California Avocado Society 1962 Yearbook 46: 83-87

AVOCADO TREE GROWTH RESPONSE TO IRRIGATION

S. J. Richards, J. E. Warneke, and F. T. Bingham
Soil Physicist, Laboratory Technician II, and Associate Soil Chemist, respectively, Department of Soils and Plant Nutrition, University of California, Riverside.

In 1952, a one-acre planting of Hass avocado trees was set out on a hillside area of the campus at Riverside. Funds to purchase the trees were contributed by the California Avocado Society. Progress reports on this planting have appeared in the 1958, 1960, and 1961 issues of the Society's Yearbook.

The site was well chosen to provide virgin soil conditions and minimum hazards from freezing temperatures. However, the area was exposed to the effects of severe fall and winter windstorms. During several successive seasons when fruit production might have shown response to management treatments, much of the fruit and, on occasion, up to 50% of the leaves were blown from trees in the more exposed portions of the grove.

Three differential irrigation treatments were started in 1954 with three replicated plots per treatment. Initially, each plot had 14 trees with a 15-by 20-foot spacing. In 1959 the trees were thinned on a diagonal pattern leaving 7 trees per plot. The irrigation treatments were based on instruments which indicate soil water conditions in the root zone. Instruments were installed to measure conditions at a soil depth of one foot and from two to four feet out from the tree trunk depending on the size and age of the tree. For the three irrigation treatments, water was applied when soil suction reached ½, 1, and 10 bars. Soil suction is the index read explicitly with tensiometers. Tensiometers are calibrated to read in centibars, and are able to indicate suction up to 80 centibars. Thus, the wettest treatment was irrigated when tensiometer readings reached 50 centibars. The irrigations for the second treatment were applied one to two days after tensiometers had reached 80 centibars. Extrapolations of the curve connecting the readings taken at lower values showed this to be a reasonable estimate of timing of irrigation at the 100-centibar (1 bar) level. The 10-bar treatment was based on the readings of resistance blocks which had been previously calibrated using laboratory techniques.

The treatments were adapted to soil and plant variables by having instruments in each of the plots. For the plots of any one treatment, for example, where one of the three plots was located in an area of coarser textured soil, that plot received more frequent irrigations because less water was retained in that soil after each irrigation and for this reason the instrument readings would increase at a faster rate.

After 1955 the irrigation system consisted of a single sprinkler located uphill two to three feet from each tree. Each sprinkler applied water over a circular area of about 15 feet in diameter. This type of water application did not cover the entire area between rows, but the limited size of the experiment did not permit the use of guard trees which would have been required for any modification of the irrigation system.

Differential nitrogen fertilizer applications were made using a split plot technique. Trees on each irrigation plot received high, low, and zero applications of calcium nitrate applied in split applications in February, May, and August. The amounts applied are shown in Table 1. After thinning, only one tree per plot received the zero nitrogen treatment, since these trees were meant to provide a wider range for studying leaf analyses.

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

	Pounds N per tree		
Year	High-N	Low-N	Zero-N
1957	2	1/4	0
1958	2 1/2	1/4	0
1959	3	3/4	0
1960	3 1/2	3/4	0
1961	3 1/2	3/4	0

RESULTS

Figure 1 shows the effects of the irrigation treatments on tree growth.

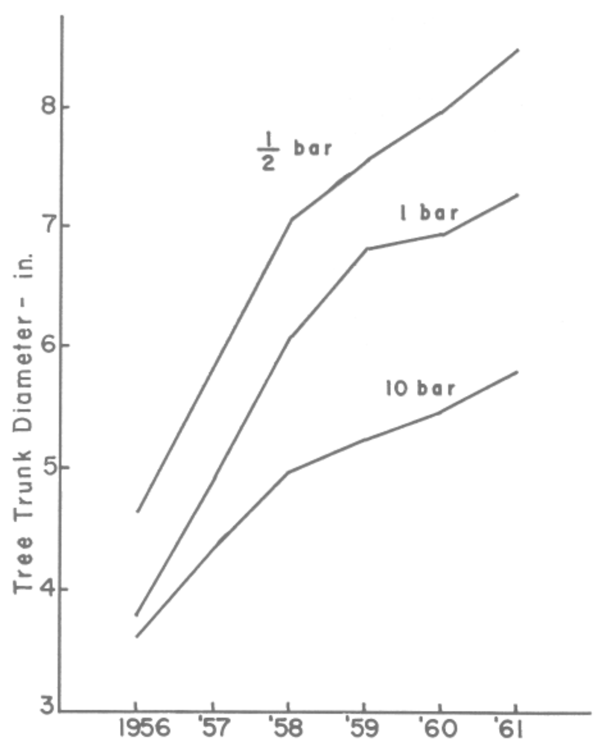

FIGURE LEGEND

FIGURE 1. Tree size measurements in terms of trunk diameter showing the progressive growth rates resulting from irrigation treatments on Hass avocado trees. Trunk circumference measurements for each treatment average was converted to equivalent trunk diameter assuming a circular trunk cross section.

Each line includes trees from the various nitrogen treatments. In October or November of each year from 1956 to 1961, the circumference of each tree trunk was measured with a flexible scale about 6 inches above the bud union. The figure shows the treatment averages which were converted to equivalent trunk diameters assuming circular cross-sections for the tree trunks. The growth curves indicate a continuing trend toward increased growth resulting from maintaining soil suction at lower levels. Table 2 shows the growth response to both fertilizer and irrigation treatments in terms of the trunk measurements at the end of 8 treatment years. The effects of fertilization are not large, but they appear to be quite consistent. For the ½ and 1-bar treatments, the Low-N treatment results in improved growth compared to the Zero-N treatment. As the fertilizer application is increased, however, to high levels, the growth is less. Where the irrigation treatment is excessively dry (10 bars) any amount of added fertilizer reduced growth. By 1960 the trees on the 10-bar irrigation plots were so lacking in vigor that a change to the 5-bar level was made. Some recovery in tree appearance was noted during 1961.

Table 2. Tree trunk diameter (inches) measured in October 1961 showing the growth response to both irrigation and nitrogen fertilization.

Irrigation (Max. soil suction)	High-N	Low-N	Zero-N	Treat Ave.
½ Bar	8.5	8.7	8.1	8.5
1 Bar	7.1	7.5	7.1	7.3
10 Bar	5.5	5.7	6.8	5.8

The effects of the fertilizer on growth may be largely explained in terms of the soil salinity resulting from the amounts of added fertilizer. Table 3 gives the soil salinity measurements for three sampling dates. At each date soil samples were taken under each tree and mixed. A saturated water extract from each soil sample was made and its electrical conductivity (EC) measured. The numbers in the table are the average values for the various treatments for the 0- to 1-foot soil depth. EC values give a good estimate of the total soluble salts present in the soil. Chemical analyses of the soil extracts showed that calcium and nitrates were the major salts causing the high EC values, which confirms the fact that high salinity was due to the fertilizer applications. The water used for irrigation was from the Riverside City domestic water supply, and is a good quality irrigation water.

Table 3. Soil salinity measured in terms of the (EC values) electrical conductivity of a saturated extract (millimhos/cm). For the 0- to 1-foot soil depth.

Irrigation Treat. (Max. soil suction)	High-N	Low-N	Zero-N	Treat. Ave.
		May — 1960		
½ Bar	1.1	.9	.8	.9
1 Bar	2.0	1.0	.9	1.3
10 Bar	3.6	1.1	.8	1.8
Treatment Ave.	2.3	1.0	.8	
		November — 1960		
½ Bar	2.7	1.6	1.3	1.9
1 Bar	5.6	2.0	1.2	3.2
10 Bar	4.4	2.0	1.1	2.5
Treatment Ave.	4.2	1.9	1.2	
		May — 1961		
½ Bar	2.2	1.3	1.1	1.5
1 Bar	3.5	1.5	1.2	2.1
10 Bar	3.7	1.1	1.0	1.9
Treatment Ave.	3.1	1.3	1.1	

DISCUSSION

The difference in tree size based on trunk measurements resulting from irrigation treatments is large enough to be significant. The average for each plot in a given treatment did not extend into the range of plot averages for other treatments. Based on many reports from other sources, the difference in size between the 1- and the ½ -bar treatments might seem unusual. Soil water is said to be "readily available" even beyond the 10-bar value used in the driest irrigation treatment of this experiment, and from such a statement no difference in growth would be expected. It needs to be pointed out, however, that an instrument reading which characterizes the condition of water at the 1-foot soil depth does not characterize the condition of the soil water throughout the rootzone. It is an accepted conclusion that the soil nearer the surface dries more rapidly than at deeper depths since, particularly for avocados, the root density is greater nearer the soil surface. As herein reported, the growth response is due to the irrigation management, and further studies will be needed to interpret the data in terms of the water availability at the root surfaces. For the present state of our knowledge concerning soil-plant water relations, it is important to note that instruments are available which are useful in evaluating and guiding irrigation practices.

Since this experiment was initiated many avocado growers have used tensiometers and quite a number of cooperative trials have been carried out to further evaluate the use of tensiometers under conditions of commercial avocado production.

The difference in trunk size resulting from irrigation treatments suggests the possibility that a very accurate measurement of the trunk growth might be a means of studying a tree response which would determine when irrigation water should be applied. Such precise growth measurements were made by methods to be described in another publication. It was found that in the 10-bar treatment, that trunk growth did stop and, on occasion, trunk size became measurably smaller prior to an irrigation However, it was found that other environmental factors, such as temperature, wind, humidity, and soil temperature also measurably effected growth rates. It was not always possible to separate the effects of soil dryness from the influence of the other variables. Hence, the use of trunk growth measurements is not likely to be a practical means of determining when to irrigate.

The growth response to levels of nitrogen was not as large as that resulting from irrigation treatments. If the levels had not covered as wide a range in the amounts of fertilizer applied, the more common response would have been for the high nitrogen treatment to have resulted in the best growth. However, the high nitrogen treatment was purposely set at or near the upper limit of commercial fertilization. This was done to evaluate the possible effect on soil salinity resulting from fertilizer applications. The higher EC values obtained under the High-N treatment amply demonstrate the measured effects on soil salinity of fertilization in excess of actual N requirements.

The difference in EC values from May to November, 1960, shows the trend toward increasing salinity during the irrigation season. The rather small lowering of the EC values from November, 1960 to May, 1961 is accounted for by the fact that very little effective rainfall occurred during that rainfall season.

The EC values for the ½ -bar irrigation treatment show that some water in excess of tree requirements was applied under this treatment. This excess resulted in the leaching of considerable amounts of the applied fertilizer below the 1-foot soil depth, particularly in the High-N treatment plots. During the 1960 and 1961 irrigation seasons, when the difference in tree size was greatest, nearly twice as many irrigations were applied to the $^{1}/_{2}$-bar plots compared with the 1-bar treated plots and approximately 1.8 times as much irrigation water was used in the former treatment compared with the latter.

It has not been possible to obtain a valid evaluation of the irrigation and fertilization treatments of this experiment in terms of fruit production. The loss of fruit by wind damage was severe, but even under more favorable conditions, it is doubtful that the number of replicated plots would have been sufficient to provide significant yield differences. It is well known that individual avocado trees vary greatly in fruit production; and this characteristic alone makes it necessary to use large numbers of trees to measure effects of management practices. One general observation was made which could be important relative to fertilizer treatments. The number of fruit dropping from trees, but not due to wind, was counted. From January 1 to June 15, the fruit drop from the High-N treated trees was large compared with the Low-N treatment. During this period in 1961 and again in 1962, the number of drops amounted to an average of approximately 50 fruits per tree for the 1-bar irrigation plots. This observation needs to be confirmed under other climatic environments.

CONCLUSIONS

As far as growth measurements of trunk size can be utilized to show response to irrigation practices, the results of this experiment show that good irrigation management is bracketed between the ½ - and the 1-bar treatments. Better growth was obtained by irrigating to maintain tensiometer readings at the 1-foot depth at 50 or lower. The extra number of irrigations and additional irrigation water to maintain this level compared with the 1-bar treatment may or may not be justified since under normal soil conditions more water will be lost by deep percolation.

Where soil salinity is a factor, due either to excess fertilizer or low quality water, then irrigation at or near the ½ -bar level is justified in order to promote leaching.