CTFA Annual Report - 1994

Project Title: Water Use and Water Management of Mid to Late Season Stone Fruit

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Objectives:

1. Determine the water requirements of mature peach trees using a weighing lysimeter.

2. 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.

3. To evaluate the rooting density and depth induced by these irrigation strategies after 5 years of treatment.

Abstract:

The water use (ET) of mature O'Henry peach trees as measured by the weighing lysimeter ranged from 36 to 46 inches over the past 4 years even though ETo only ranged from 46 to 49 inches. There were also quite large variations in daily water use within each season. We are currently analyzing the data to see if certain weather conditions can explain the differences among the 4 years or the peaks and valleys within a year.

Five years of data have now been collected on 8 irrigation management strategies. The following general conclusions can be drawn from this experiment. First, irrigating daily compared to weekly made no difference in terms of yield, fruit size, and vegetative growth as long as 100% ET was applied on this deep, fine sandy loam soil. Second, stress treatments which received less than 100% ET always reduced both vegetative and fruit growth. However, in this high density configuration the reduced vegetative growth has been advantageous for long term productivity. With increased flowering and less shading out of lower fruiting wood the stress treatments have had the highest yields for the last 2 years. They have also produced fruit with consistently higher soluble solids content. Third, the practice of applying extra water (150% ET) before harvest improved fruit size for a year or two but had long-term detrimental effects on tree vigor, yield, fruit quality and tree health. On the other hand, applying extra water before harvest after a period of stress (50% ET) consistently produced high yields. In the past 3 years this treatment has had the largest fruit size of all 8 treatments.

Despite extensive root sampling, no differences in root density or rooting depth were measured in these irrigation management treatments.

Water Use of Mature O'Henry Peach Trees

Tree water use by these mature O'Henry peach trees was about 39 inches in 1994 which is close to the average of the last 4 years (Table 1). The range from 36 inches in 1991 to nearly 46 inches in 1993 indicates a lot of variability. At this time the main source of this variability is unclear. Increasing water use from 1991 through 1993 suggested tree age or canopy volume may have been involved. However, measurements of tree dimensions and canopy light interception showed little difference among the 4 years. Furthermore, the decrease in 1994 suggests something other than tree age caused the differences.

Weather changes from year to year would be another logical explanation for the differences in water use. However it is not clear which weather parameters are most important. The equation for reference crop ET which is supposed to integrate all the weather factors important to evapotranspiration from crops, does not account for the differences very well. For instance, reference crop ET for 1991 and 1993 was almost identical while peach tree water use showed nearly 10 inches difference between these two years. The reference crop equation was developed for grass and may work well for a low continuous canopy. However, trees have a taller and more discontinuous canopy and probably respond to weather conditions differently. Therefore, it is very possible that a new equation for peach trees will need to be developed which integrates the various weather parameters in an appropriate way for tree canopies. When evaluating tree water use within a single season, there are also some substantial changes within short periods of time (Fig. 1). Again, these are probably related to weather changes but they do not correlate to variations in reference crop ET. Over the next year we will be working with this data set to see if we can develop equations to better explain both day-to-day and year-to-year variations in peach tree water use.

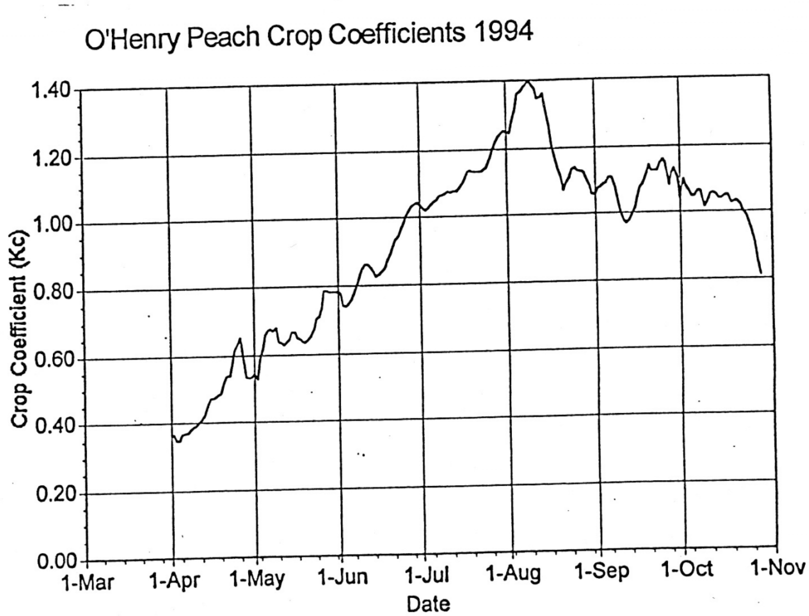

Figure 1. Crop coefficients of 7-year-old- O'Henry peach trees as measured by the weighing lysimeter.

The average tree water use for 1991 through 1994 generates a fairly smooth curve which is probably close to the long term average for peach trees (Fig. 2). This curve looks very different than the published crop coefficient curve for deciduous trees.

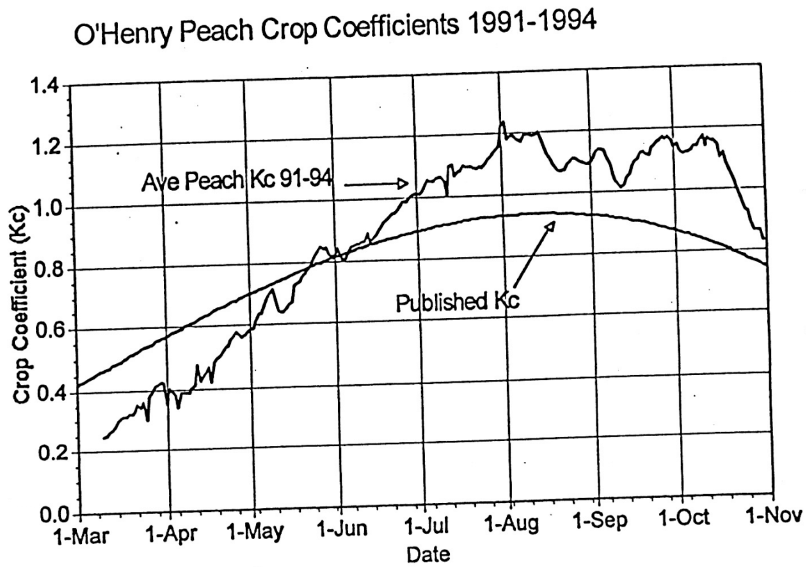

Figure 2. Crop coefficients of mature O'Henry peach trees as measured by the weighing lysimeter. Data is the average of 4 years from 1991 to 1994. Published values are for clean cultivated deciduous orchards.

Table 1. Lysimeter water use of mature O'Henry peach trees, 1991-1994.

	Water Use (acre-inches)				Crop coefficient (K_c)			
Month	1991	1992	1993	1994	1991	1992	1993	1994
March	.87	1.02	.93	.97	.31	.29	.36	.30
April	1.90	2.90	2.73	2.28	.33	.50	.59	.46
May	4.11	5.80	5.46	4.20	.61	.79	.87	.66
June	5.67	6.82	8.15	7.31	.77	.91	1.06	.87
July	7.66	7.94	9.79	9.01	.94	1.03	1.21	1.18
August	6.65	7.78	9.01	7.69	.95	1.09	1.27	1.23
Sept.	5.46	5.82	5.96	5.03	1.05	1.16	1.13	1.09
Oct.	4.15	3.68	3.65	2.73	1.10	1.15	1.06	1.07
Total	36.47	41.76	45.68	39.22				

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 2) 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 2. Irrigation treatments for O'Henry peach experiment.

Treatment	Percent of ET			Irrigation Water Applied (inches)			
	4/20-6/20	6/20-8/19	8/19-10/19	1991	1992	1993	1994
T1 Daily ET (control)	100	100	100	44.8	46.1	39.3	34.9
T2 Moderate Stress	50	100	50	29.8	29.2	27.1	23.8
T3 Extra Water	100	150	100	51.7	54.0	48.0	42.6
T4 Managed Stress	50	150	50	38.8	36.3	35.0	31.6
T5 Low Stress	100	75	100	38.9	42.6	34.8	29.8
T6 High Stress	50	75	50	25.4	25.5	21.3	19.6
T7 Semi-weekly ET	100	100	100	43.5	46.8	39.6	33.7
T8 Weekly ET	100	100	100	41.9	45.2	38.2	34.4

A great deal of scientific information has been collected over the past 5 years including soil water content, plant water relations, vegetative growth, fruit growth, yield, fruit size and fruit quality. Rather than presenting lots of graphs and figures, the most important parameters have been summarized in Tables 3 & 4. Also, a brief narrative summary of each treatment will be presented.

T1 - Daily ET (Control)

Treatment T1 is considered the control for this experiment. It is irrigated every time the lysimeter loses .21 inches of water which is about daily during the summer. In 1994 only 34.9 inches were applied to this treatment which is considerably less than previous years (Table 2). The trees grew vigorously in 1994 and carried a crop load of 14.7 tons per acre. This is about half of previous yields which was a result of heavy pruning.

Other Full ET Treatments (T7 and T8)

Treatments T7 and T8 received the same amount of applied water as the control but at different frequencies. T7 irrigated every third and T8 every sixth irrigation of T1. Therefore, they have been designated the semi-weekly and weekly ET treatments, respectively. Over the 5 years of the experiment, these two treatments have not differed from the control in any of the parameters measured. They have both had very vigorous vegetative growth which has been slightly but not significantly greater than the control (Table 3). Yields, fruit size, and fruit quality have all been virtually identical. The conclusion that can be drawn after 4 years of research is that low volume irrigation systems have a fair amount of flexibility in terms of how frequently they need to be run as long as 100% ET is applied.

Stress Treatments (T2, T5 and T6)

Stress invariably reduces both vegetative and fruit growth. However, this may be advantageous under certain conditions. In addition, stress may induce some beneficial effects such as improved fruit quality. The stress treatments in this experiment (T2, T5 and T6) have demonstrated these points, especially the most stressed treatment (T6) which has only received about 2 acre feet of irrigation water each year (Table 2).

Over the past 5 years the stress treatments, especially T2 and T6, have looked progressively better and better in this high density configuration. Because of reduced vegetative growth, lower fruiting wood has been well preserved thus maintaining even distribution of fruit along the scaffolds. This is part of the explanation for higher initial fruit loads (Table 4) which has resulted in higher yields the last 2 years (Table 3). In 1994, treatment T2 had the highest yields in the block and still had excellent fruit size. Fruit soluble solids content has also consistently been highest in the stress treatments (Table 4). In 1994, treatment T6 had an average level of 13.2% which is substantially higher than many of the other treatments and is noticeable in fruit taste.

Table 4. Fruiting and fruit quality parameters of O'Henry peaches under 8 different irrigation treatments in 1993 & 1994. See Table 2 for description of treatments. Letters in columns indicate statistical separation of treatments.

Treatment	Initial fruit load (#/tree) 1993	Initial fruit load (#/tree) 1994	Soluble Solids content (%) 1993	Soluble Solids content (%) 1994
T1	654 c	212 bc	10.2 bc	11.7 bc
T2	759 b	299 b	10.4 bc	12.4 ab
T3	532 d	186 c	10.0 c	11.0 c
T4	649 c	249 bc	10.2 bc	11.1 c
T5	640 c	254 bc	10.6 ab	12.5 ab
T6	858 a	409 a	11.0 a	13.2 a
T7	583 cd	221 bc	10.3 bc	12.1 b
T8	552 d	186 c	10.2 bc	11.7 bc

Treatments Applying Extra Water Before Harvest (T3 and T4)

Treatment T3 received 43-54 inches of irrigation water, more than any of the other treatments and 7 to 9 inches more than the control (Table 2). This extra water seemed to stimulate a little more fruit growth in 1990 and 1991 but since then the effects have all been negative. Yield was significantly reduced in 1992, 1993, and 1994 (Table 3) and fruit size has often been somewhat smaller. Vegetative growth has steadily declined over the 4 year period suggesting loss of vigor. This treatment had the lowest initial fruit load in 1993 and 1994 (Table 4). A few individual trees (~10%) have exhibited poor budbreak in the spring, lack of vegetative vigor and leaf chlorosis which is often an indication of root problems. So far, we have been unable to isolate phytophthora from these trees, so we still don't know if their condition is due to disease, waterlogging, nutrition, or some other problem. The fruit from treatment T3 has also tested lowest in soluble solids content in both 1993 and 1994 (Table 4). Therefore, our conclusion from this study is that extra water before harvest may improve fruit size for a year or two but will have long-term detrimental effects on tree vigor, yield, fruit quality, and tree health.

Treatment T4, on the other land, has yielded some very positive results. It also receives extra water before harvest (same as T3) but only receives 50% of the control before and after this period. This has resulted in water savings of 3 to 10 inches compared to the control and 11 to 18 inches compared to T3 (Table 2). This treatment has consistently had yields and fruit size greater than or equal to the control and has performed considerably better than treatment T3 (Table 3). In the past three years, treatment T4 has had the largest fruit size of all 8 treatments. Therefore, we conclude that imposed water stress early and late in the season will not hurt (and may actually help) productivity as long as it can be alleviated during the period of final fruit swell.

In this last year of the experiment we dug trenches alongside the trees to take extensive root samples. We hypothesized that five years of irrigation treatments should have caused some differences in rooting depth and rooting density. In particular, we theorized that treatment T4 which imposed moderate water stress early and late in the season should have induced more extensive and deeper rooting. After spending considerable time and effort over a 3 month period, we were unable to measure statistical differences among 4 of the treatments (Table 5). Unfortunately, the variability from one site to another was too great to show differences.

Table 5. Root densities (g/ft^2) of 7-year-old O'Henry peaches under different irrigation treatments for 5 years. See Table 2 for description of treatments.

	Soil Depth (feet)					
Treatment	1	2	3	4	5	6
T1	69.8	35.1	9.3	5.6	2.8	1.3
T3	87.4	35.0	16.2	6.0	2.9	1.8
T4	83.7	41.8	16.0	11.0	4.3	1.8
T6	116.5	38.5	16.0	7.2	7.0	1.4

Table 3. Vegetative growth, yield and fruit size of O'Henry peaches over 5 years under 8 different irrigation treatments. See Table 2 for description of treatments. Letters in columns indicate statistical separation of treatments.

Treatment	Trunk Cross-Sectional Area (cm^2)	Yield (tons/acre)					Weight/Fruit (g) Adjusted to Equal Fruit Loads				
	1994	1990	1991	1992	1993	1994	1990	1991	1992	1993	1994
T1	106.3 abc	13.3 a	22.7 a	29.0 bc	27.3 abc	14.7 bc	211.8 bc	272.8 ab	195.7 abc	211.3 ab	213.5 bcd
T2	83.9 d	13.8 a	22.4 a	28.8 bc	29.0 ab	17.7 a	205.4 c	263.9 cd	187.4 c	208.5 b	225.8 ab
T3	110.1 a	15.2 a	24.5 a	25.6 d	24.1 d	13.1 c	223.1 a	280.0 a	187.6 c	207.3 b	218.5 abc
T4	98.3 c	15.2 a	26.0 a	31.2 a	29.0 ab	16.6 ab	219.4 ab	279.8 a	203.5 a	218.9 a	229.7 a
T5	99.6 bc	14.6 a	23.5 a	30.3 ab	26.7 bcd	14.7 ab	205.6 c	267.9 bc	195.7 abc	206.9 b	207.5 cd
T6	77.0 d	13.3 a	23.2 a	26.1 d	30.3 a	16.4 ab	193.5 d	258.5 d	168.2 d	207.6 b	200.8 d
T7	107.7 ab	13.5 a	24.2 a	29.4 abc	26.5 bcd	13.6 c	214.8 abc	277.6 a	197.2 ab	209.5 b	209.5 cd
T8	107.3 ab	14.4 a	22.1 a	28.1 c	25.7 cd	15.0 bc	214.9 abc	272.9 ab	193.4 bc	212.0 ab	220.3 abc