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EFFECTS OF SALINITY STRESS ON PLANT GROWTH AND MINERAL COMPOSITION OF GRAFTED AND UNGRAFTED GALIA C8 MELON CULTIVAR

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Abstract

In this study, the growth performance and mineral composition of grafted and ungrafted melon plants were studied under salinity stress. In this study, the plant biomass such as total fresh and dry weight, roots and shoots length; and Ca^{2+}, K^+, Na^+ and Cl^- content in leaves, shoots and roots were investigated. Salt stress resulted in the decrease of total fresh and dry weight by 41.75% and 53.62% for ungrafted but this ratio was 17.17% and 19.25% for Maximus F_1/Galia, respectively. The amounts of Na^+ and Cl^- in leaves of ungrafted plants were very high levels than grafted plants. The effect of salinity was less pronounced in grafted melon plants compared with ungrafted melon plants.

Key words: Grafting melon, Salinity stress, Plant growth, Mineral content.

Introduction

The melon production was about 1.7 million tons in Turkey in 2015 (Anonymous, 2015). Kuşvuran (2010) reported that Turkey falls in the region of secondary genetic diversity region of melon and there is probability to find salt and drought tolerant genotypes. Salinity stress will be important in the future because of the global warming. It is reported that there are three main physiological mechanisms inducing stress under salinity conditions such as lower water potential of the root medium; toxic effects of Na^+ and Cl^- and third one is nutrient imbalance by depression in uptake and/or shoot transport (Lauchli, 1986; Marschner, 1995; Munns &Termaat, 1986). Some researchers reported that grafted melons increased plant growth, total and early yield (Yarşi & Sarı, 2006; Yetisir & Sari, 2003).

Salinity reduces yield and effects physiology and biochemistry of plants. Seed germination, water deficit, ion balance of the cellular ions (cause ion imbalance of the cellular ions resulting in ion toxicity) and osmotic stress is effected by salinity (Khan *et al*., 2002; Khan & Panda, 2008). Munns (2002) reported that salinity reduces the ability of plants to utilize water and causes a reduction in growth rate, as well as changes in plant metabolic processes. Salinity causes in a decreasing of K^+ and Ca^{2+} content while an increased amount of NaCl and SO_4 (Mansour *et al*., 2005).

The NaCl caused in a reduction root length, fresh and dry weight of roots, number of leaves and leaf area in pepper (Zhani *et al*., 2012). Excess of salt in many plants causes decreasing amount of Ca^{2+}, K^+ and Mg^{2+} while increases amount of Na^+ and Cl^- (Parida & Das, 2005; Kuşvuran *et al*., 2008; Yılmaz *et al*., 2011). It is reported that the salt stress increases Na^+, Ca^{2+}, Mn^{2+}, Cu^{2+} and Fe^{2+} but it causes to decrease K^+ and P^{3-} (Erdal *et al*., 2000). The studies have been focused on about this subject in recent years. Grafted plants and the plants species which are resistant to salinity have been used for this purpose.

In this study, effects of salt stress on the growth performance and mineral composition of grafted and ungrafted melon plants were investigated.

Materials and Methods

Grafted plant materials and planted: In this study, to determine the growth performance and mineral composition under salinity stress, 3 squash rootstock (Maximus F_1, Shintoza F-90 F_1 and Nun 9075 F_1) were used as rootstocks and Galia C8 melon cultivar was used as a scion. Tube grafting method was used (Fig. 1) and the grafted seedlings were planted in pots (72.0 cmx19.5cmx15.5 cm (14 liter; No:4) . The temperature was about 26-30°C during the day and 16-20°C at night and the humidity was an average of 55-65% inside the greenhouse at the time of plantation. For each replicate, 4 plants in one pot were used as one replication and for salt and control treatments 3 replicates used, separately. The plants were exposed to a salt concentration of 50 mM NaCl for 5 days and 100 mM NaCl for 5 days then the final concentration of 150 mM NaCl was applied for 10 days (Yarsi *et al*., 2017). Plants were watered following the method of Suyum *et al*. (2012).

Planted: The Seedlings were planted in plastic pods (14 liter) which were filled with peat and perlite by 2:1 ratio (Fig. 2).

Plant harvested: Plants carefully removed from the pots at the end of the study (same time and after 20 days from first treatment of NaCl) that were washed with pure water and cleaned.

The main stem and root length: The main stem and root length of the plants were measured with a ruler after harvesting.

Total fresh and dry weight: The leaves, stems and roots weight of harvested plant were taken as fresh weight and then put in oven at 65ºC for 48 hours then dry weight was taken.

Mineral composition: Ca^{2+}, K^+ and Na^+ were determined by Kuşvuran (2010) and Cl^- was determined by Johnson & Ulrich (1959).

Fig. 1. Grafted plants.

Fig. 2. Salt treatment of plants in trial.

Results and Discussion

Biomass: The total fresh and dry biomass, shoots and roots length were significantly affected by salinity (Table 1). The grafted plants were less influenced than ungrafted plants. The total fresh and dry biomass, shoots and roots length was higher in grafted plants in comparison to ungrafted plants. In this study, the biomass of grafted and ungrafted plants was decreased under the salt stress.

The salt treatment reduced the shoot and root length, and total fresh and dry biomass both grafted and ungrafted plants according to their control in Table 2. Salt treatment resulted in the reduction of plants shoot length of 45.68%, while causing a decrease of 40.46% in root length for ungrafted. The shoot length was decreased 24.89%, 17.90% and 10.34% of Shintoza F-90 F_1/Galia, Maximus F_1/Galia and Nun 9075 F_1/Galia under salt stress, respectively while the root length was decreased in Maximus F_1/Galia (10.16%), Shintoza F-90 F_1/Galia (24.32%) and Nun 9075 F_1/Galia (21.84%). When looking at the total fresh and dry weight, the Maximus F_1/Galia was less affected than other grafted plants and ungrafted plants. Salt stress also decreased the total fresh and dry weight by 41.75% and 53.62% for ungrafted but this ratio was 17.17% and 19.25% for Maximus F_1/Galia, respectively. These results agree with Zhani *et al.*, (2012) and Akça & Samsunlu (2012).

In this study, it was determined that the amounts of K^+, Na^+, Cl^- and Ca^{++} in leaves, shoots and roots were affected by salinity stress. This effect has been achieved at different levels depending on the used rootstocks (Table 3).

The nutrition contents of leaves, shoots and roots obtained for grafted and ungrafted melon plants are given Table 4. While the amount of K^+ in the leaves of ungrafted plants was decreased by 7.84% whereas it was an increase in grafted plants. These increases were Shintoza F-90 F_1/Galia (18.68%), Nun 9075 F_1/Galia (12.40%) and Maximus F_1/Galia (4.95%), respectively. It was reported that under salt stress up taking K^+ and Ca^{2+} of walnut leaves was reduced (Akca & Samsunlu, 2012). In this study, the amount of K^+ was increased in the leaves of grafted plants showing that the grafted plants were less affected than ungrafted plants under the salt stress. The changing% of Ca^{2+} content of grafted plants leaves was Nun 9075 F_1/Galia (20.99%), Maximus F_1/Galia (4.66%) and Shintoza F-90 F_1/Galia (1.24%) but -3.06% in leaves of ungrafted plants in Table 4.

The Na^+ content in leaves was increased both grafted and ungrafted plants by salt treatment. But the grafted plants were affected less than ungrafted plants. The average increasing percent of Na^+ content was % 1118.9 for the ungrafted plants, %303.58 for the Maximus F_1/Galia, %383.30 for the Shintoza F-90 F_1/Galia and % 658.8 for the Nun 9075 F_1/Galia. This increase was at different rates in root and shoot (Table 4).

About the Cl^- in leaves. The increasing in ungrafted plants was 460.00%, Shintoza F-90 F_1/Galia 358.64%, Nun 9075 F_1/Galia 214.75% and Maximus F_1/Galia 202.04%. These increasing were different rates in root and shoot (Table 4).

Table 1. Growth performance of grafted and ungrafted melon plants grown under salinity stress (150 mM NaCl).

	No salt application				Salt application			
	Ungrafted	**Maximus F_1/Galia**	**Shintoza F-90 F_1/Galia**	**Nun 9075 F_1/Galia**	**Ungrafted**	**Maximus F_1/Galia**	**Shintoza F-90 F_1/Galia**	**Nun 9075 F_1/Galia**
Shoot length	14.93 ± 0.55	22.23 ± 1.14	17.23 ± 0.73	16.15 ± 0.76	8.11 ± 1.01	18.25 ± 0.94	12.94 ± 0.88	14.48 ± 0.12
Root length	18.31 ± 0.79	33.28 ± 0.64	23.47 ± 0.56	23.48 ± 0.72	12.90 ± 0.55	29.90 ± 0.06	17.30 ± 0.91	18.35 ± 1.30
T. fresh weight	22.1 ± 0.32	41.63 ± 0.69	34.10 ±0.42	33.68 ± 0.60	12.82 ± 0.74	34.23 ± 0.76	25.99 ± 0.39	26.27 ± 0.15
T. dry weight	2.07 ± 0.22	4.26 ± 0.34	2.90 ± 0.02	3.07 ± 0.23	0.96 ± 0.07	3.44 ± 0.48	2.12 ± 0.26	2.17 ± 0.21

* T - Total

Table 2. Comparison of changing growth performance to the control of grafted and ungrafted melon plants grown under salinity stress (150 mM NaCl) (%).

	Ungrafted	Maximus F_1/Galia	Shintoza F-90 F_1/Galia	Nun 9075 F_1/Galia
Shoot length	-45.68	-17.90	-24.89	-10.34
Root length	-40.46	-10.16	-24.32	-21.84
T. fresh weight	-41.75	-17.17	-25.95	-22.00
T. dry weight	-53.62	-19.25	-26.84	-29.32

* T – total

Mineral Composition

Table 3. Mineral composition comparison of grafted and ungrafted melon plants grown under the salinity stress (150 mM NaCl).

	No salt application				Salt application			
	Ungrafted	Maximus F_1/Galia	Shintoza F-90 F_1/Galia	Nun 9075 F_1/Galia	Ungrafted	Maximus F_1/Galia	Shintoza F-90 F_1/Galia	Nun 9075 F_1/Galia
K^+/Leaf	2.68 ± 0.19	2.22 ± 0.19	2.57 ± 0.19	2.50 ± 0.20	2.47 ± 0.19	2.33 ± 0.17	3.05 ± 0.58	2.81 ± 0.53
K^+/Shoot	3.08 ± 0.55	2.47 ± 0.27	3.00 ± 0.42	2.59 ± 0.12	4.12 ± 0.34	2.12 ± 0.37	2.79 ± 0.71	2.56 ± 0.67
K^+/Root	2.72 ± 0.22	2.32 ± 0.49	2.98 ± 0.25	3.15 ± 0.19	1.71 ± 0.50	1.41 ± 0.45	1.86 ± 0.77	1.60 ± 0.18
Ca^{2+}/Leaf	3.60 ± 0.24	4.29 ± 0.36	4.02 ± 0.27	2.81 ± 0.85	3.49 ± 0.26	4.49 ± 0.42	4.07 ± 0.45	3.40 ± 0.13
Ca^{2+}/Shoot	1.99 ± 0.42	2.20 ± 0.66	2.18 ± 0.25	1.76 ± 0.21	1.94 ± 0.09	1.97 ± 0.48	2.11 ± 0.10	1.92 ± 0.10
Ca^{2+}/Root	1.22 ± 0.23	1.79 ± 0.90	1.08 ± 0.10	1.04 ± 0.06	1.04 ± 0.05	1.19 ± 0.17	1.25 ± 0.68	0.86 ± 0.06
Na^+/Leaf	0.37 ± 0.08	0.28 ± 0.01	0.30 ± 0.04	0.17 ± 0.02	4.51 ± 0.43	1.13 ± 0.36	1.45 ± 0.10	1.29 ± 0.14
Na^+/Shoot	0.28 ± 0.05	0.22 ± 0.04	0.30 ± 0.06	0.31 ± 0.07	3.50 ± 1.05	1.36 ± 0.21	1.80 ± 0.13	1.31 ± 0.04
Na^+/Root	0.98 ± 0.10	0.68 ± 0.10	0.73 ± 0.03	0.77 ± 0.06	1.13 ± 0.70	4.17 ± 0.79	3.95 ± 0.55	5.42 ± 0.50
Cl^-/Leaf	0.55 ± 0.03	0.49 ± 0.07	0.46 ± 0.05	0.61 ± 0.02	3.08 ± 0.56	1.48 ± 0.16	2.11 ± 0.13	1.92 ± 0.06
Cl^-/Shoot	0.55 ± 0.02	0.54 ± 0.02	0.62 ± 0.06	0.63 ± 0.06	3.05 ± 0.50	1.98 ± 0.16	2.24 ± 0.12	1.88 ± 0.03
Cl^-/Root	0.49 ± 0.06	0.40 ± 0.03	0.58 ± 0.05	0.49 ± 0.02	1.47 ± 0.24	1.58 ± 0.27	1.93 ± 0.06	1.64 ± 0.16

Table 4. Comparison of mineral composition of grafted and ungrafted melon plants grown under the salinity stress (150 mM NaCl) (%).

	Ungrafted	Maximus F_1/Galia	Shintoza F-90 F_1/Galia	Nun 9075 F_1/Galia
K^+/Leaf	-7.84	4.95	18.68	12.40
K^+/Shoot	33.77	-14.17	-7.00	-1.16
K^+/Root	-37.13	-39.22	-37.58	-49.21
Ca^{2+}/Leaf	-3.06	4.66	1.24	20.99
Ca^{2+}/Shoot	-2.51	-10.45	-3.20	9.09
Ca^{2+}/Root	-14.75	-33.52	15.74	-17.30
Na^+/Leaf	1118.9	303.58	383.30	658.8
Na^+/Shoot	1150.0	518.18	500.00	322.54
Na^+/Root	15.31	513.24	441.1	604.00
Cl^-/Leaf	460.00	202.04	358.69	214.75
Cl^-/shoot	454.55	216.66	261.29	198.41
Cl^-/root	200.00	295.00	232.00	234.69

Conclusion

It was seen that the grafted plants biomass was less affected than ungrafted under the salt treatment. These results agree with Kaymakanova & Stoeva (2008) in beans. When compared to grafted plants each other, the Maximus F_1/Galia was less affected than Shintoza F-90 F_1/Galia and Nun 9075 F_1/Galia.

It is concluded that salt stress reduces K^+ content of ungrafted plants leaf but increases in grafted plants. The amounts of Na^+ and Cl^- in leaves of ungrafted plants were very high levels than grafted plants. It is clear that Na^+ and Cl^- are accumulating in the stems and the roots and does not substantially transmitted to the leaves in grafted plants. It is said that the adaptation of grafted plants are better than un-grafted plants in saline condition. The ungrafted plants accumulated mostly in leaves and shoots, but the grafted plants balanced distribution in leaves, shoots and roots in grafted plants for Na^+ and Cl^-. The grafted plants grow better than ungrafted plants under the salinity, so grafted plants may be recommended for the saline soils especially Maximus F_1 as a rootstock. It is seen that the amount of Na^+ in roots of the grafted plants exceeded than ungrafted plants in saline conditions.

Although not as high as sodium, the concentration of Cl^- in the roots of grafted plants was higher than ungrafted plants. This may be due to the fact that in salty conditions, the roots of the rootstocks may use osmoregularity to take up a lot of Na^+ and Cl^- ions which are abundant in the environment. Despite their high Na intake with their roots, Maximus F_1 was as a rootstock that Na and Cl were transported by it to the leaves less than ungrafted plants. As is known, Na^+ and Cl^- are two ions which have the most toxic effect in leaves, so Maximus F_1 was the most advantageous. Of course, there may be an affect of the incompatibility between the scion and the rootstock in the transport from roots to stem and leaves. In salt stress, the reason of less influence of Maximus F_1 on total biomass, plant roots and stem lengths compared to ungrafted plants can be Na^+ and Cl^- ions which are toxic in saline conditions is less transported to the leaves and stem than the others.

According to the control in saline condition, the roots of Shintoza F-90 F_1 had the highest amount of Ca^{++}. This high Ca^{++} can also be used in osmoregulation but Ca^{++} concentrations in the stem and leaf were not too high like roots in saline conditions. The highest Ca^{++} was determined in leaves and stems of plants which was grafted on Nun 9075 F_1. Shintoza F-90 F_1 was the best rootstock that was carried to leaves for K^+ under salt stress. But this study should be continued until the yield and fruit quality should be tested in another study.

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