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SELECTION FOR ABIOTIC AND BIOTIC STRESSES: THE EXAMPLE OF F2 BREAD WHEAT SELECTION IN HIGHLAND BALOCHISTAN.

by

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Selection For Abiotic And Biotic Stresses: The Example Of F2 Bread Wheat Selection in Highland Balochistan.

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Abstract

This paper describes the results of screening work on F2 bread wheat lines carried out in multi-location trials in highland Balochistan from 1982 to 1990. The objectives were to select and evaluate desirable genotypes for winter planting. Out of a total of 816 entries only four successfully passed through the observation nurseries and yield trials. After nine years of testing only genotype ICW81.1471 was selected for wide-scale agronomic testing. Although the yield potential of this genotype was not significantly higher than that of the local check, it had the important advantage over local material of possessing good resistance to yellow rust (*Puccinia striiformis*).

The results showed that exposure of a segregating population to the prevailing environmental stresses of cold and drought was an effective selection procedure for identifying genotypes which are resistant to such environmental stresses. Useful selection indices can be developed for other desirable attributes such as disease and pest resistance, root and shoot vigour, coleoptile length, plant height and maturity length.

Introduction

In Balochistan most of the rainfed wheat is grown in the highlands. Yields are low mainly because of moisture shortages; however other causes of low yields are the very cold winters, yellow rust epidemics in the few wet years, the non-availability of improved genotypes and poor cultural practices.

Climatic conditions are severe. The most important element is the rainfall which averages 240 mm but varies greatly between and within seasons, and also spatially. Summers are hot and dry, and winters are cold and may be quite wet, with some snowfall. If adequate rainfall is received in late summer or autumn, wheat is sown in October or November. If rainfall then is too scanty and some rain falls in winter, spring planting is done. Genotypes needed for winter planting differ from those for spring planting, but both need to have a good measure of drought tolerance, as the soil moisture reserves towards the end of the growing season are usually small and diminishing rapidly..

Another important environmental constraint is the damage which can be caused by severe frost which often occurs during the early vegetative growth of crops planted in October-November. However, many genotypes can recover from such cold damage and start growing again in the spring, to give reasonable yields. Breeding, evaluation and selection for desirable characters in this environment are very difficult because cold and drought resistance characteristics are rarely found together in a single genotype. A very cold-resistant variety may not be the high yielding if it is unable to escape terminal drought; a cold-susceptible variety may be the highest yielding in a warm winter, but in a cold winter the same line may be killed completely by low temperatures. Breeding and selection for yellow rust resistance is another very important aspect, as this disease can have a major impact on wheat yields in the highlands of Balochistan (Ahmad et al. 1990, and Mohammad 1989).

Since 1982, the Arid Zone Research Institute (AZRI) has been collaborating with the International Center for Agricultural Research in the Dry Areas (ICARDA) in a wheat improvement program. It has established a multilocational testing program in Balochistan to develop improved varieties for these difficult conditions, at sites ranging from 1500 m to 2300 m elevation.

Materials and Methods

In the 1982/83 season 816 entries of winter bread wheat F2 population were received from the ICARDA Cereal Improvement Program. The segregating populations (F2-F6) were planted at Quetta from 1982 to 1988 in order to generate homogeneous lines. In the F2 generation the single plant selection method was used, but from the F3 to the F5 generation the modified bulk method was adopted for selection. Each year plants were inspected frequently to assess cold and drought tolerance and disease resistance. Lines contaminated with yellow rust and Septoria tritici, and lines showing poor stand maintenance under cold and drought conditions were eliminated from the following year's experiment. Yield parameter recording was started from the F6 generation when the selected lines were phenotypically homozygous.

Each year the seeds were planted in early winter and a single pre-planting irrigation was used where necessary to ensure uniform crop emergence and stand establishment. Unfortunately, in the 1985/86 season inadequate moisture conditions at planting and soon after caused poor seed germination which resulted in crop loss. The seed rate was 100 kg/ha, and fertilizer was applied at 60 kg P_2O_5 and N per hectare in all years except 1985/86. The selected lines were tested in observation nurseries (BWON) at Quetta, Khuzdar and Kan Mehtarzai during the 1988/89 season, and in yield trials (BWYT) at Quetta and Loralai during the 1989/90 season. Details of these locations are given in Table 1. The observation nurseries were planted in single rows of 5m length with 25cm between rows. For the analysis of variance each of the three sites was considered as a single replicate of a randomized complete block. The yield trial was laid out using a randomized complete block design with three replications per site. The row length was 5m, the row width was 25cm, and there were six rows in each entry; the four central rows of each entry were harvested to determine total dry matter production and grain yield.

Results and Discussion

Table 1 shows the climatic conditions from 1985 to 1990. It is noteworthy that the 1986/87 season was extremely cold while 1987/88 was very dry, thus two seasons applied high selection pressure for cold and drought tolerance, respectively. The pedigrees and the selection cycle of the selected lines are presented in Tables 2 and 3. From 1982-89 the number of selected entries was reduced from 374 to 4 through intensive selection for desirable parameters (Table 3). There was considerable variability across the selected lines compared with the local check but the total dry matter and grain yields of the selected lines were similar (P>0.05) to the local check. The local wheat landrace was taller than the rest of the selected genotypes (P>0.05) and the selected lines had the same level of cold tolerance as the local check.

In the selection procedure applied to this segregating population of wheat, most of the efforts were directed to the extraction of winter hardy and drought resistant genotypes. Another major consideration was selection against yellow rust which can be severe in years with high rainfall. Thus, screening for disease resistance in the field is likely to be most effective in wet years. One very severe outbreak was experienced in the 1982/83 season which was the wettest year ever recorded in Quetta. The selection pressure for yellow rust was quite intensive and only 374 entries out of 816 were selected. After the 1982/83 attack, yellow rust spore populations fell considerably in the following, much drier years and no further screening against this disease was possible until 1989/90 when the next epidemic occurred. Then, the local wheat suffered a very severe infection which caused 50-75% yield reduction at most places in the highlands of Balochistan, while the selected lines showed very good resistance to yellow rust. The screening results also confirmed that genotypes with a prostrate growth habit were usually more cold tolerant than erect or intermediate genotypes.

Selection for cold resistance in conjuction with all the other desirable characters was found to be a very complicated undertaking. Although many entries were very cold hardy during their vegetative stages, winter hardiness was not always linked with drought tolerance at later stages, or with yield. Effective evaluation and selection of winter hardy plants necessitated early planting in order to allow selection of genotypes which had passed their vegetative period in winter in the dormant phase and had started their reproductive phase after the winter. In highland Balochistan cold damage is not usually experienced later in the season during the reproductive stages, but in early May 1989 a late frost during grain setting adversely affected grain production, causing sterility and shrivelled grains with reduced kernel weights. Fletcher (1984) and

Single (1985) reported that frost after ear emergence can reduce seed set and may result in complete sterility.

Plant height is another important consideration in highland Balochistan. In this area straw production is just as important as grain due to the shortage of feed for livestock, and the price of straw often exceeds the grain price. Farmers in this area prefer tall varieties for good straw production. The common practice of grazing or cutting good crops of winter wheat provides additional valuable green forage and also minimizes cold and frost damage.

In conclusion, this type of research approach for the dry areas of highland Balochistan can provide breeders with desirable parent material, obtained through the ICARDA cereal improvement progam, for crossing or for selecting germplasm resistant to environmental stresses. Desirable attributes such as cold, drought and disease tolerance or resistance, plant height, and earliness can play a positive role as selection criteria for improvement of bread wheat in this environment.

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Table 1. Site details, total rainfall during the season and absolute minimum air temperature from 1985-90 at different sites in Balochistan.

Site	Altitude	Latitude	Longitude
ARI, Quetta	1690m	30° 07' N	66° 58' E
Khuzdar	1250m	27° 46' N	66° 39' E
Kan Mehtarzai	2250m	31° 00' N	67° 45' E
Loralai	1340m	30° 24' N	68° 36' E

Site	Season	Total Rainfall (mm)*	Absolute Minimum Air Temperature (°C)
Quetta	1985-86	208	-7
Quetta	1986-87	313	-16
Quetta	1987-88	173	-7
Quetta	1988-89	239	-8
Khuzdar	1988-89	219	-8
Kan Mehtarzai	1988-89	222	-13
Quetta	1989-90	301	-8
Loralai	1989-90	**	**

* Excluding the one supplemental irrigation applied before sowing.
** Meteorological data was not available.

TABLE 2. Genetic background of the four selected lines of winter bread wheat.

E.No.	Name, Cross/Pedigree
1	Bez//Tob/8156/4/On/3/6*Th/KF//6*Lee/KF/5/Myna 's' Icw81. 1471
2	Loml1/son64/3/Pj 's' /Gb55//093/44/Stw597949/4/Kirac 1cw81.1504
3	FAO-K350/3/5 -Mt//Gb/4/340/F2/5/2Rfn/ofn 's' /6/Lom10/7/Martonrasari 6. Icw81. 1656
4	Bez//Mnv 's' Icw81. 1683
5	Check (Local White)

TABLE 3. Selection in a segregating population of winter bread wheat.

Year	Entries Tested	Entries Selected	Generation
1982-83	816	374	F2
1983-84	374	335	F3
1984-85	335	159	F4
1985-86	159	-	F5
1986-87	159	35	F5
1987-88	35	4	F6
1988-89	4	4	BWON
1989-90	4	1	BWYT

TABLE 4. Performance of winter type bread wheat lines during 1988-89 averaged over three sites in highland Balochistan.

Entry No.	Cold resistance scale	Plant Height (cm)	Dry Matter Yield (kg/ha)	Grain Yield (kg/ha)
1	1*	63	5572	801
2	1	68	4873	725
3	1	61	4498	706
4	1	66	4758	697
5**	1	77	3469	600
CV		16	16	24
SED		5	329	74

* Resistant
** Local Check

Table 5. Dry matter and grain yields (kg/ha) of bread wheat lines during 1989-90 at two sites in highland Balochistan.

Entry No.	Dry Matter Yield		Grain Yield	
	Quetta	Loralai	Quetta	Loralai
1	10800	6533	1621	1879
2	10200	6500	1688	1591
3	9066	4000	951	814
4	6800	5800	1400	1631
5*	12000	6000	1766	1836
CV	25	30	21	34
SED	1097	762	179	238

* Local Check