Table 2
Mean number of *Chaetosiphon fragaefolii* per strawberry leaf in six areas of a field. An asterisk indicates when means on the perimeter of field were significantly different from those of the central areas.

		Area of Field						
		Perimeter				Center		Total
Julian Day	Date	West	North	East	South	West	East	
125	May 5	0.0	0.05	0.0	0.0	0.0	0.0	0.01
151	May 31	0.16	0.10	0.16	0.10	0.16	0.16	0.14
156	June 6	0.05	0.22	0.16	0.05	0.34	0.22	0.17
189	July 8	2.50	2.10	2.10	1.40	0.54	0.50	1.42*
198	July 17	1.34	1.16	0.91	0.75	0.99	1.64	1.12
237	Aug 26	0.79	1.70	1.44	0.61	1.21	1.09	1.12

Toxicity of foliar residues of phosmet to the apple maggot, *Rhagoletis pomonella* (Diptera: Tephritidae)[1]

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ABSTRACT

Mortality of apple maggot (AM), *Rhagoletis pomonella* (Walsh), was determined in the laboratory on spray deposits of phosmet (Imidan®) applied to apple foliage and fruit at rates of 0.6 and 1.2 g active ingredient (AI)/liter (0.5 and 1 pound [AI]/100 gallons). Mortality of AM adults was 100% with both rates until 16 days post-treatment. Thereafter, mortality decreased inversely with time. Probit analysis revealed insecticide residual toxicity of 24 days for 95% mortality (ET_{95}) for both rates, and 51 and 55 days, respectively, for 50% mortality (ET_{50}) at 0.6 and 1.2 g (AI)/liter. The intercepts and slopes of probit regression were not significantly different for the two rates tested, indicating little difference between their persistence and efficacy against AM adults.

INTRODUCTION

The apple maggot (AM), *Rhagoletis pomonella* (Walsh), was first reported in the western United States near Portland, Oregon (AliNiazee and Penrose, 1981). It is now well established in six western states including Oregon, Washington, California, Idaho, Utah, and Colorado (AliNiazee and Brunner, 1986). Most AM infestations in the western United States are associated with abandoned and unsprayed apple trees and hawthorn species, both the native *Crataegus douglasii* Lindley and the introduced ornamental *C. monogyna* Jacquin. Isolated infestations of prunes in the Willamette Valley of Oregon (AliNiazee, 1985) and of cherries in Utah (Jorgensen *et al.* 1986) have also been noticed. The only commercial apple-growing area infested with AM in the western United States is near Salem, Oregon (AliNiazee, 1988).

Therefore, in Oregon and Washington, the primary objective of AM control and localized eradication programs is to kill all AM females that immigrate into commercial orchards from surrounding natural habitats before oviposition occurs. Consequently, protective application of insecticides on a regular basis against immigrating AM females is the key to successful management of AM in commercial orchards of the Pacific Northwest (AliNiazee, 1988).

Azinphosmethyl and phosmet are the two most commonly used insecticides against AM in eastern North America (Reissig, 1988) and phosmet is extensively used in the west also (AliNiazee, 1988). The AM eradication program pursued in northern California for the past four years, was exclusively dependent on the use of phosment (Dowell, 1988). Bancroft *et al.* (1974) evaluated the toxicity of about 25 insecticides against AM adults in the laboratory by topical applications and concluded that phosmet was as toxic to AM adults as azinphosmethyl. Unlike azinphosmethyl, which has been tested extensively against AM, both in the laboratory (Bancroft *et al.* 1974; Reissig *et al.* 1980, 1983) and in the field (Pree *et al.* 1976; Reissig *et al.* 1978; Weires and Alm, 1981) relatively little experimental data are available on the toxicity and persistence of residue deposits of phosmet against AM adults in apple orchards. A residual toxicity of two to three weeks is generally expected but no experimental data are available to support this conclusion. Here, we report the residual toxicity against AM adults of two rates of phosmet applied in the field on apple foliage and fruit.

1. Oregon Agricultural Experiment Station Technical Paper No. 8900.

MATERIALS AND METHODS

Phosmet (Imidan 50% wettable powder [WP], Stauffer Chemical Company, Westport, CT) was applied at rates of 0.6 and 1.2 g (AI)/liter (0.5 and 1 pound [AI]/100 gallons) on young 'Red Delicious' apple trees (1–1.5meters high). The application was made to the point of drip with a backpack sprayer, in the first week of August 1987 at the Oregon State University Entomology Research Farm, Corvallis, OR. Each tree had approximately 50 fruit at the time of treatment. Four trees were treated with each rate of phosmet.

Samples of treated apples and leaves were collected in plastic bags without touching the treated surfaces at 24 h after treatment and at 4-day intervals until 56–60 days post-treatment. If adequate numbers of AM adults were not available for the tests, the sampling date was skipped and the treated apples and leaves were collected at the next consecutive sampling date.

Test insects were obtained from a continuous non-diapausing laboratory colony (Mohammad and AliNiazee 1989) maintained at a temperature of 25 ± 1°C, 70 ± 5% RH, and in constant light. The AM adults were provided with a food mixture of yeast hydrolysate enzymatic (United States Biochemical Corporation, Cleveland, OH) and honey, mixed in a ratio of 1:4. Other rearing procedures were similar to those described by Kamasaki *et al.* (1972). The colony had been reared for 4–5 generations until these bioassays. Five to 10-day-old AM adults were used in these tests.

Each post-treatment laboratory test was replicated four times. Ten AM adults (5 males and 5 females) were tested in each replication. Two additional replications with unsprayed apples and foliage were also included for assessing the natural mortality of AM flies. Modified translucent plastic canisters (Rubbermaid Servin' Saver 12 × 13.5 cm diameter) were used in an inverted position to expose each batch of AM flies to the treated apples and foliages, as described by Mohammad and AliNiazee, (1989). One treated apple and 10–12 treated leaves were placed on a paper towel and a modified canister was inverted, so that the apple and the foliage were in the center of the canister without touching the sides. Provisions were made for aeration, water, and food for the AM flies in these canisters. The tests were conducted at 25 ± 1°C in a walk-in controlled environment chamber under fluorescent lights with a photoperiod of 16:8 (L:D). The

Table 1
Mortality of apple maggot (AM) adults in the laboratory on residue deposits of phosmet on apple foliage and fruit collected at different intervals after spray applications.

Days after spray applications	AM mortality (%)[1]	
	Field rate of phosmet (g [AI]/liter)	
	0.6	1.2
1, 4, 8, 12, 16	100	100
20	100	94.6
24	94.6	94.6
28	89.1	94.6
32	83.7	75.5
36	70.1	89.1
40	–	83.7
44	75.5	–
48	–	51.1
52	45.7	–
56	–	0[2]
60	21.2[2]	–

1. Mortality corrected by Abbott's formula (Abbott, 1925).
2. Excluded from probit analysis.
Natural mortality of AM flies on unsprayed foliage was 8% (n = 300).
No. of AM flies used in each test = 40 (20 males & 20 females). Mortality counts were made after 48 h exposure.

numbers of live and dead flies were recorded after 48 hours. Flies which were unable to walk were considered dead. The mortality counts were corrected by Abbott's formula (Abbott, 1925) and the data were analyzed by probit analysis (Russell *et al.* 1977) for estimation of time to 95% and 50% mortality (ET_{95} and ET_{50}) (Pree *et al.* 1976).

RESULTS AND DISCUSSION

Residues of phosmet caused 100% mortality for 16 days at both rates (Table 1); thereafter, mortality declines inversely with time. The deposits of phosmet caused ⩾50% AM mortality until 48 days post-treatment at both rates, thus suggesting a slow rate of degradation and loss of efficacy. Residual efficacy declined rapidly at 56 and 60 days post-treatment and the insecticide was ineffective after 60 days. The average temperatures in the field for August, September, and October 1987 were 19.9, 17.1, and 14.1°C, respectively; the precipitation in Corvallis during these months was 0.43, 0.13, and 0.68 cm, respectively.

Results of probit analysis indicated that for both rates of phosmet, the estimated time to 95% mortality (ET_{95}) of AM flies from residue deposits was 24.1 days (95% CL = 21.1–26.5), and 52.8 days (95% CL = 48.0–60.9) for 50% mortality (ET_{50}). The slopes and intercepts of the probit regressions for both dosages were similar (x^2 [likelihood ratio test for equality of slopes and intercepts] = 0.458; df = 2) and the data for both dosages of phosmet (0.6 and 1.2 g [AI]/liter) could be represented by a common slope (-4.83 ± 0.56; n = 960; *t* ratio = −8.58;) and a common intercept (8.33 ± 0.87; n = 960; *t* ratio = 9.53). The probit analysis therefore, indicated little differences between efficacies of residue deposits of the two rates for a period of 48–52 days post-treatment.

Bancroft *et al.* (1974) suggested that phosmet and azinphosmethyl were equally toxic to AM adults in laboratory, and Pree *et al.* (1976) reported that foliar residues of dimethoate and azinphosmethyl caused 50% mortality (ET_{50} levels) for 28–30 and 18–20 days, respectively. Data presented here (ET_{95} = 24.1 days and ET_{50} = 52.8 days) show that phosmet was much more persistent in Oregon than either of the two insecticides tested in New York and Ontario.

Reissig *et al.* (1983) determined mortality and oviposition behavior of gravid AM females after various exposure periods on different concentrations of surface residues of azinphosmethyl and found oviposition inhibition in addition to adult mortality. Even at sublethal dosages, the inhibition of oviposition was noticeable. Most AM adults used in our study were 5–10 days old and had not yet begun oviposition, thus oviposition inhibition effects of phosmet residues were not studied. It is likely, however, that phosmet residues may also have similar oviposition deterrent effects in addition to mortality of AM adults.

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