

Effects of salinity on germination and early seedling growth of chickpea (*Cicerarietinum* L.) cultivars

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ABSTRACT: In order to evaluate the effects of NaCl salinity on germination and early seedling growth of chickpea cultivars, a CRD based factorial experiment with four replications was carried out in Agronomy Lab. of the University of Guilan, I. R. Iran. Seven chickpea cultivars (Hashem, Arman, Azad, Jam, Bevanig, ILC482, and Greet) were exposed to six NaCl based saline solution (3, 6, 9, 12, 15 and 18 dS m⁻¹) beside distilled water as control. The rate and percentage germination, root and shoot length, root, shoot and seedling dry weight, root/shoot dry weight ratio were investigated. The results indicate that effect of cultivar × salinity weren't significant on germination percentage and seedling dry weight. Cultivars and salinity had significant effect on seed germination and seedling dry weight, separately. The highest root and shoot length and shoot dry weight were related to "Arman" and "Bevanij" cultivars, respectively. The highest and lowest value for the root dry weight represented from Hashem and Greet cultivars. It was concluded that genetic variation exists among them in terms of early seedling growth rate under stress condition. In among cultivars, Arman showed higher resistance to increase of salinity.

Keywords: Chickpea (*Cicerarietinum* L.), NaCl, Percentage germination, Root weight and shoot dry weight

INTRODUCTION

Chickpea is a cool season food legume that has a wide variety of uses. It produces by many farmers of different countries as a cheap source of protein (Okcu et al., 2005) and plays a remarkable role in human diet and animal feed (Rahman et al., 2008). Among pulses, chickpea is second after fababean in terms of production. It occupies 11 million hectares of total lands set aside for chickpea production with total production about 48 million tones (FAO 2009). However, salt sensitivity can adversely affect on yield in this crop. As It is observed that yield decreases with increasing in salinity whereas a just half maximum yield obtained between 6 and 10 dS m⁻¹ (Cerdeira and Fernandez, 1989).

Salinity is a common problem in arid and semiarid regions where rainfall is insufficient to leach salts out of

the root zone and induces numerous disorders in plant growth including seeds germination and emergence (Pesarrakli, 1999). Seed germination and seedling emergence are most critical stage in seedling establishment and determining successful crop production whereas sensitive to salinity (Maghsoudi et al., 2008). Okcu (2005) and Naveed Khalid (2001) reported that high salinity reduced germination, root and shoot length and seedling fresh weight in chickpea. Germination and seedling characteristics are the most viable criteria used for selecting salt tolerance in plants. Germination percentage, germination speed and seedling growth are most important for cultivar selection. Therefore, the Screening of salt tolerant lines/cultivars has been attempted by many researches on various species at seedling growth stage (Ashraf et al., 1990; Shiri Janagard et al., 2008). Because of plant species and varieties show different response to

salinity (Ali Khan et al., 2005). So, this study was carried out to see effect of various salt concentrations on germination and early seedling growth of chickpea cultivars to the screen out salinity tolerance cultivars.

MATERIALS AND METHODS

In order to evaluate the effects of different levels of NaCl salinity on germination and early growth of chickpea seedlings, a CRD based factorial experiment with four replications was carried out in the Agronomy Lab. of the University of Guilan, I. R, Iran, in 2009. In this experiment, seven chickpea cultivars (Hashem, Arman, Azad, Jam, Bevanij, ILC482, and Greet) were exposed to six NaCl based saline solution (3, 6, 9, 12, 15 and 18 dS m⁻¹) beside distilled water as control. 25 sterilized seeds in 5% sodium hypochlorite solution for 8 min were selected and were allowed to germinate between paper. Pleated papers were well soaked by adding 10ml of respective solution at interval of 2 days (Naveed et al., 2001). Seed were allowed to germinate at 20C in the germinator for 8 day. Seed germination was counted daily for 8 days. With seed recorded as germinated when the visible radical length reached 2mm. The first count is done at 5th after start to experiment. Germination rate were calculated according to (Nicols and Heydecker, 1968) by the formula given below:

$$G = \Sigma(nt)/\Sigma n \quad (1)$$

Where *G* germination is rate, *n* the number of newly germinated seeds on each day and *t* is day of counting. Root, shoot and whole seedling dry weight were measured after 48h at 70°C oven-drying. Data obtained from this experiment were subjected to analysis of variance using SAS (version 9.1) statistical software and means were separated by Duncan's multiple range test (*p*<0.05).

RESULTS AND DISCUSSION

Salt stress declined the germination and also delayed the emergence of seed in all cultivars. The growth response to salt stress of chick-pea plants is represented in Table 1. These data indicate that germination percentage of seeds was not affected by interaction cultivar × salinity. But, salinity had significant effect on germination percentage. Result of mean value (Tab. 2) showed that salt stress had adverse effect on rate and percentage germination chickpea and reduced of them. The interaction effect cultivar × salinity was significant at rate germination. But effect of salinity on seed germination rate was more pronounced at 15 and 18 dS m⁻¹ (Tab. 2). In this experiment, interaction salinity × cultivar on root and shoot length was significant. The highest root length was related to Arman cultivar in all salinity (6, 9, 12 and 15 dS m⁻¹) and lowest root length was observed in Hashem cultivar (Fig.1a). Azad cultivar was excellent in low salinity and had high root length. However, increased

salinity (up to 6 dS m⁻¹) declined root length in this cultivar, strongly. ILS 482, despite having shorter root length in lower salinity, but it produced longer root as well as Arman cultivar in higher salinity (9, 12, 15 and 18 dS m⁻¹). Shoot length of chickpea cultivars can show significant difference in saline condition. Arman produced maximum shoot length under saline condition. The lowest shoot length related to Hashem, Azad and Jam cultivars (12, 15 and 18 dS m⁻¹) (Fig. 1B).

It was observed that the effects of salinity × cultivar were significant for root and shoot dry weight (Tab. 1). Increasing salinity levels caused remarkably decreases shoot and root dry weight (Fig. 2), although our cultivars showed different responses to each salinity levels. The highest shoot dry weight value in all salinity levels were obtained from Bevanij at 0, 3, 6, 9 and 12 dS m⁻¹. But, Jam cultivar showed high shoot dry weight at higher salinity 15 and 18 dS m⁻¹ (Fig. 2B). We will consider this point that higher root and shoot dry weight in Bevanij and Jam cultivars due to thicker root and shoot, not length of them. The lowest root and shoot dry weight observed in Greet cultivar at all salinity levels (Fig. 2). Also, salt levels had significant effect on the root dry weight of all cultivars. Maximum root dry weight obtained in Jam and Bevanij cultivars at salinity 3 and 6 dS m⁻¹; Hashem cultivar had highest root dry weight in 6, 9, 12 and 15 dS m⁻¹ (Fig. 2A). In general, seedling dry weight decreased with increase in salinity. As expected, salt levels had significant effect on the root dry weight of all cultivars. Maximum root dry weight obtained in Jam and Bevanij cultivars at salinity 3 and 6 dS m⁻¹ and Hashem cultivar had highest root dry weight in 6, 9, 12 and 15 dS m⁻¹ (Fig. 2A).

DISCUSSION

Increased salt concentration caused a decrease in germination. Strong reduction was observed mainly at the higher level of salt concentration compared to lower level. There wasn't significant difference between 0, 3 and 6 dS m⁻¹. Significant reduction in germination percentage occurred at 9, 12, 15 and 18 dS m⁻¹. It is assumed that in addition to toxic effects of certain ions, higher concentration of salt reduces the water potential in the medium which hinders water absorption by germination seeds and thus reduces germination (Jamil and Rha 2004). It appears that decrease in germination is related to salinity induced disturbance of metabolic process leading to increase in phenolic compounds (Ayaz et al., 2000) and osmotic effect (Welbaum, 1990) that causes decrease of water movement into the seeds during imbibition. These results are in close conformity with findings of Naseer (2001) on barley and Ali Khan (2005) on wheat.

Among the cultivars, Arman has highest root length in salinity condition. According to Hosseini (2003), cultivars had higher root length at salinity stress, it can absorbed water and nutrients from soil better than the

others because roots are in direct contact with soil and absorb water from soil and shoot supply it to the rest of plant. Therefore, Arman cultivar, with higher root length, can show greater resistance to adverse condition.

Increasing in salinity reduced the shoot length. Naseer (2001) reported that the reduction in shoot length is due to excessive accumulation of salt in the cell wall which modifies the metabolic activities and limits the cell wall elasticity. Further, secondary cell appears sooner and cell wall becomes rigid, as a consequence the turgor pressure efficiency in cell enlargement decreases, This processes may cause the shoot remain small (Naseer , 2001). These findings are parallel to those of Jamil et al., (2006) on vegetables species, Rahman et al., (2008) on wheat and Bybordi and Tabatabaei (2009). Jamil et al., (2006) reported that, root and shoot length are important traits in salt stress sensitivity evaluation. Maximum decrease in shoot and root length at salinity 18 dSm⁻¹ was recorded in Hashem cultivar. With increasing in NaCl salinity level, root and shoot length decreased and lowest value for all traits was obtained at 18 dS m⁻¹. The reduction root and shoot development may be due to toxic effects of the NaCl (Grieve and Suarez 1997). Salinity affects the seedling

growth of plant (Tezaraet et al., 2003) by slow or less mobilization of reserved food (Kayani et al., 1990), suspending the cell division, enlargement and injuring hypocotyls. The data on the average length of root and shoot shows that decrease in length of shoot was more pronounced as compared to root in all NaCl salt treatment (Fig. 1). This indicated that shoot is more sensitive than roots. It may be due to ability of the root system to control entry of ions of the shoot is of crucial importance.

Also, seedling dry weight decreased with increase in salinity. Reduction in root and seedling growth under saline conditions may either be due to decrease in the availability for water or increase in sodium chloride toxicity, associated with increasing salinity. Growth inhibition by salt stress also occurs due to the diversion of energy from growth to the maintenance. The maintenance under salt stress plant need to regulated ion concentration in various organs and within the cells by synthesis of organic solutes for osmoregulation or protection of macromolecules for maintenance of membranes integrity (Maghsoudi and Maghsoudi, 2008), that this subject can decrease growth plant. Suppression of plant growth by salinity stress reported in Okcu *et al.* (2005).

Table 1 Analysis of variance of cultivar and salinity levels on germination and seedling growth of chickpea.

SOV	df	MS							
		GP	GR	RDW	SHDW	SDW	RL	SHL	Root/ Shoot
Salinity	6	0.83**	0.49*	85.1**	0.4**	1.4ns	4.7**	2.61**	0.03**
cultivar	6	2.61**	0.309**	2.84**	0.9**	22.1**	104**	56.6**	1.91**
Salinity × cultivar	36	0.08ns	0.02**	3.54**	0.6**	1.1ns	1.7**	1.63**	0.39**
Error	147	0.09	0.01	0.08	0.02	0.93	0.03	0.69	0.11
Cv%		3.2	6.85	3.96	11.45	5.21	4.18	8.34	14.12

*and ** indicating significant difference at P=0.05 or 0.01 respectively

GP: Germination percentage, GR: Germination Rate, RDW: Root dry weight, SHDW: Shoot dry weight, SDW: Seedling dry weight, RL: Root length, SHD: Shoot length.

Table 2 Effect of salinity levels on germination and seedling growth of chickpea

Salinity levels (dSm ⁻¹)	GP (%)	GR (seed per day)	RDY (mg)	SHDW (mg)	SDW (mg)	RL (mm)	SHL (mm)	Root/ shoot
0	92.8a	1.11c	0.013b	0.214a	0.249a	4.13d	4.13c	1.51
3	92.6a	1.21c	0.018a	0.189ab	0.236a	7.36a	5.37a	1.07b
6	91.5a	1.24c	0.012c	0.188ab	0.257a	5.43b	4.92b	0.06d
9	86.1b	1.24c	0.011d	0.214a	0.266a	4.71c	4.36c	0.55e
12	81.2c	1.25c	0.008e	0.183b	0.253a	3.41e	3.03d	0.48f
15	73.1d	1.61b	0.008e	0.143c	0.261a	2.34f	2.42e	0.59e
18	62.7e	1.84a	0.006f	0.104d	0.255a	1.62g	1.44f	0.83c

Dissimilar letters in each column indicating non-significant difference at P=0.05 or P=0.01 respectively

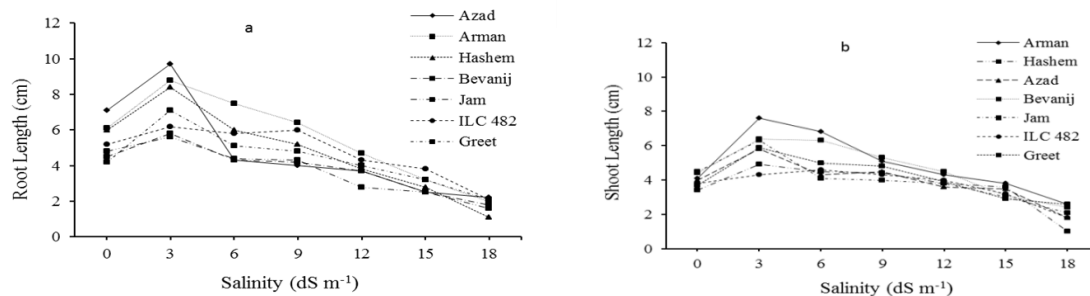


Figure 1. Interaction effect cultivar × salinity on root (A) and shoot (B) length Chickpea

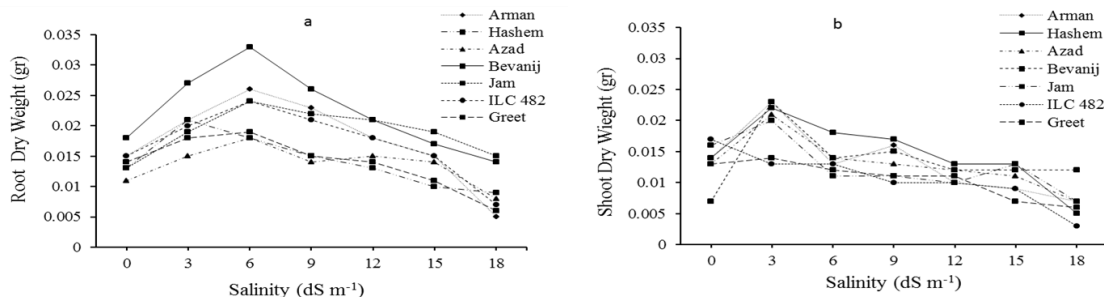


Figure 2. Interaction effect of cultivars × salinity on root (A) and shoot (B) dry weight Chickpea

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