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Full Length Research Paper

Effect of salinity stress on plant fresh weight and nutrient composition of some Canola (*Brassica napus* L.) cultivars

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Soil salinity is a major limitation to crop production in many areas of the world. A pot experiment was carried out with rapeseed cultivars in order to investigate the effects of salinity stress on plant development and nutrient composition. For the salinity studies, 150 mM NaCl concentration was applied to12 rapseed cultivars (Marinca, Kosa, Spok, Semu DNK207 NA, Tower, Liraspa, Star, Tobin, Helios, Semu 209/81, Regent and Lirawell) under the greenhouse conditions. All the cultivars were harvested after 45 days from planting. Green plants parts were weighted. Harvested rapeseed plants were separated into root, shoot and leaf parts for nutrient (K^+, Na^+, K^+/Na^+, Ca^{2+} and Cl^-) analysis. As shown in this study, salinity stress affected negatively all the canola cultivars investigated. Generally, salinity reduced the green parts' weight. K^+, Ca^{2+} and K^+/Na^+ contents in plants decreased by salt stress, but Na^+ and Cl^- content in the roots, shoots and leaves of all the cultivars significantly increased. In the salt treatment, the K^+ and Ca^{2+} concentrations were the highest in the leaf samples as compared to root and shoot samples. Furthermore, the highest concentration of Na^+ and Cl^- was observed in the leaf and shoot. Under salinity, Regent and Lirawell cultivars retained the highest K^+ and Ca^{2+} content in leaves, with respect to the K^+ content. The effect of NaCl treatment on the canola cultivars' growth was not considerable.

Key words: Canola cultivars, green plant parts, nutrient content, salt stress.

INTRODUCTION

Salinity stress is a major environmental constraint to crop productivity in the arid and semiarid regions of the World. Due to this, large areas of arable lands are substantially or partially unproductive. There is evidence that irrigation systems and type of irrigation water have contributed to a large extent in converting arable lands to saline lands (Ashraf and McNeilly, 2004).

High concentrations of salts cause ion imbalance and hyperosmotic stress in plants. As a consequence of these primary effects, a secondary stress such as oxidative damage often occurs. High salt stress disrupts homeostasis in water potential and ion distribution. This disruption of homeostasis occurs at both the cellular and the whole plant levels. Drastic changes in ion and water homeostasis lead to molecular damage, growth arrest and even death (Zhu, 2001).

Saline environments affect the plant growth in different ways such as a decrease in water uptake, an accumulation of ions to toxic levels, and a reduction of nutrient availability. In some extensive reviews concerning strategies of overcoming the salinity problem, two primary lines of action were emphasized: reclamation of salt-affected soils by chemical amendments, and alternatively, the saline soils can be used to grow salt-tolerant plants (Ashraf and McNeilly, 2004).

Most of the *Brassica* species have been categorized as moderately salt tolerant, with the amphidiploids species being the relatively salt tolerant in comparison with the diploid species. Due to the higher salt tolerance of the amphidiploids, it has been suggested that their salt tolerance has been acquired from the A (*Brassica*

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campestris) and C (*Brassica oleracea* L.) genomes (Ashraf and McNeilly, 2004).

Although *Brassica* species produce maximum yield under normal soil and environmental conditions, their growth, seed yield and oil production are markedly reduced due to environmental stresses such as drought, water logging, salinity, low or high temperature, nutrient deficiency or excess. In particular, for these crops there is a great magnitude of interspecific variation for salinity tolerance (Ashraf and McNeilly, 1990). While assessing the comparative salt tolerance of some *Brassica* species at the early growth stages, *Brassica napus*, followed by *Brassica carinata* and *Brassica juncea*, were found to be more salt tolerant than *B. campestris* (Ashraf and McNeilly, 1990).

The objective of this study was to investigate the effect of salinity on the growth of canola plant seedlings and to study the nutrient (K^+, Na^+, K^+/Na^+, Ca^{2+} and Cl^-) contents in the successive leaves, shoots and roots under salinity stress.

MATERIALS AND METHODS

The experiments were conducted in the greenhouse of the Horticulture Department of Agriculture Faculty of Yuzuncu Yil University Van (Turkey) during the months of April - June 2007. All the experiments were achieved in pots filled with soil. The experiments were carried out using a completely randomized plots design. Salinity factors were non-saline media and sodium chloride (NaCl) application by two doses (0 and 150 mM) with 3 replications. 12 rapeseed cultivars (Marinca, Kosa, Spok, Semu DNK207 NA, Tower, Liraspa, Star, Tobin, Helios, Semu 209/81, Regent and Lirawell) were used as the plant materials. In the experimental area, daily air temperature ranged from 10°C (minimum at night) to 30°C (maximum at during day), with the daily average temperature of about 25°C. Relative humidity fluctuated between 30 and 85%; the average value was about 60%.

Ten seeds of each cultivar were sown directly in plastic pots that contained 4 kg of field soil. Thinning was carried out 15 days after planting leaving four plants in each pot. Surface soil was collected from an agricultural field and passed through a 2 mm mesh screen. The texture of the soil was based on sand-clay-silt, total organic matter (1.96%), total salt (0.035%), pH (7.30), total nitrogen (0.9%), available phosphorus (28 mg kg^{-1} dry) soil and exchangeable potassium (180 mg K kg^{-1} dry soil). All the pots were fertilized with urea as a nitrogen fertilizer equivalent to 150 kg N ha^{-1} and triple- superphosphate (80 kg P_2O_5 ha^{-1}) was incorporated into the soil before seeding. For salinity treatments, non-salt-treated plants were kept as controls and salt-stressed plants were subjected to 150 mM NaCl for 30 days after sowing and all the plants, including controls, were then sampled. The salinity treatments were maintained until final harvest. The pots were randomly arranged in a greenhouse and rearranged several times during the growth period. Immediately after sowing, soils were watered and watering was carried out regularly every two days during the experiment (45 days) and 150 mM NaCl application was given together with water. Plants were irrigated until saturated and the excess solution was allowed to drain into collection pans.

All rapeseed cultivars were harvested after 45 days from planting. Harvested plant samples were washed in distilled water to remove salts from the tissue surfaces. The harvested green parts of the cultivars were weighted. Harvested plant materials were separated into roots, shoots and leaves parts for nutrient (K^+, Na^+, K^+/Na^+, Ca^{2+} and Cl^-) content analysis.

Chemical analysis for nutrients

For ion determination, fresh samples of root, shoot and leaf were extracted in concentrated 0.1 N nitric acid. Na^+, K^+ and Ca^{2+} contents in the samples were detected by flame photometry in the samples from canola plants (Taleisnik and Grunberg, 1994). Relative ion accumulation (Na^+, K^+ and Ca^{2+}) in whole plant (wp) was calculated as described by Taleisnik and Grunberg (1994). For chloride determination, Cl^- was determined by the silver ion-titration method with an automatic chloridometer (Buckhler-Cotlove chloridometer) according to Bozcuk (1970).

The data were analyzed by an analysis of variance using SAS (1985) software to test the significance of the main effects. Means separation on data was conducted using LSD multiple range tests. Terms were considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

For the 12 canola genotypes used in the salt treatments, the first marked symptomatic effect of toxic-level NaCl for 150 mM dosage was reduction in the green parts weight and inhibition on the plant growth. According to variance analysis results, plant fresh weight was influenced significantly by the salt stress ($P < 0.01$).

The effect of 150 mM NaCl treatment on the plant fresh weight of the 12 canola cultivars is shown in Table 1. Plant growth was reduced by NaCl treatment. Plant fresh weight varied between 8.37 and 12.9 g in the controls (non saline) applications. In general, salt stress affected negatively the plant fresh weight, but the effect ratio differed amongst the 12 genotypes. Fresh weights of plants under salt stress at final harvest were significantly reduced as compared to those of plants in the control treatment (Table 1). The tower cultivar was affected (20% reduction as compared to controls) more than the other cultivars. Semu-DNK207 (4.5% reduction as compared to control groups) and Helios (6.5% reduction as compared to control groups) showed a smaller reduction than the other cultivars (exposed to the salt stress). The results reported here indicated that the cultivar Semu-DNK207 and Helios were relatively salt-tolerant ones compared to other cultivars.

Reduction in plant growth by means of salt stress has also been reported for a number of plant species in scientific studies (Essa, 2002; Rameeh et al., 2004; Cicek and Cakirlar, 2002; Li et al., 2006, Kusvuran et al., 2007, Tunçtürk et al., 2008). The results confirmed these earlier observations of growth reduction due to NaCl treatment. Probably the negative effect of salinity on plants provoked osmotic potential by salt in the culture medium, such that the root cells did not obtain the required water from the medium (Mer et al., 2000). Therefore in plants, the uptakes of some mineral nutrients dissolved in water are also restricted. Thus, growth and development of plants were inhibited due to the occurring defect in metabolism. Some researchers thought that the growth reduction is the consequences of ion accumulation through the

Table 1. Roots, shoots and leaves of canola cultivars nutrient accumulations (µg/mg fresh weight) and green weight under salt treatment and non salt treatment.

N	P. O	T	Marinca	Kosa	Spok	Semu DNK207 NA	Tower	Liraspa	Star	Tobin	Helios	Semu 209/81	Regent	Lirawell	T.M	P.O. M
Na^+	Leaf	0	1.57 ef	1.83 d	1.71 de	1.26 f	1.38 f	1.50 ef	2.15 bc	2.81 a	2.41 b	1.88 cd	2.29 b	2.31 b	1.92	
		150	2.66 g	3.34 d - f	2.76 g	2.66 g	3.68 cd	3.57 c - e	4.24 ab	4.24 ab	4.52 a	3.29 ef	3.18 f	3.87 bc	3.50	2.71
	Shoot	0	2.53 a	1.23 f	1.55 e	1.19 f	1.12 f	2.21 bc	1.57 e	2.02 cd	1.56 e	1.27 f	1.83 d	2.29 ab	1.70	
		150	3.26 cd	2.64 f - h	2.04 j	2.49 g - I	2.87 ef	3.46 bc	2.24 ij	4.64 a	3.01 de	2.72 e - g	2.34 h - j	3.62 b	2.94	2.32
	Root	0	0.96 e	1.21 d	1.12 de	1.23 cd	1.18 de	1.47 ab	1.33 b - d	1.44 a - c	1.20 d	1.47 ab	1.51 ab	1.60 a	1.31	
		150	1.82 d	2.46 ab	2.57 a	2.24 bc	1.93 cd	2.39 ab	2.17 bc	2.37 ab	2.68 a	1.97 cd	2.66 a	2.23 bc	2.29	1.80
K^+	Leaf	0	21.0 c	20.8 cd	19.3 e	19.4 e	19.8 de	21.0 c	22.4 b	28.5 a	20.7 cd	20.6 cd	19.3 e	19.1 e	21.0	
		150	19.8 a	15.1 f	17.2 d	17.4 d	17.0 d	18.1 c	14.8 f	19.6 a	17.1 d	16.4 e	18.9 b	18.5 bc	17.5	19.3
	Shoot	0	24.5 b	26.8 a	17.7 ef	21.4 c	19.4 d	23.3 b	16.4 g	19.4 d	17.8 ef	20.2 d	18.9 de	17.5 fg	20.2	
		150	16.9 c	14.6 ef	14.7 ef	17.8 b	15.3 de	17.4 bc	13.2 g	14.3 f	15.7 d	14.3 f	18.8 a	16.6 c	15.8	18.0
	Root	0	18.6 c	18.3 cd	18.9 bc	18.1 c - e	16.5 ef	19.3 bc	20.9 a	20.4 ab	16.6 de	18.4 c	17.6 c - e	14.9 f	18.2	
		150	13.9 cd	15.7 b	14.2 cd	14.5 c	13.7 cd	13.4 de	14.4 cd	15.7 b	12.5 e	13.7 cd	16.8 a	14.3 cd	14.4	16.3
K^+/Na^+	Leaf	0	13.9 a	11.4 b	11.3 b	15.3 a	14.4 a	13.9 a	10.5 bc	10.2 b - d	8.68 cd	11.1 b	8.44 d	8.30 d	11.5	
		150	7.46 a	4.54 c	6.22 b	6.56 b	4.60 c	5.07 c	3.49 d	4.63 c	3.78 d	4.97 c	5.97 b	4.78 c	5.17	8.3
	Shoot	0	9.70 cd	21.7 a	11.5 c	18.1 b	17.3 b	10.6 c	10.6 c	9.65 cd	11.4 c	15.8 b	10.4 c	7.66 d	12.9	
		150	5.20 cd	5.54 c	7.19 b	7.21 b	5.33 cd	5.03 cd	5.91 c	3.07 e	5.20 cd	5.25 cd	8.04 a	4.60 d	5.63	9.24
	Root	0	19.4 a	15.0 b - d	16.9 b	14.7 b - d	13.9 ab	13.1 cd	15.7 bc	14.2 bd	14.0 cd	12.6 d	11.7 ef	9.38 f	14.2	
		150	7.60 a	6.38 b - d	5.54 de	6.46 b - d	7.10 ab	5.63 c - e	6.64 a - c	6.67 a - c	4.67 ef	6.97 ab	6.31 b - d	6.46 b - d	6.38	10.3
Ca^{2+}	Leaf	0	2.48 ef	3.43 d	2.83 e	2.32 fg	2.51 ef	1.65 h	2.18 fg	5.71 a	4.51 b	1.75 h	3.78 c	2.11 g	2.94	2.68 a
		150	2.14 d	2.30 cd	2.50 c	1.08 f	2.37 cd	1.54 e	2.16 d	2.88 b	4.16 a	1.22 f	4.36 a	2.38 cd	2.42	
	Shoot	0	1.05 f	2.15 c	1.67 d	1.46 e	0.94 f	1.37 e	1.68 d	3.92 a	0.99 f	2.85 b	2.82 b	1.07 f	1.83	
		150	0.99 ef	1.75 bc	0.96 ef	1.29 d	0.90 f	1.19 de	1.63 c	2.34 a	1.02 ef	1.95 b	1.36 d	1.18 de	1.38	1.60 b
Ca^{2+}	Root	0	4.45 b	2.32 e	2.50 e	1.05 g	3.04 d	1.70 f	4.29 b	3.42 c	2.38 e	2.27 e	4.75 b	1.54 f	2.81	2.19 c
		150	1.34 cd	1.14 d - f	0.93 f	1.03 ef	2.39 a	0.96 f	2.49 a	1.49 c	2.57 a	1.89 b	1.33 cd	1.25 de	1.57	
Cl^-	Leaf	0	2.49 b	2.63 b	3.35 a	1.72 cd	1.48 d	2.35 b	3.36 a	3.17 a	1.91 c	1.67 cd	1.66 cd	2.63 b	2.36	
		150	5.23 f	6.10 e	8.75 b	6.54 e	4.95 f	7.50 d	5.40 f	5.22 f	8.00 c	3.94 g	3.49 g	10.8 a	6.33	4.35
	Shoot	0	3.40 a	2.37 b	1.76 c	1.38 d	2.33 b	2.35 b	1.98 c	1.75 c	1.73 c	1.36 d	2.03 bc	0.76 e	1.93	
		150	6.12 c	4.53 e	6.13 c	4.21 e	7.62 b	6.24 c	4.67 e	8.68 a	4.45 e	7.29 b	5.18 d	2.53 f	5.64	3.78
	Root	0	1.77 c	2.59 a	1.56 c	1.79 c	1.75 c	1.66 c	2.11 b	1.11 d	0.95 d	1.72 c	0.96 d	1.07 d	1.59	
		150	4.39 b	9.91 a	2.74 e	3.69 cd	3.35 d	2.73 e	3.47 d	3.32 d	1.98 f	2.71 e	4.03 bc	2.25 ef	3.71	2.65
Green weight		0	10.1 cd	8.73 hi	8.89 gh	8.90 gh	10.4 c	9.23 fg	9.86 de	8.37 i	8.84 gh	10.7 b	9.56 ef	12.9 a	9.71	
		150	8.5 c	7.95 f	7.98 ef	8.50 c	8.35 cd	8.15 d - f	8.09 d - f	7.58 g	8.25 d - f	9.82 b	8.28 cd	11.8 a	8.60	9.16

Mean values indicated by the same latter are not significantly different ($P < 0.05$). N, nutrient; P.O, plant organs; T, treatment; T.M, treatment mean; P.M.O, plant organs mean.

changing of membrane permeability (Cramer et al., 1985; Grieve and Fujiyama, 1987). Most crops exposed to the saline conditions showed reduction in growth. The deleterious effect of salinity was suggested as a result of water stress, ion toxicities, ion imbalance, or combination of all these factors (Kurth et al., 1986).

According to variance analysis, the results of nutrient content of salt stress significantly affected the nutrient content in all cultivars. The concentrations of nutrient elements (K^+, Na^+, K^+/Na^+, Ca^{2+} and Cl^-) in leaves, shoots and roots are presented in Table 1.

The 12 canola genotypes had a higher Na^+ accumulation in whole plant and parts than in the control groups. The Na^+ contents in all the parts of the 12 cultivars significantly increased in the NaCl treatment (Table 1). When compared to the control plants, salt treatment caused significant increases in Na^+ content of all cultivars. Under salinity, Marinca, Semu-DNK207 and Spok cultivars retained at least Na^+ content in leaves among other cultivars. Generally, salt-tolerant plants differed from salt-sensitive ones mainly in having a low rate of Na^+. It was suggested that the capacity of ion accumulation of plants is related to their tolerance to salt stress. It was found that tolerant species accumulated lower Na^+, and the decrease of K^+ was lower than in the sensitive species (Essa, 2002; Yasar et al., 2006; Kusvuran et al. 2007).

The trend of Na^+ accumulation in the leaves of the cultivars studied was different from that of K^+ accumulation. However, there was less increase in Na^+ accumulation in roots cultivars; the highest increase was observed in the leaf and shoot of plants. The Na^+ concentration in the shoots was only slightly higher than that in the leaves. The highest Na^+ accumulation was observed in Lirawell cultivar's leaves. The highest Na^+ accumulation was observed in Helios cultivar leaf, Tobin cultivars' shoots and Helios cultivar' roots among the plants which were under stress, respectively (Table 1).

The work by Bandeh-Hagh et al. (2008) with canola, Wolf et al. (1991) with barley, Yaşar et al. (2006) with green bean, Wang and Han (2007) with alfalfa and Li et al. (2006) with soybean, reported similar results, and indicated that the distribution of Na^+ ions vary among the organs of plants and genotypes that tolerate salt well. High Na^+ content generally disrupts the nutrient balance, thereby causing specific ion toxicity despite disturbing osmotic regulation (Greenway and Munns, 1980; Grattan and Grieve, 1999). Preferential accumulation of Na^+, Cl^- or both is known to account for salt tolerance in crop species, and specific injury due to the accumulation of these ions rather than osmotic stress which was suggested to be the major factor for salt sensitivity (Grattan and Grieve, 1999; Jacoby, 1999).

Potassium contents of the 12 cultivars were affected differently by NaCl treatment (Table 1). Significant differences were determined between cultivars for K^+ content. In related studies, it was indicated that salt applications differently showed nutrient content according to canola cultivars (Ashraf and McNeilly, 2004). When compared to the control plants, salt treatment caused significant decreases in K^+ content of all cultivars. Under salinity, Marinca, Tobin and Regent cultivars retained the highest K^+ content in the leaves; in the case of K^+ these cultivars were less affected under NaCl treatment. The applied salinity caused marked reduction in the concentrations of K^+ in the shoot of all cultivars except cultivar Regent. However, it was observed in this study that the K^+ concentration in roots of all cultivars under salinity was lower than that in the control groups.

These results indicate that there was a competition between Na^+ and K^+ regarding their uptake. The salt-tolerant genotype had a greater K^+ accumulation capacity. Similar results were reported with different green bean cultivars (Yasar et al., 2006), soybean cultivars (Essa, 2002; Lİ et al., 2006) and canola cultivars (Bandeh-Hagh et al., 2008).

In the salinized treatment, the K^+ concentration was highest in leaf as compared to root and shoot. There were differences among the leaf, shoot and root for salt stress. K^+ concentrations in shoots and roots of all the cultivars decreased under the salt stress except for Regent and Lirawell cultivars. Generally, the concentration of K^+ in the leaves of Tobin was higher than that in the other cultivars. Tobin cultivars leaf (31% reduction as compared to control groups), Kosa cultivars shoot (45% reduction as compared to control groups) and Star cultivar roots (31% reduction as compared to control groups) were affected more than the other cultivars. In related studies, it was noticed that accumulation of ion in root, shoot and leaves changed under salt stressed plants (Yasar et al., 2006). The K^+ content in plant tissues represents the main cation in plant cells, and it is an important component of the cell osmotic potential (Reggiani et al., 1995). Generally, in this study, canola cultivars' root, shoot and leaf K^+ concentrations were lower at the salinity application. These results are similar to those reported by Grieve and Fujiyama (1987) and Li et al. (2006) who found that K^+ concentration reduced by salt stress in canola cultivars. One of the primary plant responses to salinity is the decrease in K^+ concentration in plant tissues (El-Samad and Shaddad, 1997) and thus the substitution of K^+ by Na^+ may lead to nutritional imbalances. Both of these ions might compete for entry into plant root cells. This competition can have significant negative effects on plant growth in saline soils, where concentrations of sodium often exceed those of potassium.

The ratio of K^+/Na^+ was significantly influenced by high NaCl application. Treatment of soil salinity resulted in the decrease of the K^+/Na^+ ratios in all cultivars. Generally, higher ratios of K^+/Na^+ were found in Semu-DNK207, Kosa and Tower cultivars than in the other cultivars under NaCl treatment (Table 1). It can be postulated that K^+/Na^+ ratios might be valid selection criteria for assessing salinity tolerance of different crop species. Previous

studies have shown that high K^+/Na^+ ratio shows a positive relationship with salt tolerance (Essa, 2002; Kusvuran et al., 2007). These findings are in agreement with the other reports suggesting that salt stress reduces the K^+/Na^+ ratio of green bean (Yasar et al., 2006), melon (Kusvuran et al., 2007), wheat (Hu et al., 2006) and legume (Amador et al., 2007). These results indicated that salt tolerance mechanisms may display differences according to cultivars. In the salinized treatment, the K^+/Na^+ concentration was highest in root as compared to leaf and shoot.

All saline-stressed plants gave lower Ca^{2+} content as compared to the control group. There were significant differences between the cultivars regarding Ca^{2+} content. In this study, NaCl treatment decreased significantly Ca^{2+} content in all cultivars, except for Lirawell and Star. In these cultivars, a significant difference between control and NaCl treatment was not found for Ca^{2+} content under salinity. This result showed that Lirawell and Star cultivars can maintain Ca^{2+} uptake although the high salt concentration, was different from the other cultivars. Furthermore, Liraspa and Semu-DNK207 cultivars had the least Ca^{2+} content in all the organs than other cultivars under salt conditions (Table 1). These results indicated that salt tolerance mechanisms may display differences according to the cultivars. All organs contents of Ca^{2+} were influenced significantly as a result of salinity treatment (Table 1). As compared to the control group, Ca^{2+} content in the leaf, shoot and root was decreased under salinity. In the salinized treatment, the Ca^{2+} concentration was highest in the leaf compared with the root and shoot. Concentrations of Ca^{2+} in the shoots were lower than those of the roots and leaves of the cultivars.

Calcium has been shown to ameliorate the adverse effects of salinity on plants (Amador et al., 2007). Calcium is well known to have regulatory roles in metabolism (Cramer et al., 1985) and sodium ions may compete with calcium ions for membrane binding sites. Therefore, it has been suggested that high calcium levels can protect the cell membrane from the adverse effects of salinity.

The effect of salinity on the nutrient composition of plant tissues, especially the concentration of calcium (Ca^{2+}) and potassium (K^+), has been extensively investigated, and several researchers have confirmed that the detrimental effects of salinity on plant growth may occur through an ionic imbalance, particularly of Ca^{2+} and K^+ (Essa, 2002; Kusvuran et al., 2007; Yasar et al., 2006). Some species and cultivars can maintain higher growth under saline conditions by accumulating fewer toxic ions and maintaining a high tissue Ca^{2+} concentration (Essa, 2002).

There were substantial differences in Cl^- content and the rate of accumulation between cultivars with NaCl application. Cl^- contents of Kosa was considerably higher than those of the other cultivars in salinity medium. In the salinized treatment, the Cl^- concentration was highest in leaf as compared to the shoot and root. Generally, salt-tolerant plants differed from salt-sensitive ones mainly in having a low rate of Na^+ and Cl^-. Experiments using different genotypes differing in rates of Na^+ or Cl^- accumulation may be able to distinguish between the effects of salt in the leaf, shoot and root, and salt in the soil (Munns, 2002). In this study, accumulation of Cl^- in the leaves, shoots and roots of the 12 canola cultivars were significantly increased due to salt stress, while K^+ and Ca^{2+} accumulation decreased.

Ions at high concentrations in the external solution (e.g. Na^+ or Cl^-) are taken up at high rates, which may lead to excessive accumulation in tissues. These ions may inhibit the uptake of other ions into the root and their transportation to the shoot. There is a potential for many nutrient interactions in salt stressed plants which may have important consequences for growth (Cramer et al., 1985). Some researcher (Li et al., 2006; Kusvuran et al., 2007; Hu et al., 2006; Amador et al., 2007) reported that salinity had a major effect on the uptake and internal concentrations of mineral elements and plant growth in many plants.

As a result, in this study, salt stress significantly decreased plant growth, while some genotypes were affected less and grew equally with the control plants, and caused no inhibition effects on saline growth. It has been understood that one of the most important reasons of the reduction in growth in different canola genotypes is the sodium ion concentration accumulated more than required and at toxic level in plant body.

This study demonstrated that under saline conditions, Na^+ and Cl^- contents of the leaf, shoot and root increased in canola while Ca^{2+}, K^+ content and K^+/Na^+ ratio contents decreased. In the light of the findings of this study, it could be said that some cultivars are relatively salt tolerant. It is evident that there is a substantial amount of variation in the characteristics associated with salt tolerance in these canola cultivars, for instance Cl^- exclusion and to some extent Na^+ exclusion and the ability to maintain high K^+ and Ca^{2+} levels in the leaf tissues in salt stress. However, further studies by using new techniques should be carried out to discover more certain realistic results.

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