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EFFECT OF SALINITY (NaCl) ON GERMINATION, SEEDLING GROWTH AND NUTRIENT UPTAKE OF DIFFERENT TRITICALE GENOTYPES

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ABSTRACT

The aim of this study was to determine effects of salinity applications on emergence rate, salt tolerance index and nutritient uptake in Triticale. Triticale cultivar Karma-2000 and 5 Triticale genotypes (4, 20, 23, 27 and 43) were used as experimental materials. The study was conducted to observe effects of different salt concentrations (EC value: 3.9, 6.1, 8.3, 10.5, 14.9, 19.3, 25.0 dSm^{-1}) on emergence rate, dry weights of green parts/roots, salt tolerance index, mineral elements (N, P, K, Ca, Na, Fe, Mn, Mg, Zn and Cu) and proline. As salt concentration increased; emergence rate, shoot and root length, dry weights of green parts and roots, and the mineral content of both roots and leaves decreased considerably. On the other hand, proline content increased when higher salt concentrations used. Genotypes differed to their reactions to different salt concentrations. Among the genotypes, the least amount of proline content was found in Karma-2000 and the highest proline content was found in genotypes 27 and 43. According to salt tolerance index results, genotype 27 was resistant and genotypes 20 and 43 were tolerant to salt stress.

Key Words: Triticale, genotype, salinity, mineral element, germination, salt tolerance index

INTRODUCTION

Agricultural production has been limited to the factors of environmental stress. Improved plant types, which can put up with the environmental stress factors, are needed in the sustainable agriculture. Wheat, barley, rye, maize and rice are among the grains that are most farmed and produced in the world. Triticale (*xTriticosecale* Wittmack), a species resulting from the intergenetic crossing of wheat and rye, and has the potential to introduce valuable economic and environmental benefits to grain production systems. Triticale is tolerant to drought, asidic soils, aluminium toxicity (Aniol 1996) and salinity. Furthermore, it has been determined that triticale can benefit from the soil better than other grains like wheat, barley and oat and thus it is more stable in the changeable environmental conditions (Anonymous 1976).

One of the factors that affect fertility in fields is salinity. Turkey has 1.518.722 ha area classified as saline and alkaline (infertil). This figure corresponds to 2 percent of surface area of our country, or 5.48 percent of total farm area (27 699 003) and as 17 percent of 8.5 million ha area that can be irrigated. Total barren areas contain 74 percent salt, 25.5 percent saline-alkali and 0.5 percent alcali (with sodium) soils. Saline soils form major part of barren lands (Anonymous 2006). In such areas where the control of salinity is impossible, plants that have high-salt-resistant should be grown to provide economical returns**.**

In arid and semi-arid regions, one of the most important environmental factors that affect uniform germination is salinity (Demir et al. 2003). When phases of plant growth are compared, more emphasis is put on the germination and seedling growth phase and the cultivars' response to salt. (Ghoulam and Fares 2001; Van Hoorn et al. 2001).

This research was planned because of the lack of information that describes the different salt concentration effects of triticale on germination and seedling growth, and recently detecting tolerance levels of improved genotypes to salt and the effects of genotypes on ion intake in different salt concentrations were investigated. In this research as well as determining recently improved and possible triticale genotypes' tolerance to salt and the threshold levels in which seedling growth are damaged, the effect of changing salt content on intake and transport of nutrients were investigated.

MATERIALS AND METHOD

The study was carried out in 2008. In the research, Karma-2000 cultivar and 5 Triticale genotypes (4, 20, 23, 27 and 43) obtained from CIMMYT were used as plant materials. These genotypes were selected by Akgün et al. (2007) among other genotypes for their performances in variety trials. In the study, harvested seeds from the previous year were used.

Laboratory study

The experiment was arranged as randomized plots design with two factors and three replications. In the test, effect on the germination rate of genotypes of different NaCl levels (control, EC value 3.9, 6.1, 8.3, 10.5, 14.9, 19.3, 25.0 dSm^{-1} (deciSiemens m^{-1}) were studied to determine the effect on

the germination ratio of seeds under different concentrations of salt seeds were placed in petri dishes and kept in incubator at 20 ^{0}C without light for 8 days and at the end of this period, germinated seeds were counted and the seeds whose root length is above 1 mm were accepted as germinated. Each petri contained 20 seeds and 4 replications were used for each genotype and treatments. In the study, 192 petri was used (6 genotype x 8 application x 4 recurrence). 10 ml solution that contains different salt concantrations was put and covered with parafilm to prevent evaporation. Results were experressed as % germination (Atak et al. 2006).

Greenhouse study

The experiment was arranged as randomized plots design with two factors and three replications. Plastic pots with 2000 g volume were filled with a mixture of 1600 g powdered soil, sand and farmyard manure in proportion of 1:1:1, 6 seeds were initially planted in each pot and after germination, 4 seedlings were allowed to establish in each pot (Alpaslan et al. 1998). Desired proportions of saline water were prepared by adding the pure NaCl in 20 l water and plants were irrigated with this water. To prevent resistance in the pots, the mortar soil was placed into polyethylene bags.

200 mg N kg^{-1} soil, 100 mg P_2O_5 kg^{-1} soil, and 125 mg K_2O kg^{-1} soil level was applied to the pots as major fertilizer (Alpaslan et al. 1998). Mortar, placed on a plastic ground cover, was filled in the pot with fertilizer by being mixed well. After sowing the seeds, the soil was saturated with irrigation, prepared in different density of salt. Whether there was a change in value of EC in the irrigation water was checked every other day. At the end of 10 week growth period, seedlings were evaluated. Plants in each pot were evaluated seperately and by determining the average each poth was considered as a recurrence. In the study, according to the principles reported by Bağcı et al. (2003); stem / root dry weight ratio, salt tolerance index [STI= (each salt concentration of the total plant dry weight / total plant dry weight in control) x 100], Fe, Ca, Cu, Mn, Zn levels were measured with an Atomic Absorbtion Spectrofotometer. N content was determied by Kjeldahl and Na and K levels were measured by Flame emission spectrophotetry. Phosphorus content was determined according to the molibdovanado-phosphoric acid method (Kacar 1972). The free proline content was analyzed as described by Bates et al. (1973).

The first section including to emergence rate depend on time, seedling length, root length, dry weights and protein content of green parts and roots of the research were published by Kara et al. (2011). The second section including to germination ratio, ratio of aboveground/root dry-weights, salt tolerance index, N, P, K, Fe, Ca, Cu, Mn, Zn, Na in overground parts and roots, proline of leaves of the study were presented in the following.

Statistical Analysis

All the data were analyzed with analysis of variance (ANOVA) using SPSS Statistical Package Program. Means were compared using the DUNCAN test.

RESULTS

In the analysed Triticale varieties, variance analysis was performed on the germination ratio, ratio of aboveground/root dry-weights, salt tolerance index, N, P, K, Fe, Ca, Cu, Mn, Zn, Na in overground parts and roots, proline of leaves. The differences between the averages were grouped according to Duncan test. In the study, poor plant development was observed only in genotypes 27 and 43 in the application of 25 dSm^{-1} salt concentration and in these genotypes just the analysis of proline could be performed, sufficient samples couldn't be obtained for the analysis of micro and macro elements. Therefore, except the analysis of proline in 25 dSm^{-1} salt concentration, other analysed features were not taken into consideration.

Germination Ratio

Variance analysis was carried out on germination ratio and the differences between means was determined according to Duncan test. The importance levels between the means were given in Table 1. In the study, significant

Table 1. Germination ratio (%) of Triticale genotypes under different NaCl concentrations

	NaCl Concentrations (dSm^{-1})								
Genotypes	**Control**	**3.9**	**6.1**	**8.3**	**10.5**	**14.9**	**19.3**	**25**	**Average**
Karma-2000	89.62	90.52	90.72	83.12	75.35	76.37	62.02	46.25	**76.75 AB**
4	88.75	84.57	82.05	77.00	55.92	63.67	50.32	31.07	**69.17C****
5	93.95	94.17	89.60	84.30	82.50	76.87	65.37	49.30	**79.50 AB**
20	81.45	82.07	72.25	67.07	70.75	72.20	68.92	36.80	**68.94 C**
27	95.65	90.62	85.00	92.07	89.37	79.30	69.45	45.32	**80.85 A**
43	91.87	90.35	85.35	77.67	86.45	73.50	67.85	38.02	**76.38 B**
Mean	**90.21 A****	**88.72 A**	**84.16B**	**80.20B**	**76.70 B**	**73.65C**	**63.99D**	**41.13E**	

$LSD_{Genotype}$: 4.343, $_{NaCl\ Concentrations}$: 4.155, $LSD_{Genotype\ x\ NaCl\ Concentrations}$: NS CV: 9.67

**:significant at P<0.01, NS: Non significant

differences were found between Triticale genotypes in terms of germination ratio and the hightest germination rate was identified on the genotype 27 (80.85%). Genotype 5 and Karma 2000 were grouped with the genotype 27. The lowest germination rate was identified on genotype 20 (68.94%).

The effect of different salt concentrations on germination ratio was statistically ($p<0.01$) significant and the highest germination ratio was determined in control application (90.21%). But, in terms of germination ratio, the differences between control and 3.9 dSm^{-1} salt application (88.72%)

were not found significant and were included in the same group. As the salt concentration increased, the germination rate decreased and the lowest germination ratio was observed in 25 dSm^{-1} salt application (41.13%)

Aboveground/Root Dry Weight

In Triticale, in terms of the ratio of aboveground/root dry weight in different salt concentrations, significant differences were found between varieties. While the highest rate of aboveground/root dry weight was found in genotype 5 (6.65), the lowest rate was found in Karma-2000.

In the different salt concentrations, while the highest rate of aboveground/root dry weight of genotypes were identified in 14.9 dSm^{-1} salt application, the lowest was found in control group. In the study, in terms of aboveground/root dry weight ratio, the interaction of genotype x salt concentration was found to be statistically significant (Table 2).

Table 2. Effect on aboveground/root dry weight of Triticale genotypes of different NaCl concentrations

	NaCl Concentrations (dSm^{-1})							
Genotypes	**Control**	**3.9**	**6.1**	**8.3**	**10.5**	**14.9**	**19.3**	**Average**
Karma-2000	1.52**	2.25	5.3	4.00	5.04	7.58	6.69	**4.90 D****
4	1.62	4.63	7.77	4.76	5.12	9.27	6.65	**5.70 BCD**
5	1.79	4.67	8.88	6.01	7.28	5.14	6.29	**6.65 A**
20	2.10	3.63	5.36	4.24	8.38	8.06	5.96	**5.38 CD**
27	1.69	4.43	4.17	7.28	7.12	6.29	4.71	**6.16 ABC**
43	1.77	6.36	5.96	5.88	6.31	3.89	5.15	**6.42 AB**
Mean	**1.71 D****	**4.32 C**	**6.24 B**	**5.37 AB**	**6.55 A**	**6.70 A**	**6.23 A**	

$LSD_{Genotype}$: 0.7963, $LSD_{NaCl\ Concentrations}$: 0.8601, $LSD_{Genotype\ x\ NaCl\ Concentrations}$: 2.784 CV:16.81

**:significant at P<0.01

Table 3. Salt tolerance index (%) of Triticale genotypes under different NaCl concentrations

	NaCl Concentrations (dSm^{-1})						
Genotypes	**3.9**	**6.1**	**8.3**	**10.5**	**14.9**	**19.3**	**Average**
Karma-2000	58.32**	25.80	28.12	22.17	16.62	7.05	**36.87 D****
4	54.82	38.42	36.17	24.07	19.07	6.62	**39.88 C**
5	54.4	48.65	35.32	29.00	16.02	6.80	**41.46 C**
20	70.47	53.70	40.45	35.00	22.32	8.95	**47.27 B**
27	80.47	62.70	47.50	33.52	23.60	10.54	**51.19 A**
43	55.77	57.85	46.27	31.17	25.30	12.10	**46.92 B**
Mean	**62.39 B****	**47.85 C**	**38.97 D**	**29.15 E**	**20.49 F**	**8.67 G**	

$LSD_{Genotype}$: 2.604, $LSD_{NaCl\ Concentrations}$: 1.994, $LSD_{Genotype\ x\ NaCl\ Concentrations}$: 6.969 CV: 7.93

**:significant at P<0.01

Salt Tolerance Index

Salt tolerance index of Triticale genotypes in different salt concentration was statistically significant (p<0.01). In the experiment, while the highest salt tolerance index between Triticale genotypes was determined in genotype 27 (51.19%), the lowest was in Karma-2000 (36.87%) (Table 3).

Salt tolerance index was higher in low salt concentrations, as salt level increased salt tolerance index decreased significantly. In the interaction of variety x salt concentration the highest salt tolerance index was identified in the interaction genotype 27 and 3.9 dSm^{-1} salt concentration. In paralel with the increase in salt concentration, salt tolerance index fell down and the lowest salt tolerance index was identified in genotype 4 and 19.3 dSm^{-1} salt applicatio

Aboveground Mineral Elements

Although the effect of different salt concentrations on P, Mg, and Zn was statistically unimportant in Triticale genotypes, effect on K, Ca, Fe, Cu, Mn and Na was significiant. Overall increase in salt concentration reduced the intake of mineral elements. But the influence of salt concentration varies in some trace elements (Cu, Mn and Zn). Except for P, Ca and Mn whose mineral elements varied, statistically significant differences were determined in other studied mineral elements (K, Fe, Cu, Mg, Zn and Na). K, Fe, Cu, Mn and Mg were found significant, but P, Ca, Zn and Na were insignificant in the interaction of genotype x salt concentration (Table 4).

Nitrogen (N) Concentration in Aboveground Parts

As seen in Table 4, the average content of aboveground nitrogen of Triticale genotypes that were grown in different salt concentrations, didn't show statistically significant differences. But, the effect of salt concentrations on the content of aboveground nitrogen was important and in paralel with the increase of salt concentration, decreasing of overground N content was observed. In different salt concentrations, while the highest soil nitrogen was found in control application (1.77%), the lowest was in 19.3 dSm^{-1} (0.79%) salt application.

The interaction of genotype x salt concentration became important (p<0.01) and while significant difference could not identified between other genotypes except for genotype 5, significant differencces were identified between the genotypes in other salt applications. In the study, in paralel

Table 4. Effect on N, P, K, Ca, Na, Fe, Mn, Mg, Zn and Cu content in aboveground of Triticale genotypes of different NaCl concentrations

Genotypes	NaCl Con. (dSm^{-1})	N (%)	P (%)	K (%)	Ca (%)	Na (%)	Fe ppm	Mn ppm	Mg ppm	Zn ppm	Cu ppm
Karma-2000	Control	1.95**	0.21	3.83**	2.95	0.62	0.28**	42.78*	0.20**	49.88	84.78**
	3.9	1.74	0.20	4.11	2.99	0.64	0.63	46.13	0.35	44.25	33.13
	6.1	1.57	0.23	3.35	3.36	0.61	0.44	44.20	0.23	47.00	51.38
	8.3	1.68	0.17	4.29	2.67	0.73	0.13	49.45	0.24	64.00	38.88
	10.5	1.61	0.14	3.35	2.41	0.73	0.20	38.13	0.22	40.45	24.05
	14.9	1.23	0.16	3.55	2.29	0.55	0.26	42.28	0.18	48.50	19.53
	19.3	1.06	0.11	2.85	1.29	0.34	0.08	30.80	0.21	36.12	28.65
	Mean	**1.55**	**0.18**	**3.62A**	**2.57**	**0.60A**	**0.29A**	**41.97**	**0.23AB**	**47.17B**	**40.05A**
4	Control	1.75	0.24	3.48	3.08	0.37	0.19	31.65	0.23	49.88	35.30
	3.9	1.64	0.21	3.33	3.21	0.52	0.61	34.62	0.17	39.65	59.23
	6.1	1.58	0.22	3.15	3.30	0.62	0.24	40.03	0.28	47.30	46.38
	8.3	1.52	0.17	3.94	2.75	0.70	0.29	49.78	0.18	56.10	35.98
	10.5	1.41	0.16	3.54	2.31	0.65	0.19	43.45	0.37	49.20	23.98
	14.9	1.18	0.13	2.54	1.81	0.55	0.11	40.13	0.16	36.85	23.83
	19.3	1.06	0.12	2.26	1.36	0.42	0.10	24.95	0.18	39.10	23.85
	Mean	**1.45**	**0.18**	**3.18C**	**2.54**	**0.54AB**	**0.24AB**	**37.80**	**0.22AB**	**45.44B**	**35.51AB**
5	Control	1.63	0.23	3.93	2.53	0.28	0.31	41.48	0.20	36.08	29.60
	3.9	1.80	0.23	3.90	3.42	0.46	0.57	45.05	0.22	52.05	52.13
	6.1	1.36	0.21	3.60	2.88	0.55	0.29	30.60	0.21	42.88	36.35
	8.3	1.51	0.15	3.86	2.55	0.58	0.21	47.35	0.19	53.45	37.00
	10.5	1.44	0.14	3.43	2.49	0.51	0.18	35.18	0.18	41.50	20.72
	14.9	1.49	0.12	2.77	0.42	0.57	0.11	36.23	0.21	39.73	22.63
	19.3	1.14	0.11	2.86	1.55	0.27	0.10	35.50	0.17	39.13	20.83
	Mean	**1.48**	**0.17**	**3.48A**	**2.55**	**0.46B**	**0.25AB**	**38.77**	**0.20B**	**43.54B**	**31.21AB**
20	Control	1.80	0.23	4.31	2.53	0.66	0.19	47.35	0.23	42.25	21.08
	3.9	1.69	0.20	3.75	3.44	0.53	0.33	42.93	0.19	46.68	28.48
	6.1	1.56	0.19	3.38	2.65	0.66	0.27	32.60	0.22	52.45	21.73
	8.3	1.49	0.17	3.44	2.02	0.64	0.39	40.53	0.23	50.15	28.55
	10.5	1.34	0.14	3.45	1.42	0.47	0.21	36.38	0.22	30.23	22.50
	14.9	1.32	0.12	3.03	1.71	0.59	0.10	40.38	0.16	39.03	24.80
	19.3	1.02	0.10	2.49	1.75	0.32	0.10	31.20	0.19	41.27	22.78
	Mean	**1.46**	**0.16**	**3.41AB**	**2.22**	**0.55AB**	**0.23BC**	**38.76**	**0.21AB**	**75.86A**	**24.27B**
27	Control	1.71	0.23	3.56	3.49	0.74	0.14	39.34	0.22	47.08	30.00
	3.9	1.67	0.19	4.04	2.80	0.90	0.30	36.78	0.34	47.68	35.65
	6.1	1.45	0.20	3.81	3.58	0.51	0.39	42.13	0.22	52.93	55.05
	8.3	1.45	0.16	3.84	2.93	0.65	0.22	57.88	0.28	56.33	21.23
	10.5	1.46	0.15	3.62	1.73	0.56	0.17	39.95	0.20	49.03	16.63
	14.9	1.50	0.12	2.91	1.84	0.58	0.13	38.15	0.24	47.58	28.88
	19.3	0.93	0.10	2.56	1.41	0.50	0.10	33.15	0.23	40.60	93.80
	Mean	**1.45**	**0.16**	**3.47A**	**2.52**	**0.63A**	**0.21BC**	**41.05**	**0.25A**	**48.74B**	**40.18A**
43	Control	1.75	0.24	3.53	3.34	0.94	0.28	36.65	0.19	61.08	27.00
	3.9	1.80	0.22	3.54	3.71	0.48	0.17	53.55	0.16	46.38	30.25
	6.1	1.59	0.18	3.68	3.23	0.66	0.29	37.75	0.17	42.15	49.18
	8.3	1.42	3.12	2.93	2.23	0.62	0.21	40.90	0.16	78.48	32.05
	10.5	1.55	0.14	3.42	2.61	0.69	0.20	41.75	0.21	39.05	21.12
	14.9	1.34	0.13	2.89	1.86	0.37	0.11	33.38	0.39	34.08	27.58
	19.3	0.79	0.09	2.59	1.16	0.35	0.11	36.25	0.20	33.60	21.73
	Mean	**1.47**	**0.59**	**3.23BC**	**2.59**	**0.59AB**	**0.19C**	**40.03**	**0.21AB**	**47.83B**	**28.84AB**
$LSD_{Genotype\ x\ NaCl}$		0.208		0.714			0.162	11.870	0.150		45.195
$LSD_{Genotype}$			0.483	0.194	0.356	0.126	0.044	4.350	0.041	25.167	12.293
NaCl Concentrations (dSm^{-1})											
Control		**1.77A****	0.23	**3.77A***	**2.98A****	**0.60A***	**0.23CD***	**39.87BC***	0.21	47.70	**37.96AB****
3.9		**1.72A**	0.21	**3.77A**	**3.26A**	**0.59A**	**0.44A**	**43.17AB**	0.24	66.11	**39.81A**
6.1		**1.52B**	0.21	**3.50B**	**3.17A**	**0.60A**	**0.32B**	**37.88C**	0.22	47.45	**43.34A**
8.3		**1.51B**	0.66	**3.72A**	**2.52B**	**0.65A**	**0.24C**	**47.65A**	0.21	59.75	**32.28ABC**
10.5		**1.47B**	0.14	**3.47B**	**2.16BC**	**0.60A**	**0.19D**	**39.14BC**	0.23	43.08	**21.50C**
14.9		**1.34C**	0.13	**2.95C**	**1.99C**	**0.53A**	**0.13E**	**38.42BC**	0.22	57.63	**24.54BC**
19.3		**1.00D**	0.11	**2.60D**	**1.42D**	**0.37B**	**0.10E**	**31.97D**	0.19	38.30	**35.27ABC**
LSD $_{NaCl\ Concentrations}$		0.086		0.210	0.384	0.136	0.047	4.699			13.278
CV		9.55	12.12	10.82	16.92	15.39	15.44	16.71	15.31	12.52	19.32

*, **: Significant at p<0.05 and P<0.01 respectively

with the increase of salt concentration, all aboveground nitrogen content of Triticale varieties decreased significantly (Table 4).

Mineral Elements in Roots

Triticale genotypes mineral element contents analysed in roots were shown in Table 5. The effect of different salt concentrations was found significant for all analysed elements (P, K, Ca, Fe, Cu, Mn, Mg, Zn and Na). Overall, increase in salt concentration reduced the intake of mineral elements. But the influence of salt concentration varies for some trace elements (Cu, Mn and Zn). The mineral content of root varied depending on genotypes and while variation was statistically significant for P, K, Mn, and Na, it was not the case for Fe, Ca, Cu, Mg, and Z. P, K, Mn, Zn, and Na were identified as insignificant, and Fe, Ca, Cu, and Mg were not significant in the interaction of genotype x salt concentration (Table 5).

Nitrogen (N) Concentration in Roots

The content of root nitrogen showed statistically significant differences and while the highest rate of N was obtained in genotype 5 (0.55%), the lowest rate of N root was in genotype 43.

In different salt concentrations, the content of root N level was significantly affected and in paralel with the increase of salt concantration, N level was reduced significantly. While the highest N content was identified in control application (0.60%), the lowest was found in 19.3 dSm^{-1} (0.31%) salt application (Table 5).

The effect of interaction of genotype x salt concentration on the content of root N level ($p<0.05$) was statistically significant. Among triticale genotypes, the highest N content was identified in roots (Table 5) of genotype 5 (0.72%) in control application, the lowest was observed Karma-2000 at 19.3 dSm^{-1} salt concentration (0.31%). In the study; the root N content of all triticale genotypes significantly decreased in paralel with the increased salt concentration

Proline Content

Grown in saline conditions, the average proline content of leaves of Triticale genotypes was statistically significant ($p<0.01$). The highest proline contents was obtained from 43 and 27 genotypes. The lowest amount of proline was identified in the Karma-2000 (Table 6).

In this study, the amount of proline increased significantly ($p<0.01$), depending on the increased salt concantration. While the highest amount of proline was obtained in 25 dSm^{-1} treatment (33.19 μM/g), the lowest was observed in control group. But in terms of the amount of proline, the interaction of genotye x salt concentration was found significant ($p<0.01$) (Table 6).

DISCUSSION

One of the factors affecting yield in agricultural areas is salinity. Therefore, the selection of plant species with high resistance to salt and providing efficiency in economic level is important. Because early periods of plant growth is sensitive and germination and seedling growth are more focused and these growth stages were taken more into account determining the cultivars' reaction to salt (Van Hoorn et al. 2001; Ghoulam and Fares 2001).

In the study, depending on the increasing salt content, the germination rate decreased significantly (Table 1). Atak et al. (2006) suggest that the main cause of decreased germination was blocakage of water intake into the seeds.

In the study, in parallel with the increase of the rate of salt concentration, significant reductions were identified with aboveground/root dry matter weight and in the content of N and aboveground. In the plants, under salt stress, significant reduction in the ability of intake of water and nutrients of roots may affect adversely the development and fertility of the plant. Salinity can affect cell division in the plant growth directly or indirectly and prevents the development of stalks and leaves. Correspondingly, plants dry matter content decreases. Significant decline was reported again under salt stress, in shoots and roots of dry matter and wet weight (Irshad et al. 2002). However, among the causes of yield decline seen in the plants that is grown in saline soils; toxic effects that such ions as excessive amount of Na and Cl causes and deterioration of plant and ion (Lewitt 1980), nutrient intake and cause trasport problems in the different parts of plants and deterioration of such physiological functions as photosynthesis and respretion have been shown (Leopold and Willing 1984; Manchester 1995). Again in salt stress, while Na that accumulated excessively in the plants can cause the intake of potassium (Siegel et al. 1980), Cl can causes the deterioration in the balance of the ion, especially by preventing the intake of NO_3 (Inal et al.1995).

Aboveground /root dry weight ratio can be discussed as an indicator of arid resistant. In the study, depending on salt content, the percentage of the aboveground weight to the root dry weight significantly decreased (Table 2). As a result of salt accumulation in leaves, it causes death of leaves in early period and directly affects the growth of plant by reducing photosynthesis. Again the intake of mineral elements by roots can be affected by imbalance in the intake of different ions. Among the causes of the decline in plant growth in wheat decline of transportation of the essential nutrients was effective (Munns and Termaat 1986). The existence of positive relationship between root dry weight and grain yield showed that the species whose roots go deeper was more resistant to drought and more productive (Demir et al. 2003).

When plants exposed to salt stress, like N, P, and Mg, and especially Ca, and K, and the intake of many macro and micro nutrients was affected. In plant tissues, Na and especially K and Ca other cationic elements compete and consequently, Na/K and Na/Ca balance spoils and intake and transportation of these elements reduced (Amacher et al. 2000).

In the study, salt application in Triticale genotypes led to decrease in P content and while this decrease in root was found significant, it was not in the aboveground parts. In the

Table 5. Effect on N, P, K, Ca, Na, Fe, Mn, Mg, Zn and Cu content in roots of Triticale genotypes of different NaCl concentrations

Genotypes	NaCl Con.s (dSm^{-1})	N (%)	P (%)	K (%)	Ca (%)	Na (%)	Fe ppm	Mn ppm	Mg ppm	Zn ppm	Cu Ppm
Karma-2000	Control	0.58*	0.16	1.63	3.18**	1.30	0.48**	30.55	0.42**	38.05	81.13**
	3.9	0.57	0.16	3.44	2.38	1.78	0.55	46.65	0.43	36.83	65.80
	6.1	0.59	0.14	1.88	3.29	1.16	0.44	45.23	0.54	40.90	39.73
	8.3	0.52	0.09	1.55	2.39	1.65	0.47	45.48	0.45	44.18	37.90
	10.5	0.56	0.12	1.14	2.40	1.26	0.43	43.70	0.46	33.85	34.50
	14.9	0.44	0.10	1.66	1.55	1.32	0.31	38.63	0.41	32.98	34.13
	19.3	0.31	0.09	1.28	1.46	1.07	0.13	33.28	0.26	30.25	19.67
	Mean	**0.51AB****	**0.12**	**1.80**	**2.37AB***	**1.36**	**0.40AB***	**40.50**	**0.42B***	**51.00AB***	**44.69A****
4	Control	0.71	0.18	1.70	2.90	1.64	0.44	41.23	0.41	46.80	61.95
	3.9	0.55	0.15	1.73	2.94	1.29	0.56	43.05	0.66	22.45	38.13
	6.1	0.57	0.13	1.64	2.49	1.41	0.47	41.25	0.48	40.88	44.45
	8.3	0.58	0.13	2.03	3.88	1.58	0.47	41.15	0.55	37.95	34.38
	10.5	0.58	0.13	1.38	2.05	1.30	0.43	44.70	0.35	36.93	31.85
	14.9	0.48	0.12	1.52	1.35	1.48	0.29	77.88	0.31	37.13	27.65
	19.3	0.34	0.09	1.22	1.45	0.92	0.11	31.10	0.20	25.00	22.67
	Mean	**0.54A**	**0.13**	**1.60**	**2.45A**	**1.37**	**0.39B**	**45.76**	**0.42B**	**49.59AB**	**37.30AB**
5	Control	0.72	0.18	1.42	3.38	1.25	0.53	44.53	0.67	20.75	79.65
	3.9	0.68	0.17	1.83	2.74	1.39	0.69	47.43	0.46	47.10	42.05
	6.1	0.67	0.13	1.59	2.05	1.38	0.54	54.73	0.49	32.80	37.70
	8.3	0.51	0.14	3.05	2.33	1.57	0.52	44.48	0.58	37.78	38.35
	10.5	0.44	0.13	1.42	1.56	1.18	0.41	58.25	0.67	37.25	37.05
	14.9	0.42	0.11	1.75	1.68	0.98	0.26	43.23	0.5	35.73	32.28
	19.3	0.41	0.09	1.16	1.60	0.88	0.09	31.80	0.43	23.75	23.25
	Mean	**0.55A**	**0.13**	**1.75A**	**2.19ABC**	**1.23**	**0.43A**	**46.35**	**0.54A**	**67.88A**	**41.48AB**
20	Control	0.56	0.18	1.63	3.11	1.19	0.53	34.23	0.57	18.28	47.35
	3.9	0.63	0.17	1.29	1.27	1.66	0.75	55.63	0.44	46.18	38.60
	6.1	0.62	0.12	1.60	2.84	1.64	0.61	37.28	0.40	45.83	34.58
	8.3	0.48	0.14	2.35	1.77	1.83	0.45	45.45	0.49	88.65	33.07
	10.5	0.39	0.11	1.59	1.58	1.13	0.37	42.73	0.49	31.15	34.85
	14.9	0.38	0.09	1.43	2.06	1.53	0.22	39.75	0.33	34.08	30.88
	19.3	0.40	0.08	1.12	1.60	0.85	0.10	30.73	0.23	22.75	55.48
	Mean	**0.49 BC**	**0.13**	**1.57**	**2.03BC**	**1.40**	**0.43AB**	**40.83**	**0.42B**	**53.84AB**	**39.26AB**
27	Control	0.51	0.18	1.84	3.00	1.49	0.61	42.13	0.36	37.98	42.88
	3.9	0.60	0.15	1.98	3.45	1.30	0.53	42.48	0.59	45.40	44.48
	6.1	0.59	0.12	1.02	2.56	1.19	0.46	43.48	0.47	42.13	43.33
	8.3	0.62	0.12	1.50	2.48	1.52	0.52	45.73	0.83	34.40	40.25
	10.5	0.51	0.10	1.37	1.91	1.50	0.41	43.50	0.39	42.08	28.43
	14.9	0.48	0.09	1.35	2.47	1.42	0.19	41.15	0.29	32.30	26.03
	19.3	0.33	0.09	1.31	1.26	0.87	0.10	27.15	0.26	24.30	18.38
	Mean	**0.52AB**	**0.12**	**1.91**	**2.45A**	**1.33**	**0.40AB**	**40.80**	**0.45B**	**36.94AB**	**34.82B**
43	Control	0.53	0.19	1.32	3.46	1.34	0.61	44.03	0.52	39.70	45.63
	3.9	0.56	0.16	1.99	2.80	1.43	0.69	44.65	0.50	39.63	47.08
	6.1	0.50	0.13	1.62	1.09	1.30	0.49	40.98	0.46	43.33	41.45
	8.3	0.54	0.13	1.29	1.69	1.72	0.48	44.48	0.75	35.58	52.00
	10.5	0.37	0.10	1.53	1.68	1.36	0.37	42.95	0.53	31.48	29.95
	14.9	0.41	0.08	1.37	1.72	0.86	0.21	46.73	0.31	31.98	29.58
	19.3	0.35	0.08	1.29	1.04	0.87	0.11	28.80	0.21	23.60	21.80
	Mean	**0.46C**	**0.12**	**1.49**	**1.93C**	**1.27**	**0.42AB**	**41.80**	**0.47AB**	**35.04B**	**38.21AB**
$LSD_{Genotype\ x\ NaCl}$		0.125			1.282		0.122		0.218		23.021
$LSD_{Genotype}$		0.044	0.012	0.493	0.349	0.211	0.034	7.125	0.080	28.725	7.008
NaCl Concentrations (dSm^{-1})											
Control		**0.60A****	**0.18A****	**1.59BC****	**3.17A****	**1.37B****	**0.53B****	**39.45A***	**0.49B***	**65.26A***	**59.76A****
3.9		**0.60A**	**0.16B**	**2.04AB**	**2.60B**	**1.47AB**	**0.63A**	**46.65A**	**0.52B**	**56.26AB**	**46.02B**
6.1		**0.59AB**	**0.13C**	**1.64BC**	**2.39B**	**1.34B**	**0.50BC**	**43.82A**	**0.47B**	**64.31A**	**40.20BC**
8.3		**0.54B**	**0.12C**	**2.38A**	**2.42B**	**1.64A**	**0.48C**	**44.46A**	**0.61A**	**63.09A**	**39.33BC**
10.5		**0.47C**	**0.12C**	**1.41C**	**1.86C**	**1.29B**	**0.40D**	**45.97A**	**0.48B**	**35.45AB**	**32.77CD**
14.9		**0.44C**	**0.10D**	**1.51BC**	**1.81C**	**1.26B**	**0.24E**	**47.89A**	**0.36C**	**34.03AB**	**30.09D**
19.3		**0.36D**	**0.09D**	**1.23C**	**1.40D**	**0.91C**	**0.10F**	**30.48B**	**0.26D**	**24.94B**	**26.87D**
LSD $_{NaCl\ Concentrations}$		0.053	0.013	0.533	0.377	0.227	0.369	7.696	0.086	31.026	7.570
CV		14.84	18.67	15.41	19.53	31.08	15.64	11.57	13.38	12.37	13.73

*, **: significant at P<0.05 and P<0.01 respectively

Table 6. Effect on proline content (μM/g) of Triticale genotypes of different NaCl concentrations

	NaCl Concentrations (dSm^{-1})								
Genotypes	**0**	**3.9**	**6.1**	**8.3**	**10.5**	**14.9**	**19.3**	**25.0**	**Average**
Karma-2000	0.85**	0.56	0.42	0.25	0.44	12.85	19.11	-	**4.92 D****
4	0.80	1.88	2.88	3.73	9.93	12.00	12.93	-	**6.23 C**
5	0.63	4.09	3.83	3.68	16.6	14.11	17.93	-	**8.69 B**
20	0.22	1.02	3.48	5.46	7.72	19.90	20.90	-	**8.38 B**
27	0.68	2.15	0.43	2.31	5.28	11.08	28.25	37.39	**10.94 A**
43	3.35	3.08	4.33	3.23	10.30	14.26	20.75	29.00	**11.03 A**
Mean	**0.99G****	**2.13 F**	**2.56 EF**	**3.11 E**	**8.38 D**	**14.03 C**	**19.97 B**	**33.19 A**	

$LSD_{Genotype}$: 2.55, $LSD_{NaCl\ Concentrations}$: 1.89, $LSD_{G\ x\ NaCl\ Concentrations}$: 8.806 CV: 10.55

**: Significant at P<0.01

studies, in which the effects of salinity on P content of plants were studied, different results were taken; while Alpaslan et al., (1998) suggested that intake of P was reduced under salt stress, Ozcan et al. (2000) suggested that P content of plants increased under salt stress.

Salt application affected the transport of K and Ca adversely in Triticale genotypes. Increasing salt concentration significantly reduced the level accumulation of these elements in roots and aboveground. But, Na content found in roots and aboveground, except for high salt content, was generally found more in other applications. Toxic rate of Na causes many negative effects in plants. Because of osmotic stres, decreasing the activity of important enzymes (like antioksidants) (Murguia et al. 1995) and intake of water in plant (Tarcynski et al. 1993) and generally cause the lack of K due to the competition between Na and K.

Among varieties, although in root no difference was found in terms of intake of Na, statistically differences occured in aboveground organs in terms of its transport. Genotype 5 ranked the last in terms of Na translocation to aboce ground, and the differences among others (43, 20 and 4) was not significant. In general, the limitation of Na transport from root to aboveground organs is one of the important indicators of tolerance to salt.

In general, the accumulation of Na in parts of aboveground is less than the accumulation in root. But, salt application (except for high-dose) increased Na content accumulated both in the parts of aboveground and in roots. In various Triticale cultivar similar results was reported by Atak et al. (2006).

While in high concentrations (10.5, 14.9 and 19.3 dSm^{-1}) the effect of salt on K and Ca of root and aboveground is negative, low concentration increases intake. K and Ca content carried to aboveground organs was higher. Similar results in barley were obtained by Bağcı et al. (2003) and Demiral et al. (2005). Generally, in the plants exposed to salt stress because of osmatic stress, intake of water decrases and due to the competition between sodium and potassium, intake and transport of K and Ca decreases (Amacher et al. 2000; Kaya et al. 2002). In plant tissue where nutrient elements connected Na/K and Na/Ca balance spoil and intake and transport of these elements are prevented (Amacher et al. 2000). In salt stres conditions, Fe content both in root and aboveground significantly decreased. Furthermore, significant differences were determined among varieties in terms of Fe intake. In the study carried on by Alpaslan et al. (1998) using wheat and rice varieties, it has been identified that while Fe content decreases in saline circumstances in some wheat and rice varieties, it increases in some others**.** In saline conditions, also in the studies that intend to determine Fe content of plants, results emerged on this matter (Martinez 1987).

In general, except for high salt concentration, Mg content was positively affected in root and stem, and there was no difference between control group and values obtained from low concentrations. Mg was found higher in root tissues. In the stduy with two different barley varieties, Demiral et al. (2005) reported that there was no significant effect of salt stress on intake and transport of Mg and salt application affects Mg content positively.

Salt application positively influenced intake and transport of Mn and Zn in Triticale genotypes. The highest salt concentration (19.3 dSm^{-1}) negatively influenced intake of these elements from root. Salt stress significantly reduces zinc that can dissolve and be available for the plant (Sing and Chatrath 2001). Likewise in this study high salt concentration significantly reduced the zinc taken by roots. In the study carried out by Alpaslan et al. (1998) it was determined that salt stress generally increased Zn, Cu, and Mn contents in wheat and rice varieties.

For tolerance to salt, biochemical markers such as proline and sugar are used. Proline that accumulated by plants in terms of durability against salt or being affected by salt undertakes osmotic protective role. In this research, depending on the increasing salt concentration, the amount of proline significantly increased. Again among genotypes, the amount of proline significantly changed. Among genotypes, while the lowest proline content is identified in Karma-2000, the highest was found in 27 and 43. In salt stress condition, plants produce secondary metabolites, different chemicals, and especially stress proteins (proline etc.), increase the cellular pressure and by balancing high osmotic pressure that emerges in the nutrients continue their lives (Köskeroğlu 2006). Evaluated in this respect, we can accept proline increase, which has been obtained at the end of our study, as a defence mechanism that Triticale plant constitutes in its metabolism against the damages that emerged as a result of saline conditions. This shows that Triticale is an alternative forage crop, is a plant that can be used to increase production in saline soils.

In terms of total dry weight, when tolerance index of genotypes to salt is analysed, varieties that are 50 % and over

are clasified as salt-tolerant but other varieties are as sensitive (Konak et al. 1999). Accordingly, while 27 can be considered salt-tolerant, 20and 43 are less tolerant because of being near the border of 50%. 6.1 dSm^{-1} salt application again caused the reduction of 50% of total dry weight during the early development of all genotypes. Different cultivars of Triticale (Presto and Tatlicak-97 Karma-2000) being used by Atak et al. (2006) Karma-2000 cultivar was shown as salt tolerant. Genotypes developed recently, were determined as more resistant to high salt concentration.

CONCLUSIONS

The effect of salt stress on all analysed features became negative. But the response of some Triticale genotypes to salt concentrations was different. Among genotypes, while the lowest proline content was identified in Karma-2000, the highest proline content was found in 27 and 43. When the index of salt tolerance was analysed again, genotype 27was determined as higly salt-tolerant, genotypes 20 and 43 was as moderately tolerant 6.1 dSm^{-1} salt application caused the decline of total dry weight of 50 % in 20, 27 and 43th genotypes.

For further studies that could be carried on to develop varieties of Triticale, genotypes 20, 27 and 43 can be the candidate of varieties has been proved as superior in terms of salt resistant.

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