INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2004/06–2–335–339
http://www.ijab.org

Phenotypic Divergence for Agro-Morphological Traits among Landrace Genotypes of Rice (*Oryza sativa* L.) from Pakistan

NABEELA ZAFAR, SUMMAIRA AZIZ AND SHAHID MASOOD†
Department of Biological Sciences, Quaid- I- Azam University, Islamabad–Pakistan
†*Plant Genetic Resource Institute, NARC Islamabad, Pakistan–Pakistan*
Corresponding author's e-mail: swat2011@hotmail.com

ABSTRACT

Landrace genotypes of rice collected from various parts of Pakistan were evaluated for seven quantitative and eight qualitative characters. A significant amount of genetic variation was displayed for most of the traits examined. The coefficient of variation was more than 10% for all the characters with the exception of grain length. Compared with the modern cultivars, the landrace genotypes were, on average, later in heading and maturity but had lower values for panicle and grain length. Days to heading was positively correlated with maturity (r = 0.838) and grain length (r = 0.452). Plant height showed positive and significant correlation with panicle length (r = 0.452) indicating the importance of plant height in improving panicle length. Seven accessions with best performance for individual character were identified. To exploit their genetic potential, these genotypes can beneficially be used in the breeding programs.

Key Words: *Oryza sativa* L.; Landrace genotypes; Genetic diversity; Pakistan

INTRODUCTION

Rice is the world's most important crop and a major source of nutrition for about two-thirds of mankind (Vaughan *et al*., 2003). More than 90% of the world's rice is grown and consumed in Asia where 60% of the earth's population live (Khush, 1997). In Pakistan, besides its importance as a food crop, about 23% of the total foreign exchange earnings is shared by rice and thus called as "Golden grain of Pakistan"(Shah *et al*., 1999). Rice production needs to be increased to keep pace with the growing population, however, its productivity is affected by several biotic and abiotic stresses. The genetic diversity for these stresses is limited in the current rice cultivars. There is an urgent need to broaden the genetic base of this important crop by introgressing genes from diverse sources. Landrace genotypes, wild and weedy relatives are an important source of useful genes.

A large number of germplasm accessions have been collected from various parts of Pakistan and maintained in the gene bank of Plant Genetic Resources Institute (PGRI) at National Agricultural Research Centre (NARC), Islamabad. The adequate characterization and evaluation is a prerequisite both for the effective management and use of plant germplasm in breeding programs. Until the collected germplasm in the gene bank is properly evaluated and its attributes are made available to the breeders, it has little practical value.

Accurate assessment of the levels and patterns of genetic diversity can be invaluable in crop breeding for diverse applications including (1) analysis of genetic variability in landrace genotype and cultivars (Cox *et al*., 1986), (2) identifying diverse parental combinations to create segregating progenies with maximum genetic variability for further selection (Barret & Kidwell, 1998), and (3) introgressing desirable genes from diverse germplasm into the available genetic base (Thompson *et al*., 1998). This paper reports on the phenotypic diversity available for 15 characters in 124 landrace genotypes of rice collected from various parts of Pakistan.

MATERIALS AND METHODS

A total of 124 accessions of rice collected from Punjab, Sindh, NWFP, Balochistan, Northern areas and Azad Kashmir were taken from the gene bank of PGRI, NARC Islamabad. The material was planted on sixth of June 2000 using augmented design and evaluated was for various traits of interest under field condition at NARC. This center is situated at 33°42 N latitude and 73°08 E longitudes at an altitude of 540 masl.

Nursery was raised in beds and transplanted in the field after a month on 10 July 2000. Four commercial rice cultivars (Basmati 370, Basmati 385, Super Basmati and JP-5) were used as check for comparison. The observations were recorded in accordance with IBPGR and IRRI descriptor. Quantitative data included days to heading, days to maturity, plant height, panicle length, productive tillers per plant, grain length and 100-grain weight and qualitative data included panicle type, awn, leaves pattern, panicle exsertion, secondary branches per panicle, ligule color, auricle color, and seed coat color.

Simple statistics (means, ranges, standard deviation and coefficient of variation) was calculated to have an idea of the level of genetic diversity. Frequency distributions were computed to categorize the genotypes into different classes. Correlation coefficients were also calculated among various characters.

RESULTS AND DISCUSSION

Basic statistics for days to heading, days to maturity, plant height, panicle length, number of productive tillers per plant, grain length and 100-grain weight is presented in Table I. A reasonable amount of genetic variation was displayed for the traits evaluated. Grain length was the only character with C.V values less than 10%. However, most traits have C.V values above 10 % and as high as 31.29% for the number of tillers per plant. Frequency distributions for six traits are presented in Fig.1. Table II show the comparison of commercial varieties with land races. These can be used to identify phenotypically divergent sources for traits of interest in breeding programs.

Days to heading. It exhibited high range and coefficient of variation for this trait was 11.82. Almost 50% of the lines fall in the range of 86-100 days (Fig. 1), whereas few late accessions were also identified. Pak 3389 was the one, which had minimum value for days to heading i.e. 72 days. Fagade *et al*. (1987) recorded days to heading in Faro 38 about 72 days and recommended it for dry upland environments as it was high yielding and resistant to diseases and drought. Katsuta *et al*. (1996) observed that in two landraces, Nali and Byene belonging to Chitral district had days to flowering ranging from 70 to 102 days and 62 to 75 days respectively. Shah *et al*. (1999) tested eight rice genotypes and found KS-282 with 57 days to 50% flowering. He further stated that the opening of the spikelets depend primarily on the prevailing atmospheric

Fig. 1. Frequency distribution of six quantitative traits in landrace genotypes of rice

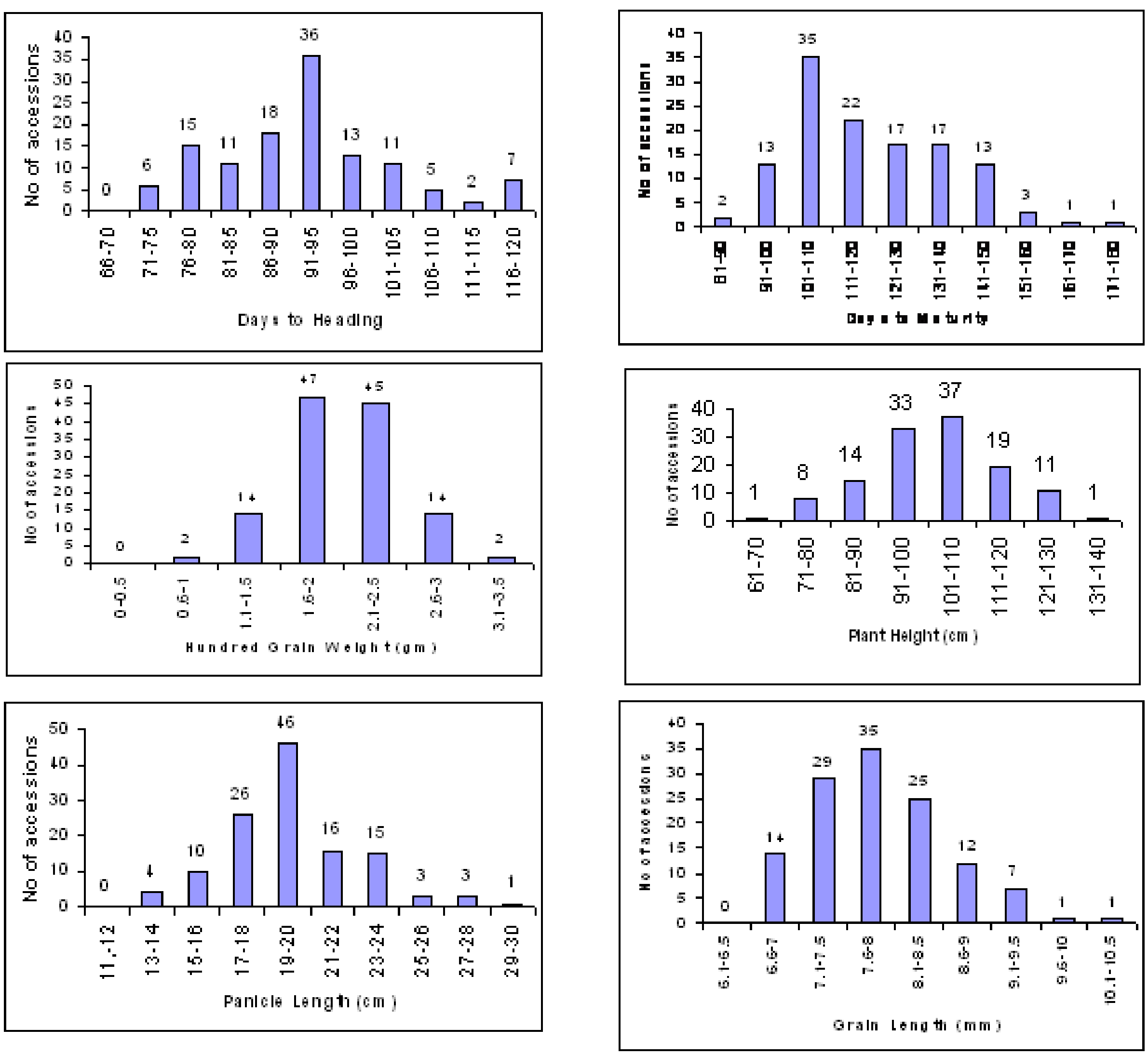

Table I. Mean ± S.E. range, coefficient of variation (C.V) and standard deviation (SD) of 124 rice accessions evaluated at NARC

Traits	Mean ± SE	Range	C.V(%)	S.D
Days to heading	92.25 ± 0.97	72 - 119	11.82	10.91
Days to maturity	119.22 ± 1.58	88 - 171	14.80	17.65
Plant height (cm)	101.53 ± 1.22	65 – 130.4	13.48	13.69
Panicle length (cm)	19.29 ± 0.26	13.3 – 29.9	15.34	2.96
Tillers per plant	13.58 ± 0.38	5 - 25	31.29	4.25
Grain length (mm)	7.85 ± 0.06	6.7 – 9.73	9.04	0.71
100-grain weight (g)	2.02 ± 0.04	0.81 – 3.47	22.27	0.45

Table II. Performance of commercial varieties of rice used as check

Traits	Basmati 370	Basmati 385	Super Basmati	JP5
Days to heading	87	81	87	90
Days to maturity	117	115	113	114
Plant height (cm)	115	110	110	99
Panicle length (cm)	22.2	24.87	26.15	18.95
Tillers per plant	12	10	14	10
Grain length (mm)	8.89	8.99	10.2	8.3
100-grain weight (g)	1.61	1.62	1.95	2.2

Table III. Correlation coefficients among seven quantitative traits of rice

Parameters	Days of maturity	Plant height	Panicle Length	Tillers/ plant	Grain length	100- Grain weight
Days of heading	0.838**	-0.006	0.155	0.078	0.452**	0.078
Days of maturity		0.040	0.118	0.106	0.440**	-0.046
Plant height			0.452**	0.095	-0.014	-0.048
Panicle length				0.140	0.278*	0.010
Tillers/ plant					0.218*	-0.146
Grain length						-0.054

*Significant; **Highly significant at P< 0.05 and 0.01

temperature, the light intensity and other climatic conditions.

Days to maturity. It also exhibited high range (88 – 171 days) along with coefficient of variation of 14.80. Pak 2950 had shorter maturity period i.e. 88 days representing earliness. Minimum value for days to maturity represents that the variety has a benefit of early ripening.

Plant height. It had mean value of 101.53 ± 1.22 and a wider range of 65 – 130.4 cm. This is typical of landrace genotypes which excel in their capacity to support panicle growth by large stem reserve mobilization. Ali *et al.* (2000) have also observed relatively greater range in plant height than the other characters. Plant height in rice is a complex character and is the end product of several genetically controlled factors called internodes (Cheema *et al*., 1987). Pak 3311 is a dwarf variety and had the plant height of 65cm. More than 50% landrace genotypes were having plant height in the range of 91 – 110 cm). Reduction in plant height may improve their resistance to lodging and reduce substantial yield losses associated with this trait (Abbasi *et al*., 1995). Shah *et al.* (1999) reported that the dwarf variety DR-83 and JP-5 possessed the plant height of 82.8 and 77.2 cm, respectively. Of the four check varieties, JP-5 had the minimum value for plant height (99.5 cm). A break through in plant breeding was attained with the development of semi dwarf cultivars characterized by lodging resistance, nitrogen responsive and erect leaves. The success of the “Green Revolution” is directly related to the intensive use of these semi dwarf varieties (Hirano *et al*., 1992). The semi dwarf plant type has been extensively utilized in the improvement of rice (*Oryza sativa* L.) cultivars throughout the world. In Kerala (India), farmers want tall rice so they can feed its straw to cattle. However, tall varieties lodge when heavily fertilized, significantly reducing yields. Thus there has been a desire to combine desirable characteristics of tall varieties with yielding ability and a new type of architecture: intermediate plant height.

Panicle length. It exhibited reasonable amount of variation with range values of 13.3 – 29.6 (cm). The average panicle length was 19.29 cm long. The maximum panicle length was observed in Pak 3169. Although it contributes positively yet maximum panicle length is not the only factor responsible for higher grain yield. Abbasi *et al.* (1995) observed that DR-39 had maximum panicle length but due to lower grain fertility exhibited lower grain yield. So panicle length alone does not determine the high grain yield as traits such as grain size, grain shape, higher numbers of tillers/plant, longer panicles and greater number of grains/panicle ultimately contribute to higher grain yield (Akram *et al*., 1994).

Table IV. Frequency distribution for eight qualitative traits in landrace genotypes of rice evaluated at NARC

Trait	No. of accession	Proportion (%)	Trait	No. of accession	Proportion (%)
Panicle Type			*Secondary Branches /panicle*		
Compact	33	26.62	Light	8	6.45
Intermediate	47	37.90	Heavy	115	92.74
Open	44	35.48	Clustering	1	0.81
Awn			*Ligule Color*		
Awn	45	36.29	White	118	95.16
Awnletted	26	20.96	Purple	6	2.41
No awn	53	42.74	*Auricle Color*		
Leaf Pattern			Pale green	115	92.74
Erect	47	37.90	Purple	9	7.26
Intermediate	23	18.55	*Seed Coat Color*		
Drooping	54	43.55	Light brown	38	30.64
Panicle Exsertion			Brown	79	63.70
Well exserted	8	6.45	Variable purple	5	4.03
Moderately exserted	30	24.19	Reddish Brown	2	1.61
Just exserted	37	29.84			
Partially exserted	49	39.52			

Number of productive tillers per plant. It is another yield attributing trait (Abbasi *et al*., 1995). A great variability with high range (13.3 – 29.6) was exhibited for number of productive tillers/plant. Highest coefficient of variability (31.29%) was observed for this trait. Ali *et al*. (2000) also observed high coefficient of variability for number of productive tillers per plant. Pak 3291 had maximum value i.e. 25.15, which was greater than those observed for check varieties. Shah *et al*. (1999) have observed that DR-82 and NIAB-6 were found to have higher tillers per plant *i.e.* 26.1 and 25.80, respectively.

Grain size. Grain size is an important quality parameter. Rice grain can be classified as extra long, long, medium and short (Akram *et al*., 1995). In the present material, long rice grains were observed, whereas none of the variety was observed with medium or short grain. The coefficient of variation for this trait was 9.04% with low standard deviation value of 0.71. Pak 3310 was observed with maximum grain length (9.73 mm).

100-Grain weight. It is also a yield-attributing trait (Abbasi *et al*., 1995). The coefficient of variation was high (22.27) with low SD values (0.45). Most of the lines were in the range of 1.6 – 2.5 g. Lines with high grain weight were also observed in this set of germplasm (Fig.1). Pak 2958 had maximum 100 grain weight i.e. 3.47g. Ali *et al*. (2000) observed maximum variation for 100-grain weight in rice ranging from 2.80 to 4.68 g. Akram *et al*. (1994) observed that JP-5 had high value for 1000-grain weight as compared to Pakhal. JP-5 with short and bold grain has higher value for 100-grain weight while Pakhal, with long and slender grains has lower value for 100-grains weight. These differences were due to grain size and grain shape. Varieties having longer and slender grains generally have lower grain weight.

Qualitative characters are also important for plant description and mainly influenced by the consumers preference, socio-economic scenario and natural selection. Frequency distribution for 8 qualitative is depicted in Table IV. The germplasm was categorized into compact, intermediate and open panicle type. Most of the accessions were with intermediate panicle type (47) followed by open panicle (44). Whereas 33 (26.62%) accessions were found with compact type panicle.

A total of forty five (36.29 %) accessions were found with awns, whereas significant proportion (42.74%) was without awn. The 20.96% of the accessions tested were awnletted. Acharya *et al*. (1991) stated that awns appear to be equipped with physiological and biological buffers that enable them to adjust to changes in the environment. Awn color also exhibited wide variation ranging from straw to different shades of brown color.

Breeding for erect leaf angle has been suggested as a method of increasing grain yield in cereal crops. Increasing light penetration into crop canopy has been suggested as one way of obtaining higher grain yield. Duncan (1971) showed that increased penetration of light into canopy would increase photosynthetic rate and perhaps enhance grain yield. Chang and Tagumpay (1970) found that erect leaf angle was associated with high yield in rice (*Oryza sativa* L.). Altogether 47 (37.90%) lines were found with erect leaf. A significant proportion (43.55) was having drooping type leaves. Ilhamuddin *et al*. (1988) observed clear differences in flag leaf angle, varying from erect to semi-erect.

A wider variation was observed for panicle exertion. Majority of the lines were partly exerted, whereas the proportion of well-exerted accession was only 6.45%. llhamuddin *et al*. (1988) found that panicle exertion was the most conspicuous character for identification of the rice cultivars. In the present germplasm it varied from well exerted to partly exerted. No accession was found with enclosed panicle exertion. Not much variation was observed for ligule and auricle color in the present germplasm. Seed coat color exhibited great variability ranging from different shades of brown to a variable range of purple color. No accession was found with red, white or purple line seed coat color.

Correlation is a measure of the degree to which variables vary together or a measure of intensity of association. Days to heading was positively and significantly correlated with days to maturity(r = 0.838, p<0.01)) and grain length (r = 0.452) presented in table III. Similar results were reported by Akhtar (1986). Days to maturity also showed positive and highly significant correlation with grain length (r = 0.440). Plant height has significant correlation with panicle length (r = 0.452, p<0.01) indicating the importance of plant height in improving panicle length in rice. Aly (1977) studied correlation and path coefficient analysis in rice and observed that plant height has highly significant and positive association with panicle length. Panicle length showed significant correlation with grain length. The results of this study were in agreement with Bhatt (1972), Amirthandevarathinam (1983), Akhtar (1986), and Buu and Troung (1988).

On the basis of experimental data, this can be concluded that a lot of variation exists in *Oryza sativa* L. in Pakistan. *Oryza sativa* throughout Pakistan over a wide agro-ecological range exhibited significant variation for quantitative and qualitative traits studied. A total of seven accessions (Pak 2950, Pak3311, Pak 3169, Pak 3291, Pak 3310, and Pak 2958) were selected based on their performance for specific characters, hence suggested for exploitation in breeding programs.

REFERENCES

Abbasi, F.M., M.A. Sagar, M. Akram and M. Ashraf, 1995. Agronomic and quality traits of some elite rice genotypes. *Pakistan J. Sci. Indust. Res*., 38: 348–50

Acharya, S., R.B. Srivastava and S.K. Sethi, 1991. Impact of awns on grain yield and its components in spring wheat under ran–fed conditions. *Rachis*, 10: 5–6

Akhtar, M.S., 1986. Path coefficient analysis in fine quality rice (*Oryza sativa* L.). *M.Sc. Thesis*. Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan

Akram, M., F.M. Abbasi, M.A. Sagar and M. Ashraf, 1994. Increasing rice productivity through better utilization of germplasm. pp: 107–14. *In: Proc. of a Nat. Semi. on Genetic Resources of Cereals and their Utilization*. Islamabad, Pakistan

Akram, M., F.M. Abbasi, M.A. Sagar and M. Ashraf, 1995. Potential donors for improving grain length in Basmati *Rice. J. Appl. Physiol*., 5: 81–3

Ali, S.S., S.J.H. Jafri, T.Z. Khan, A. Mahmood and M.A. Butt, 2000. Heritability of yield and yield components of rice. *Pakistan J. Agric. Res*., 16: 89–91

Aly, A.E., 1977. Correlation and Path coefficient analysis in some short statured rice cultivars and strains. *Int. Rice Res. Newsletter*, 13: 19–21

Amirthadevarathinam, A., 1983. Genetic variability, correlation and path analysis of yield components in upland rice. *Madras Agric. J*., 70: 781–5

Barrett, B.A., and K.K. Kidwell, 1998. AFLP–based genetic diversity assessment among wheat cultivars form the Pacific Northwest. *Crop Sci.*, 38: 1261–71

Bhatt, G.M., 1972. Significance of path coefficient analysis in determining the nature of character association. *Euphytica*, 22: 338–43

Buu., B.C. and D.X. Troung, 1988. Path analysis of rice grain yield under saline conditions. *Int. Rice Res. Newsletter*, 13: 20–1

Chang, T.T. and O. Tagumpay, 1970. Genotypic association between grain yield and six agronomic traits in a cross between rice varieties of contrasting plant types. *Euphytica*, 19: 356–63

Cheema, A.A., M.A. Awan and J. Iqbal, 1987. Improvement of Plant Height Architecture in Basmati Rice. *Pakistan J. Agric. Res*., 8: 371–4

Cox, T.S., J.P. Murphy and D.M. Rodgers, 1986 Changes in genetic diversity in the red winter wheat region s of the United States. *Proc. Natl. Acad. Sci*., (USA) 83: 5583–6

Duncan, W.G., 1971. Leaf angle, leaf area, and canopy photosynthesis. *Crop Sci*., 11: 482–5

Fagade, S.O., P.G. Pillai and J.K. Kehinde, 1987. Six upland rice varieties released in Nigeria. *Int. Rice Res. Newsletter*, 12: 5

Hirano, H., A. Nakamura, F. Kikuchi and S. Komatsu, 1992. Protein encoded by genes linked with semi dwarfing gene in Rice. *Japan Agric. Res. Quart*., 25: 223–9

Ilhamuddin, D. Rosh and M. Ahmad, 1988. Characteristics of cold tolerant rice cultivars of NWFP. *Pakistan J. Agric. Res.*, 9: 437–9

Jafri, S.J.H., M.A. Khan, H.A. Saddaqat and S.S. Ali, 1994. Correlation and Path coefficient analysis in Rice. *J. Agric. Res*., 32: 355–62

Katsuta, M., K. Okuno, M. Afzal and R. Anwar, 1996. Genetic differentiation of rice germplasm collected in Northern Pakistan. *Japan Agric. Res. Quart*., 30: 61–7

Khush, G.S., 1997. Origin, dispersal and variation of rice. *Pl. Mol. Biol.*, 35: 25–34

Shah, R., M.Z. Sulemani, M.S. Baloch and G. Hassan, 1999. Performance of coarse rice genotypes in the plains of D.I. Khan, Pakistan. *Pakistan J. Biol. Sci.*, 2: 507–9

Thompson, J.A., R.L. Nelson, and L.O. Vodkin, 1998. Identification of diverse soybean germplasm using RAPD markers. *Crop Sci*., 38: 1348–55

Vaughan, D.A, H. Morishima, and K. Kadowaki, 2003. Diversity in the *Oryza* genus. *Current Opinion in Pl. Biol*., 6: 139–46

(Received 08 December 2003; Accepted29 January 2004)