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Soil Properties and Mineral Nutrients of Clementine Mandarine (*Citrus reticulata* Blanco) Grown in the Koycegiz Region of Mugla Province

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Abstract: Soil properties of the samples from orchards and the nutrients (macro- and microelements) in the clementine mandarin (*Citrus reticulata* Blanco), widely grown in the Köyceğiz region of Muğla Province Turkey, were studied. Mandarin tree leaves and soil samples were collected from 10 different orchards. The soil samples were analyzed for its pH, $CaCO_3$, EC, sand, organic matter, nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), manganese (Mn), copper (Cu) and boron (B) while leaves were analyzed for its macro- and microelements. The results obtained from soil analysis showed suitable amount of calcium carbonate and EC. Analysis of the soil showed that organic matter, N, K and Mn were insufficient in all orchards, while Fe was higher in amount. Slight alkaline, strong alkaline and neutral pHs were determined in the orchards. Besides, the leaf samples collected from the orchards reflected deficient amount of N and Ca while higher amount of Mg and Fe.

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1. INTRODUCTION

Plants need to be balanced with the necessary nutrients for their growth and increase in yield. The deficiency of one or more nutrients in the available form significantly affects soil fertility and plant development [1]. As in all plants, the effects of fertilizers, applied to especially perennial plants such as fruit trees, on yield and quality have been proved by many studies. Since fruit trees are perennial plants, compared to single-year plants, it is much more important to determine the correct amount of nutrients to be applied for their fertilization and to confirm the effects of fertilization on product quantity and quality [2].

Citrus trees are comprised of a group of plants including citrus fruit tree species with high economic value such as orange (*Citrus sinensis*), mandarin orange (*Citrus reticulata*), lemon (*Citrus lemon*), grapefruit (*Citrus paradisi*), bitter orange (*Citrus aurantium*) and bergamot (*Citrus bergamia*). Citrus fruits are the most produced fruit species in the world with a production of approximately 136 million tons. 52.63% of the world citrus production is orange, 21.13% is mandarin, 11.19% is lemon, 6.22% is grapefruit and the rest is other citrus fruits [3].

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Total citrus production in our country is 3.783,263 tons. Nearly 47.04% of Turkey's citrus production is orange, 27.67% is mandarin, 19.16% is lemon, 6.06% is grapefruit and 0.07% is citrus fruits [4].

Due to its temperate climate as well as its 1124-kilometer coastline, Mugla city has important agricultural potential and suitable conditions for the cultivation of almost all agricultural products. In Mugla, citrus is the largest fruit crop in terms of production amount [5]. Agricultural production, especially citrus production, stands out in 3 districts of Mugla, which are Koycegiz, Dalaman, and Ortaca, and 90% of citrus fruits are cultivated in these districts [6]. Hamitkoy, Zaferler, Dogusbelen, Toparlar, Beyobasi, Kavakarasi, Yesilkoy, Koycegiz village, and Koycegiz county center are important citrus production areas. The majority of citrus fruits in Koycegiz are Washington oranges. However, due to its higher economic returns, it is observed that there has been some transition to Valencia-type orange in recent years [7].

This study aims to determine the mineral nutritional status and soil properties of Clementine mandarin (*Citrus reticulata* Blanco) cultivated in Koycegiz, Muğla. As a result of this study, stimulating/ directive contributions have been made in terms of fertilization programs via informative meetings held with the producers.

2. MATERIAL and METHODS

The locations of the Clementine mandarin (*Citrus reticulata* Blanco) where mandarin samples were obtained are shown in Table 1. Samples for this study were collected from 10 different Clementine mandarin orchards.

Table 1. The locations of the Clementine mandarin (*Citrus reticulata* Blanco) and name of the producers where leaf and soil samples were obtained.

Orchard Number	Name of the owner	Acreage (decare)	Number of trees	Tree age (year)	Latitude	Longitude	Location
1	Cemil Ölemez	4	80	30	36°57'28.87"N	28°36'41.69"E	Mugla Koycegiz
2	H. İbrahim Kaya	2	80	20	36°58'1.34"N	28°36'14.13"E	Mugla Koycegiz
3	Mehmet Ölemez	5	200	42	36°59'1.28"N	28°36'12.55"E	Mugla Koycegiz
4	H. İbrahim Kaya	2	90	20	36°58'54.94"N	28°36'10.12"E	Mugla Koycegiz
5	Mehmet Ölemez	4	140	42	36°59'22.82"N	28°36'41.93"E	Mugla Koycegiz
6	Elif Sertel	7	180	20	36°57'48.55"N	28°39'36.68"E	Mugla Koycegiz
7	Niyazi Çetinkaya	5	175	50	36°57'53.52"N	28°39'17.51"E	Mugla Koycegiz
8	Hüseyin Demirkol	4	200	40	36°58'26.59"N	28°40'16.49"E	Mugla Koycegiz
9	Niyazi Çetinkaya	4	120	60	36°58'51.01"N	28°40'7.93"E	Mugla Koycegiz
10	Yusuf Çatak	6	150	20	36°58'45.53"N	28°40'44.82"E	Mugla Koycegiz

2.1. Soil and leaf sampling and analysis

Representative soil samples were collected at a 0–30 cm depth, sampling in a "W" pattern, using a 5 cm diameter auger, after removing the aboveground biomass in early September. Sand, silt and clay fractions were measured by hydrometer method according to Bouyoucos [10], soil pH and the amount of salt by 1:2.5 soil-water mixture method according to Jackson [11], soil organic matter content by Walkley and Black [12] wet oxidation method, lime content according to Allison and Moodie [13] in calcimetry, nitrogen in soil by Keeney and Bremner [14] theoretical method, phosphorus spectrophotometrically according to Olsen et al. [15], K, Ca and Mg by ICP-OES method according to Thomas [16], Fe, Zn, Mn, Cu and B were measured by ICP-OES method according to Lindsay and Norvell [17].

The method proposed by Chapman [8] was taken into consideration when leave samples were collected. In the designated orchards, the middle leaves of 6-7 month spring growths which are human height were taken as samples from all over the trees by drawing zig zags. Leaf samples were prepared in the laboratory for analysis as reported by Kacar and Inal [9]. Determination of plant nutrient contents to eliminate possible contamination in leaf samples, they were dried to constant weight in the oven at 65-70 ^{o}C after being washed with tap water and pure water. The samples were homogenized by grinding to a particle size of less than 0,5 mm. The total nitrogen content of leaf samples burned by the Kjeldahl method was measured by steam distillation [18]. To determine the amount of other nutrients, samples were dissolved by dry combustion method [19] and then, phosphorus, potassium, calcium, magnesium, iron, zinc, manganese, copper and boron concentrations of the filtrated leaves were determined in ICP-OES device [9].

3. RESULTS and DISCUSSION

3.1. Analysis Results of Orchard Soils

As a result of the analyzes, some physical and chemical properties of the soils belonging to the orchards were given in Table 2. Basic reference values at the evaluation of the results were given in Table 3 and Table 4. The highest pH value of orchard soils was determined as the highest (8.56) in the 5th orchard whereas the lowest (7.46) was in the 8th orchard. The average pH value of all orchard soils was observed as 8.08 (Table 2) and basic properties (Table 4). Mendilcioglu [20] reported that the pH limit values for citrus fruits should be between 5 - 8.5. It was seen that 80% of the research orchards were between the limit values. The EC values of the orchard soils were observed as the lowest in the 10th orchard (0.08 mS/cm) and as the highest in the 7th orchard (0.27 mS/cm) and the average EC value of the orchard soils was measured as 0.16 mS/cm (Table 2). As a result of their study, Waters et al. [21] reported that the limit values for EC should be between 1.51–2.25 mS/cm. When the limit values are taken into consideration, it is seen that all the research orchards can be classified as salt-free and there is no problem with salinity (Table 3).

The organic matter content of the soils belonging to these orchards was found to be the lowest in the orchard 2 (0.54%) and the highest in the 4th orchard (2.77%). The average organic matter content of the orchards was 1.37% (Table 2). According to Anonymous [22], the limit value of organic substances in mandarin-cultivated soils should be between 2.01 and 3.0%. It is possible to say for the research orchards that 40% of them were very low, 40% of them were low and 20% of them were moderate (Table 3).

3.1.1. Macro and Microelement Status of Orchard Soils

The total nitrogen content of the soils belonging to the research orchards was measured as the lowest in the 2nd orchard (0.03%) and the highest in the orchard 4 (0.14%) while the average total amount of N was observed to be 0.06% (Table 2). As a result of Chapman's study

[8], it was reported that N limit values for mandarin should be between 0.11–0.15%. When the amount of N in the orchards is examined, it is possible to say that 40% of them have very low, 50% of them have low and 10% of them have a moderate amount of N (Table 3). In their study, Saatci and Mur [23] looked at the N contents of the orchards cultivated by Satsuma mandarin plants and stated that the N contents in soils varied between 0.12-0.47%. When the available Phosphorus concentration of orchard soils was examined, it was measured that it varied between 5.51-24.2 ppm and the average value was 13.10 ppm (Table 2). It has been revealed by the analyzes that 20% of these orchards have a low-level and 80% of them have a sufficient level of phosphorus (Table 3). In their study, Hakerlerler et al. [24] stated that the P concentrations of the orchards varied between 5.6-80 ppm. In this respect, our study was found to be consistent with the literature. When the changeable Potassium concentration of orchard soils was examined, the lowest level was observed in the 10th orchard (36.88 ppm), the highest level in number 4 orchard (105 ppm) and the average changeable K values of the orchards were determined as 65.6 ppm (Table 2). When the amount of K in the orchards was examined, it was seen that 30% of them were too little and 70% of them were less (Table 3). Li et al. [25] found that the amount of K in the soil of grapefruit orchards in the Fujian region of China varied between 35-645 ppm. This literature knowledge supports our study.

The changeable Calcium concentration of horticultural soils was measured as low as 557 ppm and as high as 3143 ppm. The average Ca value was determined to be 1875.2 ppm (Table 2). When the limit values were taken into consideration and the Ca values of the orchards were analyzed, it was measured that 30% of them were low and 70% of them were sufficient (Table 3). Kilic [26] suggested that the concentration of Ca in the orchards he investigated in the Gumuldur region ranged from 2850 to 4740 ppm. Saatci and Mur [23] found in their study that the concentration of Ca in the orchards was between 2900–4500 ppm values. When these studies are evaluated in general terms, it is possible to say that they support our study. The changeable Magnesium concentration in the soils belonging to these orchards varied between 461-2704 ppm, and the average value was revealed by the analyzes as 1138.5 ppm (Table 2). Considering the limit values, 10% of the orchards in which the research was conducted were sufficient, 60% of them were more than sufficient and 30% of them had too much magnesium. (Table 3). Hakerlerler et al. [24] measured the concentration of Mg in the soil as 116-480 ppm in their Satsuma mandarin research conducted in Gumuldur and Balcova. Our study is consistent with the literature. While the iron (Fe) concentration of the soils belonging to these orchards was 11.49 ppm, the highest value was found to be 24.79 ppm and the average value was measured as 17.84 ppm (Table 2). The iron concentration in all of these orchards was revealed to be a high amount by analyzes (Table 3). As a result of the study that Surwase et al. [27] carried out in India, the Fe values of orange orchards were measured to be between 8.64–18.6 ppm and these results show similarity with our study.

The Manganese concentration of the orchard soils was measured at 5.33 ppm as the lowest and at 12.98 ppm as the highest, the average was observed as 9.08 ppm (Table 2). It was seen that all of these orchards were low in Manganese (Table 3). In a study conducted in Izmir, it was measured that the Mn composition of the orchards was between 1.45-3.29 ppm [23]. When this literature review is taken into account, it is observed that it is supportive of our research findings even if it is different in terms of the limit values. The available Manganese which is deficient according to the limit values should be increased to the required level for yield and quality [28]. The available Zinc (Zn) composition in these subject soils was found to vary between 0.69-6.52 ppm and the average value was measured as 1.71 ppm (Table 2). According to these limit values, it can be said that 10% of the available Zinc value was less, 80% of it was sufficient and 10% of it was more (Table 3). In Kilic's [26] study conducted in Gumuldur, the Zn composition of soils cultivated by citrus was determined (0.59-9.13 ppm).

Table 2. Physical and chemical properties of orchard soils

Orchard Number	N (%)	P	K	Ca	Mg	Fe (ppm)	Mn	Zn	Cu	B	pH	EC (mS/cm)	Lime (%)	Organic Matter (%)	Texture
1	0.04	10.5	48.25	2530	498	15.91	6.28	0.69	1.52	0.51	8.35	0.14	6	0.73	Loamy
2	0.03	14.73	40.34	1743	461	15.19	5.33	0.8	0.8	0.35	8.04	0.13	3.7	0.54	Loamy
3	0.1	5.98	91.12	2930	2704	24.16	12.98	1.17	2.48	0.49	8.39	0.24	11	1.98	Silty-Clay
4	0.14	24.2	105	3143	1669	11.49	9.1	2.41	2.32	1.06	8.08	0.23	14.8	2.77	Silty-Clay
5	0.1	17.76	68.87	2104	1394	14.77	7.95	6.52	2.45	0.59	8.56	0.19	11.4	2.04	Clay-Loamy
6	0.06	11.43	54.06	2229	999	16.1	8.71	0.86	1.72	0.38	8.24	0.19	5.5	1.25	Loamy
7	0.06	5.51	67.44	2354	1516	14.07	10.53	0.97	1.86	0.63	8.52	0.27	5.5	1.25	Clay-Loamy
8	0.05	9.71	68.44	570	785	24.79	8.16	1.09	2.87	0.44	7.46	0.1	2.1	0.92	Loamy
9	0.05	19.52	75.6	557	766	22.42	9.84	1.24	1.95	0.38	7.73	0.09	2.1	0.95	Sandy-Clay-Loamy
10	0.06	11.71	36.88	592	593	19.56	11.92	1.37	1.96	0.41	7.5	0.08	1.4	1.27	Loamy
Average	0.06	13.10	65.6	1875.2	1138.5	17.84	9.08	1.71	1.99	0.52	8.08	0.16	6.35	1.37	

Table 3. Reference values are taken as basis in the evaluation of the analysis results of soil samples

Soil Properties	Symbol	Unit	Low	Medium-Low	Suited	High	Very High	References
Total Nitrogen	N	(%)	< 0.05	0.06–0.10	0.11–0.15	0.16–0.20	> 20	Chapman [8]
Available Phosphorus	P	(ppm)	< 3.0	3.0–7.0	7.1–25.0	> 25		Anonymous [22]
Exchangeable Potassium	K	(ppm)	< 50	50-200	201-250	251-320	> 320	Anonymous [37]
Exchangeable Magnesium	Mg	(ppm)	< 55	55-115	116-475	476-1500	> 1500	Anonymous [37]
Exchangeable Calcium	Ca	(ppm)	< 714	714-1438	1439-3862	3863-6108	> 6108	Anonymous [37]
Available Iron	Fe	(ppm)	< 2.5	2.5-5	6-10	11-25	> 25	Lindsay ve Norvell [17]
Available Zinc	Zn	(ppm)	< 0.2	0.2–0.7	0.8–2.5	2.6-8	> 8	Lindsay ve Norvell [17]
Available Manganese	Mn	(ppm)	< 4	4-14	15-50	51-170	> 170	Lindsay ve Norvell [17]
Available Copper	Cu	(ppm)		< 0.2	> 0.2			Lindsay ve Norvell [17]
Extractable Boron	B	(ppm)	< 0.4	0.4–1.0	> 1.0			Lindsay ve Norvell [17]
Organic Matter		(%)	< 1.0	1.0–2.0	2.01–3.0	3.01–4.0	> 4,0	Anonymous [22]
Lime		(%)	< 1.0	1.0–5.0	5.1–15.0	15.1–25.0	> 25	Allison ve Moodie [13]
Salt		mS/cm	< 0.50	0.50–1.50	1.51–2.25	> 2.25		Waters vd. [21]

Table 4. Reference values based on soil pH assessment

Soil Properties	Strong acid	Mid-Acid	Low acid	Neutral	Alkaline	Strong alkaline	Reference
pH	< 4.5	4.5–5.5	5.6–6.5	6.6–7.5	7.6–8.5	> 8.5	Jackson [11]

When the available Copper (Cu) concentration was considered in these orchards, the lowest value (0.8 ppm) was measured in the 2nd orchard, the highest one (2.87 ppm) was in the 8th orchard and the average amount of available Cu in these soils was 1.99 ppm (Table 2). When the soils analyzed were compared with the determined limit values, it was proved by the data that there was no deficiency in Cu (Table 3). Li et al. [25] in their study suggested that the Cu content ranged between 0.01-29.62 ppm in the soils of grapefruit orchards in the Fujian region of China. Similar values were obtained in our study.

The extractable Boron (B) content in these soils was measured to be between 0.35-1.06 ppm analysis (Table 2). When the limit values were examined, it was found that 30% of the orchards were less, 60% of them were little and 10% of them were sufficient in extractable Boron (Table 3). Saatci and Mur [23] measured that the B compositions of the orchards in Izmir where Satsuma mandarins were grown were between 0.30-0.80 ppm. Similarly, Papadakis et al. [29] claimed that the amount of B in the soils in Greece where mandarins were grown varied between 0.53-0.62 ppm. The results of both studies support our study. According to the B limit values in these soils, 90% of the orchards were low in Boron.

3.1.2. Nutrient content of leaf samples

Macro (N, P, K, Mg, Ca) and micro (Fe, Zn, Mn, Cu, B) nutrient amounts of the Clementine mandarin leaves were given in Table 5. References used in the evaluation were given in Table 6.

Table 5. Nutrient contents of leaves of Clementine mandarin orchards.

Orchard Number			%					ppm		
	N	K	Mg	P	Ca	Fe	Mn	Zn	Cu	B
1	2.41	1.09	0.6	0.13	2.91	277	10.45	17.44	3.99	43.43
2	2.84	0.93	0.62	0.14	2.41	248	218	248	7.09	17.68
3	2.73	0.75	0.71	0.16	2.42	209	15.05	16.92	23.04	30.1
4	2.43	0.92	0.7	0.14	2.64	250	193	281	11.06	29.69
5	1.97	0.91	1.11	0.17	2.21	237	41.69	60.01	15.97	45.31
6	2.52	0.97	0.67	0.19	1.93	180	14.71	17.61	14.77	28.48
7	2.29	1.18	0.75	0.19	2.04	262	17.88	18.96	13.32	26.7
8	2.3	1.03	0.71	0.14	1.61	294	12.58	18.99	13.19	236
9	2.46	1.03	0.7	0.14	2	220	14.25	21.23	12.85	169
10	2.23	0.73	0.79	0.16	2.53	247	12.5	20.02	22.22	177
Average	2.41	0.95	0.73	0.15	2.27	242.4	55.01	72.01	15.75	80.33

The lowest N content of the leaves was found at 1.97% and the highest at 2.84%. The average value of N% in the plant leaf samples taken from all orchards was determined to be 2.41% (Table 5). Considering the limit values, it was observed that the N content of Clementine mandarin plant leaves of all the orchards subjected to the research was deficient (Table 6). Cakmak et al. [30] reported that the average value of N% of mandarin leaves in the Cukurova region was 2.58%. In this literature study, similar results to our study were found.

According to the analysis results, K % content in leaves was measured between 1.18-0.73% and the average K value of leaf samples taken from all orchards was determined to be 0.95% (Table 5). When the limit values were examined, it was determined that 20% of Clementine mandarin leaves were deficient, 70% of them were sufficient and 10% of them were more in K content (Table 6). In a study conducted in Dortyol, Hatay, the amount of K% in citrus leaves in 2004 was determined as 1.15% [31]. This study is consistent with our research. When the amount of P% in the leaves was examined, the lowest was measured at 0.13%, the highest at 0.19% and the average P-value was measured as 0.15% (Table 5). When these values were examined, it was determined that 50% of the orchards were deficient at a level that could be regarded insignificant in terms of P content of Clementine mandarin leaves, but the leaf P content in the rest of the orchards was sufficient (Table 6). In Kilic [26] 's study in which he evaluated the nutritional status of citrus leaves in Gumuldur, it was reported that the P content was between 0.12-0.18%. This research supports our study. When the analysis results of our research were examined, it was determined that the Mg% content in the leaves ranged from 0.6% to 1.11% and the average value was measured to be 0.73% (Table 5). According to the limit values, it was determined that the Mg content of all the Clementine mandarin leaves was high (Table 6). Jian et al. [32] found that the Mg content of citrus leaves in the Fujian, China varied between 0.20-0.22%. Erdal et al. [33] argued that even the same species of plants grown in different ecological conditions might have different leaf analysis results. According to the results of our study, the Ca% content in the leaves was measured at the lowest in the 8th orchard (1.61%) and the highest in the 1st orchard (2.91%) while the average value was measured as 2.27% (Table 5). When we compared our results with the limit values, it was observed that all the Clementine mandarin leaves were deficient in the Ca content (Table 6). Ranjha et al. [34] reported that the Ca content of citrus leaves in the Sahiwal region of Pakistan was between 5-22%. The Ca deficiency in leaves was thought to be caused by the antagonistic effect between Fe and Ca.

According to the results of the analysis, the Fe% content in the leaves was between 180-294 ppm and the measured average value was 242.4 ppm (Table 5). When the limit values were considered, it was observed that the Fe content of 100% of Clementine mandarin leaves was high-level (Table 6). Kilic [26] found in his study in Gümüldür that the Fe content was between 54-115 ppm. This research; however, is in contradiction to our study. The lowest Mn% content in leaves 10.45 ppm and the highest value was determined as 55.01 ppm while the average value was 218 ppm (Table 5). According to the limit values, 70% of the Mn content of Clementine mandarin leaves was deficient, 10% of them were sufficient and 20% of them were found to be high in concentration (Table 6). Kaplankıran et al. [35] found that the average value of Mn of Valencia orange leaves grafted on local citrus fruits was 91.52 ppm. This result supports our study. The highest Zn% content in leaves was observed in the 4th orchard (281 ppm) while the lowest content was in 3rd orchard (16.92 ppm) and the average value was measured as 72.01 ppm (Table 5). According to these values, while 70% of the Zn content of the Clementine mandarin leaves were determined to be sufficient, 30% were determined to be high in concentration (Table 6). Toplu et al. [31] found in their study in Hatay the average Zn amount of citrus plant leaves was 28 ppm. Similar results were found also in our study. According to the analysis results, the Cu% content in the leaves ranged between 7.09-23.99 ppm and the average value was 15.75 ppm (Table 5). When the limit values were considered, it was found that 60% of Clemantine mandarin leaves were sufficient and 40% were more in Cu concentration (Table 6). In the study conducted in Gumuldur, the Cu content of the leaves was found to vary between 4 and 62 ppm [26].

Table 6. Reference values of nutrients for the Clementine mandarin plant [9].

Element	Low	Medium	High
N %	< 3.00	3.00–3.40	> 3.40
P %	< 0.15	0.15–0.25	> 0.25
K %	< 0.90	0.90–1.10	> 1.10
Ca %	< 3.00	3.00–5.00	> 5.00
Mg %	< 0.17	0.17–0.40	> 0.40
Fe (ppm)	< 60	60–150	>150
Mn (ppm)	<25	25–100	>100
Zn (ppm)	< 5	5–29	> 29
Cu (ppm)	< 6	6–15	>15
B (ppm)	< 30	31 – 100	> 100

According to the results of the analysis, the lowest B concentration was measured in the 2nd orchard as 17.68 ppm and the highest was measured as 236 ppm. The average B value was observed at 80.33 ppm (Table 5). According to the limit values, it was determined that 50% of the Clementine mandarin leaves were deficient, 20% of them were sufficient and 30% of them were high in B concentration (Table 6). Jian et al. [32] suggested that the B amounts of citrus leaves in the Fujian, China ranged between 20-150 ppm. The result of this research is similar to our study. The use of foliar fertilizer to remove Boron deficiency in leaves was suggested to be a helpful method [36].

4. CONCLUSION

Plant analysis is complementary to soil analysis. It does not indicate the amount of nutrients present in the soil, but how much the plant can benefit from the nutrients in the soil. As a result of this thesis, It was determined that there were nutrition problems related to significant plant nutrients in both soil and leaf samples. To eliminate these problems, it is necessary to increase the amount of organic matter in the soil and, through the soil, mandarin orchards should be given the nutrients they need the most. For this purpose, periodical soil and plant leaf analyzes should be done, a general nutritional status should be revealed and fertilization programs recommended by experts should be followed.

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