Assessing genetic divergence among rice germplasm based on qualitative traits

Abdul Qayyum1, Sohail Ahmad Jan2*, Azhar Hussain Shah2, Muniba Fida Abbasi1, Ishtiaq Hassan1, Muhammad Ishaq Ibrahim1, Mohammad Ilyas3 and Malik Ashiq Rabbani4

1. Department of Genetics, Hazara University Mansehra, Khyber Pakhtunkhwa-Pakistan
2. Department of Biotechnology, Hazara University Mansehra, Khyber Pakhtunkhwa-Pakistan
3. Department of Agriculture, Hazara University Mansehra, Khyber Pakhtunkhwa-Pakistan
4. Plant Genetic Resources Program, Bio-Resources Conservation Institute, National Agricultural Research Centre (NARC), Islamabad- Pakistan

*Corresponding author’s email: sjan.parc@gmail.com

Abstract

Rice is cultivated worldwide under wide range of ecological conditions and is a daily staple food crop for more than half of world’s population. The morphological characterization is usually performed to select better genotypes. This type of characterization identifies elite genotypes based on qualitative as well as quantitative traits. In present study 45 diverse rice germplasm were screened for important qualitative traits. The experiment was designed as augmented and important qualitative traits including leaf related traits, lodging, panicle shape, seed coat color and awn related traits were studied. Significant variations were observed for all the examined traits. Majority of genotypes showed resistance to lodging, and only few showed slight lodging. The brown seed coat color was found dominant among genotypes. All the studied traits included in the study were found useful for the identification of improved genotypes and these traits have direct relation with yield or yield related traits. However, to elucidate the particular responsible genes for these traits, further molecular based studies are recommended.

Keywords: Genetic variability; Lodging; Morphological traits; Rice; Qualitative traits

Introduction

The rice belongs to important plant family Poaceae. The 22 species of rice has been identified, two species (Oryza sativa and Oryza glaberrima) are widely cultivated than rest ones [1]. It is the one of the major energy source for the world population and key contributor to world agriculture sector [2]. Oryza sativa cultivated worldwide, including Asia, North and South America, throughout Europe, Middle Eastern and African countries. Oryza glaberrima is grown in many parts of Africa due to higher yields [3]. Its cultivars are divided into three main types including Indica, Javanica and Japonica. The japonica grains are shorter and broaden as compared to Indica grain and become soft and sticky when cooked [4].

Abiotic stresses affect both the morpho-biochemical, physiological and molecular
processes of crop species [5, 6]. The rice crop has been affected by both the biotic and abiotic environmental extremes. The low temperature stress decreases its yield many times. The japonica type shows resistance to low temperature (15 to 20°C) as compared to other two types. However, low temperatures (below 18°C) at night time produce sterile pollens [7]. The bacterial blight disease is one of the key diseases that significantly affect both qualitative and quantitative traits including yield [8].

Agro-morphological diversity studies play key role in the identification of improved genotypes for both qualitative and quantitative traits and to differentiate both local and exotic germplasm [9-13]. It also helps us to screen best genotypes among large population that can be further characterized in different location for both preliminary and advanced yield trails [14-17]. The rice genotypes can be characterized through various qualitative and quantitative traits like growth parameters, culms color, leaf blades types, grain color, height, diseases resistance and many more [18]. The panicle traits are important to measure genetic diversity in rice for both quantitative and qualitative traits [19, 20]. Ismaeel et al. [21] characterized 83 rice germplasm for 15 qualitative and 8 quantitative traits and recorded maximum variability among genotypes. Moukoumbi et al. [22] evaluated 78 rice genotypes for important qualitative traits including plant vigor, color of basal leaf sheath, and type of flag leaf, panicle exertion and habit of culm and recorded maximum diversity for all studied traits. In present study 45 diverse rice genotypes were evaluated for important qualitative traits and to identify climate smart genotypes for future use in rice breeding program.

**Materials and methods**

**Plant materials and field layout**

The current research work was conducted in Plant Genetic Resources Institute (PGRI), National Agricultural Research Centre (NARC), Islamabad, Pakistan. The seeds of 45 germplasm (Table 1 & 2) were sown in field by using augmented design. The row length was 4.5 meters, row to row distance 30 cm and plant to plant distance was 15 cm. Proper water treatment was applied and recommended cultural practices were followed from germination to till maturity. The following qualitative traits were measured at different growth stages.

1. **Flag leaf angle**

Four different types of flag leaves were studied like descending, horizontal, erect and semi-erect.

2. **Leaf shape**

The three different shapes of leaf (droopy, erect and semi-erect) were observed for 45 rice genotypes.

3. **Leaf appearance**

Three different types of leaf (narrow, broaden and intermediate types) were checked for all tested genotypes.

4. **Lodging**

Three standard lodging categories (slight, heavy or no lodging) were used to note the different lodging ability among genotypes.

5. **Panicle type**

The diversity in panicle types i.e. open type, compact and intermediate types were recorded.

6. **Panicle exertion**

The 5 different panicle exertion types (well, partly, just, moderate and enclosed) of rice were noted.

7. **Awn type**

The rice genotypes were divided for different awn related codes (awned, awnless and awnlated).

8. **Awn color**

Awn color (white, light and dark brown or red-black).

9. **Seed coat color**

The seed coat color is one the important qualitative traits. The rice genotypes were screened for different types of seed coat
colors (white, brown, light/ dark/ red/ speckled/ blackish brown).

Results and discussion
Morphological characterization of rice genotypes through qualitative traits
In present study 45 diverse rice germplasm were evaluated for nine important qualitative traits. The genotypes which belong to tropical, subtropical and temperate zones were analyzed under similar environmental condition at Plant Genetic Resources Institute (PGRI), National Agricultural Research Centre (NARC), Islamabad, Pakistan. All the studied genotypes showed considerable variability under similar environmental conditions. The data of following nine qualitative traits were recorded from five random selected samples.

In present study maximum diversity was observed among genotypes for flag leaf angle. Maximum genotypes (26) showed erect angle, 17 were semi-erect and 2 had horizontal type. Similar type of variability was observed for leaf shape trait. The leaf shape trait play key role in photosynthesis and the erect and semi-erect are considered more important. In our study, majority of genotypes showed erect and semi-erect leaf shape. In addition the different types of leaf appearance were observed in all 45 tested genotypes. Maximum genotypes (34) showed intermediate appearance, and 7 genotypes had broad leaves. The remaining genotypes were found narrow types (Table 1). Lodging trait is one of the key traits that have direct impact on final yield. In present study the lodging was observed visually and majority of genotypes (37) showed resistance to lodging, 2 genotypes showed maximum lodging. While 6 genotypes showed slight lodging (Table 1). The rice genotypes were characterized for compact, open and intermediate panicle types. Maximum genotypes (24) showed compact type. While, remaining 21 genotypes have intermediate appearance (Table 1). For panicle exertion trait, maximum genotypes (36) were found moderately and well exerted (Table 2).

Awn is one of the key qualitative traits that help in the identification of genotype and also protect grain from bird or other pest attack. In this study 26 genotypes were found awnless and 19 were awned. For awned panicle the brown color were predominantly observed (Table 2).

In current study maximum divergence was observed among genotypes for seed coat color. Majority of genotypes (23) showed light brown color. 20 genotypes had brown seed coat color, while other 2 genotypes had dark brown color (Table 2). Rice is one of the key cash crops of Pakistan and cultivated as one of the major crop. Therefore, Pakistan needs to further expand its export and improve its local consumption by improving grain quality as per the consumer demand around the globe and in the country. Agro-morphological based diversity helps in the identification of elite genotypes. In present study various qualitative traits of 45 rice genotypes were evaluated. High level of variability was recorded for all nine qualitative traits (Table 1 & 2). In previous studies Lei et al. [20] recorded maximum diversity in panicle related traits in Kam fragrant glutinous rice genotypes. They recorded maximum variability (CV >50%) In grain, husk and awn color. They observed 86 awned genotypes out of 95 samples. In addition they noted maximum milky green and light green grain color genotypes. Moukoumby et al. [22] also recorded higher diversity in basal leaf sheath color. They recorded maximum green color basal sheath genotypes. Similarly, Meshram et al. [23] noted dark green seed color and basal leaf sheath color rice genotypes. Jan et al. [24, 25] recorded maximum morphological and protein based variability for seed color trait of B. rapa genotypes (brown, yellow and Toraia types). In similar study, Ahmed et al. [26] evaluated 40 Balm rice landraces of Bangladesh for important qualitative traits and recorded maximum (35, 60 and 87%) colorless leaf sheath, awnless grain and green leaf blade genotypes, respectively.
Table. 1. Qualitative characters i.e. flag leaf angle, leaf shape, leaf appearance, lodging and panicle type of 45 rice genotypes

| S. No | Genotype | Flag leaf angle | Leaf shape | Leaf appearance | Lodging | Panicle type |
|-------|----------|----------------|------------|----------------|---------|-------------|
| 1     | 19-a     | Erect          | Erect      | Narrow         | No      | Intermediate |
| 2     | 24-b     | Erect          | Semi erect | Intermediate   | No      | Compact     |
| 3     | 97-b     | Erect          | Semi erect | Intermediate   | No      | Compact     |
| 4     | 108R     | Erect          | Semi erect | Intermediate   | Slight  | Compact     |
| 5     | 112L     | Erect          | Semi erect | Narrow         | Slight  | Compact     |
| 6     | 120      | Semi erect     | Erect      | Intermediate   | No      | Compact     |
| 7     | 127      | Erect          | Erect      | Intermediate   | No      | Compact     |
| 8     | 129-a    | Erect          | Semi erect | Narrow         | No      | Compact     |
| 9     | 130-b    | Erect          | Semi erect | Intermediate   | No      | Compact     |
| 10    | 131-2    | Erect          | Erect      | Intermediate   | No      | Compact     |
| 11    | 133M     | Erect          | Erect      | Intermediate   | No      | Compact     |
| 12    | 159      | Erect          | Semi erect | Intermediate   | No      | Intermediate |
| 13    | 163      | Erect          | Semi erect | Intermediate   | No      | Compact     |
| 14    | 164-a    | Semi erect     | Semi erect | Intermediate   | Slight  | Intermediate |
| 15    | 164-b    | Erect          | Erect      | Intermediate   | No      | Compact     |
| 16    | 166-b    | Semi erect     | Semi erect | Intermediate   | No      | Compact     |
| 17    | 166-c    | Semi erect     | Semi erect | Intermediate   | No      | Compact     |
| 18    | 169      | Semi erect     | Semi erect | Broad          | No      | Compact     |
| 19    | 187-a    | Erect          | Droopy     | Intermediate   | No      | Intermediate |
| 20    | 187-b    | Semi erect     | Erect      | Broad          | Heavy   | Compact     |
| 21    | MR-13-3  | Erect          | Erect      | Broad          | No      | Intermediate |
| 22    | NPT-156  | Erect          | Erect      | Intermediate   | Slight  | Compact     |
| 23    | 101-213-216 | Erect         | Semi erect | Broad          | No      | Compact     |
| 24    | 102-205-314 | Erect         | Semi erect | Intermediate   | No      | Intermediate |
| 25    | 103-208-326 | Semi erect    | Droopy     | Broad          | Heavy   | Compact     |
| 26    | 104-207-309 | Semi erect    | Erect      | Broad          | Slight  | Compact     |
| 27    | 107-217-313 | Semi erect    | Semi erect | Intermediate   | Slight  | Intermediate |
| 28    | 108-223-301 | Erect         | Droopy     | Intermediate   | No      | Compact     |
| 29    | 109-226-302 | Erect         | Erect      | Broad          | No      | Compact     |
| 30    | 111-222-308 | Erect         | Erect      | Intermediate   | No      | Intermediate |
| 31    | 112-224-320 | Semi erect    | Erect      | Intermediate   | No      | Intermediate |
| 32    | 113-225-310 | Semi erect    | Semi erect | Intermediate   | No      | Intermediate |
| 33    | 114-227-310 | Semi erect    | Semi erect | Intermediate   | No      | Intermediate |
| 34    | 115-215-317 | Semi erect    | Erect      | Intermediate   | No      | Intermediate |
| 35    | 116-211-303 | Semi erect    | Erect      | Intermediate   | No      | Intermediate |
| 36    | 117-228-311 | Semi erect    | Erect      | Intermediate   | No      | Compact     |
| 37    | 119-203-305 | Semi erect    | Semi erect | Intermediate   | No      | Compact     |
| 38    | 120-218-322 | Semi erect    | Erect      | Intermediate   | No      | Intermediate |
| 39    | 123-214-319 | Erect         | Semi erect | Intermediate   | No      | Intermediate |
| 40    | 124-204-306 | Erect         | Erect      | Intermediate   | No      | Intermediate |
| 41    | 166-221-323 | Erect         | Semi erect | Intermediate   | No      | Intermediate |
| 42    | HH2-11-Y6-Y1 | Erect         | Semi erect | Intermediate   | No      | Intermediate |
| 43    | IR6      | Droopy         | Semi erect | Intermediate   | No      | Intermediate |
| 44    | JP5      | Droopy         | Erect      | Intermediate   | No      | Intermediate |
| 45    | Super-Basmati | Erect       | Erect      | Narrow         | No      | Intermediate |
Table 2. Qualitative characteristic i.e. panicle exertion, awning, awn color, seed coat color of 45 rice genotypes

| S. No | Genotype | Panicle Exertion | Awn | Awn Color | Seed Coat Color |
|-------|----------|------------------|-----|-----------|-----------------|
| 1     | 19-a     | Enclosed         | Awned | Brown | Brown          |
| 2     | 24-b     | Moderate         | Awnless | Awnless | Brown          |
| 3     | 97-b     | Moderate         | Awned | Brown | Brown          |
| 4     | 108R     | Partially        | Awned | Brown | Brown          |
| 5     | 112L     | Moderate         | Awned | Light brown | Brown          |
| 6     | 120      | Moderate         | Awnless | Awnless | Light Brown    |
| 7     | 127      | Partially        | Awned | Brown | Brown          |
| 8     | 129-a    | Moderate         | Awnless | Awnless | Light Brown    |
| 9     | 130-b    | Well             | Awned | Brown | Brown          |
| 10    | 131-2    | Moderate         | Awned | Brown | Brown          |
| 11    | 133M     | Moderate         | Awned | Light brown | Brown          |
| 12    | 159      | Moderate         | Awned | Light brown | Brown          |
| 13    | 163      | Partially        | Awned | Brown | Light Brown    |
| 14    | 164-a    | Partially        | Awned | Brown | Light Brown    |
| 15    | 164-b    | Enclosed         | Awned | Brown | Light Brown    |
| 16    | 166-b    | Well             | Awned | Dark brown | Light Brown    |
| 17    | 166-c    | Moderate         | Awned | Light brown | Light Brown    |
| 18    | 169      | Moderate         | Awnless | Awnless | Light Brown    |
| 19    | 187-a    | Moderate         | Awned | Brown | Dark Brown     |
| 20    | 187-b    | Moderate         | Awned | Brown | Dark Brown     |
| 21    | MR-13-3  | Moderate         | Awned | Brown | Brown          |
| 22    | NPT-156  | Well             | Awnless | Awnless | Brown          |
| 23    | 101-213-216 | Well     | Awnless | Awnless | Brown          |
| 24    | 102-205-314 | Partially       | Awnless | Awnless | Light Brown    |
| 25    | 103-208-326 | Partially       | Awnless | Awnless | Light Brown    |
| 26    | 104-207-309 | Well           | Awnless | Awnless | Light Brown    |
| 27    | 107-217-313 | Moderate       | Awnless | Awnless | Light Brown    |
| 28    | 108-223-301 | Well           | Awnless | Awnless | Light Brown    |
| 29    | 109-226-302 | Well           | Awnless | Awnless | Light Brown    |
| 30    | 111-222-308 | Moderate      | Awnless | Awnless | Brown          |
| 31    | 112-224-320 | Moderate      | Awnless | Awnless | Light Brown    |
| 32    | 113-225-310 | Partially     | Awnless | Awnless | Brown          |
| 33    | 114-227-310 | Well          | Awnless | Awnless | Light Brown    |
| 34    | 115-215-317 | Moderate      | Awnless | Awnless | Brown          |
| 35    | 116-211-303 | Well          | Awnless | Awnless | Light Brown    |
| 36    | 117-228-311 | Well          | Awnless | Awnless | Brown          |
| 37    | 119-203-305 | Enclosed     | Awnless | Awnless | Brown          |
| 38    | 120-218-322 | Moderate      | Awnless | Awnless | Light Brown    |
| 39    | 123-214-319 | Well          | Awnless | Awnless | Light Brown    |
| 40    | 124-204-306 | Moderate      | Awnless | Awnless | Light Brown    |
| 41    | 166-221-323 | Well          | Awned | Brown | Light Brown    |
| 42    | HH2-11-Y6-Y1 | Well     | Awnless | Awnless | Brown          |
| 43    | IR6      | Moderate        | Awnless | Awnless | Light Brown    |
| 44    | JP5      | Partly          | Awned | Light Brown | Brown          |
| 45    | Super-Basmati | Partly     | Awned | Light Brown | Brown          |

Conclusion
Breeding is important practice for the improvement of rice germplasm. Genetic diversity study based on qualitative traits help in the identification of novel genotypes. Maximum diversity was recorded among
studied genotypes for key qualitative traits having direct relationship with yield. However a more in depth studies are needed to characterize these genotypes through biochemical and molecular markers.

**Author’s contributions**
Wrote the manuscript: proof reading and formatting: SA Jan, I Hassan, AH Shah & M Ilyas, performed experimental work: A Qayyum, MF Abbasi, MI Ibrahim & SA Jan, conceived and designed the experiments: MA Rabbani.

**References**
1. Vaughan DA & Morishima H (2003). Biosystematics of the genus *Oryza*. Rice origin, history, technology and production. John Wiley and sons Inc, Hoboken, New Jersey. 27-65.
2. Nachimuthu VV, Muthurajan R, Duraialaguraja S, Sivakami R, Pandian BA, Ponniah G & Sabariappan R (2015). Analysis of population structure and genetic diversity in rice germplasm using SSR markers: an initiative towards association mapping of agronomic traits in *Oryza sativa*. *Rice* 8(1): 30
3. Linares OF (2002). African rice (*Oryza glaberrima*) history and future potential. Proceeding of the National Academy of Science of the United State of America. 99:16360-16365.
4. Ahn S & Tanksley SD (1993). Comparative linkage maps of the rice and maize genomes. *Proc Natl Acad Sci USA* 90: 7980-7984.
5. Jan SA, Shinwari ZK & Rabbani MA (2016). Morpho-biochemical evaluation of *Brassica rapa* sub-species for salt tolerance. *Genetika* 8(1): 323 -338.
6. Jan SA, Bibi N, Shinwari ZK, Rabbani MA, Ullah S, Qadir A & Khan N (2017). Impact of salt, drought, heat and frost stresses on morpho-biochemical and physiological properties of *Brassica* species: An updated review. *J Rural Dev Agri* 2(1): 1-10.
7. McDonald DJ (1994). Temperate rice technology for the 21st century. *Aust J Exp Agric* 34: 877-888.
8. Ibrahim MI, Abbasi FM. & Khursid H (2016). Genotyping of rice germplasm for bacterial blight resistant gene (*Xa7*). *Int J Biosci* 8(4): 28-35.
9. Jan SA, Shinwari ZK, Rabbani MA, Niaz IA & Shah SH (2017). Assessment of quantitative agro-morphological variations among *Brassica rapa* diverse populations. *Pak J Bot* 49(2): 561-567.
10. Khan Q, Khan AS, Khurshid H &Arif M (2016). Exploring durable genetic resistance against leaf rust through phenotypic characterization and LR34 linked STS marker in wheat germplasm. *Biosci J* 32 (4): 986-998.
11. Jan SA, Shinwari ZK, Rabbani M.A., Khurshid H & Ahmad N (2017). Agromorphological studies revealed broad genetic structure of spatially distributed *Brassica rapa* populations. *Pak J Bot* 49(6): 2309-2312.
12. Saleem N, Khan SA & Rabbani MA (2017). Multivariate based variability within diverse Indian Mustard (*Brassica juncea* L.) genotypes. *Open J Gen* 7: 69-83.
13. Jan, SA, Shinwari ZK, Ali N & Rabbani MA (2018). Morphometric analysis of *Brassica Carinata* elite lines reveals variation for yield related traits. *Pak J Bot* 50(4): 1521-1524.
14. Nawaz S, Chaudhry Z, Bibi A, Jan SA, Bibi K & Asma (2015). Agromorphological and Molecular Characterization of Local Tomato Cultivars Grown in Pakhal Region of Pakistan Using RAPD Markers. *Middle East J Sci Res* 23(5): 856-860.C
15. Arif M, Khurshid H, Siddiqui SU, Jatoi SA & Ghafoor A (2015). Estimating spatial population structure through quantification of Oil content and phenotypic diversity in Pakistani Castor
Bean (*Ricinus communis* L.) germplasm. *Sci Technol Develop* 34(3): 147-154.

16. Ibrar D, Khan MA, Mahmood T & Ahmad R (2018). Determination of heterotic groups among sunflower accessions through morphological traits and total seed storage proteins. *Inter J Agric Biol* 20(9): 2025-2031.

17. Baig D, Khurshid H & Nawaz N (2018). Evaluation of Soybean genotypes for yield and other economically important traits under rainfed condition. *Pure Appl Biol* 7(1): 1-7.

18. Takahashi N (1984). Seed germination and seedling growth. Chapter 3. Biology of rice. Amsterdam. 7: 71-88.

19. Wu Y, Huang M, Tao X, Guo T, Chen Z & Xiao W (2016). Quantitative trait loci identification and meta-analysis for rice panicle-related traits. *Mol Genet Genomics* 291(5):1–14.

20. Lei Q, Zhou J, Zhang W, Luo J, Wu K & Long C (2018). Morphological diversity of panicle traits in Kam fragrant glutinous rice (*Oryza sativa*). *Genet Resour Crop Evol* 65(3): 775-786.

21. Ismaeel M, Shah SMA, Nawaz A & Khan A (2016). Morphological diversity of 83 rice accessions for qualitative and quantitative parameters. *Int J Biosci* 9(3): 158-169.

22. Moukoumbi YD, Sié M, Vodouhe R, N’dri N. & Ahanchede A (2011). Assessing phenotypic diversity of interspecific rice varieties using agromorphological characterization. *J Plant Breed Crop Sci* 3(5): 74-86.

23. Meshram P, Bhandarkar S, Shrivas Y, Nair SK, Ojha GC & Pachauri AK (2017). Assessment of genetic variability for quantitative and qualitative traits in Rice Germplasm Accessions (*Oryza sativa* L.). *Bull Env Pharmacol Life Sci* 6(S11): 76-83.

24. Jan SA, Shinwari ZK & Rabbani MA (2016). Agro-morphological and physiological responses of *Brassica rapa* ecotypes to salt stress. *Pak J Bot* 48(4): 1379-13.

25. Jan SA, Shinwari ZK, Rabbani, MA & Ilyas M (2017). Comparison of electrophoretic protein profiles of *Brassica rapa* sub-species brown sarson through SDS-PAGE method. *Genetika* 49(1): 95- 104.

26. Ahmed MS, Bashar MK & Shamsuddin AKM (2016). Study of Qualitative Characters of *Balam* Rice (*Oryza sativa* L.) Land Races of Bangladesh. *Rice Genomics Genet* 7(1): 1-8.