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PAKISTAN RICE GENETIC RESOURCES–I: GRAIN MORPHOLOGICAL DIVERSITY AND ITS DISTRIBUTION

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Abstract

In order to ascertain the diversity for its possible utilization in rice grain quality improvement in Pakistan, local rice genetic resources (475 accessions) collected from 3-rice cultivation zones and other parts of the country were investigated for the seed characters. The distribution patterns of some interesting observations were also carried out. A wide variation was found in grain size and shape. Pakistan rice cultivars were dominated by long grain type while the short grains were absent, according to the measured length. However, based on grain length/width ratio, 1.3 % short grain types were present in NWFP/N. Areas.

Introduction

Rice is the 2nd most important food crop in Pakistan, not only in respect of local consumption but also in view of large exports. Presently rice is grown on approximately more than 2.5 million hectares, with a total production of 5 million tones (Anon., 2005). About 1/3 of the total rice production is exported, which contributes about 20% of the foreign exchange earnings (Anon., 1993). According to IRRI report Pakistan rice export was about 10% of the world rice trade (IRRI 1993). Therefore Pakistan needs to further expand its export and improve its local consumption by expanding the grain quality types as per the consumer demand around the globe and in the country.

Grain quality is a very wide subject encompassing diverse characters that are directly or indirectly related to exhibit one quality type. Some of the important grain characteristics that constitute the grain quality are shown in Table 1. Variation in any one character or its combination results in the changed quality of rice grain. In rice, only the dehulled grain (usually milled) is consumed as food. Both hulled and un-hulled rice grains have great diversity in size and shape. This may be due to wide spread distribution in different agro-climatic conditions and diversified selection for a wide range of uses of rice grain. Satoh *et al*., (1990a, b, c, d) reported a wide variation for grain among the local rice collected from different countries. Genetic diversity is a prerequisite for increasing yields and for stabilizing production in the face of disease epidemic and fluctuating environmental condition (Sano, 2000).

Webb *et al*., (1979, 1985) noticed a particular trend of grain cooking quality characters related to grain shape. Therefore the diversity in grain morphology needs to be examined.

Land races are crop populations in balance with their environment and remain relatively stable over long periods of time. Yet their population structure has the effect of retaining a potential for adaptive change, especially where there are opportunities for gene exchange and introgression (Frankel & Bannett, 1970). Therefore if research on grain quality improvement of rice is to be done, the local rice genetic resources in Pakistan must be

evaluated to outline the variation.

Table 1. Characteristics of rice grain that constitute its quality.

Grain Morphology	
•	Color
•	Shape (Length/Width ratio)
•	Size (Length, Width and Thickness)
Starch Properties	
•	Gel consistency
•	Amylose content
•	Amylopectin content
•	Elongation on cooking
•	Gelatinization temperature
Nutrition	
•	Protein
•	Vitamins
Others	
•	Aroma
•	Taste

Table 2. Frequency distribution of grain size* diversity in Pakistan rice cultivars.

Location	Length			L/W Ratio		
	Long	Medium	Short	Long	Medium	Short
A. Kashmir	100.0	0.0	0.0	54.8	45.2	0.0
Balochistan	100.0	0.0	0.0	79.2	20.8	0.0
NWFP/NA	99.6	0.4	0.0	17.3	81.4	1.3
Punjab	100.00	0.0	0.0	82.0	18.0	0.0
No data	100.00	0.0	0.0	25.5	72.7	1.8

*Grain type	Length classification range	L/W ratio classification range
Long	6.61 mm and over	3.0 and over
Medium	5.51 - 6.60 mm	2.1 - 3.0
Short	5.50 mm or less	2.1 below

In Pakistan research activities on rice are targeted for increase in yield, and resistance to disease and pest. In this regard mechanization of rice cultivation, adaptation of improved varieties and more recently, use of biotechnology for the incorporation of gene for disease resistance have come up in PARC (Anon., 2000a). Salt tolerance studies are also in progress, but no studies have been marked for grain quality evaluation of local rice genetic resources; though grain quality of some improved varieties was carried out (Ahmad & Akram, 2005). However, recently it was realized at national level in Pakistan that rice with better grain quality should be produced (Anon., 2000b). Since grain morphology is among the first to be a visible character for selection and quality marking; and also keeping in view the importance of grain shape and the attributed characters combination for cooking quality as in US rice cultivars, investigation on seed morphological characters were carried out for Pakistan local rice cultivars with the following objectives:

To study the rice cultivars for grain morphological variation.

To determine the pattern of morphological variation in the rice collected regions.

The research was conducted at Laboratory of Plant Genetic Resources, Institute of Genetic Resources, Faculty of Agriculture, Kyushu University, Fukuoka, Japan; and funded by Ministry of Education, Sports, Culture, Science and Technology, Government of Japan.

Materials and Methods

Materials for this study were obtained from the National Genebank of MAFF (Ministry of Agriculture, Food and Fisheries) Genebank, Tsukuba, Japan. 387 accessions were obtained with record of Accession Numbers of MAFF Genebank and also the Collection number for the origin of samples i.e. Pakistan. These accessions were planted at Fukuoka and Ibusuki. 475 accessions were recognized, based on their morphological variation. They served as the research material and in all cases mature seed were used in this experiment.

Complete data (Passport information) of the provided accessions by MAFF genebank, was obtained from the National Genebank at the Plant Genetic Resources Institute (PGRI), National Agricultural Research Centre (NARC), Islamabad, Pakistan (Anon., 1995).

Measurements were done for length, width and breadth (thickness) of un-hulled grain as reported by Satoh *et al*., (1990a, b, c, d), with 5 replications. Length to width ratio was also calculated based on average of respective values of seed morphology. Pakistan rice cultivars were classified into Long-, Medium- and Short grain types according to Adair *et al*., (1973) using length and length/width ratio (Table 2). 100 grain weight was measured. Data on grain color was also recorded. Distribution of recorded characters was also considered.

Results

The Pakistan rice genetic resources showed a great diversity for all the measured grain morphological characters. The variation for grain length ranged from 10.66 ~ 6.0 mm, grain width from 3.7 ~ 1.6 mm, breadth from 2.36 ~ 1.14 mm, length to width ratio varied from 5.24 ~ 2.04, and grain weight from 3.02 ~ 0.66 g (Fig. 1). The long grain types were present in all locations (on the basis of seed length), whereas, only 0.4% medium grain types were recorded from NWFP/Northern Areas, while, the short grain types were not found. But on the basis of length to width ratio, long and medium grain types were found distributed in all locations. However, the short grain types were only recorded from NWFP/Northern Areas (Table 2). The short grain type was not recorded from Pakistan rice genetic resources for length, however, based on length/width ratio four cultivars fall into short grain type (Table 2).

Hull color consisted of four classes as yellow, yellowish, brownish and dark purple. Most of the cultivars possessed yellow hull, while the dark purple color was rare. NWFP/NA location had highest variation represented for this character, where all four color types were recorded. Both in Balochistan and Punjab three-color types were recorded and in these two locations the dark purple color type was absent. While, in A.Kashmir the color variation was more uniform and only yellow or yellowish types were recorded (Fig. 2). The pericarp color was either white or red. Both color type of pericarp showed mixed

occurrence in all the locations.

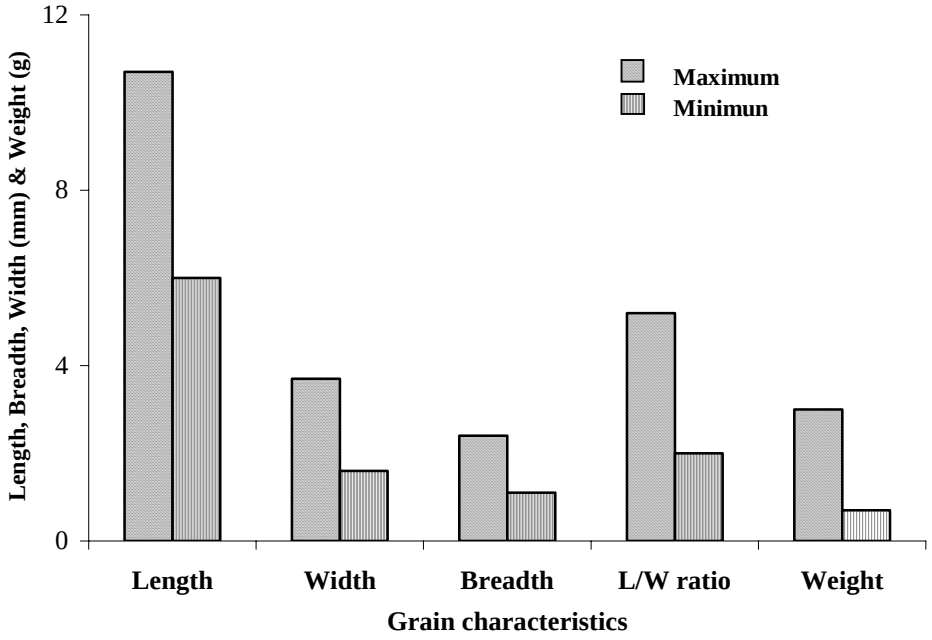

Fig. 1. Grain morphological variation for Pakistan rice germplasm.

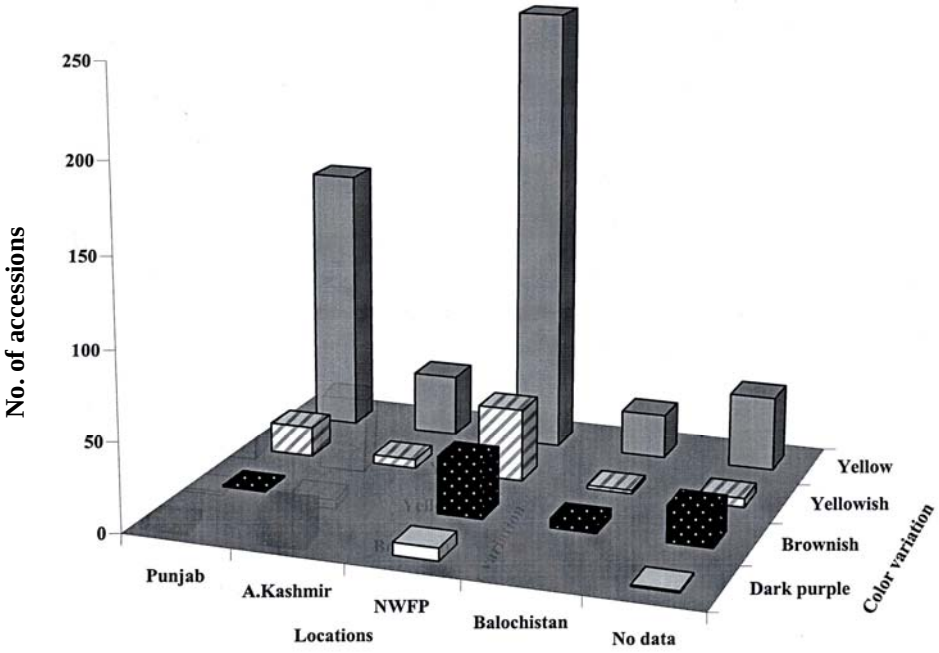

Fig. 2. Hull color variation in Pakistan rice cultivars and its distribution.

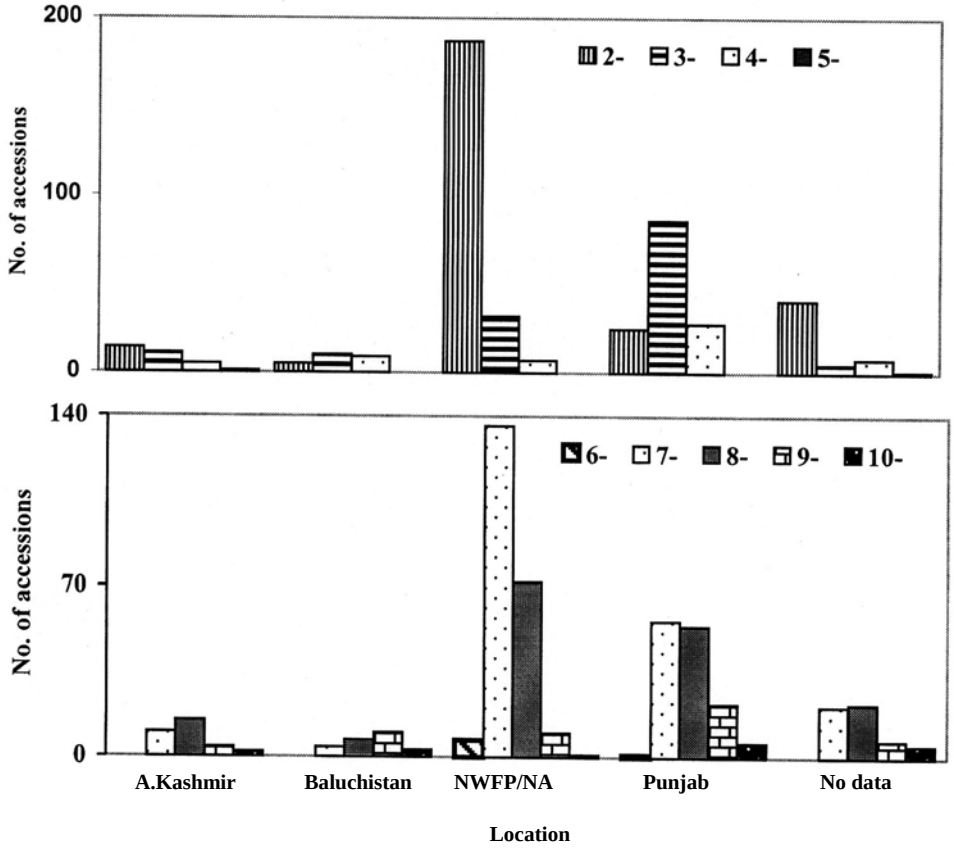

Fig. 3. Grain shape variation and its distribution in Pakistan rice genetic resources based on grain length to width ratio (top) and grain length (bottom).

Discussion

The Pakistan rice genetic resources showed a great diversity for all the measured seed morphological characters (Fig. 1). Sano (2000) have stated that phenotypic diversity increases during domestication as a general trend in crop plants. However, variation for hull (Fig. 2) and pericarp color was the minimum in Pakistan rice cultivars. Hull color consisted of four classes as yellow, yellowish, brownish and dark purple. Most of the cultivars possessed yellow hull, while the dark purple was rare. Since in NWFP/NA mostly local varieties are grown, it showed highest variation for this character, while A.Kashmir was more uniform for this character. In the Punjab region introduction of improved cultivars especially Basmati, which occupies more than 85% of cultivated rice area, has caused more loss to diversity by reducing cropped area with local rice varieties as compared to NWFP.

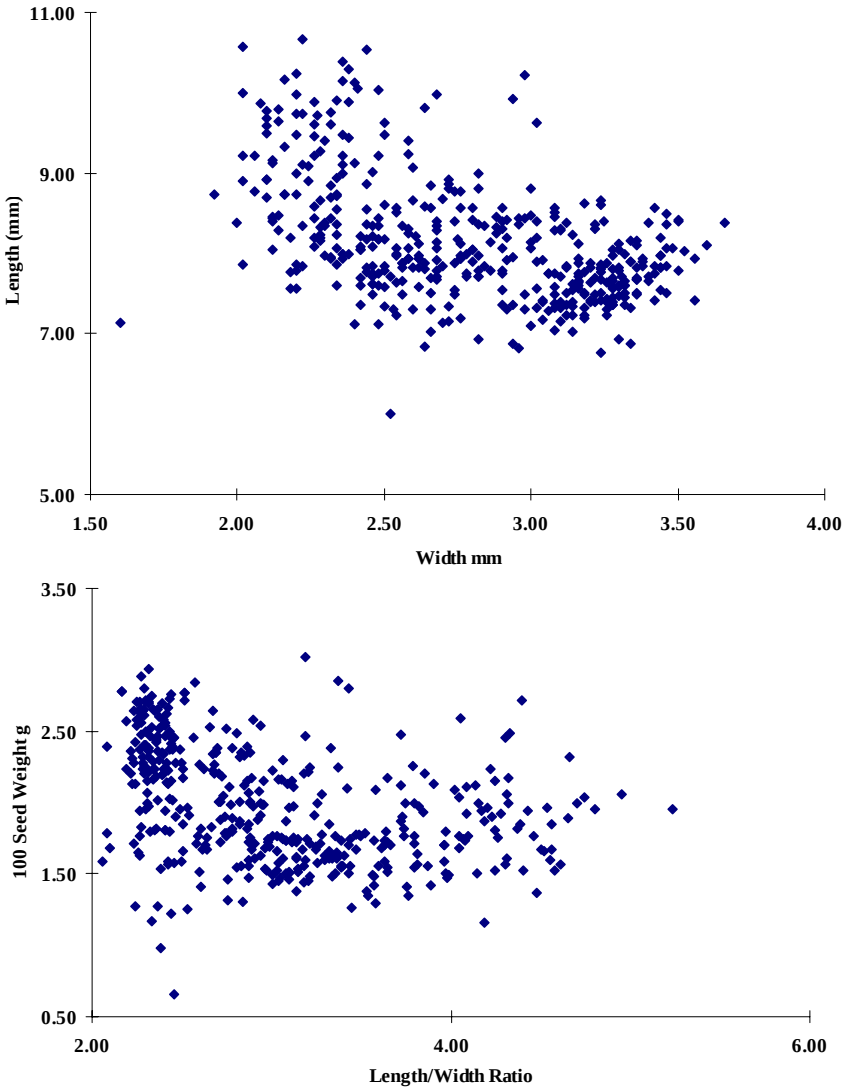

Fig. 4. Grain characteristic interrelationship among Pakistan rice genetic resources outlining the diversity pattern for length x width (above) and seed weight x length/width ratio (bottom).

The pericarp color was either white or red. Both color type of pericarp showed mixed occurrence. In Punjab nowadays about 85% of rice is under Basmati varieties that are white grain types, therefore the occurrence of red pericarp in local rice genetic resources collection in high frequency was interesting to note in the region. It also proves that with the introduction of improved varieties the local genetic resources are replaced causing extinction at times.

The existence of great diversity in the seed morphology i.e. length, width and thickness (Fig. 1, Table 2), indicates the presence of other related agronomic, physiological, cooking, nutritional traits or cultural aspects for their selection and adoption. The true short grain type is not preferred as only 4 cultivars fall in this category of the total 475 accessions. This preferential selection and adaptation is perhaps the reason of distribution presented in Table 2. However, in general long grain type is now the preferred trait in this region that will ultimately replace other types. Therefore it is important to collect the threatened (other types) rice germplasm before it is lost.

The distribution of grain size diversity is given in Fig. 3. The distribution of grain L/W ratio (Fig. 3, top) shows that NWFP/NA has highest number of accessions with less L/W ratio i.e., between 2-2.9 mm. In Punjab 3-3.9 mm L/W ratio seeds dominated. Similarly in case of seed length (Fig. 3, bottom) the pattern of geographic distribution for this character was also different among the rice collection regions. NWFP/NA and Punjab contained higher frequency for accessions with length in the range of 7-7.9 mm. In A.Kashmir it was 8-8.9 while in Balochistan it was 9.0 and above. These distribution patterns show that diversity is being maintained in all regions independently as per grower's/consumer's choice.

The existence of relationship between the different grain morphological characters was determined. In case of grain length and width (Fig. 4), it was observed that the long grains had less width. The Pakistan rice cultivars with more width (3.0 mm or more) were shorter in length. It also suggests that shape variation is very large, because for every width type a wide variation in length is present e.g., the grains having width of 2-3 mm had length range between 7-11 mm. In the relationship between grain weight and the length to width ratio (Fig. 4), it was found that most cultivars with high grain weight were those having lower ratio for length to width.

It may be concluded that the Pakistan rice genetic resources comprise of great diversity for grain morphological characteristics. However, the variation for hull and pericarp color was minimum. Northern areas of Pakistan in the NWFP/NA has more phenotypic variation for grain (especially hull color), however, in A.Kashmir it was minimum though this region is also in northern part of Pakistan. The preference of people in southern Pakistan and in plains is for long grain type rice, whereas those of people in Northern mountain region prefer for roundish grain i.e. medium grain type.

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