

IRRIGATION AND FERTILIZATION MANAGEMENT OF AVOCADO

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The overall project is divided into 3 research components, which will be discussed below.

A. *The Corona Foothill Irrigation Project*

This project was designed to determine a crop coefficient (K_c) for California 'Hass'¹ avocado. The project was initiated in spring 1987 and was terminated in the summer of 1992. We are in the process of summarizing the data from this trial and are preparing the final report. The project was composed of 3 irrigation treatments and was replicated 11 times. The irrigation treatments were designed to bracket the general irrigation requirements of the 'Hass' avocado. The differential irrigation treatments were imposed in late June 1987 and remained throughout the course of the study, even during the winter months. The irrigation amount was determined by referring to the reference E_{To} (evapotranspiration) through CIMIS (California Irrigation Management Information System) using the UC, Riverside station. Trees were irrigated at the same frequency, but received differential amounts of water. Irrigation frequency varied throughout the year and ranged from once a week (winter months) to three times a week (hot summer months). This report will discuss the major data and observations obtained during the 5 years this project was conducted.

Table 1 lists the revised K_c and the mean water use (in) per month. The total water use per year is similar to previously published amounts from Israel (Kalmar and Lahav, 1977a, 1977b). Please note these are revised K_c values and are slightly higher than previously reported. We have revised these values since we observed increased yield during the last three years (1990-1992) from the highest irrigation treatment.

Table 2 reports the effect of differential irrigation on the yield of 'Hass'¹ avocado. The first yield data that was collected (1988) is considered background data since fruit were set (spring 1987) and initially grew without the irrigation differential. Over the course of the 4 years in which we collected yield data from the trial we were able to detect significant differences between the irrigation treatments in 2 of the 4 years. Interestingly enough, these two years were the "off"¹ years (Figure 1). The 100% E_{Tc} treatment has had significantly higher fruit production since 1990. After 5 years of differential treatment the 60% E_{Tc} and 80% E_{Tc} treatments produced approximately 24% and 13% less fruit, respectively (see cumulative yield 1989-92, Table 2).

Fruit were typically harvested 2-3 times during the commercial harvest season. Table

3 summarizes the influence of the differential irrigation treatment on early size (size 48 or larger) harvests. The percentage of the total crop removed in the early harvest accounted for 15-20% of the total yield for all irrigation treatments, regardless of year or irrigation treatment.

Table 4 reports the change in tree size over the course of the study. Note that the final size of the tree was directly related to the amount of water applied. If the yield efficiency (the amount of fruit produced per cubic meter of tree) is calculated, no significant difference was detected between the irrigation treatments. This means that the yield differences detected due to irrigation treatment are related to the fact that deficit irrigation is reducing overall tree growth. We also monitored the time of flowering and intensity of bloom from 1988 onwards. We did not detect any significant shift in the time of flowering or intensity of bloom related to irrigation treatment.

B. *Cashin Creek Ranch Fertilizer Study*

The Cashin Creek Ranch fertilizer trial, located near Valley Center, was established in spring 1988. Trees have been irrigated at 100% ET_c based on Temecula CIMIS data in cooperation with the grove management. Although the trial was initiated in Spring 1988 we were not able to collect meaningful yield data until 1990 (1989 bloom), although other data such as leaf analysis and tree size data were collected beginning in 1988.

Two blocks were utilized for the study due to the established irrigation system. The two blocks are identified by color code, brown and blue (Table 5). The brown block contains a nitrogen trial replicated 24 times. The blue block contains a nitrogen, phosphorus and potassium trial replicated 12 times.

We have monitored the nutritional status of the trees in the study since Fall 1988. Table 6 reports the effect of the nitrogen fertilizer treatments on nutrient uptake based on the 1992 leaf analysis. Note that the nitrogen treatments have a significant positive effect on the zinc, manganese and iron content of the leaves. The higher nitrogen treatments in both blocks have had a negative influence on boron content. Certain nutrients, such as zinc, show similar trends in previous years. We are in the process of conducting multi-factorial regression on the leaf analysis data to determine if we can predict the effect of fertilizer treatments on other plant nutrients. Table 7 reports the influence of the phosphorus fertilizer treatments on nutrient content of the leaves. Note that the phosphorus treatments influence the calcium, boron, copper and iron content of the leaves.

Tables 8, 9 and 10 report the influence of the various fertilizer treatments on yield. We have been unable to detect any consistent significant differences between the fertilizer treatments. We have also not been able to detect any significant nitrogen, phosphorus or potassium interaction on yield in the blue block. We hope that through the regression analysis mentioned above we will be able to differentiate treatment effects on yield.

We plan to continue with this project through 1993. Although we had planned to terminate the project after the 1993 harvest, given the trends observed in leaf analysis on nutrient content we would like to continue the project through the 1994 harvest. This will give us a full 5 years of data (Note: it took 5 years of data collection to

obtain significant data from the Corona Foothill irrigation project).

C. The Covey Irrigation Trial

The Covey Lane irrigation trial (W. Lilac Rd.) was initiated in the summer of 1992. It is both an irrigation rate and frequency trial on mature 'Hass' avocado trees. The differential irrigation treatments were imposed in November 1992 and will be maintained as much as possible throughout the year. Table 10 lists the 9 irrigation treatments included in the study. The irrigation rate will be determined by using the Kc values determined from the Corona Foothill Properties irrigation trial and utilizing Temecula CIMIS data and our own E-pan and atmometer equipment on site. We anticipate that this trial will continue through harvest 1998.

We have installed a weather station at the site. It includes a Class A US Weather Bureau evaporation pan (E-pan), a hydrothermograph, rain gauge and an atmometer. We hope to take the weather data from the site and compare to the Temecula and Escondido CIMIS sites. The experimental site was thinned in 1991 and 1992. After the completion of thinning, the record trees were topped to approximately 18 feet and whitewashed to prevent sunburn (July 1992). Irrigation efficiency (average 94%) and distribution uniformity have also been measured. We also took soil samples (Nov. 92) to determine soil pH and electrical conductivity (an indication of salinity). Soil samples will be taken twice yearly (November and April-May) to monitor the effect of the irrigation treatments on any salinity buildup.

A word of acknowledgment:

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References:

- Kalmar, D. and E. Lahav, 1977a. Water requirements of Avocado in Israel. I. Tree and Soil Parameters. Aust. J. Agric. Res. 28:859-868.
- Kalmar, D. and E. Lahav, 1977b. Water requirements of Avocado in Israel. II. Influence on Yield, Fruit Growth and Oil Content. Aust. J. Agric. Res. 28:869-877.

Table 1. Revised avocado crop Kc's with mean water use in inches.
Corona Foothill, CA.

Month	Kc	100% Mean 1987 - 1991
January	0.40	0.62 ± 0.48
February	0.50	1.41 ± 0.24
March	0.55	1.51 ± 1.05
April	0.55	2.37 ± 0.76
May	0.60	3.42 ± 0.89
June	0.65	4.24 ± 0.41
July	0.65	4.83 ± 0.66
August	0.60	4.20 ± 0.58
September	0.55	3.32 ± 1.05
October	0.55	2.52 ± 0.88
November	0.55	2.02 ± 0.57
December	0.50	1.55 ± 1.27

Table 2. Effect of irrigation treatment on yield.
Corona Foothill, CA.

Irrigation Treatment (%ETc)	Pounds per Acre					Cumulative 1989-1992
	1988 ^z	1989	1990	1991	1992	
60%	11226	3057	7328	1017	12708	35336
80%	10015	4937	6532	2038	14209	37731
100%	10363	3982	8409	2716	16570	42040
Significance	N.S. ^y	0.05	N.S.	0.001	N.S.	0.05
Linear	N.S.	N.S.	N.S.	0.001	0.05	0.01
Quadratic	N.S.	0.05	0.05	N.S.	N.S.	N.S.

^zIrrigation treatment imposed 6/87. 1988 yield data considered as background data only.

^yN.S. = Not significant.

Table 3. Effect of irrigation treatment on early size harvest in pounds per acre.
Corona Foothill, CA.

Irrigation Treatment (%ETc)	Harvest Season			
	89-90	90-91	91-92	Cumulative
60%	459	187	1370	2016
80%	724	437	1657	2818
100%	1005	586	2501	4092
Significance	0.001	0.01	N.S.	0.01
Linear	0.001	0.001	0.05	0.01
Quadratic	N.S. ^z	N.S.	N.S.	N.S.

^zN.S. = Not significant.

Table 4. Effect of irrigation treatment on tree volume.
Corona Foothill, CA.

Irrigation Treatment (%ETc)	Cubic Meters				% Increase 1988-1991
	1988	1989	1990	1991	
60%	64.8	70.8	76.2	80.0	23.4
80%	70.4	77.3	87.5	90.1	28.1
100%	65.9	73.0	87.3	94.6	43.5
Significance	N.S. ^z	N.S.	0.01	0.001	0.001
Linear	N.S.	N.S.	0.01	0.001	0.001
Quadratic	0.05	N.S.	N.S.	N.S.	N.S.

^zN.S. = Not significant.

Table 5. Cashin Creek Ranch fertilizer trial (lbs /tree/year).

Fertilizer Block	Nitrogen ^z (actual)	Phosphorus (P ₂ O ₅)	Potassium (K ₂ O)
Brown	0 ^y	-	-
	1.5	-	-
	3.0	-	-
Blue	0	-	1.36
	0	-	2.72
	1.5	0	-
	1.5	4.0	-
	1.5	8.0	-
	3.0	0	-
	3.0	4.0	-
	3.0	8.0	-

^zNitrogen applied as Urea in a broadcast application. Actual phosphorus applied is 0, 0.87 or 1.74 lb P/ tree/year. Actual potassium applied is 0.56 or 1.13 lb K/tree/year.

^yMaintenance application of N applied at 0.11 lbs N/tree/year in fall of 1990, 1991 and 1992.

Table 6. Effect of nitrogen fertilizer treatment on nutrient content of 'Hass' avocado based on leaf analysis. Cashin Creek Ranch, CA.

-----1992 Leaf Analysis -----					
Nitrogen (actual)	Nitrogen (%)	Zinc ^z (ppm)	Boron (ppm)	Manganese (ppm)	Iron (ppm)
Blue Block					
1.5 lbs/tree	2.32	38.9	38	142	55
3.0 lbs/tree	2.46	56.2	32	225	57
Significance	0.05	0.001	0.01	0.001	N.S.
Brown Block					
Blank	2.07	45.1	51	100	44
1.5 lbs/tree	2.17	69.8	35	135	47
3.0 lbs/tree	2.49	92.8	35	275	51
Significance	0.001	0.001	0.001	0.001	0.01
Linear	0.001	0.001	0.001	0.001	0.001
Quadratic	N.S. ^y	N.S.	0.01	0.01	N.S.

^zSignificant difference in 1991 at the 0.001 level.

^yN.S. = Not significant.

Table 7. Effect of phosphorus fertilizer treatment on nutrient content of 'Hass' avocado based on leaf analysis. Cashin Creek Ranch, CA.

Phosphorus (P ₂ O ₅) ^z	Phosphorus (%)	-----1992 Leaf Analysis -----			
		Calcium (%)	Boron (ppm)	Copper (ppm)	Iron (ppm)
Blue Block					
Blank	0.14	1.46	37	8.2	51
4.0 lbs/tree	0.19	1.88	36	5.5	57
8.0 lbs/tree	0.21	1.73	32	5.5	60
Linear	0.001	0.001	0.05	0.001	0.001
Quadratic	0.05	0.01	N.S. ^y	0.001	N.S.

^zActual rate of phosphorus applied is 0, 0.87 or 1.74 lb P/tree/year.

^yN.S. = Not significant.

Table 8. Effect of nitrogen fertilizer treatment on yield. Cashin Creek, CA.

Nitrogen Treatment (actual) ^z	Pounds per Acre			
	1990	1991	1992	Cum.
Blue Block				
1.5 lbs/tree	8161	3514	12766	24441
3.0 lbs/tree	7189	2650	10962	20801
Brown Block				
Blank ^y	6705	1855	6299	14859
1.5 lbs/tree	7285	2930	6675	16890
3.0 lbs/tree	5924	5250	4735	15909

^zNitrogen applied as urea in a broadcast application.

^yMaintenance application of nitrogen applied at 0.11 N/tree/year in fall of 1990, 1991 and 1992.

Table 9. Effect of phosphorus fertilizer treatment on yield.
Cashin Creek Ranch, CA.

Phosphorus Treatment (P ₂ O ₅) ^z	Pounds per Acre			
	1990	1991	1992	Cum
Blank	8005	1007	13864	22876
4.0 lbs/tree	8034	5530	11106	24670
8.0 lbs/tree	6989	2710	10622	20321

^zActual rate of phosphorus applied is 0, 0.87 or 1.74 lb P/tree/year.

Table 10. Effect of potassium fertilizer treatment on yield.
Cashin Creek Ranch, CA.

Potassium Treatment (K ₂ O) ^z	Pounds per Acre			
	1990	1991	1992	Cum.
1.36 lbs/tree	7723	824	13076	21623
2.72 lbs/tree	8298	2824	15083	26205

^zActual rate of potassium applied is 0.56 or 1.13lb K/tree/year.

Table 11. Covey Lane irrigation study.

Irrigation Rate (%ETc)	Irrigation Frequency (times per week)
90	1
90	2
90	7
110	1
110	2
110	7
130	1
130	2
130	7

Figure 1. Yield of 'Hass' avocado as influenced by irrigation treatment. Corona Foothill, CA.

