RESEARCH REPORTS: 72nd ANNUAL WESTERN ORCHARD PEST & DISEASE MANAGEMENT CONFERENCE

Imperial Hotel, Portland, Oregon
January 7, 8 & 9, 1998

These are research reports only, NOT recommendations of the conference.
Recommendations can only be made by public service entomologists in their specific areas.

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MEETING NOTICE
72nd Annual Western Orchard Pest and Disease Management Conference

January 7-9, 1998

Imperial Hotel, 400 SW Broadway at Stark, Portland, Oregon 97205
Phone: (503) 228-7221

The conference will begin at 1:30 p.m. on Wednesday, January 7, 1998. Research planning and Coordination meetings by special interest groups by arrangement either before or after the WOPDMC.

**Wednesday, 7 January**

- 1:30-1:45 p.m. Opening Business Meeting——Don Thomson
- 1:45-5:00 p.m. Biology/Phenology——Steve Cockfield
  Mating Disruption/SIR——Nana Simone

**Thursday, 8 January**

- 8:30 a.m.-12:00 noon Thresholds/Monitoring/Sampling——Joan Fisher
- 1:30 p.m.-5:00 p.m. Continue Implementation
  Biological Control——Pat Weddle
  Chemical Control/New Pesticides——Dan Flick

- 8:30 a.m. - 5:00 p.m. Tree Fruit Diseases——Tim Smith

**Friday, 9 January**

- 8:30 a.m. - 11:00 a.m. Continue Chemical Control/New Pesticides
  Pesticide Resistance——Stephen Welter

- 11:00 a.m. - 12 noon Closing Business Meeting

Presenters: *Times listed above are only guidelines. You may be asked to make your presentation either before or after the time listed.* Please paraphrase your research and provide time for informal discussion of your data. Exclude common knowledge life history data from your discussion. If necessary include these data in the written research report.

**Research Report:** *In order to petition for PCA credits, titles must be sent by mail or FAX by December 1 and original copy of complete report by December 15 to:*

Deanna Watkins
Office Specialist
2046 Cordley Hall
Corvallis, OR 97331-2907
Phone: (541) 737-4733  FAX: (541) 737-3643
e-mail watkinsd@bcc.orst.edu
Please follow the format below for research reports.

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

Please send a copy of your research report to your section leader:

1. **Thresholds/Monitoring/Sampling**
   - Joan Fisher
   - Scenturion, Inc.
   - P. O. Box 585
   - Clinton, WA 98236

2. **Implementation**
   - Ted Alway
   - WSU Coop. Ext.
   - 400 Washington St.
   - Wenatchee, WA 98801

3. **Biological Control**
   - Pat Weddle
   - Weddle, Hanscn & Assoc.
   - P. O. Box 529
   - Placerville, CA 95667

4. **Chemical Control/New Products**
   - Dan Flick
   - Wilbur Ellis Co.
   - P. O. Box 710
   - Wenatchee, WA 98812

5. **Pesticide Resistance**
   - Stephen Welter
   - UCB Department of Entomology
   - 201 Wellman Hall
   - Berkeley, CA 94720

6. **Biology/Phenology**
   - Steve Cockfield
   - P & G Orchards
   - P. O. Box 1461
   - Brewster, WA 98812

7. **Mating Disruption/SIR**
   - Nana Simone
   - Private Consultant
   - 89908 Hank Road
   - Prosser, WA 99350

8. **Tree Fruit Diseases**
   - Tim Smith
   - WSU Coop. Extension
   - 400 Washington
   - Wenatchee, WA 98801

To insure clarity of pesticide designations, please submit on a separate sheet of paper, the accepted common name and trade name of any pesticide mentioned in your report.

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

**THIS WILL BE THE ONLY MEETING NOTICE. TITLES SHOULD BE RECEIVED BY MAIL OR FAX BY DECEMBER 1, REPORTS BY DECEMBER 15. REPORTS RECEIVED AFTER THE DEADLINE WILL NOT BE INCLUDED IN THE RESEARCH REPORT.**

William Barnett
Secretary/Treasurer
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January 7, 8, & 9, 1998

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SECTION 1
THRESHOLDS/MONITORING/SAMPLING

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Joan Fisher
Section Leader
I. Thresholds/Monitoring/Sampling

DEVELOPMENT OF A PHEROMONE-BASED MONITORING SYSTEM FOR *NEUROCOLPUS LONGIROSTRUS* (KNIGHT) (HEMIPTERA: MIRIDAE)

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Bioassay trials in 1996 with candidate *Neurocolpus longirostrus* pheromones were in general inconclusive but had given some leads for continuing procedures and trials in 1997. As in previous trials, all field bioassays were placed in California buckeye, *Aesculus californica*, which was in bloom. As much as possible, traps were placed fully exposed on the periphery of buckeye trees in proximity to flowers but usually not in shade as had been done in previous trials. Following the lead provided by the 1997 field bioassays with *Calocoris norvegicus*, pheromone traps used for *Neurocolpus* in 1997 were standard Jackson traps using removable sticky insert liners. Five replications per treatment were used in all *Neurocolpus* field bioassays. Candidate pheromones were applied to rubber septa at reduced rates compared to the 1996 trials. In trials with sufficient bug collections, data were analyzed using Fisher’s Protected LSD test at \( p = 0.05 \) significance level.

Following a review of volatile chemicals produced by male and female *N. longirostrus* adults, the first field bioassays with synthetic *Neurocolpus* pheromones in 1997 were emplaced on May 12 near Dunlap, Fresno County, California. This test resulted in low numbers of *Neurocolpus* males trapped only in the treatment comprised of the complete (six-isomer) blend of female-produced volatile chemicals. These collections were made on the first day of exposure of this series of chemicals.

Following the initial test with the complete blend, a second series of pheromones was tested using a fivefold increase of pheromone on each rubber septa. In this trial, no bugs were collected until the third through sixth day of exposure, perhaps due to an arresting or repellent effect of the higher load rate of pheromones in the traps. As in the first trial, *Neurocolpus* males were trapped only in treatments containing the complete blend of female-produced volatiles.

A third bioassay, again using reduced rates of pheromone loads, continued to show improvement in collection of male *Neurocolpus* (Table 1, no. 3). For the first time, several treatments showed recurrent collections of male bugs, and one five-component blend (NL-97-37), was notably better than any of the other treatments in the trial. Also, the shift to Jackson traps rather than wing traps seemed to greatly reduce the number of female bugs collected, similar to results with the last 1997 *Calocoris* test.
The fourth series of *Neurocolpus* bioassays was designed to again compare pheromone load rates and blend composition on septa. Collection of bugs continued to improve for the duration of this test with the higher rates of the five-component blend (NL-97-51, -52) significantly better than a three-component blend (NL-97-56, -57) at the same load rates (Table 1, no. 4).

The next series of *Neurocolpus* bioassays compared the best treatment (five-component blend) from Test 4 to various load rates of only a four-component blend. The results of this trial (Table 1, no. 5) showed that the highest dose rate of the four-component pheromone (NL-97-75) collected significantly more bugs than other treatments in the trial, with daily collections in most of the treatment replicates. It was noted that most of the bugs were collected after three to five days of lure exposure, indicating that the initial release rate of pheromone from the lures was again too high, thus supporting earlier observations that release rates that are too high will in fact keep bugs from moving into the traps. It was, however, observed during this bioassay series that male bugs that were eventually trapped were in close proximity to the pheromone source (on or inside rubber septa) indicating a strong attraction and movement directly to the septa. This is similar to collections of males responding to pheromones produced by virgin females placed in small cages inside sticky traps. Male *Neurocolpus* were also observed on buckeye flowers and foliage adjacent to the traps. This was also an indication that blend composition and release of pheromone was becoming more acceptable to responding male bugs. After one week of field exposure of the lures in this trial, the pheromones were no longer attracting males, suggesting that the release of attractive chemicals from septa in a proper blend and rate occurs over a very short period of time (about one week or less).

The sixth *Neurocolpus* bioassay was emplaced at a higher elevation (ca. 4000 ft) with better host conditions than in the (lower) Dunlap locations. In this trial the pheromone load rate on rubber septa was reduced from the previous trial and compared a four-component blend to a series of three-component blends. The results of this trial (Table 1, no. 6) showed that the four-component blend (NL-97-80) was superior to any of the three-component blends. It was also noted that male bugs were again attracted on the first day of trapping, probably due to improving pheromone blend composition and load rate on the lures.

It had been observed occasionally in previous 1997 trials and was strongly confirmed in this trial that *Neurocolpus* males are active on buckeye flowers early in the morning, and usually in full sunlight. In addition to bugs being trapped on sticky trap surfaces, male bugs were observed on foliage near to traps and on outer trap surfaces between 6:00 and 9:00 a.m. PST. They were moving over the trap surface and foliage in an excited and agitated manner while temperatures were increasing from approximately 65° to 75° F. on most days. It appeared from this behavior that the bugs were definitely responding to attractive chemicals coming from the pheromone traps. They had never been observed, over a period of many years, behaving in this manner or even exposed outside of protective buckeye flowers. Although male bugs were attracted to traps on the first day of pheromone presentation, maximum male response occurred on the third and fourth day of trapping, again indicating that initial release of pheromones from the rubber septa in this trial was perhaps still too high for optimum bug response.

The 1997 *Neurocolpus* pheromone bioassays produced significant advances in identification of attractive volatiles produced by female bugs and in pheromone blend composition and
presentation. In addition, several interesting observations were made regarding bug behavior and activity. In all locations where bioassays were carried out in 1997, male *Neurocolpus* responded to pheromone traps primarily in the early morning hours between sunup and 9:00 a.m. Standard time. During these bioassays early morning temperatures ranged from approximately 65° to 75° or 80° F. On one occasion a freshly caught male bug was in a trap in sunlight when the temperature was 61° F. This possibly represents the lower limit of bug activity and response to pheromones. Both male and female bugs are active on flowers in the full sunlight in preference to flowers in shade or cooler locations. Males also seem to respond better to traps that were in open sunlight rather than in shady locations. However, this was not always the case with traps that had very attractive blends. As buckeye flowers began to senesce and decline in host suitability, the bug populations seemed to enter a migratory or searching mode of behavior. This could lead to active migration from drying buckeye to other potential hosts, which could be the reason *Neurocolpus* infests pistachio orchards some distance from the native buckeye host.

It was also established during these trials that the smaller Jackson trap was a very efficient trap for collection of *Neurocolpus* males responding to pheromones. This trap is easier to handle and less expensive than the larger wing traps used in previous trials. The successful 1997 *Neurocolpus* pheromone bioassays will provide a solid starting point for final identification and development of a commercial *Neurocolpus* trapping system in 1998.
Table 1. Collections of *Neurocolpus longirostrus* in Jackson traps baited with selected pheromone isomer blends. Fresno County, California.

### Bioassay No. 3

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I. Thresholds/Monitoring/Sampling

DEVELOPMENT OF A PHEROMONE-BASED MONITORING SYSTEM FOR CALOCORIS NORVEGICUS (GMELIN) (HEMIPTERA: MIRIDAE)

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Riverside, CA 92521

Field bioassay trials designed to identify the sex pheromones of Calocoris norvegicus were continued in 1997. The purpose of this work was to develop pheromone traps as a monitoring tool to detect Calocoris migrations into pistachio orchards prior to shell hardening in early spring. Most of the 1997 field trials were carried out in a large vineyard near Avenue 10 and Highway 41 in southern Madera County, California. This vineyard was suitable as a Calocoris bioassay test area because of the vetch cover crop that existed throughout the vineyard, providing large populations of Calocoris from late March through April. Standard wing traps (Pherocon 1C, Trécé, Inc., Salinas, CA) were suspended from the center wire in the vineyard row at the top of the vetch cover crop. All treatments with candidate pheromone isomers, blends, and lure load rates were replicated at least five times in a randomized complete block design. In each test, traps were rotated one position in the trap placement array at each count interval. Bugs responding to the traps were counted and removed at one to three day intervals throughout all the tests in Madera County.

The first bioassay for Calocoris was emplaced at the Madera County location on March 31 and continued through April 7, 1997. This test used relatively high rates of pheromone on rubber septa, similar to loads used in the 1996 Calocoris trials, and compared a five-component ("complete") pheromone blend to blends containing one to four of the respective components. In addition to the traps with synthetic pheromone lures, five traps each with three virgin Calocoris females were included in this test. Although high numbers of bugs were trapped in this bioassay (Table 1), it was difficult to separate any of the respective pheromone blends and treatments because of high numbers of female bugs that were also trapped. In addition, an unacceptably high number of bugs, both male and female, were trapped in the five check or blank traps in this trial (ca. 3 m:1 f) as a result of the general movement and activity of the bugs both in the vetch and in the vine canopies. The one positive aspect of this first 1997 test was the high number of male bugs collected along with an improved male:female ratio (ca. 5:1) in the traps with virgin female bugs, confirming again the presence of a female-produced sex attractant. It was determined that the pheromones applied to red rubber septa began to lose attractiveness after only three to four days of exposure in the field. Also, the bugs were observed to be very active from early morning to midday in contrast to observations of adult Phytocoris spp. which are active primarily at night. Because of the high numbers of females collected in the trial, we continued testing only those pheromone blends that collected ratios of males to females in a ratio higher than that observed in the blank traps (approximately 3:1).
A second *Calocoris* pheromone bioassay was placed at Madera on April 7-14 using varying ratios of a three-component blend. A total of 20 pheromone blends were included in this trial. As in the first trial, high numbers of both males and females were collected in the pheromone traps. Unlike the first test, however, some pheromone blends in this second trial collected only males in most of the five trap replications. Consequently, pheromone blends that collected either relatively high numbers of males in traps, or ratios of more than three males to one female over the duration of the test were selected for continued testing.

Laboratory data from *Calocoris* electroantennagrams, along with results of the first two field bioassays for *Calocoris*, indicated that two primary components produced by *Calocoris* females were involved in the *Calocoris* sex pheromone. Consequently, the third series of *Calocoris* pheromone bioassays in 1997 was designed to evaluate various ratios of two-component blends of pheromones but using two of three candidate isomers. This trial, conducted in the Madera vineyard location April 15-21, resulted in again high collections of both males and females in all of the candidate pheromone treatments (over 1,800 bugs total in seven days). Because this test was also very difficult to evaluate because of the high numbers of females collected, a fourth set of baits, again using two-component blends of three different candidate isomers, was emplaced in late April at the Madera location. This fourth series of bioassays was again somewhat confusing and contradictory but the one result that stood out was that in several of the two-component blends in this trial, more female bugs were collected than male bugs. This was the first time this had been observed consistently in any of the *Calocoris* bioassays previously conducted, and was not the type of result expected, since the *Calocoris* pheromones are primarily produced by females and should attract males.

Because the previous two bioassays using two-component blends had been inconclusive it was decided to go back and reevaluate various three-component blends of *Calocoris* isomers, again using relatively high doses of the total blend in each rubber septa. The results of this trial showed that the three-component blends were more attractive than any of the two-component blends previously evaluated in the field. The series of *Calocoris* pheromone bioassays in Madera was terminated on April 28 due to rapidly declining adult bug populations in the test field, even though the vetch was still in relatively good condition from vineyard irrigations.

Because the loss of univoltine (one-generation) *Calocoris* populations had been anticipated in the central and southern San Joaquin Valley, a test area for *Calocoris* in the Sacramento Valley had been located through efforts of Cooperative Extension farm advisors in Sutter and Yuba counties where populations of adult *Calocoris* were still present in commercial vetch seed fields. Consequently, the last *Calocoris* pheromone bioassay test (no. six) was emplaced at Pleasant Grove, Sutter County, on May 2 using combinations of pheromone blends that had looked promising from all previous trials in 1997. This trial was designed to evaluate six candidate pheromone blends, but was different from previous trials in that the standard amount of pheromone per lure was compared to a load rate of 1/10 of the standard rate. Also, the trap design in this trial was changed from the wing trap designs previously used in all tests, to smaller Jackson traps to reduce the sticky trapping surface. As in earlier trials, five replications per pheromone blend were emplaced in a randomized complete block. Traps were suspended from wooden stakes approximately three to six inches above the vetch plants.
Results of this *Calocoris* field bioassay showed that one of the three-component blends was highly and significantly more attractive than any of the other blends in the trial (Table 2). The most attractive pheromone blend in this test (CN-97-114) was the same as treatment 104 but 1/10 the dose. This finding was our first indication that most if not all of the previous trials had been using dose rates of pheromone on rubber septa dispensers much too high for proper response and collection of male bugs at the pheromone sources. The change to the smaller Jackson traps also seemed to eliminate much of the random collection of female *Calocoris* on the sticky surfaces, which had been a perplexing and continuing problem with the larger, more open wing traps. Also for the first time in any *Calocoris* field bioassays, adult male bugs were observed walking and moving about on the surface of the Jackson traps, as well as on the plant foliage in close proximity to the trap and pheromone source. This suggests that even more male insects than those actually trapped were being attracted to the vicinity of the pheromone source. It also suggests that perhaps even further modifications in trap design for *Calocoris* (and *Neurocolpus*) should be evaluated in order to optimize or maximize collection of responding bugs.

Table 1. Field bioassay of *Calocoris norvegicus* pheromone blends, trial I. Madera County, California.

<table>
<thead>
<tr>
<th>Pheromone Blend</th>
<th>No. <em>Calocoris</em> Collected$^1$</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN-97-1</td>
<td>33</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>CN-97-2</td>
<td>37</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>CN-97-3</td>
<td>41</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>CN-97-4</td>
<td>34</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>CN-97-5</td>
<td>44</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>CN-97-6</td>
<td>48</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>CN-97-7</td>
<td>52</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>CN-97-8</td>
<td>45</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>CN-97-9</td>
<td>40</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>CN-97-10</td>
<td>37</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>CN-97-11 (blank)</td>
<td>29</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>CN-97-12 (3 females)</td>
<td>208</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

$^1$ Total bug collections from five counts and trap rotations, April 1-7, 1997.
<table>
<thead>
<tr>
<th>Pheromone Blend</th>
<th>No. <em>Calocoris</em> Collected$^1$</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN-97-101$^2$</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CN-97-102</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CN-97-103</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CN-97-104</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CN-97-105</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CN-97-106</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CN-97-111$^2$</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CN-97-112</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CN-97-113</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CN-97-114</td>
<td>23</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CN-97-115</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CN-97-116</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CN-97-117 (blank)</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

$^1$ Two counts, one trap rotation, May 5-6, 1997.
$^2$ Standard pheromone load per septa, treatments 101-106.
$^3$ 1/10 standard pheromone load per septa, treatments 111-116.
Trap Design

The purpose of this trial was to determine which of several commercial trap designs already available for grower use are best suited for trapping *Phytocoris relativus*. This test was carried out in mature almonds near Selma, CA during early July 1997 using five replications for each of six different trap designs. The traps evaluated in this trial were: standard Jackson; tent, Pherocon 1C, and Pherocon V (Trécé, Inc., Salinas, CA); and Intercept A and Intercept C traps (IPM Technologies, Inc., Portland, OR). All traps were baited with standard University of California *Phytocoris relativus* rubber septa lures loaded with 5 mg of pheromone per lure. Traps were emplaced on a 200 x 200 ft grid on July 1, 1997, were counted at two- or three-day intervals, and were rotated to the next position in the trap grid after each count. The test was terminated on July 15, 1997.

The results of this trap comparison showed the Pherocon V (scale trap), the Pherocon 1C (standard wing trap), and Intercept C to be the most efficacious of the six traps evaluated (Table 1).

Table 1. Comparisons of pheromone traps for collection of *Phytocoris relativus* in orchards.
Fresno County, California, July 1997.

<table>
<thead>
<tr>
<th>Trap Type</th>
<th>Average No. <em>P. relativus</em> per replicate&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept A</td>
<td>8.2 a</td>
</tr>
<tr>
<td>Tent</td>
<td>21.4 b</td>
</tr>
<tr>
<td>Jackson</td>
<td>25.4 b c</td>
</tr>
<tr>
<td>Intercept C</td>
<td>26.8 b c d</td>
</tr>
<tr>
<td>Pherocon IC</td>
<td>32.2 c d</td>
</tr>
<tr>
<td>Pherocon V</td>
<td>34.0 d</td>
</tr>
</tbody>
</table>

<sup>1</sup> Means followed by the same letter are not significantly different at p. = 0.05, Fisher’s Protected LSD test.
The lowest catches of *P. relativus* males occurred with the Intercept A trap, probably because the opening in this trap was too small and restricted for easy entrance of responding bugs into the trap. These results indicate that the least expensive of these traps, Pherocon V, will perform very well in routine monitoring of *Phytocoris* populations in orchard crop systems. This trap, however, is designed for collection of small insects such as male scale (California red scale, San Jose scale) and collections of *Phytocoris* probably would be adversely affected if large amounts of debris, such as dried flower petals, sepals or dirt collected on the exposed trapping surfaces over a period of time, or if trap servicing intervals were too long. If this occurred, one of the larger, covered traps could be substituted but at a greater expense than the Pherocon V (or similar) trap.

**Phytocoris** pheromone dispenser trials

Work in 1995-96 with *Phytocoris relativus* pheromone applied to rubber septa lures had shown that release of the very volatile pheromone was rapid, and field longevity was unacceptably short. This led to research in 1997 to find other types of *Phytocoris* pheromone lures that would extend efficacy and reduce monitoring costs to growers.

New *Phytocoris* pheromone lures were compared in field trials to the standard rubber septa lures provided by Dr. Jocelyn Millar, U.C. Riverside, in a mature plum orchard at the Kearney Agricultural Center. Four modifications of a small polymer reservoir lure (PTRE I-IV) were assembled by pheromone chemists at the Czech Academy of Sciences, Prague, Czech Republic, and provided through IPM Technologies, Portland, OR. These lures were loaded with the same amount of the two-isomer *Phytocoris relativus* pheromone blend as was used on the U.C. rubber septa standard lures. Lures were placed in wing traps spaced 200 ft apart, using five replications of each lure type in a randomized complete block array. Traps were placed 7 ft above the ground, serviced daily for seven days, then at 3-4 day intervals, and rotated to the next position in the array after each count. The test was emplaced on April 30 and terminated on June 4, 1997. Two treatments of the U.C. standard lures were compared to the PTRE lures. One U.C. lure was replaced weekly during the trial; the other U.C. lure and the PTRE lures were not replaced.

The results of this trial showed the expected rapid loss of attractancy in the unreplaced U.C. standard lure after only seven days of field exposure (Table 2). The PTRE I, II, and III lures were still comparable to the fresh U.C. standard lures through 21 days, but after 28 days, all PTRE lures had collections of *Phytocoris* significantly lower than the standard. These data showed that *Phytocoris* lure longevity could be improved significantly over the original rubber septa lures. A second *Phytocoris* lure efficacy trial in 1997 compared the U.C. standard rubber septa lure and the PTRE III lure to a new *Phytocoris* solid substrate lure manufactured by Scenturion, Inc., Clinton, WA. This lure was designed to have extended attractancy, perhaps season-long, compared to other lures. Five replications of each lure type were used in standard wing traps and placed in an almond orchard near Selma, CA on July 1, 1997. Traps were hung ca. 7 ft high in trees at 200 ft intervals in a randomized complete block design and were serviced and rotated at least twice weekly through September 30, and then weekly until November 11 when the test was terminated. In this test, the U.C. lures were replaced at two-week intervals, the PTRE III lures were replaced twice at four-week intervals (July 29, August 26) and the Scenturion lures were not replaced over the 4.5 month duration of the test. The U.C. and PTRE
lures were loaded with 5.0 mg of *Phytocoris* pheromone blend, the Scenturion lures were loaded with a much higher (unspecified) amount of pheromone. Data from this test were not analyzed statistically because of the differences in lure load rates.

The results of this test (Fig. 1) showed the expected biweekly oscillations typical of the U.C. rubber septa lures. After each lure change, *Phytocoris* collections increased dramatically for one week, then dropped rapidly during the second week of lure exposure. The PTRE lures collected more *Phytocoris* during the first two weeks of exposure, then fell below the number of bugs collected by fresh U.C. lures during the third and fourth weeks. This confirmed the results observed with these two lures in the earlier test in May 1997 at Parlier (Table 2).

Collections of *Phytocoris* males in the Scenturion baited traps far exceeded the other two lures after the first week of trapping. This difference in attraction and collection persisted throughout the test, probably due to a greater amount of pheromone initially loaded in the Scenturion lures, and a much larger surface area releasing the pheromone. The number of bugs collected by these lures is probably greater than necessary for adequate, routine monitoring of *Phytocoris* in orchards. However, these data show that solid dispensers hold considerable promise for improved long-life lures that use volatile pheromones such as *Phytocoris*.

The more consistent release of pheromone from the Scenturion lures also provided a better understanding of *Phytocoris relativus* population fluctuations over time than the other two dispenser types. The second generation (July-August) and third generation (September-October) of *P. relativus* shown in Fig. 1 are very similar to these two generations shown in *relativus* seasonal monitoring data (Fig. 2).
Table 2. *Phytocoris relativus* lure longevity trial, April 30 - June 4, 1997. Kearney Agricultural Center, Parlier, California

<table>
<thead>
<tr>
<th>Lure Type</th>
<th>1</th>
<th>2</th>
<th>5</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>28</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.C. Standard 3/</td>
<td>3.50 a</td>
<td>2.32 a</td>
<td>2.86 a</td>
<td>1.50 a</td>
<td>2.32 a</td>
<td>1.82 a</td>
<td>1.06 a</td>
<td>1.06 a</td>
</tr>
<tr>
<td>PTRE I</td>
<td>3.04 a</td>
<td>2.26 a</td>
<td>3.40 a</td>
<td>2.80 b</td>
<td>4.53 d</td>
<td>3.52 b</td>
<td>1.98 a</td>
<td>0.97 a</td>
</tr>
<tr>
<td>PTRE II</td>
<td>2.81 a</td>
<td>1.70 a</td>
<td>3.28 a</td>
<td>2.89 b</td>
<td>2.90 ab</td>
<td>3.46 b</td>
<td>2.02 a</td>
<td>1.97 a</td>
</tr>
<tr>
<td>PTRE III</td>
<td>2.94 a</td>
<td>2.17 a</td>
<td>3.14 a</td>
<td>2.86 b</td>
<td>5.56 e</td>
<td>4.22 b</td>
<td>2.05 a</td>
<td>1.09 a</td>
</tr>
<tr>
<td>PTRE IV</td>
<td>2.99 a</td>
<td>1.63 a</td>
<td>2.48 a</td>
<td>1.93 ab</td>
<td>3.57 bc</td>
<td>2.39 a</td>
<td>1.79 a</td>
<td>1.26 a</td>
</tr>
<tr>
<td>U.C. Standard 3/</td>
<td>3.43 a</td>
<td>2.20 a</td>
<td>3.12 a</td>
<td>2.09 ab</td>
<td>4.11 cd</td>
<td>4.29 b</td>
<td>3.57 b</td>
<td>4.13 b</td>
</tr>
</tbody>
</table>

1/ 5.0 mg/lure; five replications/treatment. Data transformed to $\sqrt{x + 0.5}$. Means in columns followed by the same letter are not statistically different, p. = 0.05, Fisher's Protected LSD test.

2/ Not replaced.

3/ Replaced weekly.
Figure 1. Collections of *Phytocoris relativus* in wing traps in response to three types of pheromone lures (rubber septa, liquid reservoir, solid matrix). Arrows indicate dates of lure replacement. Selma, Fresno County, CA.
Phytocoris seasonal monitoring

Populations of Phytocoris relativus in a 3.0 acre mixed stone fruit orchard at Parlier were monitored with pheromone traps from first adult bug appearance in April through November. Four standard wing traps were baited with U.C. rubber septa lures loaded with five mg of P. relativus pheromone. Traps were placed 180 ft apart, 6 ft high in the NE quadrant of trees and were counted twice weekly. These traps were not rotated (i.e. – static placement) when counted; lures were replaced at two-week intervals.

The trapping data for P. relativus over the 1997 season at Parlier confirmed again the rapid release and loss of pheromone from rubber septa lures resulting in an oscillating and very confusing pattern of population levels and trends (Fig. 2). However, when the total bug collections for each week were averaged with totals from the preceding week and plotted as an average for the two counts on the graph, a much smoother and clearer pattern of P. relativus populations was apparent (Fig. 2). From this, a distinct three generations of P. relativus developed in 1997 which agrees closely with beating tray sampling for relativus 10 years earlier (R. E. Rice, unpublished data) in the same orchard (Fig. 3). A partial fourth generation of P. relativus may develop in some years if fall weather is warm enough. The slight decline in bug numbers observed in the third generation peak compared to earlier peaks may be due to continuous stationary trapping in a relatively small orchard. However, these data show that growers can use Phytocoris pheromone traps effectively throughout a season, and can get a good estimate of potential overwintering egg deposition from third generation adults that will produce a new generation of Phytocoris prior to pistachio bloom and nut set the following spring.

The value of pheromone traps for monitoring Phytocoris was independently demonstrated by a cooperator near Hanford, Kings County. On April 21, four P. relativus pheromone traps in one orchard collected 46 relativus males, while ten random beating tray samples throughout the orchard yielded no Phytocoris adults or nymphs.
Figure 2. Seasonal monitoring of *Phytocoris relativus* using rubber septa lures in wing traps. Lures were replaced at two-week intervals. Kearney Agricultural Center, Parlier, Fresno County, CA.
Figure 3. Beating tray collections of *Phytocoris relativus* in French prunes. Kearney Agricultural Center, Fresno County, CA.
I. Thresholds/Monitoring/Sampling

EFFICACY OF NEW PHEROMONE LURES FOR MONITORING PEACH TWIG BORER

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9240 S. Riverbend Ave., Parlier, CA 93648

Pheromone traps have been used for monitoring populations of peach twig borer (PTB) in stone fruit and almond orchards since 1976. Typically, small rubber septa (lures) have been used to release a two-component blend of PTB pheromone in a specific isomer ratio. Due to the high volatility of the PTB pheromone blend and low load capacity, field life of the rubber septa lures is relatively short, and replacement of lures has been recommended at two-week intervals to maintain a high level of moth collections.

Recently, other types of pheromone dispensing lures have been developed, primarily to extend field longevity of lures and thereby extend replacement intervals and reduce monitoring costs. In 1997, two new lures for PTB monitoring traps were compared to standard Pherocon® rubber septa lures (Trécé Inc., Salinas, CA) that had been used since 1976.

Biolure® PTB pheromone lures (Consep, Inc., Bend, OR) and Scenturion® PTB lures (Scenturion, Clinton, WA) were compared to Pherocon PTB septa lures in a mature, unsprayed almond orchard near Selma, CA from July 1 to October 28, 1997. Lures were placed according to manufacturer recommendations in standard wing traps, with five replications of each lure. The Pherocon rubber septa lures were replaced at two-week intervals; the Biolure and Scenturion lures were not replaced during the trial. Traps were placed in a randomized complete block array; trapped PTB moths were counted and removed twice weekly from July 1 – October 7 and weekly thereafter. Traps were rotated to the next position in the array at each count date.

The results of the PTB lure comparison test (Table 1) showed no significant statistical differences in moth collections among the three lures through week 9 (September 2) even with biweekly replacement of the Pherocon lures. After 10 weeks of exposure (September 9) Biolure dispensers began to fall significantly behind the Scenturion and Pherocon lures in moth collections. By September 30 (week 13), the Scenturion lures were also beginning to fade in comparison to fresh Pherocon lures, although a “clean” statistical difference was not seen between these two lures until week 15 (October 14).

This trial demonstrated the efficacy of two new pheromone lures for monitoring PTB in orchards. The Biolure (liquid reservoir) and Scenturion (solid substrate) both showed comparable efficacy and improved longevity compared to standard rubber septa lures.
Table 1. Comparative collections of peach twig borer, *Anarsia lineatella*, in sticky traps baited with three different lures.

<table>
<thead>
<tr>
<th>Date</th>
<th>Trécé</th>
<th>Consep</th>
<th>Scenturion</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>108.0 a</td>
<td>83.4 a</td>
<td>83.2 a</td>
</tr>
<tr>
<td>15*</td>
<td>19.2 a</td>
<td>26.6 a</td>
<td>32.0 a</td>
</tr>
<tr>
<td>22</td>
<td>40.8 b</td>
<td>30.5 a</td>
<td>46.1 b</td>
</tr>
<tr>
<td>29*</td>
<td>28.2 a</td>
<td>20.0 a</td>
<td>42.6 b</td>
</tr>
<tr>
<td>August</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>30.0 a</td>
<td>23.0 a</td>
<td>36.6 a</td>
</tr>
<tr>
<td>12*</td>
<td>37.8 a</td>
<td>27.6 a</td>
<td>46.4 a</td>
</tr>
<tr>
<td>19</td>
<td>117.0 a</td>
<td>92.2 a</td>
<td>125.6 a</td>
</tr>
<tr>
<td>26*</td>
<td>92.0 a</td>
<td>97.8 a</td>
<td>122.6 a</td>
</tr>
<tr>
<td>September</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>152.8 a</td>
<td>86.8 a</td>
<td>139.8 a</td>
</tr>
<tr>
<td>9*</td>
<td>164.6 b</td>
<td>104.0 a</td>
<td>173.0 b</td>
</tr>
<tr>
<td>16</td>
<td>309.8 b</td>
<td>187.8 a</td>
<td>243.4 a b</td>
</tr>
<tr>
<td>23*</td>
<td>407.8 a</td>
<td>321.4 a</td>
<td>432.2 a</td>
</tr>
<tr>
<td>30</td>
<td>415.2 b</td>
<td>314.4 a</td>
<td>370.8 a b</td>
</tr>
<tr>
<td>October</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7*</td>
<td>115.0 b</td>
<td>64.2 a</td>
<td>81.0 a b</td>
</tr>
<tr>
<td>14</td>
<td>40.8 b</td>
<td>9.8 a</td>
<td>18.6 a</td>
</tr>
<tr>
<td>21*</td>
<td>24.2 b</td>
<td>7.2 a</td>
<td>15.4 a b</td>
</tr>
<tr>
<td>Terminated</td>
<td>9.8 a b</td>
<td>2.4 a</td>
<td>11.4 b</td>
</tr>
</tbody>
</table>

* = Trécé lure change.

1/ Means in rows followed by the same letter are not significantly different at p. = 0.05, Fisher’s Protected LSD test.
The Idaho State Department of Agriculture has had an interest in a detection program for Oriental Fruit Moth (OFM) in Boundary County, Idaho and has conducted trapping with commercial OFM sex pheromone lures in an effort to determine if OFM are present. In 1996 approximately 500 lesser appleworm (LAW) moths were captured in these traps, confounding detection efforts for OFM.

In 1997 an experiment was conducted to compare two ratios of pheromone components for attractiveness to LAW and to determine if OFM were present. These two different pheromone ratios were determined by Roelofs and Carde (1974) to be optimum for LAW and OFM respectively. The objectives of the experiment were to determine if LAW responds preferentially to one ratio of the components, determine if OFM were in the area, determine the number of generations of LAW in Boundary County, Idaho and determine the seasonal flight pattern of LAW in that area.

Red rubber septa were loaded with one mg of pheromone to make lures for LAW (2.2% E-8-12:AC in Z-8-12:AC) and for OFM (6.4%E-12:AC in Z-8-12:AC). Lures were used to bait Pherocon 1C traps placed in abandoned apple, peach, and prune trees in areas with abundant wild hawthorn, the primary host of the lesser appleworm. Traps were set up at five such sites, with a pair of traps (one with the LAW lure, one with the OFM lure) at each site, hung in trees at a height of 1.7 meters. Traps were maintained from early June through August 1997, checked weekly, and lures changed every four weeks. Trap liners were shipped to Yakima where trapped moths were identified under a dissecting microscope.

Some moths were not identifiable because of a greasing effect of the stickum in trap liners over time. However, all identifiable moths were either LAW or a third, as yet unidentified, species. No moths captured were positively identified as OFM. Lesser appleworm moths were captured throughout the experiment, but with peaks in captures during late June and again in late July, possibly indicating two flights or generations (Figure 1-A). There was no difference in numbers of LAW captured in traps baited with the LAW pheromone ratio.
the LAW pheromone ratio or in traps baited with the OFM pheromone ratio. Additional experiments are needed to determine the relationship between component ratio and LAW attraction, over a broad range of pheromone ratios.

A large number of moths of the third species were captured throughout much of the season, but with a preponderance capture in traps baited with the LAW pheromone. One peak in captures was evident with the species, not corresponding to the LAW (Figure 1-B). The size and shape of this species are close to that of OFM and LAW but the scale coloration is strikingly different. We are currently trying to determine the species of this moth.

Boundary County, ID 1997
Elevation - 800 Meters

![Graph A](image1.png)

**Figure 1-A**

![Graph B](image2.png)

**Figure 1-B**

Figure 1. Capture of LAW males, and a unknown species of male moth.
1. Thresholds/Monitoring/Sampling

MONITORING CODLING MOTH IN PHEROMONE-TREATED ORCHARDS:
COMPARISON OF LURES

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Pheromone traps baited with a high load-rate red septum (10 mg of codlemone) have been adopted as a tool for monitoring codling moth (CM) in mating disruption (MD) orchards. This trapping system can be used to track CM flight and to determine the need for supplemental treatments of pheromone or conventional insecticides where MD is failing to control CM. However, the reliability of a 10 mg lure-baited trap to indicate the potential for fruit injury in MD orchards is not as good as growers and crops consultants would like. Here we report on continuing efforts to develop more effective high load CM trapping systems.

Three kinds of experimental high load lures were tested: a biolure (Consep, Inc.), a bubble cap (Pherotech, Inc.) and a plastic resin (Scenturion, Inc.). All lures were engineered to release 5-10 µg of codlemone per hour. This emission rate was targeted because previous studies indicated a high degree of attractancy of the 10 mg red septa releasing these quantities of pheromone. We directly compared the attractancy of the three experimental lures and the commercially available red septa loaded with 10 mg of codlemone (Trécé, Inc.). The experimental design was a randomized complete block. Tests were conducted in 6 pheromone-treated blocks (Isomate C Plus at 400 dispensers/acre) at the Tree Fruit Research Center. The number of male moths captured in Delta traps (Scenturion, Inc.) baited with the different lures was recorded every 2-3 days. To minimize position effects, traps were rotated each time they were inspected. Red septa lures were replaced after three complete rotations (27 days) during the first generation flight and after two rotations (18 days) during the second generation flight. Trap bottoms were replaced after a cumulative catch of 30 moths, more often if dirty.

The relative attractancy of the various high load lures during the first and second generation flights of CM are shown in Figures 1A & 1B. Data are presented as the average capture of moths in traps baited with different lures over the course of 9 days. Each successive 9 day trapping period corresponded to a complete cycle of trap rotations. The experimental high load lures engineered by Pherotech and Consep were the most effective lures. They were as attractive as the commercial standard, a 10 mg red septa, and maintained their attractancy for a longer period of time. The Pherotech bubble cap had the greatest longevity, maintaining a high level of attractancy without replacement for 54 days of each CM flight. The Consep biolure performed well for approximately 27 days during the first and second generation flights. In contrast, a significant reduction in the relative attractancy of the red septum was observed after 9 days of field-aging during the first flight. The relative attractancy of the red septum increased following its replacement on day 27. Moth captures in traps baited with new septa or aged bubble caps were not significantly different during the next 9 day test period (day 36, Fig. 1A). However, the relative attractancy of the red septum declined over the next 18 days of trapping. Maintaining a level of attractancy for the red septa equivalent to that of the bubble cap throughout the second generation flight was achieved by shortening the replacement interval for the red septum to 18 days. The experimental high load lure engineered by Scenturion did not perform well throughout the first generation flight. However, modification of the lure by the manufacturer prior to the second generation tests improved its attractancy. During the second flight, this lure performed as well as the Consep biolure.
Figure 1. First generation (A) and second generation (B) capture of CM males in pheromone traps baited various types of high load lures. Means followed by different letters are significantly different (P<0.05) according to Fisher's Protected LSD. Trece 10X lures were replaced as indicated (new 10X), all other lures were not replaced throughout each 54 day testing period.
1. Thresholds/Monitoring/Sampling

MONITORING CODLING MOTH IN PHEROMONE-TREATED ORCHARDS: COMPARISON OF TRAP DESIGNS

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Effectiveness of traps:
We directly compared the effectiveness of three trap designs: triangular (Delta trap, Scenturion, Inc.), diamond (Pherocon IIB, Trécé, Inc.), and pentagonal (Intercept A, IPM Concepts, Inc.). The experimental design was a randomized complete block. Tests were conducted in 6 pheromone-treated blocks (Isomate C Plus at 400 dispensers/acre) at the Tree Fruit Research Center. All traps were baited with red septa loaded with 10 mg of codlemone (Trécé, Inc.). The number of male moths captured in the various traps was recorded every 2-3 days. To minimize position effects, traps were rotated each time they were inspected. Lures were replaced after three complete rotations (27 days) during the first generation flight and after two rotations (18 days) during the second generation flight. Trap bottoms were replaced after a cumulative catch of 30 moths, more often if dirty.

The effect of varying the size of the trapping surface was investigated during the second generation flight. We directly compared moth captures in a Delta trap deployed with the standard size sticky insert, and Delta, Pherocon IIB and Intercept A traps deployed with the same type of insert, but reduced in size by 33%. The standard inserts for Pherocon IIB and Intercept A traps were approximately the same size as this 66% Delta insert. The experimental design and methodology was as previously described.

The effectiveness of three kinds of pheromone traps are compared in Figure 2A. Data are presented as the average capture of moths in the various traps over the course of 14 days. Each successive 14 day trapping period corresponded to two complete cycles of trap rotation. The delta trap was the most effective trap. It captured significantly more moths than the Intercept A and Pherocon IIB traps throughout the test. The Intercept A trap was intermediate in effectiveness, capturing significantly more moths than the Pherocon IIB over the course of the study (All, Fig 2A).

The area of sticky surface available for capturing moths had a major influence on trap performance. A delta trap deployed with a sticky insert that covered the entire bottom (the same insert used in the first generation test) captured significantly more moths than a delta trap deployed with an insert that was 33% smaller (Fig. 2B). Furthermore, moth captures in Intercept A and Pherocon IIB traps fit with the 66% delta insert were equivalent to moth captures in a delta trap fit with the same, reduced-size, insert.

Using traps with a large sticky surface may provide an important means of improving trap performance. Results of the study reported herein suggest that significantly more moths are attracted to a trap than are captured. One way to improve capturing efficiency is to increase the size of the trapping surface. Further studies are needed to determine the optimal size for codling moth traps.
Figure 2. First generation (A) and second generation (B) capture of CM males in various types of pheromone traps. Each trap was baited with a 10 mg red septum. Means followed by different letters are significantly different (P<0.05) according to Fisher’s Protected LSD.
IDENTIFICATION OF THE SEX PHEROMONE OF THE APPLE PEST *LACANOBIA SUBJUNCTA*, AND DEVELOPMENT OF A LURE FOR USE IN MONITORING TRAPS.

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*Lacanobia subjuncta* is a noctuid moth that has been recently reported on apple in Washington and Oregon, causing occasional partial defoliation of trees and damage to fruit. It has likely been confused in this area with the green fruitworm (*Lithophane antennata*) and speckled green fruitworm (*Orthosia hibisci*).

The sex pheromone of the female of *Lacanobia subjuncta* Grote and Robinson was isolated from female abdominal glands and was identified by a combination of GC, GC-MS, and DMDS derivitizing techniques. Hexane extracts of excised female abdominal tips contained (Z)-11-hexadecenyl acetate, (Z)-11-hexadecenol, and (Z)-11-hexadecenal. Determination of the functional group was with mass spectal data and confirmed in part by GC retention indices. Isomer determination was made through comparison with retention indices of known compounds. Double bond position was confirmed by mass spectral comparison of DMDS derivitized standards with compounds evident in chromatograms of female gland extracts.

Initial flight tunnel assays indicated male response to a blend of (Z)-11-16:Ac and (Z)-11-16:Ald comparable to responses to female extracts.

Field tests of pheromone blends tested ratios of pheromone components and pheromone dosages, with pheromone formulated in rubber septa. All testing was done using the Universal Moth Trap. In a comparison of the ratios of (Z)-11-16:Ac and (Z)-11-16:Ald, greatest captures of males were in traps baited with these 2 chemicals loaded in ratios of 2:1 to 8:1. When the corresponding alcohol, (Z)-11-16:Alc, was added to the blend, greatest captures of males were in traps baited with 0.6 to 3.8% (Z)-11-16:Alc. In a comparison of dosages of a three component blend in a ratio of of 3 to 1 to 0.8 for the acetate, aldehyde and alcohol respectively, greatest numbers of males were captured in traps baited with the highest load tested, 6.1 milligrams per septum.

The three chemicals, (Z)-11-16:Ac, (Z)-11-16:Ald, and (Z)-11-16:Alc, loaded in rubber septa at a ratio of approximately 3 to 1 to 0.08, and at a combined dosage of 6 mg should make a very sensitive lure for trapping this moth. Because of the size and expected captures of *Lacanobia subjuncta*, a bucket type of trap is preferable.
SEX PHEROMONE OF LACANOBIA SUBJUNCTA
RATIO OF Z-11-16:ALC TO 2 COMPONENTS

DOSES OF COMBINED 3-COMPONENTS
1. Thresholds/Monitoring/Sampling

COMPARISON OF LURES FOR SAMPLING CODLING MOTH IN MATING DISRUPTION WITH LOW TRAP DENSITIES

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Wing traps and 10 mg red lures are the standard recommendations for monitoring codling moth in mating disruption. I have been using these traps in more than 1,000 acres of MD orchards since 1994. The densities range from 1 trap every 5 to 20 acres, depending on the location of the orchard block monitored and the nature of neighboring orchards. With densities so low, the traps and lures must be as efficient as possible. This article describes a search for an efficient, low maintenance system to improve monitoring.

In 1997, I set out a randomized comparison of lures in a MD area known to have a high moth population. Trap density was 1/2.5 acres. Five delta traps were loaded with red septa containing 10 mg of attractant. The lures were changed every 3 wk, as a standard. An additional five traps per treatment were loaded with either one 3-mg gray lure, two 3-mg gray lures placed together, or one experimental Biolure (Consep, Inc.), and used throughout the first flight. Traps positions were rotated twice per wk. Total catch per trap was analyzed with ANOVA after transforming the data with ln(x+1). Mean (and standard error) for each treatment was 10.2 (4.8) for red lures, 6.4 (4.2) for 3-mg gray lures, 5.0 (5.9) for "6-mg" gray lures, and 2.0 (2.9) for the Biolures. The ANOVA was not significant at the 0.05 level.

At the same time, using only delta traps, I used "6-mg" gray lures in a MD orchard of slightly over 1,000 acres and used 10-mg red lures in other MD orchards totaling slightly less than 1,000 acres. The results are reported in the table below. The two areas were similar in 1996: the average percentage of infested fruit was the same. In 1997, although the number of moths caught per trap during the first flight was similar, the damage at harvest was greater in the blocks monitored with gray lures. The percentage of false negatives was also higher. False negatives were defined as the traps indicating populations below threshold (2 moths per trap in at least one trap per block) and above damage tolerance (0.1% infested fruit). These thresholds have been used for four years to provide a sustainable program.

Although the ANOVA indicated no treatment differences, the moths caught by gray and red lures appeared different. The lower performance of the gray lures as measured in the large field trial implies that they are not a perfect substitute for red lures. However, note that using the gray lures, moth damage was reduced, as desired, between 1996 to 1997.
"PRACTICAL EVALUATION OF ADULT TENTIFORM LEAFMINERS (TLM) IN APPLE ORCHARDS IN CALIFORNIA USING TRAPS BAITED WITH DIFFERENT PHEROMONE FORMULATIONS"

Mario S. Moratorio\(^1\) and William W Barnett\(^2\)

\(^1\)Farm Advisor, UCCE - El Dorado County
\(^2\)IPM Specialist (Emeritus), UCCE - Kearney Agricultural Center

Commercially available Pherocon\(^\circledR\) traps baited with tentiform leafminer pheromone lures (Trece\(^\text{TM}\) Inc., Salinas, California) used to monitor TLM adult population were compared in three apple orchards in Apple Hill\(^\circledR\), Camino, California. During the 1996 and 1997 seasons, the traps baited with the commercially available lures (No. 3144) produced high biweekly counts of more than 500 adult TLM, from mid June until early October. The extra time required to service the traps - i.e. counting adults and changing trap bottoms more frequently - limits the usefulness of the monitoring system. If a different lure formulation able to track TLM populations present in the orchard while attracting lower number of adults were available, considerable scouting time will be saved.

The performance of six different TLM pheromone formulations, including the one commercially available was compared in 1996. Two of the formulations (8234 and 8235) attracted lower numbers of adults and followed the TLM population closely.

Further testing was undertaken during 1997. Based on the 1996 results, the performance formulations No. 8234, 8235 and 3144, (the latter used as control) were compared. Adult counts on traps baited with pheromone formulation No 8234 and 8235 was considerably lower that 3144, while 8235 was slightly lower than 8234. Traps lured with both 8234 and 8235 formulations tracked TLM population closely, and were much faster to count.
INHIBITION OF LEAFROLLER CAPTURES IN PHEROMONE TRAPS

Jay F. Brunner, Entomologist, Washington State University
Joan Fisher, Scenturion, Clinton, WA

The use of pheromone traps to monitor leafroller populations in Washington has increased in recent years in response to the increased pest status of these insects in apple orchards. This has been especially true in orchards adopting mating disruption as a major tactic to control the codling moth. In these situations leafrollers have caused more fruit damage probably because of a reduction of organophosphate applications for codling moth control. In the Codling moth Areawide Management Project (CAMP) leafrollers have been monitored with pheromone traps at densities of one trap every 10-20 acres. In 1997 coordinators of the CAMP sites noted that capture of leafrollers in pheromone traps was much less than expected based on previous experience and anticipated from the previous year's fruit damage and larval monitoring results. An investigation was initiated to determine if the lower than expected captures were real and if so what might be the cause. It was noted that traps baited with the Scenturion lures were not capturing as many moths as those baited with Trece lures and Joan Fisher, President of Scenturion, became actively involved with the investigation into the problem.

There are two dominant species of leafroller in Washington fruit orchards, the pandemis leafroller, Pandemis pyrusana Kearfott, and the obliquebanded leafroller, Choristoneura rosaceana (Harris). The pheromone reported for the pandemis leafroller is a blend of 2-11 tetradecenyl acetate and Z-9 tetradecenyl acetate. The pheromone for the obliquebanded leafroller was originally reported as a blend of 2-11 tetradecenyl acetate, E-11 tetradecenyl acetate and 2-11 tetradecenol. However, the addition of an aldehyde added to the original blend increased captures for obliquebanded leafroller in western Canada.

The major component of the pandemis and obliquebanded leafroller pheromone is Z-11 tetradecenyl acetate so it was thought that a previously unidentified inhibitor in this component might be the cause of reduced attraction of traps baited with Scenturion lures. Scenturion, working closely with the basic manufacturer, Bedoukian Research, Inc., discovered that the Z-11 tetradecenyl acetate used in lures manufactured in late 1996 and 1997 contained a synthetic byproduct that had, in the past, had been low only 0.2% (maximum) of the sample, but was as high as 0.96% in current samples due to a purification procedure requested by Scenturion. This byproduct was identified as Z-9 dodecenyl acetate and became the primary candidate for the inhibition of leafroller moth captures. Subsequent research focused on determining the role of this product in the inhibition of leafroller moth captures.

Scenturion obtained a new batch of Z-11 tetradecenyl acetate from the manufacturer that contained only 0.05% Z-9 dodecenyl acetate for subsequent testing. Pheromone blends were prepared for pandemis leafroller and obliquebanded leafroller using the new material. The pheromone blend for each insect was then "spiked" with Z-9 dodecenyl acetate to final concentrations of 0.3, 0.5, 0.9% relative to the major component, Z-11 tetradecenyl acetate.

Pheromone traps were placed in orchards with known populations of pandemis or obliquebanded leafroller and baited with one of the four lures. Four to six replications of each lure treatment (traps) were used at each location. Traps were checked 2 to 3 times per week and the location of traps rotated at each inspection to remove position effects.
LEAFROLLER CONTROL WITH SUCCESS IN SPRING AND SUMMER: 1997

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SPRING: Spinosad (Success 2 F, DowElanco) and chlorpyrifos (Lorsban 4 E and Lorsban 50 WP, DowElanco) were evaluated for their ability to control OBLR larvae of the overwintering generation. The test was conducted in an apple orchard at Milton-Freewater, OR. The trees were 2-yr-old Delicious on dwarfing rootstock. Treatments were applied to 6-row by 9-tree plots (approximately 1/8 acre), replicated three times in a randomized complete block. All treatments were applied with a Rears Pack-Blast PTO air-blast sprayer. A Tree-Row Volume formula \[ \frac{30 \times \text{tree height in feet} \times \text{tree spacing in feet}}{\text{row spacing in feet}} \] was used to calculate the volume of water needed for a dilute spray at 100 gal per acre. Application dates were 25 Mar (Half-inch green-HIG), 7 Apr (Pink), and 1 May (Petal fall). A pretreatment evaluation was made on 25 Mar. One hundred fruiting buds/replicate were collected and returned to the laboratory for inspection under a microscope. The number of live OBLR larvae was recorded. Post-treatment evaluations were made on 1 May and 16 May. The 1 May and 16 May post-treatment evaluations were visual inspections of 10 entire trees per replicate, and the number of live OBLR larvae/tree was recorded. Weather conditions on the application days were as follows: 25 Mar, 71°F, wind 1.5-2 mph; 7 Apr, 61°F, gusty winds 2-7 mph; 1 May, 60°F, wind 0-1 mph.

The OBLR population was high and uniformly distributed as measured by the pretreatment evaluation. All HIG and pink treatments reduced OBLR larval densities relative to the untreated control at the 1 May (sampled before the petal fall treatments were applied) evaluation. Both Pink treatments of Success 2 F controlled OBLR larvae significantly better than the Pink Lorsban 50 WP or the HIG Lorsban 4 E plus oil. There was no rate effect noted with the Success 2 F treatments and no timing effect noted with the Lorsban treatments. All treatments significantly reduced OBLR larval densities relative to the untreated control at the 16 May evaluation. The treatment with the lowest mean OBLR larvae/tree was the 42.6 g AI/100 gal rate of Success 2 F applied at petal fall. This application was not significantly different than the 42.6 g AI/100 gal rate of Success 2 F at Pink or the 28.4 g AI/100 gal rate of Success 2 F at Petal fall.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (AI/100 gal)</th>
<th>Timing</th>
<th>Avg no. live OBLR larvae per entire tree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>100 buds 25 Mar</td>
</tr>
<tr>
<td>Success 2 F</td>
<td>28.4 g</td>
<td>Pink</td>
<td>35.0a</td>
</tr>
<tr>
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<td>42.6 g</td>
<td>Pink</td>
<td>48.7a</td>
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<tr>
<td>Success 2 F</td>
<td>28.4 g</td>
<td>Petal fall</td>
<td>54.7a</td>
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<td>Success 2 F</td>
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<tr>
<td>Lorsban 50 WP</td>
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<td>Petal Fall</td>
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<tr>
<td>Lorsban 4 E</td>
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<td>HIG</td>
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<td>+ Orchex 796</td>
<td>+ 1% v:v</td>
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</tr>
<tr>
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</tr>
</tbody>
</table>

Means in the same column followed by the same letter not significantly different (p=0.05, Fisher's Protected LSD).
SUMMER: Spinosad (Success 2 F, DowElanco), chlorpyrifos (Lorsban 50 WP, DowElanco), and encapsulated methyl parathion (Penncap-M 2 F, Elf-Atochem North America, Inc., Agrichemicals Div.) were evaluated for their ability to control OBLR larvae of the summer generation. The test was conducted in an apple orchard at Milton-Freewater, OR. The trees were 2-yr-old Delicious on dwarfing rootstock. Treatments were applied to 54-tree plots (approximately 1/8 acre), replicated three times in a randomized complete block. All treatments were applied with a Rears Pack-Blast PTO air-blast sprayer as a concentrate (4X). The sprayer was calibrated using 5 nozzles/side at 100 gpa. Due to small tree size, only 3 nozzles were left open, approximating a 60 gpa calibration. Application dates were 23 Jun (20% egg hatch) and 8 Jul (20% egg hatch + 21d). The 16 Jul post-treatment evaluation was a visual inspection of 10 growing shoots/tree x 6 trees/rep and the number of live OBLR larvae was recorded. Weather conditions on the application days were as follows: 23 Jun, 72°F, gusty winds 5-8 mph; 8 Jul, 75°F, gusty winds 2-8 mph.

All treatments provided significant suppression of OBLR larvae relative to the untreated control. All Success 2 F treatments reduced OBLR larval numbers equivalent to or better than an industry standard, Penncap-M 2 F, and only the 118.4 ml/100 gal rate of Success 2 F was statistically inferior to Lorsban 50 WP. Two applications of Success 2 F at both rates provided significantly better control of OBLR larvae than the Penncap-M 2 F treatment. Two applications of Success 2 F provided significantly better control of the OBLR larvae than a single treatment of Success 2 F. There was no significant rate effect noted in the Success 2 F treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (Al/100 gal)</th>
<th>Timing</th>
<th>Post-treatment 16 Jul OBLR/10 shoots</th>
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<tr>
<td>Success 2F</td>
<td>28.4 g</td>
<td>20% egg hatch</td>
<td>10.9d</td>
</tr>
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<td>42.6 g</td>
<td>20% egg hatch</td>
<td>8.2b-d</td>
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<td>Success 2F</td>
<td>28.4 g</td>
<td>20% EH, 20% +14d</td>
<td>5.1ab</td>
</tr>
<tr>
<td>Success 2F</td>
<td>42.6 g</td>
<td>20% EH, 20% +14d</td>
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<td>Penncap-M 2F</td>
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<td>20% egg hatch</td>
<td>9.7cd</td>
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<tr>
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<td>20% EH, 20% +14d</td>
<td>6.4a-c</td>
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<tr>
<td>Untreated</td>
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<td>none</td>
<td>22.9e</td>
</tr>
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Means in the same column followed by the same letter not significantly different (p=0.05, Fisher's Protected LSD).
1. Thresholds/Monitoring/Sampling

**ACTION_THRESHOLDS FOR OBLIQUEBANDED LEAFROLLER LARVAE**

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The best strategy for managing leafrollers is to control the overwintering population and avoid damage by the Summer generation. However, growers would rather not use insecticide applications if they were known to be unnecessary. Sampling methods for both generations, as long as they were practical, would be valuable. But leafrollers have high fecundity, and the overwintering larvae are hard to find. Sampling must be intense, therefore time-consuming, and the risk of missing a problem could be costly. The purpose of this paper is to evaluate an ongoing sampling program for OBLR larvae in commercial orchards in North Central Washington.

My method of sampling, developed in 1994, was dictated by time available. I have no more than 20 minutes per block to make a population assessment every week; therefore, I don't randomly sample larvae, I hunt them. Only possible hot spots are checked, such as inside thick foliage, behind prop piles in the crotches of trees, or the tops of large, old trees, where previous sprays have missed. To further increase the sampling time, weekly results are added before spray decisions are made.

**The Summer Generation**

First, I will discuss sampling Summer larvae and development and testing of an action threshold. I used data from 60 blocks (10-40 Acres each) monitored in 1995. There was an apparent positive correlation between the mean larvae found per week in the Summer and the resulting damage by harvest (Fig. 1). In order to avoid more than 2% fruit damage (an amount tolerated by my clients), the threshold would have to be 1 larva per week. The practical use is a graded response. Treatments are started and continued as long as living larvae are found. The choice of insecticide also depends on the weekly sample. Depending on grower preference, if more than about five per week can be found, a more effective, residual insecticide with some unwanted side effects may be necessary. This method was tried in 1996 and 1997.

**Fig. 1. Correlation of Summer larvae sampled per week and the percentage of fruit injured by OBLR in 60 blocks in 1995.**
The Summer action threshold resulted in many correct assessments in both years (Table 1). The designation "lower than expected" included both false positives and cases where the control program was successful. There were relatively few false negatives in both years.

Table 1. Accuracy of predicting significant fruit injury by using Summer larval sampling in 60 blocks in 1996 and 88 blocks in 1997.

<table>
<thead>
<tr>
<th>Year</th>
<th>Correct</th>
<th>Lower than expected</th>
<th>False negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>62%</td>
<td>33%</td>
<td>5%</td>
</tr>
<tr>
<td>1997</td>
<td>68%</td>
<td>23%</td>
<td>9%</td>
</tr>
</tbody>
</table>

The Overwintering Generation

To assess Spring sampling, I wanted to know the correlation between the samples of the overwintering larval population and the population of the next generation. The results of monitoring 50 blocks in 1995 are reported in Fig. 2.

![Graph showing the relationship between overwintered larvae found and total overwintered larvae found](image)

Fig. 2. Sampling results for the overwintering and Summer generations of OBLR in 60 blocks in 1995. Cumulative search time in the Spring was 3 h 20 min.

Blocks with the most larvae found in the Spring were treated with the greatest amount of insecticide, so the correlation is poor. Even with more than 3 h spent searching in Spring, some blocks with only one larva found had more than 1/week found in the next generation (Fig. 2). The action threshold would have to be the lowest possible, that is, one or more larvae found at any time during Spring. Practically, the low action threshold would also work with a graded response. As mentioned above, blocks where one larva is found every week starting in the delayed dormant period would receive more applications than blocks where a larva is not found until bloom.
The Spring action threshold, tried in 1996 and 1997, was less successful. Samples indicated more larvae present in 1996 (1.7/wk/block) than in 1997 (1.0/wk/block). In 1996 most samples were above the action threshold and false negatives were very infrequent (Table 2). The opposite was true in 1997.

Table 1. Accuracy of predicting a high Summer population or significant fruit injury by using Spring larval sampling.

<table>
<thead>
<tr>
<th>Year</th>
<th>no. of blocks</th>
<th>Correct</th>
<th>Lower than expected</th>
<th>False negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>60</td>
<td>58%</td>
<td>42%</td>
<td>0%</td>
</tr>
<tr>
<td>1997</td>
<td>88</td>
<td>56%</td>
<td>32%</td>
<td>12%</td>
</tr>
</tbody>
</table>

With each sample taken in the Spring to detect the presence of larvae, the incidence of false negatives declined as samples increased (Table 3). However, while in 1996 good information was obtained by late April, in 1997 the samples had many false negatives even by early June. Therefore, given the time constraints in Spring, it appears too risky sampling the overwintering generation before making control decisions, especially when the populations are low. Some control measure is needed every Spring for normal maintenance of an orchard in a leafroller-infested area. Sampling larvae could indicate "hot" blocks where continued control is needed until no living larvae are found. Also, Spring samples could be better used to indicate the success of controls in known "hot" blocks.

Table 3. Failure of cumulative spring samples in predicting either significant Summer populations or fruit injury.

<table>
<thead>
<tr>
<th>Percentage of false negatives on Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Apr 17 Apr 23 Apr 1 May 8 May 15 May 22 May 29 May 4 June</td>
</tr>
<tr>
<td>1996</td>
</tr>
<tr>
<td>1997</td>
</tr>
</tbody>
</table>
1. Thresholds/Monitoring/Sampling

PHEROMONE TRAPS FOR MONITORING LEAFROLLERS

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Tree Fruit Research and Extension Center
Wenatchee, WA 98801

The ability to monitor and prevent the establishment of leafroller populations is crucial to the success of pheromone based pest management programs throughout the western region. Detecting larval infestations before they reach damaging levels is very difficult. An alternative approach is to monitor leafroller populations with pheromone traps. Pheromone trapping systems are commercially available for PLR and OBLR, but their use has been limited primarily to tracking the seasonal phenology of leafrollers.

We directly compared the effectiveness of three trap designs: triangular (Delta trap, Scenturion, Inc.), diamond (Pherocon IIB, Trécé, Inc.), and pentagonal (Intercept A, IPM Concepts, Inc.) for capturing PLR or OBLR males. Two other trap designs, wing (Pherocon IC, Trece, Inc) and bucket (Multipher) were included in OBLR tests only. The experimental design was a randomized complete block. PLR tests were conducted in 6 orchards at the Tree Fruit Research Center, Washington. OBLR tests were conducted in 4 commercial orchards in northeastern Oregon. All traps were baited with standard PLR or OBLR lures (Trécé, Inc.). The number of male moths captured in the different traps was recorded every 2-3 days. To minimize position effects, traps were rotated each time they were inspected. Trap bottoms were replaced after a cumulative catch of 50 moths, more often if dirty. The multipher trap is a non-sticky type trap, and moths were removed each time it was inspected.

The effectiveness of three kinds of pheromone traps for capturing PLR are compared in Figure 1. Data are presented as the average capture of moths in the various traps over the course of 14 days. Each successive 14 day trapping period corresponded to two complete cycles of trap rotation. The Delta trap was the most effective trap, capturing significantly more PLR moths than the Intercept A and Pherocon IIB traps. The intercept A and Pherocon IIB traps captured similar numbers of moths over the course of the study (All, Fig 1A).

The effectiveness of five kinds of pheromone traps for capturing OBLR are compared in Figure 2. Data are presented as the average capture of moths per 9 to 12 days of trapping. This period corresponded to a complete cycle of trap rotations. Tests were conducted for 2 trapping cycles (18d) during the first generation and 3 trapping cycles (30d) during the second generation. The Delta triangular trap performed as well as the widely used, Pherocon C wing trap (Fig 2A). The Multipher trap was also a highly effective trap, capturing a similar number of OBLR moths as the Delta trap (Figure 2B). All of these trap were more effective than the Pherocon IIB and Intercept A traps. The performance of the Intercept A was especially weak during the second generation test, capturing significantly fewer moths than all other traps including the Pherocon IIB.

For PLR, we also directly compared the effect of varying the size and age of the knockdown strip used to immobilize moths that are attracted to the Multipher trap. Four treatments were evaluated, 1/2 inch or 1 inch kill strips that were either replaced every 9 days or not replaced over the course of the test (45 days). PLR moth catch in the Multipher trap was not significantly influenced by either the size of the kill strip or the frequency of its replacement.
Figure 1. First generation capture of PLR males in various types of pheromone traps.

Figure 2. First generation (A) and second generation (B) capture of OBLR males in various types of pheromone traps.
Very few people sample for European red mite eggs in the dormant season. Most growers routinely treat mite eggs in the delayed dormant period, regardless of the population density. The treatment, usually oil, is important for added prevention of San Jose scale. The savings of skipping an inexpensive oil treatment for a few seasons may not be worth the cost of scale treatment for several seasons once the scale become established. Nevertheless, some growers do skip the oil. If the grower insists on only treating when necessary, some scouting for overwintering eggs can be done. This would be most useful for targeting the worst blocks for preventative sprays, and blocks that need to be monitored carefully for potential problems in the Summer.

In 1995, I did some preliminary scouting to determine if there was a correlation between egg densities in Winter and mite damage in Summer. The sampling plan was designed to be as quick as possible in order to cover as many blocks as necessary. Therefore, the sample sizes were determined with these time constraints. I collected 20 2-in. spurs/block from the outside of trees at chest level in 50 blocks. I divided the mean number of eggs per spur into three categories: less than one per spur, one to ten per spur, and greater than ten per spur. For this trial the eggs were counted as accurately as possible with the aid of a field glass. The grower applied no egg treatments. Starting in June, mite damage was rated every week as very low to very high. A rating of “high” meant chlorosis was visible from a distance of at least ten feet, was widespread throughout the orchard, and, above all, could cause concern to the grower. The egg estimates were matched with the highest damage rating during the Summer for each block.

A small percentage of the blocks were damaged by European red mite, even when the overwintering egg population was estimated to be less than one per spur. However, as the egg density increased, there was an apparent increase in the percentage of blocks that incurred significant damage (Fig. 1). An action threshold of ten per spur was selected because it roughly correlated with a more than 10% chance of damage to the orchard.

The threshold was tested in 1996 and 1997 with 168 blocks. In 1996, the threshold resulted in 68% correct predictions. Of the incorrect predictions, 30% of blocks were expected to develop damage but did not, and 2% of blocks were expected have no damage but did. In 1997, the percentages were 70%, 23%, and 7%, respectively. The sampling method, although crude and with a very low sample size, helps in targeting orchards for future scouting attention.

Fig. 1. Percentage of blocks with mite damage in Summer, after blocks are sorted according to density of overwintering European red mite eggs. Blocks rated “high” for mite feeding during Summer scouting were considered damaged.
1. Thresholds/Monitoring/Sampling

TRAPS FOR MONITORING LYGUS BUGS

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Prosser, WA 99350

We bought white rectangle traps from Gempler's (Mt. Horeb, WI). The traps are durable, non-UV reflective sticky traps, which are to supposed to catch adult plant bugs. The Mid-Atlantic Monitoring Guide (West Virginia University) recommends commercial apple and pear growers use 1 trap per 3-4 acres, or a minimum of 5 traps per block placed in the orchard at silver tip. It recommends hanging the trap at knee height, within 18" of the outer edge of the canopy in a tree 1-2 rows in from the outer row. It suggests checking the traps weekly and recording all plant bugs captured. For apples, it suggests that if this number exceeds 3.3 between silver tip and tight cluster, or 5.0 from silver tip to late-pink, a pesticide should be applied. These economic thresholds are for the tarnished plant bug (Lygus lineolaris).

We tested the white rectangle traps in 4 apple orchards, one peach orchard and 2 alfalfa seed fields in the Yakima Valley and North Pasco area. The traps were placed in the orchards and the seed fields as per the suggestions in the Mid-Atlantic Monitoring Guide. A total of 100 traps were placed in apple orchards, 25 in a peach orchard and 50 in the alfalfa seed fields.

Also, a 15-inch diameter sweep net (4 sets of 5 sweeps each) was used to sample vegetation near the orchards or on the orchard floor for lygus adults.

Results and Discussion:

We caught 2 brown lygus adults in all of the traps placed in the orchards (Table 1). Table 2 shows that lygus bugs were present in or near the orchards. All of the lygus bugs found in the sweep net samples in the orchard situations were either brown or green lygus.

We caught 2 brown and 4 green lygus adults in all of the traps placed in the alfalfa seed fields (Table 3). Table 4 shows that adult lygus bugs were present in the fields. All of the lygus bugs found in the sweep net samples in the seed fields were either brown or green lygus.

The results from these tests show that the white sticky traps are not a good monitoring tool for either brown or green lygus adults although they apparently work for tarnished plant bug. I have never seen a tarnished plant bug in the lower Yakima Valley, Columbia Basin, North Pasco area or Walla Walla area. In these areas, brown and green lygus are the pest species attacking tree fruits and alfalfa seed. However, I have seen a few tarnished plant bugs in the Cowiche/Tieton areas. Therefore, we have at least 3 lygus species attacking tree fruits in Washington; the tarnished plant bug (Lygus lineolaris), brown lygus (Lygus hesperus), and green lygus (Lygus elisus).

The 3 lygus species (brown, green and tarnished) have differences in their biology and green and brown lygus adults are not caught in the white sticky traps.

I presume we might have tarnished plant bug attacking tree fruits in the more northern and higher elevations of Washington and brown and/or green lygus attacking tree fruits in the other areas.
Table 1. The number of adult lygus bugs caught in 25 white sticky traps placed in each apple or peach orchard. Yakima Valley, WA. 1997.

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
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<tr>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<tr>
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<td>0</td>
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<td>0</td>
<td>0</td>
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</tr>
</tbody>
</table>

Table 2. The number of adult lygus bugs caught in 4 sets of 5 sweeps on vegetation near or in each apple or peach orchard. Yakima Valley, WA. 1997.

<table>
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<td>12</td>
<td>5</td>
<td>0</td>
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<tr>
<td>Delicious - Prosser</td>
<td>5</td>
<td>6</td>
<td>10</td>
<td>7</td>
<td>8</td>
<td>12</td>
<td>15</td>
<td>9</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Delicious - N. Pasco</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>10</td>
<td>4</td>
<td>5</td>
<td>5</td>
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<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Peaches - Buena</td>
<td>3</td>
<td>8</td>
<td>10</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3. The number of adult lygus bugs caught in 25 white sticky traps placed in each alfalfa seed field. Prosser, WA. 1997.

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>#2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. The number of adult lygus bugs caught in 4 sets of 5 sweeps in each alfalfa seed field. Prosser, WA. 1997.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
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<th></th>
<th></th>
<th></th>
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</tr>
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<tbody>
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<td>5</td>
<td>3</td>
<td>15</td>
<td>10</td>
<td>6</td>
<td>5</td>
<td>12</td>
<td>12</td>
<td>85</td>
<td>20</td>
</tr>
<tr>
<td>#2</td>
<td>5</td>
<td>6</td>
<td>10</td>
<td>7</td>
<td>22</td>
<td>12</td>
<td>15</td>
<td>21</td>
<td>10</td>
<td>19</td>
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</tbody>
</table>
SECTION 2
IMPLEMENTATION PROGRAMS

Ted Alway
Section Leader
2. Implementation

HOWARD FLAT CAMP SITE UPDATE - 1997

Brian Hendricks, Wilbur-Ellis, Chelan, WA
Kelly Denton, Howard Flat Areawide Project, Chelan, WA
J. F. Brunner and E. H. Beers
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PROJECT AREA DESCRIPTION AND PARTICIPATION: Howard Flat is one of five original Codling Moth Areawide Management Project (CAMP) sites in the western United States. In 1995, 34 of the 36 growers on Howard Flat participated in the CAMP representing 1,035 acres. In 1996, 35 of 36 growers opted to participate in the CAMP representing 1,092 acres; and in 1997 there was 100% grower cooperation with the project totaling 1,100 acres. Also in 1997, a new area was added to the original CAMP site, referred to as the Chelan River CAMP site. This new area totaled 650 acres and involved 27 growers.

CODLING MOOTH, Cydia pomonella L. activity was monitored using pheromone traps baited with 10 mg lures placed at an average density of one trap for every 2.5 acres. In 1997, 483 traps were placed at Howard Flat and 260 at Chelan River. Traps were placed in the upper part of the tree canopy and monitored weekly. Lures were changed every third week in the first generation and every other week in the second generation.

Table 1 compares data from Howard Flat over the last four years, 1994-1997, and gives data for Chelan River for 1997. The areas in which codling moth populations were detectable with traps have dramatically declined each year of the project, from 82% in 1995 to 42% in 1996 and finally to 16% in 1997. The average number of moths captured per trap declined by only 50% in 1997, whereas the average from 1995 to 1996 had declined by 82%. Both indices confirm that codling moth populations have been dramatically reduced by the areawide use of mating disruption. In the first year of the Chelan River CAMP site 73.6% of the traps captured one or more codling moths, about the same proportion as the first project year for the Howard Flat CAMP site. The average capture of moths per trap, 6.9, also was similar to that reported for Howard Flat in the first year of the project.

Table 1. Historical capture of codling moth in 10 mg lure-baited pheromone traps at the Howard Flat and Chelan River CAMP sites, 1994-1997.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total codling moth captured</th>
<th>% traps with moths</th>
<th>Avg. moths per trap</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First gen.</td>
<td>Second gen.</td>
<td>Season total</td>
</tr>
<tr>
<td>Howard Flat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1995</td>
<td>610</td>
<td>3929</td>
<td>3319</td>
</tr>
<tr>
<td>1996</td>
<td>114</td>
<td>594</td>
<td>708</td>
</tr>
<tr>
<td>1997</td>
<td>68</td>
<td>274</td>
<td>342</td>
</tr>
<tr>
<td>Chelan River</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>1429</td>
<td>304</td>
<td>1733</td>
</tr>
</tbody>
</table>

Reductions in codling moth captures at the Howard Flat CAMP site are reflected in the pattern of capture. From Table 1 it is clear that the percent of area (traps) with NO catch for the entire year was 18.5, 58.4, and 84.0% for 1995, 1996 and 1997, respectively. The only “hot spot” at Howard Flat in 1997 was near the airport, a traditional problem area.
Fruit injury by codling moth was determined by sampling as many blocks as possible at harvest for fruit injury by codling moth, leafroller and any other arthropods that might be reflected in a fruit damage inspection. One hundred fruits from at least 25 bins were sampled per block. A total of 3,334 bins was sampled from 82 blocks. Table 2 shows the historical level of injury caused by codling moth, leafrollers and other pests at Howard Flat and Chelan River from 1994-1997. Fruit injury estimates were again complicated by hail damage to fruit in 1997. Hail fell on the entire project area in June and resulted in speeding up of harvest in many small blocks where samples could not be made. Even with this complication, the same number of blocks was sampled at Howard Flat as in 1996 although the total number of fruits sampled was slightly less. The level of fruit damage by codling moth at Howard Flat was dramatically lower than in 1996. Only 41 fruits injured by codling moth were found in 1997, and these were found in only three blocks. Leafroller injury at Howard Flat was essentially the same as in 1996, and injury from bugs and cutworms (other) was significant.

Table 2. Historical data on harvest fruit injury at the Howard Flat and Chelan River CAMP sites, 1994-1997.

<table>
<thead>
<tr>
<th>Year</th>
<th>Codling moth</th>
<th>Leafroller</th>
<th>Bugs</th>
<th>Other</th>
<th>No. fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Howard Flat</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1994</td>
<td>0.80</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Packout data</td>
</tr>
<tr>
<td>1995</td>
<td>0.55</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>172600</td>
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<tr>
<td>1996</td>
<td>0.20</td>
<td>0.21</td>
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<td>NA</td>
<td>338600</td>
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<tr>
<td>1997</td>
<td>0.01</td>
<td>0.14</td>
<td>0.1</td>
<td>0.09</td>
<td>334000</td>
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<td>Chelan River</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1997</td>
<td>0.11</td>
<td>0.01</td>
<td>1.1</td>
<td>0.02</td>
<td>81700</td>
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</tbody>
</table>

LEAFROLLERS: One hundred nine traps were used to monitor each leafroller species at Howard Flat in 1997, and 55 traps were used for each species at the Chelan River site. They were scattered uniformly throughout both projects at a density of approximately one trap every 10 acres. The average capture of pandemis and obliquebanded leafroller moths per trap was about the same in 1997 as the previous year at Howard Flat and the distribution of catch was also similar, concentrated in the northern half of the project area. The obliquebanded leafroller was by far the dominant leafroller species captured in the Chelan River project (Table 3).

Table 3. Historical data on leafroller moth capture at the Howard Flat, 1995-1997, and Chelan River, 1997, CAMP sites.

<table>
<thead>
<tr>
<th>Howard Flat</th>
<th>No. traps</th>
<th>Total moths</th>
<th>% Catching</th>
<th>Avg. moths/trap</th>
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<tr>
<td>Pandemis</td>
<td>1995</td>
<td>57</td>
<td>1899</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>1996</td>
<td>108</td>
<td>1400</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>1997</td>
<td>109</td>
<td>1189</td>
<td>92</td>
</tr>
<tr>
<td>Obliquebanded</td>
<td>1995</td>
<td>57</td>
<td>889</td>
<td>98</td>
</tr>
<tr>
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<td>94</td>
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<tr>
<td></td>
<td>1997</td>
<td>109</td>
<td>2529</td>
<td>99</td>
</tr>
<tr>
<td>Chelan River</td>
<td>Pandemis</td>
<td>1997</td>
<td>55</td>
<td>86</td>
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<tr>
<td></td>
<td>Obliquebanded</td>
<td>1997</td>
<td>55</td>
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</table>
2. Implementation

West Parker Heights Areawide Codling Moth Management Project - Third Year

Brad Higbee and Carrol Calkins
U.S.D.A. - A.R.S.
5230 Konnowac Pass Rd.
Wapato, Wa. 98951

Areawide codling moth control using pheromone mating disruption as the primary control method was again very successful in the W. Parker Hts. project in 1997, the third in an anticipated five year program. The mean number of organophosphate insecticides applied for codling moth control was reduced by 80% compared to conventionally managed blocks in the area. Most of the acreage (85%) received one organophosphate cover spray during the season, directed at first generation moths. The mean number of codling moths trapped over the season was reduced nearly 20% below the 1996 total, which was a 55% reduction from 1995 (table 1). There was no detectable codling moth damage at the end of the first generation in the project and less than 0.05% damage at harvest (table 2). Pandemis and fruittree leaf rollers along with cutworms, have emerged as the pests causing the most damage to fruit. The total damage to fruit from these pests measured at the pre harvest fruit evaluation was 0.37%. Damage levels from these pests have increased over the duration of the project and could become a more serious problem. Basic biological knowledge leading to effective monitoring and control methods is needed for these pests. Fruit damage from all insect pests was well below commercially acceptable levels and organophosphate insecticides applied for secondary pests were reduced by about 70% compared to conventional apple and pear orchards.

Table 1. Mean pheromone trap captures, W. Parker Hts. areawide project.

<table>
<thead>
<tr>
<th></th>
<th>1st Generation</th>
<th>2nd Generation</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>95</td>
<td>96</td>
<td>97</td>
</tr>
<tr>
<td>AW</td>
<td>3.75</td>
<td>1.8</td>
<td>1.4</td>
</tr>
<tr>
<td>95 Conv</td>
<td>48.9</td>
<td>56.8</td>
<td>24.1</td>
</tr>
<tr>
<td>96 Conv</td>
<td>39.1</td>
<td>27.8</td>
<td>11.5</td>
</tr>
</tbody>
</table>

Table 2. Percent fruit damage at harvest, W. Parker Hts.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM</td>
<td>PLR</td>
<td>CM</td>
</tr>
<tr>
<td>AW</td>
<td>0.2</td>
<td>0.23</td>
<td>0.08</td>
</tr>
<tr>
<td>Conv</td>
<td>0.8</td>
<td>0.13</td>
<td>0.12</td>
</tr>
</tbody>
</table>
Section 2: Implementation

BENEFITS OF AN INTEGRATED FRUIT PRODUCTION (IFP) PROGRAM AND WAYS TO EVALUATE THEM

Helmut Riedl, Clark Seavert, and Franz Niederholzer
Mid-Columbia Agricultural Research and Extension Center
Oregon State University
3005 Experiment Station Drive
Hood River, OR 97031

One can apply several perspectives to the evaluation of IFP when comparing it to the conventional pear production system. Of primary interest to the grower is the economic perspective. The traditional economic evaluation looks primarily at costs, yield, quality and price. Grower acceptance of IFP will depend foremost on whether the bottom line of IFP compares favorably to the conventional production system. However, in addition to the short-term economic perspective, one also needs to examine the long-term costs and benefits of the two production systems. What is their environmental impact, particularly in regard to agricultural chemical use? Or in a more narrow sense, how do the two production systems compare in terms of impact on beneficial arthropods (biological control agents), effects on other non-targets, resistance risk, water quality, and other criteria? Several evaluation methods will be presented. Examples of this analysis using data from IFP demonstration sites collected over a three-year period will be presented.
Section 2: Implementation

UPDATE ON THE INTEGRATED FRUIT PRODUCTION (IFP)
PROGRAM IN NORTHERN OREGON

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Oregon State University
3005 Experiment Station Drive
Hood River, OR 97031

Jeff Heater and Erica Fischer
Underwood Fruit, White Salmon, WA 98672

In the fall of 1994, an IFP Committee sponsored by the Hood River Grower Shipper Association was formed to explore how the Mid-Columbia fruit industry could benefit from an IFP program and what could be done to familiarize growers with the concepts and ideas of IFP. The IFP Committee has taken leadership in the development of this program and its implementation. This industry committee consists of growers, packers, consultants and university research and extension personnel and is responsible for the pace and direction of program implementation. IFP Guidelines which spell out the specifics of the program were developed by this committee in 1994 and are up-dated annually. The IFP Committee also developed an IFP Label which will first be used for the 1997 crop and will appear on fruit boxes from several packing houses.

The adoption of production practices which are in agreement with the goals and principles of IFP depends on well-trained growers. Therefore, a major goal of this project is educational, to inform growers about the aims of IFP, to demonstrate to them the potential benefits and also costs of IFP, and to assist the industry in the development of IFP Guidelines as an essential step for a future IFP certification and marketing program. Oregon State University and the Mid-Columbia Agricultural Research and Extension Center play a supportive role in the development and implementation of the IFP program, primarily in the areas of grower education and data gap research. The principle vehicle for grower training are IFP Workshops which are held annually at various times of the year. These workshops deal with topics such as tree nutrition, leaf and soil analysis, orchard ecology, ground cover management, concentrate vs. dilute and tree-row-volume spraying, pest and disease management, and post-harvest problems. An IFP Newsletter which is published as needed and is sent to all growers in the area, provides growers with summaries of the workshops, minutes if IFP Committee meetings, and other IFP topics of interest. An IFP Web Site is also under development and will provide linkages to similar sites on the Internet. On-farm research is also an integral part of the IFP Program to demonstrate to growers the nuts and bolts of IFP and alternative production practices which growers may wish to incorporate in their orchard operation. IFP Demonstration Orchards were established at four sites in the Hood River Valley for that purpose. A permanent IFP site will be set up in 1998 at the Mid-Columbia Agricultural Research and Extension Center for research demonstrations and as a teaching
tool. A major goal in the educational arena for 1998 will be to improve sprayer calibration and introduce tree-row-volume spraying to the industry. We expect that this effort will result in lower and more efficient pesticide use.

The IFP Committee is presently involved in a number of projects to help with the implementation of the IFP program. A major effort was the development of a computerized standard spray record system (funded by the EPA Pesticide Environmental Stewardship Program) which will be used by all growers and packers in our district. This spray record system was just completed for IBM PC users. A Macintosh version will be added in the coming year. This system will allow us to track pesticide use as pest management practices change and the industry begins to adopt the IFP program. With the expanding IFP acreage in the valley fruit grown under IFP practices will be available and can be identified and sold with an IFP label. In 1998, IFP-labeled fruit from the Hood River District will be test-marketed in cooperation with The Food Alliance.

The implementation of the IFP program is proceeding at a faster pace than originally anticipated. The fruit industry is showing a strong interest in this program as evidenced by the support it has received by the local grower organization and packing houses over the last several years. It is hoped that the marketplace will reward the fruit growers in the Hood River district for their effort for using ecologically safer production practices and for being environmentally conscious stewards of the land they farm.
2. Implementation

THE USE OF PHEROMONE-OIL IN THE CODLING MOTH AREAWIDE MANAGEMENT PROGRAM (CAMP) FOR THE PEAR PEST COMPLEX IN SOUTHERN OREGON
Philip VanBuskirk, and Richard Hilton
OSU Southern Oregon Research & Extension Center
Medford, Oregon 97502

A program to control arthropod pests of pear in southern Oregon utilizing codling moth (CM) mating disruption and three horticultural spray oil applications during the foliar season was initiated in 1995 on 300 acres and has expanded to over 500 acres in 1997. During 1995, 1996 and 1997, the program reduced foliar use of organophosphates by 72%, 73% and 70% respectively and overall synthetic pesticide use by 80%, 81% and 78% respectively. Besides reducing pesticide use, the program has continued to achieve suppression of primary and secondary pear pests, maintaining damage between 1.5-2.4% fruit downgrading, while lowering the cost of arthropod control by about $179-200 per acre. The weaknesses of the program which have yet to be resolved are: the prediction of CM and leafroller damage from pheromone trap catches, management of true bugs; and concerns regarding gradual buildup in CM and other arthropod pest levels.

Basic Spray Program:

<table>
<thead>
<tr>
<th>Timing of Application</th>
<th>Target Pest(s)</th>
<th>Material and Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormant</td>
<td>Pear Psylla (PP)</td>
<td>Oil, 4 gallons</td>
</tr>
<tr>
<td>Delayed Dormant</td>
<td>PP, San Jose Scale (SJS)</td>
<td>Oil, 4 gallons</td>
</tr>
<tr>
<td></td>
<td>Pear Rust Mite (PRM), Codling Moth (CM), Two-spotted mite (TSM)</td>
<td>Lime Sulfur 12 gallons, Or Sulforix 2.5 gallons</td>
</tr>
<tr>
<td>Just Prior to Codling Moth Biofix (ca. 200 DD from January 1°)</td>
<td>CM, PP, TSM, etc.</td>
<td>Pheromone Dispensers ISOMATE C+ 400 per acre</td>
</tr>
<tr>
<td>200 DD post CM biofix</td>
<td>CM, PP, TSM</td>
<td>Orchex 796 Base Oil 1%</td>
</tr>
<tr>
<td>400 DD post CM biofix</td>
<td>CM, PP, TSM</td>
<td>Orchex 796 Base Oil 1%</td>
</tr>
<tr>
<td>600 DD post CM biofix</td>
<td>CM, PP, TSM</td>
<td>Orchex 796 Base Oil 1%</td>
</tr>
<tr>
<td>1250 DD post CM biofix</td>
<td>CM</td>
<td>Guthion 50 WP 2.5 lbs. or Imidan 70W 4 lbs.</td>
</tr>
</tbody>
</table>
% Fruit Damage By Pest:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Codling Moth</td>
<td>0.26</td>
<td>0.04</td>
<td>0.09</td>
</tr>
<tr>
<td>Leafroller</td>
<td>0.45</td>
<td>0.32</td>
<td>0.23</td>
</tr>
<tr>
<td>Pear Psylla</td>
<td>0.06</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>True Bugs</td>
<td>0.38</td>
<td>0.89</td>
<td>1.82</td>
</tr>
<tr>
<td>Other</td>
<td>0.38</td>
<td>0.23</td>
<td>0.25</td>
</tr>
<tr>
<td>Total</td>
<td>1.53</td>
<td>1.53</td>
<td>2.40</td>
</tr>
</tbody>
</table>

Summary Of Foliar Treatments Conventional vs CAMP Blocks: Bosc Cultivar Only

<table>
<thead>
<tr>
<th>Management Type</th>
<th>1995</th>
<th>1996</th>
<th>1997</th>
</tr>
</thead>
<tbody>
<tr>
<td># Of Orchards</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>15</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>CAMP</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Total Applications</td>
<td>5.4</td>
<td>4.2</td>
<td>4.9</td>
</tr>
<tr>
<td># OP's</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>3.2</td>
<td>3.7</td>
<td>1.0</td>
</tr>
<tr>
<td>CAMP</td>
<td>0.9</td>
<td>0.9</td>
<td>0.3</td>
</tr>
<tr>
<td># Other Synthetics</td>
<td>2.8</td>
<td>3.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Total Synthetics</td>
<td>6.0</td>
<td>6.7</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Note: pheromone dispenser installation not included
Although 3M markets a highly diversified range of products, few people would associate the 3M Company name with agricultural products. In fact, 3M is much better known for trademarks such as Scotch™, Post-it™, and Thinsulate™, to name a few.

Recently, our 3M Canada based Team, in collaboration with growers and academic researchers, has initiated a program aimed at the application of polymeric materials for the controlled delivery of both biorational and industrial products. Specifically, we have developed polymers for the encapsulation and controlled delivery of insect pheromones.

Pheromones are natural chemicals, which are released by organisms and affect the behavior of an individual of the same species. These chemicals are social in nature and are involved in colonization, feedant attraction, alarms, sexual attraction, etc. In other words, pheromones may be considered as the chemical vocabulary of insects. Pheromones are gaining wider acceptance among practitioners of integrated pest management, especially in the capacity to effect mating disruption.

The pheromones of lepidopteran insects are often characterized as follows:

- non-polar,
- insoluble in water,
- evaporate readily,
- subject to photo-oxidation, and
- relatively expensive.

These characteristics obviate the need for development and optimization of delivery methods. Although significant advances have been made for the application of pheromones with hand-applied devices, insufficient research and development has been conducted for the market introduction of sprayable formulations, or microencapsulated pheromones. Sprayable or microencapsulated formulations would provide the obvious benefit for using conventional spray equipment to apply the pheromones.
Microencapsulation refers to a process for coating a material in such a manner as to produce discrete capsules or reservoirs. The microcapsule, which consists of a core and shell wall, may measure from 1 to 1000 microns in diameter with the size often directly tailored to the specific application. Microcapsules are used in numerous applications including food flavoring, pesticides, biopesticides, fireproofing agents, fragrances, fracturing fluids, drugs, and photochromic agents, just to name a few examples.

The core of the microcapsule is typically a solid, liquid, or gas, and is referred to as active, fill, internal phase, or core material. Several mechanisms may be invoked for release of the core: diffusion through the wall, dissolution of the wall, hydrolyses of the wall, or fracturing of the wall. The release rate is fine-tuned by appropriate engineering of the shell material and is controlled by such factors as particle size, wall thickness, wall permeability, crystallinity, plasticizer level, configuration, and post-treatments or coatings.

Among the terms used to refer to the capsule wall, those terms commonly used include coating, shell, or membrane. The coating may be constructed from many different materials: cross-linked polymers, carbohydrates, proteins, polysaccharides, and combinations thereof.

In addition to functioning as the carrier for the contents of the microcapsule, the wall provides protection of the core material from environmental conditions including UV degradation and oxidation. 3M microcapsules provide many advantages over non-microencapsulated formulations including aqueous based, compatible with conventional spray equipment, prolonged delivery and activity of the core material, reduced contact toxicity to applicators, and improved adhesion to substrates.

3M has applied microencapsulation technology for timed-release of chemical actives for control of agricultural and forestry pests and for residential use of pesticides. These products can be used to complement other methodologies in effective integrated pest management programs.

We propose to provide a more in-depth discussion of microencapsulated pheromone formulations. In addition, we hope to receive input from the audience on potential considerations for future design of formulations.
SECTION 3

BIOLOGICAL CONTROL

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Section Leader

Pat Weddle
3. Biological Control

Predation of Codling Moth (Lepidoptera: Tortricidae) Eggs in Mating Disruption and Conventional Orchards in Washington

A. L. Knight, J. E. Turner, and B. Brachula

USDA, ARS, Wapato, WA

Predation of codling moth, *Cydia pomonella* L., eggs was assessed in June and August, 1995 in 8 apple orchards in Washington treated with organophosphate (OP) insecticides, 4 orchards treated with mating disruption (MD) plus limited OP insecticide use, and 4 orchards treated with MD and not sprayed with OP insecticides. Sentinel codling moth eggs laid by caged moths on 10 shoots in each orchard were scored as alive, dead, or missing after 7 d, and beating tray samples of insect predators were collected at the beginning and end of each trial. Levels of egg predation (dead + missing eggs) were not significantly different among orchard types in June but varied among orchard types in August (MD alone > MD + OP insecticides > OP insecticides). The percentage of dead eggs in August was significantly higher in the orchards receiving only MD than in orchards treated with OP insecticides. The percentage of missing eggs was significantly lower both months in orchards not treated with MD. Densities of spiders and all predators on both sample dates and for earwigs in August were significantly higher in orchards not treated with OP insecticides. Densities of heteropteran predators did not vary significantly by orchard type. No significant correlations were found among predator densities and egg mortality within an orchard type. However, significant correlations were found for the percentage of dead eggs and dead plus missing eggs and densities of earwigs, spiders, and all predators in tray samples across the 16 orchards.
III. Section

*XENOTEMNA PALLORANA* ROBINSON: A MODEL FOR AUGMENTING ALTERNATIVE HOSTS USING GROUND COVERS TO ENHANCE THE BIOLOGICAL CONTROL OF LEAFROLLERS IN TREE FRUITS.

Christopher A. Nobbs
Tree Fruit Research and Extension Center
Washington State University
1100 Western Ave.
Wenatchee, WA 98801

The Food Quality Protection Act of 1996 promises to eliminate or severely restrict the use of organophosphate insecticides which are relied upon heavily for leafroller control in Washington orchards. With the implementation of mating disruption as a primary control tactic for the key pest, codling moth, and use of softer pesticide programs for other pests, leafrollers have risen to major pest status in pome fruit orchards in Washington. These two factors have increased the urgency to find alternative means for controlling leafrollers. With an uncertain future for broad-spectrum pesticides, the development of new insecticide chemistries that are highly selective, and the increasing adoption of mating disruption as a control for codling moth, the window of opportunity for making better use of biological control in orchards has never been greater. *Colpoclypeus florus*, a parasitic wasp in the family Eulophidae, has shown promise as a biological control agent for leafrollers in Europe and Washington. However, although *C. florus* parasitism of *P. pyrusana* reaches very high levels (>80%) in the summer, it has not been completely effective at controlling leafroller populations. The lack of suitable overwintering hosts may result in local the extinction of *C. florus* populations, necessitating reestablishment in the orchards the following year from non-orchard habitats. The two main leafrollers found in orchards, *C. rosaceana* and *P. pyrusana*, do not overwinter in stages suitable for *C. florus*.

*Xenotemna pallorana* is a leafroller whose hosts are primarily alfalfa and white sweet clover. In orchards that use alfalfa for ground cover, populations of *X. pallorana* could be propagated and serve as an alternative host for *C. florus*. Not only might this provide for a more suitable overwintering host, but it might also enhance biological control of pest species of leafroller in summer by increasing the number of *C. florus* produced in orchards.

The first part of our research focussed on development of *X. pallorana* on the foliage of fruit crops, apple, cherry, and pear in comparison to alfalfa. It was somewhat troubling to find that *X. pallorana* was able to develop adequately on all three orchard plants. If *X. pallorana* could develop on all three fruit plants it would seem a risky suggestion to propose to introduce them into an orchard environment, even on the cover crop. However, the lack of *X. pallorana* presence in orchards even though they were evidently common in environments around
many orchards suggested that other factors might be important in this leafroller choosing its host plant. When oviposition preference was tested using apple and alfalfa, *X. pallorana* females laid on apple foliage when given no other choice. However, when provided a choice in a natural setting *X. pallorana* showed strong, almost exclusive, preference for ground cover foliage, the most preferred being alfalfa.

Next we looked at the activity of *C. florus* by examining host and habitat preferences. *Colpophyceus florus* showed no preference between OBLR and *X. pallorana* larvae in laboratory and field studies. Habitat preference studies showed that *C. florus* had a fairly strong preference for apple, compared to ground cover habitats when given the choice of finding host larvae in both locations. From these studies it seems that *X. pallorana* could serve as an alternative host for *C. florus* in orchards without increasing the risk of crop loss. At the very least, *X. pallorana* and an alfalfa cover crop could be used as a model to study the potential of enhancing leafroller biological control in orchards by augmenting populations of an alternative host for a parasite instead of the parasite population. It would seem easier to rear and augment leafroller populations in a cover crop than to rear parasites in an artificial environment, i.e. mass rearing, where concerns over fitness always abound.
3. Biological Control

**XENOTEMNA PALLORANA AS AN ALTERNATE HOST FOR COLPOCYLPEUS FLORUS**

Chris Nobbs, J. F. Brunner and R. Pfannenstiel
WSU Tree Fruit Research and Extension Center
1100 North Western Avenue, Wenatchee, WA 98801

Continuing studies were conducted by a graduate student, Chris Nobbs, in 1997 to determine the potential of *Xenotemna pallorana* as a potential alternative host for *C. florus*. Specific studies examined the potential of *X. pallorana* to attack tree fruits in Washington, preference of *C. florus* for *X. pallorana* in comparison to OBLR, and habitat vs. host preference by *C. florus* in the field. *X. pallorana* was observed to feed and develop equally well on foliage of apple, pear, cherry and alfalfa; however, in oviposition tests it was determined that *X. pallorana* females oviposit preferentially in the cover crop, especially on alfalfa. This explains why, in spite of the ability of larvae to develop on fruit tree foliage, we rarely encounter them.

Studies showed that *C. florus* find *X. pallorana* and OBLR equally attractive in the laboratory (Table 1). In a field study in apples at Columbia View farm, *X. pallorana* and OBLR larvae were placed in apple trees, and *C. florus* parasitized a higher number of *X. pallorana* than OBLR (Table 1). Further studies examining habitat preference by *C. florus* discovered that although *C. florus* did attack leafrollers in alfalfa they parasitized a much larger proportion of the hosts in apples (Table 2). If *X. pallorana* has a different life cycle than the leafrollers already present in apples it may provide an important alternate host for *C. florus* during times of host scarcity or a suitable overwintering host. This should allow the *C. florus* population to build up more easily and provide better biological control of leafrollers.

**Table 1. Host preference of *C. florus*.**

<table>
<thead>
<tr>
<th>Preference</th>
<th>12 hr</th>
<th>24 hr</th>
<th>36 hr</th>
<th>First Choice</th>
<th>Parasitism</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBLR</td>
<td>10</td>
<td>16</td>
<td>11</td>
<td>18</td>
<td>38.2</td>
</tr>
<tr>
<td><em>X. Pallorana</em></td>
<td>9</td>
<td>23</td>
<td>13</td>
<td>22</td>
<td>58.5</td>
</tr>
</tbody>
</table>

**Table 2. Preference by *C. florus* for hosts in apples vs. alfalfa ground cover.**

<table>
<thead>
<tr>
<th>Host</th>
<th>Exp. 1 Cage</th>
<th>Exp. 1 Open</th>
<th>Exp. 2 Cage</th>
<th>Exp. 2 Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree</td>
<td>49.43%</td>
<td>95.74%</td>
<td>79.63%</td>
<td>100%</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>3.77%</td>
<td>13.64%</td>
<td>31.17%</td>
<td>28.26%</td>
</tr>
</tbody>
</table>
Biological Control

EPIGEAL PREDATORS IN SARE ORCHARD SITES

David Epstein
Dept. of Entomology
Washington State University
Pullman, WA 99164-6382

The focus of this study was to determine the effects of broad-spectrum, neural-active insecticides on ground dwelling predatory arthropods of Pacific Northwest apple agroecosystems. It has been postulated that regular applications of these insecticides suppress populations of beneficial arthropods in many crops. Study organisms include ground beetles (Coleoptera: Carabidae), spiders (Aranae), harvestmen (Opiliones), earwigs (Dermaptera: Forficulidae), and centipedes (Chilopoda).

Pitfall traps were set in six apple orchards containing red delicious plantings, five in Washington (Bridgeport, Chelan, Orondo, and two in Yakima), and one in The Dalles, Oregon. Each orchard site was divided into two, ten-acre designated blocks, one managed conventionally with broad-spectrum, neural active insecticides (C blocks), and one a pheromone based pest management block managed without the use of these insecticides (N blocks). Six pitfall traps per block were placed within the tree row, at the base of trees located in the center row of the block. Eight-ounce plastic cups with a seven cm diameter were set in polyvinylchloride (PVC) irrigation pipe buried vertically in the ground, so that the top of the cup was level with the ground surface. Approximately 50 milliliters of propylene glycol based antifreeze was used in each cup as a preservative. Plywood roofs measuring 20cm x 20cm were suspended 4 cm above the traps by eight-penny nails hammered into the four corners. Traps were collected every three weeks. A total of four collections were made in 1996, from 9 July through 13 September. Nine collections were completed for 1997, from 11 April through 13 September. Collected organisms were identified in the laboratory.

The absence of broad-spectrum insecticides in the pheromone mating disruption blocks allowed for rapid increases in the populations of epigeal, generalist, mobile predators. Spraying of broad-spectrum insecticides ceased in the pheromone blocks after 1994, and pitfall trapping began in June 1996.

Statistical analysis of the collection data for both 1996 and 1997 was computed as a randomized complete block design with repeated measures [ANOVA]. Results for 1996 showed that treatment effect was significant for carabids (F value = 16.79, PR>F = 0.0094) and spiders (F value = 8.10, PR>F =0.0360). Earwigs, harvestmen, and chilopods all showed a tendency toward statistical significance for treatment effect.

Results for 1997 once again showed that treatment effect was significant for carabids (F value = 11.35, PR>F = 0.0199), and for Chilopods (F value = 17.25, PR>F =0.0089), but not for spiders.
Earwigs were notable but not significant for treatment (F value = 5.02, PR>F = 0.0752). Opiliones did not test significant.

Carabids were consistently trapped in higher numbers in the N blocks (pheromone) of all orchards for both 1996 and 1997. Twenty-three species of Carabidae were identified from the 1996 collection, six have been reported as codling moth predators. The identifications for 1997 are ongoing. Pterostichus melanarius was the most often trapped species in both 1996 and 1997. Both Riddick (1994) and Hagley (1988) identified Pterostichus spp. as the most promising carabid predators of codling moth. Feeding studies conducted recently at WSU verify that at least two carabid species (Pterostichus melanarius and Harpalus pensylvanicus) can locate and destroy the over-wintering cocoon of codling moth. Harpalus pensylvanicus has also been found in high numbers in our study orchards. Carabid predation of the larvae as they search for over-wintering sites, and even after they have spun a hibernaculum, can decrease the numbers of first generation adults emerging into the orchard in the spring.

Spiders, which were found in significantly higher numbers in N blocks in 1996, were not significantly higher in N blocks in 1997. Free hunting wolf spiders in the N blocks, though, were collected at more than double the rate collected in the C blocks for 1997. Free hunting spiders are more apt to have an impact on over-wintering codling moth populations than web spinning spiders.

Harvestmen, chilopods, and earwigs also were consistently trapped in greater quantities in N blocks for all collections in both 1996 and 1997. Harvestmen are generalist predators known to feed on aphids. They are also predators of the eggs and early instars of the Colorado potato beetle (Coleoptera: Chrysomelidae), which may indicate an ability to feed on orchard lepidopteran larvae as well. Centipedes are also generalist predators that use powerful venoms in capturing larger prey, such as lepidopteran larvae. Large populations of chilopods may also aid in reducing the population of emerging, first generation codling moth. Controversy exists over the role of earwigs in orchard systems. Carrol and Hoyt (1984) found that European earwigs, Forficula auricularia, played a role in controlling apple aphids on nonbearing apple trees, but in a follow-up study (Carrol and Hoyt, 1985), found that these earwigs failed to control aphid population growth on bearing apple trees. Questions also exist as to whether or not earwigs damage apple fruit. Carrol and Hoyt (1985) determined that where earwigs had alternative food sources, apple damage was minimal.

Populations of less mobile invertebrates did not appear to be affected by insecticide treatments. Slugs and snails were collected in higher quantities in C blocks for both 1996 and 1997. Mites and aphids were also collected in higher quantities in C blocks in 1996. Total collections of these organisms were not calculated for 1997.

One explanation for the decrease in mobile organisms in C blocks is that more mobile organisms contact more poison through their continuous movement. This may result in higher mortality rates. A second explanation is that these more mobile organisms disperse more readily to surrounding habitats after insecticide applications. A possible explanation for the higher presence of less mobile organisms in the C blocks could be the decreased presence of predators.
Section IV.
Biological & Cultural Controls

CHERRY BARK TORTRIX BIOLOGY, PHENOLOGY AND HOST PREFERENCE
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Biology & Phenology
The Cherry Bark Tortrix (CBT), *Enarmonia formosana* (Scopoli) (Lepidoptera: Tortricidae) is a major exotic pest of cherry and other fruit trees in western Washington, specifically in Whatcom County. A survey of randomly selected cherry trees in Bellingham, WA, 1996, found that 75-80% of the trees were infested by CBT. In 1997, we found that CBT has infested 100% of the sweet cherries sampled in Bellingham. This insect has the ability to expose a tree to disease, insect and freezing mortality factors. High infestations of CBT can directly cause girdling and eventually death of cherry trees.

Seven sites were chosen to monitor CBT flight activity in Whatcom county, WA: 2 in Ferndale, 1 in Lynden, 1 in Deming, and 3 in Bellingham. Typically in the Pacific Northwest, CBT has a large peak of activity in late June and a smaller peak in August. However, in Whatcom county, the general trend showed a peak in mid June and a larger peak in late July. After the last peak, populations basically crashed. Closer to the foothills in Deming, flight activity was prolonged with gradually declining populations. This bimodal flight pattern is consistent with that observed in Europe.

Coastal sweet cherry trees (naturalized *Prunus avium*) were used to monitor life stage distributions. These trees were removed in monthly intervals from a site located in Blaine. Once this stand was depleted, sites in Bellingham were harvested. Larvae and pupae were removed sequentially from individual logs until 30 larvae had been sampled. Each larva was measure for head capsule width. Head capsule measurements were classified into 5 size regimes based on instar designation by Roediger, 1956. Once 30 larvae had been recorded, the area sampled was intensely screened for the number of unhatched eggs. One 1.5 foot log usually was sufficient for sampling. No true diapausing stage occurs; larvae remain active with increased activity in warmer temperature. Based on the phenology observed this year, it is clear that CBT populations have only one functional generation per year in the Pacific Northwest.
Host preference

Host preference was determined by sampling 30 representative trees of each species or genera. Sampling sites were restricted to the Bellingham area since it has been illustrated that infestations are relative to coastal environments. Sampling areas were consistent for all species of trees. A 1000 cm² frame was used to standardize the sampling area, this was the maximum size possible to accommodate all genera sampled. The number of active frass tubes was counted for that given area. The genus, *Prunus*, was sampled by species while other genera, such as *Malus* and *Sorbus*, remained as a single classification. Graph 1 represents the average number of frass tubes found on each classification of tree. Trees in the genus, *Prunus* are still the most preferred group of hosts for CBT. Frequency of infested trees followed the same trends as the densities. Interestingly, CBT was more common on cultivated *P. avium* while naturalized *P. avium* was relatively less susceptible.

Average densities per 1000 cm² of CBT frass tubes for each tree species surveyed. Letters indicate a significant difference between means using Tukey’s mean separation ($\alpha=0.05$).
Section IV.
Biological & Cultural Controls

BIOLOGICAL CONTROL OF THE CHERRY BARK TORTRIX, 1997:
SURVEY FOR NATURAL ENEMIES
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Egg parasitoid survey
Freshly cut, small logs were exposed to mated adult CBT females in a sealed cage. Females were allowed to oviposit onto the logs for seven days. These logs were placed in the field for an additional seven days. Logs were hung parallel to tree trunks using two screw hooks. After field exposures, the logs were sealed in cardboard cylinders with a glass vial attached on one end to collect any emerging parasitoids. After two weeks, the logs were visually inspected for egg hatch or parasitization.

Sleeve cage survey
Fifteen sleeve cages were designed for determining areas of parasitoid activity. Cages were placed into the field at different time intervals. Trees were thoroughly hand cleaned of other observable organisms (e.g., mostly spiders and egg masses). The sleeves were sealed for a duration of at least one and a half months to allow any parasitoids to emerge and die. After the duration, the sleeves were cut open along the seam to survey the contents. A white plastic tarp was placed below the sleeves to catch anything falling out during the opening of the sleeve. All specimens collected were mounted and labeled. A good diversity of parasitoids was collected using this method. This survey gave an indication of areas where we can expect parasitoid activity. Most activity was found in areas of unmaintained habitats. Few parasitoids were collected from landscaped trees.

Parasitism rate
Two hundred individual cages, designed to cover and trap emerging moths and parasitoids, were placed in the field throughout the summer months. This cage fit over an area to include the larval frass tube and any other organisms were removed prior to containment. Cages remained in the field for at least 45 days. Upon removal, the contents of the cages were collected and recorded. Percent of cage effectiveness was calculated based on whether anything was contained in the cage. Percent parasitism was
determined by the number of cages containing parasitoids divided by the number of cages containing either parasitoids or CBT adults (from the previous percent calculated). Specimens were collected from 86.5% of the traps, so this trapping method was quite successful. Lack of specimens was due to inadequate sealing of the cage allowing escape of its contents, mortality other than successful parasitization of CBT larvae, or prior emergence of CBT adults. Parasitism in the field was 1.7%; three traps yielded parasitoids.

**Destructive tree sampling for parasitoids**

Trees were removed bimonthly throughout the season and sectioned into logs. Trees removed were mainly of naturalized sweet cherry (*P. avium*) and wild cherry (*P. emarginata*). Logs were placed into 50 gallon plastic containers. Three wide mouthed jars were placed on the container lid to collect any emerging insects. Containers were checked daily for contents. Any specimens collected were prepared for authoritative identification. This sampling method provided the most diversity and abundance of parasitoids.

Parasitoids were collected from 6 different sites. Parasitoids were trapped and sampled on 5 different host plants: *Prunus avium, P. serrulata, P. emarginata, P. lusitanica* and *Malus* spp. One site in Blaine proved to consistently produce multiple species of parasitoids. Tentatively, we have recovered one species each from the Trichogrammatidae, Scelionidae, Ichneumonidae, Braconidae, Eupelmidae and Eurytomidae. Specimens have been sent off to specialists for species identifications.

It is clear that currently no natural enemy endemic to the Pacific Northwest is offering any significant control of CBT populations. However, there does appear to be a rich parasitoid complex already attacking CBT and could have potential if enhanced. These preliminary studies are the starting point to understanding the current nature of CBT in North America and the potential impacts of any native or endemic parasitoids. Ultimately, it is recognized that the importation of new parasitoids, native to the homeland of the cherry bark tortrix, are the most rational and economic approach to bring CBT into balance if natural control cannot be achieved endemically in the Pacific Northwest.
3. Biological Control

STINK BUG EGG PARASITES IN WASHINGTON
AND THEIR SEASONAL DEVELOPMENT

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Species complex: Eight species of Pentatomidae were found on uncultivated plants and pome fruits in Chelan and Douglas counties in central Washington. The phytophagous species were Acrosternum hilar (Say), Euschistus conspersus Uhler, Chlorochroa ligata (Say), Euschistus variolarius (Palisot), Chlorochroa sayi (StAl), Thyanta pallidovirens (StAl), and Cosmopepla integrissus (Uhler). The species found in orchards were A. hilar, E. conspersus, C. ligata and T. pallidovirens. Acrosternum hilar was detected exclusively in riparian habitats and C. integrissus was found only associated with wild currant. One predatory stink bug was also identified, Brochymena sp.

Host plants most commonly supporting stink bugs were mullein, bitterbrush, wild currant, snowberry, wild rose, and red-osier dogwood. Low numbers of stink bugs were also collected from cottonwood, thimbleberry, asparagus, baby’s breath, balsam root, big leaf maple, blackberry, cheat grass, dalmatian toadflax, elderberry, rabbitbrush, knapweed, and vetch. No stink bugs were found on sumac or sage.

Biological control: Five species of parasites were identified attacking stink bug eggs. Levels of parasitism reached nearly 70% in mid-summer, and parasites were active all summer. Even with the high levels of egg parasitism, stink bug populations were high and fruit damage excessive. The full effect of egg parasites on stink bug populations is not well understood but no doubt has an effect in reducing densities in natural habitats.

Table 1. Wasp parasites of the egg stage of Euschistus conspersus.

<table>
<thead>
<tr>
<th>Family</th>
<th>Genus species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scelionidae</td>
<td><em>Trissolcus cosmopeplae</em> (Gahan)</td>
</tr>
<tr>
<td>Scelionidae</td>
<td><em>Trissolcus euschisti</em> (Ashmead)</td>
</tr>
<tr>
<td>Scelionidae</td>
<td><em>Trissolcus utahensis</em> (Ashmead)</td>
</tr>
<tr>
<td>Scelionidae</td>
<td><em>Telenomous podisi</em> Ashmead</td>
</tr>
<tr>
<td>Encyrtidae</td>
<td><em>Ooenycyrts sp.</em></td>
</tr>
</tbody>
</table>
Section III.
Biological Control

EGG PARASITES OF PENTATOMIDAE IN CENTRAL WASHINGTON FRUIT PRODUCING REGIONS

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Eggs of stink bugs are attacked by hymenopterous parasitoids in the genera *Telenomous*, *Trissolcus*, and *Ooenycyrtus*. Parasitoids have been reported attacking *Nezara viridula* (Linneaus), *Acrosternum hilare* (Say), *Euschistus servus* (Say), and *Euschistus variolarius* (Palisot) in soybean and alfalfa. Parasitoids of stink bug eggs occur in fruit orchards in the eastern United States and California; however, they have not been reported in Washington. Uncultivated vegetation outside of fruit orchards may play a role in managing populations of stink bug pest species because overwintering adults lay eggs in these habitats.

Five species of parasitoids were reared from *E. conspersus* eggs. This represents the first report of parasitoids attacking eggs of Pentatomidae in Washington. Four of the species are in the family Scelionidae. These species, *Telenomous podisi* Ashmead, *Trissolcus cosmopeplae* (Gahan), *Trissolcus euschisti* (Ashmead), and *Trissolcus utahensis* (Ashmead) were reported attacking the eggs of stink bugs in other regions of North America. The fifth species, an encyrtid, has also been reported attacking the eggs of stink bugs. These parasitoids appear to attack a wide range of stink bug species. There is some evidence indicating that parasitoids partition habitat in which stink bug egg masses are found and that biological control efforts should be concentrated on parasitoid species found in the habitat of preference.

There were differences in the mean number of eggs parasitized according to the date they were placed in the field. In 1996, mean egg parasitism ranged from 63.25% in early July to 12.7% in late August. High rates of parasitism in July corresponded with the highest level of oviposition activity by *E. conspersus*. Parasitoids were active on the first date sentinel egg masses were placed in the field in both years. There was an increase in the percent of eggs parasitized from 14 June through 12 July, 1996. Beginning in midsummer through late August, there was a gradual decline in the percentage of eggs parasitized. In 1997 this pattern was repeated. Parasitism increased from 42% in early June and increased to 62% in early July. The percent parasitism gradually declined to 0.0% in October. The period of peak parasitoid activity was well synchronized to stink bug development. Stink bug oviposition, especially that of *E. conspersus*,
primarily occurs during June and July in Washington and coincided with periods that had the highest incidence of parasitism in this study.

Surveys conducted during 1996 and 1997 showed that egg parasitoids were active on many different plants used as hosts by stink bugs and that their activity on these plants was similar. High rates of parasitism occurred on bitterbrush, red-osier dogwood, poplar, apple, and mullein. Phenology studies indicate that mullein was one of the primary plants used by *E. conspersus* for oviposition. This may be a reflection of the high percentage of parasitism on this plant, but it does not explain the high rates of parasitism on other vegetation. The parasitoids may just be very active searchers of potential habitats where stink bug eggs are found, or other factors such as volatiles given off by egg masses or stink bug pheromones might provide cues directing the parasitoids where to search. Tachinid flies use heteropteran pheromones as host-finding kairomones. The stink bugs *E. conspersus* and *C. ligata* frequently occur on other plant types in Washington associated with high rates of egg parasitism and, while egg masses are occasionally found on these plants, the incidence is low when compared to mullein.

Although parasitoids have been reported attacking the eggs of stink bugs known to cause injury in tree fruits, little is known about wasp biology or their potential to limit populations of their hosts. Most studies on the population dynamics of stink bugs and natural enemies have been conducted in alfalfa and soybean. In these studies, even when parasite activity resulted in high mortality levels, ~50%, they were unable to maintain stink bug populations below economic thresholds in soybean. In Washington, all of the sites where high levels of parasitism were observed have suffered high levels of fruit injury. While egg parasitoids obviously have some effect on stink bug populations, it seems doubtful that natural enemies can be relied upon to provide the primary control of stink bug populations in Washington fruit growing regions. It may be possible to enhance the biological control of stink bugs in native habitats with augmentation of parasitoids; however, difficulties in rearing host eggs to mass produce parasitoids would be a major detriment to this approach. Host plants associated with stink bug oviposition may have the potential to be used in a trap cropping strategy to increase the effectiveness of egg parasitoids within a region.
SECTION 4
CHEMICAL CONTROL/NEW PRODUCTS
***************

Dan Flick
Section Leader
This test was designed to evaluate the effects of applying Success 2SC (DowElanco) on honey bee \textit{(Apis mellifera)} (HB) foraging and mortality when applied to blooming apple \textit{(Malus domestica)}.

A 6-acre, 15-year old orchard of Red Chief apples at West Yakima, WA was used for this test. The entire orchard was treated with Success (0.09 lb\((\text{Al})/\text{acre}\) (5.8 oz) at 1900 h on 1 May. The apple trees were at 10% open bloom. There were a few blooming dandelions on the edges of the orchard. Spray applications were done using a tractor drawn air-blast sprayer at a rate of 100 gallons of water per acre.

At 2200 h on 29 April, six strong honey bee colonies were established adjacent to the orchard. On 29 April, Todd Dead Bee Traps were attached to 4 of the colonies (4 replications) when the orchard was at first bloom. The number of dead bees in the Todd traps were recorded prior to 0800 h 1 May (pre-application) and 2, 3 and 4 May (post-application).

The number of honey bees per tree per 30 seconds (10 replications) foraging the trees were recorded at 1100 h on 1, 2, and 3 May.

**Results:**

Weather conditions were good for bee flight.

There were no significant differences in the number of honey bees foraging the apple blooms after the application of Success as compared to the pre-application counts (Table 1).

There were no significant differences in the number dead honey bees in the Todd dead bee traps after the application of Success as compared to the pre-application counts (Table 2).

**Conclusion:**

In our work over the last 35 years we have correlated the number of dead bees and the magnitude of the kill as follows: up to 100 dead bees per day is normal die off; 200 to 400 dead bees per day is a low kill; 500 to 900 per day is a moderate kill; and 1,000 or more per day is a high kill (Johansen and Mayer, 1990).

Success applied in the evening to blooming apples is not hazardous to honey bees.
Table 1. Effects of applying Success to Red Chief apples (10% open bloom) at 1900 h on 1 May on honey bee (HB) foraging on blooming apples. West Yakima, WA. 1997.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>lb (Al)/acre</th>
<th>1 May*</th>
<th>2 May</th>
<th>3 May</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success 2SC</td>
<td>0.09</td>
<td>7.2a</td>
<td>8.7a</td>
<td>9.1a</td>
</tr>
</tbody>
</table>

* pre-application counts

Means within a line followed by the same letter are not significantly different at the P = 0.05 level, Newman-Keuls studentized range test.

Table 2. Effects of applying Success to Red Chief apples (10% open bloom) at 01900 h on 1 May on honey bee (HB) mortality, based on Todd dead bee traps on colonies placed adjacent to orchard. West Yakima, WA. 1997.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>lb (Al)/acre</th>
<th>1 May*</th>
<th>2 May</th>
<th>3 May</th>
<th>4 May</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success 2SC</td>
<td>0.09</td>
<td>27a</td>
<td>56a</td>
<td>45a</td>
<td>55a</td>
</tr>
</tbody>
</table>

* pre-application counts

Means within a line followed by the same letter are not significantly different at the P = 0.05 level, Newman-Keuls studentized range test.
Chemical Control

Codling Moth: Chemical Evaluations

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The results from various chemical evaluations are presented in the tables below. Use of M-96, a hydrophobic particle film gave substantial control of codling moth in a high pressure Bartlett block, control of first generation codling moth was equivalent to Guthion. An unreplicated test in a lower pressure Comice block, where the material was applied six times with a speedsprayer, resulted in a 2% infestation at harvest.

Two tests, handgun and speedsprayer, examined the effect of adding oil or Latron B-1956 to Confirm. With respect to control of codling moth the addition of oil, which has significant activity on codling moth applied by itself, significantly improved the activity of Confirm while the addition of Latron B-1956 did not. Comply with oil also provided a high level of codling moth control.

Agrimek applied once during the first codling moth generation provided a significant degree of codling moth suppression on both pear and apple. In apple no difference was seen between a 5 oz and a 2.5 oz rate per 100 gallons. In both pear and apple no difference was observed between applying the material prior to first oviposition or waiting and applying the Agrimek prior to egg hatch.

The Effect of M-96 (Hydrophobic Particle Film) Applications on Codling Moth

Handgun application approx. 200 gpa, Bartlett pear
Speedsprayer application 200 gpa, Comice pear
Fruit evaluations done after the completion of the first CM generation (7/2-3) and at harvest, 8/12 for Bartlett and 8/25 for Comice

<table>
<thead>
<tr>
<th>Material</th>
<th>Rate (form.) Per 100 gal</th>
<th>Dates of Application</th>
<th>Handgun plot 7/2 (n=200)</th>
<th>Handgun plot 8/12 (n=400)</th>
<th>Speedsprayer plot 7/3 (n=200)</th>
<th>Speedsprayer plot 8/25 (n=200)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-96</td>
<td>25 lb</td>
<td>5/2, 5/18-19, 6/6-7, 6/20-23, 7/17-18 and 8/8 on Comice</td>
<td>0.5 a</td>
<td>16.25 b</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Guthion 50 W</td>
<td>1.25 lb</td>
<td>5/15, 6/6, 7/22</td>
<td>0.5 a</td>
<td>1.0 a</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>Check</td>
<td>-----</td>
<td>-----</td>
<td>44.5 b</td>
<td>80.8 c</td>
<td>-----</td>
<td></td>
</tr>
</tbody>
</table>

Handgun treatments were replicated four times, speedsprayer treatments were not replicated. Means within a column followed by the same letter are not significantly different (P=0.05 Fisher’s protected LSD). Data were subjected to the arc sine transformation prior to analysis.
The Effect of First and Second Cover IGR Applications on Codling Moth

Handgun application approx. 200 gpa, fruit evaluated on July 2
Speedsprayer application 200 gpa, fruit evaluated on July 3

<table>
<thead>
<tr>
<th>Material</th>
<th>Rate (form.) per 100 gal</th>
<th>Dates of Application</th>
<th>Handgun Plot % CM entries on Bartlett pear (n=200)</th>
<th>Speedsprayer Plot % CM entries on Bartlett pear (n=300)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>1 gal</td>
<td>5/14-16, 6/5-6</td>
<td>10.0 b</td>
<td>14.0 c</td>
</tr>
<tr>
<td>Confirm</td>
<td>9 oz</td>
<td>5/14-16, 6/5-6</td>
<td>10.0 b</td>
<td>13.0 bc</td>
</tr>
<tr>
<td>Confirm and oil</td>
<td>9 oz</td>
<td>5/14-16, 6/5-6</td>
<td>3.5 a</td>
<td>4.3 ab</td>
</tr>
<tr>
<td>Confmn and 1 gal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confirm and Latron B-1956</td>
<td>9 oz, 7.7 oz</td>
<td>5/14-16, 6/5-6</td>
<td>11.5 b</td>
<td>12.0 bc</td>
</tr>
<tr>
<td>Comply and Oil</td>
<td>2.5 oz, 1 gal</td>
<td>5/1-5, 6/5-6</td>
<td>1.0 a</td>
<td>2.3 a</td>
</tr>
<tr>
<td>Guthion 50 W</td>
<td>1.25 lb, 5/14-16, 6/5-6</td>
<td></td>
<td>0.5 a</td>
<td>0.3 a</td>
</tr>
<tr>
<td>Check</td>
<td></td>
<td></td>
<td>44.5 c</td>
<td></td>
</tr>
</tbody>
</table>

Handgun treatments were replicated four times, speedsprayer treatments were replicated twice. Means within a column followed by the same letter are not significantly different (P=0.05 Fisher's protected LSD). Data were subjected to the arcsine transformation prior to analysis.

The Effect of First Cover Agrimek Applications on Codling Moth

Handgun application approx. 200 gpa
Fruit evaluated on July 2

<table>
<thead>
<tr>
<th>Material</th>
<th>Rate (form.) Per 100 gal</th>
<th>Date of Application</th>
<th>% CM entries on Bartlett pear (n)</th>
<th>% CM entries on Braeburn apple (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agrimek and oil</td>
<td>5 oz, 1 qt</td>
<td>5/1</td>
<td>3.75 b (400)</td>
<td>2.7 a (113)</td>
</tr>
<tr>
<td>Agrimek and oil</td>
<td>2.5 oz, 1 qt</td>
<td>5/14</td>
<td>------</td>
<td>3.1 a (163)</td>
</tr>
<tr>
<td>Agrimek and oil</td>
<td>5 oz, 1 qt</td>
<td>5/14</td>
<td>3.5 b (400)</td>
<td>4.5 a (88)</td>
</tr>
<tr>
<td>Guthion</td>
<td>0.625 lb (pears), 1.0 lb (apples)</td>
<td>5/15</td>
<td>0 a (400)</td>
<td>11.2 ab (161)</td>
</tr>
<tr>
<td>Check</td>
<td></td>
<td></td>
<td>46.0 c (300)</td>
<td>27.9 b (122)</td>
</tr>
</tbody>
</table>

All treatments were replicated four times, except the Bartlett pear check treatment which was replicated three times. Means within a column followed by the same letter are not significantly different (P=0.05 Fisher's protected LSD). Data were subjected to the arcsine transformation prior to analysis. The replicates in the Braeburn apples which had less than 15 fruit were excluded from the statistical analysis.
4. Chemical Control

GUTHION, IMIDAN, LORSBAN AND PENNCAP M FOR CONTROL OF CODLING MOTH ON APPLES

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Prosser, WA 99350

This study was designed to evaluate the effects of applying Guthion 50WP (Bayer), Imidan 70WP (Gowan), Lorsban 50WP (Gowan) or Penncap M 2F (AtoChem) for control of codling moth (Cydia pomonella) when applied to apples (Malus domestica).

The test was conducted in a 13-year-old non-commercial orchard of Golden Delicious apples planted on a 20 x 15 foot spacing located near Benton City, WA. Plot size was 0.148 acre (4 rows by 6 trees). One plot was not treated and served as the untreated check. One plot was treated with Guthion (2 lb/acre) on 20 May at 250DD after codling moth biofix, followed by a second application of Penncap M (8 pt/acre) 18 days later on 6 June. One plot was treated with Imidan (4 lb/acre) on 20 May at 250DD after codling moth biofix, followed by a second application of Lorsban (3 lb/acre) 18 days later on 6 June. On 20 May, applications were at 5 pm and temperatures were about 60°F., relative humidity 26%, solar radiation 39 and low winds. On 6 June, applications were at 5 pm and temperatures were about 71°F., relative humidity 50%, solar radiation 25 and winds less than 3 mph. Spray applications were done with a Rears (Eugene, OR) Pak-Blast air-blast sprayer using 300 gallons of water per acre.

A codling moth trap was hung on the west side of the orchard on 23 April and the number of moths caught was recorded. After counting, dead moths were scraped out or a new bottom was used. The lure was replaced every 3 weeks.

Evaluations for codling moth damage were done 1 July by examining 4 sets of 50 (200 total) randomly selected apples in each of the plots and recording the number of codling moth entries.

Results:

No phytotoxicity was observed.

This orchard had high codling moth pressure (Table 1).

**Guthion (2 lb/acre) (first cover) followed by Penncap M (8 pt/acre) (second cover):** There were significantly fewer codling moth infested fruit in this plot as compared to the untreated check (Table 2).

**Imidan (4 lb/acre) (first cover) followed by Lorsban (3 lb/acre) (second cover):** There were significantly fewer codling moth infested fruit in this plot as compared to the untreated check (Table 2).

Conclusions:

Guthion (first cover) followed by Penncap M (second cover) gave good control of
codling moth. Imidan (first cover) followed by Lorsban (second cover) gave good control of codling moth.

Table 1. The number of adult codling moths caught in a single trap placed at head height on 23 April. Benton City, WA 1997.

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of Codling Moths</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 May</td>
<td>33</td>
</tr>
<tr>
<td>6 May</td>
<td>1</td>
</tr>
<tr>
<td>14 May</td>
<td>50</td>
</tr>
<tr>
<td>20 May</td>
<td>12</td>
</tr>
<tr>
<td>3 June</td>
<td>19</td>
</tr>
<tr>
<td>10 June</td>
<td>0</td>
</tr>
</tbody>
</table>

Total = 115

Table 2. The number of codling moth entries found in 200 apples on 1 July and the percent damage. Benton City, WA 1997.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate/acre</th>
<th>No. Codling Moth Entries</th>
<th>% Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guthion 50WP (first cover)</td>
<td>2 lb</td>
<td>0a</td>
<td>0</td>
</tr>
<tr>
<td>Penncap M 2F (second cover)</td>
<td>8 pt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imidan 70WP (first cover)</td>
<td>4 lb</td>
<td>1a</td>
<td>0.5</td>
</tr>
<tr>
<td>Lorsban 50WP (second cover)</td>
<td>3 lb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated check</td>
<td>--</td>
<td>44b</td>
<td>22</td>
</tr>
</tbody>
</table>

Means within a column followed by the same letter are not significantly different at the P = 0.05 level, Tukey's studentized range test.
Methods and Materials - A study was conducted in a commercial 'Bartlett' pear orchard planted on a 25 ft. x 25 ft. spacing (70 tree/acre) in Fairfield, California. Eight treatments were replicated four times in a randomized, complete block design. Each replicate was an individual tree. Foliar sprays were applied with a handgun operating at 200 psi with a finished spray volume of 200 gal/acre (2.87 gal/tree). Applications were scheduled based on degree days (DD). DD were calculated with a biofix of 25 March for the first generation and a 1 June biofix for the second generation using a single sine horizontal cutoff model with a lower threshold of 50° F and an upper threshold of 88° F. Maximum and minimum air temperatures were obtained from the IMPACT weather station at Cordelia, CA. Flight activity of male codling moth (CM) was monitored with a pheromone trap placed high in the tree canopy. Control of the first CM generation was evaluated on 4 June by inspecting 50 fruit from both the bottom and top of the tree canopy per replicate for CM infestation (400 fruit per treatment). Control of the second generation was evaluated at harvest on 21 July by inspecting a maximum of 125 fruit from both the bottom and top of the tree canopy per replicate for CM infestation (1,000 fruit per treatment). Due to the low crop this year, the number of fruit inspected varied by treatment. Control of pear psylla nymphs, motile twospotted spider mites and European red mites was evaluated by sampling 10 exterior and 10 interior leaves per replicate weekly from 4 June through 21 July. Pear psylla nymphs and motile twospotted spider mites and European red mites were brushed from the sampled leaves and counted under magnification (20X).

Results and Discussion:

Flight Activity - The overwintering CM flight, as measured by a pheromone trap placed high in the tree canopy, indicated that flight was bimodal with the first peak of the first flight occurring about 21 April at 294 DD and the second peak of the first flight occurring about 21 May at 781 DD. The overwintering flight was completed about 31 May at 967 DD. The first peak of the second CM flight occurred about 16 June at 291 DD and the second peak of the second CM flight occurred about 7 July at 701 DD.

First Generation Evaluation All insecticide treatments had significantly lower CM infestation compared to the untreated control. At the time of the first generation evaluation, only the first two insecticide applications had been applied to the trial. The only significant difference in CM infestation among the insecticide treatments was that Comply without Volek oil followed by Azinphos-M had significantly higher CM infestation compared to Comply with Volek oil followed by Azinphos-M, two applications of Brigade and two applications of Azinphos-M.
Harvest Evaluation - The CM infestation in the untreated control was extremely high (73.7%) and was significantly higher than all the other treatments. Danitol had significantly higher infestation (41.8%) than the other insecticide treatments which were not significantly different from one another. One application of Comply with or without Volek oil followed by two applications of Azinphos-M provided CM control similar to three applications of Azinphos-M and was superior, though not significantly, to three applications of Brigade and to two applications of Comply with Volek oil followed by one application of Azinphos-M. These results would indicate that excellent CM control can be achieved by the substitution of Comply with oil for the first application of Azinphos-M.

Secondary Pest - Motile twospotted spider mites and European red mites were significantly suppressed by two applications of Comply with Volek oil followed by one application of Azinphos-M compared to the industry standard but not the untreated control. Brigade did not show mite control or flare-up, while Danitol showed a slight increase in mite populations.

Pear psylla nymphs were significantly suppressed by one application of Comply followed by two applications of Azinphos-M and two applications of Comply followed by one application of Azinphos-M compared to the industry standard and Brigade. Brigade had significantly more psylla nymphs than the untreated control and it appears to flare-up pear psylla while there was no significant difference between Danitol and the untreated control.

Mean Percent Codling Moth Infested Fruit from the First Generation and Harvest Evaluation in Fairfield, CA - 1997.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (lb/ac)</th>
<th>No. Appl.</th>
<th>Mean* % CM Infested Fruit</th>
<th>Season Mean*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1st Gen. Harvest</td>
<td>TSSM + ERM</td>
</tr>
<tr>
<td>1) Danitol 2.4EC</td>
<td>0.2</td>
<td>3</td>
<td>2.0 ab 41.8 b</td>
<td>52 ab</td>
</tr>
<tr>
<td>2) Brigade 10WP</td>
<td>0.03</td>
<td>3</td>
<td>0.0 a 6.4 a</td>
<td>31 ab</td>
</tr>
<tr>
<td>3) Comply 40WP</td>
<td>0.1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azinphos-M 50WP</td>
<td>1.5</td>
<td>2</td>
<td>3.3 b 3.9 a</td>
<td>81 ab</td>
</tr>
<tr>
<td>4) Comply 40WP + Volck oil</td>
<td>0.1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azinphos-M 50WP</td>
<td>1.5</td>
<td>2</td>
<td>0.3 a 2.2 a</td>
<td>41 ab</td>
</tr>
<tr>
<td>5) Comply 40WP + Volck oil</td>
<td>0.1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azinphos-M 50WP</td>
<td>1.5</td>
<td>1</td>
<td>0.5 ab 5.5 a</td>
<td>8 a</td>
</tr>
<tr>
<td>6) Knack 0.86EC + Volck oil</td>
<td>0.11</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azinphos-M 50WP</td>
<td>1.5</td>
<td>2</td>
<td>1.0 ab 4.9 a</td>
<td>94 ab</td>
</tr>
<tr>
<td>7) Azinphos-M 50WP (Industry Standard)</td>
<td>1.5</td>
<td>3</td>
<td>0.0 a 3.1 a</td>
<td>117 b</td>
</tr>
<tr>
<td>8) Untreated</td>
<td>---</td>
<td>0</td>
<td>9.1 c 73.7 c</td>
<td>28 a</td>
</tr>
</tbody>
</table>

* Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, P ≤ 0.05). Data analyzed using an arcsin transformation.
4. Chemical Control / New Products

Optimizing the Use of Confirm for Control of Codling Moth

A. L. Knight

USDA, ARS, Wapato, WA

The effect of the insect growth regulator, Confirm, on the eggs, larvae, and adults of codling moth were evaluated in a variety of laboratory and field studies. A synthesis of these studies will be reported. Results show that Confirm has significant ovicidal effects. Adult contact with residues of Confirm reduces egg laying and hatch and egg fertility. Larval walking on treated foliage and stems are not prevented from reaching fruits, and the percentage of fruits with stings is increased on treated versus untreated foliage. Results from several timing studies will highlight the importance in targeting the adult and egg stages.
4. Chemical Control / New Products

Management of Codling Moth (Lepidoptera: Tortricidae)
in Apple with Overhead Watering

A. L. Knight

USDA, ARS, Wapato, WA

The effects of overhead watering on the management of codling moth, *Cydia pomonella* L. were examined during 1994-95. Studies were conducted in small replicated plots of apple, *Malus domestica* (Borkham), in Yakima, WA. Treatments varied with regard to the timing and length of watering, the amount of water applied, and whether watering was continuous or cycled. Water treatments reduced fruit injury from codling moth by 60 - 90% versus the untreated control. Moth flight, oviposition, and egg and larval survivorship were all significantly reduced with watering compared with the untreated control in replicated field assays. The major impacts of these water treatments on apple trees were the accumulation of mineral deposits and a reduction in fruit size in 1994. Watering only during the evening appeared to minimize these effects. Apple scab, *Venturia inaequalis* (Cooke), increased during the second year of this study, but infection levels did not vary among treatments in either year. During 1997, four 0.7 acre apple blocks were watered for 75 d with the fog system running from 6PM to 6AM each day. Fruit injury by codling moth was reduced 60% compared with similar unwatered check plots. Fruit quality was not affected by the overhead watering, except in two blocks where the grower over-irrigated.
AFFECTS OF ADJUVANTS ON THE EFFICACY OF SUCCESS* NATURALYTE* INSECT CONTROL ON LEAFMINERS IN PACIFIC NORTHWEST APPLES

Barat Bisabri1, Elizabeth H. Beers2, Lyla J. Lampson3, and Brian L. Bret1

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Introduction

Success* Naturalyte* insect control is a fermentation-based product derived from naturally occurring soil bacterium, Saccharopolyspora spinosa. It combines the high levels of efficacy associated with synthetic insecticides with the reduced mammalian and environmental toxicity associated with biologicals. Recent research in Washington and Oregon has been conducted on oblique banded leafrollers (OBLR) and western tentiform leafminers (WTLM).

Materials and Methods

Trials were conducted in Chelan, WA and Milton-Freewater, OR. Trials were random complete block design with 4 replications at each location, 3 trees per replicate. A Rears airblast sprayer was used to make concentrate applications (100 gpa) at the 10% tissue feeding stage. Number of live WTLM mines per leaf were counted. Effects of adjuvants were evaluated by tank mixing with a crop oil concentrate or a silicone adjuvant. The effects of Sylgard at 4 and 8 oz. and oil at 0.25% and 1.0% were evaluated. OBLR were also evaluated in one of the trials since these are the primary pest in most areas.

Results

Success at 0.06, 0.09, and 0.13 lbs ai per acre applied as a concentrate spray did not provide acceptable control of summer generations of WTLM. However, addition of 0.25% oil resulted in a significant control equal to Vydate and Agri-Mek+oil. With this information, additional trials were conducted on 3rd generation WTLM to determine the effects of adjuvants. The addition of an adjuvant improved the performance of Success against WTLM. Significant differences were not seen between the effects of oil or a silicone adjuvant. When adjuvants are added to Success, control of WTLM was not significantly different than control from Vydate or Agri-Mek plus oil. Significant differences were seen with OBLR control. Success with or without adjuvants gave excellent control of OBLR. Neither Vydate nor Agri-Mek+oil controlled OBLR.

Conclusions

Success without a surfactant provides highly effective control of leafrollers. When leafminers are also present, or when leafminers are the primary pest, the addition of an oil or silicone surfactant is recommended.

*Trademark of Dow AgroSciences
A range of studies were conducted during 1997 to evaluate the effect of Kaolin M96 on the obliquebanded leafroller, *Choristoneura rosaceana* (Harris). We wanted to examine its impact on each life stage of *C. rosaceana* at a number of key management time periods during the season. We found that Kaolin has potential when applied at delayed dormant in the spring to prevent the overwintering larvae from establishing feeding sites in the new green foliage. We found that Kaolin has little effect on larvae already feeding inside leaf shelters. Kaolin has little effect on egg hatch. Moths will, however, avoid ovipositing on residues. Kaolin affects neonate survivorship and retards larval growth. Kaolin caused outbreaks and reduced parasitism of gracillarid leafminers. Kaolin was effective in controlling codling moth. Coverage of fruit and leaves is critical in achieving control of codling moth. Kaolin cannot be removed from the stem-end of apples through washing with water and brushing. Dipping apples in 1% horticultural oil removes the appearance of any residue.
4. Chemical Control/New Products

EFFECT OF APPLICATION CONCENTRATION ON LEAFROLLER CONTROL WITH SUCCESS

Mike Doerr and J. F. Brunner  
WSU Tree Fruit Research and Extension Center  
1100 North Western Avenue, Wenatchee, WA 98801

Dilute applications of Spinosad (Success 2 F, DowElanco) were compared to concentrate (3X) applications for their ability to control OBLR larvae of the summer generation. The test was conducted in an apple orchard at Milton-Freewater, OR. The trees were 2-yr-old Delicious on dwarfing rootstock. Treatments were applied to unreplicated 1/8-acre plots. This test was a direct comparison of the effectiveness of dilute versus concentrate applications. There was no plot left untreated in this test. All treatments were applied with a Rears Pack-Blast PTO air-blast sprayer. The sprayer was calibrated at 300 gpa for the dilute application and 100 gpa for the concentrate (3X) application. Application date was 20 Jul (approximately 100% egg hatch). The 31 Jul post-treatment evaluation was a visual inspection of 10 growing shoots/tree. Three trees were sampled from each of 6 rows/treatment, the number of live OBLR larvae was recorded, and counts from each row were kept separate for analysis. Weather conditions on the application day were as follows: 20 Jul, 75°F, wind 0-2 mph.

A comparison of treatments to an untreated control could not be performed on these data. However, the objective of this test was to compare dilute versus concentrate (3X) applications at two rates. A significant rate response was noted with both the dilute and concentrate (3X) applications of Success 2 F. There were no significant differences in OBLR larval mortality noted between dilute and concentrate (3X) applications for either rate of Success 2 F tested.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (AI/100 gal)</th>
<th>Concentration</th>
<th>30 Jul OBLR/10 shoots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success 2F</td>
<td>7.1 g</td>
<td>Dilute</td>
<td>7.2b</td>
</tr>
<tr>
<td>Success 2F</td>
<td>14.2 g</td>
<td>Dilute</td>
<td>3.2a</td>
</tr>
<tr>
<td>Success 2F</td>
<td>21.3 g</td>
<td>Concentrate (3X)</td>
<td>7.1b</td>
</tr>
<tr>
<td>Success 2F</td>
<td>42.6 g</td>
<td>Concentrate (3X)</td>
<td>3.3a</td>
</tr>
</tbody>
</table>

Means in the same column followed by the same letter not significantly different (p=0.05, Fisher's Protected LSD).
4. Chemical Control/New Products

COMPLY UPDATE FOR APPLES, PEARS, AND NUT CROPS
Carl Buchholz
12413 Wide Hollow Road
Yakima, WA 98908

The federal registration of Comply (fenoxycarb) for use on apples, pears, almonds, hazelnuts, pecans, and walnuts is expected early in 1998. This label has been a long time coming; fenoxycarb has been registered for use on fruit trees in some European countries since 1985.

Comply acts as a juvenile hormone mimic. The normal transformation stages in an insect's development can be disrupted by an application of Comply. When Comply is applied early in an egg's development, the egg never hatches or the nymph that develops is abnormal. An application of Comply to the last instar prevents the development to a pupa or an adult. Comply affects the eggs by contact and the larvae by contact and/or ingestion. There is translaminar movement within a leaf but no translocation between leaves. There are also sublethal effects, such as fewer viable eggs produced from treated insects.

Comply 40WP at 4oz product/acre will be registered to control codling moth, Pandemis and obliquebanded leaf rollers and tentiform leafminers in apples in the West. Only two applications will be allowed per season: pre-bloom and/or postbloom. There will be a 70 day preharvest interval (PHI). The most effective timing in the West would be a petal fall application followed by an application 14-28 days later. These applications would target codling moth eggs, the last instar of both leaf rollers, and the sap and tissue feeding stages of tentiform leafminers. This first application for codling moth should be no later than 100 degree days after biofix. As the codling moth eggs age they are more difficult to control. Bees have to be removed from the orchard before Comply can be applied. Also, at this time many of the leaf rollers are in the last larval (susceptible) stage. Once they have pupated, control is poor. Tentiform leafminers are controlled when they change from the sap feeding to the tissue feeding stage and from the tissue feeding to the pupal stage. Comply provides excellent ovicidal control of leafminers, when the application is made pre-bloom. The timing of the second application would depend on the main pest: codling moths should be 21-28 days and leaf rollers should be 14 days.

Comply 40WP at 5 oz product/acre will be registered to control
codling moth, tentiform leafminer, and pear psylla in pears. The timing for codling moths will be at petal fall plus a second application 21-28 days later. Again, the first application should be applied no later than 100 degree days after biofix, and bees have to be removed from the orchard. For pear psylla, a pre-bloom application to control eggs has provided excellent control, especially following an oil application to delay egg laying. A post-bloom application can also be made that will control pear psylla eggs and last instar nymphs. Only two applications can be made in a season, and there will be a 70 day PHI.

For nut crops, Comply 40WP at 4 to 5 oz product/acre should be applied at first egg lay, and a second application should be made 21 days later for codling moth, filbertworm, oriental fruit moth, and navel orangeworm. A maximum of two applications can be made in a year, and a 14 day PHI must be observed.

Coverage and timing is critical with Comply, especially when the timing is ovicidal, because each egg must be contacted. This can be a critical issue in large nut trees in the summer when all the foliage has developed.

Comply has an excellent integrated pest management fit and should be very helpful in controlling our major pests in apples, pears, and nut crops in the West.
IV. Chemical Control/New Products

EFFICACY OF NEW INSECT GROWTH REGULATORS FOR CONTROL OF SAN JOSE SCALE IN STONE FRUITS

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University of California, Kearney Agricultural Center
9240 S. Riverbend Ave., Parlier, CA 93648

Field trials to establish efficacy of the insect growth regulator buprofezin (Applaud®) for control of San Jose scale in deciduous fruit trees continued in 1997 at the Kearney Agricultural Center, Parlier, CA. Applaud was applied to mature Fantasia nectarines at 1.5 lb a.i./acre as a delayed dormant treatment on February 6, 1997 and against emerging first generation crawlers on April 17, 1997. In addition to the two Applaud treatments, a standard dormant treatment of diazinon plus Volck oil, at 400 gpa, was applied on January 17. An untreated check was also included in this trial. All materials were applied using an Air-O-Fan GB-34 commercial sprayer operated at 1.8 mph. Five replications comprised of nine trees each were used for each treatment, arranged in a Latin square design.

Control efficacy was evaluated by two sticky tapes applied to scaffold limbs of the center tree in each replicate to collect crawlers during the first generation emergence in late April-early May, and second generation crawler emergence in late June-early July (Fig. 1). Tapes were positioned at the same sites on each limb for all crawler collections. Scale infestation was also measured by a green fruit sample on June 4 (40 fruit per replicate) and a mature fruit harvest sample on July 7-8 using 100 fruit per replicate.

The results of this trial (Table 1) showed no statistical difference in control of San Jose scale with the standard diazinon and oil dormant spray compared to the untreated check. The delayed dormant treatment with Applaud and oil applied on February 6 provided a significant reduction in scale control, while the Applaud treatment applied in mid-April reduced the scale population, but not to a level significantly different from the untreated check. The failure of the standard diazinon dormant treatment is believed due to several factors, primarily resistance of the scale population to organophosphate insecticides as a result of over 20 years of organophosphate treatments for control of San Jose scale, oriental fruit moth, and peach twig borer. In addition, the trees in this orchard have been mechanically topped for many years, resulting in large "crow's nest" growth in the tops of the trees which tends to protect scale populations from sprays of any sort, including dormant sprays in winter. The high level of scale present in the orchard at the beginning of the trial also added to control problems, and demonstrates the value of not allowing populations of San Jose scale to reach such high levels before effective controls are applied.

These results indicate that Applaud applied as a dormant or delayed dormant treatment could provide significant improvement in San Jose scale control compared to standard organophosphate treatments currently in use.
Table 1. Efficacy of Applaud® (buprofezin) for control of San Jose scale on Fantasia nectarines. Kearney Agricultural Center, Parlier, CA, 1997.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Application</th>
<th>Average No. Scale Crawlers Per Tape</th>
<th>Percent Infested Fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1st Gen.</td>
<td>2nd Gen.</td>
</tr>
<tr>
<td>Check</td>
<td>–</td>
<td>10.2</td>
<td>25.2</td>
</tr>
<tr>
<td>Diazinon 2.0 lb a.i. plus 6.0 gal oil/acre</td>
<td>1/17/97</td>
<td>20.2</td>
<td>102.1</td>
</tr>
<tr>
<td>Applaud 1.5 lb a.i. plus 6.0 gal oil/acre</td>
<td>2/6/97</td>
<td>1.2</td>
<td>10.4</td>
</tr>
<tr>
<td>Applaud 1.5 lb a.i. plus 6.0 gal oil/acre</td>
<td>4/17/97</td>
<td>10.7</td>
<td>34.0</td>
</tr>
</tbody>
</table>

¹/ Treatments applied on dates shown at 400 gpa with an Air-O-Fan GB-34 sprayer.
²/ Means followed by the same letter are not significantly different at p. = 0.05, Fisher's Protected LSD test.

A field trial to evaluate the efficacy of Esteem® (pyriproxyfen) was also conducted at the Kearney Agricultural Center, Parlier, CA. Insecticides were applied by handgun as delayed dormant treatments on February 3, 1997 to mature Santa Rosa plums using seven single-tree replications per treatment in a randomized complete block design. Approximately three gal of spray material was applied per tree. The trees in this orchard had never been treated with organophosphate insecticides; susceptibility of scale to diazinon was expected to be high compared to orchards treated annually with dormant sprays. Esteem was applied at rates of 30 and 40 g a.i./acre in combination with Volck Supreme spray oil at six gal/acre in both treatments. Also included in this trial were a standard treatment of diazinon at two lb a.i./acre with six gal of Volck Supreme oil, an oil treatment alone at six gal/acre, and an untreated check.

Treatment efficacy was based on collection of San Jose scale crawlers on double-sided sticky tape (two per tree) over two consecutive weeks during emergence of the first generation crawlers, and also for two consecutive weeks during the second generation of crawler emergence. Sticky tapes were applied for first generation crawler emergence on April 24 and were counted on May 1 and May 8, 1997. Tapes for evaluation of crawler densities during the second generation emergence were applied to the trees on June 25 and were counted on July 2 and July 9, 1997.
Fruit samples were also collected twice during this trial. A green fruit sample comprised of 30 fruit per replication was harvested on June 3. A mature fruit sample of 75 fruit per replication was harvested on June 18.

The results of the sticky tape collections in the first generation (Table 2) show that both treatments of Esteem plus oil resulted in zero collections of scale crawlers, while the untreated check averaged 72.7 crawlers per tape over the two-week period. The diazinon plus oil standard dormant treatment averaged 2.3 crawlers per tape; the oil alone averaged 10.7 crawlers per tape (equivalent to approximately 71% reduction in crawler populations using this treatment).

Crawler collections on sticky tape during second generation peak emergence showed an average of 191 crawlers per tape in the untreated checks, with less than three crawlers per tape in the two Esteem treatments (Table 2). Green fruit harvested on June 6 showed an infestation level of 6.2% in the untreated check, while the Volck oil alone, and standard diazinon plus oil dormant treatments had only 0.5% infested fruit. Both of the Esteem treatments had no infested fruit in this sample. The mature harvest fruit sample taken on June 18 showed a slight increase in all treatments with the untreated check having 6.9% infested fruit, the Volck oil and standard diazinon plus oil treatments still with <1% infestation, while the Esteem treatments each had <0.5% infested fruit.

The results of this trial show that Esteem is a very effective insect growth regulator for control of San Jose scale on deciduous fruit trees. Registration of this product for use in stone fruits should be pursued and encouraged. It was also interesting to find that the crawler populations shown in sticky tape counts in the two standard treatments (oil, oil plus diazinon) were not reflected in the infested fruit samples. This is perhaps due to inadequate replication of sticky tapes per tree, resulting in insufficient random sampling of the crawler populations.
Table 2. Efficacy of Esteem® (pyriproxyfen; V-71639) for control of San Jose scale on Santa Rosa plums.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average No. Crawlers Per Sticky Tape&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Percent Infested Fruit</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st Gen.</td>
<td>2nd Gen.</td>
<td>June 4</td>
<td>June 18</td>
</tr>
<tr>
<td>Check</td>
<td>72.7</td>
<td>191.0</td>
<td>6.2</td>
<td>6.9 a</td>
</tr>
<tr>
<td>Volek oil</td>
<td>21.4</td>
<td>37.6</td>
<td>0.5</td>
<td>0.6 b</td>
</tr>
<tr>
<td>Diazinon + oil</td>
<td>2.3</td>
<td>6.9</td>
<td>0.5</td>
<td>0.4 b</td>
</tr>
<tr>
<td>Esteem @ 30 g a.i./acre plus oil</td>
<td>0.0</td>
<td>2.3</td>
<td>0.0</td>
<td>0.2 b</td>
</tr>
<tr>
<td>Esteem @ 40 g a.i./acre plus oil</td>
<td>0.0</td>
<td>0.6</td>
<td>0.0</td>
<td>0.4 b</td>
</tr>
</tbody>
</table>

<sup>1</sup> Applied February 3, 1997; high-volume handgun spray; seven single-tree replications per treatment. Kearney Agricultural Center, Parlier, CA.

<sup>2</sup> 1st and 2nd generation crawler collections on 4/24 – 5/8, and 6/25 – 7/9/97, respectively.

<sup>3</sup> Means followed by the same letter are not significantly different at p. = 0.05, Fisher’s protected LSD Test.
Figure 1. Seasonal monitoring of San Jose scale in pheromone (male scale) and sticky tape traps (crawlers). Parlier, Fresno County, California, 1997.
Chemical Control

Twospotted Spider Mite and Pear Psylla: Chemical Evaluations

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A test was conducted in a block of Comice pear trees to evaluate the efficacy of a number of acaricides and/or psyllicides. The initial numbers of both twospotted spider mite and pear psylla were extremely high when this trial was initiated. The post treatment averages for twospotted spider mite, pear psylla and predatory mites are shown below. Treatment with either Provado or Mitac resulted in increased twospotted spider mite levels, unlike the Mitac treatment, high numbers of predator mites were observed in the Provado treatment. The addition of Savey to the Provado treatment eliminated the mite resurgence. With regards to control of pear psylla, Mitac and Pyramite provided the highest levels of pear psylla control while Agrimek was the least effective and the Provado treatments were intermediate.

Late season application (July 10, 1997) of acaricides and/or psyllicides to Comice Pear Application made with handgun sprayer (200 gpa)
Data shown are averages from four single tree replicates

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Twospotted Spider Mite</th>
<th>Pear Psylla</th>
<th>Predator Mites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eggs</td>
<td>Motiles</td>
<td>Eggs</td>
</tr>
<tr>
<td>Pyramite 60W</td>
<td>1.0 a</td>
<td>0.5 a</td>
<td>0.5 a</td>
</tr>
<tr>
<td>8.8 oz/ac</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provado 1.6F</td>
<td>30.7 d</td>
<td>27.3 c</td>
<td>0.9 abc</td>
</tr>
<tr>
<td>20 oz/ac</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provado 1.6F</td>
<td>4.0 b</td>
<td>0.6 a</td>
<td>1.4 bc</td>
</tr>
<tr>
<td>20 oz/ac</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Savey 50W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 oz/ac</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitac 50 W</td>
<td>23.5 d</td>
<td>17.6 bc</td>
<td>0.7 ab</td>
</tr>
<tr>
<td>3 lb/ac</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agrimek 0.15EC</td>
<td>1.0 a</td>
<td>0.9 a</td>
<td>1.2 bc</td>
</tr>
<tr>
<td>16 oz + oil 0.25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check</td>
<td>14.6 c</td>
<td>15.2 b</td>
<td>1.4 c</td>
</tr>
</tbody>
</table>

Means within a column followed by the same letter are not significantly different (P=0.05 Fisher's protected LSD). Data were subjected to the log(x + 1) transformation prior to analysis.
SECTION 5
PESTICIDE RESISTANCE
***************

Stephen Welter
Section Leader
5. Pesticide Resistance

EVALUATION OF CODLING MOTH RESISTANCE TO AZINPHOS-METHYL AND CHLORPYRIFOS IN WALNUTS

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University of California, Berkeley, CA 94720

Abstract - Codling moth (CM) resistance for azinphos-methyl was screened in 15 orchards and for chlorpyrifos in 7 orchards. It appears that CM has developed a low level of azinphos-methyl resistance throughout the state with a moderate to high level of resistance in the southern San Joaquin region (Kings and Tulare counties). However, no resistance to chlorpyrifos was observed in any of the locations except possibly in an isolated untreated orchard near Hollister (San Benito county).

Methods and Materials - Adult CM were captured from 15 orchards in Kings, Tulare, San Joaquin, Yuba and San Benito counties. The orchards had a history of heavy insecticide use over the past few years except for those untreated orchards in San Benito and Tulare counties. One hundred pheromone traps were placed high in the tree canopy at about 6:00 p.m. and removed at about 5:00 a.m. the next morning. The trap bottoms with moths imbedded in the stickem were returned to Berkeley.

The CM were divided into two or three equal sets depending on the number of moths captured. If three sets were created, one set of CM was dosed with a discriminating dosage of 0.1 µg/µl of azinphos-methyl, the second set of CM was dosed with a discriminating dosage of 0.3 µg/µl of chlorpyrifos and the third set served as an untreated control. If only two sets were created, one set of CM was dosed with a discriminating dosage of azinphos-methyl and the second set served as an untreated control. The moths were scored for mortality 48 hours after treatment.

Dose mortality lines were generated for azinphos-methyl from two orchards. One orchard was susceptible to azinphos-methyl while the other orchard was resistant to azinphos-methyl based on the initial resistance screens. Dose mortality lines were generated by treating 20 to 30 moths with 6 to 7 concentrations ranging from 0.0 to 1.0 µg/µl of azinphos-methyl for both populations.

Results and Discussion - Resistance to azinphos-methyl was screened in 15 orchards throughout the state while only 7 orchards were screened for chlorpyrifos resistance. The percent corrected mortality for the discriminating dosage of azinphos-methyl ranged from 0 to 54% while the percent corrected mortality for the discriminating dosage of chlorpyrifos ranged from 68 to 86% in orchards which had a history of heavy insecticide use over the past few years. Thus, it appears that CM in most walnut orchards throughout the state have some degree of resistance to azinphos-methyl with a moderate to high level of
resistance in the Kings/Tulare county region. In addition, the azinphos-methyl resistance appears to be stable between the first and second generation. In an orchard in San Joaquin county the percent corrected mortality for the first generation was 42.3% while it was 45.2% for the second generation.

Four orchards had never been treated with insecticides and served as untreated control orchards. However, only two of the four orchards have azinphos-methyl susceptible populations. The low to moderate resistance in two of the orchards which were adjacent to treated orchards may indicate that there is mixing of the CM populations between orchards and possibly within a geographical region. This mixing of the populations may explain the wide spread moderate level of resistance. The two susceptible orchards were very isolated from any source of treated CM.

Probit analysis of the dose mortality data from the susceptible and resistant populations show a significant shift in the LC50 and CL 95% values. The LC50 and CL 95% for the susceptible population from the untreated orchard was 0.082 and 0.062 to 0.105 µg/µl, respectively and for the resistant population from a heavily treated orchard was 0.331 and 0.224 to 0.455 µg/µl, respectively. A completely susceptible CM population would be expected to have a LC50 of about 0.06 µg/µl. There appears to be about a 5 fold increase in the azinphos-methyl tolerance in the southern San Joaquin region (Kings and Tulare counties) compared to a susceptible population.

There was no resistance found to chlorpyrifos. It is interesting to note that a 46.5% mortality to chlorpyrifos was found in the azinphos-methyl susceptible population which had never been treated with insecticides. This decreased mortality to chlorpyrifos in the untreated orchard which was susceptible to azinphos-methyl is very encouraging since it may mean that azinphos-methyl resistant CM may exhibit negatively correlated cross-resistance with chlorpyrifos. Nevertheless more orchards need to be evaluated for chlorpyrifos resistance before we can determine the extent of negatively correlated cross-resistance. But if there is negatively correlated cross-resistance to chlorpyrifos and possibly to microencapsulated parathion (Penncap-M), then it may be possible to break the resistance and revert the CM population to an azinphos-methyl susceptible population.
Baseline resistance levels of obliquebanded leafroller (OBLR) larvae to tebufenozide (Confirm 2 F, Rohm and Haas), spinosad (Success 50 2 F, DowElanco), chlorpyrifos (Lorsban 50 WP, DowElanco) and azinphos methyl (Guthion 50 WP, Miles Inc., Agricultural Division) were monitored using a leaf-dip bioassay method. Bioassays were run on two field-collected OBLR populations from Mattawa, WA and Milton-Freewater, OR and a laboratory colony which has been maintained for seven years at the Tree Fruit Research and Extension Center in Wenatchee. Field populations were collected as fourth-fifth instar larvae of the overwintering generation. Larvae were returned to the laboratory and transferred to 3.25 oz plastic portion cups (Prairie Packaging #S-300) with artificial pinto bean leafroller diet. The larvae were allowed to develop to maturity and after pupating were placed in an oviposition cage. Bioassays were conducted on neonate larvae of the F1 generation. Treatments were prepared by diluting the appropriate amount of product (see table) in 500 ml water in a glass beaker. A small amount (approximately 2 µl) of wetting agent, Latron B-1956, was added to each treatment. An untreated control was prepared using water plus the wetting agent only. Untreated apple leaves were collected from Delicious trees at the WSU Tree Fruit Research and Extension Center, Wenatchee. Leaves were dipped, then allowed to dry. Two punches (2.3 cm diameter) were taken from each leaf. Four punches were placed in a petri dish (Falcon 1006, 50x9 mm). Petri dishes were chosen randomly, and five 1- to 2-d-old leafroller larvae were placed on the leaf disks. The petri dish lids were put in place, and dishes were stored inside a food storage container and kept at 75°F (±2°F) constant temperature and 16:8 photoperiod. Petri dishes were examined after 7 d and larval survival recorded. Ten dishes were used for each treatment (50 larvae per treatment).

Summaries of the LC50s for each chemical are presented in table 1. Both field-collected populations showed significant insecticide resistance to the organophosphate (OP) Guthion 50 WP. Resistance was not noted with Lorsban 50 WP, another OP. The field-collected populations had statistically higher LC50s than the laboratory colony for the insect growth regulator Confirm 2 F, indicating the possibility of cross resistance to Guthion 50 WP. There was no insecticide resistance to Success 2 F noted in the assay.

Table 1. LC50s of laboratory and field-collected obliquebanded leafroller populations to various chemicals.

<table>
<thead>
<tr>
<th></th>
<th>Success 2 F</th>
<th>Confirm 2 F</th>
<th>Lorsban 50 WP</th>
<th>Guthion 50 WP</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBLR colony</td>
<td>0.3b</td>
<td>12.4a</td>
<td>2.6a</td>
<td>4.9a</td>
</tr>
<tr>
<td>M-FW, OR (oblr)</td>
<td>0.3b</td>
<td>31.6b</td>
<td>4.3b</td>
<td>45.3b</td>
</tr>
<tr>
<td>Mattawa, WA (oblr)</td>
<td>0.1a</td>
<td>34.0b</td>
<td>2.4a</td>
<td>49.1b</td>
</tr>
</tbody>
</table>

Lethal concentration limits calculated by Polo-PC using a p=0.95. Means in the same column followed by the same letter not significantly different (P=0.05, Lethal Ratio Significance Test, Robertson and Priesler, 1991).
Field trials were conducted in several orchards at the Kearney Agricultural Center in 1997 to evaluate the efficacy of diazinon and carbaryl for control of San Jose scale and to also compare high-volume sprays (400 gpa) to low-volume (100 gpa) using the same material. In these trials, diazinon 50W was applied at 2.0 lb a.i./acre with 6 gal Volck Supreme oil per acre. Carbaryl 80S was applied at 4.0 lb a.i. with 6.0 gal oil per acre. All treatments were applied on January 24, 1997 using an Air-O-Fan GB-34 commercial sprayer. Only nectarine and plum cultivars were used in these trials because it is easier to evaluate scale control treatments on smooth-skinned fruit rather than on peaches. All orchards were mature (10-20 years old) and had been treated annually with standard organophosphate (primarily diazinon) and oil dormant sprays.

Trials were evaluated by inspection of fruit picked at random at the commercial harvest date for the respective cultivars. A minimum of 250 fruit per cultivar (range 250-600) were examined for presence or absence of scale, with presence of a single scale on a fruit scoring that fruit as infested.

The results of these trials (Table 1) show that in all comparisons of diazinon dormant sprays at 100 gpa versus 400 gpa (Fantasia, Red Diamond, Royal Diamond, and Casselman) there were no significant differences between the two rates of spray application. This result was not expected, but is consistent with a previous trial on nectarines (1996 Annual Report) and is believed due to the high level of tolerance or resistance in the respective scale populations to organophosphate insecticides. Consequently, the volume of diazinon spray applied was immaterial to success or failure of the treatment.

The comparisons of carbaryl dormant sprays at 100 versus 400 gpa (Red Diamond, Queen Rosa, and Casselman) showed that although infested fruit levels were high in all treatments, the 400 gpa rates of application reduced the infestation levels on fruit by significant amounts in two of the trials compared to the 100 gpa rates of application.

In the two orchards where diazinon and carbaryl were compared directly to each other, the 100 gpa application of carbaryl was no better than either of the diazinon rates on Red Diamond nectarines, but was significantly better on Casselman plums. The 400 gpa application of carbaryl showed significant improvement over the diazinon treatments in both orchards. It should be noted, however, that this is probably a short-term effect. Continued reliance on only one new insecticide for scale control would probably quickly lead to resistance to that material as well. Cross-resistance to organophosphates (e.g. - diazinon) and carbamates (e.g. - carbaryl) has already been observed in other insect species.
Mite samples from Red Diamond nectarines and Royal Diamond plums on July 28 and August 6 respectively (100 brushed leaves per treatment) showed no significant differences in two-spot, Pacific, or European red mite populations between the two types of insecticide (Table 4). Red mite populations were somewhat higher in the carbaryl treatment in plums, but were countered by high populations of predaceous Phytoseiid mites.

These trials demonstrate conclusively that San Jose scale populations in orchards under commercial control practices are resistant to organophosphate insecticide sprays. These results add increased emphasis to the need for improved scale control with the development and registration of insect growth regulators (IGRs) as one of the better options for stone fruit IPM programs. In addition, in situations where growers have been having difficulty controlling San Jose scale, rotation of insecticides to other currently registered products such as carbaryl, and applications at higher volumes of spray per acre, would seem to offer improved control over previous practices using low-volume application rates and organophosphate insecticides.
Table 1. Efficacy of dormant sprays for control of San Jose scale on stone fruits.  

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Treatment</th>
<th>GPA</th>
<th>Harvest Date</th>
<th>Percent Infested Fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fantasia nectarine</td>
<td>diazinon</td>
<td>100</td>
<td>7/7/97</td>
<td>20.4 a</td>
</tr>
<tr>
<td></td>
<td>diazinon</td>
<td>400</td>
<td>7/7/97</td>
<td>20.0 a</td>
</tr>
<tr>
<td>Queen Rosa plum</td>
<td>carbaryl</td>
<td>100</td>
<td>7/10/97</td>
<td>61.2 a</td>
</tr>
<tr>
<td></td>
<td>carbaryl</td>
<td>400</td>
<td>7/10/97</td>
<td>34.4 b</td>
</tr>
<tr>
<td>Royal Diamond plum</td>
<td>diazinon</td>
<td>100</td>
<td>7/16/97</td>
<td>26.2 a</td>
</tr>
<tr>
<td></td>
<td>diazinon</td>
<td>400</td>
<td>7/16/97</td>
<td>27.0 a</td>
</tr>
<tr>
<td>Red Diamond nectarine</td>
<td>diazinon</td>
<td>100</td>
<td>7/9/97</td>
<td>23.3 a</td>
</tr>
<tr>
<td></td>
<td>diazinon</td>
<td>400</td>
<td>7/9/97</td>
<td>27.1 a</td>
</tr>
<tr>
<td>Red Diamond nectarine</td>
<td>carbaryl</td>
<td>100</td>
<td>7/9/97</td>
<td>27.2 a</td>
</tr>
<tr>
<td></td>
<td>carbaryl</td>
<td>400</td>
<td>7/9/97</td>
<td>9.6  b</td>
</tr>
<tr>
<td>Casselman plum</td>
<td>diazinon</td>
<td>100</td>
<td>8/21/97</td>
<td>39.2 a</td>
</tr>
<tr>
<td></td>
<td>diazinon</td>
<td>400</td>
<td>8/21/97</td>
<td>51.2 a</td>
</tr>
<tr>
<td>Casselman plum</td>
<td>carbaryl</td>
<td>100</td>
<td>8/21/97</td>
<td>24.4 b</td>
</tr>
<tr>
<td></td>
<td>carbaryl</td>
<td>400</td>
<td>8/21/97</td>
<td>18.4 b</td>
</tr>
</tbody>
</table>

1/ Treatments applied on January 17, 1997 with an Air-O-Fan GB-34 sprayer. Diazinon @ 2.0 lb a.i.; carbaryl @ 4.0 lb a.i. per acre.

2/ Means followed by the same letter for respective cultivars are not significantly different at p. = 0.05, Fisher's Protected LSD test.
SECTION 6
BIOLOGY/PHENOLOGY

***************

Steve Cockfield
Section Leader
CODLING MOTH EMERGENCE FROM BIN PILES
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Fruit harvest bins have long been recognized as potential overwintering sites for codling moth larvae. With increased use of mating disruption for codling moth control, outside sources of infestation have become more of a concern for growers using pheromone confusion systems. Studies were designed to provide information on the source of codling moth larvae infesting bins (what proportion move from infested fruit placed in bins vs. larvae entering bins before fruit is picked) and the pattern of codling moth emergence from bin piles. The infestation experiment is in progress and includes a comparison of plastic bins. The bin pile study showed that by covering a bin pile with plastic sheeting, temperatures could be increased by 10 - 25 degrees F compared to uncovered piles and there was a distinct gradient from lower to higher levels with increasing temperatures encountered at the higher levels. This warming effect resulted in codling moth emerging from covered bin piles 20 - 40 days earlier than uncovered bin piles.

Analysis of adult emergence patterns based on mean date of emergence indicated no significant differences between positions within levels for any of the treatments. There was a significant treatment effect (F=97.65, p=.0001), level effect (F=63.37, p=.0001), and treatment x level interaction (F=21.63, p=.0002). Due to this interaction a separate analysis was run for level effects within the clear plastic and no covering treatments which indicated significant level effects in both treatments; for the clear: DF 2,4; F=479.8, p=.0001; for no cover: DF 2,4; F=20.8, p=.0077. Analysis by treatment indicated significant differences between treatments at the mid and high levels but not at the low level (mid level: F=55.2, p=.0001; high level: F=259, p=.0001). Further analysis by level showed the only difference in mean emergence date between the clear and black plastic treatments was at the high level (black = 135, clear = 122). The Tukey means separation test was used to rank order of emergence by level: for the clear plastic treatment the order of emergence was high>middle>low; for the uncovered treatment middle=high>low.

We constructed a large bin pile (10 wide X 10 high X 23 long) of 2300 bins and placed thermocouple wires at various locations to record temperature. This data is being analyzed and combined with existing data, will yield a model predicting codling moth emergence patterns from a larger bin pile.

This information could be important in developing a technique for neutralizing codling moth infested bins, and in understanding how infested bin piles may be influencing pest management in fruit orchards both in the immediate vicinity of the bins and remote locations which receive infested bins.
6. Biology/Phenology

CHARACTERIZATION OF STINK BUG DAMAGE AND DISTRIBUTION OF INJURY IN ORCHARDS

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1100 North Western Avenue, Wenatchee, WA 98801

Fruit injury: In 1997, the characterization of stink bug injury to Delicious and Gala was determined by caging *E. conspersus* and *C. ligata* adults on fruit. Five adult stink bugs of a species were caged on 2-3 apples with a wire mesh sleeve cage. Each treatment was replicated five times for each stink bug species and fruit variety. Cages were removed after seven days. Number of live and dead stink bugs was recorded. After removing sleeve cages limbs were sprayed with Carzol to protect fruit from further insect damage. Injury was characterized and photographed on each variety 14 days after caging.

All Delicious apples caged with *E. conspersus* or *C. ligata* displayed signs of injury. Small, dark depressions, ranging in diameter from 1 mm to 1 cm, were visible on the exterior of the fruit surface. Peeling the skin of the fruit revealed light to medium brown discoloration of the flesh that extended toward the center of the fruit 1-5 mm. Gala apples showed no external signs of injury two weeks after caging. Underneath the skin, injured flesh of Gala was very slightly discolored, appearing creamy white against the normally light yellow color. Gala fruit placed in cold storage did not develop any external symptoms of stink bug injury.

In 1997, three Dole orchards and one Naumes and Craft orchard were sampled to determine fruit injury by stink bugs at harvest. Fifty fruits per tree were examined on five trees in the border row and the same number of trees in two interior rows. High levels of fruit injury were detected in most orchards, and damage in the border row was consistently higher than interior rows. These data suggest that well-timed border treatments would prevent most fruit loss to stink bugs.

<table>
<thead>
<tr>
<th>Location</th>
<th>n</th>
<th>Border Row</th>
<th>1st interior row</th>
<th>2nd interior row</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craft</td>
<td>5</td>
<td>31.2</td>
<td>12.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Dole Northeast</td>
<td>5</td>
<td>76.8</td>
<td>36.8</td>
<td>13.6</td>
</tr>
<tr>
<td>Dole Northwest</td>
<td>5</td>
<td>35.6</td>
<td>12.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Dole South</td>
<td>5</td>
<td>17.2</td>
<td>3.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Naumes</td>
<td>5</td>
<td>39.2</td>
<td>6.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Section 6. Biology/Phenology

Optimizing Conditions for Mating and Oviposition of Field-Collected Codling Moths for Resistance Monitoring

Eric Paluvesky\textsuperscript{1,2}
Helmut Riedi\textsuperscript{1}

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\textsuperscript{2}Matityahu Fruit Crops Experimental Station, Upper Galilee R&D, Israel

In recent years, control failures for codling moth control with organophosphate (OP) insecticides, especially in the warmer fruit-growing areas, have become more common, and resistance has been documented. In these areas mating disruption has been adopted as a control technique to manage resistance. The pheromone trap assay used extensively in regional surveys for resistance monitoring of azinphosmethyl is not effective in pheromone disrupted orchards since trap catch is very low. Moths could be obtained by collecting damaged fruit but usually fruit damage is so low that it would be difficult to generate enough moths for a topical assay. However rearing these moths for one generation would provide enough material to conduct this assay. Another alternative to OPs are insect growth regulators (IGR). In general, IGRs target the egg and larval stages. To monitor resistance to these insecticides, eggs and larvae must be reared from field-collected moths.

Wild codling moths collected from the field must usually go through a conditioning phase before successful mating and oviposition will occur under laboratory conditions. Genetic variability and possibly resistance traits are often lost during such colony establishment.

The objective of our study was to improve the frequency of ovipositing field moths when caged in single pairs. We hypothesized that the frequency of ovipositing field moths under natural conditions would be higher than under artificial conditions in the lab.

Three different environmental conditions and two cage systems were compared in summer and fall. Both field and lab moths were studied in the summer. In fall only lab moths were tested. The three environmental conditions investigated were: 1) apple trees with natural conditions of fruit and leaf odors, natural thermoperiod and photoperiod; 2) poplar trees with no host odors, but with a natural thermoperiod and photoperiod; 3) a growth chamber in the lab with artificial conditions set at a constant temperature of 21 °C, 85% RH and a photoperiod of 16:8 (L:D) h.

The two cage systems used were: 1) a cylindrical cage made of gray fiberglass netting and wooden disks (15 cm high, 6 cm in diameter), with a twig with one leaf, placed in a floral solution, set along side a fruit; 2) a plastic cylindrical vial (9 cm long, 4 cm in diameter), lined with wax paper for an oviposition substrate. Six vials were placed in a net cage along-side a cluster of fruit. These vials were protected from the sun and rain with black landscape cloth. Each cage contained one pair of newly emerged moths and were supplied with a 5% solution of sucrose. Field moths were obtained by collecting infested fruit from an experimental apple orchard. Laboratory moths were reared on thinning apples and have been in colony since 1994. The moths were left in these cages until they died. Mating was assessed by dissecting the females. All eggs, hatched and unhatched, were counted.
In late August, the frequency of field moths laying fertile eggs was higher in apple trees than in the lab, in both types of cages (Fig. 1). The frequency of lab moths ovipositing fertile eggs in the leaf cages was also higher in apple trees than in the lab. However, in the vial cages there was no significant difference between apple trees and the lab.

![Diagram](image1.png)  
**Figure 1:** Frequency of field and lab moths laying fertile eggs in apple trees and the lab, in vial and leaf cages in summer (late August) and in the lab.

![Diagram](image2.png)  
**Figure 2:** Frequency of lab moths laying fertile eggs in apple trees, poplar trees and the lab, in vial and leaf cages in summer (late August), fall (late September-mid October) and in the lab.

In leaf cages the proportions of ovipositing lab moths in the fall, placed in a host tree (apple) and in a non-host tree (poplar) were significantly lower than in a host tree in the summer (Fig. 2). In vial cages however the proportion of ovipositing lab moths in the fall in a non-host tree was similar to egg-laying in a host tree in the summer but higher than in a host tree in the fall. This implies that the difference in the proportion of ovipositing females between the summer and fall, in the leaf cages, could not have been caused by the lower fall temperatures. Our results with field and lab moths in summer and fall (Figs. 1 and 2) suggest that odors of ripening fruit in the summer increase the proportion of ovipositing moths whereas the odors of overripe fruit and senescing leaves in the fall depress egg laying activity.

Another interesting point is the difference between cages (Figs. 1 and 2). In apple trees, both in summer and fall, the leaf cage tended to be slightly better than the vial cage although the differences were not significant. In non-host environments, both in the poplar trees in the fall and in the lab, the leaf cage was inferior to the vial cage. In leaf cages we have shown that laboratory moths can respond to natural cues such as natural photo- and thermoperiods and host odors but in vial cages they will mate and oviposit just as well in artificial as in natural conditions. The vial cage is basically very similar to our oviposition cage used in our lab colony. It is probable that we have selected a strain that oviposits readily in this environment.

In summary, the frequency of field females ovipositing fertile eggs was at least twice as high in the field on apple than in the lab regardless of the cage used. Our experiments with lab moths suggest that the natural photo- and thermoperiods may be critical for sexual activity. We intend to continue our studies with OP-susceptible and resistant field moths to determine the role of climatic and host factors on mating and oviposition.
SECTION 7
MATING DISRUPTION/SIR
***************
Nana Simone
Section Leader
7. Mating Disruption/SIR

GENETIC ENGINEERING OF THE CODLING MOTH:
STERILITY WITHOUT IRRADIATION

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Alternative control strategies are needed for the codling moth in order to reduce our reliance on chemicals. We are working on an alternative non-chemical method to establish pest-free zones which is similar to the Sterile Insect Release Program in British Columbia but does not involve irradiation. It involves the genetic engineering of a lethal trait into the codling moth.

Researchers at the University of California, Riverside, have been working on such an alternative genetic control strategy for the suppression of pink bollworm. The lethal trait they examined in Drosophila is a mutation of the Notch gene which is required for normal development of the insect embryo. The mutation is expressed at temperatures below 20°C (68°F). Thus, moths which possess this mutation could be reared in the laboratory above 20°C. However, once released in the field, matings with wild moths would produce eggs that would die at temperatures below 20°C. During the growing season, temperatures drop below 20°C nearly every night and often during spring and fall daytime. Laboratory trials of this mutation with the Drosophila fruit fly led to the extinction of the population within three generations. This alternative genetic control strategy has been named Autocidal Biological Control by Karl Fryxell and Tom Miller at UC Riverside.

We have been developing the technology to genetically transform codling moth. During the past two years we have made progress toward a stably transformed codling moth. A microinjection system used to deliver DNA into the newly laid eggs has been optimized. We have injected several DNA vectors which are pieces of DNA used as a vehicle to transport the gene of interest into the egg. These vectors contain "jumping genes" such as piggyBac and hobo, which are capable of inserting themselves into the chromosome at specific sites. Once the gene is integrated into the chromosome, it is passed down to the offspring. We are using both piggyBac and hobo vectors. Preliminary assays with piggyBac have proven that the gene is capable of functioning as a jumping gene in the codling moth embryonic environment.

Stable genetic transformation is proven by determining if the foreign gene is heritable. With our initial injections with a piggyBac vector, we now have evidence of inheritance of the injected DNA in generations 1-5 (using polymerase chain reaction (PCR) analyses of DNA). When a hobo/Notch vector (with the lethal Notch mutation) was microinjected, codling moths grown at lower non-lethal temperatures (21°C) showed eye mutations which was expected. This indicates that the Notch DNA may be affecting eye color or eye development genes. For these experiments, further molecular analyses will pinpoint the exact location of the inserted DNA in the chromosomes.

A fluorescent microscope, specifically designed to detect signal from green fluorescent protein (GFP), was recently purchased for screening transformants. In preliminary experiments, a low level of gene expression of the GFP has been found in codling moth injected with piggyBac/GFP. Future injections will involve higher concentrations of DNA and using a vector containing piggyBac, GFP, and the lethal Notch mutation. Both the transformed "green" moths and the created eye mutant lines have great potential for future codling moth basic biology and genetic research.
7. Mating Disruption

LATE-SEASON PHEROMONE HANGING TO REDUCE OVERWINTERING CODLING MOTH POPULATIONS

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As the district with the latest harvest in California (through August), Lake County fruit is vulnerable to late 2nd and 3rd generation codling moth damage during a period no cover sprays are applied. Previous experiments (1988-1994) showed that the long season renders mating disruption (MD) programs less effective than in earlier districts as populations increase year to year in treated orchards. In 1996, building on past observations by local pest control advisors, pheromone dispensers were hung in mid-July in five 10-acre blocks to disrupt mating of late season moths that normally escaped control. Trap catch and post-harvest infestation data that year showed that this method successfully reduced late flights and damage. In 1997, trap catch data showed that these effects carried over to the following spring, significantly reducing overwintering flight. Besides reducing flights for two years and post-harvest damage the year they were hung, the use of one mid-season hanging compensated for lack of organophosphate (OP) residue during the last half of harvest. This advantage will be even greater if (or when) pre-harvest intervals for OP’s are lengthened. The carryover effect may also enable Lake County growers to decrease cover spray amounts and transition more rapidly to “softer” programs using more selective chemicals and/or MD. A side benefit (as yet unstudied) may be the reduction of current or future field resistance to OP’s. Wider spread commercial implementation of this new tactic is likely to occur in 1998, as it is viewed as being more economically feasible than a full season MD program.
Table 1: CODLING MOTH-INFESTED FRUIT ON TREES AFTER HARVEST
Lake County, 1996

<table>
<thead>
<tr>
<th>Orchard</th>
<th>Pheromone-treated</th>
<th>Untreated</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. per 300 fruit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KV1</td>
<td>9</td>
<td>49</td>
<td>1:5</td>
</tr>
<tr>
<td>KV2</td>
<td>20</td>
<td>56</td>
<td>1:3</td>
</tr>
<tr>
<td>SV†</td>
<td>5</td>
<td>5</td>
<td>1:1</td>
</tr>
<tr>
<td>UL1</td>
<td>3</td>
<td>15</td>
<td>1:5</td>
</tr>
<tr>
<td>UL2</td>
<td>3</td>
<td>14</td>
<td>1:5</td>
</tr>
</tbody>
</table>

(paired t-test, significant at p = .06)

(SV†: if this orchard is removed from the data set, p = 0.05)

Table 2: Overwintering Flight Codling Moth Wing Trap Catches
March 27 - June 16, 1997
total catch per 2 traps

<table>
<thead>
<tr>
<th>Orchard</th>
<th>1 MG. LOW</th>
<th>10 MG. HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UC Pher</td>
<td>PCA Pher</td>
</tr>
<tr>
<td>KV1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>KV2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>SV</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>UL1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>UL2</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

(* paired t-test, SIGNIFICANT at p = 0.0475)
Codling moth mating disruption trials using aerosol puffers for dispersion of the pheromone were conducted in Washington State in 1997. The trials were located in Wapato (40 acres), near Pateros on the Methow river (18 acres) and a site between Brewster and Malott (15 acres). All three sites had a previous history of mating disruption and codling moth pressure was considered low to moderate. Some codling moth damage (ca. 0.5%) had been observed at the Brewster site the previous year.

The puffers used in these trials were obtained from Technical Concepts (Elk Grove, IL). The individual cans were loaded with a mixture of codlemone, methanol and propellant (36 grams of codlemone + 118 grams of ethanol + 104 grams of propellant). The dispensers were operated on battery powered timers set to puff every 25 minutes, 24 hours each day. Each 60 µl puff emitted approximately 7.5 mg of codlemone or 432 mg per day (7.5 mg x 57.6 = 432 mg). The Wapato site was treated at a rate of 1 puffer per acre or 432 mg/acre/day of codlemone. The Pateros and Brewster sites were treated with 30 puffers per site or 720 mg/acre/day and 864 mg/acre/day, respectively. Each can required replacement mid-season in order to achieve season-long control.

The Wapato site (Golden Delicious and Red Delicious) was monitored with 29 wing traps baited with 10 mg codlemone lures. During the overwintering flight (May 4 through July 4) a total of 27 moths were captured in all traps. The highest number of moths caught in a single trap was four (2 traps). A cover spray of Guthion (2 lb. a.i./acre) was applied to every other row. During the second flight a total of 23 moths were captured in all traps. The highest number of moths caught in a single trap was three (2 traps). No cover sprays for codling moth were made for the second generation. Tree samples and bin samples taken prior to and at harvest indicated one entry out of 6,000 fruit.

The Pateros site was discontinued after the first generation due to an unintended application of pheromone dispensers to the block. The Brewster (Golden Delicious, Red Delicious and Fuji) site received a border spray of Guthion during the first generation and no chemical treatments for codling moth control were made during the second generation. Bin samples at harvest found three codling moth stings in 1,400 fruit sampled or 0.21% codling moth damage.
Although significant fruit damage did not occur in any of the plots a number of technical difficulties were encountered with the operation of the puffers. A small number of the puffers failed to operate properly had required replacement during the season. A significant amount of phytotoxicity was observed directly under the puffers in trees where the puffers were placed. The phytotoxicity was observed on both the foliage and the fruit. The puffer cans did not empty uniformly. During the mid-season replacement at Wapato, 9 of the 40 cans were found to be completely empty. At the Brewster site 7 of the 30 cans were completely empty. A problem occurred during the second application in which the valves on the cans became non-operational necessitating replacement of all cans in all trials.

In spite of the numerous technical difficulties encountered it appears that the puffer technique of mating disruption may have possibilities in situations of low to moderate codling moth pressure. Additional trials need to be conducted in larger blocks and higher codling moth pressure.
Three approaches for mating disruption of leafrollers in Washington’s tree fruits are being investigated: hand-applied dispensers for both codling moth and leafrollers, a sprayable micro-encapsulated formulation for leafrollers, and the use of aerosol puffers.

The effectiveness of a polyethylene tube dispenser (ISOMATE-SPECIAL) loaded with a blend of codling moth and leafroller sex pheromones (Dual) was evaluated in three 20 ac orchards in Brewster. Each orchard was paired with a similar orchard treated only with ISOMATE-C+ for codling moth. No significant treatment effects were found for larval population densities. Codling moth lure-baited traps caught few moths and no difference was found between treatments. Moth catch in leafroller traps were significantly reduced in blocks treated with the Dual dispenser. Fruit injury was 64% lower in the orchards treated with the Dual dispenser.

The effectiveness of a sprayable leafroller pheromone product (NoMate LRX) was evaluated in replicated 20 acre orchards. Three applications were spaced 4-5 weeks apart. No reductions in fruit injury occurred in the sprayable-treated blocks compared with the untreated checks.

Preliminary trials were conducted with aerosol puffers loaded with leafroller pheromone. Moth catch in lure-baited and female-baited traps compared with similar untreated check blocks were reduced nearly 99 and 91%, respectively. Studies conducted in small plots suggested that releasing pheromone for 24 h was marginally better than 12 h for disruption of Pandemis leafroller to lure-baited traps.
I. Section Mating Disruption

SECONDARY PEST AND NATURAL ENEMY SAMPLING PROGRAM, 1997

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Objective: The objective of this project was to document changes in secondary pest and natural enemy populations in blocks managed under large-scale mating disruption (MD) when compared with conventional (organophosphate-based) management regimes. Our hypothesis is that conditions will be more favorable in blocks under MD for integrated control of secondary pests, and that the reduced need for insecticide applications for secondary pests will offset the higher cost of MD technology.

Materials and Methods: Standardized sampling protocols were developed for the principal secondary pests of apple and pear and their associated natural enemies. Seven apple sites and 3 pear sites were sampled during the 1997 growing season, for a total of 9 sites (one site contained both apple and pear orchards). A subsample of the blocks within the boundary of the MD area was chosen for intensive sampling. Orchard blocks under conventional management representative of the region were chosen as comparison blocks. Five of the sites were the primary MD projects (CAMP) established during the 1995 growing season (with the exception of Randall Island, begun in 1993). The remaining 4 sites (GRABs subproject) were apple acreage in central Washington, and differed from the CAMP sites in that they were managed by a single grower or corporation as opposed to a group of cooperating independent fruit growers.

Results: Apple: As in 1996, the % parasitism of overwintering white apple leafhopper eggs was significantly higher in MD blocks. However, this difference was not reflected in lower populations of nymphs during the growing season. Aphid populations were low in all sites and no difference was documented between the treatment types. The mite binomial counts showed low levels of infestation in both MD and CONV blocks. In the leaf-brushing samples, predatory mites and their alternate prey species (apple rust mites) were found to be more abundant in the MD blocks. Fruit damage by codling moth and leafroller was lower in MD blocks, whereas fruit damage by thrips and lygus was higher.

Pear: Psylla nymphs and adults were higher in conventional blocks than in blocks under MD, as demonstrated on both the leaf brushing and the limb tap counts. Mite populations did not differ between the 2 management regimes. Fruit damage by psylla was higher in conventional blocks, corresponding to the higher in-season populations. Fruit damage by codling moth and leafroller was the same in the 2 management regimes.

Conclusion: Data gathered during the 1997 growing season as part of the Secondary Pest and Natural Enemy Sampling program indicates that for the majority of the pest insects and natural enemies sampled, no differences occurred between the 2 management regimes. However, in most cases where differences occurred, the trend was for lower pest and/or higher natural enemy populations in blocks under mating disruption.
Economic Analysis of A Cling Peach Mating Disruption Program

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The two key insect pests in the cling peach orchard system are Oriental fruit moth (OFM) and peach twig borer (PTB). Commercial products for controlling OFM with pheromone confusion have been available since 1987. In 1995, the first commercial PTB product for pheromone confusion became available. Many growers have been reluctant to use OFM mating disruption since they still had to spray for PTB, increasing the overall cost of control. This project’s goal is to introduce a complete mating disruption program for both OFM and PTB and conduct cost analysis of this program compared to grower standards.

Methods
Demonstration blocks were around 10 acres in size, however, growers with small acreage were also included in the program. Whenever possible, a nearby “grower standard” was used for comparison. All the blocks were evaluated for efficacy of the pheromone using weekly trap catches, shoot strike counts and damage at harvest. Growers were asked to keep track of pheromone dispenser costs, application methods and application costs. They also reported pesticide application costs from grower standards. This data was used for analysis of pheromone application costs compared to costs in a sprayed orchard.

The first two years of the economic analysis included the complete mating disruption program. The last year a partial mating disruption program was incorporated into the analysis. In the complete program, the first application of OFM was typically around March 1st, and PTB around April 1st. This date varied for each grower since it was based on first trap catch and weather conditions. The second application for both OFM and PTB typically went up around June 1st. Then, growers would not have to make a separate application in a few weeks for PTB. Growers in the program used all three commercial OFM products including Isomate, Checkmate, and Hercon. The manufacturer’s recommendations for the application rate and length of product were followed.

Results and Conclusions
At the end of the season, pheromone dispenser costs, application methods and application costs were collected from the 10 cooperators in the Sacramento Valley in 1995 and 10 cooperators in Sutter and Yuba in 1996. The average dispenser cost for two OFM applications was $92.12 per acre compared to $96.60 per acre in 1995. Two applications of PTB cost was $101.56 per acre compared to $115.00 in 1995. The price of pheromone dispensers for four applications dropped $17.92 from 1995 to 1996.
Growers were also asked to keep track of their method of pheromone application and the number of hours. In both 1995 and 1996, ladders were found to be the most expensive application method although using small ladders cost much less. Growers were effective lowering costs by using poles from the ground. A trailer pulled by a tractor is the best method for getting dispensers high in the tree and the least expensive. For the three applications necessary for the program the average cost, excluding growers using ladders, was $37.90. Taking an application cost of $30.00 per acre for three applications plus the cost of pheromone, the 1996 pheromone program cost was $223.68 per acre. The cost in 1995 was $243.00 per acre, so the cost of the complete program decreased about $20.00 in 1996. This was also compared to the standard spray program in both years. In 1996, the standard program averaged $109.00 including one mite spray ($40-60 per acre) which was $115.00 less than the complete mating disruption program. To keep costs down, some growers prefer a partial program with two pheromone applications, one each of OFM and PTB plus one summer spray which costs $132.00.

Other costs associated with spraying such as worker training and safety should be considered when comparing cost of the complete pheromone program with the standard spray program. For some growers, the benefits of worker safety, no drift, and less machinery maintenance plus being able to irrigate, and thin as needed, is worth the extra cost of the complete mating disruption program. As the overall cost of mating disruption decreases and growers lose their currently registered cheaper pesticides, we expect more cling peach growers to adopt mating disruption which has been demonstrated to give growers a proven alternative.
SECTION 8
TREE FRUIT DISEASES

Tim Smith
Section Leader
RESULTS OF TRAPPING ASCOPORES OF 
VENTURIA PIRINA DURING RAINFALL PERIODS 
IN MENDOCINO COUNTY, CALIFORNIA 1989-1997

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Ascospores of Venturia pirina were trapped during rain periods using roto rod samplers (Model 20, Sampling Technologies, Inc. Minnetonka, Minnesota 55305) as part of a disease management program in Mendocino County pear orchards 1989-1997. The 3-5 samplers were located 45cm above ground level in commercial orchards and were baited with a 1 meter diameter pile of random leaf litter 10cm deep beneath the samplers in late winter.

Accumulated degree day readings were maintained at Hopland, CA, using a recording biophenometer (model TA 51, Omnidata International, Logan, Utah 84321) which made temperature readings at ten minute intervals and converted the data to a degree day readout. Data of % spores trapped for the season vs degree days above 0C for each year were compared with similar plots for % mature asci vs degree days above 0C in Figure 1B, p. 261 of Spotts, R.A. and Cervantes, L.A. 1994, Factors affecting maturation and release of ascospores of Venturia pirina in Oregon, Phytopathology 84: 260-264.

Results and Discussion

In five of the 9 years (1989, 1990, 1992, 1993 and 1997) there was reasonable agreement between the Spotts and Cervantes model of % mature asci and this clinical measurement of % spores trapped during rains, only. However, in several years, such as 1991, 1995 and 1996, successful captures during rains have lagged considerably behind the mature ascus model. 1993 and 1997 were noteworthy for heavy spore amounts trapped during rains early in the season. In 1994 captures began in agreement with the mature ascus model, but lagged in the middle of the season with a very significant spore shower occurring later. In 2 of the 8 years (1995 and 1996) successful initial captures lagged considerably behind the mature ascus model but were characterized by larger than expected later season spore captures. 1997 was the longest season of captures. Significant captures (11% of seasonal total) were made at 1/4" budswell to 3/8" grentip (2/16) and continued as late as 1418C degree days later (3% of seasonal total on 6/3) (Figures 1 & 2).

Except when significant spore capture was not accompanied by a Mills Table wetting event sufficient to result in infections, disease observations in the orchards during these years suggested these capture differences were real happenings in the sense of the disease cycle. However, any ascospores not discharged because of lack of rainfall or discharged during dew periods escaped detection in these clinical studies and could be an unknown factor contributing to the perceived lags in capture compared with spore maturation predicted by the mature ascus model. Spotts and Cervantes suggest about 50% of ascospores may be released during dew periods at Hood River, for example.
Figure 1

Spores Captured vs Degree Days

1989 - 1992

% Ascospores Captured

% Mature Asci

Spotts & Cervantes

1994

+ 1989

0 1990

. 1991

X 1992

0 200 400 600 800 1000 1200 1400

Degree Days, °C

Figure 2

Spores Captured vs Degree Days

1993 - 1997

% Ascospores Captured

% Mature Asci

Spotts & Cervantes

1994

+ 1993

0 1994

. 1995

X 1996

V 1997

0 200 400 600 800 1000 1200 1400

Degree Days, °C