

*Full Length Research Paper*

# Effects of drought and salt stresses on growth, stomatal conductance, leaf water and osmotic potentials of melon genotypes (*Cucumis melo* L.)

Sebnem Kusvuran

Kizilirmak Vocational High School, Cankiri Karatekin University, Cankiri, Turkey. E-mail: skusvuran@gmail.com.  
Tel: +903762122626. Fax: +903762128118.

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Drought and salt stress is the major constraints to crop productivity. However, resistant genotypes improve their physiological mechanisms to cope with these stresses. In this study, we have investigated the influences of drought and salt stress on dry weight, leaf osmotic potential, leaf water potential, leaf temperature and stomatal conductance in sensitive and resistant melon genotypes. Four melon genotypes (sensitive, CU 40 and CU 252; resistant CU 196 and CU 159) were grown in a mixture of peat:perlite of 2:1 ratio in growth chamber. Salt and drought stresses were observed in 30 days old melon plants. In order to perform salinity stress, 200 mM NaCl was used. The drought stress was achieved by decreasing irrigation water gradually and finally irrigation was completely stopped. The plants were subjected to the salt and drought stresses for 12 days. At the end of the experiment; shoot dry weight, osmotic potential, leaf water potential and stomatal conductance were lower in salt and drought-sensitive genotypes (CU 40 and CU 252) than the resistant ones (CU 159 and CU 196). The leaf temperature was increased under stress conditions in melon genotypes. The results showed that resistant melon genotypes have more efficient stress protection mechanisms to survive under salinity and drought conditions.

**Key words:** *Cucumis melo*, salinity, NaCl, water stress, water deficit.

## INTRODUCTION

Climatic changes due to global warming can cause serious reductions in yield and crop quality. Among the agricultural crops such as field crops and fruit trees, the vegetables are more vulnerable for climatic changes (Turkes, 1999). Drought and salinity is the major environmental constraints to crop productivity. Due to the higher productivity of irrigated land than the rain-fed land, the saline area has still been increasing as a result of improper irrigation water management. Consequently, it is necessary to study the physiological response of crop plants to salt and drought stresses in order to develop appropriate strategies to carry on food production under adverse environmental conditions (Zheng et al., 2009).

Salinity and drought causes detrimental effects on plant's life. The reduction in growth is consequence of several physiological responses including modifications of ion balance, water status, mineral nutrition, stomatal

behavior, photosynthetic efficiency, carbon allocation, and utilization. The rate of photosynthetic CO<sub>2</sub> assimilation is generally reduced by salinity and drought. This reduction is partly due to a reduced stomatal conductance and consequent restriction of the availability of CO<sub>2</sub> for carboxylation (Brugnoli and Lauteri, 1991). Physiological changes (stomatal conductance, water potential, osmotic potential) in plants growing under salt or water-deficit conditions have been developed as effective indices for resistant screening in plant breeding programs (Ashraf and Harris 2004; Parida and Das, 2005; Ashraf and Foolad, 2007; Cha-um and Kirdmanee, 2009).

Loss of water from turgid leaf tissue in response to transpiration results is not only a significant decline in water potential but also a decline in osmotic potential. Greater plant fresh and dry weights under drought and

salinity are desirable characters. A common adverse effect of water and salt stress on crop plants is the reduction in fresh and dry biomass production (Dasgan et al., 2002; Grzesiak et al., 2006; Dasgan and Koc, 2009; Kusvuran, 2010). The response of plants to salinity and drought stress have been assessed using different physiological measurement techniques, such as water potential, leaf osmotic potential and stomatal conductance and these parameters have been used in assessment of abiotic stress-related studies such as drought and salinity screening (Ashraf and Oleary, 1996).

Melon (*Cucumis melo* L.) is an important horticultural crop, often cultivated in arid and semi-arid regions of the world, where salinity begins to threaten, or has already been a problem. In general, melon is known to be moderately resistant to salinity and drought. It has been shown that these stresses cause several types of damage such as growth inhibition (Franco et al., 1997; Mendlinger, 1994; Dasgan and Koc, 2009; Kusvuran, 2010), metabolic disturbances (Mavrogianopoulos et al., 1999), and yield and quality losses (del Amor et al., 1999).

The aim of this work was to compare the changes in water potential, osmotic potential, stomatal conductance and leaf temperature of melon genotypes that have different response as resistant and sensitive to drought and salinity.

## MATERIALS AND METHODS

Two salt and drought resistant (CU 159 and CU 196) and two salt and drought sensitive (CU 40 and CU 252) melon varieties were used as plant materials (Kusvuran, 2010). Seeds of four genotypes melon were germinated in a mixture of peat:perlite substrate (2:1). After 16 days of sowing when the seedlings reached the 3 leaf stage, the uniformity seedlings were transferred to 17 cm diameter of plastic pots containing 2 L of peat:perlite substrate (2:1). The plants were grown in growth chamber and irrigated with nutrient solution. The composition of the nutrient solution used was as follows (M):  $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ ,  $3.0 \times 10^{-3}$ ;  $\text{K}_2\text{SO}_4$ ,  $0.90 \times 10^{-3}$ ;  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ,  $1.0 \times 10^{-3}$ ;  $\text{KH}_2\text{PO}_4$ ,  $0.2 \times 10^{-3}$ ;  $\text{H}_3\text{BO}_3$ ,  $1.0 \times 10^{-5}$ ;  $10^{-4}$  FeEDTA,  $\text{MnSO}_4 \cdot \text{H}_2\text{O}$ ,  $1.0 \times 10^{-6}$ ;  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ,  $1.0 \times 10^{-7}$ ;  $(\text{NH}_6)\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}$ ,  $1.0 \times 10^{-4}$ ;  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ ,  $1 \times 10^{-4}$  (Dasgan and Koc, 2009). Two plants were grown per pot and 3 pots were included in each replicate.

Salt treatment has been started by 50 mM NaCl concentration and increased by the increments of 50 mM NaCl per day until a final concentration of 200 mM NaCl was achieved at the end of 4th day. Applied amount of water in the experiment was calculated according to the ratio of "drained water / applied water" (Schröder and Lieth, 2002). Under the control conditions, without stress, this ratio was around 30%. Drought stress was achieved by decreasing irrigation water gradually during 4 days. Drought treatment has been started by saturated pots 100% and then water deficit was performed 25% decrements (75, 50, and 25%) of the control pots per day. At the end of the 4 days, the terminal water stress was started and water was completely stopped (Kusvuran, 2010; Kusvuran et al., 2011).

Control plants were grown under non-stress conditions for the same period of time. The drainage ratio in control and salt-stressed plants was always maintained around 30% of the applied water. Fully expanded melon leaves were sampled for measurement of

leaf water potential, stomatal conductance, leaf temperature and osmotic potential from 22 days after sowing (DAS) and then every 3 days that is, at 29, 32, 35 and 38 DAS the periodical measurements have been realized. Leaf water potential (MPa) was measured by the pressure chamber with Plant Water Status Console mark and 3005-1412 model instrument (Soilmoisture Equipment Corp., Goleta, California, USA; Percy et al., 1989). Measurements were done with the third leaf from the tip of the plants.

Osmotic potential (MPa) was determined according to Küçükkömürçü (2011), 1 g of fresh leaves from the fourth leaf of the plants was weighed and homogenized with 19 ml distilled water. The homogenized leaf samples were kept at  $-20^\circ\text{C}$ . The homogenized samples were passed from the  $0.45 \mu\text{m}$  precision filters. These samples were measured with the freezing point osmometer with Knauer mark and 7400 model instrument (Berlin, Germany). The osmotic potential was calculated according to the Van't Hoff equation (Silva et al., 2010). Leaf temperature was measured using infrared thermometer and stomatal conductance was measured by a porometer with Delta-T Devices mark and AP4 model instrument (Cambridge, UK) from the 5th leaves of the melon plants

## RESULTS

Salt and drought stresses significantly decreased shoot dry weight of the melon genotypes in comparison to the control plants without stress. Resistant genotypes protected their growth performances under saline (NaCl) and drought stresses. While the genotypes CU40 and CU 252 had high reductions in their shoot dry weights, CU 196 and CU 159 had relatively low reductions in their shoot dry weights. At the end of 12<sup>th</sup> days, dry weight was reduced by 63.02 and 63.99% in sensitive genotype CU 252 under salt and drought stress, respectively. However, it was decreased by 21 to 26% in resistant genotype CU 196 in salt and drought stress (Table 1).

Leaf water potential and osmotic potential of melon genotypes decreased under salt and drought stresses as compared to those in the control treatment. The leaf water potential of melon genotypes was around  $-0.60$  to  $-0.77$  throughout the 3<sup>th</sup> in salt and drought stress period. On the other hand, throughout the stress period, leaf water potential was significantly decreased, particularly in sensitive genotypes (Table 2). The effect of salinity and drought on leaf water potential and osmotic potential were more dramatic in sensitive genotypes CU 40 and CU 252 than in resistant genotypes CU 159 and CU 196. At the end of the 12 days, the osmotic potential decreased to 160 and 562% in sensitive genotypes CU 40 and CU 252, respectively, however, it decreased to 69 and 118% in resistant genotypes CU 159 and CU 196, respectively under salinity and drought. Leaf water potential and osmotic potential more effected to drought stress than salt stress. Leaf water potential decreased by average 50% under drought stress; however salinity was decreased by 37% (Table 2).

Four melon genotypes showed a higher leaf temperature under salt and drought stress than in the control treatment (Table 3). Generally, salt and drought stresses had similar affects on melon genotypes.

**Table 1.** Changes in the dry weight of four melon genotypes treated for 12 days with 200 mMol/l NaCl and drought stress.

Genotype	Days	Dry weight (g/plant)		
		Control	Salinity	Drought
CU 40	0	0.59 <sup>i</sup>	0.43 <sup>j</sup>	0.39 <sup>k</sup>
	3	1.33 <sup>d</sup>	0.83 <sup>h</sup>	0.84 <sup>h</sup>
	6	1.71 <sup>c</sup>	0.92 <sup>g</sup>	0.93 <sup>g</sup>
	9	2.63 <sup>b</sup>	1.13 <sup>e</sup>	0.98 <sup>f</sup>
	12	2.87 <sup>a</sup>	1.34 <sup>d</sup>	1.11 <sup>e</sup>
	LSD			0.030
CU 252	0	0.52 <sup>j</sup>	0.52 <sup>j</sup>	0.47 <sup>k</sup>
	3	1.16 <sup>d</sup>	0.86 <sup>i</sup>	0.91 <sup>h</sup>
	6	1.91 <sup>c</sup>	1.07 <sup>g</sup>	1.11 <sup>f</sup>
	9	2.76 <sup>b</sup>	1.13 <sup>e</sup>	1.09 <sup>f</sup>
	12	3.11 <sup>a</sup>	1.15 <sup>d</sup>	1.16 <sup>d</sup>
	LSD			0.017
CU 159	0	0.59 <sup>m</sup>	0.58 <sup>m</sup>	0.55 <sup>m</sup>
	3	1.16 <sup>i</sup>	0.98 <sup>l</sup>	1.05 <sup>k</sup>
	6	1.94 <sup>c</sup>	1.09 <sup>j</sup>	1.37 <sup>h</sup>
	9	2.83 <sup>a</sup>	1.58 <sup>f</sup>	1.60 <sup>e</sup>
	12	2.75 <sup>b</sup>	1.76 <sup>d</sup>	1.43 <sup>g</sup>
	LSD			0.029
CU 196	0	0.56 <sup>m</sup>	0.70 <sup>l</sup>	0.68 <sup>l</sup>
	3	1.27 <sup>i</sup>	1.13 <sup>k</sup>	1.22 <sup>j</sup>
	6	1.69 <sup>f</sup>	1.56 <sup>h</sup>	1.64 <sup>g</sup>
	9	2.35 <sup>b</sup>	1.82 <sup>e</sup>	1.81 <sup>e</sup>
	12	2.59 <sup>a</sup>	1.91 <sup>d</sup>	2.04 <sup>c</sup>
	LSD			0.019

\*Different letters in each column show significant differences at  $P \leq 0.05$ .

Together with the onset of stress, leaf temperature began to increase among the melon genotypes. This increase was more remarkable after the 9th day of stress. However, the 12th of stress, tolerant genotypes showed some reduction in leaf temperature compared to the sensitive genotypes.

The stomatal conductance values of all the genotypes decreased continuously during the salinity and drought. The resistant genotypes (CU 159 and CU 196) had significantly greater stomatal conductance than those of the sensitive genotypes (CU 40 and CU 252). For salinity, the stomatal conductance value on the 3<sup>th</sup> was 11.48 and 14.94% in sensitive genotypes, 16 to 21% in tolerant genotypes, on the other hand, for drought, these rates on the 3<sup>th</sup> was 33.90 to 41.76% in sensitive genotypes (Table 3). Compared to control, stomatal conductance reduced to 40 and 58% after 12 days, respectively, in CU 196 and CU 159 (resistant) genotypes, but it was 66 and 81% in CU 40 and CU 252 (sensitive) genotypes under

salt and drought stress. At the same time end of the 12th days, the stomatal conductance of drought stress was significantly lower than that of salinity. Decreasing of stomatal conductance was on average 67% in drought stress, however in salinity, it was 59%.

## DISCUSSION

There are many researches related with the salinity and drought stresses but they are separate. However our work included both drought and salinity together. This study showed the similarities and differences of the some physiological responses in melon plants under the drought and salinity conditions. So this study has given opportunity to compare both drought and salinity responses in melons.

According to the investigations on shoot fresh and dry weights, plant growth of the melon genotypes were

**Table 2.** Changes in the osmotic potential and leaf water potential level in leaves of four melon genotypes treated for 12 days with 200 mMol/l NaCl and drought stress.

Genotype	Days	Osmotic potential (MPa)			Leaf water potential (MPa)		
		Control	Salinity	Drought	Control	Salinity	Drought
CU 40	0	-0.66 <sup>f</sup>	-1.02 <sup>b-f</sup>	-0.79 <sup>d-f</sup>	-0.62 <sup>de</sup>	-0.58 <sup>ef</sup>	-0.58 <sup>ef</sup>
	3	-0.91 <sup>c-f</sup>	-1.13 <sup>b-d</sup>	-1.04 <sup>b-e</sup>	-0.60 <sup>ef</sup>	-0.64 <sup>de</sup>	-0.76 <sup>b-d</sup>
	6	-0.67 <sup>ef</sup>	-1.22 <sup>bc</sup>	-1.16 <sup>b-d</sup>	-0.58 <sup>ef</sup>	-0.67 <sup>c-e</sup>	-0.77 <sup>bc</sup>
	9	-1.06 <sup>b-d</sup>	-1.33 <sup>b</sup>	-1.36 <sup>b</sup>	-0.60 <sup>ef</sup>	-0.50 <sup>f</sup>	-0.82 <sup>b</sup>
	12	-0.85 <sup>c-f</sup>	-2.21 <sup>a</sup>	-2.37 <sup>a</sup>	-0.62 <sup>ef</sup>	-0.56 <sup>ef</sup>	-1.02 <sup>a</sup>
	LSD			0.38		1.91	
CU 252	0	-0.83 <sup>g-j</sup>	-1.12 <sup>f-h</sup>	-0.62 <sup>ij</sup>	-0.58 <sup>h</sup>	-0.61 <sup>gh</sup>	-0.58 <sup>h</sup>
	3	-1.06 <sup>f-i</sup>	-1.27 <sup>fg</sup>	-1.10 <sup>f-h</sup>	-0.62 <sup>gh</sup>	-0.67 <sup>e-g</sup>	-0.77 <sup>ef</sup>
	6	-0.81 <sup>h-j</sup>	-1.41 <sup>ef</sup>	-1.76 <sup>de</sup>	-0.66 <sup>f-h</sup>	-0.75 <sup>de</sup>	-0.87 <sup>bc</sup>
	9	-1.12 <sup>f-h</sup>	-2.34 <sup>c</sup>	-2.10 <sup>cd</sup>	-0.63 <sup>gh</sup>	-0.80 <sup>cd</sup>	-0.92 <sup>b</sup>
	12	-0.58 <sup>j</sup>	-3.08 <sup>b</sup>	-3.84 <sup>a</sup>	-0.61 <sup>gh</sup>	-0.87 <sup>bc</sup>	-1.14 <sup>a</sup>
	LSD		0.44		0.86		
CU 159	0	-0.88 <sup>ef</sup>	-0.80 <sup>fg</sup>	-0.53 <sup>j</sup>	-0.64 <sup>de</sup>	-0.64 <sup>de</sup>	-0.65 <sup>de</sup>
	3	-0.80 <sup>fg</sup>	-0.75 <sup>f-h</sup>	-0.62 <sup>h-j</sup>	-0.61 <sup>e</sup>	-0.67 <sup>c-e</sup>	-0.72 <sup>b-e</sup>
	6	-0.69 <sup>g-i</sup>	-1.25 <sup>d</sup>	-0.59 <sup>ij</sup>	-0.63 <sup>de</sup>	-0.70 <sup>b-e</sup>	-0.74 <sup>b-d</sup>
	9	-0.80 <sup>fg</sup>	-1.47 <sup>c</sup>	-1.60 <sup>bc</sup>	-0.61 <sup>e</sup>	-0.74 <sup>b-d</sup>	-0.80 <sup>ab</sup>
	12	-1.02 <sup>e</sup>	-1.73 <sup>b</sup>	-2.03 <sup>a</sup>	-0.63 <sup>de</sup>	-0.78 <sup>a-c</sup>	-0.88 <sup>a</sup>
	LSD		0.15		0.11		
CU 196	0	-0.48 <sup>d</sup>	-0.62 <sup>cd</sup>	-0.40 <sup>d</sup>	-0.63 <sup>de</sup>	-0.65 <sup>c-e</sup>	-0.66 <sup>b-e</sup>
	3	-0.98 <sup>bc</sup>	-0.83 <sup>cd</sup>	-0.61 <sup>cd</sup>	-0.60 <sup>e</sup>	-0.69 <sup>b-d</sup>	-0.71 <sup>b-d</sup>
	6	-0.50 <sup>d</sup>	-1.37 <sup>ab</sup>	-0.64 <sup>cd</sup>	-0.60 <sup>e</sup>	-0.74 <sup>b</sup>	-0.73 <sup>bc</sup>
	9	-0.97 <sup>bc</sup>	-1.39 <sup>ab</sup>	-1.50 <sup>a</sup>	-0.59 <sup>e</sup>	-0.77 <sup>b</sup>	-0.84 <sup>a</sup>
	12	-0.79 <sup>cd</sup>	-1.50 <sup>a</sup>	-1.73 <sup>a</sup>	-0.63 <sup>de</sup>	-0.82 <sup>a</sup>	-0.86 <sup>a</sup>
	LSD		0.45		0.08		

\* Different letters in each column show significant differences at  $P \leq 0.05$ .

inhibited by salt and drought stresses. The effects of the both stresses drought and salinity showed parallel degree of damages on each melon genotype. These results indicate that drought and salinity were similarly inhibited the plant growth. Similar results were found by Asraf (1994), Cha-um and Kirdmanee (2009) and Kusvuran (2010). Maintenance of plant water status is a fundamental phenomenon for the maintenance of normal growth of plants under stressful environment (Ali and Ashraf, 2011). In this study, drought and salinity adversely affected different plant-water relation parameters such as leaf water potential, osmotic potential in melon genotypes. Due to this affect, plant growth was significantly decreased, especially in sensitive genotypes. It has been generally known that tolerance to drought and salinity usually involves the development of low osmotic potentials, mainly because of accumulation of solutes in the cells (Ashraf and Oleray, 1996). Leaf water content and gas exchange parameters are very sensitive to salt

and drought stress. Reductions in leaf water potential result in photosynthetic competence in many plant species. Plants water status depends on osmotic conditions of cells and transport of water from shoot. During the inhibition of water transport from root to shoot, osmotic regulation may actively influence water potential in assimilating tissues a limiting detrimental effects of salt and drought stresses on photosynthesis.

Limitations in inhibiting photosynthesis under low osmotic potential might be caused by keeping relatively great volumes of protoplasts (Matthews and Boyer, 1984; Chaves et al., 2002; Grzesiak et al., 2006). In all the melon genotypes under salt and drought stress, leaf water potential and osmotic potential decreased. However, resistant genotypes showed higher water potential under both of the stress conditions. Levitt (1972), Ashraf and Oleary (1996), Anyia and Herzog (2004), Xu and Zhou (2008), and Echevarria-Zomeno et al. (2009) have suggested that leaf water potential may

**Table 3.** Changes in the leaf temperature and stomatal conductance level in leaves of four melon genotypes treated for 12 days with 200 mMol/l NaCl and drought stress.

Genotype	Days	Leaf temperature(°C)			Stomatal conductance(mmol m <sup>-2</sup> s <sup>-1</sup> )		
		Control	Salinity	Drought	Control	Salinity	Drought
CU 40	0	23.93 <sup>fg</sup>	24.73 <sup>f</sup>	23.73 <sup>g</sup>	340 <sup>a</sup>	237.0 <sup>c-e</sup>	226 <sup>c-e</sup>
	3	26.43 <sup>e</sup>	30.2 <sup>bc</sup>	26.4 <sup>e</sup>	220.3 <sup>c-e</sup>	195.0 <sup>d-f</sup>	128.3 <sup>g-i</sup>
	6	27.0 <sup>e</sup>	29.6 <sup>c</sup>	27.93 <sup>d</sup>	258.3 <sup>bc</sup>	182.7 <sup>e-g</sup>	88.7 <sup>ij</sup>
	9	26.97 <sup>e</sup>	30.37 <sup>bc</sup>	30.03 <sup>bc</sup>	249.3 <sup>b-d</sup>	160.3 <sup>f-h</sup>	64.0 <sup>j</sup>
	12	29.53 <sup>c</sup>	32.17 <sup>a</sup>	30.83 <sup>b</sup>	304.3 <sup>ab</sup>	102.3	74.7 <sup>ij</sup>
	LSD		0.87		58.17		
CU 252	0	23.63 <sup>h</sup>	23.70 <sup>h</sup>	22.10 <sup>i</sup>	261.0 <sup>ab</sup>	226.0 <sup>bc</sup>	192.0 <sup>cd</sup>
	3	25.67 <sup>g</sup>	29.0 <sup>cd</sup>	27.73 <sup>ef</sup>	174.0 <sup>d</sup>	200.0 <sup>cd</sup>	115.0 <sup>e</sup>
	6	27.47 <sup>f</sup>	28.93 <sup>cd</sup>	28.40 <sup>de</sup>	265.7 <sup>ab</sup>	118.7 <sup>e</sup>	94.3 <sup>ef</sup>
	9	28.93 <sup>cd</sup>	29.63 <sup>c</sup>	29.60 <sup>c</sup>	275.7 <sup>a</sup>	91.3 <sup>ef</sup>	71.0 <sup>ef</sup>
	12	28.97 <sup>cd</sup>	30.09 <sup>b</sup>	32.57 <sup>a</sup>	295.7 <sup>a</sup>	70.0 <sup>f</sup>	54.3 <sup>f</sup>
	LSD		0.89		48.79		
CU 159	0	23.30 <sup>h</sup>	23.27 <sup>h</sup>	22.97 <sup>h</sup>	258.0 <sup>b</sup>	385.0 <sup>a</sup>	396.7 <sup>a</sup>
	3	26.80 <sup>g</sup>	29.57 <sup>d</sup>	27.93 <sup>f</sup>	225.0 <sup>bc</sup>	261.0 <sup>b</sup>	232.0 <sup>bc</sup>
	6	27.55 <sup>fg</sup>	29.60 <sup>d</sup>	28.33 <sup>ef</sup>	230.0 <sup>bc</sup>	247.3 <sup>bc</sup>	226.3 <sup>bc</sup>
	9	29.05 <sup>de</sup>	30.03 <sup>cd</sup>	32.00 <sup>a</sup>	265.0 <sup>b</sup>	169.7 <sup>cd</sup>	130.7 <sup>d</sup>
	12	29.14 <sup>de</sup>	30.73 <sup>bc</sup>	31.60 <sup>ab</sup>	290.0 <sup>b</sup>	138.0 <sup>d</sup>	121.0 <sup>d</sup>
	LSD		1.07		78.01		
CU 196	0	23.50 <sup>h</sup>	23.10 <sup>h</sup>	23.00 <sup>h</sup>	324.0 <sup>ab</sup>	316.7 <sup>ab</sup>	245.0 <sup>bc</sup>
	3	26.83 <sup>g</sup>	30.47 <sup>ab</sup>	27.47 <sup>fg</sup>	225.0 <sup>cd</sup>	273.3 <sup>a-c</sup>	251.0 <sup>bc</sup>
	6	27.03 <sup>g</sup>	29.00 <sup>de</sup>	28.27 <sup>ef</sup>	275.7 <sup>a-c</sup>	348.3 <sup>a</sup>	211.3 <sup>cd</sup>
	9	30.43 <sup>ab</sup>	30.10 <sup>bc</sup>	30.6 <sup>a</sup>	342.7 <sup>a</sup>	267.0 <sup>a-c</sup>	192.3 <sup>cd</sup>
	12	30.00 <sup>bc</sup>	29.93 <sup>b-d</sup>	29.33 <sup>b-d</sup>	319.0 <sup>ab</sup>	189.0 <sup>cd</sup>	151.3 <sup>d</sup>
	LSD		0.94		89.56		

\*Different letters in each column show significant differences at P ≤ 0.05.

differentiate between resistant and sensitive cultivars of different crops. Moreover drought tolerant crops are expected to have much lower osmotic potentials than the drought sensitive ones when subjected to water deficit conditions (Ashraf and O'Leary, 1996).

Water deficit and salinity cause stomatal closure, a reduced transpiration rate, and elevated canopy foliage temperature (Halim et al., 1990). During drought, leaves are subjected to both heat and water deficiency stress (Clarke et al., 1993). As a consequence of the reduction in transpiration rates of leaves, leaf temperature increases. All of the melon genotypes were increased leaf temperature under salt and drought stress. Mohammadian et al. (2001) suggested that under drought conditions, sugar beet leaves wilt in response to water deficiency and tend to lay flat on the soil and thus increase the effective area exposed to the sun, therefore, reduction in transpiration rates of such leaves, leaf temperature increases. Azevedo et al. (2004) reported that leaf temperature increased with salinity.

Under salinity or drought, leaf water potential and thus photosynthetic activity will decrease. The reduction in photosynthetic rate is usually due to low stomatal conductance, which also reduces the transpiration rate (Razzaghi et al., 2011). Thus plant development has decreased. Stomatal conductance is changed among species and genotypes within the same genotypes. Leaf water status interacts with stomatal conductance under salt and drought stresses. In the present study, stomatal conductance of the genotypes decreased under salt and drought stress. However the resistant genotypes CU 196 and CU 159 have decreased with lower rate than sensitive genotypes CU 40 and CU 252. Medrano et al. (2002) suggested that good correlation was often observed between leaf water potential and stomatal conductance, in addition, Turner et al. (1998) reported that, stomatal conductance decreased as the osmotic potential decreased in sorghum and sunflower. Similar results were found in chickpea (Mafakheri, 2010), sugar beet (Dadkhah, 2010), and nut (Silva et al., 2011).

## Conclusion

The results from this study indicate that osmotic effect plays a vital role in salt and drought tolerance of the melon genotypes. The behaviors of the melon genotypes under saline conditions appear to be similar to those under drought conditions. Plant growth rate, osmotic potential, leaf water potential and stomatal conductance were decreased with salt and drought stresses. However, these changes occurred at lower rate in resistant genotypes, CU 159 and CU 196 than the sensitive ones, CU 40 and CU 252. For assessing and screening melon genotypes for their tolerance to salinity and drought stresses during their young plant stage, these parameters can be used.

## REFERENCES

- Ali Q, Ashraf M (2011). Induction of drought tolerance in maize (*Zea mays* L.) due to exogenous application of trehalose: Growth, photosynthesis, water relations and oxidative defense mechanism. *J. Agron. Crop Sci.*, 194(4): 258-271.
- Anyia AO, Herzog H (2004). Genotypic variability in drought performance and recovery in cowpea under controlled environment. *J. Agron. Crop Sci.*, 190:151-159.
- Ashraf M (1994). Breeding for salinity tolerance in crops. *Crit. Rev. Plant Sci.*, 13: 17-42.
- Ashraf M, O'Leary JW (1996). Effect of drought stress on growth, water relations, and gas exchange of two lines of sunflower differing in degree of salt tolerance. *Int. J. Plant Sci.*, 157(6): 729-732.
- Ashraf M, Harris PJC (2004). Potential biochemical indicators of salinity tolerance in plants. *Plant Sci.*, 166: 3-16.
- Ashraf M, Foolad MR (2007). Role of glycine betaine and proline in improving plant abiotic stress resistance. *Environ. Exp. Bot.*, 59: 206-216.
- Azevedo Neto A, Prisco JT, Filho JE, Lacerda CF, Silva JV, Costa PH, Filho EG (2004). Effects of salt stress on plant growth, stomatal response and solute accumulation of different maize genotypes. *Braz. J. Plant Physiol.*, 16(1): 31-38.
- Brugnoli E, Lauteri M (1991). Effects of salinity on stomatal conductance, photosynthetic capacity, and carbon isotope discrimination of salt-resistant (*Gossypium hirsutum* L.) and salt-sensitive (*Phaseolus vulgaris* L.) C<sub>3</sub> non-halophytes. *Plant Physiol.*, 95: 628-635.
- Cha-um S, Kirdmanee C (2009). Proline accumulation, photosynthetic abilities and growth characters of sugarcane (*Saccharum officinarum* L.) plantlets in response to iso-osmotic salt and water-deficit stress. *Agric. Sci. China*, 8 (1): 51-58.
- Chaves MM, Pereira JS, Maroco J, Rodrigues ML, Ricardo CPP, Osorio ML, Carvalho I, Faria T, Pinheiro C (2002). How plants cope with water stress in the field? Photosynthesis and growth. *Ann. Bot.*, 89: 907-916.
- Clarke N, Hetschkun H, Jones C, Boswell E, Marfaing H (1993). Identification of stress tolerance traits in sugar beet. In: "Interacting Stress on Plants in a Changing Climate." Jackson M.B. and Black C.R. (Eds.): Springer-Verlag, Berlin, pp. 511-524.
- Dadkhah AR (2010). Effect of long term salt stress on gas exchange and leaf carbohydrate contents in two sugar beet (*Beta vulgaris* L.) cultivars. *Res. J. Biol. Sci.*, 5(8): 512-516.
- Dasgan HY, Aktas H, Abak K, Cakmak I (2002). Determination of screening techniques to salinity tolerance in tomatoes and investigation of genotype responses. *Plant Sci.*, 163: 695-703.
- Dasgan HY, Koc S (2009). Evaluation of salt tolerance in common bean genotypes by ion regulation and searching for screening parameters. *J. Food Agric. Environ.*, 7(2): 363-372.
- del Amor FMV, Martinez V, Cerda A (1999). Salinity duration and concentration affect fruit yield and quality, and growth and mineral composition of melon plants grown in perlite. *HortSci.*, 34: 1234-1237.
- Echevarria-Zomeno S, Ariza D, Jorge I, Lenz C, Jesusviorri NA, Navarro R (2009). Changes in the protein profile of *Quercus ilex* leaves in response to drought stress and recovery. *J. Plant Physiol.*, 166: 233-245.
- Franco JA, Fernandez JA, Banon S (1997). Relationship between the effects of salinity on seedling leaf area and fruit yield of six muskmelon cultivars. *HortSci.*, 32 (4): 642-644.
- Grzesiak MT, Grzesiak S, Skoczowski A (2006). Changes of leaf water potential and gas exchange during and after drought in triticale and maize genotypes differing in drought tolerance. *Photosynthetica*, 44(4): 561-568.
- Halim RA, Buxton DR, Hattendorf MJ, Carlson RE (1990). Crop water stress index and forage quality relationships in alfalfa. *Agric. J.*, 82: 906-909.
- Kucukkumurcu S (2011). Screening of the okra genotypes for their tolerances to salinity and drought stress. Department of Horticulture Institute of Natural and Applied Sciences University of Çukurova, Master Thesis, 177 pp.
- Kusvuran S (2010). Relationships between physiological mechanisms of tolerances to drought and salinity in melons. Department of Horticulture Institute Of Natural and Applied Sciences University of Çukurova, Ph.D. Thesis, 356 pp.
- Kusvuran S, Dasgan HY, Abak K (2011). Responses of different melon genotypes to drought stress. *Yüzüncü Yıl University. J. Agric. Sci.*, 21(3): 209-219.
- Levitt J (1972). Responses of Plants to Environmental Stresses. Academic Press, New York.
- Matthews MA, Boyer JS (1984). Acclimation of photosynthesis to low water potentials. *Plant Physiol.*, 74: 161-166.
- Mafakheri A (2010). Effect of drought stress on yield, proline and chlorophyll contents in three chickpea cultivars. *Aust. J. Crop Sci.*, 4(8): 580-585.
- Mavrogianopoulos GN, Spanakis J, Tsikalas P (1999). Effect of carbon dioxide enrichment and salinity on photosynthesis and yield in melon. *Sci. Hort.*, 79: 51-63.
- Medrano H, Escalona JM, Bota J, Gulias J, Flexas J (2002). Regulation of photosynthesis of C<sub>3</sub> plants in response to progressive drought: stomatal conductance as reference parameter. *Ann. Bot.*, 89: 895-905.
- Mendlinger S (1994). Effect of increasing plant density and salinity on yield and fruit quality in muskmelon. *Sci. Hort.*, 57: 41-49.
- Mohammadian R, Khoyi FR, Rahimian Moghaddam HM, Ghassemi-Golezani K, Sadeghian SY (2001). The effects of early season drought on stomatal conductance, leaf-air temperature difference and proline accumulation in sugar beet genotypes. *J. Agric. Sci. Technol.*, 3: 181-192.
- Parida AK, Das AB (2005). Salt tolerance and salinity effects on plants: a review. *Ecotoxicol. Environ. Saf.*, 60: 324-349.
- Pearcy RW, Ehleringer I, Mooney HA, Rundel RW (1989). Plant physiological ecology. Chapman and Hall, New York, New York, USA.
- Razzaghi F, Ahmadi SH, Adolf VI, Jesen CR, Jacobsen SE, Andersen MN (2011). Water relations and transpiration of quinoa (*Chenopodium quinoa* Willd.) under salinity and soil drying. *J. Agron. Crop Sci.*, 197 (5): 348-360.
- Schubert S., Lauchli A (1990). Sodium exclusion mechanism at the root surface of 2 maize cultivars. *Plant and Soil*, 123: 205-209.
- Silva EN, Ribeiro R.V, Ferreira- Silva SL, Viegas RA, Silveira JAG (2010). Comparative effects of salinity and water stress on photosynthesis, water relations and growth of *Jatropha curcas* plants. *J. Arid Environ.*, 74: 1130-1137.
- Silva EN, Ribeiro RV, Silva SL, Viegas RA, Silveira JA (2011). Salt stress induced damages on the photosynthesis of physic nut young plants. *Sci. Agric.*, 68(1): 62-68.
- Turkeş M (1999). Vulnerability of Turkey to desertification with respect to precipitation and aridity conditions. *Turk. J. Eng. Env. Sci.*, 23: 363-380.
- Turner NC, Begg JE, Tonnet ML (1998). Osmotic adjustment of sorghum and sunflower crops in response to water deficits and its influence on the water potential at which stomata close. *Aust. J. Plant*

- Physiol., 5(5): 597-608.
- Xu Z, Zhou G (2008). Responses of leaf stomatal density to water status and its relationship with photosynthesis in a grass. *J. Exp. Bot.*, 59 (12): 3317-3325.
- Zheng C, Jiang D, Liu F, Dai T, Jing Q, Cao W (2009). Effects of salt and waterlogging stresses and their combination on leaf photosynthesis, chloroplast ATP synthesis, and antioxidant capacity in wheat. *Plant Sci.*, 176: 575-582.