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BREAD WHEAT SELECTION AGAINST ABIOTIC AND BIOTIC STRESSES IN HIGHLAND BALOCHISTAN, PAKISTAN

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ABSTRACT

Bread wheat (*Triticum aestivum* L. ssp. *aestivum*) lines were screened in multi-location trials in highland Balochistan, Pakistan from 1982(F2) to 1990 (fixed lines). Objective of the study was to select and evaluate desirable genotypes for winter planting. 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 of possessing good resistance to yellow rust (*Puccinia striiformis* West). The results showed that exposure of segregating population to the prevailing environmental stresses of cold and drought was an effective selection procedure for identifying genotypes which are resistant to such stresses. Effective selection can be made for other desirable attributes such as disease and pest resistance, plant height and time to maturity.

Key words: *Triticum aestivum* L. spp. *aestivum*, soft wheat, genotypes, selection, disease resistance, cold, temperature resistance, drought resistance, arid climate, highland Balochistan.

INTRODUCTION

In Balochistan province of Pakistan most of the rain-fed wheat is grown in the highlands. Yield is however, very low mainly due to moisture stress, cold winters, yellow rust epidemics in the few wet years, non-availability of improved genotypes, and poor cultural practices. Climatic conditions are severe. The most important factor is the rainfall which averages around 240 mm varying greatly between and within seasons and also spatially. Summers are hot and dry, and winters are cold and may be quite wet with some snow. If adequate rainfall is received in late summer or fall, wheat is sown in October or November. If rainfall is scanty in summer/fall and little in winter, spring planting is done. Genotypes needed for winter planting differ from those for spring planting, but both need to have good drought tolerance, as the soil moisture reserves towards the end of the growing season usually diminishes rapidly.

Another important environmental constraint is 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 difficult because cold and drought resistance are rarely found together in a single genotype. A very cold-resistant variety may not be 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 important aspect, as this disease can have a major impact on wheat yields in the highlands of Balochistan (Ahmad et *al.* 1990; Mohammad 1989). During the study period, the Arid Zone Research Institute (AZRI) collaborated with the International Center for Agricultural Research in the Dry Areas (ICARDA) in a wheat-improvement program. It established a multi-location testing program in Balochistan to develop improved varieties for these difficult conditions, at sites ranging from 1500 to 2300 m elevation. The objective of the study was to select lines for winter sowing.

MATERIALS AND METHODS

In 1982/83 season, 816 genotypes of winter bread wheat F_2 populations were received from ICARDA Cereal Improvement Program. The segregating populations (F_2- F_6) were planted at Quetta from 1982 to 1988 in order to generate homogeneous lines. In the F_2 populations, single-plant selection was used, but from the F_3 to F_5 generations a modified bulk method was adopted. Each year, plants were inspected frequently to assess cold and drought tolerance and disease resistance. Lines contaminated with yellow rust (*Puccinia* striformis West), *Septoria tritici*, Blotch, (*Mycosphaerella graminicola* (Fuckel) Sand.), and lines showing poor stand under cold and drought conditions were eliminated from the following year's experiment. Yield recording was started from the F_6 generation when the selected lines were phenotypically homogeneous.

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

Table 1. Site details, total rainfall during the season and absolute minimum air temperatures at different sites in Balochistan, 1985-9.

Site	Altitude (m)	Latitude (N)	Longitude (E)	Season	Total rainfall (mm)*	Absolute minimum air temperature (^{0}C)
AZRI, Quetta	1,690	30^0 07'	66^0 58'	1985/86	208	-7
				1986/87	313	-16
				1987/88	173	-7
				1988/89	239	-8
				1989/90	301	-8
Khuzdar	1,250	27^0 46'	66^0 39'	1988/89	219	-8
Kan Mehtarzai	2,250	31^0 00'	67^0 45'	1988/89	222	-13
Loralai	1,340	30^0 24'	68^0 36'	1989/90	**	**

*Excluding one supplemental irrigation applied before sowing

**Data not available

RESULTS AND DISCUSSION

The 1986/87 season was extremely cold, while 1987/88 was very dry (Table I), thus the two seasons applied high selection pressure for cold and drought tolerance, respectively. The selection history and pedigrees of the selected lines are represented in Tables II and III. From1982 to 1989, the number of selected entries was reduced from 374 to 4 through selection for desirable parameters (Table II). There was considerable variability for various traits across the selected lines, but the total dry matter and grain yield of the selected lines were similar ($P< 0.05$) to the local check (Tables VI and V). The local race (Local White 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.

The main selection criteria applied to this segregating population were winter hardiness and drought tolerance. 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. A very severe outbreak was experienced in 1982/83, which was the wettest season ever recorded in Quetta. The selection pressure for yellow rust was intense and only 374 of 816 F_2 entries were selected. After the 1982/83 attack, yellow rust spore population fell considerably in the following much drier years and no further screening against this disease was possible until 1989/90 when another epidemic occurred. Then, the local wheat suffered severe infection that caused 50-75 percent yield reduction at most places in the highlands of Balochistan, while the selected lines showed considerable resistance to yellow rust. The screening results also confirmed that genotypes with a prostate growth habit were usually more cold tolerant than that of erect or intermediate genotypes.

Selection for cold resistance in conjunction with all the other desirable characters was complicated. Although many entries were 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 to allow selection of genotypes which had passed their vegetative period in winter 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 shriveled grains with reduced kernel weight. 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 region, straw production is just as important as grain owing to the shortage of feed for livestock, and the price of straw often exceeds that of grain. 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.

Table 2. Selection in segregating populations of winter bread wheat

Year	Tested entries	Selected entries	Generation*
1982/83	816	374	F_2
1983/84	374	335	F_3
1984/85	335	159	F_4
1985/86	159	--	F_5
1986/87	159	35	F_5
1987/88	35	4	F_6
1988/89	4	4	BWON
1989/90	4	1	BWYT

*BWON = Bread Wheat Observation Nurseries; BWYT = Bread Wheat Yield Trials.

Table 3. Genetic Background of the four selected lines of winter bread wheat.

Entry no.	Name, cross/pedigree
1	Bez/Tob/8156/4/)n/3/6*Th/KF//6*Lee/KF/5/Myna ‘s’ ICW81.1471
2	Lomll/Son64/3/Pj ‘s’/Gb55//093/44/Stw597949/4/Kirac ICW81.1504
3	FAO-K350/3/5-Mt//Gb/4/340/F2/5/2Rfn/Ofn ‘s’/ 6/Lom10/7/ Martonvasar 6. ICW81.1656
4	Bez//Mnv ‘s’ ICW81.1683
5	Check (Local White

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Table 4. Performance of winter bread wheat lines during 1988/89 averaged over three sites in highland Balochistan.

Entry no.	Cold resistance score	Plant height (cm)	Dry Matter Yield (Kg ha^{-1})	Grain yield (Kg ha^{-1})
1	1	63	5,572	801
2	1	68	4,873	725
3	1	61	4,498	706
4	1	66	4,758	697
5*	1	77	3,469	600
CV (%)		16	16	24
SD		5	329	74

*Local check

Table 5. Dry Matter and Grain yield of bread wheat lines during 1989/90 at two sites in highland Balochistan.

Entry no.	Dry Matter Yield (Kg ha^{-1})		Grain yield (Kg ha^{-1})	
	Quetta	Loralai	Quetta	Loralai
1	10,800	6,533	1,621	1,879
2	10,200	6,500	1,688	1,591
3	9,066	4,000	951	814
4	6,800	5,800	1,400	1,631
5*	12,000	6,000	1,766	1,836
CV (%)	25	30	21	34
SD	1,097	762	179	238

*Local check

In conclusion, this type of research approach for the dry areas of highland Balochistan can provides breeders with desirable parental wheat material obtained through ICARDA cereal-improvement program, 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 be effective selection criteria for the improvement of bread wheat in this environment.

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