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Study on chickpea drought tolerance lines under dryland condition of Iran

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Abstract

Drought is one of the most important abiotic stresses, which limits crop production in different parts of the world. Estimates of yield losses due to drought range from 15 to 60% which depend on geographical region and length of crop season. Plants adapt to drought environment either through escape, avoidance, or tolerance mechanisms. Chickpea is planted on 700,000 hectares in Iran. This area is fourth in the world after India, Pakistan and Turkey. Major chickpea area (95%) is planted in rainfed condition and is grown in rotation with cereals mainly wheat and barely. Most of the farmers grow this crop on marginal areas in the spring season. Terminal drought stress is one of the major yield reducer in chickpea in Iran. Major successes due to breeding have been achieved, in the selection for drought escape. The aim of present study was to find early maturity chickpea lines, which can escape terminal drought stress. The experiment material comprised 40 kabuli chickpea lines with susceptible check (ILC 3279) in RCBD design with two replications at research stations of Kermanshah, Shirvan, Orumieh and Zanjan Province during 2002-03 and 2003-04. The experiments were sown late (10 April) by 20 days in comparison to normal sowing date for terminal drought stress. These materials were sent by ICARDA as CIDTN through Iran-ICARDA cooperation. The genotypes were recorded for drought tolerance score on a 1-9 scale on the basis of ICARDA recommendation. The result of pooled analysis of this study showed that difference between yield and drought tolerance of lines were significant. The results showed that 35 lines had significant difference at 1% level of probability over susceptible check for drought tolerance. These lines produced higher yield than check significantly. Superior lines for yield and drought tolerance were ILC 1799, ILC 3832, FLIP 98-141, ILC 3182, FLIP 98-142C, ILC 3101, ILC 588 respectively. ILC 1799 has produced the highest yield, which was drought tolerance with high adaptability, early maturity and large seed size.

Key words: Drought tolerance, dryland, chickpea**.**

Introduction

Drought is the most common adverse environment, which limits crop production in different parts of the world special in Iran that is considered as dry and semi dry country. Often drought is accompanied by relatively high temperatures, which promote evaportranspiration and hence could accentuate the effects of drought and thereby further reduce crop yields. 49.78 percent of crops are planted in rainfall in Iran due to water limitation and rate of rainfall. Productivity of crops in rainfed area in Iran is 42 percent of irrigated field. Estimates of yield losses due to terminal drought range from 35 to 50% across the SAT and WANA (Sabaghpour, 2003). Rahangdale *et al*. (1994) reported that water stress decreased seed yield 15.2%. Yield reduction differ range 30 to 60 percent in chickpea, which depend on geographical region and length of crop season. Plants adapt to drought environments either through escape, avoidance, or tolerance mechanisms (Sabaghpour, 2003). Chickpea genotypes with high growth vigor are early maturity. Initial growth vigor is suitable character for large-scale evaluation of germplasm and breeding materials (Sabaghpour *et al*., 2003). Chickpea (*Cicer arietinum* L.) is planted on 700,000 hectares in Iran and ranks fourth in the world after India, Turkey and Pakistan. Chickpea productivity in Iran is less than half of world average yield. 95 percent of chickpea areas (665000 ha) are planted in rainfed condition and is grown. Most of the farmers grow this crop in marginal areas in the spring. Due to lack of rainfall during flowering, podding and seed filling, terminal drought stress is major abiotic stress for reducing chickpea productivity in Iran. Therefore, selection for early maturity chickpea line is the most important objective for escaping terminal drought stress.

Materials and methods

Objective of present study was to find chickpea drought tolerance with desirable characters. The experiment was conducted during two years on 2002-2003 and 2003-2004 using a randomized complete block design with two replications, at four different locations at Kermanshah, Shirvan, Zanjan and Oromieh Research Station in Iran. Materials comprised 40 lines along with susceptible check (ILC 3279) with origin of India, Turkey, Morocco, Tunisia, ICARDA and ICRISAT. The genotypes were planted as single rows, with spacing of 30 cm between rows and 10 cm between plants within a row. Date of planting postpone 20 days in normal planting for more force terminal drought stress. Appropriate pesticide was used to control pest. Fertilizers were applied prior to ploughing at the recommended rates of 20 and 30 kg/ha for N, P_2O_5 respectively. Days to 50% Flowering, Days to maturity, initial growth vigor, drought tolerance score, 100-seed weight and seed yield were recorded during cropping season. The genotypes were recorded for vigor score on a 1-5 scale (1=Very good, 2=Good, 3=Average, 4= poor and 5- very poor) on the basis of ICARDA recommendation. Selection for high growth vigor enhances chance for escaping terminal drought stress (Sabaghpour and Kumar, 2003). Also on the basis of ICARDA recommendation, the drought tolerance rated on drought tolerance score (DTS) as following:

1. Free, early flowering, good early plant vigor, 100% pod setting
2. Highly tolerant, early flowering, good early plant vigor, 96-99% pod setting
3. Tolerant, early flowering, good early plant vigor, 86-95% pod setting
4. Moderately tolerant, early flowering, moderate early plant vigor, 76-85% pod setting
5. Intermediate, medium flowering, poor early plant vigor, 51-75% pod setting
6. Moderately susceptible, medium flowering, lack of early plant vigor, 26-50% pod setting
7. Susceptible, late flowering, lack of early plant vigor, 11-25% pod setting
8. Highly susceptible, late flowering, lack of early plant vigor, 1-10% pod setting
9. 100% plants killed, lack of early plant vigor, no flowering, no pod setting

Combined analysis was done on drought tolerance score and seed yield.

Results and discussion

The results of combined analysis on drought tolerance score showed that no significant difference among the years and location. But, interaction of genotypes × location was significant at 1% level of probability. The results of combined analysis of present study on drought tolerance score showed that a significant difference among the genotypes at 1% level of probability. The results of combined analysis on seed yield showed that among the years and location were not significant difference. The result indicated that interaction of genotypes × location was significant at 1% level of probability. A significant difference was also found among the genotypes yield (Table 1). 35 genotypes were significant tolerance to drought in comparison to suceptible check at 1% level of probability. These lines produced significantly higher yield than suceptible check. Genotypes such as ILC ILC 3832, FLIP 98-141, ILC 3182, FLIP 98-142C, ILC 3101 and ILC 588 were superior in respect of drought tolerance and yield in comprison to other genotypes (Table 2).

Table 1. Combined analysis of variance for grain yield at four locations in 2002-2003 and 2003- 2004 cropping season

S.O.V.	df.	M.S.
Location	3	686758.06 ns
Year	1	53095.99 ns
Location× Year	3	6835611.99**
Rep (Location ×Year)	8	27806.44
Genotype	40	83027.71**
Genotype × Year	40	23610.72ns
Genotype × Location	120	22947.95ns
Genotype × Year× Location	120	20859.1*
Error	320	15014.24
	655	Total

*ns, *, ** : Non significant, significant at 5% and 1% probability levels, respectively*

Plants adapt to drought environments either through escape, avoidance, or tolerance mechanisms. Drought escape is a particularly important strategy of matching phenological development with the period of soil miosture availability to minimize the impact of drought stress on crop production in enviroments where the growing season is short and terminal drought stress predominates (Turner, 1986 a,b). Drought escape is the most impotant success for breeders so far in comparison with other mechanisms. Famers usually are not able to plant chickpea in the begaining of March due to high miosture in field. Therefore, they often have to plant chickpea in the end March in Iran. Flowering time in chickpea will start in the first of May which rainfall will stop in many years.

Table 2. Mean of agronomic characters in different location during 2002-2004

ENT	Genotype	DF	DM	Growth vigor	DTS	Class	PH	100-sw	Kg/ha	Class
1	ILC 588	59	101	3	2.5	A	23	32	421	A
2	ILC 1799	58.5	98.5	3	3.25	A	22	36	519	A
3	ILC 3101	58.5	102.5	3	3.88	A	23	31	438	A
4	ILC 3105	57.5	101.5	4	3.75	A	24	29	357	A
5	ILC 3182	59	101.5	3	3.63	A	23	29	446	A
6	ILC 3832	57.5	102.5	5	3.5	A	24	31	514	A
7	ILC 3843	59	101.5	3	3.25	A	25	38	414	A
8	ILC 4134	58	103	3	3.38	A	25	32	403	A
9	FLIP 87-85C	58	105	4	3.13	A	23	34	373	A
10	FLIP 88-42C	58	100.5	2	3.75	A	25	33	397	A
11	FLIP 95-74C	61.5	101.5	3	4.13	A	24	40	347	A
12	FLIP 98-114C	56.5	102	3	3.25	A	21	31	328	A
13	FLIP 97-21C	60	104.5	3	4.75	A	24	35	351	A
14	FLIP 97-48C	56	101.5	3	2.75	A	24	29	410	A
15	FLIP 97-49C	58.5	102	3	3.75	A	24	34	401	A
16	FLIP 97-111C	56.5	108	3	6.13	C	23	35	237	C
17	FLIP 97-254C	58.5	100	3	4.25	A	24	26	397	A
18	FLIP 97-258C	60	105.5	3	4.5	A	23	36	378	A
19	FLIP 97-265C	56	102	3	3.88	A	23	31	373	A
20	FLIP 98-24C	60	100	3	3.63	A	22	33	393	A
21	FLIP 98-55C	61	105	4	5.5	B	26	35	255	C
22	FLIP 98-91C	57	99.5	3	3.25	A	23	29	396	A
23	FLIP 98-106C	58.5	102.5	4	3.13	A	23	35	361	A
24	FLIP 98-107C	61.5	102.5	3	5.25	A	26	28	320	A
25	FLIP 98-113C	60	104	4	5.13	A	24	31	367	A
26	FLIP 98-121C	60	101	3	4.13	A	21	35	400	A
27	FLIP 98-130C	61.5	103	3	4.75	A	26	30	341	A
28	FLIP 98-131C	61.5	103	3	4.63	A	26	32	333	A
29	FLIP 98-134C	59	103	4	4.13	A	26	35	341	A
30	FLIP 98-141C	57	103	4	2.88	A	23	32	450	A
31	FLIP 98-142C	54.5	99	3	2.38	A	22	33	445	A
32	FLIP 98-142C	58	104.5	4	3.13	A	24	29	342	A
33	FLIP 98-206C	62	106	3	5.75	B	26	33	283	A
34	FLIP 99-1C	62	102.5	3	4.5	A	23	34	303	A
35	FLIP 99-34C	59	104	3	4.25	A	22	30	305	A
36	FLIP 99-46C	63.5	100	3	6	C	23	35	252	B
37	FLIP 99-48C	60	109	4	5.88	B	21	30	304	A
38	FLIP 00-40C	61.5	103	3	3.88	A	24	34	388	A
39	FLIP 00-44C	60.5	101	3	4	A	24	38	378	A
40	ICCV –2	56.5	100	4	3.88	A	22	25	385	A
41	ILC 3279	64.5	117.5	3	7.75	C	28	29	133	C

Chickpea need the highest water during flowering, podding and seed filling. Therefore, terminal drought stress in most important abiotic stress affecting to low productivity in Iran. Postpone for date of sowing is suitable mothology to find early maturity genotypes. Several short-duration genotypes of legumes show higher and more stable yields than longer duration types (Mc Blain and Hume, 1980; Hall and Grantz 1981; Hall and Patel, 1985; Rose *et al*., 1992). Overall based on the mean of grain yield, drought tolerance score, seed size and early maturity, ILC 1799 was the most desiable line. The suceptible check (ILC 3279) had the lowest productivity and the most late maturity

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