Control of Codling Moth through Post-harvest Fruit Sanitation

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Abstract

Post-harvest fruit sanitation conducted in the fall of 1992 reduced the spring CM flight of female moths in 1993 by 30%. Based on the number of diapausing larvae found in the fall of 1992, we expected a 60% to 80% reduction in spring flight between the stripped and unstripped portions of the orchards. The lower than expected reduction in spring moth flight was the result of moth dispersal from the unstripped portion to the stripped portion of the orchards. The percent reduction in spring CM flight increased as the number of acres stripped increased. This would indicate that moth dispersal was the cause of the lower than expected percent reduction. In 1993, a 5- to 10-acre portion of six pear orchards were stripped of nearly all remaining fruit post-harvest. Immediately adjacent to the stripped portion an 8- to 15-acre portion was treated with 3 lb Guthion per acre. And adjacent to the sprayed portion of the orchards was 5- to 15-acre of untreated and unstripped control. The post-harvest fruit stripping resulted in a 86% reduction in the number of diapausing CM larvae as compared to the unstripped portion of the orchards and the post-harvest application of Guthion resulted in 78% reduction in the number of diapausing CM larvae as compared to the unstripped portion of the orchards. Hopefully, the Guthion treated portion of the orchards will provide a large enough buffer to suppress effects of moth dispersal on the stripped portion of the orchards. When Imidan was applied post-harvest for control of diapausing CM, the number of diapausing larvae was reduced by approximately 50%. In our diapause induction studies, it was found that some CM larvae, which completed their development in early July, will enter diapause and all larvae which complete their development after mid-August will enter diapause. In addition, CM larvae have a difficult time infesting immature pears in early June. As the pears mature through June and early July, CM larvae increases its ability to successfully infest and complete its development. After mid-July, which is about the time of first harvest, the CM larvae can infest the

fruit but the fruit is rotting faster than the CM larvae can complete their development.

Introduction

Codling moth (CM) is the key insect pest of pears, with annual control costs of approximately $150.00 per acre. Control of CM in pears has relied on repeated applications of Guthion or other insecticides. The repeated use of insecticides has resulted in the outbreak of a number of secondary pests, such as pear psylla and spider mites, which require additional insecticides for their control. Also, the repeated use of insecticides has resulted in the development of CM resistance to Guthion and cross-resistance to most alternative insecticides.

Pears are harvested early in the season (mid-July through mid-August) relative to other CM host crops, such as apples or walnuts. After commercial pear harvest, it is common to find a large number of unharvested fruit remaining on the trees. Since insecticides used for the CM control are usually terminated 2 or more weeks before harvest, the unharvested fruit serve as excellent sites for CM oviposition and allow for a rapid increase in the CM population. The CM which develop in these fruit after mid-August will enter the overwintering stage (diapause) and emerge as adults the following spring. A large overwintering population of CM can have a detrimental effect on the efficacy of either a pheromone- or insecticide-based control program.

A study was initiated during the fall of 1992 to determine if post-harvest fruit sanitation could reduce the number of diapausing larvae and subsequent adult CM emergence the following spring (see 1992 annual report). In 1992, commencing immediately after harvest, a 5- to 10-acre portion of each of 9 orchards located in Suisan valley, Sacramento delta, and Lake County were stripped of nearly all remaining fruit and another portion of equal or larger size was not stripped. Approximately 93% of the fruit was removed by the post-harvest fruit sanitation treatment. The average percent CM infestation in the fruit was 29.4%. An average of 1,179 CM-infested fruit per acre was generated in the unstripped portion of the orchards, while an average of 93 CM-infested fruit per acre was generated in the stripped portion of the orchards. Approximately 90% of the CM-infested fruit was reduced by the post-harvest fruit sanitation treatment. The average number of diapausing larvae found in 25 corrugated cardboard bands was 0.4 larvae in the stripped portion of the orchards and 3.1 larvae per 25

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bands in the unstripped portion of the orchards for a 87% reduction. Reported here are the results of our 1993 studies which include: 1) the effects of 1992 post-harvest fruit sanitation on 1993 spring CM flight, 2) the effects of post-harvest fruit sanitation and insecticide applications on suppression of the overwintering CM population, and 3) CM diapause induction studies.

1. Fruit Sanitation

A. Spring Flight

Methods and Materials: Four pheromone and bait-pan traps were placed in each of the stripped and unstripped portions of the 9 study orchards. All traps were placed high in the tree canopy and monitored weekly from March 25 through May 27. The pheromone traps were baited with 1 mg codlemone caps in all orchards except E and F, which were baited with 10 mg codlemone caps. Orchards E and F were under a pheromone-based control program. All pheromone caps were changed once a month and the trap bottoms were changed as needed. The bait-pan trap fluid (brown sugar, terpinyl acetate, soap and water) was replenished weekly, and the sex of the captured moths was determined.

Results and Discussion: The effect of post-harvest fruit stripping on the spring CM flight was very surprising and disappointing. The number of male moths caught in the pheromone traps for the entire trapping period was only 7% less in the stripped plots than in the unstripped plots. Similarly, the number of males caught in the bait-pan traps was 10% less, and the number of females 30% less in the stripped than in unstripped plots (Table 1). Based on last year's estimate of the number of diapausing larvae present, we expected about an 80% reduction in the number of spring flight moths caught in the stripped plots. The unexpectedly large number of moths caught is most likely the result of movement of moths from the unstripped portions of the orchards into the stripped portions.

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Table 1. Effect of post-harvest fruit stripping on trap catch of spring flight codling moths

		Percent difference between no. of moths caught in stripped and unstripped plots		
	Insecticide application	Pheromone traps	Bait-pan traps	
Orchard	dates	Males	Males	Females
A	4/24-4/26, 5/19	-20.5	55.8	18.1
B	4/24-4/26, 5/19	2.0	-23.8	34.4
C	4/30, 5/22	63.8	54.8	62.3
D	4/30, 5/22	-54.9	-63.1	-13.4
E	4/27-4/28	40.6	71.5	57.2
F	4/27-4/28	38.2	58.6	49.0
G	5/7-5/9	-2.6	-19.9	21.4
H	5/7-5/9	-6.7	-16.7	-29.2
I	5/10	-0.4	-30.4	68.8
Mean ± S.D.		6.6± 33.8	9.6 ± 47.1	29.8 ± 32.1

At first consistent moth catch (April 9 for pheromone traps and April 16 for bait-pan traps), fewer male moths were trapped in the stripped plots than in the stripped plots (Figs. 1 and 2). About 20% fewer males were trapped in pheromone traps and about 40% fewer in bait-pan traps. As the population increased, the difference between plots changed to zero, and in some cases more males were trapped in the stripped than in the unstripped portions of the orchards. After insecticides were applied, the difference was reestablished and about 30% fewer males were caught in the unstripped plots.

The catch of females in bait-pan traps showed the same pattern (Fig. 3); Seventy percent fewer females were trapped in the stripped plots initially (April 16). The catch changed to no difference in number of females trapped between

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stripped and unstripped plots at peak population. Following the application of insecticides, 30% fewer moths were trapped in the stripped than in the unstripped plots. Males are known to disperse greater distances than females. This differential dispersal would explain the larger reduction in trap catch for females than for males between the stripped and unstripped portions of the orchards.

What appears to be happening is that when moths first emerge from diapause, there is a large reduction in the moth population in the stripped portions of the orchards. As the season progresses, the moths move from the unstripped into the stripped portion of the orchards and the difference in catch changes to zero. After insecticides are applied, fewer new adults emerge in the stripped portion as compared to the unstripped portion of the orchards, reestablishing the reduced catch in stripped portion of the orchards. The reason that the reduction in trap catch after an insecticide application is not as great as in the beginning of the trapping season is not all moths are killed by the insecticide applications. This is particularly true in those orchards in which CM is resistant to Guthion.

Also, we observed a trend for an increased reduction in number of moths caught in stripped plots as the number of acres stripped increased (Fig. 4). In addition, we observed that the greater the amount of isolation of the stripped portion of the orchard from a source of CM, the greater the percent reduction in moth catch. For example, the stripped portion of orchard D was adjacent to an orchard which had a very high CM population and the stripped portion of orchard H was surrounded by unstripped orchard. If these two orchards are removed from the analysis, then the percent reduction in moth catch between the stripped and unstripped portion of the orchards is significantly increased This tends to support the explanation that moth dispersal accounts for the changes in catch throughout the season.

B. Fruit Stripping and Insecticide Applications

Methods and Materials: Six pear orchards were selected for inclusion in the study, 3 in Suisan valley, designated as orchards A, B and C, and 3 orchards in the Sacramento delta, designated D, E, and F. Commencing immediately after harvest, a 5- to 10-acre portion of orchards were stripped of nearly all remaining fruit. An 8- to 15-acre portion immediately adjacent to the stripped portion, in all orchards except B, was treated with 3 lb of Guthion per acre with a air-blast

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sprayer. Adjacent to the sprayed portion of the orchards was 5- to 15-acre of untreated and unstripped control. The number of fruit remaining in the trees after the post-harvest fruit removal was determined in 10 trees in both the stripped and unstripped portions of each orchard. After the fruit was removed, 200 rattail and 200 firm green fruit were tagged in the treated, and control (untreated and unstripped) portions of each orchard. The tagged fruit was inspected weekly from harvest through mid-October for CM infestation and fruit drop. Since it was not possible to tag 200 rattail and 200 firm green fruit in the stripped portion of each orchard due to a lack of fruit, and the position of the few remaining fruit in the trees, 100 rattail and 100 firm green fruit were inspected in the stripped portion of 5 orchards once during the season. In addition, 50 trees in each portion of each orchard were banded with single sided corrugated cardboard. CM larvae will enter the corrugated cardboard to pupate or diapause. The bands were examined in mid-October to determine the number of diapausing larvae. In the spring of 1994, CM populations will be monitored by bait-pan traps, which will be placed in the stripped, treated, and control portions of each orchard.

Results and Discussion: This year's harvest was about 2 weeks later than last year's harvest in Suisan valley and Sacramento delta. Post-harvest fruit removal was completed by August 9 in Suisan valley and August 13 in the Sacramento delta (Table 2). The Guthion treatments were applied from 4 to 6 days after fruit removal. Fruit removal required an average of 9.5 man hours per acre with a range of 5.4 to 14.4 man hours per acre. This amount of time is considerably less than last year and is approaching our target of 5 to 7 man hours per acre. The target of 5 to 7 man hours per acre would cost approximately $30.00 to $42.00 per acre at $6.00 per hour of labor which is about the cost of an insecticide application. In orchards A, B, and C, we were at or below our target. In these orchards, it would be more economical to strip than spray. The amount of time required to remove the fruit is related to tree height, tree structure, the number of trees per acre, and the number of fruit remaining in the tree after harvest.

Table 2. Date of stripping or insecticide application, acreage, time required to strip, number of trees and number of fruit remaining after stripping in 6 comparison orchards in Suisan valley and Sacramento delta, 1993.

Orchard Treatments	Date Stripping or Application Completed	No. Ac.	Man Hours/ Ac.	No. Trees/ Ac.	No. Fruit/ Ac.	% Fruit Removed
A.						
Stripped	8/5	6.7	6.2	104	520	90.6
Treated	8/9	11.25		104	5,512	
Control		8.0		104	5,512	
B.						
Stripped	8/6	9.6	5.4	75	338	91.7
Control		10.0		75	4,065	
C.						
Stripped	8/9	8.9	7.4	90	279	97.4
Treated	8/15	15.0		90	10,665	
Control		10.0		90	10,665	
D.						
Stripped	8/11	5.4	9.2	142	852	92.6
Treated	8/16	6.9		142	11,502	
Control		14.5		142	11,502	
E.						
Stripped	8/12	4.4	14.4	180	504	91.2
Treated	8/17	15.8		180	5,742	
Control		5.7		180	5,742	
F.						
Stripped	8/13	5.3	14.4	180	576	92.7
Treated	8/17	14.5		180	7,938	
Control		5.7		180	7,938	
Mean						
Stripped	---	6.7	9.5	129	512	92.7
Treated		12.7		129	7571	
Control		9.0		129	7571	

There was an average of of 129 trees per acre with a range of 75 to 180 trees per acre. There was an average of 7571 fruit per acre before fruit removal with a range of 4,065 to 11,502 fruit per acre. After fruit removal was completed, the average number of fruit remaining in the stripped portion of the orchards was 512

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fruit per acre with a range of 279 to 852 fruit per acre. Approximately 93% of the fruit was removed by the post-harvest fruit sanitation treatment.

The average percent CM infestation in the rattail fruit treated with Guthion was 27.9%, with a range of 3.5 to 72.5%, while the average percent CM infestation in rattail fruit in the untreated control was 58.7%, with an range of 18.0 to 89.0% (Table 3). The average percent CM infestation in normal green fruit treated with Guthion was 14.9%, with a range of 0.5 to 30.0%, while the average percent CM infestation in green fruit in the untreated control was 37.6%, with a range of 6.0 to 60.5 %. The average percent CM infestation in the total fruit (rattail and normal green combined) treated with Guthion was 21.4%, with a range of 3.8 to 51.3% while the average percent CM infestation in total fruit in the untreated control was 48.2%, with a range of 74.8 to 14.5%. Using the number of fruit per acre after fruit removal, the mean CM infestation data, and assuming the infestation in the stripped portion of the orchards to be the same as the unstripped portions of the orchards, an average of 3,860 CM-infested fruit per acre, with a range of 1,813 to 6,912 CM-infested fruit per acre were generated in the unstripped portion of the orchards. An average of 1,830 CM infested fruit per acre, with a range of 533 to 2,825 CM-infested fruit per acre were generated in the Guthion treated portion of the orchards. And an average of 232 CM-infested fruit per acre, with a range of 47 to 351 CM-infested fruit per acre were generated in the stripped portion of the orchards. The stripping treatment reduced the number of CM-infested pears by 94%, with a range of 90.6 to 98.2%, while the Guthion treatment reduce the number of CM-infested pears by 52.6%, with a range of 24.1 to 70.6%.

The mean number of CM-infested rattail fruit in both Guthion treated and untreated control portions of all orchards showed a steady rate of increase from August 19 through September 13 (Fig. 5). The rate of increase then slowed and by September 27, few new rattail fruit became infested. The rate of increase of infested rattail fruit was much slower in the Guthion portion of the orchards as compared to the untreated control portion of the orchards. The mean number of CM-infested normal green fruit in both Guthion treated and untreated control portions of all orchards showed a similar pattern to the rattail fruit (Fig. 6). The rattail fruit contributed more to the total infestation then the green fruit. Green fruit were rapidly maturing and dropping from the trees before they became infested. The Guthion treatment was effective in suppressing the infestation but did not eliminate it.

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When the percent CM-infested fruit was compared in the stripped and unstripped portions of 5 orchards, the average CM-infested fruit (rattail and normal green combined) in the stripped portion was 43.4%, while the average CM-infested fruit in the unstripped portion was 61.5%. Although the statistical analysis of the data has not been completed, there does not appear to be a concentration of CM-infestation in the few remaining fruit in the stripped portion of the orchards.

The average number of diapausing larvae found in the 50 corrugated cardboard bands in the stripped portion of the orchards was 3.7 diapausing larvae per 50 bands. The average number of diapausing larvae found in the 50 corrugated cardboard bands in the Guthion treated portion of the orchards was 4.2 diapausing larvae per 50 bands while the number of diapausing larvae found in the unstripped portion of the orchards was 18.3 larvae per 50 bands. Although the statistical analysis of the data has not been completed, it appears that both the fruit stripping and Guthion treatments significantly reduced the number of diapausing larvae. The post-harvest fruit sanitation reduced the number of diapausing larvae by 85.5% and the Guthion treatment reduced the number of diapausing larvae by 77.5%. The small difference in the number of diapausing larvae between the stripping and Guthion treatments, may be the result of a shifting of the CM infestation in the Guthion portion of the orchards to later in the season. After harvest CM larvae can infest the fruit but the fruit is rotting faster than the CM larvae can complete their development (see diapause induction section). The implication of these findings are that if the fruit can be protected for 2 or 3 weeks by an application of an insecticide, then the number diapause CM could be greatly reduced without manual fruit stripping.

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Table 3. Percent CM-infested fruit, number of infested fruit per acre, and number of diapausing larvae per 50 emergence bands in 6 comparison orchards in Suisan valley and Sacramento delta,1993.

Orchard Treatments	Percent Infested Rattail	Green	Total	No. Infested Fruit/ac.	No. Dia. Larvae/ 50 Bands	% Reduction in Dia. Larvae
A.						
Stripped				351	14	79.7
Treated	72.5	30.0	51.3	2,825	9	87.0
Control	83.5	51.5	67.5	3,721	69	
B.						
Stripped				253	3	75.0
Control	89.0	60.5	74.8	3,041	12	
C.						
Stripped				47	0	100.0
Treated	9.5	0.5	5.0	533	0	100.0
Control	28.0	6.0	17.0	1,813	1	
D.						
Stripped				124	0	100.0
Treated	3.5	4.0	3.8	2,622	0	100.0
Control	18.0	11.0	14.5	6,912	1	
E.						
Stripped				337	2	88.2
Treated	31.0	20.5	25.8	1,481	5	70.5
Control	80.0	53.5	66.8	3,836	17	
F.						
Stripped				278	3	70.0
Treated	23.0	19.5	21.3	1,691	7	30.0
Control	53.5	43.0	48.3	3,834	10	
Mean						
Stripped				232	3.7	85.5
Treated	27.9	14.9	21.4	1,830	4.2	77.5
Control	58.7	37.6	48.2	3,860	18.3	

C. Insecticidal Suppression of Diapausing Larvae

Methods and Materials: Three pear orchards in Lake County were selected for inclusion in the study. After harvest, a 5-acre portion of each orchard was treated

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with 8 lb Imidan per acre with an air-blast sprayer and another portion of 5 acres or larger was left untreated. After treatment, 200 rattail and 200 firm green fruit were tagged in the treated and untreated portions of each orchard. The tagged fruit was inspected weekly from September 14 through October 21 for CM infestation and fruit drop. In addition, 50 trees in each portion of each orchard were banded with single sided corrugated cardboard. CM larvae will enter the corrugated cardboard to pupate or diapause. The bands were examined in mid-October to determine the number of diapausing larvae.

Results and Discussion: This year's harvest was about 2-3 weeks later than last year's harvest in Lake County. Due to the late harvest, it was decided not to conducted a post-harvest fruit sanitation study, but concentrate on the efficacy of insecticide applications as a post-harvest treatment to suppress the diapausing CM population.

The insecticide applications were applied between September 8 to September 15 (Table 4). The average percent CM infestation in the rattail fruit treated with Imidan was 6.8%, with a range of 0.5 to 19.5%, while the average percent CM infestation in rattail fruit in the untreated control was 11.7%, with an range of 5.5 to 21.5%. The average percent CM infestation in normal green fruit treated with Imidan was 3.3%, with a range of 0.0 to 8.5%, while the average percent CM infestation in green fruit in the untreated control was 5.3%, with a range of 1.5 to 12.5 %. The average percent CM infestation in the total fruit (rattail and normal green combined) treated with Imidan was 5.1%, with a range of 0.3 to 14.0% while the average percent CM infestation in total fruit in the untreated control as 8.4%, with a range of 3.5 to 16.8%. The Imidan treatments successfully controlled the post-harvest CM population in orchards A and B but not in orchard C. Orchard C delayed application by a week. This delay allowed CM to successfully infest the fruit remaining after harvest. This points to the fact that post-harvest control techniques (either stripping or insecticide application) must be conducted immediately after harvest.

The average number of diapausing larvae found in the 50 corrugated cardboard bands in the Imidan treated portion of the orchards was 1.7 diapausing larvae per 50 bands. The average number of diapausing larvae found in the 50 corrugated cardboard bands in the untreated control portion of the orchards was 3.3 diapausing larvae per 50 bands. The number of diapausing larvae was reduced by approximately 50%. This reduction may be reflected in next year's

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spring flight. However, a number of diapausing larvae may have entered diapause before the trial was initiated, since the trials was conducted so late in the season.

Table 4. Date of application, percent CM-infested fruit, and number of diapausing larvae per 50 emergence bands in 3 comparison orchards in Lake County, 1993.

Orchard Treatments	Date of Application	Percent Infested Rattail	Green	Total	No. Dia. Larvae/ 50 Bands
A.					
Treated	9/8	0.5	1.5	1.0	1
Control		5.5	1.5	3.5	1
B.					
Treated	9/10	0.5	0.0	0.3	1
Control		8.0	2.0	5.0	2
C.					
Treated	9/15	19.5	8.5	14.0	3
Control		21.5	12.5	16.8	7
Mean					
Treated	-----	6.8	3.3	5.1	1.7
Control		11.7	5.3	8.4	3.3

2. Diapause Induction

Methods and Materials: The induction of diapause in CM was studied in Courtland. Fifty fruit were infested weekly from June 2 through August 11 by placing 2 recently hatched CM larvae on each fruit. A small plastic cup was placed over the larvae and sealed to the fruit to ensure infestation. The fruit was removed from the trees 2 weeks after infestation and placed individually in a large plastic container. The plastic container had a layer of corrugated cardboard above and below the infested fruit to serve as a site for pupation or diapause. The containers were inspected weekly for 6 weeks to determine if a larvae was present. If a larva pupated during the 6 week period, then the larva was considered to be non-diapausing. If the larva did not pupate during the 6 week period, then the larva was considered to be diapausing.

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Results and Discussion: In 1992, approximately 30% of the larvae from fruit infested on June 30 entered diapause. By July 21, 100% of the larvae entered diapause (Table 5 and Fig. 7). In 1993, between 12.5% to 16.7% of the CM larvae from fruit infested on June 2 through June 16 entered diapause. On June 23, the percent larvae entering diapause increased to 20%. By July 21, 100% of the larvae entered diapause. This data would indicate that a low percent (ca. 15%) of larvae that infest fruit in early June will enter diapause and all larvae will entered diapause from fruit infested after July 21. Diapause induction has often been based on the date of larval emergence from the fruit instead of date of larval infestation of the fruit. We then reanalyzed our data based on the date when the larvae emerged from the fruit. In 1992, 28% of the CM larvae that emerged from fruit on July 28 entered diapause (Table 6 and Fig. 8). By August 18, 100% of the larvae entered diapause. In 1993, between 0% to 14.3% of the CM larvae that emerged from June 30 through July 21 entered diapause. The percent larvae entering diapause increased to 30% on July 28. By August 18, 96.3% of the larvae entered diapause. These results indicate that some CM larvae which completed their development in early July, will enter diapause and that all larvae which complete their development after mid-August will enter diapause. The implications of these findings for control of CM through post-harvest fruit sanitation is that fruit stripping should be completed as soon as possible after harvest. The longer fruit stripping is delayed, the greater the number of diapausing larvae that will be produced. In addition, the post-harvest fruit stripping control technique, even if all fruit are removal, will not completely eliminate CM from the orchard.

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Table 5. Number of diapausing and non-diapausing codling moth larvae by date of larval infestation in Courtland, Calif.

Date of Infestation*	1992 Diapause	1992 Non-diapause	1993 Diapause	1993 Non-diapause
6/2			1	5
6/9			3	19
6/16			3	21
6/23			5	21
6/30	12	29	11	21
7/7	15	16	26	14
7/14	14	7	31	7
7/21	21	0	30	0
7/28	24	0	21	1
8/4	11	0	16	0
8/11	11	0	7	0
8/18	18	0		
8/25	7	0		

* 50 fruit infested weekly with 2 neonate larvae.

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Table 6. Number of diapausing and non-diapausing codling moth larvae by date of larval emergence from fruit in Courtland, Calif.

Date of	1992		1993	
Emergence*	Diapause	Non-diapause	Diapause	Non-diapause
6/30			0	0
7/7			3	22
7/14			3	18
7/21			2	22
7/28	7	18	12	27
8/4	19	24	29	10
8/11	13	10	30	6
8/18	23	0	26	1
8/25	21	0	22	0
9/2	14	0	26	1
9/9	8	0	1	0
9/15	16	0		
9/22	10	0		
9/29	2	0		

* 50 fruit infested weekly with 2 neonate larvae from June 30 to August 25, 1992 and June 2 to August 11, 1993.

In 1992, a total of 41 larvae (diapausing and non-diapausing combined) completed their development per 50 fruit when infested on June 30 (Fig. 9). The number of larvae gradually declined to 7 larvae for fruit infested on August 25. In 1993, the total number of larvae completing their development increased from 6 larvae from fruit infested on June 2 to 40 larvae from fruit infested on July 7. The number of larvae then gradually declined to 7 larvae for fruit infested on August 11. These results indicate that CM larvae have a difficult time infesting immature pears in early June. As the pears mature through June and early July, CM larvae increases its ability to successfully infest and complete its development. After mid-July, which is about the time of first harvest, the CM larvae can infest the fruit but the fruit is rotting faster than the CM larvae can complete their development. The implication of these finding is that if the

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maturity of pears remaining on the tree after harvest can be advanced by 2 or 3 weeks by the use of a plant growth regulator such as ethephon or if the fruit can be protected for 2 or 3 weeks by an application of an insecticide, then the number of diapauseomg CM could be greatly reduced without manual fruit stripping.

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Fig. 1 Number of male codling moths per trap per day captured in pheromone traps and percent reduction in moth catch between stripped and unstripped portion of the orchards

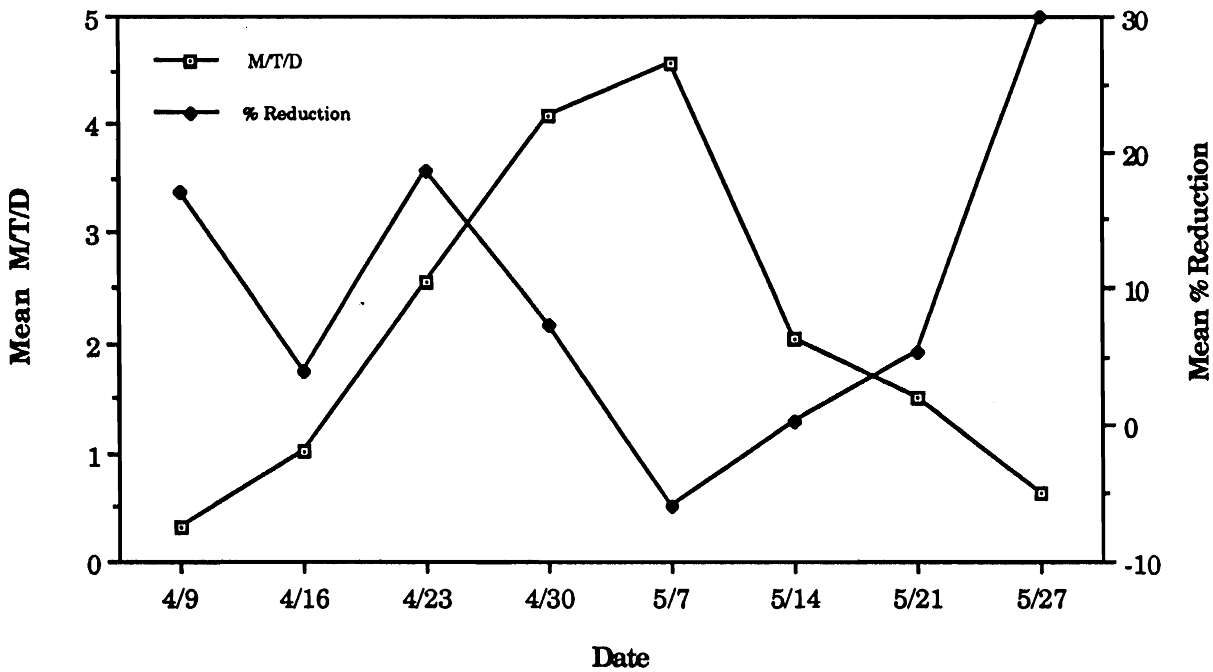

Fig. 2 Number of male codling moths per trap per day captured in bait-pan traps and percent reduction in the moth catch between stripped and unstripped portion of the orchards

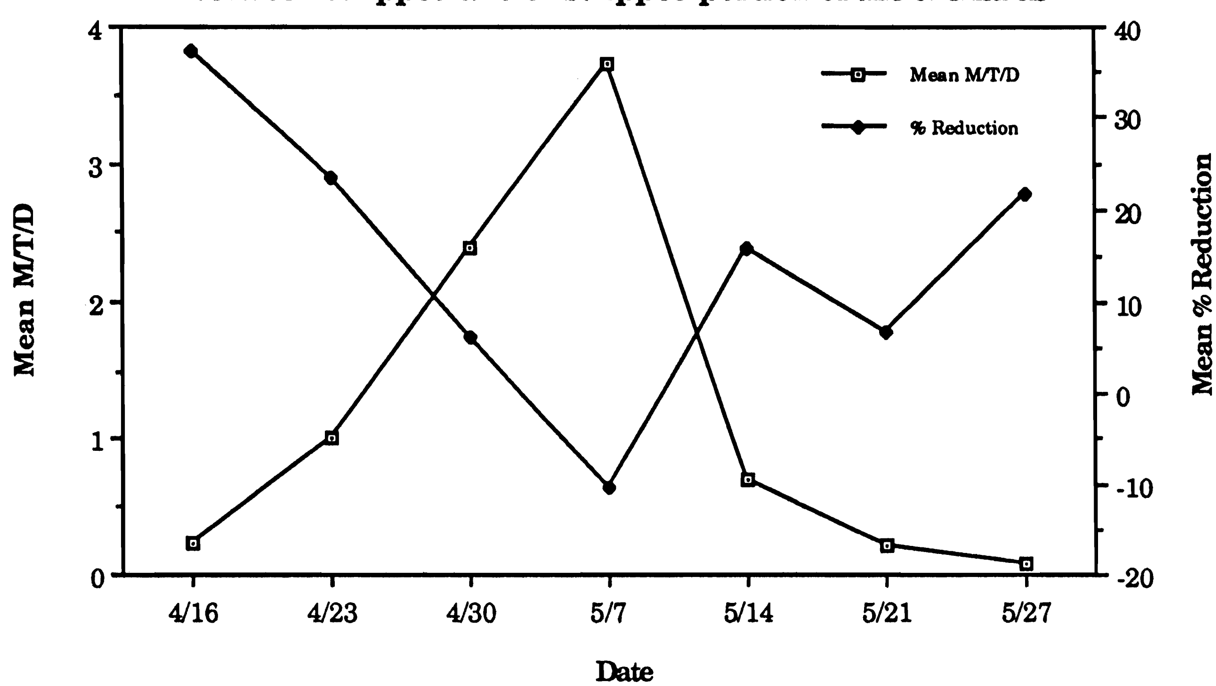

Fig. 3 Number of female moths per trap per day captured in bait-pan traps and percent reduction in moth catch between stripped and unstripped portion of the orchards

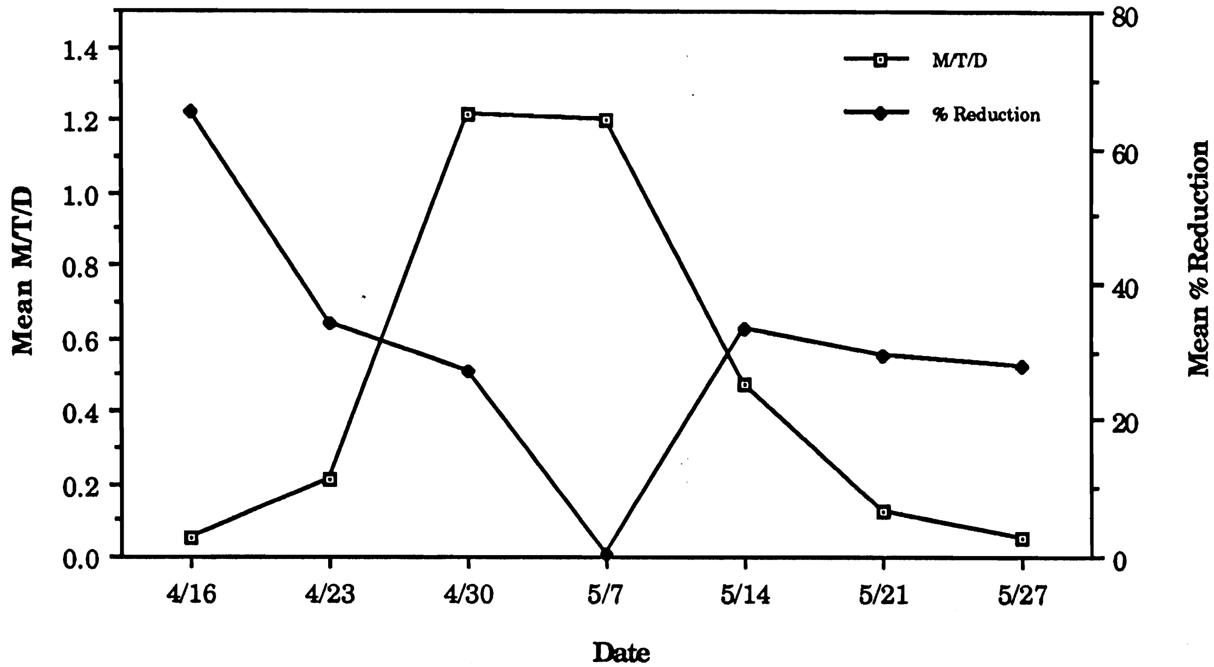

Fig. 4 Percent reduction in female moth catch between stripped and unstripped portion of the orchards in relation to the size of the stripped portion of the orchards

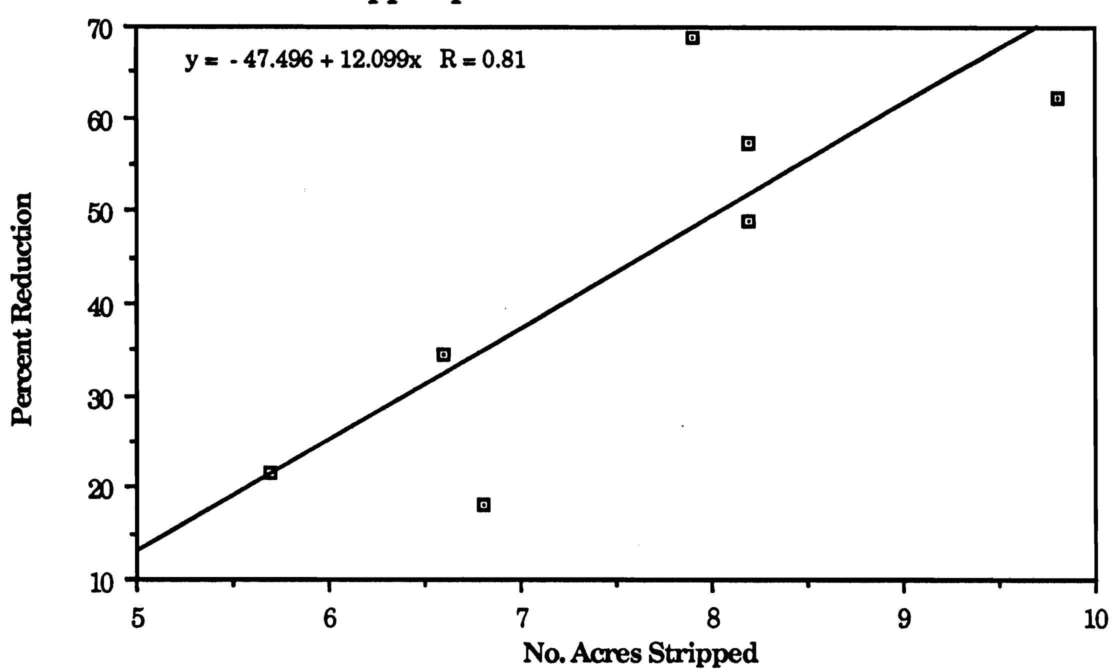

Fig. 5 Accumulated mean number of CM-infested rattail fruit in Guthion treated and untreated control portions of all orchards

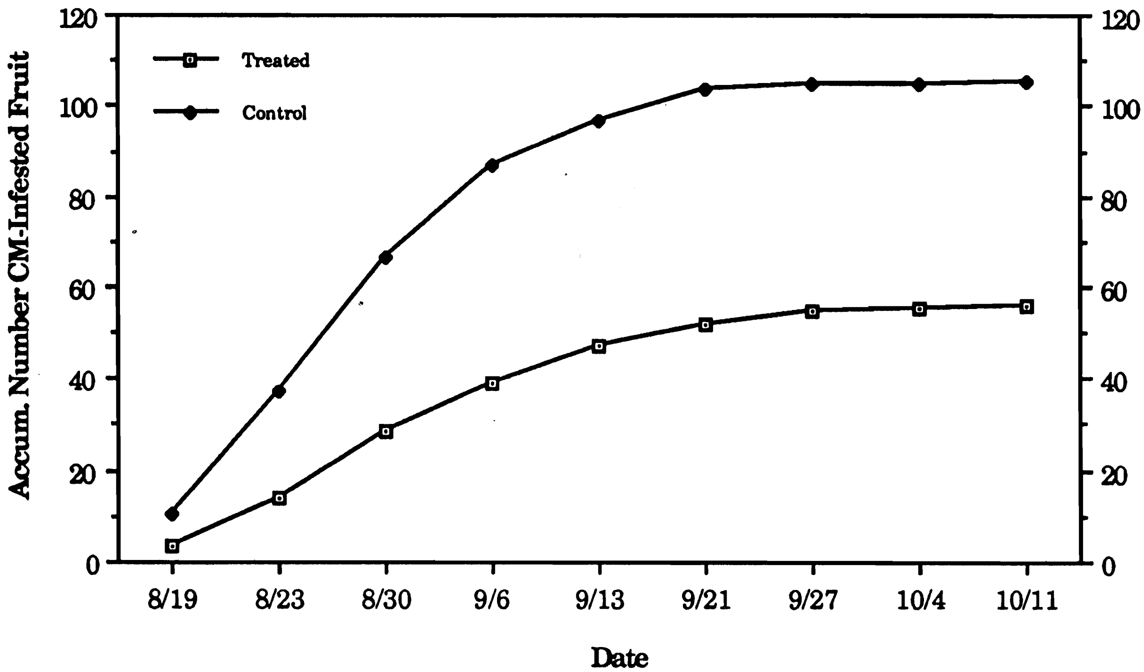

Fig. 6 Accumulated mean number of CM-infested green fruit in Guthion and untreated control portions of all orchards

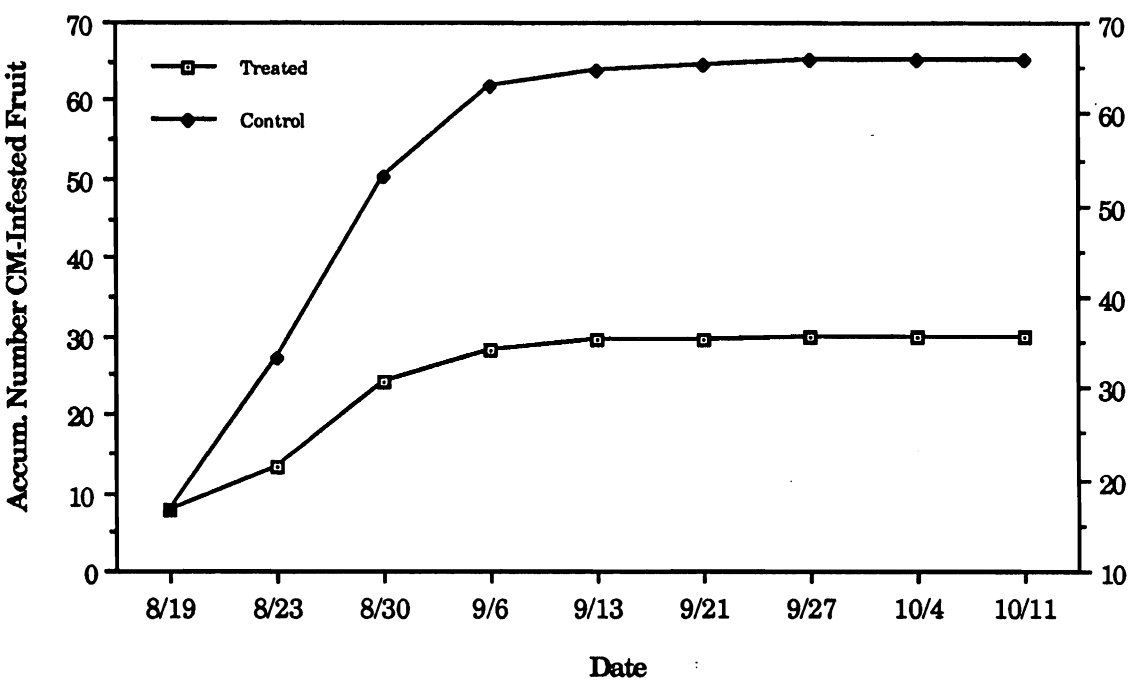

Fig. 7 Codling moth diapause induction at date of larval infestation in Courtland, CA

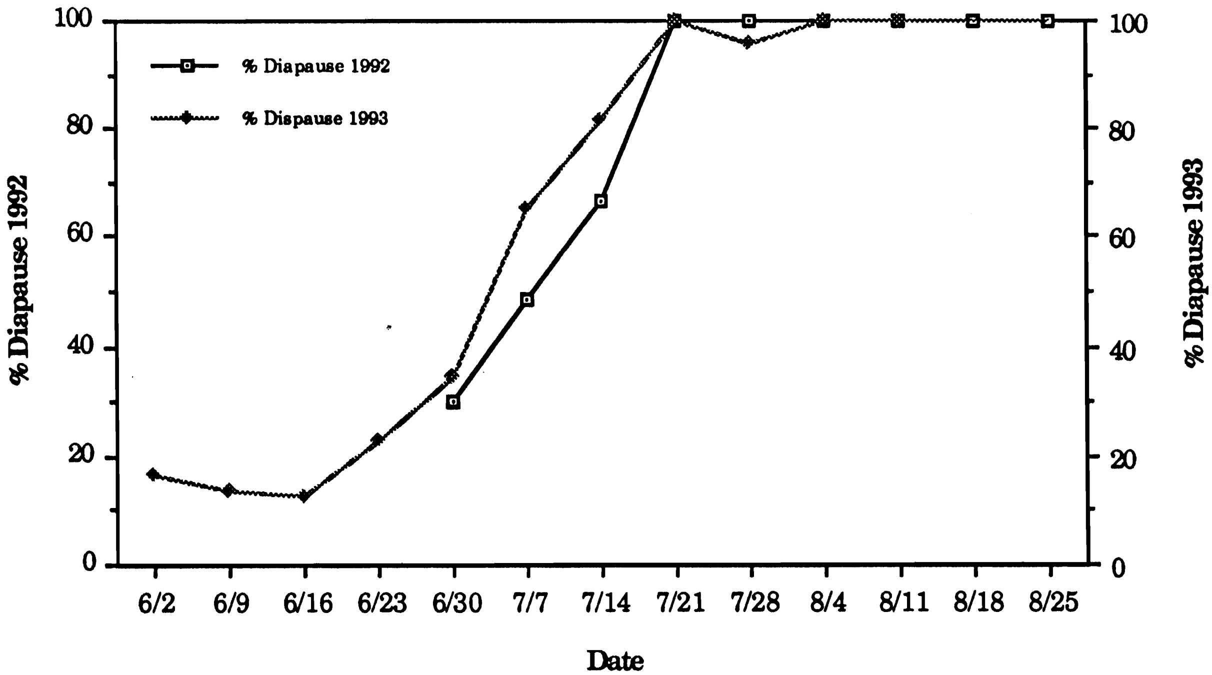

Fig. 8 Codling moth diapause induction at date of larval emergence in Courtland, CA

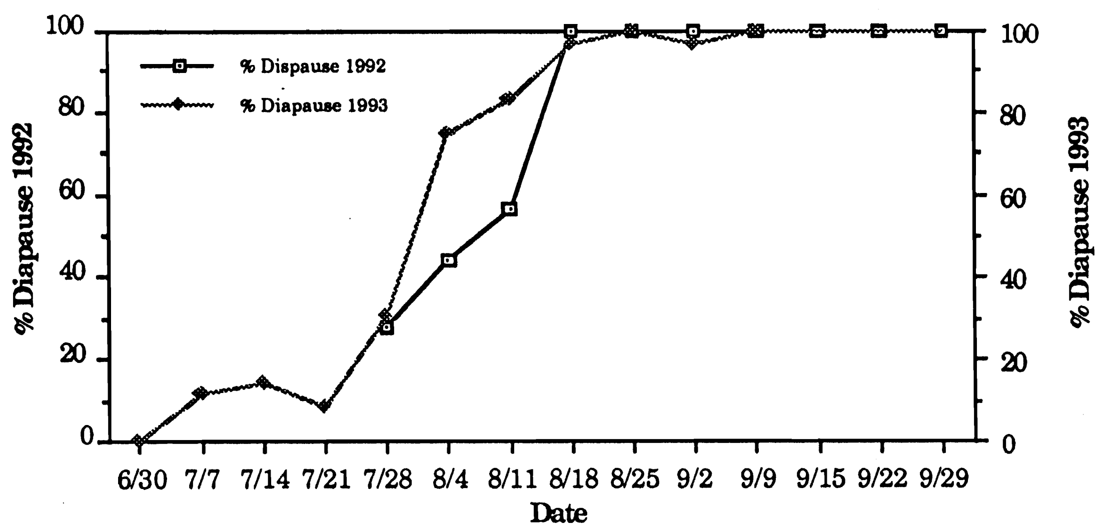

Fig. 9 Total number of diapausing and nondiapausing larvae produced from 50 infested fruit in Courtland, CA