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THE IMPACTS ON SEEDLING ROOT GROWTH OF WATER AND SALINITY STRESS IN MAIZE (*ZEA MAYS INDENTATA* STURT.)

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Abstract

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Effects of salinity and available water level at the seedling stage of dent corn variety were examined for some shoot and root characters. Two different salinity and four available soil water level had no effect on the emergence of corn. The highest values for root dry matter, leaf water loss, shoot fresh weight were obtained in 1.35 salinity water treatment. Generally, 2.7 salinity water treatment was decreased by all of the characters except for the number of leaves per plant and leaf fresh weight. 75% available water treatment caused in increasing the dry matter root and shoot, fresh weight for root and shoot, shoot and root length, number of leaves per plant and leaf fresh weight. The lowest values for all the characters were obtained by 25 % available water treatments.

Key words: salinity, drought, leaf water loss, dry matter, shoot, root, corn

Introduction

Salinity and drought are the most serious problems in arid and semi-arid areas which limit crop production (Maiti et al., 1994 and Khan et al., 2001). It is estimated that about 7 % of the land area and about 5% of agricultural land in the world has been exposed to salinity (Ghassemi et al., 1995; Flowers et al., 1997 and Munns et al., 2002), which was caused by inadequate drainage, low quality irrigation water and land clearing. Besides, bringing into cultivation efforts of marginal lands with a high degree of natural salinity to produce more food for improving the population has increased the salinity problem (Flowers and Yeo, 1995). Over 50% of all irrigated lands are affected by salinization (El Swaify et al., 1983).

Plant growth in saline soils is affected mainly by the reduced availability of water due to high osmotic pressure. The growth stage of the plants is very important when considering salt tolerance. Plants are more sensitive to high salinity during germination and seedling stages, immediately after transplanting and when subject to other (e.g., disease, insect, nutrient) stresses (Saglam, 1993). Selection of crop cultivars resistant to field drought conditions is difficult to obtain due to the fluctuation of edaphoclimatic conditions. Water stress has been defined as the induction of turgor pressure below the maximum potential pressure (Osmond et al., 1987; Fitter and Hay, 1987). The magnitude of such stress is determined by extend and duration of the deprivation.

Maize, one of the major cereal crops, is the most salt-sensitive of the cereals (Maas and Hoffman, 1977). Khan et al. (2003) stated that it contains huge

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variability in which salinity tolerance may exist. Genotypic variability of selective traits for seedling tolerance to several stress factors has been documented and is claimed to be of great importance in crop improvement (Turhan et al., 2003). Drought effects stand establishment, inhibiting the growth, leaf extension, leaf area, and initiations of reproductive meristem, and grain filling. The effects of drought on maize production vary in different growth stages, affecting dry mass and grain production in maize (Hetrick et al., 1987; Hall, 1988 and Sinclair et al., 1990). Salinity reduces water potentials in the leaves of maize and length and dry mass of the stem (Izzo et al., 1991), and affects leaf elongation and water transport in xylem vessels in maize, as well as length and conductivity of the root in maize (Azaizeth and Steudle, 1991; Evlagon et al., 1992). Adequate information on seedling tolerance of maize to drought and salinity is not available. Although from the agronomy stand point, the most important trait of maize cultivars submitted to drought or salinity reflect their adaptation at the early crop establishment phase and their potentials of grain yield.

Materials and Methods

A material of dent corn was provided by the Department of Field Crops, Agricultural Faculty, and Namэk Kemal University in Turkey. Dent corn variety Pioneer 3397 was evaluated for seedling resistance in three salinity stresses (control, 1.35 dS/m and 2.70 dS/m) and four available soil water levels (25%, 50%, 75% and field capacity), adapting a randomized plot design in three replications in each treatment (Turhan, 1997).

Five seeds were sown in each pot (13.5 cm high and 7.6 cm in diameter) with a bottom drainage hole in xeralf (Cangir and Boyraz, 2001) at 5 cm depth. Each pot contained 350 g xeralf. The permanent wilting point (PWP) was measured on xeralf samples (350 g) passing a 2 mm sieve and each pot was satured for 24 hours, and then equilibrated for 72 to 96 hours at 1500 kPa on AWC = FC-PWP. Where AWC is available water capacity; FC is field capacity and PWP is permanent wilting point (Цzdemir et al., 2000; Arэn and Kэyak, 2003). After sowing, the pots were irrigated with top water (0 dS/m, 1.35 dS/m and 2.70 dS/m salinity water) to FC. Two concentrations of NaCl (MERC) namely, 864 PPM and 1728 PPM were used for 1.35 dS/m, 2.71 dS/m salinity water. After FC, by means of above mentioned methods, pots were weighed (seeds and pots weights to eliminate replication) until determining PWP. It was maintained to AWC by weighing each pot every day applying the required amount of water (water solution was not included in plant nutrient elements and salt). Three days after the emergence of the entire seedling, the seedlings were thinned to three in each pot. Fifteen days after emergence, the plants removed from the pots, and shoots were separated from the roots and washed carefully with water (Maiti et al., 1996). Shoot and root fresh weight (FW), number of leaves per plant, shoot and root dry weight (DW), shoot and root length, leaf fresh weight and leaf weights after 2 h at 30^{o}C (Clarke and McCaig 1982) of stressed and non stressed plants in drought and saline conditions were determined. Leaf water loss was calculated using the following formula (Clarke and McCaig 1982). The Leaf water loss = Fresh leaf weight - leaf weight (after 2 h incubation in 30^{o}C). Leaf, shoot and root samples dried at 78^{o}C for 24 h, to determine dry mater (DM). The results were analyzed using the MSTAT software program.

Results and Discussion

Effects of different salinity and water stress treatments during the seedling stage in corn are given in Figures 1-6 and Tables 1 and 2.

There were found statistically significant differences among salinity level and available water level treatments for fresh leaf weight, length of shoots and roots. 1.35 and 2.70 dS/m salinity water treatment resulted in increasing shoot fresh weight, root dry matter and leaf water loss. The water loss rate 0 dS/m salinity water treatment showed the higher root and shoots length, root fresh weight; shoot dry matter weight than 1.35 dS/m and 2.70 dS/m water salinity treatments (Figures 1, 2 and 3). The water loss rate 0 dS/m sa-

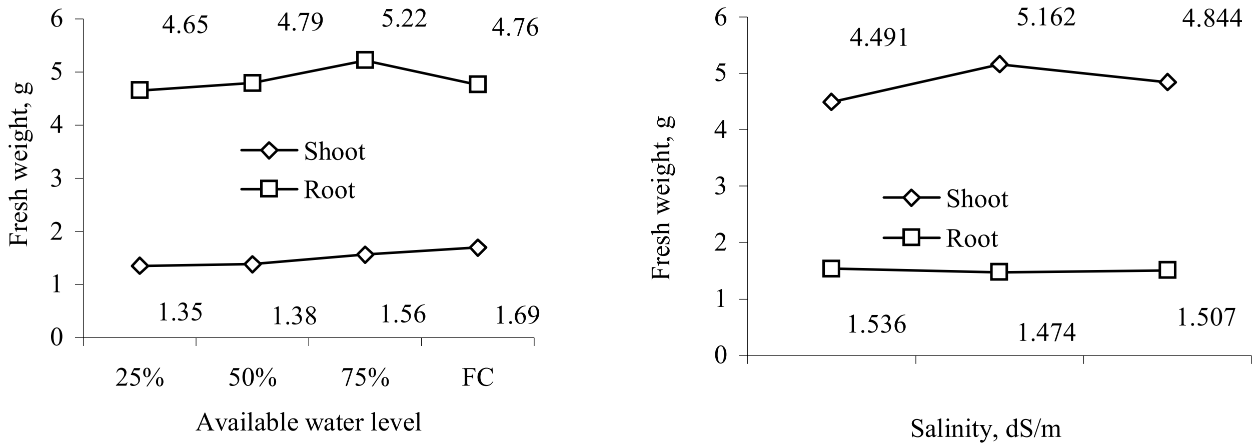

Fig. 1. Effects of salinity and available water levels on shoot and root fresh weight

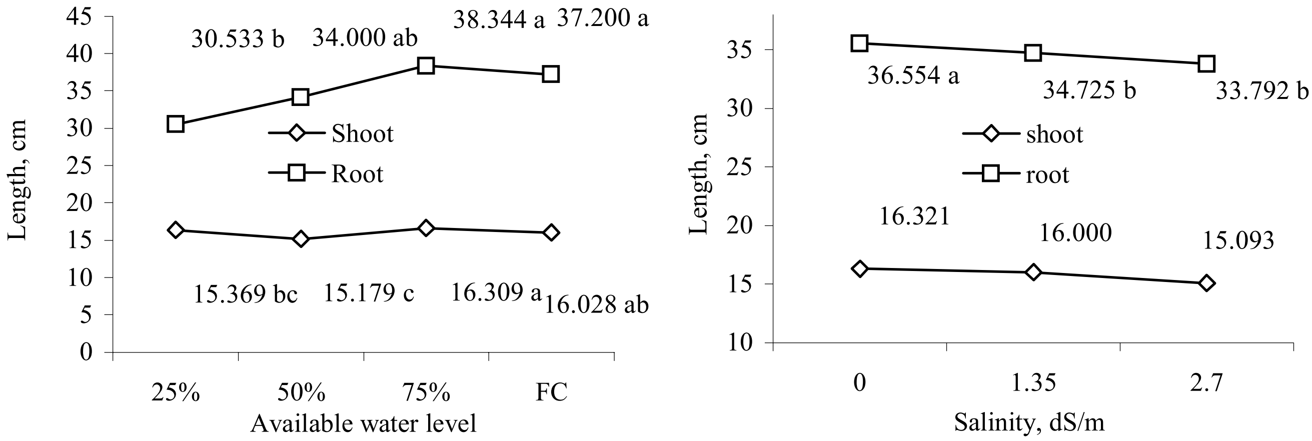

Fig. 2. Effects of salinity and available water levels on shoot and root length in corn seedling (LSD P ≤ 0.05 Shoot (available water 0.799), Root (salinity: 1.751, available water: 4.366)

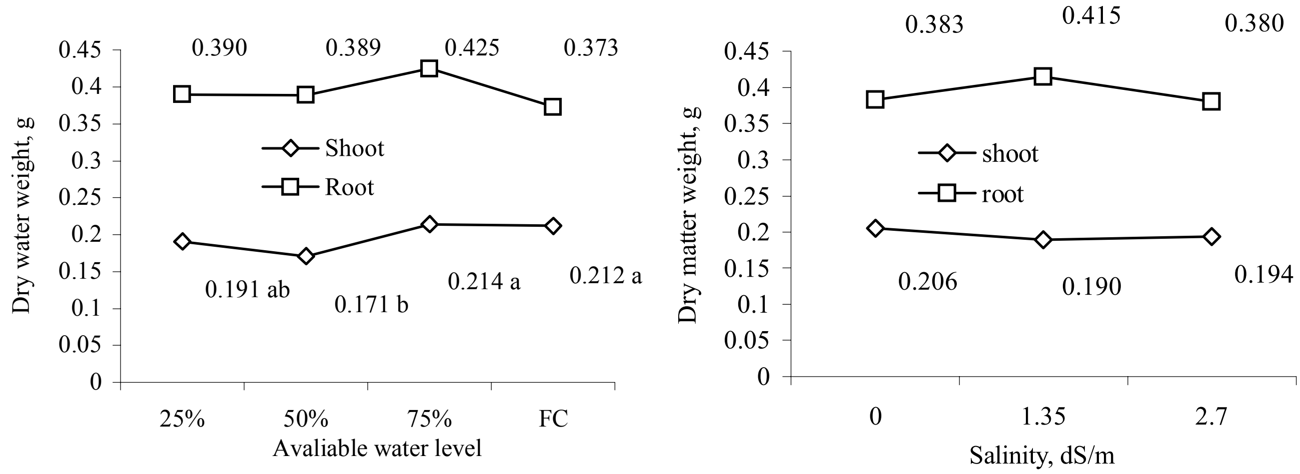

Fig. 3. Effects of salinity and available water levels on dry matter of shoots and roots (LSD P ≤ 0.05 Shoot (available water 0.027 and salinity and available water interaction 0.0542)

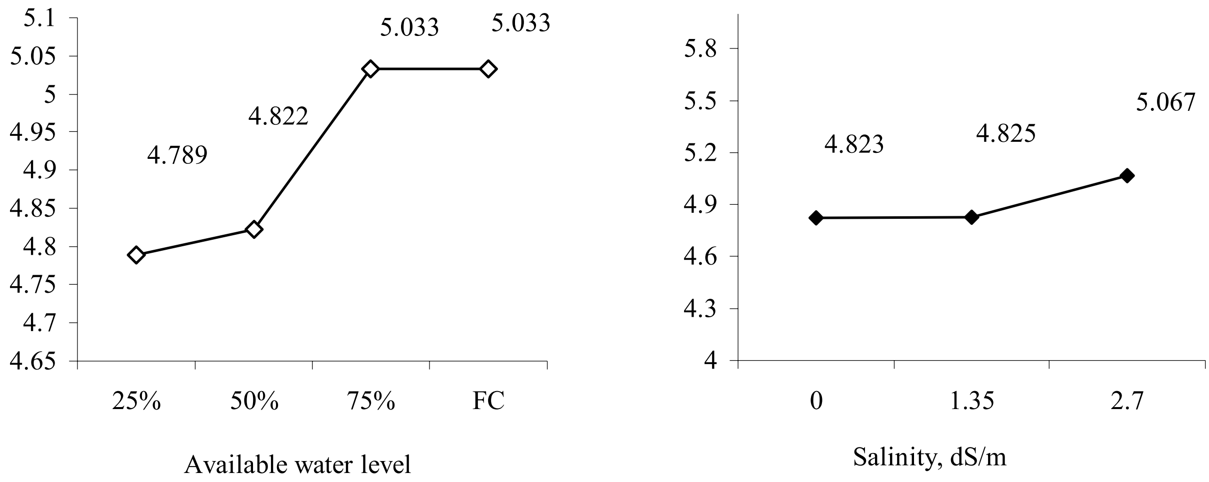

Fig. 4. Effects of salinity and available water levels on leaf number per plant

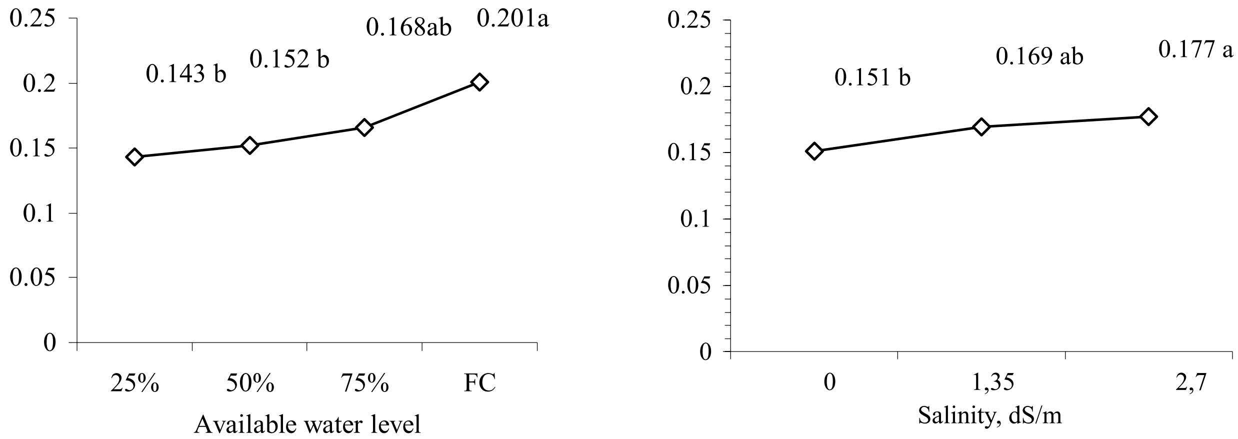

Fig. 5. Effects of salinity and available water levels on leaf fresh weight in corn seedlings (LSD P $\leq$ 0.05 Shoot (salinity: 0.018, available water level: 0.038)

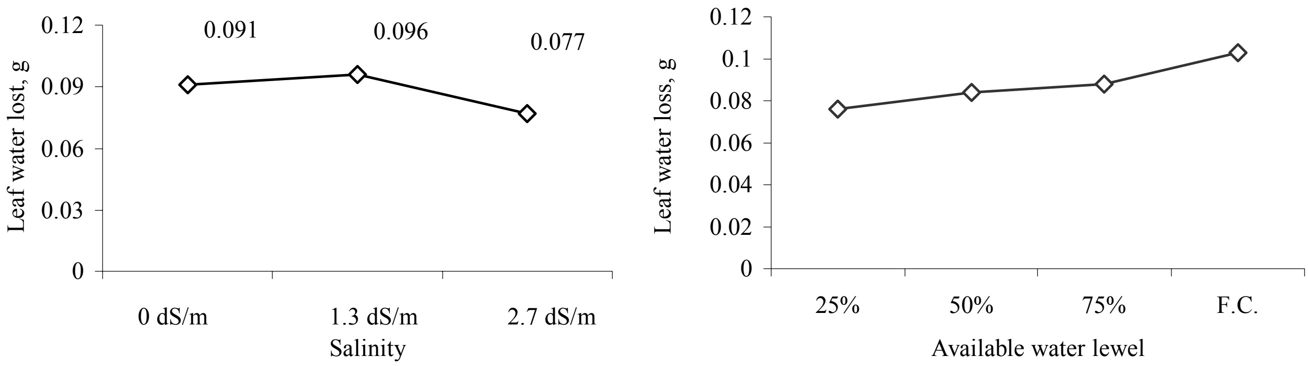

Fig. 6. Effects on salinity and available water levels on the leaf water loss

Table 1

Shoot and root fresh weights and Shoot and root length of corn seedlings

Salinity	Shoot weight, g Available water, %				Root weight, g Available water, %			
	25	50	75	FC	25	50	75	FC
0 dS/m	4.887	3.820	4.777	4.500	1.473	1.307	1.610	1.753
1.35 dS/m	5.093	5.207	5.240	5.107	1.317	1.320	1.453	1.663
2.70 dS/m	3.977	5.340	5.650	4.387	1.273	1.497	1.617	1.643

Table 1 continued

Shoot and root fresh weights and Shoot and root length of corn seedlings

Salinity	Shoot length, g Available water, %				Root length, g Available water, %			
	25	50	75	FC	25	50	75	FC
0 dS/m	15.857	15.107	17.533	16.787	31.700	35.183	39.167	40.167
1.35 dS/m	15.653	15.843	16.620	15.863	30.133	32.567	39.400	36.800
2.70 dS/m	14.597	14.587	15.753	15.433	29.767	34.300	36.467	34.633

P?0.05 Shoot (available water 0.799)

Root (salinity: 1.751, available water: 4.366)

Table 2

Shoot and root dry weights, number of leaves, leaf fresh weight and leaf retention ability of corn seedlings

Salinity	Shoot dry weight, g Available water, %				Root dry weight, g Available water, %			
	25	50	25	FC	25	50	75	FC
0 dS/m	0.191	0.139	0.245	0.25	0.39	0.341	0.381	0.418
1.35 dS/m	0.194	0.174	0.202	0.19	0.441	0.423	0.425	0.4
2.70 dS/m	0.188	0.2	0.194	0.196	0.368	0.402	0.449	0.301

P?0.05 Shoot (available water 0.027)

(salinity x available water interaction 0.0542)

Table 2 continued

Shoot and root dry weights, number of leaves, leaf fresh weight and leaf retention ability of corn seedlings

Salinity	Number of leaves, unit Available water, %				Leaf fresh weight, g Available water, %				Leaf retention ability, g Available water, %			
	25	50	75	FC	25	50	75	FC	25	50	75	FC
0 dS/m	4.633	4.733	5.000	5.100	0.131	0.121	0.163	0.19	0.072	0.074	0.103	0.114
1.35 dS/m	4.867	4.633	5.000	4.933	0.142	0.181	0.13	0.223	0.074	0.104	0.074	0.132
2.70 dS/m	5.000	5.100	5.000	5.067	0.157	0.154	0.204	0.191	0.082	0.075	0.086	0.065

linity water treatment (39.9 %) was found the lower than 1.35 dS/m (43.5 %) and 2.70 dS/m water salinity treatments (55.7 %). All of the examined characters except for leaf number per plant and leaf fresh weight, the lowest values were obtained in 2.7 dS/m salinity treatments (Tables 1 and 2**).** These results show that increasing of salinity rate causes the important decreases on the characters of corn seedlings. Arin and Kiyak (2003) state that the fresh weight and seedling diameter were increased by stress conditions; but the results were in partly accordance with Misra and Dwivedi (2004). It was reported that the FW and DW in seedlings were decreased by salinity. Other values were similar to those designated by Maas (1990), Izzo et al. (1991), Evlagon et al. (1992), Maiti et al. (1994) and Maiti et al. (1996).

As can be seen in the Figures, the effects of available water levels on the characters were found significant for shoot and root dry weight, shoot and root length, leaf fresh weight. The highest leaf fresh weight, leaf water loss rate and shoot fresh weight was obtained from field capacity soil water level. (Figures 6 and 1). In addition, the maximum root and shoot dry matter, shoot and root height, numbers of leaves per plant and root fresh weight were determined from the 75 % available water level (Figures 3, 2, 4, 1). 25% and 50% available water level treatments were caused by the higher the root dry matter weight than field capacity available water level. The maximum leaf water loss was obtained from 25%, 50% and 75% available water treatments. One of the important seedling vigor characteristics is shoot DM for seedling growth. The highest seedling dry matter was obtained from 75% and FC available water treatments while the lowest shoot dry matter was found from 25% and 50% available water treatments (Figure 3). The results of this research were similar to those of the other researchers (Forbes and Watson, 1992; Turhan et al. 2003).

When the results of the experiment were evaluated, it was shown that the highest fresh shoot weight and root weight had been obtained from 75% field capacity and 1.3 dS/m salt consistency. Diminishing available water brought about a decrease in shoot and root length, and especially shoot weight, however root and shoot weight were decreased by increasing salt intensity. Similar results were also obtained for root and shoot length. Dry matter contents of shoot and root have very low in all of the water applications except 75% field capacity. Whereas 1.35 dS/m salt consistency caused increase in shoot weight, it decreased in root weight. The highest number of leaf and leaf weight were obtained from 100% and 75% field capacities. In addition, increases were determined in them by increasing the salt concentration. The highest leaf water loss value was obtained from 1.3 dS/m salt concentration; it decreased in other salt increased concentrations.

Conclusion

The response of maize to salinity and drought differs depending upon the stage of development and tissue assayed. Shoot growth in the first weeks appears to be the stage most sensitive to stress conditions. When dent corn seedling were irrigated with 1.35 dS/m salinity water, root dry matter, leaf water loss rate and shoot fresh weight were increased at arid and semiarid lands. The highest seedling vigor, shoot and root length, number of leaves per plant and leaf water loss was determined from 75% available water level and field capacity at irrigation conditions. Obtained results showed that corn seedlings are better growing in 75% available soil water level. In addition, slight saline water sources can use 75% and field capacity level; but it would be carefully during continuous treatments.

References

Arin, L. and Y. Kiyak, 2003. The effects of pre-sowing treatments on emergence and seedling growth of tomato seed (*L. Esculentum* Mill.) under several stress conditions. *Pakistan J. Biological Sci.,* **6:** 990-994.

Azaizeth, H. and E. Steudle, 1991. Effects of salinity on water transport of excised maize roots. *Plant Physiology*, **97 (**3): 1136-1145.

Cangir, C. and D. Boyraz, 2001. Trakya'daki topraklarin alt ordolarina gцre yayilim ve farkli yцrelerdeki ilcelerin arazi kullanim potansiyellerinin degerlendirilmesi. Proceedings of Trakya Soil and Water Sources Symposium, 24-27 May, 2001, Koy Hizmetleri Ataturk Araєtirma Enstitusu Mudurlugu, Kirklareli. (Tr).

Clarke, J. M. and T. N. McCaig, 1982. Excised – leaf water retention capability as an indicator pf drought resistance of Triticum genotypes. *Can. J. Plant Sci.,* **62:** 571-578.

El Swaify, W., S. Arunin and I. Abrol, 1983. Soil salinization. Developments of salt affected soils, Natural systems for Development, What Planners Need to Know (P.W. Jordon and R. Jensen, eds), Macmillan, New York, 1983, p. 162.

Evlagon D., I. Ravina and P. M. Neumann, 1992. Effects of salinity stress and calcium hydraulic conductivity and growth in maize (*Zea mays* L.) seedlings roots. *J. Plant Nutr*., 15: 795-803.

Fitter, A. H. and R. K. M. Hay, 1995. Environmental Physiology of Plants. *Academic Press,* London, 1987.

Flowers, T. J. and A. R. Yeo, 1995. Breeding for salinity resistance in crop plants: where next. *Aust. J. Plant Physiol.,* **22:** 875-884.

Flowers, T. J., A. Garcia, M. Koyama and A. R. Yeo, 1997. Breeding for salt tolerance in crop plants-the role of molecular biology. *Acta Physiologiae Plantarum,* **19:** 427-433.

Forbes, J. C. and R. D. Watson, 1992. Plants in Agriculture. London, *Cambridge Univ. Press*., pp. 32-60.

Ghassemi, F., A. J. Jakeman and H. A. Nix, 1995. Salinisation of Land and Water Resources: Human Causes, Extent, Management and Case Studies. *UNSW Press,* Sydney, Australia and CAB International, Wallingford, U.K.

Hall, R., 1988. Effect of drought stress on corn production. *Agron. Jour*., **3** (20):1-4.

Hetrick, B. A. D., D. G. Kэtt and G. T. Wilson, 1987. Effect of drought stress on response corn, sudan grass and big bluestem to *Glomus etunicatium. New Phytol.,* **105** (3): 403-410.

Izzo, R., F. Navari-Izzo and M. F. Quartacci, 1991. Growth and mineral absorption in maize seedling as effected by increasing NaCl concentrations. *J. Plant Nutr.,* **14** (2): 687-699.

Khan, A. A., T. McNeilly and F. M. Azhar, 2001. Stress tolerance in crop plants. *Int. J. Agric. Biol.,* **3**:250-255.

Khan, A. A., A. R. Sajjad and T. McNeilly, 2003. Assessment of salinity tolerance based upon seedling root growth response functions in maize (*Zea mays* L.). *Euphytica,* **131:** 81-89.

Maas, E. V. and G. J. Hoffman, 1997**.** Crop salt tolerance current assessment. *J. Irrig &Drain Div ASCW*, **103:** 115-134.

Maas, E. V., 1990. Crop salt tolerance, In: Tanji K.K. (Ed): Agricultural Salinity Assessment and Management. New York, *ACSE Manuals and Reports on Engineering Practice,* **71:** 262-304.

Maiti, R. K., L. E. D. Amaya, S. I. Cardona, A. M. O. Dimas, M. De La Rosa Ibarra and H. D. Castillo, 1996. Genotypic variability in maize cultivars (*Zea mays* L.) for resistance to drought and salinity at the seedling stage. *J. Plant Physiol.,* **148:** 741-744.

Maiti, R. K., M. De La Rosa Ibarra and N. D. Sandoval, 1994. Genotypic variability in glossy sorghum lines for resistance to drought, salinity and temperature stress at the seedling stage. *J. Plant Physiol*., **143:** 241-244.

Misra, N. and U. N. Dwivedi, 2004. Genotypic difference in salinity tolerance of green grain cultivars. *Plant Science*, **166:** 1135-1142.

Munns, R., S. Husain, A. R. Rivelli, R. A. James, A. G. Condon, M. P. Lindsay, E. S. Lagudah, D. P. Schachtman and R. A. Hare, 2002. Avenues for increasing salt tolerance of crops, and the role of physiologically based selection traits. *Plant and Soil*, **247:** 93-105.

Osmond, C. B., M. P. Austin, J. A. Bilings, J. S. Boyer, W. H. Dacey, P. S. Noberl, S. D. Smith and W. E. Winner, 1987. Stress physiology and the distribution of plants. *Biosience,* **37:** p. 49.

Ozdemir, N., C. Gulter, and T. Askin, 2000. Determination of relations between some soil properties and some soil moisture constants using Path analysis, International Symposium on Desertification, Konya, Soil Science Society of Turkey.

Saglam, M. T., 1993. Chemical Properties of Soil. In : Saglam M.T., Bahtiyar M, Cangir C., Tok H.H. (Eds): Soil Science. Istanbul, Anadolu Matbaa Tic. Koll. Sti., Press : 177-236.

Sinclair, T. R., J. M. Bennet and R. C. Wuchow, 1990. Relative sensitivity of grain yield and biomass accumulation to drought in field grown maize. *Crop Science,* **30** (3): 690-693.

Turan, Z. M., 1997. Salinity Studies in Potato (*Solanum tuberosum* L.). Ph. D. Thesis, The University of Reading, England, 225 pp.

Turhan, H., I. Baser and F.. Onemli, 2000. In vitro and in vivo water stress in sunflower (*Helianthus annus* L.), Sixth European Conference on Sunflower Breeding, 5-9 October, Seville, 2003.

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