Control of Codling Moth, Secondary Pests and True Bugs by Reduced Risk Insecticides

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Abstract: The implementation of the Food Quality Protection Act of 1996 stands to greatly impact established pest management techniques for pears. Changes in the availability and use of current insecticides will require more reduced risk and environmentally benign pest management strategies. Accordingly, trials were conducted in an effort to develop reduced risk control strategies. Field trials were conducted to evaluate new insecticides/miticides for codling moth (CM), twospotted spider mite (TSSM), European red mite (ERM) and Pear psylla (PP) control. A single tree crop destruct trial was conducted for CM control. This trial showed that five applications of Diamond with horticultural oil is very promising for total insect pest control in pears. Diamond was examined at three rates and even the lowest rate (0.125 lb AI/ac) provides better CM control than the grower standard. At the same time, the Diamond treatments did not flare-up TSSM, ERM and PP populations. It should be noted that Diamond is not yet registered for pears in California. It is hoped that it will receive California registration within two years. The evaluation of newly registered and unregistered miticides showed that Milbemectin plus horticultural oil and Apollo provided excellent control of ERM, but were less effective against PP nymphs. Little or no control of ERM was found with Acramite and Agri-Mek.

After harvest, it is common to find a large number of unharvested fruit remaining on the trees that serve as excellent sites for CM oviposition and allow for a rapid increase in the CM population. The CM that develops in these fruit after mid-August will enter the overwintering stage (diapause) and emerge as adults the following spring. CM larvae that infest over-ripe pears do not complete their larval development. Previous studies have shown that an application of a plant growth regulator, such as Ethrel, shortly after harvest promotes early ripening and fruit drop which then would largely eliminate the overwintering CM population without the use of insecticides or post-harvest fruit removal. The inclusion of sodium bicarbonate as a buffer to increase the pH in Ethrel did increase the rate of ripening, particularly in mature green fruit pears. However, the cost/benefit of buffering the spray solution is questionable. The additional cost to the grower would produce better results by simply increasing the rate of Ethrel.

Previous studies have shown that the amount of plant bug damage appears to be related to the amount of broad leaf weeds within the orchards and not to any outside source of plant bugs. Outside sources of plant bugs can provide large mobile populations that invade the pear orchards. But without broad leaf weeds, the plant bug populations do not stay in the pear orchards and thus cause little damage.

A study was conducted on the affect of plant bug damage due to broadleaf weeds in the ground cover. The ground cover, which was mowed every other week and sprayed with two broadleaf herbicides, was compared to the untreated control for the type of vegetation cover, number of plant bugs and percent damage. There were a significantly higher number of plant bugs caught in the untreated control, while pear damage was numerically higher in the mowed-herbicide treatment. The numerically higher damage present in the mowed and herbicide treatment could be attributed to the absence of broadleaf weeds, which is the plant bugs preferred food source. If broadleaf weeds can be sustained throughout the season, there may be a further reduction in percent damage.

Introduction: In the summer of 1996, the U.S. Congress unanimously passed, and the President signed, the Food Quality Protection Act. This piece of legislation will have a significant impact on insecticides used in the U.S. and particularly on those used on agricultural crops consumed by infants and children, such as pears. It is anticipated that many of the current organophosphate (OP) insecticides used on pears may have greatly extended pre-harvest intervals and/or greatly extended worker reentry intervals, or the manufacturer may be forced to terminate their registrations by the EPA. In addition, there is a continuing development of resistance within CM to existing and new insecticide chemistry. Thus, changes in the availability and use of pesticides will require more reduced risk, environmentally benign pest management strategies.

Reported here are the results of our 2003 evaluations of new IGRs, neonicotinoids, chitin disrupters insecticides for CM control, evaluation of registered and unregistered miticides for ERM control, evaluations of a buffer on post-harvest Ethrel applications to reduce overwintering CM populations, evaluation of mowing and selective herbicide use to control LB in pear orchards from adjacent alfalfa or safflower fields, large plot evaluations of Assail (reported by L. Varela) and evaluations of experimental organic insecticides for CM control in pears (reported by R. Elkins).

1. Evaluation of New Insecticides for Codling Moth Control

Methods and Materials: This trial was conducted in a commercial 'Bartlett' pear orchard in Fairfield, CA. This orchard was planted on a 25 ft. x 25 ft. spacing (70 trees/ac). Thirteen treatments and an untreated control were replicated four times in a randomized complete block (RCB) design. Each replicate was an individual tree. Foliar sprays were applied with a hand-held orchard sprayer operating at 250 psi with a finished spray volume of 200 gal/acre (2.87 gal/tree). Applications were scheduled based on degree-days (DD). DD were calculated with a biofix of 29 March for the first generation and a 23 June biofix for the second generation using a 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 IMPACT weather station at Cordelia, CA. Flight activity of male CM was monitored with a pheromone trap placed high in the canopy of an untreated tree. The application timings and treatments are shown on Table 1. Control of the CM generations was evaluated at commercial harvest on 5 August by inspecting a maximum of 250 fruit per tree for CM infestation. Control of PP nymphs, PP eggs, motile TSSM, TSSM eggs, motile ERM, ERM eggs, SJS crawlers, WPM and PRM was evaluated by leaf-brushing 10 exterior and 10 interior leaves collected from each tree weekly from 13 May through 28 July. The plates with the contents from the brushed leaves were counted under magnification (20X) in the laboratory.

Table 1. Treatments and Application Timings for Codling Moth Control, Fairfield, CA – 2003

Treatment	Rate lb(AI)/ac	No. Appl.	Application Dates (Degree Days from 1st or 2nd Biofix)
1. Agri-Mek 0.15EC[a]	0.01465	1	18 April (140 from 1st biofix)
Imidan 70WP[b]	3.5	1	7 May (259 from 1st biofix)
Guthion 50WP	1.5	2	3 June (673 from 1st biofix) and 4 July (253 from 2nd biofix)
2. Milbemectin 1%EC[a]	0.00195	1	18 April (140 from 1st biofix)
Imidan 70WP[b]	3.5	1	7 May (259 from 1st biofix)
Guthion 50WP	1.5	2	3 June (673 from 1st biofix) and 4 July (253 from 2nd biofix)
3. Imidan 70WP[b]	3.5	1	7 May (259 from 1st biofix)
Guthion 50WP	1.5	2	3 June (673 from 1st biofix) and 4 July (253 from 2nd biofix)
4. Dimilin 2L[a]	0.75	1	27 March (Popcorn Stage)
Imidan 70WP[b]	3.5	1	7 May (259 from 1st biofix)
Guthion 50WP	1.5	2	3 June (673 from 1st biofix) and 4 July (253 from 2nd biofix)
5. Seize 35WP[a]	0.1094	1	27 March (Popcorn Stage)
Imidan 70WP[b]	3.5	1	7 May (259 from 1st biofix)
Guthion 50WP	1.5	2	3 June (673 from 1st biofix) and 4 July (253 from 2nd biofix)
6. Dimilin 2L[a]	0.25	4	7 April (72 from 1st biofix), 22 April (165 from 1st Biofix), 22 June (958 from 1st Biofix) and 16 July (503 from 2nd Biofix)
7. Diamond 7.5WG[a]	0.125	5	7 April (72 from 1st biofix), 22 April (165 from 1st Biofix), 6 May (251 from 1st biofix), 22 June (958 from 1st Biofix) and 8 July (319 from 2nd biofix)
8. Diamond 7.5WG[a]	0.1875	5	7 April (72 from 1st biofix), 22 April (165 from 1st Biofix), 6 May (251 from 1st biofix), 22 June (958 from 1st Biofix) and 8 July (319 from 2nd biofix)
9. Diamond 7.5WG[a]	0.25	5	7 April (72 from 1st biofix), 22 April (165 from 1st Biofix), 6 May (251 from 1st biofix), 22 June (958 from 1st Biofix) and 8 July (319 from 2nd biofix)

Table 1. Continued.

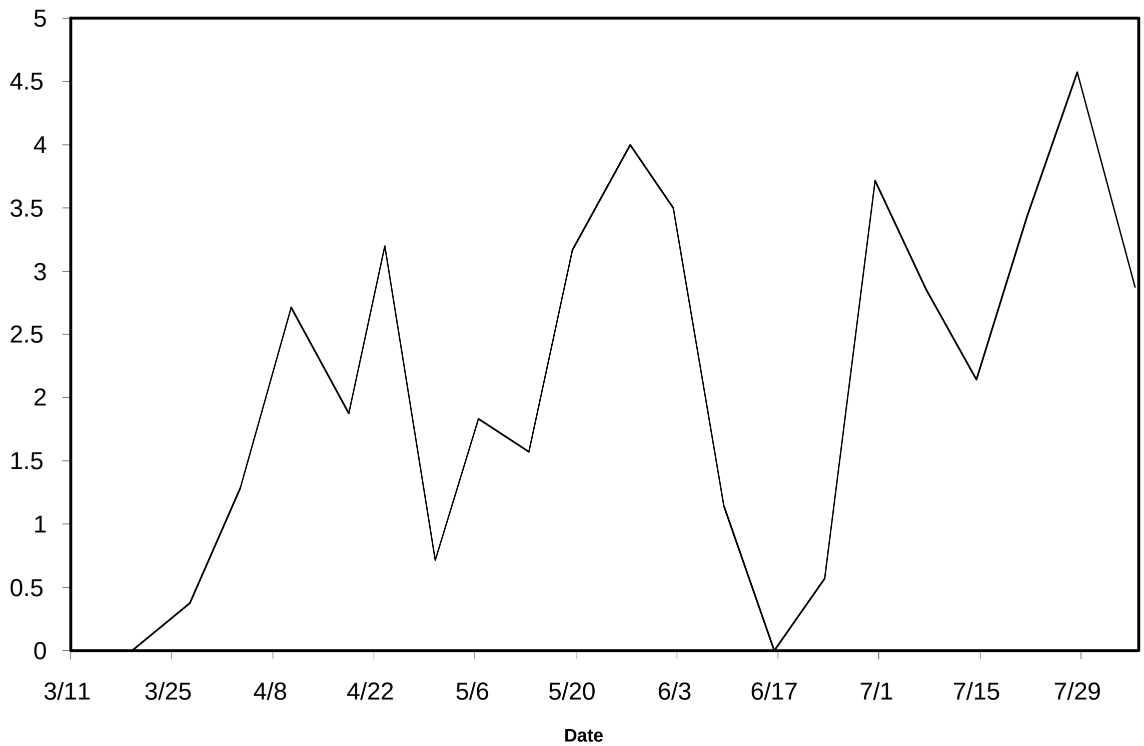
Treatment	Rate lb(AI)/ac	No. Appl.	Application Dates (Degree Days from 1st or 2nd Biofix)
10. Diamond 7.5WG[a]	0.25	3	7 April (72 from 1st biofix), 22 April (165 from 1st Biofix) and 6 May (251 from 1st biofix)
Imidan 70WP[b]	3.5	1	4 July (253 from 2nd biofix)
11. Calypso 4SC	0.1875	2	6 May (251 from 1st biofix) and 2 June (654 from 1st biofix)
Intrepid 2F[c]	0.25	1	1 July (192 from 2nd biofix)
12. Calypso 4SC	0.25	2	6 May (251 from 1st biofix) and 2 June (654 from 1st biofix)
Intrepid 2F[c]	0.25	1	1 July (192 from 2nd biofix)
13. Untreated	——		

[a] Treatments contained 0.25% Omni Supreme oil by volume.
[b] Treatment pH was adjusted to < 6.
[c] Treatments contained 0.0625% Latron B-1956 by volume.

Results and Discussion:

Flight Activity – The overwintering CM flight began 22 March (Fig. 1). The CM biofix is set when sunset air temperatures meet or exceed 62˚F and there is a sustained moth flight. This temperature is the minimum required for CM oviposition. The overwintering flight was bimodal this year. The first peak of the overwintering flight occurred around 22 April at 165 DD. The air temperatures were unseasonably cool through early May which dramatically affected the early moth flight. The first peak often occurs at 300 DD after biofix. The second peak of the overwintering flight occurred around 27 May at 532 DD. The second peak often occurs at 650 DD after biofix. The first flight was completed by 22 June at 958 DD. The first flight is usually completed by 1,000 DD. The second biofix was set on 23 June. The first peak of the second CM flight occurred approximately on 5 July at 272 DD after the 2nd biofix.

Fig. 1 – Seasonal Flight Activity of Codling Moth Captured in a Pheromone Trap Placed High in the Tree Canopy at Fairfield, CA - 2003



<u>CM Evaluation</u> – The CM infestation in the untreated control was over 70% (Table 2). Thus, this trial provided a stringent test of the experimental treatments. The CM infestation in all experimental treatments was significantly lower than in the untreated control. Although the Agri-Mek in the grower standard (GS) was applied mainly for its mite and psylla control, it also provided additional CM control when combined with Imidan and Guthion (Tr. #1). The GS is so effective that it had significantly less CM infestation compared to the similar treatments of Imidan followed by Guthion (Tr. #3) and Seize 35WP followed by Imidan and then Guthion (Tr. #5). The GS also had numerically less CM infestation compared to the similar treatments of Milbemectin followed by Imidan and Guthion (Tr. #2) and Dimilin followed by Imidan and Guthion (Tr. #4). All four Diamond treatments (Trs. #7-10) provided excellent CM control. The highest rate of Diamond plus Omni Supreme oil (Tr. #9) had significantly less CM infestation than all the other treatments except for the Diamond plus Omni Supreme oil followed by Imidan treatment (Tr. #10). Even the lowest rate of Diamond plus Omni Supreme oil (Tr. #7) had slightly less CM infestation than the GS. Diamond shows promise as a replacement product for Guthion or Imidan. However, Diamond was applied five times while there were only four applications in the GS. Four applications of Dimilin plus Omni Supreme oil (Tr. #6) and two applications of the low rate of Calypso followed by an application of Intrepid plus Latron (Tr. #11) both had significantly greater CM infestation than the GS. The two applications of the higher rate of Calypso followed by an application of Intrepid (Tr. #12) showed moderate CM control compared to all other treatments and was almost twice as effective as the lower rate of Calypso followed by Intrepid (Tr. #11).

Table 2. Mean Percent Codling Moth-Infested Fruit Inspected at Commercial Harvest in Fairfield, CA – 2003

Treatment		Rate lb (AI)/ac	No. Appl.	Mean[a] Percent Infested Fruit at Commercial Harvest
1.	Agri-Mek 0.15EC[b]	0.01465	1	3.7 bc
	Imidan 70WP[c]	3.5	1	
	Guthion 50WP	1.5	2	
2.	Milbemectin 1%EC[b]	0.00195	1	7.0 cde
	Imidan 70WP[c]	3.5	1	
	Guthion 50WP	1.5	2	
3.	Imidan 70WP[c]	3.5	1	9.4 e
	Guthion 50WP	1.5	2	
4.	Dimilin 2L[b]	0.75	1	5.5 bcde
	Imidan 70WP[c]	3.5	1	
	Guthion 50WP	1.5	2	
5.	Seize 35WP[b]	0.1094	1	9.1 e
	Imidan 70WP[c]	3.5	1	
	Guthion 50WP	1.5	2	
6.	Dimilin 2L[b]	0.25	4	8.8 de
7.	Diamond 7.5WG[b]	0.125	5	3.5 bc
8.	Diamond 7.5WG[b]	0.1875	5	3.2 b
9.	Diamond 7.5WG[b]	0.25	5	0.4 a
10.	Diamond 7.5WG[b]	0.25	3	2.5 ab
	Imidan 70WP[c]	3.5	1	
11.	Calypso 4SC	0.1875	2	8.4 de
	Intrepid 2F[d]	0.25	1	
12.	Calypso 4SC	0.25	2	4.5 bcd
	Intrepid 2F[d]	0.25	1	
13.	Untreated	–	–	70.2 f

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P \leq 0.05$). Data analyzed using an arcsin transformation.
[b] Treatments contained 0.25% Omni Supreme oil by volume.
[c] pH was adjusted to < 6.
[d] Treatments contained 0.0625% Latron B-1956 by volume

Secondary Pest Evaluations: Pear Psylla – The inclusion of Agri-Mek with Imidan and Guthion, the GS treatment (Tr. #1), was effective in suppressing most of the secondary pest flare-ups compared to the other treatments containing Imidan and Guthion (Trs. #2-5). A significant flare-up of PP nymphs was observed in the Imidan followed by Guthion treatment (Tr. #3) as well as in the Milbemectin, Dimilin and Seize followed by Imidan and Guthion treatments (Trs. #2, 4 and 5) compared to the untreated control (Tr. #13) (Table 3). The Agri-Mek in the GS successfully suppressed PP as it actually had less PP than the untreated control. The Milbemectin followed by Imidan and Guthion treatment (Tr. #2) had significantly more PP than all the other treatments. Although Milbemectin is primarily a miticidal material, it is troubling that it drastically flares up PP populations. The Imidan followed by Guthion treatment (Tr. #3) and the Seize followed by Imidan and Guthion treatment (Tr. #5) also had significantly more PP nymphs than all the other treatments except for treatments #2 and #4. In the Diamond treatments (Trs. #7, 8 and 9), the number of PP eggs increased along with the increasing rates of application and there were numerically more PP eggs in the highest Diamond rate (Tr. #9) than in all the other treatments except for treatment #2 (Table 3). However, there was no corresponding or significant increase in PP nymphs. There was also no significant difference in PP numbers between the Dimilin and Calypso treatments (Trs. #6, 11 and 12) and the untreated control (Tr. #13).

Secondary Pest Evaluations: Twospotted Spider Mite – The Seize treatment (Tr. #5) significantly flared-up the motile TSSM and eggs compared to all the other treatments (Table 4). Although a flare-up of mites is commonly associated with organophosphate insecticides such as Imidan and Guthion, it was unexpected to observe such a large flare-up of TSSM in the Seize treatment. It is unusual for any treatment to have more TSSM than the Imidan and Guthion treatment (Tr. #3). But when compared to the Imidan and Guthion treatment (Tr. #3) the Seize followed by Imidan and Guthion treatment had seven times as many motile TSSM (Table 4). Although Seize primarily targets PP, SJS and CM, it is disappointing to see that it significantly flares-up TSSM to such large populations. The GS (Tr. #1), Imidan followed by Guthion (Tr. #3) and the higher rate of Calypso followed by Intrepid (Tr. #12) treatments all showed a small increase in TSSM numbers. All of the other treatments were not significantly different from the untreated control.

Secondary Pest Evaluations: European Red Mite – The Imidan and Guthion treatment (Tr. #3) had significantly more motile ERM and ERM eggs than all the other treatments except for the Seize (Tr. #5) and Calypso followed by Intrepid treatments (Trs. #11 and 12) (Table 4). The Seize (Tr. #5) and Calypso followed by Intrepid treatments (Trs. #11 and 12) had numerically more motile ERM and eggs than the remainder of the treatments. The high motile ERM and egg numbers found in the Imidan and Guthion treatment (Tr. #3) and the Calypso followed by Intrepid treatments (Trs. #11 and 12) might be due to the lack of Omni Supreme oil. The combination of Omni Supreme oil to the Agri-Mek, Milbemectin or Dimilin treatments (Trs. #1, 2 and 4) was effective in suppressing both TSSM and ERM flare-ups that normally occur following an application of Imidan and Guthion.

Secondary Pest Evaluations: Western Predatory Mite, Pear Rust Mite and San Jose Scale – The high rate of Calypso followed by Intrepid treatment (Tr. #12) and the untreated control (Tr. #13) had significantly more WPM than all the other treatments except for the low rate of Calypso followed by Intrepid treatment (Tr. #11) (Table 5). The higher number of WPM found in the

Calypso followed by Intrepid treatments might be due to the flared-up ERM upon which the WPM feed. Also, the Calypso and Intrepid treatments did not have any added Omni Supreme oil that might suppress their populations. The Dimilin followed by the Imidan and Guthion treatment (Tr. #4) had significantly more PRM than all the other treatments (Table 5). The Imidan and Guthion (Tr. #3), the Seize followed by Imidan and Guthion (Tr. #5) and the two Calypso and Intrepid treatments (Trs. #11 and 12) all had high populations of PRM compared to the remainder of the treatments. The combination of Omni Supreme oil with Milbemectin and, to a lesser extent, Agri-Mek, was very effective in suppressing PRM flare-ups that normally occur from the Imidan and Guthion treatments that follow (Trs. #1 and 2). All of the experimental treatments were successful in suppressing SJS as they had significantly less SJS infestations compared to the untreated control (Tr. #13) (Table 5). The treatments containing Imidan and Guthion were slightly more effective at suppressing SJS than the other treatments.

Conclusions: This trial was conducted against a very high CM population with over 70% of the fruit infested at harvest in the untreated control and with 3.7% CM infested fruit in the grower standard. Diamond and the high rate of Calypso followed by Intrepid provided excellent CM control. A flare-up of PP nymph populations was observed in treatments containing Imidan and Guthion except for the treatment with Agri-Mek. A flare-up of TSSM populations was observed in the Seize treatment while a flare-up of ERM was observed in the Imidan and Guthion, Seize and Calypso treatments.

Table 3. Mean Total Number of Pear Psylla Nymphs and Eggs in Fairfield, CA – 2003.

Treatment	Rate lb (AI)/ac	No. Appl	Mean[a] Total per 20 Leaves PP Nymphs	PP eggs
1. Agri-Mek 0.15EC[b]	0.01465	1	133.3 a	39.0 a
Imidan 70WP[c]	3.5	1		
Guthion 50WP	1.5	2		
2. Milbemectin 1%EC[b]	0.00195	1	515.8 e	189.0 h
Imidan 70WP[c]	3.5	1		
Guthion 50WP	1.5	2		
3. Imidan 70WP[c]	3.5	1	387.0 d	118.5 fg
Guthion 50WP	1.5	2		
4. Dimilin 2L[b]	0.75	1	269.0 bc	95.8 def
Imidan 70WP[c]	3.5	1		
Guthion 50WP	1.5	2		
5. Seize 35WP[b]	0.1094	1	322.5 cd	128.5 fg
Imidan 70WP[c]	3.5	1		
Guthion 50WP	1.5	2		
6. Dimilin 2L[b]	0.25	4	165.8 ab	73.0 bcd
7. Diamond 7.5WG[b]	0.125	5	106.8 a	81.5 cde
8. Diamond 7.5WG[b]	0.1875	5	137.8 a	111.0 ef
9. Diamond 7.5WG[b]	0.25	5	138.5 a	147.8 g
10. Diamond 7.5WG[b]	0.25	3	138.8 a	100.0 def
Imidan 70WP[c]	3.5	1		
11. Calypso 4SC	0.1875	2	126.5 a	59.0 abc
Intrepid 2F[d]	0.25	1		
12. Calypso 4SC	0.25	2	119.3 a	43.0 ab
Intrepid 2F[d]	0.25	1		
13. Untreated	–	–	141.5 a	67.3 abcd

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P \leq 0.05$).
[b] Treatments contained 0.25% Omni Supreme oil by volume.
[c] pH was adjusted to < 6.
[d] Treatments contained 0.0625% Latron B-1956 by volume.

Table 4. Mean Total Number of TSSM and ERM Mites and Eggs in Fairfield, CA – 2003.

			Mean[a] Total per 20 Leaves			
	Rate	No.	TSSM		ERM	
Treatment	lb (AI)/ac	Appl.	Mites	Eggs	Mites	Eggs
1. Agri-Mek 0.15EC[b]	0.01465	1	4.8 a	4.8 a	1.5 a	56.5 a
Imidan 70WP[c]	3.5	1				
Guthion 50WP	1.5	2				
2. Milbemectin 1%EC[b]	0.00195	1	1.5 a	0.5 a	4.0 ab	97.0 a
Imidan 70WP[c]	3.5	1				
Guthion 50WP	1.5	2				
3. Imidan 70WP[c]	3.5	1	6.5 a	14.5 a	103.5 c	2484.3 d
Guthion 50WP	1.5	2				
4. Dimilin 2L[b]	0.75	1	0.3 a	1.8 a	7.8 ab	225.5 ab
Imidan 70WP[c]	3.5	1				
Guthion 50WP	1.5	2				
5. Seize 35WP[b]	0.1094	1	45.5 b	81.8 b	58.3 bc	1599.3 bcd
Imidan 70WP[c]	3.5	1				
Guthion 50WP	1.5	2				
6. Dimilin 2L[b]	0.25	4	0.0 a	4.0 a	1.8 a	72.0 a
7. Diamond 7.5WG[b]	0.125	5	0.5 a	3.8 a	2.0 a	106.0 a
8. Diamond 7.5WG[b]	0.1875	5	1.3 a	6.3 a	6.5 ab	325.3 abc
9. Diamond 7.5WG[b]	0.25	5	0.5 a	13.5 a	3.0 a	216.8 ab
10. Diamond 7.5WG[b]	0.25	3	1.5 a	3.0 a	5.3 ab	192.8 ab
Imidan 70WP[c]	3.5	1				
11. Calypso 4SC	0.1875	2	2.0 a	9.5 a	52.0 abc	2119.8 d
Intrepid 2F[d]	0.25	1				
12. Calypso 4SC	0.25	2	5.3 a	17.8 a	50.5 abc	1769.3 cd
Intrepid 2F[d]	0.25	1				
13. Untreated	–	–	0.5 a	6.8 a	2.3 a	169.3 ab

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P \leq 0.05$).
[b] Treatments contained 0.25% Omni Supreme oil by volume.
[c] pH was adjusted to < 6.
[d] Treatments contained 0.0625% Latron B-1956 by volume.

Table 5. Mean Total Number of Western Predatory Mites, Pear Rust Mites and San Jose Scales in Fairfield, CA – 2003.

Treatment	Rate lb (AI)/ac	No. Appl.	Mean[a] Total per 20 Leaves WPM	PRM	SJS
1. Agri-Mek 0.15EC[b]	0.01465	1	0.3 a	151.5 a	13.3 a
Imidan 70WP[c]	3.5	1			
Guthion 50WP	1.5	2			
2. Milbemectin 1%EC[b]	0.00195	1	1.3 ab	39.0 a	18.8 a
Imidan 70WP[c]	3.5	1			
Guthion 50WP	1.5	2			
3. Imidan 70WP[c]	3.5	1	1.5 ab	731.8 a	12.5 a
Guthion 50WP	1.5	2			
4. Dimilin 2L[b]	0.75	1	3.3 ab	2271.0 b	18.8 a
Imidan 70WP[c]	3.5	1			
Guthion 50WP	1.5	2			
5. Seize 35WP[b]	0.1094	1	2.8 ab	807.3 a	11.8 a
Imidan 70WP[c]	3.5	1			
Guthion 50WP	1.5	2			
6. Dimilin 2L[b]	0.25	4	2.5 ab	42.0 a	32.0 a
7. Diamond 7.5WG[b]	0.125	5	2.0 ab	58.5 a	42.0 a
8. Diamond 7.5WG[b]	0.1875	5	3.3 ab	52.5 a	58.0 a
9. Diamond 7.5WG[b]	0.25	5	3.3 ab	105.5 a	31.8 a
10. Diamond 7.5WG[b]	0.25	3	2.5 ab	103.5 a	23.8 a
Imidan 70WP[c]	3.5	1			
11. Calypso 4SC	0.1875	2	5.8 bc	955.5 a	20.3 a
Intrepid 2F[d]	0.25	1			
12. Calypso 4SC	0.25	2	8.8 c	628.5 a	22.3 a
Intrepid 2F[d]	0.25	1			
13. Untreated	–	–	8.8 c	43.5 a	163.5 b

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P \leq 0.05$).
[b] Treatments contained 0.25% Omni Supreme oil by volume.
[c] pH was adjusted to < 6.
[d] Treatments contained 0.0625% Latron B-1956 by volume.

2. Evaluation of New Insecticides for European Red Mite Control

Methods and Materials: This trial was conducted in a commercial 'Bartlett' pear orchard in Courtland, CA. This orchard was planted on a 20 ft. x 12 ft. spacing (182 trees/ac). Fifteen treatments were replicated four times in a RCB design. Each replicate was an individual tree. Foliar sprays were applied with a hand-held orchard sprayer operating at 250 psi with a finished spray volume of 250 gal/acre (1.37 gal/tree). The miticides were applied on 2 September. Control of motile European Red mites (ERM), ERM eggs, Pear Psylla (PP) nymphs and Western Predatory mites (WPM) was evaluated by leaf-brushing 10 exterior and 10 interior leaves collected from each tree on 26 August (Pre-Treatment count) and then weekly from 10 September through 1 October. The plates with the contents from the brushed leaves were counted under magnification (20X) in the laboratory.

Results and Discussion:

Motile European Red Mite Evaluation – This experiment was conducted in an orchard with heavy ERM populations. In the pre-treatment sampling, there was an average of 147 motile ERM and 1,604 ERM eggs per 20 brushed leaves. Thus, this trial provided a stringent test of the experimental treatments. One week after the applications, all of the experimental miticides caused a significant reduction in the ERM population compared to the untreated control (Tr. #15) except for all of the Acramite treatments (Trs. #1-4) (Table 6). In fact, the high rate of both Acramite 75WG (Tr. #2) and Acramite 50WS (Tr. #4) never had significantly less motile ERM than the untreated control throughout the duration of this experiment. Two weeks after the application until the end of the experiment, both rates of Agri-Mek (Trs. #5-6) never had significantly less motile ERM than the untreated control. The high rate of Agri-Mek (Tr. #6) ended up having more total motile ERM than the untreated control. Milbemectin (Tr. #9), Fujimite (Tr. #13) and Apollo as the grower standard (GS) (Tr. #14) had less total motile ERM than the remainder of the treatments and they all had significantly less total motile ERM than the untreated control (Tr. #15). Both of the Pyramite treatments (Trs. #7-8), Onager (Tr. #10) and both rates of Envidor (Trs. #11-12) also had significantly less total motile ERM than the untreated control. It is interesting to note that the results of last year's ERM trial showed that the same rates of Acramite and Pyramite consistently out performed Milbemectin without oil. This year, the performance of Milbemectin was significantly improved with the addition of Omni Supreme oil.

European Red Mite Egg Evaluation – There was no correlation between the number of ERM eggs and motile ERM. Although no treatment had significantly less total ERM eggs than the untreated control, the Acramite treatments (Trs. #1-4) and the Milbemectin treatment (Tr. #9) all had numerically less total ERM eggs than the untreated control (Tr. #15) (Table 7). The lower rate of Pyramite (Tr. #7), Onager (Tr. #10) and both rates of Envidor (Trs. #11-12) all had significantly more total ERM eggs than the untreated control.

Pear Psylla Nymph Evaluation – The higher rate of Acramite 75WG (Tr. #2) flared up the total PP population significantly compared to the untreated control (Tr. #15) and had more total PP than the rest of the treatments (Table 8). The lower rate of Acramite 75WG (Tr. #1) also flared up PP and had numerically more total PP than the remainder of the treatments, but did not differ significantly from the untreated control. The rest of the experimental treatments did not significantly flare up PP compared to the untreated control.

Western Predatory mite Evaluation – The untreated control had significantly more total WPM than all the other treatments (Table 9). The low rate of Agri-Mek (Tr. #5), both rates of Pyramite (Trs. #7-8), Milbemectin (Tr. #9) and Fujimite (Tr. #13) all suppressed WPM populations. Besides the untreated control, the Acramite treatments (Trs. #1-4) had the largest WPM populations. The high number of WPM in the Acramite treatments might be due to the high number of ERM found in these treatments upon which the WPM feed.

No significant San Jose Scale populations were found and their numbers were not reported. Also, very few twospotted spider mites or rust mites were observed among the treatments and their numbers were not reported.

Conclusions: This experiment was conducted against very high ERM populations that provided a stringent test of the experimental treatments. Milbemectin plus Omni Supreme oil and Apollo provided excellent control of ERM.

Table 6. Mean Number of Motile European Red Mite per 20 Leaves in Courtland, CA – 2003

	Rate	Mean[a] No. Motile European Red Mite per 20 Leaves					
Treatment	lb (AI)/ac	8/26[b]	9/10	9/17	9/24	10/1	Total
1. Acramite 75WG	0.375	149.5 a	85.8 bc	51.5 abcde	32.5 a	170.0 bc	339.8 bcdef
2. Acramite 75WG	0.5	165.5 a	66.5 abc	82.5 de	67.5 abcd	171.5 bc	388.0 cdef
3. Acramite 50WS	0.375	160.3 a	66.0 abc	73.0 bcde	37.5 ab	158.5 abc	335.0 bcdef
4. Acramite 50WS	0.5	148.8 a	83.5 bc	77.5 cde	91.5 d	182.0 bc	434.5 def
5. Agri-Mek 0.15EC[c]	0.0147	148.3 a	36.0 ab	64.5 bcde	78.0 cd	145.0 abc	323.5 abcde
6. Agri-Mek 0.15EC[c]	0.0188	148.8 a	56.0 ab	138.0 f	99.0 d	192.0 c	485.0 f
7. Pyramite 60W[d]	0.2475	164.3 a	41.0 ab	83.5 de	74.0 bcd	105.5 abc	304.0 abcd
8. Pyramite 60W[d]	0.495	136.5 a	37.5 ab	42.5 abcd	45.5 abc	185.0 c	310.5 abcd
9. Milbemectin EC[c]	0.015	163.0 a	39.0 ab	16.5 a	44.5 abc	74.0 a	174.0 a
10. Onager 1E	0.125	145.5 a	40.0 ab	57.0 abcde	45.5 abc	125.0 abc	267.5 abc
11. Envidor 2SC	0.2188	150.0 a	50.0 ab	47.0 abcd	38.0 ab	113.0 abc	248.0 abc
12. Envidor 2SC	0.2813	124.8 a	51.0 ab	62.0 bcde	43.0 abc	143.5 abc	299.5 abcd
13. Fujimite 5EC	1.25	136.8 a	33.5 ab	30.0 ab	44.0 abc	109.0 abc	216.5 ab
14. Apollo SC	0.1875	129.0 a	23.0 a	38.5 abc	35.0 a	88.5 ab	185.0 ab
15. Untreated	——	126.0 a	118.5 c	92.0 e	85.0 d	175.0 bc	470.5 ef

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, P < 0.05).

[b] Pre-treatment sample.

[c] Treatments contained 0.25% Omni Supreme oil by volume.

[d] Treatments contained .03125% of R-11 spreader activator by volume.

Table 7. Mean Number of European Red Mite Eggs per 20 Leaves in Courtland, CA – 2003

Treatment	Rate lb(AI)/ac	Mean[a] No. European Red Mite Eggs per 20 Leaves 8/26[b]	9/10	9/17	9/24	10/1	Total
1. Acramite 75WG	0.375	1597.5 a	815.8 abc	169.0 a	167.0 a	198.5 a	1350.3 a
2. Acramite 75WG	0.5	1774.5 a	663.0 a	189.0 a	159.5 a	222.0 a	1233.5 a
3. Acramite 50WS	0.375	1609.5 a	589.5 a	208.5 a	186.5 a	209.0 a	1193.5 a
4. Acramite 50WS	0.5	1404.0 a	659.5 a	247.0 ab	190.5 a	235.0 a	1332.0 a
5. Agri-Mek 0.15EC[c]	0.0147	1660.5 a	1327.0 bcdef	856.0 cd	905.0 c	1020.0 bcd	4108.0 bcde
6. Agri-Mek 0.15EC[c]	0.0188	1374.0 a	1102.0 abcd	771.0 bcd	952.0 cd	865.0 bc	3690.0 bcd
7. Pyramite 60W[d]	0.2475	1449.0 a	1585.5 def	1245.0 def	1196.0 cd	1315.0 cd	5341.5 def
8. Pyramite 60W[d]	0.495	1528.5 a	1189.0 abcde	897.0 cd	881.0 c	1173.0 bcd	4140.0 bcde
9. Milbemectin EC[c]	0.015	1344.3 a	742.0 ab	424.0 abc	748.0 bc	629.0 ab	2543.0 ab
10. Onager 1E	0.125	1702.5 a	1530.5 def	1763.0 f	2038.5 e	1895.0 e	7227.0 g
11. Envidor 2SC	0.2188	2100.0 a	1419.0 cdef	1251.0 def	1431.0 d	1562.0 de	5663.0 efg
12. Envidor 2SC	0.2813	1843.5 a	1851.5 f	1523.5 ef	1221.0 cd	1435.0 cde	6031.0 fg
13. Fujimite 5EC	1.25	1417.5 a	1163.0 abcd	1111.0 de	1103.0 cd	1160.0 bcd	4537.0 cdef
14. Apollo SC	0.1875	1564.5 a	1140.5 abcd	1071.0 de	1004.0 cd	943.0 bc	4158.5 bcde
15. Untreated	——	1689.0 a	1825.0 ef	506.0 abc	354.5 ab	232.5 a	2918.0 abc

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P < 0.05$).

[b] Pre-treatment sample.

[c] Treatments contained 0.25% Omni Supreme oil by volume.

[d] Treatments contained .03125% of R-11 spreader activator by volume.

Table 8. Mean Number of Pear Psylla Nymphs per 20 Leaves in Courtland, CA – 2003

Treatment	Rate lb (AI)/ac	Mean[a] No. Pear Psylla Nymphs per 20 Leaves 8/26[b]	9/10	9/17	9/24	10/1	Total
1. Acramite 75WG	0.375	0.3 a	0.3 a	0.8 a	2.0 c	1.8 a	4.9 bc
2. Acramite 75WG	0.5	0.3 a	1.0 a	2.3 b	1.5 bc	1.3 a	6.1 c
3. Acramite 50WS	0.375	0.0 a	0.8 a	0.5 a	0.3 ab	0.5 a	2.1 ab
4. Acramite 50WS	0.5	0.0 a	0.8 a	0.5 a	0.5 ab	0.8 a	2.6 abc
5. Agri-Mek 0.15EC[c]	0.0147	0.0 a	1.0 a	1.3 ab	0.5 ab	0.5 a	3.3 abc
6. Agri-Mek 0.15EC[c]	0.0188	0.0 a	0.0 a	0.5 a	0.3 ab	1.5 a	2.3 ab
7. Pyramite 60W[d]	0.2475	0.0 a	0.3 a	0.5 a	0.0 a	1.8 a	2.6 abc
8. Pyramite 60W[d]	0.495	0.0 a	0.3 a	0.5 a	0.8 abc	0.8 a	2.4 ab
9. Milbemectin EC[c]	0.015	0.0 a	0.3 a	0.5 a	0.3 ab	1.8 a	2.9 abc
10. Onager 1E	0.125	0.0 a	0.0 a	0.8 a	0.0 a	0.5 a	1.3 ab
11. Envidor 2SC	0.2188	0.0 a	0.0 a	0.3 a	0.3 ab	2.3 a	2.9 abc
12. Envidor 2SC	0.2813	0.0 a	0.0 a	0.0 a	0.0 a	0.3 a	0.3 a
13. Fujimite 5EC	1.25	0.0 a	0.0 a	0.0 a	0.8 abc	0.8 a	1.6 ab
14. Apollo SC	0.1875	0.0 a	0.5 a	0.0 a	0.3 ab	1.8 a	2.6 abc
15. Untreated	——	0.0 a	0.5 a	0.3 a	0.0 a	0.5 a	1.3 ab

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P < 0.05$).

[b] Pre-treatment sample.

[c] Treatments contained 0.25% Omni Supreme oil by volume.

[d] Treatments contained .03125% of R-11 spreader activator by volume.

Table 9. Mean Number of Western Predatory Mites per 20 Leaves in Courtland, CA – 2003

Treatment	Rate lb (AI)/ac	Mean[a] No. Western Predatory Mites per 20 Leaves 8/26[b]	9/10	9/17	9/24	10/1	Total
1. Acramite 75WG	0.375	7.8 abc	25.5 ef	15.5 ab	9.0 abcd	21.5 c	71.5 e
2. Acramite 75WG	0.5	2.5 a	16.5 cde	19.0 b	17.0 d	13.5 abc	66.0 de
3. Acramite 50WS	0.375	5.8 ab	18.0 de	16.5 ab	11.5 abcd	13.0 abc	59.0 cde
4. Acramite 50WS	0.5	9.8 abc	13.5 abcd	12.5 ab	11.5 abcd	15.0 abc	52.5 abcde
5. Agri-Mek 0.15EC[c]	0.0147	10.0 abc	7.5 abc	8.5 ab	3.5 a	10.0 ab	29.5 ab
6. Agri-Mek 0.15EC[c]	0.0188	5.0 ab	7.0 abc	11.5 ab	10.0 abcd	9.5 ab	38.0 abcd
7. Pyramite 60W[d]	0.2475	8.3 abc	4.5 a	7.5 ab	4.5 a	8.0 a	24.5 a
8. Pyramite 60W[d]	0.495	7.5 abc	9.0 abcd	5.5 a	5.5 a	8.5 a	28.5 ab
9. Milbemectin EC[c]	0.015	6.3 ab	4.0 a	8.5 ab	6.0 ab	8.0 a	26.5 ab
10. Onager 1E	0.125	2.3 a	12.0 abcd	14.5 ab	7.0 abc	11.0 ab	44.5 abcde
11. Envidor 2SC	0.2188	12.5 bc	12.5 abcd	17.0 ab	15.0 bcd	9.0 a	53.5 bcde
12. Envidor 2SC	0.2813	4.3 ab	15.0 bcd	12.0 ab	15.5 cd	8.5 a	51.0 abcde
13. Fujimite 5EC	1.25	16.3 c	6.0 ab	7.5 ab	7.5 abc	12.5 abc	33.5 abc
14. Apollo SC	0.1875	7.5 abc	11.5 abcd	15.5 ab	9.5 abcd	13.0 abc	49.5 abcde
15. Untreated	——	12.0 bc	30.5 f	34.5 c	30.5 e	19.5 bc	115.0 f

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P < 0.05$).

[b] Pre-treatment sample.

[c] Treatments contained 0.25% Omni Supreme oil by volume.

[d] Treatments contained .03125% of R-11 spreader activator by volume.

3. Codling Moth Management through Post-Harvest Control

Methods and Materials: A trial was conducted in a commercial 'Bartlett' pear orchard in Fairfield, CA. Seven treatments were replicated five times in a randomized complete block design. Each replicate was an individual tree and the trees were planted on a 24 ft. by 24 ft. spacing (76 trees/ac). The treatments were: Ethrel at 300 ppm (1 pt/100 gal) with or without 2.65 grams of sodium bicarbonate per gallon, Ethrel at 600 ppm (2 pt/100 gal) with or without 3.785 grams of sodium bicarbonate per gallon, Ethrel at 1200 ppm (4 pt/100 gal) with or without 7.57 grams of sodium bicarbonate per gallon, and an untreated control. The sodium bicarbonate was used as a buffer to increase the pH in the Ethrel solutions to 6.5 to 7. Foliar sprays were applied with a hand-held orchard sprayer operating at 250 psi with a finished spray volume of 250 gal/acre (3.29 gal/tree). The treatments were applied post-harvest on 22 August 2003.

The effect of Ethrel on fruit maturity (fruit drop, pressure and color) was evaluated weekly from 29 August through 26 September. Fruit drop was evaluated on 20 mature green fruit and 10 rattail fruit per replicate (100 mature green fruit and 50 rattail fruit per treatment). The fruit were flagged prior to the Ethrel applications. The accumulative percent fruit drop was based on the number of flagged fruit remaining on the trees at the weekly evaluations. The effect of Ethrel on fruit pressure and color was evaluated on three mature green fruit and one rattail fruit per replicate (15 mature green fruit and five rattail fruit per treatment). Fruit pressure was determined with a penetrometer by taking three readings per fruit. Fruit color was determined using standardized peach maturity color chips which were provided by the California Tree Fruit

Agreement. The chips were modified to more accurately reflect pear maturity. We assigned color A = 1, C = 2, D = 3, H = 4, I = 5, and J = 6.

Results and Discussion:

Fruit Drop Evaluation – Mean percent mature green fruit and rattail fruit drop was accelerated with a post-harvest application of Ethrel compared to the untreated control. The 1200 ppm with buffer treatment had significantly greater mature green fruit drop than the untreated control and the 300 and 600 ppm with or without buffer treatments from week 1 through week 4 (Table 10). The 1200 ppm without buffer treatment had significantly greater mature green fruit drop than the untreated control from week 2 to week 5. Although the 300 and 600 ppm with or without buffer treatments never had significantly greater mature green fruit drop than the untreated control, they had numerically greater green fruit drop compared to the untreated control from week 3 to week 5. Throughout the experiment, there were no significant differences in mature green fruit drop between any of the treatments and their buffered counterparts except for the 1200 ppm treatments at week 1. There were no significant differences among the treatments for rattail fruit drop on weeks 1 and 2 (Table 11). The 1200 ppm with buffer treatment had significantly greater rattail fruit drop compared to the untreated control from week 3 through week 5. The 300 ppm with buffer treatment, both 600 ppm treatments and the 1200 ppm without buffer treatment had significantly greater rattail fruit drop compared to the untreated control on week 4 and week 5. The 300 ppm treatment without buffer never differed from the untreated control. Throughout the experiment, there were no significant differences in rattail fruit drop between any of the treatments and their buffered counterparts except for the 300 ppm treatments at weeks 4 and 5. Rattail fruit are formed late in the season (May through June) from delayed abnormal bloom. Rattail fruit have an incomplete or no abscission layer between the fruit and the stem that prevents normal drop and response from an Ethrel application. In addition, since rattail fruit are formed late in the season, they remain firm and susceptible to CM attack through September.

Fruit Pressure Evaluation – In addition to fruit drop, mean mature green fruit and rattail fruit pressure were similarly reduced with a post-harvest Ethrel application. The 600 and 1200 ppm with or without buffer treatments had significantly lower mature green fruit pressure than the untreated control at each weekly evaluation (Table 12). The 300 ppm treatments had numerically lower green fruit pressure compared to the untreated control throughout the experiment. There was no consistently lower pressure for mature green fruit in the Ethrel treatments with buffer compared to their unbuffered counterparts. The 1200 ppm without buffer treatment had significantly lower rattail pressure than the untreated control throughout the experiment (Table 13). The 1200 ppm with buffer treatment had numerically lower rattail pressure than the untreated control from week 2 to week 5. Both 600 ppm treatments had significantly lower rattail pressure than the untreated control on week 4 and week 5. All the treatments had significantly lower rattail fruit pressure than the untreated control on week 5. There was no consistently lower rattail fruit pressure in the treatments with or without buffer. Due to the lack of rattails, several treatments were removed from the analysis during week 3 and week 4.

Fruit Color Evaluation – A corresponding change was also observed with fruit color for both mature green fruit and rattail fruit. Both 1200 ppm treatments had significantly higher mature green fruit color ratings than the untreated control throughout the experiment (Table 14). The

300 and 600 ppm with or without buffer treatments had numerically higher mature green fruit color ratings than the untreated control throughout the experiment. There was no consistently higher mature fruit color rating in the treatments with buffer versus the treatments without buffer. Both 1200 ppm treatments had significantly higher rattail fruit color ratings than the untreated control from week 2 through week 5 (Table 15). All of the 300 and 600 ppm treatments had numerically higher rattail fruit color ratings than the untreated control on week 4 and week 5. All of the treatments had significantly higher rattail fruit color ratings than the untreated control on week 5. There was no consistently higher rattail fruit color rating in the treatments with buffer versus the treatments without buffer. A few pressure and color readings reversed themselves on week 5. This is likely due to the high fruit drop by week 5 that would then skew the pressure and color data towards the unripe fruit remaining on the tree. Thus the week 5 data likely underestimates the effectiveness of the Ethrel application.

Our past research has shown that if pears reach a fruit color of 3 (D color) or greater and fruit pressure of 0.1 kg/mm^2 or less, then the pears cannot support the complete larval development of codling moth. These parameters were reached in the mature green fruit by week 1 in the 600 and 1200 ppm treatments, by week 2 in 300 ppm treatments and by week 3 in the untreated control. These parameters were reached in rattail fruit by week 3 in the 1200 ppm treatments, by week 4 in the 600 ppm treatments, by week 5 in the 300 ppm treatments and were never reached in the untreated control.

Conclusions: Post-harvest Ethrel studies showed that Ethrel accelerated mature green fruit ripening and drop and rattail fruit ripening compared to the untreated control. The inclusion of sodium bicarbonate as a buffer to increase the pH in Ethrel spray solution did increase the rate of ripening, particularly in mature green fruit pears. Unfortunately, the results were often not consistent. The cost/benefit of buffering the spray solution is questionable. The additional cost to the grower would produce better results by simply increasing the rate of Ethrel.

Table 10. Mean Accumulative Percent Mature Green Fruit Drop in Fairfield, CA – 2003.

Treatment	Rate pt/100 gal	Mean Accumulative Percent Mature Green Fruit Drop[a]				
		Week 1	Week 2	Week 3	Week 4	Week 5
Untreated Control	—	0.00 a	0.02 a	0.10 a	0.21 a	0.46 a
300 ppm	1	0.01 a	0.02 a	0.17 a	0.41 a	0.69 ab
300 ppm+buffer	1	0.00 a	0.03 a	0.26 a	0.47 a	0.68 ab
600 ppm	2	0.01 a	0.02 a	0.34 ab	0.48 a	0.57 a
600 ppm+buffer	2	0.02 a	0.08 a	0.31 a	0.47 a	0.58 a
1200 ppm	4	0.01 a	0.23 b	0.65 bc	0.84 b	0.86 b
1200 ppm+buffer	4	0.06 b	0.31 b	0.73 c	0.80 b	0.83 b

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, P $\leq$ 0.05). Data analyzed using an arcsin transformation.

Table 11. Mean Accumulative Percent Rattail Fruit Drop in Fairfield, CA – 2003.

Treatment	Rate pt/100 gal	Mean Accumulative Percent Rattail Fruit Drop[a]				
		Week 1	Week 2	Week 3	Week 4	Week 5
Untreated Control	—	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a
300 ppm	1	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a
300 ppm+buffer	1	0.00 a	0.00 a	0.03 ab	0.06 b	0.08 b
600 ppm	2	0.00 a	0.01 a	0.02 ab	0.06 b	0.06 b
600 ppm+buffer	2	0.00 a	0.00 a	0.02 ab	0.05 b	0.06 b
1200 ppm	4	0.00 a	0.02 a	0.03 ab	0.05 b	0.06 b
1200 ppm+buffer	4	0.01 a	0.01 a	0.06 b	0.06 b	0.06 b

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, P $\leq$ 0.05). Data analyzed using an arcsin transformation.

Table 12. Mean Fruit Pressure of Mature Green Fruit in Fairfield, CA – 2003.

Treatment	Rate pt/100 gal	Mean Mature Green Fruit Pressure (kg/mm^2)[a]				
		Week 1	Week 2	Week 3	Week 4	Week 5
Untreated Control	—	0.16 c	0.14 d	0.09 b	0.08 c	0.06 d
300 ppm	1	0.12 ab	0.08 c	0.06 b	0.04 b	0.02 ab
300 ppm+buffer	1	0.13 bc	0.08 c	0.02 a	0.01 a	0.05 cd
600 ppm	2	0.12 ab	0.07 bc	0.03 a	0.03 ab	0.03 bc
600 ppm+buffer	2	0.12 ab	0.06 bc	0.01 a	0.03 ab	0.02 ab
1200 ppm	4	0.08 a	0.03 a	0.02 a	0.03 ab	0.00 a
1200 ppm+buffer	4	0.10 a	0.04 ab	0.01 a	0.02 ab	0.02 ab

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

Table 13. Mean Fruit Pressure of Rattail Fruit in Fairfield, CA – 2003.

Treatment	Rate pt/100 gal	Mean Rattail Fruit Pressure (kg/mm^2)[a]				
		Week 1	Week 2	Week 3	Week 4	Week 5
Untreated Control	—	0.243 bc	0.214 b	0.175 ab	0.196 b	0.195 d
300 ppm	1	0.252 c	0.219 b	0.193 b	—	0.110 c
300 ppm+buffer	1	0.194 ab	0.248 b	—	0.208 b	0.086 bc
600 ppm	2	0.242 bc	0.221 b	0.175 ab	0.073 a	0.052 abc
600 ppm+buffer	2	0.262 c	0.241 b	—	0.079 a	0.035 ab
1200 ppm	4	0.180 a	0.097 a	—	—	0.004 a
1200 ppm+buffer	4	0.251 c	0.110 a	0.100 a	0.017 a	0.009 a

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

Table 14. Mean Fruit Color of Mature Green Fruit in Fairfield, CA – 2003.

Treatment	Rate pt/100 gal	Mean Mature Green Fruit Color[a]				
		Week 1	Week 2	Week 3	Week 4	Week 5
Untreated Control	—	1.73 a	2.53 a	3.60 a	3.93 a	5.00 a
300 ppm	1	2.87 ab	4.00 b	4.07 a	5.40 b	5.73 b
300 ppm+buffer	1	2.20 ab	4.47 bc	5.33 b	5.60 b	5.60 b
600 ppm	2	3.27 b	3.74 ab	5.27 b	5.53 b	5.53 ab
600 ppm+buffer	2	2.93 ab	4.40 bc	5.33 b	5.47 b	6.00 b
1200 ppm	4	3.07 b	5.73 d	5.73 b	5.73 b	6.00 b
1200 ppm+buffer	4	3.33 b	5.33 cd	6.00 b	6.00 b	5.60 b

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

Table 15. Mean Fruit Color of Rattail Fruit in Fairfield, CA – 2003.

Treatment	Rate pt/100 gal	Mean Rattail Fruit Color[a]				
		Week 1	Week 2	Week 3	Week 4	Week 5
Untreated Control	—	1.0 a	1.0 a	1.8 a	1.5 a	1.6 a
300 ppm	1	1.0 a	1.5 ab	1.7 a	—	3.8 b
300 ppm+buffer	1	1.0 a	1.3 ab	—	1.8 a	4.2 bc
600 ppm	2	1.0 a	1.3 ab	1.7 a	4.2 b	4.8 bc
600 ppm+buffer	2	1.0 a	1.3 ab	—	3.6 ab	5.4 bc
1200 ppm	4	1.4 a	2.7 c	—	—	6.0 c
1200 ppm+buffer	4	1.0 a	2.2 bc	3.5 b	5.8 b	6.0 c

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

4. Effect of Cover Crop Control on Plant Bug Damage in Pears

Methods and Materials: This trial was conducted in a commercial pear orchard in the Sacramento Delta. The trial was initiated on 14 May 2003 and was terminated on 14 August 2003. The pear orchard had an adjacent safflower field. There were two treatments that were replicated three times. The two treatments were: 1) mowed every other week and sprayed with two herbicide applications and 2) untreated control, which was neither mowed nor sprayed throughout the season. Mowing was started on 14 May and the entire orchard was mowed about 28 July in preparation for harvest. Two broadleaf herbicides (Orchard Master) were applied within and between the tree rows during the course of this study. Each replicate was 7 trees wide by 187 feet long. The replicates ran perpendicular to the safflower field. Along each replicate, there were four sampling locations at 1, 4, 8 and 12 trees from the safflower field. At each sampling location, plant bug populations were sampled weekly by checking a one square meter plastic sticky panel trap, taking 100 sweep net samples and making visual inspections of 100 randomly chosen fruit for plant bug damage. In addition, the safflower field adjacent to each of the six replicates was sampled for plant bugs by taking 100 sweep net samples. The type of vegetation cover both within and between the tree rows at each of the sampling locations was recorded monthly using a one square meter plastic frame (vegetation sampler). The vegetation sampler was randomly thrown three times at each trap location and the percent ground cover was recorded. The vegetation sampling between tree rows was initiated on 15 May 2003, while the vegetation sampling did not begin within the tree rows until 12 June 2003. The entire orchard was mowed about 28 July in preparation for harvest and the orchard was size-picked about 4 August with the final harvest about 12 August.

Results and Discussion: The vegetation identification samples found ten species of grasses and over 20 species of broadleaf weeds (Table 16). The most dominant grass species were dallisgrass and yellow foxtail while the most dominant broadleaf weeds were common mallow, knotweed sp., field bindweed, pale smartweed and redroot pigweed. On the first sampling date of 15 May, there was no significant difference between the tree rows in the percent grass or bare-ground (Table 17). However there was significantly higher percent cover of broadleaf weeds in the untreated control compared to the mowed-herbicide treatment. The increase in the broadleaf weeds was due to the mowing immediately prior to the first sample. The percent cover of broadleaf weeds was significantly higher in the untreated control compared to the mowed-herbicide treatment for the duration of the study. The percent grass cover was similar between the two treatments at the start of the experiment. However, the mowed-herbicide treatment had significantly higher percent cover of grasses compared to the untreated control for the remainder of the study. The herbicide applications suppressed the broadleaf weeds and the grasses then out-competed the broadleaf weeds. These two factors resulted in a die-back of the broadleaf weeds and a shifting of the weed complex in the mowed-herbicide and control treatments. There was no difference in the amount of bare-ground cover between the treatments on the first two sampling dates. However, the percent of bare-ground cover decreased through the season in both the mowed-herbicide and control treatments until the last sampling date of 14 August. The large increase in the percent bare-ground in the control on 14 August was the result of the entire orchard being mowed in preparation for harvest. The mowing of he entire orchard exposed bare ground that had been previously covered with both grasses and broadleaf weeds.

The use of glyphosate and other herbicides within the tree rows prior to the initiation of this study resulted in a large percent of bare-ground cover in both the mowed-herbicide and control treatments (Table 18). The control treatment had a steady drop in the percent of bare-ground cover, resulting in a significant difference in the mean season total between the bare-ground cover and control treatments. This was due to the in-season mowing and herbicide applications. There was no significant difference in the grass percent cover between the treatments throughout the season, although there was a steady increase in the grass percent cover in the control. There were significant differences between the treatments in the percent cover of broadleaf weeds at the start of the sampling period, due to the application of broadleaf weed herbicides within the tree row and to some extent, the mowing.

Safflower is a known host of Lygus bugs and other plant bugs. The adjacent safflower field had significantly higher number of plant bugs per sweep location than the other orchard sampling locations (Table 19). The highest number of plant bugs per sweep location was found in the first sampling location one tree in from the safflower field in both treatments. There was a significant drop in sweep net captures of plant bugs by the third sampling location (in eight trees) from the safflower field compared to the first sampling location in both treatments. However, the sweep net captures at the last sampling location (in 16 trees) increased in both treatments. This was probably due to outside pressure from plant bugs in the back edge of the orchard. The first sampling location from the safflower field had a significantly higher number of sticky trap captures of plant bugs regardless of treatment. This showed that the plant bugs were moving in from the safflower field into the pear orchard. Similar to the trend seen in the number of plant bugs per sweep location, the sticky trap plant bug captures also showed a steady decrease in trap captures until the third sampling location. There was a slight increase at the fourth sampling location as there were probably some edge effects from the rear of the sample area. Percent fruit damage was also the highest at the first sampling location, although there was no significant difference compared to the other sampling locations. At the start of the season, the safflower was just planted and the plant bugs were found in the weeds between the orchard and the safflower field. As the weeds died back, and the safflower had not formed flower buds and was not attractive to the plant bugs, the plant bugs moved into the orchard and caused fruit injury.

The type of vegetation cover present within the orchard affected the number of plant bugs present and the amount of damaged fruit. The plant bugs prefer to feed and reproduce on broadleaf weeds and avoid grasses. The control treatment had significantly higher percent broadleaf weeds and had significantly higher number of plant bugs caught in the sticky trap and sweep net samples (Table 20). The plant bugs feed and reproduce on broadleaf weeds and avoid grasses. However there was no significant difference in damage between the mowed and herbicide treatment and control treatment, although there was numerically higher damage in the mowed and herbicide treatment. The numerically higher damage present in the mowed and herbicide treatment could be attributed to the absence of broadleaf weeds, which is the plant bugs preferred food source. If the presence of host plants can be sustained throughout the season there may be a further reduction in the percent fruit damage seen in the control treatment. The percent damage caused by the plant bugs was very low and the visual inspection methodology used to identify damage was very conservative, with only obvious plant bug stings resulting in damage recorded.

Conclusions: Cover crop control of broadleaf weeds was achieved by mowing and chemical control. The first sampling location from the safflower field had significantly higher sticky trap captures of plant bugs and the highest number of sweep net captures of plant bugs compared to the other sampling locations within the orchard. There were greater numbers of plant bugs found in the untreated blocks within the orchard. However there was higher numerical damage in the treated blocks.

Table 16. Cover Crop Weed Survey, Sacramento, CA – 2003

Grasses:	
Dallisgrass*****	crabgrass
Yellow foxtail*****	Johnsongrass
Arizona Brome	Annual bluegrass
Yellow nutsedge	Barnyardgrass
Bermudagrass	Foxtail barley
Broadleaf Weeds:	
Common mallow*****	Swinecress
Knotweed sp.*****	Redstem filaree
Field bindweed*****	Shepherdspurse
Pale smartweed*****	spurge
Redroot pigweed*****	clover
Wild radish	lambsquarter
Poison hemlock	Panicle willowweed
Curly dock	pigweed sp. 2
Prickly lettuce	pigweed sp. 3
Bristly oxtongue	Black mustard
Annual sowthistle	Alkali sida
Spiny sowthistle	Italian thistle
Common groundsel	chickweed
Dandelion	burclover
Scarlet pimpernel	

* Indicates dominant cover crop in orchard – 70% or greater of the samples contained a grass species and 10% or greater of the samples contained a broadleaf species.

Table 17. Mean Percent Cover Crop Between Tree Rows, Sacramento, CA – 2003

		Mean[a] Percent Cover				
Cover Crop Type	Treatment	5/15/03	6/12/03	7/10/03	8/14/03	Mean Season Total
Grass	Control	61.6 a	54.8 a	85.3 a	60.2 a	65.5 a
Grass	M & H [b]	63.8 a	84.9 b	95.9 b	95.2 b	85.0 b
Broadleaf	Control	21.4 a	38.5 a	14.3 a	14.0 a	22.0 a
Broadleaf	M & H [b]	5.1 b	5.4 b	0.6 b	0.8 b	3.0 b
Bare-Ground	Control	17.0 a	6.7 a	0.4 a	25.8 a	12.5 a
Bare-Ground	M & H [b]	31.1 a	9.7 a	3.5 b	4.0 b	12.1 a

[a] Means followed by the same letter in a couplet within a column are not significantly different (Student's t-test).
[b] Mowed and herbicide

Table 18. Mean Percent Cover Crop Within Tree Rows, Sacramento, CA – 2003

		Mean[a] Percent Cover				
Cover Crop Type	Treatment	5/15/03	6/12/03	7/10/03	8/14/03	Mean Season Total
Grass	Control	—	11.8 a	23.2 a	39.2 a	24.7 a
Grass	M & H [b]	—	18.3 a	12.4 a	23.4 a	18.0 a
Broadleaf	Control	—	7.1 a	9.3 a	0.5 a	5.6 a
Broadleaf	M & H [b]	—	1.6 b	5.8 a	1.3 a	2.9 b
Bare-Ground	Control	—	81.1 a	67.5 a	60.3 a	69.6 a
Bare-Ground	M & H [b]	—	80.2 a	81.8 b	75.3 a	79.1 b

[a] Means followed by the same letter in a couplet within a column are not significantly different (Student's t-test).
[b] Mowed and herbicide

Table 19. Mean Number of Plant Bugs and Percent Plant Bug Damage in Orchard by Location, Sacramento, CA – 2003

	Mean[a] No. Plant Bugs/Sweep Location		Mean[a] No. Plant Bugs/Trap		Mean[a] Percent Damage	
Location	M & H [b]	Control	M & H [b]	Control	M & H [b]	Control
Weeds Border/ Safflower field	12.4 a	12.9 a	—	—	—	—
1 Trees in	1.1 b	4.3 b	0.8 a	1.4 a	0.7 a	0.6 a
4 Trees in	0.6 bc	2.6 bc	0.1 b	0.3 b	0.5 a	0.4 a
8 Trees in	0.1 c	1.8 c	0.1 b	0.1 b	0.4 a	0.4 a
16 Trees in	0.6 bc	2.6 bc	0.1b	0.1b	0.5 a	0.3 a

[a] Means followed by the same letter within a column are not significantly different (Student's t-test).
[b] Mowed and herbicide

Table 20. Mean Number of Plant Bugs and Percent Plant Bug Damage in Orchard by Treatment, Sacramento, CA – 2003

Treatment	Mean[a] No. Plant Bugs/Sweep Location	Mean[a] No. Plant Bugs/Trap	Mean[a] Percent Damage
Control	2.8 a	0.5 a	0.4 a
M & H[b]	0.6 b	0.3 b	0.5 a

[a] Means followed by the same letter within a column are not significantly different (Student's t-test).
[b] Mowed and herbicide

5. Evaluation of Assail for control of Codling Moth

Please see Lucia Varela's report.

6. Evaluation of organic insecticides for Codling Moth control

Please see Rachel Elkin's report.

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