International Scholars Journals

African Journal of Crop Science ISSN 2375-1231 Vol. 7 (4), pp. 001-005, April, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Response of some lowland growing sorghum (*Sorghum bicolor* L. Moench) accessions to salt stress during germination and seedling growth

Kinfemichael Geressu and Melkamu Gezaghegne

Department of Biology, Mekelle University (MU), Ethiopia, P. O. Box 231, Tel. +251-911-16-94-92, Fax: +251-344-409304

Accepted 15 November, 2018

This research aimed to investigate the response of some lowland growing sorghum (*Sorghum bicolor* L. Moench) accessions to salt stress during germination and seedling growth. Twenty lowland sorghum (*S. bicolor* L. Moench.) accessions were tested during germination and seedling stage at 0, 2, 4, 8 and 16 dS/m salinity levels. Data analysis was carried out using jmp5 (version 5.0) statistical software. Final germination percentage (FGP), germination rate (GR), seedling shoot length (SSL) and seedling root length (SRL) were measured. The ANOVA for accessions found to be insignificant for most parameters recorded (p>0.05) but it was significant with respect to seedling root length (SRL) (p<0.0001). The ANOVA for treatments was significant with regard to all parameters measured (p<0.0001) . Germination rate and seedling root length were more salt affected than final germination percentage and seedling shoot length respectively. Accessions such as 235461 and 69239 were found salt tolerant during germination and seedling growth. However, accessions 223550, 69029, and 23403 were salt sensitive during germination but later became salt tolerant at seedling growth. Accession 223247 was found salt-sensitive during germination and seedling growth. The rest sorghum accessions were intermediate in their salt tolerance. The study affirmed the presence of broad intraspecific genetic variation among sorghum accessions for salt tolerance.

Key words: accessions, germination, NaCl, salinity, sorghum.

INTRODUCTION

Salt-affected soils are distributed throughout the world and no continent is free from the problem (Brandy and Weil, 2002). Salt affected soils are serious threats to crop production in the arid and semi-arid tracts of the world (Verma and Yadava, 1986). Globally, a total land area of 831 million hectares is salt-affected. African countries like Kenya (8.2 Mha), Nigeria (5.6 Mha), Sudan (4.8 Mha), Tunisia (1.8 Mha), Tanzania (1.7 Mha) and Ghana (0.79 Mha) are salt affected to various degrees (FAO, 2000).

In Ethiopia, salt-affected soils are prevalent in the Rift Valley and the lowlands. The Awash Valley in general and the lower plains in particular are dominated by salt-affected soils (Tadelle, 1993). A significant abandonment of banana plantation and a dramatic spread to the adjacent cotton plantation of Melka Sadi farm was reported (Fentaw, 1995). Recent studies also depicted that of the entire Abaya State Farm, 30% has already been salt-affected (Hailay et al., 2000). This problem is expected to be severe in years to come. Because under the prevailing situation of the country, there is a tendency to introduce and implement large- scale irrigation agriculture so as to meet the demands of the ever-increasing human population by elevating productivity (Tekalign et al., 1996). In

*Corresponding author. E-mail: knife_michael2006@yahoo.com

Abbreviations

a.s.l (Above sea level), FGP (Final germination percentage), GR (Germination rate), IBC (Institute of Biodiversity Conservation), MU (Mekelle University), SRL (Seedling root length), SRR (Shoot-to-root ratio) and SSL (Seedling shoot length).

the absence of efficient ways of irrigated water management, salt build up is an inevitable problem.

The possible solution is either using physical or biological practice (Gupta and Minhas, 1993) . Since environmental management (physical approach) is not economically feasible (El-Khashab et al., 1997), there is a need to concentrate on the biological approach or crop management (Ashraf and McNeilly, 1988) . Nevertheless, to proceed with this approach, affirming the presence of genetically based variation for salt tolerance in a particular crop is a prerequisite (Marler and Mickelbart, 1993).

Therefore, this research attempted to investigate the response of twenty sorghum (*Sorghum bicolor*, L. Moench) accessions for salt stress during germination and seedling stage. The reasons for selecting sorghum for the research are: being a dual crop grown for both grain and forage, native to tropical regions (Azhar and McNeilly, 1987), and its resistance to environmental fluctuations and drought (Marambe and Ando, 1995). Moreover, previous reports on salt tolerance of sorghum are relatively few.

MATERIALS AND METHODS

Seeds of twenty lowland growing sorghum (*S. bicolor* L. Moench) accessions were obtained from the Institute of Biodiversity Conservation (IBC), Ethiopia. The specific sorghum genotypes used in the research were accessions 69029, 69086, 69117, 69239, 69309, 223247, 223550, 228851, 231190, 234071, 234093, 235461, 237264, 237265, 237266, 237267, 237311, 239211 and 239237. They are adapted to altitudes ranging between 1400 – 1550 meters a.s.l. Moreover, the NaCl concentrations used were 2, 4, 8 and 16 dS/m. These salinity levels were obtained by dissolving 1.12, 2.10, 4.95 and 9.9 g NaCl in one liter distilled water respectively. Distilled water (0 dS/m) was used as control.

Germination experiment was conducted in a laboratory at room temperature following the procedures used by Tekalign et al. (1996). Petri dishes with a diameter of 10 cm lined with Whatman No.3 filter paper were supplied with 10 ml of each treatment solution and the control. Following this, twelve uniform seeds of each sorghum accession were placed on each Petri dish and the Petri dishes were arranged in a randomized complete block design (RCBD) with four replications. Eventually, the Petri dishes were covered with a polyethylene sheet to avoid the loss of moisture through evaporation. Treatment application continued every other day and germination count was started after 48 h of sowing and continued until the 14^{th} day. The seed was considered to have germinated when both the plumule and radicle had emerged $\geq$ 0.5 cm. After the 14 days, overall shoot and the longest root length of six randomly selected seedlings from each replicate were measured using a draftsman ruler.

Final germination percentage (FGP) was calculated as a percent of the total number of seeds germinated during the 14 days over the total number of seeds planted. Germination rate (GR): the average number of days needed for plumule or radicle emergence was calculated as:

$$\text{Germination Rate (GR)} = \frac{NT_2 + NT_4 + NT_6 + TN_8 + NT_{10} + NT_{12} + NT_{14}}{\text{Total number of seeds germinated}}$$

Where: Tn = number of seeds germinate at days 2, 4, 6, 8, 10, 12 and 14
N = days (2, 4, 6, 8, 10, 12 and 14)

Statistical analysis

Data analysis was carried out by jmp5 (Version 5.0) statistical software where two way analysis of variance (ANOVA) was done.

RESULTS

Germination

Final germination percentage (FGP): The ANOVA for treatments with respect to final germination percentage (FGP) was found to be significant (p<0.0001). However it was insignificant for both accessions and treatment*accession interaction (p>0.05). Final germination percentage was facilitated at 2 and 4 dS/m in accessions 237311,239211,239237 and 69309 as compared to the controls. At 2 and 4 dS/m salinity levels, the effect of Salinity was not profound with respect to fi-nal germination percentage; however, it was significant at 16 dS/m (Figure1). Accessions 239211, 237266, 228851, 223550, 234093, 223247, 69309 and 69029 were more salt affected than accessions 237311 ,237267 ,239237 ,235 461, 237264, 231190, 234071, 69239 and 69117 at 16 dS/m salinity level. The remaining sorghum accessions were intermediate in their response to salt stress with respect to FGP.

Germination rate (GR)

The ANOVA for both accessions, and treatment* accession interaction was insignificant (p>0.05) with respect to germination rate (GR). However, it displayed statistical significance for treatment (p<0.0001). Germination rate (GR) has been facilitated at 2 and 4 dS/m in accessions like 235461, 69309, 69096 and 69086 as compared to the controls. In accessions 237267, 237266, 237265, 223247, 231190, 234093, 237264, 69096 and 69029 germination rate was quite delayed compared to the controls at 8 and 16 dS/m salinity levels. On the other hand, accessions 237311, 235461, 234071, 69239 and 69086 were not significantly delayed in their germination rate at 8 and 16 dS/m salinity levels as compared to the controls (Figure 2).

Seedling growth

Seedling shoots length (SSL)

The ANOVA for both accessions as well as treatment * accession interaction appeared insignificant (p>0.05). Nevertheless, it was significant for treatment (p<0.0001). Seedling shoot length (SSL) was enhanced at 2 dS/m in accessions 237265, 228851 and 69239 as compared to the controls. Except these accessions, an increment in salinity level reduced SSL in all accessions. Nevertheless, the influence was more pronounced at 8 and 16 dS/m salinity levels than low salinity levels (Figure 3). In

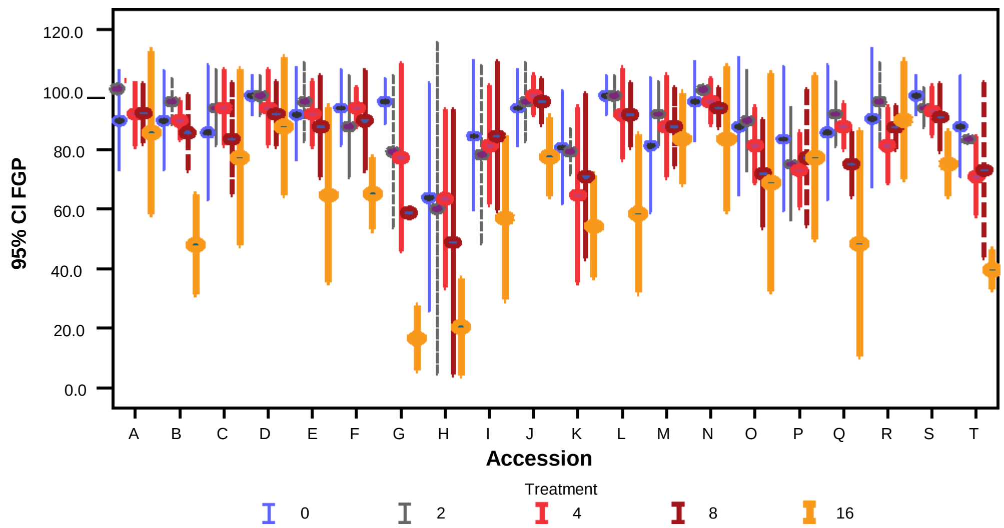

Figure 1. Effects of different salinity levels (0, 2, 4, 8 and 16 dS/m) on final germination percentage (FGP) of *Sorghum bicolor* L. Moench accessions. (Key to accessions: A=237311, B=239211, C=239237, D=237267, E=237266, F=237265, G=228851, H=223550, I=223247, J=234071, K=231190, L=234093, M=235461, N=237264, O=69117, P=69239, Q=69309, R=69096, S=69086 and T=69029)

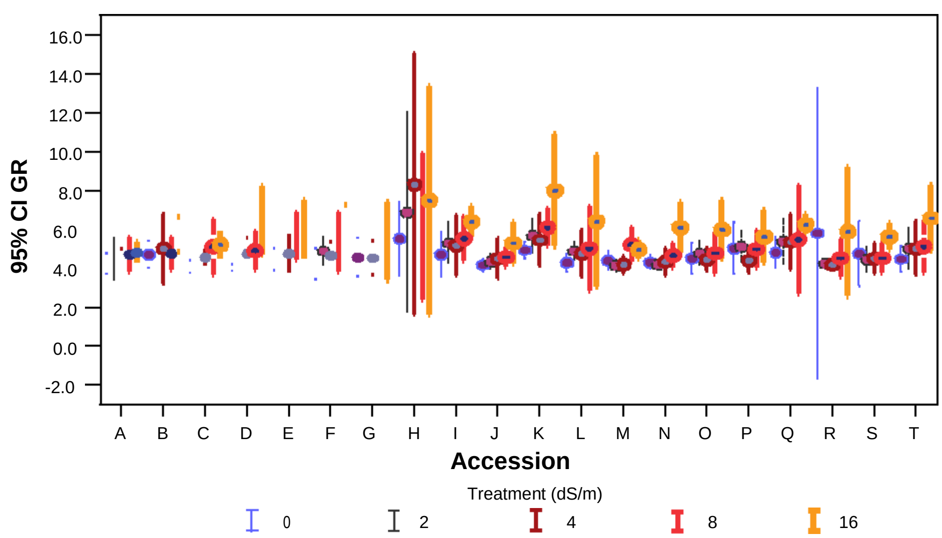

Figure 2. Effects of different salinity levels (0, 2, 4, 8 and 16 dS/m) on germination rate (GR) of *Sorghum bicolor* L. Moench accessions. (Key to accessions: A=237311, B=239211, C=239237, D=237267, E=237266, F=237265, G=228851, H=223550, I=223247, J=234071, K=231190, L=234093, M=235461, N=237264, O=69117, P=69239, Q=69309, R=69096, S=69086 and T=69029)

accessions 237311, 239237, 237267, 237266, 228851, 234071 237264, 69117 and 69086 SSL was more salt affected than accessions 239211, 237265, 223550 234093, 69239, 69309, 69029 and 235461. The remaining accessions remained intermediate in their salt tolerance with respect to seedling shoot length (SSL).

Seedling root length (SRL)

The ANOVA for accession*treatment interaction was insignificant ($p>0.05$). However, it was significant for both treatment ($p<0.0001$) and accession ($p<0.05$). Seedling root length (SRL) was facilitated at 2 dS/m in accessions 228851 and 69239 as compared to the controls. Gene-rally, 2 and 4 dS/m affected seedling root length (SRL) but not significantly from the controls. In acces-sions 239211, 223550, 234093, 69309 and 69029 SRL was more salt affected than in accessions 237311, 239237, 237265, 228851, 223247, 231190 and 237264. Almost all accessions were found to be salt sensitive at 16dS/m except accessions 239211, 223550, 234093, 69309 and 69029 (Figure 3). The remaining sorghum accessions

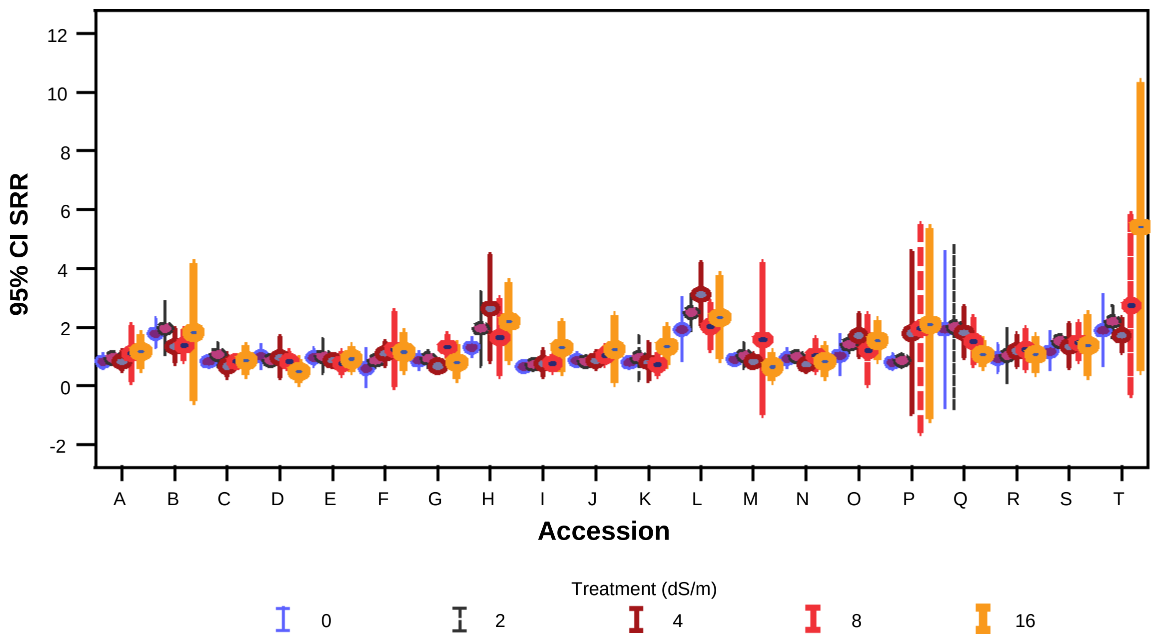

Figure 3. Effects of different salinity levels (0, 2, 4, 8 and 16 dS/m) on shoot-to-root ratio (SRR) of *Sorghum bicolor* L.Moench accessions.

were intermediate in their salt tolerance with respect to seedling root length (SRL).

Shoot-to-root ratio (SRR)

The ANOVA for treatment (p<0.01) and accession* treatment interaction (p<0.0001) was significant. Nevertheless, it was insignificant for accessions (p>0.05). In accessions 237311, 237265, 223550, 223247, 234071, 231190, 234093, 69239 and 69029 the value of shoot-to-root ratio (SRR) was high as compared to the controls at 8dS/m. But it was smaller than the controls value in accessions 237267, 228851,235461 and 69309. In the remaining accessions, SRR had almost comparable value at all salt concentrations and the controls (Figure 3).

DISCUSSION

Accession* treatment interaction was insignificant for final germination percentage (FGP), germination rate (GR), seedling shoot length (SSL) and seedling root length (SRL) during germination and seedling growth; reflecting that all accessions responded similarly to salt stress with respect to the above parameters. In general, salt stress at 2 dS/m enhanced growth with respect to FGP, GR, SSL and SRL in some sorghum accessions. The impact of 2 and 4 dS/m salinity levels was not profound with respect to all parameters considered.

The ANOVA for treatments was significant with regard to all parameters measured. On the one hand, the ANOVA for accessions was insignificant with respect to FGP, GR, SSL and SRR. This implies that there was no significant varietal difference among sorghum accessions in relation to the parameters considered. However, it was significant with respect to SRL. This reveals the presence of considerable varietal difference among sorghum accessions in seedling root length (SRL) with regard to their response to salt stress.

Increment in salinity level caused reduction in final germination percentage (FGP) in most sorghum accessions but the drop was quite sharp and rapid in accessions 223247, 237266, 228851, 233550, 234093, 69309, 69029 and 239211 at 8 and 16 dS/m salinity levels. Simi-lar results were reported in rice (Lee et al., 1998), and cowpea (Murillo- Amador and Troyo-Die'Guez, 2000). Likewise, highest salinity levels had delayed germination (increased days of emergence). The delay was pronounced in salt-sensitive accessions than in the intermediate and salt-tolerant ones which is in agreement with previous findings in sorghum (Marambe and Ando, 1995) and durum wheat and tef (Tekalign et al., 1996). Moreover, increased salinity level had simultaneously decreesed both final germination percentage and germination rate in accessions 237266, 234093, 223247 and 69029 which is in accord with previous research reports in Chick-pea (Ashraf and Waheed, 1992).

Accessions 237267, 231190, 234093 and 237264 were salt tolerant with respect to final germination percentage (FGP) but became salt sensitive with regard to germination rate (GR). This implies that the latter parameter is more salt sensitive than the former. In general, sorghum accessions under investigation were more salt sensitive in relation to germination rate (speed of emergence) than final germination percentage. Similar research findings were reported in durum wheat and tef (Tekalign et al., 1996).In all accessions used in the study, seedling mortality was aggravated as the salinity level gets maximized. Similar results were reported in rice (Lee and Senadhira, 1998).

Crop cultivar may germinate effectively under salt stress; nevertheless, its seedling growth may be salt affected (Azhar and McNeilly, 1987). In line with this, accessions 237311 and 234071 were less salt affected during germination than subsequent growth (had inadequate seedling growth). This implies that these accessions are salt tolerant during germination than subsequent growth like seedling growth. On the other hand, crop genotype may be salt sensitive during both at germination and seedling growth. This has already been reported in rice (Shannon et al., 1998), cowpea (Murrillo-Amador and Troyo-Die'guez, 2000). Similarly, in this research, accession 223247 found salt sensitive at higher salinity levels during germination and seedling growth. Thus this sorghum accession could not be cultivated even on slightly saline soils.

Contrary to this, accession 235461 and 69239 were salt tolerant during germination and seedling growth. It has already been reported that plant growth and development is dependent on crops stand establishment (Verma and Yadava, 1986), in turn, the latter is a function of effective germination (Horst and Taylor, 1983) and seedling growth (Ashraf and Waheed, 1992). Thus crops with higher germination percentage and lower germination rate could establish themselves effectively on moderately saline soils (Lee et al., 1998). Hence even if, it is difficult to extrapolate the research results obtained from controlled experiment directly to the field; in general, the above two sorghum accessions which had the highest final germination percentage (FGP) and the lowest germination rate (GR) could germinate and establish themselves effectively on moderately saline soils. However, this could not be a guarantee for them to be salt tolerant during later growth in the field. Thus there must be further green house or field study to test their response to salt stress during later growth.

ACKNOWLEDGEMENTS

We would like to express our heartfelt thanks to NORAD II Research Award, for its financial assistance. Moreover, we are greatly indebted to Mekelle University (MU), Department of Biology, for providing the laboratory and also the Institute of Biodiversity Conservation (IBC) for supplying all the twenty sorghum (*S. bicolor* Moench. L) Accessions. Finally, our great gratitude and thanks goes to Ato Hayal Lemma and Ato Getachew Gidey for their professional and genuine technical support during the experiment.

REFERENCES

Ashraf M, McNeilly T (1988). Variability in salt tolerance of nine spring wheat cultivars. J. Agron. and Crop Sci. 160: 14-21.

Ashraf M, Waheed A (1992). Screening chickpea (*Cicer arietinum L.)* for salt tolerance. *Journal of* Agric. in the Tropics and Subtropics. 93: 45-55.

Azhar MF, McNeilly T (1987). Variability for salt tolerance in *Sorghumn bicolor* (L.) Moench. under hydroponic conditions. J of Agron. and Crop Sci. 159 : 269-277.

Brandy NC, Weil RR (2002). The Nature and Properties of Soils. 13th Edition. Prentice-Hall, Upper Saddle Rivers, New Jersey.

El-Khashab AAM, Elaidy AA, EL-Sammak AF, Salama MI, Rienger M (1997). Paclobutrazol reduces some negative effects of salt stress in peach. J. Amer. Soc. Hort. Sci. 122(1): 43-46.

FAO/AGL.; [*Online*] Available *http://www.fao.orglag/agl/agll/spush/topic?.htm*.; November,2000.

Fentaw A (1995). Effects of subsurface drainage system on ground water table, Soil salinity and crop yield in Melka Sadi pilot draiange scheme. In: *Increasing Food Production through Improved Crop Management*,.ACPE, Addis Ababa, Ethiopia. pp. 139-148

Gupta, R Minhas P S (1993). Managing salt affected waters for crop production. In: Arid Land Irrigation and Ecological Management, , (Singh, S. d. ed). Scientific Publishers, Jodhpur (India), New Delhi. pp. 159-198

Hailay T, Tadele GS, Tekalign M (2000). Assessment of salinity/ sodicity problems in Abaya State Farm, Southern Rift Valley of Ethiopia. Ethiopian J of Natural Res. 2(2), 151-163.

Horst G L, Taylor R M (1983) Germination and initial growth of Kentucky blue grass in soluble salts. Agron. J. 75(4): 679-681.

Lee KS, Choi YS, Choi YW (1998). Varietal difference in salinity tolerance during germination stage of rice. Korean J. Crop Sci. 43(1): 11-14.

Lee S Y, Senadhira D (1998) Salinity tolerance of progenies between Korean cultivars and IRR's New Plant Type lines in rice. Korena J. Crop Sci. 43(4): 234-238.

Marambe B, Ando T (1995). Physiological Basis of Salinity Tolerance of Sorghum Seeds during Germination. J. Agronomy and Crop. Sci. 174: 291-296.

Marler TE, Mickelbart MV (1993). Growth and chlorophyll fluorescence of *Spondias Purpurea* L. as influenced by salinity. Trop. Agri. (Trinidad). 70(3): 245-247.

Murillo-Amador B, Troyo-Die'guez E (2000). Effects of salinity on thegermination and seedling characteristics of cowpea [*Vigna unguiculata* (L.) Walp.]. Australian J. of Exp. Agric. 40(3): 433-438.

Tadelle GS (1993). Degradation problems of irrigated agriculture: a review. In: Soil-the Resource Base for Survival,. ESSS, A.A., Ethiopia, pp.199-206.

Shannon MC, Rhoads JD, Draper JH, Scardoli SC, Spyres MD (1998). Assessment of salt tolerance in rice cultivars in response to salinity problems in california. Crop Sci. 38(2): 394-398.

Tekalign M, Richter C, Heiligatag B (1996). Response of some varieties of durum wheat and tef to salt stress. African Crop Sci. J. 4(4): 423-432.

Verma SPO, Yadava RBR (1986). Salt tolerance of some oats (*Avena sativa* L.) varieties at germination and seedling stage. J. Agron. and Crop Sci. 156: 123-127.