PROGRESS REPORT (FINAL REPORT)

TITLE: Biology and Management of Pear Pests

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FUNDING HISTORY:
1998-1999 $29,950
1999-2000 $32,240
2000-2001 $34,534

SIGNIFICANT FINDINGS:

1998-2000

- SURROUND applied at delayed dormant stage caused reduced egg-laying and numbers of 1st generation psylla relative to Superior oil (1%) applications made at the same time;
- Reductions in mowing frequency resulted in substantial increases in densities of natural enemies in the ground cover, and in densities of a subset of natural enemies (spiders, parasitoids) in the pear tree;
- Reductions in mowing frequency resulted in higher densities of spider mite in the ground cover and in the pear tree;
- Leafroller larvae were less susceptible to residues of CONFIRM or INTREPID under short-day (diapause causing) conditions that long-day (continued development) conditions;
- ESTEEM and DIMILIN had sublethal effects on pear psylla. Nymphs that survived treatment molted into adults that had reduced fecundity and longevity relative to untreated controls.
- Showed that willow, poplar, oak, cottonwood, and bitterbrush growing adjacent to pear and apple orchards of central Washington are important sources of several predators of pear psylla, including *Anthocoris antevolens*, *A. tomentosus*, and *Deraeocoris brevis*.

2000-2001

- Began to assay NOVALURON, a chitin synthesis inhibitor, against pear psylla. Preliminary trials indicated a higher level of activity against psylla nymphs than a related product, DIMILIN;
- Showed that a pre-bloom program of SURROUND followed by ESTEEM provided good control of first generation psylla. However, it was not clear from this study as to the extent that ESTEEM improved control over that provided by SURROUND alone;
- Tested whether mowing frequency affected natural enemy impact on pests in pear orchards. Showed no statistical effects on parasitism of pear psylla, parasitism of codling moth, parasitism of leafminer, host-feeding on leafminer, and predation of codling moth. However, each of these trials was restricted to a very small time frame during the summer, and the studies will be repeated next summer to include a wider range of time intervals;
- Took soil samples at monthly intervals from each mowing treatment to determine the effects of mowing frequency on densities and taxonomic composition of soil arthropods (which are likely to

be good alternative prey for several predatory insects or spiders associated with the orchard floor). The material is still being processed;

- Cardboard bands to collect overwintering predators were placed in each mowing treatment to determine effects of mowing on overwintering densities of natural enemies. Bands will be removed from the field in January 2001;

- Set-up plots to compare insect densities and taxonomic composition among 30 types of cover crops (seed donated by Pro-Gene). Nine of these cover crops are winter annuals, and have already been seeded (mid-October 2000).

RESULTS:

Product development personnel at Uniroyal Chemical asked me to assay a chitin synthesis inhibitor (NOVALURON) against pear psylla. Preliminary work with this product suggests that it has more activity against psylla nymphs than a similar product, DIMILIN (Figure 1). Studies are ongoing.

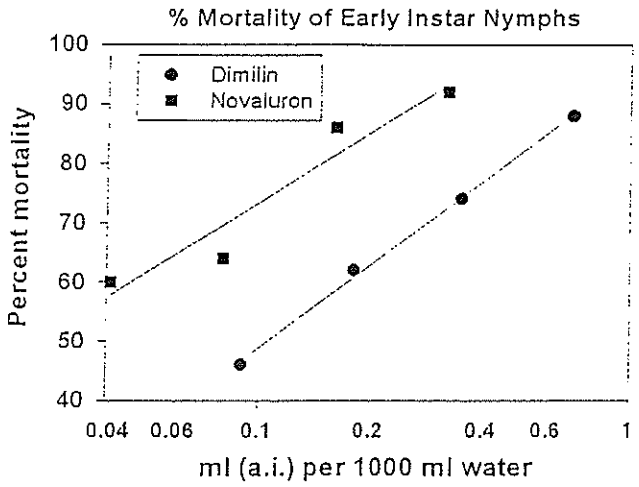

Figure 1. Percent mortality of early instar psylla nymphs topically treated with the insect growth regulators DIMILIN or NOVALURON.

Objectives were to compare several pre-bloom programs (combinations of Superior oil, SURROUND, and insect growth regulators) for controlling 1st generation pear psylla. The project was conducted using an experimental orchard (5 year-old trees) at Moxee. The 7 programs are summarized in Table 1.

Table 1. Pre-bloom programs compared in spring 2000 for pear psylla program.

Program	Delayed dormant	Clusterbud
(1)	Oil + DIMILIN	Oil
(2)	Oil	Oil + DIMILIN
(3)	SURROUND	Oil + DIMILIN
(4)	Oil + ESTEEM	Oil
(5)	Oil	Oil + ESTEEM
(6)	SURROUND	Oil + ESTEEM
(7) Control	Oil	Oil

Rates: Superior oil (1%); DIMILIN (25 WP) at 0.8 g per liter water; ESTEEM at 0.25 ml of product per liter of water; SURROUND at recommended rate.

Trees were sprayed to drip. Densities of psylla nymphs were obtained on 2 dates. Foliage was collected on 2 dates, and taken to the laboratory to monitor egg hatch.

Psylla densities. Nymphal densities were highest in control leaves and lowest in trees receiving SURROUND (Tables 2-5). Because of the experimental design, it was not clear whether the growth regulators provided control beyond that provided by the SURROUND (but see data on egg hatch rates, below). SURROUND provided better reductions in egglaying than provided by the oil treatment. ESTEEM provided slightly better reductions in nymphal densities if applied at the clusterbud stage rather than delayed dormant stage (Table 2).

Table 2. Number of pear psylla eggs and nymphs on April 24, 2000 (ESTEEM results). Densities expressed as numbers per fruiting cluster. *, differs from oil control.

Product applied			
Delayed dormant	Clusterbud	Eggs	Nymphs
Oil	Oil	168.2	65.8
Oil+ESTEEM	Oil	91.1*	37.4*
Oil	Oil+ESTEEM	29.8*	15.2*
SURROUND	Oil+ESTEEM	16.4*	0.6*

Table 3. Number of pear psylla eggs and nymphs on April 24, 2000 (DIMILIN results). Densities expressed as numbers per fruiting cluster. *, differs from oil control.

Product applied		Eggs	Nymphs
Delayed dormant	Clusterbud		
Oil	Oil	168.2	65.8
Oil+DIMILIN	Oil	31.9*	25.8*
Oil	Oil+DIMILIN	36.3*	22.4*
SURROUND	Oil+DIMILIN	2.9*	4.3*

Table 4. Number of pear psylla nymphs on May 8, 2000 (ESTEEM results). Densities expressed as numbers per leaf. *, differs from oil control. Egg densities low in all treatments.

Product applied		Nymphs
Delayed dormant	Clusterbud	
Oil	Oil	2.4
Oil+ESTEEM	Oil	3.0
Oil	Oil+ESTEEM	2.1
SURROUND	Oil+ESTEEM	0.07*

Table 5. Number of pear psylla nymphs on May 8, 2000 (DIMILIN results). Densities expressed as numbers per leaf. *, differs from oil control. Egg densities low in all treatments.

Product applied		Nymphs
Delayed dormant	Clusterbud	
Oil	Oil	2.4
Oil+DIMILIN	Oil	2.2
Oil	Oil+DIMILIN	1.2*
SURROUND	Oil+DIMILIN	0.13*

Egg hatch. ESTEEM and DIMILIN caused significant egg mortality up to 10 days following a delayed dormant application (Table 6). Effects were much less noticeable for eggs collected following the clusterbud application, most likely because eggs tended to have been deposited on newly expanded (hence untreated) foliage.

Table 6. Effects of ESTEEM and DIMILIN on hatch rate of pear psylla eggs. *, differs from oil control

Product	Date pear shoots collected	
	10 days following delayed dormant application	14 days following clusterbud application
Oil	124/155 eggs = 80% hatch	227/255 eggs = 89% hatch
DIMILIN (+ 1% oil)	87/154 eggs = 57% hatch*	261/288 eggs = 91% hatch
ESTEEM (+ 1% oil)	72/145 eggs = 50% hatch*	390/497 eggs = 79% hatch*

In the two previous years I showed that densities of natural enemies in the orchard were higher in plots that were mowed once per summer or once per month than in plots mowed regularly every 10 to 14 days. These data did not address whether the density increases translated into impact on pests. I tested whether parasitism rates of western tentiform leafminer, pear psylla, and codling moth varied with mowing treatment. I also tested whether predation rates of codling moth depended upon mowing treatment, and whether host feeding (by the parasitoid) on leafminer larvae varied with treatment.

As in previous years, the study was conducted at 3 orchards, with each orchard having 3 replications of each mowing treatment. The mowing treatments were: mowed once in early summer; mowed at monthly intervals; mowed every 10 to 14 days (= "regular mowing").

Leafminer parasitism and mortality caused by host-feeding. Mined leaves (100 per plot) were collected from each plot at the Moxee site on each of 2 dates in July. Leaves were taken to the laboratory, and mines were dissected. Leafminers were categorized as to feeding stage (sap feeder; tissue feeder). I recorded % of mines in which the leafminer was healthy, parasitized, dead due to host feeding by the parasite, or dead of unknown causes. There was a weak (but non-significant) suggestion in 3 of 4 samples that parasitism rates were higher in the least frequently mowed plots than in the regularly mowed plots (Table 7: see results for tissue feeders on both dates and data for sap feeders in the July 17 sample). Mortality rates exceeded 80% in all plots for the late July sample. Parasitism rates were higher for tissue feeders than sap feeders, whereas death due to host-feeding occurred most frequently for the sap feeders (Table 7). This study will be repeated in summer 2001 at the Moxee site.

Table 7. Effects of mowing frequency on mortality (parasitism, host-feeding, or unknown) of western tentiform leafminer on two sample dates; Moxee.

	Tissue feeders				Sap feeders			
Mowing freq.	Healthy	Host-fed	Dead (misc.)	Parasitized	Healthy	Host-fed	Dead (misc.)	Parasitized
				July 17 sample				
Regular	25.0	5.0	23.5	46.5	34.5	39.7	21.9	3.9
Monthly	23.6	9.1	27.1	40.3	42.7	40.5	15.4	4.7
Once	18.9	5.8	19.2	56.0	25.3	42.2	24.0	8.5
				July 28 sample				
Regular	7.7	6.7	22.7	63.0	2.2	59.0	15.6	23.2
Monthly	15.2	4.0	23.0	57.8	5.6	56.5	16.5	21.5
Once	9.7	4.6	14.7	71.0	5.9	54.6	18.7	20.9

Pear psylla parasitism. Psylla-infested shoots were collected in July from each plot at the Moxee site. At the laboratory, 100 third instar nymphs were randomly collected from each plot sample, and the nymphs dissected for presence of the parasitoid. Parasitism rates were not affected by mowing regime: regular mowing (12.3% parasitism); monthly mowing (14.7%); once-mowed (13.7%). This study will be repeated in summer 2001, but will involve sampling on more dates than done this year.

Codling moth parasitism and predation. Sentinel strips - - each containing a known number of diapausing codling moth larvae - - were placed in each plot at each orchard on two dates (mid-July; mid-September). Strips were stapled to the tree trunk approximately 1 foot above the ground. The sentinel strips were collected from the field 1 week (July study) or 2 weeks (September study) after having been placed in the field. In the laboratory, the strips were pulled apart, and I recorded percent of larvae that were alive and unparasitized, parasitized, or missing (and presumed attacked by a predator; based upon laboratory observations, there was very little voluntary movement from the strips by spun-up larvae).

Disappearance rates of larvae from strips tended to be higher in the July study than the September study (Table 8). Very little disappearance from strips occurred in the September study at the Hood River and Peshastin sites. The only non-trivial parasitism rates occurred at Moxee in the September study, averaging about 7%. Mowing frequency had no effect on disappearance rates or parasitism rates (Table 8). This study will be repeated at the Moxee site in summer 2001, but will be expanded to include some early-season sampling dates. The study in September (which did show some parasitism) was conducted well after most flowering plants had become senescent, thus the absence of mowing effects may have been expected.

Table 8. Effects of mowing frequency on percent of codling moth larvae (in sentinel strips) that were recovered alive, were not recovered, or were parasitized.

Mowing freq.	Hood River			Peshastin			Moxee		
	Alive	Missing	Parasit.	Alive	Missing	Parasit.	Alive	Missing	Parasit.
Mid-July study									
Regular	75.5	24.5	0	60.0	40.0	0	79.4	20.6	0
Monthly	67.3	32.7	0	56.4	43.6	0	81.5	18.5	0
Once	66.0	34.0	0	44.3	55.7	0	81.7	18.3	0
Mid-September study									
Regular	97.9	2.1	0	97.0	2.4	0.6	69.7	23.1	7.2
Monthly	96.5	3.2	0.3	95.5	4.5	0	71.5	20.2	8.3
Once	97.9	1.8	0.3	96.5	3.5	0	75.3	19.7	5.0

Soil samples were taken in each plot of the mowing study at all 3 orchards at approximately monthly intervals. Samples were placed in Berlese funnels to extract the arthropods. We are currently processing the material.

Cardboard bands were placed around the trunks of trees in each mowing treatment to determine the effects of mowing regime on densities of overwintering predators. Bands will be removed from the field in January 2001.

The cover crop study is ongoing. Nine of the cover crops to be studied are winter annuals (and require seeding in fall); these 9 crops were planted in October of this year, and included 4 types of pea, 2 varieties of *Triticale*, 2 varieties of wheat, and a winter vetch. The remaining 21 cover crops will be planted in spring 2001. Beginning in summer 2001, crops will be sampled at regular intervals to determine the types and numbers of pest and beneficial arthropods associating with the different crops.

PUBLICATIONS:

Peer-reviewed journals

Horton, D.R., et al. 1998. Photoperiod and reproductive diapause in the predatory bugs *Anthocoris tomentosus*, *A. antevolens*, *Deraeocoris brevis* (Heteroptera: Anthocoridae, Miridae) with information on overwintering sex ratios. Ann. Entomol. Soc. Am. 91: 81-86.

Horton, D.R., et al. 1998. Ovarian development in overwintering pear psylla, *Cacopsylla pyricola* (Homoptera: Psyllidae): seasonality and effects of photoperiod. Can. Entomol. 130: 859-867.

Lee, R.E., Jr., J.D. Litzgus, J.A. Mugnano, M.R. Lee, D.R. Horton, and J. Dunley. 1999. Evaluation of ice-nucleating microorganisms for reducing the supercooling capacity and cold-hardiness of *Cacopsylla pyricola* (Hemiptera: Psyllidae). Can. Entomol. 131: 715-723.

Horton, D.R. and T.M. Lewis. 2000. Seasonal distribution of *Anthocoris* spp. and *Deraeocoris brevis* (Heteroptera: Anthocoridae, Miridae) in orchard and non-orchard habitats of central Washington. Ann. Entomol. Soc. Am. 93: 476-485.

Horton, D.R. et al. 2000. Mating preference, mating propensity, and reproductive traits in *Anthocoris nemoralis* (Heteroptera: Anthocoridae): a comparison of California and United Kingdom populations. Ann. Entomol. Soc. Am. 93: 663-672.

Trade Journals, Proceedings, and Formal Presentations

Horton, D.R. 1998. Effects of mowing frequency on ground cover insects. Proc. Wash. St. Hort. Assoc. 94: 144-147.

Horton, D.R. et al. 1998. Use of new kaolin product to prevent egg-laying by overwintered pear psylla. Poster presented at 94th Annual Meeting of Wash. St. Hort. Assoc.

Horton, D.R. 2000. Natural enemies in orchards: topics for research. Good Fruit Grower 51 (#12): 17-18.

Horton, D.R. 2000. Know when to mow. Western Fruit Grower 120 (#6): 20D-20H.

Horton, D.R. 2000. Habitat management to enhance biological control in orchards? Presentation to Annual Tilth Producers - Integrated Fertility Management Conference. Chelan, Washington.

Horton, D.R. 2000. Orchard floor management for beneficial insects. Presentation at Integrated Fruit Production Workshop, Hood River, Oregon.

Field-days

Field days were held to demonstrate mowing experiment in August 1999 (Peshastin), August 2000 (Peshastin), and March 2000 (Hood River)