The Significance of Salinity Level on Seed Germination and Seedling Growth of Selected *Commiphora Species in* Yabello district, Southern Ethiopia

Mohammed Abaoli Abafogi [1], **Omer Kara** [2]
[1] Fellow, Directorate of Natural Resources, IASR. Department of Forest Engineering, Karadeniz Technical University, P.O. Box: 61080, Trabzon, Turkey.
[2] Department of Forest Engineering, Karadeniz Technical University, Trabzon, Turkey.
[1] Corresponding author: mohammedabaoli@gmail.com

OIDA International Journal of Sustainable Development, Ontario International Development Agency, Canada.
ISSN 1923-6654 (print) ISSN 1923-6662 (online) www.oidaijsd.com
Also available at http://www.ssrn.com/link/OIDA-Intl-Journal-Sustainable-Dev.html

Abstract: The experiment was carried out in Wanja Public Nursery sites in Gera, Southwest Ethiopia; in transparent plastic greenhouses on pots and laboratory *for Commiphora boranensis, Commiphora habessinica and Commiphora corrugate species by using* complete random block design with four treatments and five replications. All salinity levels (control, 8, 16 and 24dS/m) were then applied to each species with 5 replications making 20 treatments among the total of 60 pots. Data was collected on root and shoot length, root length density, root and shoot biomass by destructive methods. Germination percentage was recorded on completion of germination in lab. All data were tested at $P < 0.05$ for significant differences.*C. corrugate* and *C. boranensis recorded* only 0 and 11.4% seed germination, respectively at 24dS/m salinity level, and *C. habessinica was* more tolerant to salinity with 50.13% germination at 24dS/m. As salinity increased to 24dS/m ECe, the shoot length of *C. corrugate* was null. The result of *C. habessinica* recorded the highest shoot dry matter at control level and was radically declined to 2.05g and 1.43g at 16ds/m and 24ds/m levels respectively, while shoot dry matter of *C. corrugate* and *C. habessinica at*24ds/m showed no statistical differences.No statistical differences were observed between *C. boranensis* and *C. corrugate* at 8ds/m for root length and density. As salinity increased to 24dS/m, the root dry matter decreased for all species.Generally*, C. habessinica showed* best tolerance in salinity increment followed by *C. boranensis* and *C. corrugate* respectively.

Keywords: *Commiphora;* destructive methods; root length density; root dry matter; significance of salinity level; shoot length

Introduction

Ethiopia has one of the highest *Commiphora species* diversity in the world. About 52 species of *Commiphora* are known to exist in the country, and 14 of them are endemic (Asres *et al.,* 1998; Azene, 1993). The southeastern *Acacia-Commiphora* woodlands are the richest in the diversity of *Commiphora* species, as thirty-five of the *Commiphora* species found in the country have been recordedfrom there, including nine of the endemic species (Asres *et al.,* 1998). However, for most of the species such as *C. kua, B. neglecta*, *B.microphylla, C. habessinica*, *C. boranensis*, *C. terebinthina, C. baluensis* and *C. confusa* and *B.rivea are* showing possible human induced disturbances on their regeneration ecology (Worku *et al.,* 2014).

Though, these dryland Commiphora species has both ecological and economic contribution to the local peoples. The major *Commiphora* gums of economic importance in Ethiopia are myrrh, opoponax and Hagar. There are many more *Commiphora* species that produce gums also collected and sold under the name myrrh or opoponax such as *C. boranensis*, *C. habessinica* (Berg.) Engl., *C. corrugata* and others (Lemenih *et al*., 2003). Gum resins from these species are generally sold being mixed with resins of commercially known species. These trees produce resin in the dry season and provide people with economic activities during shortage period (Lemenih *et al*., 2003). However, the ecology of these species was very difficult due to its dry climate conditions causing difficulties of seed germination and seedling growth of the plants hindering natural regeneration capacities.

Salinity is one of the principal environmental causes of soil degradation, and consequently, a cause for agricultural productivity decline in many parts of the world (Tejedor *et al.,* 2003; Warrick, 2004). According to Szabolcs, (1992) globally, salinity affects about 1 billion hectares of land mainly located in arid and semiarid regions. According to Sissay, (1985) salt-affected soils in Ethiopia have increased from 6% to 16% of the total land area and about 9% of the population lives in these areas. If the increments of salt affected soils continue unabated, a significant part of the Ethiopian soils will be degraded and converted to desert. Currently salt-affected areas of Ethiopia are predominantly inhabited by nomadic pastoralists. The scant vegetation in these areas being used by herds owned by pastoralists and livestock from nearby sedentary farmers or migratory pastoralists from higher altitudes. As a result, unrestricted use of these vegetation has resulted in the deterioration of the land cover and the resultant soil erosion. There is an urgent need to manage the existing vegetation for improved productivity and recovery of the degraded areas. The understanding the effects of various environmental stresses on trees at different stages of their development is very important for a successful regeneration and establishment of the vegetation in such an adversely affected area. Seed germination in a plant life is the most vulnerable stage to such stresses (Freeman, 1973; Catalan *et al.*, 1994); and salinity is one of the most important factors that affect seed germination and seedling growth (Mayber, 1982).

The current research has tested *C. boranensis*, *C. habessinica* and *C. corrugate* at different salinity levels for their germination and seedling growth thereby evaluated their tolerance for salinity. Even though *C. boranensis*, *C. habessinica* and *C. corrugate* were widely distributed in the rift valley and other salt affected areas; no research was done before on these multipurpose trees for their salinity tolerance vis-à-vis seed germination and seedling growth. Therefore, understanding their salinity tolerance is important for afforestation and reforestation programs of the salt affected soils. So that, the current research has investigated the effects of salinity level on seed germination and seedling growth of selected *Commiphora* species: *C. boranensis*, *C. habessinica* and *C. corrugate*.

Research Methodologies

Experimentaldesign and layout

The experiment was carried out in Wanja Public Nursery sites Gera, Southwest Ethiopia; in transparent plastic greenhouses and laboratory in the 2018 season. Healthy and good seeds in all respects of the three *Commiphora* species (*Commiphora boranensis, Commiphora habessinica and Commiphoracorrugate*) were obtained from Forest Research Center (FRC) having all the desired merits. The research has been done both Germination test in laboratory and Seedling growth studies ingreen house on pots. The total time length for the stay of the seedling growth data were recorded for three months.

The soils and seeds for the study were obtained from the same forest area in the southern rift valley of Ethiopia around Yabello dryland vegetations. The soil was air dried and sieved through 2mm sieve and thoroughly mixed. The air dried soil was sampled and then analyzed for salinity levels and the tested soil was filled in 60 plastic pots. Each pot contained 1.87 kg of soil. All pots were arranged in four rows and each row consisted of 20 pots. Each row was considered as replicate and each pot in each row was considered as a unit pot on which treatments were applied. The design was a complete random block design with four treatments and five replications. Each pot contained 4 seeds and had a size of 15cm diameter and 25cm length. Then, three salinity levels (8, 16 and 24 dS/m ECe) were applied to the tested soils using NaCl. Forest soils were considered as control. The soil for the control treatment was analyzed in laboratory and recorded for 0.49dS/m salinity level. Thus for developing desired levels of salinity levels extra quantity of salts were added to the control treatment. All four salinity levels (control, 8, 16 and 24dS/m) were then applied to each tree species with 5 replications making a total of 20 treatments. Before sowing seeds under trial in pots, all seeds were soaked in boiling water for just five minutes and then soaked in cold water for one hour. These treated seeds were sown in the plastic pots. Tap water free of salts was applied to each pot continuously in the afternoon during sun gets cooler until the end of the research time. With the same concentration of salt, the test was repeated in the laboratory on the Petri dishes by using 18 seeds per Petri dish.

Data collection and Analysis

Germination percentage was recorded on completion of germination. Whereas, root length, shoot length, root length density, root and shoot biomass was recorded after the end of research by destructive method.

Germination percentage (GP)

Germination percentage (GP) was calculated by counting the number of emerged seedlings and dividing the number by the total number of sown seeds then a percentage was obtained by multiplying it with 100 %.

$$Gp = \left(\frac{Ng}{Np}\right) * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where Gp, is Germination percentage, Ng is Final number of emerged seeds and Np is the total number of seeds sown.

Aboveground Biomass

This was taken at the end of the experiment using the destructive method. The height was measured using a ruler. Biomass was first oven dried at 700C for 48 hours, and the dry material was measured using a balance.

Belowground Biomass

Both root length and root biomass parameters were measured by destructive method of uprooting the plant. Root length measurements were taken by the use of ruler. Roots were cleaned and oven dried using oven drier for 48 hour at 70 C^0. The dry material was weighed using a sensitive balance.

To measure the Root length density, the root of each seedling was washed by tap water, and then each fine root was distributed over a transparent paper prepared by using vertically and horizontally drawn (1cm X 1cm) grid lines (Tennant, 1975). The number of roots crossing each vertical and horizontal line was counted and then was changed to length formula by

$$RL = \mathrm{N}(0.7857) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where RL=Root Length; N=Number of intercept; and 0.7857= Length conversion Factor

The root length density was calculated as:

$$\mathrm{RLD} = \frac{NRL}{V} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

RLD = root length density; NRL= total number of root length; and V= cubic volume of soil in cm/cm^3.

Data analysis

SAS Version 10 Computer software was used to carry out statistical analysis. The results were subjected to analysis of variance (ANOVA). The least significance difference (LSD) at 5% was used to separate the means and the results were interpreted.

Results and Discussion

Commiphora seeds Germination Capacity

Laboratory Germination test of seeds under different salt concentration

All salinity levels had a significant effect ($P < 0.05$) on seed germination of the three Commiphora species. We have observed the significant differences ($P < 0.05$) in germination percentage of among the species treated under the varying salinity levels (Figure 1). Seed germination decreased as salinity level increased. The severity response of each tree species was different for each salinity level. For instance, *Commiphora corrugate*and *Commiphora boranens is* showed more susceptibility to increasing salinity. The results obtained for *C. corrugate*and *C. boranensis with the* control treatment were 74% and 83% respectively. But, as salinity level increased to 24ds/m, the germination status has decreased dramatically and observed as 0 and 11.4% as final germination percentages respectively. This result is in line with the study by Waisel (1972) reported for different halophytes showing changes with high sensitivity even to low salinity levels.

Similar declining trend was also recorded for *Commiphora habessinica*.. The Seed germination of *C.habessinica declined* from 89% for the control to 50.13% for 24ds/m salinity level. This reduction in the percentage of seed germination induced by an increase of salinity stress has been described in numerous findings on other types (Breen *et al*., 1977; Ungar, 1982) and attributed to the complete inhibition of germination at salinities beyond the tolerance limits of species (Ungar, 1991; Voigt *et al*., 2008). Germination is a critical stage in the development and life cycle of many plants; it ensures the reproduction and consequently controls the dynamics of the population. The negative effects of salinity levels on seed germination have been also reported by different scholars in many articles for several halophyte species (Boorman, 1968; Khan and Ungar, 1984; Ungar, 1987). Such a response might be related to the inhibitory effect of the solution low osmotic potential and/or to ionic toxicity (Poljakoff-Mayber *et al.,* 1994; Katembe*et al.,* 1998).

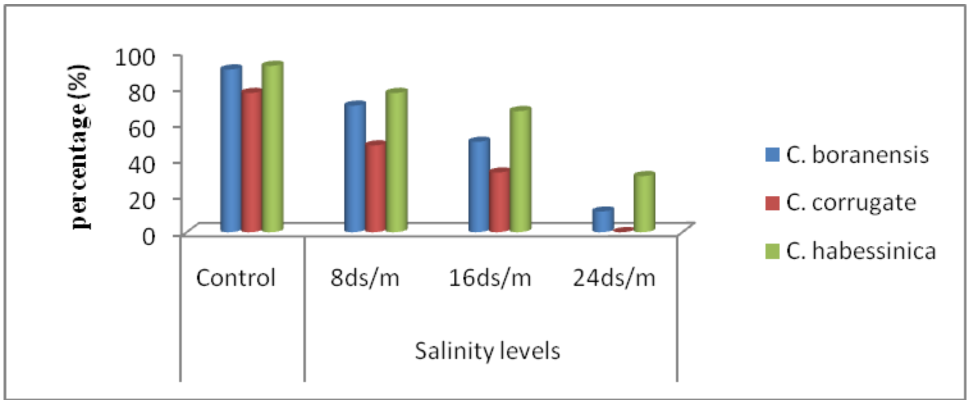

Figure 1: Seeds germination percentage tested in the laboratory under varying salt levels

These processes could be affected by both the ionic and the osmotic components of salt stresses. Similar result was also reported by Muhammad *et al*., (2006) for the species tested under different salt concentrations; Sugar beet, Cabbage, Amaranth and Pak-choi were strongly affected by salt treatments and increased salt concentration caused a decrease in germination. In the current findings, we have observed that strong reduction in germination percentage mainly at the higher levels of salt concentration compared to control. Accordingly, these effects has figured mostly on *C. corrugate* and *C. boranensis and moderately on C. habessinica* seeds. Lowest germination was observed with pak-choi when exposed to high salinity treatments while sugar beet showed a relative tolerance with the highest germination percentage among the tested plants (Muhammad *et al*, 2006). Huang and Redmann, (1995) also stated that salt induced inhibition of seed germination through osmotic stress or to specific ion toxicity. It is assumed that germination rate as well as the overall seed germination decrease with the decrease of water movement into the seeds during inhibitions (Hadas, 1977). Germination percentage also significantly decreases as the level of salinity of the medium increases (Gulzar *et al*, 2001; Mauromicale and Licandro, 2002).

Pot Seeds Germination Test Under Different Salt Levels

Similar results were obtained using pots as with the laboratory tests. All salinity levels shows significant effects ($P < 0.05$) on seed germination of forest tree species under trial (Figure 2). Seed germination decreased as salinity increased. For instance germination percentage of *C. corrugate* was 75% at control but as salt levels increased, it started to decline. The same thing was true for the rest of the species. *C.habessinica gave* 81% germination at the control but, at 8ds/m, 16ds/m, and 24ds/m level of salt concentration, the germination percentage declined to 72.81%, 59% and 50% respectively. *C. corrugate*and *C. boranensis*were highly susceptible to increased salinity. In line with the current findings, studies by Aslam *et al.*, (1986) on *Atriplex amnicola,*indicated increased growth after addition of NaCl to the growth medium up to 25-50m*M,*but after these level, growth declined with increasing salt concentration. At 5dS/m EC in *Leucaena leucocephala* germination was 100% (Yasin *et al.*, 1993). In further proof of the current research, the study by Ahmad *et al.*, (2000) on *Prosopis juliflora* salinity levels of > 10dS/m EC, seedling immergence was completely inhibited while in *Prosopis glandwose*, beyond 15dS/m EC, plants could not survive.

*C. corrugate*and *C. boranensis recorded* only 0 and 14% seed germination respectively at 24dS/m salinity level. On the other hand, *C.habessinica was* found to be comparatively more tolerant to salinity with 51.3% germination at the highest salinity level (24dS/m). Khan and Gulzar, (2003) found that, presence of NaCl around roots leads to degradation of some proteins involved in root and shoot growth of germinations. It was also reported that, some species have specific protein, which has special structure and salt resistance and resulting in increased germination. It seems that, salinity stress effects on seed germination are via limitation of water absorption by seeds (Dodd and Donovan, 1999) and creation of disorders in protein synthesis (Bouaziz and Hicks, 1990). Over all, it could be concluded that salinity increment badly affected seed germination of all tree species under trial, which decreased as the salinity increased.

Plants differ in their capacity to tolerate saline condition because salt influences seed germination and seedling growth through the osmotic retention of water in soils and specific effect on metabolite process (Akhtar *et al.*, 2003). According to the study by Gulzar and Khan (2001), When halophytic grass, *Aeluropus lagopoides* were grown under saline condition; germination, seedling growth and fresh weight registered a perceptible reduction.

Higher concentration of salt reduces the water potential in the medium which hinders water absorption by germinating seeds and thus reduces germination (Ghars *et al*, 2009). The delay in seed germination or the decrease in the percentage of *Commiphora* species under Sodium chloride concentrations may be explained as a result of lowering osmotic potential. Halophytes have the capacity to overcome both ionic and osmotic effects at different salinity levels found throughout the world (Flowers *et al*., 1999).Growth is closely linked with this ability as the availability of nutrients, their uptake and distribution becomes highly complicated in the presence of NaCl salt (Khan and Gulzar, 2003). This seems to be true because when plant are exposed to salt concentrations that are higher than normal, the passage of Sodium and chloride ions along the normal diffusion gradient will result in both a change in the ionic composition of the cell and a decrease in the water potential (Crawford, 1978).

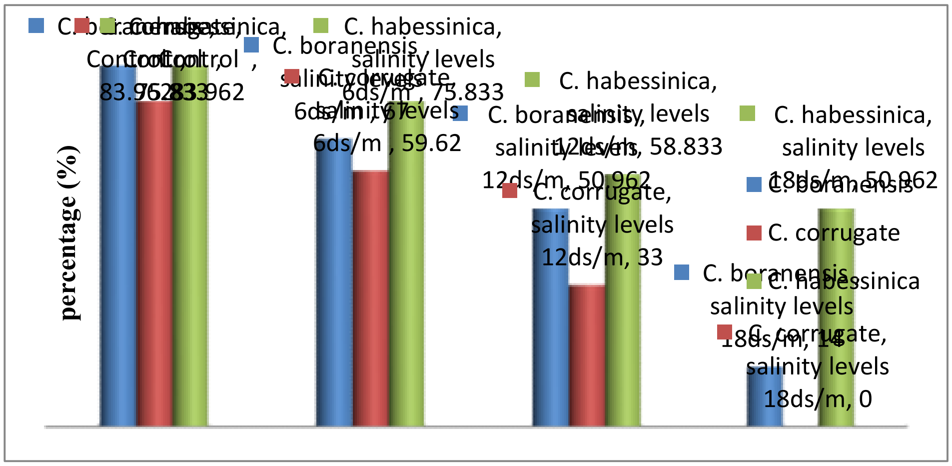

Figure 2: Seeds germination percentage test on pots for the varying salt levels

Above ground biomass growth

Shoot length

All salinity levels had significant effects (P < 0.05) on seedling growth. Shoot length of seedlings of each tree species was highest under control treatments. At this level of salinity *C. corrugate*recorded as the highest shoot length (67cm), followed by *C.habessinica with* 56.53cm. As salinity increased to 24dS/m ECe, however, the shoot length of *C. corrugate*was null, since *C. corrugate*seeds did not germinate at this level of salinity and no measurement was taken on seedling growth parameters (Figure 3a). For increased salinity level *C.habessinica and C. boranensis* on the other hand, showed a relatively slow reduction in shoot length growth which is 21.25cm and 18.05cm respectively at 24ds/m of salinity level. The variation within species may be due to the physiological and morphological differences (O' leary, 1986).

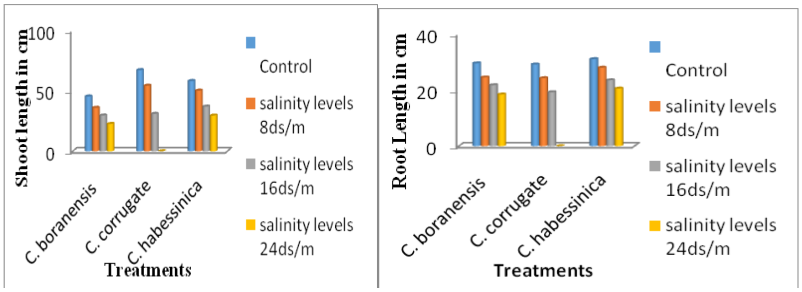

Figure 3a Shoot Length in cm **Figure 3b** Root Length in cm

Figure 3: Shoot and Root length (cm) of *C. boranensis, C. habessinica and C. corrugate* grown under different salinity levels

Lower biomass production might have resulted in a lower reproductive output, as reported by Ungar (1978, 1987). Reduced biomass as a response to increased substrate salinity is quite common in halophytes (Waisel, 1972). In fact, a salinity level of 1% is sufficient to cause a significant biomass reduction in several halophytes (Ungar, 1996). Plant growth is ultimately reduced by salinity stress, although plant species differ in their tolerance to salinity (Munns and Termaat, 1986). Results which indicated similar decreasing trends in the height of plants grown in saline medium, have been reported (Mirza and Mahmood, 1986; Cordovilla *et al*., 1996; Singla and Garg, 2005). According to Ashraf and Harris (2004), reduction of plant growth under saline condition is a common phenomenon but such reduction occurs differently in different plant organs. Jamil *et al*., (2005), also reported that salt stress inhibited the growth of shoot in *Brassica* species. Diminution in growth of plants under high salinity is obvious since salinity increases the energy needs necessary to combat the osmotic and ionic stress for normal cellular maintenance and thus there is relatively less energy available for growth processes.

Shoot Dry matter production

Shoot dry matter of seedlings of each tree species was significantly affectedfor each species at ($p<0.05$). Highest shoot dry weight was recorded at control for all tree species. As salt level increased from 8ds/m to the highest salt level of 24ds/m, the shoot dry weight of each species was reduced. The result of*C.habessinica recorded* the highest Shoot dry matter (7.56g) at control level and was radically declined to 2.05g and 1.43g at 16ds/m and 24ds/m levels respectively (Table 1), while shoot dry weight of *C. corrugate*and *C.boranensisat*24ds/m showed no statistically different values. In general, as salinity increased to 24dS/m ECe shoot dry matter decreased for all species. However, shoot dry matter of *C. corrugate*were not recorded for this level since no seedling germinated at this level. The reduction in shoot dry weight may be attributed to lower leaf number and smaller leaves development with increasing salinity level of the growth media. Toxic effects of salts are attributed to excess accumulation of certain ions in plant tissues and to nutritional imbalances caused by such ions. In the current research, the study showed that the presence of medium to high concentrations of NaCl in the soil induced more harmful effects on growth. These results fit with those previously reported on *Atriplex prostrata* (Egan *et al.,* 1998). Most species tested had their maximum biomass production at low salinity concentrations. These results broadly match with those obtained by (Glenn *et al*., 1984; Gorham, 1996) who reported that low NaCl concentrations stimulate growth of some halophytic species, but an excess of salt decreases growth and biomass production. The results obtained by Ashraf and Harris (2004), indicated that, the reduction of plant growth under saline conditions is a common phenomenon and such reduction occurs differently in different plant organs. Shoot dry weight, for instance, was reduced more than root dry weight and this may be due to the fact that the main site of Na^+toxicity for most plants is the leaf blade, where Na^+accumulates after being deposited in the transpiration stream. The accumulation of Na^+ results in reduced total leaf area and leaf number due to shading (Munns, 2002). New leaves emerge more slowly, and lateral buds develop more slowly or remain inactive, so fewer branches or only lateral shoots are formed. So that, the results of the currentresearch seems to agree with the above assertions in that shoot dry weight was more affected than root dry weight. Munns and Termaat (1986), and; Ashraf and Harris (2004), reported that shoot dry weight was reduced more than root dry weight by salt stress. Jamil *et al*., (2005), also confirmed the idea that salt stress inhibits the growth of shoot more than root in *Brassica* species.

Table 1: Shoot dry matter (g) of *C. boranensis, C. habessinica and C. corrugate*grown under varying NaCl levels

Tree species	**salinity levels**			
	Control	**8ds/m**	**18ds/m**	**24ds/m**
C. boranensis	$3.85\pm 0.6_{B}^{a}$	$2.05\pm 0.15_{C}^{b}$	$1.605\pm 0.18_{B}^{c}$	$0.560\pm0.31_{B}^{c}$
C. habessinica	$8.15\pm 0.72_{A}^{a}$	$6.05\pm 0.42_{A}^{b}$	$2.56\pm 0.28_{A}^{c}$	$1.763\pm0.20_{A}^{d}$
C. corrugate	$7.29\pm0.54_{A}^{a}$	$4.25\pm 0.24_{B}^{b}$	$1.24\pm0.151_{A}^{c}$	0.000_{C}^{d}

Note: Parameters with similar small letter in each **row**andsame capital letter in each **column** are not significant at $P<0.05$

Below Ground Biomass Growth

Root Lengthand Root Length Density

Root length of seedlings of each tree species was highest under control treatments (0.49dS/m ECe). But, as salinity level increased to 24ds/m root length of each species decreased. *C. boranensis*gave Root length of 26.5cm and 17.45cm under control and 24ds/m respectively. Whereas, root length of *C.habessinica decreased* from 27.35cm to 24.12cm under control and at 24ds/m salinity level respectively (Figure 3b). In general, as salinity increased to 24dS/m,root length decreased for all species and the response of each tree species to increased salt level differed from each other. However, no statistical differences were observed between *C. boranensis* and *C. corrugate*at 8ds/m salinity level in root lengths. The decrease in growth of root can be related to NaCl toxicity and disproportion in nutrient absorption by seedlings. According to results from the study of Werner and Finkelstein (1995), salinity decreases water absorption and growth of root and shoot. It is also reported that, salinity decreases nutrient absorption and root growth rate (Khan and Gulzar, 2003). The presence of Na^{+} salt in the growing medium of the plant also causes nutritional disorder in the tree plants as in other glycophytic herbaceous plants (Akram *et al.*, 2007 and Raza *et al.*, 2007). The availability and uptake of nutrients by plants in saline environments are affected by many factors in the soil plant environment. The concentration and ratios of accompanying elements can influence the uptake and transport of a particular nutrient and indirectly may affect the uptake and translocation of others. These interactions are complicated further by numerous environmental factors such as aeration, temperature, and stresses from both biotic and abiotic factors and finally inhibit root growth of trees (Grattan and Grieve, 1999).

On the other hand, Root length density (RLD) of seedlings of each tree species was significantly decrease at ($p<0.05$) as salinity increased. Under the control level*, C. corrugateand C.habessinica gave* highest root length density (0.174cm/cm^3) While, *C. boranensis*gave the least root length density (0.143cm/cm^3). As salinity increased to 24dS/m, however, root length density decreased for all species with *C. corrugate*showing null root length density (0cm/cm^3) since there were no measured data because of the seeds did not germinate at all at this level (Table 2).

Table 2: Root length density (RLD) in (cm/cm^3) of three *Commiphora* species grown under different NaCl levels

Tree species	**salinity levels**			
	Control	**8ds/m**	**16ds/m**	**24ds/m**
C. boranensis	$0.11\pm0.003_{B}^{a}$	$0.10\pm0.003_{B}^{a}$	$0.09\pm0.004_{A}^{b}$	$0.049\pm0.001_{B}^{c}$
C. habessinica	$0.17\pm0.003_{A}^{a}$	$0.11\pm0.001_{A}^{a}$	$0.10\pm0.002_{A}^{b}$	$0.08\pm 0.001_{A}^{c}$
C. corrugate	$0.16\pm0.002_{A}^{a}$	$0.11\pm0.002_{A}^{b}$	$0.09\pm0.001_{A}^{c}$	0.00_{C}^{d}

Note: Parameters with similar small letter in each **row**andsame capital letter in each **column** are not significant at $P <0.05$

Salinity affects the root growth and distribution of plants by affecting soil physical properties. Compactness of soil prevents root growth and distribution freely to absorb nutrient and water that support plant growth. A decrease in root length density under saline conditions may be due to decreased availability of photosynthesis from the shoots and water stress and ion toxicity due to salts around the roots. A decrease in root length under saline conditions has also been reported earlier by (Gohar *et al.*, 2003). How much water is taken up would obviously relate somewhat to the RLD. Several authors concluded that RLD and water uptake is related (Passioura, 1983; Monteith, 1986, Lafolie *et al.*, 1991). Lin and Kao (2001), reported that $NaCl^{-}$ induced cell wall stiffening is a possible mechanism of NaCl inhibiting root growth of rice seedlings. These modes of action may operate on the cellular as well as on higher organizational levels and influence all aspects of plant metabolism (Kramer, 1983).

Root Dry Matter

Root dry matter of seedlings was highest under control conditions (0.49ds/m dS/m) for all the tree species. At this salinity level, *C. habessinica gave* the maximum root dry matter (1.43g), while *C. corrugate*gave the minimum root dry matter (1.28g).

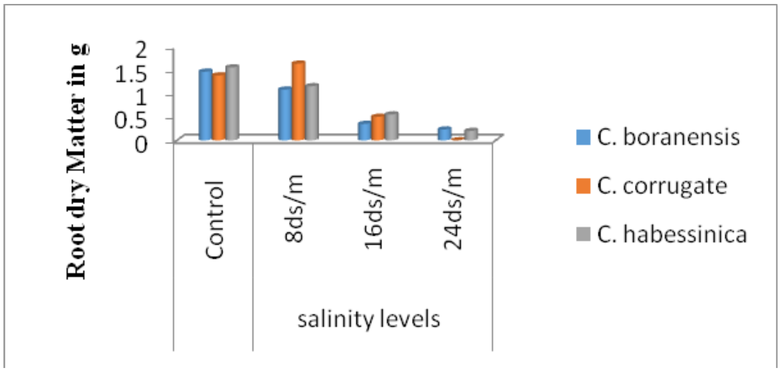

Figure 4: Root dry matter (g) of three *Commiphora* grown under different NaCl levels

However, as salinity increased to 24dS/m, the root dry matter decreased for all species. Root dry matter of *C. corrugate*was not statistically different between the control and 8ds/m. Similarly, the root dry matter for *C. corrugate* was null at the 24dS/m (Figure4). Maas *et al*., (1987) reported that in most halophytic species growth decreases gradually with the increase of salt rate in the culture medium above a critical threshold specific to each species. Reduction of plant growth under saline conditions is a common phenomenon (Ashraf and Harris, 2004) but such a significant reduction may occurs differently with different plant organs.

Conclusions

All studied species werewoody plants widely distributed in lowland dry environments of Ethiopia. Such distribution pattern implies adaptation to diverse soil conditions and provides evidence for the presence of other provenances and/or ecotypes of the species that are more tolerant to NaCl salinity. According to the current research, *C.habessinica* was found to be more tolerant followed by *C. boranensis*while *C. corrugate*did not germinate at all at the highest salinity level. For the majority of the parameters studied,*C. habessinica showed* best tolerance in salinity increment followed by *C. boranensis*. On the other hand, *C. corrugate* was the least in tolerance among the species for the parameters considered. For further information about the species regarding to its salinity tolerance, repeating the experiment and tissue analysis for specific ion concentration in plant cell will further elaborate this condition.

References

1. Ahmad, Z., Ghafoor, A., Ali, A. (2000), Evaluation of three exotic legume species for fodder potential. *Pakistan Journal of Biological Sciences* Vol. 3, 2079-2081. DOI:10.3923/pjbs.2000.2079.2081.
2. Akhtar, S., Wahid, A., Rasul, E. (2003), Emergance, growth and nutrient composition of sugarcane sprouts under NaCl salinity. *Biologia Plantarum* Vol. 46, 113-116. DOI: 10.1023/A:1022326604192.
3. Akram, M.S., Athar, H. R., and Ashraf, M. (2007). Improving growth and yield of sunflower(*Helianthus annuus* L.) by foliar application of potassium hydroxide (KOH) under salt stress. *Pak. J. Bot.* 39 (3): 769-776.
4. Ashraf, M. and Harris, P.J.C. (2004). Potential biochemical indicators of salinity tolerance in plants. *Plant Sci.,* 166: 3-16.
5. Aslam, Z., Jeschke, W.D., Barrett-Lennard, E.G, Setter, T.L., Watkin, E., Greenway, H. (1986). Effects of external NaCl on the growth of *Atriplex amnicola* and the ion relations and carbohydrate status of leaves. – *Plant. Cell. Environ.* Vol. 9, 571-580. DOI: 10:1111/1365-3040 ep.11616320.
6. Asres K, Tei A, Moges G, Sporer F, Wink M (1998) Terpenoids composition of the wound—induced bark exudate of Commiphora tenuis from Ethiopia. Planta Med 64:437–475.
7. Azene Bekele Tesemma. (1993). *Useful Trees and Shrubs for Ethiopia*. RSCU, SIDA. Nairobi, Kenya
8. Boorman, L. A. (1968). Some aspects of the reproductive biology of *Limoniumvulgare* Mill. and *Limonium humile* Mill. *Annals of Botany* 32: 803–824.
9. Breen, C.M., Everson, C. and Rogers, K. (1977). Ecological studies on Sporobolusvirginicus (L.) Kunth with particular reference to salinity and inundation. Hydrobiologia 54: 135–140.
10. Catalan, L. (1994). Effects of salinity on germination and seedling growth of Prosopis flexuosa (D.C.). Forest Ecology and Management 63: 347-357.
11. Cordovilla, M.P., Ligero, F. and Lluch, C. (1996). Growth and nitrogen assimilation in response to nitrate levels in Vicia faba under salt stress. *J. Exp. Bot. 4: 203-210.*

12. Crawford, R. M. M. (1978). Mineral Nutrition (Chapter 6). *In*: Plant Structure, Function and Adaptation. Edited by M. A. Hall. The English Language Book Society and Macmillan. London and Basingstocke. pp. 243.

13. Dodd, G. L. and Donovan, L. A. (1999). Water potential and ionic effects on germination and seedling growth of two cold desert shrubs. *Am. J. Bot. 86:1146-1153.*

14. Egan, T.P. and Ungar, I.A. (1998).The effect of different salts of sodium and potassium on the growth of Atriplex prostrate (Chenopodiaceae). *J. Plant Nutr. 21: 2193-2205.*

15. Flowers, T.J., Hajibagheri, M.A., Yeo, A.R. (1999), Ion accumulation in the cell walls of rice plants growing under saline conditions. Evidence for the Oerti hypothesis. *Plant Cell Environ* Vol. 14, 319-325. DOI: 10.1111/j.1365-3040.1991.tb01507.

16. Freeman, C. E. (1973). Germination of response of a Texas Population of Ocotillo (Fouquieria splendens Engelm) to constant temperature, water stress, pH and salinity. The American Midland Naturalist, 89: 252-256.

17. Ghars, M. A., Debez, A. and Abdelly, C. (2009). Interaction between Salinity and Original Habitat during Germination of the Annual Seashore Halophyte Cakile Maritima. Communications in Soil Science and Plant Analysis, 40: 19, 3170-3220.

18. Glenn, E. and O'Leary, J.W. (1984). Relationship between salt accumulation and water content of dicotyledonous halophytes. Plant. Cell. Environment. 7:253-261.

19. Gohar, Z.N., Ahmad, R. and Gul, H. (2003). Growth and development of cotton roots at various soil textures under soil conditions. *Pak. J. Bot.,* 35(5): 949-959.

20. Gorham, J. (1996). Mechanism of salt tolerance of halophytes in Choukr-Allah R, Malcolm CV, Hamdy A, eds. Halophytes and biosaline agriculture. New York: Marcel Dekker, Inc., 31-53.

21. Grattan, S. R. and Grieve, C. M. (1999). Salinity - Mineral nutrient relations in horticultural crops. *Sci. Hort.,* 78: 187-157.

22. Gulzar, S., and Khan, M.A. (2001), Seed germination of a halophytic grass *Aeluropus lagopoides Annals of Botany* Vol. 87, 319 -324. DOI:10.1006/anbo.2000.1336.

23. Gulzar, S., Khan M.A., and Ungar I.A. (2001). Effect of salinity and temperature on the germination of Urochondra setulosa (Trin.) C. E. Hubbard, Seed Sci. Technol. 29: 21-29.

24. Hadas, A. (1977). Water uptake and germination of leguminous seeds in soils of changing matrix and osmotic water potential, *J. Exp. Bot. 28: 977-985.*

25. Huang, J. and Redmann, R.E. (1995). Salt tolerance of Hordeum and Brassica species during germination and early seedling growth, Can. J. Plant Sci. 75: 815–819.

26. Jamil, M., Lee, C.C., Rehman, S., Lee, D.B., Ashraf, M. and Rha, E.S. (2005). Salinity (NaCl) tolerance of *Brassica* species at germination and early seedling growth. *Electronic J. Environ. Agric. Food Chem.,* 4: 970-976.

27. Katembe, W. J., I. A. Ungar, and J. P. Mitchell. (1998). Effect of salinity on germination and seedling growth of two *Atriplex* species (Chenopodiaceae). *Annals of Botany* 82: 167–175.

28. Khan, G. S., Khan, Z.H., Imran, J., Quraishi, M.U., Yaqoob Sh. and Khan, Sh. H. (2009). Effect of salinity on germination and growth of some forest tree species at seedling stage. *J. Agric. Res., 47:271-279.*

29. Khan, M. A. and Gulzar, S. (2003). Germination responses of *Sporobolus ioclados*: A saline desert grass. *J. Arid Environ. 55: 453-464.*

30. Khan, M. A., and I. A. Ungar. (1984). The effect of salinity and temperature on germination of polymorphic seeds and growth of *Atriplex triangularis.American Journal of Botany* 71: 481–489.

31. Khan, M.A., Gulzar, S. (2003), Light, salinity and temperature effects on the seed germination of perennial grasses *American Journal of Botany* Vol. 90, 131-134. DOI: 10.3732/ajb.90.1.131.

32. Kramer, P.J. (1983). Water Relations of Plants. New York, Academic Press.

33. Lafolie, F., Bruckier, L. and Tardieu, F. (1991). Modeling Root Water Potential and Soil-Root Water Transport. 1. Model Presentation. Soil Sci. Soc. Am. J. 55: 1803-1818.

34. Lemenih M, Tarekegn A., and Olsson M., (2003). Gum and resin resources from some *Acacia*, *Boswellia* and *Commiphora* species and their economic contributions in Liban, Southeast Ethiopia. Journal of Arid Environments 55: 465-482.

35. Lin, C.C. and Kao, C.H. (2001). Cell wall peroxidase activity, hydrogen peroxidase level in roots of rice seedlings. *Plant Soil,* 230: 135-143.

36. Maas, E.V., Grieve, C.M. (1987). Sodium induced calcium deficiency in salt-stressed corn. Plant Cell and Environment 10: 559-564.

37. Mayer, A. M. and Mayber, P. (1982). The germination of seeds. Pergamon Press, Oxford.

38. Mirza, R.A and Mahmood, K. (1986). Comparative effects of sodium bicarbonate and sodium carbonate on germination, growth and ion accumulation in Phaseolus aureus Roxb. cv. 6601. Biologia. 32, 257- 268.
39. Monteith, J.L. (1986). How do crops manipulate supply and demand? Phil. Trans. R. Soc. London A 316: 245-259.
40. Muhammad, J. Deog, B. L., Kwang, Y. J., Muhammad, A., Sheong, CH. L. and Eui, S. R. (2006). Effect of salt (NACL) stress on germination and early seedling growth of four vegetables species. J. Cent. Eur. Agric.7:2, 273-282.
41. Munns, R. (2002). Comparative physiology of salt and water stress. *Plant Cell Environ.* 25:239–50.
42. Munns, R. and Termaat, A. (1986). Whole plant responses to salinity. Aust. J. Plant Physiol., 13: 143-160.
43. O’ Leary, J.W. (1986). A critical analysis of the use of Atriplex species as crop plants for irrigation with highly saline water. In: Prospects for biosaline research, (eds.) Ahmad R & Pietro AS. Proc. US- Pakistan Biosaline Res. Workshop, Karachi, Paksitan. pp: 415-432.
44. Passioura, J.B. (1983). Roots and Drought Resistance. Agricultural water-Management. 7:265-280.
45. Poljakoff-Mayber, A., G. F. Somers, E. Werker, AND J. L. Gallagher. (1994). Seeds of *Kosteletzkya virginica* (Malvaceae): their structure, germination, and salt tolerance. II. Germination and salt tolerance. *AmericanJournal of Botany* 81: 54-59.
46. Raza, S.H., Athar, H.R., Ashraf, M. and Hameed, A. (2007). GB-induced modulation of antioxidant enzymes activities and ion accumulation in two wheat cultivars differing in salt tolerance. *Env. Exp. Bot.* doi:10.1016/j.envexpbot.2006.18.009 saline-sodic soils, Journal of Soil Science Society of America, 67:2256-2261.
47. Singla, R. and Garg, N . (2005). Influence of salinity on growth and yield attributes in chickpea cultivars. Turk. J. Agric. Forest. 29: 231-235.
48. Sissay B (1985) Salt-affected wasteland in Ethiopia: Potential for production of forage and fuel, Proceedings of the Research for Development Seminar on "Forage and fuel production from salt-affected wasteland". Cunderdin, W. Australia. 19-27 May 1984.
49. Szabolcs, I. (1992). Salt affected soils as the ecosystem for halophytes, International workshop on halophytes for reclamation of saline wastelands and as ressource for livestock, Nairobi, Kenya, Nov 22-27.
50. Tejedor, M., Jimenez, C. C. and Diaz, F. (2003). Use of volcanic mulch to rehabilitate Saline-sodic soils, *Journal of Soil Science Society of America*, 67:.2256–2261.
51. Tennant, D. (1975). A Test of a modified line intersection method of estimating root length.
52. Ugar, I. A. (1978). Halophyte seed germination. *Botanical Review* 44: 233–264.
53. Ungar, I.A. (1982), *Germination ecology of halophytes*. In: Sen DN, Rajpurohit KS, ed. Contributions to the ecology of halophytes. The Hague: Dr. W. Junk Publishers, 143- 154.DOI: 10.1007/978-94-009-8037-2-10.
54. Ungar, I.A. (1987). Population ecology of halophyte seeds. *Botanical Review* 53: 301–334.
55. Ungar, I.A. (1991). Ecophysiology of Vascular Halophytes. CRC Press, Boca Raton, FL.
56. Ungar, I.A. (1996). Effect of salinity on seed germination, growth, and ion accumulation of *Atriplex patula* (Chenopodiaceae). American Journal of Botany 83: 604–607.
57. Voigt, E. L., Almeida, T. D., Chagasa, R. M., Ponte, L. F. A., Vie´gas, R. A. and Silveira, J. A. G.. (2009). Source-sink regulation of cotyledonary reserve mobilization during cashew (Anacardium occidentale) seedling establishment under NaCl salinity. *Journal of Plant Physiology* 166(1): 80-9.
58. Waisel, Y. (1972). Biology of halophytes. Academic Press, New York, New York, USA.
59. Warrick, A.W. (2004). Soil physics, Soil Science Society of America, Journal of Vadose Zone3: 727.
60. Werner, J. E. and Finkelstein, R. R. (1995). Abidopsis mutants with reduced response to NaCl and osmotic stress. Physiologia Plantarum. 93:659-666.
61. Worku A, Pretzsch J, Kassa H and Auch E. (2014). The significance of dry forest income for livelihood resilience: The case of the pastoralists and agropastoralists in the drylands of southeastern Ethiopia. *Forest Policy andEconomics* 41:51-59.
62. Yasin, M., Anwar-ul-Hassan, Qureshi, R.H. (1993), Salt tolerance of three *Leucaena leucocephala* varieties Pakistan Journal of Agriculture Sciences Vol. 30, 415-419.