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The Effect of Salinity Stress on Germination of Chickpea (*Cicer arietinum* L.) Land Race of Tigray

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Abstract: Salinity is one of the major stresses especially in arid and semiarid regions, which severely limit crop production. It impairs seed germination, reduces nodule formation, retards plant development and reduce crop yield. Salinity affects germination and physiology of crops due to osmotic potential which prevents water up take and by toxic effect of ions on embryo viability. This study was conducted to assess the effect of salinity on germination of chickpea (*Cicer arietinum* L.) in the laboratory of Mekelle University by using NaCl and Na_2So_4 to simulate salinity and tape water as control group. The seeds of chickpea (*Cicer arietinum*) landraces were collected from Hagereselam and Samre. Then 10 seeds of chickpea from both sites were treated in each salt concentration in 3 replications designed by using complete random block design. The result of the experiment showed that the concentrations of salt have a negative impact on the germination and growth of chickpea, as a result when the concentration of salt increases, the germination, water uptake and length of root and shoot decreases. Furthermore we found that different salinity simulated having different impacts on germination. Our result clearly indicated that NaCl highly affects germination and growth of chickpea than Na_2SO_4. Meanwhile, the effect of salinity for both land race have significance difference in parameters of water up take, % of germination, length of root and shoot (t-test $n = 25$ $p<0.05$). Our result further indicated that there is a difference in sanity tolerance level between the 2 land races of chickpea.

Keywords: Chickpea, germination, salinity, tigray landraces

INTRODUCTION

Among agricultural practices, cultivation of crops is the most common and practiced worldwide. During their growth, crop plants are usually exposed to different environmental stresses which limit their growth and productivity. Among these, salinity and drought are the most sever once especially in arid and semi arid agro ecology (Moud and Maghsoudi, 2008). Several Researchers indicated that salinity is one of the major stresses, especially in arid and semi-arid regions, which severely limit crop production (Shannon, 1998; Greenway and Munns, 1980; Mano and Takeda, 1997; Shannon, 1985). Furthermore, salinity impairs seed germination, reduces nodule formation, retards plant development and reduces crop yield (Greenway and Munns, 1980). The effect of salinity on germination of seeds can be either by creating osmotic potential which prevent water uptake or by toxic effects of ion on embryo viability of the seeds (Houle *et al*., 2001). In addition to these, shoot growth is also reduced by salinity due to the inhibitory effect of salt on cell division and enlargement in the growing point (Kaymakanova, 2009). Since crop plants are affected by the concentration of salt in the soil or water, their productivity is also affected with sever reduction in the expected yield.

Farmers all over the world face salinity problems. Worldwide, salinity affects 100 million hectares of arable lands and this area is expanding (Ghassemi *et al*., 1995). The situation in Tigray is not different from the global trend. Recent studies in the irrigated fields of Mekelle plateau (Enderta Wereda and Hintalo-Wajerat woreda), in Tigray region by Fassil (2008) indicated that irrigated land from 9 dams evaluated in the study are experiencing moderate salinity hazard: May Gassa (EC = 2.56), Adikenafiz (EC = 2.04), Grashito (EC = 3.54) Durambessa (EC = 2.51), Ghereb segen (EC = 3.11) and Gumselasa (EC = 2.35). This clearly indicates that irrigated lands in the semi arid parts of Tigray region are increasingly becoming saltier and turning to a new scenario of hampering food production for the fast growing population in the region. And with most arable lands of the region becoming saltier more work on the screening salt tolerance land races should be done since further screening for salinity from their well developed environment could be a guarantee to solve the foreseeable future problem of salinity due to irrigation practice.

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As a result, solving such likely problem is mandatory to reduce and eradicate poverty by increasing agricultural out puts. Some of the possible solutions used to reduce the effect of salinity, includes the selection and breeding of salt tolerant crops. Improving salt tolerant varieties is of the major importance and research should be focused on finding of mechanism which is involved in salinity tolerance (Flowers and Yeo, 1986). Given the amount by which food production will have to be increased in the coming decades, it seems reasonable to predict that changing the salt tolerance of crops will be an important aspect of plant breeding in the future, if global food production is to be maintained (O'Leary, 2001). Germination and seedling characteristics are the most viable criteria used for selecting salt tolerant crops (Flowers and Yeo, 1986).

As indicated in Fassil (2008) the arable lands of Tigray are becoming saltier. As a result, to induce and address such problem, researches in related issue is necessary to this end this study was conducted to assess effect of salinity and screen salt tolerant chickpea landraces collected from different agro ecological zone of Tigray region. Thus this study was conducted:

- To assess the effect of salinity on the germination of chickpea (*Cicer arietinum*)
- To determine the effect of salinity on the rate of germination of chickpea (*Cicer ariectinum*)
- To compare the effect of different salinity on germination of chickpea (*Cicer arietinum*)

METHODOLOGY

Description of experimental set up: This experiment was conducted in Botany laboratory, Department of Biology Mekelle University, Tigray region, Northern Ethiopia. The seeds of chickpea (*Cicer ariectinum L.)* were collected from Seharti Samre and Hagereselam districts which are located at an altitudinal range of 1500-2750 mabsl. After the land races were collected and brought to the laboratory, Seeds were hand sorted to eliminate broken, small and infected seeds. Then sorted healthy seeds were allowed to germinate in laboratory condition on filter paper (What man No. 2) in petri dishes soaked in a solution of the respective salt concentration simulated using Na Cl and Na_2So_4. To simulate salinity level of 5, 10 and 15 dS/m using NaCl and Na_2SO_4 the concentration of solutions were prepared by using molar conversion method (Khalid *et al.*, 2009).

1 moL of NaC1 = 58.5g NaC1 dissolved in 1 L water
1 moL/m^3 = 0.0585g NaC1 dissolved in 1 L water
10 moL/m^3 0.00585 g NacC1 dissolved in 1L water and
10 moL/m^3 = l dS/m then, For 5 dS/m
50 moL/m^3 (5ds/m) = 0.00585 *50 g NaC1
= 0.2925 g NaC1 in 1 L water

Similarly for Na_2SO_4 solution with molecular weight of 142 g /moL

1 moL of Na_2 SO_4 = 142g Na2SO4 dissolved in 1 L water
1 moL/m^3 = 0.142 g Na_2 SO_4 dissolved in 1 L water
10 moL/m^3 = 0.0142 g Na_2 SO_4 dissolved in 1 L water
10 moL/m^3 = 1 dS/m then, for 5 dS/m
50 moL/m^3 = 0.0142*50 g Na_2SO_4
= 0.71 g of Na_2SO_4 in 1 L water

The experiment was designed by using Complete Random Block Design (CRBD) with 3 replications where for each type of solutions, 3 petridishes were prepared and in each petridishes 10 chickpea seeds of Hagereselam and 10 chickpea seeds of Seharti Samre were used. During the experiment distilled water was used as a control group.

Data collection and analysis: Analysis of variance was performed by using Microsoft excel program and differences between the means were compared through LSD test (p<l0.05). The parameters that were used to analysis the data includes:

Water up take (%): The ability of seeds to absolve water was measured after 24 h. Then the percentages of water up take for each petridishes were calculated using the equation given below:

WATER uptake percentage (%)
Weight of seeds - Weight of seed after absorbing water *100/Initial weight of seeds

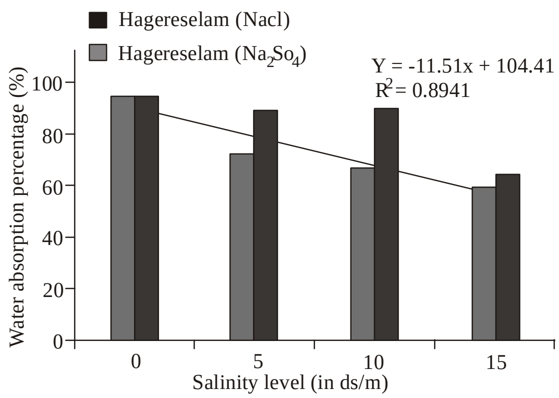
Germination percentage (%): The emergence of radical (root) and shoot from chickpea from each petridishes were assessed every 2 days after sowing. And then the salt tolerance rate was calculated using the standard formula of used in Kaymakanova (2009):

Salt tolerance = germination in salt treated seed*100/Germination in control

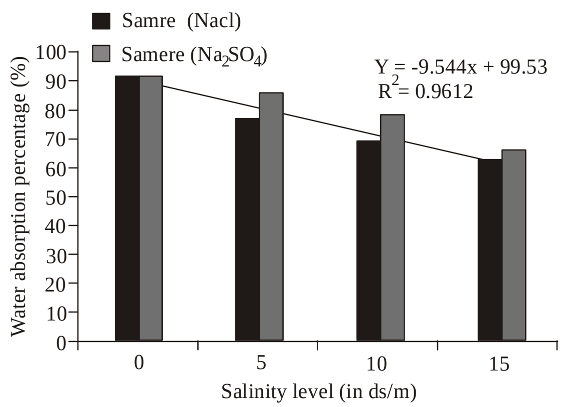
The seed germination was investigated after every 24 h. Seed germination was started after 72 h (seeds were considered to be germinated with the emergence of the radical). Then the germinating seeds were counted at regular intervals. Furthermore the lengths of root and shoot of the germinated seeds which were more than 2 mm in length were measured and recorded after 15 days of sowing. In all treatments a continuous increase in the number of germinating seeds as well as in the lengths of roots and shoots was observed during the subsequent days of germination.

RESULTS AND DISCUSSION

Water uptake percentage (%): The result indicated (Fig. 1) that water uptakes reduced in the salt treated



(a)



(b)

Fig. 1: Percentage of water uptake (%) by chickpea landraces from hagereselam and seharti samre at different salinity level treatments

seeds collected from both Hagereselam and Saharti Samre compared to those treated with distilled water (0 dS/m salinity level used as control). In both the landraces (collected from Hagereselam and Saharti Samre) the ability of seeds to absorb water is influenced by the concentration of salts and index of reduction increases with increasing salinity level from 5 to 15 dS/m. However, both landraces behave differently. The inhibition index for NaCl ranges from nearly 23% at salinity level 5 dS/m to 36.3% at salinity level of 15 dS/m for the land race collected from Hagereselam. However, the reduction in water uptake of the seed from Hagereselam when treated with Na_2SO_4 ranges from nearly 6 to 32% of the control. Meanwhile the land race collected from Saharti Samre showed a low % of water uptake reduction when treated with both NaCl and Na_2S0_4 solutions compared to that of Hagereselam. And It showed a water uptake reduction from 15 to 29% when treated with NaCl and 5.5 to 26% of the control when treated with Na_2SO_4 (Fig. 1).

Unlike the landrace from Saharti Samre, the index of reduction for water uptake for the land race collected

Table 1:(T50) germination % of landraces collected from hagereselam and seharti samre

Land race of chickpea	Salt type	Concentration in dS/m	(t50) germination (%)
	NaCl	0	70
		5	25
		10	10
Hagereselam		15	0
	Na_2SO_4	5	20
		10	20
		15	0
	NaCl	0	50
		5	20
Seharti samre		10	10
		15	0
	Na_2SO_4	5	20
		10	10
		15	0

from Hagereselam is significantly different at salinity level 5 and 10 dS/m (ANoVA F = 42, n = 25, $p<0.05$) but no statistical significant difference is observed at highest level of salinity for both salts.

Germination percentage (%): The emergence of radical (root) and plumule (shoot) from seeds that treated in different salt concentration shows that a significant difference compared with the control group (F = 42, n = 25, $p<0.05$). Furthermore the percentage of germination t_{50} was found to be lower for land races from Seharti Samre (Table 1).

Zero percent of germination was observed for high salinity level (at 15 dS/m) in both landraces and salt type (Table 1).

As can be seen from Table 1, the land races from Saharti samre landraces behave similarly when treated with 5 and 10 dS/m of NaCl and Na_2SO_4 showing a total reduction of germination 60 and 80%, respectively. However the land race from Hagereselam behaves differently when treated with diffent salt type (Table 1). Our results corresponds to these of Welbaum *et al.* (1990) that germination was directly related to the amount of water absorbed and the delay in germination to the salt concentration of the medium. Furthermore, the salt tolerance of plants varies with the type of salt and osmotic potential of the medium the plant is grown. Thus, salt stress declined the germination and also delayed the emergence of seeds. It is also 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 germinating seeds and thus reduces germination. This finding is in line with findings of Maas *et al.* (1983). It is assumed that germination rate and the final seed germination decrease with the decrease of the water movement into the seeds during imbibitions. Thus, salinity stress can affect seed germination through osmotic effects. The same finding has been reported by Welbaum *et al.* (1990).

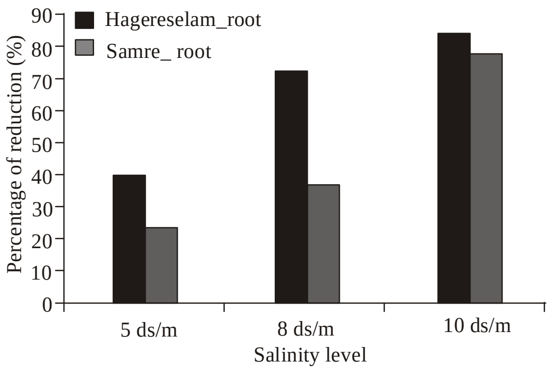


Fig. 2: Percentage of root length reduction in two landraces of chickpea
Hagereselam_root: Percentage of root length reduction of hagereselam landrace; Samre_root: Percentage of root length reduction of saharti sanmre landrace

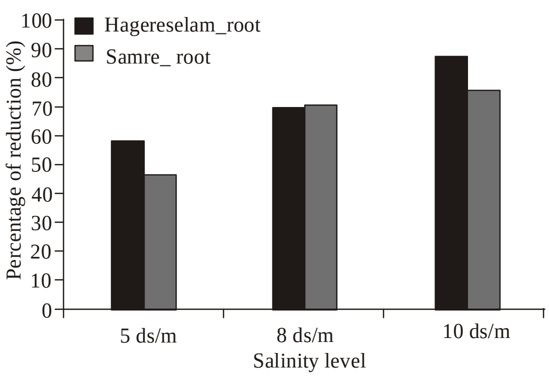


Fig. 3: Percentage of shoot length reduction in two landraces of chickpea
Hagereselam_shoot: Percentage of shoot length reduction of hagereselam landrace; Samre_shoot: Percentage of shoot length reduction of saharti sanmre landrace

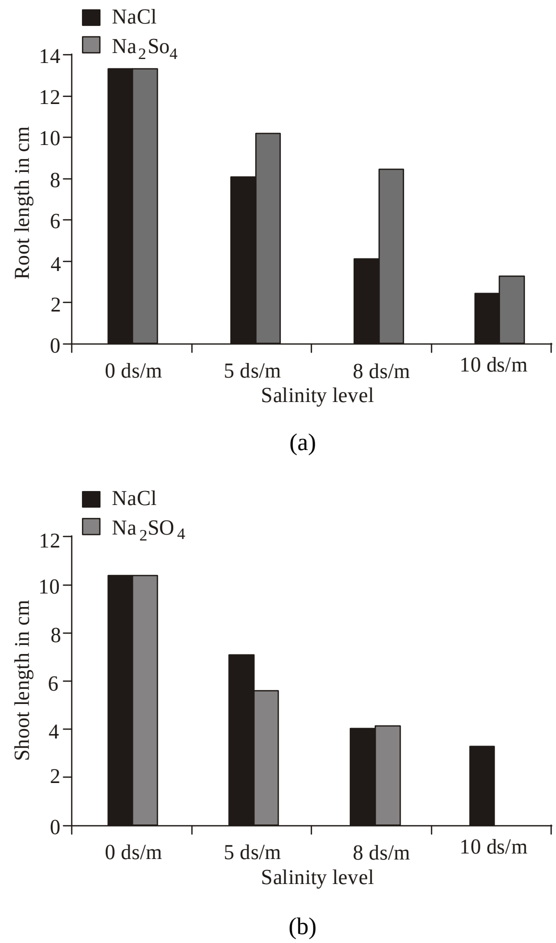


Fig. 4: (a) Root length, (b) Shoot length of the landrace from hagereselam treated with different salinity level and salt type

Impact of salt on seedling growth: Salinity had highly significant effect on root and shoots length in *Cicer ariectinum* L. (Fig. 2 and 3). Root length decreased with an increase in salinity level. And maximum root length reduction was observed at 10 dS/m for the landrace from Hagereselam (82% reduction). At 10 dS/m the shoot length reduction observed was 87 and 75% of control for the landraces from Hagereselam and Saharti samre, respectively (Fig. 3).

The concentration of salinity leads to the retardation of root and shoot growth in chickpea. When the concentration of salinity inceases, the growth of root and shoot becomes very slow and mostly the roots become lysised and dried after some days (Fig. 2 and 3). This is posibly dueto the fact that high salinity may inhibit root and shoot elongation due to slowing down the water uptake by the plant. This finding is also supported by Neumann (1995) where he reported that salinity can rapidly inhibit root growth and hence capacity of water uptake and essential mineral nutrition from soil.

Our finding indicated that salt stress inhibited the growth of shoot more than root in both landraces of chickpea. Our finding is against the study by Demir and Arif (2003) where they reported that the root growth of safflower was more adversely affected compared to shoot growth by salinity. This could possibly be due to the difference in experimental seeds' nature of germination that chickpea is hypogial germination and safflower is epigeal thus the root is affected first.

We found that chickpea to be highly sensitive to salinity induced by NaCl compared to salinity induced by Na_2SO_4 (Fig. 4 and 5). However, the oposite result was found for bean (*Phaseoucus vulgaris* L.) by Kaymakanova (2009) where he found bean to be more sensitive to Na_2SO_4 than NaCl. This is due to differnt ions affect different crops differently. Furthermore we found the effect of Na_2SO_4 to be higher than NaCl at high salinity level (15 dS/m) for the land race from Saharti Samre (Fig. 4). As indicated in Fig. 4b NaCl has strong effect on shoot length compared to Na2SO4 where no shoot growth was onserved at 10 dS/m for the land races treated with NaCl. It posible to argue that

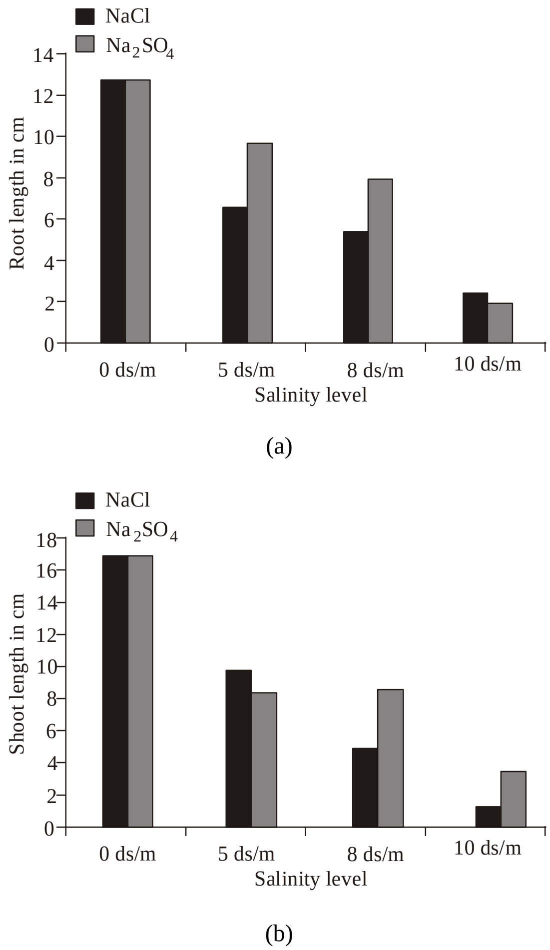


Fig. 5: (a) Root length, (b) Shoot length of the landrace from saharti samre treated with different salinity level and salt

salinity affects germination in 2 ways there may be enough salt in the medium and decrease the osmotic potentioal to such a point which retard or prevent the up take of water nesessary for moblization of nutirent requierd for germination and the salt constituents or ions may be toxic to the embroy, that leads to early death of embroy or early decline of shoot and root length and emmergence. Salinity affects the seedling growth of chickpea by slow down or less mobilization of reserve foods, suspanding the cell division, enlarging and injuring hypocotyls This result is in agreement with similar research on beans by Kaymakanova (2009). The result reported here on effect of salinity impact on shoot length is inline with previous srudies on grasspea, *Lathyrus sativus,* by Tsegazeabe and Berhane (2012) where they reported that shoot length decreased with an increase in salinity level.

CONCLUSION

Based on the data collected, it is imperative to conclude that the concentration of salt affects germination, shoot and root length and water uptake of landraces of chickpea collecetd from different areas. The germination of chickpea (*Cicer arietinum*) is reduced and the root under goes lysis and dries in high concentration of salt even if it germinates.

Meanwhile, salt type have different impact on the germination and growth of chickpea (*Cicer arietinum*). As a result, Nacl has more impact than Na_2SO_4. The maximum tolerant level of chickpea for both landrace is 5 dS/m that at these concentration the seeds of chickpea under go germination in root and shoot. However, the rate of growth is not as much enugh and some seeds dried and lysised after few days of germination. But seeds of chickpea for both landrace have a maximum tolerant level of salinity with 10 dS/m. At these concentration of salinity the seeds show a sifigicant result compaired with the control. But at concentration of 15 ds/m of Na_2so_4, the germination and growth of seeds is highly affected and only a few seeds start to germinat or rise shoot and root, which dried latter.

Both landrace of chickpea, from Hagereselam and Seharti Samre treated in the same type of treatment revealed that both landrace of chickpea have relatively similar salt tolerant level, since the result obtained due to the parameters indicate that there is a significant difference of salt tolerant level between 2 land race at different salinity level.

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