Problems with chemical control of pear psylla

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Ever since the pear psylla, *Psylla pyricola* Foerster, spread from the Pacific Northwest into northern California in the mid-1950s, California pear growers have had to contend with this pest. Its most dramatic impact on the pear industry was as the vector of pear decline. Although the seriousness of this disease has now lessened with the use of decline-tolerant or resistant root stocks, pear psylla is still of great concern, because feeding by the immatures, or nymphs, can seriously affect tree vigor, yield, and fruit quality.

Natural enemies of the pear psylla in California usually do not provide the level of control necessary for commercial production. Growers therefore, rely heavily on chemicals and apply several sprays annually for its control. High pesticide use has placed great selective pressure on psylla populations, which have developed resistance, causing chemical compounds or groups of compounds to lose their effectiveness. The pattern of chemical use and subsequent resistance development has been very similar in pear-producing regions of California, Oregon and Washington.

Chemical control

In California, insecticide applications to control pear psylla are made during two distinct times: the prebloom and the foliar periods. Organophosphates, such as malathion, parathion, Trithion, and Ethion, the first insecticides to be used for summer (foliar) control, became ineffective in the early 1960s after only five to six years of use. Azinphosmethyl combined with light petroleum oils provided acceptable control for nearly 14 years, until 1975, but in Washington and Oregon, where this insecticide was generally applied without oil, resistance developed after four to five years.

The cyclodiens aldrin and dieldrin, the first compounds used during the prebloom period, were effective for six years until 1967. In Washington, where the chlorinated hydrocarbon Perthane (no longer commercially available) was intensively used for prebloom and foliar sprays, control failures became evident after eight years.

Dormant oils for control of overwintering adults were introduced in 1970 and have since become a standard treatment. Fenvalerate—the only pyrethroid presently registered as a prebloom spray—has now taken the place of Perthane for this timing.

Chlordimeform was used as an alternative to summer sprays of azinphosmethyl plus oil between 1970 and 1976, when it was withdrawn from the market because of environmental and health concerns. Amitraz and light petroleum oils are the only effective materials now available for summer use. Because of a conditional registration, it is uncertain whether amitraz will be available beyond 1984. None of the pyrethroids tested against pear psylla have been given a label for use during the foliar period.

Why does the pear psylla develop resistance so quickly? This insect feeds and reproduces only on pear, has no wild hosts in California, does not disperse widely, has a high fecundity, and produces several generations per year. These features, coupled with the intensive insecticide use to which pear psylla is exposed annually in commercial orchards, are responsible for the resistance development and control failures over the years.

Pyrethroid use on pears

Pyrethroids as a group have shown great promise as broad-spectrum insecticides against key pests on pears. Field tests with the pyrethroid fenvalerate were conducted in a pear orchard at the University of California Deciduous Fruit Field Station in San Jose in 1977 and 1978. The codling moth, *Laspeyresia pomonella* L. proved to be very susceptible to this material.

Fenvalerate was also very effective against pear psylla. A prebloom plus two cover sprays at 0.05 and 0.1 pound active ingredient (a.i.) per 100 gallons adequately suppressed psylla populations. The same program at a lower rate (0.025 pound) or two sprays (a delayed dormant plus a first cover at 0.1 pound a.i. per 100 gallons) provided only marginal control. A single prebloom spray is usually not adequate for full season control.

In all these tests, however, large spider mite populations developed after foliar applications of fenvalerate. These buildups were often heavier on foliage treated with lower rates of fenvalerate, because higher field rates apparently had a temporary acaricidal effect. Subsequent experiments suggested that spider mite buildup was correlated with the amount of foliage present at the time of application. For instance, sprays applied before bloom caused no disruptions, but sprays during April, May, and June, when foliage was present, increased spider mite populations. Phytoseiid mites, important predators of spider mites, were virtually absent on foliage treated with fenvalerate. Laboratory assays confirmed that leaf residues of fenvalerate remained highly toxic to predatory mites for many weeks, thus preventing biological control of plant-feeding mites.

The aim of field trials in 1979 was to determine the optimal use pattern for two pyrethroids, to take advantage of their efficacy against the codling moth and pear psylla but minimize their disruptive effects (table 1). Fenvalerate sprays at 0.05 pound a.i. per 100 gallons, alone or when alternated with azinphosmethyl, controlled psylla for the full season. Surprisingly, psylla suppression by the permethrin program was temporary: a resurgence was noted two weeks after harvest. Psylla was still effectively controlled by an azinphosmethyl and oil program in this orchard, since this insecticide was sparingly used in this location in previous years.

All programs resulted in acceptable codling moth control. Treatments where the first or second cover spray was a pyrethroid were disruptive and caused mite buildups. Fenvalerate or permethrin applied once as a third cover spray at the beginning of July after an azinphosmethyl and oil program did not appear to induce mites. Pear rust mites and percent fruit russet were considerably lower in the treatments using oil. Neither fenvalerate nor permethrin affected rust mites.

Resistance development

Experience with other compounds that once controlled pear psylla suggests that resistance to pyrethroids is likely to develop, as it is to any other new insecticide. How quickly this can happen when selection is intensive was demonstrated in Oregon.

The Oregon study was conducted in a 2.5-hectare (6.2-acre) pear orchard that had been used since 1976 for experimental evalua-

TABLE 1. Evaluation of Insecticides in Seasonal Control Programs Against Pear Psylla, Codling Moth, and Plant-feeding Mites on Bartlett Pears, San Jose, California, 1979

Treatments*					Pear psylla eggs and nymphs per 10 leaves†		Codling moth infested fruit	Spider mites§	Pear rust mites	
Delayed dormant	Cluster bud	First cover	Second cover	Third cover					Mites/ leaf	Fruit russet
Mar 2	Mar 28	May 7	Jun 7	Jul 11	Jul 3	Aug 29	Aug 14†‡	Aug 29†	Aug 1†	Aug 14†‡
							%			%
0	0	Az + 0	Az + 0	Az + 0	0.3 b	0.1 b	1.0 b	0.1	30 bc	15.1 b
0	0	Az + 0	Az + 0	Fen	—	0.1 b	0.6 b	0.3 c	23 c	21.6 b
0	0	Az + 0	Az + 0	Per	—	2.2 b	1.0 b	0.1 c	28 bc	17.1 b
Fen	—	Fen	Fen	—	0 b	0 b	0.4 b	21.6 ab	246 a	62.3 a
Fen	—	Az + 0	Fen	Fen	0 b	0 b	0 b	23.4 a	194 a	55.9 a
Per	—	Per	Per	—	0.5 b	17.8 a	0 b	7.7 bc	164 a	74.4 a
Per	—	Az + 0	Per	Per	0.3 b	12.9 a	0 b	11.0 ab	164 a	69.5 a
Untreated check		—	—	—	5.1 a	9.1 a	30.6 a	0.1 c	73 b	57.7 a

*Rates are in pounds active ingredient or gallons per 100 gallons water:
0 = supreme oil, 2.5 gallons.
Az + 0 = azinphosmethyl 50W, 0.25 pound + supreme oil, 1 gallon.
Fen = fenvalerate, 2.4 EC, 0.05 pound.
Per = permethrin 3.2 EC, 0.05 pound.
†Means in each column followed by the same letter are not significantly different according to Duncan's Multiple Range Test at P = 0.05.
‡Harvest date.
§European red and two-spotted mites (all stages), per leaf.

tion of pyrethroids to suppress codling moth and psylla. Entering the 1980 season, the orchard had received about 10 sprays of fenvalerate used at an average dose of 0.05 pound a.i. per 100 gallons. In 1980 the block was treated once in the prebloom period and subsequently with three summer fenvalerate sprays. The first two summer treatments at 0.05 pound failed to provide psylla control and in early July were followed with an application containing 0.1 pound a.i., per 100 gallons. This treatment also did not give commercially adequate psylla control. Two weeks after the third fenvalerate spray, the orchard was divided into subplots, and various plots were retreated with several rates of fenvalerate, permethrin, and amitraz (table 2). Trees were sprayed until runoff with a conventional high-pressure handgun.

Relatively high numbers of pear psylla were present before treatment, despite three previous fenvalerate sprays. After treatment, numbers of adults receiving pyrethroid sprays increased or remained about the same, except at the 0.2 pound rate, which reduced the adult population by about 30 percent. Adults were reduced 90 percent over the same seven-day period after the amitraz treatment.

Nymph densities seven days after treatment were highly variable and showed little relation to pyrethroid rate. Density increased when fenvalerate was used at 0.1 pound a.i. per 100 gallons, but decreased at the lower rate. A 65 percent reduction in nymphal levels seven days after treatment was noted in the check trees, probably due to predation. Permethrin, the other pyrethroid in this field test also failed to provide control.

To measure susceptibility of psylla to fenvalerate in the laboratory, psylla adults were collected from the orchard with suspected pyrethroid resistance and from an orchard used as a control. The control orchard had previously received only dormant-season fenvalerate treatments in 1978-79 and had been left untreated in 1980. Psylla-free pear shoots were dipped into solutions containing various rates of fenvalerate, allowed to dry, and placed in water-filled metal containers. After 24 hours, psylla adults were caged with the shoots, and 48 hours later, mortality in each treatment was recorded.

The laboratory tests appeared to confirm the results from the field (table 3). Psylla

TABLE 2. Control of Pear Psylla with Insecticides, Thorniley Orchard, Medford, Oregon, Treated July 21, 1980

Material and rate (lb a.i./100 gal)	Adults/10 taps: Pre-treatment	Adults/10 taps: Days post-treatment 2	Adults/10 taps: Days post-treatment 7	Nymphs/10 leaves: Pre-treatment	Nymphs/10 leaves: Days post-treatment 2	Nymphs/10 leaves: Days post-treatment 7
Pyrethroids:						
Fenvalerate 2.4 EC, 0.025	28	28	86	68	34	20
Fenvalerate 2.4 EC, 0.10	28	20	37	13	58	35
Fenvalerate 2.4 EC, 0.20	34	33	23	26	36	26
Permethrin 3.2 EC, 0.10	23	45	53	42	72	78
Amitraz 1.5 EC, 0.38	90	53	9	25	6	7
Untreated check	100	142	98	95	59	33

TABLE 3. Survival of Pear Psylla Adults from Two Orchards in Laboratory Cage Tests on Pear Shoots Treated with Fenvalerate, Medford, Oregon, July 29, 1980

Fenvalerate rate*	Origin of psylla adults†	Mortality at 48 hr‡
		%
0.025	Thorniley (R)	42.9 b
0.10	Thorniley (R)	50.0 b
0.20	Thorniley (R)	57.1 b
0.025	Central Point (S)	100.0 a
0.10	Central Point (S)	100.0 a
Untreated check	Thorniley and Central Point	14.0 c

*Pounds active ingredient of fenvalerate 2.4 EC per 100 gallons water.
†R = resistant; S = susceptible.
‡Means followed by the same letter are not significantly different according to Duncan's multiple range test at P = 0.05.

Johannes Joos

Honeydew droplets produced by pear psylla nymphs on underside of leaf.

mortality 48 hours after release onto fenvalerate-treated shoots averaged 50 percent for adults collected from the intensively treated orchard (Thorniley), compared with 100 percent for adults from the control orchard (Central Point). There was no significant difference in adult mortality between the rates of 0.025 and 0.2 pound a.i. per 100 gallons.

The results show that the pear psylla has developed resistance to the pyrethroid fenvalerate following intense selective pressure with this chemical over a four-year period. The single field test using permethrin indicates that cross-resistance to other pyrethroids may be expected to accompany development of resistance to fenvalerate. Finally, the degree of resistance measured appeared quite high, with rates of 0.2 pound a.i. per 100 gallons reducing adult levels by only 50 percent. This dosage is four to eight times that found effective on pear psylla in previous years in this location.

Strategy for pyrethroid use

In view of the disruptive effects of pyrethroids and the demonstrated ability of the pear psylla to quickly develop resistance to these compounds if intensively used, the pattern of using pyrethroids in pear orchards should be reevaluated. Fenvalerate and other candidate pyrethroids are desirable, because they provide good control of major pear pests in the prebloom, foliar, and postharvest period. However, foliar use of these compounds can be disruptive, resulting often in explosive outbreaks of spider mites. In addition, intensive use of pyrethroids in multiple spray programs can accelerate development of resistance in the pear psylla. Therefore, it may be necessary to limit pyrethroid use to minimize problems associated with full-season applications.

Jack Kelly Clark

Fifth-stage pear psylla nymph.

Several tactics can be suggested. With other chemical groups available for summer control of pear psylla and the codling moth, pyrethroid applications can be restricted to the prebloom program for psylla control. Pyrethroid use can be further reduced by applying prebloom sprays only when psylla populations have exceeded economic threshold levels, indicating a need for control. A cooperative project between California, Oregon, and Washington has been initiated to develop this information. The early-season control program for pear psylla should allow late spring immigration of untreated psylla adults, thus ensuring a source of potentially pyrethroid-susceptible individuals.

Jack Kelly Clark

Pear psylla adult.

Alternating chemicals with a different mode of action for control of pear psylla and the codling moth may also be beneficial. Experience with azinphosmethyl has shown that light superior petroleum oils can prolong the usefulness of an insecticide. This may also apply to pyrethroids.

The number of chemical compounds being developed for pest control has generally declined in recent years. The pear psylla is one case where insecticides that are being lost because of resistance outnumber those being developed. Although we admittedly lack practical experience with a general approach to "managing" resistance in the pear psylla, it is hoped that the tactics suggested here for pyrethroids will prolong the usefulness of these compounds by delaying resistance development.

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