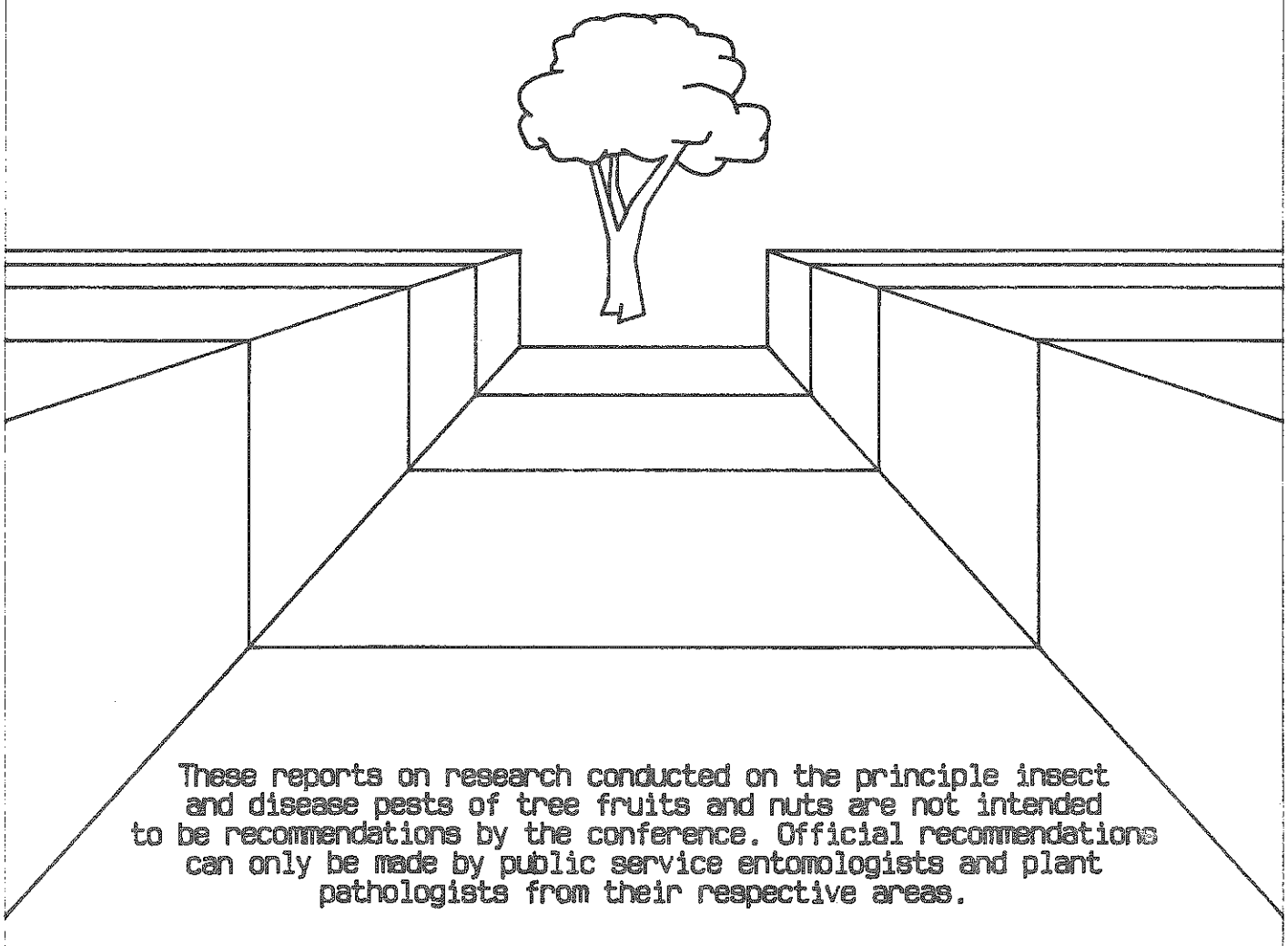
RESEARCH REPORTS FROM THE 62nd ANNUAL WESTERN ORCHARD PEST AND DISEASE MANAGEMENT CONFERENCE

Imperial Hotel, Portland, Or.
January 13-15, 1988



These reports on research conducted on the principle insect and disease pests of tree fruits and nuts are not intended to be recommendations by the conference. Official recommendations can only be made by public service entomologists and plant pathologists from their respective areas.

(Cover graphics created on Diagraph)

Research Report: Send original copy by 15 Dec. to:

Joe Capizzi
Extension Entomologist
2055 Cordley Hall
Oregon State University
Corvallis, OR 97331

Please note the earlier deadline, 15 December. Please follow the format given below for the research report:

1. No more than 2 full pages typed including graphs and tables.
2. Use white bond paper and clear legible type ready for camera-copy. Hand written copy or colored paper is not acceptable.
3. Copy format enclosed. Reports not conforming to the format will not be accepted.

Send a copy of your research report to the appropriate section leader:

1. Deciduous Orchard Diseases
   Gary Grove
   Tree Fruit Research & Ext. Ctr.
   1100 N. Western Ave.
   Wenatchee, WA 98801

2. Pome Fruits
   Nello Angerilli
   Agriculture Canada
   Summerland, B.C. V0H 1Z0

3. Stone Fruits
   Don Joy
   4205 Barge
   Yakima, WA 98908

4. Nuts
   J. L. Flexner
   Southern Oregon Expt. Sta.
   569 Hanley Road
   Medford, OR 97502

To insure clarity of pesticide designations, please submit on a separate sheet of paper, the common name and trade name of any pesticide mentioned in your report. Use names designated in the Entomological Society of America Special Publication 74-1, Oct. 1974; the list of chemical and common names suggested for use by AR-EPA 900-622; or the Agrichemicals Handbook.

Hold your slide as you want it to be seen, then mark the lower left corner. You may also bring your own carousel (Kodak) or load your own slides at the beginning of the session or at breaks.

THIS WILL BE THE ONLY MEETING NOTICE. PLEASE DO NOT FORGET THE DEC. 15 DEADLINE FOR RESEARCH REPORTS.

Frank Howell

FRANK HOWELL
Secretary/Treasurer

RESEARCH REPORTS FROM THE 62ND ANNUAL
WESTERN ORCHARD PEST
AND DISEASE MANAGEMENT CONFERENCE

January 13, 14, & 15, 1988

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SECTION I

DECIDUOUS ORCHARD DISEASES

****

Gary Grove
Section Leader

No abstracts submitted

SECTION II

POME FRUITS

****

Nello Angerilli
Section Leader

II. Pome Fruits
c. Biological control
1. Apple aphid; apple

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We established 4 treatments in a young apple orchard to evaluate the influence of ground cover management on apple tree growth and production and on the apple aphid, Aphis pomi DeGeer, and its predators. The treatments were herbicided strips with grassed alleys, woven black plastic strips with grassed alleys, overall dwarf white clover, and overall fall rye herbicided in spring and summer. Each treatment was replicated 4 times in a completely randomized design, with a minimum plot size of 177 sq m. No insecticides were applied except for 2 applications each of Bacillus thuringiensis and insecticidal soap in the spring. Plots were sampled for insects every 2-3 weeks from late April to late Aug. For each plot predators on the ground cover were counted in a 2-min observation period on the 2 m-wide strip under the 2 central trees in each plot. Then all predators were counted on current season's growth on 10 vigorous terminals on each of the 2 central trees and aphids were counted on the most infested leaf per terminal. On Sept. 9 when most limbs had set terminal buds, we measured the current season's growth on all major terminals for the 32 sample trees.

Apple aphids in trees grown in clover peaked at a much lower level and declined earlier in the season than aphids in the other treatments (Fig. 1). Predator populations followed those of the aphids with a later increase and slower decrease (Fig. 2). Terminal growth of trees in the nonclover treatments averaged more than 34 cm greater than in clover (Table 1). Total aphids for the season averaged more than 4 times as high for the nonclover treatments as for the clover and total predators averaged 4.5 times as high. There were no significant differences among the nonclover treatments in terminal growth or in numbers of aphids or predators and no significant differences among the 4 treatments in predator/aphid ratios.

There appear to be 4 main influences in the first growing season of this study: ground cover on tree growth, tree growth on aphids, aphids on predators, and predators on aphids. We observed no direct effect of ground cover on predators and no negative effect of aphids on tree growth.

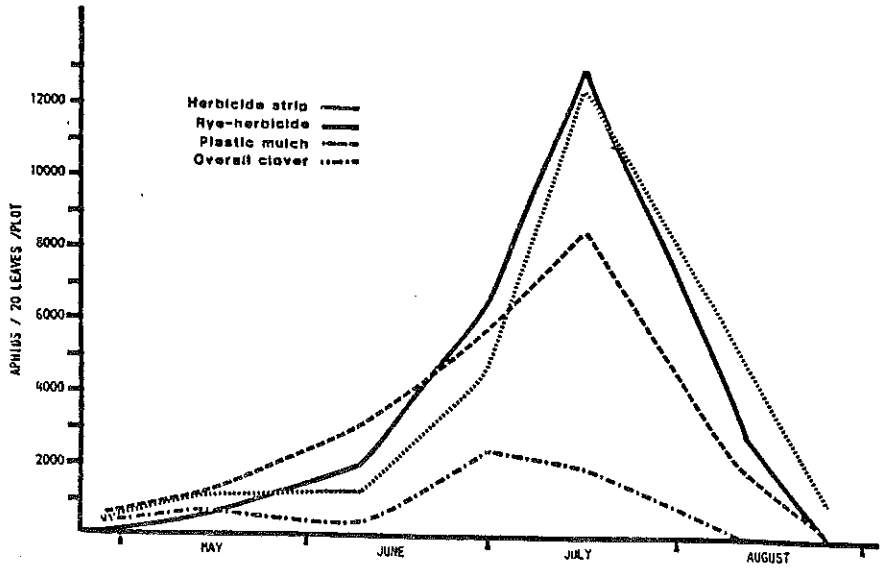

Fig. 1. Seasonal changes in apple aphid populations in young apple trees under 4 types of orchard floor management.

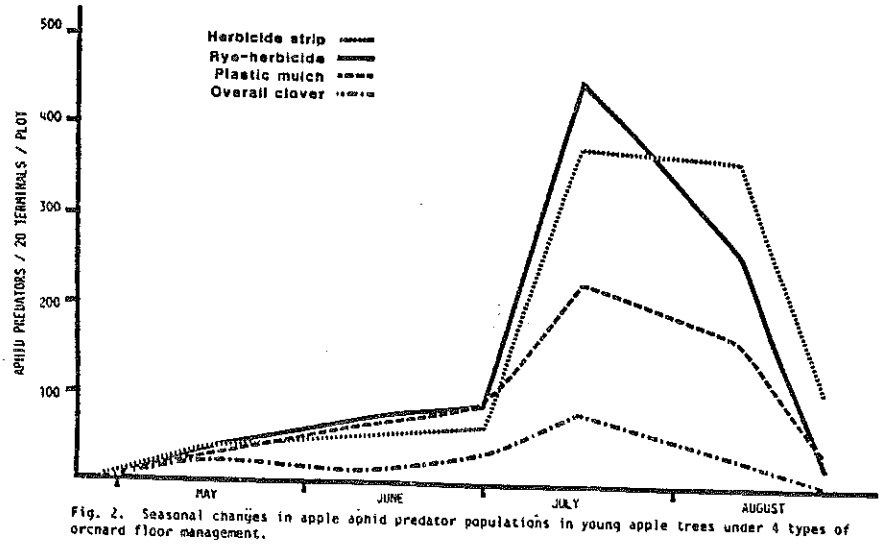

Fig. 2. Seasonal changes in apple aphid predator populations in young apple trees under 4 types of orchard floor management.

Treatment	Terminal growth (cm)	Total aphids	Aphids log (x + 1)	Total predators	Predators log (x + 1)
Herbicide strip	87.2	26,410.0	4.3956	1000.8	2.9897
Fall rye/ overall herbicide	87.1	25,800.5	4.4029	936.0	2.9630
Plastic mulch	84.3	21,614.5	4.3302	614.8	2.7811
Overall clover	52.1	6,005.3	3.6916	188.8	2.2171
Standard error	3.4	-	0.1057	-	0.08614

Table 1. Effect of orchard floor management on apple tree growth, apple aphid, and apple aphid predators.

II. Pome Fruits

c. Biological control

1. White apple leafhopper on apple

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The life cycle of an egg parasitoid of the white apple leafhopper (WALH) was studied during the 1987 season in orchards near Wenatchee. The parasitoid was tentatively identified as Anagrus epos (Hymenoptera: Mymaridae). The study forms part of a broader effort to develop an IPM program for WALH, and particularly to evaluate the potential for biological control of this pest.

The adult flight of the parasitoid was tracked along with that of adult WALH using unbaited yellow sticky panels (Phercon AM). The leafhoppers were counted in the field, but the adult parasitoids were counted on the traps using a stereomicroscope. The larval, pupal, and pre-emergence adult stages of the overwintering generation were sampled by dissecting host eggs in apple shoots. Samples were taken from 27 March to 27 July using 8 shoots per tree (2 from each cardinal direction), 1 tree per sample date. The summer generation was sampled only using the emergence holes of the adults from the midribs of leaves. The assessment of parasitism under various regimes of pesticide intensity was done in January and February by dissecting 8 shoots per tree (2 from each cardinal direction) on 20 trees per block.

The parasitoid overwinters in the egg of its host, slowly developing from egg to larva, pre-pupa, pupa, and adult during the winter and spring. The larva is identifiable because its white fat body is visible in the WALH egg. The pre-pupal, pupal, and adult stages are readily distinguishable because of their orange to brown coloration, as opposed to the translucent white of a normal egg. The samples taken in March and April were mostly in the larval stage; the pupal stage was the predominant form in mid-May. Fully formed adults would apparently rest in the wood, fully developed, for some time prior to emergence (the so-called pharate stage). Adult emergence was complete by 1 July.

Based on the adult sticky trap data, the parasitoid appears to have 2 generations/year, the same as WALH. There appears to be a good correspondence between adult flight of WALH and the parasitoid. The peaks for the first generation of the A. epos and WALH were in early June. The peak flight of WALH adults was in late September, while the peak for the parasitoid was not until early to mid-October (Fig. 1).

The effect of pesticide program on overwintering egg deposition of WALH and the percentage parasitism of overwintering WALH eggs by A. epos was studied in 1986-1987 (Table 1.). Blocks 4 and 12 received only a delayed dormant spray, plus 1 application of carbaryl in the "treated" section. Block 4 was sprayed on 22 August, and Block 12 was sprayed on 27 August. Block 50 was a commercial block on a reduced pesticide program, including a

II. Pome Fruits
c. Biological control
1. Codling Moth - Apple

Codling Moth Mating Disruption with Pheromones: An Organic Experience.

N.P.D. Angerilli[1], D. Thomson[1] and P. Kirsch[2]
[1]Agriculture Canada, Research Station
Summerland, B.C., and
[2]Biocontrol Ltd.
Davis CA.

Synthetic codling moth sex pheromone in polyethylene release devices was applied to a portion of an organic apple orchard in Cawston, B.C. just prior to the first flight of codling moth males in the spring of 1987. During the growing season, males were monitored with pheromone and virgin-female baited sticky traps in the treated orchard, an adjacent azinphosmethyl treated orchard and an adjacent organic orchard. Female flight activity and mating status was monitored with terpenyl acetate/brown sugar bait pans. Codling moth larval entries into apples were assessed on two occasions, the last being just prior to harvest.

Fewer males were caught in either type of sticky trap within the treated orchard, and damage within the treated portion of the orchard was less than in the untreated portion and comparable to the azinphosmehtyl treated orchard.

II. Pome Fruits
C. Biological Control
1. Codling Moth - Apple

Mating Disruption: Confusion Among Codling Moth Fellows

D. Thomson[1], N.P.D. Angerilli[1] and P.Kirsch[2]
[1]Agriculture Canada, Research station, Summerland, B.C.
[2]Biocontrol Ltd, Davis, CA

The potential of using high concentrations of codling moth sex pheromone to control larval infestations of fruit was examined in a commercial apple orchard near Kelowna, B.C. Polyethylene release devices containing the pheromone blend were applied to treatment blocks just prior to the first male flight in the early spring. Male codling moth numbers were assessed at weekly intervals using synthetic pheromone and virgin female traps. Female codling moth numbers were monitored with terpenyl acetate/brown sugar traps. Codling moth larval damage was quantified on two occasions by a visual examination of developing fruit. In addition, two experiments were conducted to assess the effects of high concentration of pheromone in the orchard on codling moth behavioural responses.

Traps in the control block caught significantly more male codling moths and apples sustained higher levels of larval damage than traps or apples in treatment blocks. Male codling moths released in the middle of control and treatment blocks were only recaptured in control blocks. The mating frequency of male and female codling moths introduced into cages located in the orchard was higher in the control blocks.

II. Pome Fruits

c. Biological Control

1. Codling moth, Cydia pomonella. Apples

J F. Howell, J. L. Krysan, D. F. Brown and T. R. Unruh
USDA, ARS, Yakima, Washington

Control of Codling Moth by Disruption of Mating with Sex Pheromone

At 2 sites on April 23/24 pheromone dispensers were tied into the top of 150 apple trees (10 rows, 15 trees per row), one dispenser per tree except the border and corner trees which had 2 or 3 respectively. Second dispensers were installed on July 7 and 8. First moth emergence was April 24, 1987. At each site a nearby block of 150 trees was left untreated.

The plots were sprayed in the delayed dormant, May 7, and July 2, for scale, mite, and aphid control. Border areas were sprayed May 7, June 1, June 23, and July 21 to eliminate immigrant moths. Following harvest the plots were sprayed for wooly apple aphid.

On June 4/5, fertile virgin wild-type codling moths were released, one per tree, the sexes on alternate trees, for a total of 75 pairs in each plot. Second moth releases (identical to the first releases) were made July 21/22.

All apples were visually examined every other week and wormy fruit were recorded and removed. This was continued until harvest. Bi-weekly leaf samples (20 leaves from each of 10 trees) from the pheromone plot and the grower's treated plot were examined for mites (phytophagous and predaceous), leafminers and other pest insects that were present. Visual sampling and beating trays were used to sample aphids, leafhoppers and predaceous insects.

Capillary columns in the dispensers were measured weekly to monitor pheromone emission rates. Pheromone emission rates were also determined by chemical analysis.

Temperature integrators were used to measure degree hours.

When the dispensers were new, pheromone emission rates were between 30 to 50 ug/h at 22.5°C. Measurement of the capillary column showed a linear loss from beginning to end of test (5 months). However, chemical analysis revealed pheromone emission declined faster than predicted from capillary measurements.

Separate tests showed shading the dispensers extended the period of high pheromone emission rate; after 28 days the shaded dispensers released 25 ug/h compared to 7 ug/h from those in open sunlight. Dormant sprays controlled wooly apple aphid but the green apple aphid had to be controlled using an insecticide. Leafhoppers, leafminers, and mites were not a problem in 1987.

Overall, 0.5 to 1.1% of the fruit were infested in the pheromone plots. The percentage of infestation was similar to that commonly obtained using insecticides. Based on data obtained in 1987, we will modify the system with the expectation of improved disruption in 1988.

II. Pome Fruits
C. Biological Control
1. Codling Moth - Apple

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Overall, 0.5 to 1.1% of the fruit were infested in the pheromone plots. The percentage of infestation was similar to that commonly obtained using insecticides. Based on data obtained in 1987, we will modify the system with the expectation of improved disruption in 1988.

Table 1. -- Number of infested fruit found, progeny per released female, and differences between populations of larvae in the treated and nontreated orchard blocks (%).

	Release 1			
	Orchard O		Orchard L	
	Pheromone	Check	Pheromone	Check
No. infested fruit	591	2063	609	1836
No. larvae/female	7.9	27.5	8.1	24.5
% control	71		66	
	Release 2			
No. infested fruit	158	1464	358	2437
No. larvae/female	2.1	19.5	4.8	32.5
% control	89		85	

II & III. Pome and Stone Fruits
c. Biological control
1. Codling moth - plums, apples

R.E. Rice, R.A. Jones, D.L. Flaherty, W.J. Bentley
University of California, Kearney Agricultural Center, Parlier

Field trials for mating disruption of codling moth using BioControl dispensers were conducted in plums at Parlier, Kingsburg, and Exeter and in apples at Parlier and Arvin. Results of the trials at Kingsburg and Exeter showed no significant differences between the Isomate treatment and the untreated checks, which received no insecticide treatments during the year (Table 1). Initial codling moth populations in both blocks at Kingsburg were low and this, coupled with small plot sizes at Kingsburg, probably contributed to the lack of differences between treatments in these two plots. The trial in Casselman plums at Exeter was conducted in larger commercial blocks but again initial populations of moths were low and differences between the two treatments were difficult to measure. In the Friar plum trial at Parlier, the check block received one insecticide treatment which reduced the codling moth infestation at harvest to only .2% while infested fruit in the pheromone treated block was .6%. In the Casselman mating disruption trial at Parlier green fruit samples were taken in mid-July, about one month prior to maturity. These samples showed 27.8% codling moth infestation in the check (from second-generation larvae) and 4.4% infestation in the pheromone treated block, which was unacceptably high. At harvest, in mid-August, however, infestation levels in both the check and pheromone treatments had dropped considerably; the pheromone treatment was still significantly less than the untreated check.

The codling moth disruption trial in third leaf apples in Field 22 at Parlier showed a 1.1% infestation at thinning time on 7 May. This was an unacceptably high level for this time of the year. Consequently, the block was treated with insecticide, and at harvest in early August the codling moth infestation was only .2%. It was initially believed that this young block of apples would have a relatively low resident population of codling moth. It was apparent that the pheromone was not disrupting the population to the extent required to prevent mating and subsequent infestation of fruit. However, there was also some indication that mated females were flying into this block of apples from an adjacent stone fruit block to the north, as there was a definite edge effect in infested fruit on the north side with a gradient to the south.

Results of the codling moth disruption trials in Granny Smith apples in Arvin were also disappointing. Nine acres of this isolated, high density planting were treated with codling moth pheromone. The remaining nine acres were used as an untreated check. The check was sprayed five times with insecticide through the season and the pheromone treated block was sprayed three times with insecticide. The first two sprays in the check were applied by ground sprayer, with the last three and the three sprays in the pheromone treatment, applied through overhead sprinklers. At harvest the check had .9% infested fruit while the pheromone treated block had 36.3% infestation (Table 1). These data indicate that the insecticide treatments in the check were effective but the key to control was the two early season applications applied by ground. Absence of early season moth reduction in the pheromone treated block from either insecticide or pheromone allowed the

codling moth population to develop to levels too high for the pheromone to control later in the season.

A study was conducted in walnuts in Tulare County to determine at which levels or areas within a tree codling moth is most active. Results of this study confirmed that codling moth, as with other species such as oriental fruit moth, are most prevalent in the upper portions of the tree canopy. This reaffirms the recommendation that pheromone dispensers for mating disruption need to be placed in the upper 1/3 of the canopy in trees of whatever height, if mating disruption is to reach optimum levels.

Table 1. Codling moth mating disruption trials - 1987[1/]

PLOT	VARIETY	TREATMENT	% Infested Fruit CM	PTB	OLR
Kingsburg	Red Beaut	Check	0.1	0	0.2
		Isomate	0.3	0	0.4
Kingsburg	Santa Rosa	Check	0.2	0	0
		Isomate	0.2	0.1	0
Parlier	Friar	Check (1)[2/]	0.2	0.5	0
KAC 52		Isomate	0.6	0.4	0.8
KAC 32	Casselman	Check	27.8	0.2	0
KAC 21		Isomate	4.4	0	0.4
KAC 32	Casselman	Check	4.4	2.8	0.4
KAC 21		Isomate	0.6	0.4	0.3
Exeter	Casselman	Check	0.3	0	0.9
		Isomate	0	0	0.2
KAC 22	Apples	Isomate	1.1	-	-
		Isomate (1)	0.2	-	-
Arvin	Apples	Check (5)	0.9	-	-
		Isomate (3)	36.3	-	-

[1/] BioControl pheromone dispensers; 1 application @ 100/ac, 3/18-23/87.

[2/] Number of insecticide treatments during season.

II. Pome Fruits
c Biological Control- Mating Disruption
f Implementation
1. Codling Moth
2. Fruittree Leafroller, Obliquebanded Leafroller, Omnivorous Leafroller

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Davis, California 95616
Craig Weakley and John Studdert
UC Cooperative Extension
Yuba City, California 95992

A mature Sacramento Valley Barlett pear orchard was completely treated with CM pheromone dispensers, formulated and supplied by Biocontrol Ltd., at a rate of 100 dispensers per acre. Dispensers, designed to have a 6 month field life, did not require replacement throughout the season. CM damage levels in the pheromone treated orchard were compared to damage in a conventionally treated orchard and to damage in an abandoned plot of trees at the same location. The conventionally treated orchard received five insecticide applications whereas the abandoned trees remained untreated throughout the season.

The potential for leafroller damage when replacing insecticides with mating disruption, was evaluated under five different treatment regimes in a latin square trial placed centrally within the pheromone treated orchard. Each treatment was replicated five times and each replicate was surrounded by a buffer zone. From June 2 onwards, this buffer zone was insecticide treated when insecticide treatments were applied to other parts of the trial. The five treatments and insecticide timing are shown in Table 1.

Mating disruption controlled codling moth to commercially acceptable levels in this trial. This orchard had a high resident population of CM

codling moth population to develop to levels too high for the pheromone to control later in the season.

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Exeter	Casselman	Check	0.3	0	0.9
		Isomate	0	0	0.2
KAC 22	Apples	Isomate	1.1	-	-
		Isomate (1)	0.2	-	-
Arvin	Apples	Check (5)	0.9	-	-
		Isomate (3)	36.3	-	-

[1/] BioControl pheromone dispensers; 1 application @ 100/ac, 3/18-23/87.

[2/] Number of insecticide treatments during season.

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Mating disruption controlled codling moth to commercially acceptable levels in this trial. This orchard had a high resident population of CM

codling moth population to develop to levels too high for the pheromone to control later in the season.

A study was conducted in walnuts in Tulare County to determine at which levels or areas within a tree codling moth is most active. Results of this study confirmed that codling moth, as with other species such as oriental fruit moth, are most prevalent in the upper portions of the tree canopy. This reaffirms the recommendation that pheromone dispensers for mating disruption need to be placed in the upper 1/3 of the canopy in trees of whatever height, if mating disruption is to reach optimum levels.

Table 1. Codling moth mating disruption trials - 1987[1/]

PLOT	VARIETY	TREATMENT	% Infested Fruit CM	PTB	OLR
Kingsburg	Red Beaut	Check	0.1	0	0.2
		Isomate	0.3	0	0.4
Kingsburg	Santa Rosa	Check	0.2	0	0
		Isomate	0.2	0.1	0
Parlier	Friar	Check (1)[2/]	0.2	0.5	0
KAC 52		Isomate	0.6	0.4	0.8
KAC 32	Casselman	Check	27.8	0.2	0
KAC 21		Isomate	4.4	0	0.4
KAC 32	Casselman	Check	4.4	2.8	0.4
KAC 21		Isomate	0.6	0.4	0.3
Exeter	Casselman	Check	0.3	0	0.9
		Isomate	0	0	0.2
KAC 22	Apples	Isomate	1.1	-	-
		Isomate (1)	0.2	-	-
Arvin	Apples	Check (5)	0.9	-	-
		Isomate (3)	36.3	-	-

1/ BioControl pheromone dispensers; 1 application @ 100/ac, 3/18-23/87.

2/ Number of insecticide treatments during season.

II. Pome Fruits
c Biological Control- Mating Disruption
f Implementation
1. Codling Moth
2. Fruittree Leafroller, Obliquebanded Leafroller, Omnivorous Leafroller

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A mature Sacramento Valley Barlett pear orchard was completely treated with CM pheromone dispensers, formulated and supplied by Biocontrol Ltd., at a rate of 100 dispensers per acre. Dispensers, designed to have a 6 month field life, did not require replacement throughout the season. CM damage levels in the pheromone treated orchard were compared to damage in a conventionally treated orchard and to damage in an abandoned plot of trees at the same location. The conventionally treated orchard received five insecticide applications whereas the abandoned trees remained untreated throughout the season.

The potential for leafroller damage when replacing insecticides with mating disruption, was evaluated under five different treatment regimes in a latin square trial placed centrally within the pheromone treated orchard. Each treatment was replicated five times and each replicate was surrounded by a buffer zone. From June 2 onwards, this buffer zone was insecticide treated when insecticide treatments were applied to other parts of the trial. The five treatments and insecticide timing are shown in Table 1.

Mating disruption controlled codling moth to commercially acceptable levels in this trial. This orchard had a high resident population of CM

and was treated with 4-5 applications of azinphos-methyl annually prior to 1987. CM damage levels were quite high in the adjacent abandoned trees.

In the absence of insecticidal control measures for CM, the use of mating disruption in pears will need augmentative applications of insecticide for control of leafrollers. The results indicate that one, or at most two, supplementary insecticides will be sufficient in controlling the leafrollers. These sprays will need to be timed for moth flights and additional research is required in this area. Use of pheromones for control of CM combined with these additional applications of insecticide for leafroller control should be competitive with the current spray program .

An option exists for the use of selective or microbial insecticides for the control of the leafroller larvae. This would enhance any biological control of the leafrollers, as well as increase the potential role of biological control agents in management of psylla and phytophagous mites. Further, a program integrating mating disruption pheromones with selectively timed insecticides should reduce the current insecticide load on the environment and give pear producers safer alternatives in pest management.

Table 1. Treatments and spray timing.

Treatment Number	Pheromone	Spray timing. #1 4/15	#2 5/6	#3 6/2	#4 6/17	#5 7/8
A	*	-	-	-	-	-
B	*	*	-	-	-	-
C	*	*	*	-	*	-
D	*	-	*	-	*	*
E	*	-	-	-	*	-
Insecticide Comparison	-	*	*	*	*	*

Table 2. Per Cent Lepidopterous damage to pears at harvest[1]

Treatment	CM	Leafroller Complex[2]		Total
		Early season	Mid-late season	
A (Pher. only)	0.36	1.77	13.41	15.54
B (Pher + 1)	0.0	0.34	2.28	2.62
C (Pher + 1,2,4)	0.0	0.31	0.36	0.67
D (Pher + 2,4,5)	0.01	1.76	1.65	3.42
E (Pher + 4)	0.16	2.37	7.39	9.92
Insecticide Control (5 sprays)	0.04	0.23	0.15	0.41
Abandoned Trees[3] (100 m from trial)	36.50	19.50	2.50	58.50

1. 7500 fruit sampled/treatment (except for abandoned trees)
2. Leafroller complex includes OLR, OBLR, and FTLR.
3. Total sample : 400 fruit, taken from 2 trees.

II. Pome Fruits

d. Chemical control

1. White apple leafhopper on apple

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A series of related studies on efficacy and timing of pesticides for white apple leafhopper (WALH) were performed in 1987. The effort described here is a component of an IPM program being developed for leafhoppers in Washington.

The experimental design for the efficacy and timing trials was a randomized complete block with single-tree plots replicated 4 times. Trees were sprayed to the point of drip with a handgun. WALH were sampled by counting the number of nymphs on 20 injured leaves/tree. Results for the efficacy trials are given as % reduction from a pretreatment count to a count made at 3 days (1st generation) and 5 days (2nd generation) after treatment. Results for the timing trials are given as Cumulative Leafhopper Days (CLD's) for the damage incurred by one nymphal generation:

$$CLD = (((npl_{t1}+npl_{t2})/2)*ndays)$$

where nlp_{t1} and npl_{t2} are nymphs/leaf at any two sampling dates, and ndays is the number of intervening days. This method allowed us to simultaneously evaluate the effects of mortality from the spray, residual life of the material, and the damage that was done before the spray went on. Timing studies used endosulfan 1.5 lb (AI)/acre except the split application in the second generation, which used 1.0 lb (AI)/acre.

PESTICIDE EFFICACY: Carbaryl was a very effective material against leafhoppers at rates as low as 0.25 lb (AI)/acre for both generations. Endosulfan was effective at rates as low as 0.75 lb (AI)/acre. Formetanate hydrochloride was effective at the rates tested for the first generation, but a rate higher than 0.92 lb (AI)/acre would be necessary for the second generation. Phosphamidon was effective at the lowest rate tested (0.5 lb (AI)/acre) against the first generation, but was inadequate at the highest rate tested (1 lb (AI)/acre) agianst the second generation (Table 1).

PESTICIDE TIMING: The best timing for the first generation WALH was at petal fall (1 May). The later timings had progressively more damage The best timing for second generation was a split application (28 July and 11 August). There were no significant differences among the single-application treatments, although CLD's for the 4 and 11 August timings were numerically lower (Table 2). Overall, the first generation is easier to control, and can be covered adquately by a single spray. The protracted hatch period of the second generation makes it difficult to control in terms of the total amount of damage. However, if reducing the number of adult WALH in the orchard at harvest is the primary goal, a single application in mid- to late August (before substantial adult emergence) would be adequate.

Table 1. Pesticide efficacy for first and second generation WALH nymphs, Wenatchee, Washington, 1987.

First Generation WALH Control				Second Generation WALH Control			
Treatment & lb (AI)/acre		Timing	% reduct.	Treatment & lb (AI)/acre		Timing	% reduct.
Sevin XLR Plus 4F	0.25	S	100	Sevin XLR Plus 4F	0.25	S	97
Sevin XLR Plus 4F	0.50	S	100	Sevin XLR Plus 4F	0.50	S	99
Sevin XLR Plus 4F	1.00	S	100	Sevin XLR Plus 4F	1.00	S	99
Thiodan 50WP	0.75	S	100	Thiodan 50WP	0.75	S	95
Thiodan 50WP	1.00	S	100	Thiodan 50WP	1.00	S	96
Thiodan 50WP	1.50	S	100	Thiodan 50WP	1.50	S	98
Phosphamidon 8EC	0.50	S	97	Phosphamidon 8EC	0.50	S	30
Phosphamidon 8EC	0.75	S	99	Phosphamidon 8EC	0.75	S	63
Phosphamidon 8EC	1.00	S	100	Phosphamidon 8EC	1.00	S	71
Imidan 50WP	3.00	S	8	Carzol 92SP	0.46	S	76
Zolone 25WP	1.50	S	63	Carzol 92SP	0.92	S	89
Dimethoate 2EC	1.00	S	78	UC-84572 2.1EC+PA-10	0.20	E	32
Carzol 92SP	0.92	S	100	UC-84572 2.1EC+PA-10	0.20	S	85
Carzol 92SP	0.46	S	98	DPX-EY059 50 g/L EC	0.05	E	40
Dimilin 25WP	0.25	E	-76	DPX-EY059 50 g/L EC	0.05	S	66
UC-84572 2.1EC	0.20	S	91	Control	--	-	1
UC-84572 2.1EC	0.20	E	90				
Insegar 25WP	0.13	S	2				
Insegar 25WP	0.13	E	-125				
DPX-EY059 50g/LEC	0.05	S	77				
DPX-EY059 50g/LEC	0.05	E	95				
Control	--	-	-8				

Table 2. Pesticide timing for first and second generation WALH nymphs, Wenatchee, Washington, 1987.

First Generation WALH Timing				Second Generation WALH Timing			
Treatment	lb (AI) per acre	Date Applied	CLD/leaf 5 Jun[z]	Treatment	lb (AI) per acre	Date Applied	CLD/leaf 8 Sep[z]
Thiodan 50WP	1.5	1 May	11.18 d	Thiodan 50WP	1.5	28 Jul	54.57 b
Thiodan 50WP	1.5	8 May	34.66 c	Thiodan 50WP	1.5	04 Aug	40.76 b
Thiodan 50WP	1.5	15 May	61.48 b	Thiodan 50WP	1.5	11 Aug	44.11 b
Thiodan 50WP	1.5	22 May	63.98 b	Thiodan 50WP	1.5	18 Aug	62.41 b
Control	--	--	113.98 a	Thiodan 50WP + Thiodan 50WP	1.0 1.0	28 Jul + 11 Aug	14.02 c
				Control	--	--	104.87 a

[z]Means within columns not followed by the same letter are significantly different (Waller-Duncan k-ratio t-test, k-ratio=100).

II. Pome Fruits

d. Chemical control

Codling moth (CM), San Jose scale (SJS), spotted tentiform leafminer (STLM), white apple leafhopper (WALH), European red mite (ERM), apple rust mite (ARM), phytoseiid mites; apple

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EVALUATION OF INSECT GROWTH REGULATORS FOR CONTROL OF CODLING MOTH AND THEIR IMPACT ON OTHER ARTHROPODS ON APPLE. Various rates and timings of two IGR's Dimilin (diflubenzuron) and DPX-EY059 (formerly SD115110; flufenoxuron) were evaluated in a mixed planting of Newtown and Red Delicious apples in seasonal programs. Codling moth (CM) pressure was very high (51% infested fruit in check). Cover sprays were timed according to CM development (see Table). The two IGR's were applied at the beginning and peak of egg laying while the standard spray, Guthion, was applied at the beginning and peak of egg hatch in each generation. Flufenoxuron provided control at the higher rate (4 oz form/100 gal) comparable to Guthion. It also controlled SJS (high rate only), STLM (low and high rate) and suppressed WALH. Four sprays of Dimilin as well as the Dimilin program with only one spray against the first generation at 'petal fall' reduced CM damage below the check but entries and stings were considerably higher than in the standard. The only Dimilin program which approached commercial control was one with a Dimilin-Guthion combination spray applied at first egg hatch. Dimilin had no effect on SJS and WALH but controlled STLM. The standard spray program provided CM and SJS control. STLM and WALH was not affected by Guthion, probably due to OP-resistance.

Flufenoxuron (both rates) suppressed ERM, had no effect on ARM and was toxic (high rate) to phytoseiid mites. ERM stayed at subeconomic levels in all Dimilin treatments. Phytoseiids were numerous and as high as in the check under Dimilin. Trees treated with the standard Guthion program had more ERM and fewer phytoseiids than the check.

Originally it was planned to evaluate three different timings for the application of the first Dimilin cover spray; 'petal fall', 30 DD (after Biofix) and 75 DD. However, this was not possible in 1987 due to unusual (or usual?) weather conditions. The degree-day total reached 30 on 24 Apr. The spray could not be applied on that date due to strong winds which persisted for several days. By the time spraying conditions had improved Red Delicious trees were in the 'petal fall' stage (1 May) and the degree - day total had reached 75 DD after Biofix (3 May). This points out how difficult it can be to optimize the timing of sprays in areas such as the Mid-Columbia where weather conditions are often erratic.

Treatment and amt form/gal	Application dates*	8 Oct				12 Oct			
		CM			SJS	STLM		WALH	
		% fruit with				mines/10 leaves		exuvia	% fruit
		stings	total entries	damage	% fruit damage**	Sap feeder	Tissue feeder	per 10 leaves	with tar spotting
DPX-EY 059 5%EC 2 oz	3 May (80 DD), 24 May, 11 Jul (1000 DD) 4 Aug	19 a	10 bc	29 ab	50 a	7 bc	0 c	0.2 c	54 ns
DPX-EY 059 5%EC 4 oz	Same as above	4 cde	1 d	5 d	10 bc	6 c	0 c	0.3 c	63
Dimilin 25WP 3 oz	Same as above	12 ab	2 cd	14 bc	31 ab	5 c	1 c	11.5 ab	88
Dimilin 25WP 4 oz, Dimilin 25WP 3 oz	3 May (petal fall) 11 Jul (1000 DD) 4 Aug	8 bc	10 b	18 bc	22 ab	3 c	2 c	9.1 ab	53
Dimilin 25WP 3 oz + Guthion 50 WP 4 oz, Dimilin 25WP 3 oz	13 May (250 DD) 11 Jul (1000 DD) 4 Aug	6 bcde	4 bcd	10 cd	14 abc	11 b	4 b	10.1 ab	90
Guthion 50WP 5 oz	13 May (250 DD), 3 Jun, 28 Jul (1250 DD) 18 Aug	2 e	3 bcd	5 d	6 c	25 a	11 a	7.0 b	83
Check		7 bcd	44 a	51 a	21 abc	15 a	10 a	9.9 ab	83

Means in each column followed by the same letter are not significantly different (P = 0.05; DMRT); ns = not significant.

* DD = degree days after Biofix (1st CM pheromone trap catch)

** Differences significant at P = 0.1

II. Pome Fruits

d. Chemical control

European red mite, apple
Twospotted spider mite, pear
Western predatory mite

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RESURGENCE OF EUROPEAN RED MITE FOLLOWING APPLICATIONS OF MITICIDAL PYRETHROIDS. Pyrethroid insecticides when applied as foliar sprays can be very disruptive and can induce severe outbreaks of spider mites on tree fruits. This has been documented in numerous studies. Mite outbreaks associated with pyrethroid use during the summer are one reason why postbloom sprays of these compounds are not recommended. To overcome this problem industry has developed pyrethroids such as fluvalinate (Mavrik), bifenthrin (Brigade) and fenpropathrin (Danitol) which also have acaricidal activity.

Research carried out over several years in apple orchards at the MCAREC showed that summer sprays of two of these miticidal pyrethroids, Brigade and Mavrik, also induce build-up of European red mite (ERM) after a brief suppressive effect. In contrast, in one late season test on pear Brigade controlled ERM as well as TSSM and did not cause an increase in either species while a treatment applied at the same time on apple did result in a flare-up of ERM. Typically, ERM built up rapidly (2 to 3 wks) following treatment. The 3 oz/100 gal rate of Brigade caused higher build-up than the 4 oz rate apparently because of better acaricidal activity and longer residual of the higher rate. However, ERM counts in the 4 oz treatment were still considerably higher than in the check. Phytoseiid mite predators kept ERM below treatment levels in the checks in 2 of 3 field trials. Danitol used prebloom as well as during the summer caused no build-up of ERM. Summer applications of Danitol were as effective as Vendex.

Single foliar sprays of all three miticidal pyrethroids were highly toxic (or repellent) to phytoseiid mites and eliminated them from foliage for the remainder of the season. Phytoseiids did not return to trees treated at the 'tight-cluster' stage with Brigade until July.

II. Pome Fruits

d. Chemical control

McDaniel spider mite (McDSM)
European red mite (ERM)
Twospotted spider mite (TSSM)

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COMPARATIVE TOXICITY OF CLOFENTEZINE (APOLLO) AND HEXYTHIAZOX (SAVEY) TO EGGS OF TETRANYCHID MITES ON TREE FRUITS. A whole-leaf assay was employed to assess ovicidal activity of Apollo to summer eggs of ERM. Adult ERM females were placed on single Red Delicious spur leaves (20/leaf). After 24 h females were removed and eggs were counted. Leaves with eggs 24 h old or younger were dipped in increasing concentrations of Apollo (2.5 to 100 ppm). A spreader, Triton Ag-98 at 0.25 ml/l was added to improve wetting. Egg mortality was assessed after egg hatch was complete in the check. A similar assay procedure was employed for McDaniel spider mite except that leaf discs on moist cotton were used instead of single whole leaves.

The results of these bioassays are shown below:

Ovicidal Activity of Apollo, Savey

Species	LC_{50} ppm	LC_{90} ppm	Slope
Apollo: TSSM	0.16*	0.50*	
McDSM	1.85	18.77	1.275
ERM	12.49	64.30	1.801
Savey: McDSM	0.79	2.94	2.241

* Aveyard et al. 1986

TSSM eggs (data from Aveyard et al. 1986) were 12 and 78 times more susceptible to Apollo then eggs of McDaniel and European red mite respectively. Of the three spider mite species ERM is the least susceptible to Apollo. A direct comparison of the LC_{50} values of Apollo and Savey against McDSM suggests that the latter compound is about twice as effective against eggs. The suggested field rates for both compounds range from 20 to 70 ppm. Since the LC_{90} for ERM eggs was close to 70 ppm for Apollo low rates of this miticide may not provide adequate egg control in the field. However, Apollo also kills early immature stages of spider mites (larvae and protonymphs) which increases the effectiveness of this miticide.

II. Pome Fruits

d. Chemical control

Pear psylla (PP); *Psylla pyricola* Foerster

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Research Center pear orchards were treated on September 21 and 22 with air-blast or handgun sprays when about 50% of the pear psylla population was composed of winter-form adults. Paired treatments of pyrethroids with and without pbo (as Butacide 8 EC) were evaluated by limb-tap counts of adults for initial kill and residual activity for two weeks after treatment. Some treatments included 1 percent superior type oil to duplicate spray practices used by pear growers to control adults in the spring at dormant and delayed dormant timings. About 400 gallons of spray were applied per acre in both airblast and handgun applications. Airblast spray plots were one acre in size; handgun plots were one-half acre each.

All treatments produced good initial reductions of adult psyllid populations but residual control was short in most plots. The increase in adult populations one and two weeks after application was due to maturing of winter-form 5th instars which were not killed by the treatments. I expect all treatments will produce better control next spring because all psyllids will be in the adult stage and more susceptible to pesticides because they will be physiologically more active.

Initial kill of adult psyllids increased with increased dosages of pbo through the 1 pound rate. The addition of oil to sprays increased psyllid kill with or without pbo. Cyfluthrin (Baythroid) provided good control of adult psyllids with or without pbo indicating that resistance to this compound is not present in the population. I think that in 1988 piperonyl butoxide, at 0.5 pounds per acre should be added to fenvalerate (Pydrin) and permethrin (Pounce or Ambush) used in pre-bloom sprays against pear psylla in areas of Washington where poor control was obtained with these sprays in 1987.

Chemicals and rates (AI) per acre			Days post treatment Pear psylla adults per 25 limb-taps			
Pyrethroid	Butacide 8EC	Oil	Pretreat.	2 days	7 days	14 days
Airblast sprays comparing rates of pbo						
Fenvalerate 0.3 lb	1.0 lb	4 gal	270	0	23	122
Fenvalerate	0.5 lb	4 gal	270	9	35	108
Fenvalerate	0.25 lb	4 gal	270	12	55	116
Fenvalerate	0.5 lb[a]	4 gal	270	14	51	85
Handgun sprays with and without oil						
Fenvalerate	0.5 lb	4 gal	202	5	35	34
Fenvalerate	0.5 lb	none	202	20	32	78
Airblast sprays with and without oil						
Permethrin 0.3 lb	0.5 lb	4 gal	100	13	14	37
Permethrin	0.5 lb	none	100	5	25	44
Airblast sprays of three pyrethroids with and without pbo						
Fenvalerate	0.5 lb	4 gal	258	13	90	139
Fenvalerate	none	4 gal	290	7	29	42
Permethrin	0.5 lb	4 gal	290	2	26	31
Permethrin	none	4 gal	203	11	73	78
Cyfluthrin 1 oz	0.5 lb	4 gal	203	1	1	4
Cyfluthrin	none	4 gal	70	1	0	0
Check	none	none	100	97	85	132

[a] Super Butacide 8EC

II. Pome Fruits

d. Chemical control

Pear psylla (PP); *Psylla pyricola* Foerster

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PEAR: RESIDUAL CONTROL OF PEAR PSYLLA, 1987. Mature Bartlett pear trees were sprayed with a hand gun operating at 600 psi to evaluate residual life of Abamectin and amitraz for control of pear psylla nymphs. Leaves were collected from trees at intervals after applications. Ten circular disks, 2.2 cm diameter, were punched from leaves and floated on wet paper towelling in 15 cm plastic Petri dishes for each treatment at each post application interval. Ten PP nymphs were transferred to each disk. Petri dishes containing infested leaf disks were held in a growth room at 25° C and 16:8 photoperiod. Treatments were evaluated by counting dead and live nymphs after 1, 2 and 3 days exposure on the disks. Tests were conducted with leaves collected 1, 3, 7, 10 and 14 days after sprays were applied for the 4 May test but only 1, 7 and 14 days after sprays for the 8 and 29June tests. To test toxicity of growing terminals to adult PP, shoots were collected from each treatment and the control 17 days after applications for the 4 May test but only 1, 7 and 14 days afterr sprays for the 8 and 29 June tests. Test shoots were placed upright in sand in clay pots. The pots were placed in a tray containing 2 inches of water to keep shoots turgid. Twenty-five summer-form adult PP were caged on each shoot for 3 to 6 days then surviving adults and/or eggs were counted.

The test procedure worked well for Abamectin but was less suited to testing residual activity of amitraz because the latter material repelled nymphs, causing some of them to walk onto the wet paper towelling. Seventy-two hours exposure produced the best measure of mortality on treated leaf disks with only a few nymphs dying on control disks. Activity of Abamectin decreased slowly. There was still significant mortality of nymphs exposed to 14 day old residues. An intense, short rain shower occurred about 30 minutes after sprays were applied on 8 June. Since the sprays had not dried when the rain started part of the residues were washed off. However, performances of residues on leaf disks were almost as good as those from the 4 May test. Spraying conditions for the 29 June test were good. Again there was significant activity of residues in leaf disk tests 14 days after application. Control mortality at 1 and 7 days was high suggesting that spray had drifted onto the control tree. I do not believe this happened but I cannot explain the control mortality. Results from caging adult PP on shoots collected from treated trees were not as clear as those from exposing nymphs to residues on leaf disks. None of the treatments provided good control of adults when residues were 1 wk old or older.

II. Pome Fruits

d. Chemical control

Pear psylla (PP); *Psylla pyricola* Foerster

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Adult pear psyllids were tested using the slide-dip technique of Follet et al. to determine susceptibility to pyrethroids and pyrethroid-piperonyl butoxide combinations Adult pear psylla were collected from orchards at the Research Center and other locations in central Washington. Test psylla were attached to 1" X 3" glass microscope slides by placing them on their backs and gently pressing their wings onto the sticky surface of strapping tape. Strapping tape was attached to slides with double-sided transparent tape. Psylla were not attached directly to transparent tape because the adhesive was not strong enough to hold them. Psylla on slides were dipped for 5 seconds in water dilutions of candidate pesticides, then placed in covered plastic refrigerator trays (12" X 10" X 4") with a layer of moist paper toweling on the bottom to increase humidity. Controls were dipped in tap water. Tests consisted of 5 serial dilutions of each candidate pesticide. Treatments were replicated 3 or more times and each replicate included a water-only control. Mortality was determined at 24, 48 and 72 hours after treatment by teasing each test psylla with a 000 size camel's hair brush. Those responding to this stimulus with rapid leg movement or with a typical jumping movement were classed as alive. Mortality checking was done using a binocular dissecting microscope.

Results show an increased resistance of overwintered adult PP to Pydrin. The lab dosage of 90 ppm is equivalent to the field use rate when 400 gallons of spray are applied per acre. This dosage killed only 34 percent of test psylla. A few years ago kill was near 100 percent at 45 ppm. Results were quite different when the synergist piperonyl butoxide was added to Pydrin; nearly 100 percent kill was obtained at dosages as low as 11.25 ppm after 3 days' exposure. The poor kill by Pydrin alone and the strong synergistic effect of piperonyl butoxide demonstrate two points about psylla susceptibility to pyrethroids: that populations in Washington are becoming resistant and that the resistance is caused by increased activity within the psylla of mixed function oxidase, an enzyme system that is known to deactivate pyrethroids and some other pesticides. Generally resistance due to increased mixed function oxidase can be overcome and commercial control can be obtained, at least for a while by adding synergists to sprays that deactivate this enzyme system. Butacide 8, a commercial formulation of pbo designed for mixing with pyrethroids in water diluted sprays is available and registered for use on crops in Washington. It has been used on pear in Italy and on other crops in the US to improve control of pyrethroid resistant insects.

Tests with summer-form adults were aimed at determining the optimum dosage of pbo for control of resistant adults and the extent of cross resistance to several pyrethroids. Results indicate that 75 to 150 ppm of pbo as Butacide 8 EC should produce maximum kill of pear psylla adults in field sprays. Populations tested were resistant to fenvalerate, permethrin and flucythrinate but not to fenpropanate or cyfluthrin. I do not know the significance of this resistance spectrum except that the first three compounds have been used to control winter-form adults in dormant sprays for several years while to last two are not registered for use on pear and therefore have not been used commercially. Additional work needed before this combination can be recommended include field trials to confirm lab results and determine the optimum ratio of pbo to pyrethroid. I will test this product this fall against winter-form psylla to determine relative effectiveness of synergized and non-synergized pyrethroids.

II. Pome Fruits
d. Chemical control
Pear psylla (PP), pear

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FIELD AND LABORATORY EVALUATION OF INSECT GROWTH REGULATORS FOR PEAR PSYLLA CONTROL. In the field tests sprays were applied by handgun to 14-year-old (early season test) and 26-year-old (late season test) pear trees. In the early-season test timings, rates and formulations of three IGR's, XRD-473, fenoxycarb and Dimilin, were compared. None of the treatments affected egg-laying. XRD-473 applied at 'petal fall' and 75 DD (after Biofix) did not reduce PP nymphs; however, the high rate (4.8 oz form/100 gal) at 150 DD gave a temporary reduction until early June. All three timings of fenoxycarb 25 WP (2.1 oz form/100 gal) at 75, 150 and 250 DD controlled nymphs by early June; only the last timing (250 DD; 13 May) suppressed nymphs until July. Dimilin 25 WP and 2F (4 oz form/100 gal) applied at 75 DD (3 May) had little effect on PP nymphs. Only a Dimilin-oil (1%) combination provided some temporary suppression.

In the late-season field test the following IGR's were compared at similar ai/acre (44 to 60 g): XRD-473 5 EC, fenoxycarb 25 WP, CME-13406 15 EC, UC84572 2F and DPX-EY059 5EC. Thiodan and amitraz were included as standards. The IGR's as well as Thiodan had no adulticidal effect and caused no measureable reduction in eggs over the duration of the test (5 wks). Only one IGR, XRD-473, gave nymph control comparable to the standard amitraz but not as quickly. Thiodan also provided effective nymph control.

In the laboratory none of the IGR's used in the late-season field test had any adulticidal activity. Only fenoxycarb at rates comparable to 50 and 100 g ai/acre caused a substantial reduction in egg hatch; the other IGR's had no or only some ovicidal activity. Adults exposed for 48 h to residues of various IGR's and then transferred to untreated pear leaves produced viable eggs which hatched normally.

TREATMENT HISTORIES

Plot No.	Date	Materials	Rate/100 gal	(AI)/acre [2]
Plot 1	6 Mar (D) [1]	Wettable sulfur	5 lb	20 lb
		Superior type oil	2 gal	8 gal
	25 Mar (DD)	Wettable sulfur	3 lb	12 lb
		Dimilin 25 % WP	4 oz	0.25 lb
		Superior type oil	1 gal	4 gal
	28 Apr (PF)	Dimilin 25 % WP	4 oz	0.25 lb
		Superior type oil	1 gal	4 gal
	2 Jun (CS)	Dimilin 25 % WP	4 oz	0.25 lb
	14 Jul (CS)	Dimilin 25 % WP	4 oz	0.25 lb
		Abamectin .15 EC	160 ml	0.025 lb
Plot 2	6 Mar (D)	Pydrin 2.4 EC	4 oz	0.3 lb
		Superior type oil	1 gal	4 gal
	1 Apr (CB)	Pydrin 2.4 EC	4 oz	0.3 lb
		Morestan 25 % WP	1 lb	1 lb
		Parathion 25 % WP	1 lb	1 lb
	13 may (CS)	Guthion 50 % WP	.5 lb	2 lb
		Mitac 50 % WP	12 oz	1.5 lb
	17 Jun (CS)	Guthion 25 % WP	.5 lb	2 lb
		Mitac 50 % WP	12 oz	1,5 lb
	14 Jul (CS)	Guthion 50 % WP	.5 lb	2 lb
		Mitac 50 % WP	12 oz	1.5 lb
		Plictran 50 % WP	4 oz	0.5 lb
Plot 3	6 Mar (D)	Wettable sulfur	5 lb	20 lb
		Superior type oil	2 gal	8 gal
	25 Mar (DD)	Wettable sulfur	3 lb	12 lb
		Superior type oil	1 gal	4 gal
		ABG 6243 25 % WP	4 oz	0.25 lb
	28 Apr (PF)	ABG 6243 25 % WP	4 oz	0.25 lb
		Superior type oil	1 gal	4 gal
	3 Jun (CS)	ABG 6243 25 % WP	4 oz	0.25 lb
	14 Jul (CS)	ABG 6243 25 % WP	4 oz	0.25 lb
Plot 4	No sprays applied			

[1] D, DD, CB, PF and CS equal dormant, delayed dormant, cluster bud, petal fall and cover spray respectively.

[2] Based on 400 gallons per acre.

II. Pome Fruits

d. Chemical control

Pear psylla (PP); *Psylla pyricola* Foerster
Pear rust mite (PRM); *Epitrimerus pyri* (Nalepa)
European red mite (ERM); *Panonychus ulmi* (Koch)
Twospotted spider mite (TSM); *Tetranychus urticae* Koch

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PEAR: SOFT PESTICIDE TEST, 1987. 'Bartlett' and 'Anjou' pears were sprayed with handguns operating at 600 psi to compare seasonal programs of soft pesticides for control of insect and mite pests of pear and survival of beneficial arthropods. Plots consisted of three 30 -tree replicates in 3-row blocks. An untreated check was also included in the randomized block design. PP adults, PP predators and the parasite *Trechnites insidiosus* densities were monitored by limb-taps. PP nymphs were counted on 50-leaf samples per replication. Samples for first generation nymphs were collected from fruiting spurs, whereas those for second and subsequent generations were collected from growing shoots. The proximal leaf, distal leaf and 3 leaves from the middle were picked from each of 10 shoots. Leaves were processed with a leaf brushing machine and PP nymphs and mites were counted on 20% of the resulting slides using a binocular dissecting microscope. Pest damage to fruit was determined by examining 250 fruits per replication at harvest. Fruit firmness, size and soluble solids content were compared on two 25-fruit samples per replication.

The Dimilin-oil program in plot one controlled PP through mid June but nymph density increased thereafter until Abamectin was applied on July 14. The standard program, plot two, provided good control of PP but caused a flare-up of PRM and TSM. The ABG 6243-oil, plot three, program controlled PP without flaring mites. Predators of PP were rendered ineffective by the standard program but were abundant enough in the two soft plots to influence PP and other pests' densities. PRM was also controlled during the early post-bloom period by the soft programs, probably by prebloom sprays containing sulfur. A few fruit tree leafrollers survived in the soft plots long enough to cause some fruit damage. None of the programs caused significant phytotoxicity but a few fruits in the standard plot had noticeable solvent ring-type injuries. There were no significant treatment associated differences in fruit firmness, size or soluble solids.

II. Pome Fruits

d. Chemical control

Pear psylla (PP); *Psylla pyricola* Foerster
Pear rust mite (PRM); *Epitrimerus pyri* (Nalepa)
Twospotted spider mite (TSM); *Tetranychus urticae* Koch

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PEAR, PEAR PSYLLA CONTROL, 1987. Six-year-old pear trees were sprayed with handguns operating at 600 psi to evaluate pesticides for control of PP. Plots consisted of unreplicated blocks 2 rows wide containing ca. 48 trees. The test orchard was sprayed on 6 Mar with Pydrin 2.4 EC, 1 pt/100 gal and superior type oil 1 gal/100 gal to reduce density of overwintered adult PP. Experimental programs were compared to a standard program consisting of a 1 Apr spray containing Pydrin 2.4 EC 4 oz, parathion 25 % WP 1 lb and Morestan 25 % WP 1 lb/100 gal, sprays on 21 May and 17 Jun containing Guthion 50 % WP 8 oz, Amitraz 50 % WP 12 oz/100 gal and a 14 Jul spray containing Guthion 50 % WP 8 oz, amitraz 50 % WP 12 oz and Plictran 50 % WP 6 oz/100 gal. PP eggs, nymphs and adults were counted at 2-wk intervals. Eggs and nymphs were counted on 10 fruiting spurs/plot on 24 Apr and 2 50-leaf samples/plot thereafter. Entire spurs were examined using a dissecting microscope; leaf samples consisted of the proximal leaf, the distal leaf and 3 leaves from the middle of 10 shoots and were processed by the standard leaf-brushing technique. Adults were counted by the limb-tap method. Phytophagous mites were also counted on the brushed leaf samples. PP, PRM russet and CM damage were rated according to US grade standards for fresh pears on 2 samples of 25 mature fruits/per plot.

All programs provided good control of PP and PRM; Dimilin, ABG 6243 and DPX EY 059 programs did not cause an increase in TSM density that occurred in the standard program. Codling moth, *Cydia pomonella* (L.), population did not develop in the test orchard sufficiently to provide performance data. DPX EY 059 program caused russet rings on some fruits; none of the other programs caused any phytotoxicity.

Treatment and lb (AI)/100 gal	PP nymphs per 10 spurs 24 Apr	PP nymphs/100 leaves 4 May	18 May	1 Jun	16 Jun	29 Jun	13 Jul	20 Jul	27 Jul	11 Aug
Dimilin 50 % WP 0.0625 at CB, PF[1] 0.03125 in CS	31	10	0	20	40	30	10	15	0	25
ABG 6243 25 % WP 0.0625 at CB, PF 0.03125 in CS	0	5	0	0	0	5	0	5	0	50
DPX EY 059 4 EC 0.013 at CB, PF 0.0065 in CS	21	5	0	5	25	15	15	10	15	55
Standard program See text for details	2	0	5	5	40	0	90	50	0	75
Check	351	64	105	35	155	435	285	320	150	130

Treatment and lb (AI)/100 gal	PP adults/25 limb taps 30 Mar	9 Apr	14 May	28 May	10 Jun	22 Jun	7 Jul	20 Jul	3 Aug	17 Aug
Dimilin 25 % WP 0.0625 at CB, PF[1] 0.03125 in CS	289	68	26	93	81	38	82	93	127	145
ABG 6243 25 % WP 0.0625 at CB, PF 0.03125 in CS	200	59	31	70	46	121	54	70	178	197
DPX EY 059 4 EC 0.013 at CB, PF 0.0065 in CS	111	18	57	30	140	81	129	153	253	248
Standard program See text for details	121	4	57	30	54	93	79	98	190	243
Check	192	315	69	637	477	246	803	1788	1039	719

Treatment and lb (AI)/100 gal	TSM per 100 leaves 16 Jun	29 Jun	13 Jul	20 Jul	27 Jul	11 Aug	% Fruit damage PP russet US 2	PP russet cull	PRM russet cull
Dimilin 25 % WP 0.0625 at CB, PF[1] 0.03125 in CS	0	20	0	0	0	0	2	0	0
ABG 6243 25 % WP 0.0625 at CB, PF 0.03125 in CS	0	15	0	0	0	0	0	0	0
DPX EY 059 4 EC 0.013 at CB, PF 0.0065 in CS	0	0	0	0	0	0	0	0	0
Standard program See text for details	45	50	135	0	0	10	0	0	0
Check	0	5	0	0	0	0	16	18	8

[1] Dimilin, ABG 6243 and DPX EY 059 were applied 1 Apr (delayed dormant), 28 Apr (clusterbud), 3, 17 Jun and 14 Jul (cover sprays).
These 3 programs also included superior type oil at 1 gal/100 gal on 1 Apr and 1 qt/100 gal on the other spray dates .

II. Pome Fruits

e. Pesticide Resistance

Tentiform leafminer (TLM) - apple
Codling moth (CM) - apple
Obliquebanded leafroller (OBLR) - apple

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MONITORING PESTICIDE RESISTANCE IN TENTIFORM LEAFMINER, CODLING MOTH AND OBLIQUEBANDED LEAFROLLER. The pheromone trap assay as described by Riedl et al (1985) for the codling moth was applied with some modifications to tentiform leafminer and obliquebanded leafroller to determine susceptibility to azinphosmethyl in the field. One focus of the research in 1987 was to evaluate how various parameters (type of trap adhesive, pre- and posttreatment environmental conditions, position of insect on trap) affect bioassay results. Additional work with a carbamate and pyrethroid insecticide will follow in 1988. Comparison between the pheromone trap assay and other resistance monitoring methods are also planned for next year.

Tentiform leafminer - Certain parameters which influence the variability of the pheromone trap bioassay technique are discussed. Post treatment temperatures affected the dose response lines of the trapped male moths. At 55° F, the LC_{50} was 1.64 micrograms/moth which was twice as high than at 60° F and four times as high than at 65° F. Moths bioassayed from 2 commercial sites showed high levels of resistance to azinphosmethyl. Moths from an isolated, abandoned orchard were 200 times more susceptible although approximately 10% of the TLM were resistant.

Codling Moth. The concentration-response to azinphosmethyl was determined for populations from 4 different sites: 2 from pear at OSU's experiment station in Medford, 1 from apple at the MCAREC, and 1 from an abandoned apple orchard in the Columbia Gorge. The LC_{50} values ranged from 0.028 (abandoned orchard) to 0.166 micrograms/moth (SOES/Medford). These values fall within the range of LC_{50}'s reported in the literature.

Obliquebanded leafroller. Male moths were collected with pheromone traps in a partially sprayed apple block at the MCAREC. Great variability was noted in the size and coloration of trapped moths. This variability in field-collected moths may contribute to considerable heterogeneity in bioassay data. It may be necessary to adjust for size/weight differences or treat only groups of moths of similar size. An LC_{50} value of 0.128 micrograms/moth was calculated for 24 h-mortality data. Check mortality was 3.7% at 24 h but had increased to 21% after 48 h.

II. Pome Fruits

e. Pesticide Resistance

1. McDaniel and twospotted mites--Pear

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Mite Resistance in the Hood River Valley

Twospotted and McDaniel mites were collected from pear orchards throughout the Hood River Valley and bioassayed for resistance to Plictran. Both McDaniel and twospotted mites were collected from trees and covercrops in the same orchard when possible. This was often difficult since McDaniel mites were not as common on covercrops as twospotted mites. Field collected material was used for bioassays where possible. If mite populations were too low to test field collected adults, colonies were established on lima beans and reared until enough mites were available. In all cases mites were reared on beans for 30 days or less before testing was conducted.

Tests were conducted using a method similar to that described by Pree. Two cm disks were punched from peach leaves and placed top side down on wet cotton. Disks were sprayed in a Potter tower with 4 ml of a suspension of various rates of cyhexatin in tap water. Check disks were sprayed with 4 ml tap water. A minimum of five concentrations were used for each test. Residues on disks were allowed to dry and twenty female mites were transferred to each treated disk using a fine camel hair brush with all but one or two hairs removed. Each treatment was replicated five times. Disks were held at 70°F, 60% R.H. and mortality was assessed after 48 hours. Mites were considered to be dead if they did not move one body length after being prodded.

Twospotted mites collected from both trees and orchard floors were highly susceptible at rates well below the low field rate. Although there was some variation in susceptibility McDaniel mite was resistant to cyhexatin at rates more than 18 times the field rate.

These data were partially confirmed by field tests. Twospotted mite was controlled by field rates of cyhexatin in single tree handgun plots on both pears and apples. Although not confirmed by replicated plots fieldmen, reported control failures with cyhexatin in several of the orchards where McDaniel mite resistance was detected in lab bioassays.

SECTION III

STONE FRUITS

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Don Joy
Section Leader

III. Stone Fruits

a. Biology

1. Apple maggot; cherries

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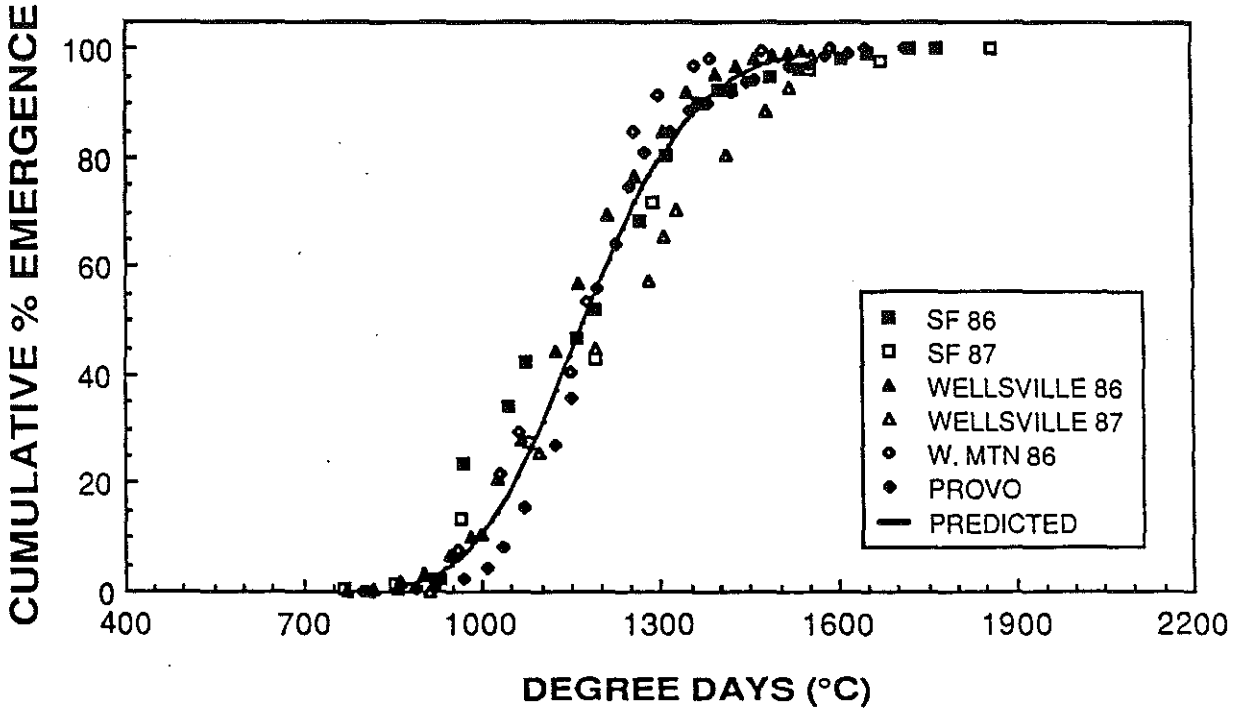
The phenology of the adult apple maggot associated with its 3 main hosts in Utah (sweet cherry, Prunus avium, tart cherry, P. cerasus, and black hawthorn, Crataegus douglassii) was investigated. Apple maggots associated with all 3 hosts had a similar emergence curve on a degree-day scale (6.7° C base), but on a calendar basis, populations in different parts of the state emerge up to 4 weeks apart. Cumulative percent emergence curves were fit to an Erland density distribution function with a DEL = 1180 and k = 65. The oviposition and curve occurred about 110 °D later. Emergence curves for populations of apple maggot from Canada, New York, and Wisconsin were compared to the Utah populations and found to vary enough that phenology models from one location could not be used to predict emergence between regions.



III. Stone fruits
a. Biology
1. Apple maggot; cherries

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The developmental threshold and number of degree days required for development of the egg and larval stages of the apple maggot were determined using a populations of adults aspirated from black hawthorn, Crataegus douglasii.

Eggs were collected from wax domes and placed in either 15, 20, 25, or 30°C for development. A developmental threshold of 8.9°C with 78.1 degree days required to complete development was estimated for the egg stage.

Larvae development time was determined in black hawthorn and tart cherry, Prunus cerasus, in the same temperatures as above. The developmental threshold was estimated to be 7.63°C in tart cherries and 6.5°C in black hawthorn. The number of degree days required to complete development were 233 in tart cherries and 270 in black hawthorn.

III. Stone Fruits
b. Thresholds, monitoring and supply
1. Apple maggot; cherries

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Four different types of traps (red ball, baited red ball, Pherocon AM, and Pherocon AM + ammonium carbonate) were evaluated over the length of the 1987 trapping season. Results indicated that the modified Pherocon AM trap consistently performed better than the other traps in both cherry and hawthorn.

Lure longevity was also found to be problematical with the Pherocon AM trap; significantly lower catches were found when traps were aged 9 days.

Shorter term studies were run to evaluate the different apple volatile lures and to evaluate the Ladd trap. We found no significant differences in attractiveness between the full 'Fein' blend of apple volatiles and the single component lures. The Ladd trap proved to be most efficient when an ammonium carbonate bait was added.

III. Stone Fruits
c. Biological control
1. Oriental Fruit Moth - peaches and nectarines

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Mating disruption trials for OFM were conducted using Shin-Etsu three-month pheromone dispensers at an application rate of 400 dispensers per acre. Pheromone traps were used to monitor the response of male moths to pheromone point sources. Terpinyl acetate bait traps collected female moths for dissection and determination of mating success in the female population. At fruit maturity in each of the trials, a minimum of 2,000 fruit were inspected for infestation by oriental fruit moth. Infestation data was also collected on secondary pests such as peach twig borer and omnivorous leafroller.

OFM mating disruption was continued in two trials at the Kearney Agricultural Center (KAC) at Parlier and three trials at Kingsburg. Results of these five field trials (Table 1) show that the mating disruption treatments were equivalent or better in control of oriental fruit moth compared to untreated checks. None of the five check blocks in the OFM trials in 1987 used insecticides during the season. In the three trials at Kingsburg, the 1987 check blocks had all been treated with pheromones in 1986. Consequently, resident populations in the three check blocks were relatively low compared to surrounding untreated orchards, due to the carry-over influence of the 1986 treatments.

These results confirm the efficacy of mating disruption for control of oriental fruit moth with synthetic pheromones and it is anticipated that use of this technique for OFM control will increase in future years. Infestations of peach twig borer in harvest samples at Kearney (Table 1) showed high levels of twig borer damage in both check blocks, neither of which received dormant sprays. Both of the pheromone treatment blocks at Parlier, however, did receive standard dormant treatments and twig borer damage was held to negligible levels. These data confirm the value of dormant sprays for control of peach twig borer, particularly in orchards that are being treated with pheromones and do not receive in-season sprays for oriental fruit moth. Although higher in several of the pheromone treated blocks, infestations of omnivorous leafroller were not significantly different in check and pheromone treatment blocks in any of the five locations in 1987. OLR populations were not nearly as severe in 1987 in pheromone treatments as they had been observed in previous years. The commercial formulation of oriental fruit moth pheromone (Isomate-M) was approved and registered by EPA and CDFA in February, 1987, for commercial use by growers in California.

Dissections of oriental fruit moth females collected in bait traps at Parlier again showed that mating success in each of the five OFM generations exceeded 90% in check blocks throughout the year with increasing population levels as the season progressed. In the pheromone treated blocks at Parlier (Fields 21 and 72) mating success was less than 50% in the first generation and then began to increase in the second or third generations and approached a high percentage at the end of the season. In each generation, however, mating success in the pheromone treatments was always less than in the

codling moth population to develop to levels too high for the pheromone to control later in the season.

A study was conducted in walnuts in Tulare County to determine at which levels or areas within a tree codling moth is most active. Results of this study confirmed that codling moth, as with other species such as oriental fruit moth, are most prevalent in the upper portions of the tree canopy. This reaffirms the recommendation that pheromone dispensers for mating disruption need to be placed in the upper 1/3 of the canopy in trees of whatever height, if mating disruption is to reach optimum levels.

Table 1. Codling moth mating disruption trials - 1987[1/]

PLOT	VARIETY	TREATMENT	% Infested Fruit CM	PTB	OLR
Kingsburg	Red Beaut	Check	0.1	0	0.2
		Isomate	0.3	0	0.4
Kingsburg	Santa Rosa	Check	0.2	0	0
		Isomate	0.2	0.1	0
Parlier	Friar	Check (1)[2/]	0.2	0.5	0
KAC 52		Isomate	0.6	0.4	0.8
KAC 32	Casselman	Check	27.8	0.2	0
KAC 21		Isomate	4.4	0	0.4
KAC 32	Casselman	Check	4.4	2.8	0.4
KAC 21		Isomate	0.6	0.4	0.3
Exeter	Casselman	Check	0.3	0	0.9
		Isomate	0	0	0.2
KAC 22	Apples	Isomate	1.1	-	-
		Isomate (1)	0.2	-	-
Arvin	Apples	Check (5)	0.9	-	-
		Isomate (3)	36.3	-	-

[1/] BioControl pheromone dispensers; 1 application @ 100/ac, 3/18-23/87.

[2/] Number of insecticide treatments during season.

IV. Nuts

d. Chemical control

1. Parthenolecanium scales - pistachio

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Dilute sprays were applied by handgun to mature pistachio trees in Madera County, California to control mixed populations of European fruit lecanium, Parthenolecanium corni (Bouché), and frosted scale, P. pruinosum (Coq.). Sprays were applied to one set of trees at first leaf fall, November 4, 1986; a second group of trees was sprayed at dormancy on February 5, 1987. Ten 3-tree replicates per treatment were used at each spray timing. Treatments were evaluated by weekly counts of scale crawlers trapped on two sticky tapes per replicate from late April through early June, 1987.

The results of the fall treatment showed that all treatments significantly (DMRT, p = 0.05) reduced crawler populations below the untreated check, with a combination of Sevin plus oil giving the best control (Table 1). In the dormant timing all treatments except the oils alone and Supracide plus oil were significantly better than the check.

Table 1. Insecticide sprays on Parthenolecanium scales in Pistachios; 1986-87

Treatment	A.I./Acre	$\bar{X}$ No. Crawlers Collected Per Rep[1/] Fall[2/]	Dormant[3/]
Check	-	230.4 a	52.6 a
Gavicide	4.0 gal.	16.6 b	43.4 a
Gavicide	6.0 gal.	29.2 b	44.6 a
Lorsban 4E	2.0 lbs.	3.8 b	-
Lorsban 4E + oil	2.0 lbs. 4.0 gal.	-	10.0 b
Diazinon 50W	2.0 lbs.	6.0 b	-
Diazinon 50W + oil	2.0 lbs. 4.0 gal.	-	10.8 b
Supracide 2E	2.0 lbs.	2.8 b	12.2 b
Supracide 2E + oil	2.0 lbs. 4.0 gal.	-	34.8 a
Sevin 80S	3.2 lbs.	5.6 b	-
Sevin 80S + oil	1.6 lbs. 4.0 gal.	1.2 b	11.0 b

1/ Sampled 1X/wk, 4/29 - 7/30/87; 2 tapes/rep.
2/ Treated November 4, 1986.
3/ Treated February 5, 1987.

IV. Nuts

f. Implementation

1. Miscellaneous beneficial and pest insects Hazelnuts

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A computer key to identify common beneficial and pest insects of hazelnut orchards was developed using PERSONAL CONSULTANT EASY, an expert system shell developed by Texas Instruments. The key was made to be used by consultants or growers with a small to moderate knowledge of insects. Graphics are used throughout the key to help users answer questions concerning the insect's appearance. A graphic representation of the identified insect is displayed on the screen at the end of the run as well as text information on the biology of that insect. Users are also informed at the end to take their specimen to an expert before beginning any control programs.

This identification key is to be the first of several hazelnut management computer programs to be developed off of the PERSONAL CONSULTANT EASY system. Future applications will contain information on identifying problems based on tree damage, monitoring insect pests, and controlling insect pests.