Insecticide/Miticide Evaluations for Control of Codling Moth, Pear Psylla and Mites in Pears

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Abstract: This experiment compared the volatile organic compound (VOC) compliant formulations of abamectin (Agri-Flex & Agri-Mek SC) with the non-compliant formulation (Agri-Mek 0.15EC) for mite and pear psylla control. This experiment also compared HGW86 10SE, a second-generation diamide, with Altacor 35WDG for codling moth control. The treatments were applied using a hand-held orchard sprayer based on degree-day considerations in a commercial 'Bartlett' pear orchard in Suisun Valley. Codling moth (CM) populations were monitored using pheromone traps. Fruit damage was visually assessed CM damage just prior to harvest. Both VOC compliant and non-compliant formulations of abamectin performed with equal efficacy in suppression of mite and psylla populations; likewise, HGW86 10SE was as efficacious as Altacor 35WDG in control of CM.

Introduction: In an attempt to reduce ground level ozone precursors the California Department of Pesticide Regulation, under the initiative of the Clean Air Act, issued requirements to pesticide manufactures that their products be volatile organic compound (VOC) compliant. VOC compliance means that less than 20% of the formulation volatilize. The purpose of this experiment was to compare the VOC compliant abamectin formulations (Agri-Flex & Agri-Mek SC) with the non-compliant formulation (Agri-Mek 0.15EC) for mite and pear psylla control and to also compare HGW86 10SE, a second-generation diamide, with Altacor 35WDG for codling moth control.

Methods and Materials: This trial was conducted in a commercial 'Bartlett' pear orchard in Suisun Valley, CA. This orchard was planted on a 25 by 25 ft. spacing (70 trees/ac). Seven experimental treatments and an untreated check were replicated four times in a randomized complete block design where each replicate consisted of an individual tree. Foliar sprays were applied with a hand-held orchard sprayer operating at 200 psi with finished spray volume approximately 200 gal/ac (2.87 gal/tree). Treatments were applied based on degree days (DD) development of the codling moth population. DD were calculated with a biofix of 16 Apr for the first generation and 8 Jul for the second generation using single sine horizontal cutoff model with a lower threshold of 50˚F and an upper threshold of 88˚F. Maximum and minimum air temperatures were obtained from the Solano Irrigation District (SID) weather station on Williams Rd. in Suisun Valley, CA. Treatments were targeted at the beginning of egg deposition (50–75 DD), beginning of egg hatch at 125–200 DD for the first peak and 550–650 DD for the second peak of each flight. In many years the second peak of the second flight occurs after pear harvest.

Pear psylla (PP), *Cacopsylla pyricola*, web spinning mites (WSM), *Tetranychus spp.*, pear rust mite (PRM), *Epitrimerus pyri*, Western flower thrips (WFT), *Frankliniella occidentalis*, Western predatory mite (WPM), *Galandromus occidentalis*, yellow mite (YM), *Lorryia formosa*, and European red mite (ERM), *Panonychus ulmi*, were monitored by sampling 10 exterior and 10 interior leaves per replicate weekly from 21 Jun through 8 Aug. The 20 leaf samples were transported to UCB in ice chests and brushed. All motile psylla, thrips, and mites were counted under magnification in the laboratory.

The codling moth (CM), *Cydia pomonella*, flight was monitored from 29 Mar to 16 Aug with one pheromone trap placed high in the tree canopy. CM infestation was evaluated by inspecting 250 fruit per replicate just before commercial harvest on 16 Aug for stings and strikes. Strikes were when CM larvae tunneled into the core of the fruit while stings were when CM larvae only fed on the first few millimeters into the fruit. In addition, fruit was inspected for damage from mealybugs (MB), probably grape mealybug *Pseudococcus maritimus*, leafroller, probably fruit tree leafroller (FTLR), *Archipos argyrospila*, green fruit worm (GFW), *Orthosia hibisci*, and piercing/sucking bugs (P/SB), probably *Lygus hesperus*. Also PRM fruit russeting damage was scored on a scale ranging between 0 and 3. A pear was scored as 0 if there was little or no russetting on the pear; as 1 if there was rust damage on approximately ¼ of pear surface; 2 if there was rust covering ¼ to < ¾ of pear surface; and 3 if there was rust covering ¾ or more or pear surface. Scores of 2 or 3 would be unmarketable.

Treatments and Application Timings, Suisun Valley, CA – 2011

	Materials	Rate form/ac	No. appl.	Application date & timing
1.	Imidan 70WP +	7.125 lbs	2	9 May (266 DD after 1st biofix) &
	Agri-Mek SC +	3.5 fl. oz		10 Jun (540 DD after 1st biofix)
	PureSpray Green oil	0.5% v/v		
	Guthion 50WP	2.0 lbs	1	22 Jul (282 DD after 2nd biofix)
2.	Imidan 70WP +	7.125 lbs	2	9 May (266 DD after 1st biofix) &
	Agri-Flex +	8.5 fl. oz		10 Jun (540 DD after 1st biofix)
	PureSpray Green oil	0.5% v/v		
	Guthion 50WP	2.0 lbs	1	22 Jul (282 DD after 2nd biofix)
3.	Imidan 70WP +	7.125 lbs	2	9 May (266 DD after 1st biofix) &
	Agri-Mek 0.15EC +	16.0 fl oz		10 Jun (540 DD after 1st biofix)
	PureSpray Green oil	0.5% v/v		
	Guthion 50WP	2.0 lbs	1	22 Jul (282 DD after 2nd biofix)
4.	Altacor 35WDG	4.0 oz	3	26 Apr (94 DD after 1st biofix),
				9 May (266 DD after 1st biofix) &

				10 Jun (540 DD after 1st biofix)
	Guthion 50WP	2.0 lbs	1	22 Jul (282 DD after 2nd biofix)
5.	Altacor 35WDG	3.0 oz	3	26 Apr (94 DD after 1st biofix), 9 May (266 DD after 1st biofix) & 10 Jun (540 DD after 1st biofix)
	Guthion 50WP	2.0 lbs	1	22 Jul (282 DD after 2nd biofix)
6.	HGW86 10SE	13.5 fl. oz	3	26 Apr (94 DD after 1st biofix), 9 May (266 DD after 1st biofix) & 10 Jun (540 DD after 1st biofix)
	Guthion 50WP	2.0 lbs	1	22 Jul (282 DD after 2nd biofix)
7.	Imidan 70WP	7.125 lbs	2	9 May (266 DD after 1st biofix) & 10 Jun (540 DD after 1st biofix)
	Guthion 50WP	2.0 lbs	1	22 Jul (282 DD after 2nd biofix)
8.	Untreated check	--	0	

Results and Discussion: CM flight as measured by pheromone trap indicates a very erratic and choppy flight pattern making it very difficult to accurately determine the biofix dates or peak flights dates throughout the season (Fig. 1). However, the first flight was set on 16 Apr and the second flight set on 8 Jul.

Populations of ERM, YM and WFT were very low in all treatments and there was no significant difference among treatments at any date or for the season total. These data are not reported here. There was no significant difference in the mean number of WSM and WPM per 20 leaves in the weekly samples (Tables 1 and 2). However, there were significantly lower WSM populations in the season total in the treatments with various abamectin products as compared to all other treatments and the untreated check. Thus the inclusion of the various formulations of abamectin with standard organophosphate (OP) CM control measures (Imidan and Guthion) controlled WSM. There was no significant difference among the different formulations of Agri-mek. Altacor 35WDG and HGW86 10SE did not significantly flare WSM. The WPM populations mirrored the WSM populations in that there were lower WPM populations in the season totals of treatments with various abamectin products as compared to other treatments and the untreated check. Also, there were significantly lower WPM populations in the Agri-Flex treatment compared to the untreated check.

The PP populations were significantly lower in the Imidan 70WP with Agri-Mek 0.15EC compared to Altacor 35WDG at 4 oz/ac on 21 Jun (Table 3). However there was no significant difference between any experimental treatment and the untreated check. On 29 Jun, the PP

populations in Imidan 70WP with Agri-Flex and Imidan 70WP with Agri-Mek 0.15EC were significantly lower compared to all other treatments except Imidan 70WP with Agri-Mek SC. After that date there was, with the exception of 25 Jul, no significant difference among the treatments and there was no significant difference among the treatments in the season total. The 25 Jul sample appears to be an anomaly in the data in that both the Altacor 35WDG and untreated check counts were unusually low and should not be considered. In the season total, all Agri-Mek treatments had numerically lower numbers of PP as compared to all other experimental treatments but very similar numbers to the untreated check.

The PRM populations were significantly lower in the treatments containing the various Agri-Mek products as compared to all other treatments on 25 Jul and in the season total (Table 4). There was no difference among the treatments on 2 Aug sample but on the 8 Aug samples there was again significantly lower PRM populations in all treatments containing the various Agri-Mek products as compared to all experimental treatments. Thus the various Agri-Mek products suppressed the PRM populations; yet, neither Altacor 35WDG nor HGW86 10SE flared the PRM populations.

At harvest the CM infestation was much lower than observed in prior years and is attributed to increased CM control measures applied to the orchard the prior two years. There were significantly lower CM strikes and total CM infestations but not CM stings in all experimental treatments compared to the untreated check (Table 5). There was no significant difference among the experimental treatments in stings, strikes or total CM infestation. There was no rate response between 3 oz/ac of Altacor 35WDG and 4 oz/ac of Altacor 35WDG. HGW86 10SE was as efficacious as Altacor 35WDG in control of CM. The addition of the various formulations of abamectin to Imidan 70WP and Guthion 50WP improved the CM control efficacy over Imidan 70WP and Guthion 50WP alone. Also there was no significant difference among the treatments in damage from MB, FTLR, GFW and P/SB. The damage from PRM was significantly suppressed with the inclusion of the various formulations of abamectin (Table 6). There was no significant difference in the amount of russetting among the Altacor 35WDG, HGW86 10SE, Imidan 70WP and untreated check treatments. Again, fruit with scores of 2 or 3 are not marketable.

Conclusions: Agri-Mek SC and Agri-Flex were as efficacious as Agri-Mek 0.15 EC in control of WSM, PRM and PP and provided significant control as compared to the grower standard and untreated check. Agri-Mek SC, Agri-Flex and Agri-Mek 0.15 EC improved control of CM when combined with the grower standard. Thus there are no apparent deleterious effects of the VOC compliant formulation of Agri-Mek when compared to the non-compliant formulation. There was no apparent rate response between 3 and 4 oz of Altacor and HGW86 10SE was as efficacious as Altacor 35WDG in control of CM. HGW86 10SE and Altacor 35WDG did not flare WSM, PRM or PP.

Table 1. Mean number of web spinning mites per 20 leaves in Suisun Valley, CA – 2011.

Treatment	Rate form/ac	No. appl.	Mean[a] number of web spinning mites per 20 leaves								
			21 Jun	29 Jun	6 Jul	11 Jul	19 Jul	25 Jul	2 Aug	8 Aug	Season total
Imidan 70WP +	7.125 lbs	2	0.0 a	0.0 a	0.0 a	0.7 a	0.0 a	1.8 a	0.8 a	0.3 a	3.3 d
Agri-Mek SC[b]	3.5 fl. oz										
Guthion 50WP	2.0 lbs.	1									
Imidan 70WP +	7.125 lbs	2	1.0 a	1.3 a	0.3 a	1.8 a	0.5 a	0.8 a	0.8 a	1.3 a	7.3 cd
Agri-Flex[b]	8.5 fl. oz										
Guthion 50WP	2.0 lbs	1									
Imidan 70WP +	7.125 lbs	2	0.0 a	0.0 a	0.0 a	0.5 a	0.5 a	1.3 a	1.3 a	0.8 a	4.3 d
Agri-Mek 0.15EC[b]	16.0 fl. oz										
Guthion 50WP	2.0 lbs	1									
Altacor 35WDG	4.0 oz	3	0.3 a	1.3 a	0.8 a	4.0 a	3.0 a	1.8 a	3.0 a	1.3 a	15.3 ab
Guthion 50WP	2.0 lbs	1									
Altacor 35WDG	3.0 oz	3	1.3 a	2.0 a	0.3 a	1.8 a	5.0 a	2.3 a	1.0 a	2.5 a	16.0 ab
Guthion 50WP	2.0 lbs	1									
HGW86 10SE	13.5 fl. oz	3	0.0 a	4.0 a	2.8 a	5.5 a	7.3 a	2.3 a	2.8 a	2.0 a	26.5 a
Guthion 50WP	2.0 lbs	1									
Imidan 70WP	7.125 lbs	2	0.0 a	0.5 a	0.5 a	1.3 a	2.3 a	1.3 a	2.0 a	3.0 a	10.8 bc
Guthion 50WP	2.0 lbs	1									
Untreated check	--	0	0.8 a	2.3 a	2.5 a	2.8 a	3.5 a	3.8 a	1.8 a	1.5 a	18.8 a

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).
[b]PureSpray Greeen horticultural oil at 0.5% v/v.

Table 2. Mean number of Western predatory mites per 20 leaves in Suisun Valley, CA – 2011.

Treatment	Rate form/ac	No. appl.	Mean[a] number of Western predatory mites per 20 leaves								
			21 Jun	29 Jun	6 Jul	11 Jul	19 Jul	25 Jul	2 Aug	8 Aug	Season total
Imidan 70WP +	7.125 lbs	2	0.5 a	0.0 a	0.0 a	0.0 a	0.3 a	0.5 a	0.3 a	0.0 a	1.5 bc
Agri-Mek SC[b]	3.5 fl. oz										
Guthion 50WP	2.0 lbs	1									
Imidan 70WP +	7.125 lbs	2	0.3 a	0.0 a	0.0 a	0.5 a	0.3 a	0.0 a	0.0 a	0.0 a	1.0 c
Agri-Flex[b]	8.5 fl. oz										
Guthion 50WP	2.0 lbs	1									
Imidan 70WP +	7.125 lbs	2	0.0 a	0.0 a	0.5 a	0.5 a	0.8 a	0.0 a	0.0 a	0.0 a	1.8 bc
Agri-Mek 0.15EC[b]	16.0 fl. oz										
Guthion 50WP	2.0 lbs	1									
Altacor 35WDG	4.0 oz	3	0.8 a	0.5 a	1.0 a	2.5 a	0.3 a	0.0 a	0.3 a	0.0 a	5.3 ab
Guthion 50WP	2.0 lbs	1									
Altacor 35WDG	3.0 oz	3	0.8 a	1.8 a	1.8 a	0.8 a	1.5 a	0.8 a	0.0 a	0.0 a	7.3 a
Guthion 50WP	2.0 lbs	1									
HGW86 10SE	13.5 fl. oz	3	0.3 a	1.3 a	1.8 a	1.8 a	1.0 a	0.0 a	0.0 a	0.0 a	6.0 a
Guthion 50WP	2.0 lbs	1									
Imidan 70WP	7.125 lbs	2	0.3 a	1.3 a	0.3 a	1.5 a	0.5 a	0.0 a	0.3 a	0.3 a	4.3 ab
Guthion 50WP	2.0 lbs	1									
Untreated check	--	0	0.0 a	1.5 a	0.8 a	0.3 a	1.0 a	0.5 a	0.0 a	0.3 a	4.3 ab

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).
[b]PureSpray Greeen horticultural oil at 0.5% v/v.

Table 3. Mean number of pear psylla per 20 leaves in Suisun Valley, CA – 2011.

Treatment	Rate form/ac	No. appl.	Mean[a] number of pear psylla per 20 leaves								
			21 Jun	29 Jun	6 Jul	11 Jul	19 Jul	25 Jul	2 Aug	8 Aug	Season total
Imidan 70WP +	7.125 lbs	2	9.8 ab	10.8 cd	5.5 a	14.7 a	7.8 a	15.5 a	17.3 a	11.3 a	67.3 a
Agri-Mek SC[b]	3.5 fl. oz										
Guthion 50WP	2.0 lbs	1									
Imidan 70WP +	7.125 lbs	2	20.0 ab	10.8 d	5.0 a	17.0 a	10.5 a	13.5 a	15.3 a	8.8 a	95.8 a
Agri-Flex[b]	8.5 fl. oz										
Guthion 50WP	2.0 lbs	1									
Imidan 70WP +	7.125 lbs	2	7.8 b	10.3 d	14.0 a	9.8 a	11.3 a	9.8 abc	19.8 a	10.3 a	92.8 a
Agri-Mek 0.15EC[b]	16.0 fl. oz										
Guthion 50WP	2.0 lbs	1									
Altacor 35WDG	4.0 oz	3	40.8 a	18.5 bc	8.0 a	9.8 a	11.3 a	7.8 bc	13.8 a	12.8 a	122.5 a
Guthion 50WP	2.0 lbs	1									
Altacor 35WDG	3.0 oz	3	36.3 ab	21.8 ab	11.0 a	12.5 a	11.0 a	5.8 c	14.5 a	13.3 a	126.0 a
Guthion 50WP	2.0 lbs	1									
HGW86 10SE	13.5 fl. oz	3	28.5 ab	29.8 a	10.5 a	14.3 a	11.5 a	12.8 ab	11.8 a	13.3 a	132.3 a
Guthion 50WP	2.0 lbs	1									
Imidan 70WP	7.125 lbs	2	30.0 ab	25.8 ab	15.8 a	13.5 a	15.3 a	13.3 a	20.3 a	13.5 a	147.3 a
Guthion 50WP	2.0 lbs	1									
Untreated check	--	0	17.0 ab	17.3 bc	9.5 a	10.3 a	10.0 a	5.8 c	12.3 a	11.3 a	93.3 a

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).
[b]PureSpray Greeen horticultural oil at 0.5% v/v.

Table 4. Mean number of pear rust mites per 20 leaves in Suisun Valley, CA – 2011.

Treatment	Rate form/ac	No. appl.	Mean[a] number of pear rust mites per 20 leaves			
			25 Jul	2 Aug	8 Aug	Season total
Imidan 70WP +	7.125 lbs	2	219.8 b	270.8 a	303.0 cd	793.5 b
Agri-Mek SC[b]	3.5 fl. oz					
Guthion 50WP	2.0 lbs	1				
Imidan 70WP +	7.125 lbs	2	194.5 b	208.5 a	127.5 d	530.5 b
Agri-Flex[b]	8.5 fl. oz					
Guthion 50WP	2.0 lbs	1				
Imidan 70WP +	7.125 lbs	2	197.3 b	204.8 a	126.3 d	528.3 b
Agri-Mek 0.15EC[b]	16.0 fl. oz					
Guthion 50WP	2.0 lbs	1				
Altacor 35WDG	4.0 oz	3	846.8 a	1136.3 a	667.5 b	2650.5 a
Guthion 50WP	2.0 lbs	1				
Altacor 35WDG	3.0 oz	3	1227.8 a	964.0 a	855.8 ab	3047.5 a
Guthion 50WP	2.0 lbs	1				
HGW86 10SE	13.5 fl. oz	3	1252.3 a	1036.8 a	612.8 a	2901.8 a
Guthion 50WP	2.0 lbs	1				
Imidan 70WP	7.125 lbs	2	1150.8 a	1194.3 a	1052.3 ab	3397.3 a
Guthion 50WP	2.0 lbs	1				
Untreated check	--	0	1025.8 a	1030.5 a	838.5 bc	2894.8 a

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).
[b]PureSpray Greeen horticultural oil at 0.5% v/v.

Table 5. Mean percent infested or damaged at harvest in Suisun Valley CA – 2011.

Treatment	Rate form/ac	No. appl.	Mean[a] percent infestation at harvest						
			CM stings	CM strikes	Total CM	MB	FTLR	GFW	P/SB
Imidan 70WP + Agri-Mek SC[b]	7.125 lbs 3.5 fl. oz	2	1.5 a	0.5 a	2.0 a	0.9 a	0.2 a	0.0 a	3.8 a
Guthion 50WP	2.0 lbs	1							
Imidan 70WP + Agri-Flex[b]	7.125 lbs 8.5 fl. oz	2	0.9 a	0.4 a	1.3 a	0.3 a	0.4 a	0.1 a	3.7 a
Guthion 50WP	2.0 lbs	1							
Imidan 70WP + Agri-Mek 0.15EC[b]	7.125 lbs 16.0 fl. oz	2	3.1 a	0.3 a	3.4 a	1.3 a	0.2 a	0.6 a	5.0 a
Guthion 50WP	2.0 lbs	1							
Altacor 35WDG	4.0 oz	3	6.0 a	0.4 a	6.4 a	4.1 a	0.1 a	1.2 a	6.3 a
Guthion 50WP	2.0 lbs	1							
Altacor 35WDG	3.0 oz	3	3.1 a	0.6 a	3.7 a	5.3 a	0.2 a	1.2 a	4.0 a
Guthion 50WP	2.0 lbs	1							
HGW86 10SE	13.5 fl. oz	3	2.2 a	0.2 a	2.4 a	5.1 a	0.0 a	0.0 a	3.5 a
Guthion 50WP	2.0 lbs	1							
Imidan 70WP	7.125 lbs	2	5.0 a	1.2 a	6.2 a	2.3 a	0.1 a	0.7 a	3.2 a
Guthion 50WP	2.0 lbs	1							
Untreated check	--	0	7.4 a	7.7 b	15.1 b	2.4 a	0.1 a	0.4 a	7.5 a

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).
[b]PureSpray Greeen horticultural oil at 0.5% v/v.

Table 6. Mean percent russet damage from PRM in Suisun Valley, CA – 2011.

Treatment	Rate form/ac	No. appl.	Mean[a] percent rust mite damage scores[b] at harvest							
			0		1		2		3	
Imidan 70WP +	7.125 lbs	2	49.5	a	49.7	a	0.6	c	0.1	c
Agri-Mek SC[c]	3.5 fl. oz									
Guthion 50WP	2.0 lbs	1								
Imidan 70WP +	7.125 lbs	2	60.4	a	38.4	ab	0.8	c	0.4	c
Agri-Flex[c]	8.5 fl. oz									
Guthion 50WP	2.0 lbs	1								
Imidan 70WP +	7.125 lbs	2	61.9	a	36.9	bc	1.1	c	0.1	c
Agri-Mek 0.15EC[c]	16.0 fl. oz									
Guthion 50WP	2.0 lbs	1								
Altacor 35WDG	4.0 oz	3	11.9	b	17.5	d	16.4	a	54.2	a
Guthion 50WP	2.0 lbs	1								
Altacor 35WDG	3.0 oz	3	18.6	b	24.8	cd	13.9	ab	42.8	ab
Guthion 50WP	2.0 lbs	1								
HGW86 10SE	13.5 fl. oz	3	28.9	b	25.8	cd	13.7	ab	31.5	b
Guthion 50WP	2.0 lbs	1								
Imidan 70WP	7.125 lbs	2	25.9	b	22.9	d	8.4	b	42.8	ab
Guthion 50WP	2.0 lbs	1								
Untreated check	--	0	20.5	b	26.9	bcd	17.3	a	35.3	ab

[a]Means followed by the same letter in a column are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).

[b]0 – Little or no rust damage; 1 – Rust covering approximately ¼ of pear surface; 2 – Rust covering ¼ to < ¾ of pear surface; 3 – rust covering ¾ or more of pear surface.

[c]PureSpray Green horticultural oil at 0.5% v/v.

Figure 1. CM pheromone trap captures per trap per day and application timings in Suisun Valley, CA – 2011.