Selcuk J Agr Food Sci, 29(1):15-24

Selcuk Journal of Agriculture and Food Sciences

Salinity Tolerance During Germination and Seedling Growth of Some Lentil (*Lens culinaris* Medic.) Cultivars

Sariye Uzun Kayıs[1], Ercan Ceyhan[1*]

[1]Department of Field Crops, Agriculture Faculty, Selcuk University, 42075, Konya, Turkey

ARTICLE INFO

Article history:
Received 02 February 2015
Accepted 13 March 2015

Keywords:
Emergence
Lentil
Salt tolerant
Seedling development

ABSRACT

The research was conducted to determine effects of salt concentrations on emergence and seedling development of lentil varieties. Trials were made during the year of 2013 on the laboratory and greenhouse of Selcuk University, Agricultural Faculty. Emergency trial was set up according to "Randomized Plots Design" by two factors and four replications; greenhouse trial was also set up according to "Randomized Plots Design" by two factors and three replications. The lentil varieties; Altın Toprak, Fırat-87, Kafkas, Malazgirt-89, Meyvesi-2001, Seyran-96, Sultan-I, Çağıl, Çiftçi and Özbek were used as material for both of the trials. Effects of the five doses of salt concentrations [0 (control), 30 mM, 60 mM, 90 mM and 120 mM] on the ratio of emergency, speed of emergency, average time for emergency, index of sensibility, length of shoot and root, fresh weight of shoot and root, dry weight of shoot and root, index of salt tolerance were evaluated. Responses of the lentil varieties for salt concentrations were differed. Comparing to the control, all of the investigated characteristics on the lentil genotypes showed significant reduction by depending on the increasing salt level. According to the effects of salt application, the lentil varieties Malazgirt-89, Fırat-87 and Çiftçi were the most tolerance by view of plant dry weights while the lentil varieties Özbek and Seyran-97 were the most sensitive. Consequently, the lentil varieties Malazgirt-89, Fırat-87 and Çiftçi showed high tolerance ratio for the salt application.

1. Symbols and Abbreaviations

Cl	: Chlorine
dS/m	: Desiemens / meter
MPa	: Mega Pascal
mmhos/ cm	: Milliohms/ centimeter
mM	: Mili molar
Na	: Sodium
NaCl	: Salt
NO_3	: Nitrat

2. Introduction

Salinity is one of factors that affect to yield in cultivated plants. According to salinity and alkalinity standards which is done, salinity and alkalinity (aridness) problems is identified in point of 1 518 722 ha areas in Turkey. According to these data, arid fields equal to %2 of the land area of the country, %5,48 of total cultivated fields (27699003 ha), %17 of 8,5 million economically irrigable fields. %74 of total arid areas are made up of saline soils, % 25,5 of saline- alkaline soils and %0,5 of alkaline (sodium) soils. Large parts of the arid soils constitute saline soils (Anonymous 2012). Cultivated plants that provide high resistance to salt and economically is obtained yield must be grown in the saline areas.

Salinity that affects uniform germination is one of the most important environmental factors in arid and semi-arid areas. Salt accumulation in soils both affects plant development in different degrees and changes responses of different plant sorts. When growth terms of the plant compare in salinity studies, germination and seedling growth terms are more important terms and this growth terms are more considerable terms for determination of salt responses of the plant sorts (Van Hoorn et

* Corresponding author email: eceyhan@selcuk.edu.tr

al. 2001). The main reason of this problem seen during germination term in high salt concentrations is prevented to water intake to inner seed (Mansour 1994). In addition, the causes of yield declines of the plants which is grown in saline soils are toxic effect and deteriorations in plant ion balance caused excessive quantity ions like Na and Cl (Flowers and Yeo 1981), problems to do with nutrient intake and moving to different sections of the plant and damage of physiological functions like photosynthesis and respiratory (Leopold and Willing 1984). Excessive accumulations of Na also prevent potassium intake in the plants seen salt stress (Siegel et al. 1980), because of Cl prevents especially NO_3 intake (İnal et al. 1995), ion balance of the plants cause deteriorate.

Therefore, determination of lentil varieties that are high resistance to salt and can obtain economically yield is a extremely important. The most vulnerable term to salt of the cultivated plants is early growth period. For this reason, germination and seedling growth term is more important terms and the growth terms are more considerably important in determination of salt responses. The study was conducted so as to determine effects of different salt concentrations on germination and seedling development that the first growth terms of lentil varieties.

2. Material and Methods

2.1. Materials

Registered 10 pieces of lentil varieties were used as material in the study. Lentil varieties used in the study were Altın Toprak, Fırat-87, Kafkas, Malazgirt-89, Meyvesi-2001, Seyran-96, Sultan-I, Çağıl, Çiftçi and Özbek.

3.2. Methods

3.2.1. Germination experiment

According to "Factorial Randomized Plots Design" as four replications, in control cabinet that have fixed 22±1.0 ºC ambient temperature in dark conditions, the study was conducted. In germination trials were used 5 different NaCl concentrations (0 (control), 30 mM, 60 mM, 90 mM and 120 mM). Germination trials was conducted in 10 cm diameter plastic petri cases placed 2 pieces of blotters to bases of the cases. For surface sterilization of lentil seeds, firstly the seeds kept waiting in %1.5 sodium hypochlorite solution for 5 minutes, subsequent to kept waiting in pure water for 5 minutes. 20 pieces of seeds, which were done surface sterilization, was placed to each petri cases and added 20 ml solutions on each petri cases. For prevention of fungi development during germination, each solutions were added 0.5 g l^{-1} benomyl active ingredient fungicide (benomyl 50wp trading name) was added to each solutions.

In the trial, germination features which was indicated in the below were examined.

3.2.1.1. Ratio of emergency

Seeds which was germinated counted each day at the same time. When radicle reached 10 mm, seed accepted as germinated seed and ward off environment (Goertz and Coons 1989; Elkoca 1997).

Ratio of emergency (%) = (the number of germinated total seed / 20) x 100

3.2.1.2. Speed of emergency

It was calculated by using the below formula (Murillo-Amador et al. 2002). n1, n2… defines the number of germinated seed, t1, t2….. defines the number of days occured germination.

Speed of emergency =n1/t1+n2/t2+…….+nn/tn

3.2.1.3. Average time for emergency

According to the below formula, average time for emergency (ATE) was calculated (Güldüren, 2012). f defines the number of germinated seed in the day which was done counting; x defines the day which was done counting in formula.

ATE (day)=$\Sigma(fx)/\Sigma f$

3.2.1.4. Index of sensibility

Index of sensibilities (IS) of genotypes in saline enviroment was determined by means of the below proportion seperately in each salt concentration (Foolad and Lin 1997).

IS= AGT in salt application / AGT in control application

3.2.2. Greenhouse trial

According to "Randomized Plots Design" as three replications in factorial regulation in greenhouse trials was conducted. First factor was made up of NaCl concentrations (0 (control), 30, 60, 90 and 120 mM), second factor was washed of lentil varieties. For seed sowing in greenhouse trials, firstly 500 ml pots was cleaned and sterilized. After seeds treated with %5 sodium hypochlorite for ten minutes, seeds were sterilized with deionized water (dI -H2O) by washing three times. Pots that had 500 ml volumes and were punctured four holes with 3-4 mm diameter in its base was inserted peat and pearlite. Each pots were sown 5 pieces of seed on 01 July 2013. Pots which were done sowing kept with 25 ºC temperature, % 40-50 moisture conditions in control climate chamber throughout five days after sowing as covered upper of pots, seeds of varieties were germinated and uncovered upper of pots and plants were inserted in controlled climate chamber with 25 ºC temperature, % 40-50 moisture conditions. Until emergency of plant completed, all pots were given deionized water (dI -H2O), after emergency of plant completed, salt applications were started. After 21 days, in pursuit of salt applications to seedlings began, seedings with roots removed and trial was concluded. After roots of seedlings were washed with water, root and shoot detached and as several researchers specified (Goertz and Coons 1991; Karakullukçu and Adak 2008), features specified in the below were examined.

3.2.2.1. Length of shoot

Distance between root crown and the end leaf by measuring with ruler was determined as mm.

3.2.2.2. Length of root

Distance between root crown and root tip with milimetric ruler was measured.

3.2.2.3. Fresh weight of shoot

After harvest, root and shoot was detached and shoots were weighted at once and fresh weight of shoots were determined as mg.

*3.2.2.4. Fresh weight of roo*t

After harvest soon after, roots were washed with water and after drying well, roots were weighted and fresh weight of roots were determined as mg.

3.2.2.5. Dry weight of shoot

After shoots determined fresh weight were dried with 65 ºC for 24 hours, shoots were weighted again and dry weight of shoots were determined as mg.

3.2.2.6. Dry weight of root

After roots determined fresh weight were dried with 65 ºC for 24 hours, roots were weighted again and dry weight of roots were determined as mg.

3.2.2.7. Percentage of salt tolerance

By means of the below equality, it was calculated.

Salt tolerance (%) = (DWSP / DWCP) x 100

DWSP : Dry weight of plant in salt application

DWCP : Dry weight of plant in control application

3.3. Evaluations of data

According to "Randomized Plots Design" with two factors before observation and measurements done in the study were subjected to variance analysis and were done LSD analysis on features found 1 % and the least 5% importance level variance and were done classifications (Düzgüneş et al., 1987). The analysis and calculations were done with JUMP package programmer.

3. Results

4.1. Germination trial

There were statistically significant differences within the salt concentration, variety and salt concentration x variety interaction for all traits in germination trial (Table 1).

4.1.1. Ratio of emergency

While the highest ratio of emergency was obtained 96.50% in control, the lowest ratio of emergency was obtained 21.75% with 120 mM NaCl applications in the study. However, when it compared to control, ratio of emergencies were decreased dramatically in 30, 60 and 90 mM NaCl applications and respectively 82.13%, 71.13% and 56.13% were occurred.

Ratio emergencies of varieties ranged from 55.50% (Özbek) to 77. 50% (Altın Toprak). Ratio of emergencies of varieties ranged from 93.75% to 98.75% relatively in narrow limit in control application. However, as salt levels increased (in 30 mM NaCl concentrations 75.00 - 91.25%, in 60 mM NaCl concentrations 55.00 - 88.75%, in 90 mM NaCl concentration 31.25 - 76.25% and in 120 mM NaCl application 5.00 - 41.25%), genotypic different emerged markedly and between ratio of emergencies of varieties occured larger variations. In the high salt levels, particularly ratio of emergencies of Sultan-I, Malazgirt-89 and Özbek varieties caused to decrease dramatically (Table 2). In terms of ratio of emergency and vulnerable to salt, genotype differents in germination phase dramatically emerged in particularly 90 and 120 mM NaCl applications.

Table 1

Variance analysis of ratio of emergencies, speed of emergency, average time for emergency and suscebility ındex in different NaCl concentrations of lentil varieties used in the study

Source of variance	SD	Ratio of emergency	Speed of emergency	Average time for emergency	Susceptibility index
Salt concentration (SC)	4	32709.81**	2.820**	19.687**	1.083**
Variety (V)	9	1123.74**	40.898**	52.187**	0.133**
SC x V Interaction	36	194.74**	0.246**	1.452**	0.049**
Error	150	43.71	0.035	0.124	0.005

**: $p<0.01$

4.1.2. Speed of emergency

While the highest speed of emergency occurred 3.160 (day) in control, the lowest speed of emergencies of varieties determined 0.485 (day) with 120 mM NaCl application. Varieties of speed of emergency ranged from 1.235 (Malazgirt-89) to 2.358 (Altın Toprak) day. In comparison to control in varieties of speed of emergencies of varieties of different NaCl applications, when decrease ratios occured took into consideration, Altın Toprak, Fırat and Seyran-96 varieties in terms of speed of emergency except to 120 mM NaCl level, in the other salt application levels were achieved quite better performance. On the other hand, as salt levels increased speed of emergencies of Malazgirt-89 and Özbek varieties were the furthest decreasing varieties in comparison to control (Table 2).

Table 2
Ratio of emergencies, speed of emergency, average time for emergency and suscebility ındex of lentil varieties used in the study in different NaCl concentrations

Varieties	NaCl Concentrations					Mean
	Control	30 mM	60 mM	90 mM	120 mM	
			Ratio of emergency (%)			
Altın Toprak	96.25 ab[1]	85.00 b-e	88.75 a-d	76.25 e-h	41.25 opq	77.50 a
Fırat-87	97.50 a	91.25 abc	70.00 f-j	70.00 f-j	28.75 rs	71.50 b
Kafkas	98.75 a	80.00 c-f	68.75 f-j	55.00 lmn	23.75 rs	65.25 cd
Malazgirt-89	95.00 ab	76.25 e-h	66.25 h-l	46.25 nop	5.00 u	57.75 ef
Meyveci-2001	93.75 ab	80.00 c-f	75.00 e-i	56.25 k-n	35.00 pqr	68.00 bc
Seyran-96	97.50 a	85.00 b-e	75.00 e-i	63.75 i-l	22.50 st	68.75 bc
Sultan-I	95.00 ab	78.75 d-g	55.00 lmn	45.00 nop	11.25 tu	57.00 ef
Çağıl	96.25 ab	91.25 abc	85.00 b-e	68.75 f-j	23.75 rs	73.00 ab
Çiftçi	96.25 ab	78.75 d-g	60.00 j-m	48.75 mno	21.25 st	61.00 de
Özbek	98.75 a	75.00 e-i	67.50 g-k	31.25 qrs	5.00 u	55.50 f
Mean	96.50 a	82.13 b	71.13 c	56.13 d	21.75 e	65.53
			Speed of emergency (day)			
Altın Toprak	3.401 abc[1]	2.772 f-i	2.831 efg	1.860 o-r	0.928 vw	2.358 a
Fırat-87	3.615 a	3.129 cde	2.473 h-k	2.209 j-n	0.560 xyz	2.397 a
Kafkas	3.200 bcd	2.272 j-m	1.979 m-p	1.356 tu	0.540 yz	1.869 c
Malazgirt-89	2.150 k-o	1.625 q-t	1.428 stu	0.893 vwx	0.077 z	1.235 e
Meyveci-2001	2.774 f-i	2.205 j-o	2.104 l-o	1.458 stu	0.777 wxy	1.864 c
Seyran-96	3.637 a	2.837 efg	2.502 g-j	2.041 l-p	0.513 yz	2.306 ab
Sultan-I	3.445 abc	2.370 jkl	1.519 r-u	1.234 uv	0.273 z	1.768 c
Çağıl	3.038 def	2.929 def	2.467 ijk	1.896 n-q	0.534 yz	2.173 b
Çiftçi	3.532 ab	2.337 jkl	1.738 p-s	1.388 tu	0.549 xyz	1.909 c
Özbek	2.814 e-i	2.158 j-o	1.887 n-q	0.751 wxy	0.100 z	1.542 d
Mean	3.160 a	2.463 b	2.093 c	1.508 d	0.485 e	1.942
			Average time for emergency (day)			
Altın Toprak	5.85 xy[1]	6.40 v-y	6.66 s-w	8.62 ghi	9.23 efg	7.35 d
Fırat-87	5.78 y	6.48 t-x	6.33 v-y	7.45 n-r	11.07 b	7.42 d
Kafkas	6.67 s-w	7.82 j-o	7.75 k-p	8.70 gh	9.12 fg	8.01 bc
Malazgirt-89	9.47 def	10.64 bc	9.78 de	9.94 d	13.00 a	10.57 a
Meyveci-2001	7.63 l-q	8.03 i-n	7.88 j-o	8.25 h-l	9.55 def	8.26 b
Seyran-96	5.92 xy	7.05 q-t	6.99 q-u	7.13 p-s	10.02 cd	7.42 d
Sultan-I	6.05 wxy	7.28 o-s	7.71 k-p	7.85 j-o	8.29 h-k	7.44 d
Çağıl	6.84 r-v	6.86 r-v	7.88 j-o	8.15 h-m	9.71 def	7.89 c
Çiftçi	5.86 xy	7.33 o-r	7.33 ghi	7.42 n-r	7.87 j-o	7.16 d
Özbek	7.52 m-q	7.60 m-q	7.82 n-r	8.45 hij	10.00 cd	8.28 b
Mean	6.76 d	7.48 d	7.61 c	8.26 a	9.79 b	7.98
			Suscebility Index			
Altın Toprak		1.094 klm[1]	1.094 klm	1.474 cd	1.578 bc	1.310 ab
Fırat-87		1.122 klm	1.122 klm	1.289 f-i	1.920 a	1.363 a
Kafkas		1.172 i-l	1.172 i-l	1.304 e-h	1.368 def	1.254 b
Malazgirt-89		1.050 lm	1.050 lm	1.123 j-m	1.372 def	1.149 c
Meyveci-2001		1.053 lm	1.053 lm	1.082 klm	1.253 f-j	1.110 c
Seyran-96		1.191 h-k	1.191 h-k	1.205 g-k	1.691 b	1.319 ab
Sultan-I		1.204 g-k	1.204 g-k	1.298 e-i	1.370 def	1.269 b
Çağıl		1.010 m	1.010 m	1.198 h-k	1.424 de	1.160 c
Çiftçi		1.253 f-j	1.253 f-j	1.267 f-i	1.343 ef	1.279 b
Özbek		1.011 m	1.011 m	1.123 j-m	1.330 efg	1.119 c
Mean		1.116 c	1.116 c	1.236 b	1.465 a	1.233

[1]Between averages showed same letter differences isn't important statistically.

4.1.3. Average time for emergency

According to average of varieties, while the highest average time for emergency 9.79 days with 120 mM NaCl application was obtained, the lowest average time for emergency 6.76 days in control group was obtained. As average of salt levels, the longest emergency time detected in Malazgirt-89 variety (10.57 days). As salt levels increased in the study, when it was compared to control groups, emergency time of variances increased dramatically. While the rising in emergency time was

low in Çiftçi, Sultan-I, Meyveci-2001 and Kafkas varieties, the rising in emergency time was high in Fırat-87 and Seyran-96 varieties (Table 2).

4.1.4. Susceptibility Index

As salt levels increased, susceptibility indexes of varieties caused to increase dramatically. Susceptibility index was 1.116 in 30 and 60 mM NaCl application, it increased dramatically in 90 and 120 mM NaCl application and it reached respectively 1.236 and 1.465 (Table 2).

Susceptibility indexes of varieties to salt ranged from 1.110 (Meyveci) to 1.363 (Fırat-87). When the varieties compared to the other varieties, because of the highest susceptibility index showed in Fırat-87, Seyran-97 and Altın Toprak varieties in particularly 120 mM NaCl application, it indicated that the varieties were more vulnerable tolerant varieties to salt. On the other hand, because of the lowest susceptibility index showed in Meyveci-2001, Özbek and Çiftçi varieties, it indicated that the varieties were beter tolerant varieties to salt (Table 2).

4.2. Greenhouse Trial

Salt concentration and variety had significant effect on all traits in greenhouse trial (Table 3). Significant interactions existed between variety by salt concentration application for all traits except for dry weight of root and percentage to salt tolerant (Table 3).

4.2.1. Length of shoot

Length of shoot was 15.60 cm in control in the research, Length of shoot decreased in 30, 60, 90 and 120 mM NaCl applications dramatically and length of shoots were 14.57, 13.60 and 10.83 cm respectively (Table 4). Length of shoot of varieties ranged from 9.07 cm (Kafkas) to 15.73 cm (Seyran-9). We think that the situation was different responses to salt applications in terms of length of shoot of varieties. While Seyran variety in 60 and 90 mM NaCl applications was the higher length of shoot than control application, the other varieties used in the study were the higher length of shoot than salt applications in control (Table 4).

Table 3
Variance analysis of length of shoots, length of root, fresh weight of shoot, fresh weight of root, dry weight of shoot, dry weight of root and percentage to salt tolerant of lentil varieties in different salt dose

Variance source	SD	Length of shoot	Length of root	Fresh weight of shoot	Fresh weight of root
Salt concentration (SC)	4	119.557**	17.627**	4559661**	417116**
Variety (V)	9	65.277**	27.745**	3482453**	2773766**
SC x V Interaction	36	5.620**	27.882**	237168**	290031**
Error	100	1.453	3.667	58645	85742**
Variance source	SD	Dry weight of shoot	Dry weight of root	Percentage to salt tolerant	
Salt concentration (SC)	4	124785.25**	6506.70**	1650.01**	
Variety (V)	9	65372.83**	15747.35**	1013.49**	
SC x V Interaction	36	5130.00**	2460.66	166.60	
Error	100	1429.80	1639.62	195.80	

**: $p<0.01$

4.2.2. Length of root

As salt concentrations increased, firstly length of root of varieties increased, after 90 mM NaCl application, length of root caused to decrease particularly. As average of varieties, while the highest length of root was obtained in 60 mM NaCl application with 18.57 cm, length of root was followed 30 mM NaCl (18.47 cm), control and 90 mM NaCl applications (17.17 cm) and 120 mM NaCl applications (17.03 cm) respectively with decreasing orders (Table 4).

When the highest length of root was 20.13 cm with Çiftçi variety in the research, the lowest length of root was 15.60 cm with Altın Toprak variety. When salt applications seperately in themselves were done analysis, length of roots of varieties in terms of salt applications differed from. As salt applications increased, length of root of Çağıl, Çiftçi and Özbek varieties increased and the highest length of root of these varieties detected 120 mM NaCl applications which were the highest salt level (Table 4).

4.2.3. Fresh weight of shoot

As salt concentrations increased, fresh weight of shoot of varieties caused to decrease dramatically. While the highest fresh weight of shoot was 1647.50 mg in control application, fresh weight of shoot followed 30 mM NaCl (914.78 mg), 60 mM NaCl (834.24 mg), 90 mM NaCl (729.12 mg) and 120 mM NaCl application (706.35 mg) with descending order (Table 4).

While the lowest fresh weight of shoot was 418.05 mg with Altın Toprak variety, the highest fresh weight of shoot was 2023.20 mg with Meyveci-2001 variety in the study (Table 4). In terms of fresh weight of shoots of varieties, responses to salt applications generally was the same responses. As salt dose increased, fresh weight

of shoot of all varieties also parallelly decreased. The decreasing ratio was lower fresh weight of shoot than Altın Toprak, Kafkas and Özbek varieties in control that made up of the lower fresh weight of shoot (Table 4).

Table 4

Length of shoots, length of root, fresh weight of shoot and fresh weight of root of lentil varieties used in the study in different NaCl concentrations

Varieties	NaCl Concentrations					Mean
	Control	30 mM	60 mM	90 mM	120 mM	
			Length of shoot (cm)			
Altın Toprak	15.33 c-g[1]	16.00 b-f	11.67 k-p	14.33 d-j	13.67 f-l	14.20 bc
Fırat-87	13.00 g-m	11.67 k-p	11.33 l-q	10.00 o-r	9.33 p-s	11.07 f
Kafkas	13.00 g-m	9.33 p-s	9.00 q-s	7.00 s	7.00 s	9.07 g
Malazgirt-89	15.00 d-h	16.00 b-f	14.33 d-j	11.33 l-q	11.67 k-p	13.67 cd
Meyveci-2001	18.00 ab	15.67 b-f	15.00 d-h	14.00 e-k	12.67 h-n	15.07 ab
Seyran-96	15.33 c-g	15.33 c-g	19.33 a	16.00 b-f	12.67 h-n	15.73 a
Sultan-I	16.67 bcd	15.67 b-f	13.00 g-m	12.67 h-n	12.00 j-o	14.00 bc
Çağıl	17.67 abc	16.33 b-e	15.33 c-g	14.00 e-k	12.33 i-o	15.13 ab
Çiftçi	16.67 bcd	14.67 d-i	12.67 h-n	10.33 n-r	8.33 rs	12.53 de
Özbek	16.33 b-e	15.00 d-h	10.67 n-r	9.00 q-s	8.67 rs	11.93 ef
Mean	15.60 a	14.57 b	13.60 c	11.60 d	10.83 d	13.24
			Length of root (cm)			
Altın Toprak	17.33 f-l[1]	17.67 f-l	17.00 f-l	12.33 mn	13.67 lmn	15.60 c
Fırat-87	19.33 d-h	17.00 f-l	16.67 f-l	18.67 e-i	16.67 f-l	17.67 b
Kafkas	16.33 g-m	19.67 c-g	20.67 b-f	15.33 h-n	13.67 lmn	17.13 bc
Malazgirt-89	16.00 g-n	24.33 ab	19.00 e-i	18.00 e-k	17.00 f-l	18.87 ab
Meyveci-2001	20.67 b-f	14.00 k-n	18.00 e-k	14.33 j-n	12.00 n	15.80 c
Seyran-96	15.33 h-n	19.33 d-h	22.00 a-e	16.00 g-n	13.67 lmn	17.27 bc
Sultan-I	19.33 d-h	18.67 e-i	20.00 c-g	16.33 g-m	14.00 k-n	17.67 b
Çağıl	16.00 g-n	20.00 c-g	17.33 f-l	18.33 e-j	20.67 b-e	18.47 ab
Çiftçi	15.33 h-n	16.67 f-l	20.00 c-g	23.33 a-d	25.33 a	20.13 a
Özbek	16.00 g-n	17.33 f-l	15.00 i-n	19.00 e-i	23.67 abc	18.20 b
Mean	17.17 b	18.47 a	18.57 a	17.17 b	17.03 b	17.68
			Fresh weight of shoot (mg/plant)			
Altın Toprak	748.83 i-t[1]	434.67 o-t	351.11 q-t	270.49 st	285.17 rst	418.05 e
Fırat-87	1266.67 e-i	739.75 j-t	797.23 i-r	563.60 m-t	450.93 o-t	763.64 cd
Kafkas	975.08 g-n	508.08 n-t	578.90 l-t	447.73 o-t	407.67 p-t	583.49 de
Malazgirt-89	1041.75 g-m	726.30 j-t	652.55 k-t	934.94 g-o	778.67 i-s	826.84 c
Meyveci-2001	3379.58 a	2080.20 cd	1696.73 cde	1561.60 def	1397.88 efg	2023.20 a
Seyran-96	2809.08 b	1144.55 f-k	1234.02 e-j	596.65 l-t	760.25 i-t	1308.91 b
Sultan-I	1955.53 cd	980.53 g-n	1083.94 f-l	867.05 h-q	922.37 g-p	1161.88 b
Çağıl	2134.44 c	1072.00 f-m	844.65 i-q	1008.87 g-n	935.87 g-o	1199.17 b
Çiftçi	1363.92 e-h	1022.07 g-n	705.13 k-t	795.60 i-r	687.20 k-t	914.78 c
Özbek	800.11 i-r	439.69 o-t	398.08 q-t	244.67 t	437.53 o-t	464.02 e
Mean	1647.50 a	914.78 b	834.24 bc	729.12 c	706.35 c	966.40
			Fresh weight of root (mg/plant)			
Altın Toprak	184.83 h-k	332.00 g-k	227.44 h-k	32.05 k	41.14 jk	163.49 f
Fırat-87	110.33 ıjk	227.50 h-k	185.22 h-k	421.93 f-k	213.67 h-k	231.73 def
Kafkas	548.08 f-k	267.83 g-k	559.05 f-k	285.80 g-k	423.53 f-k	416.86 c-f
Malazgirt-89	173.00 h-k	973.64 c-f	253.50 h-k	399.72 f-k	496.17 f-k	459.21 cde
Meyveci-2001	3036.80 a	1762.27 b	1323.33 bc	1198.40 b-e	892.67 c-g	1642.69 a
Seyran-96	460.78 f-k	425.90 f-k	511.35 f-k	501.87 f-k	588.17 e-k	497.61 bcd
Sultan-I	1255.40 bcd	761.80 c-h	708.26 c-i	507.24 f-k	595.69 e-k	765.68 b
Çağıl	886.11 c-g	580.00 e-k	248.83 h-k	395.33 f-k	546.87 f-k	531.43 bc
Çiftçi	572.00 e-k	754.67 c-h	630.27 d-k	781.07 c-h	666.67 d-j	680.93 bc
Özbek	102.00 ıjk	201.00 h-k	202.25 h-k	175.58 h-k	283.40 g-k	192.85 ef
Mean	732.93 a	628.66 ab	484.95 b	469.90 b	474.80 b	558.25

[1]Between averages showed same letter differences isn't important statistically.

Table 5

Dry weight of shoot, dry weight of root and percentage to salt tolerant of lentil varieties used in the study in different NaCl concentrations

Varieties	NaCl Concentrations					Mean
	Control	30 mM	60 mM	90 mM	120 mM	
			Dry weight of shoot (g/plant)			
Altın Toprak	140.39 f-n	69.63 m-s	70.42 m-s	58.73 o-s	65.99 n-s	81.03 fg
Fırat-87	172.17 e-j	103.50 j-s	108.93 j-s	78.73 l-s	74.52 m-s	107.57 ef
Kafkas	125.00 g-q	49.17 p-s	60.00 n-s	63.67 n-s	31.93 s	65.95 g
Malazgirt-89	175.08 e-j	125.89 g-q	105.83 j-s	113.22 i-r	55.67 o-s	115.14 ef
Meyveci-2001	470.44 a	276.73 bc	233.80 cde	211.57 c-f	172.30 e-j	272.97 a
Seyran-96	435.83 a	156.37 e-l	191.32 d-i	83.95 k-s	80.83 k-s	189.66 bc
Sultan-I	267.27 bcd	128.80 g-p	132.82 f-o	133.52 f-o	116.34 h-r	155.75 cd
Çağıl	343.11 b	202.47 c-g	136.32 f-o	150.47 f-m	140.20 f-n	194.51 b
Çiftçi	196.17 c-h	122.87 g-q	108.00 j-s	86.87 k-s	84.67 k-s	119.71 de
Özbek	161.33 e-k	72.28 m-s	39.00 rs	30.25 s	47.42 qrs	70.06 g
Mean	248.68 a	130.77 b	118.64 bc	101.10 cd	86.99 d	137.24
			Fresh weight of shoot (g/plant)			
Altın Toprak	41.95	67.88	60.53	29.04	18.85	43.65 d
Fırat-87	49.83	56.33	46.00	75.53	33.40	52.22 cd
Kafkas	50.83	34.67	44.50	33.60	29.00	38.52 d
Malazgirt-89	45.75	104.64	53.00	57.56	74.83	67.16 cd
Meyveci-2001	259.53	140.87	103.47	99.35	72.73	135.19 a
Seyran-96	128.92	105.05	117.97	115.97	104.88	114.56 ab
Sultan-I	65.80	91.00	65.11	54.90	48.22	65.01 cd
Çağıl	171.22	89.93	68.62	55.60	60.47	89.17 bc
Çiftçi	60.58	66.60	50.93	59.80	46.00	56.78 cd
Özbek	38.78	44.58	31.08	48.42	60.48	44.67 d
Mean	91.32 a	80.16 ab	64.12 ab	62.98 b	54.89 b	70.69
			Percentage of salt tolerance			
Altın Toprak		50.79	50.22	41.68	47.13	47.45 ab
Fırat-87		61.26	63.31	46.75	44.30	53.90 ab
Kafkas		40.32	50.61	52.66	28.86	43.11 bc
Malazgirt-89		72.99	63.53	64.69	34.26	58.87 a
Meyveci-2001		63.27	51.91	47.87	37.75	50.20 ab
Seyran-96		35.91	44.47	19.47	19.32	29.79 c
Sultan-I		48.38	49.90	50.04	43.85	48.04 ab
Çağıl		58.99	39.72	43.90	40.81	45.86 ab
Çiftçi		62.77	55.24	44.16	43.05	51.31 ab
Özbek		44.40	28.85	22.37	30.57	31.55 c
Mean		53.91 a	49.78 ab	43.36 bc	36.99 c	46.01

[1]Between averages showed same letter differences isn't important statistically.

4.2.3. Fresh weight of root

While the highest fresh weight of root was 792.93 mg in control application, 30 mM NaCl (638.66 mg), 60 mM NaCl (484.95 mg), 90 mM NaCl (469.90 mg) and 120 mM NaCl application (474.80 mg) followed with descending order (Table 4).

Fresh weight of root of varieties ranged from 231.73 mg (Fırat-87) to 1642.69 mg (Meyveci-2001) (Table 4). Fresh weight of roots of varieties which were used in research were affected from salt applications differently. In terms of fresh weight of root, control and salt applications were different dramatically. As increasing of salt applications increased, fresh weight of root of Meyveci-2001, Sultan-I and Çağıl varieties which were the highest fresh weight of root in control decreased parallelly, on the other hand, fresh weight of roots of Çiftçi, Özbek and Fırat-87 varieties increased (Table 4).

4.2.4. Dry weight of shoot

While the highest dry weight of shoot was 248.68 mg in control, 30 mM NaCl (130.77 mg), 60 mM NaCl (118.64 mg), 90 mM NaCl (101.10 mg) and 120 mM NaCl application (86.99 mg) followed with descending order (Table 5). Dry weight of shoots of varieties ranged from 65.95 mg (Kafkas) to 272.97 mg (Meyveci-2001). As salt concentrations increased, dry weight of shoot of all varieties increased (Table 5).

*4.2.5. Dry weight of roo*t

While the highest dry weight of root was 91.32 mg in control, 30 mM NaCl (80.16 mg), 60 mM NaCl (64.12 mg), 90 mM NaCl (62.98 mg) and 120 mM NaCl application (54.89 mg) followed with descending order respectively in trial (Table 5). The highest dry weight of

roots ranged from 38.52 mg (Kafkas) to 135.19 mg (Meyveci-2001) (Table 5).

4.2.6. Percentage of salt tolerance

While the highest percentage of salt tolerance was 53.91% in 30 mM NaCl application, 60 mM NaCl (49.78%), 90 mM NaCl (43.36%) and 120 mM NaCl applications (36.99%) followed with descending order (Table 5). Percentage of salt tolerance of varieties ranged from 29.79% (Seyran-97) to 58.87% (Malazgirt-89). As depending on salt levels, salt tolerance of varieties differed from each other and these features of some varieties which were the more tolerant varieties to low salt levels than the other varieties weren't continued in high salt level particularly (Table 5).

5. Discussion

5.1. Germination Test

In lentil, just as all crop plant, the germination stage is the most critical stage along total life cycle of plant (Güldüren 2012) and plants generally are more sensitive to salinity than next stages are (Ashraf and Waheed 1990; Güldüren 2012). Genotipic differences at the germination stage are extremely important to determine resistance to salinity (Saxena et al. 1994). Thus, germination tests in the saline environment are used largely for the purpose of determining resistance to salinity fastly (Kantar and Elkoca 1998). Essa (2002) and Sadeghian and Yavari (2004) indicated that the salt added to germination environment effects to germination negatively by increasing the osmotic pressure due to inhibiting water taking by seeds or toxic effect of ions like Na^+ and Cl^-. Also in our study, increasing NaCl doses cause to germinate seeds of lentil varieties at a lower rate and more slowly. Germination ratio in control as average of seeds was 96.50%. Germination ratio occurred at rates of 82.13%, 71.13%, 56.13% and 21.13% respectively in 30, 60, 90 and 120 mM NaCl applications. As a result of average of varieties, on different salt applications, the speed of emergency changed between 0.485 days (120 mM NaCl) and 3.160 days (control), average time for emergency changed between 676 day (control) and 9.79 days (120 mM NaCl), sensitivity index to salt index changed between1.116 (30 and 60 mM NaCl) and 1.465 (120 mM NaCl). Also, varieties showed a different reactions to salt applications in terms of all parameters examined in germination stage and as a result of this, salt x variety interactions was found important. Varieties, at increasing salt levels, couldn't protect their resistance which plant showed at a certain level at. Genetic differences at germination stage in terms of resistance to salt occured more clearly at high salt levels (90 and 120 mM NaCl). That result showed that genotypic differences occur clearly at increasing salt levels and choosing of varieties resistant to salt can be made easily. Especially, it is our opinion that AltınToprak, Çağıl and Fırat-87 varieties showing high germination rate at high salt doses must be put emphasis on.

Salinity is first encountered problem on lentil cultivation and effects negatively the efficiency of lentil plant. On the purpose of this, susceptibility indexes to salt of lentil varieties grown in Turkey were determined on the study. Susceptibility indexes to salt of different plants at the germination stage were determined on many previous studies and that results showed parallelism with our results (Saxena and al. 1994; Elkoca 1997; Elkoca et al. 2003). In parallel with our results, it was determined that on high salinity conditions, sensivity indexes in many plants increased on many researches carried out (Goertz and Coons 1989; Elkoca 1997; Elkoca et al. 2003; Güldüren 2012).

5.2. Greenhouse Test

Salinity is very important problem on osmotic pressure of soil solution and decreases the water efficiency significantly. Even if enough water exists on field conditions, high salt levels create physiologic drought. As a result of this, plant wilting may happen (Goertz and Coons 1991). Also, the length of shoot on increasing salt amounts decreased significantly on our research.

It was stated that lengthof root of plants exposed to salt application decreased on many previous studies (Elkoca 1997; Elkoca et al. 2003; Güldüren 2012). However, in our research, root lengths as stated above literatures decreased significantly as salt doses increase. It increased on first salt applications and decreased on next 90 and 120 mM NaCl applications. Many research results in which resistance varieties to salt can be determined successfully by considering shoot development in salty environment exist by the reason of important differences between varieties in terms of shoot wet weight in salty conditions (Ashraf and Waheed 1990; Elkoca 1997; Karakullukçu and Adak 2008). In this study, weight of shoots of all varieties used as from 30 mM salt level on research decreased significantly according to their own controls. Similar results were gained between our research results and above research results.

They stated that salinity had important effects on weight of roots of plants and root wet weight decreased as depending on salinity amount increasing (Elkoca, 1997; Güldüren 2012). Also in this study, wet weight of roots diminished significantly depending on salinity amount increasing.

Previously, many researches stated that important differences exist between varieties in terms of wet weight of roots on saline conditions (Ashraf and Waheed 1990; Elkoca 1997; 2006; Karakullukçu and Adak 2008). In this study, wet weight of shoots of all varieties used 30 mM salt level onwards on research decreased significantly according to their own controls.

As a result of physiological drought caused by salinity, plants can't take water enough (Goertz and Coons 1991) and plant development is limited by diminishing cell turgor pressure (Ashraf and Waheed 1990). Hence, shoot dry weight also decreased depending on having wet weight of shoots as a result that plants can't take

water. In this study, it was determined that shoot wet weights of all varieties used 30 mM salt level onwards on research decreased significantly according to their own controls.

Effects of salt on dry weight of root indicated a important situation in former studies (Elkoca 1997; Güldüren 2012). As salt quantity increased, dry weight of root of varieties dramatically decreased in our study.

Plants accumulate Na^+ and Cl^- ions taken from soil to root, trunk and leaves, as depending on Na^+ and Cl^- ions accumulation, plant growth receded and percentages of salt tolerance of plants decreased (Essa 2002; Güldüren 2012). As salt level increased, percentages of salt tolerance also importantly decreased in our study.

6. Suggestions

While ratio of emergency of lentil varieties which was used with salt application in gremination trial in the study decreased, on the other hand, average time for emergency dramatically caused to elongate by causing slowly seed germination. As depending on salt application in greenhouse trial, weight of shoot and root caused to decrease dramatically. While the lowest salt level used in research was 30 mM NaCl application even had adverse effect to plant growth, the highest salt level was 120 mM NaCl application caused to decrease dramatically to plant growth. The situation indicated that after 60 mM NaCl application in lentil growing, this wasn't convenient.

Former three varieties in 10 varieties were Altın Toprak, Çağıl ve Fırat-87 ranked in germination and greenhouse trial in all salt application had a high ratio of emergency. Between root growth and shoot growth detected a important genetic variation. When descending ratios of dry weight of plant of variaties took into consideration, the best tolerant varieties to salt were Malazgirt-89, Fırat-87 and Çiftçi varieties, the most vulnerable varieties were Özbek and Seyran-97.

7. Acknowledgements

This work was supported by the Scientific Research Project Coordinatorship of Selçuk University (project number 09201108). The authors are grateful to the Coordinator for providing financial support. This paper is a part of this project and was summarized from MSc thesis of Sariye UZUN KAYIŞ.

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