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Effect of Salinity on Germination and Seedling Growth of Chickpea (*Cicer arietinum* L.) Genotypes

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ABSTRACT

Germination and seedling growth responses of 30 genotypes of chickpea were determination at a range of irrigation water salinities. All genotypes showed salt tolerance either at germination or seedling growth stage at low level of salinity (4 dSm^{-1}). In the presence of polyethylene glycol of a molecular weight of 600 at 4 dSm^{-1} salinity. Genotypes C_{10}, C_{14}, C_{16}, C_{17}, C_{19} and C_{29} also showed tolerance to medium level of salinity (6 dSm^{-1}). Only two salt tolerant genotypes out of those tested proved to be C_{28} and C_{29} which perform well both at germination and seedling stage under all salt levels. Threre were also significant genotypic differences in seedling growth on acid washed sandy soil with increasing NaCl, $CaCl_2$ and $MgSO_4$ over the same range of salinity as used to test germination.

Key Words: Salinity; Seedling; Chickpea; Genotypes

INTRODUCTION

In arid and semi-arid regions, where growth is limited by water shortage or by water of poor quality, the use of saline water for crop production is often unavoidable. Most crops tolerate salinity to a threshold level above which yields decrease as salinity increases (Maas, 1986; Swalem, 2000; Kafi & Goldani, 2001).

Saline soils contain soluble salts in quantities that affect plant growth at various stages and create yield differences between crops and differences in the ion composition of crops at maturity (Sharma, 1997). The process of soil salinization and the preponderance of saline water sources point to a future reliance on salt resistant crops (Saxena, 1990; Hamdy *et al.*, 1993; Francois & Maas, 1994)

Chickpea (*Cicer arietinum* L.), is the third most extensively planted grain legume (D'amore *et al*., 1996). Besides being an important source of human and animal food, the crop also plays an important role in the maintenance of soil fertility, particularly in arid regions (Saxena, 1990). A major constraint on chickpea production in Saudi Arabia is soil salinity, predominately due to chloride and sulphate accumulation. Although some soils are naturally saline, the secondary salinization largely about by the use of irrigation systems, that is the greatest threat to legume sustainability in arid and semi-arid regions, where water supplies are limited, irrigation is essential to improve poor crop yields. As with many other pulses, chickpea is a salt-sensitive crop, and yields are seriously reduced particularly by chloride salinity (Manchanda & Sharma, 1990). The effects of salinity on chickpea are wide ranging. Seed germination is delayed and reduced, and vegetative plant growth is suppressed under saline conditions (Sharma *et al*., 1982; Yadav *et al*., 1989).

This research describes the effects of salinity on the germination and seedling growth of selected genotypes of chickpea. Thirty genotypes of chickpea were used to study their response to salinity at germination and seedling stage.

MATERIALS AND METHODS

Experiment-1. The seeds of different chickpea genotypes were obtained from the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria.

Selected 50 seeds of each genotype were grown in a petri dish containing polyethylene glycol of a molecular weight of 600. The salinity treatment used were 0, 4, 6 and 8 dS/m. The petri dishes were kept in a growth chamber for 8 days at day/night temperatures of 28°/23°C. Artificial light was provided for a 12-h photoperiod. The seed was considered as having germinated when the radicle protruded to a length of 3 mm. Germinating seeds were counted every other day starting two days from the beginning of the test. The germination stress index (G.S.I) was then calculated as follows:

$$1.\ \text{P.I.(Promotion Index)} = \text{nd}2(1.00) + \text{nd}4(0.75) + \text{nd}6(0.50)\text{nd}8(0.25)$$

Where nd2, nd4, nd6, nd8 were percentages of seeds observed to germinate on the 2^{nd}, 4^{th}, 6^{th} , and 8^{th} day, respectively.

$$11.\ \text{G.S.I.} = \frac{\text{P.I. of stressed seeds (P.I.S)} \times 100}{\text{P.I. of control seeds (P.I.C)}}$$

Experiment-2. This experiment was a continuation of experiment 1 such that the germinating seeds from experiment-1 were further subjected to the same salinity levels to evaluate the effects of salinity on the early growth of seedlings. Eight-day seedlings from all selected genotypes of chickpea were transplanted in plastic plots (16-cm diameter) containing acid-washed sand. The pots were placed in a greenhouse with controlled temperatures of about 28°/23°C day and night. Irrigation water was artificially constructed using a base of distilled water and addition of NaCl, $CaCl_2$ and $MgSO_4$. Before application of the salinity treatments, the seedlings were given a pre-conditioning period of one week during which the seedlings were supplied with Hoagland's solutions. The salinity treatments were then imposed on the seedlings at weekly intervals for a period of 5 weeks, during which the seedlings also received Hoagland's solution. The plants were then removed from the pots and the following measurements were carried out:

i. Plant height (cm).
ii. Oven dry-weight of shoots (g).
Stress indices were than calculated as follows:

$$\text{a. Seedling height stress index (S.H.S.I.)} = \frac{\text{Seedling height of stressed seedlings}}{\text{Seedling height of control seedlings}} \times 100$$

$$\text{b. Dry-matter index (D.M.S.I.)} = \frac{\text{Dry-matter of stressed seedlings}}{\text{Dry-matter of control seedlings}} \times 100$$

Data from Experiment-1 and -2 were statistically analyzed as factorial experiments in a completely randomized block design with four replications. The Least significant different was used to compare treatments.

RESULTS AND DISCUSSION

Effects of salinity on germination chickpea genotypes are shown in Table I. The results indicated that most genotypes (86.7%) germinated satisfactorily because their germination stress index (G.S.I.) being 50 or more, at the lower salinity level of 4 dS/m. However, when salinity was raised to 6 dS/m, a substantial reduction in the G.S.I. occurred in almost all genotypes, to the extent that only 56.7% of the genotypes had a G.S.I. of 50 or more. At 8 dS/m only 40% of the chickpea genotypes had a G.S.I. of 50 or more. Six genotypes (23.3%), namely C_{10}, C_{14}, C_{16}, C_{17}, C_{19} and C_{30} had a G.S.I. of more than 60 at the highest level of salinity. Genotype C_{11} performed extremely well (Table I). These results are in agreement with the finding of other investigators (Kafi & Goldani, 2001; Ashraf & Waheed, 1993; Sekeroglu *et al*., 1999) who reported that the rate and percentage of seed germination of chickpea were significantly reduced by increasing salinity levels and the mangitude of the reduction varied among genotypes.

Table I. Germination stress index (GSI) of 30 genotypes of chickpea in response to 3 levels of salinity

Code	Genotypes	Salinity level (dS/m)		
		4	6	8
C_1	C8.4.85	70	50	43
C_2	C11.4.85	40	10	10
C_3	C17.4.85	53	41	36
C_4	C21.4.85	50	11	10
C_5	C36.4.85	59	13	12
C_6	C7.4.85	99	77	36
C_7	C2.5.85	76	25	0
C_8	C10.5.85	80	0	0
C_9	C12.5.85	72	0	0
C_{10}	C14.5.85	82	68	62
C_{11}	C1.9.85	99	80	80
C_{12}	C4.9.85	99	88	52
C_{13}	C5.9.85	99	98	70
C_{14}	C6.9.85	96	79	57
C_{15}	C7.9.85	89	66	53
C_{16}	C8.9.85	66	31	32
C_{17}	C9.9.85	74	65	65
C_{18}	C10.9.85	80	90	33
C_{19}	C13.9.85	94	61	61
C_{20}	C14.9.85	89	68	6
C_{21}	C15.9.85	75	48	48
C_{22}	C16.9.85	70	48	48
C_{23}	C17.9.85	99	91	34
C_{24}	C19.9.85	63	47	47
C_{25}	C20.9.85	79	56	56
C_{26}	C21.9.85	71	43	43
C_{27}	C23.9.85	93	61	17
C_{28}	CLN.86	99	61	58
C_{29}	CLJ.86	89	61	56
C_{30}	CLK.86	99	98	70
	$LSD_{0.05}$	11.9	8.4	3.8
	C.V.(%)	19.3	16.4	17.4

The seedling stage appears to be more sensitive to salinity than the germination stage. At 8 dS/m, 36.7% of the chickpea genotypes had a dry matter stress index (D.M.S.I.) of only 15 or more, whilst at germination 76.7% of the genotypes had G.S.I. of 15 or more (Table III). However, the seedling height seems to be the least affected by salinity since 80% of the genotypes attained a S.H.S.I. of 15 or more at highest salinity level. These results suggest that chickpea is more sensitive to salinity particularly at the seedling stage, since no genotypes of chickpea had a D.M.S.I. of more than 32 at the highest salinity level. This supported by several investigators (Sekeroglu *et al*., 1999; Grag & Gupta, 1998; Zurayk *et al*., 1998) who noted that the reductions on seedling root and shoot lengths caused by increasing salinity levels were more pronounced than reduction in seed germination percentage. They also reported that the response to salinity varied significantly between genotypes.

Some genotypes of chickpea, e.g. C_{30}, germinated extremely well at all salinity levels, but their seedling growth was very poor at higher salinity. The other two local types, C_{28} and C_{29}, performed well during germination and seedling growth at different levels of salinity. Some genotypes with low G.S.I. e.g. C_3, had a satisfactory seedling growth whilst others of the same group germinated

Table II. Seedling height stress index (SHSI) of 30 genotypes of chickpea in response to 3 levels of salinity

Genotypes	Salinity level (dS/m)		
	4	**6**	**8**
C_1	67	29	27
C_2	63	20	8
C_3	71	58	33
C_4	67	19	7
C_5	29	12	9
C_6	82	36	26
C_7	83	61	0
C_8	29	0	0
C_9	80	0	0
C_{10}	85	63	41
C_{11}	78	42	38
C_{12}	48	19	31
C_{13}	75	50	36
C_{14}	80	62	33
C_{15}	77	61	31
C_{16}	82	67	39
C_{17}	80	61	34
C_{18}	82	33	26
C_{19}	81	60	38
C_{20}	69	28	18
C_{21}	87	53	29
C_{22}	76	60	39
C_{23}	68	35	27
C_{24}	60	48	32
C_{25}	65	52	42
C_{26}	71	65	40
C_{27}	60	39	30
C_{28}	76	70	64
C_{29}	85	66	45
C_{30}	73	32	17
$LSD_{0.05}$	6.4	5.7	3.5
C.V.(%)	17.1	20.9	28.8

Table III. Dry matter stress index (DMSI) of 30 genotypes of chickpea in response to 3 levels of salinity

Genotypes	Salinity level (dS/m)		
	4	**6**	**8**
C_1	77	41	8
C_2	55	19	4
C_3	58	26	20
C_4	56	17	11
C_5	35	15	16
C_6	66	34	7
C_7	76	34	0
C_8	50	0	0
C_9	66	0	0
C_{10}	57	50	15
C_{11}	73	38	6
C_{12}	70	36	5
C_{13}	70	38	32
C_{14}	59	46	13
C_{15}	61	48	17
C_{16}	94	44	12
C_{17}	62	38	12
C_{18}	66	32	5
C_{19}	87	49	14
C_{20}	69	31	3
C_{21}	91	44	15
C_{22}	75	36	4
C_{23}	80	35	8
C_{24}	76	37	4
C_{25}	66	38	21
C_{26}	87	33	23
C_{27}	58	34	4
C_{28}	95	51	30
C_{29}	80	45	30
C_{30}	70	34	9
$LSD_{0.05}$	8.7	5.3	3.7
C.V.(%)	11.7	17.8	11.4

will but failed almost completely at the seedling stage, e.g. C_2. These results are in agreement with those of Papadopoulos *et al*. (1985), Csizinsky (1986), Coons and Pratt (1988), Pessarakli and Tucker (1988) and Katerji *et al*. (2001) who found significant differences in salt tolerance of different bean cultivars and several other crop. Van Hoorn (1991) reported similar inhibition of seedling growth of many crops by salt stress. Alislail and Bartels (1990) also reported that salinity reduced dry weights of tepary bean seedlings.

CONCLUSION

In summary, the results indicate that some genotypes of chickpea can tolerate high salinity at germination stage (C_{10}, C_{14}, C_{16}, C_{17}, C_{19} and C_{30}). Germination and seedling growth of chickpea genotypes decreased significantly as salinity increased. However, considerable diversity in regared to salt tolerance exists. The genotype didn't perform well at seedling stage. The two genotypes that showed salt tolerance at seedlings stage and above so germination index at high level of salinity were C_{28} and C_{29}. The study illustrates the necessity of establishing and maintaining sources of genetic diversity for use in crop improvement and counter present and future agricultural dilemmas.

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