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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 was to investigate whether this yellowing of leaf veins is related to plant nutrients. The 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) 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 N, P, K, Ca, Mn, and Zn. However, in general, Fe and Mn 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.

Keywords: Plant nutrient elements, Watermelon, Yellow color leaf veins.

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 Turkey (3.5 M t^{-1}), India (2.8 M t^{-1}), Iran (2.7 M t^{-1}), Algeria (2.3 M t^{-1}), Brasil (2.2 M t^{-1}), and other nations (FAOSTAT, 2020).

In some areas of Turkey, watermelons have been grown 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. Watermelon should not be produced in the fusarium-contaminated fields 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 (Korkmaz and Saltalı, 2012; Marschner, 2012). Greater than 30% of the agricultural lands in the world has high pH soils (Chen and Barak, 1982). The majority of Turkish soils have low levels of organic matter and relatively high $CaCO_3$, which results in soils with a high pH (Erdal *et al*., 2006). Over 63% of agricultural areas in Turkey 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

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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 the 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, during which leaf yellowing is controlled by a single recessive gene. In the ethylmethanesulfonate mutagenesis population of the "703" watermelon variety, Xu *et al*. (2023) identified a chlorophyll-deficient mutant with Yellow leaf (Yl2) color, and 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. 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 was to investigate whether this yellowing of leaf veins was related to plant nutrients.

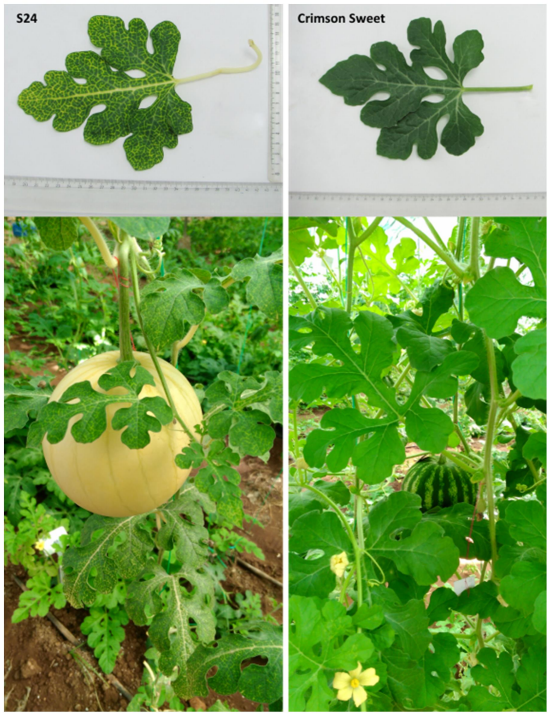

Figure 1. The S24 line and Crimson Sweet variety used in the study.

MATERIALS AND METHODS

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 S24 line used in the experiment has yellow fruit and leaf veins. While there is no abnormality in the seedling stage, the 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 and 34° 20' 43.6" E) and on April 24 in 2018 (at latitude 36° 37' 49.2" N and 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, and the second was the period when the fruits reached 11-12 cm size.

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

Climatic data for both years are shown in Table 1. In 2016, the highest temperatures were in May (31.3°C). In terms of relative humidity, the highest value was taken in May (89.3%) and the lowest value was in April (37.0%). In 2018, the highest value was in May (34.7°C) and the lowest (6.7°C) in March. In terms of relative humidity, the highest relative humidity (86.4%) was in April, and the lowest (39.6%) was in May (Table 1).

A drip irrigation system was used for 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 matter, alkali, very poor in potassium, and optimum phosphorus (Table 2).

According to the findings of the soil study, fertilizers were applied in the amounts of 60-

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

Year	Climate Factor		March	April	May
2016	Temperature (°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 (°C)	Minimum	6.7	7.2	12.7
		Maximum	27.3	31.9	34.7
		Average	15.6	18.1	22.9
	Relative humidity (%)	Minimum	47.7	41.7	39.6
		Maximum	85.4	86.4	82.1
		Average	72.8	69.7	67.3

Table 2. Soil analysis results for both years.

Analyzes	Limit Values	Analysis Results (0-30 cm)	
		2016	2018
Texture (100 g ml^{-1})	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^{-1} (25 °C)	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^{-1})	244-300	69.80 (Very low)	122.80 (Very low)
Receivable phosphorus (mg kg^{-1})	20-40	32.30 (Optimum)	28.10 (Optimum)

80 kg K_2O ha^{-1}, 80-100 kg P_2O_5 ha^{-1}, and 140-160 kg N ha^{-1} 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. The first stage was defined up to the first female blossom. The second phase spanned the time between the point at which the first female bloom appeared and the time when the fruits were the 7-8 cm. The third stage included the time between the fruits' apple-size development and harvest. Regular pesticides were applied for disease and pests' control, and mechanical weeding and trimming were also carried out.

Plant Nutrient Analysis

Nitrogen (N) determination in dried and ground leaf samples was made according to the modified Kjheldahl method (Kacar, 1972), who reported 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) were 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^{-1} of dry matter (Table 3).

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 design, at 0.05 significance level. Statistical analyses were performed after angle transformation was applied to the percentage data.

RESULTS AND DISCUSSION

The results related to macro-nutrient (N, P, K, Ca and Mg) contents of accessions are 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 from below the female flower of the S24 and the control plants in both years and average of the two years were not statistically significant. The N content of leaves taken from the top of the female flower of control plants was higher than that of S24 plants in both years and the average of the two years of the experiment. While the N content of the leaf samples taken from below and above the fruit was found to be insignificant in both control and S24 plants in 2016, but the content of S24 plants was found to be significant compared to the control in 2018. While the N content of leaf samples taken from below the fruit was insignificant in terms of the average of two years, the content of S24 plants in leaf samples taken from above the fruit was

significant compared to the control. The N amounts in the samples taken in both years were close to sufficient limit (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 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 below the female flower, above the flower, below and above the fruit, in both S24 and control plants in 2016. In 2018, while the P content of control plants was found to be significant

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

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

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

[a] LSL: Leaf Sampling Location, BFF: Below Female Flower, AFF: Above Female Flower, BF: Below Fruit, AF: Above Fruit. * Angle transformation was applied to the percentage values.

compared to S24 in the leaf samples from below 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 below and above the fruit. In terms of the average of the two years, the P content of the leaf samples taken from above the 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 below the female flower, below and above the 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 in the leaves were 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 below the female flower in 2016 and 2018 and from above the 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 above the female flower in 2018 and both from below and above the fruit in 2016, higher K values were obtained than S24 plants. However, K contents in the leaf samples taken from below and above the 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 below and above the female flower and the above fruit, the leaf samples taken from below the 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 the control in the leaf samples taken from below the female flower in 2018, from above the female flower in 2016, from below the fruit in 2018, from above fruit the in 2016 and 2018. Higher Ca values were obtained in leaves below the female flowers than the control plants in 2016, while leaf samples taken from above the female flower in 2018 and below the fruit in 2016 were higher in S24 than the control plants. While the Ca amounts in the leaf samples taken from the above fruit were insignificant in terms of the average of both years, Ca was higher than the control plants taken from the above female flower, also higher in the leaf samples taken from the female flower and below the fruit in S24 plants. Ca content

values obtained from the leaves of both S24 and control plants sampled above the female flower were 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 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). **E**xcept leaf sampling location, the below and above female flower, and the below and above fruit, Ca values of all samples 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 and the below female flower in 2016, the above female flower, the below and the above fruit in 2018 was higher in S24 compared to the control. In terms of the two years average data, 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).

The results of micronutrient (Fe, Zn and Mn) contents are 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, samples above the 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 and above the female flower were not 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 above the fruit in 2018, were insufficient and below the limit values (120-335 mg kg^{-1}) in both years (Reuter and Robinson, 1986; Zengin, 2012; Egel *et al*., 2017).

Table 4. Microelement contents of leaves taken from different parts of the plant.[a]

LSL	Variety	Fe (mg kg^{-1})			Zn (mg kg^{-1})			Mn (mg kg^{-1})		
		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

[a] LSL: Leaf Sampling Location, BFF: Below Female Flower, AFF: Above Female Flower, BF: Below Fruit, AF: Above Fruit. * Angle transformation was applied to the percentage values.

In terms of Zinc (Zn), there was no statistically significant difference in leaf samples taken from below the female flower, below and above the fruit in 2016. Leaf samples of the 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 above the 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 below the female flower, the below fruit and the above the fruit, in terms of the average of two years, were higher in the leaf samples taken from below the 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^{-1}) (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 below and above the 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 below and above the female flower, and below and above the fruit in 2018. Average Mn contents of the two years were higher in leaf samples from below the female flower and below the fruit in S24 than in the control plants, while samples taken from above the female flower and above the fruit were not statistically significant. The Mn amounts of the leaf samples taken from above the female flower in both 2016 and 2018 were below the limit (60-240 mg kg^{-1}) 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 do not 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).

CONCLUSIONS

When the locations where the leaf samples were taken and leaf sampling years are considered together, there is no difference between varieties regarding N, P, K, Ca, Mg and Zn. However, in general, Fe and Mn contents in the S24 line were higher than the control. In terms of the average of two years, the Ca content in leaf samples taken from below the female flower was higher in the control plants than in S24, while in terms of Mg content, the content of S24 was higher than in the 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 the 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 the 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 consisted 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, therefore, this candidate region plays a very important role in the control of plant photosynthesis. After all, it will be possible to clarify this issue by means of mapping studies.

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رابطه عناصر غذایی گیاهی با تشکیل رنگ زرد در رگبرگهای هندوانه

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چکیده

در حالی که در رگبرگ برخی از هندوانه ها در مرحله گیاهچه زردی وجود ندارد، رگبرگ ها پس از شروع رشد گیاه شروع به زرد شدن می کنند و با رشد گیاه رگبرگ ها زردتر می شوند. هدف این پژوهش بررسی این موضوع بود که آیا این زرد شدن رگبرگ با عناصر غذایی گیاه مرتبط است یا خیر. این مطالعه در موسسه تحقیقات باغبانی آلاتا در مرسین، ترکیه، در طول فصل رشد بهار و تابستان ۲۰۱۶ و ۲۰۱۸ انجام شد. از لاین S24 با رگبرگهای زرد و رقم Crimson Sweet به عنوان شاهد استفاده شد. از برگ های زیر و بالای گل ماده در دوره گل ماده و از برگ های زیر و بالای میوه زمانی که میوه ها به اندازه گریپ فروت رسیدند نمونه برداری شد. نیتروژن (N)، فسفر (P)، پتاسیم (K)، کلسیم (Ca)، منیزیم (Mg)، آهن (Fe)، روی (Zn) و منگنز (Mn) در تجزیه برگ بررسی شد. زمانی که مکان‌هایی که نمونه‌برداری از برگ‌ها و سال‌ها با هم ارزیابی شدند، تنوعی از نظر N، P، K، Ca، Mn و Zn در خط مقدم قرار نگرفت. با این حال، به طور کلی، محتوای آهن و منگنز از خط S24 بالاتر از شاهد بود. در راستای این نتایج، نمی توان گفت که بین زرد شدن رگبرگ برگ و عناصر غذایی گیاه رابطه وجود دارد.