Developing a Method for Saving Substantial Amounts of Irrigation Water After Harvest in Early Maturing Peach Orchard

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Introduction

In arid regions where peaches and nectarines are grown, water for irrigation can often be a major limiting factor. Many strategies for reducing applied water have been attempted. One approach is to cut back substantially on irrigation after harvest of early ripening cultivars. In the past we have conducted numerous studies in this area of imposing water stress after harvest on May and June ripening peach and nectarine varieties. We have shown that yields can be maintained and significant water savings achieved under such a strategy. The main drawback is an increase in defective fruit the season following the imposed stress. Both double and deep-sutured fruit have been documented. However, the timing of water stress during the postharvest period may have an effect on the formation of these defective fruit. If stress is relieved late in the summer the defects can often be minimized. There is some uncertainty as to the best timing for this approach. We hypothesized that the most detrimental time for imposing stress is during the differentiation of flower parts in the developing bud, particularly the carpel, which happens in late August or early September in California. Thus, irrigation strategies designed to impose water stress during June and July, but relieve it during August and September, should give the best results in terms of fruit quality. Therefore, we initiated an experiment to test this hypothesis on a late May harvested peach cultivar, 'Crimson Lady'. Seven different treatments were imposed that withheld varying amounts of irrigation water during the June-July or the August-September period. The experiment was carried out during 2004 and 2005 with yield and fruit quality measurements taken in the spring of 2005 and 2006.

Materials and Methods

The experiment was conducted in an orchard of Crimson Lady peach trees surrounding the lysimeter. The lysimeter was built in 1986 and has been used to measure tree water use and to control irrigation of the surrounding trees. The field was planted with 1200 Crimson Lady peach trees in 1999 and grown uniformly for 4 years. The trees were planted 6 ft apart in 16 ft rows and trained to a perpendicular "V". Each tree has an individual fanjet emitter with an output of about 6 gals/hr. Seven irrigation regimes were imposed after harvest in late May, 2004 and 2005 (Table 1). In addition, all the trees in the block were mechanically topped to 11' in early June of both years. Similar treatments were imposed in 2003, but without the mechanical topping. Evaluation of the treatments was made by measuring canopy light interception, soil water content, midday stem water potential, leaf nutrient content in July, dormant pruning weights and final tree heights. Notes were also made of defoliation, mite damage, shoot dieback and gumming. In 2005, fruit were harvested in two picks on May 23 and 27. For each harvest, all defective fruit (doubles, deep sutures and external split pits) were counted and removed. The remaining good fruit were counted and weighed. For the last pick, fruit not passing through an 84 sizing ring were also removed and categorized as undersize (no undersized fruit were harvested in the first pick). In 2006, fruit were harvested on June 5 and June 9 and run through a fruit sorting machine which separated them into 10 size categories. The smallest two sizes were equivalent to undersize fruit in 2005. From the other 8 sizes, 200 fruit samples per plot were collected for evaluation of defective fruit. Besides the 3 defects measured in 2005, fruit with dimples were also scored. In addition, 50 fruit showing no external defects were cut open to determine internal split pits. Statistical differences among treatments were evaluated using Duncan's Multiple Range Test at P=0.05.

Results and Discussion

The different irrigation treatments caused severe stress in these 'Crimson Lady' peach trees after harvest. The most severe treatment (Trt 7) received no irrigation during June and July and its stem water potential (SWP) dropped steadily to a level of -2.4 MPa in 2004 (Fig. 1). With irrigation water supplied for a week in early August, its SWP nearly recovered to the level of the fully irrigated control, but then dropped steadily again once water was cutoff for the second time. The other treatments all showed patterns of SWP that reflected the amount of water they were receiving during different periods after harvest (Fig. 1). Patterns in 2005 (data not shown) were very similar to 2004.

Double fruit have been reported to increase due to water stress late in the previous summer. In this experiment, doubles were greater in the stress treatments, but were relatively low throughout the block compared to levels reported for other experiments. Even the most severe water stress treatment (Trt 7) only induced 15% of the fruit to have this defect in 2005 and about 6% in 2006 (Table 2). During normal hand thinning operations, most of these doubles were easily detected and removed, leaving only about 2% defective fruit at harvest in both years. For many of the treatments, the percent double fruit were thinned down to the level of the control. Thus, the problem of double fruits would not be considered serious for this 'Crimson Lady' cultivar.

On the other hand, deep sutures can be a much more serious problem. In 2005, this defect was very prevalent throughout the orchard and was significantly increased by those treatments that imposed stress late in the season (Table 2). In 2006, less of this disorder occurred, but was still highest in the treatments showing extreme stress at the end of the season (Trts 5 and 7). Even extreme stress in June and July did not cause an increase in this defect as long as the stress was relieved during August and September (Trt 3).

External split pits have not been reported to increase with water stress. In this experiment, only one treatment (Trt 3) in one of the two years caused a significant increase in this disorder (Table 2). Internal split pits were measured in 2006 to see if there was a relationship between external and internal splits. However there were no statistical differences that year. Thus, many questions remain and more research is needed to determine if this is a consistent result of water stress or whether some other factors are also involved.

Dimples in the fruit were not measured in 2005 but general observations suggest they were not present that year. In 2006, this disorder was significantly increased in the most severely stressed treatment (Trt 7). It is uncertain what caused the defect but it might have been an indirect effect of the water stress. The damage looks similar to that caused by the sting of a plant bug. Perhaps plant bugs were more attracted to the stressed trees for some reason. Also, there was a mild freeze (-2.0^{0}C) that occurred during early bloom and damaged some flowers. Although detailed measurements were not taken, it was clear that treatment 7 was slightly more advanced in bloom than the control and thus may have been more susceptible to the frost damage. As with split pits, more research is needed in order to show the relationship between water stress and this fruit disorder.

In 2005 fruit set was high and all treatments were thinned to about the same fruit load per tree (Table 3). The only difference in marketable yield was due to fruit defects, particularly deep sutures. Thus, treatments 4, 5, 6 and 7 all had significantly reduced yields of good fruit. Treatment 3 had no reduction in yield and even had a slight increase in fruit size compared to the control. In 2006, fruit set was abnormally low and was affected by the different stress treatments. Treatment 7 had the lowest percent set and treatment 3 the highest (Table 3). This led to marketable yields showing the same pattern: treatment 7 had significantly lower yield and treatment 3 significantly higher yield than the control. It is uncertain why set was affected so drastically in 2006 and whether the differences among treatments would continue in future years. Again, the bloom time frost may have had an effect in that year.

Based on all the above results, is one of these postharvest stress treatments better than the others? Generally, treatment 3 performed the best. This treatment was completely deprived of water during the very hot months of June and July which caused extreme stress in the trees (Fig. 1). The trees were then irrigated with 100% ET and SWP recovered to control levels. Except for an increase in external split pits and a slight increase in doubles in 2005, it had no increase in fruit defects and no decrease in marketable yield. It even showed an increase in fruit size one year and an increase in yield the next. However, there are a number of problems with this treatment that need to be taken into consideration. Because the trees were stressed severely right after topping, sunburn damage to the scaffolds was increased (Table 4). Also, mite damage tended to be high in this treatment, especially in 2004. These types of problems could lead to long- term damage to the trees.

In conclusion, all the postharvest water stress treatments in this 'Crimson Lady' peach orchard caused some type of problem with either fruit quality or tree health. If water is not limited, none of the treatments would be recommended as a standard practice. However, under water limiting conditions, the results of this experiment suggest the best strategy to be one of withholding water during the June-July period and then fully irrigating during August and September.

Table 1. Irrigation treatments imposed on Crimson Lady peach trees in 2004. All treatments received 100% ET through harvest in late May and during non-stress periods. Each treatment was replicated 6 times.

Treatment		
Number	Name	Description
1	Control	Fully irrigated with 100% ET
2	Early Slow Stress	Irrigation at 25% ET in June & July
3	Early Fast Stress	Irrigation cut off in June & July
4	Late Slow Stress	Irrigation at 25% ET in August & September
5	Late Fast Stress	Irrigation cut off in August & September
6	Continual Slow Stress	Irrigation at 50% ET from June to September
7	Continual Fast Stress	No irrigation after harvest except 1 week in early August

Table 2. Fruit defects on 'Crimson Lady' peach trees subjected to different postharvest water stress treatments in 2004 and 2005. Total defects do not include internal split pits as they are still marketable fruit. See Table 1 for treatment details.

Treatments	Double Fruit		Deep Suture	External Split Pits	Internal Split Pits	Dimples	Total Defects
	% at thinning	% at harvest	% at harvest	% at harvest	% at harvest	% at harvest	% at harvest
2005							
1	0.1 d[z]	0.1 d	14.2 d	6.8 b	-	-	19.2 d
2	11.0 ab	1.2 bc	19.9 cd	7.5 b	-	-	28.6 bc
3	14.2 a	1.5 b	12.6 d	11.3 a	-	-	25.3 cd
4	1.1 cd	0.4 cd	28.7 ab	6.1 b	-	-	35.2 ab
5	1.7 cd	0.6 bcd	34.6 a	4.7 b	-	-	39.9 a
6	6.9 bc	1.1 bc	25.1 bc	7.4 b	-	-	33.5 ab
7	15.0 a	2.4 a	28.8 ab	6.9 b	-	-	38.1 a
2006							
1	0.3 b	0.0 b	1.7 c	1.1 a	4.4 a	0.8 b	3.6 c
2	0.3 b	0.1 b	5.8 bc	0.8 a	4.0 a	0.4 b	7.1 c
3	0.6 b	0.0 b	2.8 c	1.3 a	8.0 a	0.4 b	4.5 c
4	1.3 b	0.5 b	5.7 bc	1.3 a	8.3 a	1.3 b	8.7 bc
5	5.0 a	0.3 b	9.5 b	2.3 a	10.3 a	2.6 ab	14.7 b
6	0.0 b	0.3 b	3.3 c	0.7 a	4.3 a	1.4 b	5.8 c
7	6.3 a	1.8 a	16.3 a	1.8 a	7.0 a	4.8 a	24.8 a

[z]Values within columns for each year that are followed by the same letter are not significantly different at P = 0.05 by Duncan's Multiple Range Test.

Table 3. Components of yield for 'Crimson Lady' peach trees subjected to different postharvest water stress treatments in 2004 and 2005. See Table 1 for treatment details.

Treatment	Fruit Set (%)	Fruit Load (#/tree)	Marketable Fruit (% of total)	Marketable Fruit (kg/tree)	Fruit Weight (g/fruit)	Undersize Fruit (% of total)
2005						
1	91.8 a[z]	134 a	66.0 a	12.6 a	137 bc	12.9 bc
2	88.5 a	139 a	56.4 bc	11.1 ab	139 ab	15.0 ab
3	92.2 a	126 a	64.1 ab	11.6 ab	144 a	10.6 c
4	83.1 a	117 a	49.7 cde	7.8 cd	136 bc	15.1 ab
5	81.1 a	114 a	42.0 e	6.3 d	132 c	18.1 a
6	96.6 a	132 a	51.1 cd	9.3 bc	134 bc	15.3 ab
7	88.3 a	121 a	44.5 de	7.3 cd	135 bc	17.4 a
2006						
1	37.1 bc	120 bcd	80.8 a	13.6 bc	139 a	15.6 a
2	47.3 ab	142 ab	74.9 ab	15.0 ab	140 a	18.1 a
3	52.3 a	162 a	79.9 a	18.0 a	141 a	15.6 a
4	36.8 ab	121 bcd	75.6 ab	12.6 bc	139 a	15.7 a
5	42.7 ab	109 cd	69.8 b	10.8 cd	140 a	15.5 a
6	41.6 ab	133 abc	79.4 a	14.8 ab	140 a	14.8 a
7	26.9 c	102 d	54.3 c	7.5 d	139 a	20.9 a

[z]Values within columns for each year that are followed by the same letter are not significantly different at P = 0.05 by Duncan's Multiple Range Test.

Table 4. Other stress related parameters in 'Crimson Lady' peach trees subjected to different postharvest water stress treatments in 2004 and 2005. See Table 1 for treatment details.

Treatment	Pruning Weight (kg/tree)		Tree Height (m)	Mite Damage Rating[y]		Sunburn Damage[x]
	12/2004	12/2005	12/2005	8/2004	8/2005	3/2006
1	3.0 a[z]	2.6 a	4.2 a	1.7 c	0.9 d	0.4 b
2	1.4 d	2.0 bc	3.8 c	2.1 bc	1.3 cd	1.7 a
3	1.0 de	1.7 cd	3.6 cde	2.5 ab	1.8 cd	2.5 a
4	1.9 c	1.9 bc	4.0 b	2.0 bc	1.8 cd	0.7 b
5	1.8 c	2.0 b	4.1 ab	2.3 abc	2.2 abc	0.7 b
6	1.3 d	1.8 bcd	3.8 cd	2.2 bc	2.0 bc	0.8 b
7	0.8 e	1.3 d	3.5 e	3.0 a	3.0 a	2.3 a

[z] Values within columns that are followed by the same letter are not significantly different at P = 0.05 by Duncan's Multiple Range Test.
[y] Mite damage rated on a 1 to 5 scale with 1 =minor leaf stippling and 5 = major webbing with some defoliation.
[x] Sunburn damage determined by counting the number of damaged areas of at least 10 cm in length on the scaffolds.

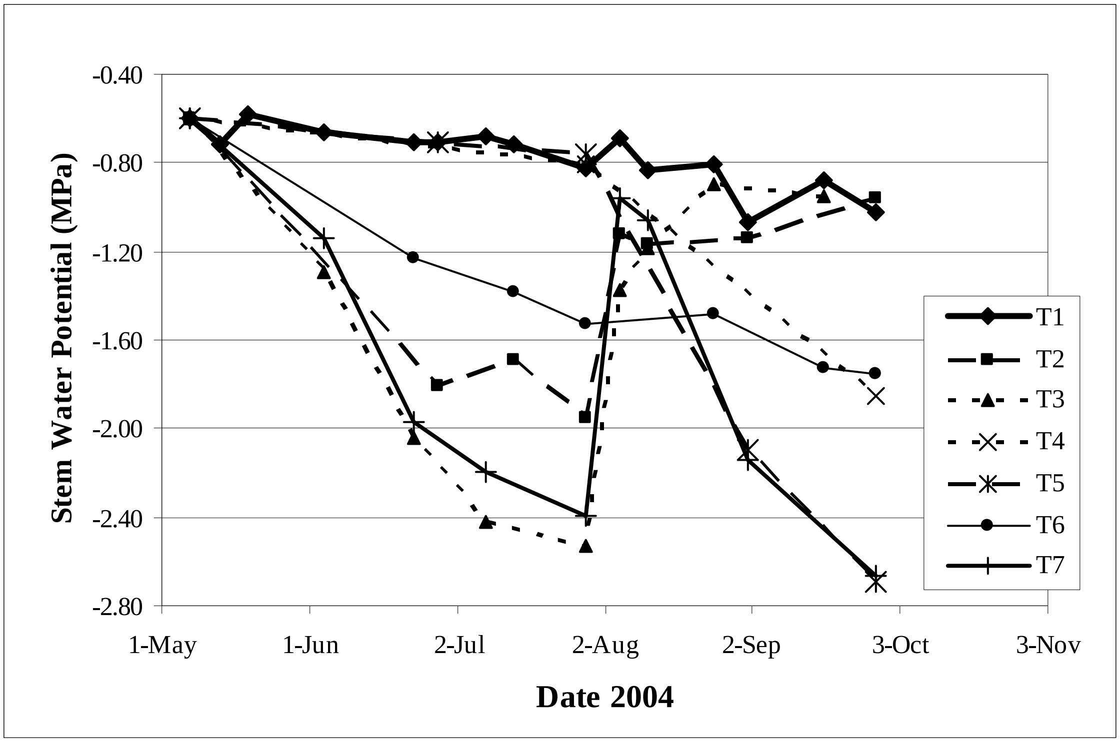

Fig. 1. Seasonal stem water potential (SWP) pattern of 'Crimson Lady' peach trees subjected to 7 irrigation treatments after harvest in 2004. See Table 1 for treatment details.