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Performance of durum wheat landraces in a Mediterranean environment (eastern Sicily)

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Summary

The evaluation aimed at identifying landrace genotypes adapted to the rather unfavourable growing conditions of durum wheat in Sicily, to be used as parental material in a breeding programme. The trial was carried out in three seasons experiencing varying climatic conditions, and included 75 landraces, 25 of which were selected under severe drought in Syria. Wide differences were observed for most traits among genotypes and seasons of evaluation. Yields of the best performing entries identified in each season never significantly differed from that of the best check variety. The top-yielding landraces were consistently better than the remaining entries for the three yield components, viz. number of spikes per plant, number of kernels per spike and mean kernel weight. In the driest season they were also significantly earlier in heading, confirming the importance of earliness under drought. An analytical breeding approach relying on an array of morpho-physiological traits as selection criteria did not seem appropriate for the given environment, as the variable stress level enhanced the importance of specific traits under specific situations. The genotypic response was largely season-specific. Nonetheless, five landraces were in the best group in all seasons. The selection made in Syria also appeared somewhat effective in Sicily, particularly in the less favourable seasons.

Introduction

Of the about 2.8 million ha devoted to durum wheat (*Triticum turgidum* conv. *durum*) in the European Union, 66.6% are situated in Italy and correspond to 65.7% of the total production. In the country, Sicily occupies a leading position of durum wheat growing, with 31% of the national crop acreage and 25.6% of the production. However, while in the rest of Italy durum wheat area has increased during the last 30 years (mainly due to the selection of varieties suited to the conditions of central and, even, northern Italy), in Sicily during the same period 15.4% of the crop acreage has been abandoned. The main reason for such contraction is the tendency by farmers to give up those lands that, because of their location (mainly their slope) and their pedoclimatic characteristics, are no longer cost-effective for durum wheat growing. Stressful conditions in late spring are widespread, due to low amount and erratic distribution of rainfall, and are often accentuated by the sharp rise in temperatures caused by the 'Scirocco', i.e., hot winds from the desert, resulting in crop failure.

In the face of these unfavourable conditions, durum wheat breeding has not achieved dramatic results. While the overall average yield per hectare in Italy has increased by 110% between 1955 and 1985 (from 1.20 t ha^{-1} to 2.52 t ha^{-1}), during the same period the increase in Sicily has been 55%, passing from 1.12 to 1.74 t ha^{-1} (Foti et al., 1988). In Sicily old cultivars cover a large part of the total area, and some landraces are still grown, particularly in the mountainous areas (Boggini et al., 1990). The reason for the choice of germplasm of low potential is to be found in the traditionally low-input farming system adopted in the island, and in the better adaptability of these cultivars to the prevailing growing conditions, which ensures a fair stability of production.

The stagnation of yields in the less favourable areas of Italy during the last few decades (Annicchiarico & Pecetti, 1988) is also related to the narrow genetic base of the more recently bred, high-yielding durum wheat varieties (Boggini et al., 1992). For this reason, the introduction of adapted germplasm from the crop's centres of diversity, and particularly from the Mediterranean basin, could be useful to successfully breed for low-yielding conditions.

In different dry Mediterranean regions, breeding programmes seek to combine the favourable adaptive traits of landraces and old cultivars with the high yield potential of modern genotypes, with the aim of producing varieties of high yield stability under unpredictably variable climatic conditions. Examples of this strategy are reported from Syria (Srivastava, 1987), Jordan (Duwayri et al., 1987), Tunisia (Daaloul et al., 1990), as well as Sicily (Boggini et al., 1990).

The aim of the present evaluation was to identify landrace genotypes adapted to the pedoclimatic conditions of Sicily to be used in a breeding programme for this area. At the same time, a wide array of morpho-physiological traits was recorded with the further aims of: i) studying the relationship between grain yield and these characters in different seasons; and ii) assessing the suitability of the traits as selection criteria in an analytical breeding approach to identify the best materials across seasons.

Materials and methods

Seventy-five accessions from the world durum wheat germplasm collection held at ICARDA were grown during three seasons between 1990–91 and 1992–93 at Libertinia, Catania (37°30′ N, 14°35′ E, 150 m above sea level). Twenty-five of them were selected twice in very dry seasons in Syria (< 250 mm rainfall) on the basis of their agronomic score, used to visually assess drought tolerance (Annicchiarico & Pecetti, 1990). Given the generally more favourable climatic conditions experienced in Sicily relative to those in Syria, the remaining 50 genotypes were taken from the germplasm not selected for extremely dry conditions but performing satisfactorily in Syria under moderately favourable conditions (> 350 mm rainfall). The 75 entries were all landraces of various geographic origin, most of them originating from west Asia and north Africa. Sicily was purposely not represented in the set, as Sicilian landraces are already largely utilized in the breeding for the region (Boggini et al., 1990).

The rainfall and temperature patterns of the three evaluation seasons are shown in Fig. 1. The first two seasons were rather favourable for winter cereals, being characterised by good rainfall amount (378 mm in 1990–91 and 511 mm in 1991–92) and distribution, and absence of high temperatures at the end of the crop cycle. Conversely, the season 1992–93 was characterised by low rainfall (268 mm). The abundant rainfall in the first ten days of May probably did not completely compensate for the low rainfall in the preceeding months, and the season overall must be regarded as rather unfavourable. Maximum temperatures showed a steep increase in the second half of May, which hastened the physiological maturity of the crop.

In 1990–91 the 75 accessions were sown as single-head-progenies in rows, 17 cm apart, of 30 spaced seeds (at 4.5 cm) derived from individual plants collected from the plots grown in Syria. As no replications could be made due to the limited seed available, the rows were laid out according to the modified augmented design (Lin & Poushinsky, 1983). In order to improve the efficiency of adjustment allowed by the design, data of most characters were not recorded on a plot basis, but on ten plants per row and averaged to one value. 'Simeto', 'Duilio', 'Capeiti' and 'Russello' were used as control cultivars, i.e., two modern, improved varieties, one old cultivar and one local landrace, respectively. Due to late autumn rains, sowing was delayed to the 20^{th} of December, about three weeks later than usual. Fertilizer was applied at a rate of 36 kg ha^{-1} of N and 92 kg ha^{-1} of P_2O_5 prior to sowing and 32 kg ha^{-1} of N in each of two applications during winter (end of January and end of February).

In 1991–92 the 75 genotypes were sown in a randomised complete block design with three replications. The cultivars 'Russello', 'Capeiti', 'Vespro' and 'Simeto' were used for reference. Each entry in each replication was a plot of three rows, 1.5 m long and 17 cm apart. Sowing took place at the end of November at a rate of about 400 seeds m^{-2}. Fertilizer rates were the same as in 1990–91.

In the season 1992–93 the experiment was carried out exactly as in 1991–92 in terms of plot size, experimental design, sowing rate and date, and fertilizer rate.

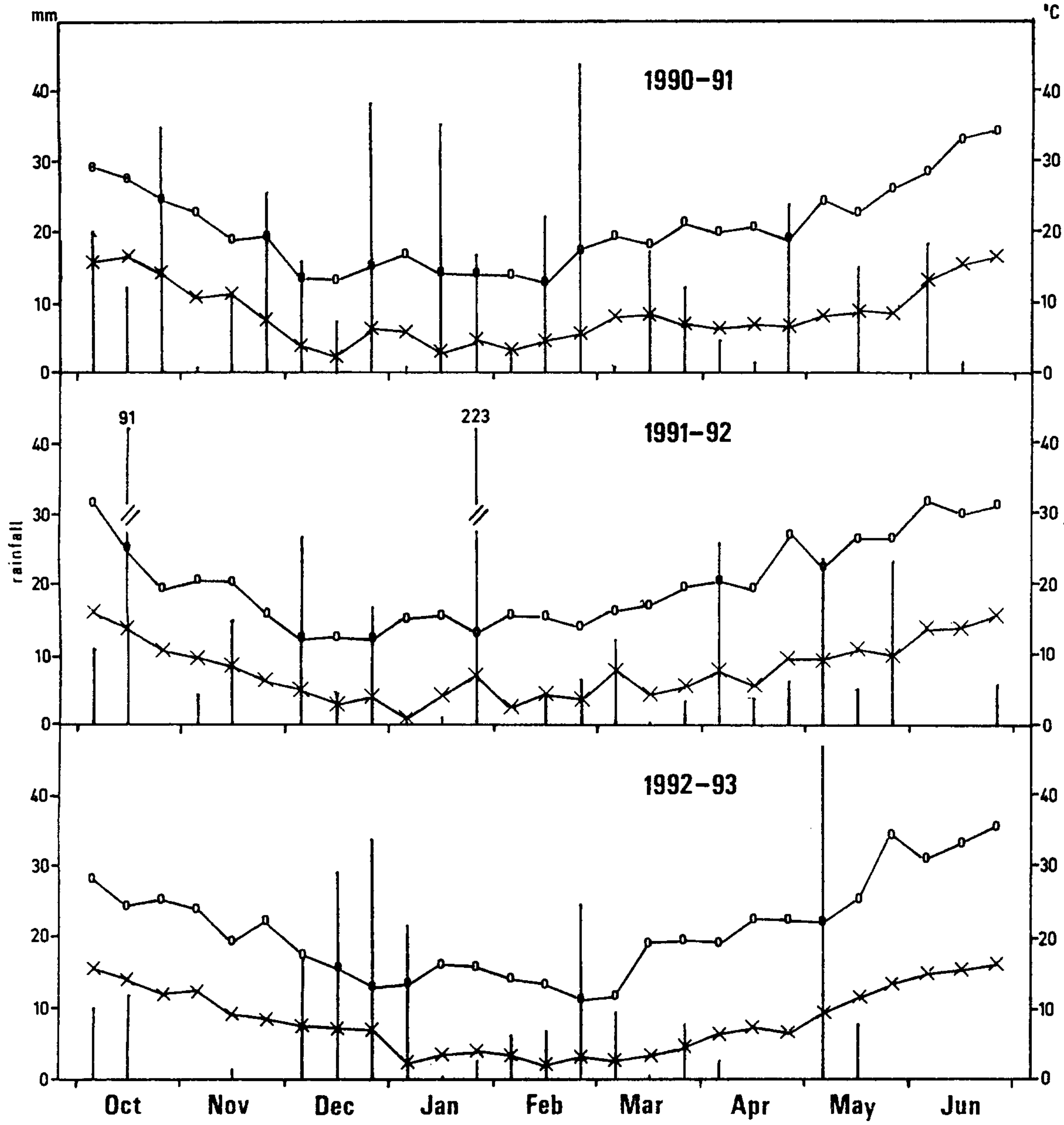

Fig. 1. Ten-day rainfall (vertical lines), and mean values of daily maximum (o), and minimum (X) temperature recorded in 1990–91, 1991–92 and 1992–93 at Libertinia, eastern Sicily.

'Simeto', 'Capeiti', 'Arcangelo' and 'Vespro' were the reference cultivars added to the 75 entries.

The following characters were recorded at a juvenile stage (at about emergence of the sixth leaf) in each of the three seasons: a) early growth vigour, scored on a plot basis using a 5-level scale from 1 = very poor to 9 = very good; b) total leaf area, measured on each of ten plants taken at random from the row (excluding the two end plants) in 1990–91, from the plot in the two following seasons; c) shoot fresh weight, measured immediately after harvesting on ten random plants from the row (in 1990–91) or from the plot (in the two following seasons); d) shoot dry weight, measured after oven drying the same ten plants at 105° C for 24 hrs.

Heading date (e) and maturity date (f) were recorded as number of days from January 1^{st} to, respectively, 50% heading and 50% physiological maturity in the row or in the plot. On each of ten random plants per row or per plot the following traits were further recorded: g) plant height; h) peduncle length; i) number of spikes per plant; j) number of spikelets per spike; k) number of kernels per spike; l) 1000-kernel weight; m) grain weight per spike; n) awn length and o) awn weight, measured at maturity on a single awn from a spikelet in the middle of the spike; p) awn weight per unit length, calculated by dividing the weight of the awn by its length; q) grain yield per plant. Although in 1991–92 and in 1992–93 plants were sown at normal density, grain production was also expressed as yield per plant. Obviously, the competition caused by plant density was different in the first season relative to the other two.

The best performing entries, not differing from the top-yielding one, were identified in each season. Entry separation was according to the computed LSD for the modified augmented design in 1990–91, according to Duncan's test in 1991-92 and 1992–93. To identify the characteristics which contributed to the genotype's better adaptation, the group of top lines was compared by t-test with the remaining entries for all recorded traits. Correlation coefficients between grain yield per plant and other traits were calculated for the whole set of lines in each season.

In order to verify in other environments the efficacy of selection based on the visual score, as adopted in Syria for drought tolerance assessment, the two groups of 25 selected (according to the score) and 50 non-selected entries which constituted together the full set of 75 lines were also compared by t-test for all characters in each season.

Results

Overall mean values for the recorded traits in the three seasons are shown in Table 1. Wide phenotypic variation existed for most traits. For instance, there were both semi-dwarf entries as short as the improved control cultivars and very tall lines.

In the second and third season, variation among genotypes was highly significant ($P \leq 0.01$) for most traits. Variation of characters observed at juvenile stage (shoot fresh and dry weight and total leaf area) was not significant.

There were between-season differences in all characters except days to heading according to ANOVA. The separation of seasonal mean values is shown in Table 1. The overall mean yield per plant in 1991–92 was similar to that in 1990–91 while other traits differed between the 1990–91 and 1991–92 seasons. Despite the dense conditions of growth, in 1991–92 plants produced more fertile tillers than in 1990–91, thus compensating for the reduction of the other yield components.

The data from 1992–93 highlight the effect of the most stressful season of evaluation on some characters. Indeed, grain yield per plant was much lower than in both 1990–91 and 1991–92. At the same time, a drastic reduction relative to the two previous seasons occurred for plant height (and peduncle length), kernel number and weight, number of fertile spikelets per spike and awn length. The growth cycle was shorter, with an earlier date of maturity. As already mentioned, this was due to a terminal heat stress which occurred in 1992–93 (see Fig. 1).

Analysis of grain yield per plant resulted in 11 entries as best yielding in 1990–91 (Table 2). Their yield values were superior or not significantly different from that of the best check variety 'Duilio' (13.8 g per plant).

In 1991–92, differences in grain yield per plant were significant ($P \leq 0.01$), however, entry mean separation was not as distinct. Duncan's test separated 36 entries as the best yielding (Table 2) not significantly differing from each other and from the highest yielding check variety 'Vespro' (14.5 g per plant).

In 1992–93, differences in grain yield per plant were also highly significant ($P \leq 0.001$), and Duncan's test identified 20 entries as the top yielding (Table 2). None of these entries differed significantly from the control cultivars, the best of which was 'Capeiti' (9.0 g per plant).

The group of top yielding entries in each season was compared with the group of remaining entries for all characters. Table 2 reports the traits for which the group mean values differed significantly ($P \leq 0.05$) in each season according to t-test. The best yielding lines obviously yielded significantly higher than the remaining ones, which was always accompanied by higher values for the three yield components, viz. number of spikes per plant, number of kernels per spike and 1000-kernel weight. As the combination of the latter two traits, grain weight per spike was also higher in the top than in the other group in each season. Other differences between the two groups were specific to just one season of the three (Table 2).

Correlation analysis of grain yield per plant with the other characters largely confirmed the relative importance of the various features contributing to good performance in each season (Table 3). Grain yield per plant was correlated in all three seasons with the three

Table 1. Mean values of 75 durum wheat entries for the characters recorded in three seasons at Libertinia

Character	1990–91 Mean (± s.e.)	1991–92 Mean (± s.e.)	1992–93 Mean (± s.e.)
Early growth vigour (scale 1–9)	7.3 ± 0.2 A	6.8 ± 0.1 B	6.7 ± 0.1 B
Leaf area/plant[a] (cm^2)	16.6 ± 0.8 A	9.6 ± 0.3 B	8.2 ± 0.2 C
Fresh weight/plant[a] (mg)	693.4 ± 30.3 A	447.5 ± 9.2 B	490.2 ± 15.0 B
Dry weight/plant[a] (mg)	129.5 ± 15.7 A	73.0 ± 1.7 B	115.1 ± 6.2 A
Heading date (dd. from Jan 1)	125.3 ± 0.7 A	124.3 ± 0.6 A	125.9 ± 0.3 A
Maturity date (dd. from Jan 1)	165.5 ± 0.4 A	165.0 ± 0.2 A	157.1 ± 0.2 B
Plant height (cm)	109.5 ± 2.0 A	105.1 ± 1.6 A	69.9 ± 1.3 B
Peduncle length (cm)	40.3 ± 0.9 A	41.8 ± 0.6 A	23.0 ± 0.7 B
No. spikes/plant	6.2 ± 0.2 B	7.9 ± 0.2 A	7.9 ± 0.2 A
No. spikelets/spike	22.8 ± 0.3 A	20.2 ± 0.3 B	14.2 ± 0.2 C
No. kernels/spike	52.7 ± 1.6 A	48.7 ± 0.9 B	28.5 ± 0.7 C
1000-kernel weight (g)	47.9 ± 0.9 A	38.3 ± 0.9 B	35.4 ± 0.6 C
Grain weight/spike (g)	2.55 ± 0.10 A	1.81 ± 0.04 B	1.03 ± 0.03 C
Awn length (cm)	13.7 ± 0.3 A	13.0 ± 0.2 A	10.7 ± 0.2 B
Awn weight (mg)	401.2 ± 20.5 A	215.1 ± 8.9 B	197.6 ± 6.2 B
Awn weight/unit length ($mg\ cm^{-1}$)	29.3 ± 1.3 A	16.2 ± 0.5 B	18.1 ± 0.4 B
Grain yield/plant (g)	10.43 ± 0.64 A	10.39 ± 0.28 A	5.66 ± 0.24 B

[a] at a juvenile stage.
Seasonal mean values for each character followed by the same letter are not different at $P \leq 0.05$, according to Duncan's test.

Table 2. Comparison of character mean values between the group of best yielding entries (Top) and the group of the remaining entries (Rest) in each season. Number of top entries was: 11 in 1990–91, 36 in 1991–92, and 20 in 1992–93. In each season, only significant ($P \leq 0.05$) differences are reported

Character	1990–91 Top		1990–91 Rest	1991–92 Top		1991–92 Rest	1992–93 Top		1992–93 Rest
Fresh weight/plant[a] (mg)	865.9	*	660.8		–			–	
Heading date (dd. from Jan 1)		–			–		123.6	***	126.8
Peduncle length (cm)	44.6	*	39.3		–			–	
No. spikes/plant	8.9	***	5.7	8.2	*	7.5	9.4	***	7.3
No. spikelets/spike		–			–		16.1	***	13.5
No. kernels/spike	59.9	*	51.1	51.6	***	45.7	34.6	***	26.2
1000-kernel weight (g)	54.7	***	46.5	40.1	*	36.2	39.2	***	34.0
Grain weight/spike (g)	3.24	**	2.41	2.00	***	1.62	1.37	***	0.91
Awn weight (mg)		–		233.4	*	195.8		–	
Awn weight/unit length ($mg\ cm^{-1}$)		–		17.3	*	15.2		–	
Grain yield/plant (g)	18.72	***	8.86	12.25	***	8.42	8.46	***	4.63

[a] at a juvenile stage.
*, **, ***: group means in each season different at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$, respectively, according to t-test.

yield components, and with grain weight per spike. Other significant correlations, although of a much lower magnitude, were shown in 1990–91 with the parameters of juvenile growth, peduncle length, number of fertile spikelets and awn weight. Awn weight, both absolute and relative, was also positively correlated with grain yield in the season 1991–92. In that season all significant correlations were lower than in the two other seasons. In 1992–93, the correlation analy-

Table 3. Correlation coefficients (r) between grain yield per plant and other characters in each season of evaluation at Libertinia. Only significant ($P \leq 0.05$) coefficients are reported. Number of observations is 75 for all correlations

Character	1990–91	1991–92	1992–93
No. spikes/plant	0.80 ***	0.45 ***	0.66 ***
Grain weight/spike	0.72 ***	0.61 ***	0.84 ***
No. kernels/spike	0.61 ***	0.35 **	0.78 ***
1000-kernel weight	0.61 ***	0.32 **	0.59 ***
Awn weight/unit length	0.41 ***	0.33 **	–
Fresh weight/plant[a]	0.39 ***	–	–
Awn weight	0.36 **	0.29 *	–
Early growth vigour	0.31 **	–	–
Dry weight/plant[a]	0.29 *	–	–
Peduncle length	0.29 *	–	- 0.24 *
Leaf area/plant[a]	0.25 *	–	–
No. spikelets/spike	0.24 *	–	0.71 ***
Heading date	–	–	- 0.68 ***
Plant height	–	–	- 0.37 **
Maturity date	–	–	- 0.25 *

[a] at a juvenile stage.
*, **, ***: significant at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$, respectively.

sis highlighted the relevance of earliness in conferring good performance in a poor year (Table 3).

The entries identified as top yielding were overall 49 in the three seasons: that is, two thirds of the 75 entries appeared at least once in the group of the best performing lines. It is evident that the genotypic response was largely season-specific. That was confirmed by the genotype × season interaction analysis which was allowed by the replicated trials carried out in 1991–92 and 1992–93. This interaction for grain yield per plant was significant at a probability level of 2% (data not shown). Nonetheless, there were entries included in the top yielding group in more than one season. Five entries were present in the top yielding group in all three seasons, viz. 'ICDW4727' from Ethiopia, 'ICDW20892' from Jordan, 'ICDW20866' from Jordan, 'ICDW20429' from Greece, and 'ICDW20863' from Jordan. All these five entries belonged to the group of selected materials on the basis of the visual evaluation of drought tolerance carried out in Syria (Annicchiarico & Pecetti, 1990; Pecetti & Annicchiarico, 1991).

When the groups of selected and non-selected entries on the basis of the drought tolerance score used in Syria were compared for their behaviour at Libertinia, they were significantly ($P \leq 0.05$) different in the three seasons for the characters reported in Table 4. In 1990–91 the selected entries showed a yield superiority over the other materials. The higher 1000-kernel weight of the selected group certainly contributed to its better performance. In 1992–93 the discrimination among accessions made in Syria appeared also very effective in Sicily, the selected group showing higher yield than the non-selected one (Table 4). Both in 1991–92 and in 1992–93 the selected entries had shorter stature than the non-selected ones. In all three seasons the selected group was earlier in heading.

Discussion

The data presented above show that the set of landraces evaluated formed a variable pool of durum wheat germplasm. Variability might be very desirable in breeding activities for drought tolerance, as genetic diversity for key physiological processes or for morphological traits may be lacking in improvement programmes, so that important genes may not be available for selection to act (Richards, 1989). If the objective was to evaluate and validate the potential of a trait, Acevedo & Ceccarelli (1989) and Richards (1989) stated that testing a substantial number of diverse geno-

Table 4. Comparison of character mean values between the group of 25 selected (S) entries and the group of 50 non-selected (NS) entries on the basis of their agronomic score in Syria, evaluated in three seasons at Libertinia. In each season, only significant ($P \leq 0.05$) differences are reported

Character	1990–91			1991–92			1992–93		
	S		NS	S		NS	S		NS
Heading date (dd. from Jan 1)	121.1	***	127.2	121.2	***	125.8	124.0	***	126.9
Plant height (cm)		–		99.3	*	108.0	64.6	**	72.5
Peduncle length (cm)		–			–		21.1	*	24.1
No. spikelets/spike		–		19.2	**	20.6	15.7	***	13.5
No. kernels/spike		–			–		33.2	***	26.1
1000-kernel weight (g)	52.1	**	46.2		–		38.5	***	33.8
Grain weight/spike (g)	2.86	*	2.43		–		1.30	***	0.90
Grain yield/plant (g)	12.15	*	9.68		–		7.43	***	4.77

*, **, ***: group means in each season different at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$, respectively, according to t-test.

types would avoid bias associated with the type of germplasm, being an alternative to the use of near-isogenic lines.

The study failed to identify any character, in a wide range of morphological, phenological and physiological traits possibly contributing to the mechanisms of adaptation to drought, consistently related to a desirable level of yield and, hence, to yield stability. Only the yield components *per se* (number of spikes per plant, number of kernels per spike and mean kernel weight) resulted constantly associated to grain yield across different seasons. The results suggest that an empirical, or synthetic, breeding strategy based on the direct selection of grain yield (or of its components) seems suitable for the target area. The adoption of an analytical breeding approach as a way to increase efficiency of selection (Richards, 1982; Ceccarelli et al., 1991) does not seem appropriate under the given conditions, as the variable stress level enhanced the importance of specific traits under specific situations. Similar conclusions were reached by Ceccarelli et al. (1991) on barley.

In our evaluation, only in 1990–91 there appeared to be a relationship between plant weight at early stage of development and grain yield per plant, in line with the findings of Turner & Nicolas (1987). The observed low genotypic variation of the characters recorded at juvenile stage may have hindered their usefulness as selection criteria. In 1990–91 and 1991–92 there was a positive relationship between awn weight (both absolute and relative) and grain yield. In 1992–93 this correlation was not present. Attributing a role in drought tolerance to the awns (Evans et al., 1972; Richards, 1982; Ali Dib et al., 1990), it seems that in 1992–93 (the most stressed of the three seasons) the mechanism(s) of stress escape (not relevant in the first two relatively favourable seasons) prevailed over the mechanism(s) of stress tolerance. Awn length was never correlated with grain yield, suggesting that the awn parameters contributing to a better performance were their area and/or thickness. Earliness of heading confirmed to be an essential escape mechanism under stressful conditions (Richards, 1989). Plant height appeared negatively correlated with yield in the least favourable season, despite its claimed importance as a selection criterion in moisture-limiting environments (Ceccarelli et al., 1987). The role of this character under drought is still controversial. Acevedo & Ceccarelli (1989) found that in 2-row barley genotypes one of the attributes associated with a drought resistance index was the short stature and that this trait was better expressed in the naturally adapted germplasm (the landraces). One explanation for the short-statured genotypes performing well in dry environments could be their better harvest index (HI) which becomes a basic feature to maximise yield under stress conditions (Richards, 1987). It is acknowledged by physiologists and breeders that high HI is a desirable and beneficial trait to improve drought resistance (Baker, 1989, chapter 16).

The lower correlations observed in 1991–92 than in the two other seasons between grain yield and the correlated traits (Table 3) suggest a smaller influence of these traits on higher yields in that season, characterised by unusual rainfall. Other characters that those recorded might account for the genotype performance under these conditions. Among them are likely to be lower susceptibility to lodging and to pathogens (in particular mildew).

Differences of character mean values between 1990–91 and 1991–92 (both rather favourable to the crop) could be generally explained by the greater plant density in the latter season. However, an effect of the severe lodging due to high rainfall in 1991–92 cannot be excluded on those characters recorded at maturity. In general, when the evaluation was carried out with dense sowing (seasons 1991–92 and 1992–93), the variability of the genotype values was smaller than that recorded when the plants were spaced (season 1990–91), as indicated by the standard error of means (Table 1).

Selection for grain yield proved to be rather environment (= season)-specific, due to the occurrence of a strong genotype × season interaction. Nonetheless, some lines which were able to perform well in more than one season could be identified. Eight of the 11 best yielding entries in 1990–91 were also included among the best 36 in 1991–92. These lines were therefore highly responsive to favourable growing conditions, such as those experienced in 1990–91 and 1991–92. Of the 20 entries belonging to the best yielding group in 1992–93, 10 were also present in the top group in 1991–92. Given the different climatic conditions between the two seasons, for these 10 entries a good adaptation to a range of environments could be postulated.

Also some genotypes which were adapted to both the stressful conditions of Breda and the relatively favourable conditions of Libertinia could be identified. To some extent, the selection made under severe stress also seemed effective for the Sicilian locality. Indeed, five out of 25 selected entries for drought tolerance in Syria not only confirmed their adaptation to the stressful conditions at Libertinia in 1992–93, but had also a good performance in the two more favourable seasons 1990–91 and 1991–92. It has already been shown for barley (Ceccarelli & Grando, 1991) and durum wheat (Pecetti et al., 1992) that some of the material selected under unfavourable conditions is able to retain its superiority in a more favourable environment. For barley, the proportion was about 20% of the selected genotypes, and for durum wheat about 30%. In both cases, such a proportion was higher (8-fold for barley, 7-fold for durum wheat) than the proportion of lines selected under favourable conditions which were also able to perform well in a stressful environment. The proportion observed in the present study (20%) seems in line with those previously reported.

The visual assessment of performance especially devised for the Syrian environment was an effective means of selection in Sicily under lower rainfall. The mean yield of the selected group was 103% that of the non-selected group in 1991–92 (511 mm rainfall), 125% in 1990–91 (378 mm), and 156% in 1992–93 (268 mm). Similarly, Clarke et al. (1991) reported that superior agronomic score in a dry season was most effective for selection of durum wheat genotypes in a subsequent very dry season, but not in a season with above-average rainfall.

The results showed that durum wheat landraces could be a reservoir of adapted materials for the Sicilian environment. In particular, the Jordanian gene pool was confirmed to be a source of valuable germplasm under Mediterranean conditions (Pecetti & Annicchiarico, 1991). If one of the main aims of the breeding activities in Sicily is to broaden the genetic base of the varieties presently available (Boggini et al., 1990, 1992), the five genotypes here identified as the best yielding across seasons could certainly be suitable for the purpose. They could possibly introgress variability into existing genetic backgrounds without deteriorating their positive features for productivity.

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