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Barley populations for drought tolerance *

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ABSTRACT

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After evaluation under drought conditions of S1 progenies from four different Composite Crosses, CC XXXIX developed in US for one irrigation culture regime, and CRC-1 developed in Spain for drought tolerance, were selected to be used as a bridge for the introduction and recombination of local adapted old cultivars, and to undergo recurrent selection processes.

Both populations showed acceptable drought tolerance, and high within population variability for most of the traits studied. Visual scores on tillering at stem elongation, and biomass at spike emergence offer good opportunities as indirect indicators of yield.

INTRODUCTION

The identification and selection of crop varieties capable of enduring drought, is of prime importance for optimising and stabilising production on these drylands (Sinha and Patil, 1986).

In Spain there are some 1.5 million ha of barley cultivated under extreme drought conditions. A single 6-row variety, Albacete, selected at the Aula Dei Experimental Station in 1956, is grown on most of this acreage. The failure to develop an alternative variety could be due to a narrow genetic basis, poorly adapted to our dry conditions. This in conjuntion with the classic crossing methods did not produce a sufficient amount of new

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genetic combinations to succeed.

Recurrent selection has been extensively employed in cross-pollinated crops to improve the open-pollinated populations. Also in some self-pollinated crops, like soybean, the results have been encouraging (Kenworthy and Brim, 1979; Sumarno and Fehr, 1982), with the main difficulty being the production of the large number of crosses needed in the recombination phase of each cycle (Compton, 1968).

In barley, Composite-Cross breeding started when Harlan produced CCI and CCII (Harlan and Martini, 1929) by crossing 11 and 28 lines respectively. Suneson (1940), was the first to employ male sterility to produce CCXIV and CCXV (Suneson, 1945). In the same way Suneson and Wiebe (1962) developed CCXXI from the 6200 spring barleys of the USDA World Collection. Finally Ramage et al., 1976) formed CCXXX-A by introducing spring and winter barleys from the World Collection into one and the same composite cross. Good surveys of composite-cross breeding in barley have been published by Wesenberg and Craddock (1974) and Lehmann (1983).

Composite Crosses, developed by the use of male sterility, have the advantage that a large number of crosses can be made. This means that there should be greater variation to utilize in the search for transgressive segregates and desired background genotypes. It also makes possible for breeders to develop their own populations using their own material or to combine their adapted material with available composites (Lehmann, 1983).

Composite Crosses could be very useful for adaptative selection in particular environments through "in situ" selection and new recombination cycles involving out-breeding or mass-pollination (Jain and Qualset, 1975; Patel et al., 1985).

When Suneson (1956) described his Evolutionary Plant Breeding Method, and recomended cyclic hybrid recombinations he was opening the way for Male Sterile Facilitated Recurrent Selection (MSFRS) in self-pollinated crops, as described by Ramage (1978, 1980).

With this purpose, the objective of the present work was to study and select barley composite crosses to be used in recurrent selection for tolerance to drought, as such, or as a bridge to recombine local adapted cultivars.

MATERIAL AND METHODS

Based on information in the review of Lehmann (1983) and contacts with barley breeders, four composite crosses were initially selected to be studied under drougth conditions in Spain. These populations were:

1. CC XXXII - Short straw (Ramage et al., 1980).
2. CC XXXIX - One irrigation regime (Ramage and Thompson, 1980).
3. CC XLII - Moderate rainfall and powdery mildew resistance (Bockelman et al., 1983).
4. CRC - 1 - Drougth tolerance, good grain characteristics (From Dr. Molina-Cano, Cruz del Campo, Spain).

The populations were evaluated on the basis of a number of selected fertile plants ranging from 83-116 per population (Luckett and Sharif, 1987; Patel et al., 1987). The cultivars Albacete and Barberousse were used as checks. The frequency of male sterile plants was found to be similar in the four populations.

The evaluation was performed in the Monegros area (Aragón) in 1985-86 with a total rainfall for the crop of 208 mm. An Augmented Design (Petersen, 1985), consisting of blocks of 27 progenies and two duplicated checks per block, was used. The experimental plots, each of two rows, 0.2 m apart and 1.2 m long, were sown 0.4 m apart with pathways 1 m wide between blocks. 120 seeds were sown per plot.

The following traits related to crop development, growth and yield components were used for the evaluation:

- FL: Days from sowing to 50 % spike emergence.
- RP: Days from sowing to 50 % maturity.
- GF: Grain filling = RP - FL.
- TL: Tillering, visual score (1-9=high), at stem elongation.
- BV: Breeding value, visual score (1-5=best), at 50 % spike emergence.
- LD: Lodging, visual score (1-9=high).
- YI: Yield in g m-2.
- TW: Test weight in g dl-1.
- KW: 100 kernel weight in g.
- KT: Kernel type, visual score (1-5=best).

Statistical analyses were performed with the use of an SPSS/PC+ package (Norusis, 1986). Estimations of environmental variances were calculated through the data from the homozygous check varieties. Estimations of genetic variances among progenies of the selected populations were calculated as an indicator of the within population genetic variability.

RESULTS AND DISCUSSION

Mean values of the four populations and the checks are presented in Tables 1 and 2, for vegetative traits and yield characteristics, respectively.

Significant differences among populations and from the checks, were present for all the traits. In most of them, the local cultivar Albacete gave the best results, with the exception of test weight, and lodging. Albacete was the latest in flowering, and had the shortest grain filling period.

Among populations, and based on yield and test weight, CC XLII was discarded due to its poor values under drought conditions. On the other hand, in spite of its potential in many of the traits, we had to discard CC XXXII due to its dwarfing genes, that would cause many problems for harvest operations under our growing conditions.

Therefore, CC XXXIX and CRC-1 have been selected to be used as a bridge for the introduction and recombination of local

Table 1.- Mean values of vegetative traits. Means followed by the same letter do not differ at the 0.05 level.

	FL	RP	GF	TL	LD
CC XXXII	151.1 b	176.2 b	25.1 cd	4.5 c	1.0 c
CC XXXIX	140.6 e	172.5 e	31.8 a	3.5 e	2.3 b
CC XLII	146.4 d	173.5 d	27.1 b	4.0 d	2.7 a
CRC-1	146.8 d	173.9 d	27.1 b	5.4 b	2.7 ab
ALBACETE	155.0 a	178.5 a	23.5 d	7.2 a	3.1 a
BARBER.	149.2 c	174.5 c	25.3 c	5.2 b	

Table 2.- Mean values of yield components. Means followed by the same letter do not differ at the 0.05 level.

	YI	KW	TW	BV	KT
CC XXXII	133.7 ab	3.74 a	62.7 d	3.9 b	3.4 a
CC XXXIX	73.3 c	3.74 a	62.1 c	3.2 c	3.4 a
CC XLII	68.3 c	3.57 b	62.0 c	3.3 c	3.2 a
CRC-1	125.2 b	3.80 a	65.6 b	4.5 a	3.4 a
ALBACETE	152.8 a	3.88 a	62.6 c	4.2 ab	3.3 a
BARBER.	90.3 c	3.44 b	67.6 a	3.8 bc	3.4 a

adapted old cultivars, and to undergo recurrent selection processes.

In Figures 1 and 2, it is possible to observe the histograms of frequencies for the different traits in populations CC XXXIX and CRC-1, respectively, compared with values for the checks . An estimate of the amount of within population genetic variability, can be obtained in Table 3, through the comparison of environmental variances developed from the results of the checks, with the genetic variances of CC XXXIX and CRC-1.

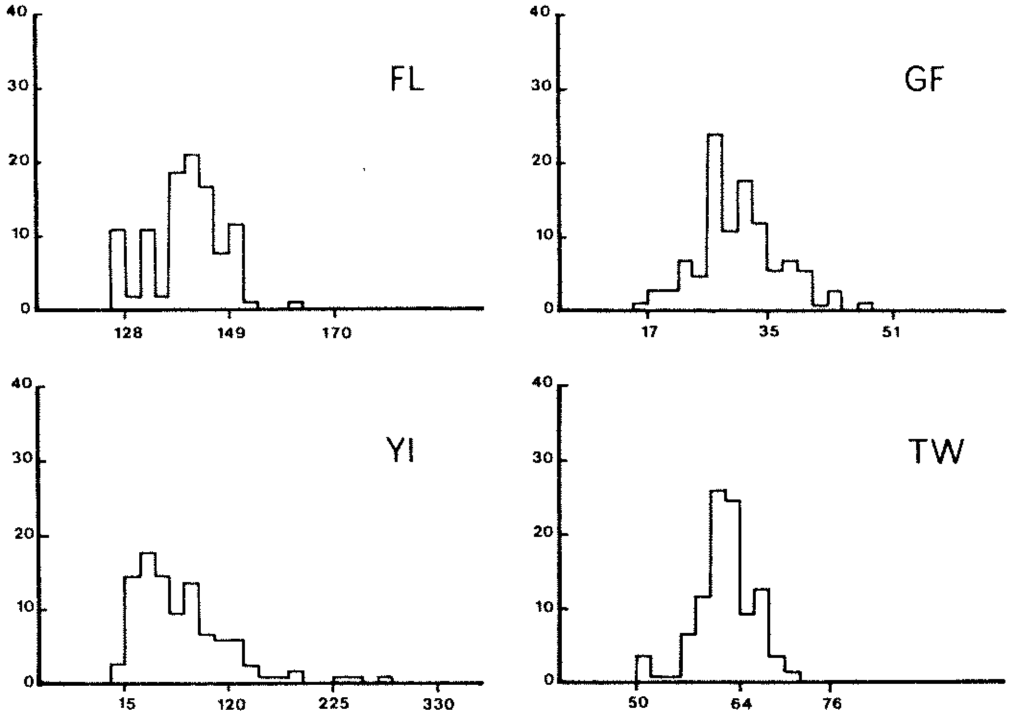

Figure 1.- Flowering (FL), Grain Filling (GF), Yield (YI) and Test Weight (TW) distributions of 116 S1 progenies

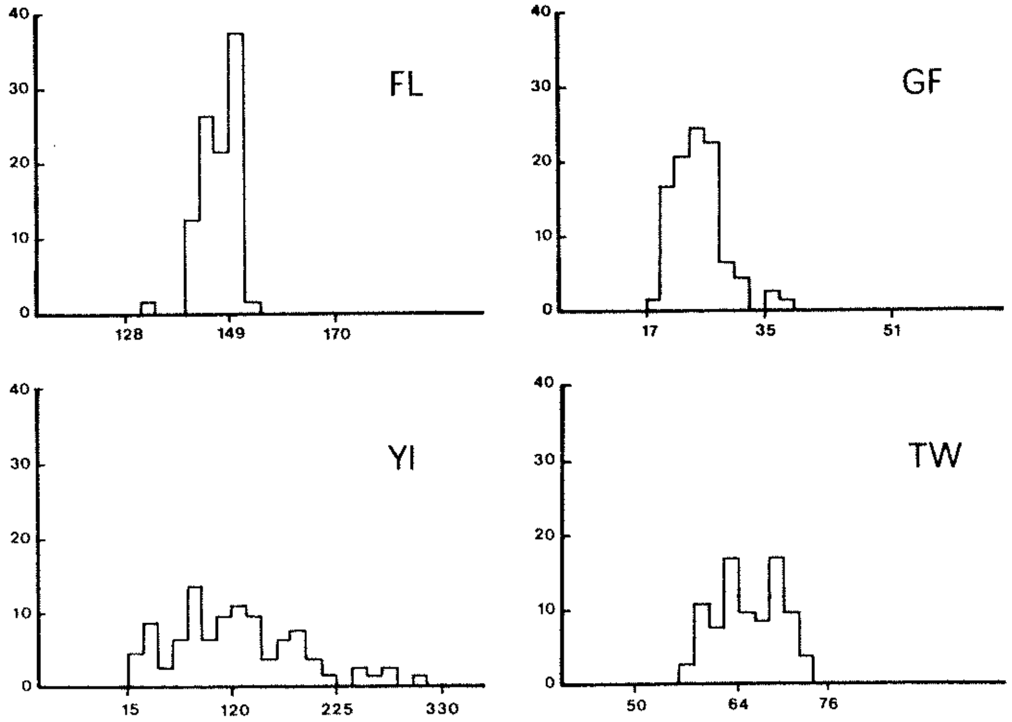

Figure 2.- Flowering (FL), Grain Filling (GF), Yield (YI) and Test Weight (TW) distributions of 116 S1 progenies from CRC-1.

Table 3.- Estimates of Genetic variances in the populations CC XXXIX and CRC-1, and environmental variances.

TRAITS	VARIANCES		
	Environment	Gen CC XXXIX	Gen CRC-1
FL	30.47	2887.80	543.27
RP	23.60	510.48	221.98
GF	46.37	1749.39	392.70
TL	31.21	35.80	39.77
LD	42.30	61.70	74.42
BV	32.40	103.21	87.24
YI	46487.77	98107.68	127000.91
TW	93.10	819.15	615.79
KW	1.35	10.21	5.19
KT	2.73	24.57	13.40

Figures 1 and 2 and Table 3, ilustrate the great amount of genetic variability available in both populations, in particular in CC XXXIX, which has higher genetic variances than CRC-1 for most of the traits than CRC-1. These results suggest very good prospects for breeding for drought tolerance, within the two Composite Crosses.

Table 4.- Correlation coefficients between traits in selected populations: (a) CC XXXIX, (b) CRC-1.

	FL	BV	TL	RP	GF	LD	YI	TW	KW
BV (a)	-.03								
(b)	-.04								
TL (a)	.07	.65**							
(b)	-.09	.62**							
RP (a)	.66**	-.08	-.01						
(b)	.50**	-.24	-.15						
GF (a)	-.91**	-.00	-.10	-.30*					
(b)	-.76**	-.12	-.00	.16					
LD (a)	-.06	.01	-.10	-.07	.04				
(b)	-.10	.15	.00	.02	.13				
YI (a)	-.06	.79**	.56**	-.10	.02	.02			
(b)	-.19	.73**	.42**	-.31*	-.01	.01			
TW (a)	-.00	.20	.13	.01	.01	-.01	.18		
(b)	.06	.33*	.17	-.02	-.09	-.31*	.34*		
KW (a)	.13	.46**	.30*	.17	-.07	.04	.43**	.20	
(b)	.04	.31*	.16	-.06	-.10	.18	.22	.00	
KT (a)	.06	.34**	.29*	.16	.00	.02	.33**	.33**	.66**
(b)	.28*	.31*	.25	.03	-.29*	.02	.11	.23	.57**

To increase the efficiency of the selection within the population, it is useful to know the possible correlations between the different parameters for plant selection. In Table 4, correlation coefficients developed in both populations are shown.

In both populations yield is very highly correlated with visual scores for tillering and breeding value at spike emergence, the latter being a visual score for biomass production. This is contradictory to the Sinha and Patil (1986) ideotype for drought conditions, wich is a plant with few leaves. The figures presented in Table 4 suggest good opportunities for visual biomass assesment in the selection within populations.

With respect to test weight, CCXXXIX contains considerable variability and should offer good opportunities for visual selection throught the indirect trait of grain type. Population CRC-1, wich has been subjected to stringent selection for grain characteristics, shows less variability.

Days to flowering, and length of the grain filling period did not show significative correlations with yield, confirming the results from Hadjichristodoulou (1987) for flowering in the Mediterranean area, and Metzger et al.(1984) for grain filling period.

RESUMEN

Tras la evaluación en condiciones de sequía de familias S1 procedentes de cuatro Cruzamientos Compuestos de cebada, las poblaciones CC XXXIX desarrollada en USA para condiciones de un único aporte de agua, y CRC-1 desarrollada en España para tolerancia a sequía, han sido seleccionadas para su utilización como puente en la introducción y recombinación de antiguos cultivares locales, y su posterior manejo mediante selección recurrente.

Ambas poblaciones muestran un aceptable nivel de tolerancia a sequía y elevada variabilidad intrapoblacional para la mayor parte de los caracteres estudiados. Las estimaciones visuales de ahijamiento en fase de elongación, y de biomasa en el inicio de espigado, ofrecen buenas posibilidades como indicadores de la producción.

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