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RESPONSE OF SOME FORAGE PEA GENOTYPES TO SALT STRESS DURING THE SEEDLING STAGE

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Abstract

Salinity stress is a common problem under dry climatic condition all over the world. The determination of salt tolerant genotypes has a crucial importance to alleviate this problem. Pea known as the most salt tolerant plant among legumes and seedling stage is the most sensitive to salt stress than the other growth stages. The experiment was carried out in the growth chamber to observe tolerance of the examined genotypes to different salt doses. Therefore germination rates, mean germination time (mgt), root/shoot lengths and fresh/dry seedling weights of some *forage pea genotypes (Local population, Crackerjack, Golyazi, Ozkaynak, Rose, Taskent, Tore, Ulubatlı) under different salt concentrations (Control, 5, 10, 15 and 20 dS m^{-1}) were determined. The results showed that salinity x genotype interaction was significant among genotypes with respect to all investigated parameters. Crackerjack had the highest germination rate and root length with the increasing salt levels and it was followed by Ozkaynak, Rose, Taskent and Tore. Ozkaynak was the fastest germinated genotype with respect to mgt with 1,92 days and the genotype had the longest shoot length. Fresh seedling weight of Crackerjack was the higher than all other genotypes but there was not a significant difference between Rose and Crackerjack. Results indicated that Taskent, Tore, Ozkaynak, cultivars could be recommended upto moderate saline areas while Crackerjack and Rose could be recommended for slightly saline areas.*

Keywords

Forage pea, Germination, Salinity, Seedling vigor

1. Introduction

Soil salinity is a widely known problem of plant growth especially in arid and semi-arid areas of the world. The problem may occur due to improper usage of irrigation and fertilizers or it can be also originated from parent materials or weathering of salt minerals (Matternicht et al., 2008; Barbouchi et al., 2014; Gorji et al., 2017). All over the world, more than 20% of the cultivation lands suffer from salinization (Moud & Maghsoudi, 2008). Fundamentally, salt stress is an osmotic problem that reduces water uptake and thereby plant growth from germination to blooming stage affects negatively but it also causes significant problems in enzyme activities and other metabolic processes (Abdul-Jaleel et al., 2007; Wang et al., 2009). The severity of adverse effect of salinity on plants differs among the genotypes (Carpici et al., 2009) but most of the legumes are showed sensitivity to salt stress (Bonilla et al., 2004). Therefore, salt tolerant genotypes should be determined for salinity problematic areas.

Forage pea is an annual forage legume cultivated for both forage and grain feed for livestock industry and the plant was also known that the most salt tolerant genus among the legumes (Noreen & Ashraf, 2009). Both forage and grains of the plant are rich in minerals and amino acids (Acıkgoz, 2001; Tan et al, 2011). High protein content of the forage (about 20%) and the grain (about 30%) and about 70-80% forage digestibility make it a valuable forage plant (Uzun et al., 2005; Avcioglu et al., 2009). It can be cultivated in the Central Anatolia conditions as winter and spring sowing and also can be grown sole or mixtured with cereals. The plant is also used widely for multiple purposes as forage, hay, grain, feed or green manure.

Seed germination and seedling growth were early stages of the plant growth that were considered very critical for crop production (Almansouri et al., 2001; Okcu et al., 2005). Various studies indicate that responses of the genotype to salt stress vary in different growth stages (Almansouri et al., 2001; Jamil et al., 2006). However germination and seedling stages are considered as an early indicator to salt tolerance (Carpici et al., 2009; Zhu & Banuelos, 2016). Noreen et al. (2007) observed that germination of field pea seeds was severely reduced with increasing salinity levels (0, 60 120, 180 and 249 mM NaCl) and Steppuhn et al. (2001) reported that seed production decreased in line with increasing salinity stress and did not produced any grain under severe salinity condition but there were significant differences among pea genotypes (Olmos & Hellin, 1996; Noreen & Ashraf, 2009).

This research was carried out to determine seedling growth performance of some forage pea genotypes under different salt levels because seedling response is considered as an early indicator of tolerance to salt stress.

2. Materials and Methods

The experiment was carried out in the growth chamber of Eskisehir Osmangazi University, Faculty of Agrıculture, and Department of Field Crops in 2016. Eight forage pea (*Pisum sativum* L.) genotypes (one of them was local population and the other 7 were Crackerjack, Golyazi, Ozkaynak, Rose, Taskent, Tore, Ulubatli cultivars) were used as material.

Solutions were prepared in 4 levels using NaCl and adjusted in 5, 10, 15 and 20 dS m^{-1} EC values and distilled water was used as control. With 4 replications and in every replication, 25 seeds of each genotypes were germinated in triple rolled filter paper that moistened using 14 ml of test solutions per paper. Seeds were left to germinate at 20 ^{o}C in the dark for 10 days and then seedling measurements were performed (Okcu et al., 2005). The paper was replaced every two days to prevent accumulation of salt (Rehman et al., 1996). Seeds were considered as germinated when the radicle length reached to 1 mm and germinations were recorded in every 24 h (Okcu et al., 2005). Mean germination time was calculated considering Ellis & Roberts (1980)’s suggestion. Ten seedlings from every replicates were choosen randomly than, shoot and root legths were measured seperately from these seedlings. Roots and shoots were weighed to calculate fresh seedlings weight and oven dried at 70 ^{0}C for 48 h (Uzun et al., 2005).

All data were subjected to analysis of variance based on general linear models for factorial arrangement (5 solutions x 8 genotypes) of treatments in a completely randomized design using SAS 9.3 software. Means were seperated using TUKEY Multiple Range Test.

3. Results and Discussion

Genotypes showed different response with respect to investigated parameters to salt concentration, thus salt levels x genotype interactions were significant for all investigated characteristics. About all genotypes showed highest germination ratio at 5 dS m^{-1} salt concentration but the response to salt levels changed at the other levels. For example, the lowest germination ratio recorded at control treatment for Golyazi cultivar while Rose and Taskent had the lowest germination ratio at 20 dS m^{-1} salt level.

Salt level was significantly affect mgt, especially mgt was delayed after 10 dS m^{-1} salt level. Genotypes also showed significant differences with respect to mgt. While mgt did not change in Taskent and Tore cultivars, the other genotypes showed different responses to salt levels. It was suprising that the highest salt content did not adversely affect mgt in the genotypes except for Ulubatli and Rose cultivars.

Root length was affected differently by salt content and it changed significantly among the genotypes. While there were great decreases at Crackerjack, Rose, Taskent and Tore in 10 dS m^{-1}, Ozkaynak was not significantly affected upto 15 dS m^{-1} with respect to root length. However higher and similar root lengths were recorded at 5 dS m^{-1} among the genotypes.

Genotypes showed different responses to changing salt concentrations with respect to shoot length. Shoot length of the genotypes were higher at 5 dS m^{-1} salt level than the other levels but Population, Crackerjack, Golyazi, Taskent and Tore showed great decreasing trend after 5 dS m^{-1} salt level, Ozkaynak was not greatly affected upto 10 dS m^{-1}. Crackerjack, Ozkaynak, Rose, Taskent and Tore cultivars had slightly higher but statistically insignificant shoot length.

Table 1: *Germination rates of genotypes x salt interactions*

Cultivar/Dosage	**Control**	**5 ds m^{-1}**	**10 ds m^{-1}**	**15 ds m^{-1}**	**20 ds m^{-1}**	***Mean***
Population	$91{,}5^{abc}$	$90{,}0^{abc}$	$91{,}0^{abc}$	$90{,}0^{abc}$	$87{,}0^{c}$	***$89{,}9^{d}$***

Crackerjack	100[a]	100[a]	99,5[a]	99,0[ab]	98,0[abc]	***99,3[a]***
Golyazı	88,0[bc]	99,0[ab]	97,0[abc]	94,5[abc]	94,5[abc]	***94,4[c]***
Ozkaynak	100[a]	99,0[ab]	98,5[ab]	99,5[a]	95,5[abc]	***98,5[ab]***
Rose	99,0[ab]	100[a]	99,0[ab]	99,0[ab]	92,0[abc]	***97,8[abc]***
Taskent	100[a]	99,5[a]	97,5[abc]	98,0[abc]	87,0[c]	***96,4[abc]***
Tore	97,0[abc]	97,5[abc]	95,5[abc]	95,5[abc]	90,5[abc]	***95,2[bc]***
Ulubatlı	35,5[e]	50,0[d]	36,0[e]	48,5[d]	32,0[e]	***40,4[e]***
Mean	***88,9[b]***	***91,7[a]***	***89,2[ab]***	***90,5[ab]***	***84,6[c]***	

P<0.1

Table 2: *Mean germination time values of genotypes x salt interactions*

Cultivar / Salt	Control	5 ds m^{-1}	10 ds m^{-1}	15 ds m^{-1}	20 ds m^{-1}	*Mean*
Population	2,73	2,51	2,27	2,45	2,88	***2,57[d]***
Crackerjack	2,66	2,30	2,16	2,18	2,50	***2,36[c]***
Golyazı	3,53	2,66	2,31	2,83	3,42	***2,95[f]***
Ozkaynak	1,97	2,00	1,61	1,86	2,17	***1,92[a]***
Rose	2,53	2,61	2,40	2,70	3,43	***2,74[e]***
Taskent	2,08	2,02	1,86	2,04	2,06	***2,01[ab]***
Tore	2,01	2,06	2,04	2,02	2,08	***2,04[b]***
Ulubatlı	2,96	2,86	2,60	2,99	3,47	***2,98[f]***
Mean	***2,56[c]***	***2,38[b]***	***2,16[a]***	***2,38[b]***	***2,75[d]***	

P<0.1

Fresh seedling weights were always higher in all genotypes at 5 dS m^{-1} salt level compared to the other treatments but the response of fresh seedling weight of the genotypes was fluxional at the other treatments. Crackerjack, Rose, Taşkent and Tore cultivars were affected negatively after 5 dS m^{-1} salt content but Ozkaynak was not affected seriously upto 10 dS m^{-1}. Similar responses to salt levels were also recorded for dry seedling weight for genotypes.

Table 3: *Root lengths of genotypes x salt interactions*

Cultivar / Salt	Control	5 ds m^{-1}	10 ds m^{-1}	15 ds m^{-1}	20 ds m^{-1}	*Mean*
Population	4,65	4,85	4,72	3,77	2,30	***4,06[d]***
Crackerjack	9,35	9,57	6,15	6,32	4,05	***7,09[a]***
Golyazı	2,47	8,52	4,17	3,35	2,97	***4,30[cd]***
Ozkaynak	7,92	7,70	6,97	6,05	2,17	***6,16[b]***

Rose	9,10	8,32	4,60	6,32	3,10	***6,29***^{b}
Taskent	6,82	6,95	4,27	4,50	2,10	***4,93***^{c}
Tore	7,77	6,17	3,75	4,30	2,37	***4,87***^{c}
Ulubatlı	0,32	6,22	3,70	2,05	0,18	***2,49***^{e}
Mean	***6,05***^{b}	***7,29***^{a}	***4,79***^{c}	***4,58***^{c}	***2,40***^{d}	

P<0.1

Table 4: *Shoot lengths of genotypes x salt interactions*

Cultivar / Salt	Control	5 ds m^{-1}	10 ds m^{-1}	15 ds m^{-1}	20 ds m^{-1}	*Mean*
Population	6,42	8,27	5,00	2,40	1,02	***4,62***^{c}
Crackerjack	6,55	4,97	3,00	2,32	2,27	***3,82***^{de}
Golyazı	1,00	6,75	4,27	2,57	2,00	***3,32***^{e}
Ozkaynak	12,05	10,27	9,67	6,77	2,45	***8,24***^{a}
Rose	8,05	6,32	3,17	2,40	1,60	***4,31***^{cd}
Taskent	10,00	9,32	6,60	6,65	3,12	***7,14***^{b}
Tore	11,75	10,45	7,30	4,27	1,50	***7,05***^{b}
Ulubatlı	2,85	4,90	3,70	0,47	0,30	***2,44***^{f}
Mean	***7,33***^{a}	***7,65***^{a}	***5,34***^{b}	***3,48***^{c}	***1,78***^{d}	

P<0.1

The plants are the most sensitive to salt stress during seedling stage and considerable differences occur among genotypes belonging to species are originated from genetical differences (Cerda et al., 1982; Jayasundara et al., 1998; Noreen & Ashraf, 2009). In this study, investigated genotypes showed different response to salt stress with respect to germination percentage and it was decreased at high salt levels. Similar results were also recorded by Dua et al. (1989).

Table 5: *Fresh seedling weights of genotypes x salt interactions*

Cultivar / Salt	Control	5 ds m^{-1}	10 ds m^{-1}	15 ds m^{-1}	20 ds m^{-1}	*Mean*
Population	1,59	2,16	1,37	0,66	0,48	***1,25***^{c}
Crackerjack	4,05	4,17	2,61	1,65	1,39	***2,77***^{a}
Golyazı	0,22	2,37	1,00	1,10	0,91	***1,12***^{c}
Ozkaynak	2,25	2,36	2,02	1,23	0,91	***1,75***^{b}
Rose	3,89	4,40	2,21	1,15	1,40	***2,61***^{a}

Taskent	1,71	2,04	1,43	1,06	0,78	***1,40***[bc]
Tore	1,84	2,14	1,62	1,03	0,70	***1,47***[bc]
Ulubatlı	0,21	1,29	0,46	0,29	0,11	***0,47***[d]
Mean	***1,97***[b]	***2,62***[a]	***1,59***[c]	***1,02***[d]	***0,83***[d]	

P<0.1

Table 6: *Dry seedling weights of genotypes x salt interactions*

Cultivar / Salt	Control	5 ds m^{-1}	10 ds m^{-1}	15 ds m^{-1}	20 ds m^{-1}	*Mean*
Population	0,20	0,20	0,16	0,12	0,09	***0,15***[d]
Crackerjack	0,42	0,39	0,31	0,27	0,22	***0,32***[a]
Golyazı	0,06	0,24	0,19	0,14	0,13	***0,15***[d]
Ozkaynak	0,26	0,25	0,21	0,17	0,12	***0,21***[b]
Rose	0,48	0,42	0,28	0,21	0,17	***0,31***[a]
Taskent	0,25	0,23	0,15	0,15	0,12	***0,18***[c]
Tore	0,25	0,24	0,18	0,14	0,10	***0,18***[c]
Ulubatlı	0,05	0,16	0,07	0,04	0,02	***0,07***[e]
Mean	***0,25***[b]	***0,27***[a]	***0,20***[c]	***0,16***[d]	***0,12***[e]	

P<0.1

Mean germination time increased upto 10 dS m^{-1} salt treatment in most of the investigated genotypes in the experiment. But this increasing ratio showed differences among genotypes. These results mainly originated from salt stress tolerance differences of the genotypes as mentioned by Noreen & Ashraf (2009).

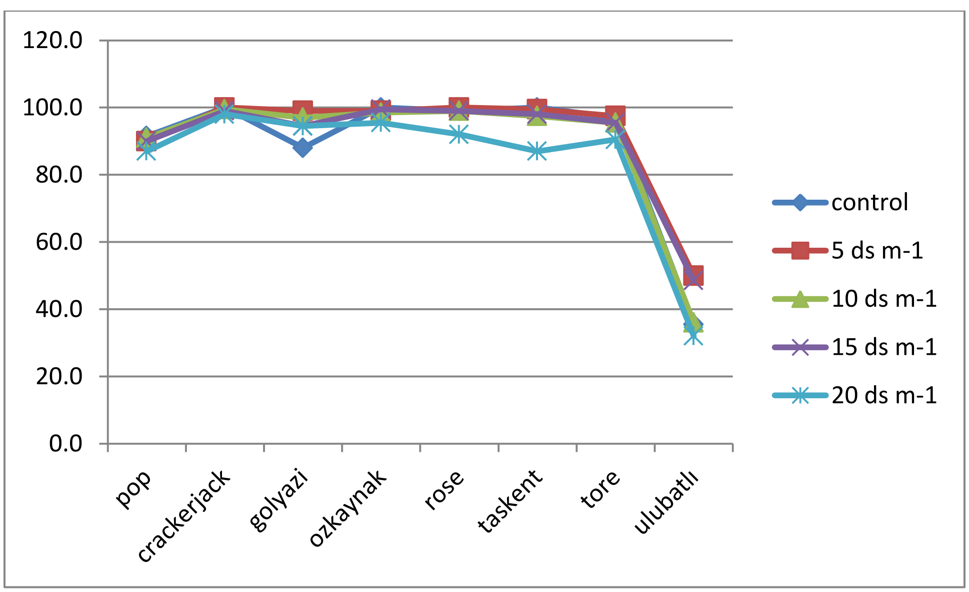

Figure 1: *Germination rates of genotypes under different salinity levels*

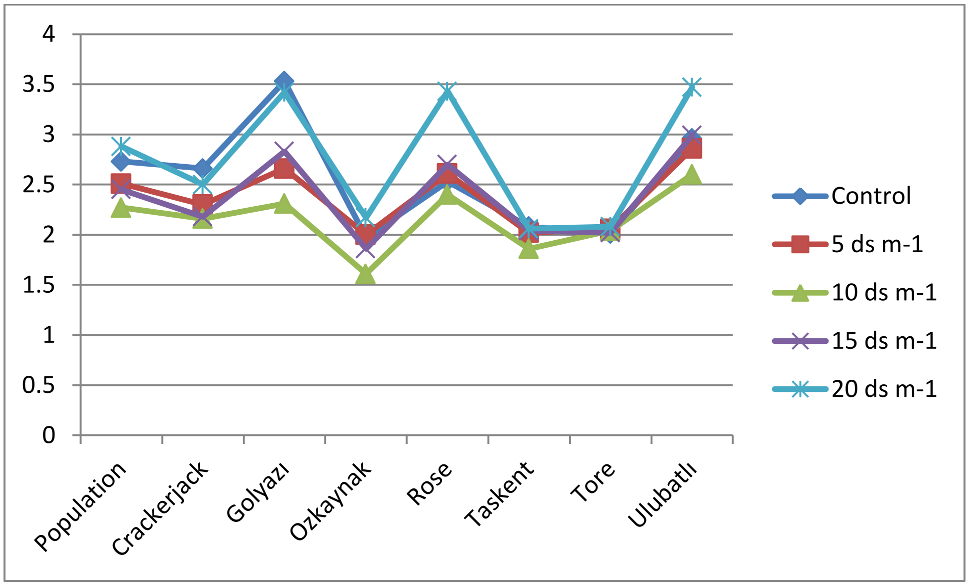

Figure 2: *Mean germination time of genotypes under different salinity levels*

Root and shoot lengths showed considerable changes among the genotypes. In general, root and shoot lengths were decreased as salt level increase but decreasing trend was different among the genotypes. Generally, root growth was less affected by salt stress than shoot growth (Table 1). Similar results were also reported by Jayasundara et al. (1998) and Noreen & Ashraf (2009).

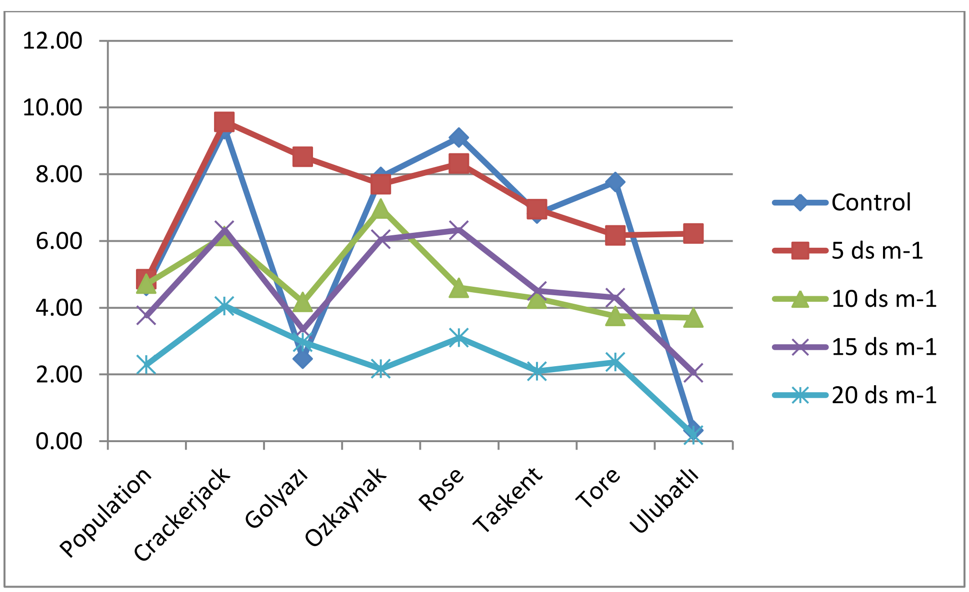

Figure 3: *Root lengths of genotypes under different salinity levels*

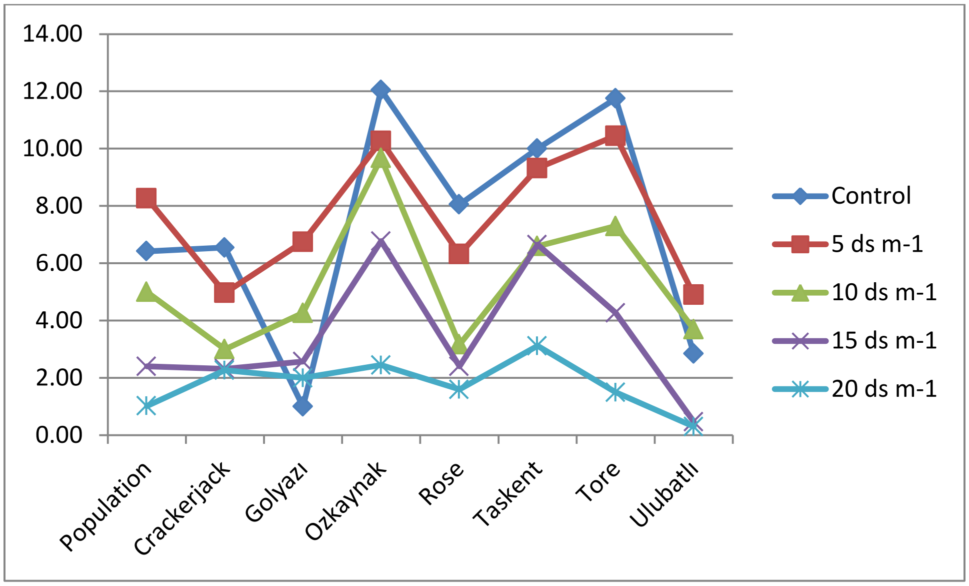

Figure 4: *Shoot lengths of genotypes under different salinity levels*

As salt level increase, seedling fresh and dry weights were decreased especially it was more pronounced after 5 dS m^{-1} salt content (Table 1). This was mainly orriginated from negative effect of salt stress on plant growth (Parida & Das, 2005). The genotypes showed different response to salt levels with respect to fresh and dry seedling weight (Figure 5,6). Reduction in fresh and dry seedling weight were low in Taşkent, Ozkaynak and Tore cultivars upto 10 dS m^{-1} salt level and in Rose and Crackerjack upto 5 dS m^{-1}. These results clearly pointed out those salt tolerances of the investigated genotypes were different, as reported in the other studies (Najafi et al., 2007; Noreen & Ashraf, 2009).

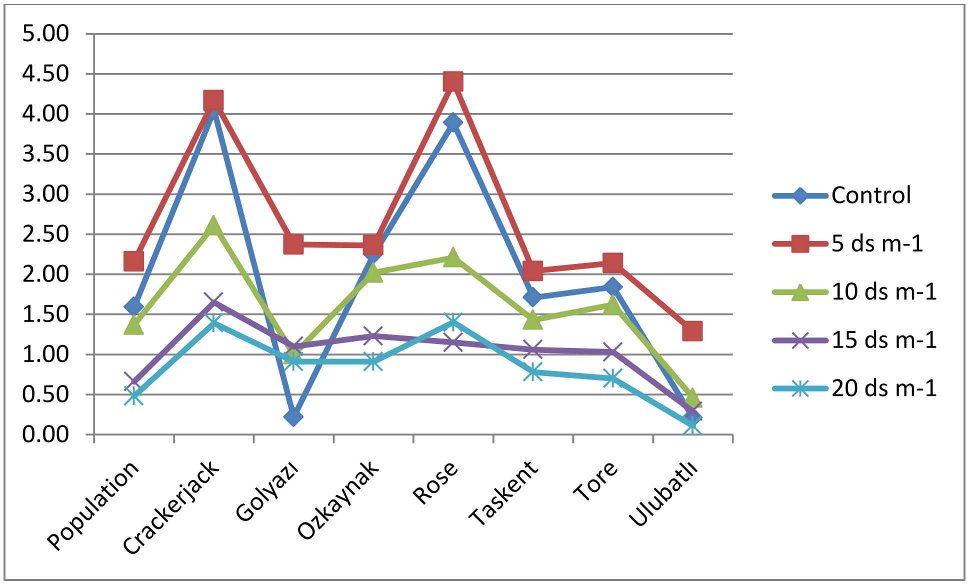

Figure 5: *Fresh seedling weights of genotypes under different salinity levels*

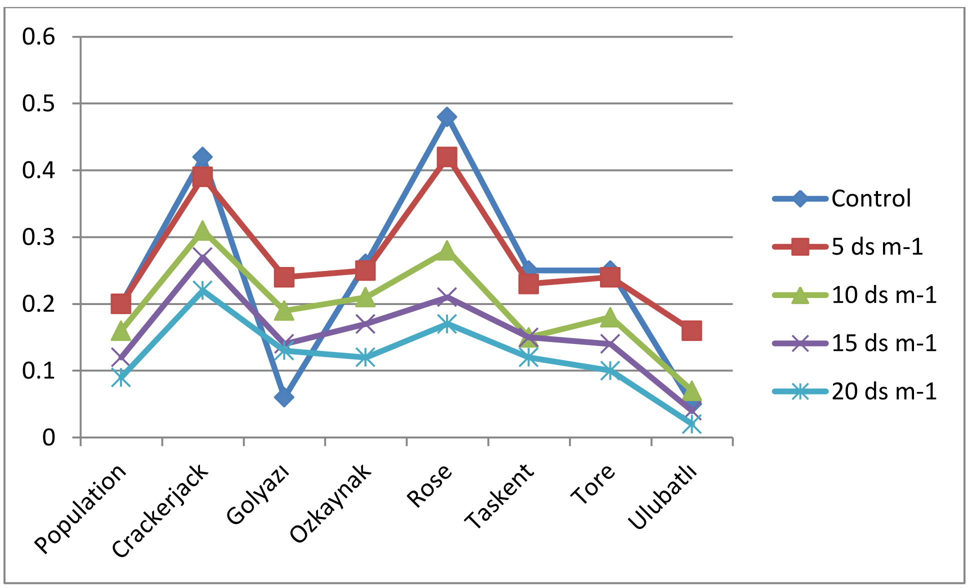

Figure 6: *Dry seedling weights of genotypes under different salinity levels*

In the experiment, some investigated parameters showed slight increase in lower salt content compared to the control. This situation can be related to characteristics of the plant because the pea genus has been categorized as one of the most tolerant legume to salinity (Noreen & Ashraf, 2009). Similarly, Najafi et al (2007) were also reported positive result under lover salt levels in pea under greenhouse conditions.

4. Conclusion

Salination is an inevitable and a serious problem under dry environment, especially irrigated areas. It is important to select suitable crops species to alleviate negative effect of salinization under salt affected areas.

Germination and seedling growth in the investigated genotypes showed different response to salinity levels. Among the genotypes, Taskent, Tore and Ozkaynak were seen to be more resistant to salt stress because their growing performances were not affected seriously upto 10 dS m^{-1} salt level. On the other hand, Crackerjack and Rose cultivars performance was not affected seriously by 5 dS m^{-1} salt level. According to the result; these 5 cultivars can be suggested for slightly salt affected areas and firstly mentioned 3 cultivars (Taskent, Tore, Ozkaynak) can be suggested for moderately salt affected areas. However, further researches are needed with respect to investigate field performance of the suggested cultivars.

References

Abdul-Jaleel, C., Gopi, R., Sankar, B., Manivannan, P., Kishorekumar, A., Sridharan, R. & Panneerselvam, R. (2007). Studies on germination, seedling vigour, lipid peroxidation and proline metabolism in Catharanthus roseus seedlings under salt stres. South African Journal of Botany, 73, 190–195. https://doi.org/10.1016/j.sajb.2006.11.001

Acikgoz, E. (2001). Yem Bitkileri. Bursa, Uludag Universitesi Guclendirme Vakfi, Yayin No: 182.

Almansouri, M., Kinet, J. M. & Lutts, S. (2001). Effect of salt and osmotic stresses on germination in durum wheat (*Triticum durum* Desf.). Plant and Soil, 231, 243–254. https://doi.org/10.1023/A:1010378409663

Avcıoglu, R., Hatipoglu, R. & Karadag Y. (2009). Yem Bitkileri. Izmir, TC Tarım ve Koyisleri Bakanlıgı Tarımsal Uretim ve Gelistirme Genel Mudurlugu.

Barbouchi, M., Abdelfattah, R., Member, S., Chokmani, K., Aissa, N. B., Lhissou, R. & El-Harti, A. (2014). Soil salinity characterization using polarimetric In SAR coherence: case studies in Tunisia and Morocco, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 1–10.

Bonilla, I., El-Hamdaoui, A. & Bolaños Boron, L. (2004). Pisum sativum seed germination and seedling development under salt stres. Plant and Soil, 267, 97–107. https://doi.org/10.1007/s11104-005-4689-7

Carpici, E. B., Celik, N. & Bayram, G. (2009). Effects of salt stress on germination of some maize (*Zea mays* L.) cultivars. African Journal of Biotechnology, 8(19), 4918 - 4922.

Cerda, A., Caro, M. & Fernandez, F. G. (1982). Salt tolerance of two pea cultivars. Agronomy Journal, 74, 796-798. https://doi.org/10.2134/agronj1982.00021962007400050007x

Dua, R., Sharma, S. & Mishra, B. (1989). Response of broad bean (*Vicia faba*) and pea (*Pisum sativum*) to salinity. Indian Journal of Agricultural Sciences, 59, 729-731.

Ellis, R. H. & Roberts, E. H. (1980). Towards a rational basis for testing seed quality. London. In: Hebblethwaite, P.D. (Ed.). Seed Production. Butterworths, pp. 605–635.

Gorji, T., Sertel, E. & Tanik, A. (2017). Monitoring soil salinity via remote sensing technology under datascarce conditions: A case study from Turkey. Ecological Indicators, 74, 384–391. https://doi.org/10.1016/j.ecolind.2016.11.043

Jamil, M., Deog-Bae, L., Kwang-Yong, J., Ashraf, M., Sheong-Chun, L. & Eui-Shik, R. (2006). Effect of salt (NaCl) stress on germination and early seedling growth of four vegetables species. Journal of Central European Agriculture, 7(2), 273-282.

Jayasundara, H. P. S., Thomson, B. D. & Tang, C. (1998). Response of cool season grain legumes to soil abiotic stresses. Advances in Agronomy, 63, 77-151. https://doi.org/10.1016/S0065-2113(08)60242-4

Metternicht, G. I. & Zinck, J. A. (2008). Remote sensing of soil salinization: impact onland management. In: Shrestha, D.P., Farshad, A. (Eds.), Mapping Salinity Hazard: An Integrated Application of Remote Sensing and Modeling-BasedTechniques, 1st ed. Taylor & Francis Group, LLC, pp. 257–272. https://doi.org/10.1201/9781420065039

Moud, A. M. & Maghsoudi, K. (2008). Salt stress effects on respiration and growth of germinated seeds of different wheat (*Triticum aestivum* L.) cultivars. World Journal of Agricultural Sciences, 4(3), 351-358.

Najafi, F., Khavari-Nejad, R. A., Rastgar-Jazii, F. & Sticklen, M., (2007). Growth and some physiological attributes of pea (*Pisum sativum* L.) as affected by salinity. Pakistan Journal of Biological Sciences, 10(16), 2752-2755. https://doi.org/10.3923/pjbs.2007.2752.2755

Noreen, Z., Ashraf, M. & Hassan M. U. (2007). Inter-accessional variation for salt tolerance in pea (*Pisum sativum* L.) at germination and seedling stage. Pakistan Journal of Botany, 39(6), 275-285.

Noreen, Z. & Ashraf, M. (2009). Assessment of variation in antioxidative defense system in salt-treated pea (*Pisum sativum*) cultivars and its putative use as salinity tolerance markers. Journal of Plant Physiology, 166(16), 1764-1774. https://doi.org/10.1016/j.jplph.2009.05.005

Okcu, G., Kaya, M. D. & Atak, M. (2005). Effects of salt and drought stresses on germination and seedling growth of pea (*Pisum sativum* L.). Turkish Journal of Agriculture and Forestry, 29, 237-242.

Olmos, E. & Hellín, E., (1996). Mechanisms of salt tolerance in a cell line of *Pisum sativum*: biochemical and physiological aspects. Plant Science, 120(1), 37-45. https://doi.org/10.1016/S0168-9452(96)04483-4

Parida, A. K. & Das, A. B. (2005). Salt tolerance and salinity effects on plants: a review. Ecotoxicology and Environmental Safety, 60(3), 324-349. https://doi.org/10.1016/j.ecoenv.2004.06.010

Rehman, S., Harris, P. J. C., Bourne, W. F. & Wilkin, J. (1996). The effect of sodium chloride on germination and the potassium and calcium content of Acacis seeds. Seed Science and Technology, 25, 45-57.

Steppuhn, H., Volkmar, K. M. & Miller, P. R. (2001). Comparing canola, field pea, dry bean, and durum wheat crops grown in saline media. Crop Science, 41(6), 1827-1833. https://doi.org/10.2135/cropsci2001.1827

Tan, M., Koç, A., Çomaklı, B. & Elkoca, E. (2011). Dogu Anadolu Bolgesi'nden toplanan yem bezelyesi populasyonlarının bazı özellikleri. Uluslararası Katılımlı I. Ali Numan Kıraç Tarım Kongresi ve Fuarı, 27-30 Nisan.

Uzun, A., Bilgili, U., Sincik, M., Filya, I. & Acikgoz, E., (2005). Yield and quality of forage type pea lines of contrasting leaf types. European journal of agronomy, 22(1), 85-94. https://doi.org/10.1016/j.eja.2004.01.001

Wang, W. B., Kim, Y. H., Lee, H. S., Kim, K. Y., Deng, X. P. & Kwak, S. S. (2009). Analysis of antioxidant enzyme activity during germination of alfalfa under salt and drought stresses.

Plant Physiology and Biochemistry, 47, 570–577. https://doi.org/10.1016/j.plaphy.2009.02.009

Zhu, H. & Banuelos, G. (2016). Influence of salinity and boron on germination, seedling growth and transplanting mortality of guayule: A combined growth chamber and greenhouse study. Industrial Crops and Products, 92, 236–243. https://doi.org/10.1016/j.indcrop.2016.07.027