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FERTILIZER EFFECTS UPON MICRONUTRIENT NUTRITION OF THE AVOCADO

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Deficiencies of micronutrients in avocado trees are often an important problem in southern California avocado orchards. Results of recent research show more clearly that fertilization practice has an important influence on the micronutrient nutrition of avocado trees. Specifically, this paper presents 3 years of research data from a field experiment dealing with the effects of soil applications of nitrogen, phosphate, potash, dolomite, and steer manure on the micronutrient (zinc, copper, manganese, boron, iron) concentrations in the leaves from Fuerte avocado trees. Effects of soil applications of the above mentioned fertilizers of the macronutrient (nitrogen, phosphorus, potassium, calcium, magnesium, sodium, chloride) concentrations in Fuerte avocado leaves from this experiment has been reported by Embleton et al. (2).

MATERIALS AND METHODS

A Fuerte avocado orchard in northern San Diego County was selected on Ramona stony sandy loam, a light-textured, well-drained, shallow, acid soil having a cation exchange capacity of less than 4 milliequivalents per 100 grams. The soil was nontilled; irrigation was by individual under-tree sprinklers; weeds under the trees were controlled with oil and other chemical herbicides.

The avocado trees were planted in 1939 where Navel orange trees had been removed. Prior to the establishment of the experiment, the avocado trees received three pounds of actual nitrogen per tree per year from sulfate of ammonia broadcast under the trees. Differential treatments were started in 1951 for the purpose of evaluating the effects of two levels each of dolomite, nitrogen, potash, and steer manure, and three levels of phosphate, on yield, fruit size and quality, tree growth, and chemical composition of avocado leaves. The 18 fertilizer treatments are summarized in Table 1. Each treatment was replicated five times in single-tree plots, making a total of 90 plots. Leaf samples for chemical analysis were obtained in October, 1955, August, 1956, and September, 1957, from the spring and summer flushes of growth. The method of preparing avocado leaves for micronutrient analysis has been described elsewhere (7). Only the main effects of nitrogen, phosphate, dolomite, potash, and steer manure on the mean concentrations of micronutrients for three years are presented in this paper.

RESULTS AND DISCUSSION

Nitrogen effects: Nitrogen was applied in one application per year at two rates, (N_1) and (N_2). Prior to 1955, the low-nitrogen treatments (N_1) did not receive any nitrogen; in 1955, 1956, and 1957, 0.5 pound of nitrogen was applied per tree from ammonium nitrate. The data presented in Table 2 show that leaves from avocado trees that received 2 pounds of actual nitrogen per tree annually (N_2) contained significantly less zinc, copper, and boron, and significantly more manganese and iron than leaves from trees that received the low-nitrogen rate (N_1). Although the high rate of nitrogen (N_2) resulted in lower zinc, copper, and boron concentrations in avocado leaves than did the low rate, only occasional recognizable zinc deficiency symptoms were observed on trees that also received high rates of both nitrogen and phosphate. On the other hand, recognizable copper and boron deficiency symptoms were not observed. The data presented in Table 2 are in agreement with previous results from this experiment (4) and with results from an irrigation-fertilizer experiment on Hass avocados at the Citrus Experiment Station (3). Our observations of a reduction in zinc and copper concentrations in avocado leaves as a result of large applications of nitrogen fertilizers are in agreement with observations in Florida by Ruehle (6) and Lynch (5).

Table 1. Soil treatments used in Fuerte avocado fertilizer experiment in northern San Diego County, California.

	Pounds per tree per application			
Treatment	N	P_2O_5	K_2O	Dolomite[1]
N_1	0.5-0.75[2]	----	----	----
N_1P_1	0.5-0.75[2]	4.6[3]	----	----
N_1P_2	0.5-0.75[2]	9.2[3]	----	----
N_2	2.0[4]	----	----	----
N_2P_1	2.0[4]	4.6[3]	----	----
N_2P_2	2.0[4]	9.2[3]	----	----
N_2K_1	2.0[4]	----	10.2[5]	----
$N_2P_2K_1$	2.0[4]	9.2[3]	10.2[5]	----
Steer manure[6]	2.0	0.9	3.9	----
$N_1Dol._1$	0.5-0.75[2]	----	----	50
$N_1P_1Dol._1$	0.5-0.75[2]	4.6[3]	----	50
$N_1P_2Dol._1$	0.5-0.75[2]	9.2[3]	----	50
$N_2Dol._1$	2.0[4]	----	----	50
$N_2P_1Dol._1$	2.0[4]	4.6[3]	----	50
$N_2P_2Dol._1$	2.0[4]	9.2[3]	----	50
$N_2K_1Dol._1$	2.0[4]	----	10.2[5]	50
$N_2P_2K_1Dol._1$	2.0[4]	9.2[3]	10.2[5]	50
Steer manure[6], $Dol._1$	2.0	0.9	3.9	50

[1]*Applied August 1951, May 1952, and August 1952. Dolomite contained 60% $CaCO_3$ and 39% $MgCO_3$.*

[2]*One-half pound N applied February 1955 and 1956; 0.75 pound applied February 1957; source: ammonium nitrate, 33.5% N. Prior to 1955, N_1 treatments did not include nitrogen.*

[3]*Applied August 1951 and 1952; source: treble superphosphate, 46% P_2O_5.*

[4]*Applied annually, starting August 1951; source: ammonium nitrate, 33.5% N.*

[5]*Applied August 1951 and 1952; source: potassium sulfate 51% K_2O.*

[6]*Applied annually, starting August 1951.*

Phosphate effects: Differential rates of treble superphosphate (45 per cent P_2O_5) were applied to avocado trees in 1951 and 1952. Since that time no phosphate fertilizers have been applied. The data obtained from 1955, 1956, and 1957 leaf analyses (Table 2) show that phosphate soil applications (P_1P_2) to avocado trees in 1951 and 1952 resulted in significantly lower concentrations of zinc and copper, and significantly higher concentrations of manganese in the leaves in the 1955-57 period. The same effect of phosphatic fertilizers on zinc was found in three consecutive years and on copper in only the first two years. Some of the trees that received high-phosphate plus high nitrogen rates showed zinc deficiency symptoms on the leaves and the incidence of the deficiency symptoms was in close agreement with results from leaf analysis. Although high-phosphate treatments applied to the trees reduced the copper concentration in the leaves, no recognizable copper deficiency symptoms were observed. Boron and iron concentrations were unaffected by the differential phosphate treatments.

Dolomite and potash effects: Dolomite soil applications to avocado trees significantly reduced manganese and zinc concentrations in the leaves (Table 2). Copper, boron, and iron concentrations were unaffected by dolomite soil applications. The mean values for the dolomite treatments do not include those dolomite treatments which receive potash fertilizers. Potash soil applications to avocado trees in 1951 and 1952 did not have any significant effect on the micronutrient concentrations in the leaves sampled in 1955, 1956, and 1957.

Table 2. Mean effect of soil applications of nitrogen, phosphorus, dolomite, potash, and steer manure on the micronutrient concentrations in Fuerte avocado leaves, for 1955, 1956, and 1957[1].

	Parts per million in oven-dried leaves				
Application rate	Zn	Cu	Mn	B	Fe
N_1[2]	25	6.5	443	43	53
N_2[2]	22	5.7	568	30	56
F value	**	**	**	**	*
P_0[3]	26_y	6.5_y	443_x	39	55
P_1[3]	23_x	6.0_{xy}	566_y	35	54
P_2[3]	22_x	5.7_x	508_{xy}	36	56
F value	**	**	**	NS	NS
K_0[3]	22	5.8	529	30	57
K_1[3]	22	6.1	555	33	57
F value	NS	NS	NS	NS	NS
Dol_0[2]	24	5.9	552	39	55
Dol_1[2]	23	6.3	459	35	54
F value	*	NS	**	NS	NS
Steer manure[4]	26	7.8	295	45	57
Ammonium nitrate[4]	21	6.4	481	33	56
F value	**	**	**	**	NS

[1]*Subscript letters* x *and* y *after values indicate populations at the level of probability indicated by the asterisks. Mean values are statistically different from each other if they do not have a common subscript letter after them.*

[2]*Each value is a mean of 30 trees for 3 years, iron for 2 years only.*

[3]*Each value is a mean of 20 trees for 3 years, iron for 2 years only.*

[4]*Each value is a mean of 10 trees for 3 years, iron for 2 years only.*

NS *Indicates that the differences between means are not statistically significant.*

* *F value significant at the 5% level.*

** *F value significant at the 1% level or higher.*

Manure effects: In this nontilled orchard the application of 2 pounds of actual nitrogen per tree annually as a steer manure mulch resulted in significantly more zinc, copper, and boron, and significantly less manganese in the leaves than the application of 2 pounds of nitrogen per tree annually from ammonium nitrate (Table 2). The zinc, copper, and boron in the steer manure may partly account for the increase of these three elements in trees treated with manure. However, Embleton and Jones (1) showed that the nitrogen in the leaves of the manure-treated trees was much lower than that in the leaves of trees receiving ammonium nitrate. Thus it appears that the level of micronutrients in the leaves from the manure-treated trees was indirectly affected by the low level of nitrogen in these trees. The root system of avocado trees treated with steer manure was more extensively developed in the surface soil and in the mulch than was that of trees receiving ammonium nitrate.

DISCUSSION

These studies show that high rates of nitrogen fertilization or high rates of phosphate fertilization reduce the concentration of zinc in Fuerte avocado leaves. Corrective or preventative treatments for zinc deficiency are used in a large percentage of the avocado orchards in California. Data presented in this report indicate that zinc deficiency is likely to be more of a problem in orchards that use large quantities of nitrogen or phosphate or large quantities of both than in orchards that use minimal amounts of nitrogen or phosphate.

Copper deficiency has not been reported in California avocado orchards. However, copper deficiency does occur on other tree crops in California. Therefore, there is a likelihood that it may occur in avocado orchards in the future. The data presented here suggest that copper deficiency would be more likely to occur in orchards that use large quantities of nitrogen and phosphate or both.

SUMMARY

The effects of soil applications of nitrogen, phosphate, dolomite, potash, and steer manure on the zinc, copper, manganese, boron, and iron concentrations in Fuerte avocado leaves were studied in a field experiment.

1. Four, five, and six years after differential nitrogen treatments were established, high annual rates of nitrogen fertilization resulted in a significantly lower concentration of zinc, copper, and boron, and a significantly higher concentration of manganese in Fuerte avocado leaves than did low rates of nitrogen fertilization.

2. High rates of phosphate applied in 1951 and 1952 resulted in a reduction in the concentrations of zinc and copper and an increase in the concentration of manganese in the leaves in 1955, 1956, and 1957. Boron and iron concentrations were not significantly affected by phosphate fertilization.

3. Residual effects of dolomite soil applications to avocado trees in 1951 and 1952 significantly reduced manganese and only slightly reduced zinc concentrations in the leaves when sampled in 1955, 1956, and 1957.

4. No significant residual effects of potash soil applications to avocado trees in1951 and 1952 were found in the concentrations of micronutrients in the leaves sampled in 1955, 1956, and 1957.

5. Trees that received 2 pounds of nitrogen annually as a steer manure mulch contained significantly more zinc, copper, and boron in the leaves, and significantly less manganese, than trees that received 2 pounds of nitrogen annually from ammonium nitrate. These differences could be associated with the markedly lower nitrogen concentration in the leaves of trees that received steer manure.

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