COMPREHENSIVE PROJECT REPORT
1995-96

Project No. 95-M7 - Residual Effects of Water Deficits and Irrigation Strategies on Almonds

Project Leader: Terry L. Prichard, Water Management Specialist
University of California
420 South Wilson Way
Stockton, CA 95205
(209) 468-2085

Cooperating Personnel: Paul Verdegaal, Wes Asai, Warren Micke

Objective:

Evaluate the residual effects of water deficits and irrigation strategies on almond under full water conditions.

Background:

The proper use of water in California is a major topic of discussion. Fueled by drought conditions, a suggestion often overheard is that the tree growers can easily reduce tree water use during periods of water shortage. Additionally, when the water shortage is alleviated, full irrigation could be resumed with no long-term crop effects. Such a management strategy has not been verified and is therefore essential that information be developed before adoption of such a strategy.

Site:

This study is conducted in cooperation with San Joaquin Delta College, using part of their teaching farm orchard located near Manteca, California. A 10-acre block of 14-year-old trees were used as the experimental area. The orchard is planted to 50 percent Nonpareil and equal numbers of alternating rows of Peerless and Price. The soil is a sandy loam of moderate depth with ground water of excellent quality used for irrigation. Irrigation is provided by a solid set sprinkler system.

Almond Board project, "Effects of Water Supply and Irrigation Strategies on Almond" (Project No. 93-H5), provides the ideal conditions to measure the residual effects of water deficits. Irrigation treatments were imposed beginning in the 1990 season and continued through the 1993 season. Imposed treatments included one treatment which provides water for full consumptive use (100% ET) and four treatments which provide for less than full water use (70% and 50% ET) on a seasonal basis while imposing water deficits during either midseason or postharvest. A sixth treatment (Pii or plant-indicated irrigation) utilizes leaf water potential as an indicator of plant water status for scheduling irrigations after June 15, rather than using set values of water use and static times of deficit imposition.

After four years of the six imposed treatments, two treatments were not significantly different in yield while the other four were reduced as much as 36 percent in the 1993 season. In this current trial, the full water requirement was applied to all previous water quantity and timing treatments.

Summary of Results, "Effects of Water Supply and Irrigation Strategies on Almond" :

After four years of imposed irrigation treatments varying the amount of water and timing of its use, significant differences in yield, progression of hull split, hull tights and vegetative growth (weight of prunings) were found to exist. No differences were found in other nut quality parameters (Tables 1 and 2). Yield reductions are primarily a result of reduced nut load. However, reduced nut size accounted for a small portion of reduced yield. In high-set years, nut number is of greatest importance while in low-set years, kernel size takes on increased importance. Less vegetative growth occurred in all but the full water use treatments. Reduced vegetative growth influences yield by reducing fruitwood.

One of the most encouraging treatments was the plant indicated irrigation (Pii, Treatment 6). Over the four-year duration of the experiment, this strategy has resulted in 93% of the yield of the full water treatment while using an average of 66% of the water. Of concern was the reduced vegetative growth observed in 1993, which may lead to a long term production decline. This method (T6) of using a pre-dawn leaf water potential threshold of -12 bars to schedule irrigation is the most promising strategy to minimize effects of a reduced water supply.

Table 1.

Treatment	Combined Years, 1990-93				
	Nuts/Tree x1000	Kernel Wt	Pruning Wt lbs/tree	Green Tip %	Hull Tights Wt % of Meat Yield
1 (100% use)	15.8 AB	1.28 A	38.8 A	3.3 AB	0.7 B*
2 (70% use) (postharvest deficit)	13.7 D	1.22 B	25.6 C	3.2 AB	0.3 B
3 (70% use) (midseason deficit)	14.1 CD	1.09 DE	27.1 C	4.2 A	4.8 B
4 (50% use) (midseason & postharvest deficit)	15.2 ABC	1.12 D	32.2 ABC	2.0 B	0.5 B
5 (50% use) (midseason deficit)	14.6 BCD	1.08 E	27.7 BC	4.6 A	23.1 A
6 (Pii)	16.3 A	1.17 C	34.4 AB	4.1 A	0.5 B
P-value	0.0012	0.0	0.003	0.039	0.0

* Common letters among means within columns denote no significant difference at $P \leq 0.05$.

Table 2.

Treatment	Combined Years, 1990-93			
	Percent Seasonal Use	Consumptive Water Use (in)	Average Yield (lbs of kernels/acre)	Relative Yield % of Treatment 1
1 (100% use)	100	37.4	3358 A	100
2 (70% use) (postharvest deficit)	72	26.9	2755 BC	82
3 (70% use) (midseason deficit)	66	24.7	2572 C	77
4 (50% use) (midseason and postharvest deficit)	52	19.8	2841 B	85
5 (50% use) (midseason deficit)	50	18.5	2623 C	78
6 (Pii)	66	24.7	3136 A	93
P-value			0.0054	

* Common letters among means within runs denote no significant difference at $P \leq 0.05$.

1994-95 Practices and Procedures:

All six previous treatments were irrigated to provide the full mature almond tree water requirement. An on-site CIMIS weather station was used to estimate full water use. Neutron probe measurements were used to verify adequate irrigation and to ensure adequate water storage during orchard floor harvest preparation and harvest. In 1994, a measurement of 7.5 inches of water was used from soil storage, while 40.0 inches of irrigation was applied to accommodate the estimated 39 inches of total seasonal water used. All treatments were postharvest irrigated after harvest of the Price variety in 1994. In 1995, 12.2 inches of water was used from soil storage while 36 inches was applied to meet the total seasonal water use of 37.6 inches. All treatments were postharvest irrigated after Nonpareil harvest.

1994 Results:

Yield: Treatment 1 (previous full water treatment) yielded significantly more meats per acre than all other treatments at 3684 lbs/acre (Table 3). Yields of Treatments 2, 4 and 6 were reduced by 10 percent, or 350 lbs/acre less than the previous full water treatment. Treatments 3 and 5 were similar at about a 20 percent reduction from the previous full water treatment. Treatments previously receiving full water (T1) or those not experiencing midseason water deficits out-performed those treatments with midseason water deficits and a postharvest irrigation.

The largest single factor responsible for yield differences in 1994 was nut load (nuts/tree) (Table 3). A simple regression analysis shows a good relationship with a linear correlation coefficient of 0.87 on a R^2 of 76% (Figure 1). This supports the notion that nut load is mostly a result of increased vegetative growth. It was found that the vegetative growth, measured as prunings, was related to the nut load (Figure 2). Another factor related to yields of meats/acre is the previous year's (1993) yield (Figure 3).

Hull Split: Hull split progressed slower with the previous 1990-93 full water treatment; however, by August 25, all were hulls were fully split (Table 3).

Quality Parameters: No significant differences were found in the number of or weights of: shrivel, doubles, abortions, worms or hull tights.

Table 3.

Previous Treatment	1994 Season		
	Avg Yield lbs kernel/acre	Yield Relative to Treatment 1 (%)	Avg Kernel Mass (g)
1 (100% use)	3684 A*	100	1.22 B
2 (70% use) (postharvest deficit)	3333 B	90	1.30 AB
3 (70% use) (midseason deficit)	2961 C	80	1.27 B
4 (50% use) (midseason and postharvest deficit)	3210 B	87	1.37 A
5 (50% use) (midseason deficit)	2895 C	79	1.28 B
6 (Pii)	3331 B	90	1.36 A
P-value	0.0000		0.0142

* Common letters among means within columns denote no significant difference at $P \leq 0.05$.

Table 4.

	Hull Split Percent			1994 Season	
Previous Treatment	8/5/94	8/10/94	8/19/94	Nut Load nuts/tree (x1000)	Prunings lbs/tree
1 (100% use)	47 B*	74 B	95 C	18.1 A	19.1 A
2 (70% use) (postharvest deficit)	75 A	94 A	100 A	15.5 B	13.5 B
3 (70% use) (midseason deficit)	79 A	94 A	100 A	14.0 C	8.1 C
4 (50% use) (midseason and postharvest deficit)	74 A	89 A	99 AB	14.2 C	14.4 B
5 (50% use) (midseason deficit)	70 A	88 A	95 BC	13.7 C	9.0 C
6 (Pii)	81 A	94 A	99 AB	14.7 BC	14.3 B
P-value	0.0430	0.0033	0.0222	0.001	0.0010

* Common letters among means within columns denote no significant difference at $P \leq 0.05$.

FIGURE 1.

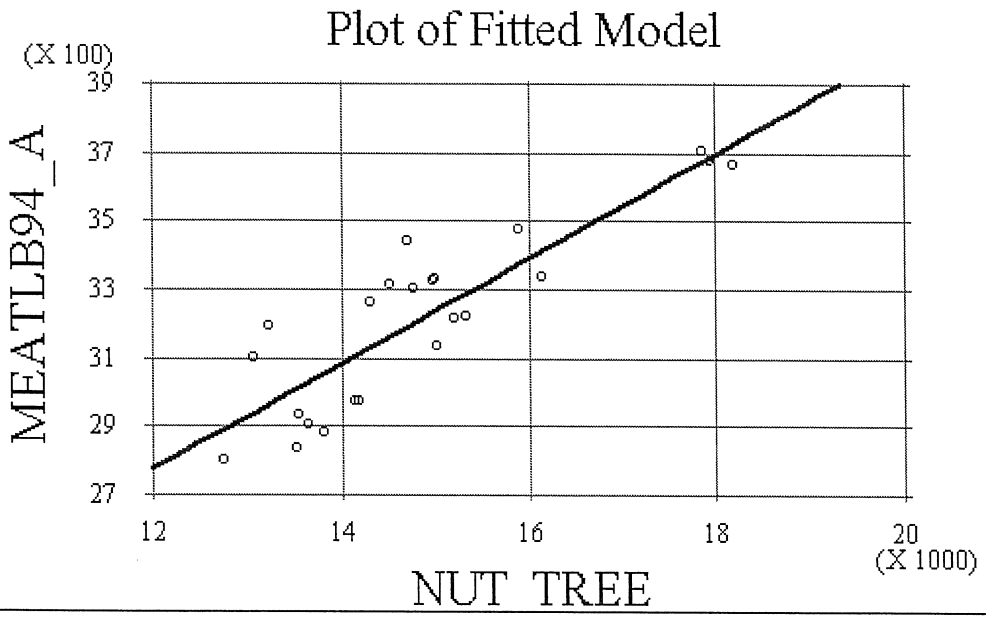


FIGURE 2.

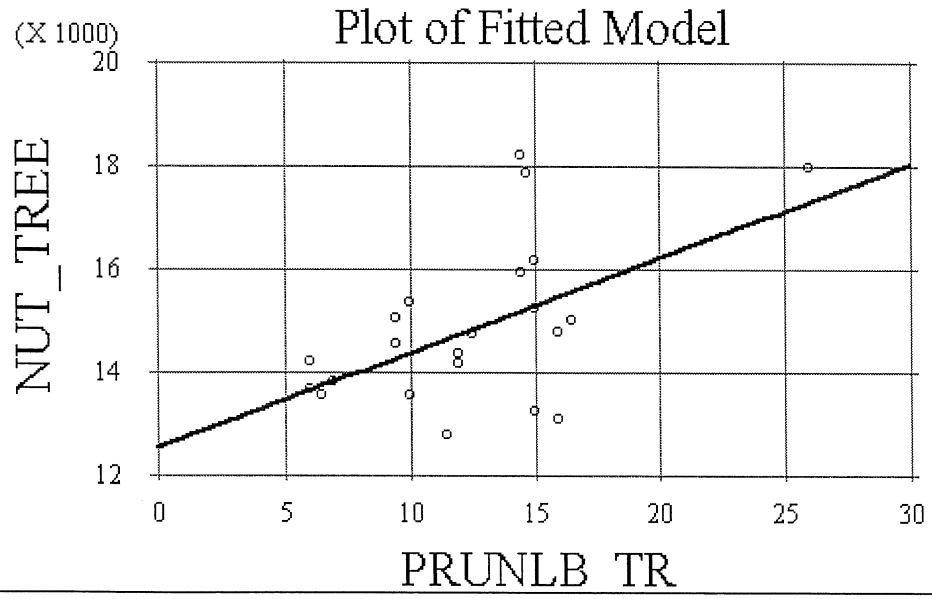
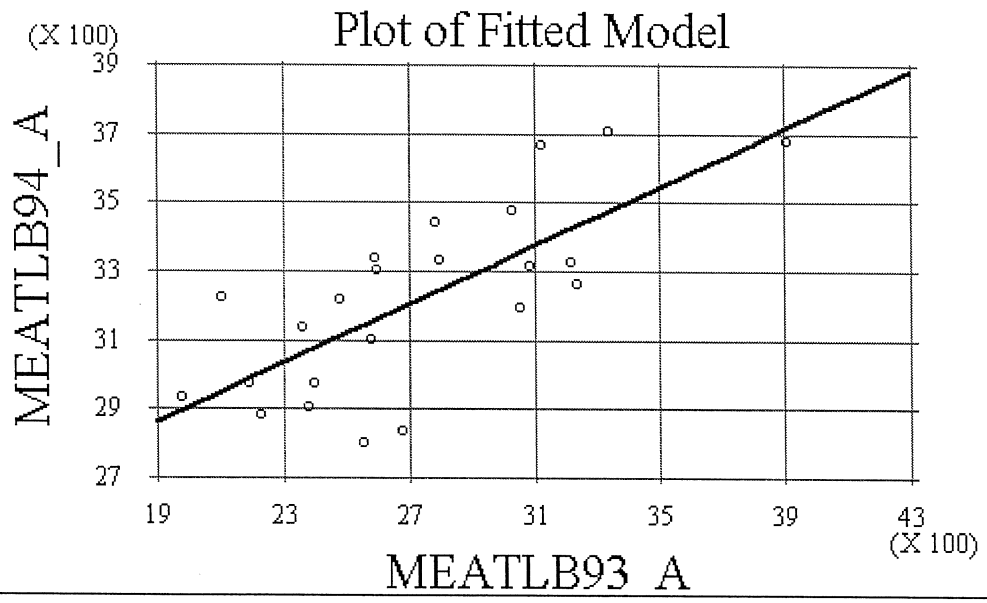


FIGURE 3.



1995 Results:

Yield: No significant differences were found to exist between previous water use treatments (Table 5). The average yield of all treatments was 2260 pounds of meats per acre. Treatments varied only +138 pounds per acre (T6) and -93 pounds per acre (T5) or 4 to 5 percent of the average yield.

Hull Split. Unlike previous year's results, no differences in the timing or progression of hull split was found among treatments.

Yield Components. The basic yield components are nut load (nuts per tree) and the kernel mass. Significant differences due to previously imposed treatments were not found in either of these basic components.

Table 5.

Previous Treatment	1995 Season			
	Avg Yield lbs kernel/acre	Yield Relative to Treatment 1 (%)	Avg Kernel Mass (g)	Nut Load nut/tree (x1000)
1 (100% use)	2270	100	1.44	9.47
2 (70% use) (postharvest deficit)	2160	95	1.47	8.84
3 (70% use) (midseason deficit)	2193	97	1.47	8.98
4 (50% use) (midseason and postharvest deficit)	2369	104	1.43	9.97
5 (50% use) (midseason deficit)	2167	95	1.51	8.65
6 (Pii)	2398	106	1.43	10.1
P-value	0.4535		0.0839	0.1224

Project Summary.

After four years of imposing reduced water use treatments on almond, yields were reduced in the last year of the study to near 36 percent (T3) of the yield in the full water use treatment. The average yield of all treatments receiving less than full water, yields were reduced by an average of 25 percent in 1993. By resuming a full water supply in 1994, an average of 10 percent yield improvement occurred across all water deficit treatments. The treatment with the lowest yield in 1993 (T3) had the greatest improvement at 16 percent over the 1993 production level.

In 1995, yields improved to average 99.4 percent of full water use yield. This is a single year average improvement of 14.2 percent. A regression analysis indicates that nut load is still the major factor for yield differences; however, these differences are small at only 5 percent and are not statistically significant.

The results of this project clearly indicate mature almond orchards that experience reduced yield due to water deficits can recover. After two years of supplying a full water supply and good cultural management, previously water-stressed trees within all treatments recovered to equal the yield of non-stressed, fully watered trees.