THE MART/AZR PROJECT

HIGH ELEVATION RESEARCH IN PAKISTAN

Pakistan Agricultural Research Council

ARID ZONE RESEARCH INSTITUTE

Brewery Road, Quetta, Pakistan.

No. 60

SELECTION OF BARLEY LINES SUITABLE FOR SPRING SOWING IN THE ARID HIGHLANDS OF BALOCHISTAN

by

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1990

MART/AZR PROJECT RESEARCH REPORTS

This research report series is issued by the Management of Agricultural Research and Technology Project/Arid Zone Research Component (MART/AZR). This project is sponsored financially by the Mission to Pakistan of the United States Agency for International Development (USAID).

The project contract is implemented by the International Center for Agricultural Research in the Dry Areas (ICARDA) at the Pakistan Agricultural Research Council's Arid Zone Research Institute (AZRI).

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SELECTION OF BARLEY LINES SUITABLE FOR SPRING SOWING IN THE ARID HIGHLANDS OF BALOCHISTAN

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ABSTRACT

Barley experiments were conducted for three years at multi-locational test sites in highland Balochistan ranging from 1750 to 2250m elevation in order to evaluate barley lines suitable for spring planting. Such lines have to have characteristics of enhanced drought tolerance, short maturity and sustained yield to be successful under the harsh environmental conditions experienced in highland Balochistan. Selection parameters such as, erect growth habit, low tillering, high kernel weight, high harvest index and tolerance to heat and terminal drought stresses have been found to be associated with more consistent grain yield in spring-sown barley in the variable environments of the highlands.

One line, W12291/W12269, has been selected after three years of testing as it was found to be more tolerant to environmental stresses and gave higher grain yields than the local barley landrace under dry conditions.

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INTRODUCTION

The highlands of Balochistan (>1000m elevation) experience a principally continental Mediterranean climate, with monsoonal influences in some years. Depending on the location up to five years out of every ten receive insufficient summer rain for successful crop emergence before winter (Kidd et al 1988). As a result, spring sowing of short season cereals and legumes could be useful alternatives to current practices which are dominated by the growth of long duration winter wheat. So far, alternative varieties have not been clearly identified as potential replacements for the long duration local landraces of wheat, barley and lentils which are mostly quite sensitive to periodic disease epidemics.

In this paper we report three years' results of multi-location screening trials of barley germplasm suitable for spring sowing in the highlands of Balochistan. Results for other crops are reported elsewhere (ICARDA, 1990, Ali et al 1989). The identification of suitably adapted germplasm for the highlands is a difficult task owing to the harshness of the physical environment experienced in Balochistan. Qualities required for successful genotypes are considered to be:

- An ability to emerge rapidly at low soil temperatures, often in the presence of soil crusts;
- A considerable measure of cold tolerance in the early vegetative growth stage;

- Resistance to a range of rust diseases, periodically experienced in epidemic form;
- Overall drought tolerance at all growth stages in an environment where annual rainfall is both inconsistent in its temporal distribution and restricted in amount (150 - 275mm);
- Specific tolerance to combined drought and heat stress during anthesis and grain filling.

To obtain these desired qualities for such severe conditions, AZRI and ICARDA initiated a joint germplasm evaluation program in highland Balochistan. The tests included only material with enhanced disease resistance that has been selected from ICARDA rust resistance nurseries in Aleppo, Syria. Progress to date in this search for suitably adapted material is reported in this paper. The program is continuing and in the near future, well adapted spring barley varieties should be ready for release; these should help farmers to cope better with the severe conditions experienced in the arid highlands of Pakistan.

MATERIALS AND METHODS

In the 1986-87 cropping season, two different sets of barley yield trials (ICARDA international trials for moderate and low rainfall areas, BYT-MR and BYT-LR 1986/87) with 24 entries in each were planted in spring at Quetta and Khuzdar, in order to make initial selections of adapted material. All trials were sown at all sites in early spring (late January to early March), a practice followed by a minority of farmers in this area (Rees et al 1988). The trials were laid out as randomized complete blocks with three replications and were sown with a single row hand drill in plots of 1.5 x 5m. Each plot consisted of six rows with a 25cm spacing between rows. Fertilizers were applied at a rate of 60kg/ha N and 60kg/ha P2O5 at the time of sowing. As insufficient rainfall was received to ensure uniform crop emergence, 50mm (rainfall equivalent) of irrigation water was applied before sowing at both locations. In addition, a further 100mm of water was applied, at Khuzdar only, at flowering to ensure grain filling as the seasonal rainfall total was very low (<100mm, Table 1).

Superior lines were selected from each trial and in the following two years these lines were all tested together in a wide range of environmental conditions. The test sites employed were Quetta (altitude 1750m, latitude 30^0 14' N, longitude, 67^0 2' E), Khuzdar (altitude 1250m, latitude 27^0 46' N, longitude 66^0 39' E), Kan Mehtarzai (altitude 2250m, latitude 67^0 45' N, longitude 31^0 00' E) and Kalat (altitude 1850m, latitude 29^0 7' N, longitude 66^0 24' E). The Kalat site was used only for the 1987/88 season.

In the 1987-88 season a yield trial of 18 entries was selected from ICARDA BYT-MR 1986/87 and ICARDA BYT-LR 1986/87. Trials in 1987-88 were planted in the same manner as previously at the four locations. Pre-sowing irrigation was required at all sites as rainfall was considerably below average (Table 1, Kidd et al 1988) and further additional irrigation water was applied later in the season at Kalat, Kan Mehtarzai and Khuzdar in the face of acute drought. The site at Quetta was selected to examine germplasm performance under severe terminal drought conditions and no further irrigation water was applied at this location.

In the 1988-89 season a yield trial of the seven best entries selected from the 1987-88 trials was planted with the same agronomic practices at three sites: Quetta, Khuzdar and Kan Mehtarzai. Pre-sowing irrigation of 75mm was applied only at Khuzdar to ensure uniform crop emergence. At Quetta and Kan Mehtarzai sufficient moisture from winter rain and snowmelt was present to ensure uniform crop establishment. For yield data recording the four middle rows were harvested from each plot to exclude border effects. The crop was harvested by hand in June and July depending on elevation. Total dry matter production, seed yield, harvest index and 1000 kernel weight were recorded for each entry.

RESULTS AND DISCUSSION

The pedigrees and performance of the seven selected barley lines over all the experimental sites and seasons are presented in tables 2-7. In the 1986/87 season some differences between lines in seed yield, harvest index and thousand kernel weight were significant ($p<0.05$) at Quetta and Khuzdar, while biological yield differences were significant ($p<0.05$) only at Quetta table 3. At both sites sufficient rainfall (>200mm) was recorded to ensure good seed production (table 1) but the distribution at Quetta was such that severe terminal drought was experienced. The grain production of the local check barley landrace (entry No. 7) was considerably lower than that of some of the introduced lines. In particular, at Khuzdar entry No. 6 showed a promising yield level as did entry No. 3 at Quetta. This latter result was due to a significantly higher harvest index value for entry No. 3 ($p<0.05$) than that of the local check. Harvest index data from Quetta indicated that drought seriously affected the grain-filling process and that most lines effectively hayed off.

The environmental conditions of the 1987/88 season were relatively less favourable as severe drought was experienced at all locations. However, a few entries particularly Nos. 2 and 6 showed some evidence of drought tolerance (table 4). Yield differences were significant ($p<0.05$) only at Khuzdar and Kan Mehtarzai. The harvest index and thousand kernel weight data were extremely variable (table 5).

The 1988/89 season was somewhat more favourable for the growth of spring sown crops. Well distributed rains were received during the growth period at both Quetta and Kan Mehtarzai. However, a very damaging frost occured during the grain-filling period (mid-May), and grain yields were seriously depleted. A frost as severe as this experienced so late in the season is extremely rare (Rees et al 1989), and thus its importance should not be over-emphasized. Grain yield differences were significant ($p<0.05$) at all sites with the local landrace performing best at Kan Mehtarzai. The harvest index and thousand kernel weight values were significant ($p<0.05$) at Quetta and Kan Mehtarzai, and Quetta and Khuzdar respectively (table 7). At Quetta and Khuzdar the performance of entry No. 6 was comparatively better than the local barley landrace (table 6). At Kan Mehtarzai the local check was the highest yielding line and this may have been due to the relatively cool temperatures experienced during the early crop growth stages, as the local landrace is a winter type.

Results from three years' tests of spring-sown barley lines in highland Balochistan have shown considerable variability in grain yield across years and locations. Nevertheless, it is evident that some of the introduced lines have the potential to perform better than the local landrace when spring-sowing, in any specific season, is the only option available to farmers.

From this series of trials line W12291/W12269 (entry No.6) has been selected for further wide-scale agronomic testing in highland Balochistan, as its overall performance was the most promising under a wide range of environmental conditions. This two row entry has an erect growth habit, is medium in height and is early maturing. An erect growth habit is considered to be a desirable selection criterion as it implies a greater insensitivity to photoperiod and the absence of any vernalization requirement. Likewise, in an environment where terminal drought is the norm, early maturity is a major advantage (Fischer and Maurer, 1978), particularly when this is combined with the ability to retain a high harvest index value. Entry No. 6 has shown some evidence of having desirable genetic characteristics for this harsh highland environment.

The results reported in this paper are not final conclusions, but are intended to show the start of a process. Nevertheless, some progress has been made, and in due course, farmers in highland Balochistan should have an optional adapted variety to plant in seasons in which the absence of summer rainfall makes spring-sowing unavoidable.

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Table 1. Rainfall+supplemental irrigation during three crop growth seasons in highland Balochistan.

Site/Year		Rainfall (mm)	Supplemental irrigation	Total Water (mm)
Quetta	1986-87	191.7	50	241.7
Khuzdar	1986-87	71.7	150	221.7
Quetta	1987-88	142.2	50	192.2
Kalat	1987-88	39.0	100	139.0
Khuzdar	1987-88	31.3	150	181.3
Kan Meh-tarzai	1987-88	31.2	150	181.2
Quetta	1988-89	187.0	0	187.0
Khuzdar	1988-89	41.0	75	116.0
Kan Meh-tarzai	1988-89	181.2	0	181.2

Table 2. Pedigrees of selected barley lines.

Entry No.	Name/Cross/Pedigree
1.	As46/Ath s2 Sel.2L-1AP-3AP-Sel.2AP-1AP-OAP
2.	W12291/4/11012-2/70-22425/3/APM/1865//A16 ICB78-0635-1AP-OAP
3.	W12291
4.	W12269
5.	Harmal
6.	W12291/W12269
7.	Local Landrace

Table 3. Biological and grain yield (kg/ha), harvest index (%) and 1000 kernel weight (gm) of barley lines tested at two sites in highland Balochistan during 1986/87.

Entry No.	Biological yield		Grain yield		Harvest index		1000 kernel weight	
	QTA	KHZ	QTA	KHZ	QTA	KHZ	QTA	KHZ
1	4360	-	483	-	11	-	23	-
2	6410	-	557	-	9	-	29	-
3	5190	-	760	-	15	-	27	-
4	-	6710	-	2216	-	33	-	39
5	-	7890	-	2190	-	29	-	37
6	-	8310	-	2486	-	30	-	35
7	4220	8060	206	2142	5	29	29	36
p.	<0.05	>0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Coeff.V	41	21	41	25	37	26	13	18
S.E.	31	318	31	91	6	2	0.71	1

Note. Coefficient of variation and standard error are calculated from the total number of tested entries in the trial(24).

Table 4. Biological and grain yield (kg/ha) during 1987/88 at different sites in highland Balochistan.

Entry No.	Biological yield				Grain yield			
	QTA	KL	KHZ	K.MEH	QTA	KL	KHZ	K.MEH
1	1060	1313	1353	1933	81	442	130	99
2	953	1446	1466	3066	103	277	117	280
3	948	1251	1266	1800	71	674	224	188
4	815	1051	1066	1677	41	352	200	155
5	1000	810	820	1780	60	578	122	177
6	1267	1380	1420	2133	58	458	338	223
7	900	805	838	2123	31	520	125	93
p.	>0.05	>0.05	<0.05	>0.05	>0.05	>0.05	<0.05	<0.05
Coeff.V	52	31	1	24	72	43	95	59
S.E.	117	119	7	112	9	42	23	18

QTA= Quetta, KL= Kalat, KHZ= Khuzdar, K.MEH= Kan Mehtarzai
Note. Coefficient of variation and standard error are calculated from the total number of tested entries in the trial (18).

Table 5. Harvest index (%) and 1000 kernel weight (gm) of barley lines during 1987/88 at different sites in highland Balochistan.

Entry	Harvest index				1000 kernel weight			
No.	QTA	KL	KHZ	K.MEH	QTA	KL	KHZ	K.MEH
1	7	27	9	4	28	32	30	19
2	10	19	7	9	27	28	31	36
3	8	36	17	9	25	35	27	30
4	5	21	21	9	24	27	32	32
5	6	32	15	16	22	27	34	37
6	5	29	21	10	20	30	27	31
7	3	34	13	4	22	31	41	30
p.	>0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Coeff.V	43	25	51	52	0.57	4	1	0.46
S.E.	6	.01	1	8	3	0.26	7	3

Note. Coefficient of variation and standard error are calculated from the total number of tested entries in the trial (18).

Table 6. Biological and grain yield (kg/ha) of barley lines during 1988/89 at different sites in highland Balochistan.

Entry	Biological yield			Grain yield		
No.	QTA	KHZ	K.MEH	QTA	KHZ	K.MEH
1	1228	533	2633	114	80	686
2	902	366	2900	68	108	444
3	1362	483	2383	282	139	765
4	1275	1066	2300	337	276	695
5	1125	533	2066	257	240	614
6	1268	1470	2333	365	400	782
7	1802	1383	2833	319	320	944
p.	<0.05	<0.05	>0.05	<0.05	<0.05	<0.05
Coeff.V	21	44	13	23	50	13
S.E.	100	138	126	21	42	35

Table 7. Harvest index (%) and 1000 kernel weight (gm) of barley lines during 1988/89 at different sites in highland Balochistan.

Entry	Harvest index			1000 kernel weight		
No.	QTA	KHZ	K.MEH	QTA	KHZ	K.MEH
1	10	14	26	19	25	26
2	8	27	15	21	33	29
3	21	37	32	22	33	26
4	26	35	31	25	36	27
5	24	47	30	26	35	30
6	31	28	34	24	34	27
7	18	23	34	21	33	27
p.	<0.05	>0.05	<0.05	<0.05	<0.05	>0.05
Coeff.V	34	41	10	7	9	5
S.E.	3	0.04	1.1	0.6	1	0.5