EFFICACY OF PESTICIDES ON THE WESTERN SPOTTED TENTIFORM LEAFMINER (LEPIDOPTERA:GRACILLARIIDAE) IN THE PACIFIC NORTHWEST

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ABSTRACT

A serious infestation of the western spotted tentiform leafminer, *Phyllonorycter elmaella* Doganlar and Mutuura, was discovered in a commercial apple orchard in southeastern Washington in 1980. By 1983, the insect was found in many orchards in Washington, northern Oregon, and parts of Idaho on the foliage of apple, cherry, pear, and prune trees. A number of insecticides were tested against the leafminer in the Kennewick, Pasco, Prosser, and Moxee areas of Washington during 1983 and 1984. In one orchard, early season control was best with oxamyl, permethrin, cypermethrin and diflubenzuron. In another orchard, oxamyl, endosulfan at pink stage, an endosulfan-methoxychlor mix applied in mid-June and fenvalerate applied in April were all highly effective in controlling leafminers. Diflubenzuron, permethrin, chlorpyrifos, and FMC 54800, all controlled leafminers. Aldicarb, a systemic insecticide, provided good control. Efficacy tests show that with proper timing, many materials effectively reduce leafminer populations.

INTRODUCTION

During 1980-84, gracillarid leafminer infestations in commercial apple, cherry, pear, and prune orchards were reported from Washington, northern Oregon, and Idaho fruit growing regions. In 1980, D. R. Davis[2], and D. M. Weisman[3] identified the leafminer species found in Washington State as *Phyllonorycter elmaella* Doganlar and Mutuura. Since 1980, *P. elmaella*, the western spotted tentiform leafminer (WSTLM) has reached outbreak numbers in some areas of the Pacific Northwest.

Doganlar and Mutuura (1980) found *P. elmaella* on unsprayed apple in 1976 and 1977 in the Vancouver, B.C. area. They stated that this was the same species recorded by Pottinger and LeRoux (1971) on apple in Oregon. A. F. Allred (unpublished data) found *P. elmaella* infesting leaves in Utah orchards in 1977. Don Davis (unpublished data) tentatively identified the leafminer from the Provo area of Utah as *P. elmaella*. He also found that many leafminer populations in apple orchards in Utah were high for four seasons in a row, then declined.

In eastern North America, severe tentiform leafminer infestations debilitate trees in several ways: by causing premature leaf fall, fruit ripening and fruit drop, reduced terminal growth and fruit size, and reduced fruit set for the following year (Kremer 1963, Pottinger and LeRoux 1971).

Reissig *et al* (1982) quantitatively measured the effects of the apple-blotch leafminer, *Phyllonorycter (Lithocolletis) crataegella* (Clements), on McIntosh apple in New York, where more than two mines per leaf caused premature fruit drop during the current season and reduced fruit set and production in the following season. They also found that the spotted tentiform leafminer, (STLM) (*P. blancardella* (F.), had little effect on growth or production of Idared or Rome Beauty cultivars during the first year of infestation, but reduced fruit set and production the following year. They stated that second generation larvae caused more damage than the first generation larvae.

At present, we know very little about the effect of WSTLM infestations on tree growth and fruit production in the Pacific Northwest. In Washington, we have observed an average of nine mines per leaf on Red Delicious and Criterion apple at mid-season, and as many as 25 mines per leaf at the end of the growing season. A tentative economic threshold for Red Delicious in Washington is three mines per leaf during June-July.

In Washington, growers apply a variety of insecticides for WSTLM, particularly in the post bloom period, but such treatments may well lead to increases in pest mite populations. The objectives of the study reported in this paper were to determine the efficacy of and timing for several insecticides for WSTLM and to monitor their effects on mite populations.

MATERIALS AND METHODS

1983 Experiments

In 1983, we evaluated 10 foliar and five systemic pesticides for control of WSTLM populations. We

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used plots at three sites. One plot was established near Kennewick, WA, in an orchard with 7-year-old Criterion apple trees in a 3.0 x 6.1 m spacing. A second test block, established near Prosser, WA, was in an orchard with 4-year-old Red Delicious apple trees in a 3.0 x 5.5 m spacing. A third test block was established near Pasco, WA, in an orchard with 4-year-old Red Delicious apple trees in a 3.0 x 5.5 m spacing. All orchards were irrigated by sprinkler and had grass cover crops. The infestation of WSTLM varied from 2-15 mines per leaf when evaluated in the fall of 1982. Foliar applications were tested at Kennewick and Prosser; plot size ranged from 0.2 to 0.8 ha and insecticides were applied with an airblast sprayer at "pink stage", in mid June or at both times. Systemic materials were evaluated at Pasco; replicated plots composed of 5 trees were used and the systemic insecticides were applied to the soil during late May.

In the test plots we evaluated populations of WSTLM, active stages of apple rust mite, (*Aculus schlectendali* Nalepa), European red mite, (*Panonychus ulmi* Koch), McDaniel spider mite, (*Tetranychus mcdanieli* McGregor), and the western orchard predator mite, (*Typhlodromus occidentalis* Nesbitt). During the season at Kennewick and Prosser, 10 leaves were collected weekly or biweekly at random from fruiting clusters from each of the same 10 trees at the center of each plot. At Pasco, leaves from the fruiting cluster were randomly collected from the center tree in each plot. Individual leaves were examined under a dissecting microscope.

For insecticide efficacy studies, the total number of mines per leaf was counted. Also, on each leaf we counted the total number of active stages of the mite species mentioned above.

At Kennewick, "pink stage" applications were applied March 31 and the post-bloom applications on June 4. In all applications, 2.377 kl/ha of water was applied. Materials, rates and timing are given in Table 1. At Prosser, applications at "pink stage" were applied on April 6 using 0.561 kl/ha of water. Applications at "post-bloom" were applied on June 17 using 0.935 kl/ha of water. In addition, aldicarb was broadcast within the dripline around individual trees, worked into the soil, and water applied. Materials, rates, and timing are given in Table 2. At Pasco, systemic pesticides were applied to the soil during late May. Aldicarb was broadcast in a 1.4 m band, .152 m from the tree on both sides of the row and rototilled 0.76 m deep; carbofuran was broadcast and ethoprop was sprayed in a .92 m band, .152 m from the tree on both sides of the row and rototilled; phenamiphos was sprayed in a .152 m continuous band in the row; oxamyl was sprayed in two 2.5 m bands at 1.22 m from the tree on both sides. Rates are given in Table 3.

TABLE 1. Mean number of WSTLM miners per leaf in plots after foliar applications, sampled on two dates. Kennewick, WA, 1983.

Material[1]	Applied	Rate (kg AI/ha	Sampling Dates 7/8	Sampling Dates 10/14
Check	--	--	3.2 a	19.0 a
Oxamyl[2]	March	1.121	1.24 b	15.4 b
Carbosulfan	March	2.240	0.98 bc	12.1 c
	June	1.121		
Chlorpyrifos	March	1.680	0.8 bcd	6.6 d
Chlorpyrifos	June	1.680	0.7 bcd	6.0 de
Permethrin	March	0.225	0.4 de	4.0 f
Diflubenzuron	March & June	0.561	0.1 e	1.2 f
Methomyl	March & June	2.016	0.0 e	3.9 f
Cypermethrin	March & June	0.111	0.08 e	2.0 f
Oxamyl	June	1.121	0.03 e	4.9 d f
Oxamyl	March	1.121	0.02 e	2.5 f

1 Means within a column followed by the same letter are not significantly different (P = 0.05) DMRT.

2 Next to cherry orchard heavily infested with WSTLM.

TABLE 2. Mean number of WSTLM mines per leaf after foliar applications, sampled on two dates. Prosser, WA, 1983.

Material[1]	Applied	Rate (Kg AI/ha)	Sampling Dates 7/15	Sampling Dates 10/26
Check	--	--	1.9 a[1]	11.7 a
Formetanate	June	1.121	0.68 b	8.2 b
Chlorpyrifos	June	1.680	0.55 bc	7.5 b
Endosulfan	June	3.364	0.51 cd	5.6 c
Chlorpyrifos	April	1.680	0.44 cd	5.5 cd
Formetanate	April	1.121	0.36 d	5.4 cd
Chlorpyrifos	April & June	1.680	0.19 e	5.3 cde
Endosulfan	April	3.364	0.17 e	4.5 cdef
Oxamyl	April	1.121	0.15 e	4.0 ef
Formetanate	April & June	1.121	0.14 e	4.2 def
Fenvalerate	April	0.336	0.06 e	4.0 ef
Endosulfan	April & June	3.364	0.06 e	3.3 ef
Oxamyl	June	1.121	0.01 e	3.8 f
Aldicarb	April	4.486	--	1.4 f

[1] Means within a column followed by the same letter are not significantly different (P = 0.05) DMRT.

TABLE 3. Means numberof WSTLM mines per leaf in systemic insecticide plots, treated in late May and sampled on two dates. Pasco, WA, 1983.

Material[1]	Rate (kg AI/ha)	Sampling Dates 8/16	Sampling Dates 9/29
Ethoprop	13.457	0.16 a	1.42 a
Check	--	0.16 a	1.38 ab
Phenamiphos	22.428	0.14 ab	1.36 ab
Carbofuran	11.214	0.14 ab	1.20 abc
Phenamiphos	11.214	0.12 abc	1.26 abc
Ethoprop	6.728	0.12 abc	1.26 abc
Aldicarb	4.486	0.12 abc	1.06 abc
Oxamyl	11.214	0.10 abc	.98 bc
Ethoprop	10.092	0.10 abc	1.06 abc
Oxamyl	5.607	0.8 bc	1.00 bc
Aldicarb	8.972	0.04 c	.88 c
Ethoprop + Aldicarb	6.728 + 4.486	0.04 c	.96 bc

[1] Means within a column followed by the same letter are not significantly different (P = 0.05) DMRT.

1984 Experiment

In 1984, we evaluated five foliar insecticides at two application dates and one systemic pesticide at one site near Moxee. Plots were established in an orchard with 5-year-old Red Delicious apple trees in a 3.0 x 6.1 m spacing. Each plot consisted of 16 trees and each plot was replicated twice in a randomized complete block design. Foliar applications of insecticides were with a handgun to the point of runoff; "pink stage" applications were done in April and mid-summer. The systemic tested, aldicarb, was worked into the soil at four locations within the dripline of individual trees and was followed by water application. Populations of WSTLM and active stages of the mites listed above were evaluated by examining with a stereomicroscope, 10 leaves collected at random from fruiting clusters from each of the same four center trees per plot.

RESULTS AND DISCUSSION

Results of the insecticide tests are given in Tables 1 through 4. All materials provided some control of leafminer populations, especially during the June-July period, although there were significant differences in the treatments. At Kennewick, one of the two plots treated at "pink stage" with oxamyl, was adjacent to a cherry orchard heavily infested with WSTLM and adults apparently moved into our plot, resulting in the high infestation. In 1983, in general, applications at "pink stage" provided control as good as, or better than, applications in June and two applications were better than one. In 1984, insecticides, except for permethrin, applied at "pink stage" did not provide as good control as mid-summer applications and two insecticide applications were again better than one.

In the eastern USA, methomyl and oxamyl effectively control STLM *(P. blancardella* (F.)). But these carbamates can also precipitate spider mite outbreaks, be detrimental to predator mites and precipitate outbreaks of insects such as the woolly apple aphid (Leeper 1981). Baird and Homan (1983) state that methomyl may disrupt integrated mite control efforts. In 1983, in the plots at all three of our test sites, populations of all mite species were low and spider mites did not reach damaging levels.

TABLE 4. Mean number of WSTLM mines, European red mites (ERM), and McDaniel mites, (MCM) per leaf on September 13, 1984, Moxee, WA.

Material[1]	Applied	Rate (kg AI/ha	Mean No. Mines/Leaf	Mean No. ERM/Leaf	Mean No. MCM/Leaf
Check	--	--	2.2 a	0.2 a	0.04 a
Diflubenzuron	April	0.56	2.0 ab	0.2 a	0 a
Diflubenzuron	April	0.28	2.0 ab	0.3 a	0.06 a
Diflubenzuron	April	0.21	1.8 ab	0.2 a	0.01 a
FMC 54800	April	0.09	1.6 abc	0.4 a	0.08 a
Thiodicarb	July	0.84	1.3 abcd	0.6 a	0.01 a
Thiodicarb	April	0.84	1.1 abcd	0.6 a	0.08 a
Thiodicarb	April & July	0.84	0.9 abcd	0.6 a	0.01 a
Diflubenzuron	July	0.28	0.8 bcd	0.2 a	0 a
Diflubenzuron	April & July	0.56	0.7 bcd	0.6 a	0 a
Permethrin	April	0.225	0.7 bcd	0.3 a	0.6 b
Chlorpyrifos	July	1.680	0.6 bcd	4.1 ab	
Diflubenzuron	April & July	0.21	0.4 cd	0.3 a	0 a
Diflubenzuron	April & July	0.28	0.3 cd	1.6 a	0 a
Diflubenzuron	July	0.21	0.3 cd	0.4 a	0 a
Diflubenzuron	July	0.56	0.2 cd	1.1 a	0.09 a
FMC 54800	July	0.09	0.08 d	7.4 bc	0.2 ab
FMC 54800	April & July	0.09	0.05 d	10.5 c	1.3 c
Aldicarb	May	4.486	0.03 d	1.5 a	0.2 a

[1] Mean within a column followed by the same letter are not significantly different (P=0.05) DMRT.

However, in the fall of 1984, following the 1984 tests, populations of European red mites and McDaniel mites were significantly higher in plots treated during the summer with FMC 58400 than in the check.

We found the eulophid parasite, *Pnigalio maculipes* Crawford, parasitizing WSTLM larvae infesting apple and cherry leaves in central Washington. Weires *et al.* (1982) demonstrated that several insecticides used in eastern USA are toxic to a braconid, *Apanteles ornigis* Weed, which is a principal parasite of STLM. Dutcher and Howitt (1978) found parasitism by all eulophid parasites was significantly lower in all insecticide plots than in the control plots in Michigan apple orchards. During 1981-84 many Washington fruit growers applied various insecticides for control of WSTLM and these applications might have reduced parasite populations.

WSTLM may continue to spread and infest fruit growing areas of British Columbia which includes fairly large numbers of McIntosh apples. In eastern New York, McIntosh appears to be quite susceptible to leafminer damage (Reissig *et al.* 1982).

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