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MORPHOLOGICAL CHARACTERISTICS AND ION CONCENTRATIONS OF GRAFTED AND NON-GRAFTED EGGPLANT SEEDLINGS UNDER DROUGHT AND SALT STRESS

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ABSTRACT

The performance of 4 eggplant genotypes grafted on the salt-tolerant rootstocks under drought and salt stress conditions was evaluated at the seedling stage in a hydroponic system. Four eggplant scion genotypes (Salt-tolerant: Mardin Kızıltepe, Burdur Merkez; Salt-sensitive: Artvin Hopa and Kemer) and 2 rootstocks (Köksal-F_1, Vista-306) were selected for the study. Drought and salt treatments were applied to all materials separately. Drought stress (D_1) was created by adding 15% (w/v) PEG-6000 to growth ambient growth solution. PEG was not added to the growth solution of control plants (D_0). For salt stress (S_1), 100 mM NaCl was added to the growth solution and salt was not added to control plants (S_0). Stress-induced variations in shoot-root fresh and dry weights, relative water contents and ion concentrations were investigated. With regard to investigated parameters, differences were observed between rootstock/scion combinations. Grafted plants showed significantly superior performance against drought and salt stress. The rootstock Köksal-F_1 resulted in greater resistance to drought and salt stress. The grafted plants had higher shoot-root fresh and dry weights, relative water contents and shoot-root Ca^{+2} and K^+ concentrations than non-grafted plants under both stress conditions. The grafted plants also had less reductions in Na^+ and Cl^- accumulation under salt stress.

Key words: *Solanum melongena*, salinity, drought, grafting, ion.

INTRODUCTION

Global warming and climate change have resulted in significant reduction in precipitations in some regions, that has resulted in widened arid and semi-arid zones worldwide. The development of crops in dry or partially dry areas, are heavily effected by salinity stress, which is a major environmental hindrance. Watering with saline water, rocks originating from that area, increased levels of evaporation and wrong watering administrations may result in salinity stress in farming lands. Drougth and salt stresses leads to a series of morphological, physiological, biochemical and molecular changes that adversely affect plant growth and productivity (Wang *et al.* 2001; Feleafel and Mirdad, 2014). Along with oxidative stresses such as drought and salt can lead to similar damage in the cell. Drought tolerance has been observed in all plant species, but its extent varies from species to species (Hussain *et al.*2015). Majority of economically valuable plants are sensitive to drought and salinity (Bletsos, 2003). Eggplant (*Solanum melongena* L.) is classified as medium-sensitive to soil salinity (1.1 ds/m) (FAO, 1992). Following potato and tomato of *Solanaceae* family, eggplant is the third plant cultivated worldwide (Sekara *et al.,* 2007). World annual eggplant production is about 50 million tons, but production and quality are occasionally significant declines. Grafting over rootstocks, can be used to increase resistance to drought and salinity, and improve yield and water use efficiency, and, thus, decrease losses in yield and quality. Grafting is commonly and effectively used in vegetables of *Solanaceae* and *Cucurbitaceae* families against biotic and abiotic stress factors (Fernández-Garcia *et al,.*2003; Rivero *et al.,* 2003). In majority of rootstocks, there is a relationship with wild species or the rootstock directly belongs to a wild species. In eggplant, primarily *Solanum torvum* and the other wild relative-originated rootstocks are commonly used for grafting against biotic stressors (Bletsos *et al.,* 2003; Daunay, 2008). The interaction between the rootstock and the species grafted over it (scion) directly influences the growth and plant performance (Cohen *et al.,* 2005; Davis *et al.* 2008). For developing drought tolerance in faba beans (Siddiqui *et al.,* 2015) and tobacco (Liu *et al.,* 2014), and salt tolerance in tomatoes (Cuartero *et al.,* 2006) and watermelons (Goreta *et al.,* 2008), genotypes pertaining to drought and salt tolerance may be used. It has been reported that, that grafting reduced the losses in shoot-root fresh and dry biomass in different vegetables under drought and salinity stress conditions (Santa-Cruz *et al.,* 2000; He *et al.,* 2009; Öztekin (2009) by preserving the leaf relative water content (Weng, 2000; Sanchez-Rodriguez *et al.,* 2010), reducing K^+ and Ca^{+2} losses (Santa-Cruz *et al.,* 2000), and limiting Na^+ and Cl^- ion absorption and transport to scion under saline conditions

(Fernandez-Garcia *et al*., 2002; Estan *et al*., 2005). An efficient cultivation can be performed in eggplant-like graft-able plants through using salt and drought tolerance-like superior characteristics of rootstock and genotypes. Al-Harbi *et al.,* (2018) also reported the favorable effects on the height of the plant, stem, root and leaf fresh and dry weights under low water stress or no water stress, drought tolerance in cucumbers. The present study was conducted to investigate morphological characteristics and variations in ion concentrations of seedlings obtained through grafting some eggplant (*Solanum melongena* L.) genotypes with specific tolerance to drought and salinity over salt-tolerant rootstocks under drought and salt stress conditions.

MATERIALS AND METHODS

Materials: The eggplant genotypes with pre-determined salt and drought tolerance levels at seedling stage (Salt-tolerant: Mardin Kızıltepe (MK) and Burdur Merkez (BM) and Salt-sensitive: Artvin Hopa (AH) and Kemer (K) (Yaşar, 2003; Kıran *et al.,* 2014) were grafted over quite salt-tolerant commercial Köksal-F_1 and Vista-306 eggplant rootstocks (*Solanum incanum* x *Solanum melongena*) (Kıran *et al.,* 2015). The control treatment comprised of the 4 genotypes *S.melongena* that were un-grafted and allowed to develop their own roots. Salt and drought stress were investigated separately. Seeds were sown into viols filled with 2:1 turf:perlite mixture. The seedlings with 2-3 true leaves were then transplanted into hydroponic system containing Hoagland nutrient solution (Hoagland and Arnon, 1938). Experiments were conducted in a glasshouse with automatic temperature and relative humidity control (at 25ºC temperature and 50-55% relative humidity). When the seedlings had 4-5 true leaves, they were exposed to salt and drought treatments.

Methods

Drought and salt treatments: All seedlings were kept in hydroponic culture for 7 days, and then exposed to stress treatments. Drought stress (D_1) was applied through adding 15% (w/v) PEG-6000 to trays (Nemeth *et al.,* 2002). PEG was not added to growth solution of control plants (D_0). For salt stress, salt was not added to trays of control plants (S_0) and 100 mM salt was added to nutrient solution of other plants (S_1) (Yaşar, 2003; Wei *et al.,* 2009). Experiments were terminated on the 7th day of drought stress and the 12th day of salt stress when the effects of stress were distinctively observed in sensitive genotypes. . Plant and leaf samples taken from drought and salt stress treatments and analyzed for shoot-root fresh and dry weight, relative water content and shoot-root ion content.

Plant shoot-root fresh and dry weight measurements: Randomly selected 4 plants from control and stress treatments of each species were weighed with a digital balance (±0.0001 g) to get their fresh weights. Samples were then dried in an oven at 65°C for 48 hours and reweighed to get their dry weights.

Relative water content (RCW): Relative water content was measured in accordance with the method specified by Dhanda and Sethi (1998) and resultant values were calculated by using the following equation:

RWC (%) = [FW-DW]/(TW-DW]x100

RWC (%): Relative water content, FW: Fresh weight, DW: Dry weight, TW: Turgor weight

Determination of ion content: Stem and root sections of four randomly selected plants were used for mineral element analyses. In shoot and root samples, K^+ and Ca^{+2} contents were determined for drought stress and Na^+, K^+, Ca^{+2} and Cl^- contents were determined for salt stress (Kacar and İnal, 2008).

Statistical analysis: Experiments were conducted in randomized plots with a factorial design with 3 replications for drought and salt stress separately. The resulting data was subjected to variance analysis. MSTAT-C (Freed *et al.,* 1989) statistical software was used in statistical analyses.

RESULTS AND DISCUSSION

The effects of salt and drought stresses were evaluated according to rootstock x scion x treatments interactions. The results of the interactions, shoot Ca^{+2}, root K^+, and K were found to be statistically significant under drought stress, while the root dry weight, shoot Ca^{+2}, K^+, Cl^-, root Ca^{+2}, Na^+, Cl^- activities were statistically significant under salt stress ($p<0.05$). On the other hand, the parameters for shoot fresh and dry weight, root fresh and dry weight, relative water content, shoot K^+, root Ca^{+2} at drought stress and shoot fresh and dry weight, root fresh weight, relative water content, shoot K^+, and root Ca^{+2} under salt stress were found to be statistically insignificant ($p\geq0.05$).

Shoot fresh and dry weight: With regard to differences in shoot-root fresh and dry weights of eggplant genotypes under drought and salt stress conditions, only the differences in root dry weights of salt treatments was significant ($p\geq0.05$). Both stressors decreased shoot fresh and dry weights. While the fresh and dry weights of grafted plants were higher than the control plants, stress-induced losses were higher in grafted plants (Figure 1a, 1b and Figure 2a, 2b). The lowest loss ratios under drought and salt stress were observed in Köksal-F_1/MK and Köksal-F_1/BM combinations (for drought stress: 25. 38 and 31.94%, for salt stress 10.17 and 11.93%). The same combinations also resulted in retaining higher dry weights under stress conditions (for drought stress: 11.55 and 14.38%, for salt stress: 6.97 and 7.56%). The rootstock Köksal-F_1 had a superior performance than Vista-306 under stress conditions. Drought and salt stresses affects the plant growth by several physiological and biochemical means like osmotic stress, ion toxicity, nutritional imbalance (Kao *et al*., 2003). Since the rootstocks are stronger and have a more intense root system than scions, they allow more water and nutrient uptake and increase internal plant hormones and photosynthesis rates, thus promoting plant growth and development and enhance the plant's resistance to stress conditions (Ahn *et al.,* 1999; Cohen *et al.,* 2002). In similar studies, Behnamnia *et al.* (2009) and Altunlu and Gül (2012) reported decreased shoot-root fresh and dry weights with drought stress in tomatoes, Zhou *et al*. (2012) in eggplants, Khakwani *et al*. (2012) in wheat and Liu *et al.,* (2012) in zucchini and that such losses are decreased in plants grafted over resistant rootstocks. Increased plant growth due to increases in watering levels, can be associated with the suitable water content equilibrium acquired in the plant tissues. This water content equilibrium provides the needed conditions for photosynthesis, taking up of nutrients, and translocation of metabolites, thus resulting in the quickening of plant growth rate. Therefore, it could be determined from these results that grafting can decrease the negative effects of water stress.

Root fresh and dry weight: Root fresh and dry weights of grafted and non-grafted eggplants decreased under drought and salt stress (Figure 1c, 1d, Figure 2c and Table 2). However, the decreases in root fresh and dry weights of all grafted genotypes were lower than non-grafted plants under both stress conditions. The rootstock Köksal-F_1 had better performance as compared to the Vista-306 root stock. Salinity and drought stresses have been reported to decrease root and dry weights in tomatoes (Sánchez-Rodríguez *et al.,* 2014). High foliar concentration of Na^+ is capable of reducing CO_2 assimilation because of ion toxicity. A comparable decrease in root stress was observed by Liu *et al.,* (2012) and Huang *et al.* (2011). The salt stress decreases the growth of the root (Munns and Tester, 2008). It has been reported that salinity causes several kinds of injuries such as growth inhibition, metabolic disturbances (Carvajal *et al.,*1998; del Amor *et al.,* 2000). Increased water and nutrient uptake due to strong root system of the rootstocks and reduced sodium adsorption from the roots can cause root dry weight to increase. Therefore, the salinity tolerant rootstocks may help in reducing the losses of the plants (Nomura *et al.,* 1998; Yao *et al.,* 2003; Oztekin, 2009).

Relative water content: All the genotypes varied significantly in relative water content under drought and salt stress conditions. However, the Köksal-F_1/MK combination retained higher turgor in drought and salt stress conditions (4.13, 8.58%) (Figure 1e and Figure 2d). It has been reported that the root systems of genotypes used as root stocks allow greater water and nutrient uptake from the soil by the plants, that results in higher CO_2 assimilation, thus, less damage by the drought stress (Rouphael *et al.,* 2008). The superior performance of the grafted plants increased could also be due to soluble sugar accumulation and osmotic pressure with a concomitant decrease in salt ion accumulation as well as moisture preservation by the plants grafted over resistant rootstocks (Munns and Tester 2008; Huang *et al.,* 2009). Rouphael *et al.* (2008) and Sanchez-Rodríguez *et al.* (2011) under drought stress and Huang *et al.* (2009 and 2010) under salt stress, reported relatively better preservation of moisture in grafted plants than in nongrafted ones. The cases varied based on the strength of the rootstocks used in grafting.

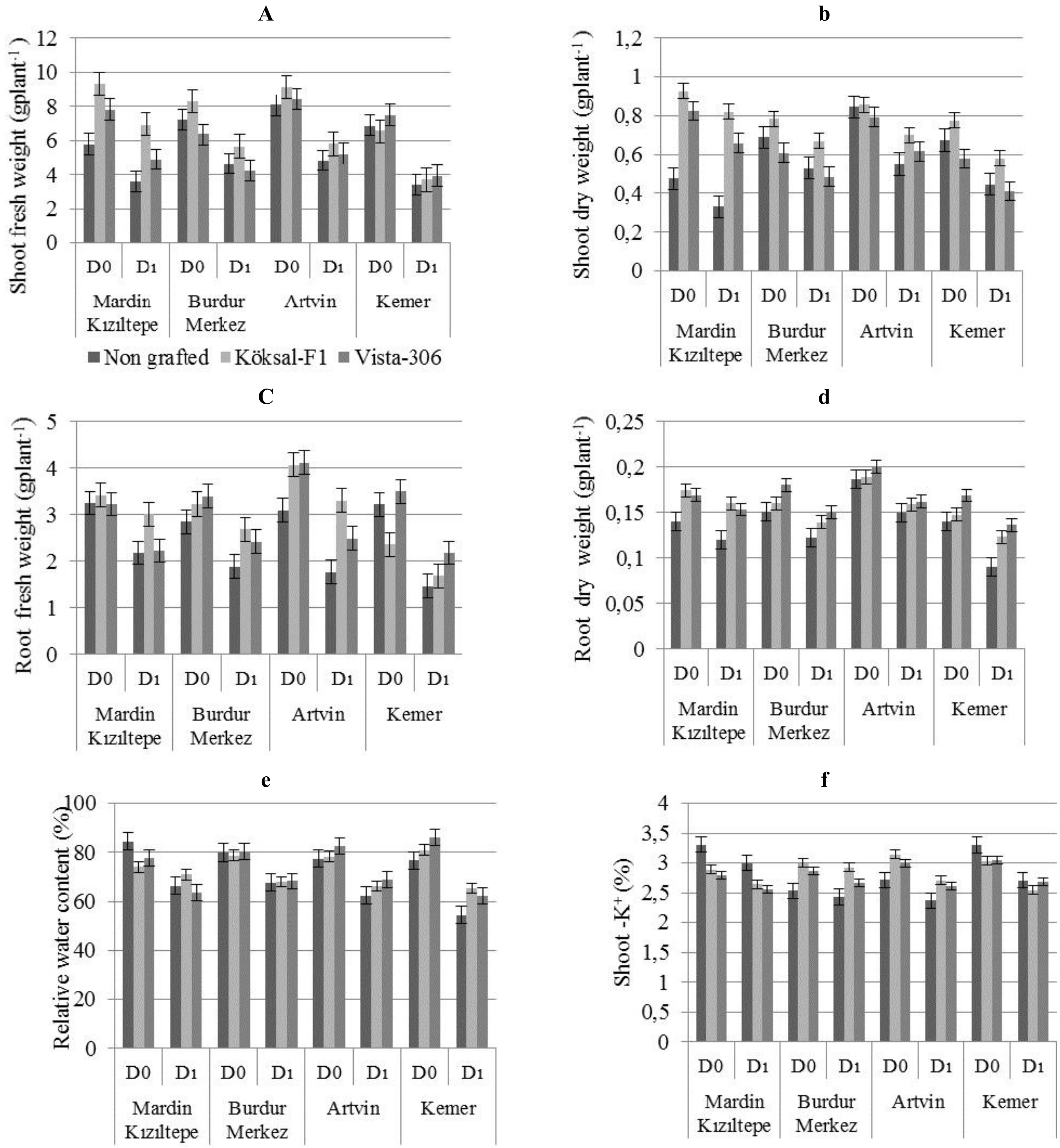
Shoot and root Ca^{+2} concentrations: Both salinity and drought stress decreased the Ca^{+2} of the tissue. However, the Ca^{+2} concentrations in shoot and root varied with different rootstock/scion combinations under drought and salt stress (Figure 1g, Table1, 2, 3). The combinations yielding the greatest Ca^{+2} concentrations under drought and salt stress control treatments were respectively Vista-306/K (5.40%) and Vista-306/AH (6.03%). Köksal-F1/MK (34.71%) under drought stress and Köksal-F1/MK (53.03%) under salt stress, were able to best preserve Ca^{+2} ion concentrations as compared to their control plants. Drought and salt stress decreased Ca^{+2} concentrations of grafted and non-grafted plants (Table 3 and 5). The combination with the least Ca^{+2} losses was Vista-306/K (44.65%) under drought stress and Köksal-F_1/BM (46.27%) under salt stress. These results showed that drought and salt tolerant rootstocks increased drought and salt tolerance of scion by promoting Ca^{+2} and K^+ accumulation in shoot and root. Grafted plants were avoided from toxic and nutrient deficiency effects of salinity on plant growth due to lower Na^+ but higher K^+ and Ca^{+2} accumulation. Besides, the vigorous root system of rootstocks is often capable of absorbing plant nutrients more efficiently than scion roots (Pulgar *et al.,*2000) and serves as a good supplier of endogenous hormones (Jang,1992). This result confirms our hypothesis that grafted plants on vigorous rootstocks can improve mineral nutrition and nutrient uptake with respect to ungrafted plants. These results can be correlated with the results from Khah *et al.,* (2006), which reports that in grafted tomatoes a higher rate of Ca^{+2} was found than in non-grafted ones and in which they hypothesized that this higher rate of Ca^{+2} absorption could be due to the higher absorption levels by the roots of minerals and water. Kaya *et al.,* (2003); Rouphael *et al.,* (2008) and Huang *et al.,* (2010) also reported that grafted plants were more effective in Ca^{+2}uptake under drought and salt stress conditions.

Shoot and root K^+ concentrations: Decreases were observed in shoot and root K^+ concentrations of grafted and non-grafted eggplants under stress conditions (Figure 1f, 2e and Table 1, 2). The decrease in K^+ concentrations in non-grafted plants under both stress conditions was higher than non-grafted plants. Therfore under drought stress, Köksal F_1/BM was prominent as the most successful combination (2.55%). Under salt stress, the greatest shoot K^+ concentration was observed in the non-grafted K and MK (respectively with 3.53 and 3.41%). K^+ reduction ratios were quite low in Köksal-F_1/MK and Vista-306/BM combinations (14.26 and 18.57%). With regard to root K^+ concentrations of grafting combinations, the greatest values in drought treatments were observed in Vista-306/BM (3.04%), Köksal-F_1/BM (3.03%), and the control treatment of non-grafted K (3.00%). A similar case was observed when treated with salt. Grafted plants preserved more K^+, and Köksal-F_1/MK also presented a high performance (11.40%). The plants grafted onto Köksal-F_1 and treated with salt solution in comparison to ungrafted plants exposed to identical under drought and salinity stresses levels was attributed to their strong capacity to inhibit the Na^+ translocation to the aerial parts and to maintain a better plant nutritional status with higher shoot and root K^+ concentration. There is an antagonistic relationship between Na^+ and K^+, thus the competition with Na^+ may reduce K^+ uptake (Levitt, 1980). It was reported in previous studies that different salt treatments may reduce shoot and/or root K^+ uptake in eggplant, cotton and tomato (Assaha *et al.,* 2013; Zhang and Shi, 2013; Yong *et al.,* 2014), more K^+ may be accumulated in shoots than in roots (Jalali-Honarmand *et al.,* 2014).

Shoot and root Na^+ concentrations: The Na^+ concentrations increased in all combinations under salt stress in our study. The difference between the Na^+ concentration between the graft and the non-graft, it is important in grafted plants and non-with inoculated plant salt application. Rootstocks showed a significant difference in Na^+ concentration in this study. Köksal-F1/MK was more selective, limited Na^+ uptake and non-grafted genotypes accumulated more Na^+ (Figure 2f and Table 3). The lowest increase in root Na^+ ratio was observed in the Köksal-F1/MK (302.78%) combination. The greatest increase in ratios were observed in non-grafted genotypes. Ashraf and Harris, (2013), Zhu *et al.,* (2008) and Assaha and Ueda, (2013) indicated excess Na^+ as a growth-hindering toxic substance and reported increased Na^+ accumulation under salt stress. The excessive Na^+ inhibits the uptake of other essential minerals like K and Ca (Nouman *et al.,*2012). This nutritional imbalance resulted in the reduction of shoot and root growth. It was seen that grafting increased the tolerance to salt stress. It is clear that the salt tolerance is related to the low intake of Na^+ (Santa-Maria and Epstein, 2001, Tester and Davenport, 2003). Grafted plants reduced Na^+ adsorption through roots and kept Na^+ ion concentrations at low levels under stress conditions. In the present study, the concentration of Na^+ in root was lower in grafted plants than the ungrafted ones, suggesting that grafting of eggplant plants onto the sodium exclusion hypothesis was supported by Colla *et al.,* (2006), Huang *et al.* (2009) and Rouphael *et al.,* (2012) who observed Na^+ ion exclusion in grafted watermelon, cucumber and pumpkin respectively.

Shoot and root Cl^- concentrations: The Cl^- concentrations of shoot and root significantly increased under salt stress ($p<0.05$) (Table 2 and 3). The greatest shoot Cl^- concentration was observed in the Vista-306/K (0.61%) combination and the greatest root Cl^- concentration was observed in the Köksal-F_1/AH (0.58%) and Vista-306/MK (0.58%) combinations. The increase in Cl^- concentration was higher in roots than in the shoots for all of the plants. Cl^- accumulation was higher in grafted plants than in non-grafted ones. Similar findings were reported for cucumbers (Romero *et al.,* 1997), tobacco (Ruiz *et al.,* 2006) and zucchinis (Raouphael *et al.,* 2012). Carjaval *et al.* (1998) and Kuşvuran *et al.* (2007) reported specific toxicity of Na^+ and Cl^- ions in melons, Huang *et al.* (2009) and Zhang and Shi, (2013) reported that NaCl treatments resulted in Cl^- accumulation in shoots and roots. Reductions in the concentration of Cl^- were observed in grafted plants indicating that the tested eggplant rootstocks were able to exclude and/or retain Cl^-in the roots; thus, Cl^-, the translocation of which to the leaves is limited by grafting, becomes the less harmful toxic component of the saline solution. It was found that plants which were self-rooted under salinity stress conditions, had less Na^+ and Cl^- concentrations in their leaves (Bai *et al.,* 2005; Wei *et al.,* 2007). Therefore, it can be determined that various mechanisms may have evolved in grafted plants to prevent damage that could occur in the physiology of the leaves due to excess build-up of salt ions; thus can be implying, in some cases, the effects caused on other ion mechanisms.

In summary, negative impacts of drought and salt stress were less observed in grafted eggplant genotypes than in non-grafted plants. Considering the findings obtained under both stress conditions together, it was observed that such effects of stress conditions varied based on the rootstock and the genotype grafted over it, the use of rootstocks reducing the losses in shoot-root fresh and dry weights, the relative water contents, and shoot-root Ca^{+2} and K^+ concentrations under drought and salt stress. Under salt stress, plant Na^+ and Cl^- accumulation levels decreased with the use of rootstocks. The rootstock Köksal-F_1 was able to better prevent the genotypes grafted over it from negative effects of drought and salt stress. Köksal-F_1/MK was identified as the most successful rootstock/scion combination. Since both the rootstock and the scion were stress tolerant, this combination exhibited the greatest resistance. As they were in the seedling stage, assessment of the resistance status of grafted and non-grafted plants until the yielding stage is also quite a significant issue. It was concluded, based on the rootstocks and genotypes, that grafting could be used as a strategic practice to improve drought and salt tolerance in eggplants.



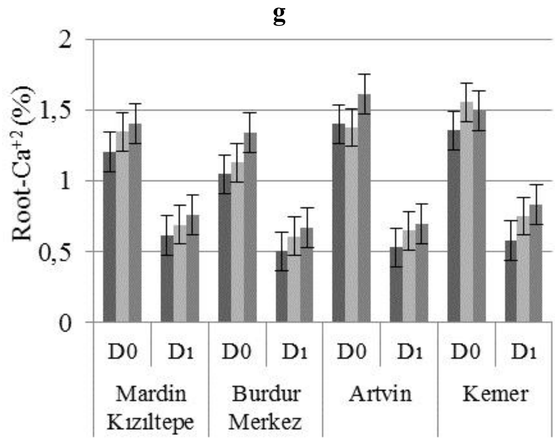
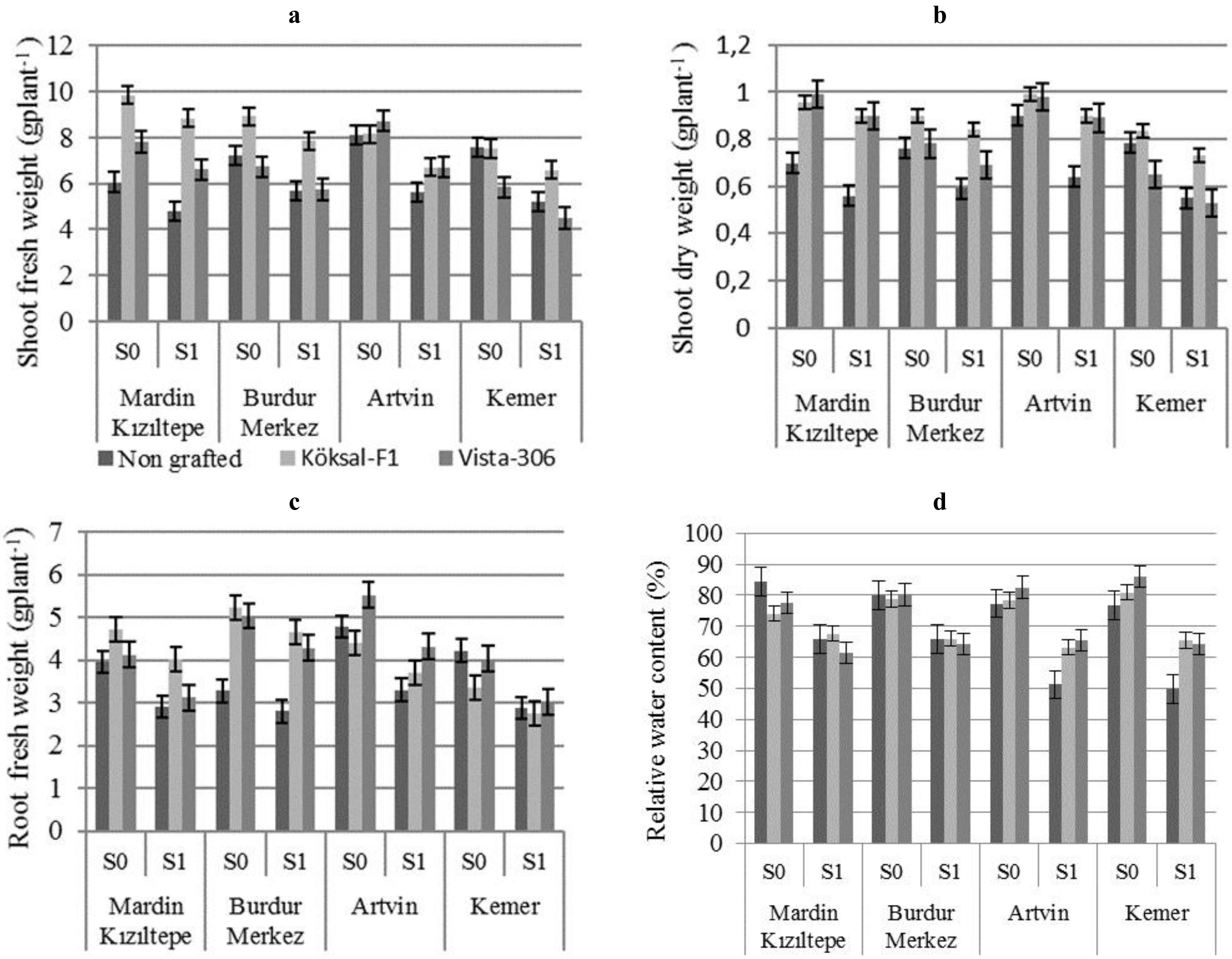


Figure 1. Shoot fresh weight (a), shoot dry weight (b), root fresh weight (c), root dry weight (d), relative water content (e), shoot K^{+} (f) and root Ca^{+2} (g) contents in eggplants under drought stress.



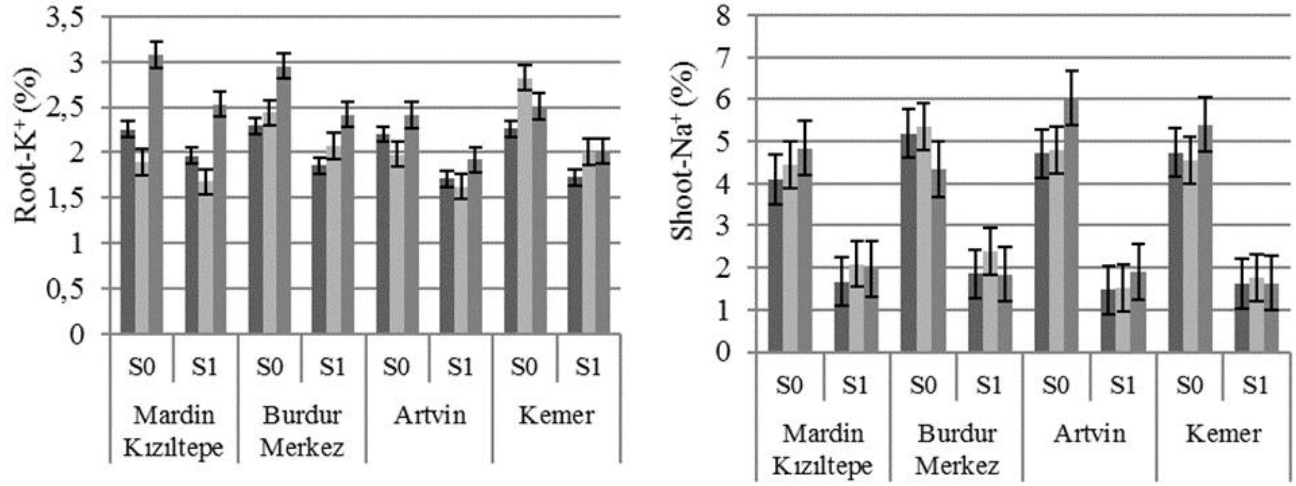


Figure 2. Shoot fresh weight (a), shoot dry weight (b), root fresh weight (c), relative water content d), root K^+ (e) and shoot Na^+ (f) contents in eggplants under salt stress.

Table 1. The change of shoot Ca^{+2} and root K^+ ion concentrations in grafted and non-grafted eggplant seedlings under drought stress

G	R	Treat.	Shoot -Ca^{+2} %	Increase %	Root-K^+ %	Increase %
MK	NG	D_0	3.94 ^{h}		2.89 ^{b}	
		D_1	1.93 ^{n}	-50.95	2.28 ^{i}	-20.95
	Köksal-F1	D_0	4.31 ^{g}		2.88 ^{b}	
		D_1	2.81 ^{i}	-34.71	2.31 ^{hi}	-19.65
	Vista-306	D_0	4.72 ^{de}		2.67 ^{cd}	
		D_1	2.76 ^{ij}	-41.57	2.07 ^{jk}	-22.43
BM	NG	D_0	4.93 ^{c}		2.52 ^{ef}	
		D_1	2.38 ^{lm}	-51.77	1.87 ^{mn}	-25.61
	Köksal-F1	D_0	4.71 ^{de}		3.03 ^{a}	
		D_1	2.51 ^{kl}	-46.73	2.14 ^{j}	-29.44
	Vista-306	D_0	4.72 ^{de}		3.04 ^{a}	
		D_1	2.75 ^{ij}	-41.79	2.40 ^{gh}	-21.01
AH	NG	D_0	5.11 ^{b}		2.74 ^{c}	
		D_1	2.33 ^{m}	-54.44	1.62 ^{p}	-40.89
	Köksal-F1	D_0	4.87 ^{cd}		2.61 ^{de}	
		D_1	1.85 ^{no}	-62.10	1.74 ^{o}	-33.32
	Vista-306	D_0	4.66 ^{ef}		2.40 ^{gh}	
		D_1	2.61 ^{jk}	-43.98	1.73 ^{o}	-27.80
K	NG	D_0	4.73 ^{de}		3.00 ^{a}	
		D_1	1.73 ^{o}	-63.35	1.95 ^{lm}	-34.84
	Köksal-F1	D_0	4.55 ^{f}		2.45 ^{fg}	
		D_1	2.33 ^{m}	-48.67	1.79 ^{no}	-27.07
	Vista-306	D_0	5.40 ^{a}		2.87 ^{b}	
		D_1	2.73 ^{ij}	-49.40	2.01 ^{kl}	-29.77
CV(%)			2.62		2.60	

The same superscript letters within each column are not significant different between interactions (rootstock x genotype x treatments) ($p \geq 0.05$). Rootstock:R, Genotype:G, NG:Non grafted

Table 2. The change of root dry weight, shoot Ca^{+2}, K^{+} and Cl^{-} ion concentrations in grafted and non-grafted eggplant seedlings under salt stress

G	R	Treat.	RDW mgplant^{-1}	Increase %	Shoot-Ca^{+2} %	Increase %	Shoot-K^{+} %	Increase %	Shoot-Cl^{-} %	Increase %
MK	NG	S_0	0.24 ^{de}	0.00	4.09 ^{h}		3.41 ^{ab}		0.09 $^{g\text{-}j}$	
		S_1	0.12 ^{o}	-38.05	1.67 ^{no}	-59.14	2.30 ^{hı}	-32.50	0.50 ^{e}	456.33
	Köksal-F1	S_0	0.22 $^{f\text{-}h}$	0.00	4.45 ^{f}		2.89 ^{ef}		0.11^{g}	
		S_1	0.18 $^{j\text{-}l}$	-21.30	2.09 ^{j}	-53.03	2.48 ^{gh}	-14.26	0.58 ^{b}	443.93
	Vista-306	S_0	0.26 ^{c}	0.00	4.84 ^{d}		2.79 ^{f}		0.08 $^{ı\text{-}m}$	
		S_1	0.17 ^{kl}	-35.69	1.97 ^{k}	-59.34	2.01 ^{jk}	-27.93	0.43 ^{f}	472.00
BM	NG	S_0	0.24 ^{cd}	0.00	5.19 ^{c}		2.53 ^{g}		0.08 $^{h\text{-}l}$	
		S_1	0.13 ^{no}	-44.82	1.85 $^{k\text{-}m}$	-64.35	1.92 ^{k}	-24.10	0.53 ^{d}	534.14
	Köksal-F1	S_0	0.28 ^{b}	0.00	5.35 ^{b}		3.08 ^{cd}		0.10 ^{gh}	
		S_1	0.23 $^{e\text{-}g}$	-19.48	2.39 ^{ı}	-55.36	2.43 ^{gh}	-21.14	0.49 ^{e}	415.38
	Vista-306	S_0	0.31 ^{a}	0.00	4.34 ^{g}		2.47 ^{gh}		0.07 $^{k\text{-}m}$	
		S_1	0.18 ^{jk}	-43.08	1.84 ^{lm}	-57.66	2.01 ^{jk}	-18.57	0.44 ^{f}	527.27
AH	NG	S_0	0.26 ^{c}	0.00	4.71 ^{e}		2.75 ^{f}		0.06 ^{m}	
		S_1	0.13 ^{o}	-49.71	1.47 ^{q}	-68.80	1.34 ^{l}	-51.12	0.53 ^{d}	736.77
	Köksal-F1	S_0	0.24 $^{d\text{-}f}$	0.00	4.78 ^{de}		3.27 ^{bc}		0.09 $^{ı\text{-}k}$	
		S_1	0.18 ^{j}	-22.31	1.53 ^{pq}	-68.03	2.15 ^{ıj}	-34.20	0.57 ^{b}	552.67
	Vista-306	S_0	0.32 ^{a}	0.00	6.03 ^{a}		3.13 ^{cd}		0.07 ^{lm}	
		S_1	0.20 ^{ı}	-38.38	1.90 ^{kl}	-68.56	2.08 ^{jk}	-33.50	0.50 ^{e}	639.23
K	NG	S_0	0.21 $^{g\text{-}ı}$	0.00	5.40 ^{b}		3.53 a		0.07 $^{j\text{-}m}$	
		S_1	0.13 ^{o}	-40.60	1.64 $^{n\text{-}p}$	-69.64	2.12 ı-k	-39.88	0.58 ^{b}	706.36
	Köksal-F1	S_0	0.20 ^{hı}	0.00	4.56 ^{f}		3.03 ^{de}		0.08 $^{h\text{-}m}$	
		S_1	0.15 ^{mn}	-29.41	1.76 ^{mn}	-61.38	2.29 ^{hı}	-24.46	0.55 ^{c}	608.64
	Vista-306	S_0	0.23 $^{d\text{-}g}$	0.00	4.73 ^{de}		3.17 ^{cd}		0.09 $^{g\text{-}ı}$	
		S_1	0.16 ^{lm}	-30.36	1.62 ^{op}	-65.73	2.07 ^{j}k	-34.73	0.61 ^{a}	570.42
CV(%)				4.70	2.10		4.37		2.78	

The same superscript letters within each column are not significant different between interactions (rootstock x genotype x treatments) ($p \geq 0.05$). Rootstock:R, Genotype:G, NG:Non grafted, RDW: Root dry weight

Table 3. The change of root Ca^{+2}, Na^{+} and Cl^{-} ion concentrations ingrafted and non-grafted eggplant seedlings under salt stress

G	R	Treat.	Root-Ca^{+2} %	Increase %	Root-Na^{+} %	Increase %	Root-Cl^{-} %	Increase %
MK	NG	S_0	1.27 $^{c\text{-}e}$		0.53 ^{jk}		0.04 ^{gh}	
		S_1	0.67 ^{gh}	-47.37	2.60 ^{e}	393.50	0.54 ^{bc}	1269.57
	Köksal-F1	S_0	1.19 ^{ef}		0.70 ^{hı}		0.06 ^{g}	
		S_1	0.64 ^{gh}	-46.46	2.82 ^{a}	302.78	0.50 ^{d}	759.78
	Vista-306	S_0	1.20 $^{d\text{-}f}$		0.60 $^{ı\text{-}k}$		0.05 ^{gh}	
		S_1	0.62 ^{gh}	-47.94	2.78 ^{d}	365.70	0.58 ^{a}	1179.21
BM	NG	S_0	1.27 ^{cd}		0.78 ^{gh}		0.03 ^{h}	
		S_1	0.67 ^{gh}	-47.49	4.14 ^{b}	428.59	0.53 ^{c}	1438.71
	Köksal-F1	S_0	1.13 ^{f}		0.44 ^{k}		0.06 ^{g}	
		S_1	0.61 ^{gh}	-46.27	2.14 ^{f}	384.72	0.53 ^{c}	870.12
	Vista-306	S_0	1.22 ^{de}		0.61 $^{ı\text{-}k}$		0.06 ^{g}	
		S_1	0.67 ^{gh}	-45.27	2.54 ^{e}	317.10	0.53 ^{c}	819.04
AH	NG	S_0	1.40 ^{b}		0.86 ^{g}		0.03 ^{h}	
		S_1	0.64 ^{gh}	-54.43	4.82 ^{a}	457.92	0.54 ^{c}	1836.19
	Köksal-F1	S_0	1.24 ^{de}		0.49 ^{jk}		0.04 ^{gh}	
		S_1	0.59 ^{h}	-52.63	2.54 ^{e}	421.41	0.58 ^{a}	1317.77
	Vista-306	S_0	1.34 ^{bc}		0.79 ^{gh}		0.03 ^{h}	
		S_1	0.66 ^{gh}	-50.99	4.27 ^{b}	439.84	0.48 ^{e}	1305.94

K	NG	S_0	1.56 ^{a}		0.53 ^{jk}		0.03 ^{h}	
		S_1	0.66 ^{gh}	-57.46	3.15 ^{c}	494.98	0.56 ^{b}	1805.03
	Köksal-F1	S_0	1.36 ^{b}		0.62 ^{ij}		0.04 ^{gh}	
		S_1	0.66 ^{gh}	-51.61	3.14 ^{c}	404.28	0.43 ^{f}	940.32
	Vista-306	S_0	1.50 ^{a}		0.60 $^{i-k}$		0.04 ^{gh}	
		S_1	0.68 ^{g}	-54.49	3.22 ^{c}	439.91	0.48 ^{e}	1046.33
CV(%)			4.70		4.72		5.39	

The same superscript letters within each column are not significant different between interactions (rootstock x genotype x treatments) ($p \geq 0.05$). Rootstock: R, Genotype: G, NG: Non grafted

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