Testing Of New Codling Moth Granulosis Virus Products and Spinosad To Supplement Mating Disruption in Bartlett Pear Orchards

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ABSTRACT

Codling moth (*Cydia* (Laspeyresia) *pomonella*) (CM) mating disruption (MD) has become the standard practice in the California pear industry. Effective, environmentally acceptable alternative insecticides are needed to replace or complement the limited number of currently available materials that are used to supplement pheromone dispensers. The problem is particularly acute for organic growers or those transitioning to organic practices. Several materials were tested in 2003 in California Bartlett pear orchards in order to gain adequate efficacy data to support GV registration in California and provide an objective evaluation to supplement grower experience. Two were new formulations of CM granulosis virus (GV), Carpovirusine® (Sumitomo Corp., NY, NY) and Cyd-X® (Certis USA, Columbia, MD). The third was an organically acceptable formulation of spinosad, Entrust® (Dow AgroSciences, IN). Replicated trials, one single tree and three large-scale, were carried out in four counties. Treatments were compared to conventional grower standards Imidan® and Assail®, the organic standard, horticultural oil, MD alone, and at two sites, completely untreated controls. Test treatments were applied 3 – 11 times, depending on location. Data included weekly trap catches and percent damage throughout the season. In all four trials, CM damage was 70-90% less than using MD alone and 60-90% less than in completely untreated controls. Results varied with initial CM pressure, MD efficacy, and other non-treatment materials being applied for secondary pests. The test materials performed as well as the conventional insecticide program in one of the two conventional trials. Results thus showed that these new GV formulations, as well as Entrust, offer organic, as well as conventional growers, several new materials to supplement CM MD.

INTRODUCTION

Codling moth mating disruption (CM MD) has become the standard practice in the California pear industry. It must however, be supplemented by insecticides in at least some locations and years in order to maintain overall efficacy. The lack of effective supplements will likely render the technique ineffective over time due to CM population buildup in warm years or where sources of infestation exist.

Effective, environmentally acceptable alternative insecticides are needed to replace or supplement currently available materials in MD programs. Current materials are mainly broad-spectrum organophosphates that are being increasingly restricted and are becoming less effective due to resistance, and certain reduced risk materials (e.g. Confirm®, Intrepid®, Success® WP). The problem is particularly acute for organic growers or those interested in transitioning to organic practices. Besides limiting their own ability to control CM, the lack of effective options for organic growers increases pressure in neighboring non-organic orchards, thereby jeopardizing established and areawide control programs.

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The most widely utilized organically approved insecticides currently used for CM control are oils of various types. Ryania was used until it was withdrawn by the manufacturer. Dr. Louis Falcon of UC Berkeley isolated and developed a codling moth granulosis virus (GV) for use as a biopesticide. His work was partially funded by the pear industry during the late 1970's and early 1980's. The product was used by a few organic growers, but was never fully developed commercially and eventually faded from use some years ago. A new GV product, Virosoft CP4® (Biotepp, Quebec, Canada), was tested in 2001, but failed due to inadequate formulation. Virosoft was apparently reformulated and sold under a different label in the Northwest in 2003 (unconfirmed report).

Several potentially useful non-GV were tested in 2002 and showed significant control in a single tree plot in Lake County when applied multiple times: kaolin clay (Surround®, Engelhard Corp., New Jersey) is widely used in the Pacific Northwest pre-bloom for pear psylla control, as well as to enhance fruit finish and reduce sunburn; an organic formulation of spinosad (Entrust® 80WP, Dow Agrosciences, Indiana) which was approved by EPA and OMRI for use in organic pome fruit orchards in 2003; and a relatively new pyrethrum formulation (PyGanic 1.4 EC, McLaughlin Gormley King Co., Minnesota), which failed to provide significant control.

In 2003, Entrust®, as well as two new GV products, Carpovirusine® (Sumitomo Corp., New York, NY) and Cyd-X® (Certis USA, Columbia, MD) were tested in Bartlett pear orchards in four locations in Northern California. Two orchards were conventionally farmed, one was certified organic, and one was in the third year of transition to organic. The purpose was to gain adequate efficacy data on selected available materials in order to support California registration and provide an objective evaluation to supplement grower experience.

The project was supported by the USDA IR-4 Program, Pear Pest Management Research Fund, and Gerber Products Company.

PROCEDURES AND RESULTS

Four replicated trials were carried out in mature Bartlett pear orchards in Mendocino, Sacramento, and Solano Counties. The first was a single tree trial comparing different rates of several test materials to standard insecticide and completely untreated controls. The other three were large scale grower-treated trials comparing Entrust, Carpovirusine and/or Cyd-X to oil and mating disruption (MD) alone. Data from a non-replicated, untreated control is included for one of the Mendocino County trials (Potter Valley).

I. Single tree trial (R.A. Van Steenwyk)

Site description: Hansen Orchard, Fairfield, Solano County, CA (conventional)
Mature trees, 25' x 25' spacing, 70 trees per acre
No mating disruption was applied in this orchard

Trial Design: RCBD, 4 single tree replications per treatment.

CM Pressure: Heavy

All timings were applied at semi-concentrate rate (200 gpa, 287 gal/tree) by hand held orchard sprayer operating at 250 psi.

Treatments and timings were:

Treatment	Rate lb(AI)/ac or GV part./ac	No. Appl.	Application Dates (Day-Degrees 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. Carpovirusine[c]	7.6 X 10^{12}	11	30 April (207 from 1st biofix), 6 May (251 from 1st biofix), 13 May (316 from 1st biofix), 30 May (587 from 1st biofix), 9 June (758 from 1st biofix), 16 June (864 from 1st biofix), 1 July (192 from 2nd biofix), 8 July (319 from 2nd biofix), 16 July (503 from 2nd biofix), 22 July (660 from 2nd biofix) and 29 July (810 from 2nd biofix)
3. Cyd-X[c]	5.9 X 10^{12}	11	30 April (207 from 1st biofix), 6 May (251 from 1st biofix), 13 May (316 from 1st biofix), 30 May (587 from 1st biofix), 9 June (758 from 1st biofix), 16 June (864 from 1st biofix), 1 July (192 from 2nd biofix), 8 July (319 from 2nd biofix), 16 July (503 from 2nd biofix), 22 July (660 from 2nd biofix) and 29 July (810 from 2nd biofix)
4. Entrust	0.15	11	30 April (207 from 1st biofix), 6 May (251 from 1st biofix), 13 May (316 from 1st biofix), 30 May (587 from 1st biofix), 9 June (758 from 1st biofix), 16 June (864 from 1st biofix), 1 July (192 from 2nd biofix), 8 July (319 from 2nd biofix), 16 July (503 from 2nd biofix), 22 July (660 from 2nd biofix) and 29 July (810 from 2nd biofix)
5. Untreated	—		

[a] Treatments contained 0.25% Omni Supreme oil by volume.
[b] Treatment pH was adjusted to < 6.
[c] Treatments contained 0.0625% NuFilm-17.

Evaluation

Degree-days and trap catches: Degree-days were monitored using an automated CIMIS weather station located in Cordelia, CA. 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. Flight activity of male CM was monitored with a pheromone trap placed high in the canopy of an untreated tree. The trap was placed on March 11 and inspected weekly from 19 March through 5 August.

CM Infestation: Control of CM was evaluated on August 5 by inspecting a maximum of 250 fruit per tree for CM infestation.

Secondary Pest Evaluation: Control of pear psylla (PP) nymphs, PP eggs, motile 2-spotted spider mite (TSSM) adults, TSSM eggs, motile European red mite (ERM) adults, ERM eggs, San Jose Scale (SJS) crawlers, Western predator mite (WPM) and pear rust mite (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.

Results and Discussion:

Degree-days and trap catches: The overwintering CM flight began on 22 March. Biofix was set on 29 March. 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 peak of the second CM flight occurred approximately on 5 July at 272 DD after the 2nd biofix (Figure 1).

CM infestation: CM infestation in the untreated control was over 70%. Thus, this trial provided a stringent test of the experimental treatments. Although the Agri-Mek in the grower standard (GS) (Tr. #1) was applied mainly for its mite and psylla control, it also provided additional CM control when combined with Imidan and Guthion. The Entrust treatment (Tr. #4) was only slightly less effective than the GS. Both the GS and Entrust treatments had significantly less CM infestation than the Carpovirusine and Cyd-X GV treatments (Trs. #2 and 3) and the untreated control (Tr. #5). However, it should be noted that Entrust was applied at over 3.7 times the registered amount for the season. This high amount of Entrust was used for comparison purposes only (Table 1).

Although the Carpovirusine and Cyd-X GV treatments had high CM infestation levels, they still had significantly less CM infestation than the untreated control. Both GV treatments were applied with NuFilm-17 that likely increased their efficacy. The Cyd-X treatment showed slightly better CM control than the Carpovirusine treatment.

Secondary Pest Evaluations: The Agri-Mek plus Omni Supreme oil in the GS treatment (Tr. #1) was effective in suppressing most secondary pest flare-ups that are caused by organophosphate chemicals such as Imidan and Guthion. The other treatments also did not flare-up most of the secondary pests and there was no significant difference between the number of PP nymphs or eggs, TSSM or ERM among any of the treatments. However, the GS had a slightly increased level of TSSM adults compared to the other treatments. The Cyd-X treatment (Tr. #3) had numerically more ERM adults and eggs than the rest of the treatments (Tables 2 and 3).

There was significantly more WPM in the untreated control than in the GS, Carpovirusine or Entrust treatments. The Cyd-X treatment had more than 3 times the number of WPM than the other organic treatments. The PRM was elevated in all the treatments compared to the untreated control. The extremely high number of PRM in the Entrust treatment is mainly due to one heavily infested replicate that greatly inflated the entire Entrust treatment's PRM mean population. All the treatments had significantly less SJS than the untreated control (Table 4).

I. Large scale trials

A. Site description: Hooper Vallette Orchard, Ukiah, Mendocino County, CA (conventional)
Mature trees, 20' x 20' spacing, 109 trees per acre

Trial Coordinator: Lucia Varela

Trial design: RCBD, 4 replications, 132 trees = 1.2 acres per plot (6 rows x 22 trees/row)
Data was taken from the center rows of each plot.

CM pressure: Moderate

Treatments applied by the grower using a commercial engine-driven air blast sprayer.

Treatments and timings were:

The entire orchard was treated with CheckMate CM-F sprayable CM pheromone (Suterra LLC, Bend, OR), 20 gms./acre, applied April 14, May 14, June 14, and July 14 (4 applications).

1) [1]MD plus Cyd-X @ 3 oz./100 gal./acre, applied May 12, 20, and 27 (1st generation), July 7, 14, 21 (2nd generation) (6 applications)
2) [2]MD plus Carpovirusine, 1 liter/264 gal./acre, applied May 12, 20, and 27 (1st generation), July 7, 14, 21 (2nd generation) (6 applications)
3) MD plus Assail @ 3 oz./acre, applied on June 14 (1B peak) (1 application)
4) MD alone

[1,2] Both GV treatments were applied with Nufilm 17 (Miller Chemical & Fertilizer Co., Hanover, PA) @ 16 oz./100 gal.

Evaluation

Degree-days and trap catches: One trap each of 1x low and 10x high were placed in the center of each plot and monitored weekly. Degree-days were monitored using an automated CIMIS weather station located in Hopland, CA.

CM infestation: 1000 fruit per replicate (500 top and 500 bottom) were sampled on July 3-17 (1061-1337 °D, 1st generation larvae) and August 7 (1803 °D, late 1st and 2nd generation larvae). The following categories were counted: emerged from egg but no sting (July sample only), sting but no worm, dead worm (July sample only), live worm, damage but worm gone (August sample only). This was done to detect GV activity as it is necessary for the larvae to ingest the GV in order to introduce it into the gut system and multiply.

Results

Degree-day and trap catches: Biofix was on March 27. Trap catches indicate two generations occurred in the orchard (Figure 1). The 1B peak occurred on June 8 (700 °D). The 2B peak occurred on August 17 (2150 °D) (Figure 2).

Egg and larval infestation: First generation damage was very low, never exceeding 0.05% in any plot, and there was no significant difference between treatments. Second generation damage (worm gone) reached 1.0% in the MD alone plot, but was only .1-.2% in the GV plots, statistically equal to the grower standard. There were, however, significantly more stings in both the GV treatments and the MD alone treatment (Tables 5 and 6).

B. Site description: Peck Ranch, Courtland, Sacramento County, CA (transition organic)
18’ x 20’ spacing, 121 trees/acre

Trial Coordinator: Chuck Ingels

Trial design: RCBD, 3 replications, 88 trees per plot=.83 acres per plot (8 rows x 11 trees per row)
Data was taken from the center of each plot.

CM pressure: High

All treatments applied by grower using a commercial engine driven sprayer @ 200 gpa

Treatments and timings were:

The entire orchard treated with Isomate Twin Tubes @ 200 per acre

Prior to initial replicated treatments, the entire orchard was treated with kaolin clay (Surround®, Engelhard Corp., NJ), 50 lbs. on March 25, 25 lbs. on April 15 and 23; oil (Gavicide Super 90, (Western Farm Service, Fresno, CA) 1 gal./acre on May 16 and 22. MD was Isomate Twin Tube dispensers applied @ 200/acre.

1) MD alone (through June 25 then oversprayed with oil due to high CM pressure).
2) MD plus oil @ 2 gal/acre, applied May 29, June 7, June 13, June 20, June 27, July 5, and July 12 (7 applications).
3) [1]MD plus Cyd-X @ 6 oz./acre applied May 29, June 7, June 13, June 20, June 27, July 5, and July 12 (7 applications).
4) [2]MD plus oil, then Entrust plus 1% oil @ 3 oz./acre applied May 29, June 7, and July 12 (3 applications).

[1] Cyd-X was applied with Nufilm 17 @ 16 oz./acre.

[2] Prior to May 29, 1% oil was applied on the same dates as above treatments to avoid damage while waiting for Carpovirusine to become allowable by OMRI for organic use which failed to occur in time for the 2003 season.

Evaluation

Degree-days and trap catches: Degree-days were calculated using an automated CIMIS weather station west of Lodi, CA. Male flight was monitored by placing traps with 1x and 10x lures high in trees in the orchard.

CM infestation: 1000 fruit per tree (500 top and 500 bottom) were sampled on June 23 (1030 °D, 1st generation larvae) and 2000 (1000 top and 1000 bottom) on July 18 (1576 °D, late 1st and 2nd generation larvae). 300 fruit remaining on the trees were sampled after harvest on September 20 to assess overwintering potential.

Results

Degree-days and trap catches: Biofix occurred later than normal on March 28. Cold, rainy weather prevailed through April and early May, delaying subsequent flights (Figure 3).

Egg and larval infestation: First generation damage in plots treated with oil, Cyd-X and Entrust was significantly lower than in MD alone plots (no stings were found). At this time, the MD alone plots were oversprayed with oil to avoid unacceptable damage. Second generation damage averaged 7.9% in the MD alone/oil overspray plots at harvest, while damage in MD plus season-long oil, Cyd-X and Entrust was over 50% less. (Tables 7 and 8).

C. Site description: Todd Boynton Orchard (certified organic)
20' x 20' spacing, 108 trees/acre

Trial Coordinator: Rachel Elkins

Trial design: RCBD, 3 replications, 108 trees per plot=1 acre per plot (9 rows x 12 trees per row)
Data was taken from the center rows of each plot

CM pressure: High

All treatments applied by the grower using a commercial engine-driven air blast sprayer.

Treatments and timings were:

The entire orchard was treated with Isomate Twin Tube pheromone dispensers @ 36/acre plus Suterra puffers @ 1.5/acre located in outside the plot in surrounding orchards.

Prior to initial replicated treatments, the entire orchard was treated with Surround @ 25 lbs./acre applied every other row on March 31, April 9, April 14, April 19, April 30, May 6, May 19, May 26, June 4, June 14, and June 21 (total of 5.5 applications of 50 lbs./acre) to control pear slug.

1) MD alone
2) [1] MD plus 415 oil applied @ 2.5 gal./acre July 2, July12, July 24, and August 4 (4 applications)
3) [2] MD plus Entrust, applied @ 2 oz./acre July 2, July 12, July 24, and August 4 (4 applications)
4) [3]MD plus Cyd-X, 3 oz./acre, applied July 2, July 12, July 24, and August 4 (4 applications)
5) Untreated control – one set of completely untreated Bartlett pear trees provided comparison data.

[1] Oil @ 3 gal./acre also included on August 4 to all treatments to control spider mites.
[2] Entrust® also applied @ 1 oz./acre on July 12 in all treatments to control pear slug.
[3] Cyd-X applied with Nufilm 17 @ 16 oz./acre.

Evaluation

Degree-days and trap catches: Degree-days were monitored using an automated Adcon weather station located in the trial orchard. One set each of 1x low, 1x high, 10xH and DA traps were hung in each block and monitored weekly.

CM infestation:

1) 600 fruit per replicate were sampled on July 14 (947 °D, 1st generation). Varying numbers of fruit (due to lack of fruit in orchard) per plot were sampled again on August 7 (1450 °D, late 1st and 2nd generation). An unreplicated post-harvest sample of fruit remaining on trees was taken in mid-September to assess overwintering potential.

Results

Degree-day and trap catches: Biofix was fixed on May 12, nearly two months later than normal due to unseasonably cold spring weather (Figure 4).

Egg and larval infestation: There were no significant first generation treatment differences. There was a trend toward significant difference (p=.07) between MD alone and Cyd-X for the August 7 pre-harvest sample. Damage ranged from 7.2% in the MD alone to 2.3% in the Cyd-X plots. Damage in the unreplicated untreated control was 34% (Table 9).

DISCUSSION

Carpovirusine and Cyd-X both controlled codling moth to some extent in all four trial locations. Level of control at harvest ranged from about 60 to over 90% versus completely untreated controls, and from about 70 to 90% versus mating disruption alone. Entrust exhibited about this level of control as well, faring even better when applied at rates above the label limit. The organic standard, oil, also reduced CM damage versus controls. The GV treatments controlled CM as well as a standard insecticide program in the one location it was used, however these treatments had a higher incidence of fruit stings.

Entrust and oil have the added benefits of being useful for controlling secondary pests. Entrust, a formula of spinosad, controls obliquebanded leafroller, and in the case of the Potter Valley location in 2003, pear slug. Oil suppresses pear psylla and mites. The need to control secondary pests with a limited range of available products resulted in both organic sites being oversprayed with Surround, Entrust, and oil at various times during the season (see above sections). Despite these variations at each site, a pattern of codling moth control was clearly established.

All the test materials were applied 3 -11 times. Since this was an unseasonably cool, prolonged spring, even more treatments may be needed in a "normal" or warm season. Cost, therefore, becomes a factor when deciding whether to use GV or Entrust. Growers, however, gain several new tools to incorporate into a codling moth program, either for full-season use or as a rotation material with other broad-spectrum or reduced-risk materials.

One aspect of GV untested in 2003 was the hypothesis that GV will "carry over" to subsequent seasons within the bodies of pupating larvae. This remains to be shown in California, but if proven, has the potential to drive down CM populations over time.

There are several relatively new possibilities for supplemental CM control in organic pear orchards. Future testing should look at various combinations in combination with MD to develop a true integrated pest management that manages CM while ensuring a good overall pest/predator balance.

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REFERENCES

Elkins, R. 2002. Control of codling moth in organic pear orchards. *2002 California Pear Research Repts.* p. 7-17.

Elkins, R. and B.Van Steenwyk. 2001. Control of codling moth with VirosoftCP4® bio-insecticide containing *Cydia Pomonella* granulosis virus in pears. *2001 Pear Res. Repts*. p. 3-14.

Falcon, L.A. 1981. Efficacy of SAN406 for control of codling moth on Bartlett pear. Progress report to California Tree Fruit Agreement Pear Zone 1.

Falcon, L.A. 1982 and 1984. The efficacy and usefulness of codling moth granulosis virus in pear. Ibid.

Falcon, L.A. 1985. Improved pest and disease control and frost protection through better timing and management. Ibid.

Falcon, L.A. 1986. Improved pest management studies; automated weather monitoring system. Ibid.

Unruh, T. 2000. Particle films for suppression of the codling moth (*Lepidoptera:Tortricidae*) in apple and pear orchards. *J. Econ. Entomol*. 93(3):787-743

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

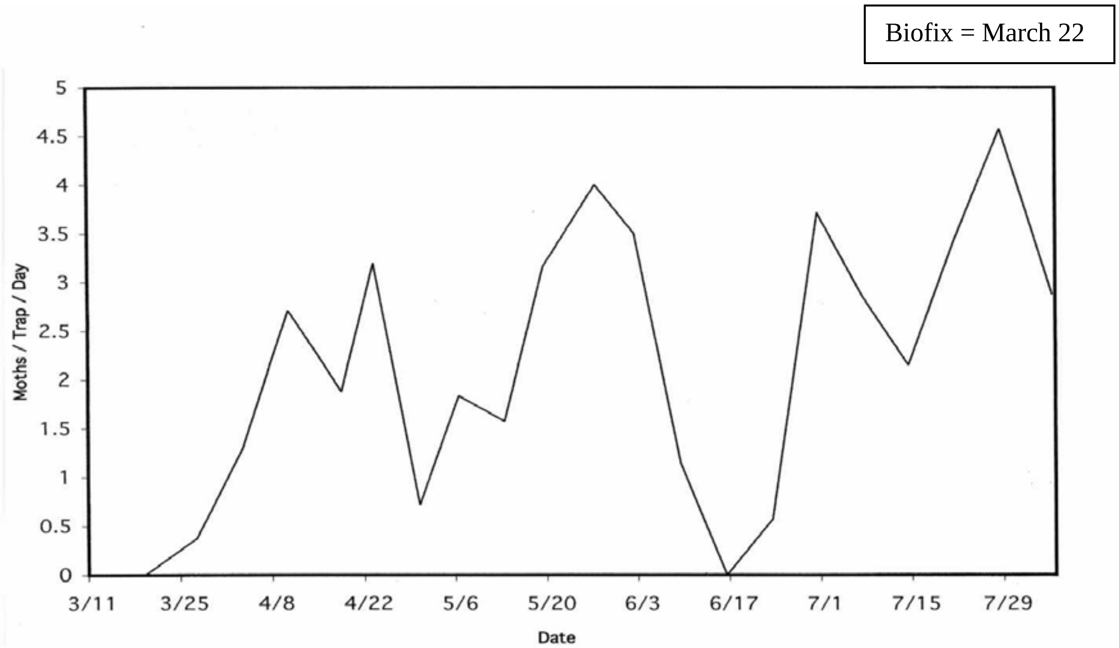

Fig. 2 – Seasonal Flight Activity of Codling Moth Captured in a Pheromone Trap Placed High in the Tree Canopy at Ukiah Valley, CA - 2003

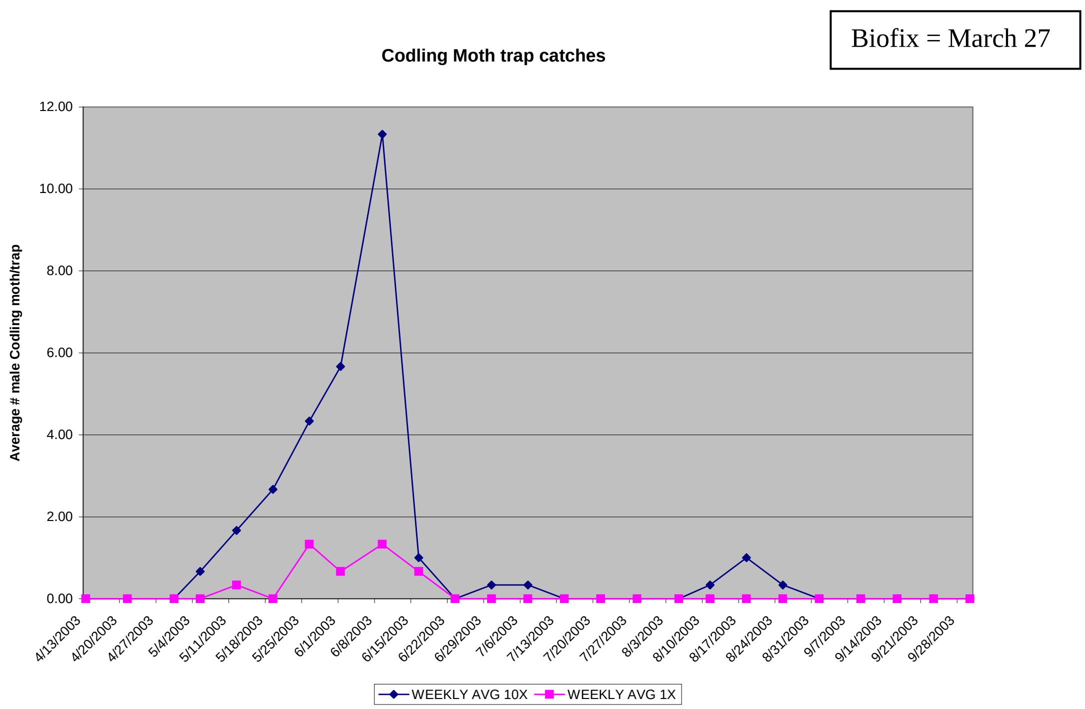

Fig. 3 – Seasonal Flight Activity of Codling Moth Captured in a Pheromone Trap Placed High in the Tree Canopy at Sacramento, CA - 2003

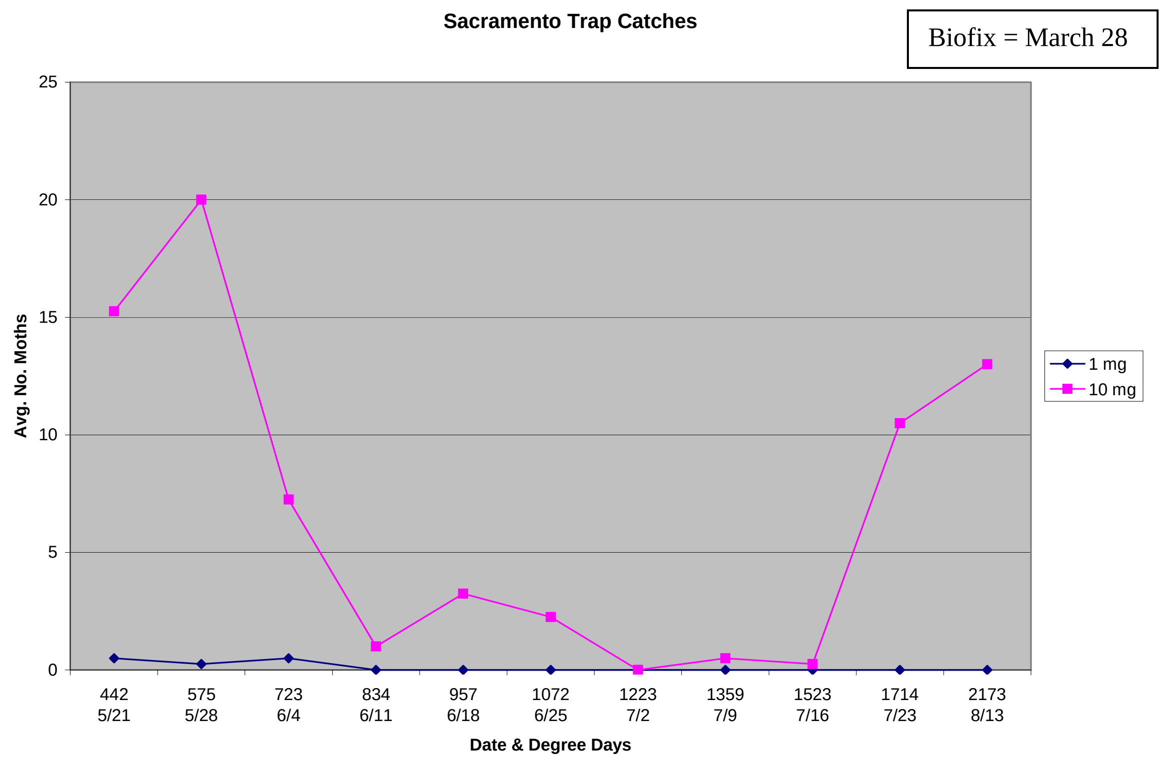

Fig. 4 – Seasonal Flight Activity of Codling Moth Captured in a Pheromone Trap Placed High in the Tree Canopy at Potter Valley, CA - 2003

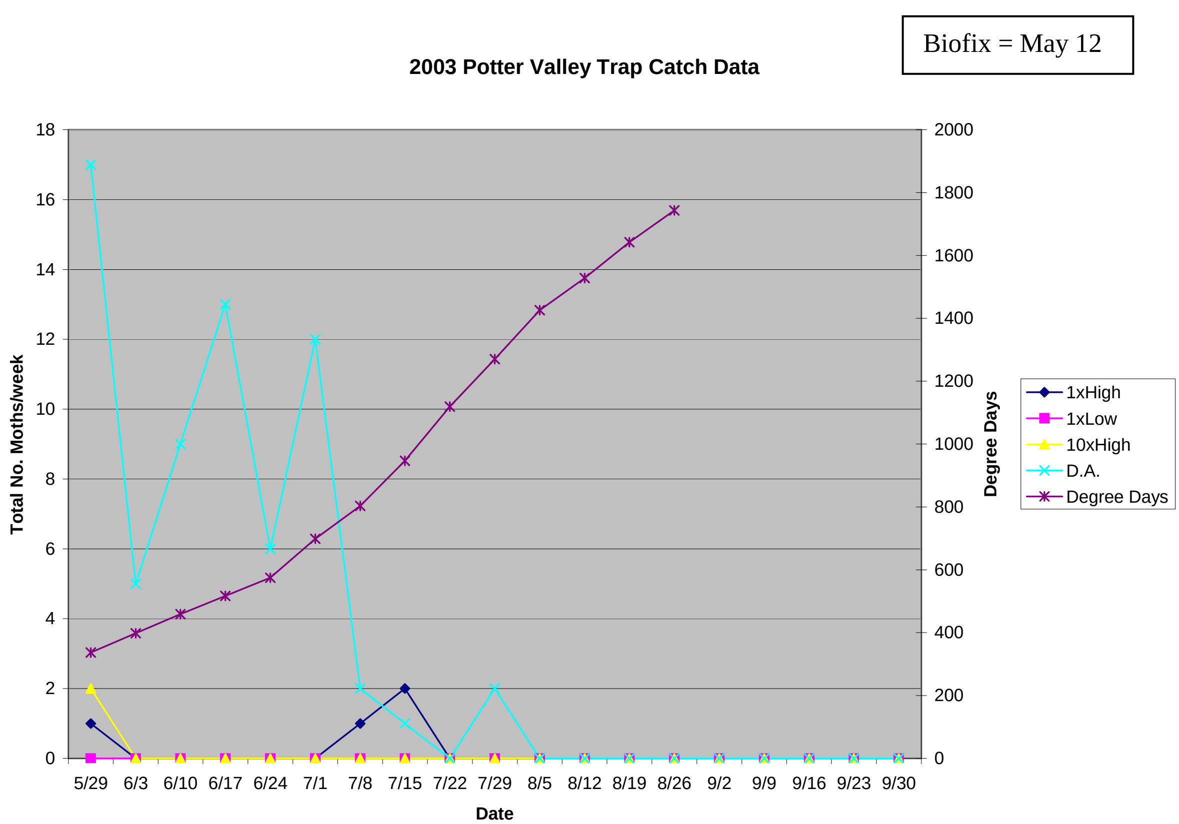

Table 1. Mean Percent Codling Moth-Infested Fruit Inspected at Commercial Harvest in Fairfield, CA - 2003.

Treatment	Rate lb (AI)/ac or GV part./ac	No. Appl.	Mean[a] Percent Infested Fruit at Commercial Harvest
1. Agri-Mek 0.15EC[b]	0.01465	1	3.7 a
Imidan 70WP[c]	3.5	1	
Guthion 50WP	1.5	2	
2. Carpovirusine[d]	7.6 X 10^{12}	11	30.5 b
3. Cyd-X[d]	5.9 X 10^{12}	11	26.9 b
4. Entrust	0.15	11	3.9 a
5. Untreated	–	–	70.2 c

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, P ≤ 0.05). Data analyzed using an arcsin transformation.
[b] Treatments contained 0.25% Omni Supreme oil by volume.
[c] Treatment pH was adjusted to < 6.
[d] Treatments contained 0.0625% NuFilm-17.

Table 2. Mean Total Number of Pear Psylla Nymphs and Eggs in Fairfield, CA – 2003.

Treatment	Rate lb (AI)/ac or GV part./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. Carpovirusine[d]	7.6 X 10^{12}	11	112.5 a	70.5 a
3. Cyd-X[d]	5.9 X 10^{12}	11	150.0 a	60.8 a
4. Entrust	0.15	11	119.8 a	43.8 a
5. Untreated	–	–	141.5 a	67.3 a

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, P ≤ 0.05).
[b] Treatments contained 0.25% Omni Supreme oil by volume.
[c] Treatment pH was adjusted to < 6.
[d] Treatments contained 0.0625% NuFilm-17.

Table 3. Mean Total Number of TSSM and ERM Mites and Eggs in Fairfield, CA – 2003.

Treatment	Rate lb (AI)/ac or GV part./ac	No. Appl.	Mean[a] Total per 20 Leaves			
			TSSM		ERM	
			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. Carpovirusine[d]	7.6×10^{12}	11	0.3 a	3.5 a	1.8 a	111.5 a
3. Cyd-X[d]	5.9×10^{12}	11	0.8 a	3.3 a	7.5 a	273.0 a
4. Entrust	0.15	11	1.3 a	6.3 a	5.8 a	208.5 a
5. Untreated	–	–	0.5 a	6.8 a	2.3 a	169.3 a

[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] Treatment pH was adjusted to < 6.
[d] Treatments contained 0.0625% NuFilm-17.

Table 4. Mean Total Number of Western Predatory Mites, Pear Rust Mites and San Jose Scales in Fairfield, CA – 2003.

Treatment	Rate lb (AI)/ac or GV part./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. Carpovirusine[d]	7.6×10^{12}	11	1.8 a	178.5 a	33.0 a
3. Cyd-X[d]	5.9×10^{12}	11	6.5 ab	375.0 a	40.0 a
4. Entrust	0.15	11	2.0 a	1712.0 a	48.3 a
5. Untreated	–	–	8.8 b	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] Treatment pH was adjusted to < 6.
[d] Treatments contained 0.0625% NuFilm-17.

Table 5. Mean Percent Codling Moth Infested Fruit Inspected After the First Generation, Ukiah, CA – 2003

Treatment	% infestation/1000 fruit [a] Emerged from egg, no sting	Sting No worm	Dead worm	Live worm
MD plus Cyd-X[b]	.00	.02	.00	.01
MD plus Carpovirusine[c]	.02	.05	.01	.02
MD plus Assail	.00	.01	.00	.02
MD alone	.00	.00	.00	.00

[a] There was no significant difference between treatments (Fisher's protected LSD, $p \geq 0.05$). Data analyzed using an arcsin square root transformation.

[b, c] Treatments applied with 16 oz. NuFilm-17.

Table 6. Mean Percent Codling Moth Infested Pear Fruit Inspected Prior to Commercial Harvest after the 2nd generation, Ukiah, CA – August 7, 2003

Treatment	% infestation/1000 fruit [a] Sting – no worm	Live worm	Worm gone
MD plus Cyd-X[b]	0.4	0.0	0.1 a
MD plus Carpovirusine[c]	0.3	0.1	0.2 a
MD + Assail	0.0	0.1	0.0 a
MD alone	0.4	0.2	1.0 b

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

[b, c] Treatments contained 0.0625% NuFilm-17.

Table 7. Mean Percent Codling Moth Infected Fruit After the 1st Generation, Courtland, CA – 2003

Treatment	Rate	No. Appl.	% Damage[a] Tree (July 23)	Ground (July 1)
MD plus oil	2 gal.	7	0.2 a	1.4
MD+oil+Entrust	3 oz.	7+3	0.2 a	1.0
MD+Cyd-X[b]	6 oz.	7	0.1 a	1.7
MD alone, then oil	-	3	0.8 b	2.3

[a] means followed by the same letter within a column are not significantly different (Fishers protected LSD, $P \leq .05$).

[b] 16 oz. Nufilm 17 applied with Cyd-X.

Table 8. Mean Percent Codling Moth Infected Fruit at Harvest, Courtland, CA – 2003

Treatment	Rate	No.Appl.	% Damage[a] Tree (July 18)	PH (Sept. 20)
MD plus oil	2 gal.	7	2.5 a	10.0
MD+oil then Entrust	2 gal. + 3oz.	7 + 3	1.6 a	10.2
MD+Cyd-X[b]	6 oz.	7	2.0 a	6.4
MD alone, then oil	2 gal.	3	8.1 b[c]	14.6

[a] Means followed by the same letter within a column are not significantly different (Fishers protected LSD, P≤.05).
[c] No. strikes significantly higher in lower fruit
[b] Cyd-X applied with 16 oz. Nufilm 17

Table 9. Mean Percent Codling Moth-Infested Fruit, Potter Valley, CA – 2003

Treatment	Rate	No.Appl.	% Damage[a] 1st Gen. (July 14)	Harvest (Aug. 7)
MD plus 415 oil [b]	2.5 gal.	4	0.5	4.0 ab
MD plus Entrust [c]	2 oz.	4	0.8	3.7 ab
MD plus Cyd-X [d]	3 oz./16 oz.	4	1.0	2.3 a
MD alone	-	-	0.7	7.2 b
Untreated Control	-	-	3.8	34.0 -

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, P≤0.05). Data analyzed using an arcsin square root transformation.
[b] 3 gal. 415 oil applied to all treatments on August 4 to control spider mites.
[c] 1 oz. Entrust® applied to all treatments on July 12 to control pear slug.
[d] Cyd-X applied with 16 oz. Nufilm 17.