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Investigation of the Relationship between Plant Nutrient Elements and Yellow Color Formation in the Leaf Veins of Watermelon

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Abstract

While there is no yellowing in the leaf veins of some watermelons during the seedling stage, veins start to turn yellow after the plant starts to grow, and veins become more yellow as the plant grows. The aim of this study is to investigate whether this yellowing of leaf veins is related to plant nutrients. This study was carried out at the Alata Horticultural Research Institute in Mersin, Turkey, during the spring and summer growing seasons of 2016 and 2018. The S24 line with yellow veins and the Crimson Sweet variety were used as controls. Samples were taken from the leaves below and above the female flower during the female flower period and from the leaves below and above the fruit when the fruits reached the size of a grapefruit. Nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), and manganese (Mn) elements were examined in leaf analysis. When the places where the leaf samples were taken and the years were evaluated together, there was not a variety that came to the forefront in terms of nitrogen, phosphorus, potassium, calcium, magnesium, and zinc. However, in general, the iron and manganese contents of the S24 line were found to be higher than the control. In line with these results, it is not possible to say that there is a relationship between the yellowing of leaf veins and plant nutrients.

Key words Watermelon, yellow color leaf veins, plant nutrient elements.

1. Introduction

A vegetable with a global production of 101.6 million tons, watermelon is very significant economically. China (60,1 million tons) is the world's greatest producer, followed by Türkiye (3.5 million tons), India (2.8 million tons), Iran (2.7 million tons), Algeria (2.3 million tons), Brasil (2.2 million tons), and other nations (FAOSTAT, 2020).

In some areas of Türkiye, watermelons have been farmed extensively for many years. A reduction in yield brought on by consecutive cropping and soil-borne infections, particularly fusarium, are one of the most important issues with watermelon cultivation. It is advised that watermelon not be produced in the fusarium contaminated field for at least five years in the

battle against fusarium (Messiaen, 1974). However, grafting weaker varieties onto stronger rootstocks might aid in the control of some soil-borne diseases and enhance production and quality (Lee, 1994; Oda, 1995; Yetisir et al., 2003). One of the goals of grafting in watermelon was to promote nutritional intake (Ruiz et al., 1997; Pulgar et al., 2000). Organic matter content, soil moisture, $CaCO_3$ levels, pH and biological properties of the soil affect plant nutrient uptake by plants (Korkmaz and Saltalı, 2012; Marschner, 2012). Greater than 30% of the agricultural lands in the world is made up of high pH soils (Chen and Barak, 1982). The majority of Turkish soils have low levels of organic matter and relatively high $CaCO_3$ content, which results in soils with a high pH (Erdal et al., 2006). Over 63% of agricultural areas in Türkiye have a pH level higher than 7.5, and 59% of soils have more than 5% $CaCO_3$ (Eyuboglu, 1999). Yellowing on the leaves can sometimes be due to plant nutrients (Turan and Horuz, 2012; Marschner, 2012) and sometimes genetic factors (Guner and Wehner, 2004). According to Warid and Abd-El-Hafez (1976), the yellow leaf (*Yl*) gene produces yellow leaves and is only marginally dominant over green leaves (Guner and Wehner, 2004). The first few nodes have light green cotyledons and leaves due to a delay in the formation of green leaves, but following leaves have a more usual green color. Even when the genotype is *dgdg*, the inhibitor of delayed green leaf (*i-dg*) restores the usual green color of the leaves (Rhodes, 1986). When plants are cultivated under short day environment, the juvenile albino *ja* gene results in decreased chlorophyll in seedling tissues, as well as in leaf edges and fruit rind (Zhang et al., 1996). Zhu et al. (2022) reported in their study to map and functionally verify the leaf yellowing genes in watermelon throughout the entire growth period that leaf yellowing is controlled by a single recessive gene. Xu et al. (2023), in the ethylmethanesulfonate mutagenesis population of the "703" watermelon variety, a chlorophyll-deficient mutant with yellow leaf (Yl2) color was identified, and the chlorophyll a, chlorophyll b and carotenoid contents in Yl2 leaves were lower than those in wild type (WT) leaves, and the chloroplasts in the leaves were identified. They reported that the ultrastructure revealed the disintegration of chloroplasts in Yl2. Although it is stated that some virus diseases can cause yellow leaf spots on watermelon (Venkataravanappa et al., 2020; Jailani et al., 2022; Iriarte et al., 2023), no virus disease that causes yellow veins as in our study has been found. While there is no yellowing in the leaf veins of some watermelons during the seedling stage, veins start to turn yellow after the plant starts to grow, and veins become more yellow as the plant grows (**Figure 1**). It is generally thought that yellowing of leaves may reduce plant photosynthesis and growth (Gao et al., 2016 ; Miao et al., 2016; Zhu

et al., 2022). The aim of this study is to investigate whether this yellowing of leaf veins is related to plant nutrients.

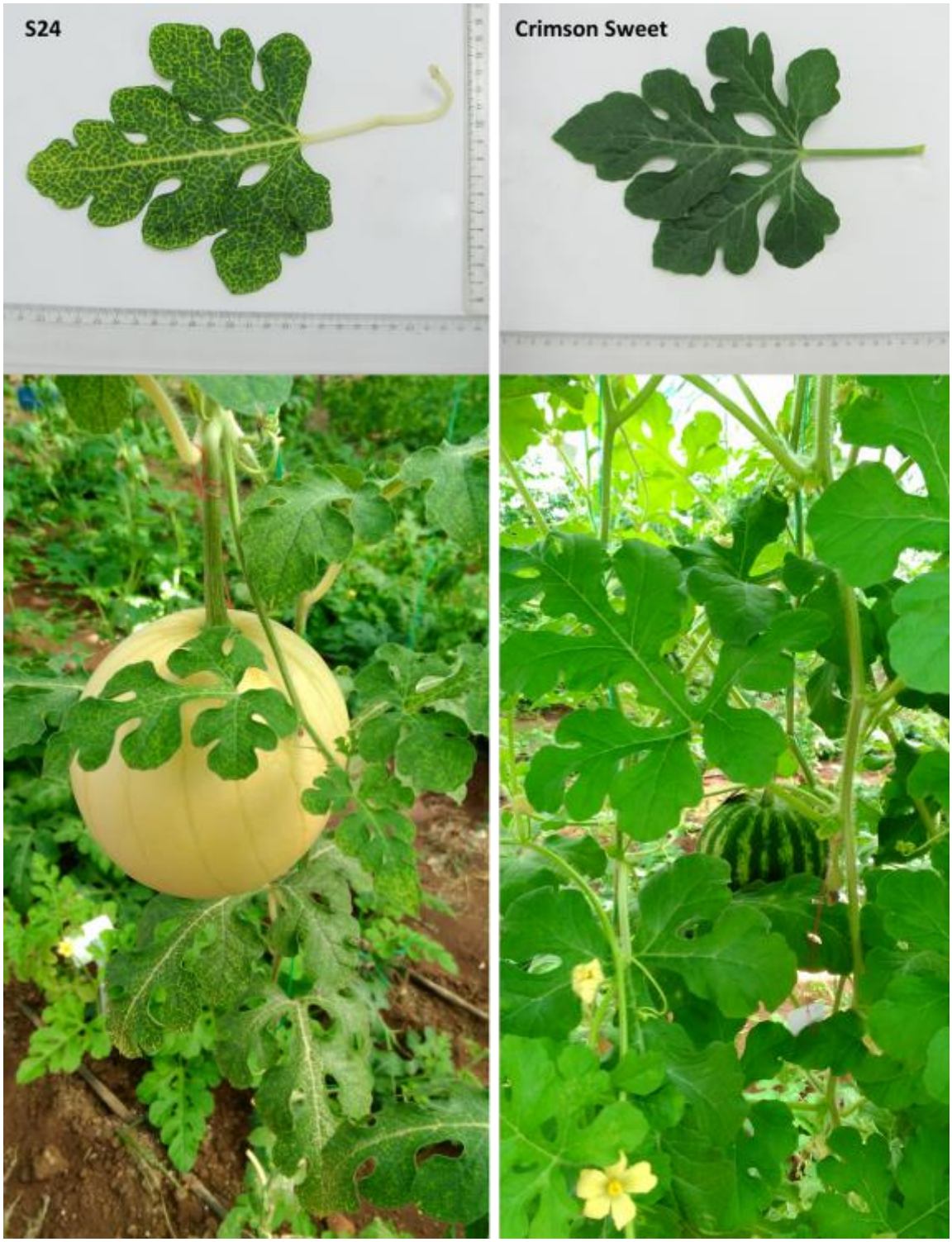

Figure 1. The S24 line and Crimson Sweet variety used in the study.

2. Material and Method

This study was carried out in the greenhouses and laboratories of the Alata Horticultural Research Institute in Mersin, Turkey, during the spring and summer growing seasons of 2016 and 2018. The S24 line with yellow veins leaves found in the Alata Horticultural Research Institute gene pool and the Crimson Sweet variety were used as a control (**Figure 1**). The fruit and leaf veins of S24 used in the experiment are a line with yellow. While there is no abnormality in the seedling stage, but veins start to turn yellow after the plant starts to grow, and veins become more yellow as the plant grows.

The seedlings were planted with a 1.5 m between and 0.4 m within plant distances in greenhouses on March 24 in 2016 at latitude 36°37'51.1"N 34°20'43.6"E and on April 24 in 2018 at latitude 36°37'49.2"N 34°20'41.6"E. Plants were grown on a single stem by being suspended on a rope and having their secondary axes removed.

The experiment was established according to a completely randomized block design with 3 replications and 10 plants per replication. Two periods were determined as the leaf removal period. The first was the female flower formation period, the second was the period when the fruits reached 11-12 cm size.

Samples were taken from leaves below (4^{th} and 6^{th} leaves apart from the soil level in plants) and above (10^{th} and 12^{th} leaves apart from the soil level in plants) female flower during the female flower period, and from the leaves below (8^{th} and 9^{th} leaves from the soil level in plants) and above (14^{th} and 16^{th} leaves from the soil level in plants) the fruit when the fruits reached the size of a grapefruit.

Climatic data (monthly minimum, maximum and average temperature and relative humidity values) for both years in Table 1. In 2016, the highest temperatures were seen in May (31.3 ^{o}C). In terms of relative humidity, the highest value was taken in May (89.3%) and the lowest value was taken in April (37.0%). In 2018, the highest value was taken in May (34.7 ^{o}C) and the lowest (6.7 ^{o}C) temperatures were seen in March. In terms of relative humidity, the highest (86.4%) relative humidity was recorded in April, and the lowest (39.6%) relative humidity was recorded in May (**Table 1**).

Table 1. Climate values during the trial months in 2016 and 2018.

Year	Climate Factor		March	April	May
2016	Temperature (^{o}C)	Minimum	5.2	7.1	10.0
		Maximum	25.7	30.9	31.3
		Average	14.9	18.4	20.3
	Relative humidity (%)	Minimum	37.9	37.0	46.1
		Maximum	77.4	78.6	89.3
		Average	62.8	62.7	73.0
2018	Temperature (^{o}C)	Minimum	6.7	7.2	12.7
		Maximum	27.3	31.9	34.7
		Average	15.6	18.1	22.9

	Minimum	47.7	41.7	39.6
Relative humidity (%)	Maximum	85.4	86.4	82.1
	Average	72.8	69.7	67.3

A drip irrigation system was used for the watering and fertilizing. 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 environment. During the experiment, the soil of old greenhouses was analyzed. During both years of the study, soil was loamy, calcareous, optimum salty, weak inorganic substances, alkali, very poor in potassium and optimum phosphorus (**Table 2**).

Table 2. Soil analysis results for both years.

Analyzes	**Limit Values**	**Analysis Results (0-30 cm)**	
		2016	**2018**
Texture (100 g/ml)	30-50	38.00 (loamy)	29.00 (loamy)
Total Calcitic ($CaCO_3$ %)	5-15	28.20 (high calcareous)	27.90 (high calcareous)
Salinity E.C. ds/m (25 ºC)	0-0.8	0.73 (optimum)	0.94 (optimum)
Organic matter (%)	3-4	2.62 (deficient)	2.90 (deficient)
pH 1: 2,5	6.0-7.0	7.58 (slightly alkaline)	7.49 (slightly alkaline)
Available potassium (mg/kg)	244-300	69.80 (very low)	122.80 (very low)
Receivable phosphorus (mg/kg)	20-40	32.30 (optimum)	28.10 (optimum)

According to the findings of the soil study, fertilizers were applied in the amounts of 60-80 kg K_2O/ha, 80-100 kg P_2O_5/ha, and 140-160 kg N/ha as pure substances (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. Up to the first female blossom, the first stage was defined. The second phase spanned the time between the point at which the first female bloom appears and the time when the fruits were the size of 7-8 cm. The third stage included the time between the fruits' apple-size development and harvest. Regular pesticide applications were made for disease and pests that were seen, and mechanical weeding and trimming were also carried out.

2.1. Plant Nutrient Analysis

Nitrogen (N) determination in dried and ground leaf samples was made according to the modified Kjheldahl method (Kacar, 1972). As reported by Kacar (1972), phosphorus (P) was determined colorimetrically according to the vanadomolybdophosphoric yellow color method in the filters obtained by the nitric-perchloric acid mixture (4:1) wet burning method. Potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn) and zinc (Zn); It was determined with the help of Inductively Coupled Plasma (ICP) in the filters obtained

from the leaf samples as a result of wet burning. Results of K, Ca, and Mg are given as percentage (%) in dry matter; for Fe, Zn and Mn, it is given as mg/kg of dry matter.

2.2. Statistical analysis

Statistical analyzes were performed using the JMP 7.0 statistical program (v7.00, SAS Institute Inc., NC 27513-2414, USA) with LS Means Differences Student's t test, according to the randomized block trial design, at the P 0.05 significance level. Statistical analyzes were performed after angle transformation was applied to the percentage data.

3. Result and Discussion

The results related to macro-nutrient (N, P, K, Ca and Mg) contents of accessions were given in Table 3. The most needed element by plants is N. About 1-5% of the total plant dry matter is made up of N, which is a crucial component of proteins, nucleic acids, chlorophyll, co-enzymes, phytohormones, and secondary metabolites (Hawkesford et al., 2012).

In terms of N content, the differences in leaves sampled taken from below the female flower of the S24 and control plants in both years and average of two years were not statistically significant. N content of the leaves sampled above the female flower of control plants were higher than S24 plants that of the in both years and average of two years of the experiment. While the N content of the leaf samples taken from the below fruit and the above fruit was found to be insignificant in both control plants and S24 plants in 2016, the content of S24 plants was found to be significant compared to the control plants in 2018. While the N content of leaf samples taken from the below fruit was insignificant in terms of the average of two years, the content of S24 plants in leaf samples taken from the above fruit was significant compared to control plants. The N amounts in the samples taken in both years were close to sufficient limit values (2.5-4.5%) (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017) and were within these values. N deficiency is one of the most common plant nutrient problems for watermelon production. N deficiencies can affect crop yield and quality at any time during the growing season (Doerge et al., 1991). Lack of N causes plants to become smaller and have lighter-green leaves than usual. The reduced concentration of chlorophyll is what causes this color effect (Hawkesford et al., 2012). As N is remobilized to younger leaves, chlorosis brought on by N shortage usually starts in the older leaves. Crops lacking in N appear light green or even yellow (Tucker 1984; Taiz and Zeiger, 2006). Since the amount of N in leaf samples is mostly at a sufficient level, it is not considered to be a problem caused by N (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017).

In terms of P, no statistical difference was found in the leaf samples taken from the below female flower, the above female flower, the below fruit and the above fruit in both S24 and control plants in 2016. In 2018, while the P content of control plants was found to be significant compared to S24 in the leaf samples taken from the below female flower and above the female flower, the P content of S24 plants was higher than that of the control plants in the leaf samples taken from the below fruit and the above fruit. In terms of the average of the two years, the P content of the leaf samples taken from the above female flower was higher in S24 compared to the control plants, while there was no significant difference in terms of P content in the leaf samples taken from the below female flower, the below fruit and the above fruit. P is a significant macronutrient for plants since it is not only a component of vital substances (Akhtar et al., 2009; Cetner et al., 2020), but also because it is required for energy transmission and storage during cell metabolism (Jin et al., 2006; Amtmann and Blatt, 2009). P is an essential plant nutrient for good fruit set and fruit growth, mainly from flowering to final fruit formation. Almost all of the P values in the leaves were found to be insufficient (0.3-0.7%) below the cutoff values (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017). Plants grown in P-deficient soil grow slowly and frequently become scarlet from increased anthocyanin production (Marschner, 1995). Plants with low levels of P frequently have deeper green leaves and stems as well as the development of red and purple hues (Sanchez, 2007). The low amount of P in both years and in different regions of the sample suggests that P will not have an effect on the color difference.

In the leaf samples taken from the below female flower in 2016 and 2018 and from the above female flower in 2016, there was no statistical difference between S24 and the control plants in terms of K. In the leaf samples of control plants taken from the above female flower in 2018 and both from the below fruit and the above fruit in 2016 higher K values were obtained than S24 plants. However, K contents in the leaf samples taken from the below fruit and the above fruit were found to be higher at S24 compared to the control in 2018. While there was no statistical difference between S24 and control plants in terms of K in the average of both years in terms of leaf samples taken from the below female flower, above the female flower and the above fruit, the leaf samples taken from the below fruit had a higher K content in the control plants compared to S24. P is a nutrient needed for watermelon in greater amounts than nitrogen. K is a crucial nutrient for plant growth and development (Schachtman and Liu, 1999). It involves important processes in plant cells including osmoregulation, photosynthesis, enzyme activation, the production of carbohydrates, nucleic acids, and proteins, as well as the control of water status (Mengel and Kirkby, 2001). K also helps plant

disease control and resistance to heat, cold, and drought (Qian et al., 1997; Fageria, 2009; Rowland et al., 2010). The lowest leaves of the plant usually show the first signs of P deficiency. A drop in plant development rate (resulting in stunted growth) and darker-than-normal leaf color are the first signs of K deficiency. As the plant matures, more obvious deficiencies begin to show themselves. The distal end (tip) of the leaf is where symptoms first appear. Normally, the leaf's base is still dark green (Tiwari, 2005). In all of the samples taken in both years, the amount of K was insufficient below the limit values (2.5-3.7%) (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017).

In terms of Ca, there was no statistical difference between S24 and control in the leaf samples taken from the below female flower in 2018, from the above female flower in 2016, from the below fruit in 2018, from the above fruit in 2016 and 2018. Higher Ca values were obtained in leaves the below female flowers than control plants in 2016, while leaf samples taken from the above female flower in 2018 and the below fruit in 2016 were higher in S24 than control plants. While the Ca amounts in the leaf samples taken from the above fruit were found to be insignificant in terms of the average of both years, Ca was found to be higher than control plants taken from the above female flower, also higher in the leaf samples taken from the female flower and the below fruit in S24 plants. Ca content values obtained from the leaves of both S24 and control plants sampled above the female flower were found to be below the limit values (2.2-5.5%) (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017) range in 2016. Living things require Ca to function. It is particularly significant in the physiology of cells because it serves as a signal for a variety of cell processes, including the production of new cell walls in the mitotic spindle during cell division (Taiz and Zeiger, 2006; Shao et al., 2008). Ca deficiency results in wilting, deformity, necrosis of fruit and tubers, chlorosis of the youngest leaves and shoot apices, weak stems, early flower dehiscence, and failure to set seed in some plants (Bould et al., 1983; Bergmann, 1992; Pilbeam and Morley, 2007). Ca values of all samples except these samples (Leaf sampling location, the below female flower, the above female flower, the below fruit and the above fruit) were within the sufficient limit values (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017).

In terms of Mg, there was no statistical difference in leaf samples taken from the above female flower and the above fruit in 2016. In the leaf samples taken from the below female flower in 2016, higher results were obtained than the control compared to S24. However, Mg content in leaf samples taken from the below fruit in 2016 and the below female flower, the above female flower, the below fruit, and the above fruit in 2018 was higher in S24 compared to the control. In terms of the average data of two years, the Mg content of the leaf samples

taken from S24 was higher than that of the control plants in the leaf samples taken from above the female flower and the below fruit, while no statistical difference was found in the leaf samples taken from below the female flower and the above fruit. Except for the S24 and control plants the above female flower leaf samples in 2016, the Mg contents of the leaves from different regions were within the sufficient limit values (0.4-1.2%)(Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017). In order to develop and reproduce, plants need a lot of Mg, an important macronutrient (Gransee and Führs, 2013; Cakmak and Yazici 2010). Mg serves as the core atom in chlorophyll molecules, which in turn establishes a biological foundation for the absorption of solar energy and the subsequent creation of oxygen and carbohydrates (Grzebisz, 2015). Mg also contributes to the conversion and preservation of energy (Amtmann and Blatt, 2009). Growth sluggishness and interveinal chlorosis on older leaves are typical signs of Mg shortage (Cakmak and Yazici, 2010). Chlorosis often starts in older leaves and spreads to younger leaves (Cakmak and Kirkby, 2008; Farhat et al., 2014).

Table 3. Macro element contents of leaves taken from different parts of the plant.

LSL	Variety	N (%)*			P (%)*			K (%)*		
		2016	2018	Av.	2016	2018	Av.	2016	2018	Av.
BFF	S24	2.38	3.47	2.93	0.18	0.18 b	0.18	1.50	1.20	1.35
	Control	2.77	3.52	3.14	0.15	0.22 a	0.19	1.52	1.26	1.39
	CV	0.04	0.02	10.03	0.05	0.02	2.89	0.03	0.02	1.75
	Prob > F	0.0702	0.6361	0.0778	0.0618	0.0020	0.7288	0.8656	0.1596	0.4527
AFF	S24	2.58 b	3.37 b	2.98 b	0.18	0.25 b	0.22 b	1.70	1.46 b	1.58
	Control	3.52 a	4.09 a	3.81 a	0.23	0.34 a	0.28 a	1.66	1.62 a	1.64
	CV	0.04	0.02	1.78	0.05	0.02	2.61	0.02	0.02	1.05
	Prob > F	0.0084	0.0020	0.0134	0.0643	0.0004	0.0249	0.4447	0.0187	0.1530
BF	S24	2.55	3.37 a	2.96	0.18	0.15 a	0.15	0.81 b	0.87 a	0.84 b
	Control	2.82	2.89 b	2.85	0.18	0.14 b	0.16	1.37 a	0.77 b	1.07 a
	CV	0.16	0.02	3.24	0.05	0.02	4.58	0.03	0.02	3.23
	Prob > F	0.6307	0.0047	0.0115	0.0618	0.0188	0.0115	0.0006	0.0106	0.0115
AF	S24	2.30	4.00 a	3.15 a	0.23	0.20 a	0.21	1.05 b	1.32 a	1.19
	Control	2.43	3.32 b	2.88 b	0.18	0.17 b	0.18	1.36 a	1.07 b	1.21
	CV	0.16	0.02	3.23	0.05	0.02	3.23	0.05	0.02	3.23
	Prob > F	0.8978	0.0024	0.0115	0.0643	0.0044	0.0115	0.0320	0.0015	0.0115

* Angle transformation was applied to the percentage values.(LSL: Leaf sampling location, BFF: Below female flower, AFF: Above female flower, BF: Below fruit, AF: Above fruit)

Table 3 – cont.

LSL	Variety	Ca (%)*			Mg (%)*		
		2016	2018	Av.	2016	2018	Av.
BFF	S24	4.26 b	3.70	3.98 b	0.70 b	0.77 a	0.73
	Control	5.12 a	3.71	4.42 a	0.81 a	0.70 b	0.76
	CV	0.03	0.02	0.36	0.02	0.02	0.72
	Prob > F	0.0243	0.9416	0.0032	0.0088	0.0270	0.1180
AFF	S24	1.27	3.31 a	2.29 a	0.34	0.64 a	0.49 a
	Control	0.95	2.37 b	1.66 b	0.32	0.40 b	0.36 b
	CV	0.11	0.02	2.45	0.04	0.02	1.56
	Prob > F	0.1974	0.0002	0.0152	0.4351	<.0001	0.0068
BF	S24	7.20 a	3.91	5.55 a	0.95 a	0.87 a	0.90 a
	Control	3.82 b	3.92	3.87 b	0.60 b	0.77 b	0.68 b

	CV	0.11	0.02	3.23	0.08	0.02	3.23
	Prob > F	0.0205	0.9586	0.0115	0.0193	0.0112	0.0115
AF	S24	4.72	3.62	4.17	0.68	0.68 a	0.68
	Control	4.00	3.73	3.86	0.63	0.63 b	0.63
	CV	0.07	0.02	3.23	0.07	0.02	3.23
	Prob > F	0.1962	0.3152	0.0115	0.6620	0.0385	0.0115

* Angle transformation was applied to the percentage values. (LSL: Leaf sampling location, BFF: Below female flower, AFF: Above female flower, BF: Below fruit, AF: Above fruit)

The results of micronutrient (Fe, Zn and Mn) contents were given in Table 4. In terms of Fe, no statistically significant difference was found in the leaf samples taken the below female flower in both years, the above female flower and the below fruit in 2016. Higher Fe values were found in leaves of S24, sampled the above female flower, the below fruit and the above fruit in 2018, and the above fruit in 2016 compared to the control plants. While the leaf samples taken from below the and the above female flower were not found to be statistically significant in terms of the average of both years, it was determined that the leaf samples taken from the below fruit and the above fruit were higher in Fe in the S24 plant than in the control. Fe content values related to S24 plants from all samples except for the samples the above fruit in 2018 were insufficient and below the limit values (120-335 mg/kg) in both years (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017).

In terms of zinc (Zn), there was no statistically significant difference in leaf samples taken from the below female flower, the below fruit and the above fruit in 2016. Leaf samples of control plants taken from the below female flower in 2018 and the above female flower in 2016 gave higher Zn values than S24. However, the leaf samples of S24 taken from the above female flower and both the below and above fruit in 2018 gave higher leaf Zn content values than the control plants.

While the Zn contents in the leaf samples were not found to be significant in the samples taken from the below female flower, the below fruit and the above the fruit, in terms of the average of two years, they were higher in the leaf samples taken from the below fruit than in S24 in control plants. In 2016 and average of two years, Zn contents of all samples except for the sample taken from the above female flower, were insufficient and below the limit values (20-60 mg/kg) (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017). Numerous macromolecules, including hundreds of enzymes, depend on Zn for their structural and functional integrity (Alloway, 2009; Broadley et al., 2012; Coleman, 1998). Zn is essential for the metabolism of auxins, proteins, and carbohydrates, among other processes (Marschner, 1995; Reddy, 2006; Broadley et al., 2007). Interveinal chlorosis (mottling), a lighter green to pale yellow tint that occurs between the midrib and secondary veins, is the earliest symptom

of Zn deficiency in all plants. The internodes are short and the developing leaves are smaller than usual. These conditions are sometimes referred to as tiny leaf and rosetting (Storey, 2007).

In terms of Mn, no statistically significant difference was found in the leaf samples taken from the below female flower, the above female flower and the above fruit in 2016. Higher Mn results were obtained in S24 compared to the control in leaf samples taken from below fruit in 2016, and the below female flower, the above female flower, the below fruit, the above fruit in 2018. Average of two years, Mn contents were higher in leaf samples from the below female flower and the below fruit in S24 than in control plants, while samples taken from the above female flower and the above fruit were not found to be statistically significant. The Mn amounts of the leaf samples taken from the above female flower in both 2016 and 2018 were below the limit (60-240 mg/kg) values (Reuter and Robinson, 1986; Zengin, 2012). Due to its impacts on photosynthesis, plant hormone activity, carbohydrate synthesis, and disease resistance, Mn plays important roles in plant growth and development and, therefore, in crop production and quality (Eaton, 2015). The breadth and scope of the issue, which limits agricultural yield in many parts of the world due to Mn shortage, are sometimes hidden by the absence of visible leaf symptoms (Schmidt et al., 2016). Plants typically don't show symptoms of Mn shortage until growth rate and production are severely stunted. Mn deficiency-related foliar symptoms often manifest as diffuse interveinal chlorosis on young, enlarged leaf blades (Memon et al., 1981). On the leaves of plants with severe deficiencies, significant necrotic patches or streaks can also appear. The center leaves are frequently where symptoms initially appear (Humphries et al., 2007).

Table 4. Micro element contents of leaves taken from different parts of the plant.

LSL	Variety	Fe (mg/kg)			Zn (mg/kg)			Mn (mg/kg)		
		2016	2018	Av.	2016	2018	Av.	2016	2018	Av.
BFF	S24	68.57	85.06	76.82	20.83	18.39 b	19.61	72.53	82.95 a	77.74 a
	Control	70.81	83.33	77.07	13.26	20.41 a	16.83	86.73	51.77 b	69.24 b
	CV	0.07	0.03	3.61	0.35	0.03	17.97	0.11	0.03	3.04
	Prob > F	0.7849	0.4907	0.9211	0.1932	0.0186	0.4083	0.1285	<.0001	0.0431
AFF	S24	95.98	75.58 a	85.78	25.81 b	16.67 a	21.24 b	37.77	45.34 a	41.55
	Control	104.29	56.17 b	80.23	34.45 a	14.98 b	24.72 a	30.88	29.27 b	30.07
	CV	0.13	0.03	6.10	0.08	0.03	1.41	0.19	0.03	9.30
	Prob > F	0.4742	0.0004	0.3116	0.0097	0.0172	0.0058	0.2733	0.0001	0.0518
BF	S24	80.99	78.79 a	79.89 a	14.93	17.00 a	15.96	133.31 a	115.15 a	124.23 a
	Control	78.21	63.10 b	70.65 b	21.93	12.05 b	16.99	79.71 b	78.46 b	79.08 b
	CV	0.06	0.03	2.72	0.34	0.03	18.40	0.20	0.03	7.25
	Prob > F	0.5033	0.0013	0.0312	0.2398	0.0002	0.7183	0.0394	0.0002	0.0173
AF	S24	88.39 a	155.16 a	121.77 a	15.72	14.38 a	15.05	99.81	70.92 a	85.36
	Control	77.88 b	61.32 b	69.60 b	20.86	10.89 b	15.88	82.64	59.04 b	70.84
	CV	0.04	0.04	0.80	0.28	0.03	12.97	0.15	0.03	8.35
	Prob > F	0.0249	<.0001	0.0001	0.2794	0.0005	0.6637	0.1888	0.0026	0.1122

* Angle transformation was applied to the percentage values. (LSL: Leaf sampling location, BFF: Below female flower, AFF: Above female flower, BF: Below fruit, AF: Above fruit)

4. Conclusion

When the places where the leaf samples were taken and the years were evaluated together, there was not a variety that came to the forefront in terms of N, P, K, Ca, Mg and Zn. However, in general, Fe and Mn contents in the S24 line were found to be higher than the control. In terms of the average of two years, the Ca content in leaf samples taken from the below female flower was higher in control plants than in S24, while in terms of Mg content, the content of S24 was higher than in control plants, and there was no difference in the contents of other elements. In terms of the average of two years, the N, P and Zn contents in leaf samples taken from the above female flower was higher in control plants than in S24, while in terms of Ca and Mg content, the content of S24 was higher than in control plants, and there was no difference in the contents of other elements. In terms of the average of two years, the N and Fe contents in leaf samples taken from the above fruit was higher in S24 than in control plants, while there was no difference in the contents of other elements. In line with these results, it is not possible to say that there is a relationship between yellowing of leaf veins and plant nutrients. It has been concluded that the yellowing of these leaf veins may be due to genetic factors, not plant nutrients. Dou et al. (2018), in their study for the genetic mapping of watermelon yellow skin color, used the watermelon with yellow leaf veins as in our study and stated that the genetic material of wild watermelon consists mainly of green skin; different skin colors emerged as a result of the progress of evolution, artificial selection, and gene mutations, including yellow skin. Mutation of the gene can occur in the anterior region of chromosome 4 in the watermelon genome, and there may be two or three closely related genes in this range that control the phenotype of yellow skin, yellow veins, and yellow petioles. Mutation in this region not only causes the skin color of the fruit to change but also the veins and leaves. They concluded that leaf color mutations may affect plant photosynthesis, growth, and development, but yellow veins and petioles did not show any effect in their experiments, so this candidate region plays a very important role in the control of plant photosynthesis. After that, it will be possible to illuminate it with a mapping study to be carried out on this subject.

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