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Irrigation and Fertilization Management of Avocados Research Findings

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The irrigation and fertilization management of avocado project utilizes an integrated approach to determine the amount and cost of irrigation water applied in relation to fertility management, nitrogen movement, root distribution, yield, and fruit quality. The project commenced in the spring of 1987 at two sites: Corona Foothill Properties near Corona (Riverside County) and Cashin Properties near Valley Center (San Diego County). Historically, water usage can be as much as 55% of production costs and may increase in the next decade. The Corona project will be completed with the 1991 harvest. The Cashin project should continue through 1993.

At Corona, the three irrigation treatments are 80%, 100%, and 120% of evapotranspiration (ETc). ETo (reference) is based on measurements taken at UCR. The crop coefficients (Kc's) in the formula ETc = ETo x Kc are determined for Corona Foothill on a weekly basis using CIMIS ETo's and are correlated to tensiometer and neutron probe site readings. In 1989, pressure bomb readings were taken to verify soil moisture conditions. The interrelationship of the irrigation treatments to nitrogen and zinc nutrition are monitored as well as deep percolation of nitrogen.

At the Valley Center site, three fertilizer trials have been initiated using a single irrigation treatment of 100% ETc, ETo's are used from the Rancho California CIMIS station. The first trial evaluates the interaction of nitrogen and phosphorus nutrition, the second trial monitors the possible influence of potassium nutrition, and the third involves differential nitrogen rates.

The results from the fertilizer treatments at both sites are related to leaf analysis collected on individual trees in the fall of each year. Selected trees in each irrigation treatment at the Corona location are monitored annually for the relative amounts of bloom, fruit set, and post harvest quality. These data are correlated to yield and leaf analysis the prior fall, and the relative amount of starch in the leaf. At each site, root lengths at depths of 0-8", 8-16", and 24" are evaluated by irrigation regime.

The initial evaluation of individual tree leaf analysis, condition, and frost damage indicated that no significant differences existed among trees prior to initiation of the various treatments.

Practical Application

The irrigation crop coefficients for mature avocado trees have been calculated for 1987, 1988, 1989, and 1990 according to actual water usage. The crop coefficients are characterized by a peak of 0.55 for July and a low of 0.35 in December. Complete monthly Kc's are shown in Table 1; it should be noted they are data for 3½ years. Actual water usages for 1989-1990 for the three irrigation treatments are shown in Figure 1 and Table 2. Actual water use in the contract year 1989-1990 for the three treatments was 80% ETc, 21"/A; 100% ETc, 26"/A; and 120% ETc, 32"/A. Water use for 1988 was 15-20% higher than 1990, due to weather conditions.

In considering the economics of producing avocados, a major input into total costs is price of the water. A determination of water costs (high, low, and median) were obtained from San Diego County Advisor Weisheit at the onset of the project. In 1989, Eta Takele began an analysis of economic yields in relationship to fertility and water treatments. The 1990 economic study is contained, now, in Ms. Takele's separate report. The relationship between the ETc and early yield is shown in Figure 4. Table 5 and Figure 4 show that we observed a significant increase in the yield due to irrigation treatment when fruit were size picked early in the season. This demonstrates that irrigation practices can influence fruit growth in a manner that can have a significant economic impact.

Short Term Relevance

The irrigation crop coefficient for mature avocado trees was determined for 1987, 1988, 1989, and 1990 from actual water usage. Table 1 shows that crop coefficients of 0.45 are used in November and 0.40 in December.

Tables 3, 4, and 5 show yield data for 1989-1990 for the Corona Foothill Project. The data are separated into the effect of irrigation (Table 3), nitrogen fertilization (Table 4), and the impact of irrigation on two early season size picks in 1989/1990 (Table 5). We observed a significant difference ($P = 0.05$) due to irrigation treatment when the site was size picked (8 ounce or larger) in November 1989 and January 1990 (Table 5, Figure 4). There was, however, no significant difference due to irrigation treatment after the trees were stripped in June 1990. On an annual basis, we have not observed yearly differences in yield due to irrigation treatment (Table 3, Figure 5), although the cumulative yield (1988-1990) shows a trend toward higher production in the 120% ETc treatment.

Table 6 shows the Cashin Ranch yield for 1989-1990 as related to nitrogen treatment. In the blue block, nitrogen is differentially applied with phosphorus and potassium. The trees in the brown block are only being differentially treated for nitrogen. It is interesting to note that the trees receiving 4.0 Ibs N/tree have lower yields than the 2.0 Ibs N/tree. We will continue to monitor yield throughout the project.

Leaf analyses of both ranches are shown in Tables 7 and 8 and Figures 2 and 3. Although symptoms of nitrogen deficiency are apparent in the untreated trees (blanks) at the Cashin Ranch, yield has not yet been significantly affected in the three years of treatment.

Trunk circumference and tree height at Corona Foothill as related to irrigation or nitrogen treatment are presented in Tables 9 and 10. There has been a slightly greater amount of tree growth in the trees receiving 120 % ETc as compared to 80 % ETc. The differential nitrogen treatments at Corona Foothill have also resulted in slightly greater tree height.

Tree growth at the Cashin Creek Ranch as related to nitrogen treatment is reported in Table 11. As observed at the Corona Foothill site, there apparently has been no effect on trunk circumference due to nitrogen treatment although tree height is slightly increased due to nitrogen application.

We have also determined canopy volume (cubic meters of canopy) of the experimental trees. The general trends of increased growth agree with the data reported in Tables 9-11. These data will be used in future years to help us determine yield efficiency as related to field treatment by calculating the yield (lbs.) per cubic meter of tree canopy.

Tables 12 and 13 relate to canopy volume of the trees at the Corona Foothill site with respect to the irrigation and nitrogen treatments. The 120% ETc trees showed the greatest amount of increase in canopy volume during the 1988-1989 growing season. The two nitrogen treatments also showed a greater percent increase during 1988-1989. We will collect the same information in fall 1990. Table 14 reports canopy volume for the three nitrogen treatments at the Cashin Creek site and indicate a slight increase with 2# N/tree vs. no nitrogen.

Figure 6 shows that there are significant differences (P 0.05) in total root length comparing 0-8" depths and 8-16" depths under the low volume, 6.0 GPH, sprinklers at Corona Foothill. From irrigation, fertilizer, and N movement criteria, these data indicate the need for careful evaluation of management techniques under low volume irrigation; that is, large applications of fertilizers at any one time should be avoided.

Long Term Relevance

The long term goal of this project is to integrate fertility, water use, and certain other management principles to yield, quality, and dollar return to growers. The NO_3-N movement under various application times of fertilization is discussed by Dr. M. V. Yates within the new Ventura County project. The study does show much less movement under monthly applications than annual or biannual application. Long term expectations:

- water management efficiency determinations (CU's)
- refine monthly crop coefficients (Kc's)
- refine fertility needs (as related to tissue analysis)
- relationship between productivity, cost input, and dollar return
- appropriate fertilizer applications to prevent downward movement of N
- refine rooting characteristics in relationship to low volume sprinkler irrigation
- relationship between fruit maturity, size, storage quality, and production practices

Fruit yield data at Corona, water use data, fertility, and cost relationships have been completed for 1989-1990. Bloom, fruit set, and yield relationships are being evaluated for each irrigation treatment and fertility level. Both tensiometer and neutron probe soil moisture determinations are conducted at each site. Refinement of monthly crop coefficients (Kc's) for growers is continuing in 1991.

A modeling study of geostatistical spatial variability of nitrogen concentration in the soil and the development of a nitrogen movement (transport) model have been initiated by Dr. Marylynn Yates, hydrologist/toxicologist UC CE, and funded by TVA.. This conjunctive study at Corona Foothill, Cashin Ranch, and Ventura will help define predictability of nitrogen movement from soils or waters resulting from our experimental fertility applications.

The project time line for 1987-1993 is as follows:

1987	ETc irrigation, 80%, 100%, 120% ETo & Kc Leaf analysis Soil/water analysis Flower bloom Tree measurements	1987	Irrigation uniformity Leaf analysis
1988	Continue 1987 studies Leaf area index Bloom/yield Establish fertilizer treatments Begin nitrate movement studies	1988	100% ETc scheduling Establish N/P, N, K treatments Tree measurements
1989	Continue 1988 studies Begin storage tests Begin cost studies	1989	Continue 1988 studies Yield information, fruit storage quality and economic studies
1990	Continue 1989 studies, economic studies	1990	Continue 1989 studies Fruit storage quality Economic studies
1991	Continue 1990 studies Projected completion with 1991 crop harvest	1991-93	Continue 1990 studies Projected completion, 1993

Table 1. Avocado Crop Kc's for CIMIS ETo

January	.35
February	.40
March	.45
April	.45
May	.50
June	.55
July	.55
August	.50
September	.45
October	.45
November	.45
December	.40

Table 2. Actual Water Use (Irrigation) in Inches for 1987 - 1990. Corona Foothill, Ca.

	80%				100%				120%			
Months	'87	'88	'89	'90	'87	'88	'89	'90	'87	'88	'89	'90
January		0.64	0.61	0.00		0.93	0.76	0.00		1.04	0.94	0.00
February		1.16	1.06	1.24		1.45	1.16	1.28		1.74	1.18	1.30
March		1.53	1.06	1.56		1.92	1.33	1.89		2.30	1.56	2.13
April		1.92	2.06	1.22		2.40	2.58	1.58		2.88	3.15	2.01
May		2.53	2.61	1.54		3.16	3.16	1.87		3.84	3.73	2.11
June		3.00	2.77	3.20		3.84	3.32	3.91		4.58	3.87	4.62
July		3.47	3.76			4.21	4.66			5.05	5.56	
August		3.16	3.18			3.90	4.00			4.65	4.74	
September	3.18	3.25	2.21		3.90	3.29	2.75		4.68	3.29	3.28	
October	2.72	1.18	1.40		3.47	2.04	1.73		3.96	2.28	2.11	
November	2.04	1.16	1.31		2.40	1.34	1.64		3.00	1.57	2.00	
December	0.99	0.49	0.95		1.30	0.53	1.16		1.55	0.59	1.40	

Table 3. Average Yield Data per Irrigation Treatment. Corona Foothill, Ca.

Irrigation Treatment	Pounds per Acre			
(% ETc)	---- 1988 ----	---- 1989 ----	---- 1990 ----	-- Cumulative --
80%	6859	3026	7432	17317
100%	6708	3844	7313	17865
120%	6046	3312	8651	18009

Table 4. Average Yield Data per Nitrogen Treatment. Corona Foothill, Ca.

Nitrogen Treatment (Actual)	Pounds per Acre ---- 1988 ----	---- 1989 ----	---- 1990 ----	-- Cumulative --
Blank	8045	3831	7608	19484
1.5 lbs/tree	7983	5204	6515	19702
3.0 lbs/tree	7777	3734	6994	18505

Table 5. Average Size Pick Data per Irrigation Treatment. Corona Foothill, Ca.

Irrigation Treatment (%ETc)	Pounds per Acre — 11/89 —	—1/90 —	—Total —
80%	287	129	416
100%	544	244	788
120%	771	314	1085
Significance Level:	0.05	0.10	

Table 6. Yield Data in Pounds per Acre per Nitrogen Treatment. Cashin Creek Ranch, Ca.

	Nitrogen Applied (actual)		
Block	Blank	2.0 lbs/tree	4.0 lbs/tree
Blue	8010	8161	7190
Brown	6705	7284	5923
Average	7357	7810	6683

Table 7. Total Nitrogen based on Leaf Analysis. Corona Foothill, Ca.

Nitrogen Treatment (Actual)	Total Nitrogen in Percent		
	---- 1987----	---- 1988 ----	---- 1989 ----
0 lbs/tree	1.87	1.98	1.92
1.5 lbs/tree	1.84	2.12	2.10
3.0 lbs/tree	1.87	2.19	2.19

Table 8. Total Nitrogen based on Leaf Analysis. Cashin Creek, Ca.

Nitrogen Treatment (Actual)	Total Nitrogen in Percent		
	---- 1987----	---- 1988 ----	---- 1989 ----
0 lbs/tree	2.00	1.94	1.77
2.0 lbs/tree	1.97	2.23	2.17
4.0 lbs/tree	1.95	2.33	2.30

Table 9. Tree Dimensions by Irrigation Treatment. Corona Foothill, Ca.

Irrigation Treatment (% ETc)	Trunk Circumference cm				Tree Height meters			
	1987	1988	1989	%Increase ('87 - '89)	1987	1988	1989	%Increase ('87 - '89)
80%	54.2	62.3	66.2	22.14	4.36	5.61	5.85	34.17
100%	55.1	62.6	66.5	20.69	4.35	5.74	6.00	37.93
120%	55.2	63.7	69.6	26.09	4.23	5.61	5.84	38.06

Table 10. Tree Dimensions by Nitrogen Treatment. Corona Foothill, Ca.

Nitrogen Treatment (Actual)	Trunk Circumference cm				Tree Height meters			
	1987	1988	1989	%Increase ('87 - '89)	1987	1988	1989	%Increase ('87 - '89)
Blank	54.4	62.9	67.2	23.53	4.31	5.70	5.80	34.57
1.5 lbs/tree	55.5	63.1	67.5	21.62	4.36	5.68	5.96	36.70
3.0 lbs/tree	54.6	62.6	67.7	23.99	4.27	5.59	5.93	38.88

Table 11. Tree Dimensions by Nitrogen Treatment. Cashin Creek, Ca.

Nitrogen Treatment (Actual)	Trunk Circumference cm			Tree Height meters		
	1988	1989	%Increase ('88 - '89)	1988	1989	%Increase ('88 - '89)
Blank	44.43	50.63	13.95	3.72	4.38	17.74
2.0 lbs/tree	45.01	52.91	17.55	3.73	4.58	22.79
4.0 lbs/tree	44.36	51.44	15.96	3.73	4.53	21.45

Table 12. Canopy Volume by Irrigation Treatment. Corona Foothill, Ca.

Irrigation Treatment (% ETc)	Canopy Volume meters		
	1988	1989	%Increase ('88 - '89)
80%	66.4	71.6	7.83
100%	70.4	77.9	10.65
120%	67.9	76.6	12.81

Table 13. Canopy Volume by Nitrogen Treatment. Corona Foothill, Ca.

Nitrogen Treatment (Actual)	Canopy Volume meters		
	1988	1989	%Increase ('88 - '89)
Blank	67.3	72.6	7.88
1.5 lbs/tree	69.4	77.5	11.67
3.0 lbs/tree	68.0	76.0	11.76

Table 14. Canopy Volume by Nitrogen Treatment. Cashin Creek, Ca.

Nitrogen Treatment (Actual)	Canopy Volume meters
	1989
Blank	38.82
2.0 lbs/tree	45.80
4.0 lbs/tree	43.22

Figure 1. Actual Water Applied (Irrigation + Rainfall, Jan '89 - June '90) vs. ETc Values at 100%. Corona Foothill, Ca.

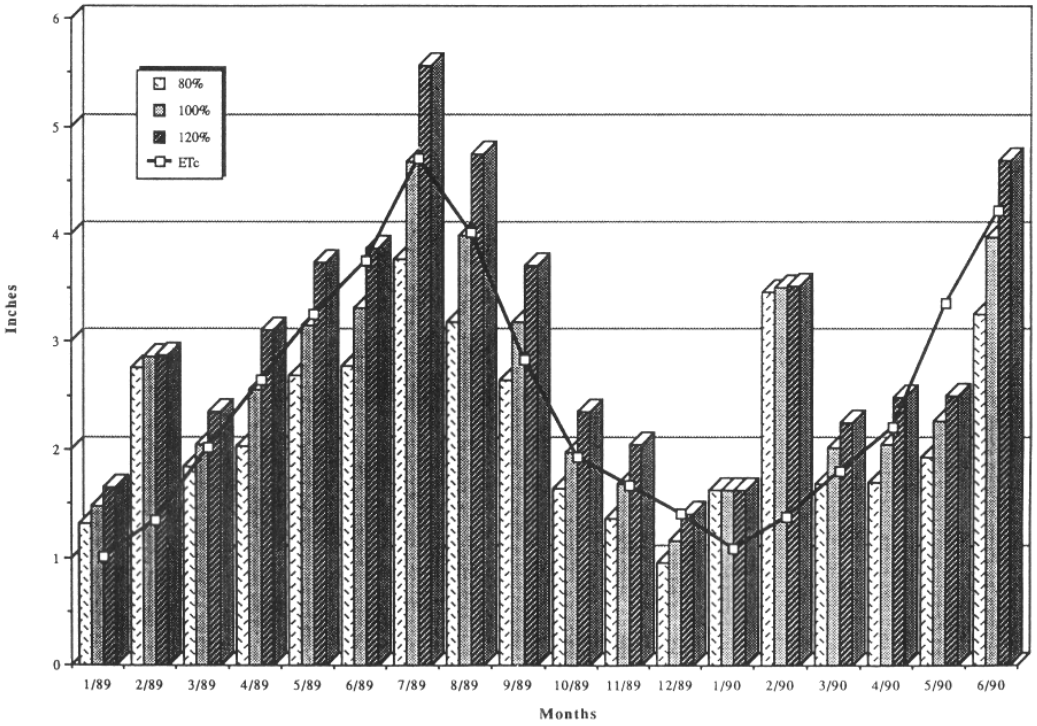

Figure 2. Average NO_3-N Levels for each Nitrogen Treatment based on Leaf Analysis. Corona Foothill, Ca.

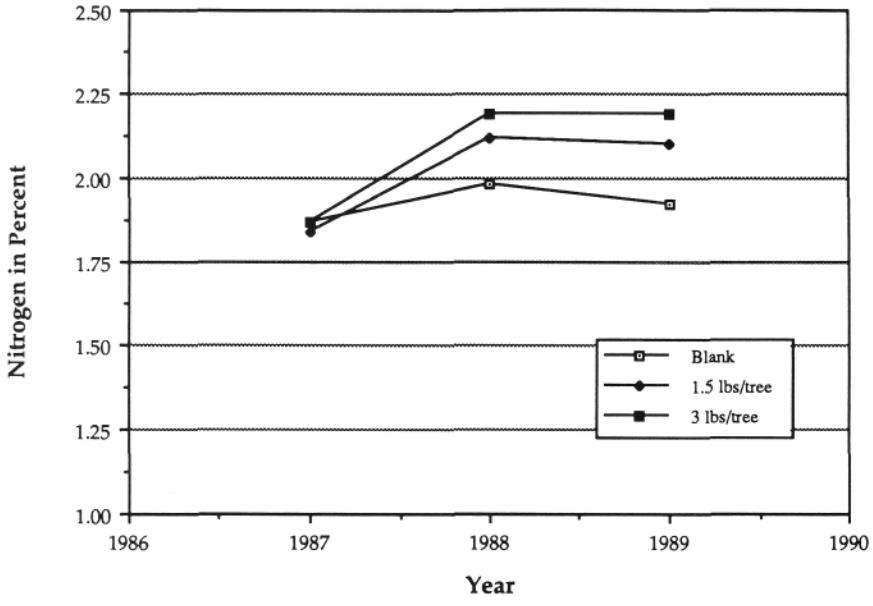

Figure 3. Average NO_3-N Levels for each Nitrogen Treatment based on Leaf Analysis. Cashin Creek, Ca.

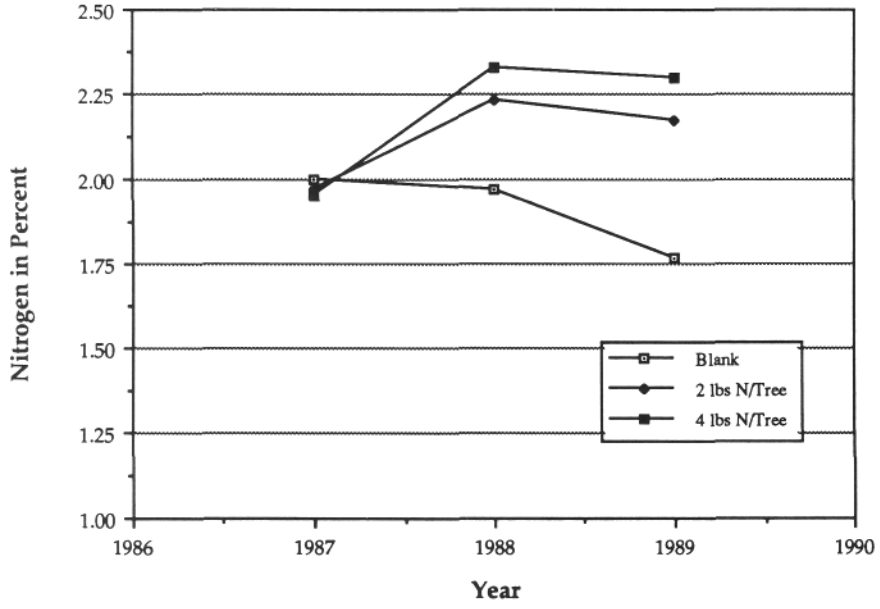

Figure 4. Record Row Yield Data per Irrigation Treatment for Two Size Harvests. Corona Foothill, Ca.

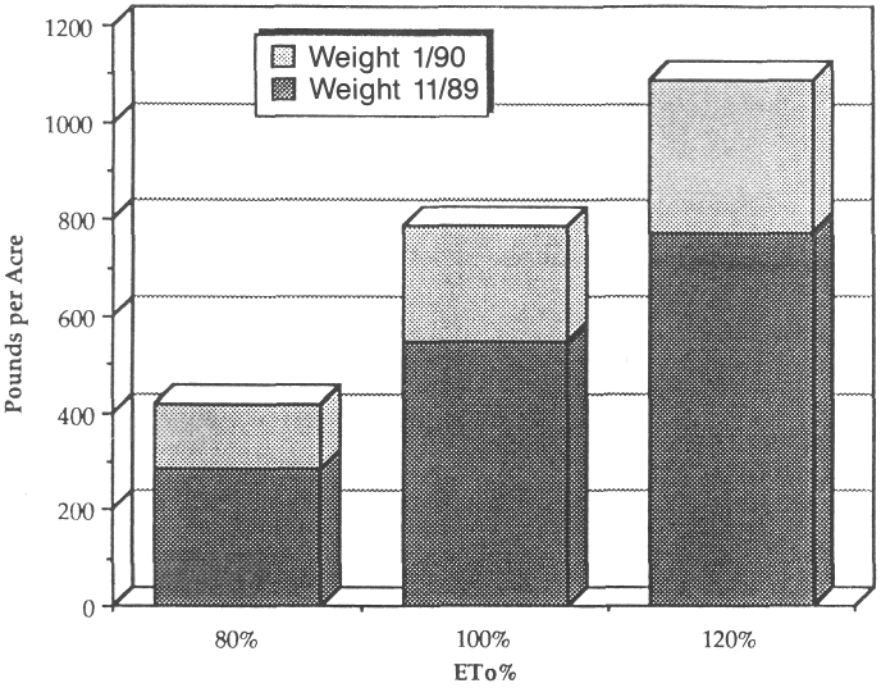

Figure 5. Average Yield per Acre as Influenced by Irrigation Treatment (1988-1990). Corona Foothill, Ca.

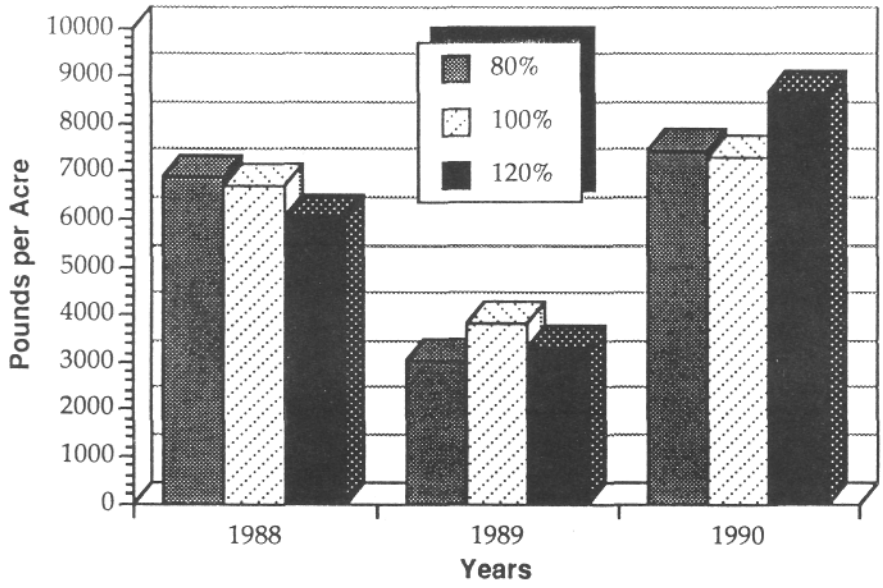

Figure 6. Average Total Root Length as Influenced by Irrigation Treatment and Soil Depth (June 1990). Corona Foothill, Ca.