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IRON CHLOROSIS AND CHELATE STUDIES IN AVOCADO ORCHARDS

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Iron chlorosis may be described as a state of malnutrition due to low concentrations of iron in plants. In the case of the avocado tree, such a condition is usually associated with yellow foliage which may show green venation, marginal leaf burn, defoliation, poor root system and possibly, death of the affected tree.

CAUSES

Although the cause or causes of iron chlorosis are poorly understood, poor soil aeration, soil moisture, salinity, and soil lime, are some of the factors usually considered in chlorosis studies. It is generally agreed that the deficiency does not stem from the quantity of iron present in the soil but rather from the chemical status of the soil iron. To be effective in maintaining a proper nutritional balance, soil iron must exist in an "available" state — that is, be in a form that is easily absorbed by plants. Furthermore, upon absorption, iron must move in sufficient quantity to the leaf zone for chlorophyll production. This qualification is necessary since there is evidence that in some instances, iron may be in relatively large concentrations within the plant but still fail to support adequately the production of the green pigment, chlorophyll.

IRON LEAF SURVEY

To understand better the nature of iron chlorosis and find the range of iron content in the avocado tree, leaf samples were collected in all major avocado-producing areas of southern California. Samples of most recently matured leaves were taken from trees which had been rated visually with respect to the severity of chlorosis as slight, moderate and severe. Results of this general iron survey are given in Table 1.

Table 1. Results of leaf survey showing the agreement between visible symptoms and leaf iron content.

County	Chlorosis Rating: None to Slight	Moderate	Severe
	ppm Fe	ppm Fe	ppm Fe
Santa Barbara	44	40	30
Ventura	54	46	36
Los Angeles	53	38	----
Orange	48	41	34
Riverside	64	----	----
San Diego	86	69	----
Mean	56	43	32

Leaf values less than 40 ppm Fe were associated with chlorosis, whereas foliage from healthy appearing trees contained 50 to 80 ppm Fe. Values below 30 ppm Fe were extremely low and were invariably associated with severely chlorotic trees. Of the areas visited, chlorosis is widespread in the coast range of Los Angeles and Orange counties. In Los Angeles County, approximately 15,000 avocado trees are afflicted with slight to severe iron chlorosis. In these locations, the soils are fine-textured and frequently contain lime, both of these factors contributing to the unavailability of soil iron. Under these circumstances, chlorosis is usually referred to as "lime-induced" or "bicarbonate-induced" chlorosis.

CORRECTIVE MEASURES

A number of attempts to correct the disorder have been taken in the past but none has achieved any real success. Perhaps less frequent irrigation has been as effective as any practice in reducing chlorosis, especially in fine-textured soils. A variety of iron compounds have been tried as sprays, trunk injections and soil applications, and thus far, no treatment has proved to be consistently effective. Numerous attempts to correct chlorosis by sulfur applications to the soil can be observed, especially in the La Habra Heights district, and all have been without positive effect.

Iron Chelates

Recently two government workers (Holmes and Brown, 1955) reported favorable results attained in calcareous soils fertilized with two new iron chelates, DTPA (diethylenetriaminepentaacetic acid) and Chel 138-HFe. *(Formula not available.)*

With the idea that these materials offered some promise for chlorosis control in avocados, arrangements were made with Geigy Company to obtain sufficient quantities of the above two chelates to run several field tests on avocados. Avocado trees in the La Habra Heights district were selected for these experiments, and soil applications of Fe-DTPA and Chel 138-HFe were made in June, 1955, to 5-year-old Hass trees. Response to treatment was gauged by the extent of regreening and the increase in iron content of the foliage. Results from just one of the field experiments are given in Table 2, since the data reflect the general trend of field responses noted in several separate experiments. No response to Fe-DTPA could be seen in any of the plots, even though large amounts were used in certain instances. However, the 1-pound treatment of Chel 138-HFe was encouraging in that leaf levels of iron were doubled within 60 days following soil application and the foliage developed a normal, healthy appearance.

On the basis of the 1955 chelate tests performed here and elsewhere by other investigators, Fe-DTPA was eliminated, shifting efforts for the 1956-1957 season to evaluating Chel 138-HFe and two similar compounds which could be manufactured more cheaply, RA 157-HFe and RA 159-HFe. All three iron chelates are produced by Geigy Company, and at present in quantities for research purposes only. A summary of the 1956-1957 tests is given in Table 3. As before, Chel 138-HFe appears to be superior in terms of resultant tree appearance and absorption of iron. However, the benefit diminishes with time, which suggests that the activity of the chelate is reduced

after six months or so. Possibly a question of maintenance is raised suggesting the need for retreating the soil. Some of the 1957-1958 field work will be along this line.

The manufacturer is supplying only Chel 138-HFe and RA 157-HFe for field tests during the 1957-1958 season. At present the manufacturing costs for Chel 138-HFe are considered to be sufficiently high to warrant further tests of cheaper derivatives.

The information presented above is only in the form of a progress report, given at the time to acquaint the reader with the general nature of the investigation. Considerably more work is required before this or any other chelate can be recommended for chlorosis correction in California avocado orchards. There does appear though, to be experimental material which may have prospects of being effective when used on calcareous soils.

Table 2. Chlorosis condition and leaf iron content of 5-year-old Hass avocado trees treated with DTPA-Fe and Chel 138-HFe, 1955.

Treatment	Chlorosis Condition, 0 - 4*		ppm Fe — Foliage		
lbs./tree	7/55	12/55	8/55	10/55	12/55
¼ Chel 138-HFe	2½	1½	28	45	44
½ Chel 138-HFe	2½	½	32	43	52
1 Chel 138-HFe	2½	½	32	60	64
½ DTPA-Fe	3½	3	31	43	41
1 DTPA-Fe	3	3	28	36	34
2 DTPA-Fe	3	2½	28	39	43
5 DTPA-Fe	3	3	28	43	40
Control	3	3	26	40	43

**0=healthy, 4=severe.*

Table 3. Chlorosis condition and leaf iron content of Hass avocado trees treated with iron chelates, 1956-1957.

Treatment	Chlorosis Condition, 0 - 4*				ppm Fe — Foliage			
lbs./tree	5/56	7/56	9/56	2/57	5/56	7/56	9/56	2/57
			6-year-old Hass trees					
2 Chel 138-HFe	3	1	0	½	40	76	59	41
2 RA 157-HFe	2½	1	1	1½	30	32	46	32
2 RA 159-HFe	2½	2	1	1	35	39	51	33
Controls	2	1½	2	2	35	42	38	38
			1-year-old Hass trees					
½ Chel 138-HFe	2½	1	0	0	35	148	55	47
½ RA 157-HFe	3	2	0	1½	30	86	55	36
½ RA 159-HFe	3	2½	0	0	38	51	70	37
Control	2½	3	3	2	40	46	51	23

**0=healthy, 4=severe.*