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LOW LEVELS OF MANGANESE IN AVOCADO TREES

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In 1961 we applied iron chelate (1) to the soil around some young avocado trees (mixed Hass and Bacon) in an orchard on the hillside south of Corona to correct severe iron deficiency. The soil is a calcareous clay loam, rather compact and apparently poorly aerated. Two to four ounces of EDDHA-Fe per two-year-old tree were effective in promoting green leaves and healthy appearance although the problem commonly reappeared within a year. Meanwhile, some of the treated trees that received up to eight ounces of iron chelate developed a different kind of chlorosis in the leaves that bore some resemblance to zinc deficiency symptoms. Leaf analyses showed, however, that zinc was adequate (more than 20 ppm) but the manganese concentrations were lower than we had ever found in avocado leaves — 6 to 16 ppm.

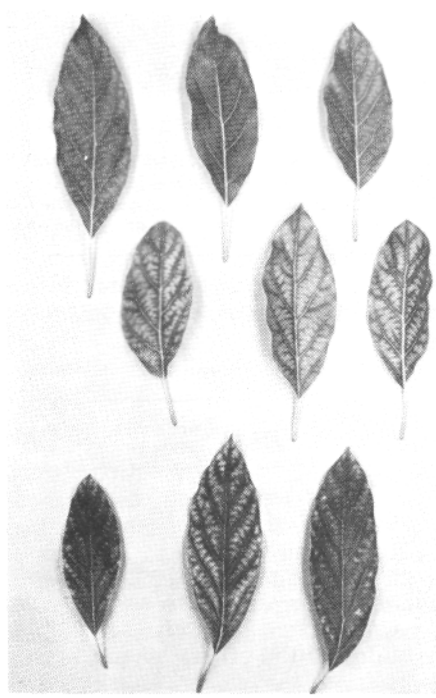

FIGURE 1. Leaves from Hass avocado trees in the Corona area, exhibiting chlorosis symptoms typical of low manganese levels (top and middle) and of mild zinc deficiency (bottom).

Similar visible symptoms in avocado leaves have previously been produced in potted or boxed trees (Haas, 1939; Lynch, 1941; Furr, *et al.,* 1946) and shown to clear up when manganese was added to the soil or nutrient solution. We have been unable to find reports of field occurrence of these symptoms and, therefore, decided to investigate the matter further. We have repeated the iron chelate treatments on various trees with similar results. Both the Hass and Bacon varieties exhibited iron deficiency symptoms that were corrected by treatment with iron chelate but only the Hass variety has developed the leaf symptoms that we now associate with low manganese concentrations in the leaves. Figure 1 shows Hass leaves having this chlorosis pattern in mild form (top row) and more severe form (second row). These can be compared with moderate zinc deficiency (bottom row) of leaves taken from another orchard. The difference in leaf patterns is in the contrast between the darker and lighter portions of the leaf, similar to that found in citrus and many other crops. Zinc deficiency usually causes the pale spots between veins to be yellow whereas with low manganese they are only less green than the tissue along the veins.

The concentrations of iron, manganese, and zinc in these leaves are given in table 1. Past experience indicates that deficiency patterns in avocado leaves begin to appear when iron concentration falls below 40 ppm or when zinc concentration is 15 ppm or less. Comparing the figures in table 1 and the pictures in figure 1, it appears that iron was adequate in all the leaves; zinc was adequate in the first two samples but caused incipient chlorosis at 15 ppm in the third set of leaves; the low manganese chlorosis started at 16 ppm and was more severe at 10 ppm.

TABLE 1. Concentrations of nutrient elements in spring cycle leaves of Hass avocados sampled in July (Corona).

	Iron	**Manganese**	**Zinc**
	Concentration in dry leaves — p.p.m.		
Mild manganese pattern (figure 1, top)	43	16	29
Strong manganese pattern (figure 1, middle)	46	10	26
Slight zinc pattern (figure 1, bottom)	56	52	15

In 1964 one of us (M.P.M.) observed similar leaf symptoms in the Hass (figure 2), Zutano (figure 3), and Nowels varieties of avocado trees growing in soils derived from lava and volcanic ash on the slopes of Mt. Etna in Sicily. Again, leaf analysis (2) showed that zinc supply was adequate but that manganese concentrations were low (table 2).

FIGURE 2. Leaves from Hass avocado trees in Sicily, showing chlorosis symptoms associated with low concentrations of manganese.

FIGURE 3. Leaves from Zutano avocado trees in Sicily, showing chlorosis symptoms associated with low concentrations of manganese.

TABLE 2. Concentrations of nutrient elements in summer cycle leaves of avocados in Sicily sampled in January.

Variety	Iron	Manganese	Zinc
	Concentration in dry leaves — p.p.m.		
Hass (figure 2)	68	5	26
Zutano (figure 3)	52	8	31
Nowels (not shown)	88	7	63

Citrus trees in the vicinity were subject to extreme manganese deficiency. This may be the first recorded instance of naturally occurring manganese deficiency in the avocado, all the others having been induced by special treatment.

We are in the process of determining whether these leaf symptoms (at Corona) can be corrected by applying manganese to the soil or leaves, which is a necessary step required to identify the symptoms as being caused by manganese deficiency. Meanwhile, the evidence favoring this view may be summarized as follows:

1. Increasing severity of the chlorosis symptom is associated with decreasing manganese concentration;
2. The type of leaf chlorosis pattern is similar to that which resulted from withholding manganese from nutrient cultures of avocado (Hass; Furr, *et al.);*

3. The leaf chlorosis pattern differs from that caused by zinc deficiency in the same way that the two patterns differ in citrus and other species;
4. Leaf concentrations of manganese associated with the symptom are similar to those found in manganese deficient leaves of citrus and numerous other types of plants;
5. Similar patterns occur in at least four different varieties of avocado, namely, Taylor (by Furr, *et al*), Hass, Zutano, Nowels (in this report).

With the limited number of trees available for study in the Corona orchard, it is not expected that information will be derived from it on effects of manganese deficiency on fruit production and quality. How- ever, with the above description of symptoms and information on leaf composition, it is hoped that any future instances will be recognized so that suitable control measures can be developed.

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(2) *The authors wish to acknowledge with thanks the generous cooperation of Dr. Francesco Russo of the Stazione Sperimentale di Agrumicoltura in Acireale, Sicily, in collection and preparation of the leaf samples.*

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