FIRST YEAR RECOVERY FOLLOWING A SIMULATED DROUGHT IN WALNUT

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ABSTRACT

A one year drought was simulated in 1989 on mature conventionally spaced cv. Chico walnuts. A controlled deficit irrigation (CDI) regime was used to apply 16 inches of water for the season. Yield in that year was not significantly different than fully irrigated (41 inches) trees. The CDI trees were returned to full irrigation in 1990. This year, nut yield was dramatically lower due to about an 80% reduction in nut load. The one year delay in a negative impact on production was presumably due primarily to carryover effects of reduced stress year shoot growth that limited the number of fruiting positions in the following season. This study illustrates that maintaining production during a drought year **does not** indicate success in overcoming limited water supplies. Success of CDI must be measured over both the drought and following seasons. Walnut production responds negatively to CDI--severe water stress cannot be tolerated.

OBJECTIVES

To evaluate the short and long term effects of a CDI strategy applied during a simulated drought year in 1989. The CDI regime was developed based on our previous work that applied only 16 inches of water in 1989 and the trees were returned to full irrigation this year; the tree performance results of which are covered in this report.

PROCEDURES

As the California drought entered its third year in 1989, growers in some irrigation districts were told to plan on receiving only 16 inches of water. This project was designed to evaluate a strategy that best applied this limited amount of water. A block of cv. Chico trees (22 x 22 ft spacing) planted in early 1982 at the Kearney Ag. Center and grown under full irrigation were used for this work. Our previous work showed that tree growth, nut expansion, and stomatal conductance peaked early in the season. A CDI regime was designed to apply relatively large amounts of water in the spring and progressively less and the season advanced. The 1989 CDI regime was based on applying certain percentages of estimated ETc (Table 1).

A randomized complete block design was used with three replications of three treatments, which included two sets of the CDI treatment. The original plan was to stress trees for both one and two years followed by a return to full irrigation. However, crop load variability was such that the second set of CDI trees could not be used in any comparison with the nonstressed trees. This resulted in simulating only a one year drought and the second set of CDI trees was used for a test of heavy vs. no pruning following a drought year. We designated 12 pairs of trees with similar crop loads that received the pruning treatments. Since heavy pruning obviously decreased yields this year, the outcome of this pruning test depends largely on 1991 results and we will report results of test next year.

The trees in the study reported herein were pruned by selective heading of major limbs. This involved cutting one year old wood in half. No thinning cuts were made.

Each experimental plot contained eight trees and were isolated with respect to irrigation treatments by heavy wall polyethylene sheeting that was installed to a depth of 4 ft midway between trees. Water was applied using circular low volume sprinklers positioned in the tree rows 5.5 ft from the tree. Orchard water use (ETc) was estimated from reference crop water use (ETo) and previously determined hedgerow crop coefficients (Kc). Since we have evidence that conventionally spaced trees have somewhat higher Kc's than hedgerow trees and we didn't want water stress in 1990, the hedgerow Kc's were increased by 10%.

Predawn leaf water potential was taken generally on a weekly basis with a pressure chamber. Measurements were made on single leaves on each of four trees per replication (12 per regime). Radial trunk growth was measured usually once per week on eight trees per plot with a microdendrometer.

The orchard was harvested on September 18 with a commercial shaker and individual tree weights were determined. Composite nut samples for each plot were taken, dried, and analyzed by Diamond Walnut Growers, Inc. for nut component weights (shell and kernel), size (commercial classifications), and quality.

RESULTS AND DISCUSSION

Plant Water Status

Predawn leaf water potentials were generally above -2.0 bars throughout the season (Figure 1). Values for both the 1989 100% ETc and CDI regimes were similar except for one date in mid September. This indicates that tree water status showed no "memory" of stress history and is consistent with results from previous work. It should also be noted that mid August diurnal measurements of leaf water potential, stomatal conductance and canopy temperature showed that the old CDI trees had completely recovered with respect these these parameters (data not shown).

Trunk Growth

Radial trunk growth rates were highest in May and early June for the control (old 100% ETc) trees (Figure 2). However, trunk growth for the 1989 CDI trees peaked in late June and was still relatively high through early August. The former stressed trees had appreciably higher trunk growth rates after mid May than the control trees. This was presumably due to the lower 1990 crop load with the 1989 CDI trees. This data also illustrate that normal vegatative growth returns rapidly after a drought year.

Nut Yield and Fruit Load

Marketable nut yields and fruit loads were significantly lower for the old CDI trees (Table 2). Fruit load was the most sensitive yield component to the previously year's stress; it was reduced by more than 80%. This was presumably due to fewer fruiting positions this year as a result of lower shoot growth in 1989. Shoot growth is important since fruit is borne on the previous year's wood. Stress-related effects on bloom and fruit set (other potential yield components) cannot be ruled out as other possible explanations since we did not take these measurements in early 1990.

With the lighter fruit loads in the old CDI trees, individual nut weights were significantly higher due to the compensatory effects of nut load on nut weight (Table 2). Commercial nut size characterization showed a shift toward larger sizes for the old CDI trees with "Jumbo" accounting for almost 90% of the crop (Table 3). Surprisingly, kernel percentage was significantly lower for the old CDI trees (Table 2).

Nut Quality

Lower kernel percentages for the old CDI trees resulted in significantly lower edible yield (Table 4). Lower nut loads for these trees resulted in significantly higher large sound nuts. RLI was significantly lower for the previously stressed trees. Offgrade, internal damage, and insect damage were not significantly different.

CONCLUSIONS

Dramatic reductions in marketable yield occurred in the year following the application of a CDI regime (16 inches total) on mature conventionally-spaced trees. The CDI did not significantly affect yield during its application in the simulated drought year. The one year delay in a negative impact on productivity following a return to full irrigation was presumably due primarily to carryover effects of reduced stress year shoot growth that limited the number of fruiting positions in the following season. There may also have been some influence on bloom and fruit set although this was not documented.

This work illustrates that maintaining production during a drought year **does not** indicate success in overcoming limiting water supplies. The success of a CDI regime must be measured by tree performance in both the drought and following seasons. Walnut responds negatively to CDI (as opposed to almonds, pistachio, and prunes, for example) indicating that severe water stress cannot be tolerated and production will be reduced.

Table 1. Controlled deficit irrigation (CDI) strategy used to apply 16 inches of water for the 1989 simulated drought year.

Period	Applied (% ETc)
through March 15	0
March 16-April 30	85
May 1-May 15	75
May 16-May 31	65
June 1-June 30	50
July 1-September 7 (harvest)	25
Postharvest	0

Table 2. Harvest and fruit load related data.

Treatment	Yield dry in-shell[1/] (lbs/tree)	Fruit load (nuts/tree)	Individual nut weight (gm/nut)	% Kernel
1989 100% ET_c (41 inches)	59.2 a	2378 a	11.0 a	47.9 a
1989 CDI (16 inches)	12.8 b	444 b	12.6 b	45.3 b
	*	*	*	*

1/ 8% water content by weight.

* Asterisk beneath columns indicates significant differences at the 5% confidence level between numbers followed by different letters. NS indicates no significant differences in the column.

Table 3. Commercial nut size categories.

Treatment	Jumbo	Large	Medium	Baby
	------------------ % by #			-------------------
1989 100 ET (41 inches)	64.0 a	16.9 a	11.5 a	7.6
1989 CDI (16 inches)	88.8 b	3.4 b	2.0 b	0
	*	*	*	NS

* Asterisk beneath columns indicates significant differences at the 5% confidence level between numbers followed by different letters. NS indicates no significant differences in the column.

Table 4. Commercial harvest quality parameters.

Treatment	Edible yield[1/]	Large sound[1/]	Off-grade[2/]	Internal damage[3/]	Insect damage[1/] (% by #)	RLI #1[4/]
	------------- % by weight			------------		
1989 100% ETc (41 inches)	47.7 a	83.9 a	1.6	2.1	0.7	30.2 a
1989 CDI (16 inches)	45.1 b	95.1 b	2.1	2.5	0.2	23.8 b
	*	*	NS	NS	NS	*

1/ of tree nut load.
2/ of kernels.
3/ of large externally sound nuts.
4/ Reflective Light Index. The higher the RLI, the lighter the kernel color.

* Asterisk beneath columns indicates significant differences at the 5% confidence level between numbers followed by different letters. NS indicates no significant differences in the column.

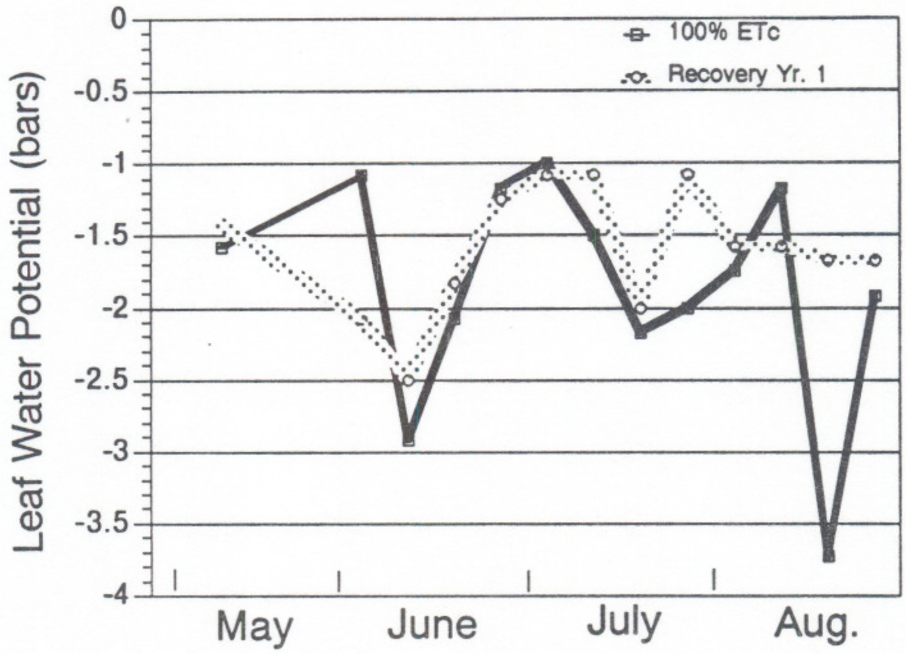

Figure 1. Predawn leaf water potential over the season.

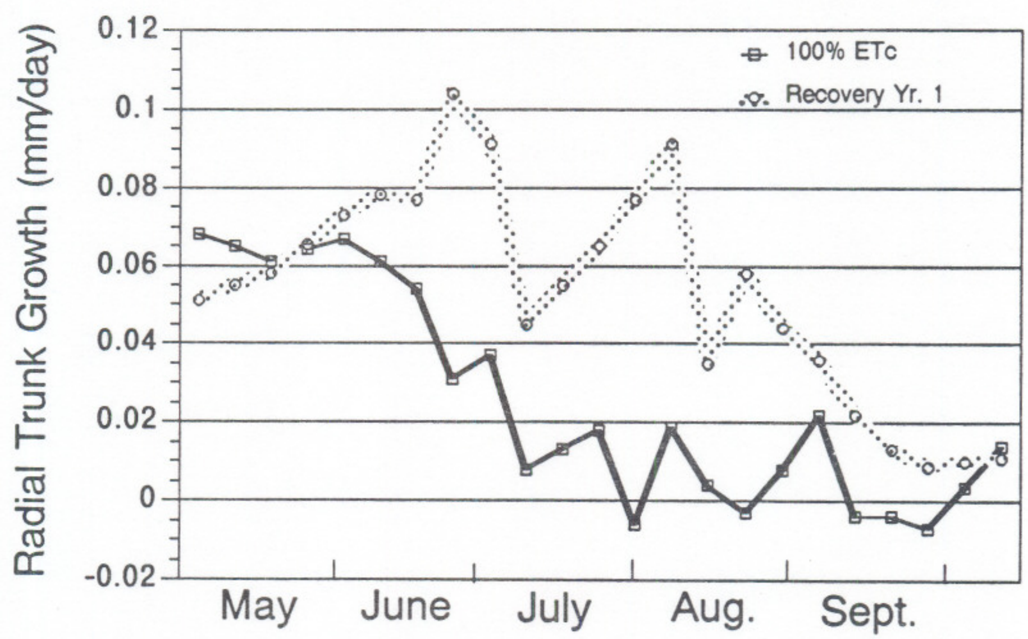

Figure 2. Radial trunk growth rates over the season.