Project Title: Water Management for Early and Late Season Stone Fruit

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Project Objectives:

1. To conclude the study of postharvest water stress on an early season peach under low volume irrigation.
2. To study the effects of postharvest water stress on an early season plum variety.
3. Determine the water requirements of four-year-old peach trees using a weighing lysimeter.
4. To study the effects of 8 different water management strategies on yield and fruit size. The treatments will involve stress during "non-critical" periods of fruit growth, extra irrigations during the final period of fruit swell, and irrigation frequency.

Abstract

A 3-year study of postharvest water stress on an early maturing peach was concluded in 1991. Stress was severe enough on several of the reps to decrease marketable yield due to high production of double and deep sutured fruit. Rewatering in August eliminated this problem.

A second year of postharvest stress was applied to an early season plum variety. Doubling was very low and not affected by the stress treatments. Yield and fruit size were also not affected.

Water use (ET) was measured on 4 year old O'Henry peach trees using a large weighing lysimeter. Seasonal water use was very similar to the values reported for mature deciduous orchards but the pattern over the season was very different. Until several more years of data are collected, it will not be clear whether this pattern is consistent for peaches or only due to the weather pattern of 1991.

Eight irrigation treatments were applied for a second year to the O'Henry tree surrounding the lysimeter. Slight increases in fruit size were observed in treatments receiving greater than 100% ET before harvest. However, more optimal vegetative growth and better fruit quality were obtained with treatments that imposed moderate levels of water stress.

Post harvest water stress on early maturing varieties:

Spring Lady Peaches

This experiment was initiated after harvest in 1988 and concluded at harvest in 1991. The stress treatment consisted of 100% ET before harvest in early June and about 25% ET for the rest of the season. Control trees received 100% ET for the full growing season. In 1990, 2 reps of the stress treatment were re-watered with 100% ET starting in early August. The stress trees only received 1.7 acre feet of water compared to 3.9 for the control and 2.9 for the rewatered treatment (Table 1).

Table 1. Postharvest water stress of Spring Lady peaches, 1990-91.

	Control	Stress Treatment	Re-watered
Water Applied 1990 (acre feet)	3.9	1.7	2.9*
Flower Density 1991 (flowers/ft.)	15.8	15.8	15.1
Fruit Set 1991 (%)	83.5%	83.8%	84.0%
Double Fruit Before Thinning (%)	7.5	44.8	2.9
Harvest 1991			
Number per Tree (#)	108.0	85.1	119.0
Avg. Fruit Wgt. (g)	131.2	139.5	133.4
Marketable Yield (kg/tree)	11.5	9.0	13.8
Percent Double Fruit (%)	.3	4.2	.3
Percent Deep Sutures (%)	4.4	10.1	4.1

*Estimate-due to a broken water meter.

After three years of postharvest water stress, results have remained fairly constant. The stress treatment has shown no decline in tree health, flower density or fruit set. However, the production of double fruit was dramatically increased by water stress just as in the previous 2 years. The rewatered treatment effectively reduced double fruits at thinning time and thus reduced the percent of harvested fruit that were doubles or deep sutured. The rewatered treatment was equal to or better than the control in all harvest parameters. Under drought conditions, the rewatered treatment appears to be a viable option for saving water without negatively impacting yield or fruit quality.

In the stress treatment, several reps were stressed to the point of having very high doubles (Fig. 1). During the normal thinning procedure, just removing doubles and misshapen fruit left fewer than normal good fruit on some trees. As a result, yields of marketable fruit were reduced on those reps (Fig. 2). These data point out that stress can become severe enough to reduce yields.

A secondary objective of this experiment has been to develop a method of predicting the severity of doubling during the previous summer so management practices could be implemented to minimize the negative effects of stress on yield and fruit quality. The method of estimating stress in this experiment was

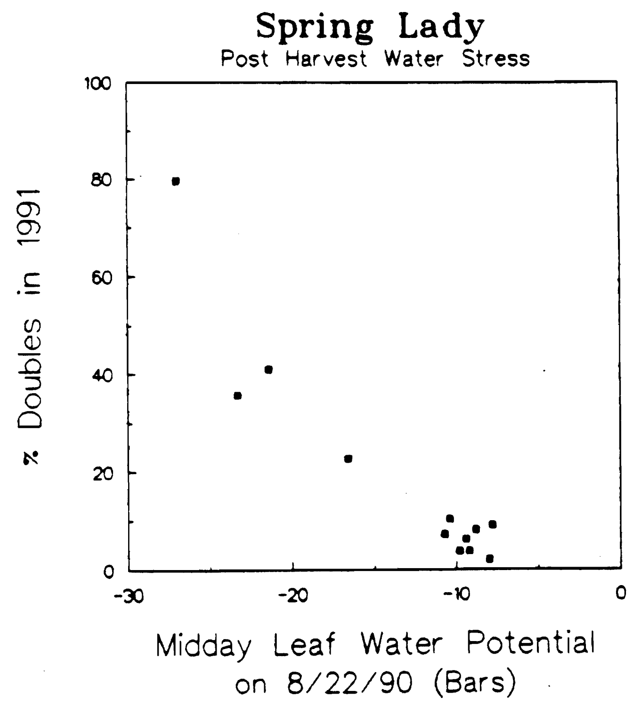


Fig. 1. Percent doubles in Spring Lady peaches in spring 1991 as related to midday leaf water potential on August 22, 1990. Correlation coefficient = .94.

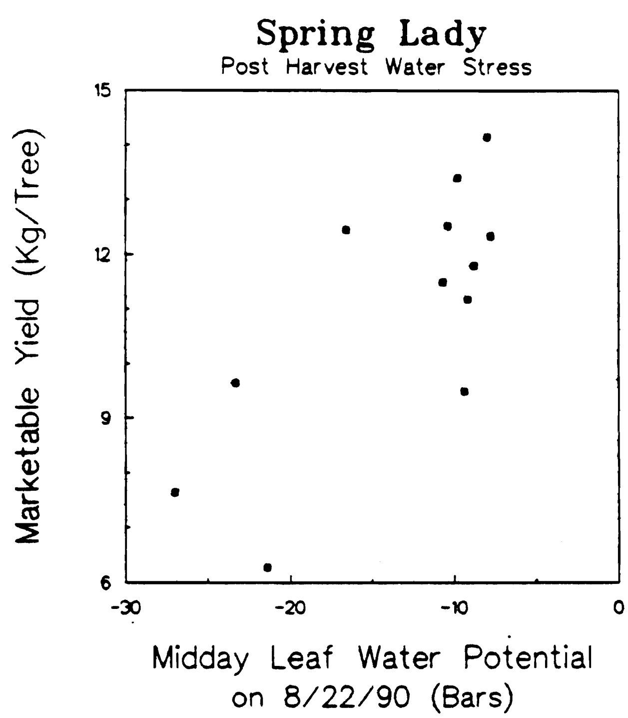


Fig. 2. Marketable yield in Spring Lady peaches in 1991 as related to midday leaf water potential on August 22, 1990. Correlation coefficient = .75.

to measure the leaf water potential at midday of bagged leaves using a pressure bomb. These values from August 22, 1990 correlated very well with percent doubles in 1991 (Fig. 1) and also showed some correlation with marketable yields (Fig. 2). Using the pressure bomb, an orchard manager could implement irrigation practices which prevented the midday leaf water potential from dropping below -20 bars. This should insure a reasonably low production of double and deep sutures fruit so there would not be a serious problem in the following season.

Red Beaut Plums

This experiment was initiated after harvest in 1989 and will be concluded at harvest in 1992. Three different irrigation treatments have been imposed. The control treatment received 100% ET for the entire season. The two stress treatments also received 100% ET through harvest in late May. The first stress treatment had 1 of 2 foggers per tree shut off in early June, thus receiving 50% ET for the postharvest period. The second stress treatment was subjected to 3 cycles of 6 weeks each starting in early June. A cycle consisted of 3 weeks with no irrigation followed by 3 weeks of 100% ET. Both stress treatments received about 60-70% of the irrigation water applied to the control for the whole season (Table 2).

Table 2. Postharvest water stress of Red Beaut plums, 1990-91.

	Control	Stress Treatment 1	Stress Treatment 2	Significantly different (5% level)
Water Applied 1990 (acre-ft.)	3.3 a	2.0 b	2.3 b	Yes
Flower Density 1991 (flower/ft)	32.1	31.9	33.0	No
Percent Double Fruit Before Thinning 1991 (%)	1.9	1.0	1.2	No
Harvest 1991				
Total Yield (kg/tree)	51.8	44.0	48.6	No
Avg. Fruit Wgt. (g)	49.1	52.7	56.9	No
Percent Double Fruit (%)	0.9	0.6	0.7	No

After two seasons of postharvest water stress, the trees still looked healthy by the end of the season. Some defoliation occurred on the second stress treatment but there was no major problem with gumming or twig dieback. The stress treatments also had no effect on flowering, yield or fruit size (Table 2). There was a slight reduction in yield especially in stress treatment 1 but it was not statistically significant. However, it may be an indication of a trend which could become more pronounced after several years of stress.

Percent double fruits were quite low both before thinning and at harvest. Also, the stress treatments did not have more doubles than the control. Border trees of both Durado and Ambra varieties of plum were also evaluated for percent doubling before thinning. Both varieties showed slightly higher levels of doubling (3-6%), but the stress treatments did not increase the problem. In sharp contrast to the peaches, it appears doubling is not a problem of any consequence when imposing postharvest water stress on plums.

In an effort to find out the effects of extreme water stress on plums, stress treatment 2 was modified in 1991. After harvest in late May, irrigation was cut off completely except for the period of July 23 to August 15 when 100% ET was applied. Severe defoliation occurred in some of the trees. Effects on doubling, yield and fruit size will be determined in 1992.

Water Use of 4-Year-Old O'Henry Peach Trees

Water use of 4-year-old peach trees was measured with the weighing lysimeter. The lysimeter has been automated since the beginning of 1989 and irrigates every time .21 inches is lost by tree transpiration or soil evaporation. The irrigation system turns on about once per day in the middle of the summer. A heavy crop load was supported by the trees in 1991. Since the trees are planted in a high density configuration, they basically reached maturity in terms of yield and water use in 1991.

Daily water use of the peach trees was quite consistent from day to day, fairly well tracking reference crop ET (Fig. 3). The ratio between peach ET and reference crop ET, or crop coefficient (Kc), showed a steady increase throughout the season until about the middle of October (Fig. 4). There is also a noticeable dip in the middle of August which seems to be associated with harvest. The same dip was also observed in 1990. This phenomenon will be monitored carefully in 1992 to make sure it is not just an artifact or related to environmental conditions.

Total water use of 36.47 inches (Table 3) compares quite well with published values of about 38 inches for clean cultivated mature deciduous orchards in the San Joaquin Valley. However, the pattern of water use is quite different. The crop coefficients derived from the lysimeter in 1991 were considerably lower early in the season and higher later in the season compared to published crop coefficients.

It is not known whether these differences will remain constant from year to year or are just due to the particular weather conditions of 1991. This will be studied in greater detail over the next few years so revised crop coefficients can be developed, if necessary.

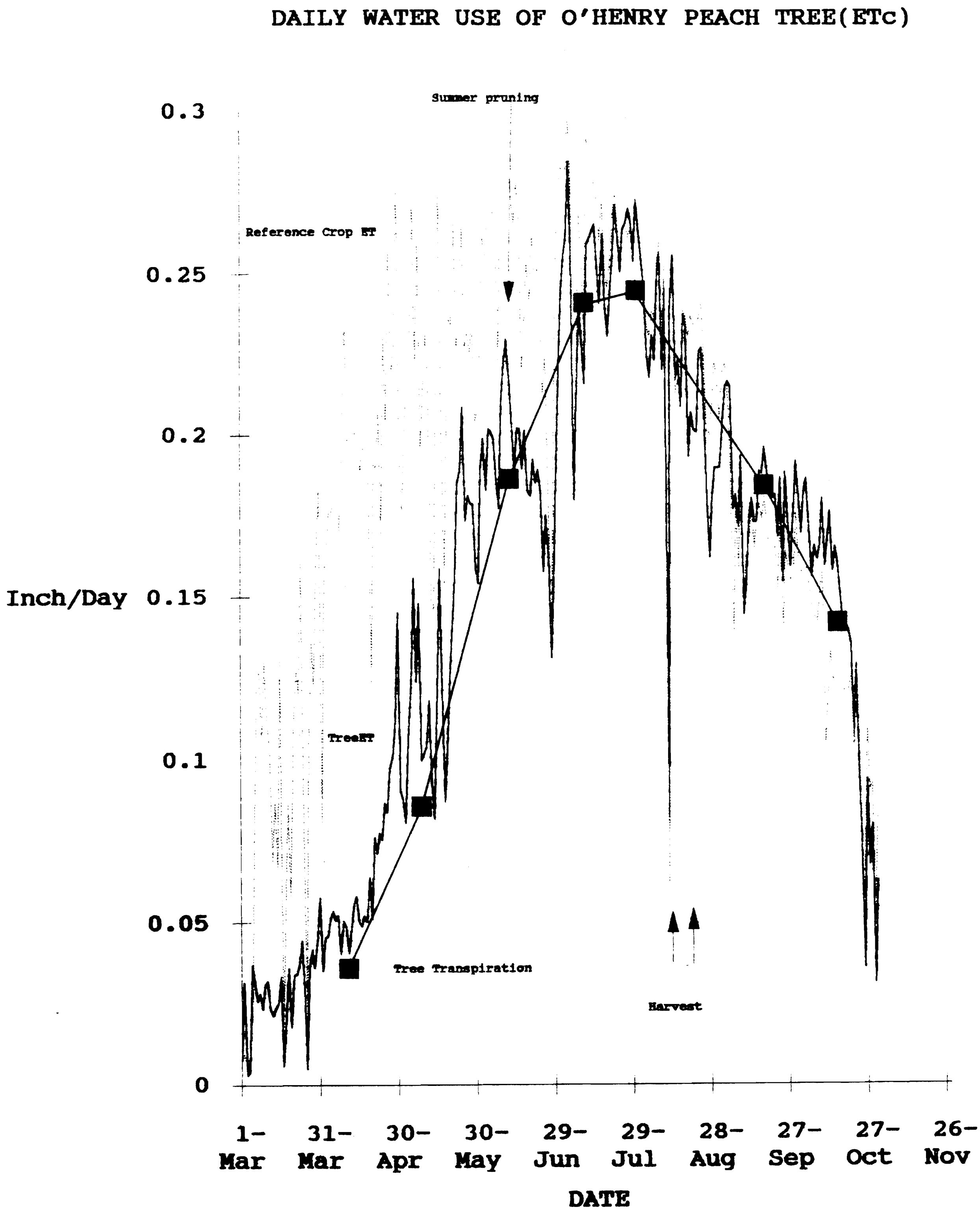


Fig. 3. Daily water use (Tree ET) of 4-year-old O'Henry peach trees as measured by a weighing lysimeter. Reference crop ET values were derived from a nearby weather station. Tree transpiration values were obtained from the lysimeter by covering the soil surface to prevent soil evaporation for at least 24 hours.

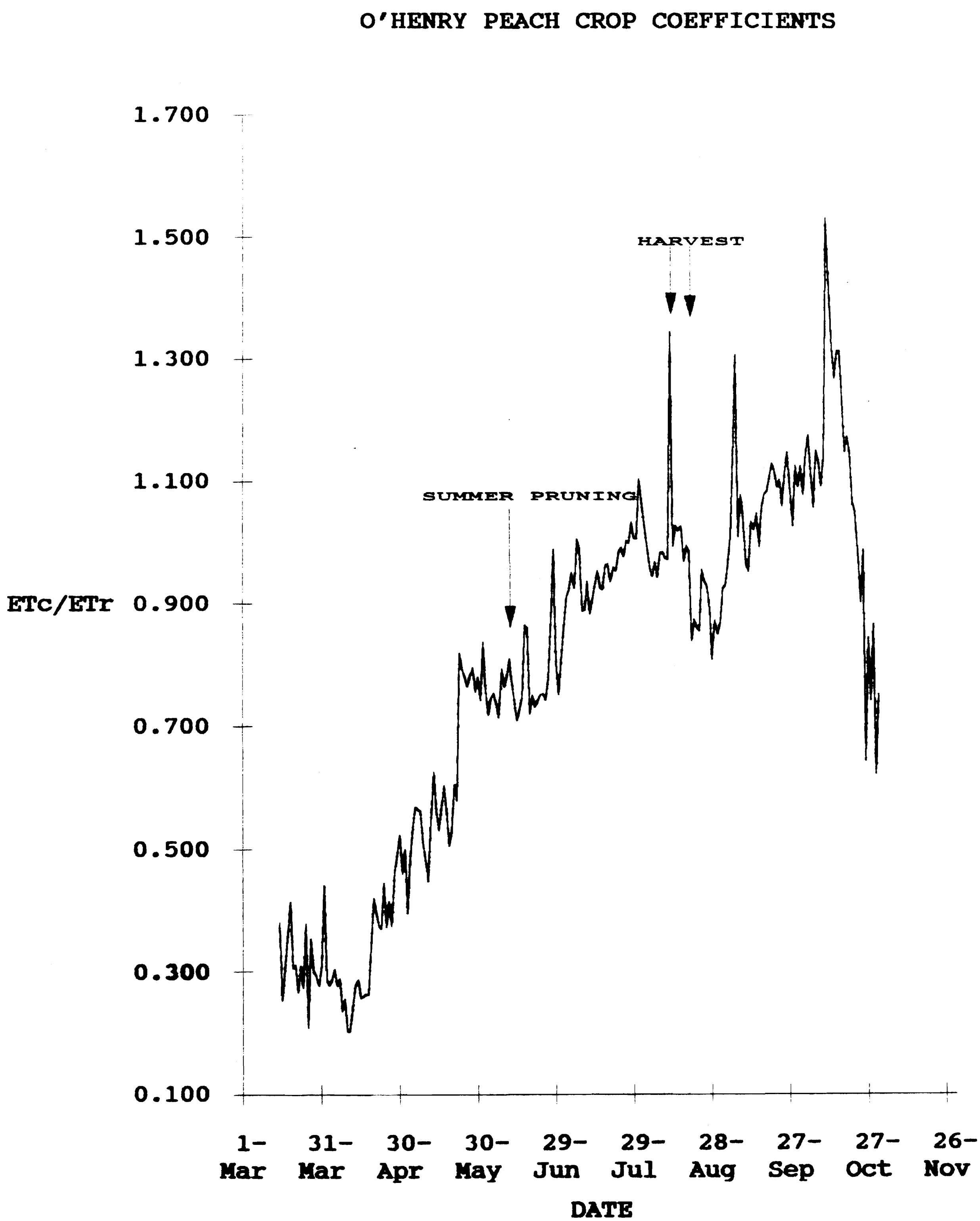


Fig. 4. Crop coefficients of 4-yr-old O'Henry peach trees as measured by a weighing lysimeter.

Table 3. Lysimeter water use of 4-year-old O'Henry peach trees, 1991.

Month	Water Use		Crop coefficient
	acre-inches	acre-inches/day	(K_C)
March	.87	.03	.31
April	1.90	.06	.33
May	4.11	.13	.61
June	5.67	.19	.77
July	7.66	.25	.94
August	6.65	.21	.95
Sept.	5.46	.18	1.05
Oct.	4.15	.13	1.10
Total	36.47		

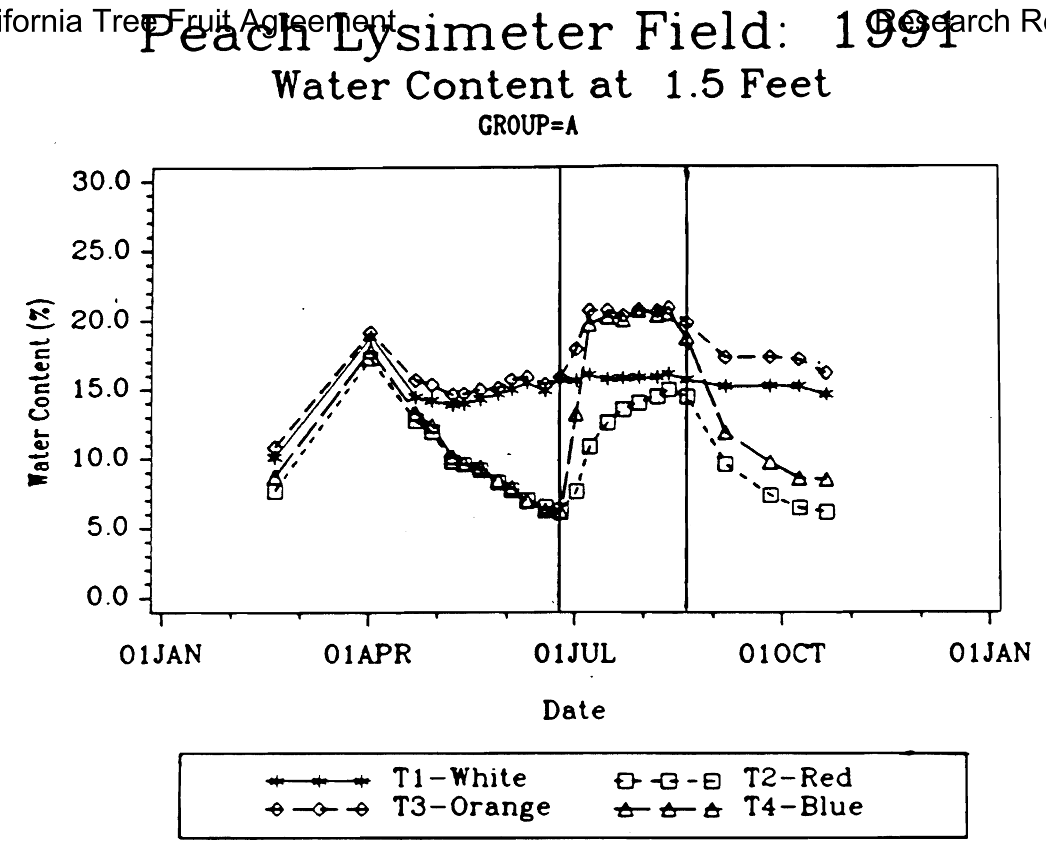
Water Management of O'Henry Peach Trees

The 3 acres surrounding the lysimeter were planted in 1988 with 1200 O'Henry peach trees spaced 6 ft. apart in 16 ft. rows. The trees were trained to a perpendicular "V" shape. For the first 2 years, the whole field was irrigated uniformly with fanjets to achieve optimum growth. Beginning in 1990, eight irrigation treatments (Table 4) were imposed with six replications of each treatment. The purpose of these treatments was to apply different amounts of water during different phases of fruit growth and to test the effect of irrigation frequency.

Table 4. Irrigation treatments for O'Henry peach experiment.

Trtmt.	Percent of ET			Frequency of Irrigation (After X inches loss from lysimeter)
	(4/1-6/23)	(6/23-8/11)	(8/21-10/18)	
T1 Control	100	100	100	.21
T2	50	100	50	.21
T3	100	150	100	.21
T4	50	150	50	.21
T5	100	75	100	.21
T6	50	75	50	.21
T7	100	100	100	.63
T8	100	100	100	1.26

A vast amount of information was collected in 1990 and 1991 covering many aspects of soil water, plant water relations, vegetative growth and fruit growth. There is insufficient space to present all the information here so only a few points will be emphasized. First, as in 1990, the 3 treatments involving frequency of irrigation showed no differences in any aspect of vegetative growth, fruit growth, or yield (Table 5). All 3 received about the same total amount of water but at intervals of approximately daily (T1), semi-weekly (T7) and weekly



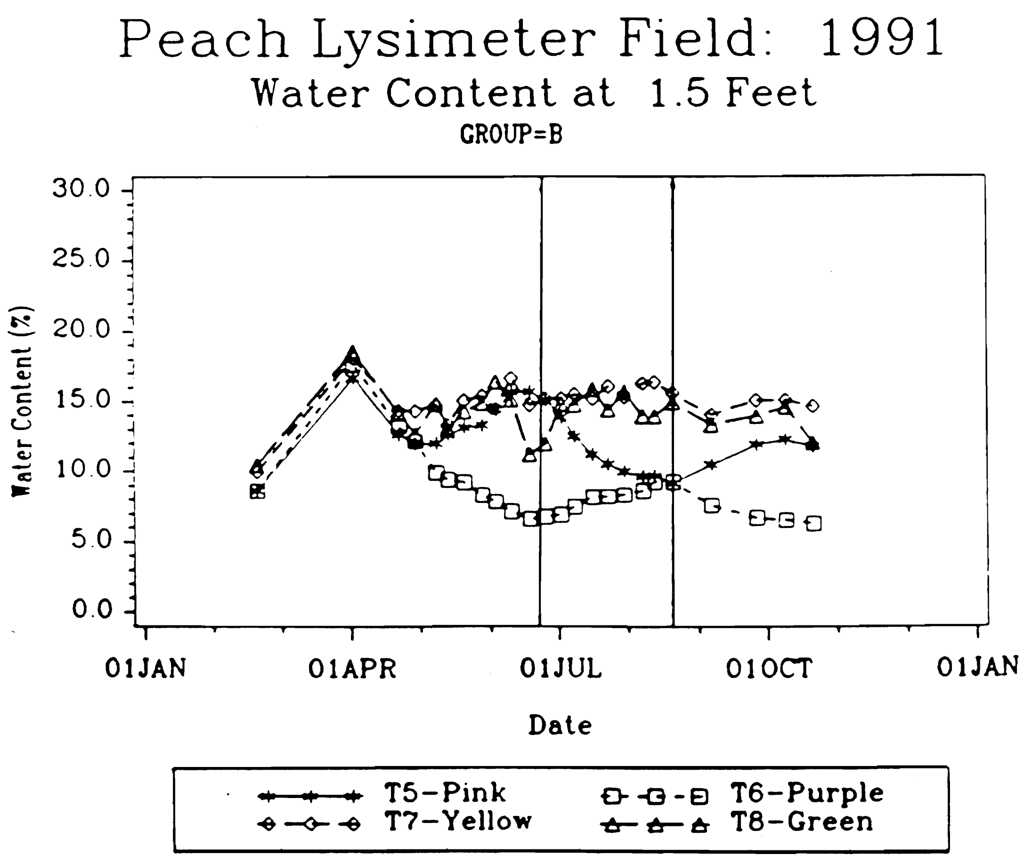


Fig. 5. Soil water content (% by volume) at a depth of 1.5 ft. under O'Henry peach irrigation treatments. Treatments T1-T4 are shown in top graph and T5-T8 in bottom graph. Vertical lines indicate dates when irrigation treatments changed. See Table 4 for description of treatments.

(T8) in mid summer.

The remainder of the treatments applied different amounts of water ranging from 25 to 52 inches of water and had significant effects on various vegetative and fruit parameters. First, the treatments were successful in achieving quite different soil water contents (Fig. 5). The control (T1) was kept very constant at about 15% water content. When 150% ET was applied (T3,T4), the soil water content rose to about 20%. When only 50% ET was applied (T2,T4,T6 before June 23), the soil water content dropped to about 5%.

Tree water status was monitored in various ways including predawn leaf water potential, midday leaf water potential, canopy temperature, and stomatal conductance. Each of these showed differences among treatments but never as great as was observed among soil water contents. One of the secondary objectives of this study is to evaluate various measures of tree water status in hopes of finding an instrument that will help determine optimum irrigation timing. So far, midday leaf water potential of bagged leaves using a pressure bomb seems to be the best indicator of tree water status.

Vegetative growth responded well to the irrigation treatments, especially pruning weights above 10 feet where there was nearly a 3X difference between T3 and T6 (Table 5). Excessive vegetative growth in the top of the tree is largely detrimental since it shades out shoot growth lower in the tree. This was apparently the situation with the treatment which received the most water, T3. It had the highest pruning weight above 10 feet but the lowest below. Only the two treatments that received the least amounts of water (T2, T6) had significantly less shoot dieback in the bottom part of the tree. It will take several more years to fully evaluate the effect of these irrigation treatments on shoot survival and productivity in the bottom part of the tree.

Fruit growth did not respond as dramatically as vegetative growth to the different irrigation treatments. There were some significant differences but they were quite small. In fact, all 8 treatments produced heavy yields of at least 20 tons/acre with very large fruit sizes peaking between size 48 and 30. There were no statistical differences in total yield per tree but this was partly due to the variability associated with different fruit loads per tree. When all treatments were adjusted to the same fruit load, small but significant differences in fruit weight became apparent (Table 5). Treatments T3 and T4 produced the largest fruit but they were not significantly greater than the control (T1). When comparing T3 and T4, T4 is obviously a better irrigation strategy since it produces the same fruit size with considerably less water and somewhat less top growth.

When deciding upon the best irrigation strategy both short term and long term effects should be considered. In the short term, treatments which apply lots of water such as T3 appear to give the best results. However, the excessive top growth and resulting shoot dieback may eventually reduce yields and fruit size. In the long term, the best treatments may be those which apply moderate stress during certain periods such as T3 or even T2 and T6. Although fruit size is slightly reduced, fruit quality is often improved and top growth is cut back considerably. These long term effects will be the main emphasis of this study over the next few years.

Table 5. Applied water, vegetative growth and fruit quality parameters of O'Henry peaches under 8 different irrigation treatments. See Table 4 for description of treatments.

Treatment	Actual Amount of Water Applied in 1991 (inches)	Pruning Weights (Kg/tree)		Shoot Dieback Around Scaffolds in Lower 6' of Tree (% of Total Shoots	Weight/Fruit (g) Adjusted to Equal Fruit Loads	% Soluble Solids
		Above 10'	Below 10'			
T1	44.8	5.4 ab	2.8 ab	47 a	272.8 ab	9.9 c
T2	29.8	2.7 c	2.7 ab	27 b	263.9 cd	10.1 bc
T3	51.7	6.3 a	2.3 b	45 a	280.0 a	9.7 c
T4	38.8	5.2 ab	2.6 ab	46 a	279.8 a	10.0 bc
T5	38.9	4.4 b	2.9 a	42 a	267.9 bc	10.8 ab
T6	25.4	2.2 c	2.3 b	26 b	258.5 d	11.2 a
T7	43.5	5.5 a	2.4 ab	41 a	277.6 a	10.4 abc
T8	41.9	5.7 a	3.0 a	45 a	272.9 ab	10.5 abc