Effect of Salt Stress Induced by NaCl on Safflower (*Carthamus tinctorius* L.) Cultivars at Early Seedling Stages

NaCl'nin İndüklediği Tuz Stresinin Erken Büyüme Evresindeki Aspir (*Carthamus tinctorius* L.) Çeşitleri Üzerine Etkisi

Research Article / Araştırma Makalesi

Şeküre Çulha* and Hüsnü Çakırlar
Hacettepe University, Faculty of Science, Department of Biology, Beytepe, Ankara, Turkey

ABSTRACT

Salinity is one of the major problems to affect plant growth and development in arid and semi arid regions. The reasons of the formation of the salty soil are climatic factors, weathering of parental rocks, oceans and using salty water for irrigation. In this study, the effect of different salt concentrations [0 (control), 75, 150, 225 and 300 mM NaCl] on the germination and early seedling stage of the three safflower (Carthamus tinctorious L.) cultivars (Dinçer, Remzibey-05 and Yenice) which are registered cultivars of Turkey were investigated. By the experimental study it was reported that safflower cultivars were negatively affected from different NaCl concentrations at early seedling stages and also, some differences at their salt tolerances to compare each others. Thus, it is suggested that safflower is moderately salt tolerant plant and safflower cultivars may be classified as tolerant (Yenice), moderately tolerant (Dinçer) and sensitive (Remzibey-05) by evaluating results obtained from both stage.

Key Words
Salt stress, *Carthamus tinctorius* L., early seedling stage, NaCl.

ÖZET

Tuzluluk, kurak ve yarı kurak bölgelerde bitki büyümesi ve gelişimini etkileyen önemli problemlerden birisidir. İklimsel faktörler, ana kayaların ayrışması, okyanuslar ve sulama sularının kullanımı tuzlu toprakların oluşmasının nedenleridir. Bu çalışmada, Türkiye'nin tescilli aspir (*Carthamus tinctorious* L.) çeşitlerinin (Dinçer, Remizbey-05 ve Yenice) çimlenme ve erken fide evresi üzerine farklı tuz konsantrasyonlarının [0 (kontrol), 75, 150, 225 ve 300 mM NaCl] etkileri incelenmiştir. Bu deneysel çalışma ile aspir çeşitlerinin erken fide evresinde farklı NaCl konsantrasyonlarından olumsuz etkilendiği ve çeşitler birbirleriyle karşılaştırıldıklarında tuz toleranslarında bazı farklılıklar olduğu da gösterilmiştir. Bu nedenle, aspir bitkisinin tuza karşı orta derece toleranslı olduğu ileri sürülebilir ve her iki evreden elde edilen sonuçların değerlendirilmesine göre aspir çeşitleri toleranslı (Yenice), orta derece toleranslı (Dinçer) ve duyarlı (Remzibey-05) olarak sınıflandırılabilir.

Anahtar Kelimeler
Tuz stresi, *Carthamus tinctorius* L., erken fide evresi, NaCl.

Article History: Received August 12, 2010; Revised October 27, 2010; Accepted November 17, 2010; Avaliable Online: February 16, 2011.
Correspondence to: Şeküre Çulha, Hacettepe University, Faculty of Science, Department of Biology, 06800, Beytepe, Ankara, Turkey
Tel: +90312 297 6786 Fax: +90312 299 2028 E-Mail: sekureculha85@gmail.com

INTRODUCTION

Salinity is one of the major problems to affect plant growth and development in arid and semi arid regions. The reasons of the formation of the salty soil are climatic factors [1], weathering of parental rocks [2], oceans [3] and using salty water for irrigation [4]. Salt affected soil are nearly covered half of the irrigated land, 20% of the world's cultivated land and 7% of the world's land areas [5]. In Turkey, about 1.5 million hectares have salinity and alkalinity problems [6]. Salinity has negative effects on plant growth and development due to specific ions effects, nutritional imbalance, low osmotic potential of soil solution and combinations of these factors [7,8]. All of these factors caused by high salinity can affect various major plant processes like photosynthesis, protein synthesis and also energy and lipid metabolisms [9].

Seed germination, which is the first growth stage of a plant, is basic phase to limit plant development under saline conditions [10]. Soil salinity may affect the seed germination via increasing the toxic effects of Na^+ and Cl^+ ions or generating external osmotic potantial which results in decreasing of water uptake [11]. These effects may cause inadequate imbibition, inhibition of the metabolic activities, destruction of enzymes and imbalance of growth regulators [12]. Thus, salinity leads decreasing or delaying germination of plants, especially glycophytes. In addition, depending on plant species, salt stress not only affects germination percentage but also affects the germination rate and seedling growth in different ways [13].

Safflower (*Carthamus tinctorius* L.) a member of the family *Asteraceae*, is an annual herbaceous plant and grows in hot and drought conditions [14]. It is one of the world's oldest oil seed crops and researchers have suggested that it originates from eastern Mediterranean [15,16]. Historically, safflower has been mainly cultivated for medicinal purposes and extracting cartamin from its florest which is used for coloring foods and clothes [17]. However, safflower has been grown commercially since the 1950s for oil production in West Asia and North Africa, the plant has been cultivated for edible oil in other parts of the world only in recent years [16].

Safflower has a deep root system and it is able to take moisture and nutrients from considerable depth by this system [18]. Through this feature, safflower becomes more tolerant to drought and salinity than other oil seed crops [15]. As a result of tolerance to drought, it can grow on dry lands of Central Anatolia [19].

The aim of this study is to investigate the effect of salt stress on germination and early growth stage of safflower (*Carthamus tinctorius* L.) cultivars induced by NaCl.

MATERIAL AND METHODS

Three safflower (*Carthamus tinctorius* L.) cultivars (Dinçer, Remzibey-05 and Yenice) grown in Turkey were used for the study. Seeds of cultivars were obtained from Ankara Central Research Institute for Field Crops. The seeds surface were sterilized in 5% sodium hypochlorite solution (NaOCl) for 3 min and then carefully washed with distiled water. After sterilization, seeds were put into solutions containing different amount of NaCl [0 (control), 75, 150, 225 and 300 mM NaCl] for imbibitions during 2 h. Seeds were transferred in germination boxes (20x13.5x8 cm) which were filled with perlite and the boxes were placed to controlled growth room at 25 ± 2°C with 16 h day long and with a relative humidity at 65 ± 5%. At the end of the eighth day, the percentage of germination (%) was determined as described by Sıddıqı et al. [20] and hipocotyl and radicle lenght were measured.

A completely randomized block design was used with three replicates. Differences among treatments and cultivars were tested using SPSS statistical program, version 11.5. Statistical variance analysis of the data was performed using ANOVA and compared with least significant difference (LSD) at the 5% level.

RESULTS AND DISCUSSION

Salinity is one of the environmental stress factors limiting the plant growth and development. The differences in salt tolerance of plants not only among different species, but also within certain species are observed [4]. Also, at different stages

of development, species are effected distinct degrees and give various responses to salt stress [21]. Especially, germination which is the most important stage of the plant life is affected seriously from salinity [22].

Salt stress induced by NaCl adversely affected germination percentage of the three safflower cultivars (Figure 1). Higher concentrations than 75 mM NaCl significantly reduced the germination percentages of safflower cultivars, except Yenice at 150 mM. The percentage at the highest salt concentration, 300 mM, was approximately 20-30% compared to their controls. The lowest germination percentage belonged to Remzibey-05 at these concentrations. Consequently, NaCl treatments have inhibitive effects on germination of cultivars.

Our findings are supported by Ghorashy et al. [23], Meloni et al. [24] and Huang et al. [25] who found that higher concentrations than 120, 100 and 200 mM NaCl decreased the germination of safflower, red quebracho and saxaul, respectively. Sıddıqı et al. [20] reported that lower external salt levels were not important to identify the variation of cultivars. Therefore, to distinguish the differences between germination percentage of the cultivars, it is necessary to exposure the higher NaCl concentrations which cultivars show nearly maximum germination. Yenice cultivars had the highest germination percentage under 150 mM and higher NaCl concentrations, whereas Remzibey-05 showed the lowest percentage (Figure 1).

The effects of salt stress by using different NaCl concentrations on radicle and hypocotyl lenght of safflower cultivars were demonstrated in Figures 2 and 3. Salt treatments significantly decreased both lenght of all three cultivars investigated in this study. Higher NaCl concentrations beyond 75 mM reduced either radicle or hypocotyl length by approximately 80-95% compared to their controls. Our results are consistent with the results of reported by Misra and Dwivedi [22] and Kaya et al. [11]. NaCl inhibited the radicle elongation more than hypocotyl growth except at the highest NaCl concentrations (225 and 300 mM). Although, Remzibey-05 cultivars exhibited the lowest values of radicle and hypocotyl length at these concentrations, Yenice had the highest values. Thus, in consequence of statistical

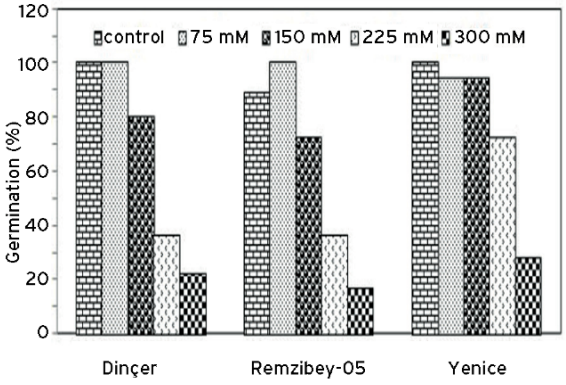

Figure 1. Percentage of germination of safflower seeds exposed to different NaCl concentrations.

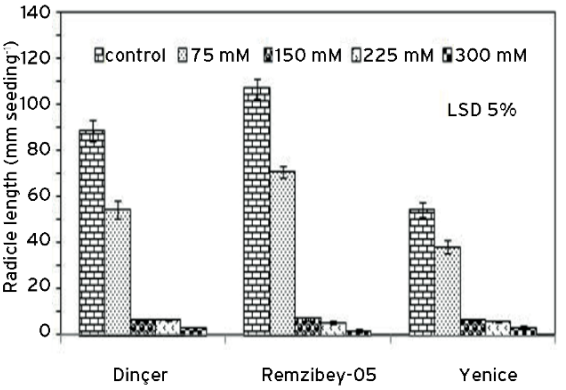

Figure 2. Length of radicle of safflower seeds exposed to different NaCl concentrations.

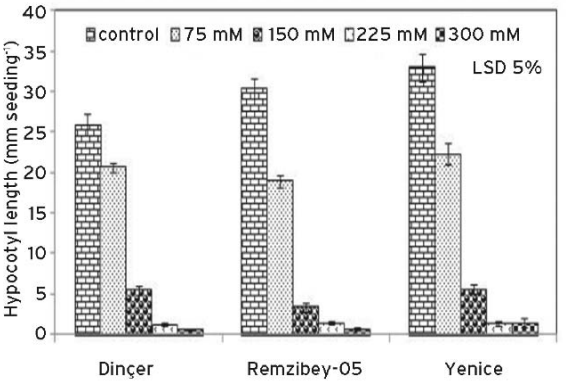

Figure 3. Length of hypocotyl of safflower seeds exposed to different NaCl concentrations.

analysis, it was found that there was no significant differences between cultivars under higher salt concentrations than 75 mM ($p > 0.05$).

As results; though it is suggested that safflower is a moderately salt tolerant oil plant, 150 mM and higher NaCl concentrations inhibit the germination parameters of all three safflower cultivars. In the light of our investigated parameters, three cultivars may be classified like; Yenice is salt tolerant, Dinçer is moderately tolerant and Remzibey-05 is salt sensitive.

ACKNOWLEDGEMENT

Authors would like to thank Hacettepe University, Scientific Research Unit (Project No: 010D02601008) for the financial support.

REFERENCES

[1] K.K. Tanji, Salinity; Environment-Plants-Molecules, Kluwer Academic Publishers Dordrecht, Boston, London, 2002.

[2] R. Munns, M. Tester, Mechanisms of Salinity Tolerance, Annu. Rev. Plant Biol., 59 (2008) 651.

[3] W. Larcher, Physiological Plant Ecology, Third Edition, Springer, New York, 1995.

[4] K. Chartzoulakis, G. Klapaki, Response of two greenhouse pepper hybrids to NaCl salinity during different growth stages, Scientia Horticulturae, 8 (2000) 247.

[5] P. Sudhır, S.D.S. Murthy, Effect of salt stress on basic processes of photosynthesis, Photosynthetica, 42 (2004) 481.

[6] E. Ekmekçi, M. Apan, T. Kara, Tuzluluğun bitki gelişimi üzerine etkisi, OMÜ Zir. Fak. Dergisi, 20 (2005) 118.

[7] M. Ashraf, P.J.C. Harris, Potential biochemical indicators of salinity tolerance in plants, Plant Science, 166 (2004) 3.

[8] M. Ashraf, Some important physiological selection criteria for salt tolerance in plants, Flora, 199 (2004) 361.

[9] Q.Y. Li, H.B. Niu, J. Yin, M.B. Wang, H.B. Shao, D.Z. Deng, X.X. Chen, J.P. Ren, Y.C. Li, Protective role of exogenous nitric oxide against oxidative-stress induced by salt stress in barley (*Hordeum vulgare*), Colloid. Surf. B., 65 (2008) 220.

[10] P.J. Zapata, M. Serrano, M.T. Pretel, A. Amorós, M.Á. Botella, Changes in ethylene evolution and polyamine profiles of seedlings of nine cultivars of *Lactuca sativa* L. in response to salt stress during germination, Plant Sci., 164 (2003) 557.

[11] M.D. Kaya, G. Okçu, M. Atak, Y. Çıkılı, O. Kolsarıcı, Seed treatments to overcome salt and drought stress during germination in sunflower (*Helianthus annuus* L.), Europ. J. Agronomy, 24 (2006) 291.

[12] M.A. Khan, R. Ansari, B. Gul, W. Li, Dormancy and germination responses of halophyte seeds to the application of ethylene, C. R. Biologies, 332 (2009) 806.

[13] P.J. Zapata, M. Serrano, M.T. Pretel, A. Amorós, M.Á. Botella,, Polyamines and ethylene changes during germination of different plant species under salinity, Plant Science, 167 (2004) 781.

[14] M.H. Pahlavanı, A.F. Mırlohı, G. Saeıdı, Inheritance of flower color and spininess in safflower (*Carthamus tinctorius* L.), J. Heredity, 95 (2004) 265.

[15] H. Baydar, O.Y. Gökmen, Hybrid seed production in safflower (*Carthamus tinctorius* L.) following the induction of male sterility by gibberellic acid, Plant Breeding, 122 (2003) 459.

[16] S.K. Yau, Winter versus spring sowing of rain-fed safflower in a semi-arid, high-elevation Mediterranean environment, Europ. J. Agronomy, 26 (2007) 249.

[17] S. Knight, Safflower: potential & world adaptability, IREC Farmers´ Newsletter, 176 (2007) 34.

[18] L. Dajue, H-H. Mündel, Safflower *Carthamus tinctorius* L., Promoting the conservation and use of underutilized and neglected crops, 7. International Plant Genetic Resources Institute, 1996.

[19] B. Coşge, B. Gürbüz, M. Kıralan, Oil content and fatty acid composition of some safflower (*Carthamus tinctorius* L.) varieties sown in spring and winter, Int. J. Natural Eng. Sci., 1 (2007) 11.

[20] E.H. Siddiqi, M. Ashraf, N.A. Akram, Variation in seed germination and seedling growth in some diverse lines of safflower (Carthamus tınctorıus l.) under salt stress, Pak. J. Bot., 39 (2007) 1937.

[21] O. Vicente, M. Boscaiu, M.Á. Naranjo, E. Estrelles, J.M. Bellés, P. Soriano, Responses to salt stress in the halophyte *Plantago crassifolia* (Plantaginaceae),, J. Arid Env., 58 (2004) 463.

[22] N. Misra, U.N. Dwivedi, Genotypic differences in salinity tolerance of green gram cultivars, Plant Sci., 166 (2004) 1135.

[23] S.R. Ghorashy, N. Sionit, M. Kheradnam, Salt tolerance of safflower varieties (*Carthamus tinctorius* L.) during germination, Agronomy J., 64 (1972) 256.

[24] D.A. Meloni, M.R. Gulotta, C.A. Martínez, Salinity tolerance in Schinopsis quebracho colorado: Seed germination, growth, ion relations and metabolic responses, J. Arid Env., 72 (2008) 1785.

[25] Z. Huang, X. Zhang, G. Zheng, Y. Gutterman, Influence of light, temperature, salinity and storage on seed germination of *Haloxylon ammodendro*, J. Arid Env., 55 (2003) 453.