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Development of barley (*Hordeum vulgare* L.) as a feed/fodder crop for the Mediterranean environment of highland Balochistan, Pakistan

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SUMMARY - Local landrace of barley, susceptible to fungal disease, yellow rust (*Puccinia striiformis*) produces low yields during good production years in highland (>1000 m) Balochistan. Therefore, an improved variety is required for feed and food purposes. It must also withstand biotic (yellow rust) and abiotic (cold and drought) stresses. Such variety can offer a good alternate source of feed to small ruminants during winter when depleted rangelands cannot fulfil feed requirements. AZRC scientists along with ARI counterparts have released a stress (cold, drought and disease) resistant barley variety (Sanober-96) which offers a great promise for sustainable production. Sanober-96 (two row barley) gives TDM (total dry matter) 7.1 tonnes ha^{-1} and grain yield 2.1 tonnes ha^{-1} as compared to local barley's TDM of 6.1 tonnes ha^{-1} and grain yield 1.2 tonnes ha^{-1} under rainfed conditions.

Key Words: Highland, landrace, yellow rust, biotic/abiotic, feed, small ruminants.

RESUME *- "Développement de l'orge (*Hordeum vulgare *L.) comme aliment/culture fourragère dans des milieux méditerranéens des montagnes du Baloutchistan, Pakistan" Les variétés locales d'orge, susceptibles à la maladie fongique Rouille Jaune (*Puccinia striiformis*) produisent de faibles rendements pendant les bonnes années de production dans les zones montagneuses (>1000m) du Baloutchistan. Par conséquent, il est nécessaire d'avoir une variété améliorée pour l'alimentation animale et humaine. Elle doit supporter aussi le stress biotique (rouille jaune) et abiotique (froid et sécheresse). Une telle variété peut offrir une bonne source alternative d'alimentation aux petits ruminants pendant l'hiver quand les parcours épuisés ne peuvent plus subvenir aux besoins alimentaires. Les scientifiques de l'AZRC avec leurs collègues de l'ARI ont mis au point une variété d'orge résistante au stress (froid, sécheresse et maladie) (Sanober-96) qui promet un grand potentiel pour une production durable. Sanober-96 (orge à deux rangs) donne 7,1 tonnes ha^{-1} de MST (matière sèche totale) et un rendement du grain de 2,1 tonnes ha^{-1} par rapport à la MST de l'orge local de 6,1 tonnes ha^{-1} et rendement du grain 1,2 tonnes ha^{-1} en conditions de non-irrigation.*

Mots-clés *: Pays montagneux, variété locale, rouille jaune, biotique/abiotique, aliment, petits ruminants.*

Introduction

Barley is the second most important cereal crop in highland Balochistan where about 47,097 hectares is grown (Directorate General of Agriculture Department, 1997). About 17 million hectares are sown with barley in developing countries (ICARDA, 1992), mostly in areas where rainfall is lower than for wheat due to barley's better drought tolerance. In West Asia and North Africa it is the dominant crop in areas receiving less than 300 mm annual rainfall (Ceccarelli *et al.*, 1987). However, as annual rainfall varies from 200 to 300 mm in the region, it is suggested that barley should be a more appropriate crop than wheat for rainfed crop production. Experimental results have demonstrated that barley is well adapted to rainfed areas of Balochistan (Rees *et al.*, 1989; Ahmad *et al.*, 1991) and its yields are 20% higher than wheat under dryland conditions of upland Balochistan (Khan *et al.*, 1993). In highland Balochistan barley is grown as feed crop by producing grain and straw for small ruminants during winter. Sometimes it is used as green fodder for winter grazing. In dry seasons, much of barley is grazed continuously with no grain harvest. The purpose of this study was to develop and evaluate a high yielding barley variety which could not only withstand the prevalent biotic and abiotic stresses of the area but also could offer a sustainable feed production for livestock of the area.

Materials and methods

Four test sites were used for conducting yield trials: Quetta (altitude 1690 m), Kalat (altitude 1850 m), Loralai (altitude 1340 m) and Surab (altitude 1800 m). These sites represent different agro-ecological zones of the area. The experiments were planted during fall (mid-October to mid-November) at the test sites in 1990/91, 1991/92 and 1992/93. The material was planted after getting the first showers caused by western disturbances which is a usual phenomenon of this Mediterranean region. The genotypes including Sanober-96 were evaluated and selected against the prevalent biotic and abiotic stresses. The Sanober-96 was also tested in 9 different environments of upland Balochistan ranging from 1340 m to 2250 m in spring planting (February 1991). The spring planting is also a usual practice here which is dependant upon the late winter rains. A randomized complete block design was used with three replicates and each entry/genotype had six rows per plot at all test sites. Rows were 5 m long with an inter-row distance of 0.25 m. Twenty kg N and P was used before sowing the trials. Harvesting was done from mid-May to the end of June depending upon the maturity times at the different test sites. Stability of genotypes, higher TDM production, and wider adaptability were also taken into consideration while selecting genotypes. Moreover, soft-strawed genotypes were also given preference because the straw of such varieties is preferably and easily taken by the animals, especially small ruminants. Observations were made before harvesting on growth habit, cold tolerance (0-5 scale), plant height (cm), tillers m^{-2} and yellow rust resistance (Modified Cobb Scale). Production data total biological yield as total dry matter (TDM), grain yield and 1000 kernel weight were also recorded. The middle four rows of each plots were harvested.

Results and discussions

A. Fall Trials

In 1990/91 season the eight test entries comprising of exotic material were planted at Quetta, Kalat and Loralai (Table 1). The Sanober-96 produced more TDM at all test sites than the local landrace. Similarly the local barley was outyielded by Sanober-96 significantly ($p<0.05$) at Quetta and Kalat whereas it was also left behind in TDM and grain production at Loralai (Table 1). Yellow rust hit hard some of the barley growing areas (Kalat and Quetta) of the highlands of Balochistan because of favourable climatic conditions. At Loralai, planting was possible on pure Sailaba conditions because of sufficient conserved soil moisture from monsoon rains. This confirmed the germination and emergence of the said variety in deep sowing. However, later in the season rains were scanty and screening for drought was possible at this place. Material for cold resistance was screened at Quetta where minimum temperature reached -11°C. The total precipitation received during the season was 344 mm at Quetta, 249 mm at Kalat and 141 mm at Loralai. The Quetta and Kalat received more than average rainfall and that is why the crop was confronted with yellow rust infestations.

Table 1. Performance of Sanober-96 at different sites: Quetta, Kalat and Loralai in 1990/91

Entry	No./Location	TDM (Tonnes ha^{-1})			Grain Yield (Tonnes ha^{-1})		
		Quetta	Kalat	Loralai	Quetta	Kalat	Loralai
1	BOC87 34	9.3	2.6	3.7	2.4	0.6	1.0
2	BYL88 6	9.8	2.7	3.5	2.4	0.5	1.2
3	IWFBSN 20	9.7	4.4	4.3	1.5	1.1	0.6
4	BKL88 114	8.3	4.7	2.7	1.3	1.1	0.7
5	BKL88 266	9.3	4.6	4.0	1.6	1.3	1.3
6	BKL88 372	9.1	3.8	4.0	1.3	0.8	1.0
7	Sanober-96	9.9	4.9	4.1	2.9*	1.9*	1.6
8	Frontier-87	9.4	2.1	3.6	1.1	0.5	0.8
9	Local	8.6	4.8	3.5	1.4	1.2	1.3
	LSD (5%)	ns	1.5	ns	0.8	0.6	ns

In 1991/92 the performance of 9 test entries including Sanober-96 was evaluated at Quetta and Loralai (Table 2). Yellow rust was again a peculiar feature of the growing season due to favourable climatic conditions (301 mm rain) at Quetta. Cold screening was also possible at Quetta because mercury reached -8°C. Trials of barley were sown at Loralai on conserved soil moisture. This practice allowed us to use deep sowing methodology which is commonly employed by the farming community of Balochistan. At later stages drought screening was also possible because of the drier conditions (150 mm rain) at this test site. Under these biotic and abiotic stresses the Sanober-96 again proved itself as No. 1 both in TDM and grain production (Table 2).

Table 2. Performance of Sanober-96 at different sites: Quetta and Loralai during 1991/92

Entry	No./Location	TDM (Tonnes ha^{-1})		Grain Yield (Tonnes ha^{-1})	
		Quetta	Loralai	Quetta	Loralai
1	BOC87 92	9.8	3.7	3.2	0.6
2	BYL88 6	10.8	2.5	2.4	0.6
3	IWFBSN 20	9.0	2.9	1.5	0.3
4	ABU88 150	9.0	4.7	1.8	0.6
5	BKL88 114	7.0	4.1	1.3	0.5
6	BKL88 187	9.8	4.1	1.8	0.9
7	BKL88 197	8.4	3.5	1.2	0.8
8	Sanober-96	11.0	3.6	2.9	1.0
9	Frontier-87	8.2	3.0	2.2	0.5
10	Local	8.6	3.2	1.4	0.7
	LSD (5%)	3.1	1.3	0.8	ns

In 1992/93 Sanober-96 along with other 7 exotic genotypes was again tested at Quetta and Surab (Kalat). It maintained its superiority over the local barley by giving higher yields (TDM plus grain) as shown in Table 3. Yellow Rust was again witnessed at Quetta because of favourable climatic conditions (285 mm rain) but, due to strong desiccating winds, humidity went down drastically and disease could not spread all over. Moreover, Quetta also witnessed sub-zero temperatures at anthesis (-8.8°C) which caused partial spike sterility in many barley lines and as a result yield of the affected varieties went down. This was an unusual phenomenon but the chosen variety escaped this spell of unusual cold. The trials at Surab (Sur.) were under drought stress at post-anthesis stage because of non-availability of rain. In a separate study (Rafique *et al.*, 1993), Sanober-96 produced more forage than local barley at pre-anthesis, anthesis and maturity stages.

B. Spring Trials

Sanober-96 was also tested in late planting (February) at different agro-ecological zones of upland Balochistan. The results revealed that the variety in question also carries facultative traits and is a good alternate of local barley for spring/late planting. The trials were conducted during 1990/91 in nine different environments (Table 4).

Conclusion

The Sanober-96 was released for highland Balochistan in 1995/96 because of its suitability for the target stressful environment. It showed its immunity to yellow rust whereas the local barley showed 80S, 90S and 50S susceptibility in three respective years. The released Sanober-96 is a of facultative nature and can be used in spring planting as well.

Table 3. Performance of Sanober-96 at different sites: Quetta and Surab during 1992/93

Entry	No./Location	TDM (Tonnes ha^{-1})		Grain Yield (Tonnes ha^{-1})	
		Quetta	Surab	Quetta	Surab
1	BOC87 92	10.2	1.9	2.8	0.6
2	BYL88 6	7.4	2.2	1.3	0.5
3	IWFBSN 20	10.0	1.6	2.3	0.4
4	ABU88 150	8.6	2.6	0.9	0.9
5	BKL88 114	9.0	1.7	1.4	0.5
6	BKL88 187	9.8	2.1	1.9	0.6
7	BKL88 197	9.6	2.3	1.7	0.8
8	Sanober-96	13.8	2.4	2.9	1.0
9	Frontier-87	11.0	2.0	1.6	0.6
10	Local	13.0	2.1	2.0	0.5
	LSD (5%)	2.8	1.4	1.3	0.6

Table 4. Performance of Sanober-96 in spring planting at different sites in highland Balochistan (average of 9 environments)

Variety	TDM (Tonnes ha^{-1})	Grain Yield (Tonnes ha^{-1})
Arabi Aswad	3.4	0.7
Sanober-96	3.3	0.5
Wadi Hassa	3.6	0.6
Tadmor	2.9	0.5
Local	3.3	0.4
LSD (5%)	ns	ns

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