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Influence of Different Levels of Salinity Stress on Germination and Growth Attributes of Sorghum Cultivars

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ABSTRACT:

Salinity stress is a major environmental constrain now a day that is considerably reducing the agricultural production. This study was planned to determine the impact of different levels of salinity stress on the germination and growth attributes of different sorghum cultivars. The experiment comprised of four different levels of salinity stress i.e., T_1= 0 mM NaCl, T_2= 40 mM NaCl, T_3= 80 mM NaCl and T_4=120 mM NaCl and five sorghum cultivars i.e., C_1=JS-263 C_2=Hagari, C_3= JS-2002, C_4=Jawar-2011 and C_5=YS-2016. The results revealed that salinity levels significantly reduced the germination and growth attributes, while the tested cultivars also had the differential response towards the salinity tolerance. As regard the salinity stress minimum T_{50}, maximum germination percentage, root and shoot growth were recorded without salinity stress, whereas the maximum T_{50}, lowest germination percentage and substantial reduction in root and shoot growth were recorded with 120 mM NaCl solution. Similarly, cultivar JS-263 performed superiorly in terms of germination, root and shoot growth, followed by Jawar-2016, whereas cultivar JS-2002 performed poorly among the tested cultivars. These results suggested that salinity stress considerably reduced the germination and root and shoot growth of seedlings, in addition, cultivar JS-263 was characterized as more salt tolerant as compared to the other tested cultivars.

Keyword: *Salinity stress, Sorghum, Cultivars, Germination, Seedlings*

INTRODUCTION

Sorghum is a major cereal crop, it is cultivated on an area of 44 mha [1], with annual production of 60 million tons [2]. In Pakistan, sorghum crop cultivated on an area of 257 thousand hectares with production 149 thousand tones [3]. Sorghum is potential multi proposes crop, as it is being cultivated as grain, and fodder crop, and for syrup and bio-fuel production [4]. Despite its importance, the productivity of sorghum is below than its genetic potential. Salinity stress is one of prime factor which restricts the sorghum productivity [5]. Salinity stress is major problem around the globe and one of the important impediments to agricultural productivity. This problem is more severe in those areas where irrigation water contains large amount of salts [6].

Plant species have different abilities to tolerate the salt stress according to their genetic makeup. The relative growth rate of the plants in response to differential salinity level is known as their salt tolerance. Salinity stress substantially reduced the seed germination and stand establishment. In addition salinity stress puts deleterious effects on plant which restricts the plants in maintaining their nutritional needs essential for proper growth [7]. Salinity stress also brings about the osmotic stress, deficiency of minerals and ion toxicity, which adversely affect physiological and biochemical functions that limits the crop yield [7, 8]. Boursier and Lauchli, [9] reported that salinity stress substantially reduced the sorghum root and shoots weight and total dry matter as well.

Among the management strategies, selection of suitable cultivar plays a fundamental role in the final outcome under saline conditions. One of the important strategies that are being used by the plant scientist is to explore the genetic variations among the cultivars for salinity stress and the development of salt tolerant genotypes [10]. Seed germination and seedling characters are the most prime criteria for identifying and selecting the salt tolerant plants. Germination index, percentage and rate of germination as well as the seedling growth are the most important characters to identify and select the most tolerant genotypes [11, 12]. Therefore, this study was planned to screen out the different sorghum cultivars against the different levels of salinity stress.

Materials and Methods

The experiment was conducted in Department of Agronomy, University of Agriculture, Faisalabad, during the year 2016. The study was conducted in complete randomized design with factorial arrangement having three replications. In each replication each treatment comprised a set of three Petri plates. The experiment comprised of five sorghum cultivars i.e., C_1=JS-263 C_2=Hagari, C_3= JS-2002, C_4=Jawar-2011 and C_5=YS-2016 and four different salinity levels i.e., T_1= 0 mM NaCl, T_2= 40 mM NaCl, T_3= 80 mM NaCl and T_4=120 mM NaCl. Seeds of sorghum cultivars were obtained from Fodder Research Institute, Ayub Agriculture Research Institute Faisalabad.

The seeds of sorghum cultivars were surface sterilized in aqueous solution of 0.1% $HgCl_2$ for 30 seconds, after that seeds were washed with distilled water. Five seeds of sorghum were placed on filter paper in petri plates, and petri plates were visited twice a day and salinity solutions were added to perti plates according to the treatments and requirements.

The time to 50% germination (T50) and mean germination time

(MGT) time were determined by the standard procedures of Farooq *et al.*, (2008), whereas the final germination percentage was calculated by the following formula; Germination %age = Germinated Seeds/ Total seeds × 100. At the end fifteen seedlings from each treatment were selected to determine the root, shoot length and fresh and dry weight of roots and shoots. Shoots were separated from roots by scissor and then the root length and shoot length were measured by measuring type. The fresh weight of shoots and roots were measured and after that they were dried separately in oven at 72ºC until constant weight in order to determine dry weights. The collected data were analyzed by Statistics 8.1 software and treatment means were compared by using LSD test at 5% probability [13].

RESULTS

Salinity stress significantly affected all the tested parameters ($p<0.05$). The maximum the time to fifty percent (T_{50}) germination (2.85 days) was recorded where 120 mM NaCl solution was applied, while the minimum time to fifty percent germination (2.41 days) was recorded where 0 mM NaCl was applied (Table 1). Sorghum cultivars also had differential response for the T_{50}. The maximum time to fifty percent germination (2.79 days) were taken by JS-2002, followed by Hagari, however, the minimum value of T_{50} was recorded by JS-263 (Table 1). The results revealed that salinity stress considerably reduced germination percentage of sorghum cultivars (Fig 1). The highest value of germination percentage was recorded under control conditions, while lowest germination percentage was recorded with 120 mM NaCl (Fig 2). The cultivar JS-263 attained highest germination percentage, while JS-2002 was poorest in this regard. As regard the root and shoot length, cultivar JS-263 performed relatively better with the maximum root and shoot length (13.43 and 14.51 cm) while cultivar JS-2002 performed poorly with lowest value of root and shoot length (11.66 and 11.70 cm) (Table 1). Similarly, the lowest root and shoot length was recorded with 120 mM NaCl solution while highest root and shoot length was recorded with 0 mM NaCl (Table 1).

Table 1: Effect of different levels of salinity stress on the germination percentage, root length, shoot length, root and shoot fresh and dry weights

Salinity Levels (SL)	Time to 50% Germination	Root length (cm)	Shoot Length (cm)	Root Fresh Weight (g)	Shoot Fresh Weight (g)	Root Dry Weight (g)	Shoot Dry Weight (g)
0 mM NaCl	2.41d	13.58a	14.75a	0.92a	1.10a	0.26a	0.32a
40 mM NaCl	2.54c	12.97b	13.54b	0.87b	1.00b	0.23b	0.29b
80 mM NaCl	2.71b	12.02c	12.43c	0.78c	0.95c	0.22c	0.26c
120 mM NaCl	2.85a	10.96d	11.16d	0.69d	0.91d	0.19d	0.23d
LSD (P ≤0.05)	0.051	0.196	0.363	0.025	0.037	0.015	0.019
Cultivars (C)							
JS-263	2.59b	13.43a	14.51a	0.92a	1.19a	0.26a	0.33a
Hagari	2.75a	11.76d	11.75c	0.77c	0.78d	0.21bc	0.25c
JS-2002	2.79a	11.66d	11.70c	0.72d	0.76d	0.19c	0.23c
Jawar-2011	2.53c	12.69b	13.58b	0.85b	1.13b	0.24a	0.29b
YS-2016	2.49c	12.36c	13.35b	0.83b	1.08c	0.22b	0.28b
LSD (P ≤0.05)	0.057	0.219	0.406	0.029	0.041	0.017	0.021
SL×C	NS	NS	NS	NS	NS	NS	NS

The data regarding root and shoot fresh and dry weight revealed that the cultivar JS-263 attained highest value of root and shoot fresh and dry weights, followed by Jawar-2011 and YS-2016 while, the minimum values was recorded in JS-2002 (Table 1). Similarly, salinity levels also substantially reduced the root and shoot fresh and dry weights. The highest value of root and shoot fresh and dry weights were recorded with 0 mM NaCl, followed by 40 mM NaCl and 80 mM NaCl, while lowest values of root and shoot fresh and dry weights were recorded with 120 mM NaCl registered the lowest value of (Table 1). The interactive effect of sorghum cultivars and all the tested parameters were found non-significant.

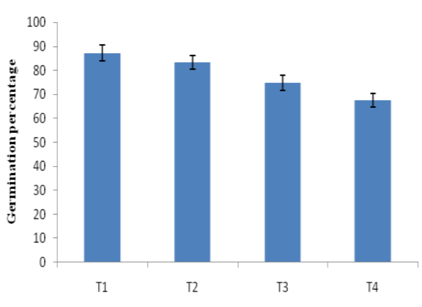

Fig. 1a: Effect of different levels of salinity stress on germination percentage. T_0: 0 mM NaCl, T_1=40 mM NaCl, T_2= 80 mM NaCl, T_3=120 mM NaCl

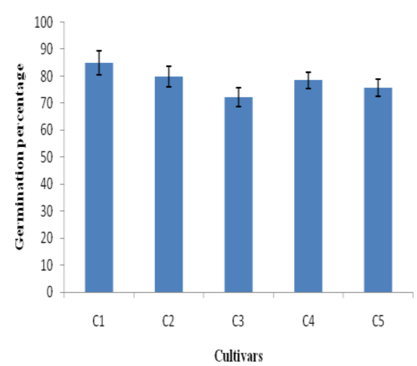

Fig. 1a: Effect of different levels of salinity stress on germination percentage of sorghum cultivars. C_1= JS-263, C_2= Hagari, C_3= JS-2002, C_4= Jawar-2011, C_5=YS-2016

DISCUSSION

This study was conducted to indentify the salt tolerant cultivar of sorghum at initial growth stages under varying salinity levels. The results indicated all the salinity levels variably affected the sorghum cultivars. Similarly, all the tested genotypes had variable response towards salinity stress (Table 1). Increment in salinity levels substantially reduced germination percentage, similarly under high salinity stress seeds took more time for fifty percent germination. Salinity stress restricts the water absorption thus increased the time for germination [14]. The reduction in germination percentage might be due to the harmful effect of ions and higher salt concentration which restricts the water absorption thus reduced the germination [15]. These results are supported with previous findings of Krishnamurthy *et al*., [8] who reported that salinity stress reduced the germination.

The difference for germination percentage and T_{50} among the cultivars might be due to their genetic makeup [8]. The salinity stress also substantially reduced the root and shoot length (Table 1). The salinity stress reduce the root and shoot growth due toxic effect of salt Amin *et al*., [16] as well as by slow downing the water uptake Werner and Finkelstein, [17]. The salinity tolerant cultivars produced maximum root and shoot fresh and dry weights (Table 1). The increased in salinity stress substantially reduced the proportion of fresh and dry weights allocated to root and shoot (Table 1). Salinity stress reduced the root and shoot weights due to less growth of root and shoots by toxic effect of salts Amin *et al*., [16] and less biomass accumulation [18].

CONCLUSION

All the salinity stress levels considerably reduced the germination, root and shoot growth of sorghum cultivars. However, the considerable reduction in these attributes was recorded with 120 mM NaCl solution as compared to other tested levels. Moreover, cultivar JS-263 was characterized as more salt tolerant as compared to the other tested cultivars. In addition, JS-263 can be used in future breeding programmes for the development of salt tolerant genotypes.

REFERENCES

1. R. Prakash, K. Ganesamurthy, A. Nirmalakumari, P. Nagarajan, Heterosis for fodderyield in sorghum (*Sorghum bicolor* L. Moench), Exp. J. Plant Bio. 1(3) (2010) 319–327.
2. A. Iqbal, B. Sadia, A.I. Khan, F.S. Awan, R.A. Kainth, H.A. Sadaqat, Biodiversity in the sorghum (*Sorghum bicolor* L. Moench) germplasm of Pakistan. Gen. Mol. Res. 9(2) (2010) 756–764.
3. Govt. of Pakistan. Pakistan Economic Survey 2015-16. Finance Division, Economic Advisor's Wing, Islamabad (2016) pp: 29.
4. P. Steduto, N. Katerji, H. Puertos-Molina, M. Unlu, M. Mastrorilli, G. Rana, Water-use efficiency of sweet sorghum under water stress conditions: Gas-exchange investigations at leaf and canopy scales, Field Crops Res., 54 (1997) 221–234.
5. W. Wang, B. Vinocur, A. Altman, Plant responses to drought, salinity and extreme temperatures: towards genetic engineering for stress tolerance. Planta. 218 (2003) 1–14.
6. T.J. Flower, Improving crop salt tolerance, J. Exp. Bot. 55(2004) 307–319.
7. M. Hamid, M.Y. Ashraf, K.U. Rehman, M. Arshad, Influence of salicylic acid seed priming on growth and some biochemical attributes on wheat growth under saline conditions, Pak. J. Bot., 40(1) (2008) 361–367.
8. L. Krishnamurthy, R. Serraj, C.T. Hash, A.J. Dakheel, B.V.S. ReddyScreening sorghum genotypes for salinity tolerant biomass production, Euphytica, 156 (2007) 15–24.
9. P. Boursier, P.A. Lauchli, Growth response and mineral nutrient relations of salt-stressed sorghum, Crop Sci. 30 (1990) 1226–1233
10. M.Y. Ashraf, K. Akhtar, F. Hussain, J. Iqbal, Screening of different accession of three potential grass species from Cholistan desert for salt tolerance, Pak. J. Bot. 38(2006) 1589–1597.
11. A. Bybordi, J. Tabatabaei, Effect of salinity stress on germination and seedling properties in Canola Cultivars (Brassica napus L.). Notulae Bot. Hort. Agrobot, Cluj-Napoca. 37(1) (2009) 71–76.
12. T. Endalew, A. Mebeaselassie, T. Kindie, Response of sorghum (Sorghum biclor (L) Moench) genotypes to sodium chloride levels at early growth stages. Afric. J. Agricul. Res. 7(43) (2012) 5711–5718.
13. R.G.D. Steel, J.H. Torrie, D.A. Dickey, Principles and procedures of statistics: a biometricapproach, Third edn. McGraw Hill Book Co. Inc.: New York, USA 1997.
14. A.K. Abari, M.H. Nasr, M. Hojjati, D. Bayat, Salt effects on seed germination and seedling emergence of two Acacia species, Afr. J. of Agric. Res. 5(1) (2011) 52–56.
15. M. Jamil, D.B. Lee, K.Y. Jung, M. Ashraf, S.C. Lee, E.S. Rha, Effect of Salt (NaCl) Stress on Germination and Early Seedling Growth of Four Vegetables Species, J. Cent. Eur. Agric. 7(2) (2006) 273–282.
16. M. Amin, A. Hamid, M.T. Islam M.A. Karim, Root and shoot growth of rice cultivars in response to salinity, Bangl. Agron. J. 6 (1996) 41–46.
17. N.B. Amor, K.B. Hamed, A. Debez, C. Grignon, C. Crabbedly, Physiological and antioxidant responses of perennial halophyte Crithmum maritimum to salinity, Plant Science 4(2005) 889–899.
18. J.E. Werner, R.R. Finkelstein, Arabidopsis mutants with reduced response to NaCl and osmotic stress, Physiologia Plantarum. 93(1995) 659–666.

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