Effect of Different Tomato Rootstocks and EC Levels on the Nutrient Content of Fresh Tomatoes

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Abstract
This study was conducted to determine the effects of different tomato rootstocks and high EC levels in order to increase the mineral content of tomatoes, one of the most consumed vegetables in the world. The research was carried out in perlite medium in a non-heated polycarbonate covered greenhouse the in spring production period during 2-years. In the study, 5 different EC levels were applied 2, 3, 5, 7 and 9 dS m^{-1}. In the research, Newton F_1 tomato variety was grafted onto 11 different commercial tomato rootstock. Also, for control purposes, non-grafted and self-grafted plants were used. The P, K, Ca, Mg, Fe, B, Mn and Zn contents of fruit samples were determined according to the dry burning method. The P, K, Ca, Mg, Fe, Mn and Zn contents of fresh fruit increased with increasing EC levels, according to the two year average results of the study. The effects of the rootstocks on the nutritional content of the fruit were found to be statistically nonsignificant. According to the results of the study it was determined that the mineral content of tomato fruit could be increased by changing the concentration of the nutrient solution.

Keywords: *Solanum lycopersicon*, grafting, electrical conductivity (EC), mineral content

Introduction

The tomato is one of the most important vegetables growing in the open field and in the greenhouse and it contains important antioxidant compounds, vitamins and minerals and it has an important place in nutrition. Tomato fruits are a major component of daily meals in many countries (Ünlükara et al., 2006). One of the most important properties of tomato is that it contains micro elements such as Mn, Fe, Zn and Cu which are the cofactors of antioxidant enzymes. It is assumed that these microelements play an important role in the protection mechanisms by scavenging free radicals (Fernandez-Ruiz et al., 2011). Consumption of tomato and tomato products can significantly reduce the risk of cancer (Sainju et al., 2003). The mineral content of the tomato is important in terms of product preservation, nutritional value, taste and endogenous quality (Sanders et al., 1981, Rijck and Schrevens, 1998). Improvement of phytonutrients in tomatoes can be achieved by variety selection, environmental factors, agronomic applications, stage of ripeness at harvest and distribution under suitable conditions (Dorais et al., 2008). The higher EC value in the irrigation water increases the internal quality of the fruit, but causes a decrease in yield (Soylemez and Pakyurek, 2017; Kamburoğlu -Çebi et al., 2018).

The use of grafted plants in tomato production has increased in recent years. The grafted plant usage against to biotic and abiotic stress, such as soil-borne diseases and pests, low temperature, low water quality and drought conditions is becoming increasingly widespread. By the use of rootstock can obtain strong plants due to the increase intake of water and nutrients , so the physiological disorders reduce and the fruit yield increase (Dorais et al., 2008). Many studies have been carried out related to the effects of rootstocks and / or salinity on the mineral content of the leaves (Amor et al., 2001; Fernandez-Garcia et al., 2004; Tuna et al., 2007; Bilgin & Yildiz, 2008; Giuffrida et al., 2009; Mohammed et al., 2009; Eraslan et al., 2008; Huang et al., 2010; Zhu et al., 2008; Eraslan et al., 2012). However, there is inadequate research on the nutrient content of fresh tomato fruit. For this reason, it is important to establish the nutrient composition in tomatoes and to illuminate the main factors affecting this composition

(Hernandez Suarez et al., 2007). In this study, we aimed to determine the effects of nutrient-based EC levels and different tomato rootstocks on the nutrient content of fresh tomato fruit.

Material and Method

Research area and plant material

The experiment was carried out during the spring season in the polycarbonate covered R&D greenhouse at the Agricultural Faculty of Harran University. The study was carried out in a closed feed technique of soilless agriculture and in a perlite medium. Newton F_1 tomato variety was used as a scion. This variety has been grafted onto the rootstocks of Unifort, Beaufort, Maxifort, Kemerit, Yedi RZ, Kingkong, Body, Toro, Spirit, Heman and Resistar by tube grafting method. In addition, non-grafted and self-grafted plants (Newton / Newton) were used as controls.

Applications in the greenhouse

The grafted plants were supplied as grafted from seedling company and planted in 135x25 cm distances in pots (20*20*100 cm) filled with perlite. The plants were grown as a single stem and when necessary applied pruning and pesticide. Weekly mean temperature and relative humidity values are given in Figure 1.

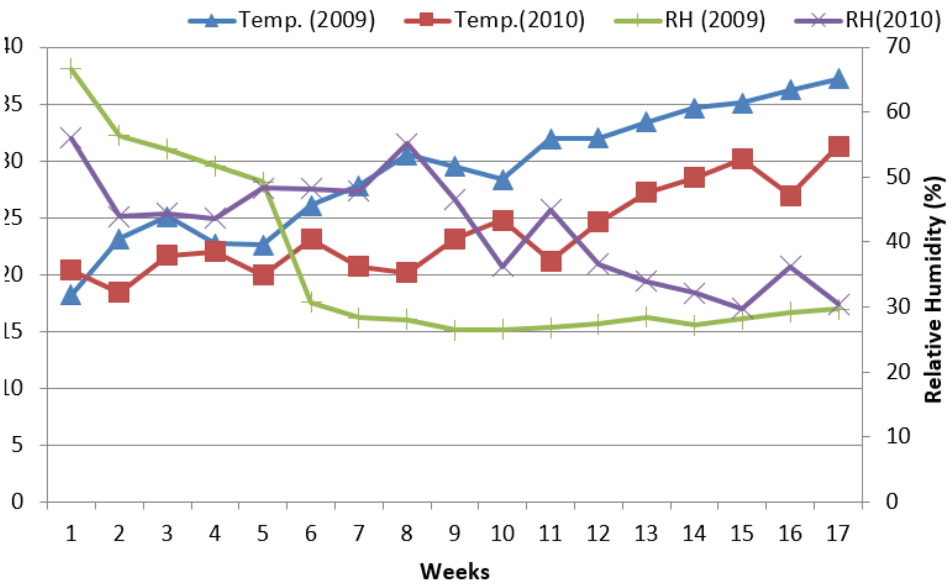

Figure 1. Weekly mean temperature and relative humidity values

Nutrient solution and irrigation

In the experiment five different nutrient induced EC levels were used, 2, 3, 5, 7 and 9 dS m^{-1}. EC levels were obtained by increasing of all macro and micro elements in the nutrient solution. The content of the nutrient solution modified according to Arnon and Hogland are given in Table 1. Normal EC were used (EC: 2 dS m^{-1}) for the first 10 days after sowing and EC levels step by step have been increased (1 dS m^{-1} per day) after 10th day and reached the final EC levels. The pH of the nutrient solution adjusted between 5.8 and 6.5 by nitric acid. Amounts of irrigation water were determined according to the drainage volume and 25-30% of the irrigation water was drained. Depending on the air temperature and day length, irrigation was done 6-10 times in a day. The experiment was established in the closed feed system and drain solution was used again after the EC and pH adjustments. However, when the EC value of drain exceeded 1.5 times (50% excess) of initially nutrient solution EC value, the old solution was emptied and a new nutrient solution was prepared.

Table 1. The mineral content of the nutrient solution used in the experiment (ppm)

N	P	K	S	Mg	Mn	B	Cu	Zn	Mo	Ca	Fe
210	31	234	64	48	0.5	0.5	0.02	0.05	0.01	200	2.8
Stock A										Stock B	

Mineral matter analysis

Mineral matter content in the fruit was determined by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) (Perkin-Elmer Optima 5300 DV) according to the dry-burn method. Macro nutrient results were determined as mg 100 g^{-1} fresh weight and micronutrient element results mg kg^{-1} fresh weight.

Experimental design and statistical analysis

The experiment was established with three replications according to the design of factorial random blocks and 8 plants were used in each replicate. The data obtained by averaging the two-year results were analysed in the SAS 6.0 statistical package program and the Duncan test was performed to compare the averages.

Results and Discussion

Two-year average results related to effects of nutrient induced salinity levels and the rootstocks on the minerals content of fresh fruit are given in Table 2. It was determined that the content of P, K, Ca and Mg in the fresh fruit increased with the increase of nutrient induced salinity levels. The highest P, K, and Mg contents were 35.51, 332.34 and 11.10 mg 100 g^{-1} fresh weight, respectively, at EC: 9 dS m^{-1} application. The highest Ca content was determined at EC: 7 dS m^{-1} application with 7.41 mg 100 g^{-1} fresh weight. When the electrical conductivity increased from 2 dS m-1 to 9 dS m-1 the phosphorus content of fresh fruit 144.73%, K content of 44.46%, Ca content of 2.13%, Mg content raised 50.61% ratios. The P, K, Ca and Mg contents of the rootstocks were found to be statistically insignificant. Phosphorus, K, Ca and Mg contents of rootstocks were between 25.60-28.33, 288.15-309.07, 5.94-7.02 and 8.82-9.90 mg 100g- 1 fresh fruit respectively.

Fernandez-Ruiz et al. (2011) reported that the K content of varieties of 20 cultures and 10 wild tomatoes was 78.47, the content of Ca 23.57, the content of Mg 8.4 mg 100g-1 fresh weight, and these values were higher in wild tomato species. Similarly, Hernandez Suarez et al. (2007), conducted a study to determine the effects of variety, growth environment and sampling time on the mineral matter contents of tomato hydroponically grown. They found that content of P was between 26.9-33.6, K content of 215.6-263.1, Ca content 6.8-11.9 of and Mg content of 6.7- 10.9 mg 100 g^{-1}. Costa et al. (2011) reported that P, K, Ca and Mg contents of tomato fruits in the postharvest ripening period were between 7-13, 202-314, 19-32 and 12-20 mg 100 g^{-1} respectively. Rijck and Schrevens (1998) reported that the mineral element content of the fruit was increased by increasing the concentration of K^{+}, Ca^{+2} and Mg^{+2} in the nutrient solution.

Gundersan et al. (2001) investigated the effect of different growth media on the mineral matter contents of tomatoes. While the increased content of K from 151.0 to 153.0 and content of Mg from 0.85 to 0.87 g 100 g^{-1} fresh weight, decreased content of Ca from 0.71 to 0.51 and content of P from 3.20 to 3.10 mg 100 g^{-1} fresh weight with the increase electrical conductivity from EC:2.5 dS m^{-1} to 3.5 dS m^{-1} in the rockwool medium. The researchers were reported that these increases and decreases were not important except Ca content. Our findings are similar to those of other investigators.The results of the effects of the applications on the content of micronutrient elements of the fruit are given in Table 2. By increasing the nutrient induced salinity levels, the content of Fe, Mn and Zn increased significantly.The highest content of Fe was obtained from application of EC: 7 dS m^{-1} with 3.50 mg kg^{-1} fresh weight, while the highest contents of Mn and Zn were obtained from EC: 9 dS m^{-1} application with of 1.45 and 1.90 mg kg^{-1} fresh weights respectively. As the electrical conductivity increased from 2 dS m^{-1} to 9 dS m^{-1}, it was found that Fe content increased by 42.22%, Mn content by 61.11% and Zn content by 65.22%.

The effects of the rootstocks on Fe, B, Mn and Zn contents were found statistically insignificant and the results are presented in Table 2. Iron, B, Mn and Zn contents of fresh fruit were between 2.90 -3.25, 0.65-0.70, 1.05-1.30 and 1.45-1.70 mg kg^{-1} fresh weight respectively. Nour et al. (2013) examined the mineral contents of 10 different fruit shapes tomatoes cultivated in Romania. The researchers reported that depending on the varieties varied the content of Fe between 4.6-9.7, the B content 1.3- 3.9, the Mn content 0.7-2.5 and the Zn content 6.2-8.0 mg kg^{-1} fresh weight. On the other hand, Guil-Guerrero and Rebolloso-Fruentes (2009) investigated the mineral nutrient content of 8 tomato varieties and they found content of Fe, Mn and Zn between 4.9-35.1, 0.7-3.1 and 1.6-54.8 mg kg^{-1} respectively. Gundersan et al. (2001) investigated the effect of different growth media on the mineral nutrient contents of tomato fruit by raising the level of EC from 2.5 dS m^{-1} to 3.5 dS m^{-1} in the rocky medium. The researchers reported that the contents of Fe in the tomato increased from 2.4 to 2.8 and Zn from 1.01 to 1.08 mg kg^{-1} fresh weight, while the Mn content decreased from 0.93 to 0.89 mg kg^{-1} fresh weight by raising the level of EC from 2.5 dS m^{-1} to 3.5 dS m^{-1}. But the only Fe content was statistically significant from these changes.

Table 2. Effect of nutrient salinity levels on the macro and micronutrient contents of the fruit of the Newton F1 tomato cultivar and rootstocks according to the two year average results

	mg 100g-1 fresh weight.				mg kg-1 fresh weight			
	P	K	Ca	Mg	Fe	B	Mn	Zn
EC:2 dS m-	14.51 e	230.05 d	6.05 cd	7.37 d	2.25 c	0.75 b	0.90 c	1.15 d
EC:3 dS m-	20.19 d	292.80 c	6.42 c	9.14c	3.25 b	0.85 a	0.95 c	1.80 a
C:5 dS m-1	31.48 c	321.75 b	5.91 d	9.47cb	3.20 b	0.55 d	1.15 b	1.40 c
EC:7 dS m1	32.89 b	310.54 b	7.41 a	9.64 b	3.50 a	0.60 c	1.20 b	1.60 b
EC:9 dS m-	35.51 a	332.34 a	6.88 b	11.10a	3.2 b	0.70 b	1.45 a	1.90 a
	**	**	**	**	**	**	**	**
Non-rafted	26.33	299.66	6.40	9.15	3.00	0.65	1.10	1.55
Self-grafted	28.33	299.17	6.32	9.90	3.25	0.70	1.20	1.65
Heman	27.04	309.07	7.02	9.54	3.10	0.70	1.30	1.55
Resistar	25.96	299.13	6.66	9.35	3.10	0.65	1.05	1.50
Unifort	26.96	304.00	6.41	9.39	3.10	0.70	1.15	1.55
Beaufort	26.11	294.98	6.89	9.31	3.10	0.70	1.15	1.55
Maxifort	25.60	288.15	6.59	8.82	3.05	0.65	1.05	1.50
Kemerit	27.22	293.45	6.65	9.16	3.20	0.70	1.10	1.70
Yedi RZ	27.14	302.82	6.66	9.43	3.00	0.70	1.15	1.65
Spirit	28.16	298.11	5.94	9.70	3.25	0.70	1.20	1.65
Toro	27.71	293.64	6.21	9.58	3.00	0.70	1.05	1.50
Body	26.80	296.02	6.56	9.17	2.95	0.65	1.15	1.50
Kingkong	26.55	289.26	6.61	8.97	2.90	0.65	1.10	1.45
	ns	ns	ns	ns	ns	ns	ns	ns

ns: nonsigificant; **: p<0.01

Conclusion

The importance of vegetables, which is an indispensable place for people to supply their daily nutritional needs, is getting better and better every day. The tomato is used in human nutrition because of its vitamins, minerals and antioxidants and it is one of the most important vegetables, which can consume as fresh or/and processed. The tomato, which is at the head of the most produced and consumed vegetables has a rich nutrient content and it is located in our tables in every season of the year as raw, cooked, dried, canned, processed in the industry and gives taste to our meals. In recent years, researchers have been focusing on studies to produce foods rich in nutritional value in terms of human health, taking into consideration the demands of the consumer as well as improving the yield and physical qualities. In this study, it was aimed to determine the effects of different nutrient induced salinity levels and rootstocks on nutrient content of tomatoes. It was determined that the nutrient induced salinity levels applied in the study were statistically significant on the nutrient content of the tomato, but the effect of the rootstocks was not significant. The highest nutrient contents were obtained from the highest EC level, EC: 9 dS m^{-1}, while the lowest nutrient contents were obtained from EC: 2 dS m^{-1}. If the EC level of the nutrient solution increase, content of nutrient in the fresh fruit such as P, K, Ca, Mg, Fe, B, Mn and Zn can be increased.

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