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REGULAR ARTICLE

Estimation of pedigree based diversity in Pakistani wheat (*Triticum aestvium* L.) germplasm

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ABSTRACT

Pedigree based diversity among Pakistani wheat germplasm was estimated to formulate future strategies for germplasm enhancement. Pakistani wheat germplasm was judged on several criteria, i.e., contribution of land races per cultivar, total number of unique land races utilized during particular decade, proportion of unique land races to the total land races, pedigree distance between the cultivar of various decades. Introduction of CIMMYT material did not resulted in the loss of diversity, it actually increased over time. Introduced germplasm from CIMMYT had more total and unique number of land races in their pedigree. Proportion of unique land races to the total utilized land races decreased. However, it was restored and surpassed to that of pre green revolution period during 1991-2000. Little efforts were carried out for the introgression of useful traits in indigenous pre green revolution germplasm. Resultantly, distance between the local and introduced germplasm increased with varieties released in various decades of previous century. In future, it seems that conventional introductions would continue to come from CIMMYT and diversity of Pakistani wheat germplasm will be regulated by the efforts at CIMMYT.

Key Words: *diversity; wheat; land races; CIMMYT.*

INTRODUCTION

Genetic diversity within crop species has gained significant importance in the current scenario of modern intensified agriculture and has been subject of large number of studies in various crop species (Rauf et al., 2010). Numerous factors have been shown to cause reduction in genetic diversity such as population explosion, urbanization, fast industrial growth, modern agriculture and rapid industrialization, causing destruction of natural gene sanctuaries. Plant breeding has also been shown to reduce the genetic diversity (Rauf et al.

2010). It was noted that replacement of landraces by high-yielding uniform varieties had reduced the total genetic characteristics of cultivated germplasm and increased dependence on farm inputs, thus polluting the agro-ecosystems.

Several benefits of high genetic diversity may be narrated. Genetic diversity within crop variety acts as buffer against the outbreak of epidemics. Zhu et al. (2000) noted that a mixture of susceptible and resistant plants had increased the performance of susceptible type and also delayed the evolution of new pathotypes. Knowledge about the genetic distance between the breeding lines is also needed for the manipulation of heterosis or hybrid vigor.

Diversity estimation in wheat germplasm is not new (Cox et al. 1986; Vierling and Nguyen, 1992; Plaschke et al. 1995). However, development of molecular based studies had resulted in the rapid estimation of diversity and large numbers of studies are available (Prasad et al. 2000; Reif et al. 2005; Landjeva et al. 2006; Bibi et al. 2009). Molecular based diversity overcame the drawbacks of phenotypic characteristics based diversity such as reduced polymorphism, laborious nature of fieldwork (Rauf et al. 2010). Previous findings in wheat showed non-random distribution of diversity around the globe thus showing spatial or temporal trends. However, molecular distance was not correlated with the hybrid performance. Rauf et al. (2010) showed that molecular based studies may not be an indicator of functional diversity.

Studies have shown that reduction of genetic diversity also occurred due to utilization of similar type of parents or having similar pedigree in the development of transgressed generation. Therefore estimation of the pedigree-based distance between cultivar has provided useful insight in the germplasm (Martin et al. 1995; Barrnet et al. 1998; Solemeni et al. 2002). Solemeni et al. (2002) traced the ancestry of Canadian cultivars back to 125 cultivars including selections, breeding lines and land races and estimated pedigree wise distance between the cultivars. Various studies have also indicated positive correlation between the molecular and pedigree based genetic diversity (Martin et al. 1995; Barnett et al. 1998).

Keeping the same in mind, the pedigree based distance of Pakistani wheat cultivars was estimated to obtain the following information: (1) Pedigree based distance between the cultivar released in post and pre-green revolution period; (2) Changes in pedigree diversity over time; and (3) Status of utilization of local germplasm in breeding programs.

MATERIAL AND METHODS

Germplasm was selected on the basis of date of release for general cultivation. Germplasm development in Pakistan may be divided a pre green revolution and a post green revolution phase. Germplasm released pre green revolution (1947-1964) was tall and low yielding, while germplasm released after 1965 and onward was semi dwarf and introduced from CIMMYT. Pedigree information of released cultivars was obtained from the Wheat Research Institute Faisalabad (WRI), the CIMMYT website and USDA germplasm. Initial information about the pedigree was obtained from WRI and CIMMYT and the pedigree abbreviations were decoded with CIMMYT standard catalogues. Afterward the pedigree of parents and grandparents was expanded by searching their pedigree over the website of USDA, germplasm collections. Full sketch pedigree of each cultivar was drawn (Fig. 1) and saved in separate file. The parental land races of all cultivars were scored as present (1) or absent (0) within each cultivar. Cultivar pedigree relationships and Euclidian distance matrix was estimated from these scores using principal component analysis, statistical software Minitab 15. Several authors have used qualitative data for estimation of genetic diversity in conjunction with a Euclidean distance matrix (Nagella et al. 2007; Seethram et al. 2009; Khodadi et al. 2011).

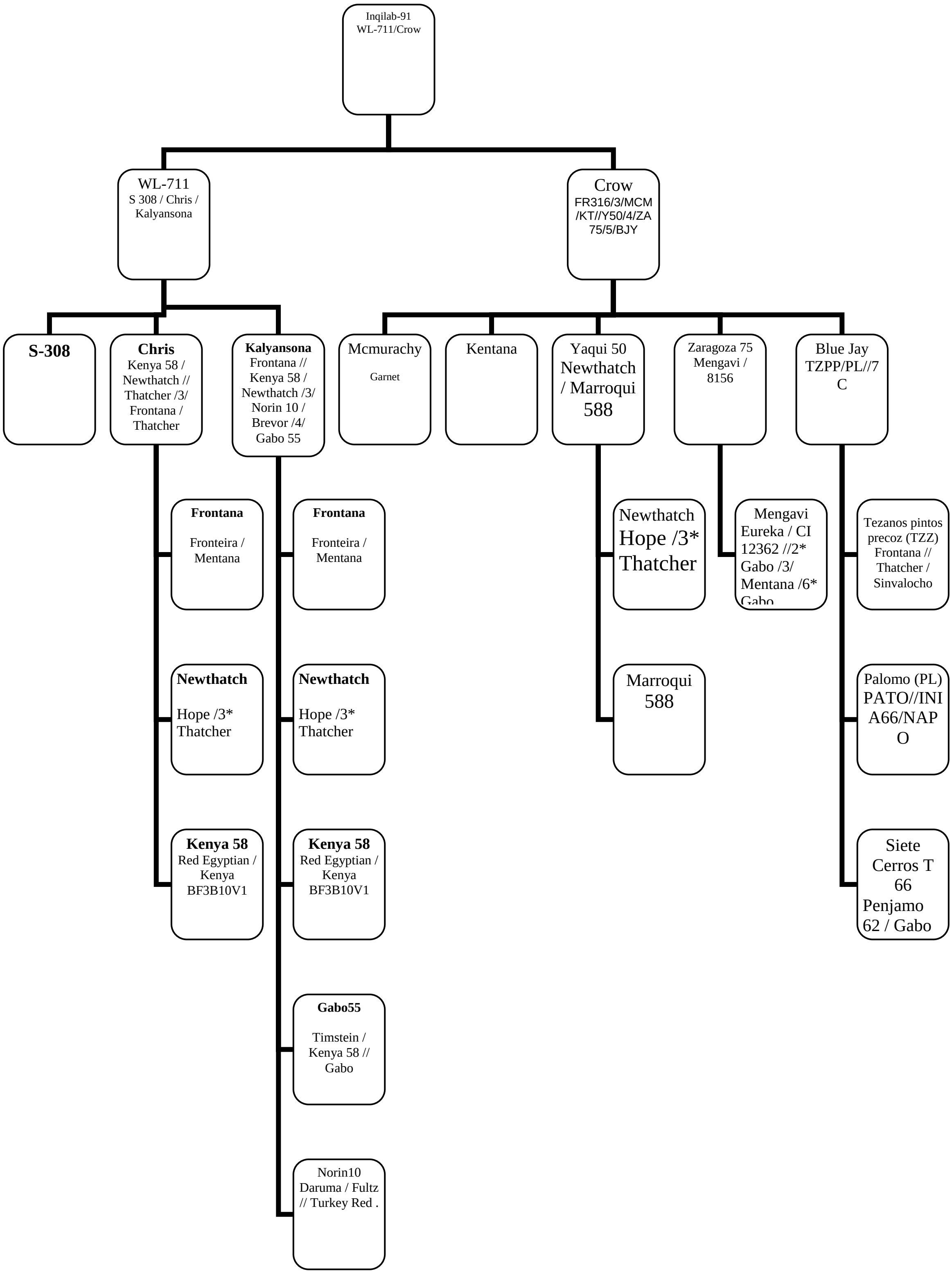

Figure 1: Pedigree of Pakistani wheat cultivar "Iquilab 91"

RESULTS

Wheat yield in Pakistan have shown significant progress after post green revolution era (Table 1). Average utilization of various land races for the development of each cultivar also progressively increased in various decade of breeding. The highest number of land races was present in cultivar released during 1981-1990. Thus showing that pedigree of wheat cultivar became complex over time. The total number of unique land races decreased in the post green revolution period of 1965-1970. Afterward there was increase in the number of unique land races. The highest number of unique land races was utilized during 1991-2000. The proportion of unique landraces to total land races decreased to that of the pre-green revolution period. However it showed progressive increase after 1971. The highest proportion of unique land races utilization was observed in cultivar released during 1991-2000. The proportion also surpassed to that of pre green revolution period.

Table 1. Temporal changes in yield, land races utilization, unique land races utilization and pedigree distance within cultivars.

	1934-1964	1965-1970	1971-1980	1981-1990	1991-2000
Yield, kg ha^{-1}	832	978	1331	1684	2072
Average no. of land races within pedigree of each cultivar	2.3	8.5	12.5	17.3	15.5
Total number of unique land races	6	4	11	23	56
Proportion of unique land races to the total land races used	0.38	0.11	0.11	0.27	0.61
Average pedigree distance of cultivar released during 1934-1964	1.63	3.17	3.77	4.36	4.11
Average pedigree distance of cultivar released during 1965-1970	3.17	2.03	3.37	4.19	3.97
Average pedigree distance of cultivar released during 1971-1980	3.77	3.37	3.09	4.01	4.06
Average pedigree distance of cultivar released during 1981-1990	4.36	4.20	4.01	3.74	4.50
Average pedigree distance of cultivar released during 1991-2000	4.11	3.97	4.06	4.50	3.96

The average pedigree distance between cultivars released within specific decade was low. However pedigree distance was high when compared with cultivar released in various decades. The pedigree distance between cultivar released within specific decade increased over time and the highest pedigree distance was estimated for 1991-2000. When cultivars released during different decade were compared, the highest pedigree distance was observed between cultivars released 1981-1990 vs. 1991-2000. This may be due to utilizing of unique land races in the pedigree. The pedigree of the distance between cultivars of pre-green revolution period increased with that of post green revolution cultivar. Thus showing low utilizing of historic indigenous cultivars in further breeding programs.

Data on the utilization of 105 parents or grandparents was obtained. However some influential parents showing high frequency of utilization in the development of Pakistani elite germplasm are shown in Table 2. None of the parental line was utilized in breeding programs of all decades. Germplasm of pre-green revolution showed least utilization; only two parental lines of that era - C230 and PI65 - were utilized in breeding programs of the post green revolution period. These two lines were utilized in all decades of post green revolution period except 1980-1990. Among various lines, Norin10B was the most influential line and was present in pedigree of all post green revolution period cultivars. Kenya 58 and Newthatch or Barleta, Adino and Chino share similar frequency of utilization thus showing that these grandparents were introgressed to produce parental lines which were further utilized in the production of the elite cultivar "Inquilab 91" (Fig 1). After Norin10B, Yaktana 54, C230, IPI65 had the highest frequency of utilization during 1965-1970. Frontana had similar frequency of Norin10B during 1971-1980 followed by Newthatch, Kenya58, Yaktana

54. In 1981-1990, Yaktana54 had the highest frequency followed by Yaqui54. Few breeding lines, i.e., 8156, Thatcher, Barleta, Chino, Ardino were absent during the initial post green revolution period (1965-1980).

Table 2. Temporal changes in utilization of some influential parents or grandparents in Pakistani germplasm

Parents	1934-1964		1965-1970		1971-1980		1981-1990		1991-2000	
Utilization	Total	Avg.	Total	Avg.	Total	Avg.	Total	Avg.	Total	Avg.
C230/IP165	1	0.14	3	0.75	3	0.20	0	0.00	1	0.17
New Thatch	0	0	2	0.50	13	0.87	8	0.80	4	0.67
Kenya58	0	0	2	0.50	13	0.87	6	0.60	4	0.67
Norin 10B	0	0	4	1.00	15	1.00	10	1.00	6	1.00
Frontana	0	0	2	0.50	15	1.00	7	0.70	4	0.67
Yaktana54	0	0	3	0.75	11	0.73	9	0.90	4	0.67
Yaqui54	0	0	2	0.50	9	0.60	8	0.80	4	0.67
Yaqui 50	0	0	2	0.50	6	0.40	7	0.70	4	0.67
Gabo	0	0	2	0.50	7	0.47	1	0.10	2	0.33
Lerma rojo	0	0	2	0.50	6	0.40	7	0.70	3	0.50
8156	0	0	0	0	5	0.33	5	0.50	3	0.50
Barleta/Chino/Ardino	0	0	0	0	7	0.47	6	0.60	2	0.33
Thatcher	0	0	0	0	8	0.53	3	0.30	3	0.50

Generally the average utilization frequency of selected breeding lines per cultivar increased from 1965-70 to 1981-90 and decreased in 1991-2000. Norin10B had the maximum utilization in all post green revolution decades. Frontana had the maximum utilization in 1971-1980 while Yaktana 54, Yaqui 50, Lerma rojo, 8156, Barleta, Chino, Ardino had the highest utilization in 1981-90 after Norin10B. On an overall basis, Norin10B followed by Yaktana54, Newthatch, Kenya58 and Yaqui 54 had the highest utilization.

Pedigree wise Euclidean distance between various cultivar released during different decade are shown in Figure 2. On the basis of the dendogram, germplasm may be divided into two major groups of pre or post green revolution period. Pre-green revolution period cultivars formed separate cluster and were related to each other. Pedigree distance of pre green revolution period was lower to that of post green revolution period cultivar. Post green revolution cultivars released during various decades were randomly distributed in four clusters.

Cluster I (colored red in Figure 2) contained the varieties of pre-green revolution period and a few post green revolution cultivars. Cultivar C-228 and C-250 had the lowest pedigree wise distance in cluster I and thus show similar pedigree. In contrast, Kohinoor-83 showed the highest pedigree distance in Cluster I. Cultivar released during 1991-2000 decade had the cultivar with the highest pedigree distance i.e. Kohistan-97, Parwaz-94.

In Cluster II (colored green in Figure 2) Mexipak and WL-711 had the lowest pedigree distance and are related to each other. Rohtas-90 and Rawal-87 showed the highest pedigree distance. In Cluster III (colored in blue in Figure 2), Pari, Yecora and Sandal were similar to each other and showed zero pedigree distance. Custer-IV (colored in orange in Figure 2) was represented by single genotype Kohistan-97, which showed the highest pedigree distance within wheat germplasm.

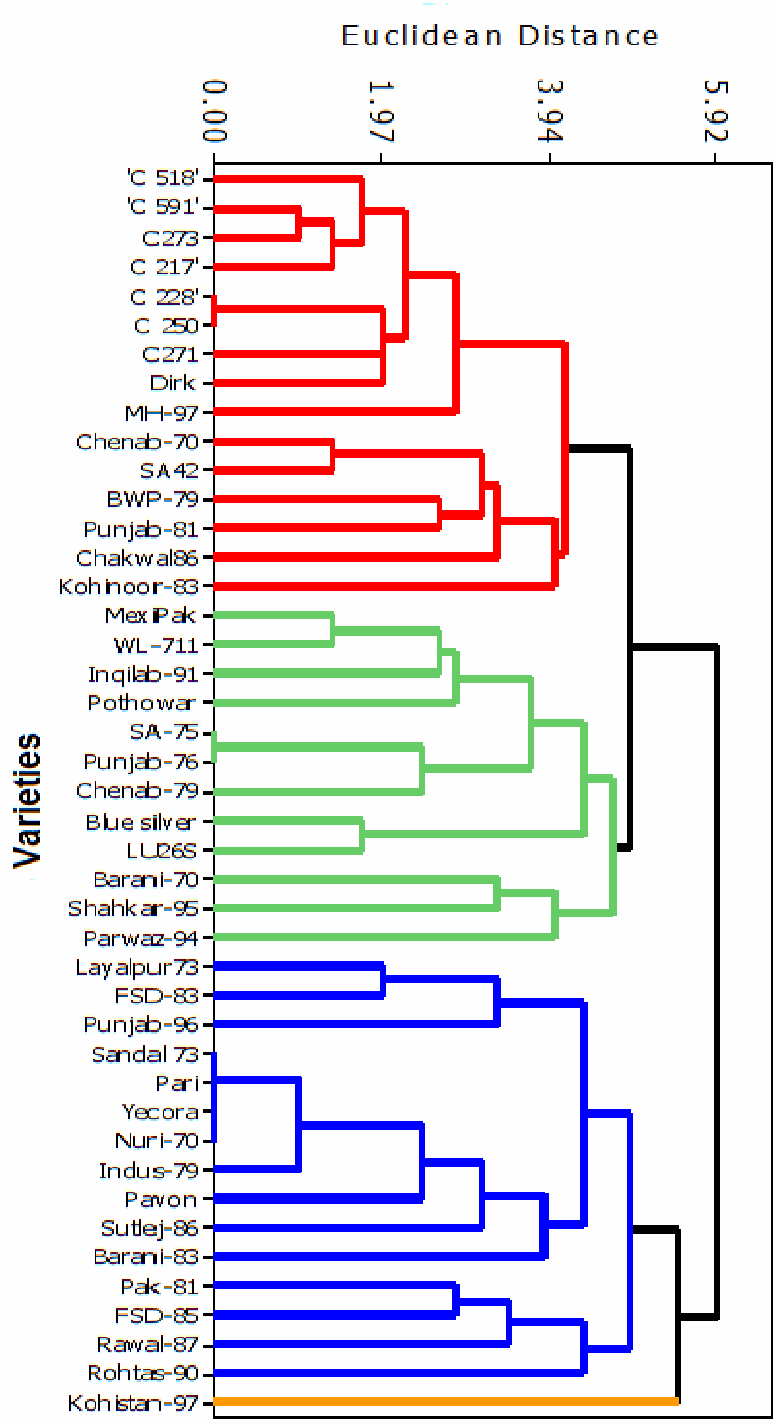

Figure 2. Pedigree based distance between various Pakistani cultivars

DISCUSSION

Variety development of wheat on the Indian sub-continent started before current India and Pakistan were split from one another in 1947; several high quality varieties were released for general cultivation (Khan et al. 2005). However these lines were tall and had low yield. Therefore, these varieties were replaced by semi dwarf high yielding varieties. Varietal development in Pakistan was solely dependent on the introduction, acclimatization or transgressive segregation of CIMMYT breeding stock during the post green revolution period. Little efforts were carried out for the introgression of useful traits in indigenous pre green revolution germplasm. Resultantly, the distance between the local and introduced germplasm increased with varieties released in various decades of previous century.

Pakistani wheat germplasm was judged on several criteria. i.e. contribution of land races per cultivar, total number of unique land races utilized during particular decade, proportion of unique land races, proportion of unique land races to the total land races, pedigree distance between the cultivar and decades. The introduction of CIMMYT material did not resulted in the loss of diversity. In fact, it increased over time. Introduced germplasm had more number of land races and unique land race in their pedigree. However, proportion of unique land races to the total utilized land races decreased initially to that of post green revolution. However, it was restored and surpassed during 1991-2000. Rauf et al. (2010) noted that wheat genetic diversity improved during last decade of previous century and it will further enhance due to growing awareness among plant breeders regarding the issue of genetic diversity, and improved and rapid methods of diversity estimation. Parker et al. (2002) also showed that the genetic diversity of Australian wheat germplasm also increased over time due to the introduction of semi dwarf wheat.

The issue of diversity in Pakistani wheat germplasm has discussed by various author(s) using various germplasm samples and molecular, biochemical or morphological markers (Khan et al. 2005; Iqbal et al. 2009; Zeb et al. 2009; Khan et al. 2010; Ahmed et al. 2010). These studies made variable conclusions based on their germplasm sample. Khan et al. (2005) showed narrow genetic base of wheat Pakistani wheat germplasm. However some results corroborate with this study. For instance Sutluj-86 and Barani-83 were shown distinct in their study. Similarly in our study these varieties also remained distinct in Cluster III of the pedigree based dendogram. Contrastingly some studies have also indicated significant genetic diversity in cultivated wheat germplasm (Zeb etal. 2009). Author(s) have also mentioned significant genetic diversity in local land races collected from various regions of Pakistan (Masood et al. 2004; Khan et al. 2010). These authors suggested the need to utilize these genotypes for the enhancement of diversity and quality.

In concluding the above discussion, Pakistani germplasm diversity increased over time and introduction from CIMMYT increased the diversity during post green revolution period. In future, it seems that conventional introductions would continue from CIMMYT and diversity of Pakistani wheat germplasm will be regulated by the efforts at CIMMYT. At CIMMYT, efforts are under way to expand the diversity of wheat germplasm by introgression from wild relatives (Warburton et al. 2006). These results may applicable to the neighboring country India, which shares several cultivars with similar pedigree due to introduction from CIMMYT.

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