DESCRIPTION:	**Control of Codling Moth and True Bugs by Reduced Risk Insecticides**
PROJECT LEADER:	**R. A. VanSteenwyk, UC Berkeley**
2001 FUNDING:	**$28,900.00**
FUNDING SOURCE:	**Pear Pest Management Research Fund**

Control of Codling Moth and True Bugs by Reduced Risk Insecticides

R. A. Van Steenwyk & R. M. Nomoto
Dept. E. S. P. M.
University of California
Berkeley, CA. 94720

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, environmentally benign pest management strategies. Accordingly, trials were conducted in an effort to develop reduced risk control strategies. Field and laboratory trials were conducted to evaluate new insecticides for codling moth (CM) and lygus bug (LB) control. A single tree crop destruct trial was conducted for CM control. This study showed that Assail combined with horticultural oil and Calypso following or proceeding Intrepid are very promising combinations for total insect pest control in pears. These treatment programs provided acceptable CM control that was very similar to the grower standard while at the same time suppressed twospotted spider mites (TSSM), European red mites (ERM) and pear psylla (PP) populations. Areas of future research include the combination of horticultural oil with Calypso and the combination of Dimilin/Novaluron with Calypso or Assail to further suppress CM populations.

New true bug insecticides, which are effective, environmentally benign, biologically selective and exhibit low mammalian toxicity must be found and registered in order to reap the ecological benefits of the pheromone based CM management strategy. To that end, studies were conducted to investigate the efficacy of a number of neonicotinoid insecticides for lygus bug (LB) control. V-10066 provided consistently greater LB mortality than the other neonicotinoid insecticides. Based on this and past years' research, V-10066 would be the most effective replacement for Carzol or Dimethoate. Provado, which is currently registered on pears, provided adequate control of LB but was consistently out performed by V-10066. In addition to the foliar evaluation of neonicotinoid insecticides, systemic neonicotinoid insecticides (Admire and Platinum) were evaluated for LB control. It appears that the amount of Admire or Platinum translocated to the fruit was insufficient to cause increased mortality and the amount of foliage feeding and/or the amount of Admire or Platinum translocated to the foliage was insufficient to cause increased mortality. Control of LB with neonicotinoid insecticides should concentrate on foliar applications. The use of Admire or Platinum as soil systemic insecticides in pears should target foliage pests such as PP, but not fruit pests such as LB. There are some indications that PP populations were suppressed with the systemic applications of Admire and Platinum. Future research will investigate the use of systemic neonicotinoid for PP and San Jose scale (SJS) control.

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. Changes in the availability and use of pesticides will require more reduced risk, environmentally benign pest management strategies. Codling moth (CM) pheromone mating disruption program is one such program that has been very successful in reducing OP use. An overall reduction in the use of OP pesticides by 75% or greater has resulted from the CM mating disruption program in pears. However, for pheromonal control to be cost effective only one pheromone application can be used. This often requires application of a supplemental OP insecticide for additional CM control. Possible replacements for OP insecticides, that can be used alone or in conjunction with pheromonal control of CM, are: insect growth regulators (IGR), e.g. Confirm, Intrepid and Dimilin; neonicotinoid, e.g. Assail or Calypso; or other reduced risk insecticides, e.g. Avaunt and Success. However, the use of more selective controls for CM has resulted in an increase of secondary pest populations, e.g. true bugs and obliquebanded leafroller (OBLR), which had been indirectly controlled by OP insecticides. Some orchards under mating disruption for CM control have experienced greater economic losses due to secondary pests than from CM. Reported here are the results of our 2001 evaluations of insect IGR, neonicotinoid, chitin disrupters and combinations of new insecticides for CM control, evaluation of neonicotinoid insecticides for lygus bug (LB) control, soil applied systemic neonicotinoid insecticides for LB control and trunk injection of Admire for LB control.

1. Evaluation of new insecticides for CM 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). Fourteen 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 27 March for the first generation and a 10 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. Target application timings were (Table 1): Assail 70WP with and without Omni Supreme oil at 200 and 600 DD from the 1st biofix and 200 DD from the 2nd biofix; Calypso 4SC at 200 and 600 DD from the 1st biofix followed by Intrepid 2F with Omni Supreme oil at 200 DD from the 2nd biofix; Intrepid 2F with Omni Supreme oil at 200 DD from the 1st biofix followed by Calypso 4SC at 600 DD from the 1st biofix and 200 DD from the 2nd biofix; Intrepid 2F, Dimilin 2L, Dimilin 25WP, and Avaunt 30WG were all combined with Omni Supreme oil at 200 and 600 DD from the 1st biofix and 200 DD from the 2nd biofix; V-10066 50WDG and Novaluron 7.5WG at 200 and 600 DD from the 1st biofix and 200 DD from

the 2nd biofix; Esteem 0.86EC or Dimilin 2L, both combined with Omni Supreme oil, at petal fall followed by Imidan 70WP at 250 DD from the 1st biofix and Guthion 50WP at 650 DD from the 1st biofix and 250 DD from the 2nd biofix; Omni Supreme oil at 250 and 650 DD from the 1st biofix and 250 DD from the 2nd biofix. The grower standard was Agri-Mek 0.15EC at 200 DD from the 1st biofix followed by Imidan 70WP at 250 DD from the 1st biofix and Guthion 50WP at 650 DD from the 1st biofix and 250 DD from the 2nd biofix. Control of first generation CM (overwintering flight) was evaluated on 6 June and control of the second generation (summer flight) was evaluated at commercial harvest on 24 July by inspecting a maximum of 250 fruit per tree for CM infestation. Control of pear psylla (PP) nymphs, motile twospotted spider mites (TSSM), European red mites (ERM), San Jose scale (SJS) crawlers, western predatory mites (WPM) and western flower thrips (WFT) was evaluated by leaf-brushing 10 exterior and 10 interior leaves collected from each tree weekly from 15 May through 16 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 - 2001

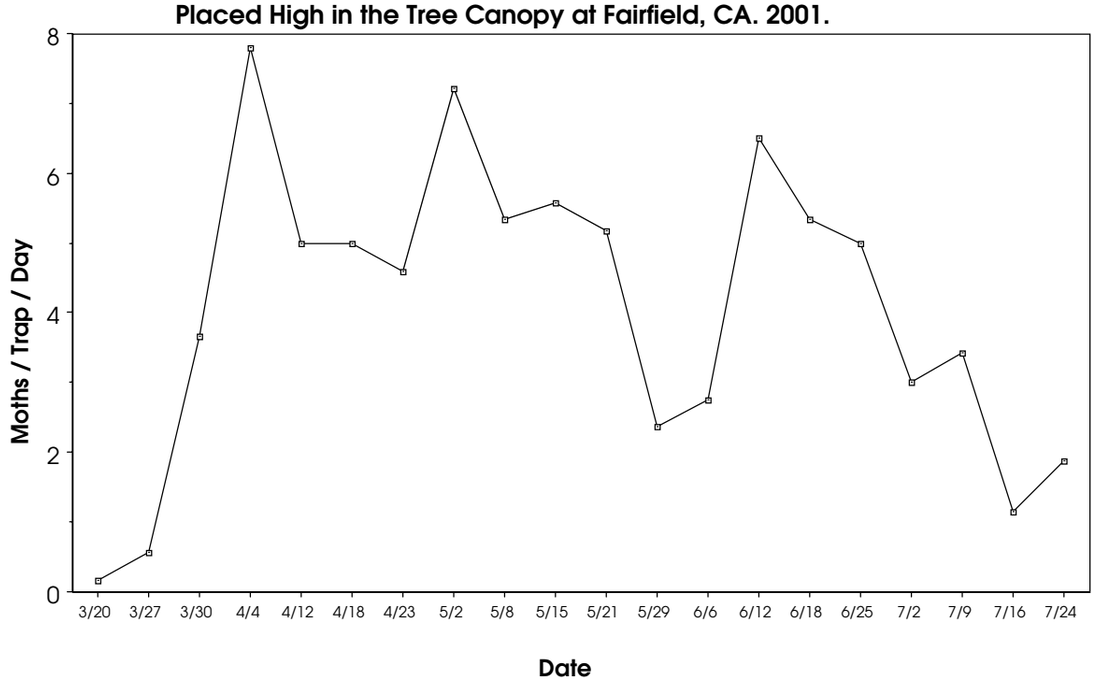
Treatment	Rate lb (AI)/ac	No. Appl.	Application Dates (Degree Days from 1st or 2nd Biofix)
1. Assail 70WP[a]	0.21	3	23 April (199 from 1st biofix), 18 May (608 from 1st biofix) and 18 June (199 from 2nd biofix)
2. Assail 70WP	0.21	3	23 April (199 from 1st biofix), 18 May (608 from 1st biofix) and 18 June (199 from 2nd biofix)
3. Calypso 4SC	0.1875	2	23 April (199 from 1st biofix) and 18 May (608 from 1st biofix)
Intrepid 2F[a]	0.25	1	18 June (199 from 2nd biofix)
4. Intrepid 2F[a]	0.25	1	23 April (199 from 1st biofix)
Calypso 4SC	0.1875	2	18 May (608 from 1st biofix) and 18 June (199 from 2nd biofix)
5. Intrepid 2F[a]	0.25	3	23 April (199 from 1st biofix), 18 May (608 from 1st biofix) and 18 June (199 from 2nd biofix)
6. Dimilin 2L[a]	0.25	3	23 April (199 from 1st biofix), 18 May (608 from 1st biofix) and 18 June (199 from 2nd biofix)
7. Dimilin 25WP[a]	0.25	3	23 April (199 from 1st biofix), 18 May (608 from 1st biofix) and 18 June (199 from 2nd biofix)
8. V-10066 50WDG	0.0625	3	23 April (199 from 1st biofix), 18 May (608 from 1st biofix) and 18 June (199 from 2nd biofix)
9. Avaunt 30WG[a]	0.111	3	23 April (199 from 1st biofix), 18 May (608 from 1st biofix) and 18 June (199 from 2nd biofix)
10. Novaluron 7.5WG	0.1665	3	23 April (199 from 1st biofix), 18 May (608 from 1st biofix) and 18 June (199 from 2nd biofix)
11. Esteem 0.86EC[a]	0.1075	1	20 March (petal fall)
Imidan 70WP[c]	4.2	1	27 April (256 from 1st biofix)
Guthion 50WP	1.5	2	21 May (681 from 1st biofix) and 21 June (278 from 2nd biofix)
12. Dimilin 2L[a]	0.75	1	20 March (petal fall)
Imidan 70WP[c]	4.2	1	27 April (256 from 1st biofix)
Guthion 50WP	1.5	2	21 May (681 from 1st biofix) and 21 June (278 from 2nd biofix)
13. Agri-Mek 0.15EC[b]	0.0117	1	23 April (199 from 1st biofix)
Imidan 70WP[c]	4.2	1	27 April (256 from 1st biofix)
Guthion 50WP	1.5	2	21 May (681 from 1st biofix) and 21 June (278 from 2nd biofix)
14. Omni Supreme oil by volume	1.0%	3	27 April (256 from 1st biofix), 21 May (681 from 1st biofix) and 21 June (278 from 2nd biofix)
15. Untreated Control		----	

[a] Treatments contained 1.0% Omni Supreme oil by volume.
[b] Treatments contained 0.25% Omni Supreme oil by volume. [c] Treatment pH adjusted to < 6.0.

Results and Discussion:

Flight Activity – The first CM flight began between 20 March and 4 April (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 not bimodal this year. A very early spurious peak occurred around 4 April at 87 DD. This was in response to very warm temperatures in late March. The air temperatures then turned cool until 22 April. During the period from 1 April to 22 April, moths continued to emerge but the air temperatures were not conducive for flight. Then in late April and early May, air temperatures turned warm, the CM flight peak occurred on 2 May at 324DD. The first peak often occurs at 300 DD after biofix. The first flight was completed by 9 June at 1,020 DD. The first flight is

Fig. 1. Seasonal Flight Activity of Codling Moth Captured in a Pheromone Trap Placed High in the Tree Canopy at Fairfield, CA. 2001.



usually completed between 1,000 to 1,100 DD in pear orchards. The second biofix was set on 10 June. The peak of the second CM flight occurred approximately on 20 June at 250 DD.

First Generation Evaluation – All experimental treatments had significantly lower CM infestation compared to the untreated control (Tr. #15) (Table 2). V-10066 50WDG (Tr. #8), Avaunt 30WG (Tr. #9), Novaluron 7.5WG (Tr. #10) and the 1% Omni Supreme oil (Tr. #14) all had significantly higher CM infestation compared to the grower standard (Tr. #13).

Table 2. Mean Percent Codling Moth-Infested Fruit Inspected at First Generation and at Commercial Harvest in Fairfield, CA - 2001

Treatment	Rate lb (AI)/ac	No. Appl.	Mean[a] Percent Infested Fruit: First Generation	Mean[a] Percent Infested Fruit: Commercial Harvest
1. Assail 70WP[b]	0.21	3	0.4 ab	3.5 abc
2. Assail 70WP	0.21	3	0.6 ab	4.5 abc
3. Calypso 4SC	0.1875	2	0.1 a	3.5 abc
Intrepid 2F[b]	0.25	1		
4. Intrepid 2F[b]	0.25	1	0.3 ab	4.0 abc
Calypso 4SC	0.1875	2		
5. Intrepid 2F[b]	0.25	3	1.3 bcd	7.4 bcd
6. Dimilin 2L[b]	0.25	3	0.8 abc	7.0 bcd
7. Dimilin 25WP[b]	0.25	3	0.7 abc	7.8 cd
8. V-10066 50WDG	0.0625	3	2.4 ef	29.8 f
9. Avaunt 30WG[b]	0.111	3	2.0 de	17.5 e
10. Novaluron 7.5WG	0.1665	3	1.7 cde	10.4 d
11. Esteem 0.86EC[b]	0.1075	1	0.5 ab	1.5 a
Imidan 70WP[d]	4.2	1		
Guthion 50WP	1.5	2		
12. Dimilin 2L[b]	0.75	1	0.3 ab	0.7 a
Imidan 70WP[d]	4.2	1		
Guthion 50WP	1.5	2		
13. Agri-Mek 0.15EC[c]	0.0117	1	0.4 ab	2.8 ab
Imidan 70WP[d]	4.2	1		
Guthion 50WP	1.5	2		
14. Omni Supreme oil by vol.	1.0%	3	3.3 f	35.8 g
15. Untreated Control			9.5 g	71.7 h

[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 1.0% Omni Supreme oil by volume.
[c] Treatments contained 0.25% Omni Supreme oil by volume.
[d] pH was adjusted to < 6.0.

Harvest Evaluation – 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. The experimental treatments which had significantly higher CM infestation than the grower standard were Dimilin 25WP (Tr. #7), V-10066 50WDG (Tr. #8), Avaunt 30WG (Tr. #9), Novaluron 7.5WG (Tr. #10) and 1% Omni Supreme oil (Tr. #14). Although the Omni Supreme oil treatment had over 35% CM infestation, the oil still provided significantly lower CM infestation than the untreated

control. The application of Dimilin 2L or Esteem 0.86EC at petal fall followed by Imidan 70WP and Guthion 50WP (Tr. #11 & #12) improved CM control compared to the grower standard (Tr. #13). Assail 70WP with and without horticultural oil (Trs. #1 & 2) and two applications of Calypso 4SC followed or proceeded by one application of Intrepid 2F (Trs. #3 & 4) also provided excellent CM control. The inclusion of Omni Supreme oil with Assail slightly improved its CM efficacy. Intrepid 2F (Tr. #5), Dimilin 2L and Dimilin 25WP (Trs. #6 & 7) provided less than desirable control.

Secondary Pest Evaluations: Mites – There were significantly more motile TSSM and total mites in V-10066 50WDG (Tr. #8) and Dimilin 2L followed by Imidan 70WP and Guthion 50WP (Tr. #12) compared to the untreated control (Tr. #15) (Table 3). There were significantly more motile ERM in Assail 70WP without oil (Tr. #2) and V-10066 50WDG (Tr. #8) compared to the untreated control (Tr. #15) (Table 3). Although the remaining treatments did not differ significantly from the control, Calypso 4SC followed or preceded by Intrepid 2F (Trs. #3 & 4), Novaluron 7.5 WG (Tr. #10) and the Esteem 0.86EC followed by Imidan 70WP and Guthion 50WP (Tr. #11) had high numbers of TSSM and ERM. It appears that the neonicotinoid insecticides (Assail, Calypso and V-10066) will cause TSSM and ERM populations to flare-up. Agri-Mek followed by Imidan 70WP and Guthion 50WP (grower standard) (Tr. #13) had very low TSSM and ERM populations. An early season application of Agri-Mek still provides adequate mite control. The addition of Omni Supreme oil to Assail 70WP (Tr. #1) resulted in less mites than the Assail 70WP without oil (Tr. #2). The inclusion of horticultural oil suppressed the mite population and slightly increased the CM efficacy of Assail 70WP. The addition of Omni Supreme oil to Intrepid 2F (Tr. #5), Dimilin 2L (Tr. #6), Dimilin 25WP (Tr. #7) and Avaunt 30WG (Tr. #9) also appear to suppress TSSM and ERM populations.

Secondary Pest Evaluations: Pear Psylla – The Esteem 0.86EC followed by Imidan 70WP and Guthion 50WP (Tr. #11) and the Dimilin 2L followed by Imidan 70WP and Guthion 50WP (Tr. #12) both had significantly greater PP numbers compared to all other treatments (Table 3). It appears that Esteem and Dimilin were unable to suppress the PP flare-ups that are often associated with Guthion. The application of Agri-Mek followed by Imidan 70WP and Guthion 50WP (Trs. #13) provided excellent control of PP. This shows that Agri-Mek was able to suppress the PP flare-ups that are often associated with Guthion. It is possible that the Dimilin and Esteem was applied too early in the season before leaf expansion. Dimilin and Esteem were applied at petal fall on 20 March while Agri-Mek was applied a month later on 23 April. The Agri-Mek had much greater leaf target area than either Dimilin or Esteem. Both Assail 70WP treatments (Trs. #1 & 2), Calypso 4SC followed by Intrepid 2F (Tr. #3) and V-10066 50WDG (Tr. #8) had significantly less PP than the untreated control. It appears that the neonicotinoid compounds suppress PP populations.

Table 3. Mean Total Number of Motile Twospotted Spider Mites, European Red Mites and Pear Psylla Nymphs in Fairfield, CA - 2001

Treatment	Rate lb (AI)/ac	No. Appl.	Mean[a] Total per 20 Leaves TSSM	ERM	PP
1. Assail 70WP[b]	0.21	3	26.0 a	9.5 a	17.8 ab
2. Assail 70WP	0.21	3	132.3 ab	222.3 bc	13.5 a
3. Calypso 4SC	0.1875	2	42.5 a	93.5 ab	15.0 ab
Intrepid 2F[b]	0.25	1			
4. Intrepid 2F[b]	0.25	1	36.0 a	47.8 ab	23.8 abc
Calypso 4SC	0.1875	2			
5. Intrepid 2F[b]	0.25	3	1.0 a	3.8 a	24.5 abc
6. Dimilin 2L[b]	0.25	3	5.8 a	20.3 ab	21.0 abc
7. Dimilin 25WP[b]	0.25	3	3.8 a	10.5 a	23.0 abc
8. V-10066 50WDG	0.0625	3	226.0 bc	398.8 c	19.5 ab
9. Avaunt 30WG[b]	0.111	3	5.8 a	10.3 a	30.0 abc
10. Novaluron 7.5WG	0.1665	3	35.0 a	121.5 ab	35.0 bc
11. Esteem 0.86EC[b]	0.1075	1	40.3 a	44.3 ab	104.3 d
Imidan 70WP[d]	4.2	1			
Guthion 50WP	1.5	2			
12. Dimilin 2L[b]	0.75	1	327.3 c	191.0 ab	98.8 d
Imidan 70WP[d]	4.2	1			
Guthion 50WP	1.5	2			
13. Agri-Mek 0.15EC[c]	0.0117	1	4.8 a	11.5 a	19.5 ab
Imidan 70WP[d]	4.2	1			
Guthion 50WP	1.5	2			
14. Omni Supreme oil by vol.	1.0%	3	2.3 a	5.8 a	20.0 abc
15. Untreated Control			2.8 a	14.8 a	40.3 c

[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 1.0% Omni Supreme oil by volume.
[c] Treatments contained 0.25% Omni Supreme oil by volume.
[d] pH was adjusted to < 6.0.

Secondary Pest Evaluations: San Jose Scale – There was no significant difference in the number of SJS among the experimental treatments and the untreated control (Table 4). However, treatments containing Imidan and Guthion (Trs. #11, 12 & 13) had less SJS than all the other treatments. It appears that the OP insecticides were able to control SJS. Dimilin 25WP (Tr. #7) and Novaluron 7.5WG (Tr. #10) had significantly higher SJS populations than the grower standard.

Secondary Pest Evaluations: Beneficial Insects and Mites – There was very little difference in the number of WPM and WFT among the treatments (Table 4). Only Intrepid 2F preceded or followed by two applications of Calypso 4SC (Trs. #3 & 4) had significantly higher WPM than

in the untreated control. The WPM density was not correlated with the TSSM and ERM population densities. Both Assail 70WP treatments (Trs. #1 & 2), Intrepid 2F preceded or followed by two applications of Calypso 4SC (Trs. #3 & 4) and the Dimilin 2L followed by Imidan 70WP and Guthion 50WP (Tr. #12) had significantly higher WFT than in the untreated control. The WFT correlated with the TSSM and ERM population densities since all of the above treatments had higher densities of TSSM and ERM.

Table 4. Mean Total Number of Western Predatory Mites and Western Flower Thrips per 20 Leaves in Fairfield, CA - 2001.

Treatment	Rate lb (AI)/ac	No. Appl.	Mean[a] Total per 20 Leaves	
			W.P. Mites	Thrips
1. Assail 70WP[b]	0.21	3	5.0 ab	64.5 e
2. Assail 70WP	0.21	3	6.8 abc	65.8 e
3. Calypso 4SC	0.1875	2	9.0 bc	40.0 d
Intrepid 2F[b]	0.25	1		
4. Intrepid 2F[b]	0.25	1	10.8 c	30.0 cd
Calypso 4SC	0.1875	2		
5. Intrepid 2F[b]	0.25	3	4.0 ab	6.5 a
6. Dimilin 2L[b]	0.25	3	4.8 ab	12.8 abc
7. Dimilin 25WP[b]	0.25	3	4.8 ab	7.8 ab
8. V-10066 50WDG	0.0625	3	5.0 ab	21.8 abcd
9. Avaunt 30WG[b]	0.111	3	5.3 ab	8.8 ab
10. Novaluron 7.5WG	0.1665	3	2.3 a	5.3 a
11. Esteem 0.86EC[b]	0.1075	1	3.0 a	16.3 abc
Imidan 70WP[d]	4.2	1		
Guthion 50WP	1.5	2		
12. Dimilin 2L[b]	0.75	1	3.0 a	27.8 bcd
Imidan 70WP[d]	4.2	1		
Guthion 50WP	1.5	2		
13. Agri-Mek 0.15EC[c]	0.0117	1	2.8 a	9.3 ab
Imidan 70WP[d]	4.2	1		
Guthion 50WP	1.5	2		
14. Omni Supreme oil by vol.	1.0%	3	4.8 ab	5.5 a
15. Untreated Control			3.5 a	5.3 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 1.0% Omni Supreme oil by volume.
[c] Treatments contained 0.25% Omni Supreme oil by volume.
[d] pH was adjusted to < 6.0.

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 2.8% CM infested fruit in the grower standard. Thus, this trial should be considered a rigorous test of the experimental materials. Assail combined with horticultural oil and Calypso following or proceeding Intrepid are very promising combinations for total insect pest control in pears. These treatment programs provided acceptable CM control that was very similar to the grower standard while at the same time suppressed TSSM, ERM and PP populations. Areas of future research include the combination of horticultural oil with Calypso and the combination of Dimilin/Novaluron with Calypso or Assail to further suppress CM populations.

2. Evaluation of Neonicotinoid Insecticides for Lygus Bug Control in Pears

Methods and Materials: This trial was conducted in a commercial 'Bartlett' pear orchard in Isleton, CA. This orchard was planted on a 16 ft. x 16 ft. off-set spacing (170 trees/ac). Five treatments and an untreated control were replicated four times in a RCB design. Each replicate was an individual tree with buffer trees in each direction. Foliar sprays were applied with a hand-held orchard sprayer operating at 250 psi with a finished spray volume of 300 gal/acre (1.76 gal/tree). The effectiveness of neonicotinoid insecticides was evaluated by caging 15 male and 10 female laboratory-cultured adult LB on pear foliage. Mesh bags approximately 60 cm x 35 cm contained the LB on individual branches with fruit (unless otherwise indicated) at 0, 7, 14 and 21 days after treatment (DAT). LB were caged on the branches at about 1 p.m. and examined after 1, 4 and 7 days of exposure (DOE).

Results and Discussion:

Effects of Insecticides - At 1 DOE and 0 DAT, all insecticides showed significantly greater LB mortality as compared to the untreated control with V-10066 providing significantly greater LB mortality as compared to Provado, Calypso or Actara (Table 5). By 7 DAT, mortality decreased and only V-10066 provided significantly greater mortality than in the untreated control. By 14 DAT, there was no significant difference among treatments. At 4 DOE and 0 DAT, again all insecticides showed significantly greater LB mortality as compared to the untreated control with V-10066 providing significantly greater LB mortality as compared to Provado and Calypso (Table 6). At 7 DAT, V-10066, Assail and Calypso showed significantly greater LB mortality as compared to the untreated control and there was no significant difference among the insecticides. At 14 DAT, only V-10066 exhibited significantly greater mortality than in the control and there was no significant difference among the experimental insecticides. At 21 DAT, V-10066 and Actara gave significantly greater mortality than the control. However, at 21 DAT pesticide activity greatly diminished. At 7 DOE and 0, 7 and 14 DAT, all insecticides showed significantly greater LB mortality as compared to the untreated control (Table 7). By 21 DAT, V-10066, Calypso and Actara showed significantly greater LB mortality as compared to the untreated control. However control mortality was unacceptable and ranged from 34.8% at 21 DAT to 60.8% at 0 DAT. This high untreated control mortality brings into question the true efficacy of the insecticides at 7 DOE.

Effects of Fruit on Longevity - LB longevity was increased in cages that contained a fruit. On untreated control trees at 1 DOE, there was no significant difference observed in LB mortality between cages with or without fruit except at 14 DAT (Table 8). However, while no statistically significant difference ($P \leq 0.05$) *was found, a decrease of about 20% in LB mortality was* observed in cages with fruit compared to LB caged without fruit. A similar pattern was found when LB were caged with and without fruit on pear tree branches treated with Provado (Table 9). At 4 and 7 DOE, LB mortality was significantly increased in most cages with fruit compared to LB caged without fruit in both the control and Provado treated trees. The difference in mortality in cages with or without fruit on Provado treated trees was more pronounced at 14 and 21 DAT. It appears that as the efficacy of Provado decreases the effects of fruit on mortality become more pronounced.

Effects of Gender on Longevity - There was no significant difference in mortality between males and females except Actara at 7 DAT and Assail at 21 DAT (Table 10). These results indicate that there does not seem to be a gender mortality difference. However, in laboratory studies females tend to live significantly longer than males.

Table 5. Mean Percent Mortality of Lygus Bugs Caged on Foliage for 1 day at Isleton, CA - 2001

Treatment	Rate lb (AI)/acre	0	7	14	21
V-10066 50WG	0.06	89.0 c	69.8 b	34.0 a	25.6 b
Assail 70WP	0.18	75.0 bc	61.5 ab	25.5 a	18.7 ab
Provado 1.6F	0.10	74.8 b	36.7 ab	27.7 a	7.7 a
Calypso 4SC	0.19	72.3 b	44.4 ab	19.5 a	14.1 ab
Actara 25WP	0.06	71.5 b	25.6 a	27.8 a	24.8 ab
Untreated	---	15.3 a	20.1 a	12.6 a	10.4 ab

[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.

Table 6. Mean Percent Mortality of Lygus Bugs Caged on Foliage for 4 days at Isleton, CA - 2001

Treatment	Rate lb (AI)/acre	0	7	14	21
V-10066 50WG	0.06	92.0 c	83.9 b	87.0 b	56.5 b
Assail 70WP	0.18	80.8 bc	77.4 b	64.2 ab	43.3 ab
Provado 1.6F	0.10	79.3 b	67.8 ab	53.0 ab	25.3 a
Calypso 4SC	0.19	80.3 b	69.7 b	69.1 ab	41.5 ab
Actara 25WP	0.06	86.5 bc	56.1 ab	64.4 ab	50.5 b
Untreated	---	29.5 a	31.4 a	36.0 a	26.1 a

[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.

Table 7. Mean Percent Mortality of Lygus Bugs Caged on Foliage for 7 days at Isleton, CA-2001

Treatment	Rate lb (AI)/acre	0	7	14	21
V-10066 50WG	0.06	100.0 b	96.0 b	100.0 b	75.1 c
Assail 70WP	0.18	96.8 b	94.7 b	93.7 b	48.3 ab
Provado 1.6F	0.10	95.0 b	85.5 b	96.2 b	45.4 ab
Calypso 4SC	0.19	92.0 b	91.0 b	95.6 b	71.0 c
Actara 25WP	0.06	100.0 b	95.8 b	100.0 b	60.9 bc
Untreated	---	60.8 a	46.7 a	55.7 a	34.8 a

[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.

Table 8. Mean Percent Lygus Bug Mortality Caged on Untreated Foliage With and Without Fruit at Isleton, CA - 2001

Days of		Mean[a] Percent Mortality at DAT				Season
Exposure	Fruit	0	7	14	21	Avg.
1	Yes	15.3 a	20.1 a	12.6 b	10.4 a	14.6 a
1	No	32.5 a	24.3 a	5.3 a	25.2 a	21.8 a
4	Yes	29.5 a	31.4 a	36.0 a	26.1 a	30.8 a
4	No	53.0 a	48.7 a	55.3 b	43.5 a	50.1 b
7	Yes	60.8 a	46.7 a	55.7 a	34.8 a	49.5 a
7	No	70.5 a	69.1 b	85.1 b	55.6 a	70.1 b

[a] Means followed by the same letter within a couplet are not significantly different (Fisher's protected LSD P ≤ *0.05). Data analyzed using an* arcsin transformation.

Table 9. Mean Percent Lygus Bug Mortality Caged With and Witout Fruit on Foliage Treated with Provado at Isleton, CA - 2001

Days of		Mean[a] Percent Mortality at DAT			
Exposure	Fruit	0	7	14	21
1	Yes	74.8 a	36.7 a	27.7 a	7.7 a
1	No	72.3 a	54.2 a	27.2 a	12.1 a
4	Yes	79.3 a	67.8 a	53.0 a	25.3 a
4	No	78.5 a	76.9 a	67.9 b	40.4 b
7	Yes	95.0 a	85.5 a	96.2 a	45.4 a
7	No	92.8 a	97.0 a	99.0 a	63.1 b

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

Table 10. Mean Percent Mortality of Male and Female Lygus Bugs Caged on Foliage after 7 days of exposure at Isleton, CA - 2001

	Mean* Percent Mortality at DAT		
Sex	7	14	21
	Control		
Males	38.6 a	40.2 a	39.0 a
Females	58.3 a	77.8 a	27.7 a
	Provado 1.6F		
Males	83.3 a	93.6 a	43.2 a
Females	75.0 a	100.0 a	46.1 a

Table 9 (cont)

	Actara 25WG		
Males	93.3 a	100.0 a	68.5 a
Females	100.0 b	100.0 a	50.0 a
	Assail 70WP		
Males	93.0 a	91.7 a	63.5 b
Females	97.5 a	96.9 a	28.7 a
	V-10066 50WG		
Males	95.0 a	100.0 a	81.1 a
Females	97.5 a	100.0 a	66.7 a
	Calypso 4SC		
Males	85.1 a	94.8 a	67.5 a
Females	100.0 a	97.2 a	77.2 a

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

Conclusions: This trial should be considered a rigorous test of the experimental materials. Any movement by a LB, however small, resulted in scoring the bug alive. However, alive LB on treated branches were lethargic and were incapable of feeding. V-10066 provided consistently greater LB mortality than the other neonicotinoid insecticides. Based on this and past years' research, V-10066 would be the most effective replacement for Carzol or Dimethoate. Provado, which is currently registered on pears, provided adequate control of LB but was consistently out performed by V-10066.

3. Soil Applied Systemic Neonicotinoid Insecticides for Control of Lygus Bugs in Pears

Methods and Materials: This trial was conducted in a commercial 'Bartlett' pear orchard in Fairfield, CA. This orchard was planted on a 21 ft. x 21 ft. spacing (99 trees/ac). Seven treatments were replicated three times in a RCB design. The seven treatments were Admire 2F and Platinum 2SC, each applied at three monthly intervals, and an untreated control. Each systemic insecticide was applied to the soil surrounding individual trees with buffer trees in each direction. The Admire 2F and Platinum 2SC treatments were applied on 8 March, 4 April and 2 May at a rate of 0.64 fl oz formulated product per tree (1.0 lb (AI)/acre). The formulated product was diluted into 10 gal of water and was uniformly applied to the ground from the trunk to the drip line. About 24 hours preceding application, the ground surrounding each tree was watered (about 50 gal per tree). Following the application and absorption of material into the soil, 20 gal of water were applied per tree to move the material to the root zone. There were three untreated control trees.

Evaluation Procedures - Control was evaluated by confining 25 laboratory-cultured adult LB on the foliage of each pear tree. The LB were confined in mesh bags approximately 60 cm x 35 cm. The LB were caged on 14 May and mortality was determined for 1, 3 and 7 DOE One or more attached fruit were included in each cage to increase adult longevity. Soil moisture was determined by taking soil samples immediately prior to ground application. Soil samples (top 1 ft) were taken about 2.5 ft from trunk of tree.

Results and Discussion: There was no significant difference among the treatments in LB mortality at the three application dates (Table 11). However, compared to the control, there was increased morality at 7 DOE to the Platinum treatments that were applied in March and April, but not May. This could indicate uptake of a small amount of Platinum. There was a significant difference in the soil moisture at the time of treatment despite the pretreatment watering (Table 12). The soil moisture showed a slight decrease over the three months of the experiment. Thus the pretreatment watering did not overcome the soil drying and a greater amount of water over a longer period of time should have been applied prior to treatment. However, it is believed that the lower soil moisture in April and May would not prevent significant movement of the material into the trees.

Table 11. Mean Percent Mortality of Caged LB at different lengths of foliage exposure at Fairfield, CA - 2001

Treatment	Rate lb (AI)/ac	Mean[a] Percent Mortality Days of Exposure 1	3	7
			March	
Admire 2F	1.0	1.3 a	2.2 a	15.2 a
Platinum 2SC	1.0	2.5 a	3.9 a	31.7 a
Untreated	---	0.0 a	4.8 a	15.5 a
			April	
Admire 2F	1.0	0.0 a	0.0 a	14.5 a
Platinum 2SC	1.0	2.8 a	5.5 a	26.2 a
Untreated	---	0.0 a	4.8 a	15.5 a
			May	
Admire 2F	1.0	1.3 a	4.1 a	8.2 a
Platinum 2SC	1.0	0.0 a	0.0 a	18.8 a
Untreated	---	0.0 a	4.8 a	15.5 a

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

Table 12. Mean percent Soil Moisture at Fairfield, CA - 2002

Date	Mean[a] Percent Soil Moisture
March	0.19 a
April	0.13 b
May	0.11 b

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

Conclusions: LB are mainly fruit feeders. It appears that the amount of Admire or Platinum translocated to the fruit was insufficient to cause increased mortality and the amount of foliage feeding and/or the amount of Admire or Platinum translocated to the foliage was insufficient to cause increased mortality. Control of LB with neonicotinoid insecticides should concentrate on foliar applications. The use of Admire or Platinum as soil systemic insecticides in pears should target foliage pests such as PP, but not fruit pests such as LB. There are some indications that PP populations were suppressed with the systemic applications of Admire and Platinum. Future research will investigate the use of systemic neonicotinoid for PP and SJS control.

4. Trunk Injected Admire for Control of Lygus Bugs in Pears

Methods and Materials: This trial was conducted in a commercial 'Bartlett' pear orchard in Fairfield, CA. This orchard was planted on a 21 ft. x 21 ft. spacing (99 trees/ac). Two treatments were replicated four times in trial 1 and three treatments were replicated four times in trial 2 in a RCB design. Each treatment was injected into individual trees with buffer trees in each direction. Admire 2F was injected on 23 May at a rate of 0.04 fl. oz. formulated product per tree (0.063 lb (AI)/acre) and 30 May at a rate of 0.5 fl. oz. formulated product per tree (0.78 lb (AI)/acre). The formulated product was diluted into 100 ml of water and injected at four cardinal points into the trunk. Four 1.6 cm (5/8 in.) diameter by 3.75-5.0 cm (1.5-2 in.) deep holes were drilled into the trunk of each tree. Treatments were injected using four 25 ml disposable plastic pipettes that were filled with the Admire 2F solution. Pipettes were inserted into each hole and allowed to drain into the trees.

Evaluation Procedures - Control was evaluated by confining 25 laboratory-cultured adult LB on the foliage of each pear tree. The LB were confined in mesh bags approximately 60 cm x 35 cm. LB were caged on 23 May (trial 1) and 30 May (trial 2) and mortality was determined for 1, 3 and 7 DOE. One or more attached fruit were included in each cage to allow feeding and increased adult longevity.

Results and Discussion: There was no significant difference among the treatments in LB mortality for 1, 3 and 7 DOE in trial 1 (Table 13). Since the results from trial 1 were unexpected, the trial was repeated with greater than 10 times the amount of Admire 2F that was used in trial 1. Again, there was no significant difference among the treatments in LB mortality at 1, 3 and 7 DOE. It is possible that the translocation of Admire took longer than one week or that Admire was not translocated into the fruit. When fruit are present, LB feed primarily on fruit and not foliage.

Table 13. Mean Percent Mortality of Caged Lygus Bugs at Fairfield, CA – 2001

		Mean[a] Percent Mortality Days of Exposure		
Treatment	Rate lb (AI)/ac	0	3	7
			Trial 1	
Admire 2F	0.063	0.06 a	0.10 a	0.16 a
Untreated	---	0.04 a	0.10 a	0.17 a
			Trial 2	
Admire 2F	0.063	0.02 a	0.06 a	0.09 a
Admire 2F	0.781	0.02 a	0.04 a	0.05 a
Untreated	---	0.02 a	0.04 a	0.09 a

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

Conclusions: LB are primarily fruit feeders. It appears that the amount of Admire translocated to the fruit was insufficient to cause increased mortality and the amount of foliage feeding and/or the amount of Admire translocated to the foliage was insufficient to cause increased mortality. Control of LB with neonicotinoid insecticides should concentrate of foliar applications.

Acknowledgments: We gratefully acknowledge the PCA and growers whose assistance made the above studies possible: David Elliot, Larry Glashoff, Bob Hansen, Doug Hemly, Matthew Hemly, Cindy Seabeck and Thom Wiseman