Scientific Papers. Series A. Agronomy, Vol. LIX, 2016
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EFFECTS OF SALT STRESS ON GERMINATION OF SOME SILAGE MAIZE (*Zea mays* L.) CULTIVARS

Mevlüt TURK, Ozge ESER

Süleyman Demirel University, Faculty of Agriculture, Department of Field Crops, Isparta, Turkey

Corresponding author email: mevlutturk@sdu.edu.tr

Abstract

This study was conducted to investigate the effects of salt stress on germination of four silage maize (Zea mays L.) cultivars (Ozgem, Efe, Safak and Side). The degree of salinity tolerance among these cultivars was evaluated at seed germination stage at four different salt concentrations (0, 4, 8 and 12 dS m^{-1} NaCl). The germination percentage, salt tolerance index, shoot dry weight, root dry weight were determined in this research The results showed that in all cultivars as the salt concentration increased, germination percentage decreased significantly. Responses of cultivars to salt stress indicated differences. Cultivar Efe had the highest germination percentage. The highest shoot dry weight was obtained from cultivar Efe while the lowest shoot dry weight was obtained from cultivar Ozgem. Salt concentration decreased shoot and root dry weight. Efe and Safak had the highest root dry weight. The results showed that Efe is the cultivar to be recommended for saline soils.

Key words: *maize, germination percentage, salt tolerance index, shoot dry weight, root dry weight.*

INTRODUCTION

Maize (*Zea mays* L.) is in the third rank after wheat and rice and is grown all over the world in a wide range of climatic condition. Being highly cross pollinated, maize has become highly polymorphic through the course of natural and domesticated evolution and thus contains enormous variability in which salinity tolerance may exist (Paterniani, 1990).

High salt content in the soil is one of the most important environmental factors limiting global crop production. Out of 230 million hectares of irrigated agricultural land approximately 45 million hectares are salt-affected (Athar and Ashraf, 2009). Salinity is a major environmental constraint to crop productivity throughout the arid and semi-arid regions of the world (Foolad and Lin, 1997). Salinity has reached a level of 19.5 % of all irrigated-land (230 million ha of irrigated land, 45 million ha are salt-affected soils and 2.1 % of dry-land (1500 million ha of dryland agriculture, 32 million are salt-affected soils) agriculture worldwide. According to the FAO, around 1.5 million ha of land have both salinity and sodicity problems (FAO, 2009).

Seed germination is a major factor limiting the establishment of plants under saline conditions. Salinity may cause significant reductions in the rate and percentage of germination, which in turn may lead to uneven stand establishment and reduced crop yields (Foolad et al., 1999).

Maize, which belongs to the plants with C4 metabolism, is also classified as moderately sensitive to salinity. For maize grown under salinity, reduction in growth characters and yield were observed (Ouda et al., 2008).

This study was conducted to determine the silage maize cultivars resistant to salt stress which can be grown on cultivated lands having salt problems.

MATERIALS AND METHODS

This study was carried out in Suleyman Demirel University, Agricultural Faculty, Field Crops Department, Turkey in 2011. Four cultivars (Ozgem, Efe, Safak and Side) of silage maize (*Zea mays* L.) were used and their seeds were obtained from the Bati Akdeniz Agricultural Research Institute. These cultivars are largely grown in Mediterranean Region by the farmers.

To obtain homogeneous emergencies after seedlings, seeds with similiar size and weight were selected. Seeds were surface sterilized in 1.5 % (v/v) sodium hypochlorite for 10 min and thoroughly washed with distilled water. Twenty seeds were placed on filter papers which contained different salt concentrations and located in 15 cm diameter steril petri dishes. Salt stress was realized by subjecting the seeds to 15 ml salt solutions of 0, 4, 8 and 12 dS m^{-1} NaCl. In addition 15 ml of distilled water without NaCl was used as control. The filter papers were changed with the new ones after 48 hours in order to avoid salt accumulation.

Germination percentage: Initiation and completion of germination was recorded daily. The germination percentage was recorded daily for 10 days and germination percentage was calculated with the following formula (Carpıcı et al., 2009):

Germination percantage (%)= Number of germinated seeds / Number of total seeds x 100.

The dry weights of the shoots and roots of the seedlings were measured immediately after 10 days. The dry weights were meausered after drying the shoot and root at 80 ºC for 24 h, to standardize the weight (Carpıcı et al., 2009).

Salt tolerance index: This value was calculated as the ratio of the total dry weight of plants subjected to different salt concentrations to the total dry weight of plants of control.

Salt tolerance index (%) = (TDW at S_x/TDW at S_0) × 100.

TDW= total dry weight, S_0 =Control, S_x=A given concentration out of five salt concentration.

The experiment was conducted by using randomized block desing with 3 replications. The data of germination percentage and stress tolerans index were transformed using by arcsine values prior to statistical analysis. Significant differences between treatments were determined using LSD test at the 0.05 level.

RESULTS AND DISCUSSIONS

The results showed that measured components of maize cultivars were significantly affected by salt concentrations (Table 1). At different salt concentrations, Efe and Safak had the highest and lowest germination percentage as 93.58% and 89.75% respectively. Rahman et al.(2000) reported that maize cultivars were significantly more tolerant to salt stress at germination than at later stages of growth. Seeds in the control and 4 dS m^{-1} NaCl treatments had the highest germination percentage (100%), and as the salt concentration increased, germination percentage decreased up to 12 dS m^{-1} NaCl treatment. There were no statistically significant differences in germination percentage among control and 4 dS m^{-1} NaCl treatments. A higher germination percentages of cultivars at control (0 dS m^{-1} NaCl) were due to lack of salt in the medium. High concentration of NaCl in the salt solution increases its osmotic potential. In addition, high absorption of Na and Cl ions during seed germination can be due to cell toxicity that finally inhibits or slows the rate of germination and thus decreases germination percentage (Taiz and Zeiger, 2002). Our results were supported by many researchers conducted on this subject (Rahman et al., 2000; Gill et al., 2002; Almodares et al., 2007; Blanco et al., 2007; Sozharajan and Natarajan, 2014).

Shoot dry weights of cultivars were negatively affected by increasing salt treatments. The average shoot dry weight of cultivars was 26.3 mg $plant^{-1}$ at control and this value gradually decreased throughout the increasing salt concentrations, and reached to 18.1 mg $plant^{-1}$ at 12 dS m^{-1}. The highest shoot dry weight was obtained from cultivar Efe while the lowest shoot dry weight was obtained from cultivar Ozgem. Our results are in agreement with the results of other researchers. For example, Hussein et al. (2007), reported that a negative relationship was detected between vegetative growth parameters and increasing salinity. In same study, shoot dry weight was 52.01 mg plant-1 at control while it decreased linearly to 25.26 mg plant-1 at 4000 ppm. The same results were also obtained by other researchers (Alberico and Cramer, 1993; Cramer et al., 1994; Mansour at al., 2005; Hoque et al., 2015; Shtereva et al., 2015).

Root dry weight of cultivars decreased significantly as the levels of salinity increased from 0 to 12 dS m^{-1} NaCl. Thus, the highest root dry weight (55.3 mg $plant^{-1}$) was determined at control and the lowest root dry weight (42.6 mg $plant^{-1}$) at the highest salinity level. Among the cultivars, Efe and Safak were affected least by salinity. Akram et al. (2007)

reported that root dry weight of all corn hybrids showed a decline towards increase in salinity level. On the other hand, reduction in plant growth as a result of salt stress has also been reported in several other plant species (Mishra et al., 1991; Ashraf and O'leary, 1997).

Table 1. Effects of different salinity levels on germination and seedling characteristics of four maize cultivars

		Germination Percentage (%)	Shoot Dry Weight (mg $plant^{-1}$)	Root Dry Weight (mg $plant^{-1}$)	Salt Tolerance Index
Salt Concentrations (dS m^{-1})					
0		100.00 a	26.3 a	55.3 a	100.00 a
4		100.00 a	23.5 b	52.4 b	70.51 b
8		92.14 b	20.8 c	48.3 c	44.29 c
12		75.02 c	18.1 d	42.6 d	26.76 d
LSD (5%)		6.42	1.8	2.4	12.25
Cultivars					
Özgem		91.50 b	20.1 d	47.1 c	60.00
Efe		93.58 a	24.4 a	51.8 a	59.21
Şafak		89.75 c	23.5 b	51.2 a	61.50
Side		92.33 b	20.7 c	48.5 b	59.85
LSD (%5)		1.05	0.5	1.2	ns
Significance	df				
Cultivars (C)	3	*	**	**	ns
Salt (S)	3	**	**	**	**
C * S int.	9	ns	ns	ns	ns

Means followed by the same letter were not significantly different at 0.05 level using LSD test. *, **, F-test significant at $P < 0.05$ and $P < 0.01$, respectively. ns, not significant.

There were no statistically significant differences in salt tolerance index among cultivars. The effects of different salt concentrations on salt tolerance indices of cultivars were significant. As the salt concentrations increased the salt tolerance indices of cultivars decreased. Therefore, the lowest value of salt tolerance index (26.76) was determined at 12 dS m^{-1} NaCl (Table 1). Our results were supported by Carpici et al. (2009). Salt tolerance at germination stage is important factor, where soil salinity is mostly dominated at surface layer. High concentration of salts have detrimental effects on germination of seeds (Rahman et al., 2000; Sharma et al., 2004; Saboora and Kiarostami, 2006). Plant growth is ultimately reduced by salinity stress but plant species differ in their sensitivity or tolerance to salts (Rogers et al., 1995).

CONCLUSIONS

The results from the effects of salt stress on germination of four silage maize in Mediterranean conditions of Turkey can be summarized as follows.

The results showed that in all cultivars as the salt concentration increased, germination percentage decreased significantly. Responses of cultivars to salt stress indicated differences. Cultivar Efe had the highest germination percentage. The highest shoot dry weight was obtained from cultivar Efe while the lowest shoot dry weight was obtained from cultivar Ozgem. Salt concentration decreased shoot and root dry weight. Efe and Safak had the highest root dry weight. The results showed that Efe is the cultivar to be recommended for saline soils.

REFERENCES

Alberico G.J., Cramer G.R., 1993. Is the salt tolerance of maize related to sodium exclusion? I. Preliminary screening of seven cultivars. J. Plant Nut., 16, 2289-2303.

Almodares A., Hadi M.R., Dosti B., 2007. Effects of Salt Stres on Germination Percentage and Seedling Growth in Sweet Sorghum Cultivars. Journal of Biological Sciences 7(8):1492-1495.

Ashraf M., O'leary J.M., 1997. Ion Distribution in Leaves Of Salt–Tolerant and Salt-Sensitive Lines of

Spring Wheat Under Salt Stress. *Acta Bot. Neerl.,* 46: 207-217.

Athar H.R., Ashraf M., 2009. Strategies for crop improvement against salt and drought. An overview. In A.M. Ozturk & H.R. Athar (Eds.), *Tasks for Vegetation Science 44, Salinity and Water Stress*. (pp. 1-18). Heidelberg, Germany.

Blanco F.F., Folegatti M.V., Gheyi H.R., Fernandes P.D., 2007. Emergence and Growth of Corn and Soybean Under Saline Stress. Sci. Agric. (Piracicaba, Braz.), 64(5):451-459.

Çarpıcı E.B., Çelik N., Bayram G., 2009. Effects of salt stress on germination of some maize (*Zea mays* L.) cultivars African Journal of Bio., 8(19): 4918-4922.

Cramer G.R., Alberico G.J., Schmidt C., 1994. Leaf Expansion Limits Dry Matter Accumulation of Salt-Stressed Maize. Aust. J. Plant Physiol. 21:663-674.

FAO, 2009. Global Network on Integrated Soil Management for Sustainable Use of Salt Effected Soils. Available in: http:/www.fao.org/ag/AGL/agll/spush/intro.htm

Foolad M.R., Lin G.Y., 1997. Genetic Potential for Salt Tolerance During Germination in Lycopersicon Species. HortScience, 32:296-300.

Foolad M.R., Hyman J.R., Lin G.Y., 1999. Relationships Between Cold and Salt Tolerance During Seed Germination in Tomato: Analysis of Response and Correlated Response to Selection. Plant Breeding, 118: 49-52.

Gill P.K., Sharma A.D., Singh P., Bhullar S.S., 2002. Osmotic Stres-Incuded Changes in Germination, Growth and Soluble Sugar Changes of Sorghum bicolor (L.) Seeds. Bulg. J. Plant Physiol., 28:12-25.

Hoque M.M.I., Jun Z., Guoying W., 2015. Evaluation of salinity tolerance in maize (*Zea mays* L.) genotypes at seedling stage. *J. BioSci. Biotechnol.* 2015, 4(1): 39-49.

Mansour M.M.F., Salama K.H.A., Ali F.Z.M., Abou Hadid A.F., 2005. Cell and Plant Repsonses to NaCl in Zea mays L. Cultivars Differing in Salt Tolerance. Gen. Appl. Plant Physiology, 31(1-2), 29-41.

Mishra S.K., Subrahmanyam D., Singhal G.S., 1991. Interrelationship Between Salt and Light Stress on Primary Processes Of Photosynthesis. *J. Plant Physiol.,* 138: 92-96.

Ouda S.A.E, Mohamed S.G., Khalıl F.A., 2008. Modeling The Effect of Different Stress Conditions on Maize Productivity Using Yield-Stress Model. International Journal of Natural and Engineering Sciences 2 (1): 57-62.

Paterniani E., 1990. Maize breeding in tropics. *Cri. Rev. Plant Sci*., 9: 125-154.

Rahman M, Kayani S.A., Gul S. 2000. Combined Effects of Temperature and Salinity Stress on Corn Cv. Sunahry, Pak. J. Biological Sci., 3(9): 1459-1463.

Rogers M.E., Noble C.L., Halloran G.M., Nicolas M.E. 1995. The Effect of NaCl on the Germination and early Seedling Growth of White Clover (*Trifolium repens* L.) Populations Selected for High and Low Salinity Tolerance. Seed. Sci. Technol., 23:277-287.

Saboora A., Kiarostami K., 2006. Salinity (NaCl) Tolerance of Wheat Genotypes at Germination and Early Seedling Growth. Pakistan Journal of Biological Sciences 9(11):2009-2021.

Sharma A.D., Thakur M., Rana M., Singh K., 2004. Effect of Plant Growth Hormones and Abiotic Stresses on Germination, Growth and Phosphatase Activities in *Sorghum bicolor* (L.) Moench Seeds. Afr. J. Biotechnol., 3:308-312.

Shtereva L.A., Vassilevska-Ivanova R.D., Karceva T.V., 2015. Effect of salt stress on some sweet corn (*Zea mays* L. *var. saccharata*) genotypes. Arch. Biol. Sci., Belgrade, 67(3), 993-1000.

Sozharajan R, Natarajan S., 2014. Germination and seedling growth of *Zea mays* L. under different levels of sodium chloride stress. International Letters of Natural Sciences 7, 5-15.