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THE EFFECTS OF DIFFERENT SALT CONCENTRATIONS ON GERMINATION AND SEEDLING PARAMETERS OF SILAGE CORN (*Zea mays* L.) VARIETIES

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ABSTRACT: The study was carried out to determine the effects of different NaCl concentrations (0 "control", 2, 4, 6, 8 and 10 dS m^{-1}) on seed germination and early seedling growth of silage corn cultivars (Burak, Efe, Hido, Safak). Eight seeds of each cultivar for each treatment were placed in a petri-dish having a diameter of 15 cm. While the germination rate was measured 5 days after sowing, root length (cm), shoot length (cm), wet root and shoot weight (mg) and dry root and shoot weight (mg) were measured 9 days after sowing. The study showed that cultivars had different responses to NaCl concentrations. It was determined that the germination rate and some seedling characteristics were reduced with increasing salinity level. The results revealed that salinity had significantly ($p \leq 0.001$) affected all the parameters studied. Maximum root length (14.6 cm), shoot length (6.8 cm), root fresh weight (365 mg $plant^{-1}$), shoot fresh weight (235.7 mg $plant^{-1}$), root dry weight (51.5 mg $plant^{-1}$), shoot dry weight (30.6 mg $plant^{-1}$) were recorded in Hido variety. Among the cultivars, Hido was the most tolerant cultivar, while Efe was the most sensitive.
Keywords: Silage corn, salinity, germination, seedling growth

FARKLI TUZ KONSANTRASYONLARININ SİLAJLIK MISIR (*Zea mays* L.) ÇEŞİTLERİNİN ÇİMLENME VE FİDE ÖZELLİKLERİNE ETKİSİ

ÖZET: Bu çalışma, farklı NaCl konsantrasyonlarının (0 "kontrol", 2, 4, 6, 8 ve 10 dS m^{-1}) bazı silajlık mısır çeşitlerinin (Burak, Efe, Hido ve Şafak) çimlenmesi ve erken fide gelişimi üzerine etkisini belirlemek amacıyla yürütülmüştür. Silajlık mısır tohumları 15 cm çapındaki petrilere her bir petride 8 adet tohum olacak şekilde ekilmişlerdir. Tohum ekiminden itibaren 5 gün sonra çeşitlerin çimlenme oranı, 9. günde ise çeşitlerin kök uzunluğu (cm), sürgün uzunluğu (cm), yaş kök ve sürgün ağırlığı (mg) ve kuru kök ve sürgün ağırlığı (mg) ölçümleri yapılmıştır. Araştırma sonucunda, çeşitlerin NaCl konsantrasyonlarına farklı tepkiler gösterdiği belirlenmiştir. Tuz stresi arttıkça çimlenme oranı ve bazı fide özellikleri ile ilgili değerlerde çeşitlere göre belirgin bir azalma olduğu belirlenmiştir. Maksimum kök uzunluğu (14.6 cm), sürgün uzunluğu (6.8 cm) kök taze ağırlığı (365 mg $bitki^{-1}$), sürgün taze ağırlığı (235.7 mg $bitki^{-1}$), kök kuru ağırlığı (51.5 mg $bitki^{-1}$) ve sürgün kuru ağırlığı (30.6 mg $bitki^{-1}$) Hido çeşidinden elde edilmiştir. Çeşitler arasında tuz stresine toleransı en yüksek Hido çeşidi olurken, tuz stresine en hassas çeşit Efe olmuştur.
Anahtar Sözcükler: Silajlık mısır, tuzluluk, çimlenme, fide gelişimi

1. INTRODUCTION

Salinity is a common abiotic stress factor seriously affecting crop production in different areas of the world, particularly in arid and semi-arid regions. Over 6 % of the world's total land area and 20% of the irrigated land area are salt-affected. Most importantly, between 35% and 50% of the world's population in about 80 countries live in semi-arid areas where salinization is a major problem. 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 in Turkey have both salinity and sodicity problems (FAO, 2009; Sönmez, 2004).

Increasing intensity of salinity affects germination, growth and development negatively. Mainly, germination and seedling development stages have been used in salinity stress studies when compared to the other growth stages (van Hoorn 1991; Ghoulam and Fares, 2001). The main reason for this is prevention of water intake by high salt concentration in the seed and thus, it shows adverse effect on the germination (Coons et al., 1990; Mansour, 1994). In addition, yield losses of plants, which have been grown in saline soils, reported by the researchers are attributed to the toxic effects of excessive ions such as Na and Cl, unbalances of the plant ion problems on nutrient uptake and disturbances, damages on photosynthesis, respiration and physiological functions (Levitt, 1980; Yeo and Flowers, 1983; Leopold and Willing, 1984).

Maize *(Zea mays* L.), which is a source of food and oil for human consumption and feed for livestock, ranks third after wheat and rice production in the world. It is grown all over the world under a wide range of environmental conditions. Maize, which belongs to the plants with C_4 metabolism, is also classified as moderately sensitive to salinity (Mass and Hofffman, 1977; Katerji et al., 1994; Ouda et al., 2008). It is accepted that the germination and seedling stage of plant life cycle is more sensitive to salinity than the adult stage.

The present study was therefore initiated to investigate the effects of different salt concentrations on germination and plant growth of corn varieties, Burak, Efe, Hido and Şafak, which can be planted in cultivated lands having salt problems in Turkey.

2. MATERIAL AND METHODS

The study was carried out in Bati Akdeniz Agricultural Research Institute in 2010. Burak, Efe, Hido and Şafak cultivars that have been registered as silage maize by the Variety Registration and Seed Certification Centre of Turkey were used as plant sources (TTSM, 2013). These cultivars are largely grown in Mediterranean Region by the farmers. Maize seeds were surface-sterilized for 20 minutes using 20% sodium hypochlorite (NaOCl) solution, then left in 70% ethyl alcohol for 5 seconds and finally kept 24 hours in distilled water. Eight seeds of each cultivar were placed on two layers of Whatman filter paper No.41 at the bottom of 15 cm diameter petri dishes. . Sodium chloride (NaCl) (Sigma Chemicals Company, St Louis, MO, USA) solution was used in order to induce salt stress. Salt concentrations including 0 (control-pure water), 2, 4, 6, 8 and 10 dS m^{-1} were prepared before starting seed germination tests. Twenty ml of each solution containing different concentrations were applied to the seeds and the edges of the petri dishes were covered with a transparent tape in order to prevent water loss. Petri dishes were kept in a germination cabinet for 9 days at 24°C and 80 % humidity for 14 h in light and at 21°C for 10 h in dark (El-Hendawy et al., 2011). Observations were taken at the same time each day, and the root length of 1 mm was considered as germinated seeds.Seed was considered as germinated when the root reached a minumum length of 1 mm.

The experiment was conducted in a factorial experiment fashion with three replications. Totally, 72 petri dishes were used and every petri dish was considered as one replication. The germination rate, root and shoot length, fresh root and shoot weight, dry root and shoot weight, traits of the varieties under salt stress were determined. Germination rate was calculated by the formula given below:

Germination rate (%) =Number of germinated seeds / Total number of seeds × 100

Root and shoot lenghts were measured using scale meter. The dry weights were measured after drying the roots and shoots at 80°C for 24 h. The relationship between germination rates changing over time and salt concentrations were shown on a graph. Variance analysis (ANOVA) applied to the root length, dry root weight, shoot length, dry shoot weight, and comparisons were made according to Duncan Multiple Tests based on 5 % significant level (Gomez and Gomez 1984).

3. RESULTS AND DISCUSSION

The results of analysis of variance test presented in Table 1 showed that salinity had significant effect on all growth parameters. The measured components (root and shoot length, fresh and dry root and shoot weight) of maize varieties were significantly affected by salt concentrations. According to the results, root length, shoot length, fresh root and shoot weight, and dry root and shoot weight were significant in 0.001 percentages for salt levels and varieties. The varieties x salt concentrations interaction had significantly ($P<0.001$) affected root and shoot length, fresh and dry shoot weight of different corn varieties except fresh and dry root weight.

Table 1. Varience anaysis results with respect to some germination characteristics of corn varieties

Source of variation	df	Root length (cm)	Shoot length (cm)	Fresh root weight (mg)	Fresh shoot weight (mg)	Dry root weight (mg)	Dry shoot weight (mg)
Varieties V)	3	***	***	***	***	***	***
Error (V)	6						
Salt concentrations (S)	5	***	***	***	***	***	***
V x S	15	***	***	N.S.	***	N.S.	***
Error (V x S)	48						
Total	71						

N.S., and ***: Non significant and significant at % 0.1, respectively.

The effect of different salt concentrations on germination ratio (%) was shown in Fig. 1. Generally, in all varieties studied, germination ratio decreased as salt concentration increased. Seeds in all treatments reached 100 % germination ratio in five days in Hido variety while a germination ratio less than 80 % was obtained from Efe, except for 0 and 2 dS m^{-1} treatments. After fifth days, 100 % of the seeds in all of the control treatments were germinated, indicating that there was no difference among varieties in terms of germination ratio under non-saline conditions. The germination ratio in the first three days decreased depending on the salt concentrations for all varieties. Although the germination ratio increased as time progressed, it was differentiated depending on various salt concentrations in the fifth day of the experiment. Seed germination of Burak, Efe, and Şafak were more affected by salt stress than Hido.

The decrease in germination ratio in higher salt concentrations may be caused by hindrance of water uptake, toxic effect of a special ion or inactivation of some enzymes necessary for germination (Greenway and Munns, 1980; Shalhevet et al., 1995; Wang and Shannon, 1999; Shonjani, 2002; Khlajeh-Hosseini et al., 2003; Dan and Brix, 2007; Tavili and Biniaz, 2009). The results obtained in this study are consistent

with results obtained in the other studies (Katerji et al., 1994; Marambe and Ando, 1995; Almodares et al., 2007; Geressu and Gezaghegne, 2008; Mustafa et al., 2010).

The effects of different salt concentrations on root and shoot length of corn cultivars are presented in Table 2 and 3, respectively. Statistical analysis of the data indicated that corn varieties and various salinity levels had a significant ($p \leq 0.001$) effect on root length. It was clear from the data that the root lengths of varieties were significantly reduced with an increase in salinity levels. The maximum root length among the varieties was obtained with cv. Hido (19.3 cm) in control treatment while minimum root length of was obtained with cv. Şafak (7.8 cm) in 10 dS m^{-1}. Mean values of the data revealed that root length was maximum (14.6 cm) in cv. Hido while was minimum (12.2 cm) in cv. Burak. Statistical analysis of the data indicated that different salinity levels had significantly ($p \leq 0.001$) effect on shoot length. Analysis of the data showed that maximum shoot length of 9.7 cm was measured at control treatment while the shoot length was minimum (1.1 cm) when the plants were exposed to high levels of salinity (10 dS m^{-1}).

The root and shoot length are important criteria in salinity studies as these plant parts are in direct contact with soil particles and solution. In the study, when the salinity levels increased, root and shoot length decreased. The reason for that the root and shoot length are affected negatively by salt stress stems from the fact that cytokinesis and cell expansion are inhibited by toxic effect of salts. Additionally, the decrease in hormones that stimulate the growth and increase in hormones that hinder growth can cause shorter root and shoot lengths (Prakash and Prathapasenan, 1990; Begum et al., 1992; Foolad, 1996; Taiz and Zaiger, 1998; Atak et al., 2006). The increase in osmotic pressure around the roots as a result of saline environment can also prevent water uptake by roots, resulting shorter root and shoot length (Radic et al., 2007; Farsiani and Ghobadi, 2009).

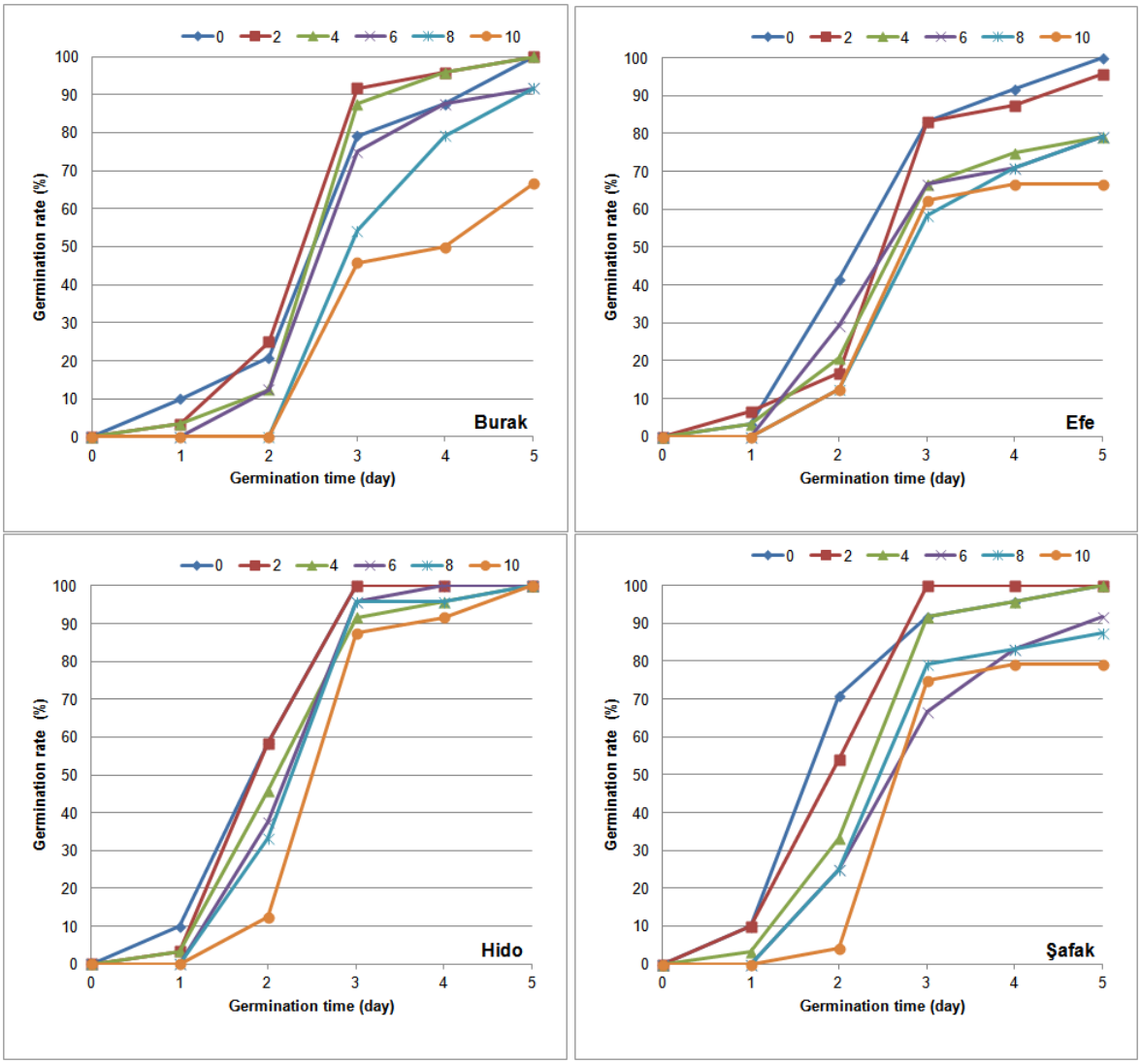

Figure 1. The effects of different salt concentration on maize germination ratio.

The effects of different salt concentrations on fresh and dry root weight of corn seeds are presented in Table 4 and 5. It was determined that variety, concentration, and interaction of variety-concentration is significant at 0.1 % confidence level. In the study, fresh root weights are ranged from 122.6 to 496.7 mg. The highest fresh root weights, as expressed the mean of varieties, are obtained from Hido variety (365.0 mg) and this was followed by Efe (315.0 mg), Şafak (263.4 mg) and Burak (193.4 mg) varieties. The highest fresh root weight, as a mean of concentrations, was acquired from 2 dS m^{-1}, it decreased as salt concentration increased and reached the lowest fresh root weight (170.6 mg) in the treatment of 10 dS m^{-1} (Table 4).

Table 2. The effects of different salt concentrations on root length of corn varieties (cm)

Varieties	Salt concentrations (dS m^{-1})						Mean of varieties
	0	2	4	6	8	10	
Burak	16.5 bc	16.2 bd	11.7 gj	11.2 hk	8.8 lm	9. km	12.2 C[y]
Efe	14.6 cf	16.1 bd	16.0 bd	14.0 dg	10.3 ıl	9.6 jm	13.4 B
Hido	19.3 a	18.3 ab	15.1 ce	13.5 eh	12.3 fi	9.4 jm	14.6 A
Şafak	18.1 ab	16.9 bc	15.4 ce	12.6 fı	8.7 lm	7.8 m	13.2 B
Mean of concentrations	17.1 A	16.8 A	14.5 B	12.8 C	10.1 D	9.0 D	

Significance: Variety (V): ***[z] Salt concentrations (S): *** VxS: ***

[y]:Means different according to Duncan test at 5% confidence level are shown using different letters.

[z]: ***, significant at 0.1% confidence level.

Table 3. The effects of different salt concentrations on shoot length of corn varieties (cm).

Varieties	Salt concentrations (dS m^{-1})						Mean of varieties
	0	2	4	6	8	10	
Burak	4.1 ef	3.3 fi	2.3 ık	2.1 jl	2.1 ıl	1.5 kl	2.6 D[y]
Efe	6.4 c	8.4 b	5.7 cd	4.6 ed	2.4 ık	2.7 ıj	5.0 B
Hido	9.7 a	9.6 a	7.8 b	7.9 b	3.8 eg	2.1 ıl	6.8 A
Şafak	4.6 ed	4.6 ed	3.8 eg	3.6 eh	2.2 ıl	1.1 l	3.3 C
Mean of concentrations	6.2 A	6.5 A	4.9 B	4.5 B	2.6 C	1.8 D	

Significance: Variety (V): ***[z] Salt concentrations (S): *** VxS: ***

[y]:Means different according to Duncan test at 5% confidence level are shown using different letters.

[z]: ***, significant at 0.1% confidence level.

Root dry weight of varieties decreased significantly as the levels of salinity increased from 0 to 10 dS m^{-1} NaCl. Thus, the highest root dry weight was found in the control (55.7 mg) and the lowest root dry weight at the highest salinity level (34.2 mg). Among the varieties, Hido was the least affected variety by salinity. The first organ that interacts with salt is roots, as in the case for most crops. From this point of view, the results are in accord with the already published studies which reported that increasing salt concentration negatively affects root development (Çarpıcı et al., 2009; Collado et al., 2010; Hussain et al., 2010; Akram et al., 2010; Khayatnezhad and Gholamin, 2011).

The analysis of variance results for fresh and dry shoot weight of 4 varieties were presented in Table 6 and 7. Data showed differing responses of the varieties to increasing NaCl levels and it was also showed that the varieties responded differently to increasing NaCl levels than control. All the varieties studied were affected significantly and the effect was found to be similar to each other in all varieties, except in Burak. Means of fresh shoot weight values showed that all varieties except these three varieties (Burak, Efe and Hido) showed better response and fresh shoot weight ranging from 65.0 and 235.7mg (Table 6).

The effects of salinity for the dry shoot weight results mentioned in Table 7 showed that dry shoot weight in control and 2 dS m^{-1} treatments were maximum in all varieties but it was gradually decreased as the NaCl concentration was increased. There was no statistically difference among treatments in control, 2, 4 and 6 dS m^{-1}. The lowest dry shoot weight was found to be in the case of highest salinity level (10 dS m^{-1}). Maximum dry shoot weight was obtained from cv. Hido (30.6 mg $plant^{-1}$). Efe and Şafak cultivars ranked 2nd and 3rd with dry shoot weight of 20.9 and 14.2 mg $plant^{-1}$, respectively. Minimum dry shoot weight was recorded in Burak (13.2 mg $plant^{-1}$). The increase in salinity up to 10 dS m^{-1} caused a 66 % reduction of shoot dry weight compared with control. It has been reported that high concentrations of salinity caused lower shoot fresh and dry weight in maize (Kayani and Rahman, 1987; Jan et al., 1995; Farahbakhsh and Saiid, 2009; Bakht et al., 2011; Khodarahmpour and Motamedi, 2011).

As a result, salt treatment affects differently early growth stages of plants. It is supposed that seeds could germinate at several salt levels, but they could not continue their development. Salinity has both osmotic and specific ion effects on plant growth. In present study, salt stress caused a significant decrease in shoot and root length, fresh and dry weights of shoot and root of four varieties with increased stress treatments. In the light of the findings of this study, it could be said that the variety Hido is more salt tolerant than the other varieties. This variety seems to be promising to be grown in salt affected soils.

Table 4. The effects of different salt concentrations on fresh root weight of corn varieties (mg).

Varieties	Salt concentrations (dS m^{-1})						Mean of varieties
	0	2	4	6	8	10	
Burak	234.0	276.7	230.0	148.3	148.6	122.6	193.4 D[y]
Efe	347.3	411.0	378.0	325.6	234.0	194.3	315.0 B
Hido	440.3	496.7	365.3	333.0	297.6	257.3	365.0 A
Şafak	352.3	340.3	360.3	268.6	150.6	108.0	263.4 C
Mean of concentrations	343.5 A	381.2 A	333.4 A	268.9 B	207.7 C	170.6 C	

Significance: Variety (V): ***[z] Salt concentrations (S): *** VxS: N.S.
[y]: Means different according to Duncan test at 5% confidence level are shown using different letters.
[z]: N.S., and ***, not significant and significant at % 0.1, confidence level, respectively.

Table 5. The effects of different salt concentrations on dry root weight of corn varieties (mg).

Varieties	Salt concentrations (dS m^{-1})						Mean of varieties
	0	2	4	6	8	10	
Burak	50.9	51.1	43.9	42.8	32.2	28.3	41.5 B[y]
Efe	55.3	49.4	53.9	56.0	46.6	31.6	48.8 A
Hido	56.5	57.6	51.5	44.0	51.5	47.6	51.5 A
Şafak	60.1	55.7	57.2	47.7	35.4	29.4	47.6 A
Mean of concentrations	55.7 A	53.5 AB	51.6 AB	47.6 B	41.4 C	34.2 D	

Significance: Variety (V): ***[z] Salt concentrations (S): *** VxS: N.S.
[y]: Means different according to Duncan test at 5% confidence level are shown using different letters.
[z]: N.S., and ***, not significant and significant at % 0.1, confidence level, respectively.

Table 6. The effects of different salt concentrations on fresh shoot weight of corn varieties (mg).

Varieties	Salt concentrations (dS m^{-1})						Mean of varieties
	0	2	4	6	8	10	
Burak	86.3 gi	78.0 gj	60.6 hj	55.1 ıj	65.7 hj	44.5 ij	65.0 C
Efe	193.3 de	245.9 cd	164.5 ef	123.3 fg	64.1 hj	93.0 gi	147.4 B
Hido	313.0 ab	365.5 a	279.5 bc	270.6 bc	113.2 fh	72.6 gj	235.7 A
Şafak	98.7 gi	97.1 gi	88.7 gi	94.9 gi	46.6 ij	26.4 j	75.4 C
Mean of concentrations	172.8 AB	196.6 A	148.3 BC	136.0 C	72.4 D	59.1 D	

Significance: Variety (V): ***[z] Salt concentrations (S): *** VxS: ***
[y]:Means different according to Duncan test at 5% confidence level are shown using different letters.
[z]: ***, significant at 0.1% confidence level.

Table 7. The effects of different salt concentrations on dry shoot weight of corn varieties (mg).

Varieties	Salt concentrations (dS m^{-1})						Mean of varieties
	0	2	4	6	8	10	
Burak	19.2 dg	13.6 gj	11.3 ij	11.2 ij	12.5 hj	11.2 ij	13.2 C[y]
Efe	25.4 cd	25.6 c	21.9 cd	20.8 cf	14.3 gi	17.1 ei	20.9 B
Hido	35.2 b	42.8 a	36.6 ab	36.6 ab	19.9 cg	12.7 hj	30.6 A
Şafak	17.1 ei	15.3 fi	16.1 ei	17.8 eg	11.1 ij	7.8 j	14.2 C
Mean of concentrations	24.2 A	24.3 A	21.5 A	21.6 A	14.5 B	12.2 B	

Significance: Variety (V): ***[z] Salt concentrations (S): *** VxS: ***
[y]:Means different according to Duncan test at 5% confidence level are shown using different letters.
[z]: ***, significant at 0.1% confidence level.

5. REFERENCES

Akram, M., Ashraf, M.Y., Ahmad, R., Waraich, E.A., Iqbal, J., Mohsan, M. 2010. Screening for salt tolerance in maize (*Zea mays* l.) hybrids at an early stage. Pakistan Journal of Bot., 42: 141-151.

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 Sci., 7(8):1492-1495.

Atak, M., Kaya, M.D., Kaya, G., Killi, Y., Ciftci, C.Y. 2006. Effects of NaCl on the germination, seedling growth and water uptake of triticale .Turkish Journal of Agricultural For., 30: 39-47.

Bakht, J., Shafi, M., Jamal, Y., Sher, H., 2011. Response of maize (*Zea mays* L.) to seed priming with NaCl and salinity stres. Spanish Journal of Agricultural Res., 9(1): 252-261.

Begum, F., Karmoker, J.L., Fattah, Q.A., Maniruzzaman, A.F.M. 1992. The Effect of salinity on germination and its correlation with K, Na, Cl accumulation in germinating seeds of *Triticum aestivum*. Plant Cell Phys., 33: 1009-1014.

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.

Collado, M.B., Arturi, M.J., Aulicino, M.B., Molina, M.C. 2010. Identification of salt tolerance in seedling of maize (*Zea mays* L.) with the cell membrane stability trait. International Research Journal of Plant Sci., 1(5): 126-132.

Coons, J.M., Kuehl, R.O., Simons, N.R. 1990. Tolerance of ten lettuce cultivars to high temperature combined with NaCl during germination. Journal of American Society for Hortic. Sci., 115:1004–1007.

Dan, T.H., Brix, H. 2007. The influence of temperature, light, salinity and seed pre-treatment on the germination of sesbania sesban seeds. African Journal of Bio., 6(19): 2231-2235.

El-Hendawy, S.E., Hu, Y., Sakagami, J.I., Schmidhalter, U. 2011. Screening Egyptian wheat genotypes for salt tolerance at early growth stages. International Jornal of Plant Pro., 5(3):283-298.

FAO, 2009. FAO Land and Plant Nutrition Management Service. Available from URL:http://www.fao.org/ag/agl/agll/spush/ [Ulaşım:15 Eylül 2011].

Farahbakhsh, H,. Saiid, M.S. 2009. Effects of seed priming NaCl on ermination traits of maize under different saline conditions. Plant Ecophys., 3: 119-122.

Farsiani, A., Ghobadi, M.E. 2009. Effects of PEG and NaCl stress on two cultivars of corn (*Zea mays* L.) at germination and early seedling stages. World Academic Science Engineering Technol., 57: 382-385.

Foolad, M.R. 1996. Response to selection for salt tolerance during germination in tomato seed derived from PI174263. Journal of American Society Hortic. Sci., 121: 1001-1006.

Geressu, K., Gezaghegne, M. 2008. Response of some lowland growing sorghum (*Sorghum bicolor* L. Moench) accession to salt stress during germination and seedling growth. African Journal of Agricultural Res., 3(1): 44-48.

Ghoulam, C., Fares, K. 2001. Effect of salinity on seed germination and early seedling growth of sugar beet (*Beta vulgaris* L.). Seed Science Tech., 29: 357-364.

Gomez, K.A., Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. 2nd Edition, John Wiley & Sons, New York.

Greenway, H., Munns, R. 1980. Mechanism of salt tolerance in non-halophytes. Annual Review Plant Phys., 31: 149-190.

Hussain, K., Majeed, A., Nawaz, K., Nisar, M.F. 2010. Changes in morphological attributes of maize (*Zea mays* L.) under NaCl salinity. American-Eurasian J. Agric. & Environ. Sci., 8(2): 230-232.

Jan, N., Khatak, S.G., Khattak, J. 1995. Effect of vaious levels of salinity on germination of different maize cultivars. Sarhad J. Agric., 11: 721-724.

Katerji, N., van Hoorn, J.W., Hamdy, A., Karam, F., Mastrorilli, M. 1994. Effect of salinity on emergence and on water stress and early seedling growth of sunflower and maize. Agricultural Water Man., 26: 81-91.

Kayani, S.A., Rahman, M. 1987. Salt tolerance in corn (*Zea mays L.*) at the germination stage. Pakistan Journal Bot., 19: 9-15.

Khayatnezhad, M., Gholamin, R. 2011. Effects of salt stress levels on five maize (*Zea mays* L.) cultivars at germination stage. African Journal of Bio., 10 (60): 12909-12915.

Khlajeh-Hosseini, M., Powell, A.A., Bingham, I.J. 2003. The interaction between salinity stres and seed vigour during germination of soybean seeds. Seed Sci. &Technol., 31: 715-725.

Khodarahmpour, Z., Motamedi, M. 2011. Evaluation of drought and salinity stress effects on germination and early growth of two cultivars of maize (*Zea mays* L.). African Journal of Bio., 10(66): 14868-14872.

Leopold, A.C., Willing, R.P. 1984. Evidence of Toxicity Effects of Salt on Membranes. In: Salinity Tolerance in Plants. pp. 67-76. John Wiley and Sons, New York.

Levitt, J. 1980. Responses of Plants to Environmental Stresses. 2nd Ed. Academic Press, New York.

Maas, E.V., Hoffman, G.J. 1977. Crop salt tolerance-current assesment. J. Irrig. Drain. Div. Am. Soc. Civ. Eng., 103: 115-134.

Mansour, M.M.F. 1994. Changes in growth, osmotic potential and cell permeability ofwheat cultivars under salt stres. Biologica Plan., 36: 429-434.

Marambe, B., Ando, T. 1995. Physiological basis of salinity tolerance of sorghum seeds during germination. Journal of Agronomy and Crop Sci., 174(5): 291-296.

Mustafa, M., Shabber, S., Hussain, K. 2010. Growth retitence of maize (*Zea mays* L.) under different levels on NaCl stres. American-Eurasian J. Agric. &Environ. Sci., 7(5): 583-585.

Ouda, S.A.E., Mohamed, S.G., Khalil, F.A. 2008. Modeling the effect of different stress conditions on maize productivity using yield-stress model. Int. J. Natural Eng. Sci., 2(1): 57-62.

Prakash, L., Prathapasenan, G. 1990. Interactive effect of NaCI salinity and gibberellic acid and gibberellin like substances and yield of rice (*Oryza sativa* L. var. G.R.3). Proceedings of the Indian Academy of Sci., 100: 173-181.

Radic, V., Beatovic, D., Mrda, J. 2007. Salt tolerance of corn genotypes (*Zea mays* L.) during germination and later growth. Journal of Agricultural Sci., 52(2): 115-120

Shalhevet, J., Huck, M.G., Schroeder, B.P. 1995. Root and shoot growth responses to salinity in maize and soybean. Agronmy Jour., 87(3): 512-516.

Shonjani, S. 2002. Salt sensivity of rice, maize, sugar beet, and cotton during germination and early vegetative growth. PhD Thesis, Inst. of Plant Nutrition, Justus Liebig Univ.

Sönmez, B. 2004. Türkiye Çoraklık Kontrol Rehberi. Toprak ve Gübre Araştırma Enstitüsü Müdürlüğü, Teknik Yayın No:33, Ankara.

Taiz, L., Zeiger, E. 1998. Plant Physiology. 2nd Edition. Sinauer Associates Ins. Publisher, Sunderland, Massachusetts, USA.

Tavili, A., Biniaz, M. 2009. Different salts effects on the germination of *Hordeum vulgare* and *Hordeum bulbosum*. Pakistan J. of Nut., 8(1): 63-68.

TTSM, 2013. Tarla bitkileri milli çeşit listesi: Tescilli çeşitler. http://www.ttsm.gov.tr/TR/belge/1-248/tescilli-cesitler-listesi.html

Van Hoorn, J.W. 1991. Development of soil salinity during germination and early seedling growth and its effect on several crops. Agricutural Water Man., 20: 17-28.

Wang, D., Shannon, M.C. 1999. Emergence and seedling growth of soybean cultivars and maturity groups under salinity. Plant and Soil, 214: 117-124.

Yeo, A.R., Flowers, T.J. 1983. Varietal difference in the toxicity of sodium ions in rice leaves. Physiologia Plan., 159: 189-195.