

ACCEPTED ARTICLE

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

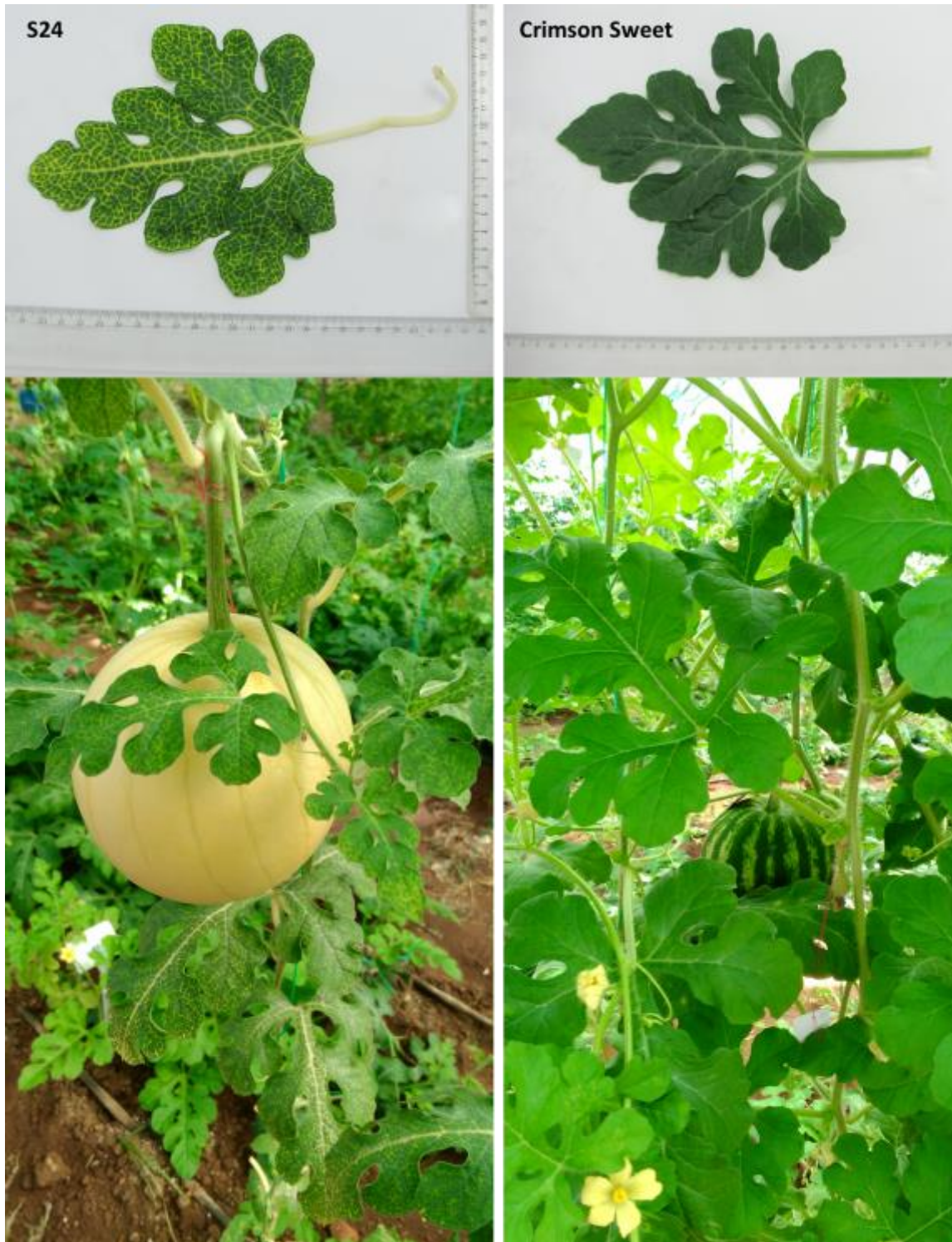
A vegetable with a global production of 101.6 million tons, watermelon is very significant economically. China (60,1 million tons) is the world's greatest producer, followed by Türkiye (3.5 million tons), India (2.8 million tons), Iran (2.7 million tons), Algeria (2.3 million tons), Brasil (2.2 million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

38 battle against fusarium (Messiaen, 1974). However, grafting weaker varieties onto stronger
39 rootstocks might aid in the control of some soil-borne diseases and enhance production and
40 quality (Lee, 1994; Oda, 1995; Yetisir et al., 2003). One of the goals of grafting in
41 watermelon was to promote nutritional intake (Ruiz et al., 1997; Pulgar et al., 2000). Organic
42 matter content, soil moisture, CaCO₃ levels, pH and biological properties of the soil affect
43 plant nutrient uptake by plants (Korkmaz and Saltalı, 2012; Marschner, 2012). Greater than
44 30% of the agricultural lands in the world is made up of high pH soils (Chen and Barak,
45 1982). The majority of Turkish soils have low levels of organic matter and relatively high
46 CaCO₃ content, which results in soils with a high pH (Erdal et al., 2006). Over 63% of
47 agricultural areas in Türkiye have a pH level higher than 7.5, and 59% of soils have more than
48 5% CaCO₃ (Eyuboglu, 1999). Yellowing on the leaves can sometimes be due to plant
49 nutrients (Turan and Horuz, 2012; Marschner, 2012) and sometimes genetic factors (Guner
50 and Wehner, 2004). According to Warid and Abd-El-Hafez (1976), the yellow leaf (*Yl*) gene
51 produces yellow leaves and is only marginally dominant over green leaves (Guner and
52 Wehner, 2004). The first few nodes have light green cotyledons and leaves due to a delay in
53 the formation of green leaves, but following leaves have a more usual green color. Even when
54 the genotype is *dgdg*, the inhibitor of delayed green leaf (*i-dg*) restores the usual green color
55 of the leaves (Rhodes, 1986). When plants are cultivated under short day environment, the
56 juvenile albino *ja* gene results in decreased chlorophyll in seedling tissues, as well as in leaf
57 edges and fruit rind (Zhang et al., 1996). Zhu et al. (2022) reported in their study to map and
58 functionally verify the leaf yellowing genes in watermelon throughout the entire growth
59 period that leaf yellowing is controlled by a single recessive gene. Xu et al. (2023), in the
60 ethylmethanesulfonate mutagenesis population of the “703” watermelon variety, a
61 chlorophyll-deficient mutant with yellow leaf (Y12) color was identified, and the chlorophyll
62 a, chlorophyll b and carotenoid contents in Y12 leaves were lower than those in wild type
63 (WT) leaves, and the chloroplasts in the leaves were identified. They reported that the
64 ultrastructure revealed the disintegration of chloroplasts in Y12. Although it is stated that
65 some virus diseases can cause yellow leaf spots on watermelon (Venkataravanappa et al.,
66 2020; Jailani et al., 2022; Iriarte et al., 2023), no virus disease that causes yellow veins as in
67 our study has been found. While there is no yellowing in the leaf veins of some watermelons
68 during the seedling stage, veins start to turn yellow after the plant starts to grow, and veins
69 become more yellow as the plant grows (Figure 1). It is generally thought that yellowing of
70 leaves may reduce plant photosynthesis and growth (Gao et al., 2016 ; Miao et al., 2016; Zhu

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

73



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

75

76 **2. Material and Method**

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

84 The seedlings were planted with a 1.5 m between and 0.4 m within plant distances in
 85 greenhouses on March 24 in 2016 at latitude 36°37'51.1"N 34°20'43.6"E and on April 24 in
 86 2018 at latitude 36°37'49.2"N 34°20'41.6"E. Plants were grown on a single stem by being
 87 suspended on a rope and having their secondary axes removed.

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

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

97 Climatic data (monthly minimum, maximum and average temperature and relative humidity
 98 values) for both years in Table 1. In 2016, the highest temperatures were seen in May (31.3
 99 °C). In terms of relative humidity, the highest value was taken in May (89.3%) and the lowest
 100 value was taken in April (37.0%). In 2018, the highest value was taken in May (34.7 °C) and
 101 the lowest (6.7 °C) temperatures were seen in March. In terms of relative humidity, the
 102 highest (86.4%) relative humidity was recorded in April, and the lowest (39.6%) relative
 103 humidity was recorded in May (**Table 1**).

104 **Table 1.** Climate values 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

105
106 A drip irrigation system was used for the watering and fertilizing. The irrigation system began
107 with the planting of seedlings of all the accessions utilized in this study, and it was continued
108 as needed based on the greenhouse environment. During the experiment, the soil of old
109 greenhouses was analyzed. During both years of the study, soil was loamy, calcareous,
110 optimum salty, weak inorganic substances, alkali, very poor in potassium and optimum
111 phosphorus (**Table 2**).

112 **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 °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)	244-300	69.80 (very low)	122.80 (very low)
Receivable phosphorus (mg/kg)	20-40	32.30 (optimum)	28.10 (optimum)

113
114 According to the findings of the soil study, fertilizers were applied in the amounts of 60-80 kg
115 K₂O/ha, 80-100 kg P₂O₅/ha, and 140-160 kg N/ha as pure substances (Gucdemir, 2012). Drip
116 irrigation was used to apply fertilizers. By separating the watermelon into three sections
117 according to the three stages of growth, nitrogen, phosphorus, and potassium are provided. Up
118 to the first female blossom, the first stage was defined. The second phase spanned the time
119 between the point at which the first female bloom appears and the time when the fruits were
120 the size of 7-8 cm. The third stage included the time between the fruits' apple-size
121 development and harvest. Regular pesticide applications were made for disease and pests that
122 were seen, and mechanical weeding and trimming were also carried out.

123 2.1. Plant Nutrient Analysis

124
125 Nitrogen (N) determination in dried and ground leaf samples was made according to the
126 modified Kjeldahl method (Kacar, 1972). As reported by Kacar (1972), phosphorus (P) was
127 determined colorimetrically according to the vanadomolybdophosphoric yellow color method
128 in the filters obtained by the nitric-perchloric acid mixture (4:1) wet burning method.
129 Potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn) and zinc (Zn); It
130 was determined with the help of Inductively Coupled Plasma (ICP) in the filters obtained

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

133

134 **2.2. Statistical analysis**

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

139

140 **3. Result and Discussion**

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

145 In terms of N content, the differences in leaves sampled taken from below the female flower
146 of the S24 and control plants in both years and average of two years were not statistically
147 significant. N content of the leaves sampled above the female flower of control plants were
148 higher than S24 plants that of the in both years and average of two years of the experiment.
149 While the N content of the leaf samples taken from the below fruit and the above fruit was
150 found to be insignificant in both control plants and S24 plants in 2016, the content of S24
151 plants was found to be significant compared to the control plants in 2018. While the N content
152 of leaf samples taken from the below fruit was insignificant in terms of the average of two
153 years, the content of S24 plants in leaf samples taken from the above fruit was significant
154 compared to control plants. The N amounts in the samples taken in both years were close to
155 sufficient limit values (2.5-4.5%) (Reuter and Robinson, 1986; Zengin, 2012; Egel et al.,
156 2017) and were within these values. N deficiency is one of the most common plant nutrient
157 problems for watermelon production. N deficiencies can affect crop yield and quality at any
158 time during the growing season (Doerge et al., 1991). Lack of N causes plants to become
159 smaller and have lighter-green leaves than usual. The reduced concentration of chlorophyll is
160 what causes this color effect (Hawkesford et al., 2012). As N is remobilized to younger
161 leaves, chlorosis brought on by N shortage usually starts in the older leaves. Crops lacking in
162 N appear light green or even yellow (Tucker 1984; Taiz and Zeiger, 2006). Since the amount
163 of N in leaf samples is mostly at a sufficient level, it is not considered to be a problem caused
164 by N (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017).

165 In terms of P, no statistical difference was found in the leaf samples taken from the below
166 female flower, the above female flower, the below fruit and the above fruit in both S24 and
167 control plants in 2016. In 2018, while the P content of control plants was found to be
168 significant compared to S24 in the leaf samples taken from the below female flower and
169 above the female flower, the P content of S24 plants was higher than that of the control plants
170 in the leaf samples taken from the below fruit and the above fruit. In terms of the average of
171 the two years, the P content of the leaf samples taken from the above female flower was
172 higher in S24 compared to the control plants, while there was no significant difference in
173 terms of P content in the leaf samples taken from the below female flower, the below fruit and
174 the above fruit. P is a significant macronutrient for plants since it is not only a component of
175 vital substances (Akhtar et al., 2009; Cetner et al., 2020), but also because it is required for
176 energy transmission and storage during cell metabolism (Jin et al., 2006; Amtmann and Blatt,
177 2009). P is an essential plant nutrient for good fruit set and fruit growth, mainly from
178 flowering to final fruit formation. Almost all of the P values in the leaves were found to be
179 insufficient (0.3-0.7%) below the cutoff values (Reuter and Robinson, 1986; Zengin, 2012;
180 Egel et al., 2017). Plants grown in P-deficient soil grow slowly and frequently become scarlet
181 from increased anthocyanin production (Marschner, 1995). Plants with low levels of P
182 frequently have deeper green leaves and stems as well as the development of red and purple
183 hues (Sanchez, 2007). The low amount of P in both years and in different regions of the
184 sample suggests that P will not have an effect on the color difference.

185 In the leaf samples taken from the below female flower in 2016 and 2018 and from the above
186 female flower in 2016, there was no statistical difference between S24 and the control plants
187 in terms of K. In the leaf samples of control plants taken from the above female flower in
188 2018 and both from the below fruit and the above fruit in 2016 higher K values were obtained
189 than S24 plants. However, K contents in the leaf samples taken from the below fruit and the
190 above fruit were found to be higher at S24 compared to the control in 2018. While there was
191 no statistical difference between S24 and control plants in terms of K in the average of both
192 years in terms of leaf samples taken from the below female flower, above the female flower
193 and the above fruit, the leaf samples taken from the below fruit had a higher K content in the
194 control plants compared to S24. P is a nutrient needed for watermelon in greater amounts than
195 nitrogen. K is a crucial nutrient for plant growth and development (Schachtman and Liu,
196 1999). It involves important processes in plant cells including osmoregulation,
197 photosynthesis, enzyme activation, the production of carbohydrates, nucleic acids, and
198 proteins, as well as the control of water status (Mengel and Kirkby, 2001). K also helps plant

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

207 In terms of **Ca**, there was no statistical difference between S24 and control in the leaf samples
208 taken from the below female flower in 2018, from the above female flower in 2016, from the
209 below fruit in 2018, from the above fruit in 2016 and 2018. Higher **Ca values** were obtained
210 in leaves the below female flowers than control plants in 2016, while leaf samples taken from
211 the above female flower in 2018 and the below fruit in 2016 were higher in S24 than control
212 plants. While the **Ca amounts in the leaf samples taken from the above fruit were found to be**
213 **insignificant in terms of the average of both years, Ca was found to be higher than control**
214 **plants taken from the above female flower, also higher in the leaf samples taken from the**
215 **female flower and the below fruit in S24 plants. Ca content values obtained from the leaves of**
216 **both S24 and control plants sampled above the female flower were found to be below the**
217 **limit values (2.2-5.5%) (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017) range in**
218 **2016. Living things require Ca to function. It is particularly significant in the physiology of**
219 **cells because it serves as a signal for a variety of cell processes, including the production of**
220 **new cell walls in the mitotic spindle during cell division (Taiz and Zeiger, 2006; Shao et al.,**
221 **2008). Ca deficiency results in wilting, deformity, necrosis of fruit and tubers, chlorosis of the**
222 **youngest leaves and shoot apices, weak stems, early flower dehiscence, and failure to set seed**
223 **in some plants (Bould et al., 1983; Bergmann, 1992; Pilbeam and Morley, 2007). Ca values of**
224 **all samples except these samples (Leaf sampling location, the below female flower, the above**
225 **female flower, the below fruit and the above fruit) were within the sufficient limit values**
226 **(Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017).**

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

233 taken from S24 was higher than that of the control plants in the leaf samples taken from above
 234 the female flower and the below fruit, while no statistical difference was found in the leaf
 235 samples taken from below the female flower and the above fruit. Except for the S24 and
 236 control plants the above female flower leaf samples in 2016, the Mg contents of the leaves
 237 from different regions were within the sufficient limit values (0.4-1.2%)(Reuter and
 238 Robinson, 1986; Zengin, 2012; Egel et al., 2017). In order to develop and reproduce, plants
 239 need a lot of Mg, an important macronutrient (Gransee and Führs, 2013; Cakmak and Yazici
 240 2010). Mg serves as the core atom in chlorophyll molecules, which in turn establishes a
 241 biological foundation for the absorption of solar energy and the subsequent creation of
 242 oxygen and carbohydrates (Grzebisz, 2015). Mg also contributes to the conversion and
 243 preservation of energy (Amtmann and Blatt, 2009). Growth sluggishness and interveinal
 244 chlorosis on older leaves are typical signs of Mg shortage (Cakmak and Yazici, 2010).
 245 Chlorosis often starts in older leaves and spreads to younger leaves (Cakmak and Kirkby,
 246 2008; Farhat et al., 2014).

247 **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

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

250 **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

251 * Angle transformation was applied to the percentage values. (LSL: Leaf sampling location, BFF: Below female
252 flower, AFF: Above female flower, BF: Below fruit, AF: Above fruit)
253

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

265 In terms of zinc (Zn), there was no statistically significant difference in leaf samples taken
266 from the below female flower, the below fruit and the above fruit in 2016. Leaf samples of
267 control plants taken from the below female flower in 2018 and the above female flower in
268 2016 gave higher Zn values than S24. However, the leaf samples of S24 taken from the above
269 female flower and both the below and above fruit in 2018 gave higher leaf Zn content values
270 than the control plants.

271 While the Zn contents in the leaf samples were not found to be significant in the samples
272 taken from the below female flower, the below fruit and the above the fruit, in terms of the
273 average of two years, they were higher in the leaf samples taken from the below fruit than in
274 S24 in control plants. In 2016 and average of two years, Zn contents of all samples except for
275 the sample taken from the above female flower, were insufficient and below the limit values
276 (20-60 mg/kg) (Reuter and Robinson, 1986; Zengin, 2012; Egel et al., 2017). Numerous
277 macromolecules, including hundreds of enzymes, depend on Zn for their structural and
278 functional integrity (Alloway, 2009; Broadley et al., 2012; Coleman, 1998). Zn is essential for
279 the metabolism of auxins, proteins, and carbohydrates, among other processes (Marschner,
280 1995; Reddy, 2006; Broadley et al., 2007). Interveinal chlorosis (mottling), a lighter green to
281 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

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

307

308 **4. Conclusion**

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

336

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339

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