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 semi-arid 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 uptake 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 Na2SO4 to simulate salinity and tap 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 Na2SO4. Meanwhile, the effect of salinity for both land race have significance difference in parameters of water uptake, % of germination, length of root and shoot (t-test n = 25 p<0.05). Our result further indicated that there is a difference in salinity 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.
As a result, solving such likely problem is mandatory to reduce and eradicate poverty by increasing agricultural outputs. 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 arietinum*)
- 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 arietinum L.*) were collected from Seharti Samre and Hagereselam districts which are located at an altitudinal range of 1500-2750 masl. 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 (Whatman No. 2) in petri dishes soaked in a solution of the respective salt concentration simulated using NaCl and Na2SO4. To simulate salinity level of 5, 10 and 15 dS/m using NaCl and Na2SO4 the concentration of solutions were prepared by using molar conversion method (Khalid et al., 2009).

\[
\begin{align*}
1 \text{ mol of NaCl} &= 58.5g \text{ NaCl dissolved in 1 L water} \\
1 \text{ mol/m}^3 &= 0.0585g \text{ NaCl dissolved in 1 L water} \\
10 \text{ mol/m}^3 &= 0.00585g \text{ NaCl dissolved in 1L water and} \\
\text{10 mol/m}^3 &= 1 \text{ dS/m then, For 5 dS/m} \\
\text{50 mol/m}^3 (5 \text{ds/m}) &= 0.00585*50 \text{ g NaCl} \\
&= 0.2925 \text{ g NaCl in 1 L water}
\end{align*}
\]

Similarly for Na2SO4 solution with molecular weight of 142 g /molL.

\[
\begin{align*}
1 \text{ mol of Na}_2\text{SO}_4 &= 142g \text{ Na2SO4 dissolved in 1 L water} \\
1 \text{ mol/m}^3 &= 0.142g \text{ Na}_2\text{SO}_4 \text{ dissolved in 1 L water} \\
10 \text{ mol/m}^3 &= 0.0142g \text{ Na}_2\text{SO}_4 \text{ dissolved in 1 L water} \\
10 \text{ mol/m}^3 &= 1 \text{ dS/m then, for 5 dS/m} \\
\text{50 mol/m}^3 &= 0.0142*50 \text{ g Na}_2\text{SO}_4 \\
&= 0.71 \text{ g of Na}_2\text{SO}_4 \text{ in 1 L water}
\end{align*}
\]

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<0.05). The parameters that were used to analysis the data includes:

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

\[
\text{WATER uptake percentage} = \frac{\text{Weight of seeds} - \text{Weight of seed after absorbing water}}{\text{Initial weight of seeds}} * 100
\]

**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):

\[
\text{Salt tolerance} = \frac{\text{germination in salt treated seed}}{\text{Germination in control}} \times 100
\]

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) Hagereselam (NaCl) Hagereselam (Na₂SO₄) Y = -11.51x + 104.41 
R² = 0.89412

(b) Samre (NaCl) Samre (Na₂SO₄) Y = -9.544x + 99.53 
R² = 0.96122

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

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 t₅₀ 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 Na₂SO₄ showing a total reduction of germination 60 and 80%, respectively. However the land race from Hagereselam behaves differently when treated with different 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).
Impact of salt on seedling growth: Salinity had highly significant effect on root and shoots length in *Cicer arietinum* 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 increases, 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 possibly due to 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 Na2SO4 (Fig. 4 and 5). However, the opposite result was found for bean (*Phaseolus vulgaris* L.) by Kaymakanova (2009) where he found bean to be more sensitive to Na2SO4 than NaCl. This is due to different ions affect different crops differently. Furthermore we found the effect of Na2SO4 to be higher than NaCl at high salinity level (15 dS/m) for the landrace 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 observed at 10 dS/m for the land races treated with NaCl. It possible to argue that...
salinity affects germination in 2 ways there may be enough salt in the medium and decrease the osmotic potential to such a point which retard or prevent the up take of water nesary for mobilization of nutrient requird for germination and the salt constituents or ions may be toxic to the embryo, 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 studies 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 collected 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 Na2SO4. 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 Na2SO4, 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.

**REFERENCES**


