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Seasonal Changes in Concentrations of Zinc, Copper, Boron, Manganese, and Iron in Fuerte Avocado Leaves[1]

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Seasonal fluctuations" in concentrations of micronutrients have been observed in young Hass avocado leaves (3). Leaf analysis is being widely used as an aid in diagnosing micronutrient nutritional status of avocado trees, but if leaf analysis is to be used effectively as a diagnostic tool either experimentally or commercially, the seasonal trends for the elements in question must be known. This paper presents such seasonal trend data to show the relationship between the age of Fuerte avocado leaves and. the micronutrient concentrations in them.

MATERIALS AND METHODS

The experimental orchard previously described (2, 4) is located on acid soil, sprinkler-irrigated, and nontilled—weeds under the trees were controlled with oil herbicides. Prior to the establishment of the experiment, the avocado trees received 3 pounds of actual N per tree per year from sulfate of ammonia broadcast under the trees.

The fertilizer treatments (71, 73, 74, 76, 77, 78, 79, 80, 82, 83, 85, 86, 87, and 88) considered in the present report have been described in detail previously (2). Each treatment was replicated 5 times in single-tree plots, making a total of 70 plots.

Leaf samples for micronutrient chemical analysis were obtained within each replication of each treatment at monthly intervals over 3-yearly periods—from June, 1952, to January, 1954; and from May, 1957, to April, 1958, inclusive. Samples consisted of leaves developed during the preceding spring and early summer. Leaves from 5 replications were pooled into one sample.

At each sampling date, 10 outside leaves of the desired age were selected from non-fruiting shoots around each tree at a height of 4-to 6 feet. Shoots sampled did not have a cycle of leaves younger than those sampled. The samples included both the petioles and blades of the leaves.

Methods of preparing leaf samples for analysis and of analyzing the leaves for zinc, copper, boron, manganese, and iron were the same as those used previously (3).

Polynomial equations were fitted to data obtained from the analyses. Reductions in sums of squares were tested for significance (9). There were no significant interactions between fertilizer treatment and age of leaf on micronutrient concentrations in the leaves.

This indicated that fertilizer treatments had similar relative influences on each sampling date. The influence of fertilizer treatments on concentrations of micronutrients in the leaves in October, 1955 has been reported previously (4). Therefore, only the mean effects of sampling dates on the age of leaf on the micronutrient concentrations in the leaves are presented here. No annual micronutrient maintenance spray applications have been applied.

RESULTS

Zinc:—The data presented in Fig. 1 show a significant curvilinear regression of the zinc concentration in avocado leaves on age of the leaves sampled from June, 1952, to April, 1953, and from May, 1957, to April, 1958, inclusive. The zinc concentration in the leaves sampled from May, 1953, to January, 1954, did not change significantly during that season. The concentration of zinc in the leaves sampled in June, July, August, September, and October, 1952 (1, 2, 3, 4, and 5 months old, respectively) increased slightly and after that decreased with the age of the leaves. The zinc concentration in the leaves sampled in May, June, July, and August, 1957 (1, 2, 3, and 4 months old, respectively) decreased very rapidly. The leaves sampled in September, October, November, December, January, and February of the same year (5, 6, 7, 8, 9, and 10 months old, respectively) contained almost constant concentrations of zinc. Thereafter, in March and April, 1958 (11 and 12 months old, respectively) the zinc concentration in the leaves tended to decrease rapidly. In the growing season of 1957 and 1958, zinc concentration decreased for the first 4 months, then leveled off for the following 6 months, and then decreased again for another 2 months.

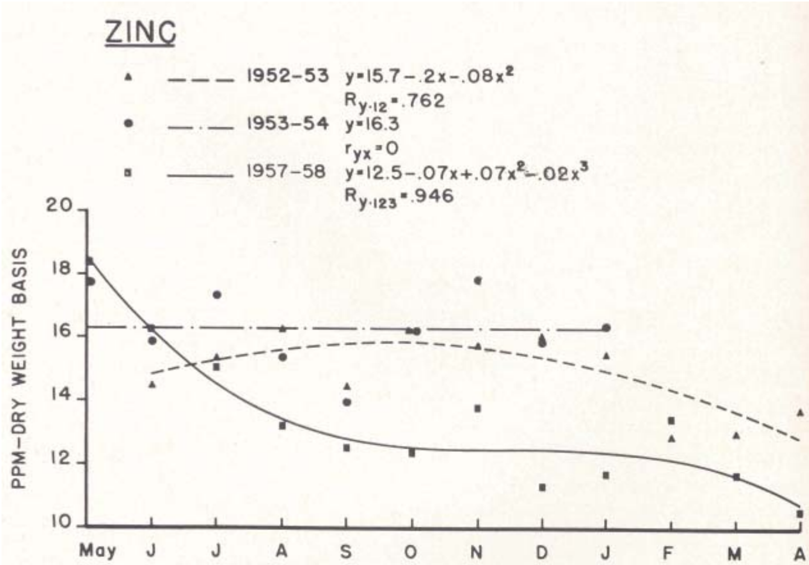

Fig. 1. Seasonal changes in zinc concentration in Fuerte avocado leaves as affected by the age of the leaves.

Copper:—The data presented in Fig. 2 show a significant linear regression of the copper concentration as the 1953-54 avocado leaves aged. On the other hand, the concentration of copper in the 1957-58 leaves showed a significant curvilinear regression: an increase in the first 3 months of the season and after that a decrease until November (7 months old leaves), and finally, a decrease for the rest of the season. The 1952-53 leaves did not show any significant changes in copper concentration.

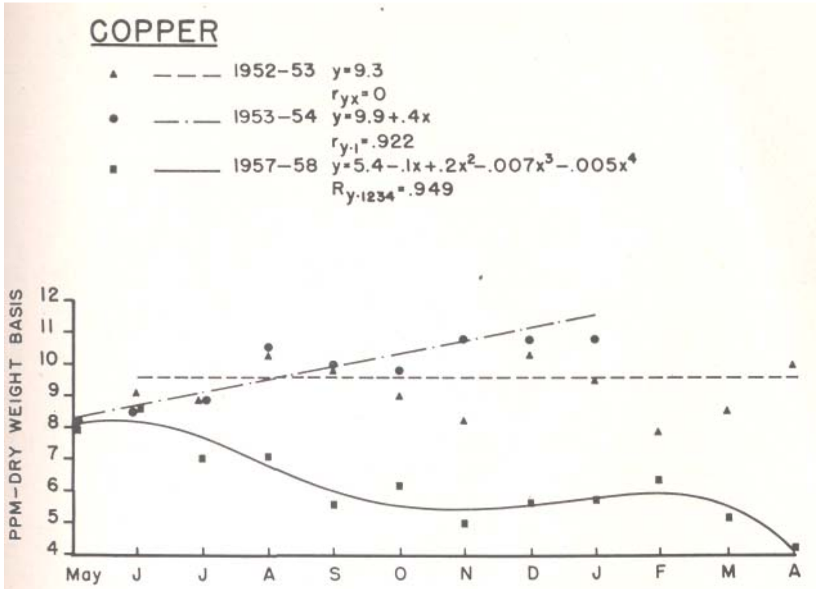

Fig. 2. Seasonal changes in copper concentration in Fuerte avocado leaves as affected by the age of the leaves.

Boron:—The data presented in Fig. 3 show a significant cubic relationship between boron concentration and the age of the leaves sampled in 1957-58 season. The boron concentration increased during the early part of the growing season until the end of July, 1957 (3 months old). Thereafter, boron concentration tended to decrease with the age of the leaves until the end of April, 1958 (from 4 to 12 months old). The concentration in leaves sampled in 1953-54 season decreased with the age of the leaves. The 1952-53 leaves did not show any significant changes in boron concentration. The boron concentration in the 1953-54 and 1957-58 avocado leaves decreased substantially with the age of the leaves. It is not known, however, whether this is typical of avocado trees when grown under high-level boron conditions. The concentration of boron in the leaves of this Fuerte avocado orchard was quite low as compared to concentrations found in the MacArthur variety sampled in other parts of southern California. MacArthur avocado leaves from Ventura County were analyzed for boron concentration and the data obtained from low-nitrogen, medium-nitrogen, high-nitrogen, and extra high-nitrogen treated trees were 71, 65, 50, and 46 ppm, respectively.

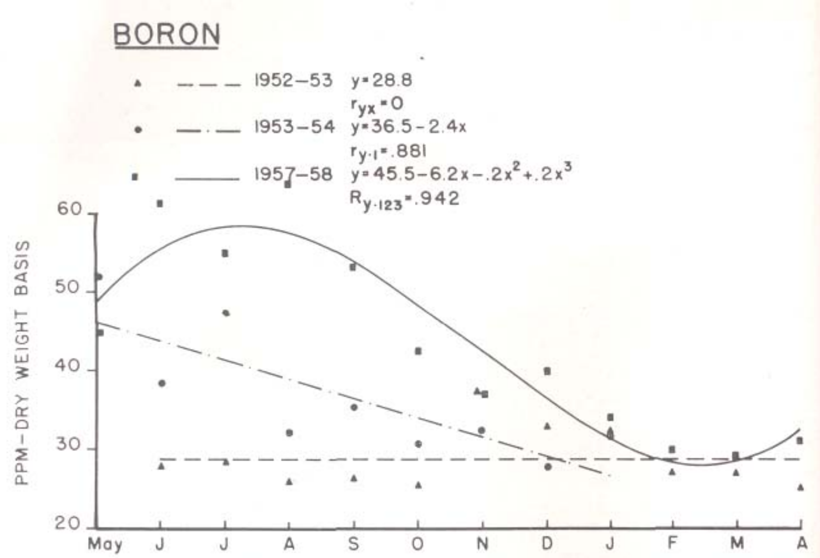

Fig. 3. Seasonal changes in boron concentration in Fuerte avocado leaves as affected by the age of the leaves.

Manganese:—A significant curvilinear regression of the manganese concentration in avocado leaves on age occurred in the 3 seasons sampled (Fig. 4). It is not known whether this trend is typical of avocado trees when grown under low-level manganese conditions. Manganese concentration was found to be much greater in avocado leaves than in citrus leaves growing under similar soil conditions (5).

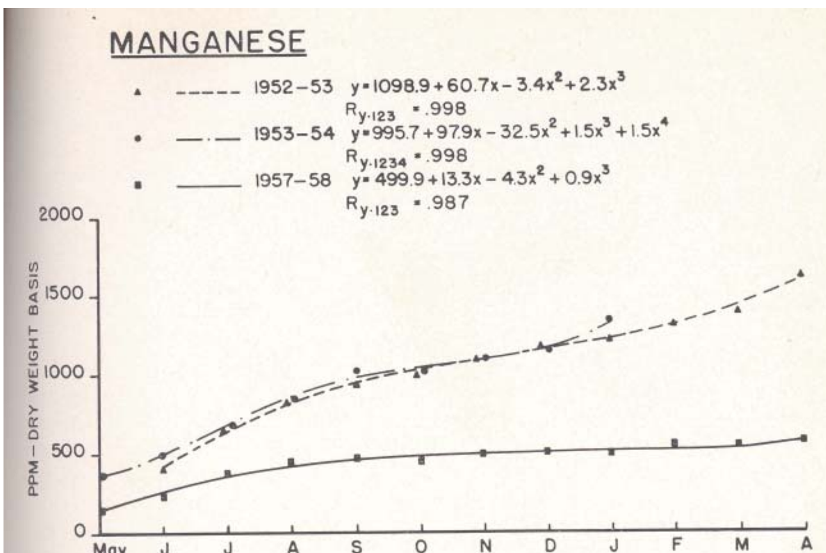

Fig. 4. Seasonal changes in manganese concentration in Fuerte avocado leaves as affected by the age of the leaves.

Iron:—A significant curvilinear regression of the iron concentration in avocado leaves on age of the leaves occurred in all three seasons (Fig. 5). The iron concentration increased with the age of the 1952-53 leaves until the end of August (3 months old); thereafter, it tended to decrease until the end of January (8 months old), and finally, tended to increase again. This alternating trend was a significant quartic relationship between iron concentration in the leaves and age of the leaves. A similar quartic relationship in iron concentration was found in the leaves of trees sampled in 1953-54 season. The iron concentration in the 1957-58 leaves increased slightly from May until November (1 to 7 months old) and thereafter tended to decrease very slightly for the rest of the season.

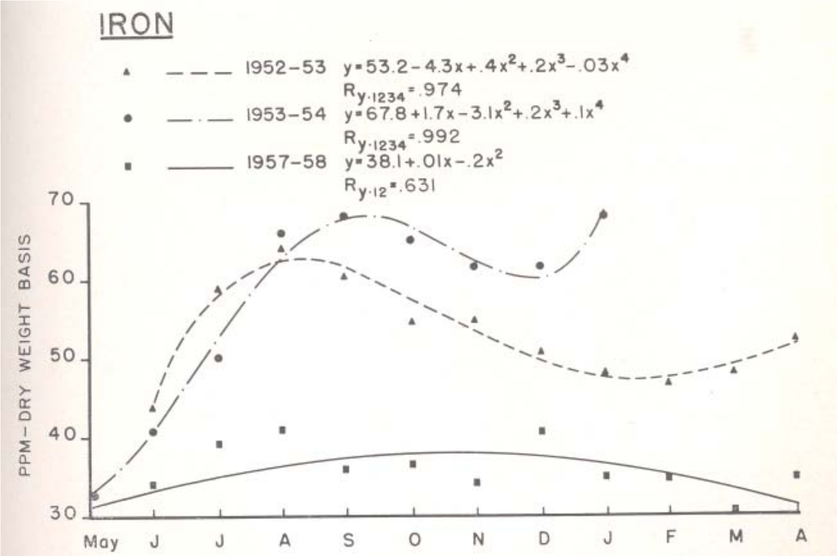

Fig. 5. Seasonal changes in iron concentration in Fuerte avocado leaves as affected by the age of the leaves.

DISCUSSION

The concentrations of zinc, copper, manganese, and iron were higher and boron lower in the leaves sampled in 1952-53 and 1953-54 seasons than those found in analogous leaves of the same trees sampled in 1957-58. Primarily, this is due to the acidifying effects of ammonia sulfate used prior to the establishment of the experiment in 1951 after which date different fertilizers were used (2).

There is strong reason to believe that soil applications of 3 pounds of actual nitrogen from ammonia sulfate for many years increases soil acidity and, as a consequence, zinc, copper, manganese, and iron become more available to the plant, while boron under the same conditions is leached out more readily. In addition, various environmental factors such as temperature, rainfall, and other factors, such as yield and vegetative growth affect the concentrations of micro-nutrients in the leaves from season to season-Seasonal changes of zinc, copper, and manganese concentrations in Fuerte avocado leaves in relation to age coincide partially with findings by Bradford and Harding (1) arid Labanauskas *et al.* (6) 011 orange leaves and by McClung and Lott (7) on peach leaves. All of these workers found that zinc and copper tended to decrease and manganese to increase with the age of the leaf through the growing season. On the other hand, Smith *et al.* (8) found that accumulation of zinc, copper, and manganese in Valencia orange leaves ceased after a given amount was taken up and might be redistributed in part thereafter. In general, the relation of the concentration of zinc, copper, or manganese in avocado leaves to age of the leaf followed just about the same pattern that was found in Valencia orange, Navel orange, and peach leaves.

The relation in Fuerte avocado leaves of boron concentration to age does not coincide with the findings by Smith *et al.* (8) and Bradford and Harding (1) in Valencia orange leaves, by Labanauskas *et al.* (6) in Navel orange leaves, and by McClung and Lott (7) in peach leaves, all of whom found that boron concentration tended to increase throughout the life of the leaf, except in the winter months. Boron toxicity or deficiency has not been observed in avocado trees growing in southern California. Citrus trees, however, are being affected quite severely by boron toxicity in the later parts of the growing season in some of the citrus producing areas. Seasonal changes of boron concentration in avocado leaves may partially explain why boron toxicity has not been observed in avocado leaves and still may be quite severe on citrus.

The relationship found (Fig. 5) between iron concentration in the leaves and age of leaf do not coincide completely with the findings by Bradford and Harding (1), Smith *et al.* (8), and Labanauskas *et al.* (6) in citrus leaves. These authors stated that accumulation of iron was nearly continuous over the entire period without any removal from the leaf during the period of spring growth. The data presented in this paper indicate that the seasonal changes of boron and iron concentrations in avocado leaves do not follow the pattern found in Valencia and Navel orange leaves, and in peach leaves.

SUMMARY

Seasonal changes in concentrations of micronutrients in leaves of Fuerte avocado over a 12-month period for 3 different years are reported here.

A significant curvilinear regression of the zinc concentration in avocado leaves on age of the leaves sampled from June, 1952, to April, 1953, and from May, 1957, to April, 1958, was found.

Significant curvilinear regressions of copper and boron concentrations in avocado leaves on age in 1953-54 and in 1957-58 seasons sampled were found. The 1952-53 leaves did not show any significant changes in copper and boron concentrations.

Significant curvilinear regressions of the manganese and iron concentrations in avocado leaves on age of the leaves were found in all three seasons sampled.

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