**California Avocado Society 1958 Yearbook 42: 25-29**

# AVOCADO IRRIGATION AND NITROGEN FERTILIZATION PLOTS AT THE CITRUS EXPERIMENT STATION

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Plots to study the response of Hass avocado trees to various irrigation and nitrogen fertilization treatments were started in 1952 at the Citrus Experiment Station. A brief progress report of this experiment appears in the 1955 Yearbook of the California Avocado Society. Research funds from the Society provided the trees for this experiment.

A sprinkler irrigation system was essential because the planting was located on high sloping ground to avoid winter frost injury. A riser and sprinkler head at each tree provided good water distribution. The area wetted around each tree was increased from year to year as the trees grew.

Irrigation treatments were based on readings taken on soil moisture measuring instruments. These instruments were placed at a 1-foot depth in the soil but were moved each year outward from the tree trunks to correspond to tree growth and to the distribution of water from the sprinklers. For the wettest treatment, irrigations were applied when tensiometer readings approached ½ bar, or 50 on a dial instrument whose scale reads 0 to 100. For a second or intermediate treatment, irrigations were applied 1 or 2 days after tensiometer readings reached 80. By extrapolation of the earlier readings, it was possible to estimate when the soil suction reached the 1-bar value. The third, and driest treatment, was irrigated when calibrated soil moisture resistance units indicated values near 10 bars. Thus, the treatments were based on the maximum suction values just prior to an irrigation of ½, 1, and 10 bars on a scale where saturation is indicated by zero suction and permanent wilting conditions, where plants no longer grow, is considered to be 15 bars.

Table 1. Average number of irrigations and amounts of water applied to avocado plots to maintain soil suction below the values indicated.

| Irrigation Treatment | No. of Irrigations | | | Water, in Surface Inches† | | |
|---|---|---|---|---|---|---|
| (Maximum Soil Suction) | 1955 | 1956 | 1957 | 1955 | 1956 | 1957 |
| ½ bar | 38 | 36 | 24 | 43 | 53 | 63 |
| 1 bar | 21 | 18 | 17 | 26 | 31 | 41 |
| 10 bars | 12 | 11 | 8 | 18 | 21 | 22 |

†*Surface inches of water based on area wetted by sprinklers. Acre-inches per acre would be approximately one-half the values shown.*

To determine how much water to apply per irrigation, additional tensiometers were placed at a 2-foot depth. By experience it was found that 1 to 1½ surface-inches of water over the area wetted by the sprinklers were needed to make the 2-foot tensiometers respond downward on the day following the irrigation. This plan resulted in large differences in amounts of water applied as well as in the frequency of irrigations under the various treatments. Table 1 gives the average irrigation program for 3 years under each of the three treatments. Each treatment had three replicated plots.

The nitrogen treatments were applied as a split plot arrangement on the irrigation plots. On each irrigation plot two trees were left without additional nitrogen beyond the small amounts (1/12 lb./tree/year) used the first 2 years when all the trees were treated uniformly. Six trees were given a low nitrogen treatment consisting of ¼ lb./tree/year except in 1954 when they received only 1/6 lb./tree/year. The remaining six trees per plot were given a high level of nitrogen. This started at 2/3 lb./tree/year in 1954 and was increased each successive year to 2 lbs./tree/year in 1957. Calcium nitrate was used as the nitrogen source and the amounts given were applied in three split applications in February, May, and August. A zinc foliar spray was used uniformly on all of the treatments once or twice a year.

## GROWTH AND YIELD MEASUREMENTS

Various attempts to evaluate the indicated treatments were made in advance of the time when the trees came into bearing. Table 2 gives the tree growth as measured by the trunk circumferences in the fall of 1956. Larger trees resulted from the ½ -bar, or most frequently irrigated, treatment. No significant response to the nitrogen fertilization treatments was found, but a trend toward smaller trunk size is indicated with the higher nitrogen levels under the 10-bar treatment.

Table 2. Trunk circumference measurements (in inches) at the end of the 1956 irrigation season.

| Fertilization Treatments† | Irrigation Treatments (Maximum Soil Suction) ½ bar | 1 bar | 10 bars |
|---|---|---|---|
| Zero — N | 13.4 | 13.6 | 13.7 |
| Low — N | 14.8 | 12.1 | 11.4 |
| High — N | 14.8 | 11.8 | 10.6 |
| | 14.3* | 12.5 | 11.9 |

**Significant at the .05 level between irrigation treatment means.*

*†Six trees per treatment for Zero-N; 18 trees each for the others. Refer to the text for descriptions.*

Photographs of typical trees taken in April 1958 show that the response to the ½ -bar treatment (Plot 7) is observable in the field as compared with the 10-bar irrigation treatment (Plot 6). Another photographic comparison shows the fall flush of growth under the 10-and ½ -bar irrigation treatments.

Because of severe wind storms and unusual hot spells, the fruit production has not been as large on these Hass trees as might have been expected under more favorable

climatic conditions. Table 3 gives the average production and fruit size for the crop set in the spring of 1957 and picked in April, 1958. The trend in production is in favor of irrigating at the lower suction values, but because of the great variability among avocado trees these yield data cannot differentiate statistically between the production at the ½ - and 1-bar levels. Yield differences did not result from the nitrogen fertilization levels, hence no benefit from the high nitrogen application was found.

Table 3. Average weight, number of fruit per tree and fruit size on Hass avocado trees on the irrigation plots, 1957-1958 crop year.

| Irrigation Treatments (Maximum Soil Suction) | Fruit per Tree | | Ave. Fruit |
|---|---|---|---|
| | No. | Weight, lbs. | Weight, oz. |
| ½ bar | 96 | 44 | 7.4 |
| 1 bar | 55 | 25 | 7.4 |
| 10 bars | 25 | 9 | 5.9 |


Representative trees from plots at the Citrus Experiment Station showing the increased size of a Hass avocado tree irrigated frequently at the ½-bar level (Plot 7) as compared with the 10-bar or infrequent irrigation (Plot 6). Photographed by Ken Middleham, April 1958.


Examples of the fall growth flush occurring on Hass avocado trees under different irrigation treatments. The pair on the left are exposed laterals and on the right are lower, shaded lateral branches. The irrigation treatments are designated by the soil suction values just prior to irrigation, the 10-bar being an infrequent irrigation schedule and the ½-bar a frequent irrigation schedule. Photographed by Ken Middleham, April 9, 1958.

Repeated measurements of some growth index has been often suggested as a means of telling when to irrigate. Trunk diameter measurements and leaf water deficit determinations were made on selected trees under these irrigation treatments. The sizing of the trunks slowed measurably and even decreased slightly before the 1 level of soil suction was reached. Also, the leaf water deficit was observed to increase as well. However, such indices change so gradually with the drying of the soil that they show little promise as criteria on which to base irrigation needs. Leaf water deficits on trees under the 10-bar treatments showed some delay in returning to their normal values after an irrigation was applied.

Visual symptoms are often used to evaluate management practices on avocados. Tree and leaf characteristics were rated at several times during 1955 and 1956.

Tipburn was more prevalent on the dryer irrigation plots, and, under the same irrigation treatment, it was less severe where higher amounts of nitrogen were used.

Leaf color was observably darker green when more nitrogen was used, and in December the wetter plots were darker green as well. Leaf size increased with the more frequent irrigation treatments, but no influence of the nitrogen was found.

Sunburn of shoots and branches occurred following severe wind storms which partially defoliated the trees. The wettest, ½ -bar, irrigation treatment showed the least amount of sunburn.

Shoot dieback and leaf scorch resulted from excessively high air temperatures. These occurred on all plots, but the leaf scorch was somewhat greater under the wet irrigation treatment where the leaves were more succulent.

Tree vigor ratings were based on general appearance related to leaf size, density of foliage, and amount of new growth developed in successive growth cycles. The ½ -bar irrigation plots were rated higher, and no differentiation was found among the nitrogen

treatments.

## SOIL CHEMICAL PROPERTIES

An important correlative study on these avocado plots is an evaluation of the long-time effects of the irrigation and nitrogen treatments on the chemical properties of the soil. Before the trees were planted the soil had not previously been cultivated. The initial chemical properties have been recorded.

Table 4 gives the average values of several soil chemical properties observed from four sampling dates during 1956. The nitrogen treatments provided a wide range of the soil nitrogen. The additional irrigation water used in the ½ -bar treatment has reduced the soil nitrogen very little and seems to bring about the highest chloride levels. Soil salinity was increased markedly by the high nitrogen treatment.

Table 4. Average values of three soil chemical properties from four sampling dates during 1956 under various irrigation and nitrogen treatments.

| Nitrogen Treatments* | Irrigation Treatments (Maximum Soil Suction)* ½ bar | 1 bar | 10 bars |
|---|---|---|---|
| | Soil Nitrogen, ppm $NO_3$ as N. | | |
| Zero — N | 3 | 5 | 4 |
| Low — N | 11 | 15 | 16 |
| High — N | 38 | 51 | 63 |
| | Chloride, m1/1 in sat. extract | | |
| Zero — N | 2.0 | 1.3 | 0.9 |
| Low — N | 1.7 | 1.7 | 1.0 |
| High — N | 1.7 | 1.0 | 0.9 |
| | Salinity Status, millimho/cm. in sat. ext. | | |
| Zero — N | .8 | .7 | .6 |
| Low — N | .9 | 1.0 | .9 |
| High — N | 1.5 | 1.9 | 2.2 |

*Refer to text for descriptions.*

Further studies are being carried out to evaluate the effect of the calcium applied with the fertilizer on the exchangeable cations in the soil.

## LEAF ANALYSES

Chemical analyses of the avocado leaves from selected trees under the various treatments were carried out to further measure the effects of the irrigation and fertilization treatments. The mean percentage N in the leaves from 1953 to 1957 was 2.27, 2.35, and 2.43 for the ½ -, 1-, and 10-bar irrigation treatments respectively. The soil applications of nitrogen fertilizer also brought about a small but significant increase in the leaf nitrogen with increased amounts added to the soil. The levels of leaf nitrogen under all of the treatments are still above the value where yield response to nitrogen would be indicated. The calcium content of the leaves was increased due to the use of calcium nitrate as the fertilizer.

The chloride content of the leaves from the ½ -bar irrigation plots showed little variation with nitrogen treatments. The values ranged from 0.19 to 0.24 per cent. On the 10-bar irrigation plots, however, when no nitrogen was used the leaf chloride content increased to 0.33 per cent, and where a high level of nitrogen was used the chloride content was reduced to 0.13 per cent.

Phosphorus, potassium, magnesium, and sodium contents of the leaves were not significantly different under the various treatments.

Analyses for the micronutrient elements showed 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. When soil moisture was held at the high level in the ½ -bar treatment there was a tendency for the iron and zinc concentrations to be lower.

The foregoing comprises a progress report. The effects of the irrigation and fertilization treatments will undoubtedly be accentuated as they are carried longer. A further expansion of this integrated program on irrigation and fertilization is being carried out on a 7-acre planting of Bacon avocado trees at the South Coast Field Station of the University of California.