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Time of Avocado Pruning Affects Fruit Set and Avocado Thrips Occurrence in Southern California Groves

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Abstract

Pruning as a cultural practice has been increasingly used in Southern California avocado orchards. This practice promotes the production of flush growth, which is the preferred food source of avocado thrips (*Scirtothrips perseae* Nakahara). Currently, most pruning activities take place in January, February or March. To determine when pruning 'Hass' avocado least affects fruit set and minimizes avocado fruit relates monthly pruning times in 2002 to the presence of flushing leaves as a food source for avocado thrips, the numbers of immature avocado thrips, and to the 2002 and 2003 fruit set. Pruning between January and May promoted the prolonged presence of flush during fruit set and early fruit development through August and delayed the hardening of the leaves. With the grower's IPM program, which used 4 chemical treatments to suppress avocado thrips, the number of thrips was significantly higher on trees pruned in April than on un-pruned trees, while pruning in January, February or March 2002 did not affect avocado thrips numbers. Pruning in January did not affect fruit set, while pruning in February and March caused significant decreases in the 2002 and 2003 fruit set. These results indicate that in coastal California, pruning in January 2002 was a better option than pruning in February or March 2002. Further studies are suggested before pruning activities can be incorporated into an IPM system for avocado in California.

Introduction

Beginning in the mid 1990s, pruning as a cultural practice has been increasingly used in 'Hass' avocado (*Persea americana* Mill. cv. Hass) orchards in most of the world including Southern California. Reasons for pruning fruit trees include controlling tree size, increasing canopy light penetration, regulating crop production, and facilitating pest control activities (Lahav, 1999; Newett, 1999; Stassen *et al.,* 1999;Torien, 1999; Thorp & Stowell, 2001; Wolstenholme, 1999). Although the effects of tree pruning time on regional fruit production have been studied for several fruits including apple (Barden, 2002) and apricot (Sharma *et al.,* 1997), information on pruning time in avocado is scarce and not current (e.g. Farre *et a*l., 1987).

Since the introduction of avocado thrips *(Scirtothrips perseae* Nakahara) (Thysanoptera: Thripidae) in California in 1996, the species has developed into a serious pest (Hoddle *el al,* 2003). Although, *S. perseae* preferentially feed on flushing avocado leaves, feeding on small fruit during early development causes fruit surface scarring (Yee *et al.,*

2001 a). Most of the damage occurs during the period of fruit development directly after fruit set (Yee *et al.,* 2001 b). The hardening of flushing leaves during and shortly after fruit set is considered to be the underlying force that causes thrips to move to the fruit. In its native range in Mexico, avocado thrips are not causing economic scarring of fruit, which could be related to the presence of flushing leaves during fruit set and fruit development in those regions (Phillips, personal observation).

Selective chemical sprays are currently used in most commercial groves to suppress avocado thrips populations during fruit set (Yee *et al.,* 2001 bc, Oevering *et al.,* 2002). Alternative control methods for avocado thrips are being investigated and thus far not economically viable (Hoddle *et al.,* 2004). A growing number of avocado orchards are being pruned regularly to facilitate avocado thrips monitoring and pest control applications. Pruning activities vary from light trimming to stumping, and most often occur between January and March (Faber and Bender, 2003). Pruning stimulates growth and development of dormant buds in trees (Stassen *et al.*, 1999) which, in Southern California avocado groves, would increase the food source availability for *S*. *perseae* and could result in an increase in avocado thrips numbers.

The hypothesized correlation between avocado thrips numbers and pruning activities makes the timing of pruning activities very important in Southern California. Certain pruning times may increase the availability of flushing leaves during the critical early fruit development stage, which would reduce the number of thrips moving to fruit and thus possibly limit fruit feeding damage. Other pruning times may increase the amount of flushing leaves during the early season, which would support larger thrips numbers that would subsequently search for an alternative food source such as fruit when the flush hardens.

The objective of this study was to investigate correlations between pruning, occurrence of flushing leaves and avocado thrips numbers and ultimately aims to determine a time to prune 'Hass' avocado in Southern California that minimizes both the impact on fruit set and avocado thrips damage to fruit.

Materials and Methods

The grove used in the pruning trial 2002-2003

'Hass' trees grafted on 'Duke 7' rootstock growing in a three-year old commercial orchard in Santa Paula, Ventura County, California were used. Trees were planted in 1999 at 20 x 20 ft spacing on a sandy loam soil (pH = 7.2). The orchard was regularly irrigated to supplement the annual rainfall of 6 inches in 2002 and winter/spring rainfall of about 5 inches in early 2003. In June and September 2002, nitrogen fertilizer (CAN-17) was applied through the irrigation system at a rate of 36 gallons per acre per year.

Pest management

The manager of the commercial property made all pest management decisions and all trees were treated equally. To suppress avocado thrips numbers, spinosad (Success 6oz in 80 gal/acre with 1% NR415 oil) was applied on March 10, 2003, and abamectin (AgriMek 12oz in 80 gal/ acre with 0.25% NR415 oil) was applied on April 24, July 10,

2002 and on April 9, 2003. This intensive chemical pest control program may not be representative of control programs used by other growers, who often limit chemical applications to two per year.

For control of persea mite (*Oligonychus perseae* Tuttle, Baker & Abbatiello), 60,000 and 100,000 predatory mites *(Amblyseius* [= *Neoseiulus*] *californicus* McGregor) were released per acre on September 20 and December 5, 2002 respectively.

Pruning and subsequent observations

In a random design, 20 trees were assigned to each of 12 monthly pruning treatments and 20 were not pruned (260 trees in total; 13 trees in 20 rows). A different set of 20 trees was lightly pruned in the first week of each month in 2002, starting in January. Using a machete, branch tips were removed to reshape trees into a pyramid shape, with lower branches removed to 2ft above the ground.

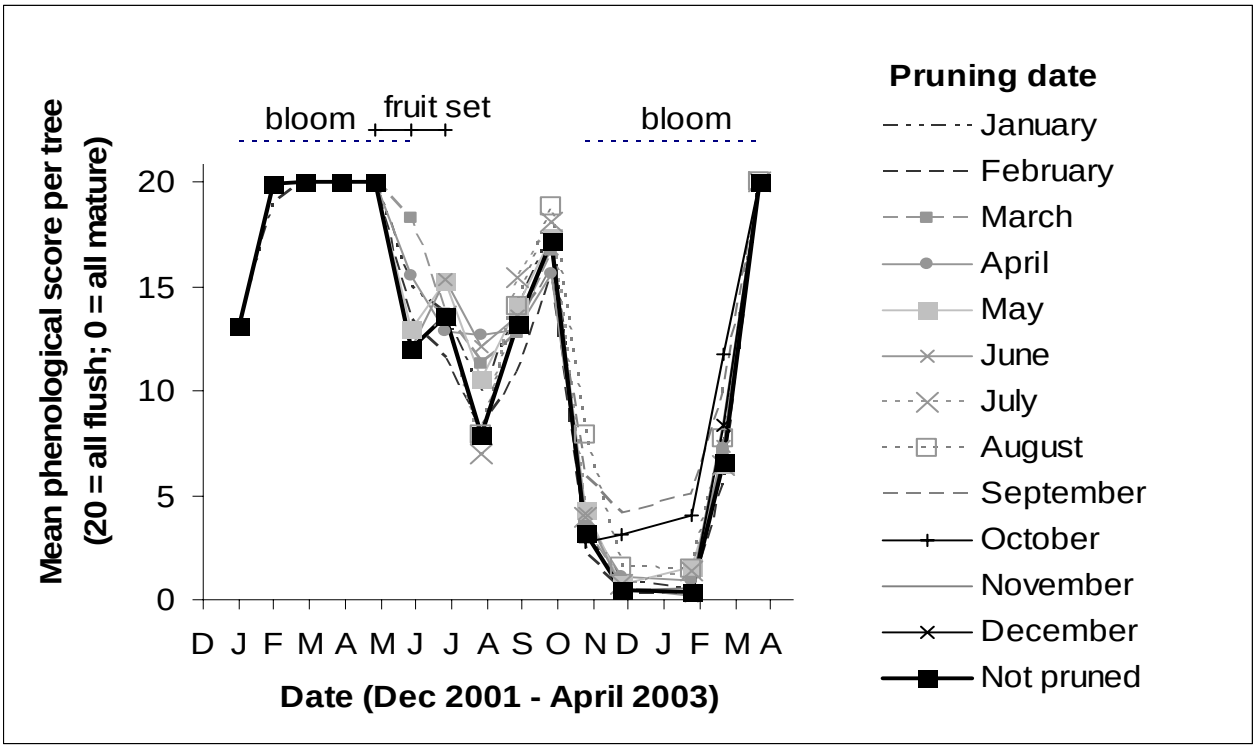

Figure 1. Mean phenological score observed for trees from pruning date through to April 2003.

Once a month, the numbers of immature avocado thrips were counted on ten flushing leaves per tree. Because small susceptible fruit only occur for a short period of time and avocado thrips prefer to feed on flushing leaves (Yee *et al.,* 2001 b), observations of immature thrips on fruit were omitted from the monthly observations. The use of thrips numbers per leaf as an indicator for fruit scarring has been validated in the past (Yee *et al.,* 2001 b). Additionally, a phenological score was determined monthly for each tree using the following method: each cardinal quadrant of the tree (North, East, South and West) was observed and for 5 randomly selected branches in each quadrant, one point

was given to a flushing terminal. Thus, a score of 20 indicated a tree in full flush and a score of 0 a tree without flush. The fruit development stages (bud, flower, fruit set, fruit size) of the trees were also recorded with every monthly observation.

Monthly observations were discontinued after April 2003,4 months after the last pruning activity, when effects of pruning on leaf flushing were no longer apparent and all treatment phenology scores were identical to the un-pruned control trees (all in flush, score = 20). In March 2003, the total number of fruit per tree was counted on the trees a week before harvest of the 2002 crop. August 2003, the 2003 fruit set was recorded on the trees. Fruit scarring was assessed by visual inspection of fruit on the trees, estimating the scarred surface area of the fruit as a percentage of total surface area.

Table 1. Mean phenological score per tree, averaged for all months observed from date of pruning until April 2003

	Mean phenological score ± se**		t-test	
Prune Date (2002)*	Pruned trees	Control trees	t value	*P* value
January	12.4 ± 0.058	10.69 ± 0.053	-2.765	0.006#
February	10.95 ± 0.066	10.69 ± 0.066	-0.382	0.703
March	10.28 ± 0.066	10.47 ± 0.067	-0.284	0.770
April	10.28 ± 0.068	9.51 ± 0.071	-1.138	0.256
May	9.33 ± 0.071	8.34 ± 0.072	1.525	0.128
June	8.77 ± 0.086	7.87 ± 0.083	-1.247	0.213
July	7.92 ± 0.107	7.05 ± 0.095	-1.094	0.275
August	8.61 ± 0.119	6.91 ± 0.121	-1.981	0.049#
September	8.28 ± 0.111	5.63 ± 0.147	-3.204	0.002#
October	5.41 ± 0.132	2.71 ± 0.096	-4.245	3.748E-05#
November	3.2 ± 0.19	2.53 ± 0.152	-0.875	0.383
December	4.38 ± 0.316	3.59 ± 0.296	-0.809	0.421

*20 trees were lightly pruned during the first week of the month, removing branch tips to reshape the tree into a pyramid shape, 20 trees were never pruned and observed as a control.
**20 branches per tree (5 per quadrant) were scored. A score of 1 indicated flushing leaves on the branch, 0 indicated mature leaves, hence a phenological score of 20=all flush; 20 trees were pruned per date.
# indicates that the phenological score is significantly ($P<0.05$) higher than in unpruned trees.

Results and Discussion

Presence of flushing leaves on trees

Trees in the control treatment (no pruning) were flowering when the trial started in January 2002 and continued to do so through June. Fruit set occurred from April through June, with the main set in the middle of June. Fruit developed to over 2 inches in length between June and August. Flowers were not observed in August, September or October. Following the early rains in October, bloom commenced once more in November and continued for the remainder of the observed time period (Fig. 1). Fluctuations of the phenological scores for all treatments followed the same general pattern throughout the year (Fig. 1).

Mean phenological scores for all treatments were compared to un-pruned trees over the same time period until the end of the trial (from one month after pruning until the last observations in April 2003). In the cooler months of November and December, the trees

had low phenology scores in general (small amounts of flush present), and pruning activities in those months did not increase production of flushing leaves in the subsequent months. Significantly higher phenological scores were recorded following pruning in January, August, September and October (T-test, $P < 0.05$) (Table 1). When considering the presence of flush during the months of fruit set and early fruit development (June, July, August), pruning between January and May increased the presence of flush in June and August, but not in July (Table 2). Most early pruning dates increased the overall phenological score during the critical fruit development stage (Table 2), which confirms that pruning promotes growth and development of dormant buds (Stassen *et al.,* 1999). In July, when this relationship was not apparent, all pruned and un-pruned trees were in bloom and producing flush on all terminals.

Table 2. Mean phenological score per tree observed in June, July and August 2002 for trees pruned between January and July 2002.

Month	Prune Date*	Mean phenological score ± se**	t value	*P* value
June	Not Pruned	12.05 ± 0.344		
	January	15.0 ± 0.223	-3.371	0.002#
	February	15.76 ± 0.252	-3.973	< 0.001#
	March	18.3 ± 0.286	-6.544	< 0.001#
	April	15.5 ± 0.213	-3.992	< 0.001#
	May	13.0 ± 0.235	1.067	0.293
July	No Prune	13.6 ± 0.246		
	January	13.65 ± 0.207	-0.073	0.942
	February	13.59 ± 0.302	0.014	0.989
	March	13.7 ± 0.315	-0.117	0.907
	April	12.85 ± 0.187	1.370	0.263
	May	15.2 ± 0.275	-2.152	0.038#
	June	15.3 ± 0.277	-2.369	0.023#
August	No Prune	7.9 ± 0.206		
	January	9.9 ± 0.215	-3.146	0.003#
	February	9.47 ± 0.182	-2.638	0.012#
	March	11.35 ± 0.323	-4.217	< 0.001#
	April	12.65 ± 0.149	-8.736	< 0.001#
	May	10.6 ± 0.202	-4.377	< 0.001#
	June	1.71 ± 0.288	-4.983	< 0.001#
	July	7.89 ± 0.227	-0.008	0.994

* 20 trees were lightly pruned during the first week of the month (2002), removing branch tips to reshape the tree into a pyramid shape, 20 trees were never pruned and observed as a control.

**20 branches per tree (5 per quadrant) were scored. A score of 1 indicated flushing leaves on the branch, 0 indicated mature leaves, hence a phenological score of 20 = all flush.

# indicates that the phenological score is significantly ($P<0.05$) higher than in unpruned trees.

When considering the flushing leaves as a possible food source for avocado thrips, these results indicate that any early pruning activity will increase the food availability and may increase the number of avocado thrips present during fruit set. At the same time, the prolonged presence of flushing leaves through August on trees pruned early in the year may prevent thrips from moving to the developing fruit. In control trees, leaves hardened after the observations in July, which caused a significant decrease in the

availability of flush growth recorded in August. The occurrence of hardening of leaves on control trees in July would have forced thrips to find other food sources such as the small tender fruit that was still developing.

Following a nitrogen fertilizer application in June 2002, only the trees that had been pruned between January and May 2002 produced a flush of growth in August. Since fertilizers can be applied any time in spring after the soil has started to warm up (Faber, personal communication), we believe that an earlier application of nitrogen fertilizer (in April or May) may encourage the presence of flush throughout July when fruit is of critical size. Incorporating a regime of nitrogen fertilizer applications in a future pruning trial may determine if early applications could promote flush and provide the desired effects on fruit set and alternate bearing. Applications of nitrogen fertilizers in April have been reported to positively affect fruit set in avocado, but no data is available on the effect of an application in May (Lovatt, 2001).

Table 3. Mean number of immature avocado thrips per observation of 10 leaves per tree averaged for all months observed from date of pruning until April 2003

	Mean number of immature avocado thrips per 10 leaves ± se**		t-test	
Prune Date*	Pruned trees	Control trees	t value	*P* value
January	32.97 ± 0.482	30.54 ± 0.411	-0.488	0.626
February	29.44 ± 0.457	33.25 ± 0.461	0.782	0.435
March	44.24 ± 0.677	36.48 ± 0.522	-1.266	0.206
April	55.99 ± 0.844	39.74 ± 0.600	-2.308	0.022[#]
May	57.39 ± 0.927	44.68 ± 0.693	-1.715	0.087[##]
June	63.55 ± 1.184	48.68 ± 0.831	-1.719	0.087[##]
July	54.44 ± 1.042	56.32 ± 0.983	0.237	0.813
August	82.00 ± 1.637	64.18 ± 1.234	-1.725	0.086[##]
September	84.23 ± 2.077	61.75 ± 1.638	-1.891	0.060[##]
October	74.57 ± 2.908	69.27 ± 2.320	-0.368	0.714
November	30.93 ± 2.450	34.40 ± 2.555	0.314	0.754
December	0.70 ± 0.127	2.25 ± 0.387	1.781	0.083

* Trees were lightly pruned during the first week of the month, removing branch tips to reshape the tree into a pyramid shape, 20 trees were never pruned and observed as a control.
**each month immature avocado thrips were counted on 10 flushing leaves per tree.
[#] Number of immature thrips is significantly (P<0.05) higher than unpruned trees.
[##] Number of immature thrips shows a trend (P<0.10) to be higher than in unpruned trees.

Occurrence of avocado thrips

Because all trees were subject to treatments of the grower's chemical control program, absolute effects of pruning on avocado thrips population development could not be determined. However, with 4 chemical applications in 16 months, significantly higher numbers of thrips were recorded between May 2002 and April 2003 on trees pruned in April 2002, compared to the numbers of thrips recorded on un-pruned trees in the same time period (t=-2.308, P=0.022). Similarly, a trend (t-test, P< 0.1) of higher numbers of thrips recorded between the month after pruning and April 2003 was found for trees pruned in May, June, August and September 2002 (Table 3). Pruning in January, February, March, July, October, November or December had no effect on the number of thrips.

All trees received one spinosad and 3 abamectin applications for control of avocado thrips, which suppress populations for 2-4 weeks and at least 60 days respectively (Oevering *et al.,* 2002). Additionally, the predatory mites that were released twice may also prey on first instar avocado thrips (Oevering, personal observation). With such an intensive thrips control regime, effects of pruning on avocado thrips numbers were not expected. This suggests that with fewer applications or in the absence of chemical treatments, pruning after March may increase thrips numbers to a larger extent than was found in this study.

Table 4. Mean number of fruit per tree (n = 20) per prune date observed for the 2002 and 2003 fruit set.

Prune Date (2002)*	Mean number of fruit per tree ± se**		
	2002 fruit set (on trees in March 2003)[#]	2003 fruit set (on trees in August 2003)[#]	Cumulative 2002 + 2003[#]
January	14.4 ± 1.90 bc	44.8 ± 10.57 d	59.2 ± 12.47 b
February	7.1 ± 1.59 a	22.4 ± 4.08 bc	29.5 ± 5.67 a
March	6.1 ± 1.97 a	17.3 ± 4.19 ab	23.4 ± 6.16 a
April	14.0 ± 2.15 b	17.7 ± 3.43 ab	31.7 ± 5.58 a
May	13.1 ± 2.22 b	20.8 ± 3.19 ab	33.9 ± 5.41 a
June	13.9 ± 2.21 b	14.4 ± 4.22 ab	28.3 ± 6.43 a
July	13.3 ± 2.27 b	14.5 ± 3.14 ab	27.8 ± 5.41 a
August	13.5 ± 1.83 b	18.1 ± 3.02 ab	31.6 ± 4.85 a
September	13.3 ± 2.05 b	13.3 ± 2.24 ab	26.6 ± 4.29 a
October	13.7 ± 2.14 b	7.2 ± 1.08 a	20.8 ± 3.22 a
November	13.7 ± 2.37 b	12.3 ± 2.41 ab	25.9 ± 4.78 a
December	14.4 ± 1.64 bc	7.3 ± 1.36 a	21.7 ± 2.0 a
Unpruned Control	20.1 ± 2.19 c	36.8 ± 11.67 cd	56.9 ± 13.86 b

*Trees were lightly pruned during the first week of the month, removing branch tips to reshape the tree into a pyramid shape, 20 trees were never pruned and observed as a control.
**n=20 trees per prune date and 20 trees per control.
[#]Different letters indicate significantly different mean number of fruit set per tree.
ANOVA 2002: 12df, F = 2.62, *P* = 0.02596, LSD *P*<0.05.
ANOVA 2003: 12df, F = 4.24, *P* = 0.00001, LSD *P*<0.05.
ANOVA 2002+2003: 12df, F = 3.17, *P* = 0.0003, LSD *P*<0.05.

Fruit scarring and fruit set on pruned trees

No treatment differences were found in the scarring of fruit. No fruit had economic levels of scarring (>10% surface area) and 0.7% of the fruit had scarring of between 1 and 10% of the surface area (results not shown). This indicates that the chemical control applications in 2002 and 2003 suppressed the avocado thrips population below the economic threshold levels (Yee *et al.,* 2001 b).

The numbers of fruit set in 2002 (as observed in March 2003) from trees pruned in January 2002 or December 2002 were not significantly different from the un-pruned trees. However, when trees were pruned in February and March 2002, the fruit set was significantly lower than any of the other pruning times (Table 4, ANOVA12df, F=2.62, *P*=0.026). January 2002 was the only month in which pruning did not negatively affect the number of fruit set in 2003. In all other months, especially in October 2002 and December 2002, pruning significantly reduced the number of fruit set in 2003 (Table 4, ANOVA 12df, F=4.24, *P*=0.00001). The cumulative fruit set data for 2002 and 2003

shows that only pruning in January did not negatively affect fruit set (Table 4, ANOVA 12df, F=3.17, *P*=0.0003).

Conclusions: Can pruning be a part of a future IPM program?

The results of this coastal study indicate that in combination with chemical thrips control, only light pruning of young trees in January 2002 did not impact the numbers of avocado thrips or the fruit set in 2002 and 2003. The frequently observed practice of pruning in February or March had no impact on avocado thrips populations but significantly reduced fruit set in 2002 and 2003. Pruning in January will establish avocado thrips presence on flushing leaves during fruit set and because the current IPM practice uses numbers of immature thrips per leaf to trigger the use of chemical control methods, this timing of pruning in commercial groves will initially lead to an increase in recommendations for use of chemical treatments.

Before pruning can be used in an IPM management program, long-term trials are required with replication at different locations to include climate effects. These future studies should omit or strictly limit chemical control applications for avocado thrips and include different fertilizer application times to evaluate whether higher numbers of thrips on flushing leaves during fruit development affect fruit scarring and how yield is affected by this practice.

To obtain all general benefits associated with pruning practices such as facilitation of pest control activities in the grove and control of tree size, increase in light penetration and regulation of crop production (Stassen *et al*., 1999; Thorp & Stowell, 2001, Faber and Bender, 2003), additional long-term research using mature avocado orchards and a range of pruning practices is needed.

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