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THE EFFECTS OF DIFFERENT DOSES OF SALT IN THE INITIAL DEVELOPMENT PERIODS OF SOME SUNFLOWER GENOTYPES

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Abstract

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In this research carried out in the greenhouse of Uludag University, Mustafakemalpaşa Vocational School, the initial development of 11 lines (CMS01, CMS10, CMS23, RHA03, RHA10, CMS01 x RHA03, CMS01 x RHA10, CMS10 x RHA03, CMS10 x RHA10, CMS23 x RHA03 and CMS23 x RHA10) and two varieties (MAY AGRO and SANAY) of sunflower, with four different doses of salt (0, 4, 8 and 12 dSm^{-1}) was examined. Ion analysis was done at the Faculty of Agriculture, Department of Soil Laboratory. The roots and leaves of the plants were analyzed for variation with respect to salt dosage in terms of the concentrations of Ca, Na and K and the ratios of Ca/Na and K/Na.

According to our research results, Ca, K, Ca/Na and K/Na ratios as opposed to the increase of salt dose reduced, but Na ratios increased. Ca and K in the leaves and Na accumulated in the roots.

The minimum and maximum average values of Ca in roots (2.02-3.46%) and leaves (1.87-3.41%); of K in roots (1.91-3.33%) and leaves (3.34-3.97%); values of Na in roots (2.48-5.67%) and leaves (1.63-3.09%) all changed. The CMS01 line had the highest concentrations of Ca and K, while the CMS23 line had the highest tissue concentration of Na.

Key words: sunflower, genotypes, salt doses, ions

Introduction

Sunflower is a very important oil seed crop, with a cultivated area worldwide of about 23 million hectares and seed production of about 31 million tons (Anonymous, 2005). Sunflower is grown in irrigated and non-irrigated semi-arid regions in Turkey. About 60% of vegetable oil consumption in Turkey is met with sunflower oil; the rest is obtained from olives, cottonseed, soybeans and sesame seed. Thus, sunflower is very important in Turkish agriculture. However, in some areas sunflower production faces salinity problems, especially in basins (Turhan and Ayaz, 2004).

Soil salinity is one of the most severe environmental stresses and affects plant production in arid

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and semi-arid lands. An increasing proportion of the world's food supply is produced in semi-arid regions with irrigation (Shannon et al., 1994), and decreases in agricultural crop production in these areas sometimes reach up to 50% due to salinity problems (McWilliams, 1986; Evengelou, 1994).

Sunflower is moderately sensitive to soil salinity; with variations in tolerance across sunflower genotypes. Reported salinity tolerances of sunflower genotypes ranges from EC of 1.7 dSm^{-1} (Ayers and Wescott, 1985; Allen et al., 1998; Katerji et al., 2000; Flagella et al., 2004) to 4.8 dSm^{-1} (Francois, 1996; Katerji et al., 2003). Variations have been noted in responses of sunflower genotypes to salinity. The tolerant strains accumulate less Na and more K in their leaves than salt-sensitive accessions, leading to higher K/Na ratios under saline conditions in tolerant strains (Ashraf and Tufail, 1995; Muralidharudu et al., 1998).

High concentrations of salts in soils impose both ionic and osmotic stresses on plants. Water deficits always have a negative effect, but many crop plants are primarily sensitive to Na excess (Greenway and Munns, 1980) due to its adverse effects on cytosolic enzyme activities, photosynthesis and metabolism (Niu et al., 1995). In addition, the disproportionate presence of Na in both cellular and extracellular compartments negatively impacts the acquisition and homeostasis of essential nutrients such as K and Ca (Maathuis, 2006). Soil salinity inhibits plant growth as a result of stomal closure, which decreases the CO_2 to O_2 rate in the leaves and inhibits CO_2 fixation (Epstein, 1989); as a result, salinity reduces the rate of elongation, enlargement and cell division (Allen et al., 1998). Furthermore, salts in the soil water solution can reduce evapotranspiration by making soil water less available for plant root extraction (Shalhevet, 1994).

High levels of soil Na can inhibit tissue K concentrations and, as a result, increase the Na/K ratio. This change may disturb the ion balance in plants by increasing Na uptake, resulting in increased ion concentrations in the leaves (Israeli et al., 1986; Mohamedin et al., 2006). Salinity has been shown to increase the uptake of Na or to decrease the uptake of Ca and K (Neel et al., 2002). Tissue Ca decreases with increasing NaCl concentration in the root medium up to 100 mM (Salim, 2006). Salinity results in ion toxicity because a high concentration of Na is bad for cells (Serrano et al., 1999).

By increasing NaCl applications, the amount of Na increased and the amounts of Ca and K ions decreased in salt-tolerant cultivars with the same growth parameters. Thus, plants that absorb more K or Ca, with high K/Na and Ca/Na ratios, are more salt tolerant (Turhan and Kuscu, 2009).

Accumulation of Na ions in plant tissues creates metabolic problems such as cell injuries, nutrient imbalances and abnormal water potential (Yeo and Flower, 1984). Na mainly accumulates in stems and roots of seedlings. In general, Ca and K concentrations decrease with salinization, but not in all genotypes (Bolarin et al., 1995). The ability of plant genotypes to maintain high levels of K and Ca and low levels of Na within their tissues is one key mechanism contributing to high salt tolerance. In most cases, salt-tolerant genotypes are able to maintain higher K/Na and Ca/Na ratios in their tissues (Santa-Cruz et al., 2002; Munns and James, 2003; Mansour, 2003; Zeng et al., 2003; Ashraf and Harris, 2004; Habib-ur-Rehman et al., 2005).

The present study was conducted to determine the effect of NaCl on seedlings of sunflower hybrids and their parents.

Materials and Methods

As plant material, 13 sunflower (*Helianthus annuus* L.) lines and cultivars were used (Table 1). Individuals of each cultivar were treated with four different salt concentrations (0, 4, 8 and 12 dSm^{-1}).

The studies were conducted under glasshouse conditions in the garden of Uludag University,

Table 1
Parents, hybrids and commercial hybrids used in the experiment

Parents	Hybrids	Commercial hybrid
CMS01	CMS01 x RHA03	MAY AGRO
CMS10	CMS10 x RHA03	SANAY
CMS23	CMS23 x RHA03	
RHA03	CMS01 x RHA10	
RHA10	CMS10 x RHA10	
		CMS23 x RHA10

Mustafakemalpasa Vocational High School. Seeds were initially germinated in organic enriched peat, with a vermiculite cover to facilitate aeration, in open plastic trays. The average glasshouse temperature was 15 and 25°C during the night and day, respectively, and the relative humidity was maintained at 70 %.

Pot-grown seedlings were thinned, and only one seedling was left per pot. Seedlings of the sunflower were grown in a peat/perlite medium for 30 days. When the plants developed 3-4 true leaves, applications of Hoagland's solution containing 0 (control), 4, 8 and 12 dSm^{-1} NaCl were started via drip irrigation. The composition of the nutrient solution, given per 1000 L, was as follows: 38.32 g monoammonium phophate (MAP), 202.00 g potassium nitrate (KNO_3), 393.24 g calcium nitrate [$Ca(NO_3)_2.4H_2O$], 164.00 g magnesium sulfate ($MgSO_4.7H_2O$), 11.65 g iron chelate (Fe-EDTA), 0.95 g boric acid (H_3BO_3), 0.11 g zinc sulfate ($ZnSO_4.7H_2O$), 0.0095 g ammonium molybdate [$(NH_4)_6$ $Mo_7O_{24}.4H_2O$], 0.77 g manganese sulfate ($MnSO_4.H_2O$) and 0.04 g copper sulfate ($CuSO_4.5H_2O$). Plants were irrigated with their respective solution 1-2 times per day. It was attempted to keep the quantity of drainage water at 30% of the amount of nutrient solution applied. The salt level was gradually increased over 1 week to avoid osmotic shock.

Plants were grown in a controlled greenhouse with an average photoperiod of 16 h. The experiment was set up using a randomized block design and replicated 3 times.

At the end of the experiments, plants were separated into leaf, stem and root tissues. The tissues were first washed with tap water to remove growing media and nutrient solutions and then dried at 70°C for 48 hours. Finally, dry weights were measured. Total Ca, K and Na concentrations were also measured with nitric-perchloric acid digests of root and leaf tissues by Eppendorf Elex model Fleymfotometry. Ca/Na and K/Na ratios were calculated for plants growing under control (0), 4, 8 and 12 dSm^{-1} NaCl applied environments.

Data were analyzed using MSTAT-C (version 2.1, Michigan State University, 1991) and MINITAB 14.0 software. Analysis of variance (ANOVA) was conducted and significance of differences among treatments was tested using the least significant difference (LSD). Differences

Table 2
Results analysis of variance (Mean square)

Characters	Genotypes	Doses	G X D
Root Ca	4.78**	85.61**	0.69**
Root Na	42.56**	16.73**	15.34**
Root K	7.02**	76.74**	1.38**
Root Ca/Na	0.94**	54.40**	0.23**
Root K/Na	1.13**	64.31**	0.25**
Stem Ca	4.13**	55.49**	0.79**
Stem Na	6.99**	945.02**	1.89**
Stem K	4.22ns	61.29**	1.00**
Stem Ca/Na	2.27**	114.93**	0.86**
Stem K/Na	3.06**	236.00**	1.25**
Leaf Ca	10.18**	35.17**	0.80**
Leaf Na	7.99**	439.24**	2.24**
Leaf K	0.86**	89.57**	0.91**
Leaf Ca/Na	5.29**	237.74**	1.42**
Leaf K/Na	2.70**	479.54**	1.52**

were declared significant at $P<0.05$ probability levels by the F test. The F-protected LSD was calculated at 0.05 probability levels according to Steel and Torrie (1980).

Results and Discussion

Results of variance analysis demonstrated that different doses of salt significantly affected ion accumulation in the roots and leaves of the sunflowers. These results showed that variation in salt exposure significantly affects exchange of Ca, Na and K, as well as the Ca/Na and K/Na ratios, in different organs of sunflowers. The concentrations of these ions, except for K, varied significantly across genotypes (Table 2).

Ca Concentrations

According to the average results, Ca concentrations in all investigated organs decreased with increasing salt doses. With regard to genotype, the highest Ca concentrations were determined in the roots of CMS01 and in the leaves of MAY AGRO, CMS10 x RHA10, CMS10 x RHA03, CMS01 and CMS01 x RHA03 lines. In root tissues, CMS01 had the highest concentration of Ca, and all other genotypes were not statistically different from each other. Ca concentrations were arranged as leaf (2.76%) and root (2.37%), according to genotype and salt doses (Table 3). These results demonstrated that the highest Ca accumulation takes place in leaves. Similar results were reported by Bolarin et al., 1995; Neel et al., 2002; Salim,

Table 3
Ca concentrations on the root and leaf, %

Genotypes	Root					Leaf				
	Control	4 dSm^{-1}	8 dSm^{-1}	12 dSm^{-1}	Means	Control	4 dSm^{-1}	8 dSm^{-1}	12 dSm^{-1}	Means
CMS01	4.18 a	3.90 a	3.36 a	2.42 a	3.46 a	3.73 b	3.06 bc	2.92 c-e	2.83 a	3.14 a
CMS10	3.00 b-d	2.82 b-d	1.57 cd	1.80 bc	2.29 b	2.95 e	2.78 c-e	2.59 e-g	2.37 b-d	2.67 bc
CMS23	3.23 bc	3.14 b	1.47 d	1.42 c-e	2.31 b	2.37 f	1.85 g	1.11 ı	1.40 g	1.87 e
RHA03	3.27 bc	3.06 bc	1.95 c	1.37 de	2.41 b	2.94 de	2.61 ef	1.59 h	1.44 g	2.15 de
RHA10	2.93 b-d	2.76 b-e	1.43 d	1.85 b	2.24 b	2.82 e	2.40 f	2.33 g	2.22 cd	2.44 cd
CMS01xRHA03	3.00 b-d	2.82 b-d	1.49 d	1.68 b-d	2.24 b	3.68 bc	3.36 ab	2.94 cd	2.52 a-c	3.13 a
CMS01xRHA10	2.68 d	2.60 c-e	2.42 b	2.00 ab	2.42 b	3.12 de	2.98 cd	2.72 d-f	2.21 d	2.76 b
CMS10xRHA03	3.26 bc	2.83 b-d	1.68 cd	1.63 b-e	2.35 b	4.41 a	3.59 a	2.48 ab	2.18 de	3.17 a
CMS10xRHA10	3.29 bc	3.02 bc	1.76 cd	1.62 b-e	2.42 b	4.15 a	3.72 a	3.54 a	2.15 de	3.39 a
CMS23xRHA03	2.95 b-d	2.33 e	1.67 cd	1.29 e	2.06 b	2.94 de	2.65 d-f	2.29 g	1.90 ef	2.45 c
CMS23xRHA10	2.81 cd	2.49 de	1.51 d	1.27 e	2.02 b	3.12 de	2.96 cd	2.46 fg	1.73 f	2.57 bc
MAY AGRO	3.41 b	2.94 b-d	1.80 cd	1.38 de	2.38 b	4.42 a	3.44 a	3.15 bc	2.64 ab	3.41 a
SANAY	3.23 bc	2.76 b-e	1.67 cd	1.35 de	2.25 b	3.34 cd	2.71 d-f	2.49 fg	2.36 b-d	2.73 bc
MEANS	**3.17 A**	**2.88 A**	**1.82 B**	**1.62 B**	**2.37**	**3.38 A**	**2.93 B**	**2.63 C**	**2.15 D**	**2.76**
LSD(0.05) Salt Doses	**0.4192**				**0.436**	**0.2816**				**0.2931**
LSD(0.05) Salt Doses x Genotypes	**0.8727**	**0.8727**	**0.873**	**0.8727**		**0.5863**	**0.5863**	**0.5863**	**0.5863**	

Means sharing similar letters are statistically non significant at 5% probability

Table 4
Na concentrations on the root and leaf, %

Genotypes	Root					Leaf				
	Control	4 dSm^{-1}	8 dSm^{-1}	12 dSm^{-1}	Means	Control	4 dSm^{-1}	8 dSm^{-1}	12 dSm^{-1}	Means
CMS01	1.06 bc	1.39 de	5.12 c-e	6.10 de	3.41 de	0.49	1.14 ef	2.06 gh	4.16 d-f	1.96 de
CMS10	1.22 a-c	1.28 e	5.35 c-e	5.94 e	3.44 de	0.65	1.70 cd	2.02 gh	4.49 b-e	2.22 b-d
CMS23	1.56 a	6.22 a	6.62 a	8.28 a	5.67 a	0.58	2.08 a-c	2.73 ef	4.95 a-d	2.59 a-c
RHA03	1.40 ab	1.90 bc	6.33 ab	7.04 bc	4.16 bc	0.61	1.80 cd	3.59 b-d	4.91 a-e	2.73 ab
RHA10	1.31 a-c	1.56 c-e	4.83 e	6.12 de	3.45 de	0.5	2.52 a	3.13 de	4.28 c-e	2.61 a-c
CMS01xRHA03	1.00 c	1.45 c-e	5.03 de	6.44 c-e	2.48 f	0.56	1.43 de	2.33 fg	3.36 g	1.92 de
CMS01xRHA10	1.01 c	1.49 c-e	5.65 b-d	6.65 b-e	3.70 c-e	0.62	1.42 de	3.44 cd	4.11 ef	2.40 b-d
CMS10xRHA03	1.23 a-c	1.42 de	5.51 b-e	5.81 e	3.49 de	0.67	1.20 ef	2.12 gh	4.51 b-e	2.13 c-e
CMS10xRHA10	1.35 a-c	1.77 b-d	5.84 a-c	5.91 e	3.71 c-e	0.52	0.89 f	1.64 h	3.46 fg	1.63 e
CMS23xRHA03	1.15 bc	1.40 de	5.33 c-e	7.47 ab	3.83cd	0.66	1.11 ef	2.49 e-g	5.18 ab	2.36 b-d
CMS23xRHA10	1.33 a-c	2.04 b	6.51 a	8.10 a	4.49 b	0.55	1.89 b-d	4.29 ab	5.44 a	3.04 a
MAY AGRO	1.17 a-c	1.41 de	5.25 c-e	6.95 b-d	3.69 c-e	0.59	2.36 ab	4.36 a	5.03 a-c	3.09 a
SANAY	1.13 bc	1.52 c-e	4.83 e	5.80 e	3.32 e	0.56	2.58 a	3.91 a-c	4.80 a-e	2.96 a
MEANS	**1.22 D**	**1.91 C**	**5.55 B**	**6.66 A**	**3.83**	**0.58 D**	**1.70 C**	**2.93 B**	**4.51 A**	**2.43**
LSD(0.05) Salt Doses	**0.4876**				**0.5075**	**0.5338**				**0.5556**
LSD(0.05) Salt Doses x Genotypes	**1.015**	**1.015**	**1.015**	**1.015**		**NS**	**1.11**	**1.11**	**1.11**	

Means sharing similar letters are statistically non significant at 5% probability

2006; Turhan and Kuscu, 2009.

Na Concentrations

Changes in Na concentrations were between 2.48-5.67% for root and 1.63-3.09% for leaf (Table 4). Excess accumulation of Na can be harmful to cells and is not desired. Across genotypes, the lowest concentrations of Na were found in SANAY (roots, 3.32%) and CMS10 x RHA10 (leaves, 1.63%). All the results, averaged across lines and varieties, revealed that accumulation of Na was lowest (2.43%) in leaves and highest (3.83%) in roots.

Increased salt doses increased accumulation of Na, also. At the highest dose, 12 dSm^{-1}, Na accumulated lowest in leaves and highest in roots. Our findings agree with those of Israeli et al. (1986); Neel et al. (2002); QingSong et al. (2005); Mohamedin et al. (2006); Turhan and Kuscu (2009).

K Concentrations

In all investigated organs, increasing salt doses reduced absorbed K concentrations. Over all doses, K concentrations were highest (3.73%) in the leaves and lowest (2.58%) in the roots (Table 5).

Genotype responses to salt were different. The highest and lowest concentrations were, respectively, found for leaves in CMS01 (3.33%) and RHA03 (1.91%) and for roots in CMS01 x RHA10 (3.97%) and MAY AGRO (3.34%). Israeli et al. (1986); Bolarin et al. (1995); Neel et al. (2002);

Table 5
K concentrations on the root and leaf, %

Genotypes	Root					Leaf				
	Control	4 dSm^{-1}	8 dSm^{-1}	12 dSm^{-1}	Means	Control	4 dSm^{-1}	8 dSm^{-1}	12 dSm^{-1}	Means
CMS01	3.85 a	3.53 a	3.23 a	2.74 a	3.33 a	4.02 f	4.03 bc	3.47 a-c	3.03 a	3.64 a-c
CMS10	3.58 a-c	2.97 a-c	2.60 ab	1.57 d-f	2.68 bc	4.22 d-f	4.26 b	3.44 a-c	2.90 ab	3.71 a-c
CMS23	3.41 a-c	2.50 cd	1.66 d	0.94 g	2.12 cd	5.31 ab	5.03 a	2.77 d	2.02 e	3.78 ab
RHA03	2.81 c	2.14 d	1.60 d	1.12 fg	1.91 d	5.60 a	4.43 ab	3.15 b-d	2.45 b-d	3.91 a
RHA10	3.84 a	2.77 a-d	2.30 bc	1.20 fg	2.52 b-d	4.59 c-f	4.28 b	3.67 ab	2.34 c-e	3.72 a-c
CMS01xRHA03	3.79 ab	3.43 ab	2.53 ab	2.23 a-c	2.99 ab	5.10 a-c	4.42 ab	3.45 a-c	2.45 b-d	3.86 ab
CMS01xRHA10	2.99 bc	2.74 b-d	2.44 bc	2.38 ab	2.63 bc	5.09 a-c	4.40 b	3.59 ab	2.78 a-c	3.97 a
CMS10xRHA03	3.26 a-c	2.91 a-c	2.56 ab	1.80 b-e	2.63 bc	4.64 c-e	3.99 bc	3.36 a-c	2.39 c-e	3.60 a-c
CMS10xRHA10	3.76 ab	2.85 a-c	1.85 cd	1.49 d-f	2.48 b-d	4.75 b-d	4.25 b	3.73 a	2.18 de	3.73 a-c
CMS23xRHA03	3.29 a-c	2.84 a-c	2.68 ab	1.75 c-e	2.64 bc	4.96 a-c	4.47 ab	3.55 ab	2.50 b-d	3.87 ab
CMS23xRHA10	3.58 a-c	2.71 b-d	2.13 b-d	1.88 b-d	2.57 bc	5.19 a-c	4.42 ab	3.77 a	2.32 de	3.93 a
MAY AGRO	3.88 a	2.75 b-d	2.02 bd	1.77 b-e	2.60 bc	4.07 ef	3.68 c	3.00 cd	2.61 a-d	3.34 c
SANAY	3.94 a	3.11 a-c	1.60 d	1.30 e-g	2.48 b-d	4.29 d-f	4.13 bc	2.98 cd	2.46 b-d	3.47 bc
MEANS	**3.53 A**	**2.86 B**	**2.24 C**	**1.70 C**	**2.58**	**4.75 A**	**4.29 B**	**3.37 C**	**2.49 D**	**3.73**
LSD(0.05) Salt Doses	**0.6138**				**0.6389**	**0.3958**				**0.412**
LSD(0.05) Salt Doses x Genotypes	**1.278**	**1.278**	**1.278**	**1.278**		**0.824**	**0.824**	**0.824**	**0.824**	

Means sharing similar letters are statistically non significant at 5% probability

Mohamedin et al. (2006); and Turhan and Kuscu (2009) reported that increasing NaCl concentrations resulted in increasing K.

Ca/Na Ratios

With increasing doses of salt, the Ca/Na ratio decreased. The highest ratios were found in the control dose for all three organs. With the highest dose, 12 dSm^{-1}, the highest ratios were found in leaves, followed by roots (respectively, 0.49 and 0.25 %).

The genotypes with the highest Ca/Na ratios were CMS01 (1.95%) in roots and CMS10 x RHA10 (3.88%) in leaves. At the highest salt dose, 12 dSm^{-1}, there was not a significant difference in Ca/Na ratio across the genotypes for all three organs (Table 6). According to genotype averages, the highest ratios are in the leaves (2.38%), followed by roots (1.27%). The Ca/Na ratio increased significantly with decreasing NaCl concentrations in all plant organs. Plants that absorbed more K or Ca, with high Ca/Na, ratios were more salt tolerant (Munns and James, 2003; Mansour, 2003; Zeng et al., 2003; Ashraf and Harris, 2004; Habib-ur-Rehman et al., 2005).

K/Na Ratios

K/Na ratios decreased with increasing doses of salt (Table 7). The maximum average ratio (8.33%) was found in control dose and at the leaf. In the

Table 6
Ca/Na concentrations on the root and leaf, %

Genotypes	Root					Leaf				
	Control	4 dSm^{-1}	8 dSm^{-1}	12 dSm^{-1}	Means	Control	4 dSm^{-1}	8 dSm^{-1}	12 dSm^{-1}	Means
CMS01	3.96 a	2.80 a	0.65 a	0.4	1.95 a	7.66 a	2.68 bc	1.41 ab	0.68	3.11 b
CMS10	2.48 c-e	2.26 b	0.30 ab	0.3	1.33 b-d	4.62 fg	1.64 de	1.29 bc	0.53	2.02 e
CMS23	2.11 e	0.50 f	0.22 b	0.17	0.83 f	4.06 g	0.90 e	0.44 c	0.29	1.42 f
RHA03	2.40 de	1.63 de	0.31 ab	0.19	1.13 de	4.80 e-g	1.47 e	0.44 c	0.29	1.75 ef
RHA10	2.24 de	1.83 cd	0.30 ab	0.3	1.16 d	5.77 b-d	0.99 e	0.75 bc	0.52	2.01 e
CMS01xRHA03	3.02 b	2.02 b-d	0.32 ab	0.27	1.40 b	6.61 b	2.50 cd	1.28 bc	0.79	2.80 bc
CMS01xRHA10	2.65 b-d	1.79 cd	0.43 ab	0.3	1.29 b-d	5.01 d-f	2.23 bc	0.79 bc	0.54	2.14 de
CMS10xRHA03	2.95 b	2.01 b-d	0.31 ab	0.28	1.38 bc	6.70 b	3.56 ab	1.17 bc	0.49	2.98 bc
CMS10xRHA10	2.45 c-e	1.72 cd	0.30 ab	0.27	1.18 cd	8.18 a	4.44 a	2.25 a	0.63	3.88 a
CMS23xRHA03	2.60 b-d	1.69 cd	0.31 ab	0.17	1.19 b-d	4.51 fg	2.59 c	0.94 bc	0.37	2.10 e
CMS23xRHA10	2.15 e	1.25 e	0.23 ab	0.16	0.94 ef	5.65 c-e	1.58 de	0.58 bc	0.32	2.03 e
MAY AGRO	2.96 b	2.10 bc	0.34 ab	0.2	1.40 b	7.69 a	1.47 e	0.73 bc	0.53	2.61 cd
SANAY	2.87 bc	1.83 cd	0.35 ab	0.23	1.32 b-d	5.99 bc	1.11 e	0.64 bc	0.5	2.06 e
MEANS	**2.68 A**	**1.91 B**	**0.33 C**	**0.25 C**	**1.27**	**5.94 A**	**2.08 B**	**0.97 C**	**0.49 D**	**2.38**
LSD(0.05) Salt Doses		**0.2027**			**0.211**		**0.4562**			**0.4748**
LSD(0.05) Salt Doses x Genotypes	**0.4219**	**0.4219**	**0.4219**	**NS**		**0.9497**	**0.9497**	**0.9497**	**NS**	

Means sharing similar letters are statistically non significant at 5% probability

4 dSm^{-1} treatment, the K/Na ratio in same organ was much lower (2.95%). The average ratios was detected in leaves (3.29%), followed by roots (1.37%).

Responses to salt varied across genotypes, except for the 8 and 12 dSm^{-1} doses in the roots and 12 dSm^{-1} doses in leaves. The highest K/Na ratios were found for root tissues in CMS01 (1.82%) and for leaves in CMS10 x RHA10 (4.38%). An increased K/Na ratio is an indication of increased K and reduced Na ion uptake (Joshi, 1984). A greater K/Na ratio reduces the deleterious effects of Na ions on plant growth (Prakash et al., 1996).

Salt tolerant genotypes are capable of maintaining higher K/Na ratios in tissues (Santa-Cruz et al., 2002; Munns and James, 2003; Mansour, 2003; Zeng et al., 2003; Ashraf and Harris, 2004; Habib-ur-Rehman et al., 2005).

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Table 7
K/Na concentrations on the root and leaf, %

Genotypes	Root					Leaf				
	Control	4 dSm^{-1}	8 dSm^{-1}	12 dSm^{-1}	Means	Control	4 dSm^{-1}	8 dSm^{-1}	12 dSm^{-1}	Means
CMS01	3.65 a	2.54 a	0.63	0.45	1.82 a	8.23 ab	3.53 bc	1.68 ab	0.73	3.54 bc
CMS10	3.02 b-d	2.38 ab	0.49	0.26	1.54 bc	6.65 c	2.51 cd	1.71 ab	0.65	2.88 c-d
CMS23	2.21 ef	0.40 f	0.25	0.11	0.74 f	9.13 a	2.45 cd	1.13 b	0.41	3.28 b-d
RHA03	2.00 f	1.14 e	0.25	0.16	0.89 f	9.19 a	2.50 cd	0.88 b	0.5	3.27 b-d
RHA10	2.95 cd	1.84 cd	0.48	0.2	1.37 c-e	9.30 a	1.75 d	1.18 ab	0.55	3.20 b-d
CMS01xRHA03	3.79 a	2.46 a	0.56	0.35	1.79 ab	9.17 a	3.33 bc	1.52 ab	0.76	3.70 ab
CMS01xRHA10	2.96 cd	1.91 bc	0.43	0.36	1.42 cd	8.19 ab	3.29 bc	1.04 ab	0.68	3.30 b-d
CMS10xRHA03	2.93 cd	2.07 a-c	0.46	0.31	1.44 cd	7.09 bc	3.97 ab	1.58 ab	0.53	3.29 b-d
CMS10xRHA10	2.78 d	1.62 c-e	0.32	0.25	1.24 de	9.44 a	5.06 a	2.39 a	0.64	4.38 a
CMS23xRHA03	2.92 cd	2.05 a-c	0.5	0.23	1.43 cd	7.72 bc	4.39 ab	1.46 ab	0.49	3.52 bc
CMS23xRHA10	2.72 de	1.36 de	0.33	0.23	1.16 e	9.40 a	2.37 cd	0.89 b	0.43	3.27 b-d
MAY AGRO	3.39 a-e	1.93 bc	0.39	0.26	1.49 cd	7.10 bc	1.58 d	0.70 b	0.52	2.48 e
SANAY	3.48 ab	2.06 a-c	0.33	0.22	1.52 c	7.70 bc	1.68 d	0.76 b	0.52	2.67 de
MEANS	**2.98 A**	**1.82 B**	**0.41 C**	**0.26 C**	**1.37**	**8.33 A**	**2.95 B**	**1.30 C**	**0.57 D**	**3.29**
LSD(0.05) Salt Doses	**0.2482**				**0.2583**	**0.6754**				**0.703**
LSD(0.05) Salt Doses x Genotypes	**0.5166**	**0.5166**	**NS**	**NS**		**1.406**	**1.406**	**1.406**	**NS**	

Means sharing similar letters are statistically non significant at 5% probability

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