

# PACIFIC SOUTHWEST Forest and Range Experiment Station

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## Toxicity of Stabilized and Unstabilized PYRETHRINS APPLIED TO WESTERN SPRUCE BUDWORM

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In the search for a safe, efficient, and selective means of controlling the highly destructive western spruce budworm (*Choristoneura occidentalis* Freeman), pyrethrins have emerged as one of the superior candidate insecticides.<sup>1</sup> Pyrethrins have long been known to be highly toxic to a closely related spruce budworm—*C. fumiferana* (Clemens).<sup>2</sup> But because the insecticide is labile in air and sunlight and is expensive, pyrethrins have not been widely used for insect control outdoors. The recent stabilization of pyrethroid compositions has greatly improved the prospect of using them in forest insect control.<sup>3</sup> Field tests of stabilized pyrethrins against the western hemlock looper and against *C. fumiferana* have produced generally satisfactory results.<sup>4</sup>

As a prerequisite to field use of pyrethrins against the western spruce budworm, it was necessary to develop information from laboratory studies. We found that all larval stages showed about the same tolerance to pyrethrins, that the adjuvants used in stabilization did not affect basic contact toxicity, that the residual activity apparent on Douglas-fir foliage was only slight, that the biological activity of the commercial formulation was about the same as that of the laboratory formulation, and that spray concentration ranging through about one order of magnitude did not significantly affect toxicity of the spray.

### METHODS

Insects used for bioassay were obtained from a non-diapausing colony reared continuously in the laboratory on an artificial diet.<sup>5</sup> The insects were selected for testing in the 6th instar at an average body weight of 85 mg. They were treated in a laboratory spray chamber in replicates of 10.

*Abstract:* Stabilized pyrethrins were tested in a laboratory spray chamber to provide information for planning field trials of this insecticide against the western spruce budworm (*Choristoneura occidentalis* Freeman). No significant differences were found in toxicity to instars 3 to 6. Stabilizers appear to have had no effect on basic contact toxicity. The commercial formulation of pyrethrins was as toxic as the laboratory formulated standard. Probably only slight residual activity can be expected. No effect on basic contact toxicity could be produced by increasing concentration through a range of about one order of magnitude.

*Oxford:* 453:145.7x18.28:414.414.4.

*Retrieval Terms:* *Choristoneura occidentalis*; insecticide evaluation; contact toxicity; pyrethrins; environmental effects.

Treatment procedure was that described by Lyon *et al.*<sup>6</sup> except that an unaltered No. 40 DeVilbiss<sup>7</sup> nebulizer was used for spray atomization. The size of spray chamber used varied with the subject of the test. Spray chamber I, measuring 15 inches tall by 5-1/4 inches inside diameter, produced spray droplet sizes of about 20 $\mu$  mass median diameter (MMD). Spray chamber II, measuring 21-1/2 inches tall by 8 inches inside diameter, produced droplets of about 49 $\mu$  MMD.

All expressions of dosage in the spray chambers refer to the active ingredient (AI) deposited at the base of the chamber. Deposit was measured by using a Cahn Electrobalance to weigh the spray impinging on 12-mm. aluminum pans.

Insects were held after treatment at 22 to 24°C. in 100- by 20-mm. plastic petri dishes (10 per dish) lined with filter paper and provided with sections of artificial diet. The number of dead insects was tallied 7 days after treatment.

#### Toxicity, by Instar

The insect was treated in four instars as follows: (a) third and fourth stage larvae combined, (b) fifth stage, and (c) sixth stage. First and second stage larvae were not tested since our studies were aimed at providing data for field tests against post-diapause larvae.

The insects were treated in laboratory spray chamber I at five different spray concentrations replicated 8 to 10 times. The spray volume deposited in the spray chamber was equivalent to 0.375 gal./acre (0.0351  $\mu$ l./sq. cm.). The pyrethrins were formulated in tripropylene glycol monomethyl ether (TPM). Mortality data were processed by a computer program of probit analysis.<sup>8</sup>

#### Bioassay of Stabilized Formulations

To provide information on the effect of adjuvants on toxicity, and to bioassay the purity of the stabilized pyrethrins, we tested these formulations:

- Two commercial stabilized field formulations—designated PS-1 and PS-2.<sup>9</sup> PS-1 was the original field formulation having the ultraviolet screen Permasorb MA.<sup>10</sup> To improve the quality of the solution, Permasorb MA was replaced by benzyl cinnamate in PS-2. Concentration of pyrethrins in both formulations was 24 mg./ml. (2.86 percent w/w).

- Laboratory formulated pyrethrins—designated PS-3—stabilized according to patent specifications.
- An unstabilized formulation in mineral oil—designated PMO—since mineral oil is the principal carrier in the stabilized formulation.
- An unstabilized formulation in TPM—designated PTPM—was included as a second control to provide information on the influence of the mineral oil itself on spray performance.

The larvae were treated in spray chamber II. Four concentrations of each formulation were tested, and replicated 6 to 10 times. The formulations and the spray volume (gallon per acre) deposited in the chamber were: PS-1: 0.478; PS-2: 0.272; PS-3: 0.477; PMO: 0.501; and PTPM: 0.482. The data were analyzed by probit analysis.<sup>8</sup>

#### Residual Toxicity

Potted Douglas-fir trees, 5 years old, in full flush of new growth, were treated in spray chamber II with the PS-1 stabilized formulation (*fig. 1*). The plants were then aged in sunlight for 0, 1, and 4 hours before larvae were caged on them. Ten larvae were placed in each cage. The cage was composed of light weight 22- by 22- mesh gauze secured around the trunk and above the crown (*fig. 1*).

Post-treatment observations were made 1/2 hour as well as 7 days after caging larvae to determine "knockdown," i.e., insects that fell out of the foliage and were writhing and regurgitating.

Three spray application rates (per acre) were tested: 0.05 lb. AI per 1/4 gallon; 0.1 lb. AI per 1/2 gallon; and 0.2 lb. AI per 1 gallon. Each spray dosage and exposure period was replicated four times.

The data were analyzed on a computer program of the two sample Wilcoxon test.<sup>8</sup>

#### Importance of Spray Concentration

Larvae were sprayed directly in spray chamber II by using an approximate LD<sub>50</sub> dosage (0.2 oz./acre) of pyrethrins applied at four different spray volumes: 0.125, 0.25, 0.5, and 1 gal./acre. Each treatment was replicated 10 times and analyzed by the two sample Wilcoxon test.<sup>8</sup>

## RESULTS AND DISCUSSION

#### Toxicity, by Instar

All larval stages treated showed about the same tolerance level (*fig. 2*). The small differences were not

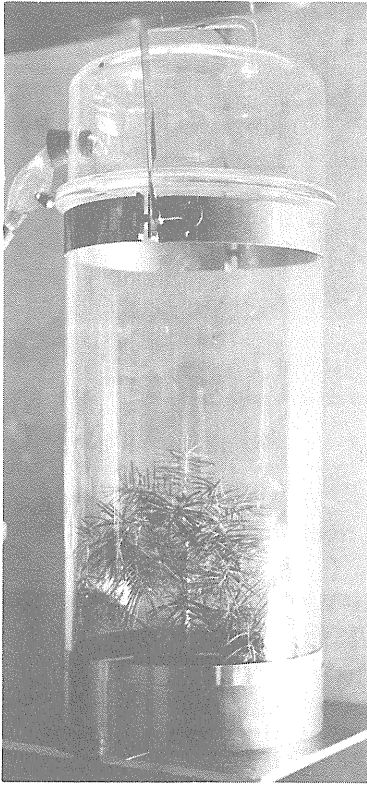


Figure 1—Treatment of potted Douglas-fir trees in tests of stabilized pyrethrins: Left, potted tree sprayed in a chamber; right, western spruce budworm larvae on treated Douglas-fir were caged by a mesh gauze.

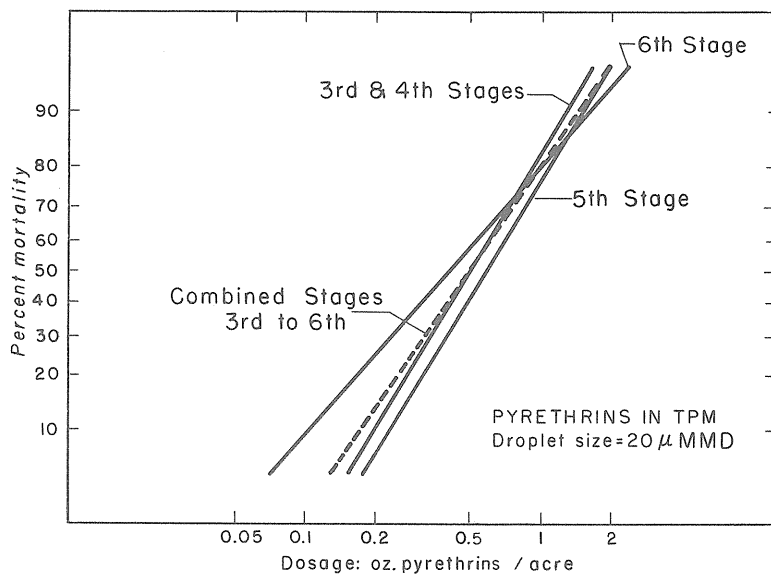


Figure 2—Western spruce budworm larvae sprayed with pyrethrins did not show any significant difference in tolerance among stages.

statistically significant. The dosage needed for LD<sub>90</sub> was as follows:

Larval stage:	LD <sub>90</sub> dosage
	(oz./acre)
3 + 4	1.29
5	1.53
6	1.65
Combined	1.49

No appreciable differences in mortality, from the standpoint of inherent contact toxicity, as the composition of the last four instars changes should be expected. These data at face value suggest a wide latitude in spray application timing. Differences in behavior of the different instars may, however, determine their degree of exposure to the insecticide. Other considerations, such as the desire to minimize insect damage, may dictate that spray application be made when earlier instars comprise most of the population.

The 20 percent pyrethrins concentrate used in this test had been refrigerated for more than 3 years and showed significant breakdown. The absolute dosage figures shown therefore are overestimated, and differ from those of the other tests which were done with a fresh pyrethrins concentrate. This breakdown should not affect relative toxicity, however, so comparisons made between larval stages should be valid.

#### Bioassay of Stabilized Formulations

The adjuvants used in stabilizing pyrethrins did not affect the basic contact toxicity of the spray (table 1). Also the biological activity of the commercial field formulation was clearly no different from the laboratory standard formulated according to patent specifications. The commercial field formula-

Table 1—Bioassay of stabilized and unstabilized pyrethrins formulations on 6th-instar western spruce budworm with laboratory spray chamber

Formulation	Median effective dose and 95 percent confidence limits at . . .	
	LD <sub>50</sub>	LD <sub>90</sub>
	Oz./acre AI	
STABILIZED PYRETHRINS		
PS-1	0.175 (0.033 - 0.283)	0.561 (0.235 - 9.42)
PS-2	.167 (.098 - .216)	.669 (.444 - 1.43)
PS-3	.159 (.043 - .222)	.465 (.212 - 2.74)
UNSTABILIZED PYRETHRINS		
PTPM	.140 (.093 - .171)	.535 (.379 - .94)
PMO	.181 (.100 - .239)	.853 (.518 - 3.03)
PMO (repeat)	.183 (.115 - .234)	.722 (.487 - 1.50)

tion as supplied by the formulator showed a level of biological effectiveness that fulfilled the expectations from the purity statements on the label.

The change of ultraviolet screens from Permasorb MA in PS-1 to benzyl cinnamate in PS-2 did not change biological activity. Both screens stabilize pyrethrins equally.<sup>3</sup>

#### Residual Toxicity

Little residual activity was apparent on Douglas-fir foliage (table 2). The highest dosage of 0.2 lb./acre (3.2 oz./acre) caused only 41 percent kill of budworm larvae with no aging of the deposit and only 19 percent kill with 1 hour of aging. These levels of

Table 2—Residual toxicity to western spruce budworm larvae of stabilized pyrethrins (PS-1 formulation) applied to potted Douglas-fir trees

Dosage (lb./acre AI)	Exposure to sunlight	Average mortality
	Hours	Percent
Control	—	5
0.05	0	14*
.05	1	12
.05	4	2
Control	—	7
.1	0	34*
.1	1	11
.1	4	8
Control	—	7
.2	0	41*
.2	1	19*
.2	4	5

\*Statistically significant at 6 percent level of probability according to Wilcoxon two-sample test.

mortality were significantly higher than those in the control test. The test of 0.1 lb./acre (1.6 oz./acre) caused 34 percent kill, with no aging of deposit (significantly different from control), but no significant kill after 1 hour of aging. When these results are compared to those in the previous test of direct contact toxicity (in which the LD<sub>90</sub> was about 0.03 lb./acre or about 0.5 oz./acre), it is apparent that contact of the larvae by the spray cloud directly will probably be the major source of toxic effects so that little residual activity can be expected.

Knockdown was appreciable only at the two highest dosage levels and where deposits were not aged (table 3). After 1 hour of aging, knockdown was reduced to 25 percent or less and after 4 hours of aging was nil.

This test at best only partially simulated field conditions. Even the small amount of residual activity shown by the data is likely to be an overestimation.

Table 3—Knockdown of western spruce budworm larvae caused by stabilized pyrethrins applied to potted Douglas-fir trees

Dosage (lb./acre AI)	Exposure to sunlight	Average knockdown
	Hours	Percent
Control	—	0
0.05	0	13
.05	1	12
.05	4	0
Control	—	0
.1	0	54
.1	1	25
.1	4	8
Control	—	0
.2	0	72
.2	1	20
.2	4	0

We so conclude because the degrading atmospheric affects on the descending spray cloud were not taken into account. Also, the “deposit” is usually much less than the release rate from an airplane, and our dosage expressions were based on spray deposited in the spray chamber.

#### Importance of Spray Concentrations

Spray concentration ranging through about one order of magnitude had no significant (measured by Wilcoxon two sample test) effect on toxicity of the spray to the budworm larvae (table 4). An exact deposit of 0.2 oz./acre (the approximate LD<sub>50</sub> for pyrethrins) was not achieved as shown in table 3, but

Table 4—Spray concentration of pyrethrins as related to contact toxicity to western spruce budworm larvae

Spray concentration (mg./ml.)	Theoretical dosage	Actual deposit in spray chamber	Average mortality
	Gal./acre	Oz./acre AI	Percent
1.5	1.0	0.174	47
3	.5	.194	48
6	.25	.215	52
12	.125	.225	55

ranged from 0.174 to 0.225 (0.2 ± 13 percent oz./acre). The small differences in mortality can be attributed entirely to this variation in deposit.

#### NOTES

<sup>1</sup>Moore, Arthur D. *New developments in forest insect problems*. Trans. 34th N. Amer. Wildlife & Natural Resources Conf. 1969: 155-159. 1969.

Miskus, Raymond P. *Report on the Insecticide Evaluation Project, 1969*. Proc. Ann. Meet. West. Forest Pest Committee, West. Forestry & Cons. Ass. 1969: 30-33. 1969.

<sup>2</sup>Brown, A. W. A., W. W. Hopewell, B. J. Wenner, and H. McDonald. *Laboratory assessment of organic insecticides for control of certain Lepidopterous larvae*. Can. Entomol. 79: 161-166. 1947.

<sup>3</sup>Miskus, R. P., and T. L. Andrews. *Stabilization of pyrethroid compositions*. U.S. Patent, No. 3,560,613, Feb. 2, 1971.

<sup>4</sup>Mounts, Jack, Leon F. Pettinger, and Robert Phillips. *A field test of stabilized pyrethrins against the western hemlock looper Mt. Baker National Forest, 1969*. USDA Forest Serv. Pacific NW. Region, Portland, Ore. 14 p. 1970.

Mason, Richard R. *Controlled field test of stabilized pyrethrins against the western hemlock looper*. USDA Forest Serv. Res. Note PNW-120, Pacific NW. Forest & Range Exp. Sta., Portland, Ore. 9 p. 1970.

Personal communication from J. J. Fettes, Chemical Control Research Institute, Ottawa, Ontario, Canada, 1970.

<sup>5</sup>Lyon, Robert L., C. E. Richmond, J. L. Robertson, and B. A. Lucas. *Rearing diapause and diapause-free western spruce budworm on an artificial diet*. Submitted to Can. Entomol.

<sup>6</sup>Lyon, Robert L., Marion Page, and Sylvia J. Brown. *Tolerance of spruce budworm to malathion...Montana, New Mexico populations show no differences*. USDA Forest Serv. Res. Note PSW-173, Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 6 p. 1968.

<sup>7</sup>Trade names and commercial enterprises or products are mentioned solely for necessary information. No endorsement by the U.S. Department of Agriculture is implied.

<sup>8</sup>Computer program provided by Gerald Walton, U.S. Forest Service, 6816 Market St., Upper Darby, Pa. 19082.

<sup>9</sup>Samples of both formulations were provided by the McLaughlin Gormley King Company.

<sup>10</sup>2-hydroxy-4-(2-hydroxy-3-methacryloxy) propoxy-benzophenone (National Starch Company).

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