WATER USE REQUIREMENTS OF HIGH AND CONVENTIONAL DENSITY WALNUTS UNDER LOCALIZED IRRIGATION

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ABSTRACT
Crop water use (ET) of third year Chico walnuts under low volume sprinkler irrigation in both high and conventional density plantings were measured at the Kearney Agricultural Center in 1984. Crop yield was also evaluated. Additionally, the yield response to varying levels of pruning of selected high density guard row trees was assessed. On a per tree basis, high density tree peak ET (25 gal/tree/day) was lower than that of conventionally-spaced trees (41 gal/tree/day). Maximum daily ET took place in later July. Although canopy cover, reflected by orchard floor shading, was lower with the conventional density, advective energy transport from the sunlit areas of the dry orchard floor to the tree canopies presumably enhanced the transpiration component of ET. Additionally, the greater percentage of the wetted surface area exposed to direct sunlight undoubtedly increased surface evaporation rates. Both of these processes apparently resulted in the relatively high rate of ET in the conventionally-spaced trees. However, on a per acre basis, ET was lower in the conventional planting due to the lower number of trees. This was reflected by peak crop coefficient (Kp) values of approximately 0.60 and 0.45 for the high and low densities, respectively.

Nut yields were 241 and 36 lbs dry in shell/acre in conventional sections, respectively. This was due to both the greater number of fruiting positions and the number of trees in the high density planting.

The high density guard row pruning trial showed that the standard practice (main uprights pruned 2 ft) yielded 323 lbs dry in shell/acre, partially pruned trees (6-8 in off main uprights) yielded 754 lbs dry in shell/acre, and 877 lbs dry in shell/acre were obtained from unpruned trees. Since partially pruned trees had only modestly lower yields, it suggests that this practice, on a long term basis, may be an attractive alternative for sustaining both high yields and tree growth rates.

OBJECTIVE
This report details the third year results of a project to evaluate water use of high and conventionally spaced walnuts under localized irrigation. The long range goals of this project are to establish the relationship between crop water use (ET) and canopy development from the time of planting to orchard maturity, as well as to identify the degree of canopy cover that corresponds to maximum orchard ET. Additionally, the relationships between productivity and crop water use of both planting densities will be investigated. This includes evaluating the relationships between ET and nut yield, quality, and biomass production for mature trees. The effect of water stress on stomatal behavior and carbon exchange will be addressed after the trees reach maturity.
The 1984 objectives were:

1) To measure crop water use of third year, high and conventional density walnut trees, and

2) To evaluate crop yield under both planting densities.

PROCEDURE

A three year old experimental block of Chico trees equipped with a low volume sprinkler irrigation system was used for this study. This 2.5 acre orchard, which is divided into high (11 x 22 ft) and conventional (22 x 22 ft) sections, is located at the Kearney Agricultural Center in Fresno County. The sprinklers are set in the tree rows 5.5 ft away from each tree and apply water at a rate of 5.4 gallons per hour over a circular area 9 ft in diameter. Two trees in each planting density are intensively instrumented with neutron probe access tubes installed in a grid pattern to a depth of 10 ft.

Neutron probe measurements were taken at one ft intervals in each tube approximately weekly during the growing season. The volume of water applied by the low volume sprinklers during the growing season was determined from water meter readings. Individual emitter output measurements were used to verify the meter readings.

Water use estimates were based on water application rates and changes in soil water contents. Weekly soil water storage changes, either positive or negative, subtracted from the amount of applied water, represented net water use. Water applications were made twice per week and the duration based on currently available estimates of ET for deciduous trees adjusted for the degree of canopy cover of the orchard floor.

To assess the magnitude of deep percolation of water, if any, field measurements of soil hydraulic conductivity over a wide range of water contents were conducted during the winter. With this information, and assuming unit hydraulic gradient, weekly water flux estimates during the season at the 5 ft depth were made. Since these values were low, generally less than .01 in/day, deep percolation was not included in the water balance procedure used to calculate ET.

A pruning trial was conducted on the outside guard rows of the high density planting to evaluate the effect of different degrees of pruning on high density planting yield. There were three pruning treatments:

(1) Standard - main uprights pruned down by two ft
(2) Partial - pruned 6-8 in off main uprights
(3) Unpruned - only low interfering branches removed

Each treatment consisted of six trees per row.

All trees were harvested on October 9, 1984, by knocking each tree with a rubber mallet. The nuts were collected, hulled, and weighed on a field scale. Composite subsamples were oven dried
for dry in shell yield determination.

Shaded areas of the orchard floor were assessed on May 22, June 28, and August 28 for both planting regimes. Measurements were taken by laying a 6 ft x 6 ft sheet of butcher paper divided into 4 in x 4 in sections in the shaded area of the tree and counting the number of sections shaded.

RESULTS AND DISCUSSION

Seasonal water use rates for both the high and conventional density walnuts are shown in Figure 1. Water use increased steadily in the high density to approximately 25 gal/tree/day by early July. Crop water use remained well over 20 gal/tree/day through August, declining to about 7 gal/tree/day by early November. Water use rates in the conventional density planting displayed the same pattern of water use, but were consistently higher throughout the growing season. Crop water use depends mostly on the evaporative demand and leaf area intercepting solar radiation. Evaporative demand, as indicated by pan evaporation measurements taken in a grass environment located near the orchard, increased through mid July, followed by a gradual decline. While this was reflected by rising walnut ET through July, ET rates during August and September remained relatively high. This was due to the increased size of the tree canopies. As shown in Figure 1, canopy size, reflected by the percent shaded area of the orchard floor, increased rapidly during the season. For example, between June 28 and August 28, shaded area nearly doubled for both planting regimes. The trees had several vigorous flushes of growth throughout the growing season, which accounted for the observed increases in shaded area. Direct injection through the irrigation system of 0.50 and 0.25 lbs N/tree on April 12 and July 25, respectively, may have influenced the timing of these flushes.

On a per tree basis, water use in the conventional density planting generally exceeded that in the high density planting. Since canopy cover of the low density trees, and thus intercepted solar radiation was less, one might expect lower transpiration rates. However, advective energy transport from the sunlit areas of the dry orchard floor to the tree canopies may have enhanced the transpiration component of ET. Additionally, the fact that a greater percentage of the wetted soil area was exposed to direct sunlight undoubtedly increased surface evaporation rates relative to the high density planting. These two factors presumably accounted for the ET of conventionally spaced trees exceeding that of the high density planting on a per tree basis. Efforts are being made to quantify surface evaporation rates under both planting regimes.

While ET on a per tree basis was greater in the conventional density planting, it was lower on a per acre basis because of the lower number of trees. This is shown by seasonal values of the crop coefficients (Kp) in Figure 2. Crop coefficients represent the ratio of crop ET to some reference value; in this case, pan evaporation. High density Kp values were consistently higher throughout the growing season, reaching a peak of about 0.60 in mid August, followed by a gradual decline through October. A similar pattern is shown for the low density trees, whose peak Kp was approximately
A late June pruning undoubtedly affected Kp values in this section of the orchard.

Table 1 shows the 1984 yield results from the two planting densities. The high density yield of 241 lbs dry in shell/acre is more than six times the yield of 36 lbs dry in shell/acre harvested in the conventional density. This is due to both the greater number of fruiting positions and the number of trees in the high density plantings.

Table 1 also shows the results of the pruning trial. The unpruned treatment had the highest yield at 877 lbs dry in shell/acre; slightly greater than the 754 lbs dry in shell/acre from the partially pruned trees. The standard pruning was 323 lbs dry in shell/acre. One should be cautioned, however, not to directly compare the yields of the pruning trial to the previously stated orchard yields. The pruning trial yield was on guard trees, with the consequent border effects in terms of light, water, nutrients, etc. Nevertheless, it appears that removal of the upper 2 ft of the main uprights, and consequently, a large number of fruiting buds, by the standard pruning impacted heavily on yields. While the unpruned treatment may have had the highest yield, lack of growth and bud formation next year is anticipated. This may reduce both yield and the rate of orchard development. Partial pruning appears to be an attractive alternative method.

CONCLUSIONS

Third year Chico walnut ET was lower in a high density planting on a per tree basis, compared with conventional spacing, but higher on a per acre basis. This was presumably due to differences in canopy size, transpiration and surface evaporation rates, in addition to tree numbers. Shaded area in both conventional density and high density plantings increased five-fold over the course of the growing season. Nut yield in the high density planting was over six times greater than that of the conventional density. In a high density pruning trial, yield of partially pruned trees far exceeded yields under standard pruning, and was only modestly less than nonpruned trees. On a long term basis, partial pruning would appear to be more conducive to sustaining both high yields and tree growth rates.
Table 1. Harvest yields of third year Chico walnuts in high and conventional planting densities.

<table>
<thead>
<tr>
<th>Tree Density</th>
<th>Yield (dry in shell) (lbs/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>241</td>
</tr>
<tr>
<td>Conventional</td>
<td>36</td>
</tr>
<tr>
<td>Pruning Trial</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>323</td>
</tr>
<tr>
<td>Partial</td>
<td>754</td>
</tr>
<tr>
<td>Unpruned</td>
<td>877</td>
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</tbody>
</table>
Figure 1. Water use (ET) rates, on a per tree basis, and canopy development, reflected by percent ground cover, measured over the 1984 season, for high and conventional density third year Chico walnut trees.
Figure 2. Crop coefficients ($K_p$) for third year Chico walnut trees in high (11 x 22 ft) and conventionally (22 x 22 ft) spaced plantings.