Control of Codling Moth by Postharvest Application of Ethephon 2SL and Lorsban 4E

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Introduction

The elimination or restriction of older organophosphate insecticides, as well as the development of resistance in codling moth (CM) to Guthion and other commonly used insecticides has brought about the need for new strategies for controlling this pest. Pear pest management relies on mating disruption for CM control and supplemental insecticides to maintain a low CM population. CM pheromone disruption has been demonstrated to be efficacious under low CM population pressure. Several supplemental insecticide applications may be required to maintain a low CM population. The supplemental insecticides may cause a substantial increase in pear psylla and twospotted spider mite populations. When no supplemental insecticides are applied, these secondary pests may be held under control by beneficial arthropods. Thus environmental benign methods are needed to supplement pheromone mating disruption.

Past research supported by the CPAB and PPMRF has demonstrated that the application of ethephon shortly after harvest will result in rapid maturation and drop of unharvested fruit. CM larvae that infest unharvested fruit treated with ethephon do not complete their larval development. The pears rot faster than the larvae can complete their development. This suppresses the overwintering CM population and thus decreases the CM population the following spring. Ethephon 2SL was registered in 2007 by Makhteshim-Agan as a postharvest application on pears in combination with an insecticide.

Chlorpyrifos (Lorsban 4E) has been shown to exhibit negative correlated cross-resistance to organophosphate, pyrethroid and some insect growth regulator insecticide-resistant CM. The combination of Lorsban 4E and Ethephon 2SL applied shortly after harvest would suppress the overwintering CM population and at the same time reduce insecticide resistance. However, chlorpyrifos is a restricted use pesticide and its use requires a closed cab, and many growers no longer have closed cabs. It also has a restricted entry interval (REI) of 4 days, during which personal protective equipment must be worn. Furthermore, water quality and sustainable agriculture concerns make the use of chlorpyrifos less desirable. Therefore, most growers choose to use other insecticides with Ethephon 2SL.

Methods and Materials

In August 2007, trials were initiated in four commercial pear orchards in Sacramento County and one orchard in Mendocino County following the 2007 harvest. Ethephon 2SL at 4 pt/ac plus 2 pt/ac of Lorsban 4E was applied to 10-20 acres shortly after harvest using a commercial air-blast sprayer. The application dates were 4-9 August 2007 in Sacramento County and on 14 August 2007 in Mendocino County. In each orchard, 10-20 acres of trees adjacent to the treated plots were left untreated with Ethephon/Lorsban.

In 2008, the same orchards were again treated in Sacramento County and another orchard was added, and three orchards in Lake County and two Mendocino County orchards (including the orchard used in 2007) were used in the study. This time, Ethephon 2SL at 4 pt/ac was mixed with a different insecticide (Delegate, Altacor, Lorsban, or oil alone). The application dates were 12-15 August in the Sacramento Delta and on 22 August to 5 September in Lake and Mendocino Counties.

In both years, fruit pressures were determined on 25 normal and 10 rattail fruit in both the treated and untreated portion of each orchard about two weeks after application.

CM populations were monitored during spring 2008 by placing five bait pan traps high in the tree canopy in both the treated and untreated portion of each orchard. A bait mixture was prepared with 3 gal. water, 2.4 lbs. brown sugar, 6 ml terpinyl acetate, and 1.4 ml soap. The bait pan trap is a quart-size container with 3 inches of bait mixture. One pheromone trap was placed high in the tree canopy in the center of each plot. The traps were monitored weekly from late March through late May. CM control during the season was the same on both the treated and untreated portions of the orchard and was at the discretion of the grower.

Two weeks prior to harvest the number of rattail fruit per tree were determined on 50 trees in each portion of each orchard. To determine if ethephon has an effect on return bloom, yields for each portion of each orchard were obtained at commercial harvest each year by counting the number of trees required to fill a trailer of bins at four locations in each block. One hundred fruit per tree were selected at random from each tree to obtain weight and fruit size.

Moth counts and harvest data were collected from 3 of the orchards only in Sacramento County, since in one orchard (Orchard T), data were collected from incorrect areas of the orchard.

Results and Discussion

Fruit Pressure

In **2007**, fruit pressure of normal fruit in orchards treated with Ethephon was significantly reduced in the Sacramento orchards compared to untreated orchards 2 weeks after the application (Table 1). Although rattail fruit of Ethephon-treated trees had lower pressure readings than those of untreated trees, the difference between the means of all orchards was not significant. Average fruit pressures of normal fruit in the Mendocino orchard were substantially lower than untreated fruit after 2 weeks, and Ethephon-treated rattail fruit in this orchard were reduced after 3 weeks (Table 2).

In **2008**, fruit pressures on normal fruit were reduced with Ethephon after 1 week (Table 3), but not significantly (P=0.053). Pressures in Ethephon-treated normal fruit were significantly reduced in weeks 2 and 3 compared to untreated fruit. Pressures of rattail fruit were significantly reduced 2 weeks after treatment with Ethephon. In Lake County, there were no differences in pressures on either normal or rattail fruit (Table 4).

Once fruit pressure falls below 6.5 kg/cm^2 CM cannot complete its larval development. In Sacramento orchards, and in the Mendocino orchard in 2007, this point was generally reached in normal fruit 2 weeks after Ethephon treatment, and at 3 weeks in rattail fruit.

Trap Counts

Sacramento CM trap counts in 2008 showed that there was a substantial reduction in moth counts in both pheromone and bait pan traps in the Ethephon treated plots as compared to the untreated plots (Table 5). Pheromone traps in Ethephon-treated blocks caught an average of 55% fewer moths, mainly the result of one high-pressure orchard. Bait pan traps caught similar numbers of male and female moths, but only females were counted. Among all 5 bait pan traps in each block, there was a 25% reduction in moths caught in the Ethephon blocks compared to the untreated blocks. Among traps in the center of each block only, 38% fewer moths were caught in the Ethephon blocks.

In the Mendocino orchard, the pheromone traps showed that moth populations were far higher in the Ethephon-treated block, due mainly to the choice to use Ethephon on the block with the highest CM pressure (Table 5). In the 5 bait pan traps, however, the relative difference between the blocks was less than in the pheromone traps, and in only the center traps, fewer moths were caught in the Ethephon-treated block.

Yields and Fruit Size

Several methods were used to determine if yields or fruit size were affected by Ethephon treatment. Randomly selected fruit (100 in Sacramento and 50 in Mendocino) from each of 4 trailers were weighed (Table 6). In Sacramento, Ethephon-treated fruit from all blocks sampled were slightly lighter numerically than untreated fruit, but the mean weight of fruit across all orchards was not significantly different. However, in the Mendocino orchard, Ethephon-treated fruit were slightly heavier. It should be noted that in orchard H during the first sampling for fruit weight, workers began picking in the Ethephon block and they were later instructed by the grower to pick to a larger size.

The average number of bins required to fill a bin could be a useful way to determine the yield in each block. However, sometimes different size standards are used at the different times that individual blocks are harvested. Nonetheless, the number of trees required to fill a bin in the Ethephon-treated blocks appeared to be the same or slightly fewer than untreated blocks in Sacramento orchards (Table 7). Thus, treated trees did not appear to have lower yields than untreated trees.

In an additional yield measure, in Orchard M the total number of bins for 3 uniform, equidistant rows in each block were obtained from the grower. A total of 130 bins were harvested by the grower in the 3 Ethephon-treated rows, whereas 120 bins were harvested from 3 untreated rows.

There is no clear indication that Ethephon affects fruit size or yield, but with the addition of more orchards, a clearer picture should develop in 2009.

Table 1. Mean normal and rattail fruit pressure (kg/cm^2) at 2 weeks after application with 4 pt Ethephon 2SL per acre, Sacramento Delta, CA – 2007.

		Orchard				Mean	P Value[1]
		G	T	M	H		
Normal Fruit	Ethephon	4.3	4.5	9.1	4.6	5.6	**[2]
	Untreated	9.4	10.8	13.0	11.1	11.1	
Rattail Fruit	Ethephon	29.0	27.5	10.1	6.2	18.2	NS (0.11)
	Untreated	35.1	38.9	25.3	24.5	31.0	

[1]T-test to compare means, $P < 0.05$

[2] ** Indicates significance at $P \leq 0.01$. NS indicates not significant.

Table 2. Mean normal and rattail fruit pressure (kg/cm^2) after application with 4 pt Ethephon 2SL per acre, Mendocino County – 2007 (spray date 14 Aug.).

			Avg. Fruit Pressures
28 Aug.	Normal Fruit	Ethephon	2.0
		Untreated	10.2
	Rattail Fruit	Ethephon	11.5
		Untreated	13.9
3 Sept.	Normal Fruit	Ethephon	2.9
		Untreated	9.8
	Rattail Fruit	Ethephon	5.9
		Untreated	22.2

Table 3. Mean normal and rattail fruit pressure (kg/cm^2) after application 12 August to 15 August with 4 pt Ethephon 2SL per acre, Sacramento Delta, CA – 2008.

			Orchard					Mean	P Value[1]
			T	G	H	M	L		
20 Aug.	Normal Fruit	Ethephon	8.9	10.1	4.3	11.0	6.1	8.1	NS (0.053)
		Untreated	11.8	12.0	10.0	12.0	9.9	11.1	
	Rattail Fruit	Ethephon	18.4	12.7	12.0	13.3	12.0	13.7	NS (0.13)
		Untreated	19.8	12.3	17.7	16.4	16.9	16.6	
28 Aug.	Normal Fruit	Ethephon	6.7	9.1	0.1	0.7	0.8	3.5	*[2]
		Untreated	9.0	6.5	8.4	10.1	10.0	8.8	
	Rattail Fruit	Ethephon	16.0	10.6	3.9	10.0	10.8	10.2	*
		Untreated	18.8	16.3	18.7	16.7	14.1	16.9	
5 Sept.	Normal Fruit	Ethephon	4.3	4.1	N/A	N/A	N/A	4.2	**
		Untreated	6.3	6.3	N/A	N/A	N/A	6.3	
	Rattail Fruit	Ethephon	3.6	0.7	N/A	N/A	N/A	2.2	NS (0.12)
		Untreated	19.9	10.3	N/A	N/A	N/A	15.1	

[1]T-test to compare means, $P < 0.05$

[2] *, **Indicate significance at $P \leq 0.05$ and 0.01 respectively. NS indicates not significant.

Table 4. Mean normal and rattail fruit pressure (kg/cm^2) on 11 September after application 22 August to 5 September with 4 pt Ethephon 2SL per acre, Lake & Mendocino Counties – 2008.

		Orchard					Mean	P Value[1]
		Z	N	C	L	I		
Normal Fruit	Ethephon	11.9	2.1	13.2	11.2	5.3	8.7	NS (0.44)
	Untreated	11.6	8.0	13.1	10.9	9.5	10.6	
Rattail Fruit	Ethephon	22.0	7.7	16.9	15.3	13.4	15.1	NS (0.38)
	Untreated	18.7	14.5	21.6	14.8	18.0	17.5	

[1] T-test to compare means, $P < 0.05$

Table 5. Total first generation CM trap counts.

Orchard	Pheromone (10X)		Bait Pan – All 5 Traps (Females)		Bait Pan – Center Trap (Females)	
	Ethephon	Untreated	Ethephon	Untreated	Ethephon	Untreated
Sacramento						
M	2	2	29	34	2	4
G	48	109	152	203	24	33
H	1	1	10	17	2	8
Totals	51	112	191	254	28	45
% Reduction	55%		25%		38%	
Mendocino	32	1	45	24	3	6

Table 6. Average weight (lbs.) of randomly selected fruit (100 in Sacramento, 50 in Mendocino) from 4 bin-trailers per block.

	Sacramento Orchards					Mendocino Orchard
Treatment	M (1st Pick)	G (1 Pick Only)	H (1st Pick)	H (2nd Pick)	Mean[1]	
Ethephon	43.1	30.6	33.2	38.4	36.3 NS	22.3
Untreated	44.0	30.8	38.4	39.7	38.2 NS	20.9

[1] T-test to compare means, $P < 0.05$

Table 7. Average number of trees required to fill one bin.

Orchard	Ethephon	Untreated
M (1st Pick)	9.3	9.8
H (1st Pick)	25.4	27.7
H (2nd Pick)	5.9	10.8
Mendocino	3.0	2.7