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Research Paper

Effect of salinity stress on germination and seedling vigour of chickpea (*Cicer arietinum* L.) cultivars

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ABSTRACT

A laboratory experiment was conducted at Ambo University, College of Agriculture, to evaluate the effect of different salt concentrations on germination of two chickpea cultivars viz; (*Worku* and *Shasho*), which were obtained from Debrezeite Research Center. Sodium chloride was used as a source of graded levels of salinity. The salinity levels imposed were - control (deionized water), 50mM, 100mM, 150mM and 200mM, tested factorials in a Completely Randomized Design (CRD) with three replications. The study showed that germination rate and germination percentage significantly decreased with increase in salt concentration. The genotype *Shasho* showed better performance in terms of germination percentage, while *Worku* proved better in germination rate. A reduction in dry weight and lengths of radical and plumule was observed with increasing salt concentration. Growth inhibition rate also increased as the concentration of NaCl increased, where as the seedling vigour declined with increase in NaCl concentrations, in both the cultivars. Both the genotypes showed salt tolerance during germination at low salinity level of 50mM. *Shosho* genotype was found tolerant to high salinity level at germination stage than *Worku* genotype, indicating differential response of chickpea genotypes.

Key words: Germination, genotype, growth, inhibition rate, salinity, seedling vigour.

INTRODUCTION

Globally more than 45 million hectares of irrigated land, which account for 20% of total land, have been brought with salinity and 1.5 M ha are taken out of production each year due to high salinity levels in the soil (Pitman and Lauchli, 2002 ; Munns and Tester, 2008). However, in arid and semi - arid regions, where crop growth is limited by shortage of water or poor quality of water; the use of saline water for crop-production is often unavoidable. Most crops tolerate salinity to a threshold level above which yield decreases as salinity increases (Maas, 1986). Saline soil contains soluble salts in quantities that affect plant growth at various stages and creates yield differences between crops (Saxena, 1990). The process of soil salinization and the preponderance of saline water source point to a future reliance on salt resistance crops.

Chickpea (*Cicer arietinum* L.) is one of the earliest grain crops cultivated by humans. Today chickpea ranks third among food legumes in world production after beans (*Phaseolus spp*.) and field pea (*Pisum sativum* L) (FAO, 2008). Besides, being important source of food for human and animals, the crop also plays an important role in maintaining soil fertility, particularly in arid regions (Saxena, 1990). One of the major constraints in chickpea production is soil salinity, predominantly due to chloride and sulfate accumulation (Asfaw and Ghosh, 2000). Although some soils are naturally saline, the secondary salinization is largely due to use of irrigation system that is the greatest threat to legume sustainability in arid and semi arid regions where water supply is limited. Chickpea is salt sensitive and its yield is seriously reduced particularly by

chloride salinity (Manchanda and Sharma, 2000). The effects of salinity on chickpea are wide ranging, which varies from germination to vegetative stage, and from fruiting to the podding stage; at the same time the tolerance of chickpea for salinity differs from one genotype to another (Rupela, 1999). Some have a very high germination capacity as well as seedling growth on saline soil, while others germinate well in saline soil, but with a very poor seedling growth (Asfaw and Ghosh, 2000).

Identification and selection of salt tolerant cultivars of a species have immense value for agriculture. Germination and seedling characteristics are the most viable criteria used for selecting salt tolerance in crop plants (Jamil and Rha, 2004); hence, percentage and rate of germination, and seedling growth are important growth parameters to be studied for cultivar selection (Khodarahmpour et al., 2011). Germination and seedling growth of germinated seeds at a particular time varies considerably among species and cultivars; hence, the present study was conducted to evaluate the effect of different salt concentrations on the germination and seedling growth of chickpea genotypes.

MATERIALS AND METHODS

A laboratory experiment was conducted in May, 2012 at the Department of Plant Science and Horticulture, Ambo University to study the effect of salinity on the germination of two chickpea cultivars. Twenty randomly selected seeds of two chickpea genotypes *Worku* (DZ-10-16.2), Dessi type; and *Shasho* (ICCV- 93512), Kabuli type were obtained from Debrezeite Research Center, and seeds of each genotype were placed in a Petri plate (9cm diameter) using a forceps. The treatments comprised control (deionized water), 50mM, 100mM, 150mM and 200mM of Sodium Chloride (NaCl) which were tested factorially in a completely randomized deign (CRD) with three replications. Five milliliter solution of each concentration was applied to each Petri plate as per treatment, and same volume of deionized water added in the control Petri plate using disposable syringes. All the Petri plates were covered with lids and kept at a room temperature (24 ± 2 ^{o}C). All the seeds in Petri plates were moistened with the respective treatment concentrations uniformly. This continued throughout the course of the experiment. The counting of germinated seeds was started after three days. The seeds were considered germinated when radicals appeared and are visible enough to be counted. The experiment duration was 15 days. The whole procedure was repeated for duration of 15 days. Germination count was made through the experimental period until all the seeds were either germinated and/or dead.

The parameters measured included: percent germination, germination rate, seedling vigor index, and percent inhibition. Besides, the root and shoot length of seedling were measured using a ruler. Root and shoot dry weights were recorded after oven drying for 72 hour at 50 ^{o}C on the 15th day.

Germination percentage was calculated using the following formula:

Germination percentage = Number of germinated seeds / number of total seed X 100.

Germination rate (GR) was calculated by the formula proposed by Maguire (1962):

Germination Rate = Number of Normal seedlings / Days of the first count +…+ Number of Normal seedlings / Days of final count.

Seedling vigour index was calculated based on the formula used by Hossein and Kasra (2011):

Seedling vigour index = germination % × Seedling dry weight.

The inhibition (%) was calculated using the formula described by Chung *et al.,* (2001) as under:

Inhibition % = [(Control –Treatment)/Control] ×100

The data recorded from both experiments were added and means were computed. The means were then subjected to Analysis of Variance (ANOVA) using MSTATC statistical analysis. Wherever there were significant differences, means were separated by the least significant difference (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Effect of salinity levels on seed germination

Salinity reduced germination percentage of chickpea seeds, although there was variation among cultivars. The maximum seed germination (99.2%) was observed in the control treatment and the minimum (79.8%) was found with 200mM NaCl concentration (Table 1). Bordi (2010) reported that the germination percentage in *B. napus* was significantly reduced at 150 and 200 mM NaCl. Cultivars showed variability for salinity treatment; where in distinctly higher germination percentage (96.8%) was recorded in *Shasho* cultivar than in *Worku* (85.9%). Germination percentage of *Shasho* cultivar declined significantly as NaCl conc. increased above 150mM. However, in case of *Worku,* germination declined significantly above 50mM indicating its sensitivity. This indicated that *Shasho* cultivar was more tolerant to salinity than *Worku* cultivar; which could be due to their genetic variability. Datta and Sharma (1990) have also reported genetic variation in salinity resistance of bean cultivars.

The germination rate of *Worku* cultivar was 94.7% on the 3rd day in the control treatment, while *Shasho* recorded germination of 78.5%. On the 4th and 5th day *Worku* showed better germination rate than *Shasho* in 0mM and 50mM salt concentration, but on the 6th day *Shasho* germinated better in all concentration of salts (Figure. 1 and 2). When salt concentration was raised to more than 100mM *Worku* showed better performance on the 3rd day, however *Shasho*

Table 1. Germination percentage of chickpea cultivars in relation to salinity levels.

Chickpea cultivar	NaCl treatment					Mean
	Control (Deionized water)	50 mM	100 mM	150 mM	200 mM	
Worku	98.5[a]	96.2[b]	87.7[c]	77.2[d]	70.2[d]	85.96 [b]
Shasho	100[a]	100[a]	100[a]	94.7[b]	89.5[c]	96.8[4a]
Mean	99.25[a]	98.1[a]	93.85[b]	85.95[c]	79.85[d]	-

Values followed different letters alongside the numbers indicate significant differences at p <0.05.

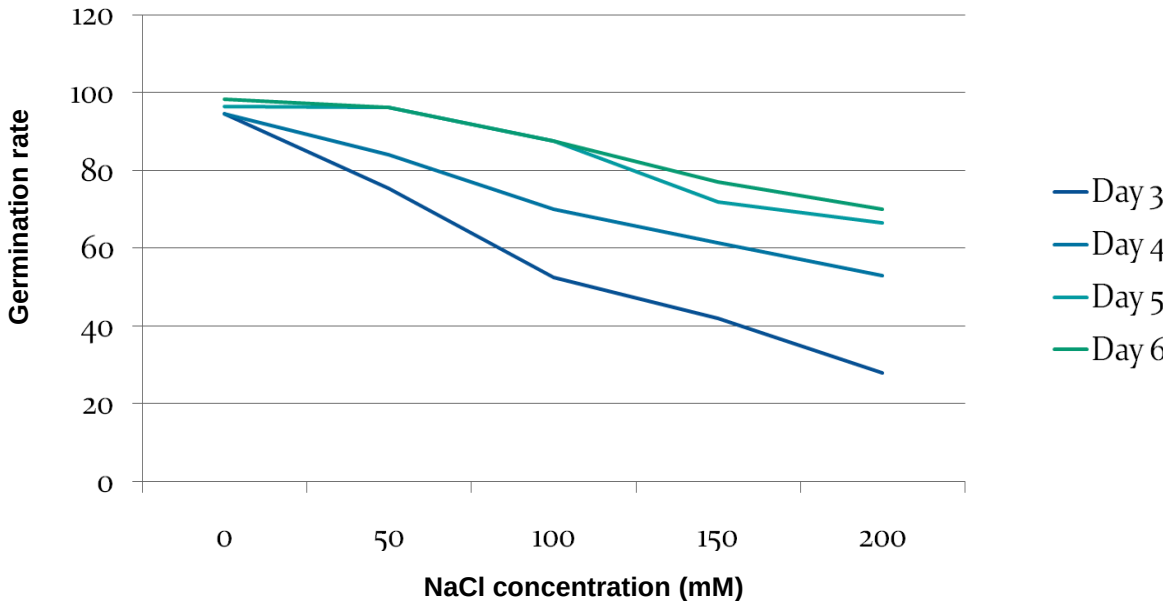

Figure 1. Effect of salinity on the germination rate of worku cultivar.

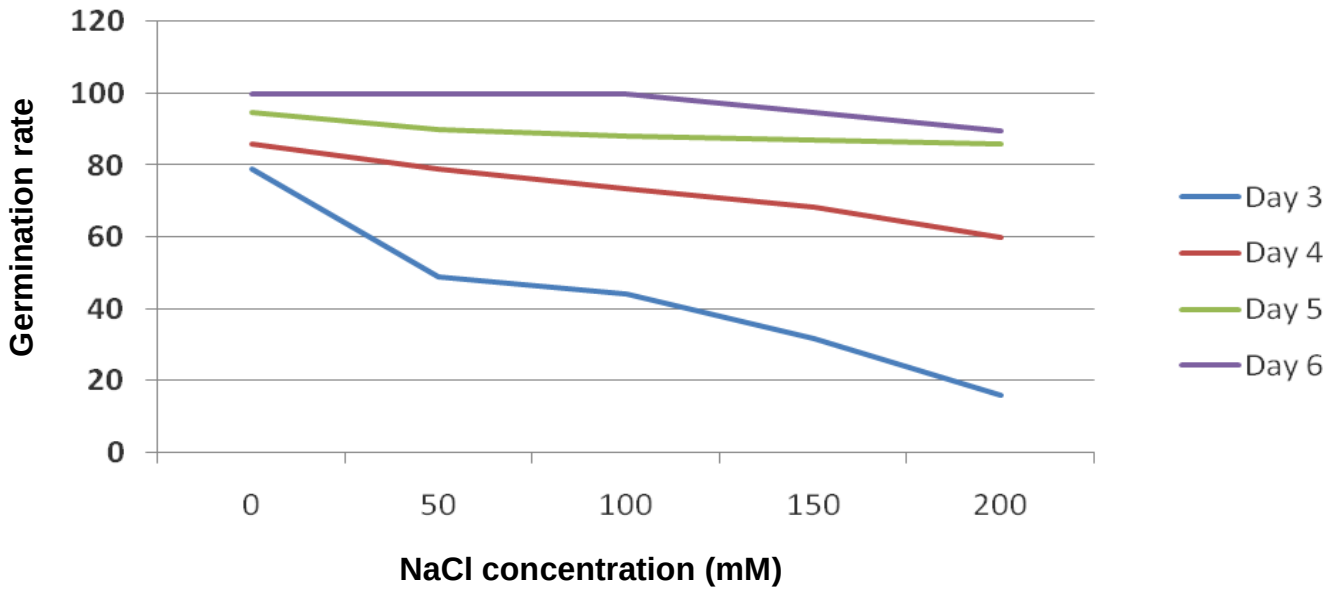

Figure 2. Effect of NaCl concentration on the germination rate of Shasho cultivar.

Table 2. Plumule and radical lengths of chickpea in relation to salinity levels.

Cultivar	Salt concentration	Plumule length (cm)	Radicle length (cm)
	Control (Deionized water) (mM)	5.40[a]	7.40[a]
	50	4.30[b]	7.35[a]
Worku	100	2.70[c]	7.30[a]
	150	1.50[d]	3.40[b]
	200	0.30[e]	2.20[bc]
	Control (Deionized water) (mM)	3.90[b]	7.50[a]
	50	3.60[b]	7.00[a]
Shasho	100	2.50[c]	4.70[b]
	150	1.40[d]	2.70[cb]
	200	0.70[e]	1.00[c]
$LSD_{0.05}$		0.95	2.50

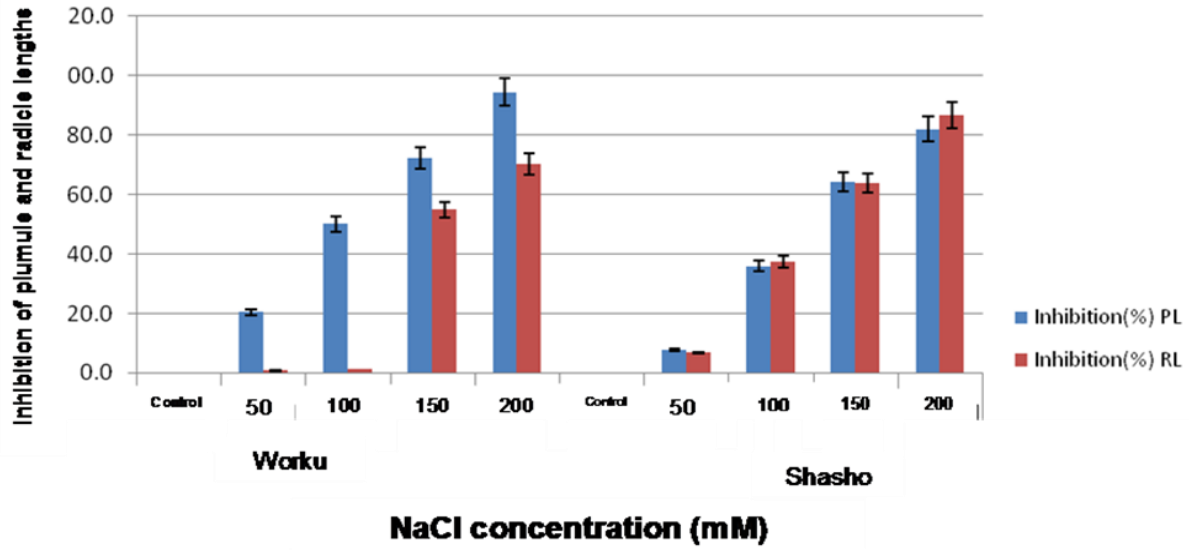

Figure 3. Effect of different NaCl concentrations on the inhibition of radicle and plumule lengths of chickpea cultivar.

showed better rate of germination on 4th, 5th and 6th day. This showed that *Worku* germinated faster in control treatment and 50mM concentration, beyond which it becomes slow in germination rate except in 3rd day.

The result of the study showed that *Worku* cultivar had high germination rate with low germination percentage, where as *Shasho* cultivar had high germination percentage with low germination rate. This result is in agreement with Yan-Bing Wu *et al.,* (2010) who reported the existence of little difference in germination rates between low sodium content and controls, however higher concentration showing strong inhibition. Similarly Foolad and Lin (1999) also described in certain conditions, seed germination rate unchanged because of the possible genetic resistance or specific physiological mechanisms. Ashiraf and Wahead (1999) also reported that the rate of seed germination of chickpea significantly reduced by increasing salinity levels; however, the magnitude of the reduction varied among genotypes.

Effect of salinity on the growth of chickpea seedlings

The plumule length of both cultivars decreased significantly, as concentration of NaCl increased (Table 2). The radical length of *Worku* cultivar decreased significantly ($p<0.05$) as the NaCl concentration increased above 100mM, while in the case of *Shasho* cultivar a significant reduction in radical length was observed after 50mM NaCl concentration. The growth inhibition rate of plumule and radicle also increased with an increase in NaCl concentrations (Figure. 3). The reduction in plumule length

Table 3. Values of dry weight of plumule and radical as influenced by salt concentrations.

Variety	Salt concentration (mM)	Dry weight of plumule (g)	Dry weight of radicle (g)
	0	2.10[a]	1.80[a]
	50	1.30[b]	1.40[a]
	100	1.00[b]	0.90[ab]
Worku	150	0.70[c]	0.80[b]
	200	0.40[c]	0.50[b]
	0	2.70[a]	2.00[a]
	50	2.00[b]	1.50[ab]
	100	1.40[c]	1.30[ab]
Shasho	150	1.10[cd]	1.00[b]
	200	0.60[cd]	0.50[bc]
LSD (0.05)		0.64	0.76

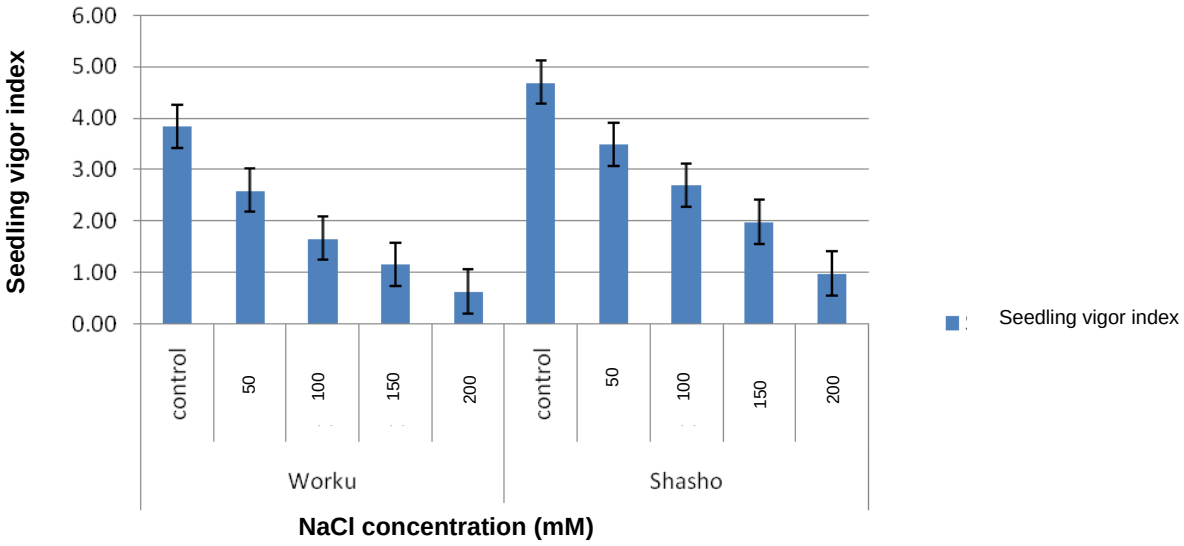

Figure 4. Effect of different NaCl concentrations on seedling vigor of germinating chickpea cultivars.

and radical length with concentration increase could probably be due to the inhibitory effect of salinity, a result of salinity effect on water uptake by the radical. This finding was in agreement with Yan-bing Wu *et al.,* (2010) who found the decrease in plumule length and radical length as the concentration of NaCl increases; and an increase in inhibition rate as the NaCl concentration increased in wheat cultivars. Similarly, Papedo and Redman (2007) also reported inhibitory effect of salinity on different bean cultivars.

Effect of salinity on dry weight of plumule and radicle, and seedling vigour

As the concentration increased, the dry weight of the plumule and radical in both cultivars significantly decreased although there was difference between genotypes (Table 3). This observation was in agreement with Al-mutawa, (2003) who found negative correlation between shoot and root dry matter, and concentration of NaCl. The seedling vigor of both cultivars decreased significantly as the concentration of NaCl increased; however, there was differential response of genotypes (Figure. 4). Yan-Bing Wu *et al*., (2010), also reported similar results in wheat and Khajeh-Hosseini et al. (2003) in soya bean.

Conclusion

The current study indicates that increasing NaCl concentra-

tion exhibited inhibitory effect on germination rate and its percentage, length of plumule, radicle length, dry weights of plumule and radicle, and seedling vigour of both chickpea cultivars. However, *Shasho* cultivar *(*Kabuli type*)* found more tolerant to salt stress during germination compared than *Worku* cultivar (Dessi type). The salinity effect under the field condition may not be the same due to the large variations in the environmental conditions.

Therefore, further studies needed to validate these findings under field conditions.

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