Development of Ultra Low Volume Spray Applications of Sex Pheromone for Mating Disruption of Oriental Fruit Moth

PROJECT LEADER: Dr. Alan Knight

COOPERATORS: Walt Bentley, Carolyn Pickel, Christeen Abbott, Suterra LLC, Jeff Downs, Trécé Inc.; and John Post, Agricultural Advisors Inc.

Objectives

1. Evaluate the use of ULV applications of OFM microencapsulated sex pheromone.
2. Evaluate the use of ULV insecticide sprays for OFM.
3. Develop an effective monitoring program for OFM in MD orchards.
4. Develop killing stations to control OFM along orchard borders.

Results

1. ULV Spray Applications. A study was run in the same peach orchard we used in 2005 located near Yuba City by my technician in collaboration with Carolyn Pickel's group who also collected the weekly data. Five replicates of each treatment (Checkmate dispenser, ULV spray, and untreated) were randomly established and plots were separated by > 50 m. The Checkmate hand-applied dispenser was put out on 15 March. A 50% rate of the microencapsulated formulation (12.4 g AI per hectare) was used and the first spray was not applied until the beginning of the second moth flight (1 May). Subsequent applications were made on 2 June, 28 June, and 3 August. The mid-season cultivar was sampled on 3 August and the late-season cultivar on 21 August. One hundred fruits per plot were examined for injury on each date. The entire orchard was sprayed with one application of esfenvalerate during the season at 1,170 ml per 1,000 l water per hectare.

Moth catches were much lower in the Yuba City orchard in 2006 versus 2005 (Table 1). Following the first ULV application (delayed until May) no significant difference in moth catches occurred between either pheromone treatment and both were significantly lower than in the untreated plots. Levels of fruit injury were very low in all plots and no difference was found among treatments.

The season-long ULV spray application of sex pheromone was found to be a very effective program for management of OFM in stone fruit orchards in California during 2005. Yet, it was clear that the

early-season ULV applications were compromised by the wet spring weather that occurs frequently in California. Modifying this five-spray application program by starting sprays later in the season appears to be a reasonable approach. Unfortunately, the populations of OFM were very low in California during 2006 and the data did not allow for comparison of the effectiveness of hand-applied dispensers with the ULV sprays. Yet, the data does strongly suggest that using a ½ rate of the microencapsulated sex pheromone was effective in suppressing moth catches in traps throughout the season. Cutting the cost of material by 50% would be a significant factor promoting the use of the sprayable formulation.

Growers in California continue to disagree whether the 1st generation of OFM in the spring needs to be actively managed. Yet, it is more likely that populations of OFM early in the season will be problematic following the grower's failure to maintain mating disruption the previous season following harvest. This 'rebound' effect after harvest may be an important factor maintaining OFM as a serious pest year-after-year in some orchards. In addition, the record levels of spring precipitation during the past two seasons in California have made early-season management of OFM difficult. Thus, it seems reasonable to consider the adoption of maintaining mating disruption of OFM populations after harvest in early and mid-season cultivars by applying reduced rates of microencapsulated sprayables. Additional studies are needed to assess the potential value of this multi-season management program for OFM.

Table 1. Comparison of mean cumulative moth catches in sex pheromone-baited traps and fruit injury by OFM in replicated plots (n = 5) treated with either hand-applied dispensers, a microencapsulated sex pheromone applied as an ultra low volume spray or in untreated plots in a Yuba City, CA peach orchard in 2006.

Treatment [a]	Mean (SEM) cumulative moth catch per trap between				% fruit injury [b]
	Dispensers applied and 1st spray	1st and 2nd spray	2nd and 3rd spray	3rd and 4th spray	
No pheromone	12.1 (3.8)a	5.6 (1.3)a	2.4 (0.4)a	25.5 (5.6)a	0.2 (0.2)a
Dispensers 300/hectare	0.2 (0.2)b	0.0 (0.0)b	0.0 (0.0)b	0.3 (0.2)b	0.4 (0.4)a
ULV spray 12.4 g a.i.	6.5 (1.9)ab	0.2 (0.2)b	0.0 (0.0)b	0.0 (0.0)b	0.0 (0.0)a
ANOVA:	$F_{2,12} = 5.90$ $P = 0.02$	$F_{2,12} = 17.10$ $P = 0.0003$	$F_{2,12} = 31.10$ $P < 0.0001$	$F_{2,12} = 6.73$ $P = 0.01$	$F_{2,12} = 1.00$ $P = 0.40$

Means in the same column followed by the same letters were not significantly different, LSD test, $P < 0.05$.
[a] Dispensers were applied on 15 March. All ULV sprays were applied in 12 l of water per hectare. Sprays were applied on 1 May, 2 June, 28 June, and 3 August.
[b] Fruit were sampled on 3 and 21 August, 100 per plot.

Our results support the use of ULV pheromone sprays to manage OFM populations late into the season regardless of harvest dates and that by reducing the overwintering populations of OFM in their orchards, growers can eliminate the need to treat the following spring generation. Further demonstrations of this approach are needed.

2. ULV pheromone plus insecticides. A second study was conducted to evaluate the use of adding an insecticide to the ULV pheromone application. Plots were established by my technician and monitored by Carolyn Pickel's group. This was a young block that was not sprayed with any other insecticide. Six replicates were established. All plots received four applications of the half rate of sex pheromone on the same dates as the previous study. The second treatment added Asana at 4 oz per acre and the third treatment added 1.0 lb of Imidan to the spray. This rate of Imidan was determined to be about the highest rate we could spray in such a concentrated volume. A nearby block was used as the grower standard program. This block was sprayed twice with Asana and also with a miticide.

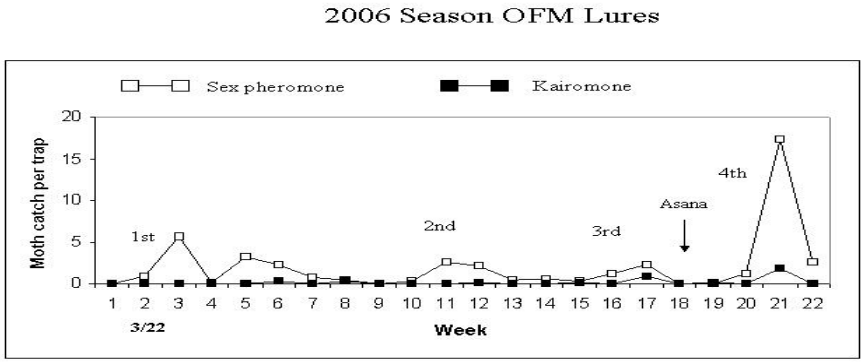
The benefit of adding an insecticide to the ULV pheromone spray could not be evaluated due to the low moth pressure in 2006: no shoot strikes or OFM injury was found in samples in June or August respectively. The addition of the ULV-applied insecticide reduced the densities of two-spotted mite densities but did not reduce the numbers of predatory mites. Studies with codling moth have been extremely successful and the use of Warrior with Zeon Technology is allowed at volumes of $\geq$ 2 GPA applied by ground. In addition, the use of Assail has proven to be very effective. Further studies are needed to address the value of this approach for California stone fruit growers.

Table 2. Comparison of mean cumulative moth catches in sex pheromone- and kairomone-baited traps and densities of two-s[potted and predatory mites in replicated plots (n = 6) treated with a ½ rate of microencapsulated sex pheromone either alone or with Asana or Imidan versus the grower's insecticide standard program, Yuba City, CA peach orchard in 2006.

Sample type	Grower standard	ULV Pheromone	ULV Pheromone + Asana	ULV Pheromone + Imidan
Cumulative moths in pheromone trap	28.0b	0.0a	0.2a	0.0
Cumulative moths in kairomone trap	2.7a	0.7a	1.3a	1.8a
# two-spotted mites per leaf	0.0a *	8.0c	3.9b	3.4b
# predatory mites per leaf	0.3a	0.3a	0.5a	0.4a

Row means followed by a different letter were significantly different, Fisher's LSD, $P < 0.05$.
* Miticide applied.

3. Effective monitoring program for OFM in MD orchards. During 2005 both the sex pheromone and kairomone lures were effective in detailing the four generations of OFM. This year, however, the kairomone was not very useful in detecting the start of moth flights. The key difference between years is probably the dramatically lower moth flight in 2006 versus 2005.



Fresno Study 1. This study was originally set-up by Jeff Downs and looked at moth counts in pheromone and kairomone-baited traps in five orchard sites where plots received different pheromone treatments. In general, four replicates of each trap type were monitored in each treatment. Data are presented from 1 March to 27 July in the following table. These data show that the kairomone-baited trap consistently outperformed the pheromone lure across all pheromone treatments. However, in the untreated plots the pheromone-baited trap was much more attractive.

Table 3. Summary of cumulative moth catches in various trials conducted in stone fruit orchard plots treated with several types of sex pheromone dispensers or left untreated, Fresno, CA, 2006.

		Cumulative moths caught per trap	
Orchard #	Treatment	Pheromone	Kairomone
1	Cidetrak	0	2.75
1	Isomate tt	0	1.25
2	Cidetrak	0	1
2	Puffers	1.5	2
2	MEC Spray	0.25	0.25
2	Untreated	7.75	2
2	Untreated	4.25	0.25
3	Cidetrak	0.5	5.0
3	M-Rosso	0.25	4.25
4	Cidetrak	0.25	0.75
4	Isomate tt	0.5	01.75
5	Cidetrak	1.25	3.0
5	Isomate tt	0.25	0

Fresno Study 2. This study was set up initially by Christine Abbott and later monitored by Walt Bentley's group. The study was initiated rather late and ULV sprays were applied on 12 May, 7 June, and 12 July. Checkmate hand-applied dispensers were also applied on 12 May. Orchards were divided into two blocks with high moth pressure and two blocks with low moth pressure. Each plot had two pheromone and two kairomone-baited traps. A bait pan was added to each plot on 15 June. The grower made several insecticide applications and the study was terminated.

Data from this study was somewhat different than our Yuba City studies. The kairomone-baited traps performed poorly and actually caught fewer moths than the pheromone baited traps in the high-pressure orchards. The bait pans were very effective.

Table 4. Summary of a study comparing the effectiveness of ULV sprayable versus hand applied dispensers.

Sample	Untreated	ULV (full rate)	Hand-applied
Pheromone trap	59.2	1.8	0.0
Kairomone trap	1.2	1.0	0.5
Shoot strikes per tree	14.6	10.9	8.7
Bait pan	52.0	43.5	49.0

Yuba City Study 3. John Post placed 27 pairs of kairomone-baited sticky traps and bait pans 25' apart in one commercial clients orchard. Moth counts were extremely low this year and he caught only 4.6 and 0.3 moths per bait pan and kairomone-baited trap, respectively. Since the bait pans are much more attractive than the kairomone lure it would have been a better test if the two trap types had been spaced further apart. Last year, Doug Light found that the bait traps caught less than twice the number of moths as the kairomone-baited sticky trap.

Yakima / Medford Studies 1. A new kairomone lure was developed for 2006 and compared with the older lure in peach and pear orchards in Yakima and in peaches in Medford by Rick Hilton. In all cases the new lure was somewhat more effective but in these untreated orchards caught only 2 – 7% as many moths as a sex pheromone-baited trap.

Table 5

	Cumulative moths per trap		
Orchard/ dates	Old lure	New lure	Pheromone lure
Medford peach 23 June – 5 July	3.25	5.75	166.0
Yakima pear 14 June – 10 Aug	2.5	8.0	376.0
Yakima peach 14 June – 10 Aug	21.0	41.5	650.0

The kairomone lure can be an effective tool to monitor adult densities within pheromone-treated orchards early in the year. In combination with a June sample of shoot strikes this timely information can be useful to help growers decide whether to supplement their use of sex pheromones. Unfortunately, the kairomone lure was found to be effective for only a few weeks

in the spring and only 1 week during periods of high temperatures in 2006. Also the lure is not very effective in monitoring low-density OFM populations. Another kairomone lure supplied by another company was tested and found to be somewhat more attractive and longer lasting. Yet, significant improvements are still needed in both lures before these products could be commercialized.

4. Develop killing stations. The codling moth attract and kill system I have been working on for five years was tested in 16 experimental plots and in small plots within six commercial apple orchards in 2006. Unfortunately, results were poor and additional problems were experienced. For example, the lures placed in full sunlight were found to be effective for only one week and the initial insecticide residue was effective for only a few weeks and efforts to re-treat stations produced marginal results. Beginning in 2007 a 'final' effort will be made with this approach for codling moth using several new ideas (the nature of science). When this approach can be adequately developed for codling moth then future development of a similar system for oriental fruit moth using the kairomone lure could be possible.

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