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*Full Length Article*

# Ion Regulation in Different Organs of Melon (*Cucumis melo*) Genotypes under Salt Stress

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## ABSTRACT

The changes in ion acumulation with respect to the tolerance of salt stress were determined in melon (*Cucumis melo* L.). The study was performed in hydroponic conditions in growth chamber using salt tolerant (CU 196) and salt sensitive (CU 252) genotypes. Plants were subjected to 100 mM NaCl for 12 days. Fresh and dry weights were decreased by salinity. The genotypes exposed to 100 mM NaCl application developed different mechanisms to be protected against toxic effects of Na ion. Salt tolerant genotype CU 196 limited Na accumulation in all organs and acted selectively among ions. K and Ca concentrations was high in plant organs in which Na concentration were low and tolerant genotype had higher K/Na and Ca/Na ratios than sensitive genotype. The present results demonstrated that toxic ion, which Na could be stored in old leaves and having a restricted transposition of salt into young leaves as a diminishing disruptive influence of salinity. © 2012 Friends Science Publishers

**Key Words:** *Cucumis melo*; Ion accumulation; Potassium; Salt stress; Sodium

## INTRODUCTION

Agricultural practices in arid and semi arid regions around the world are under the threat of multiple abiotic stresses such as salinity. Salinity stress is one of the most serious abiotic stresses that cause reduction in plant growth, development and yield in many parts of the world (Kaya *et al.,* 2007). Most of the agricultural crops are sensitive and cannot survive under saline conditions or their growth is hindered with decreased yields (Dasgan & Koc, 2009). The growth medium with high salinity causes many opposite effects on plant growth, which are possibly due to a low osmotic potential of soil solution, specific ion effects (salt stress), imbalance in nutrition, or a combination of such factors. All the factors mentioned have the negative effects on plant development at physiological and biochemical levels. In order to evaluate the tolerance of plants to salinity stress, growth or survival of the plant is determined because it integrates the up or down regulation of many physiological mechanism arising within the plant (Ashraf, 2004; Azooz *et al.*, 2009; Hajlaoui *et al.,* 2010).

Sodium is the principal soluble cation in many of the soils of arid and semi arid regions. However, most plants are very susceptible to high Na concentrations (Wahid *et al*., 1999; Kaya *et al*., 2007). High salt concentrations in the external solution of plants cells cause several deleterious effects. Ionic imbalance is the first consequence of salt stress. An increased concentration of Na and Cl under salt (NaCl) stress is deleterious to several cellular systems. It has been demonstrated that, under salinity, not only the homeostasis of Na but also Ca and K ions are disturbed (Borsani *et al*., 2003; Xue *et al*., 2008). Reduced Na loading into the xylem is one of the main mechanisms of salinity tolerance and it is often considered one of the most crucial features of restricting Na accumulation in plant tissues (Tavakkoli *et al*., 2011). Under saline conditions, plants maintain low concentrations of Na and high concentrations of K in cytosol. They do this by the expression and activity of K and Na transporters and of H pumps that produce the driving force for ion movement. There is a negative relationship between Na and K levels in roots and leaves of most plants. The selective uptake of K as opposed Na is anticipated to be one of the essential physiological mechanisms contributing to salt tolerance in many plant species (Ahmadi *et al*., 2009).

Calcium (Ca) plays significant role structure of cell wall and linkage between cells (Maeda *et al*., 2003). On the other hand, it plays a regulatory role in balance of cation-anion and acts an activator for few enzymes (Akıncı & Simsek, 2004). However, toxic ion (Na) into growth medium causes a decreased in Ca concentration in plant tissues due to the antagonism of Na and K, or Ca at sites of uptake in roots (Abo-Kassem, 2007).

Melon is a crop with high potential in arid and semi arid areas having salinity problems (Botia *et al*., 2005). Generally, despite melon is known to be moderately tolerant to salinity, it has been reported that salt tolerance in melons dependents on the cultivars and there are sensitive cultivars as well as tolerant ones (Kuşvuran *et al*., 2007).

The aim of this research is to identify differences in

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salt tolerance (CU 196) and salt sensitive (CU252) genotypes by using examination of the levels of ions in root, shoot, fresh and old leaves. Determining of the mechanism of ion regulation in melon is important to determine whether there are any relations between ion accumulation levels and saline tolerance ability. Therefore, these results could be used breeding program aimed at increasing the salt tolerance of melon.

## MATERIALS AND METHODS

As the plant, material salt tolerant CU196 and salt sensitive CU252 melon genotypes were used. Seeds were germinated in a mixture of peat: perlite of 2:1 ratio in growth chamber with 16/8 h light/dark photoperiod, at 25±2°C and 65% humidity. After 16 days of sowing, the seedlings were transferred to the hydroponic cultures. For hydroponic culture, plastic dishes (3 L) filled with nutrient solution in molar (M) concentrations of $3.0x10^{-3}$ $Ca(NO_3)_2$; $0.9x10^{-3}$ $K_2SO_4$; $1.0x10^{-3}$ $MgSO_4$; $0.2x10^{-3}$ $KH_2PO_4$; $1.0x10^{-5}$ $H_3BO_3$; $1.0x10^{-6}$ $MnSO_4$; $1.0x10^{-7}$ $CuSO_4$; $1.0x10^{-8}$ $ZnSO_4$; $1.0x10^{-4}$ $(NH_4)_6Mo_7O_{24}$ and $10^{-4}$ Fe-EDTA (Dasgan & Koc, 2009). Nutrient solution was renewed every 3 days. Seedlings were grown under control conditions until the emergency of the fourth leaf; at the same time salt treatment started and the NaCl concentration was increased by increments of 50 mM until a final concentration of 100 mM was achieved. Non-salt-treated plants were kept as controls. Salt-stressed plants were subjected to 100 mM NaCl for 12 d and all plants, including controls, were then sampled. Whole plant weights were measured and these plants were separated into root, shoot and leaves (young & old leaves) for ion analysis.

**Determination of ion content:** For ion determination**,** the plants were harvested and dried at 65°C for 48 h and root, shoot, first two old leaves and first two young leaves of one shoot were ashed at 550°C and dissolved in 1% (v/v) HCl, analyzed for Na, K and Ca by using an atomic absorption spectrometer (Varian Spectra AA 220 FS) (Aktas *et al.,* 2006; Dasgan & Koc, 2009).

**Statistical analysis:** The experiment was designed as completely randomized plot with three replicates, and each replicate comprised ten plants. The collected data were analyzed statistically and the means were separated by Duncan's Multiple Range Test using SAS (1985) software.

## RESULTS

The effects of salt stress on fresh and dry weight of the treated melon seedlings were evaluated. Salt tolerant and salt sensitive genotypes showed very different development patterns (Table I). While the sensitive genotype CU 252 had high reductions in fresh and dry weights (72.49% & 63.02% decrease, respectively) salt tolerant genotype CU 196 fresh and dry weight decreased less in comparison to control plant (33.17% & 26.25%, respectively).

All plant organs Na concentration (on dry-weight basis) of both salt sensitive and salt tolerant genotypes increased in response to salinity (Table II). The average Na concentrations of the 2 genotypes in control and saline conditions were 0.35 and 5.14%, respectively. The Na concentrations were lower found in young leaves and the highest were found in old leaves both cultivars. However, Na accumulation was highest in all plant organs, was observed in CU 252 among plants grown under salinity. The CU 252, on the average, had 498-1672% increase in leaves, shoot and root Na concentration compared to control plants, but, salt tolerance genotype CU 196, had 162-407% increase in all organs.

The mean K concentrations of two genotypes in saline and non-saline control conditions were 0.57 and 4.94%, respectively (Table II). Salinity was accompanied by a corresponding reduction in K concentration. This reduction was greater in CU 252 than in CU 196, and was more conspicuous in old leaves and root. Salt sensitive genotypes, CU 252, was decreased K accumulation by 57-61%, however, CU 196 was decreased by 21-26% in old leaves and root. K accumulation was high in organs in which Na concentration was low, and vice versa. Na concentration was high in old leaves and root of CU 252, K content was contrary. K accumulation in this genotype was lower in all organs compared to CU 196. In presence of salinity, CU 196 had significantly higher K/Na ratios than CU 252 in young and old leaves, shoot and root.

Plant Ca concentration of the genotypes in control and saline conditions, on the average, were 1.38 and 4.86%, respectively (Table II). Salinity application caused a significant decrease in Ca concentration in the all organs of the melon plants. There was 5 to 26% reduction in salt tolerant genotype Ca concentration of the salt stressed melons compared to their control plants. On the other hand Ca content of salt sensitive genotype (CU 252) decreased by 41 to 55% under salinity. Ca accumulation in young leaves in CU 196 (4.01%) was higher compared to other organs and with CU 252 under salt condition. Decreasing Ca concentration beside Na concentration lower increase Ca/Na ratio, which was lower in CU 196. The result of this discrimination is higher Ca/Na ratio in tolerant genotype; the ratio was highest in young leaves and shoot.

## DISCUSSION

Since salt stress involves both osmotic and ionic stresses, growth suppression is directly related to the total concentration of soluble salts and osmotic potential of the soil solution. The detrimental effect is observed at the whole-plant level as the death of plants or a decrease in productivity (Hussasin *et al*., 2010; Tavakkoli *et al*., 2011). Plants growing of the melon genotypes were significantly reduced by 100 mM NaCl stress. The foliar accumulation of Na could inhibit plants growth and development (Aktas *et al*., 2006; Hajlaoui *et al*., 2010; Kuşvuran, 2010).

**Table I: The effects of 100 mM NaCl salinity for 12 days on fresh and dry weights**

| | Fresh weight (g/plant) | | | Dry weight (g/plant) | | |
|---|---|---|---|---|---|---|
| | Control (%) | Salinity (%) | Difference (%) | Control (%) | Salinity (%) | Difference (%) |
| 196 | 31.53b | 21.07a | -33.17 | 2.59a | 1.91a | -26.25 |
| 252 | 45.22a | 12.44b | -72.49 | 3.11a | 1.15b | -63.02 |

*Means with different letters in the same column are significantly different at P≤ 0.05 by Duncan test

**Table II: The effects of 100 mM NaCl salinity on Na, K, Ca concentrations and K/Na, Ca/Na ratios in the young and old leaves, shoot and root of the melons**

| | | Young leaves | | | Old leaves | | | Shoot | | | Root | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Control (%) | Salinity (%) | Diff. (%) | Control (%) | Salinity (%) | Diff. (%) | Control (%) | Salinity (%) | Diff. (%) | Control (%) | Salinity (%) | Diff. (%) |
| **Na** | 196 | 0.55f | 1.50e | 172.73 | 0.45f | 2.00d | 344.44 | 0.58f | 1.52e | 162.07 | 0.40f | 2.03d | 407.50 |
| | 252 | 0.35f | 3.47b | 891.43 | 0.29f | 5.14a | 1672.41 | 0.51f | 3.05c | 498.04 | 0.33f | 3.71b | 1024.24 |
| **K** | 196 | 4.94a | 4.31b | -12.75 | 4.02b | 3.17cd | -21.14 | 2.82c-e | 2.59d-f | -8.16 | 2.00f-h | 1.47h | -26.50 |
| | 252 | 4.89a | 2.35e-g | -51.94 | 4.55ab | 1.95gh | -57.14 | 3.21c | 2.04f-h | -36.45 | 1.49h | 0.57i | -61.74 |
| **K/Na** | 196 | 9.18bc | 2.93f-h | -68.08 | 11.71b | 1.77g-I | -84.88 | 7.61cd | 3.82fg | -49.80 | 5.58d-f | 0.77hi | -86.20 |
| | 252 | 16.66a | 0.69hi | -95.86 | 17.05a | 0.39hi | -97.71 | 6.86c-e | 0.72hi | -89.50 | 4.61ef | 0.16i | -96.53 |
| **Ca** | 196 | 4.01ab | 3.78b | -5.74 | 3.11c | 2.69c-e | -13.50 | 2.96cd | 1.98g-i | -33.10 | 2.25f-h | 1.84hi | -18.22 |
| | 252 | 4.86a | 2.61d-f | -46.30 | 3.61b | 1.60ij | -55.67 | 2.86cd | 1.65ij | -42.31 | 2.36e-g | 1.38j | -41.53 |
| **Ca/Na** | 196 | 7.19cd | 2.67ef | -62.87 | 9.37c | 1.55e-g | -83.46 | 7.80cd | 3.16e | -59.49 | 5.99d | 0.94e-g | -84.31 |
| | 252 | 16.08a | 0.77fg | -95.21 | 13.63b | 0.30g | -97.80 | 6.08d | 0.59fg | -90.30 | 7.31cd | 0.38g | -94.80 |

*Means with different letters in the same lines are significantly different at P≤ 0.05 by Duncan test.

Siringam *et al*. (2011), Zhang *et al*. (2011) and Heidari and Jamshidi (2011) showed that salinity affects generally plant growth and development.

The growth of melon genotypes used in this study was reduced in response to NaCl in the growth medium. Salt tolerant CU 196 generally excludes Na from their organs to prevent Na toxicity. There are reports showing that salt tolerance was inversely correlated with shoot Na concentration of the plants, a control mechanism of absorption, transport and accumulation of toxic ion into plant should be involved (Dasgan *et al*., 2002; Yasar *et al*., 2006; Dasgan & Koc, 2009). Both melon genotypes had a higher Na accumulation in old leaves and roots. Many studies showed that transportations of Na ions into young leaves were limited because the plants keep them in old leaves, which is known as the most desirable features of salt tolerant plant. Moreover, K ion levels were higher in young leaves than old leaves in melon; osmo regulation was achieved by limited Na uptake and transporting K in old leaves to young leaves through phloem (Yasar *et al*., 2006; Dasgan & Koc, 2009; Kuşvuran, 2010).

Potassium concentration of the melon genotypes reduced with salinity. The high concentration of sodium in medium impairs the potassium uptake, and its accumulation in the protoplasm of plant tissues results in toxic effects (Loupassaki *et al*., 2002). Previously, studying on rice Zhang *et al*. (2011) demonstrated that the uptake and distribution of K and Ca decrease along the continuum from root to shoot when the concentration of NaCl in culture solution increases. However, young leaves K concentrations of the genotypes in salt treatment were higher than that of the other plant organs. Because of a competition between Na and K regarding their uptake, Na concentration was low in young and high in old leaves of melon, K content was contrary. K/Na ratio in NaCl treatment was significant different among tolerant and sensitive genotype. Higher uptake and accumulation of K in the presence of sodium chloride is regarded as a better salt tolerance that K plays important roles to stomatal aperture and osmoregulation. Elevated K levels act osmotically, preventing Na influx into roots and shoots (Perez-Alfocea *et al*., 1996; Kuşvuran *et al*., 2007; Keutgen & Pawelzik, 2009; Dasgan & Koc, 2009; Kuşvuran, 2010). The plants take up more K from the medium having higher K/Na ratio. Similar results were reported in bean (Dasgan & Koc, 2009), melon (Kuşvuran, 2010) and maize (Tavakkoli *et al*., 2011). Maintenance of high K concentrations in salt-tolerant genotypes may be one of the mechanisms underlying their superior salt tolerance (Tavakkoli *et al*., 2011).

The ameliorating effects of Ca therefore play a key role in membrane integrity and control of selective ion uptake and transport. High Ca concentration can reduce permeability of the plasma membranes to Na (Dasgan *et al*., 2002). The reduction of membrane permeability to Na with Ca reduces accumulation of Na. Presence of high Na concentrations in the growth medium, disturb uptake and transport of Ca and thus the plants with the capability of taking up more Ca from medium have higher Ca/Na ratios (Grattan & Grieve, 1999; Al-Karaki, 2000; Dasgan *et al*., 2002). Results showed that tolerant genotype CU 196 improved Ca and limited Na intake, so that having higher Ca/Na ratio compared the sensitive genotype CU 252.

In conclusion, NaCl concentration caused reduction in plant growth and development of melon. However salt sensitive genotype (CU 252) was more affected than salt tolerant genotype (CU 196) under salinity. CU 196 partitioned Na ions mainly in old leaves and limited their transport into young leaves. In addition, accumulation of K

and Ca was related to increase of Na and may play a role as an osmotic regulation to maintain the K/Na and Ca/Na rate in the cells when exposed to salt stress.

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