Proceedings of the
AMERICAN SOCIETY FOR HORTICULTURAL SCIENCE
1958 71:310-314

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

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This paper presents the phase of a cooperative field experiment dealing with the effects of nitrogen and irrigation treatments on the macronutrient content of leaves from young Hass avocado trees.

MATERIALS AND METHODS

The experimental orchard and treatments are described by Richards *el al.* (6). For the sampling of leaves one tree for each nitrogen level in each irrigation plot was selected. Samples were obtained in November, 1953, August, 1954, September, 1955, January, 1956, August, 1956, and February, 1957. At each sampling date 20 of the youngest, fully expanded, mature leaves were selected per tree from shoots that were not fruiting or flushing. Both petioles and blades were included in the samples. Methods of preparing the leaf samples for analysis, and the analysis of the leaves for N, P, K, Ca, Mg, and Na were the same as those used by Embleton *et al.* in 1956 (2). Chloride was determined by the method of Brown and Jackson (1), using a Beckman electrotitrimeter.

RESULTS AND DISCUSSION

Main effects:—The main effects of irrigation and nitrogen treatments, and of date of sampling on concentrations of macronutrients in leaves appear in Table 1.

Irrigation had a statistically significant influence on the percentage of nitrogen in the leaves. Effects on the oilier elements in the leaves were not significant. Within the range of this experiment, the drier the soil was allowed to become before irrigating, the greater was the percentage of nitrogen in the leaves. Leaves from young trees in highly irrigated plots, compared with leaves from trees receiving rainfall only, had higher phosphorus and calcium but lower nitrogen and magnesium concentrations (5).

An increase in the level of applied nitrogen increased the concentration of nitrogen and calcium and reduced the concentration of chloride in the leaves; phosphorus, potassium, magnesium, and sodium were not significantly influenced.

Although the N-zero trees were not fertilized after the differential treatments were started, the concentration of nitrogen in the leaves remained higher than in leaves of trees of the same variety in an other experiment in a different location (3). Under similar growing conditions, the Hass variety had a higher concentration of nitrogen in the leaves than did the Fuerte variety (3).

Received for publication January 21, 1958. paper No. 1004, University of California Citrus Experiment Station, Riverside, California. This is the fourth in a series of five companion papers reporting results of an interdepartmental cooperative study.

Table 1.—Main effects of irrigation and nitrogen treatments and of date of sampling on concentrations of macronutrients in leaves of young Hass avocado trees.

Variables and statistical indices	Per cent dry weight of leaves[a]						
	N	P	K	Ca	Mg	Na	Cl
Irrigation treatment[b] (maximum soil suction)							
1/2 bar	2.27_a	0.153	0.93	1.37	0.446	0.046	0.22
1 bar	2.35_{ab}	0.147	1.00	1.53	0.430	0.041	0.21
10 bars	2.43_b	0.147	0.86	1.39	0.411	0.043	0.21
Significance[c]	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Nitrogen treatment[b]							
N-zero	2.27_a	0.148	0.98	1.30_a	0.432	0.040	0.27_a
N-low	2.36_b	0.151	0.89	1.41_{ab}	0.426	0.045	0.21_a
N-high	2.42_b	0.148	0.92	1.57_b	0.430	0.045	0.15_b
Significance[c]	*	N.S.	N.S.	*	N.S.	N.S.	***
Date of sampling[d]							
November, 1953	2.16_a	0.156_a	0.95_b	0.93_e	0.319_c	0.020_c	—
August, 1954	2.25_{ab}	0.140_b	0.90_b	1.46_b	0.465_a	0.054_a	0.20_b
September, 1955	2.58_d	0.156_a	1.16_a	1.36_b	0.463_a	0.053_a	0.22_a
January, 1956	2.54_{cd}	—	—	—	—	—	0.24_a
August, 1956	2.38_{bc}	0.154_a	0.96_b	1.39_b	0.403_b	0.056_a	—
February, 1957	2.17_a	0.139_b	0.68_c	1.98_a	0.497_a	0.033_b	0.19_b
Significance[c]	***	***	***	***	***	***	***
Significant Interactions[c,e]	None	None	None	IxD* NxD***	IxNxD**	None	IxN* IxNxD*

[a]Subscript letters a, b, c, and d after mean values indicate populations at the level of probability indicated by the asterisks. Mean values are statistically different if they do not have a common subscript letter after the values.
[b]Each value is the mean from nine trees for all dates listed.
[c]N.S. indicates that differences between means are not statistically significant.
*indicates significance of F at the 5% level.
**indicates significance of F at the 1% level.
***indicates significance of F at the 0.1% level.
[d]*Each value is the mean from 27 trees and includes all nitrogen and irrigation treatments.*
[e]I indicates irrigation treatments; N indicates nitrogen treatments; D indicates date.

Unpublished data from another experiment on Fuerte avocados shows that an increase in the rate of nitrogen from ammonium nitrate had no significant effect on the percentage of calcium in the leaves. Possibly the increase in the concentration of calcium in the leaves, observed in the experiment being reported here, resulted from the calcium in the calcium nitrate.

The main effects of nitrogen treatments on the chloride concentration in the leaves were very highly significant. An increase in the rate of nitrogen reduced the concentration of chloride in the leaves. However, to get a more complete understanding one must look at the interaction of nitrogen and irrigation treatments on chloride in the leaves which appears later.

The main effects of date of sampling were significant for all elements observed. Age of leaves and seasons had a marked influence on the concentration of macronutrients in the leaves of the Fuerte avocado (4). This should probably be expected since the avocado tree has several flushes of growth every year making uniform sampling difficult.

Interactions:—The summary in Table 1 indicates that there were several significant interactions. The first-order interaction between irrigation and date of sampling showed that the one-bar irrigation treatment was higher in calcium in November, 1953, before differential treatment was initiated. Therefore, the significance of similar trends which existed on other sampling dates is open to question, and the interaction data are not presented.

The effect of interaction between nitrogen treatments and date of sampling on the

percentage of calcium in the leaves appears in Table 2. Except for the samples that were taken in November, 1953, before differential treatment started, an increase in nitrogen applied increased the concentration of calcium found in the leaves.

Table 2.—Effect of interaction between nitrogen treatments and date of sampling on percentage of calcium in leaves.[a]

Nitrogen treatment	Date of sampling				
	Nov. 1953	Aug. 1954	Sept. 1955	Aug. 1956	Feb. 1957
	Per cent calcium[b,c]				
N-zero	0.90	1.38	1.25_a	1.21_a	1.76_a
N-low	0.95	1.47	1.34_{ab}	1.40_{ab}	1.86_a
N-high	0.93	1.53	1.50_b	1.57_b	2.34_b
Significance[b]	N.S.	N.S.	*	**	**

[a]Interaction significant at the 0.1% level.
[b]See Table 1, footnotes a and c, for meaning of statistical symbols.
[c]Each value is the mean from nine trees.

The effect of interaction between irrigation treatments and nitrogen treatments on the percentage of chloride in the leaves is shown in Table 3. At the zero level of nitrogen the chloride concentration in the leaves increased as the soil was allowed to become drier before irrigating. At the low and high levels of nitrogen, the chloride concentration in the leaves decreased as the soil was allowed to become drier before irrigating. In the ½-bar irrigation treatment an increase in the nitrogen rate had very little influence on the chloride concentration in the leaves, whereas in the 1-bar and 10-bar irrigation treatments an increase in the nitrogen rate decreased the concentration of chloride in the leaves.

In other fertilizer experiments on avocados, now in progress, in which no consistent, measured irrigation treatment is being maintained, rates of nitrogen have shown variable results on the concentration of chloride in the leaves. Perhaps this variability is associated with variations in irrigation practices. However, observations by the senior author in many orchards have usually indicated that less leaf tipburn occurred on trees at a higher level of nitrogen nutrition than at a lower level. Lynch (4) states: "Occasionally tipburn can be alleviated by adequate fertilizing with nitrogen which in turn brings about a greater leaf surface, probably 'diluting' the chloride content."

Table 3.—Effect of interaction between irrigation treatments and nitrogen treatments on percentage of chloride in leaves.[a]

Nitrogen treatment	Irrigation treatment (maximum soil suction)		
	1/2 bar	1 bar	10 bars
	per cent chloride[b]		
N-zero	0.22	0.28	0.33
N-low	0.24	0.24	0.16
N-high	0.19	0.11	0.13

[a]Interaction significant at 5% level.
[b]Each value is the mean from three trees for August, 1954, September, 1955, January, 1956, and January, 1957.

Lynch (4) quotes a personal communication from Haas suggesting that a burn similar to chloride tipburn could be obtained, if soil moisture were deficient. Haas also suggested, that if the negatively charged ions, such as nitrate, were in low concentration in the soil solution, then the increased chloride effect would probably be greater, as it is used to balance the intake of positive elements.

Most of the avocados grown in California show leaf tipburn during the winter as a result of excessive chloride accumulation in the leaves. In some orchards as much as half of the leaf area becomes necrotic in the winter from excessive chloride accumulation. Therefore, any measure which can be taken to reduce the chloride accumulation in the leaves is worthy of commercial consideration.

The second-order interactions among irrigation treatments, nitrogen treatments, and sampling date on the percentage of magnesium and chloride in the leaves showed that the interaction between, irrigation and nitrogen treatments differed among the sampling dates. This is not surprising, since the sampling months included August, September, November, January, and February.

SUMMARY

Young Hass avocado trees in the field were subjected, to a factorial experiment with three levels of nitrogen and three irrigation treatments for a period of three years. Leaf samples were taken periodically and analyzed for macroelements: nitrogen, phosphorus, potassium, calcium, magnesium, sodium, and chloride. The data obtained show not only some strong major effects, but also some important interactions between irrigation and nitrogen fertilization treatments on tree nutrition.

The drier the soil before irrigating, the greater was the nitrogen concentration found in the leaves.

An increase in the applied nitrogen, rate resulted in an increase in the percentage of nitrogen and calcium found in the leaves.

Where nitrogen was not applied, the concentration of chloride in the leaves increased as the soil was permitted to become drier before irrigating. In the "wet" irrigation plots, nitrogen rate had very little influence on the chloride concentration in the leaves, but in the "drier" irrigation plots an increase in the nitrogen applied resulted in a decrease in the percentage of chloride found in the leaves.

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