice breeding depends upon the presence of genetic diversity to develop high yieldable and quality cultivars (Huang *et al*., 2013). Genetic diversity and its continued availability are very necessary for development of new modern rice varieties (Jackson and Juggan, 1993; Bellon *et al*., 1998). The first step towards the commencement of any judicious crop breeding program is to consider genetic diversity of crop for improving crop productivity and resistance to biotic and abiotic stresses (Padulosi, 1993). The study of rice accessions at morphological and molecular level can add in creating useful genetic database which will be efficiently used for the genetic improvement of local rice varieties for increased food production.

Presently the genetic base of rice is declining continuously with increasing genetic vulnerability because modern high yielding varieties takes place of the traditional genetically diverse varieties. Thus there is a direful need to collect, exploit and evaluate the unexploited diverse rice germplasm to broaden the genetic base of modern cultivars by the introgression of genes for various traits of interest (Alia *et al*., 2016).

For the purpose, rice accessions in large number collected from various parts of Pakistan were maintained in the gene bank of Plant Genetic Resources Institute (PGRI) at National Agricultural Research Centre (NARC), Islamabad. Thus proper characterization, evaluation and classification of the collected germplasm is of utmost importance for the effectual management and their use in future rice breeding programs. But if the collected germplasm in the gene bank has not been properly evaluated and its characteristic data are not made available to the breeders, it has of neglected practical value (Zafar *et al*., 2004). Counce *et al*. (1996) evaluated various rice genotypes for grain yield and related traits. They observed higher degree of variation among the genotypes for tillers, grains panicle^{-1}, days to maturity and seed weight. Therefore, the present study was undertaken to morphologically characterize the indigenous rice germplasm using qualitative and quantitative traits and to identify the desirable rice genotypes for future use in rice breeding programs.

Materials and methods

The present research was performed to characterize indigenous rice germplasm for morphological parameters at the Plant Breeding and Genetics Research Farm, The University of Agriculture Peshawar-Pakistan, during 2010 rice crop growing season. The genotypes used in the study were 83 accessions of rice, provided by Institute of Agriculture Biotechnology and Genetic Resources (IABGR), National Agricultural

Table 1. List of the rice genotypes used in the study.

S. No	Rice accessions	S. No.	Rice accessions
1	006505	43	006680
2	006506	44	006685
3	006508	45	006697
4	006509	46	006698
5	006511	47	006699
6	006512	48	006700
7	006514	49	006701
8	006515	50	006702
9	006517	51	006703
10	006520	52	006704
11	006522	53	006706
12	006523	54	006709

S. No	Rice accessions	S. No.	Rice accessions
13	006525	55	006710
14	006527	56	006711
15	006536	57	006716
16	006538	58	006718
17	006541	59	006720
18	006543	60	006728
19	006549	61	006729
20	006559	62	006731
21	006560	63	006734
22	006571	64	006737
23	006581	65	006764
24	006596	66	006765
25	006612	67	006767
26	006613	68	006768
27	006616	69	006769
28	006619	70	006771
29	006620	71	006772
30	006622	72	006774
31	006624	73	006778
32	006627	74	006781
33	006629	75	006783
34	006630	76	006784
35	006633	77	006787
36	006634	78	006789
37	006640	79	006795
38	006642	80	006797
39	006650	81	006799
40	006655	82	006807
41	006663	83	006811
42	006666		

Research Center (NARC), Islamabad. The rice genotypes used in the study are listed in Table 1. Nursery of the respective genotypes was raised on well prepared seed beds in the last week of May and then the seedlings were transplanted into the well puddled field in the last week of June. Each rice accessions was planted in two rows with row length of 2 m. Row-to- row and plant-to-plant distances of 30 and 20 cm were maintained, respectively. Standard recommended cultural practices were used for growing rice. Data were recorded on five randomly selected plants of each accession for 15 qualitative (culm angle, internode color, node color, basal leaf sheath color, flag leaf angle, ligule color, awning, awn color, apiculus color, anther color, auricle color, blooming time, panicle type, grain shape and seed coat color). Eight quantitative traits were also measured including panicle length (cm), spike lets panicle^{-1}, awn length (cm), grain length (mm), grain width (mm), 1000-grain weight (g), biological yield (kg plot^{-1}) and grain yield (kg plot^{-1}, respectively.

Data analysis

Simple statistical parameters i.e. mean, standard deviation, variance and standard error where determined for all the metric traits among the rice genotypes using computer software 'Statistica' v 6.0. Mean values per accession were used for analysis. The resulting matrices were used to synthesize dendrograms using NTSYS-pc 2.02k version (Rohlf, 1994).

Results

Qualitative traits

Sufficient genetic variability was observed among the rice genotypes for most of the qualitative parameters except ligule and anther colors.

Culm angle is an indicator of growth habit of a particular plant species. The accessions displayed erect and intermediate types of culm angle. Internode color was observed light gold for the accessions 006522, 006549, 006560, 006612, 006613, 006616, 006663, 006718, 006728 and 006807, while green internode with purple lines and green type of internodes were observed for remaining accessions. Node color of accession 006596 was observed purple, while remaining accessions showed two types of node color gold and green. The studied rice genotypes were characterized for leaf traits at late vegetative and flowering stages. Basal leaf sheath color of all rice accessions was green with purple lines and green. The rice genotypes used in the study manifested variation for flag leaf angle. Flag leaf angle of studied rice accessions was observed erect, intermediate and horizontal, however the accessions 006541,006624 and 006685 manifested descending flag leaf angle. White ligule color was observed for all the accessions (Table 2). Most of the accessions showed pale green auricle color. However, accessions 006525 and 006596 showed purple and purplish green auricle color, respectively (Table 3).

Table 2. Culm angle, internode color, node color, basal leaf sheath color, flag leaf angle, ligule color and awning of 83 accessions of rice.

Rice accessions	Culm angle	Internode color	Node color	Basal leaf sheath color	Flag leaf angle	Ligule color	Awning
006505	Erect	Green	Light Gold	Green	Horizontal	White	Short/partly
006506	Erect	Green	Green	Green	Erect	White	Long/partly
006508	Erect	Green	Green	Green	Erect	White	Long/fully
006509	Erect	Green	Green	Green	Horizontal	White	Short/fully
006511	Erect	Green	Green	Green	Erect	White	Long/fully
006512	Erect	Green	Green	Green	Intermediate	White	Absent
006514	Erect	Green	Green	Green	Intermediate	White	Short/partly
006515	Erect	Green	Green	Green	Intermediate	White	Short/partly
006517	Erect	Green	Green	Green	Erect	White	Short/partly
006520	Erect	Green	Green	Green	Intermediate	White	Long/partly
006522	Erect	Light Gold	Green	Green	Horizontal	White	Long/partly
006523	Erect	Green	Green	Green	Horizontal	White	Short/partly
006525	Erect	Green	Green	Green	Intermediate	White	Long/partly
006527	Erect	Green	Green	Green	Erect	White	Short/partly
006536	Erect	Green	Green	Green	Intermediate	White	Short/partly
006538	Erect	Green	Green	Green	Intermediate	White	Long/partly
.006541	Erect	Green	Green	Green	Descending	White	Long/partly
006543	Erect	Green	Green	Green	Horizontal	White	Long/fully
006549	Erect	Light Gold	Green	Green	Erect	White	Short/partly
006559	Erect	Green	Light Gold	Green	Intermediate	White	Absent
006560	Erect	Light Gold	Light Gold	Green	Horizontal	White	Short/partly
006571	Erect	Green	Green	Green	Intermediate	White	Short/partly
006581	Erect	Green	Green	Green	Intermediate	White	Long/fully
006596	Erect	Purple-lines	Purple	Purple-lines	Intermediate	White	Absent
006612	Erect	Light Gold	Green	Purple-lines	Intermediate	White	Long/partly
006613	Erect	Light Gold	Light Gold	Green	Erect	White	Long/fully
006616	Intermediate	Light Gold	Light Gold	Green	Erect	White	Long/fully
006619	Erect	Green	Green	Green	Horizontal	White	Long/fully
006620	Erect	Green	light gold	Green	Intermediate	White	Long/fully
006622	Erect	Green	Green	Purple-lines	Intermediate	White	Absent
006624	Intermediate	Green	Green	Green	Descending	White	Long/partly
006627	Intermediate	Green	Green	Purple-lines	Intermediate	White	Long/fully
006629	Erect	Purple-lines	Green	Green	Horizontal	White	Long/partly
006630	Intermediate	Green	Green	Green	Horizontal	White	Long/fully
006633	Erect	Green	Green	Green	Erect	White	Long/fully
006634	Erect	Green	Green	Green	Horizontal	White	Short/partly
006640	Intermediate	Purple-lines	Green	Purple-lines	Erect	White	Long/partly
006642	Erect	Green	Green	Green	Erect	White	Long/fully
006650	Erect	Green	Green	Purple-lines	Horizontal	White	Long/fully
006655	Intermediate	Green	Green	Green	Horizontal	White	Absent
006663	Intermediate	Light Gold	Green	Purple-lines	Intermediate	White	Absent
006666	Erect	Green	Green	Green	Horizontal	White	Absent

Continue table 2. Culm angle, internode color, node color, basal leaf sheath color, flag leaf angle, ligule color and awning of 83 accessions of rice.

Rice accessions	Culm angle	Internode color	Node color	Basal leaf sheath color	Flag leaf angle	Ligule color	Awning
006680	Erect	Green	Green	Green	Horizontal	White	Absent
006685	Intermediate	Green	Green	Purple-lines	Descending	White	Absent
006697	Erect	Green	Green	Green	Intermediate	White	Absent
006698	Intermediate	Green	Green	Green	Horizontal	White	Short/partly
006699	Erect	Purple-lines	Green	Purple-lines	Intermediate	White	Absent
006700	Erect	Green	Green	Green	Intermediate	White	Long/partly
006701	Erect	Green	Green	Green	Horizontal	White	Absent
006702	Erect	Purple-lines	Green	Purple-lines	Intermediate	White	Absent
006703	Erect	Green	Green	Green	Intermediate	White	Long/partly
006704	Erect	Green	Green	Green	Intermediate	White	Absent
006706	Intermediate	Green	Green	Green	Horizontal	White	Absent
006709	Intermediate	Green	Light Gold	Green	Intermediate	White	Absent
006710	Erect	Green	Light Gold	Green	Intermediate	White	Absent
006711	Intermediate	Green	Green	Green	Horizontal	White	Absent
006716	Erect	Green	Green	Green	Intermediate	White	Long/fully
006718	Intermediate	Light Gold	light gold	Green	Horizontal	White	Short/partly
006720	Erect	Green	Green	Green	Erect	White	Absent
006728	Erect	Light Gold	Green	Purple-lines	Erect	White	Long/partly
006729	Erect	Green	Green	Green	Horizontal	White	Absent
006731	Erect	Green	Green	Green	Erect	White	Long/partly
006734	Erect	Green	Green	Green	Intermediate	White	Short/partly
006737	Erect	Purple-lines	Green	Green	Intermediate	White	Absent
006764	Erect	Purple-lines	Green	Purple-lines	Erect	White	short/fully
006765	Erect	Purple-lines	Green	Purple-lines	Intermediate	White	Short/partly
006767	Erect	Green	Green	Green	Horizontal	White	Short/partly
006768	Erect	Green	Green	Green	Erect	White	Long/fully
006769	Erect	Green	Green	Green	Horizontal	White	Short/partly
006771	Erect	Purple-lines	Green	Green	Intermediate	White	Absent
006772	Erect	Green	Green	Purple-lines	Intermediate	White	Long/partly
006774	Erect	Green	Green	Green	Intermediate	White	Absent
006778	Erect	Green	Green	Purple-lines	Intermediate	White	Long/fully
006781	Intermediate	Green	Green	Green	Intermediate	White	Absent
006783	Intermediate	Purple-lines	Green	Purple-lines	Horizontal	White	Short/partly
006784	Intermediate	Green	Green	Purple-lines	Erect	White	Short/partly
006787	Erect	Purple-lines	Green	Purple-lines	Intermediate	White	Short/fully
006789	Erect	Purple-lines	Green	Purple-lines	Intermediate	White	Short/partly
006795	Erect	Purple-lines	Green	Purple-lines	Horizontal	White	Absent
006797	Erect	Green	Green	Purple-lines	Intermediate	White	Short/fully
006799	Erect	Green	Green	Green	Erect	White	Absent
006807	Erect	Light Gold	Green	Purple-lines	Erect	White	Short/partly
006811	Erect	Green	Green	Green	Intermediate	White	Absent

Proper recording of the blooming time of rice accessions is very vital for their hybridization with commercial cultivars in wide rice breeding programs. All of the studied rice accessions started opening of spikelets and pollen shedding from 9:00 to 11:30 am. Variation among the rice genotypes was observed for panicle type. Panicle type was recorded as compact, intermediate and open for the rice genotypes (Table 3). Awning and awn color traits manifested variation among the studied rice genotypes. Awning of the accessions was recorded short and fully awned, long and fully awned, long and partly awned, short and partly awned while the accessions 006512, 006559, 006596, 006622, 006655, 006663, 006666, 006680, 006685, 006697, 006699, 006701, 006702, 006704, 006706, 006709, 006710, 006711, 006720, 006729, 006737, 006771, 006774, 006781, 006795, 006799 and 006811 were awnless (Table 2). Awn color of the accession 006581 was brown, while the remaining accessions exhibited purple and straw awn color. Rice genotypes varied for the trait apiculus color. The accessions 006581, 006774, 006778 and 006781 showed brown apiculus color whereas apiculus color of the accessions 006769 and 006807 was observed white. Remaining genotypes exhibited purple and straw color of apiculus. Anther color among all the rice accessions was recorded as yellow. Grain shape among the rice genotypes was observed three types slender, medium and bold. Marked variation was observed among the rice genotypes for seed coat color. Some of the accessions showed brown seed coat color whereas the accessions 006581, 006697, 006711 and 006772 had purple color seed coat. Other accessions manifested white and light brown seed

coat color, while the accessions 006543, 006620 and 006710 exhibited speckled brown seed coat color. Red color of seed coat was observed for the accessions 006633, 006769, 006795 and 006811 (Table 3).

Table 3. Awn color, apiculus color, anther color, auricle color, blooming time, panicle type, grain shape and seed coat color of 83 accessions of rice.

Rice accessions	Awn color	Apiculus color	Anther color	Auricle color	Blooming time	Panicle type	Grain shape	Seed coat color
006505	Purple	Purple	Yellow	Pale Green	9:30 am onwards	Compact	Slender	Light Brown
006506	Straw	Purple	Yellow	Pale Green	10:45 am nwards	Open	Slender	Brown
006508	Purple	Purple	Yellow	Pale Green	11:00 am onwards	Intermediate	Slender	Light Brown
006509	Purple	Purple	Yellow	Pale Green	10:30 am onwards	Intermediate	Slender	Light Brown
006511	Straw	Straw	Yellow	Pale Green	10:45 am onwards	Intermediate	Slender	Light Brown
006512	Absent	Purple	Yellow	Pale Green	10:30 am onwards	Open	Slender	Light Brown
006514	Straw	Straw	Yellow	Pale Green	9:30 am onwards	Open	Slender	Light Brown
006515	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Intermediate	Slender	White
006517	Straw	Straw	Yellow	Pale Green	10:15 am onwards	Compact	Slender	Light Brown
006520	Straw	Straw	Yellow	Pale Green	10:30 am onwards	Compact	Slender	Light Brown
006522	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Compact	Medium	White
006523	Straw	Straw	Yellow	Pale Green	10:30 am onwards	Intermediate	Slender	Light Brown
006525	Straw	Straw	Yellow	purple	10:30 am onwards	Intermediate	Slender	Light Brown
006527	Straw	Straw	Yellow	Pale Green	11:00 am onwards	Compact	Slender	Light Brown
006536	Straw	Straw	Yellow	Pale Green	9:45 am onwards	Open	Slender	Light Brown
006538	Straw	Straw	Yellow	Pale Green	9:45 am onwards	Open	Slender	Light Brown
006541	Straw	Straw	Yellow	Pale Green	10:30 am onwards	Intermediate	Slender	Light Brown
006543	Purple	Straw	Yellow	Pale Green	10:20 am onwards	Open	Medium	Speckled brown
006549	Straw	Straw	Yellow	Pale Green	10:30 am onwards	Open	Slender	Light Brown
006559	Absent	Straw	Yellow	Pale Green	10:00 am onwards	Compact	Slender	Light Brown
006560	Purple	Purple	Yellow	Pale Green	10.00 am onwards	Compact	Slender	White
006571	Purple	Purple	Yellow	Pale Green	9:50 am onwards	compact	Medium	Light Brown
006581	Brown	Brown	Yellow	Pale Green	10:30 am onwards	Intermediate	Medium	Purple
006596	Absent	Purple	Yellow	purple-lines	9:30 am onwards	Compact	Bold	Light Brown
006612	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Open	Slender	White
006613	Straw	Straw	Yellow	Pale Green	10:30 am onwards	Open	Slender	Light Brown
006616	Straw	Straw	Yellow	Pale Green	9:30 am onwards	Compact	Slender	Light Brown
006619	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Open	Slender	Light Brown
006620	Straw	Straw	Yellow	Pale Green	9:30 am onwards	Compact	Medium	Speckled brown
006622	Absent	Straw	Yellow	Pale Green	10:30 am onwards	Open	Slender	Light Brown
006624	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Open	Slender	Light Brown
006627	Straw	Straw	Yellow	Pale Green	10:15 am onwards	Open	Medium	Light Brown
006629	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Open	Slender	Light Brown
006630	Straw	Purple	Yellow	Pale Green	9:30 am onwards	Intermediate	Medium	Light Brown
006633	Straw	Straw	Yellow	Pale Green	11:30 am onwards	Compact	Slender	Red
006634	Straw	Straw	Yellow	Pale Green	11:00 am onwards	Open	Medium	Light Brown
006640	Straw	Straw	Yellow	Pale Green	9:30 am onwards	Open	Medium	Brown
006642	Straw	Straw	Yellow	Pale Green	9:00 am onwards	Intermediate	Slender	Light Brown
006650	Straw	Straw	Yellow	Pale Green	10:30 am onwards	Open	Slender	White
006655	Absent	Straw	Yellow	Pale Green	10:30 am onwards	Compact	Slender	Brown
006663	Absent	Straw	Yellow	Pale Green	9:45 am onwards	Compact	Slender	Light Brown
006666	Absent	Straw	Yellow	Pale Green	9:45 am onwards	Compact	Medium	Light Brown

Continue table 3. Awn color, apiculus color, anther color, auricle color, blooming time, panicle type, grain shape and seed coat color of 83 accessions of rice.

Rice accessions	Awn color	Apiculus color	Anther color	Auricle color	Blooming time	Panicle type	Grain shape	Seed coat color
006680	Absent	Straw	Yellow	Pale Green	10:00 am onwards	Compact	Medium	Brown
006685	Absent	Straw	Yellow	Pale Green	10:30 am onwards	Compact	Medium	Light Brown
006697	Absent	Straw	Yellow	Pale Green	10:30 am onwards	Intermediate	Medium	Purple
006698	Straw	Straw	Yellow	Pale Green	9:30 am onwards	Compact	Slender	Light Brown
006699	Absent	Straw	Yellow	Pale Green	10:00 am onwards	Compact	Medium	Brown
006700	Straw	Straw	Yellow	Pale Green	9:30 am onwards	Open	Medium	Light Brown
006701	Absent	Straw	Yellow	Pale Green	10:15 am onwards	Compact	Medium	Brown
006702	Absent	Straw	Yellow	Pale Green	9:00 am onwards	Compact	Bold	Light Brown
006703	Straw	Straw	Yellow	Pale Green	9:30 am onwards	Compact	Slender	Light Brown
006704	Absent	Straw	Yellow	Pale Green	10:00 am onwards	Compact	Medium	Brown
006706	Absent	Straw	Yellow	Pale Green	10:30 am onwards	Compact	Medium	White
006709	Absent	Straw	Yellow	Pale Green	10;00 am onwards	Compact	Medium	Brown
006710	Absent	Straw	Yellow	Pale Green	11:00 am onwards	Open	Slender	Speckled brown
006711	Absent	Straw	Yellow	Pale Green	11:00 am onwards	Compact	Medium	Purple
006716	Straw	Straw	Yellow	Pale Green	9:30 am onwards	Compact	Medium	Brown
006718	Straw	Straw	Yellow	Pale Green	9:45 am onwards	Open	Medium	White
006720	Absent	Straw	Yellow	Pale Green	9:30 am onwards	Intermediate	Medium	Light Brown
006728	Straw	Straw	Yellow	Pale Green	9:30 am onwards	Intermediate	Bold	Light Brown
006729	Absent	Straw	Yellow	Pale Green	11:00 am onwards	Intermediate	Slender	Light Brown
006731	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Open	Medium	Light Brown
006734	Straw	Straw	Yellow	Pale Green	9:30 am onwards	Open	Medium	Brown
006737	Absent	Straw	Yellow	Pale Green	9:30 am onwards	Compact	Slender	White
006764	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Compact	Slender	Light Brown
006765	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Intermediate	Medium	White
006767	Purple	Purple	Yellow	Pale Green	9:30 am onwards	Open	Medium	Light Brown
006768	Straw	Straw	Yellow	Pale Green	9:45 am onwards	Compact	Medium	White
006769	Purple	White	Yellow	Pale Green	11:00 am onwards	Open	Medium	Red
006771	Absent	Straw	Yellow	Pale Green	10:00 am onwards	Intermediate	medium	Light Brown
006772	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Compact	Medium	Purple
006774	Absent	Brown	Yellow	Pale Green	10:00 am onwards	Intermediate	Medium	White
006778	Straw	Brown	Yellow	Pale Green	10:15 am onwards	Open	Medium	White
006781	Absent	Brown	Yellow	Pale Green	9:45 am onwards	Compact	Medium	White
006783	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Open	Medium	White
006784	Straw	Purple	Yellow	Pale Green	11:30 am onwards	Intermediate	Medium	Brown
006787	Straw	Straw	Yellow	Pale Green	10:00 am onwards	Open	Medium	Brown
006789	Purple	Purple	Yellow	Pale Green	9:30 am onwards	Open	Medium	Brown
006795	Absent	Straw	Yellow	Pale Green	10:30 am onwards	Open	Medium	Red
006797	Straw	Straw	Yellow	Pale Green	9:15 am onwards	Open	Slender	Light Brown
006799	Absent	Straw	Yellow	Pale Green	10:30 am onwards	Intermediate	Medium	Brown
006807	Purple	White	Yellow	Pale Green	10:30 am onwards	Compact	Medium	Light Brown
006811	Absent	Straw	Yellow	Pale Green	9:45 am onwards	Open	Medium	Red

Quantitative traits

Panicle length among the rice genotypes varied from 18.58 to 38.7 cm. Accession 006728 exhibited minimum panicle length (18.58 cm) whereas accession 006511 showed maximum value for panicle length (38.7 cm). Range of number of spikelets panicle^{-1} varied from 95.0 to 362.0.

Maximum number of spikelets panicle^{-1} were displayed by the accession 006630 (362.0), followed by the accessions 006508 and 006511 with 267.0, accession 006509 with 272.0 and accession 006541 with 284.0 number of spikelets panicle^{-1}.

The accession 006783 showed minimum number of spikelets panicle^{-1} (95.0). Awn length among the rice genotypes varied from 0.94 to 6.92 cm. Minimum value for awn length (0.94 cm) was observed for the accession 006765 whereas maximum value of awn length (6.92 cm) was displayed by the accession 006642. Range of grain length among the rice genotypes varied from 5.6 to 10.2 mm.

The accession 006728 displayed minimum value of grain length (5.6 mm) whereas maximum value of grain length (10.2 mm) was observed for the accession 006505.

Grain width varied among the rice genotypes from 1.8 to 4.08 mm. Maximum value of grain width (4.08 mm) was recorded for the accession 006702, while the accession 006515 exhibited minimum value for grain width (1.8 mm) (Table 4).

Table 4. Mean values for panicle length (PL), spikelets panicle^{-1} (SPKP), awn length (AL), grain length (GL), grain width (GW), thousand grain weight (TGW), biological yield plot^{-1} (BY) and grain yield plot^{-1} (GY) of 83 accessions of rice.

Rice accessions	PAL	SPKP	AL	GL	GW	TGW (g)	BY	GY
	(cm)		(cm)	(mm)	(mm)		(kg)	(kg)
6505	37.00	180.0	2.10	10.20	2.20	29.2	3.0	0.17
6506	32.06	180.0	4.98	8.60	2.66	23.9	2.6	0.13
6508	30.96	267.0	3.44	9.70	2.98	29.2	4.0	0.92
6509	30.40	272.0	1.98	9.40	2.00	25.4	4.3	1.10
6511	38.70	267.0	5.20	9.20	2.68	30.8	4.2	0.90
6512	31.16	240.0	0.00	9.50	2.36	24.3	3.2	0.10
6514	30.22	227.0	2.22	8.70	2.02	24.0	5.2	0.30
6515	30.50	173.0	1.03	9.28	1.80	24.0	4.2	0.40
6517	29.40	237.0	1.76	9.20	2.72	24.5	3.2	0.40
6520	29.98	190.0	2.84	9.90	2.54	24.8	3.5	0.22
6522	32.96	226.0	3.98	9.00	3.10	23.6	2.5	0.32
6523	30.22	195.0	2.20	9.30	2.30	23.4	3.3	0.13
6525	31.00	172.0	4.58	8.82	2.92	25.9	3.3	0.54
6527	28.30	211.0	2.22	9.26	2.14	25.3	5.4	0.50
6536	24.96	195.0	2.32	8.82	2.88	25.5	4.4	0.28
6538	31.06	154.0	3.68	9.20	2.50	21.3	5.7	0.31
6541	32.58	284.0	2.92	9.40	2.60	25.3	4.6	0.90
6543	33.08	219.0	3.88	8.20	2.92	20.6	4.6	0.51
6549	29.62	133.0	2.74	10.00	2.78	24.3	5.7	0.41
6559	25.00	182.0	0.00	8.68	2.78	23.3	2.2	0.41
6560	26.74	129.0	2.46	9.30	3.00	28.7	2.2	0.39
6571	22.70	171.0	1.08	7.20	2.94	29.6	2.0	0.40
6581	22.54	161.0	3.90	9.00	3.18	23.9	2.5	0.50
6596	20.70	141.0	0.00	5.80	3.78	30.5	2.2	0.49
6612	25.98	157.0	5.64	9.36	2.90	31.2	3.3	0.71
6613	25.20	164.0	5.82	8.82	2.92	30.5	3.4	0.58
6616	27.40	127.0	4.92	9.16	3.10	22.6	2.7	0.50
6619	23.00	117.0	6.22	9.58	2.94	25.4	3.3	0.80
6620	24.80	210.0	6.26	9.00	3.14	34.9	2.7	0.61
6622	24.46	149.0	0.00	7.60	2.78	16.0	1.6	0.40
6624	27.00	175.0	4.80	9.14	2.96	25.4	2.5	0.32
6627	21.80	102.0	3.40	8.32	3.00	30.7	3.7	0.71
6629	26.54	205.0	6.22	9.56	2.98	22.1	3.1	0.53
6630	37.00	362.0	3.86	9.66	2.86	20.9	3.2	1.80
6633	24.40	149.0	3.88	8.32	2.88	25.1	2.7	0.10
6634	28.40	188.0	1.84	8.40	2.82	17.8	3.1	0.32
6640	24.44	166.0	4.66	9.30	2.86	27.5	3.6	0.50
6642	28.34	171.0	6.92	9.48	2.98	22.9	3.1	0.80
6650	25.68	122.0	5.90	9.20	3.00	30.2	3.5	0.31
6655	23.30	133.0	0.00	9.64	3.00	23.4	1.4	0.23
6663	26.06	163.0	0.00	9.40	2.96	27.1	1.5	0.42
6666	24.42	166.0	0.00	9.04	3.20	23.0	1.8	0.32

Table continued.....

Continue table 4. Mean values for panicle length (PL), spikelets panicle^{-1} (SPKP), awn length (AL), grain length (GL), grain width (GW), thousand grain weight (TGW), biological yield plot^{-1} (BY) and grain yield plot^{-1} (GY) of 83 accessions of rice.

Rice accessions	PAL (cm)	SPKP	AL (cm)	GL (mm)	GW (mm)	TGW (g)	BY (kg)	GY (kg)
6685	25.16	226.0	0.00	8.40	3.18	25.5	1.8	0.22
6697	26.96	262.0	0.00	8.60	3.40	22.3	1.2	0.10
6698	26.28	189.0	1.76	9.34	2.84	23.7	1.8	0.31
6699	26.56	191.0	0.00	9.40	3.40	24.2	2.3	0.35
6700	19.62	102.0	4.34	8.20	3.40	24.9	1.3	0.12
6701	21.40	149.0	0.00	8.70	3.04	15.6	1.6	0.12
6702	28.40	206.0	0.00	7.42	4.08	24.5	2.5	0.41
6703	23.06	182.0	4.18	9.00	2.94	25.6	2.1	0.20
6704	27.16	198.0	0.00	8.40	2.98	16.6	2.1	0.11
6706	27.52	213.0	0.00	8.60	3.00	18.8	2.0	0.21
6709	27.08	201.0	0.00	8.60	3.00	23.0	2.0	0.12
6710	26.50	175.0	0.00	9.20	3.04	32.1	1.8	0.20
6711	27.02	205.0	0.00	8.02	3.06	25.6	2.0	0.35
6716	27.20	225.0	5.76	8.40	3.00	28.5	3.1	0.70
6718	26.86	180.0	1.18	7.48	3.04	26.5	2.5	0.60
6720	25.02	194.0	0.00	7.62	3.46	23.3	2.2	0.62
6728	18.58	184.0	4.90	5.60	3.20	23.3	2.7	0.54
6729	24.98	160.0	0.00	9.20	2.94	25.3	2.5	0.40
6731	30.00	192.0	4.42	9.80	3.60	15.8	2.1	0.44
6734	25.50	208.0	1.56	8.40	3.00	26.6	2.7	0.51
6737	25.80	168.0	0.00	9.60	2.96	27.0	2.2	0.20
6764	27.20	174.0	2.18	9.60	2.96	19.2	0.9	0.10
6765	28.16	182.0	0.94	7.20	3.10	23.4	2.9	0.24
6767	29.20	170.0	1.68	8.60	3.00	23.2	1.4	0.12
6768	32.86	260.0	5.38	7.74	3.20	24.5	1.7	0.80
6769	33.18	203.0	2.34	9.00	3.80	17.6	1.9	0.30
6771	21.46	148.0	0.00	8.50	2.98	25.2	1.9	0.50
6772	31.50	175.0	2.88	8.38	3.00	22.6	2.7	0.32
6774	24.60	171.0	0.00	8.80	2.94	18.0	2.4	0.50
6778	31.62	214.0	4.76	7.20	3.20	41.4	1.9	0.32
6781	27.22	133.0	0.00	7.20	3.40	22.2	1.8	0.32
6783	26.84	95.0	2.04	8.40	2.80	23.0	1.2	0.31
6784	27.36	199.0	1.32	9.20	3.20	21.4	2.5	0.30
6787	27.34	197.0	1.94	8.30	3.40	26.6	2.2	0.48
6789	31.70	161.0	2.12	8.60	3.40	26.9	2.4	0.40
6795	29.46	205.0	0.00	7.40	3.40	25.5	2.4	0.61
6797	35.60	215.0	2.72	9.40	2.98	19.2	2.3	0.41
6799	20.80	156.0	0.00	8.20	3.32	27.5	1.8	0.50
6807	34.96	241.0	1.22	8.40	3.00	19.5	2.5	0.23
6811	26.30	131.0	0.00	7.60	3.20	20.4	1.8	0.31
Mean	27.7	186.9	2.30	8.70	3.00	24.5	2.7	0.40
Variance	16.2	1998.5	4.42	0.74	0.14	18.7	1.08	0.07
Standard error	0.44	4.91	0.23	0.09	0.04	0.47	0.11	0.03

Thousand grain weight among the rice genotypes ranged from 15.6 to 41.4 g. The accession 006701 showed minimum 1000-grain weight (15.6 g) while accession 006778 showed maximum (41.4 g), followed by the accessions 006620 (34.9 g), 006710 (32.1 g) and 006612 (31.2 g). Biological yield among the rice genotypes varied from 0.9 to 5.7 kg plot^{-1}. The accessions 006538 and 006549 gave maximum biological yield (5.7 kg plot^{-1}), followed by the accessions 006527 (5.4 kg plot^{-1}) and 006514 (5.2 kg plot^{-1}), respectively. Minimum biological yield (0.9 kg plot^{-1}) was observed for the accession 006764**.**

Range of grain yield among the rice genotypes was from 0.1 to 1.8 kg plot^{-1}. Accessions 006512, 006633, 006697, 006764 showed minimum grain yield (0.1 kg plot^{-1}). Maximum grain yield (1.8 kg plot^{-1}) was observed for the accession 006630, followed by the accessions 006509, 006508, 006511 and 006541 which showed grain yield of 1.1, 0.92 and 0.9 kg plot^{-1}, respectively (Table 4).

Cluster analysis

On the basis of cluster analysis for qualitative traits, five clusters can be identified at a dissimilarity level of 7.47 (Fig. 1).

The first cluster comprised accessions 006630 and 006509, while the second cluster consisted of accessions 006633, 006768, 006616, 006764, 006520, 006619, 006613, 006642, 006511, 006581 and 006508. The third cluster contained accessions 006789, 006767, 006787, 006797, 006650, 006778, 006627, 006640, 006783, 006778, 006629, 006624, 006811, 006734, 006795, 006769, 006634, 006543, 006710, 006622, 006549, 006731, 006200, 006612, 006538, 006536, 006514, 006784, 006512 and 006506. The fifth cluster consisted of accessions 006596, 006702, 006571, 006560 and 006505 while remaining accessions were included in the fourth cluster. At dissimilarity level of 6.22 six clusters were identified for quantitative traits (Fig. 2). The first cluster contained accession 006630 while the second cluster comprised of accessions 006541, 006509, 006511 and 006508. The third cluster consisted of accessions 006527 and 006523; fourth cluster 006622 and fifth cluster comprised of accessions 006728 and 006596. The remaining accessions were included in the sixth cluster.

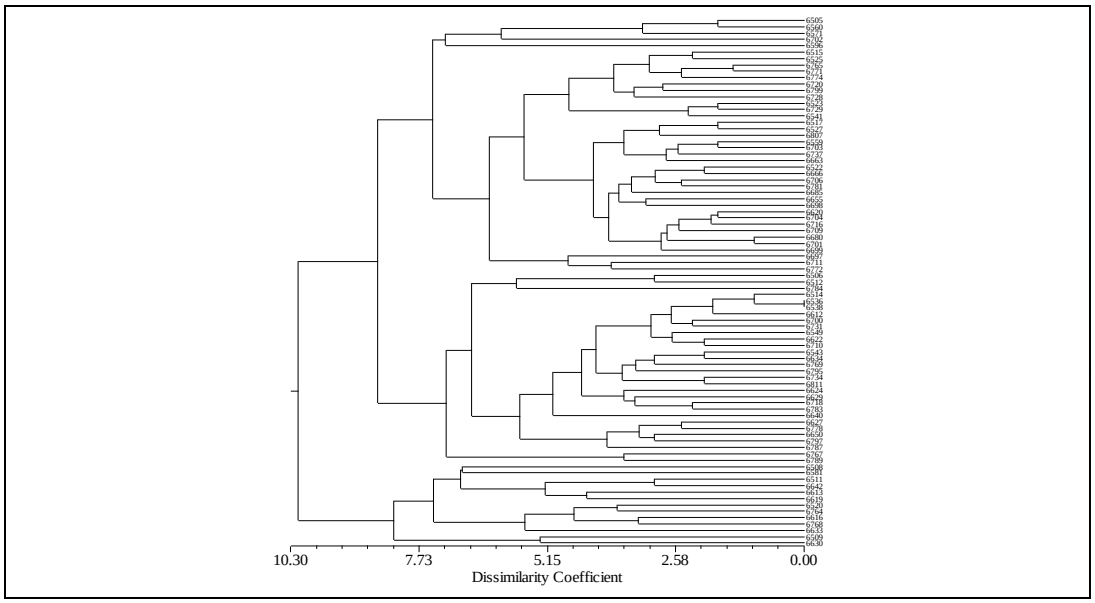

Fig 1. Dendrogram of rice accessions based on dissimilarity matrix of euclidean distances for qualitative traits.

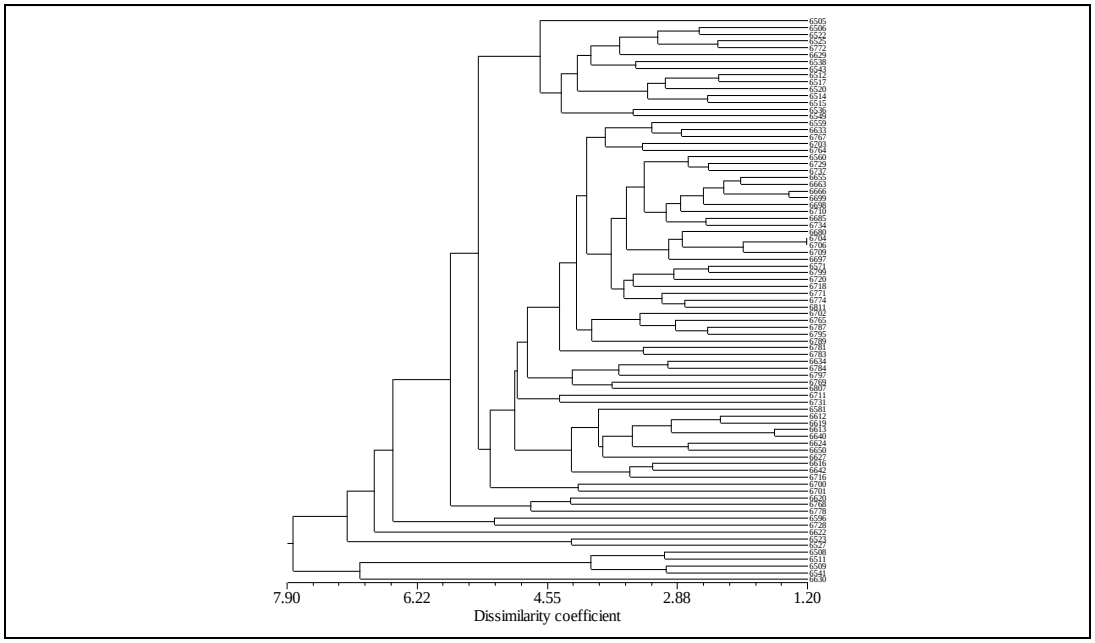

Fig 2. Dendrogram of rice accessions based on dissimilarity matrix of euclidean distances for quantitative traits.

Discussion

Morphological characterization of rice accessions is a fundamental breeding procedure and it provides basic information of the germplasm for its future use (Lin, 1991). Yawen *et al*. (2003) studied 5285 accessions of indigenous rice in China for genetic diversity and found that the accessions are genetically variable at morphological level. Patra and Dhua (2003) studied upland rice genotypes for morphological diversity in India while Fukuoka *et al*. (2006) analyzed land race populations of rice and assessed genetic variability among these genotypes for morphological traits in Vietnam. The rice germplasm used in the present study displayed variability for all the studied traits. Zafar *et al*. (2004) also observed reasonable amount of genetic variation for different traits. Kaul and Kumar (1982), Das *et al*. (1992) and Mall *et al*. (2005) also reported that the rice genotypes used in the study have sufficient amount of genetic variability for different traits of interest. The findings of Nascimento *et al*. (2012) are also in accordance and found that the studied accessions are genetically variable for panicle length, number of panicles plant^{-1}, spikelets panicle^{-1}, 1000-grain weight and production plant^{-1}. Veasey *et al*. (2008) also found significant differences and high variability for 11 populations of *O. glumaepatula*, mainly for the characters number of tillers, plant height at flowering, leaf length and width, culm length, days to heading, panicle number, panicle height, flag leaf length, spikelet length and awn length. Variation in the mean values of spikelets panicle^{-1} and panicle length has been previously reported by Mall *et al*. (2005). Cluster analysis in the present study separated relatively diverse genotypes and is compatible with the findings of Veasey *et al*. (2008) and Thenmozhi and Rajasekaran (2013). Thenmozhi and Rajasekaran (2013) identified nine clusters of 40 rice accessions at 86% similarity level.

Conclusions

Sufficient genetic variability was observed among the studied genotypes for various morphological traits. On the basis of cluster analysis for qualitative traits, five clusters were identified at a dissimilarity level of 7.47. At dissimilarity level of 6.22 six clusters were identified for quantitative traits. The accession 006630 manifested maximum values for spikelets panicle^{-1} and grain yield plot^{-1}. The accessions 006505 and 006702 showed excellence for grain length and grain width. The accession 006511, 006778 and 006549 showed better performance for panicle length, 1000-grain weight and biological yield. The accessions 006630,006549, 006511, 006778, 006505 and 006702 showed excellence for most of the yield and its associated traits and are recommended for onward use in rice breeding programs.

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