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THE POTENTIAL OF NEW BARLEY VARIETIES IN THE HIGH ELEVATION DRYLAND OF BALUCHISTAN, PAKISTAN

by

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THE POTENTIAL OF NEW BARLEY VARIETIES IN THE HIGH ELEVATION DRYLAND OF BALUCHISTAN, PAKISTAN.

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ABSTRACT

In upland Baluchistan winter cereals are grown under dryland conditions, with the addition of conserved moisture from monsoonal rains. The major constraints to production are limited water, uncertain rainfall and extremes of temperatures in winter. The most productive manner to reduce the effects of environmental stresses is through the development and evaluation of tolerant genotypes. Four Syrian barley landraces, that have proved to be better adapted to dry conditions than conventionally bred improved material were tested for two years against the local landrace under rainfed conditions at three sites which were chosen to represent the broad range of environmental conditions experienced in upland Baluchistan. Arabi Abiad and Arabi Aswad were found to be more tolerant to environmental stresses and gave higher grain yield than the local barley landrace under dry conditions.

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INTRODUCTION

Upland Baluchistan has a continental Mediterranean climate where water limitations, low winter temperatures and year to year environmental variability are major constraints to sustained crop production. In West Asia and North Africa barley is the predominant crop grown in areas receiving less than 300mm of annual rainfall. Such areas are characterized by high inter-seasonal and intra-seasonal variation in terms of amount and distribution of rainfall (Ceccarelli et al. 1987).

Sheep grazing in barley fields during the winter season, when there is a scarcity of green feed, followed by harvesting of the crop for grain and straw in early summer is the common practice in Baluchistan. If farmers are unable to harvest the crop for seed in a dry season the straw of the crop is of considerable value as a source of animal feed. In consequence, in such a crop-livestock production system not only the grain yield is important but also crop straw products play a major role in the economy of the area. As a result, prices of barley seed and straw in Baluchistan during 1988 were not dissimilar Rs. 235 per 100 kg and Rs. 175 per 100 kg respectively (Nagy et al. 1989).

After wheat, barley is the second most important dual purpose crop in Baluchistan, grown at all elevations and mostly under rainfed conditions. In upland Baluchistan the area of barley is small, just less than 4000 ha under rainfed conditions, with average yield levels of approximately 565 kg/ha (Asif Masood et al. 1988). The area of

Wheat grown is twenty times greater than that of barley in upland Baluchistan. However, as annual rainfall varies from 200 to 350 mm it suggests that barley might be a more appropriate crop than wheat for rainfed crop production in this area. Experimental results have demonstrated that barley yields, although low, average 20% higher than wheat under dryland conditions (Rees et al. 1989). The introduction of new more productive and disease resistant varieties might lead to an expansion of barley production in Baluchistan.

In the past little research attention has been given to barley improvement in Baluchistan. However, as the demand for livestock feed is increasing very rapidly in Baluchistan with a small ruminant population growth rate exceeding 7% per year (Asif Masood et al. 1988) and that malnutrition in animals is now a major constraint to improved ruminant productivity (ICARDA, 1989) the need for increased yields of forage crops such as barley in Baluchistan is self-evident. The Arid Zone Research Institute has undertaken a barley improvement program in upland Baluchistan for the last six years. A number of barley lines have been identified from this program with enhanced cold and drought tolerance, early growth vigour and higher grain yields.

Promising lines to date are landraces from Syria which may be suitable replacements for the local barley landrace as their yield levels are satisfactory under a wide range of environmental conditions and they are expected to be more resistant to losses from local rust diseases.

MATERIALS AND METHODS

The experiment was conducted during the 1986-87 and 1987-88 cropping seasons at three different sites: 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) and Kan Mehtarzai (altitude 2250m, latitude 67^0 45'N, longitude 31^0 00'E). These sites were selected to represent the broad range of environmental conditions experienced in upland Baluchistan. The experiment was sown with one pre-planting irrigation (equivalent to 50mm precipitation) at all the sites except Khuzdar in 1986-87 where sufficient conserved moisture from monsoonal rains existed to ensure good stand establishment (Table 1b). Planting time was mid-September to mid-October and harvesting of the crop occurred between the last week of May and the last week of June. The experimental design used was a randomized complete block with four replications. The plot size was 5 x 1.5m with six rows giving a row to row distance of 25cm. At each site the experiment was planted with a single row hand drill. Phosphate and nitrogen fertilizer were applied at a rate of 60 kg/ha each at the time of planting. Observations on cold tolerance, days to heading, days to maturity, plant height, spike length, tillers per plant, total dry matter, grain yield, straw yield and 1000 kernel weight were made from the central four rows of the plot only to exclude border effects.

CLIMATIC CONDITIONS

Baluchistan has a continental Mediterranean climate (Rafiq, 1976). Winters have very low night air temperatures and summers are normally hot and dry. Rain usually occurs in winter. Considerable variability in weather conditions are experienced from year to year (Kidd et al 1988). If monsoon rains are received, these usually occur in the summer months. If heavy rain is experienced farmers seek to preserve run-off moisture and where possible direct ephemeral streams onto their land. This moisture is the main source of water for planting crops in autumn (sailaba farming).

The climatic conditions in Baluchistan are highly inconsistent with generally 200mm precipitation or less being expected at least three years in ten (Kidd et al. 1988). Rainfall distribution in the 1986-87 season was more favourable for crop growth than in the 1987-88 season (Tables 1a, 1b, 1c). Monsoonal rains received early in the 1986-87 growth year played an important role in providing a substantial amount of residual moisture for crops (Tables 1a, 1b, 1c). Monsoonal rains did not occur in effective quantities at any of the sites during 1987-88 season (Tables 1a, 1b, 1c). The 1987-88 season was comparatively dry and the first rain of the winter season occurred late, in January, at all sites. Furthermore, crops suffered severely from terminal drought at all sites which resulted in low productivity.

Minimum air temperatures during 1986-87 at Quetta and Kan Mehtarzai were extremely low (-16 to -19^{0}C) (Tables 1a, 1c) and provided a useful natural screening pressure for cold tolerance in the germplasm being tested. As the environmental conditions are generally severe, it is a requirement for new varieties that they must be robust for successful introduction and that their yield consistency in a variable environment is probably a more important criterion than yield potential.

RESULTS AND DISCUSSION

Varietal differences in total dry matter were significant in both the 1986-87 and 1987-88 seasons ($P < 0.05$) at Quetta, but not at Khuzdar and Kan Mehtarzai (Table 2). In the comparatively wet season of 1986-87 the local barley landrace had a higher total dry matter at all sites than the introduced lines Wadi Hassa, Tadmor, Arabi Abiad and Arabi Aswad. However in 1987-88 which was a dry year, the production of local barley, in terms of total dry matter, was not better than the introduced lines. Arabi Aswad had a slightly higher total dry matter at Quetta and Kan Mehtarzai during 1987-88 than local barley but at Khuzdar, in consequence of soil crusting and low moisture availability, the dry matter production of all the lines was low in comparison to other two sites. Although the total dry matter production of the introduced lines were not significantly higher than local barley landrace however, the grain yield of Arabi Abiad and Arabi Aswad were better in the dry year of 1987-88 at Quetta and Kan Mehtarzai when compared to the local barley (Table 3).

Dry matter production of Arabi Aswad was greater than in the other lines probably because it uses the available moisture more efficiently early in the season. The early growth vigour of Arabi Abiad is greater than local barley and by cutting in early winter it can be produce more green fodder and hay production. Rees et al (1989) reported that Arabi Abiad produced 20% more hay production than local barley.

Differences in grain yield among all the lines were also significant (P < 0.05) at Quetta in 1986-87 and Kan Mehtarzai in 1987-88 but not at Khuzdar (Table 3). Arabi Abiad was the highest yielding line in 1986-87 and 1987-88 at Quetta, and during 1986-87 at Kan Mehtarzai. In 1987-88 at Kan Mehtarzai Arabi Aswad gave a significantly higher grain yield.

Arabi Aswad and Arabi Abiad are six to ten days earlier in maturity than the local barley and this characteristics is likely to be associated with a more stable yield under dry conditions (Ceccarelli and Mekni, 1985). The tillering tendency of Arabi Abiad and Arabi Aswad is slightly better under dry conditions than local barley. Seasonal rainfall is the most important factor affecting cereal yields in the rainfed areas of North Africa and the Middle East. Upto 82% of the variation in cereal grain yield was found to be determined by seasonal rainfall in areas receiving 133-454 mm with 11-19 kg/ha being produced for each additional millimeter of rain (Ketata, 1989). Arabi Abiad and Arabi Aswad both have higher kernel weights than the local barley and this character is sometimes useful for selecting high yielding varieties (McNeal et al. 1987). Rees et al (1989) reported that Arabi Abiad showed a greater environmental stability than the local landrace with a 30% increase in grain production, and 19% increase in gross benefits.

Differences in harvest index was significant ($P < 0.05$) at Quetta in 1986-87 and Kan Mehtarzai in 1987-88, while in all other sites and seasons differences in harvest index were not significant (Table 4). The harvest index of specific varieties varies markedly at different sites and between seasons due to environmental variability. The results shown in Table 4 suggest that Arabi Abiad and Arabi Aswad were more tolerant to the environmental stresses experienced in upland Baluchistan and showed a higher harvest index than other lines particularly in comparatively dry seasons and hence seem to be genetically more efficient in moisture limiting conditions. However, it is very clear from the results shown in Table 4 that in three of the site/season combinations under test that none of the lines managed to achieve their potential in terms of grain filling as determined by their dry matter production. Harvest index values for Arabi Abiad and Arabi Aswad are usually between 0.3 and 0.4 under less severely moisture limiting conditions (Brown et al. 1988).

Significant differences in cold tolerance were observed ($P < 0.05$) among the tested lines at Quetta and Kan Mehtarzai (Table 5). Arabi Abiad and Arabi Aswad were more tolerant to low temperatures (- 19 ^{0}C) at Kan Mehtarzai than Wadi Hassa and Tadmor, and slightly less tolerant to cold than the local barley landrace, but *this* differences did not seem to effect the final yield level for these two cultivars.

Arabi Abiad and Arabi Aswad both have a prostrate winter growth habit which is a desirable characteristic for cold tolerance in high elevation areas (Ceccarelli et al. 1987). Damage by frost is one of the important yield limiting factors in the continental Mediterranean climatic zone in combination with other biotic and nonbiotic stresses. Low temperatures retard the growth of the crop and in severe conditions susceptible genotypes can be killed completely. Therefore it is necessary to try to identify and develop such genotypes which can grow faster at low temperatures (Nachit, 1984). Low winter temperatures restrict crop growth rates, which results in the slow development of full ground cover by crops. Poor ground cover allows increased evaporative loss from the bare soil surface which can reduce the amount of water available for subsequent crop use considerably (Cooper et al. 1984).

In upland Baluchistan minimum air temperatures well below freezing can occur in the vegetative and early reproductive crop growth stages. This can cause the death of the main stem or leaf burning of some genotypes but the tillering capacity is usually unaffected. The severity of damage is related to the growth stage at which cold events occur and appears to be increased by lack of acclimatization. During the 1986-87 season extremely low minimum air temperatures (-16 to -19 ^{0}C) were immediately preceded by several weeks of much warmer minimum air temperatures (close to or above 0^0C) at Quetta and Kan Mehtarzai and much of the germplasm of wheat and barley planted in these sites were killed (ICARDA, 1988).

If cultivars having the characteristics of cold tolerance and early growth vigour can be identified, farmers can take better advantage of the early growth of barley to feed sheep and cattle in early winter when green feed is scare in upland Baluchistan.

Results from the two years experimentation described in this paper suggest that the introduced lines Arabi Abiad and Arabi Aswad have sufficient resistance to cold and drought to perform, as well, if not better than the local landrace in the harsh environment of upland Baluchistan. The major advantage of introducing these lines would be in their a greater potential resistance to rust diseases which is reported by Nagy et al (1989) to be a constraint to production of the local landrace. This has yet to be confirmed in trials at Arid Zone Research Institute but it is known that in the last decade two severe outbreaks of yellow rust (*Puccinia striiformis*) have occurred in upland Baluchistan. Clearly, the availability of better adapted varieties to farmers in upland Baluchistan would lead to further yield increases and a greater reliability of production. This would be a positive step forward in starting to address the considerable deficit in animal feed currently experienced in Baluchistan.

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Table 1a. Climatic Data for Quetta in Two Growth Years (1986-88).

Month	Quetta 1986-87			Quetta 1987-88		
	Total Rain-fall (mm)	Mean Max. temp* (°C)	Mean Min. temp. (°C)	Total Rain-fall (mm)	Mean Max. temp. (°C)	Mean Min. temp. (°C)
Jul	2.0	33.7	21.8	0.0	35.5	18.8
Aug	73.2	30.0	19.0	25.0	35.5	18.6
Sep	0.0	30.4	10.2	0.0	32.1	12.6
Oct	0.0	26.4	6.1	0.0	25.3	6.3
Nov	6.9	20.2	-0.1	0.0	18.0	-3.4
Dec	11.4	11.7	-3.6	0.0	17.0	-2.3
Jan	28.2	12.9	-3.0	9.1	13.4	-1.1
Feb	64.5	14.7	3.2	17.8	15.6	1.3
Mar	106.0	17.9	8.4	117.0	19.0	4.3
Apr	11.8	24.1	12.1	3.6	26.9	13.1
May	9.4	29.0	16.4	0.0	32.4	18.0
Abs. Min. air temp. during the season (°C)			-16			-7

* Screened air temperature at 1.5 m.

Table 1b. Climatic Data for Khuzdar in Two Growth Years (1986-88).

Month	Khuzdar 1986-87			Khuzdar 1987-88		
	Total Rain-fall (mm)	Mean Max. temp* (°C)	Mean Min. temp. (°C)	Total Rain-fall (mm)	Mean Max. temp. (°C)	Mean Min. temp. (°C)
July	81.3	38.2	21.9	2.0	39.8	23.5
August	380.2**	37.5	20.2	2.5	39.6	22.8
September	0.0	35.0	14.0	0.0	37.1	17.4
October	0.0	35.6	9.3	0.0	33.7	11.4
November	4.2	27.9	4.8	0.0	27.3	9.0
December	0.0	25.7	3.3	0.0	22.1	1.8
January	9.5	25.5	3.2	10.6	20.3	1.5
February	46.7	26.4	4.2	14.5	20.4	5.2
March	0.0	27.0	7.9	2.0	24.3	8.4
April	0.0	32.8	10.8	0.0	33.2	14.1
May	25.0	36.6	11.6	0.0	35.1	17.4
Absolute Min.Temp. during the season(°C)			0			-5

* Screened air temperature at 1.5 m.
** Monthly total received from two intense storms of more than 100 mm each, runoff will have occurred at this site.

Table 1c. Climatic Data for Kan MEHTARZAI in Two Growth Years (1986-88).

Month	Kan Mehtarzai1986-87			Kan Mehtarzai 1987-88		
	Total Rain- fall (mm)	Mean Max. temp* (^0C)	Mean Min. temp. (^0C)	Total Rain- fall (mm)	Mean Max. temp. (^0C)	Mean Min. temp. (^0C)
July	0.0	30.2	15.5	0.0	30.1	15.2
August	50.0	28.8	11.4	0.0	29.9	14.5
September	0.0	28.1	8.0	0.0	29.1	12.0
October	0.0	20.2	3.9	0.0	27.2	6.4
November	0.0	17.1	-9.0	0.0	16.0	-7.3
December	0.0	5.0	-11.0	0.0	7.5	-9.0
January	0.0	0.0	-12.1	34.4	2.4	-9.7
February	15.0	6.0	-4.2	31.2	11.5	-2.3
March	128.8	12.2	-1.6	0.0	7.4	-2.4
April	22.8	20.1	-0.4	0.0	17.7	0.5
May	3.6	27.0	0.0	0.0	22.4	7.2
Absolute Min.Temp. during the season(^0C)			-19			-12

* Screened air temperature at 1.5 m.

Table 2. Total Dry Matter (kg/ha) of Barley Lines at Three Sites in Upland Baluchistan

S.NO	VARIETY	QUETTA		KHUZDAR		KAN MEHTARZAI	
		1986-87	87-88	86-87	87-88	86-87	87-88
1.	Wadi Hassa (LB 50)	3327	1800*	2860	753	2499	2320
2.	Tadmor (LB 90)	4974	3700	3524	376	3193	2720
3.	Arabi Aswad	4437	4050	3930	451	2820	3040
4.	Arabi Abiad	5234	3200	3574	491	3320	2320
5.	Local Barley (Check)	6718*	3900	4680	281	3812	2550
Coefficient of Variation (%)		18	30	51	82	41	48
Standard Error		400	448	855	173	572	508

* Significant at 0.05 Level

Table 3. Grain Yield (kg/ha) of Barley Lines at Three Sites in Upland Baluchistan.

S.NO	VARIETY	QUETTA		KHUZDAR		KAN MEHTARZAI	
		1986-87	87-88	86-87	87-88	86-87	87-88
1.	Wadi Hassa (LB 50)	378	571	962	225	88	679
2.	Tadmor (LB 90)	194	291	1188	116	81	823
3.	Arabi Aswad	316	564	1086	136	84	941*
4.	Arabi Abiad	382*	599	1184	94	179	773
5.	Local Barley (Check)	241	284	1821	77	151	253
Coefficient of Variation (%)		28	94	57	107	49	25
Standard Error		38	194	319	62	26	165

* Significant at 0.05 Level.

Table 4. Harvest Index of Barley Lines at Three Sites in Upland Baluchistan.

S.NO	VARIETY	QUETTA		KHUZDAR		KAN MEHTARZAI	
		1986-87	87-88	86-87	87-88	86-87	87-88
1.	Wadi Hassa (LB 50)	0.07	0.08	0.26	0.26	0.03	0.29*
2.	Tadmor (LB 90)	0.07	0.07	0.32	0.15	0.05	0.26
3.	Arabi Aswad	0.11*	0.14	0.33	0.14	0.03	0.29
4.	Arabi Abiad	0.04	0.17	0.33	0.19	0.02	0.27
5.	Local Barley (Check)	0.04	0.07	0.39	0.20	0.03	0.12
Coefficient of Variation (%)		25	234	17	68	35	27
Standard Error		8	0.25	0.025	6	6	3

* Significant at 0.05 Level.

Table 5. Cold Tolerance** of Barley Lines at Three Sites in Upland Baluchistan.

S.NO	VARIETY	QUETTA		KHUZDAR		KAN MEHTARZAI	
		86-87	87-88	86-87	87-88	86-87	87-88
1.	Wadi Hassa (LB 50)	3	2	1	1	2	2
2.	Tadmor (LB 90)	3	2	1	1	3	2
3.	Arabi Aswad	2	1	1	1	2	2
4.	Arabi Abiad	2	1	1	1	2	2
5.	Local Barley (Check)	1*	1*	1	1	1*	1*
Coefficient of Variation (%)		21	25	-	-	15	16
Standard Error		0.25	0.19	-	-	0.16	0.15

* Significant at 0.05 Level

** Using 1-5 scale: 1 = high resistant (Plant survival = 100%)
5 = Susceptible (Plant survival = 0%)