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Screening for Drought Resistance in Spring Chickpea in the Mediterranean Region*

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With 2 figure and 4 tables

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Abstract

Even though chickpea (*Cicer arietinum* L.) is well adapted to growing on stored soil moisture in drought-prone environments, drought is a major yield reducer in most chickpea-growing regions. Little progress has been made in breeding for improved performance under drought stress for want of a reliable and repeatable method of screening for drought resistance. Therefore, a study was initiated in 1990 to develop a screening technique and a rating scale to evaluate germplasm for drought resistance. A spring date-of-planting experiment was conducted during spring from 1990 to 1992 at Tel Hayda (northern Syria) to see if the expression of genotypic differences in drought resistance should be accentuated. Simultaneously, a rating scale was developed. Using the screening technique and rating scale, over 4000 germplasm lines were evaluated from 1992 to 1995. The resulting screening technique involves delayed sowing by 3 weeks during spring at a relatively dry site (long-term average annual rainfall of 328 mm), preliminary evaluation of materials on a rating scale of 1–9 to discard susceptible lines, and final evaluation of promising lines under stress (drought) and non-stress (supplemental irrigation) conditions, selecting drought-resistant lines which perform well under both conditions. In the 1–9 rating scale that was developed: 1 = no yield reduction as compared to a non-stress control and 9 = all plants dry without producing any seed. Using this technique, 19 lines out of 4165 lines screened were identified as drought resistant, producing over 1 t ha^{-1} seed yield under drought conditions while being able to yield over 2 t h^{-1} under non-stress conditions. Resistant lines are being used by national programs in the Mediterranean region and by ICARDA for developing drought- and disease-resistant, high-yielding cultivars.

Key words: chickpea — screening — resistance — drought

* Joint contribution from ICARDA (Syria) and ICRISAT (India).

Introduction

Chickpea is the third most important pulse crop in the world, and it ranks first in the Mediterranean region (FAO, 1995). It is primarily grown on stored soil moisture under rain-fed conditions. Because of large seasonal variations in rainfall in this region, the crop often suffers. Although chickpea is more drought-resistant than other cool-season food legumes, drought is the most important yield reducer in this crop (Saxena, 1987; Singh, 1993; Johansen et al., 1994a, 1994b).

Drought resistance is defined here as a term inclusive of escape and avoidance (e.g. early flowering and better water extraction from soil through a larger root system) and desiccation tolerance (continuation of metabolism at low tissue water potential). These may include greater rooting capacity (Gupta et al., 1987; Saxena et al., 1993), osmoregulation (Locoeur et al., 1992; Morgan et al., 1991), accumulation of amino acids (Singh et al., 1985), control of leaf water potential (Jones and Corlett, 1992) and increased seed size (Singh et al., 1995).

For terminal drought environments, where chickpea is most often cultivated, a first step in minimizing effects of drought is shorten crop duration to permit drought escape (Saxena et al., 1993; Subbarao et al., 1995). Progress has been made in selecting early-flowering lines for this purpose (Van Rheenen et al., 1990). Having optimized the crop duration for a particular target terminal-drought environment, the next step should be to genetically enhance the other drought-resistance characteristics, using germplasm base containing large genotypic variation.

However, the methods so far developed to ident-

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ify genotypic differences for drought resistance are cumbersome and generally inappropriate for handling the large number of lines needed for a plant breeding programme, in terms of screening germplasm of both parental material and progenies. And the efficiency of conducting a standard breeding programme in a drought-prone environment can be greatly reduced because of the large seasonal variations in the magnitude of drought stress and possible low yield potential in selected types. These factors have discouraged concerted efforts to breed specifically for drought resistance in chickpea, as well as in most other crops.

We have, therefore, attempted to develop a drought-screening methodology for a chickpea breeding programme which has drought resistance as a major breeding objective. As a target production system, we chose spring chickpea of the Mediterranean region, which invariably faces terminal drought stress (Saxena, 1990).

Materials and Methods

Screening technique

To develop a reliable and simple screening technique for field evaluation of large numbers of germplasm and breeding lines for drought resistance, a set of 25 chickpea genotypes with a range of maturity, plant height, seed size, and seed yield were sown. This was done on four dates, February 28, 1990 (a normal date of sowing for a spring crop of chickpea), and March 10, 20, and 30, 1990 (late sowing dates) at Tel Hadya, Syria (36°01N, 36, 36°56E, 284 m asl), ICARDA's main research station, during the 1990 spring season. Due to seed limitation, the plot size was small (four rows, 2.5 m long, 0.3 m apart). The design used was split-plot, with sowing dates in the main plot and genotypes in the subplots, with three replications. Superphosphate was applied at the rate of 50 kg P_2O_5 ha^{-1}. The crop was hand-weeded and protected from ascochyta blight by spraying chlorothalonil (tetrachloroisophthalonitrile) at the rate of 2 kg a.i. ha^{-1}. Harvesting was done by hand at maturity in June. Observations were recorded on 15 morphological, phenological, and seed characters. Also recorded were plant count at emergence and maturity, percent emergence, and canopy temperatures at late vegetative, flowering, and pod-filling stages. Soil moisture was monitored using a neutron probe.

The same set of genotypes were grown in 1991 on two dates (February 28 and March 20) with and without supplemental irrigation to simulate non-stress and stress conditions. The plot size was four rows, 4 m long with 0.3 m row spacing. A split-plot design with three replications, and moisture regimes (rainfed and supplemental irrigation) in the main plots, and with two treatment factors, genotypes and dates in subplots was used. For supplemental irrigation, three irrigations of 50 mm each were applied by sprinkler scheduled when water deficit exceeded 50 % of available capacity based on soil-water balance estimated from rainfall and pan evaporation. Observations on variables were collected as in 1990. The 1991 experiment was repeated in 1992.

The analysis of variance and correlation of yield with other characters were done following Steel and Torrie (1980).

Rating scale

To allow faster evaluation of a large number of lines, a nine-point rating scale for drought resistance was developed. This rating system was chosen for compatability make it compatible with the 1–9 scales used for screening against the other major biotic and abiotic constraints addressed in the breeding programme at ICARDA (Singh, 1993). The rating was done at the late pod-filling stage, when the crop was approaching maturity and the potential yield of a plant was apparent. For developing the rating scale for the first time, rating 1 was chosen as a plot free from drought stress, usually the best cultivar of a nearby irrigated plot. Rating 9 was chosen as a plot in which plants were unable to set seed in the prevailing stress conditions. An intermediate plot between the extremes in terms of estimated final seed yield was chosen from among the set germplasm under test as rating 5. Rating 7 was then chosen as intermediate between 5 and 9 and rating 3 intermediate between 1 and 5. Similarly, ratings 2, 4, 6 and 8 were identified. The above-selected standard plots were marked for regular reference when all plots were rated.

The above 1–9 scale corresponds to the descriptions as follows: 1 = free, no visible symptoms of damage, early flowering, profuse podding and seed formation, normal maturity, high productivity; 2 = highly resistant, early flowering, profuse podding and seed formation, normal maturity, high productivity; 3 = resistant, early flowering, normal podding and seed formation, normal maturity, relatively high productivity; 4 = moderately resistant, early–medium flowering, normal podding and seed formation, normal maturity and relatively high productivity; 5 = intermediate; early–medium flowering, normal podding but many without seeds, normal maturity and moderate productivity; 6 = moderately susceptible, early–medium flowering, shy podding and many without seeds, forced maturity and moderate productivity; 7 = susceptible, late flowering; few pods and many without seeds, forced maturity and low productivity; 8 = highly susceptible, late flowering, pods rare and mostly without seeds, forced maturity and nominal productivity; and 9 = all plants dried without any seed, later flowering and no pod formation or productivity.

Evaluation of germplasm accessions

During the 1992 spring season, 1000 germplasm accessions of chickpea were sown on March 20 at Tel Hayda. Each accession was sown in a single row 4 m long, spaced 0.35 m apart. The susceptible control, ILC

72, was sown after every nine test rows. Two border rows were sown on either side of the experimental plot. The same cultural practices were followed as described earlier. The materials were evaluated for drought resistance on the 1–9 scale when near maturity. Following the above method, an additional 1980 lines were screened in 1993 and 1185 in 1994. From these evaluations, 85 promising lines were identified.

In 1995, 79 lines, found promising for drought resistance in the above evaluations, and for which sufficient seeds were available for replicated tests, were grown along with two susceptible controls (ILC 72 and ILC 1171) in a triple lattice design with and without irrigation in adjoining plots. Each plot had two rows, 4 m long, spaced 0.35 m apart. For supplemental irrigation, a total of 80 mm water was provided in two applications by sprinklers, based on daily water-balance computation of rainfall and pan evaporation and verified by soil-moisture measurements using a neutron probe. The cultural practices followed and observations recorded were same as described earlier.

In addition, drought susceptibility index (S) (Fisher and Maurer, 1978) was calculated as follows:

$$S = (1 - Y_d/Y_p)/D$$

Y_d = yield under drought; Y_p = yield potential (yield under supplemental irrigation); D = drought intensity = 1 − mean Y_d of all genotypes/mean Y_p of all genotypes.

Results and Discussion

Weather

Tel Hadya average rainfall for 18 years is 328 mm, but during the study period of 1989–1990 to 1994–1995 it was 314 with a range of 233 (1989–1990) to 371 mm (1994–1995) (Fig. 1). In all 6 years, it was less than 400 mm, which is considered to be the minimum rainfall required for raising a rain-fed spring chickpea crop in the Mediterranean region. Little rainfall was received in the spring in most seasons (except in 1990–1991), which permitted the development of terminal drought. Therefore, the amount and distribution of rainfall as well as temperature conditions were suitable for developing the technique and evaluation of germplasm for drought resistance.

Screening technique

The combined analysis of variance (ANOVA) for seed yield for four dates revealed that the mean squares due to dates, genotypes, and genotypes × dates were significant, indicating influence of these on seed yield. The genotypic means over each date revealed that the dates 3 and 4 gave the lowest mean yields which were statistically not different from each other, but were different from dates 1 and 2. The results of the study in 1990 with four dates of sowing indicated that the genotypic differences in response to drought stress were accentuated when sowing was done 3–4 weeks later than the normal sowing time in spring (Table 1). In subsequent years, 1991 and 1992, only two dates, i.e. normal (28 February) and late (20 March), were chosen to verify the results. These trials supported the finding of the first year (Table 2). On average over 2 years under rainfed conditions, a few genotypes produced approximately 1 t ha^{-1} seed yield. On the other hand, two genotypes, FLIP 85-142C and ILC 72, produced less than 0.3 t ha^{-1}.

The genotype × date of sowing trials during 1991 and 1992 were grown both under rain-fed and supplemented irrigation conditions. The latter was done to know the potential of genotypes without water stress. From a farmer's point of view, cultivars that can perform well under both drought and water-sufficient conditions are preferred. The ANOVA for split plot with irrigation in the main plot, and dates and genotypes in the subplot (as two treatment factors in the subplot revealed that there were significant differences between the rainfed and irrigated means, and date 1 and date 2 means). The genotype × irrigation, genotype × date, and genotype × date × irrigation interactions were non-significant in both the years (1991 and 1992) with the exception of genotype × irrigation interaction, which was significant in the year 1992 only. Only two lines, FLIP 87-59C and ILC 6104, performed well under both drought and irrigated conditions in both years (Table 2). However, there were a few lines, such as ILC 1929 and FLIP 87-5C, which performed well in one year but not in the other.

The correlation of seed yield with other variables sown at a normal time (February 28) or late (March 20) for 3 years are shown in Table 3. Seed yield under drought conditions simulated by sowing late on March 20 was positively correlated with early flowering and maturity, early plant vigor, shoot biomass yield, and short plant stature. To some extent, seed yield was associated with the large seed size and pod number. In general, the number of primary and secondary branches was not related to drought resistance of the test lines.

Breeding efforts to increase drought resistance in chickpea are limited, despite the fact that drought is the most important yield-reducing factor in production (Van Rheenen et al., 1990). A major reason for this has been a lack of reliable screening techniques for large-scale evaluation of germplasm and

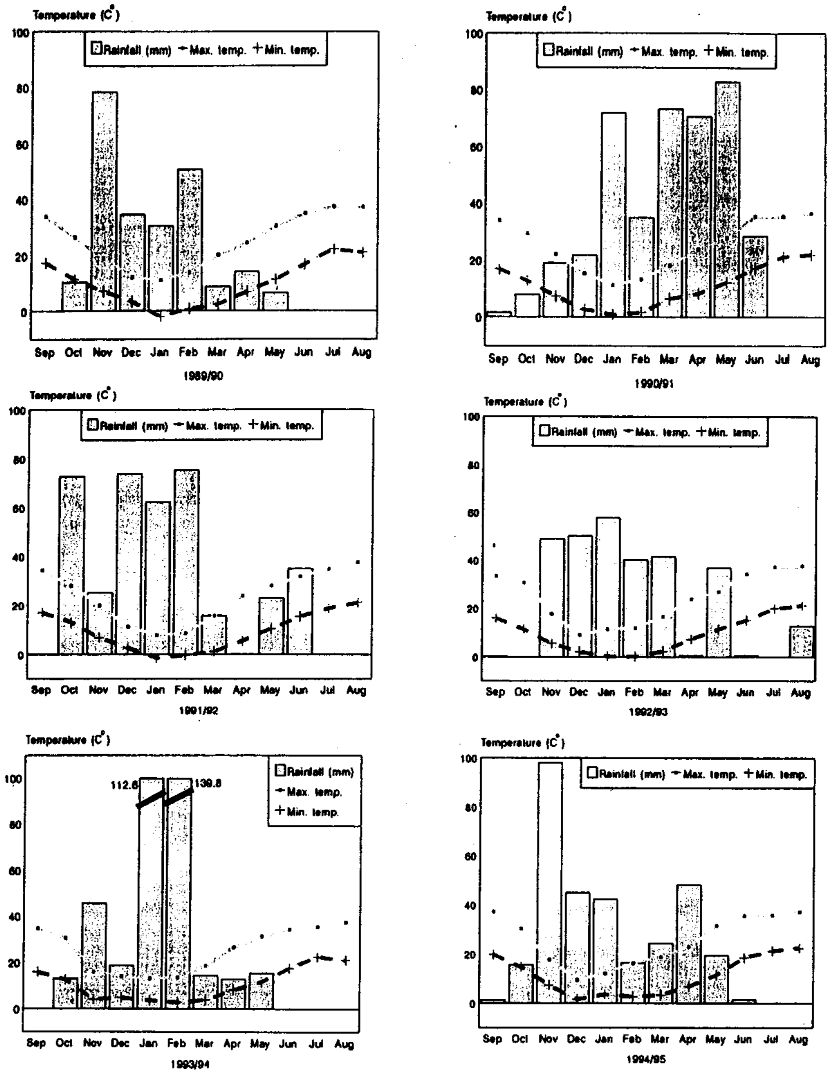

Fig. 1. Monthly rainfall and mean minimum and maximum temperature from 1989–95 at Tel Hadya, Syria

breeding materials. While there has been some research in this area for chickpea in the tropics (Saxena et al., 1993; Subbarao et al., 1995; Johansen et al., 1994b), there has been little research in the Mediterranean region.

We have developed a screening technique for areas typified by Tel Hadya, which are generally considered too dry for growing chickpea during spring. By sowing 3–4 weeks later than the normal sowing of spring chickpea in the Mediterranean region, reproducible drought stress conditions can be created and genotypic response to drought can be identified, as shown by the data in Tables 1 and 2.

Rating scale

During 1992, the 25 test lines were evaluated visually for drought resistance using the 1–9 scale. Significant correlations ($r = -0.76$ in normal date and $r = -0.87$ on late date) between seed yield and rating were found (Table 3). Correlation between seed yield under stress conditions and rating was again calculated in 1995, when 81 lines were grown under stress and non-stress conditions. The correlation was $r = -0.70$ (Table 4), supporting the 1992 result. This gave us confidence that the rating procedure was discriminative and workable. Hence it was used for preliminary screening to discard drought-susceptible lines.

The 1–9 scale which was used in this study appears effective in rejecting materials susceptible to drought by a mass-screening exercise. Of course, the technique may need fine tuning to meet local needs in different breeding programs. Singh et al. (1989) have developed a similar scale for evaluation of materials for cold tolerance, and this has been widely accepted by programmes involved in breeding for this trait. It is envisaged that the drought-resistance rating scale would also be readily adopted because of its simplicity and effectiveness.

Table 1: Seed yield (kg ha^{-1}) of chickpea genotypes at four dates of sowing during the 1990 spring season

Entry	Dates of planting 28 Feb	10 Mar	20 Mar	30 Mar	Mean
ILC 72	485	130	11	7	158
ILC 3279	570	365	76	37	262
FLIP 85-142C	339	150	3	6	124
FLIP 86-12C	702	522	98	9	333
ICCV 85504	602	619	530	380	532
ICCV 88512	787	661	419	356	556
ILC 1929	1439	1276	948	737	1100
ILV 482	1215	1033	661	444	838
ILC 1919	1043	863	524	652	770
FLIP 87-5C	1281	1126	776	704	972
FLIP 87-7C	1213	1200	778	833	1006
FLIP 87-8C	1341	898	713	754	949
FLIP 87-51C	1420	1144	1020	728	1078
FLIP 87-58C	1409	1157	635	887	1022
FLIP 87-59C	1435	1420	935	1189	1245
FLIP 87-80C	824	854	309	257	561
FLIP 87-85C	1294	1096	833	943	1042
ILC 710	1278	1159	781	470	922
ILC 830	909	961	543	517	732
ILC 1130	1020	1135	689	604	862
ILC 1141	1200	833	369	441	711
ILC 1687	585	633	385	352	489
ILC 1748	1113	1237	965	694	1002
ILC 6104	1611	1176	893	1007	1172
ILC 6118	1507	1263	789	963	1131
Mean	1065	920	587	559	783
SE± (Dates)					42.92
SE± (Entry)					67.35
SE± (Dates across entries or entries across dates)					138.78
C. V. % (Date)					33.58
C.V. % (Entry)					21.07
L.S.D. (0.05) Dates					105.03
L.S.D. (0.05) Entries					132.01
L.S.D. (0.05) (Dates across entries or entries across dates)					278.48

Evaluation of germplasm

Preliminary evaluation

A total of 1000, 1980, and 1185 germplasm accessions were evaluated during 1992, 1993, and 1994, respectively (Fig. 2). One line in 1992 and two lines in 1993 were rated 3, or most resistant. Eighty-two lines were found moderately resistant (rating of 4). Another 265 lines had an intermediate rating. A total of 3815 lines were found susceptible.

Final evaluation

Results from the 81 selected relatively-resistant lines grown under drought (stress) and irrigated (non-stress) conditions are presented in Table 4. These lines were also evaluated on the 1–9 scale. Nineteen lines were considered as relatively drought resistant: ILC 142, -391, -588, -1306, -1799, -2216, -2516, -3550, -3764, -3832, -3843, -4236, FLIP 87-7C, -87-8C, -87-58C, -87-59C, -87-85C, -88-42C, and ICC 4958. Out of these, one line (ILC 142) was rated 3, 14 rated 4, one rated 5, and one line had a rating of 6.

We also estimated the drought susceptibility index for all the lines (Table 4). Given that a score of less than one indicates resistance, only four of the 19 resistant lines would have been rated as susceptible on the basis of drought-susceptibility score; and the remainder as drought-resistant.

Most of the 19 lines that were identified as

Table 2: Yield performance (kg ha^{-1}) of chickpea genotypes as affected by dates of sowing and moisture regimes during the 1991 and 1992 spring season at Tel Hadya, Syria

Entry	1991 Rainfed 28 Feb	1991 Rainfed 20 Mar	1991 Rainfed Mean	1991 Irrigated 28 Feb	1991 Irrigated 20 Mar	1991 Irrigated Mean	1991 Overall Mean	1992 Rainfed 28 Feb	1992 Rainfed 20 Mar	1992 Rainfed Mean	1992 Irrigated 28 Feb	1992 Irrigated 20 Mar	1992 Irrigated Mean	1992 Overall Mean
ILC 72	9	1	5	595	166	381	193	1173	885	1029	2311	1790	2051	1540
ILC 3279	76	8	42	783	220	501	272	1431	1030	1230	2476	2035	2255	1743
FLIP 85-142C	5	3	4	265	465	365	185	913	817	865	2431	1890	2161	1513
FLIP 86-12C	78	4	41	611	318	465	253	1235	952	1094	2708	2199	2454	1774
ICCV 88504	193	0	130	654	584	619	375	1639	1450	1545	2575	2172	2373	1959
ICCV 88512	59	22	40	969	412	691	365	1629	1332	1480	2557	2239	2398	1939
ILC 1929	332	120	226	953	936	945	585	1959	1944	1952	3414	3112	3263	2607
ILC 482	316	98	207	833	731	782	495	1967	1716	1841	3094	2671	2882	2362
ILC 1919	246	48	147	537	729	633	390	1899	1750	1825	3105	2666	2885	2355
FLIP 87-5C	296	231	263	653	865	759	511	1869	1576	1722	2916	2790	2853	2288
FLIP 87-7C	421	83	322	1087	999	1043	682	2122	1686	1904	3454	3086	3270	2587
FLIP 87-8C	405	187	296	1227	803	1015	656	2033	1724	1879	3401	3006	3203	2541
FLIP 87-51C	365	129	247	766	1135	950	599	2197	2131	2164	3598	2758	3178	2671
FLIP 87-58C	559	284	421	860	603	731	576	2141	1979	2060	3672	3099	3386	2723
FLIP 87-59C	492	289	390	882	676	779	585	2123	2152	2138	3697	2986	3341	2740
FLIP 87-80C	48	0	26	393	531	462	244	1835	1512	1674	2844	2333	2589	2131
FLIP 87-85C	493	138	399	960	570	465	582	1893	1858	1875	3388	2893	3140	2508
ILC 710	322	55	188	616	987	801	495	1769	1801	1785	2952	2916	2934	2359
ILC 830	284	48	166	561	704	632	399	1910	1596	1753	2862	2634	2748	2251
ILC 1130	289	14	151	856	714	785	468	1915	1727	1821	3063	2705	2884	2353
ILC 1141	1825	24	103	1052	898	975	539	2087	1829	1958	3344	2858	3101	2530
ILC 1687	346	202	274	637	759	698	486	1918	1788	1853	3156	2657	2906	2380
ILC 1748	310	113	211	703	669	686	449	1797	1775	1786	3249	2588	2919	2352
ILC 6104	438	224	331	875	666	770	551	1850	1759	1804	3316	2576	2946	2375
ILC 6118	474	257	366	848	655	752	559	1745	1541	1643	3048	2422	2735	2189
Mean	288	102		767	672			1802	1612		3065	2603		

S.E. of difference between two comp. of the two levels of:

	1991	1992
Irrigation	74.68 (321.36)	119.89 (515.87)
Date	24.88 (48.76)	21.09 (41.33)
Date at the same level of irrigation	35.18 (68.96)	29.82 (58.44)
Irrigation at the same level of date	78.72 (320.30)	121.73 (515.23)
Entry	87.96 (172.40)	74.55 (146.11)
Entry at the same level of irrigation	124.40 (243.81)	105.43 (206.63)
Irrigation at the same level of entry	142.94 (371.59)	158.25 (522.96)
Entry at the same level of date	124.40 (243.81)	105.43 (206.63)
Date at the same level of entry	124.40 (243.81)	105.43 (206.63)

The values in brackets are the L.S.D. values at $P = 0.05$.

drought-resistant produced >1 t ha^{-1} of seed yield under stress conditions and about 2 t ha^{-1} under non-stress conditions. Such a material is of particular value for those areas around the Mediterranean Sea where long-term average rainfall is less than 400 mm, with large temporal variations. These lines will also be of great use to farmers who have access to supplemental irrigation.

Of course, most of the susceptible types eliminated by this screening technique are mainly long-duration types unable to 'escape' the terminal drought. However, the method also identifies the truly resistant lines within the early-flowering group. It would be desirable to determine the physiological basis for this resistance, and possibly identify suitable markers — molecular or others — which may further improve the efficacy of breeding chickpea for drought resistance.

Table 3: Correlation of seed yield with other variables as affected by dates of sowing at Tel Hadya in the 1990, 1991, and 1992 spring season

Variable	Date of sowing 1990		1991		1992	
	28 Feb	20 Mar	28 Feb	20 Mar	28 Feb	20 Mar
Days to flowering	−0.754	−0.774	−0.612	−0.641	−0.613	−0.660
Plant vigor	−0.657	−0.630	−0.748	−0.654	—	—
Ground cover (%)	0.444	0.701	0.740	0.324	—	—
Days to maturity	−0.688	−0.771	−0.478	−0.366	−0.662	−0.788
Plant height (cm)	−0.363	−0.501	−0.219	0.219	−0.590	−0.696
Primary branches	−0.169	−0.140	−0.267	−0.145	−0.102	−0.152
Secondary branches	0.051	−0.327	0.243	0.102	0.107	−0.288
Pod number	0.205	0.476	0.385	0.241	0.205	0.205
Filled pod	0.199	0.463	0.331	0.337	0.105	0.178
% filled pod	0.107	0.560	−0.085	−0.213	−0.347	−0.098
Shoot biomass (kg/ha)	0.751	0.541	0.716	0.777	0.644	0.718
Harvest index (%)	0.854	0.878	0.914	0.355	0.852	0.845
100-seed weight (g)	0.499	0.622	0.516	0.708	0.055	0.032
Rating score for drought					−0.764	−0.867

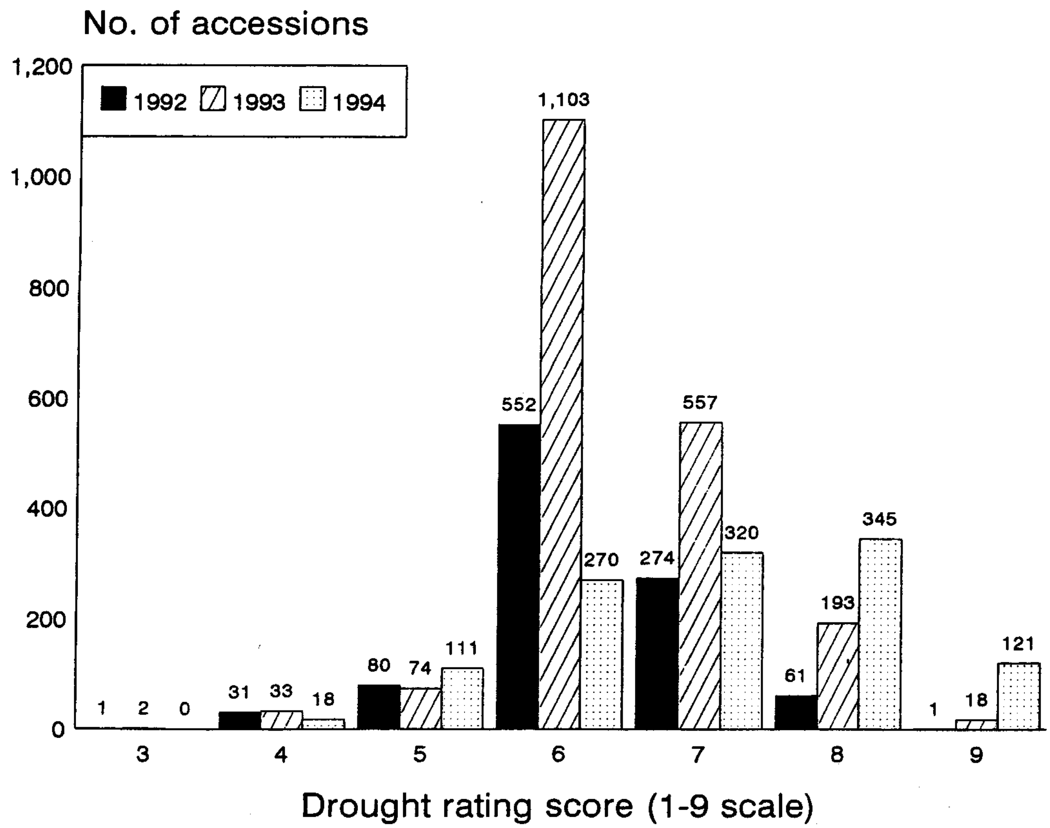

Fig. 2. Reaction of chickpea germplasm accessions to drought at Tel Hadya from 1992 to 1994

The drought resistant lines adapted to spring sowing in the Mediterranean environment identified in this study are being applied to national scientists in the West Asia and North Africa region; and are being used as parental material at ICARDA to combine this trait with disease resistance and high yield. The resulting materials will be of use to national programmes in their effort to attain sustainable increases in the productivity of spring chickpeas in the rainfall areas of West Asia and North Africa.

Table 4: Performance of 19 highest yielding genotypes from the previously identified drought-resistant lines under rainfed and irrigated conditions at Tel Hadya during the 1995 spring season

Entry name	Days to flower (rainfed)	Rainfed seed yield (kg ha^{-1})	Drought resistance score[a]	Irrigated seed yield (kg ha^{-1})	Drought susceptibility index
ILC 142	48	1426	3	2212	0.744
ILC 391	56	1166	5	1988	0.981
ILC 588	50	1113	4	2176	0.986
ILC 1306	54	1352	4	1950	0.716
ILC 1799	54	1135	4	2376	1.033
ILC 2216	51	1141	6	1952	0.695
ILC 2516	51	1171	4	1858	0.853
ILC 3550	50	1135	4	2055	0.810
ILC 3764	53	1246	4	2310	0.674
ILC 3832	52	1200	4	2022	0.975
ILC 3843	49	1332	4	2532	0.765
ILC 4236	50	1064	4	2325	1.046
FLIP 87-7C	49	1100	4	2520	0.961
FLIP 87-8C	49	1016	4	2368	0.969
FLIP 87-58C	46	1085	4	2197	1.069
FLIP 87-59C	48	1191	4	2245	0.995
FLIP 87-85C	49	1028	4	2075	1.043
FLIP 88-42C	49	1392	4	1858	0.789
ICC 4958	49	1194	5	1931	0.968
Susceptible controls					
ILC 72	68	74	9	1445	1.644
ILC 1171	65	161	8	931	1.697
Mean of 81 genotypes		961.4		1854.7	
SE±		119.2		214.4	
C.V. (%)		21.5		20.0	
LSD at P ⩽ 0.05		330.3		594.1	

[a]Score: 1 = free from damage; 9 = plants died without producing any seed.

Zusammenfassung

Auslese auf Dürreresistenz bei Sommer-Kichererbse in mediterraner Region

Obwohl die Kichererbse (*Cicer arietinum* L.) Wachstumsbedingungen in dürregefährdeten Umwelten, in denen die Wasserversorgung aus dem Bodenwasservorrat erfolgt, gut angepaßt ist, ist Dürre ein Hauptfaktor des Ertragsrückgangs in den meisten Kichererbsen anbauenden Regionen. Es ist als Folge des Mangels an einer zuverlässsigen und wiederholungsfähigen Methode für die Auslese und Verbesserung der Leistungsfähigkeit unter Dürrestreßbedingungen nur geringer Fortschritt in der Züchtung auf Dürreresistenz gemacht worden. Es wurden daher im Jahre 1990 Untersuchungen durchgeführt, um eine Auslesetechnik und ein Bewertungssystem für genetisches Material im Hinblick auf Dürreresistenz zu entwickeln. In den Frühjahren 1990 bis 1992 wurden Bestellungsexperimente in Tel Hayda (Nordsyrien) durchgeführt, um genotypisch bedingte Differenzen gegenüber Dürreresistenz erkennbar zu erzeugen. Eine entsprechende Bewertungsskala wurde entwickelt. Unter Verwendung der Auslesetechnik und der Bewertungsskala wurden über 4000 genetisch unterschiedliche Linien in den Jahren 1992 bis 1995 ausgewertet. Die sich als geeignete erweisende Auslesetechnik basiert auf einer Verzögerung der Aussaat um 3 Wochen während des Frühjahrs auf einem relativ trockenen Standort (langzeitlich durchschnittlicher jährlicher Regenfall von 328 mm), Vorauswertungen des Materials aufgrund einer Bewertungsskala von 1–9, um empfindliche Linien zu entfernen und eine abschließende Auswertung vielversprechender Linien unter Streß-(Dürre) und Nichtstreß-(Ergänzungsbewässerungen) Bedingungen auszuwerten, wobei dürreresistente Linien, die sich unter beiden Bedingungen als leistungsfähig erwiesen, ausgelesen wurden. In der von 1–9 aufgestellten Bewertungsskala bedeutet 1 = keine Ertragsreduktion im Vergleich zu einer nicht unter Streßbedingungen wachsenden Kontrolle und 9 = alle Pflanzen ohne Samen. Unter Verwendung dieser Technik wurden 19 von 4 165 Linien ausgelesen als dürreresistent, wobei eine Samenproduktion von mehr als einer t/ha unter Dürrebedingungen produziert wurde, während unter Nichtstreßbedingungen der Ertrag über 2 t/ha

betrug. Resistente Linien werden in nationalen Programmen in der mediterranen Region von ICARDA zur Entwicklung dürre- und krankheitsresistenter, hochertragreicher Kultivare verwendet.

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