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Growth and Photosynthetic Response of Two Persimmon Rootstocks (*Diospyros kaki* and *D. virginiana*) under Different Salinity Levels

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Abstract

Salinity continues to be a major factor in reduced crop productivity and profit in many arid and semiarid regions. Seedlings of *Diospyros kaki* Thunb. and *D. virginiana* L. are commonly used as rootstock in persimmon cultivation. In this study we have evaluated the effects of different salinity levels on photosynthetic capacity and plant development of *D. kaki* and *D. virginiana*. Salinity was provided by adding 50 mM, 75 mM and 100 mM NaCl to nutrient solution. In order to determine the effects of different salinity levels on plant growth, leaf number, plant height, shoot and root dry mass were recorded. Besides leaf Na, Cl, K and Ca concentrations were determined. Also leaf chlorophyll concentration, chlorophyll fluorescence (*Fv'/Fm'*) and leaf gas exchange parameters including leaf net photosynthetic rate (P_N), stomatal conductance (g_S), leaf transpiration rate (E), and CO_2 substomatal concentration (Ci) were investigated. Significant decrease of leaf number, shoot length and plant dry mass by increasing salinity levels was observed in both rootstocks. *D. virginiana* was less affected in terms of plant growth under salinity stress. Leaf chlorophyll concentration reduction was higher in the leaves of *D. kaki* in comparison to *D. virginiana* in 100 mM NaCl treatment. By increasing salinity levels P_N, g_S and E markedly decreased in both rootstocks and *D. kaki* was more affected from salinity in terms of leaf gas exchange parameters. In addition there was no significant difference but slight decreases were recorded in leaf chlorophyll fluorescences of both rootstocks.

Keywords: abiotic stress, gas exchange parameters, growth, NaCl, persimmon, rootstock

Introduction

Persimmon (*Diospyros kaki*) is originally from China, and from there it spread to Korea and Japan. Its cultivation in western countries dates only since the second half of the 19th century. In recent years, the cultivation of persimmon has found renewed interest in various countries of the Mediterranean basin, as well as in Turkey. According to 2011 data, Turkey's persimmon production was 28295 tonnes on 2090 ha planted orchards (TUIK, 2014). Most of these orchards are located in the Mediterranean region where salt accumulation in soils is a natural process favoured by the ecological conditions and foremost by the water balance of the area (Zalidis *et al.,* 2002). Persimmons can be grown in a wide range of soils, but prefer well-drained loam. The tree does not tolerate high salinity. Persimmons grow better in heavier soils than the most deciduous tree fruits and are sensitive to boron and salts in the soil (Farrar, 1999).

Salinity is a major environmental factor affecting the performance of many crop plants (Munns, 2002). The effects of salinity on plants are evidenced by a severe reduction in plant growth and yield and, if the saline conditions persist, plant death can occur (Storey and Walker, 1999). Salinity causes a deficiency of water in plant tissue, and low water potential reduces growth by inhibiting cell division and cell expansion (Hasegawa *et al.,* 2000). The reduction in growth is mainly due to an osmotic effect of the accumulation of salts near the root zone, whereas the build up of toxic saline ions in plant tissues is responsible for the progressive impairment of several physiological processes (Munns, 2002). Salinity affects the crop during both the vegetative and the reproductive stage and, therefore, it causes reduction in plant growth and development with low water potential in the root medium (osmotic effect), too high internal ion concentration (ion excess/toxicity) and nutritional imbalance by depressing uptake and/or shoot transport (ion deficiency) (Levitt, 1980). Most of the salt stress in nature is due to sodium salts, particularly NaCl (Levitt, 1980; Muns and Termaat, 1986). High concentrations of Na^+ and Cl^- in the root medium saturation depress nutrient-ion activities and produce extreme ratios of Na^+/Ca^{2+}, Na^+/K^+, Ca^{2+}/Mg^{2+} and Cl^-/NO^{3-} (Grattan and Grieve, 1999). Osmotic effects resulting from salinity may cause disturbances in the water balance of the plant, including a reduction of turgor and an inhibition of growth, as well as stomatal closure and reduction of photosynthesis (Navarro *et al.,* 2000; Romero-Aranda *et al.,* 2001; Li and Stanghellini, 2001; Heuvelink *et al.,* 2003). The primary effect of high salt concentration in plants is stomatal closure. This causes a

low transpiration rate and reduces the CO_2 availability for photosynthesis (Flexas *et al.,* 2007). Hussain *et al.* (2012) indicated that salinity reduced photosynthetic availability of some citrus species and genera. As a result, plants become susceptible to osmotic and specific-ion injury as well as to nutritional disorders that may result in reduced yield and quality.

The impact of using rootstocks to fruit crop production includes not only a stronger resistance against pathogens but also a higher tolerance to abiotic stress conditions such as salinity, heavy metal, nutrient stress, water stress and alkalinity (Rouphael *et al.,* 2012). The rootstocks used for persimmon cultivation belong essentially to four species of *Diospyros*: *lotus*, *virginiana*, *kaki* and *rhombifolia*. The most commonly used rootstock for persimmon production in Turkey is *D. kaki* (the oldest existing rootstock, of Japanese origin). However, *D. virginiana* (American origin) is an easily propagated rootstock, which has greater resistance to heavy and moist soils more than *D. kaki*. Persimmon is very sensitive to salinity so it is not suited to saline soil types or saline irrigation water (Mowat *et al.,* 1995).

Relatively few studies have been focused on the consequences induced by salinity stress on photosynthesis in persimmons. Besides there are only few studies carried out to determine the response of persimmon rootstocks to salinity stress by assessing gas exchange, to our knowledge. Fujita *et al.* (2003) measured the effects of salinity stress on photosynthetic rate, pre-dawn water potential, stomatal conductance, transpiration and Na and K contents of *D. kaki* leaves. The author indicated that salt stress reduced water potential, photosynthesis, transpiration and stomatal conductance. Specific salinity stress studies based on salinity levels are very limited for both *D. kaki* and *D. virginiana*. The aim of the present study is to determine the effects of different salinity levels on seedling growth rate and photosynthetic performances of both *D. kaki* and *D. virginiana* and to characterize their salt stress tolerances.

Materials and methods

Plant material, salinity treatment and salt stress symptom score

Seeds of *D. kaki* and *D. virginiana* were obtained from Cukurova University, Faculty of Agriculture, Department of Horticulture, Persimmon Germplasm orchard. Seeds were germinated in the dark at 22 °C in plastic trays with peat at the beginning of March. After germination, the seedlings were transferred and grown in moist peat for three months. Uniform sized seedlings were selected and transferred to quartz sand for an inert growth medium. Eight plants were used per treatment from each rootstock, distributed in a complete randomized design. The experiment was conducted in greenhouse conditions. The seedlings were fertilized for 15 days for adaptation to growth medium with the following solutions: 1.25 mM K_2SO_4, 0.625 mM KH_2PO_4, 2mM $MgSO_4$, 2mM $Ca(NO_3)_2$, 25 μM H_3BO_3, 2μM $MnSO_4$, 2μM $ZnSO_4$, 0.5 2μM $CuSO_4$, 0.065 μM $(NH_4)6Mo_7O_{24}$ and 50 μM Fe EDDHA. The pH of the nutrient solution was adjusted 6.0-6.5 with nitric acid. The plants were subjected to four levels of salinity with application of 0, 50, 75 and 100 mM NaCl. Seedlings were progressively adapted to salt stress in order to avoid osmotic shock. Stress conditions were maintained during 70 days. At the end of the experiment, severity of leaf symptoms were ranked as follows: 1 - normal healthy green plants without any injury; 2 - slightly wilted, damages on leaf tip; 3 - moderate to severe damages on leaves; 4 - most leaves with drying damages.

Photosynthetic measurements and chlorophyll concentration

At the end of the experiment, ten measurements were taken from each replicates of *D. virginiana* and *D. kaki* for each salinity treatment in the greenhouse. Transpiration rate (*E*) (mmol $m^{-2}s^{-1}$), stomatal conductance (g_S) [(mmol H_2O $m^{-2}s^{-1}$)], net photosynthetic rate (*Pn*) [μmol(CO_2) $m^{-2}s^{-1}$] and substomatal CO_2 concentration (ppm) were measured at the end of the experiment using a portable photosynthesis system (model LCA-4, ADC Bioscientific Ltd., Hoddesdon, UK). All gas exchange measurements were taken on attached fully expanded young leaves without visible injury symptoms and with an apparent homogeneous green colour. Measurements were recorded in the morning from 08:00 to 10:00 h to avoid high temperatures and low humidity in the afternoon. Average saturation irradiance was 1000 μmol $m^{-2}s^{-1}$ and leaf temperature ranged between 28 and 30 °C.

Leaf chlorophyll concentration was estimated using a portable SPAD meter. Chlorophyll fluorescence parameter (*Fv'/Fm'*) was measured with a portable fluorimeter in light adapted stage of the fully developed leaf of each plant. Readings were taken on the same leaves which the gas exchange measurements were recorded from.

Growth parameters and leaf tissue mineral analysis

After scale scoring, leaf chlorophyll concentration, PSII efficiency and leaf gas exchange measurements, the plants were harvested and leaf number and plant height (cm) were measured. Furthermore the plants were separated into shoots (all leaves and stem) and roots for dry matter assimilation and dried at 72 °C for 48 hours using a thermo ventilated oven.

At the end of the experiment, plants were removed from the pots and separated to root and shoots then washed with deionized water. Roots and shoots were oven dried for two days at 72 °C. The dry material was grounded. Chloride concentration was determined using a scientific chloride analyzer. K, Ca and Na were determined by atomic absorption spectrophotometry.

Experimentation and data analysis

The experiment was arranged as 4 x 2 x 8, four treatments, two rootstocks, eight replicates, respectively, in a 'Complete Randomized Design'. Data were subjected to two-way analysis of variance (ANOVA) in order to determine salinity effects on each rootstock. The means and calculated standard deviations are reported. Significant differences between means were evaluated by using LSD multiple range test at $P \leq 0.05$. In addition, two rootstocks were compared for each NaCl treatments by using t test at $P \leq 0.05$ in order to examine if there are significant differences between two rootstocks for each salinity levels in itself. All statistical analyses were performed by using SAS statistical software (v9.00, SAS Institute Inc., NC 27513-2414, USA) and SigmaPlot® (version 11.00, Systat Software, San Jose, CA, USA) was used for data presentation.

Results and discussions

At the end of the experiment, *D. kaki* and *D. virginiana* showed significant differences in their response to salt treatments. A two-way ANOVA indicated a significant main effect of rootstock and salinity treatments and also their interaction ($p \leq 0.01$) on the leaf salinity symptom (Tab. 1). Both genotypes showed salinity symptoms with increasing salinity levels. *D. virginiana* was less affected than *D. kaki*, based on severity of leaf symptoms. Furthermore, significant differences were obtained according to a t test between *D. kaki* and *D. virginiana* in the 50, 75 and 100 mM NaCl treatments (Tab. 2). Persimmon is recorded as very sensitive to salinity so it is not suited to saline soil types or saline irrigation water (Mowat *et al.,* 1995). In the present study, salinity symptoms were determined in different salinity levels.

In terms of leaf number and plant height, only the main effect of salinity treatments was significant ($p \leq 0.01$) according to a two-way ANOVA (Tab. 1). Significant decreases were recorded in plant leaf number and plant height for both genotypes by the increasing salinity levels (Tab. 3). Although no significant differences were determined regarding t-test between genotypes, the reduction in plant leaf number and height were higher in *D. kaki* then *D. virginiana* when the difference between 0 mM NaCl and 100 mM treatments were considered. Several authors claimed that NaCl reduced plant growth (Hassan and Galal, 1989; Abbas *et al.,* 1991; Franco *et al.,* 1993; Meneguzzo *et al.,* 2000; Zapata *et al.,* 2004) and similarly in this study, plant leaf number and plant height were significantly reduced by increasing salinity levels.

In 50, 75 and 100 mM saline conditions shoot and root dry matter productions of *D. kaki* and *D. virginiana* were decreased in comparison to 0 mM NaCl treatment (Tab. 4). On the other hand, the shoot and root dry weights in 50 and 75 mM NaCl treatments had similar values in both genotypes. A significant difference between genotypes was only obtained in 100 mM NaCl treatment, regarding t tests. Based on shoot and root dry matter productions, of *D. virginiana* was less affected than *D. kaki* regarding 100 mM NaCl treatments. It is well known that one of the first plant responses to salinity stress is a reduction in plant growth rate with associated reductions in leaf area available for photosynthesis. Subsequently, excessive accumulation of salts can lead to death of tissues, organs, and whole plants (Munns and Termaat, 1986). Similarly in the present study, the decrease in plant leaf number and leaf chlorophyll concentration of both genotypes under saline conditions resulted as a reduction in plant dry matter production. Cruz and Cuartero (1990) reported that both dry weights of leaf and stem are diminished in saline conditions, but the reduction of leaf dry weight is greater than that of dry shoot weight, which is in agreement with the present study. Furthermore, the relationship between shoot and root dry matter production and symptom scores of NaCl treatments for both *D. kaki* (Fig. 1A, B) and *D. virginiana* (Fig. 1C, D) were investigated in the present study. Although coefficients of determination were low, the relationship between plant dry matter productions and salinity symptoms were significant.

Tab. 1. Results of two-way analysis of variance (ANOVA) of rootstock (R) and salt treatment (S) effects and their interaction (R × S) for the dependent variables considered

Dependent variable	Independent variable		
	R	S	R x S
Salinity symptom	28.90**	28.01**	5.01**
Leaf number	3.65	18.83**	0.08
Plant height	0.42	7.24**	0.31
Shoot dry mass	0.91	22.83**	0.17
Root dry mass	2.15	10.26**	0.71
Na	413.54**	196.86**	65.87**
Cl	0.07	76.26**	1.06
K	37.90**	18.20**	15.10**
Ca	2.07	3.82*	1.22
SPAD	1.90	4.26*	3.29*
Fv'/Fm'	0.18	0.10	0.31
P_N	33.64**	102.98**	0.83
E	0.37	31.51**	2.08
g_S	1.23	490.86**	4.79*
C_i	11.61**	30.45**	4.87*

Note: Numbers represent *F* values. * $p \leq 0.05$; ** $p \leq 0.01$.

Tab. 2. Score scale of *D. kaki* and *D. virginiana* leaves under 0, 50, 75 and 100 mM NaCl treatments

NaCl treatment	Salinity symptom		t-test
	D. kaki	*D. virginiana*	
0 mM	1.00[y] b[z]	1.00 c	-
50 mM	2.60 a	1.64 b	*
75 mM	2.83 a	1.86 ab	*
100 mM	3.00 a	2.17 a	*
Prob>F	*<.0001*	*<.0001*	
LSD (0.05)	*0.638*	*0.393*	

[z]Means followed by different letters in the same column are significantly different (LSD, $P \leq 0.05$).

[y] Symptom score: 1 - normal healthy green plants without any injury; 2 - slightly wilted, damages on leaf tip; 3 - moderate to severe damages on leaves; 4 - most leaves with drying damages

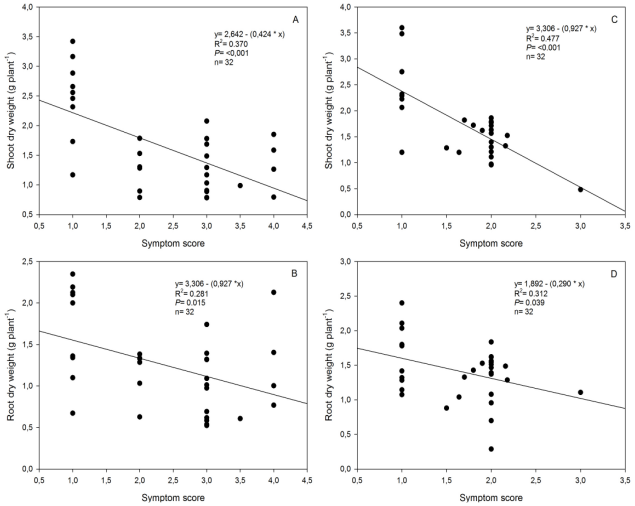

Fig. 1. Relationship between shoot (A) and root (B) dry matter production and symptom scores of *D. kaki*. Relationship between shoot (C) and root (D) dry matter production and symptom scores of *D. virginiana*. Symptom score: 1-normal healthy green plants without injury; 2-slightly wilted, damages on leaf tip; 3-moderate to severe damages on leaves; 4-most leaves with drying damages

Tab. 3. Leaf number and plant height (cm) of *D. kaki* and *D. virginiana* under 0, 50, 75 and 100 mM NaCl treatments

NaCl treatment	Leaf number		t-test	Plant height (cm)		t-test
	D. kaki	*D. virginiana*		*D. kaki*	*D. virginiana*	
0 mM	13.00 a[z]	13.71 a	NS[y]	25.60 a	26.86 a	NS
50 mM	11.00 a	12.57 ab	NS	24.00 a	23.86 ab	NS
75 mM	8.80 b	10.00 bc	NS	23.80 a	22.95 ab	NS
100 mM	6.60 c	7.86 c	NS	18.83 b	21.00 b	*
Prob>F	*<.0001*	*0.0019*		*0.0101*	*0.0385*	
LSD (0.05)	*2.092*	*2.953*		*3.944*	*3.933*	

[z]Means followed by different letters in the same column are significantly different (LSD, $P \leq 0.05$).
[y]*: significant at $P \leq 0.05$, NS: not significant according to t-test between *D. kaki* and *D. virginiana*

Tab. 4. Dry matter production (g plant^{-1}) of *D. kaki* and *D. virginiana* under 0, 50, 75 and 100 mM NaCl treatments

NaCl treatment	Shoot		t-test	Root		t-test
	D. kaki	*D. virginiana*		*D. kaki*	*D. virginiana*	
0 mM	2.66 a[z]	2.75 a	NS[y]	1.81 a	1.79 a	NS
50 mM	1.69 b	1.65 b	NS	1.39 ab	1.43 ab	NS
75 mM	1.29 bc	1.45 b	NS	1.08 bc	1.39 ab	NS
100 mM	0.89 c	1.20 b	*	0.62 c	1.04 b	*
Prob>F	*0.0004*	*0.0002*		*0.0036*	*0.0397*	
LSD (0.05)	*0.616*	*0.535*		*0.538*	*0.454*	

[z]Means followed by different letters in the same column are significantly different (LSD, $P \leq 0.05$).
[y]*: significant at $P \leq 0.05$, NS: not significant according to t-test between *D. kaki* and *D. virginiana*

Reduction in leaf chlorophyll concentration based on SPAD readings was observed in both *D. kaki* and *D. virginiana* under saline conditions compared to the control (Fig. 2A). At the end of the experiment *D. virginiana* leaves had higher chlorophyll concentration than *D. kaki* in 100 mM NaCl treatment. In addition, SPAD readings were higher in *D. virginiana* at 0, 50 and 75 mM salinity levels. Chlorophyll content can be considered as one of the few physiological parameters that show a good correlation with salinity tolerance (Ashrafuzzaman *et al.,* 2000; Hakam *et al.,* 2000; Ali *et al.,* 2004). Similar findings were reported for other plants such as in maize (Ashrafuzzaman *et al.,* 2000) and rice (Ali *et al.,* 2004). Furthermore NaCl stress decreases total chlorophyll content of the plant by increasing the activity of the chlorophyll degrading enzyme: chlorophyllase (Rao and Rao, 1981), inducing the destruction of the chloroplast structure and the instability of pigment protein complexes (Sing and Dubey, 1995).

Chlorophyll fluorescence analysis has proven to be a sensitive method for the detection and quantification of stress-induced changes in PSII (Mehta *et al*., 2010), and both light- and dark-adapted measurements can be used to determine whether photodamage has occurred in leaves or not (Naumann *et al.,* 2008). In the present study, slight decreases were determined in terms PSII in both genotypes with increasing salinity levels (Fig. 2B). Although there were no significant differences in both genotypes, *Fv'/Fm'* of *D. virginiana* was less affected than *D. kaki* in 100 mM NaCl treatment. It has been concluded that salt stress affects reaction centers of PSII either directly or indirectly (Masojidek and Hall, 1992; Moradi and Ismail, 2007).

Different NaCl treatments had significant reductions on photosynthetic performances of *D. kaki* and *D. virginiana* (Fig. 3). Of different gas exchange attributes, net CO_2 assimilation rate (P_N) (Fig. 3A) and transpiration rate (E) (Fig. 3B) of both genotypes were reduced significantly due to increasing salinity levels, respectively. Salt stress caused a marked reduction in stomatal conductance (g_S) too (Fig. 3C). Because of the stomatal closure under saline conditions, the availability of leaf sub-stomatal CO_2 (Ci) concentration was also decreased (Fig. 3D). Similar observations were also determined by Fujita *et al.* (2003) who reported that leaf gas exchange parameters of *D. kaki* were significantly reduced under salinity stress. Salinity affects plant growth due to changes in many physiological processes including photosynthesis (Kalaji and Pietkiewicz, 1993; Kalaji and Guo, 2008). A reduction in chlorophyll content, stomatal conductance, ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) activity and an increase in the chlorophyll a/b ratio had been observed earlier (Kalaji and Nalborczyk, 1991; Delfine *et al.*, 1999). Netondo *et al.* (2004) found that the photosynthesis rate of sorghum grown under salinity stress was affected primarily by stomatal closure. Banuls *et al.* (1997) associated reduction in photosynthetic capacity and stomatal conductance of citrus leaves treated with NaCl with high concentration of Cl. Garcia-Sanchez *et al.* (2002) studied effects of high salinity on different citrus rootstocks and reported that the higher reduction in leaf gas exchange parameters occurred in trees on 'Carrizo' where leaves accumulated more Cl and Na than in leaves on 'Cleopatra'. It has been proposed that the reduction of leaf gas exchange in response to salinity is due to the increase in leaf Na concentration (Garcia-Legaz *et al.*, 1993; Walker *et al*., 1993).

A two-way ANOVA indicated a significant main effect of rootstock and salinity treatments and also their interaction ($p \leq 0.01$) on the leaf Na and K concentrations (Tab. 1). NaCl treatments resulted in accumulations of Na and Cl in leaves for both *D. kaki* and *D. virginiana*. The data shown in Tab. 5 suggested that, Cl content of leaves increased with increasing salinity in both genotypes. Cl accumulations in leaves were grouped in the same subset for 50 and 75 mM saline treatments in both genotypes whereas 100 mM NaCl treatment remarkably increased. The highest Na and Cl concentrations were determined in the leaves of *D. kaki*. Similarly, Fujita *el al.* (2003) reported high accumulation of Na in leaves of *D. kaki* under 100 mM NaCl treatment. Also at 200 mM NaCl, a great accumulation of Cl in both leaves and roots of sugar beet was reported (Ghoulam *et al.,* 2002). The K concentrations of the leaves of both genotypes were gradually decreased in response to NaCl and significantly affected by the increasing NaCl treatments (Tab. 6).

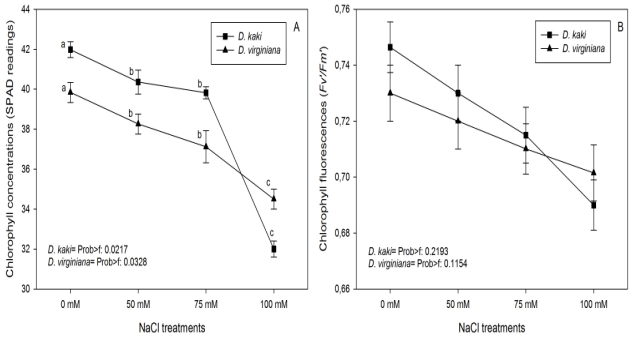

Fig. 2. Chlorophyll concentrations (SPAD readings) (A) and chlorophyll fluorescence (*Fv'/Fm'*, in light adapted stage) efficiency (B) of *D. kaki* and *D. virginiana* under 0, 50, 75 and 100 mM NaCl treatments; bars indicate SD

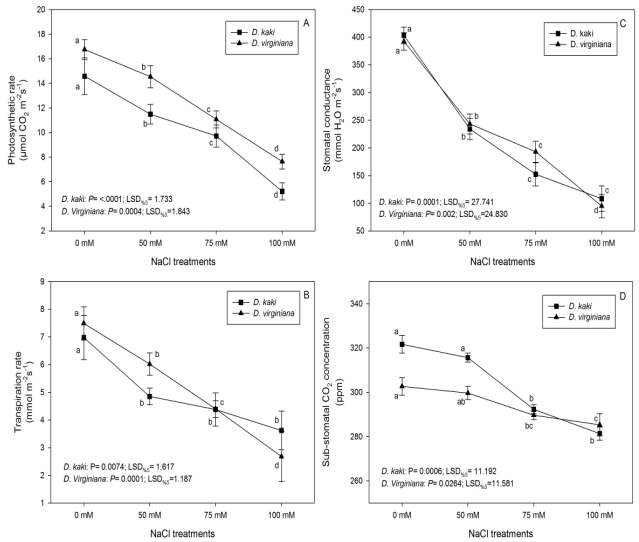

Fig. 3. Net photosynthetic rate (A), transpiration rate (B), stomatal conductance (C) and sub-stomatal CO_2 concentration (D) of *D. kaki* and *D. virginiana* under 0, 50, 75 and 100 mM NaCl treatments; bars indicate SD

Tab. 5. Leaf Na (%) and Cl (mg l^{-1}) concentrations of *D. kaki* and *D. virginiana* under 0, 50, 75 and 100 mM NaCl treatments

NaCl	Na		*t*	Cl		*t*
treatment	*D. kaki*	*D.virginiana*	test	*D. kaki*	*D.virginiana*	test
0 mM	0.20 a[z]	0.18 c	NS[y]	23.00 a	30.33 c	NS
50 mM	0.87 b	0.28 bc	*	115.67 b	125.00 b	*
75 mM	1.03 c	0.40 b	*	134.33 b	134.00 b	NS
100 mM	1.80 d	0.60 a	*	200.00 c	175.00 a	*
Prob>F	*<.0001*	*0.0029*		*<.0001*	*0.0001*	
LSD (0.05)	*0.0851*	*0.1744*		*34.367*	*36.295*	

[z]Means followed by different letters in the same column are significantly different (LSD, $P \leq 0.05$).
[y]*: significant at $P \leq 0.05$, NS: not significant according to t-test between *D. kaki* and *D. virginiana*

Tab. 6. Leaf K (%) and Ca (%) concentrations of *D. kaki* and *D. virginiana* under 0, 50, 75 and 100 mM NaCl treatments

NaCl	K		*t*	Ca		*t*
treatment	*D. kaki*	*D.virginiana*	test	*D. kaki*	*D.virginiana*	test
0 mM	2.35 a[z]	3.58 a	*[y]	1.10	1.35 b	NS
50 mM	2.34 a	2.69 b	NS	1.42	2.08 a	NS
75 mM	2.25 ab	2.30 bc	NS	1.88	1.85 a	NS
100 mM	1.92 b	2.25 c	*	1.77	1.74 a	NS
Prob>F	*<.0001*	*0.0001*		*0.2402*	*0.0119*	
LSD (0.05)	*0.3485*	*0.3839*		*-*	*0.3722*	

[z]Means followed by different letters in the same column are significantly different (LSD, $P \leq 0.05$).
[y]*: significant at $P \leq 0.05$, NS: not significant according to t-test between *D. kaki* and *D. virginiana*

Ghoulam *et al.* (2002) reported that K concentration in sugar beet was decreased under saline conditions. K is an essential macronutrient and the most abundant cation in higher plants, whereas the closely related ion Na is toxic to most plants at high concentrations (Mäser *et al.,* 2002). There were no statistically significant differences in Ca concentration of *D. kaki* in all NaCl treatments. On the other hand a slight increase in Ca concentration of the leaves of *D. virginiana* under saline conditions was recorded (Tab. 6).

Conclusions

In this article, we described how different salinity levels affected the growth and the photosynthetic performance of two persimmon rootstocks. According to the data obtained from plant growth, mineral nutrients uptake and leaf gas exchange parameters, we conclude that *D. kaki* and *D. virginiana* did not respond in the same way. In this study, it can be suggested that *D. virginiana* has more tolerance to salinity than *D. kaki*. However, the plant materials utilized in this experiment were from un-grafted rootstocks. Therefore, when a commercial cultivar of persimmon is grafted, the results could differ. Also, further studies are needed to evaluate these rootstocks under field conditions.

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