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Original Article

Effect of Drought and Salinity Tensions on Germination and Seedling Growth of Artichoke (*Cynara Scolymus* L.)

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A B S T R A C T

Objective: Germination is one of the most important stages of plants growth that affected by environmental stresses, especially drought and salinity. **Methods:** In order to study of Artichoke germination under different levels of salinity and drought, two separate experiments were performed. The four levels of salinity by NaCl (0, 50, 100, 150 mM) with three replications and five levels of drought by PEG (0, 10%, 15%, 20% and 25%) with three replications were used based on completely randomized design. **Results:** Results showed that drought and salinity stresses reduced significantly germination rate, shoot length, root dry Weight and shoot dry Weight. In salinity condition, there was insignificant difference between treatments for germination percent, but in drought condition, there was significant difference. Moisture range optimum for germination was determined non-stress to 20% PEG concentration. It seemed that among traits, shoot length was more sensitive than others to salinity and drought stresses. It can be concluded that Artichoke can tolerate salinity up to 150 Mm, but in drought conditions it cannot germinate in 25% PEG.

1.INTRODUCTION

Artichoke (*Cynara scolymus* L.) is a medicinal plant belonging to the Asteraceae family that are widely cultivated in Europe and the United States of America. This plant only cultivated in some areas like Ghazvin and Andimeshk of Iran. Nowadays, artichoke heads production is widely distributed all over the world (121,000 ha), even though it is mainly concentrated in Mediterranean regions, which produce 800 thousand tons per year (about 65% of the global production) (FAO, 2005). Breeders seek to develop and identify cultivars that are more tolerant of salinity and drought (Janmohammadi et al., 2008). Seed sowing generally considered the first critical and most sensitive stage in the live cycle of plants and seeds are frequently exposed to unfavorable environmental conditions that may compromise the establishment of seedling (Figueiredo-e-Albuquerque and Carvalho, 2003; Misra and Dwivedi, 2004). Several environmental factors such as temperature, salinity, light, and soil moisture simultaneously influence germination (El-Keblawy and

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Al-Rawai, 2006; Zia and Khan, 2004) which salinity and drought are widespread problems around the world (Soltani et al., 2006). Germination is considered one of the critical steps of plants, because it has a major role in determining final plant density. The germination of seeds is inhibited by both drought and salt stresses (Abid et al., 2011; Li et al., 2011; He et al., 2011). In the light of economic and environmental significance of drought, increasing concern has been voiced regarding impacts of climate change on future drought frequency, duration and severity in various regions of the globe (Davatgar et al., 2009). NaCl and PEG compounds have been used to simulate osmotic stress effects in petri dish (*in vitro*) for plants to maintain uniform water potential throughout the experimental period (Kulkarni and Deshpande, 2007; Khayatnezhad et al., 2010). High levels of soil salinity inhibit productivity of most field crops but germination is the most important process for good seed emergence in medicinal plants (Bannayan et al., 2006). In a study on the effect of salinity stress on the germination of *Limonium stocksii*, Zia and Khan (2004) stated that the highest germination was observed in no-salinity treatment and it decreased with the salinity. Research carried out on *Seidlitziarosmarinus* (Hadi et al., 2007), *Salsolasp* (Zahtabian and Javadi, 2005), suggested that increased level of NaCl and polyethylene glycol provides unsuitable medium for seeds germinations so that the more salinity and drought stress levels had the less germination rate. The purpose of this experiment was the effect of drought and salinity based on PEG and NaCl on seed germination of *Cynara scolymus* L.

2.MATERIALS AND METHODS

Artichoke (*Cynara scolymus* L.) seeds were obtained from the Department of Natural Resources, Agriculture Research Center of Hamedan. To investigate the effects of drought and salinity on germination of seeds, two separate experiments were conducted in a research lab of scientific – Applied University of Jihad- Agriculture. NaCl (Merck, Germany) and PEG 6000 were used for salinity and drought testing, respectively. Four levels of salinity concentration by NaCl (0, 50, 100, 150 mM) with three replications and five levels of drought by PEG 6000 (0, 10%, 15%, 20% and 25%) with three replications were used in completely randomized designs. before experiments, Seeds were disinfected with 2% sodium hypochlorite (bleaching liquid) for 2 min. Then, they were washed with distilled water and sterilized with Benomyl 0.2% (for 2 min). Gama sterilized Petridishes were used for these tests. Sterile whatman filter papers were placed on the bottom of Petridishes. Thirty seeds were selected and placed into a Petridishes. Then 5 ml of the prepared solution (NaCl and PEG) were added. Petridishes and seeds treated in 25 ± 2° C. Petridishes are monitored on a daily basis and the number of germinated seeds and roots, they were seen (more than 2 mm in length) were counted as germinated seeds. Root and shoot dry weight was measured (after maintaining in the oven at 70 ° C for 48 h) by a digital scale (0.0001 g). Germination percentage and germination rate were calculated by formulas:

Germination Percentage (GP) = (total germinated seeds/ total seeds) × 100

$$\frac{X_1}{Y_1} + \frac{X_2 - X_1}{Y_2} + \cdots + \frac{(X_n - X_{n-1})}{Y_n}$$

Germination Rate (GR) **=**

Where, X_n was the number of germinated seeds at the *n*th day and Y_n was the number of days from sowing until the *n*th sowing time.

Statistical analysis of data was performed by SAS statistical software (SAS Institute Inc, 2003). Comparing all averages by Duncan's multiple test range was conducted in level 5%. All graphs were plotted with Excel software.

3.RESULTS AND DISCUSSION

3.1. Drought

With increasing stress, there was significant difference between treatments in germination rate, germination percent, root length, shoot length, root dry Weight and shoot dry Weight (Table 1). Root length decreasing reported with increasing water potential by Takel (2000) and one of the causes of shoot length reduction in drought stress conditions has been found reduction or non-transfer of nutrients from seed `storage tissues to the embryo; generally germinated seeds in environments under stress conditions have shorter shoot and root (Al Ebrahim et al., 2008). The highest root length related to the control (90.87 mm) and the minimum related to concentration of 25% PEG (no germination). Also, shoot length reduced like other characteristics, but it showed more sensitivity to drought. The longest and the shortest shoot length related to control (30.07 mm) and concentration of 25% PEG (zero), respectively (Fig1.a). Results obtained in this study is in agreement with many researches (Gholamin and Khayatnezhad, 2010; Farsiani and Ghobadi, 2009; Mohammadkhani and Heidari, 2008; Jajarmi, 2009; Khayatnezhad et al., 2010). The highest percentage of germination related to the control treatment (94.44%) and the lowest related to concentration of 25% PEG (no germination) (Fig1.c). Germination rate decreased with increasing drought. The highest germination rate was 8.48 $P.d^{-1}$ that related to control treatment and the lowest was zero (25% PEG) (Table 1). Barzegar and Rahmani (2004) reported that there was a significant difference between values of percentage averages and germination speed of hyssop seed (*Hyssopus officinalis*) under affection of drought stress levels (0, -1, -3, -6 and -9 bar), and with increasing stress intensity, the values of these traits got lower. If water absorption disturbed or delayed, it could delay in seed metabolic processes. Also germination rate had the most important effect on stand establishment and plan density under laboratory and greenhouse conditions. This agreed with the results of Farsiani and Ghobadi (2009) and Khayatnezhad et al. (2010) in maize; Gholamin and Khayatnezhad (2010) in wheat and Mostafavi (2011) in safflower and confirmed our results. Reduction of germination process due to drought stress can be related to a decrease in water absorption by seeds. Also, reduction of root length with increasing in water potential has been reported by Takel (2000). One of the factors that Caused shoot length decreased in during drought conditions is reduction or lack of transferring nutrients from seed storage tissues to embryo. In addition, decreasing in water absorption by seed under drought stress causes to decrease in hormones secretion and enzymes that result to impair seedling growth (root and shoot) (Asghari, 2002).

3.2. Salinity

With increasing salinity, there were significant differences between treatments based on rate of germination, shoot length, root dry Weight and shoot dry Weight. Seed germination decreased. Germination rate decreased with increasing salinity. The highest germination rate was related to the concentration of 150 mM (8.83 $p.d^{-1}$) and the lowest related to control (5.37 $p.d^{-1}$). With increasing in concentrations, root length, root dry weight and soot dry weight of seedlings decreased (Table 1). The longest root length obtained in control treatment (90.20 mm) and the shortest obtained in concentration of 150 mM (86.30 mm) (Fig 1.b). Also, shoot length reduced with increasing salinity, like other parameters, but it showed more sensitivity to salinity, therefore, in concentrations of 100 and 150 mM, shoot length reduced. The highest shoot length related to control (30.07 mm) and the lowest related to 150 mM (15.60 mm) (Fig 1.b). results showed that shoot dry weight reduced with increasing salinity and this reduction has been reported in sweet sorghum cultivars (Almodares *et al*., 2007), *Triticum aestivum* (Akbari et al., 2007) which is in agreement with the results of current study. Al Ebrahim et al. (2008) while evaluating effect of salinity and drought on germination and growth of corn inbred lines revealed that osmotic potential affected significantly germination index, germination percent, seed viability index, radical and shoot lengths and seedling dry weight so that as osmotic potential was decreased, it inhibited germination and primary seedling development and salinity stress reduced seedling growth (radical and shoot lengths) much more than germination components. There was no significant difference between treatments for germination percent ($P> 0.01$), nevertheless, the highest germination percent related to control (96.67%) and the lowest related to 150 mM (94.44%) (Fig1.d). Also, Seyyed Sharifi (2007) in an experiment with study on four salinity levels (0, 25, 50 and 100 Mm) NaCl on germination of *Silybum marianum* showed that salinity stress has significant effect on germination percentage and germination uniformity and germination percentage average in salinity potential 25 and 50 Mm NaCl decreased compared to control (distilled water) respectively 17.20 and 43.00 percent. This reduction showed that *Silybum marianum* was sensitive than Artichoke to salinity. Also in a study on the effect of salinity on germination of Roselle, *Hyssopus officinalis* and Basil seeds, Khammari et al. (2007) found the loss of their seed germination percentage and rate with the increase in salinity stress. Similar results were obtained by Ghanbari et al. (2013) reported that there were significant differences between salinity levels and increasing salinity. Their results showed that minimum root length and shoot length of plants was recorded under saline-treated 8 dS m and the highest was recorded in controls. In other study, it was declared that reduction of different germination parameters can be related to reduction of speed and rate of water absorption and also, negative effect of low osmotic potentials by salt and ions toxicity on enzyme hydrolysis of seed storages and new tissues development by hydrolyzed materials. In addition, the salinity in the seed germination stage damage the membrane of the cell, particularly the cytoplasm membrane that results in increasing permeability of the membrane due to the replacement of Ca^{+2} by Na^{+} that resulted to increasing in K^{+} losses (Takel, 2000) .

4.CONCLUSIONS

From the result of this study, it can be concluded that Artichoke can tolerate salinity up to 150 Mm, but in drought conditions it cannot germinate in 25% PEG. The result clearly demonstrated that the effectiveness of salinity on the shoot length was more than root length and similar results were observed in drought conditions. Also, germination rate decreased with increasing in salinity and drought that the highest germination rate related to control in both condition and the lowest related to concentration of 150 mM NaCl and 25% PEG, respectively for salinity and drought.

Table 1:

Effects of PEG and NaCl on germination characteristics and seedling growth of artichoke

Treatments	Germination percent (%)	Germination Rate (p.d-1)	Root length (mm)	Shoot length (mm)	Root dry Weight (mg/plant)	Shoot dry Weight (mg/plant)
PEG						
Distilled water (control)	94.44 a	8.48 a	90.87 a	30.07 a	0.0232 a	0.0879 a
10%	90.00 a	5.97 b	12.87 b	1.27 b	0.0053 b	0.0807 a
15%	85.56 a	4.91 c	4.60 b	0.74 b	0.0049 b	0.0755 a
20 %	42.22 b	2.02 d	4.18 b	0.00 b	0.0031 b	0.0000 b
25%	0.00 c	0 00 e	0.00 b	0.00 b	0.0000 c	0.0000 b
P value	**	**	*	**	**	**
CV	8.93	10.88	21.87	24.64	18.37	15.11
NaCl						
Distilled water (control)	96.67 a	8.83 a	90.20 a	30.07 a	0.0232 a	0.09203 a
50 mM	95.56 a	8.48 a	89.53 a	28.80 a	0.0205 ab	0.0840 ab
100 mM	95.55 a	7.44 b	88.53 a	21.27 ab	0.0186 bc	0.0807 ab
150 mM	94.44 a	5.37 c	86.13 a	15.60 b	0.0150 c	0.0801 b
P value	ns	**	ns	*	*	*
CV	3.02	5.31	20.38	19.75	11.92	6.97

ns, * and **: Not significant, significant at 5% and 1% probability levels, respectively.
Amounts of P value are means of square in ANOVA.
Similar letters in each column (between two horizontal lines) indicate no significant difference at 5% probability levels (Duncan test).

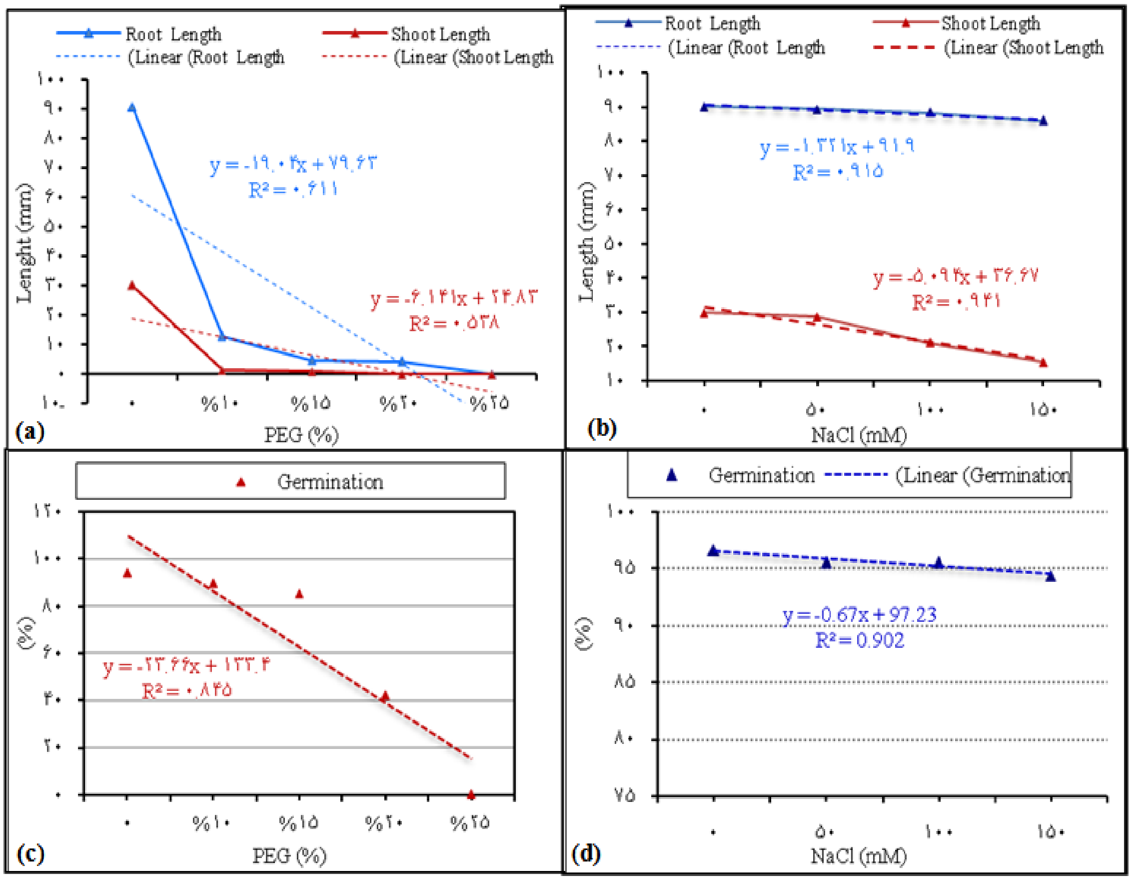

Figure 1: Effect of PEG on (a) shoot and root length, (c) germination and NaCl on (b) shoot and root length, (d) germination

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COMPETING INTERESTS

The authors declared no competing interests.

REFERENCES

Bid, M., Salim, M., Bano, A., Asim, M. and Hadees, M. (2011). Physiology and productivity of rice crop influenced by drought stress induced at different developmental stages. *African Journal of Biotechnoly.* 10: 5121-5136.

Akbari, G., Modarres Sanavy, S.A.M. and Yousefzadeh, S. (2007). Effect of auxin and salt stress (NaCl) on seed germination of wheat cultivars (*Triticum aestivum* L.). *Pak. J. Bio. Sci*. 10(15): 2557- 2561.

Al Ebrahim, M., Jan Mohammadi, T., Sharif Zadeh, F. And Takasi, N. (2008). Investigation of salinity and drought stress on germination and seedling development of corn inbred line. *Journal of Crop Production*. 1(2): 35 - 43.

Almodares, A., Hadi, M.R. and Dosti, B. (2007). Effects of salt stress on germination percentage and seedling growth in sweet sorghum cultivars. *J. Biolog. Sci*. 7(8): 1492- 1495.

Asghari, M. (2002). Ethylene effect on osmotic adjustment and growth of axial and cotyledon tissues of sunflower seeds under drought stress. Industry Journal of Agricultural Science. 7: 137-145. (In Persian).

Bannayan M, Nadjafi F, Tabrizi L. and Rastgoo M (2006). Seed germination and dormancy breaking techniques for *Ferula gummosa* and *Teucrium polium*. *J Arid Environments.* 64(3): 542-547.

Barzegar, A. and Rahmani, M. (2004). The effects of environmental stresses on germination stimulation of *Hyssopus officinalis. The proceedings of the second conference on herbal plants, Shahed University, P. 67.*

Davatgar, N., Neishabouri, M.R., Sepaskhah, A.R. and Soltan, A. (2009). Physiological and morphological responses of rice (*Oryza sativa* L.) to varying water stress management strategies. *Int. J. Plant Prod*. 3: 19-32.

El-Keblawy, A. and Al-Rawai, A. (2006). Effects of seed maturation time and dry storage on light and temperature requirements during germination in invasive *Prosopis juliflora*. Flora - Morphology, Distribution. *Functional Ecology of Plants.* 201: 135–143.

F.A.O. Production year book. 2005. Food and Agricultural Organization of United Nation, Rome, Italy, 51:209P.

Farsiani, A. and 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 Acad. Sci. Eng. Tech*. 57: 382-385.

Figueiredo, E., Albuquerque, M.C. and De Carvalho, N.M. (2003). Effect of type of environmental stress on the emergence of sunflower (*Helianthus annuus* L.), Soybean (*Glycine max* (L.) Merril) and maize (*Zea mays* L.) seeds with different levels of vigor. *Seed Sci. Tech*. 31, 465-469.

Ghanbari, A., Najafi, M.A., Al-Athar, M. and Mohajeri, F. (2013). Effect of priming on morphological characteristics, proline, carbohydrate and essential oil contents of basil seed (*Ocimum basilicum*) under salt stress. *International Journal of AgriScience*. 3(4), 308-315.

Gholamin, R. and Khayatnezhad, M. (2010). Effects of polyethylene glycol and NaCl stress on two cultivars of wheat (*Triticum durum*) at germination and early seeding stages. *American – Eurasian J. Agric. Environ. Sci*. 9(1): 86-90.

Hadi, M., Taheri, R. and Sharif, M. (2007). Evaluation of salinity effect on seed germination of *Seidlitzia Rosmarinus. Journal of Research and Productivity*. 76: 151-157.

He, L., Jia, X. and Gao Li, Z.R. (2011). Genotype-dependent responses of wheat (*Triticum aestivum* L.) seedlings to drought, UV-B radiation and their combined stresses. *African Journal of Biotechnoly.* 10: 4046-4056.

Jajarmi, V. (2009). Effect of water stress on germination indices in seven wheat cultivar. *Acad Sci Eng Technol*. 49: 105-106.

Janmohammadi, M., Moradi Dezfuli, P. and Sharifzadeh, F. (2008). Seed invigoration techniques to improve germination and early growth of inbred line of maize under salinity and drought stress. *Gen. Appl. Plant Physiol*. 34(3-4): 215-226.

Khammari, I., Sarani, S.A. and Dahmardeh, M., (2007). The effect of salinity on seed germination and growth in six medicinal plants. *Iranian Journal of Medicinal and Aromatic Plants*. 23(3): 331-339. (In Persian).

Khayatnezhad, M., Gholamin, R., Jamaati – e – Somarin, S.H., and Zabihi – Mahmoodabad, R. (2010). Effects of peg stress on corn cultivars (*Zea mays* L.) at germination stage. *World Appl. Sci. J.* 11(5), 504-506.

Kulkarni, M., and Deshpande, U. (2007). *In vitro* screening of tomato genotypes for drought resistance using polyethylene glycol. *Afr. J. Biotech*. 6(6): 691-696.

Li, Z., Bian, M., Wu, Z., Zhang, X., Yang, Q. and Huang, C. (2011). Isolation and drought-tolerant function analysis of ZmPti1-1, a homologue to Pti1, from maize (*Zea mays* L.). *African Journal of Biotechnoly.* 10: 5327-5336.

Misra, N. and Dwivedi, U.N. (2004). Genotypic differences in salinity tolerance of green gram cultivars. *Plant Sci*. 166: 1135-1142.

Mohammadkhani, N. and Heidari, R. (2008). Water stress induced by polyethylene glycol 6000 and sodium chloride in two maize cultivars. *Pak. J. Biol. Sci*. 11(1): 92-97.

Mostafavi, K.H. (2011). An evaluation of safflower genotypes (*Carthamus tinctorius* L.), seed germination and seedling characters in salt stress conditions. *Afr. J. Agric. Res*. 6(7): 1667-1672.

SAS Institute Inc (2003). SAS Online Doc, Version 9.2. SAS Institute Inc., Cary, NC.

Seyyed Sharifi, R. (2007). The study of the effect of salinity on germination variables of MS indices. *The third conference on herbal plants*, Shahed University, Tehran, p.207.

Soltani, A., Gholopoor, M. and Zeinali, E. (2006). Seed reserve utilization and seedling growth of wheat as affected by drought and salinity. *Environ. Exp. Bot.* 55: 195-200.

Takel, A. (2000). Seedling emergence and growth of sorghum genotypes under variable soil moisture deficit .*Agronomy Journal.* 48, 95-102.

Zahtabian, G.h., Azarnivand, H., Javadi, M. and Shahriari, A. (2005). Evaluation of salinity stresses effect on germination of two range species of *Agropyron*, *Journal of Desert*. 10 (2): 301-310.

Zia, S. and Khan, M.A. (2004). Effect of light, salinity, and temperature on seed germination of *Limonium stocksii*. *Canadian Journal of Botany*. 82, 151–157.