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Effects of Irrigation Treatments and Rates of Nitrogen Fertilization on Young Hass Avocado Trees. V. Micronutrient Content of Leaves[1]

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This paper presents one phase of a cooperative field experiment dealing with the effects of nitrogen and irrigation treatments on the micro-nutrient concentration of leaves from young Hass avocado trees. Other aspects of this experiment are presented in companion papers. Several reports indicate that continued applications of nitrogen may change the zinc, iron, and manganese nutrition of citrus trees. Reuther and Smith (7) observed that, as the rate of nitrogen fertilization of Valencia trees was increased, mottle-leaf: increased and zinc concentration in the leaves decreased. Camp (1) found that zinc deficiency symptoms of citrus became more prevalent as the level of nitrogen applied to the soil was increased. Chapman (2) reports that citrus plants grown under high-nitrogen conditions in culture solution studies were more severely mottled than plants grown under low-nitrogen conditions. Ruehle (9) observed that little-leaf was especially severe on avocado trees in certain groves where nitrogen applied, in the fertilizer for several years was mainly from synthetic sources. Lynch (6) observed that die-back and ammoniation. in avocados was often induced by excessive nitrogen fertilization. Labanauskas *et al.* (5) presented data showing that leaves from Fuerte avocado trees that received the high rate of chemical nitrogen contained appreciably lower concentrations of zinc, copper, and boron than leaves from trees that received the low rate of nitrogen.

MATERIALS AND METHODS

The experimental orchard and treatments are described by Richards *et al.* (8). The field lay-out was a split-plot design, in which irrigation treatments were conducted in the main plots and nitrogen in the subplots. Statistical comparisons were on 3 x 3 split-plot design with a sampling date as a sub-subplot. Nitrogen and irrigation differences were evaluated by a multiple range test (3, 12).

Leaf samples for micronutrient chemical analysis were obtained in January, 1956, August, 1956, and. February, 1957, from one permanent tree in each nitrogen subplot. Thus 27 trees were sampled. Each sample consisted of 20 fully developed avocado leaves and included both leaf petioles and blades. The method of preparing avocado leaves for micronutrient analysis has been described elsewhere (13). Zinc and copper were determined by using 2-carboxy-2'-hydroxy-5'-sulformazylbenzene (10). Manganese was determined by the permanganate method (11), iron by the 0-phenanthroline method (11), and boron by the carmine method (4). All five micro-

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nutrient elements were determined colorimetrically with a Beckman Model B spectrophotometer.

RESULTS AND DISCUSSION

Nitrogen Effects:—The data presented in Table 1 show that leaves from young Hass avocado trees treated with High-N contained significantly smaller concentrations of zinc than leaves from trees treated with Zero-N or Low-N. The copper concentration in the leaves was significantly decreased when the level of nitrogen applied to the trees was increased (Table 1). Leaves from avocado trees that were treated with Low-N and with High-N contained a lower concentration of boron than leaves from the trees that were treated with Zero-N. The differences are statistically significant at the 1 per cent level for zinc and copper, and at the 5 per cent level for boron in differential comparisons. Manganese and iron concentrations were not affected either way by nitrogen treatments.

Table 1.—Effects of irrigation and of soil application of nitrogen on micronutrient concentrations in avocado leaves.[a]

	Concentration in dry leaves (ppm)[b]				
	Zn	Cu	Mn	Fe	B
Irrigation treatments (maximum soil suction)					
1/2 bar	25.5_a	6.5_a	60_a	79_a	28.8_a
1 bar	26.8_a	5.3_a	63_a	82_a	31.1_a
10 bars	29.6_a	5.4_a	59_a	85_a	26.8_a
F Value	NS	NS	NS	NS	NS
Nitrogen treatments					
Zero-N	29.6_a	7.1_a	56_a	81_a	33.0_a
Low-N	28.0_a	5.7_b	66_a	80_a	27.2_b
High-N	24.4_b	4.4_c	60_a	83_a	26.5_b
F Value	**	**	NS	NS	*

[a]NS indicates that the differences between means are not statistically significant.
*F value significant at the .05 level of probability.
**F value significant at the .01 level of probability. Nitrogen and irrigation differences were evaluated by a multiple range test (3, 13).
[b]Subscript letters a, b, and c after values indicate populations at the level of probability indicated by the asterisks. Different subscript letters after values in Tables 1 and 2 indicate that the differences between means are statistically significant. Similar subscript letters after values in Tables 1 and 2 indicate that the differences between means are not statistically significant.

Because zinc deficiency symptoms were present on some trees, the whole experimental orchard was sprayed with 3 pounds of zinc sulfate plus 1½ pounds of soda ash per 100 gallons of water in June, 1956. The nitrogen treatments decreased the copper level in the leaves, but deficiency symptoms were not yet visible. Avocado leaves that were sampled in August, 1956, were not analyzed for zinc because the zinc deposits from the June sprays were still present on the leaves.

The reduction in copper in avocado leaves as a result of applications of nitrogen fertilizer in this experiment is in close agreement with observations by Lynch (6). The effects reported here of nitrogen fertilization on the composition of avocado leaves are in agreement with observations on avocado by Ruehle (9) arid on citrus by Camp (1), Chapman (2), and Reuther and Smith (7), who reported than an increase in the rate of nitrogen applications to citrus was associated with an increase in zinc deficiency symptoms.

Irrigation Effects:—The data presented in Table 1 show that irrigation treatments did not have any significant effect on the micro-nutrient content of avocado leaves. This could be due to winter rainfall, which actually preceded the samplings of January, 1956, and February, 1957. Leaves sampled in August, 1956, could not be analyzed for zinc because the experimental plot was sprayed with zinc sulfate in June, 1956, and the deposit on the leaves from the zinc spray material could not be removed even by the most extensive washing. However, there was a trend showing that when soil moisture was made more available by frequent irrigations, the zinc and iron contents of the leaves were reduced.

Sampling Date Effects:—The avocado leaves were sampled three times from the same tree in each nitrogen-treated subplot, and the leaf material was analyzed separately for each sampling date. The data presented in Table 2 indicate that the concentration of micro-nutrients in avocado leaves varied from sampling date to sampling date during the season. The differences due to sampling dates are statistically significant at the 1 per cent level or higher for all the micronutrients studied except manganese. Embleton (unpublished studies) has shown that the macroelements in Fuerte avocado leaves have been influenced by age of leaves, season, and fertilizer applications and it is possible that the concentration of micronutrients in avocado leaves is also affected by such factors.

Table 2.—Effects of three differential sampling dates on micronutrient concentrations in avocado leaves.[a]

Sampling dates	Concentration in dry leaves (ppm)[b]				
	Zn	Cu	Mn	Fe	B
January, 1956	37.4_a	4.98_a	60.3_a	88.2_a	42.0_a
August, 1956	—	5.59_a	61.1_a	62.4_b	24.2_b
February, 1957	17.2_b	6.64_b	60.6_a	94.4_a	20.5_b
F Values	**	**	NS	**	**

[a]See footnotes of Table 1.
[b]See footnotes of Table 1.

Interactions:—The interaction of the effects of irrigation and of date of sampling on the zinc concentration in avocado leaves is shown in Table 3. This was the only significant interaction found. The data presented in Table 3 indicate that the leaf material sampled in January, 1956, contained lower concentrations of zinc when available soil moisture was maintained at a relatively high level by frequent irrigation. On the other hand, the leaves that were sampled in February, 1957, did not show any significant effect of differential levels of irrigation on zinc concentration.

The data presented in this paper indicate that soil applications of nitrogen fertilizers have complicated effects on the micronutrient concentrations in avocado leaves. Application of nitrogen to avocado trees not only increases the nitrogen in the plant tissue, but also affects, directly, or indirectly, the micronutrient content. Similar observations have been made in other orchards and with different avocado varieties.

Table 3.—Interaction of effects of irrigation and of date of leaf sampling on zinc concentration in Hass avocado leaves.

Irrigation treatments (maximum soil suction)	Zinc in dry leaves (ppm)	
	Sampled January, 1956	Sampled February, 1957
1/2 bar	33.4	17.6
1 bar	37.5	16.1
10 bars	41.4	17.8
Interaction F Value	*	

*Indicates F value significant at the .05 level of probability.

SUMMARY

The results of an irrigation and fertilizer experiment in an avocado orchard at the University of California Citrus Experiment Station show that when the level of nitrogen applied to young Hass avocado trees was increased, the zinc, copper, and boron concentrations in the leaves decreased. Differential levels of irrigation did not affect significantly the micronutrient concentrations in the leaves. However, there was a continuous trend showing that when soil moisture was maintained by frequent irrigations, the iron and zinc concentrations in the leaves were reduced. Concentrations of the micro-nutrients studied varied from sampling date to sampling date within the same season. The interaction of the effects of irrigation and of leaf sampling dates on the zinc concentration in the leaves was the only significant interaction, leaf material sampled in January, 1956, containing a lower concentration of zinc in leaves of trees grown where soil moisture was maintained by frequent irrigations. On the other hand, the leaves from the same young Hass avocado trees sampled in February, 1957, did not show any significant effect on zinc concentration due to differential levels of irrigation.

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