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Araştırma Makalesi

Farklı Anaçlar Üzerine Aşılı Bazı Karpuz Hatlarının Sera Koşullarında Yaprak Besin İçerikleri Üzerine Etkileri

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ÖZ

Bu çalışmanın amacı, farklı anaçlara ve çeşitli kabuk zemin renklerine sahip karpuz bitkilerinde aşılamanın bitki besin maddelerinin konsantrasyonunu nasıl etkilediğini incelemektir. Bu çalışma 2020 ilkbahar/yaz yetiştirme sezonunda, Mersin Alata Bahçe Bitkileri Araştırma Enstitüsü sera ve laboratuvarlarında yürütülmüştür. Anaç olarak Lagenaria spp. grubundan Argentario, Cucurbita maxima×C. moschata grubundan Nun9075 ve TZ148 ve Citrullus amarus grubundan PI 296341 kullanılmıştır. Türkiye, karpuza anaç olarak kullanılan Nun9075 ve TZ148 için önemli bir üretici konumundadır. Kalem olarak B1, B2, S1 ve S2 saf hatları kullanılmıştır. Çizgili kabuk zemin desenine sahip S1 ve S2 saf hatları, koyu yeşil kabuk zemin rengine sahip B1 ve B2 saf hatları kullanılmıştır. Sonuç olarak, anaçlar arasında ve karpuz hatları arasında bitki besin alımı bakımından doğrudan bir ilişki bulunamamıştır. N içeriği, en yüksek Argentario (2.58%) anaçlarında ve S1 hattında (2.60%) görülmüştür. P ve Fe içeriği, anaçlar arasında ve hatlar arasında istatistiksel olarak anlamlı bir farklılık göstermemiştir. K içeriği en yüksek Argentario (2.83%) ve NUN9075 (2.82%) anaçları ile S1 (2.88%) ve B1 (2.81%) hatlarında bulunmuştur. En yüksek Mg içeriği NUN 9075 (0.39%) ve B2 hatlarından elde edilirken, diğer hatlarda yüksek değerler almış ve aynı grupta yer almıştır. Zn içeriği en yüksek NUN9075 (40.03 ppm) anacından elde edilirken, diğer anaçlarda yüksek değerler alarak aynı grupta yer almıştır. Mn içeriğinin en yüksek 3335 (58.80 ppm) anacından ve B1 hattından (52.01 ppm) alınmıştır.

Anahtar kelimeler: Karpuz, aşılama, bitki besleme, anaç.

Effects of Grafting Some Watermelon Lines on Different Rootstocks on Leaf Nutrient Contents under Greenhouse Conditions

ABSTRACT

The aim of this study is to examine how grafting affects the concentration of plant nutrients in watermelon plants with different rootstocks and various skin color. This study was carried out in the greenhouses and laboratories of Mersin Alata Horticultural Research Institute in the 2020 spring/summer growing season. As rootstock, from the Lagenaria spp. group Argentario, from the Cucurbita maxima×C. moschata group Nun9075 and TZ148; and from the Citrullus amarus group PI 296341 were used. Turkey is an important producer for Nun9075 and TZ148, which are used as rootstocks for watermelon. B1, B2, S1 and S2 pure lines were used as scions. Pure lines S1 and S2 with striped rind ground pattern and pure lines B1 and B2 with dark green rind ground color were used. As a result, no direct relationship was found between rootstocks and watermelon lines in terms of plant nutrient uptake. Nitrogen (N) content was highest in Argentario (2.58%) rootstocks and S1 line (2.60%). Phosphorus (P) and iron (Fe) content did not show a statistically significant difference among rootstocks and lines. The highest potassium (K) content was found on Argentario (2.83%) and NUN9075 (2.82%) rootstocks and S1 (2.88%) and B1 (2.81%) lines. While the highest Mg content was obtained from NUN 9075 (0.39%) and B2 lines, it had high values in other lines and was included in the same group. While the highest Zn content was obtained from NUN 9075 (40.03 ppm) rootstock, it was in the same group with high values in other rootstocks. The highest Mn content was obtained from rootstock 3335 (58.80 ppm) and B1 line (52.01 ppm).

Key words: Watermelon, grafting, plant nutrition, rootstock.

INTRODUCTION

Watermelon is one of the most important members of the Cucurbitaceae family. World vegetable production is 1.3 billion tons, watermelon accounts for 7.7% (101.7 million tons) of this production. China is the world's largest producer of watermelons with a share of 59.19% (60 million tons), and Turkey is the second-largest producer with a share of 3.43% (3.5 million tons) (Faostat, 2020). A reduction in yield brought on by successive cropping and soil-borne infections, particularly *Fusarium* spp., is one of the most important issues with watermelon cultivation. Crop rotation, which suggests that watermelon should not be grown for at least five years in the same field infected with the Fusarium wilt pathogen, is one of the most successful techniques for reducing Fusarium wilt of watermelon (Messiaen, 1974). Besides that, grafting susceptible types onto resistant rootstocks may help manage some soil-borne diseases and improve yield and quality (Lee, 1994; Oda, 1995; Yetisir et al., 2003). The first goals of grafting in watermelon were to prevent soil-borne diseases such Fusarium wilt (Salam et al., 2002; Yetisir et al., 2003; Yetisir et al., 2007), to encourage nutrient uptake (Pulgar et al, 2000) and plant growth (Yamasaki et al., 1994; Yetisir et al., 2003; Karaca et al., 2012), but these goals have increased significantly over time. Today's grafting techniques have been employed to increase plant tolerance to salt (Romero et al., 1997; Yetisir and Uygur, 2010), high (Bulder et al., 1990) and low (Rivero et al., 2003) temperatures, improved nutrient uptake (Ruiz et al., 1997), better water use (Cohen and Naor, 2002), improved alkalinity tolerance (Colla et al., 2010), improved tolerance to excessive soil moisture (Yetisir et al., 2006) and bioactive properties of grafted watermelons (Davis and Perkins-Veazie, 2005; Turhan et al., 2012; Petropoulos et al., 2014; Aras et al., 2015).

Previous researches (Yetisir, 2001; Colla et al., 2010; Yetisir et al., 2013) indicated that rootstock has an impact on the absorption, transport, and use of plant nutrients. However, there are no published data on the impact of rootstocks on the plant nutrient content of various ground watermelon skin colors. Goal of this study was to look at how grafting affects the concentration of plant nutrients in watermelon plants which different rootstocks and ground skin colors lines..

MATERIAL AND METHOD

During the 2020 spring/summer growing season, this study was conducted in the greenhouses and labs of the Alata Horticultural Research Institute in Mersin, Türkiye.

Plant Materials

Rootstocks included Argentario (Syngenta Seed Company, Holland) from a commercial rootstock, 3335 from Turkish landraces of the *Lagenaria* spp. group, Nun9075 (Nunhems Seed Company, Holland) and TZ148 (HM Clause Seed Company, France) from commercial rootstocks of the *C. maxima*×*C. moschata* group, and PI 296341 from *Citrullus amarus*. Türkiye is a major producer of the hybrid rootstocks Nun9075 and TZ148. Türkiye has recently seen a decline in the use of gourd group rootstocks. The hybrid Argentario was chosen from the gourd family and was utilized for a while in Turkey. Additionally, 3335 lines generated by Yetişir et al. (2007) and Karaca et al. (2012) from the gourd group were employed. PI296341, a watermelon genotype resistant to races 0, 1, and 2, belongs to the *Citrullus amarus* genus. As scions, the Alata Horticultural Research Institute in Turkey's B1, B2, S1, and S2 pure lines were used. Striped rind pattern can be seen on the S1 and S2 pure lines. Dark green rind pattern can be found in the B1 and B2 pure lines (Figure 1). All pure lines were grafted onto each rootstock. Three duplicates in the randomized complete block design with twenty plants in each replicate made up the experimental design.

Figure 1. The lines used in the study (S1 and S2 striped rind pattern lines; B1 and B2 dark green rind pattern lines)

Seed sowing, grafting, and transplanting

Seed sowing for all scions and rootstocks were started on 30th December 2020. In Antalya Seedling Company, the grafting was done using the splice/one cotyledon grafting technique. When the rootstock and cotyledons first genuine leaf start to form, grafted is carried out. The growing tip and cotyledon are clipped. In order to remove one cotyledon and its growing tip, the seedling is cut obliquely from the base of one cotyledon to 0.8–1.0 cm below the other cotyledon. An angle of 35° to 45° should be used when cutting the hypocotyl of the scion, with the length matching that of the rootstock (Davis et al., 2008; Bie et al., 2017). The grafting clip is used to secure the scion to the rootstock. Before being transferred to a greenhouse maintained at 21 °C to 30 °C or until the joint had healed, the grafted plants were housed in a dark environment at 25°C and 100% humidity for three days. On March 6, 2020, all seedlings were planted at 36°37'50.73"N, 34°20'43.68"E, and 4 meters above sea level in various polyethylene covered greenhouses at the Alata Horticultural Research Institute, with a 1.5 m between and 0.4 m within plant distances. By suspending plants from a rope and eliminating their secondary axes, plants were grown on a single stem.

Device called hobo were placed in greenhouses to collect climate data. Table 1 lists the minimum, maximum, average, and relative humidity readings for each month. March saw both the greatest (46.4°C) and the lowest (4.2°C) temperatures. The maximum relative humidity (97.5%) and the lowest (23.1%) were measured in terms of relative humidity, respectively, in March and May.

Table 1. Climate values during the trial in greenhouse

Climate Factor		March	April	May	June	July
Temperature (°C)	Minimum	4.2	7.5	10.5	12.9	22.3
	Maximum	46.4	33.4	44.6	41.2	40.5
	Average	19.9	19.4	23.9	26.4	29.9
Relative humidity (%)	Minimum	25.5	24.0	23.1	33.3	41.9
	Maximum	97.5	72.4	97.2	97.0	89.6
	Average	71.4	72.4	67.0	71.0	70.8

A drip irrigation system was used for the watering and fertilization. The irrigation system began with the planting of seedlings of all the accessions utilized in this study, and it was continued as needed based on the greenhouse climate. Before the experiment, the soil of old greenhouses was analyzed. The soil had a loamy texture, was highly calcareous, had a normal salinity, was alkaline, had weak inorganic compounds, and had little potassium to support a significant amount of phosphorus (Table 2). According to the findings of the soil study, pure fertilizers in the amounts of 140–160 kg N/ha, 80–100 kg P_2O_5/ha, and 60–80 kg K_2O/ha were used (Gucdemir, 2012). Drip irrigation was used to apply fertilizers. By separating the watermelon into three sections according to the three stages of growth, nitrogen, phosphorus, and potassium are provided. Since phosphorus fixation is high in calcareous soils, phosphorus was divided into the experimental area. Up to the first female blossom, the first stage is defined. The second phase spans the time between the points at which the first female bloom appears and the time when the fruits are the size of an apple. The third stage includes the time between the fruits' apple-size development and harvest. Regular pesticide applications for identified illnesses and pests were made, and mechanical weeding and trimming were also carried out.

Table 2. Analysis of the greenhouse's soil

Analyzes	Limit Values	Analysis Results (0-30 cm)
Texture (100 g/ml)	30-50	34.00 (loamy)
Total calcitic ($CaCO_3$ %)	5-15	27.20 (high calcareous)
Salinity E.C. ds/m (25 °C)	0-0.8	0.85 (optimum)
Organic matter (%)	3-4	2.20 (deficient)
pH 1: 2,5	6.0-7.0	7.66 (alkaline)
Available potassium (mg/kg)	244-300	54.70 (very low)
Receivable phosphorus (mg/kg)	20-40	34.10 (optimum)

Statistical analysis

The JMP 7.0 statistics program's (v7.00, SAS Institute Inc., NC 27513-2414, USA) Tukey test according to random blocks trial design was used for the statistical analysis, with a significance threshold of $P \leq 0.05$. After applying angle transformation to percentage data, statistical analyses were carried out.

RESULTS

In terms of nitrogen, the highest value among rootstocks was taken from Argentario (2.58%), and the lowest value was taken from TZ148 (2.40%). In terms of lines, the highest value was obtained from line S1 (2.60%) and the lowest value was obtained from line B2 (2.43%). In terms of interaction, the highest value was obtained from line S2 grafted on PI296341 (2.85%), and the lowest value was obtained from line S2 grafted on TZ148 rootstock (2.20%) (Table 3). Nitrogen (N) is the element that plants require the most. N, an essential component of proteins, nucleic acids, chlorophyll, co-enzymes, phytohormones, and secondary metabolites, makes up about 1-5% of the total dry matter in plants (Hawkesford et al., 2012). One of the most frequent issues with plant nutrients for the production of watermelons is nitrogen deficit. Any time during the growing season, n deficits can have an impact on crop productivity and quality (Doerge et al., 1991). Nitrogen deficiency causes plants to shrink and have lighter-green leaves than typical. This color effect is brought on by the decreased chlorophyll concentration (Hawkesford et al., 2012). Chlorosis brought on by a lack of N often begins in the older leaves and spreads as N is remobilized to the younger leaves. According to Tucker (1984); Taiz and Zeiger (2006); crops deficient in N seem light green or even yellow.

Table 3. The effect of grafting different lines on different rootstocks on the nitrogen element content in the leaf(%)*

Rootstocks	Pure Lines				
	B1	B2	S1	S2	Average
NUN9075	2.55 abc	2.37 abc	2.83 a	2.40 abc	2.54 AB
TZ148	2.65 abc	2.42 abc	2.32 bc	2.20 c	2.40 B
Argentario	2.50 abc	2.42 abc	2.78 ab	2.63 abc	2.58 A
3335	2.40 abc	2.32 bc	2.73 ab	2.8 ab	2.56 AB
PI296341	2.45 abc	2.63 abc	2.32 bc	2.85 a	2.56 AB
Average	2.51 AB	2.43 B	2.60 A	2.58 AB	
CV: 3.02					
	Rootstocks	Lines	Rootstock×Line		
Prob>f	0.0334	0.0329	<.0001		

* Angle transformation was applied to the percentage values and statistical analyses were performed after that

In terms of phosphorus, there was no statistically significant difference between rootstocks, and between lines. In terms of interaction, the highest value was obtained from line B1 (0.30%) grafted on TZ148, and the lowest value was obtained from line S1 (0.24%) grafted on PI296341 rootstock (Table 4). Since it is necessary for the transmission and storage of energy during cell metabolism (Jin et al., 2006; Amtmann and Blatt, 2009), phosphorus (P) is an important macronutrient for plants (Akhtar et al., 2009; Cetner et al., 2020). A necessary ingredient for effective fruit set and fruit growth, particularly from flowering through final fruit formation, is phosphorus. Due to increased anthocyanin synthesis, plants growing in P-deficient soil frequently appear crimson (Marschner, 1995). In addition to developing red and purple colours, plants with low amounts of phosphorus usually have darker green leaves and stems (Sanchez, 2007).

Table 4. The effect of grafting different lines on different rootstocks on the phosphorus element content in the leaf (%)*

Rootstocks	Pure Lines				
	B1	B2	S1	S2	Average
NUN9075	0.27 a-d	0.25 cde	0.28 abc	0.24 de	0.26
TZ148	0.30 a	0.25 b-e	0.25 b-e	0.24 de	0.26
Argentario	0.26 b-e	0.26 a-e	0.28 ab	0.25 b-e	0.26
3335	0.26 b-e	0.24 de	0.28 ab	0.28 ab	0.27
PI296341	0.25 b-e	0.28 ab	0.24 e	0.27 a-e	0.26
Average	0.27	0.26	0.27	0.26	
CV: 3.88					
	Rootstocks	Lines	Rootstock×Line		
Prob>f	0.9217	0.3969	0.0038		

* Angle transformation was applied to the percentage values and statistical analyses were performed after that

Among the rootstocks, the highest values for potassium were obtained from Argentario (2.83%) and NUN9075 (2.82%), while the lowest values were obtained from 3335 (2.45%), TZ148 (2.56%) and PI296341 (2.64%). In terms of lines, the highest values were obtained from line S1 (2.88%) and line B1 (2.81%), and the lowest value was obtained from line B2 (2.37%). In terms of interaction, the highest value was obtained from line B1 (3.30%) grafted on PI296341, and the lowest value was obtained from line B2 (1.22%) grafted on PI296341 rootstock (Table 5). According to Schachtman and Liu (1999), K is an essential component for plant growth and development. Osmoregulation, photosynthesis, enzyme activation, the synthesis of carbohydrates, nucleic acids, and proteins, as well as the regulation of water status are among the critical processes it plays a role in in plant cells (Mengel and Kirkby, 2001). K also aids in the control of plant diseases and increases drought, heat, and cold resistance (Qian et al., 1997; Fageria, 2009; Rowland et al., 2010). The earliest indications of a K deficit are a decrease in plant growth rate (leading in stunted growth) and darker-than-normal leaf color. More glaring defects start to emerge as the plant ages. The symptoms begin at the distal end (tip) of the leaf. The base of the leaf is typically remains a dark green color (Tiwari, 2005).

Table 5. The effect of grafting different lines on different rootstocks on the potassium element content in the leaf (%)*

Rootstocks	Pure Lines				
	B1	B2	S1	S2	Average
NUN9075	3.12 ab	2.46 cde	3.11 ab	2.60 b-e	2.82 A
TZ148	2.48 cde	2.77 a-d	2.79 abc	2.20 de	2.56 B
Argentario	2.48 cde	2.88 abc	2.89 abc	3.06 abc	2.83 A
3335	2.66 b-e	2.54 b-e	2.47 cde	2.15 de	2.45 B
PI296341	3.30 a	1.22 f	3.17 ab	2.86 abc	2.64 B
Average	2.81 A	2.37 C	2.88 A	2.57 B	
CV: 3.76					
	Rootstocks	Lines	Rootstock×Line		
Prob>f	<.0001	<.0001	<.0001		

*Angle transformation was applied to the percentage values and statistical analyses were performed after that

In terms of calcium content, the lowest value among rootstocks was obtained from TZ148 (2.98), while other rootstocks took the highest values and took place in the same group. In terms of lines, while line S2 (2.99%) had the lowest value, the other lines had the highest values and were in the same group. In terms of interaction, the highest values were obtained from line B2 (3.36%) grafted on 335, line B1 (3.32%) grafted on Argentario rootstock, line B2 grafted on TZ148 rootstock and line B1 (3.28%) grafted on NUN9075 rootstock, while the lowest values were obtained from line no. line S2 (2.58%) was grafted onto TZ148 rootstock (Table 6). Calcium is necessary for life to exist. Because it acts as a signal for numerous cell functions, such as the creation of new cell walls in the mitotic spindle during cell division, it is very important to the physiology of cells (Taiz and Zeiger, 2006; Shao et al., 2008). Weak stems, early flower dehiscence, necrosis of fruit and tubers, chlorosis of the youngest leaves, deformities, necrosis of fruit and tubers, necrosis of shoot apices, and failure to set seed are all symptoms of cacium deficiency in various plants (Bould et al., 1983; Bergmann, 1992; Pilbeam and Morley, 2007).

Table 6. The effect of grafting different lines on different rootstocks on the calcium element content in the leaf (%)*

Rootstocks	Pure Lines				
	B1	B2	S1	S2	Average
NUN9075	3.28 a	3.24 ab	3.07 abc	3.17 abc	3.19 A
TZ148	3.21 abc	3.29 a	2.86 cd	2.58 d	2.98 B
Argentario	3.32 a	3.15 abc	3.24 ab	3.16 abc	3.22 A
3335	3.16 abc	3.36 a	3.26 ab	2.90 cd	3.17 A
PI296341	2.99 abc	3.16 abc	3.21 abc	3.12 abc	3.12 A
Average	3.19 A	3.24 A	3.13 A	2.99 B	
CV: 1.93					
	Rootstocks	Lines	Rootstock×Line		
Prob>f	0.0001	<.0001	<.0001		

*Angle transformation was applied to the percentage values and statistical analyses were performed after that

Regarding magnesium content, the highest value among rootstocks was obtained from NUN9075 (0.39%) and the lowest value was obtained from PI296341 (0.32%). Among the lines, line B2 exhibited the lowest value, whereas the other lines exhibited higher values and belonged to the same group. In terms of interaction, the highest value was obtained from line B1 (0.41%) grafted on NUN9075, and the lowest value was obtained from line B2 (0.16%) grafted on PI296341 rootstock (Table 7). Magnesium (Mg), a crucial macronutrient, is required in large quantities by plants in order to grow and reproduce (Gransee and Führs, 2013; Cakmak and Yazici, 2010). The biological framework for the uptake of solar energy and the subsequent production of oxygen and carbohydrates is established by the role of magnesium as the core atom in chlorophyll molecules (Grzebisz, 2015). According to Amtmann and Blatt (2009), magnesium also plays a role in energy conversion and preservation.

Table 7. The effect of grafting different lines on different rootstocks on the magnesium element content in the leaf (%)*

Rootstocks	Pure Lines				
	B1	B2	S1	S2	Average
NUN9075	0.41 a	0.39 abc	0.37 abc	0.40 ab	0.39 A
TZ148	0.36 a-d	0.39 abc	0.33 bcd	0.29 d	0.34 B
Argentario	0.36 a-d	0.34 a-d	0.35 a-d	0.35 a-d	0.35 B
3335	0.34 a-d	0.34 a-d	0.33 bcd	0.32 cd	0.33 BC
PI296341	0.36 a-d	0.16 e	0.39 abc	0.37 abc	0.32 C
Average	0.36 A	0.33 B	0.35 A	0.35 A	
CV: 3.40					
	Rootstocks	Lines	Rootstock×Line		
Prob>f	<.0001	<.0001	<.0001		

* Angle transformation was applied to the percentage values and statistical analyses were performed after that

In terms of iron, the highest values among rootstocks were obtained from 3335 (81.73 ppm), Argentario (78.46 ppm), TZ148 (75.42 ppm) and the lowest value was obtained from PI296341 (58.79 ppm). In terms of iron, the highest values among lines was obtained from B1 (84.94 ppm) and the lowest value were obtained from S2 (63.67 ppm) and S1 (67.71). In terms of interaction, the highest value was obtained from line B2 (120.84 ppm) grafted on 3335, and the lowest value was obtained from line B2 (23.29 ppm) grafted on PI296341 rootstock (Table 8).

Table 8. The effect of grafting different lines on different rootstocks on the iron element content in the leaf (ppm)

Rootstocks	Pure Lines				
	B1	B2	S1	S2	Average
NUN9075	77.98 a-d	59.51 cde	70.98 bcd	70.80 bcd	69.82 AB
TZ148	101.50 abc	87.27 a-d	53.72 de	59.21 cde	75.42 A
Argentario	104.11 ab	84.37 a-d	64.90 b-e	60.45 b-e	78.46 A
3335	69.79 bcd	120.84 a	74.99 bcd	61.32 b-e	81.73 A
PI296341	71.33 bcd	23.29 e	73.96 bcd	66.58 b-e	58.79 B
Average	84.94 A	75.06 AB	67.71 B	63.67 B	
CV: 19.39					
	Rootstocks	Lines	Rootstock×Line		
Prob>f	0.0029	0.0011	<.0001		

Regarding to zinc element, the lowest value among rootstocks was obtained from 3335 (17.50 ppm) rootstock, while other rootstocks took the highest values and took place in the same group. There was no statistically significant difference between the lines. In terms of interaction, the highest value is from line B2 grafted on TZ148 (40.03 ppm), the lowest values were obtained from line B2 grafted on nun9075 (13.46 ppm), line S1 grafted on NUN9075 (16.17 ppm), line S2 grafted on NUN9075 (16.24 ppm), line S2 grafted on 3335 (16.50 ppm), line B1 grafted on TZ148 (18.00 ppm), and line B2 grafted on 3335 (18.62 ppm) (Table 9). Zinc (Zn) is essential for the structural and functional integrity of many macromolecules, including hundreds of enzymes (Alloway, 2009; Broadley et al., 2012; Coleman, 1998). Auxin, protein, and carbohydrate metabolism are only a few of the processes that Zn is crucial for (Marschner, 1995; Reddy, 2006; Broadley et al., 2007).

Table 9. The effect of grafting different lines on different rootstocks on the zinc element content in the leaf (ppm)

Rootstocks	Pure Lines				
	B1	**B2**	**S1**	**S2**	**Average**
NUN9075	23.79 bcd	40.03 a	16.17 d	16.24 d	24.06 A
TZ148	18.00 d	21.65 bcd	30.08 abc	31.42 ab	25.29 A
Argentario	32.32 ab	13.46 d	30.56 ab	29.93 abc	26.57 A
3335	22.27 bcd	18.62 d	12.61 cd	16.50 d	17.50 B
PI296341	18.72 cd	30.93 ab	30.65 ab	23.27 bcd	25.89 A
Average	23.02	24.94	24.01	23.47	
CV: 15.96					
	Rootstocks	Lines	Rootstock×Line		
Prob>f	<.0001	0.5554	<.0001		

In terms of manganese, the highest value was taken from 3335 (58.80) rootstock and the lowest value was obtained from TZ148 (32.60) rootstock. Among the lines, the highest value was obtained from line B1 (52.01), and the lowest value was obtained from line S2. In terms of interaction, the highest value was obtained from line B2 (81.44) grafted on 3335, and the lowest value was obtained from line B2 (10.64) grafted on PI296341 (Table 10). Typically, plants don't exhibit signs of Mn deficiency until their growth and productivity are severely stunted. Diffuse interveinal chlorosis on young, expanded leaf blades is a frequent manifestation of the foliar symptoms of Mn insufficiency (Memon et al., 1981). Significant necrotic patches or streaks may also emerge on the leaves of plants with severe deficits. Symptoms typically start out on the center leaves (Humphries et al., 2007).

Table 10. The effect of grafting different lines on different rootstocks on the manganese element content in the leaf (ppm)

Rootstocks	Pure Lines				
	B1	**B2**	**S1**	**S2**	**Average**
NUN9075	46.14 d-h	35.16 hij	30.22 ij	35.52 g-j	36.76 CD
TZ148	41.52 e-i	37.69 f-i	25.21 j	25.99 j	32.60 D
Argentario	61.19 bc	53.48 bcd	48.40 def	46.78 d-g	52.46 B
3335	60.22 bc	81.44 a	61.90 bc	31.64 ij	58.80 A
PI296341	50.99 cde	10.64 k	62.84 b	39.67 e-i	41.04 C
Average	52.01 A	43.68 B	45.71 B	35.92 C	
CV: 8.38					
	Rootstocks	Lines	Rootstock×Line		
Prob>f	<.0001	<.0001	<.0001		

DISCUSSION and CONCLUSION

In our study, NUN9075 and Argentario rootstocks generally came to the fore in terms of elements, while B1 and S1 lines came to the fore from the lines. In terms of rootstock×scion interaction, 3335×B2 interaction came to the fore in terms of magnesium, calcium and iron, while there was no rootstock×scion combination that came directly to the fore in terms of other elements.

This outcome demonstrates the critical impact of root system vigor on vegetative development (Chouka and Jebari, 1999). This could be explained by varying plant vigor in various rootstock/scion combinations (Leonardi and Giuffrida, 2006) because of a robust root system that is frequently capable of absorbing water and nutrients more efficiently than scion roots (Ruiz et al., 1997; Rivero et al., 2003), or by changes in endogenous hormone levels (Zijlstra et al., 1994). Although scion genotypes were discovered to be more successful in modifying leaf mineral content, considerable rootstock influence on leaf mineral content was not identified in grafted fruit plants (Chaplin et al., 1980). One of the main reasons for the widespread use of rootstocks is to improve the uptake of water and minerals, which is how the rootstock's impact on the mineral composition of aerial plant parts was primarily explained by physical characteristics of the root system, such as lateral and vertical development (Yetisir et al, 2013). Increased use of N grafted melon (Ruiz et al., 1997) and watermelon (Colla et al., 2010) was recorded, and it was suggested that the strength of the scion and rootstock played a significant influence in the uptake and transfer of nutrients in grafted fruit trees (Tagliavani et al., 1993). The nitrogen content in grafted Solanaceous crops (tomato and pepper) plants did not change significantly among the graft combinations (tomato/tomato, tomato/pepper, pepper/tomato, and pepper/pepper) (Kawaguchi et al., 2008). Under better alkalinity circumstances, grafted watermelon onto several rootstocks showed no discernible variation in nitrogen status (Colla et al., 2010). The amount of N in our leaf samples was sufficient (2.5-3.5%) (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017). In our study, N content showed statistical differences between rootstocks and lines. According to Kawaguchi et al. (2008), rootstocks play a significant part in the uptake and transfer of P in solanaceous plants. The rootstock × scion interaction had a positive impact on the P content of the grafted melon plants, as shown by Ruiz et al. (1997). Under salt (Uygur, 2009), alkalinity (Colla et al., 2010), and heavy metal (Rouphael et al., 2008) stress conditions, grafted watermelon showed greater leaf P content. The amount of P in the leaf samples was sufficient (0.3-0.7%) (Reuter and Robinson, 1986). P content there was no statistically significant difference between rootstocks, and between lines. Some authors found similarly that (Leonardi and Giuffrida, 2006; Qi et al., 2006; Goreta et al., 2008; Zhu et al., 2008; Ceylan et al., 2018) to our study, grafting increases K absorption, while Ruiz et al. (1997) reported that it decreased. In the leaf samples, the amount of K was generally sufficient (2.2-5.5%) (Reuter and Robinson, 1986).

Ruiz et al. (1997) and Ceylan et al. (2018) did not find a significant effect on the leaf Ca and Mg contents of varieties and rootstocks. But according to Colla et al. (2010), Ca and Mg contents were influenced by the scion and rootstocks, and the grafted plant onto pumpkin rootstocks had a higher Mg content than the rootstocks of bottle gourds. In our study, Ca content (2.2-5.5%) was sufficient, while Mg content (0.4-1.2%) was found to be slightly low in general (Reuter and Robinson, 1986).

According to Savvas et al. (2010), grafting onto certain rootstocks may improve the efficiency of macronutrient absorption and/or use by plants. Ceylan et al., (2018) found significant differences in terms of Fe content both in terms of varieties and in terms of rootstocks. According to Savvas et al. (2009), grafted tomatoes collected less Cu and Fe. The total amount of microelements decreased, according to Huang et al. (2010), although Fe, Mn, Cu, and Zn did not differ significantly from ungrafted control plants. It has been suggested that phytosiderophores and the acidifying chemicals altering the availability of these elements in the rhizosphere may be the cause of the variations between rootstocks with regard to the uptake of Fe and Cu (Mench and Farques 1994). According to Ceylan et al., (2018), while the Zn content of leaves showed a significant difference between rootstocks, no difference was found in terms of Mn content. The rootstock's capacity to reject excessive micronutrients was hypothesized to be the cause of the decrease in microelement in grafted plants (Rouphael et al., 2008; Huang et al., 2010). The rootstock and scion features affect the mineral composition of the plants, albeit the effect of the scion and rootstocks may vary depending on the element's availability and the environment (Martínez-Ballesta et al., 2010). According to Ruiz et al. (1997) and Uygur and Yetişir (2009), grafted plants grew more successfully than non-grafted ones, and the mineral content of the leaves of sweet melons and watermelons was significantly affected. In our study, Fe (120-335 ppm) and Mn (60-240 ppm) contents were found to be low, while Zn contents (20-60 ppm) was generally sufficient (Reuter and Robinson, 1986).

As a result, there was no direct prominence in plant nutrient intake in terms of pumpkin and bottle gourd rootstocks and dark or striped rind pattern lines. A scion/rootstock combination did not come into prominence directly. Different combinations for each element came to the fore. Any deficiency symptoms were not seen, and the nutritional concentration ranges of the measured components were within the standard or normal levels stated for watermelon however iron element level was low (Reuter et al., 1986; Egel et al., 2017). Both rootstocks and scions had a considerable impact on the concentration of plant nutrients in the leaf. Under certain climatic and geographic conditions, rootstock/scion combinations should be carefully chosen, and cultural activities (plant density, fertilization, irrigation, and harvest) should be carried out appropriately depending on the rootstocks/scion combination (Yetisir et al., 2013).

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