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Effect of Salinity Stress on Nutrient Composition of Field Pea Genotypes *(Pisum sativum. sp. arvense L.)*

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Abstract: The present study aimed to investigate the effect of different days (0, 7 and 15th days) and salt applications (salty and saltness) on nutrient element compositions of root, shoot and leaf organs of 11 field pea genotypes (which are nominate pea) and 2 pea cultivars. For this aim, the data were analyzed using three-way-ANOVA (genotypes, salt application and time). In this study determining, the effects of salt stress on nutrient element compositions of these organs, although the effects of salt application, salt by variety and salt by day interactions on Cu element in root were only found to be non-significant, genotypes, salt application, days and their interactions with 2 and 3 degree for other elements were found to be significant. In root and shoot organs, salt application increased significantly Ca, Mg and Zn amounts, but other minerals decreased compared to control group. The application in leaf increased Ca and Mg, whereas others reduced.

Key words: Pea genotypes, salt stress, plant nutrient composition

INTRODUCTION

It is well-known that salt application had a depressing effect on development-growth, nutrient substance reception mechanism, but an increase effect in proline of plants.

Lynch and Lauchli (1984) reported that soil salinity on two barley varieties reduced Ca content of shoots and young leaves and blocked Ca transport from roots to shoot, which was concerned with Ca occurring in root.

Al-Karaki (1997) mentioned that destructive effect of NaCl application with increasing P doses on plant reduced. In the effect of NaCl applications (0, 50, 75, 100 nM) on two chickpea cultivars, stated that plant's development and photo-synthesis was effected adversely by salt applications and N fixation and nodulation in Pedrosillano cultivar was influenced more than those in other cultivars.

Grattan and Grieve (1999) mentioned that salinity in terms of plant performance led to disorders on nutrient element mechanism and salinity had effect directly on nutrient reception and Na decreased K reception and Cl reduced NO_3 reception.

Erdal *et al.* (2000), who worked the effect of potassium fertilizer on development and change of some nutrient substance contents of cucumber seedling under salt stress stated that high salinity increased Na, Ca, Mn, Cu and Fe contents of the plant, but reduced K and P contents of the plants and K, Zn, Mn, Cu and Fe contents of plant with potassium applications enhanced, whereas Na, Ca, Mg and P contents decreased.

Lacerda *et al.* (2000), who exposed sorghum genotypes to NaCI from 25-100 nM by 25 nM once 12 h, investigated the effect of salt application on shoot and root development and organic and inorganic substance amounts of plant after a week. Salinity reduced dry matter amount, root and shoot lengths of delicate genotype and caused an increase in Na and Cl amounts moved into shoots, but a decrease in K and Ca amounts.

Bayuelo-Jimenez *et al.* (2002) tested performances of some bean species under salt applications, whose levels are 0, 60, 120 and 180 mM NaCl. The authors reported that salt application slowed these germinations at various degrees and bean species studied were more durable under salt media than wild bean and phaseolus filiformis species.

Inal (2002) investigated the influences of salt application on development, proline accumulation, ion extent and reception of tomato plants at 2 months. The author reported that with salinity, plant's nutrient balance demolished and K:Na and NO_3 N:Cl proportions decreased, whereas Na and Cl contents increased.

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Besides, Na reception increased with salt application, but P and S reception shown a decrease with less amount compared to control group. It was reported that two different salt sources effected tomato plant's performance, but the effect of Na_2SO_4 on these performance was found to be more negatively than that of NaCl.

Munns (2002), who studied on comparison of water and salt stress, reported that water stress reduced plant's water reception and growth rate. However, extremely high salt amount going through into plants led to early aging and a decrease in photosynthesis area. Under Salinity application, old leaves affected more harmfully than young leaves.

Bandeoğlu *et al.* (2004), who examined the effect of salt stress on antioxidant condition in shoot and root of lentil plants, stated that shoot length, root length, wet and dry weights of the plant decreased with salt stress but proline level increased.

Bhivare and Nimbalkar (2005), who applied Sodium Chloride and Sodium sulphate as salt applications on bean plant, determined that these substances had inhibitor effect on its development. These salt applications provided an increase in leaf's diameter and humid and shown an increase in, Na, Ca, Fe, nutrient contents and Mg, but a reduction in N, K, Cu and Zn contents.

In a study on response of two corn cultivars to salt stress, salt stress led to unbalances in metabolism of these plants, growth ending and accumulation of toxic ions in plant metabolism and especially old leaves (Demiral and Türkan, 2005).

In an investigation conducted to determine the effect of four different salt applications (non saline, saline, saline- alkaline and alkaline) on sunflower plant, it was determined that salt stress had noticeably negative effects on growth parameters and concentrations of macro and micro nutrient elements and effectuated high degree Na:K rate and ion balance destructed (Mohammedin *et al.*, 2006). Endris and Mohammed (2007) stated that salinity in semi-drought and drought regions consisted of an important problem and led to product loss with evaporation of pure water in soil.

Psarras *et al.* (2008) examined the effects of NaCl salinity (with three salt doses) and K (with two doses) applications on photosynthesis, yield, growth and ion accumulation of tomato plant under greenhouse condition. In the study, salinity reduced photos-ynthesis and 35 nM salt and 70 nM applications led to 25 and 69% of decrease on plant height, dry matter amount and yield, respectively. With high K application, Na concentration reduced, but K amount increased and high K application had positive-insignificant contribute to plant development.

The present study aimed to determine the effects of salinity, genotype and treatment time on nutrient composition of field Pea, which plays an important role for animal nutrition.

MATERIALS AND METHODS

Plant material: Eleven field pea genotypes and two pea cultivars from different region of the Anatolia were used in the study.

Plant growth and treatments: Pea seeds were germinated in a growth chamber at 20±2°C and 70% humidity with a 16-h photoperiod. Seeds were placed in plastic pots (40×25×5 cm) filled with pumice and seedlings were irrigated with Hoagland nutrient solution following the emergence of the first true leaves. Following the emergence of the second true leaf, seedlings were transplanted to plastic developing dishes (25×25×5 cm) for hydroponics culture using a Hoagland solution replaced at weekly intervals.

Seedlings were grown in control conditions until emergence of the fourth true leaf, at which time salt stress treatment was initiated. Salt treatment consisted of adding 25 mM NaCl daily until a concentration of 75 mM NaCl was attained. The experiment used a randomized design of 15 plants per genotype with 4 replications. Fourteen days after the initiation of salt treatment, 6 plants were randomly harvested from each genotype, separated into root, shoot and leaf components and the fresh weights of each component measured.

For micronutrients determination, dry samples of roots, shoots and leaves were extracted in concentrated HNO_3 and HClO4. Fe, Mn, Cu and Zn contents were determined by atomic absorption spectrometry (AAS). The others were determined by flame photometer.

Statistical analysis: The aim of the present study was to determine the effects of cultivar, time and salt application as well as these factor's two and three-way interactions on Ca, Mg, Fe, Mn, Cu, Zn elements in root, shoot and leafs of plant. For this aim, the data on elements were analyzed using three-way ANOVA with three replications. Statistical Analyses were performed using GLM (General Linear Model) procedure of SAS package program (SAS, 1998). Duncan's Multiple Range Test was used to determine whether the difference between two means was statistically significant.

RESULTS AND DISCUSSION

Table 1 presents ANOVA and Duncan's Multiple Range test results of Ca, Mg, Fe, Mn, Cu and Zn contents

Table 1: ANOVA and Duncan's Multiple Range test results of Ca, Mg, Fe, Mn, Cu and Zn compositions in root

	F values					
Variation source	CA	MG	FE	MN	CU	ZN
Salty S	413.45**	10.57**	4984.65**	454.36**	0.13	10.37**
Genotype G	287.9**	19.02**	353.58**	43.70**	3.27**	19.67**
Day D	17365.72**	1860.3**	7787.65**	785.14**	10.25**	673.12**
S*G int.	228.6**	7.47**	210.63**	10.08**	0.58	8.09**
S*D int.	2223.99**	134.35**	3106.62**	211.35**	0.24	25.1**
G*D int.	285.72**	5.98**	269.96**	33.52**	1.70*	8.66**
S*G*D int.	325.73**	8.52**	122.64**	14.95**	0.38	7.1**
R^2 (%)	99.743	96.765	99.640	96.464	42.910	93.141
Salinity						
Saltness(0)	33.4321b	12.0610 b	11371.44 a	2292.37 a	0.0084a	0.0183b
salty(1)	41.0754 a	13.0101 a	6667.78 b	1597.70 b	0.0082a	0.02a
Daytime						
0	7.18c	4.30c	4857.33c	1161.20c	0.0065b	0.0091c
7	18.21b	8.41b	7504.81b	1931.24b	0.0079b	0.0169b
15	86.38a	24.90a	14696.69a	2742.67a	0.0103a	0.0315a
Genotype						
10431	56.59a	17.52a	8299.9f	1617.3g	0.0096bc	0.0247a
1121918	50.23b	14.64b	10872.8c	2750.5a	0.0069c	0.0202bc
B-8	50.15b	14.04bc	10579.8c	1429.4h	0.0084bc	0.0243a
1084222	49.3b	14.82b	11363.3b	1980.7de	0.014a	0.0156d
1101545	43.77c	12.73cd	8006.4fg	1831.2ef	0.0118ab	0.0139d
110121	29.46e	12.08de	7366.7h	2275.2c	0.0074c	0.0210bc
B-6	24.02f	11.78de	9709.9d	2007.4de	0.0071c	0.0162d
1131556	35.83d	12.09de	13.87.8a	2507.1b	0.0076c	0.0188c
1011917	22.86f	11.63de	7923g	1718.7fg	0.0064c	0.0138d
1103220	29.26e	12.15de	4344.4j	2050.1d	0.0066c	0.0143d
110121-1	27.63e	10.12f	6826.2ı	1543.4gh	0.0063c	0.0225ab
Winner	28.05e	10.76ef	9837.7d	1976.6de	0.0077c	0.0239a
Karina	37.11d	8.6g	9037.1e	1598gh	0.0081c	0.0199bc

Same Letters indicate treatment groups between which no significant differences were found

Table 2: ANOVA and Duncan's Multiple Range test results of Ca, Mg, Fe, Mn, Cu and Zn contents in shoot

	F values					
Variation source	CA	MG	FE	MN	CU	ZN
Salty S	1980.68**	66.32**	42.82**	1.02	10.01**	8.79**
Genotype G	479.90**	15.9**	34.09**	36.5**	171.24**	14.21**
Day D	18893.59**	2339.81**	155.78**	704.34**	272.36**	70.8**
S*G int.	272.3**	9.56**	46.98**	13.77**	3.11**	4.74**
S*D int.	1734**	148.12**	63.07**	3.47*	16.01**	23.04**
G*D int.	309.66**	4.96**	90.7**	19.7**	161.68**	15.57**
S*G*D int.	486.99**	8.45**	34.6**	14.02**	1.77*	9.83**
R^2 (%)	99.782	97.322	96.621	94.774	97.692	86.886
Salinity						
Saltness(0)	28.7501b	10.3136b	0.0119231a	0.0074103a	0.0036154a	0.0098034b
salty(1)	44.6804a	12.4876a	0.0102564b	0.0072308a	0.0032650b	0.00110342a
Daytime						
0	6.727c	3.924c	0.008c	0.004c	0.005a	0.007c
7	17.929b	6.021b	0.012b	0.006b	0.003b	0.011b
15	85.489a	24.257a	0.013a	0.012a	0.002c	0.013a
Genotype						
10431	70.85a	13.17c	0.01311b	0.00306h	0.00244de	0.00817c
1121918	52.05b	14.08ab	0.00794e	0.00944b	0.0025cde	0.00789c
B-8	47.42c	13.13bc	0.01311b	0.00717cde	0.00311bc	0.01422a
1084222	46.35c	14.94a	0.00783e	0.00739cd	0.01256a	0.0105b
1101545	41.77d	11.76cd	0.01050cd	0.00761cd	0.00272bcde	0.01056b
110121	25.52g	10.56def	0.00944d	0.00694de	0.00272bcde	0.00883bc
B-6	23.54h	9.71efg	0.01050cd	0.00639ef	0.00261cde	0.00822c
1131556	23.52h	11.21de	0.00911ed	0.0095b	0.00294bcd	0.01333a
1011917	28.22f	10.48def	0.01311b	0.01056a	0.00222e	0.00844bc
1103220	29.23f	10.71def	0.01089c	0.006fg	0.00256cde	0.00778c
110121-1	27.46f	10.59def	0.01189bc	0.00806c	0.00328b	0.00806c
Winner	29.05f	9.48fg	0.01756a	0.00544g	0.00222e	0.01444a
Karina	32.33e	8.4g	0.00917ed	0.00761cd	0.00328b	0.015a

*Same Letters indicate treatment groups between which no significant differences were found

Table 3: ANOVA and Duncan's Multiple Range test results of Ca, Mg, Fe, Mn, Cu and Zn contents in leaf

	F values					
Variation source	CA	MG	FE	MN	CU	ZN
Salty S	2474.95**	12.09**	359.28**	33.43**	18.27**	16.02**
Genotype G	373.96**	5.05**	24.74**	21.91**	328.84**	8.38**
Day D	20233.81**	1040.22**	464.57**	503.69**	374.92**	68.22**
S*G int.	257.12**	2.94**	18.86**	16.01**	4.8**	3.87**
S*D int.	3621.09**	96.78**	100.66**	13.21**	11.14**	4.40*
G*D int.	285.77**	6.36**	37.95**	28.93**	296.46**	5.39**
S*G*D int.	279.17**	3.51**	7.73**	13.15**	2.83**	3.53**
R^2 (%)	99.781	94.378	95.222	95.196	98.714	76.998
Salinity						
Saltness(0)	27.9721b	11.4846b	0.0174a	0.02743a	0.0049a	0.0143a
Salty(1)	44.8914a	12.8138a	0.0117b	0.02480b	0.0045b	0.0124b
Daytime						
0	9.04c	4.77c	0.0083c	0.0163c	0.0064a	0.0095b
7	15.59b	7.28b	0.0159b	0.0286b	0.0047b	0.0158a
15	84.66a	24.39a	0.0192a	0.0334a	0.0029c	0.0147a
Genotype						
10431	55.95a	14.43a	0.0107h	0.0255de	0.00472b	0.01844a
1121918	51.71bc	12.66abc	0.0154cd	0.0246e	0.00339f	0.01244cd
B-8	52.72b	13.71ab	0.0168bc	0.03ab	0.004cde	0.01528b
1084222	50.07c	13.57ab	0.0177b	0.0262cde	0.01589a	0.01206cd
1101545	23.54g	11.96bcde	0.0106h	0.0204f	0.00367def	0.01206cd
110121	30.44e	14.39a	0.0133ef	0.0285bc	0.004cde	0.01394bc
B-6	27.68f	10.06de	0.0161cd	0.0297ab	0.00356def	0.01328bcd
1131556	24.34g	10.57cde	0.0194a	0.0252e	0.00311f	0.00922e
1011917	26.95f	11.13cde	0.0136ef	0.0279bcd	0.00344ef	0.01083de
1103220	35.56d	12.09bcd	0.0128fg	0.0178g	0.00356def	0.01083de
110121-1	27.81f	11.79bcde	0.0117gh	0.0278bcd	0.00311f	0.01567b
Winner	30.87e	9.76e	0.0157cd	0.0315a	0.00405cd	0.01533b
Karina	35.98d	11.83bcde	0.0147ed	0.0245e	0.0045bc	0.01383bc

Same Letters indicate treatment groups between which no significant differences were found

in root. As seen from Table 1, the effects of salt, genotype, time and, their interactions with two and three degrees on Ca, Mg, Fe, Mn and Zn contents were found to be more significant ($p<0.01$). However, the effects of genotype ($p<0.01$), day ($p<0.01$) and their interaction ($p<0.05$) on Cu content were only found to be significant. Besides, Determination coefficients (R^2) of Ca, Mg, Fe, Mn, Cu and Zn elements for root were estimated as: approximately 93.74, 96.77, 99.64, 96.46, 42.91 and 93.14%, respectively (Table 1). With salt application, Ca, Mg, Zn compositions in root increased ($p<0.05$), but Fe and Mn compositons decreased ($p<0.05$) and Cu reception didn't not changed. It is clear in Table 1 that amounts of all elements in root increased from 0-15th days ($p<0.05$). Except for Cu, the salt effect on other elements in root shown to vary genotypes.

ANOVA and Duncan's Multiple Range test results of Ca, Mg, Fe, Mn, Cu and Zn contents in shoot are given in Table 2. It demonstrated clearly in Table 2 that the effects of salt, genotype, time and, their interactions with two and three degrees on Ca, Mg, Fe, Mn, Cu and Zn contents were found to be more significant ($p<0.01$). Determination coefficients (R^2) of Ca, Mg, Fe, Mn, Cu and Zn elements for shoot were calculated as: approximately 99.78, 97.32, 96.62, 94.77, 97.69 and 86.87%, respectively (Table 2). With salt application, Ca, Mg, Zn compositions in shoot increased ($p<0.05$), but Fe and Cu compositons decreased ($p<0.05$) and Mn reception didn't not changed. It is clear in Table 2 that except for Cu amounts of all elements in shoot increased from 0-15th days ($p<0.05$). Except for Cu, the salt effect on other elements in shoot was shown to vary from one genotype to another.

ANOVA and Duncan's Multiple Range test results of Ca, Mg, Fe, Mn, Cu and Zn contents in leaf are summarized in Table 3. It is clear in Table 3 that the effects of salt, genotype, time and, their interactions with two and three degrees on Ca, Mg, Fe, Mn, Cu and Zn contents were found to be more significant ($p<0.01$; $p<0.05$ for only Salt×Day interaction in Zn).

Determination coefficient (R^2) values of Ca, Mg, Fe, Mn, Cu and Zn elements for leaf were calculated as: approximately 99.78, 94.38, 95.22, 95.2, 98.71 and 76.998%, respectively (Table 3). With salt application, Ca and Mg compositions in leaf increased ($p<0.05$), but other element compositions decreased ($p<0.05$).

It is clear in Table 3 that except for Cu, amounts of all elements in leaf increased from 0-15th days ($p<0.05$). Except for Cu, the salt effect on other elements in leaf were said to fluctuate from one genotype to another.

These findings on salt stress in the present paper were in consistent with those reported by Erdal *et al.* (2000), who studied on cucumber seedling. Salt tolerances

of genotypes used in present paper were found to be different from each other. Thus, nutrient compositions of genotypes were suggested being different from one another. The finding was in agreement with findings of many authors, who studied on different plants (Grattan and Grieve, 1999; Erdal *et al*., 2000; Lacerda *et al*., 2000, Bayuelo-Jimenez *et al*., 2002; Inal 2002; Munns 2002; Bandeoğlu *et al*., 2004, Bhivare and Nimbalkar 2005; Demiral and Türkan, 2005).

CONCLUSION

As a result, it was concluded that salinity had a negative effect on nutrient composition of field peas.

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