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SOIL APPLICATIONS OF ZINC FOR AVOCADOS

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The deficiency of zinc in avocados was apparently first described as "frizzles" by Coit (1928), but he did not associate "frizzles" with a shortage or insufficiency of zinc. Parker (1936) reported that foliar sprays of zinc corrected "frizzles" and, indeed, "frizzles" was a symptom of zinc deficiency.

The effect of zinc deficiency on the shape of Fuerte fruits is shown in Figure 1. The expression of the symptoms of the deficiency on the Fuerte variety may vary. Sometimes round fruits may be observed on the trees with no visible symptoms of the deficiency on the leaves; at other times the symptoms may appear on the foliage, but fruit shape will be normal; most frequently, the symptoms occur on both foliage and fruit.

Figure 1. Left — Normal Fuerte avocado fruit and leaves. Right — Round fruit and small, mottled leaves from a Fuerte avocado tree with severe zinc deficiency.

Foliage symptoms of zinc deficiency can be confused with a leaf mottling that results from excess chloride. The two leaf symptoms are contrasted in Figure 2. Zinc deficiency

results in a rather uniform mottling between the veins. Mottling from excess chloride is more severe near the tip and edges than in the central and basal portions of the leaf; this mottling usually occurs in advance of tip and sometimes marginal dying of the leaf.

The leaf symptoms of zinc deficiency are practically indistinguishable from those of manganese. Fortunately, manganese deficiency is rare in commercial avocado orchards in California. Wallihan and Miller (1966) describe the manganese-deficiency symptoms and give the first documented evidence of the deficiency on field grown trees in California. The two deficiencies can be identified by leaf analysis.

After the report by Parker (1936), spraying became the routine commercial method for supplying zinc.

Under some conditions, problems are associated with foliar sprays of zinc. Some orchards are situated on steep hillsides where it is difficult and expensive to operate ground spray equipment. Many orchards are too crowded for proper operation of ground spray equipment. Traffic from heavy spray equipment may compact the soil and reduce infiltration rate of rain and irrigation water into the soil. Spray applications of zinc materials may leave a spray deposit on the leaves; dusts and other residues on the leaves may interfere with the pest control program (Fleschner, 1958; Holloway, Henderson, and McBurnie, 1942; Spencer, Osburn, and Norman, 1954). There is evidence that, if effective, one soil application of zinc will remain effective for several years, while sprays need to be repeated annually. Thus, there are ample reasons for wanting an effective method of supplying zinc to avocado trees by means of soil applications.

Gustafson (1957) showed that soil applications of zinc sulfate were effective in the avocado orchards in which he worked and recommended rates, dependent upon age of the trees, from one to ten pounds of zinc sulfate (23-28% zinc) per tree to be applied in a two- to three-foot band at the drip line of the trees, Some soils in San Diego and Santa Barbara counties are slightly acid in reaction. One would expect soil applications of zinc to be more effective on acid than on alkaline soils.

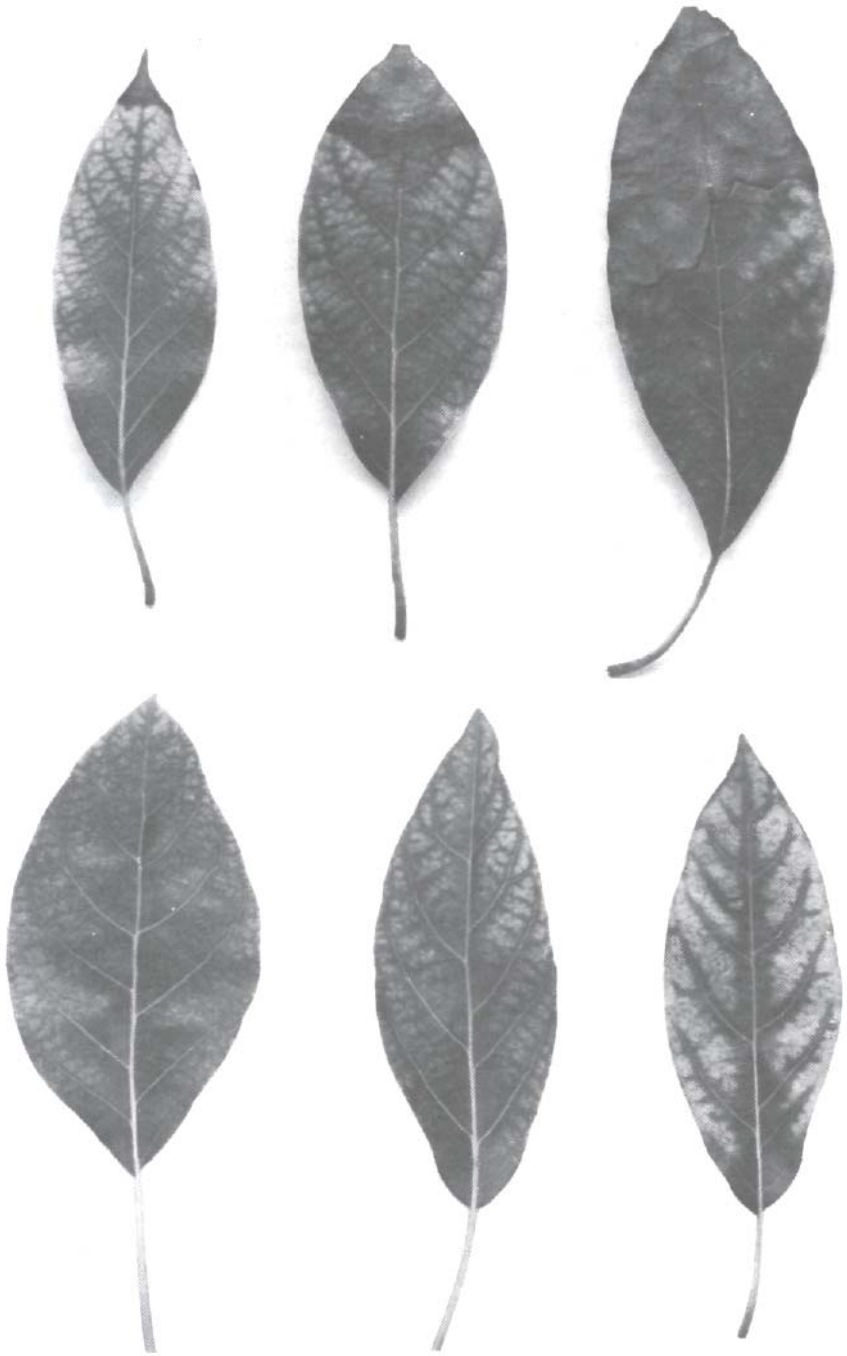

Figure 2. Top — Excess chloride symptoms on Fuerte avocado leaves; increasing severity from left to right. Bottom — Zinc deficiency symptoms on Fuerte avocado leaves; increasing severity from left to right.

Exploratory trials by the authors showed that in some orchards, the symptoms of zinc deficiency (foliage symptoms and round Fuerte fruits) could be eliminated and the concentrations of zinc in the leaves could be increased by soil applications of zinc

chelates. Some of these observations were reported by Wallihan, Embleton, and Printy (1958). In one comparison, injection of Na2Zn EDTA into the irrigation water to give one pound of material per six-year-old Fuerte tree, eliminated the symptoms of zinc deficiency on the fruit and leaves and increased the concentration of zinc in the leaves from 15 to 50 ppm. Subsequent observations showed that this one application was effective for at least four years. The surface foot of soil in this orchard had pH values ranging from 7 to 8.

Since part of the observations in these exploratory trials were negative, more detailed experiments were in order. Treatments and results from an experiment on Fuerte trees about ten years old, near Fallbrook, where the pH of the soil ranged between 7 and 8, are shown in Table 1. Each treatment was replicated three times with five trees per plot. Soil applications of Orzan-Zn (a zinc complex with a by-product from paper pulping) and synthetic zinc chelates were not effective in increasing the concentrations of zinc in the leaves. One year after treatment there was no residual effect of a zinc spray. This is not surprising, since very little zinc is translocated from old to young foliage. After periods of three months, and one year after treatment, zinc sulfate applied in the irrigation water or in a band resulted in significant increases in the concentration of zinc in the leaves. Two years after treatment only the band application remained effective.

Results from another experiment near Santa Paula on twelve-year-old Fuerte trees are shown in Table 2. The pH of the soil in this orchard also ranged between 7 and 8. There were three replications of three trees per plot for each treatment. Five months after treatment the concentration of zinc in the leaves from the sprayed trees was significantly higher than in leaves from the control trees; one year after treatment there was no residual effect of the foliage spray. In this experiment soil applications of zinc chelates and zinc sulfate by three methods of application were not effective. Although the half-pound rate of NaZn HEEDTA applied in a band at the drip line of the trees showed an increase in zinc content in the leaves above that in the control trees, the magnitude of the increase was so small that it is considered to be of no practical consequence.

Discussion and Summary

From these limited experiments in Fuerte avocado orchards with slightly alkaline soils, it appears that soil applications of zinc sulfate at rates of five pounds per tree may be effective in some orchards and not in others. Band applications at the drip line of the trees were more effective than injecting the material into the irrigation water. One would expect such applications to be more effective on acid than on alkaline soils.

TABLE 1. Treatments for Fuerte avocado zinc experiment near Fallbrook and the effects on zinc concentrations in leaves.

Form of zinc	Pounds zinc material per tree, 7/57	per cent zinc in material	Method of application	Before treatment, 7/57	ppm zinc in dry leaves 10/57	8/58	8/59
Control	0	—	—	15.9	14.8_{y}[a]	13.1_{x}[b]	16.3_{y}[b]
Na2Zn EDTA[c]	¼	8	Solution injected in irrigation water	18.0	—	15.8_{xy}	16.4_{y}
”	½	8	” ” ” ” ”	13.9	—	14.6_{xy}	16.5_{y}
”	1	8	” ” ” ” ”	12.9	14.8_{y}	13.6_{x}	14.9_{y}
NaZn HEEDTA[d]	¼	10	” ” ” ” ”	15.2	—	15.2_{xy}	17.2_{y}
”	½	10	” ” ” ” ”	14.5	—	16.2_{xy}	17.2_{y}
”	1	10	” ” ” ” ”	15.2	17.5_{y}	16.1_{xy}	16.7_{y}
Orzan-Zn	5	10	” ” ” ” ”	13.9	18.2_{yz}	14.1_{xy}	15.6_{y}
Sulfate	5	36	” ” ” ” ”	14.2	25.2_{z}	20.1_{y}	20.4_{y}
Na2Zn EDTA	½	8	Three-inch band at dripline of tree	13.4	—	14.1_{xy}	14.4_{y}
Sulfate	5	36	” ” ” ” ” ” ”	15.7	25.2_{z}	30.4_{z}	29.6_{z}
”	—	36	Foliar spray[e]	15.8	—	15.2_{xy}	18.2_{y}
Significance[f]				NS	*	**	**

[a] Means are significantly different at the 5% level if they do not have a subscript letter in common.
[b] Means are significantly different at the 1% level if they do not have a subscript letter in common.
[c] Na2Zn EDTA = Disodium zinc ethylenediamine tetraacetate.
[d] NaZn HEEDTA = Monosodium zinc hydroxyethylethylene diaminetriacetate.
[e] Foliage spray was applied 8/57 at the rate of 3.5 pounds of 36% zinc sulfate plus 1.75 pounds of soda ash per 100 gallons of water.

[f] NS indicates treatment effects are not statistically significant.
* indicates treatment effects are significant at the 5% level.
** indicates treatment effects are significant at the 1% level.

TABLE 2. Treatments for Fuerte avocado zinc experiment near Santa Paula and the effects on zinc concentrations in leaves.

Form of zinc	Pounds zinc material per tree, 7/58	Per cent zinc in material	Method of application	Before treatment, 5/58	ppm zinc in dry leaves 1/59	5/59
Control	0	—	—	22.7	9.7_{y}[a]	13.1_{y}[a]
NaZn HEEDTA	½	10	Three-inch band at dripline of tree	21.0	12.3_{y}	17.1_{z}
”	½	10	Injected into soil in 1 gal. of solution	22.4	12.4_{y}	12.9_{y}
”	½	10	Solution injected in irrigation water	25.1	11.9_{y}	16.1_{yz}
Sulfate	5	36	Three-inch band at dripline of tree	18.9	11.0_{y}	14.4_{yz}
”	5	36	Injected into soil in 1 gal. of solution	22.8	13.9_{y}	14.1_{yz}
”	5	36	Solution injected in irrigation water	21.9	15.6_{y}	16.2_{yz}
”	—	36	Foliar spray[b]	21.5	29.6_{z}	15.3_{yz}
Significance[c]				NS	**	**

[a] Means are significantly different at the 1% level if they do not have a subscript letter in common.
[b] Foliar spray was applied 8/58 at rate of 2 pounds of 36% zinc sulfate plus 1.4 pounds of soda ask per 100 gallons of water.

[c] NS indicates treatment effects are not statistically significant.
** indicates treatment effects are significant at the 1% level.

Exploratory trials indicated that zinc chelates were effective in some orchards but not in others. In the two more detailed experiments reported here, neither NaZn HEEDTA nor Na2Zn EDTA were effective when applied to the soil at the rates indicated in the experiments.

Presumably, in any orchard zinc deficiency could be corrected if enough zinc material were added to the soil. Larger applications induce the hazard of injury to the trees. Larger applications must also be viewed from the standpoint of economy.

Where effective, soil applications of zinc remain effective for several years, while foliage applications of zinc must be applied annually.

In a given orchard, the effectiveness of a soil application of zinc could be rather easily determined in a small trial by using leaf analysis to determine if such applications increase the concentration of zinc in the foliage. Leaf analysis standards were reported by Goodall, Embleton, and Platt (1965).

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