

Effects of Irrigation Treatments and Rates of Nitrogen Fertilization on Young Hass Avocado Trees. I. Growth Response to Irrigation¹

By S. J. RICHARDS, L. V. WEEKS, and J. C. JOHNSTON,
*University of California Citrus Experiment Station and Agricultural Extension Service,
Riverside, Calif.*

Several important cultural problems of avocado production in southern California are related to irrigation, management. When a specific fungus is present in the soil, avocado root rot develops more rapidly under high soil moisture conditions (7). Tipburn of avocado leaves is often associated with soil salinity, which in turn is influenced by water quality, soil drainage, and irrigation practices (1). Field observations indicate that avocado trees respond favorably to a relatively high level of soil moisture. To study specific responses to irrigation, a one-acre planting of Hass avocados was set out in June, 1952. Since irrigation treatments are known to influence soil fertility, nitrogen fertilizer levels were included in a split-plot design.

In the Riverside area it was necessary to select a sloping hillside site to avoid winter frost injury to avocados. Prior to 1952 the land was under native brush. The only site preparation was to remove the brush and dig holes in which to set the commercially grown, balled trees. A Mexican seedling rootstock was used. For two years all the young trees were grown under uniform treatments. During the first year, water was applied in small basins around the trees. For the second year a permanent pipe irrigation system provided a riser by each tree with spitter-type nozzles applying water only locally near the trees. As the trees grew, the nozzles were changed, first to half-circle heads, then to full-circle rotating heads. Approximately $\frac{1}{12}$ of a pound of nitrogen per tree was applied in split applications each of the first two years.

A close planting, approximately 15 by 20 feet, was used to give more trees for growth measurements during the early years. (When crowding occurs, alternate trees in a symmetrical pattern will be removed.) The plot design provided nine plots of 14 trees per plot. The sprinkler irrigation system was designed to irrigate and meter the water to each plot individually. On a hillside planting uniform distribution of water was difficult to obtain, but each plot had a similar layout with respect to elevation. To make maximum use of a limited number of trees, no border trees between plots were provided. Irrigation water and fertilizers were applied locally around each tree. The growth response to date has justified this procedure.

Irrigation experiments in the past have been based largely on soil moisture sampling procedures or on some plant response index. Tensiometers and resistance block soil moisture units have become widely used, however. It was proposed in this experiment to base the irrigation treatments on such instruments. Three treatments were planned in which irrigation water was applied when soil suction (soil moisture tension) values

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reached $\frac{1}{2}$, 1, and 10 bars (atmospheres), respectively, at selected points in the root zone. The selected locations for measuring suction were 1, 2, and 3 feet out from the tree trunks in the respective years 1954, 1955, and 1956, all at the 1-foot depth. Duplicate tensiometer readings were used to indicate directly the irrigation timing for the 1/2-bar treatment. Tensiometers will not indicate soil suction as high as 1 bar, but by plotting suction values between irrigations it was found that extrapolation of the data gave a reliable estimate of the times when suction values reached 1 bar (5). The 10-bar level was measured by using fiberglas soil moisture resistance units (3) which had been calibrated by means of laboratory pressure membrane equipment (4). The number of irrigations required to maintain these prescribed treatments in 1954, the first year of the differential treatments, has been reported (5). The treatment designations represent the maximum soil suction values and not integrated values as reported by Taylor for similar irrigation experiments on vegetables and field crops (6).

Starting in 1954, differential nitrogen treatments were also applied. Of the 14 trees in each irrigation plot, 2 trees received no additional nitrogen, 6 trees received a low commercial level of nitrogen, and the remaining 6 trees received a high level of nitrogen based on leaf analysis. Calcium nitrate was used. The annual amounts given in Table 1 were applied in three split applications, in February, May, and August, and were spread on the soil surface under the young trees where the surface area was wetted by the sprinklers.

Table 1.—Annual nitrogen treatments applied as calcium nitrate in three split applications, in February, May, and August.

Year	Pounds N per tree		
	Zero-N	Low-N	High-N
1954.....	0	1/6	2/3
1955.....	0	1/4	1
1956.....	0	1/4	1 1/2
Total.....		2/3	3 1/6

IRRIGATION TREATMENTS

Table 2 gives the number of irrigations necessary to maintain soil suction below the values indicated for the treatments for each of the nine plots individually during the 1955 and 1956 irrigation seasons. Considerable variation between plots in the 1/2 bar and 1-bar treatments is evident and could be due either to soil differences or to plant use differences. The relative numbers of irrigations for given plots for the two consecutive years are consistent, however, even though the tensiometers were moved to new locations in 1956. The amounts of water applied per irrigation were sufficient to penetrate to the 2-foot depth as indicated by additional tensiometers placed at that depth. This plan resulted in large differences in amounts of water applied as well as in frequency of irrigations under the various treatments.

Table 2.—Annual number of irrigations and total amounts of irrigation water applied to avocado orchard plots to maintain soil suction below the values indicated.

Irrigation treatment (maximum soil suction)	Plot no.	1955		1956	
		No. of irrigations	Water, in surface- inches ^a	No. of irrigations	Water, in surface- inches ^a
1/2 bar.....	2	42	47	45	64
	7	35	39	28	46
	9	37	43	35	50
1 bar.....	1	25	28	21	35
	4	17	23	15	29
	8	20	26	17	29
10 bars.....	3	12	18	11	21
	5	13	19	12	21
	6	12	18	10	21

^aSurface-inches of water based on area wetted by sprinklers, not on entire surface of field.

The differences in the total amounts of water applied under the treatments are given in Table 3 for all three years of differential treatment. Since the area covered by the sprinklers varied, the results are expressed both as the surface-inches of water applied to the area wetted and as acre-inches per acre for the total area. As is shown by the study of soluble salts in the soil (2), very little leaching took place even under the 1/2 bar treatment.

Table 3.—Average amounts of irrigation water used when the irrigation treatments were based on maintaining the soil suction below the values indicated.^a

Irrigation treatment (maximum soil suction)	1954		1955		1956	
	A	B	A	B	A	B
1/2 bar.....	63	10.3	43	16.4	53	28.6
1 bar.....	39	6.6	26	10.6	31	16.3
10 bars.....	34	5.8	18	7.5	21	11.3

^aA = surface-inches over area wetted by sprinklers.
B = acre-inches per acre for total area.

GROWTH MEASUREMENTS

An evaluation of the response to irrigation treatments will not be complete until fruit production has been measured. In the meantime several measurements of vegetative growth have been attempted. Table 4 gives the plot averages of tree heights measured in the falls of 1955 and 1956. The treatment averages are statistically significantly different between the 1/2 bar and the 10-bar treatments. The wide range in plot averages for the 1-bar treatment indicates that other factors are involved and that this experiment is not adequate to evaluate this particular treatment properly.

Trunk circumference is another index to tree size commonly used. Table 5 gives treatment averages, with the trees receiving various nitrogen levels shown separately. The average for the 1/2 bar irrigation treatment is statistically different from that for the other two treatments. Although the effects of the nitrogen are not large enough to be significant, the trends indicate that high nitrogen levels may be a factor in reducing growth under the 10-bar irrigation treatment.

One further means of evaluating vegetative growth was made by counting the leaves in February, 1957. These data in Table 6 show similar differences and trends as indicated by the trunk circumference measurements in Table 5. In addition a sample picking of 20 typical leaves per tree gave results showing a 20 per cent increased size of leaf for the 1/2-bar irrigation treatment relative to the other two treatments based on dry-weight values.

Table 4.—Tree height measurements taken at end of irrigation seasons, 1955 and 1956.

Irrigation treatment (maximum soil suction)	Plot no.	Tree height in feet	
		1955	1956
1/2 bar.....	2	10.3	12.7
	7	11.6	14.1
	9	10.5	12.1
	Mean	10.8	13.0*
1 bar.....	1	8.0	9.5
	4	9.2	10.4
	8	9.7	12.1
	Mean	9.0	10.6
10 bars.....	3	8.9	10.2
	5	8.5	9.9
	6	8.8	9.9
	Mean	8.7	10.0

*Significant at .05 level between treatment means.

Table 5.—Trunk circumference measurements (in centimeters) at end of 1956 irrigation season.

Treatment ^a	Irrigation treatment (maximum soil suction)		
	1/2 bar	1 bar	10 bars
Zero-N.....	cm 34.1	cm 34.5	cm 34.8
Low-N.....	37.6	30.8	29.0
High-N.....	37.7	30.0	26.9
Mean.....	37.1*	30.9	28.8

*Significant at the .05 level between treatment means.

^aSix trees per treatment for Zero-N; 18 trees each for other treatments. Refer to Table 1 for descriptions.

Table 6.—Leaf count per tree, taken in February, 1957.

Treatment ^a	Irrigation treatment (maximum soil suction)		
	1/2 bar	1 bar	10 bars
Zero-N.....	9,000	7,040	6,350
Low-N.....	9,980	6,970	6,480
High-N.....	10,200	7,020	5,890
Mean.....	9,730**	7,010	6,240

**Significant at the .01 level.

^aSix trees per treatment for Zero-N; 18 trees each for other treatments. Refer to Table 1 for descriptions.

An attempt to evaluate day-to-day changes in the growth pattern of avocado trees was made by measuring small increases in trunk diameters. This was done by cementing nylon blocks on either side of the trunk. The blocks had countersunk holes for accurately locating an indicator gauge fastened to a "C" clamp made of plastic. Daily changes in the average trunk diameters of three trees, under the 1/2 bar and 10-bar treatments, are shown in Fig. 1. Continuous increases in the growth pattern are

indicated for the frequently irrigated trees, while for a period of time before the 10-bar level was reached, growth, as measured by trunk diameter, was reduced.

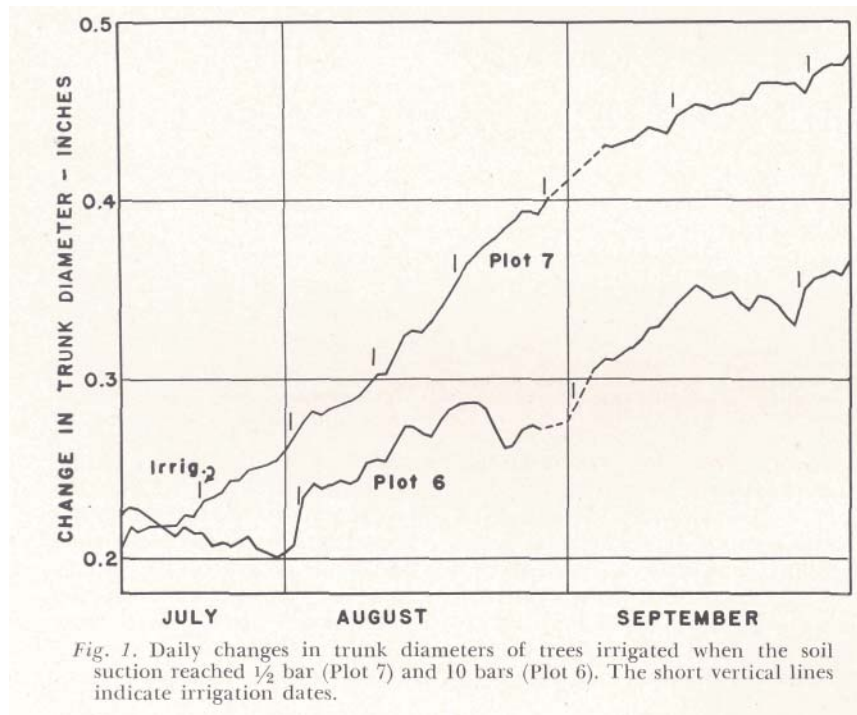


Fig. 1. Daily changes in trunk diameters of trees irrigated when the soil suction reached $\frac{1}{2}$ bar (Plot 7) and 10 bars (Plot 6). The short vertical lines indicate irrigation dates.

SUMMARY

Irrigation treatments on young Hass avocado trees were based on readings of tensiometers and of soil moisture resistance blocks. Irrigations applied when soil suction values reached $\frac{1}{2}$ bar resulted in significantly greater vegetative growth than those applied when soil suction values reached 1 and 10 bars. To carry out these treatments on a sandy loam soil the number of irrigations required in 1956 amounted to 36, 17, and 11 for the three treatments, and the amounts of water applied were 28, 16, and 11 acre-inches per acre for the three treatments respectively. Growth evaluation was based on measurements of tree height and trunk diameter, and on leaf count. Daily measurement of trunk diameters showed a continuously increasing growth pattern for the $\frac{1}{2}$ -bar treatment, while the 10-bar treatment resulted in a period of no growth prior to irrigations during the summer months.

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