EFFICACY OF INSECTICIDES AGAINST GEOMETRID LARVAE, *OPEROPHTERA* SPP., ON SOUTHERN VANCOUVER ISLAND, BRITISH COLUMBIA[1]

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ABSTRACT
Permethrin, acephate, diazinon, malathion, endosulfan, methoxychlor, Imidan, naled and a spray containing surfactant only were the most effective treatments for control of winter moth, *Operophtera brumata* (L.), and Bruce spanworm, *O. bruceata* (Hulst), on apple in the tight cluster bud stage. Resmethrin, trichlorfon, and Dipel and Thuricide formulations of *Bacillus thuringiensis* were less effective. The growth disruptor, Dimilin, provided good control at the pink bud stage. At this same stage, sprays with surfactant only were no better than untreated controls.

INTRODUCTION

Outbreak populations of hardwood-defoliating geometrid larvae on southern Vancouver Island in 1976 were composed of about 10% Bruce spanworm, *Operophtera bruceata* (Hulst) and 90% winter moth, *O. brumata* (L.) (Gillespie *et al* 1978). Both species are very similar in appearance, habits and hosts. The Bruce spanworm is a North American species which occurs across southern Canada and the northern U.S.A. The winter moth is a European insect which became established in Nova Scotia (Cuming 1961). The Vancouver Island outbreak is the first record of winter moth from western North America.

Both moths feed on various ornamental, shade and fruit trees. DDT, lead arsenate and azinphosmethyl controlled winter moth in Nova Scotia (Sanford and Herbert 1966). Azinphosmethyl, diazinon and endosulfan controlled Bruce spanworm on apples in the Okanagan Valley, British Columbia (McMullen 1973). Dimilin, an insect growth disruptor, has also shown promise as a winter moth control (Pree 1976). This paper examines the efficacy of 13 insecticides for control of geometrids involved in the current outbreak on Vancouver Island. Examination of larval characteristics (Eidt and Embree 1968) indicate that these are mostly winter moth, with a small population of Bruce spanworm.

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CONTROL EXPERIMENTS

Treatments listed in Table 1 were applied to dwarf apple trees (variety unknown) in the tight cluster bud stage in a neglected orchard on the campus of the University of Victoria. Resmethrin was applied with a battery-operated Turbair ULV applicator. All other materials were applied to the point of run-off with a hand-operated Solo Sprayer Model 425. Surfactant Triton B 1956 was added to all sprays at 30 ml per 100 litres. The experimental plot consisted of 57 trees in randomized complete blocks containing 19 treatments per block. There were 3 single-tree replicates per treatment. Living larvae were counted on 10 leaf clusters selected at random from each tree 8 and 14 days after treatment. Counts from these 2 samples were combined to give 20 samples per tree for statistical analysis.

In a second experiment 3 rates of Dimilin 25% W.P. were applied at the pink bud stage in the same manner as above, but no surfactant was used. These treatments are listed in Table 2. The experimental plot in this trial consisted of 12 trees in randomized complete blocks containing 4 treatments per block, with 3 single-tree replicates per treatment. Living larvae were counted on 10 leaf clusters selected at random from each tree 9 days after treatment.

In a third experiment, methoxychlor, naled and Permethrin sprays with and without surfactant were applied in the pink bud stage. This trial also included an untreated control and a control spray containing surfactant only. Treatments were not replicated. Living larvae

Table 1. Number of living *Operophtera* larvae per leaf cluster on apple treated with various materials at the tight cluster bud stage.

Treatment	Rate of formulation per 100 litres	Larvae per Cluster [1,2]
Permethrin 50% E.C.	19 ml	0.20 a
Permethrin 50% E.C.	37 ml	0.52 ab
Acephate 75% S.P.	68 g	0.78 ab
Endosulfan 4 E.C.	124 ml	0.92 abc
Surfactant spray only	30 ml	1.10 abc
Diazinon 50% E.C.	124 ml	1.17 abc
Malathion 50% E.C.	249 ml	1.47 abcd
Methoxychlor 25% E.C.	498 ml	1.53 abcd
Imidan 50% W.P.	100 g	1.60 abcd
Imidan 50% W.P.	200 g	1.60 abcd
Naled 9.6 E.C.	124 ml	1.88 abcd
Acephate 75% S.P.	131 g	2.05 abcde
Thuricide HPC (*Bacillus thuringiensis*)	498 ml	2.38 bcde
Trichlorfon 50% S.P.	299 g	2.88 cdef
Thuricide HPC	996 ml	3.22 cdef
Dipel W.P. (*Bacillus thuringiensis*)	124 g	3.92 ef
Dipel W.P.	248 g	4.20 ef
Resmethrin 0.84% a.i. per litre	-	4.27 f
Control (untreated)	-	8.40 g

1 Mean of 3 replicates.

2 Values followed by the same letter are not significantly different at p = .05 (Duncan 1955).

were counted on 10 leaf clusters selected at random from each tree 5 days after treatment.

Data from the first two experiments were analyzed using a nested analysis of variance. Treatment means were compared using Duncan's Multiple Range test (Duncan 1955; Zar 1974). Data from treatments in the third experiment were analyzed by a two-way analysis of variance with replication.

Table 2. Number of living Operophtera larvae per leaf cluster on apple treated with Dimilin at the pink bud stage.

Treatment	Rate of formulation per 100 litres	Larvae per cluster [1,2]
Dimilin 25% W.P.	25 g	0.73 a
" " "	50 g	0.50 a
" " "	100 g	0.33 a
Control	-	3.00 b

[1] Mean of 3 replicates.

[2] Values followed by the same letter are not significantly different at p = .05 (Duncan 1955).

RESULTS AND DISCUSSION

In the first experiment, larval infestations were reduced by all treatments compared to the untreated control (Table 1). Permethrin, acephate, endosulfan, diazinon, malathion, methoxychlor, Imidan, naled and sprays containing surfactant only were most effective. Resmethrin, trichlorfon and the Dipel and Thuricide formulations of *B. thuringiensis* were less effective.

In this experiment, unsprayed trees and those sprayed with *B. thuringiensis*, trichlorfon and Resmethrin were completely defoliated within 48 days after the tight cluster bud stage. Trees sprayed with Permethrin were undamaged. Most of the remaining materials may have provided better protection from partial defoliation if a second spray had been applied in the pink bud stage.

In the second experiment, Dimilin reduced

Table 3. Number of living Operophtera larvae per leaf cluster on apple treated with various materials at the pink bud stage.

Treatment	Rate of formulation per 100 litres	Larvae per cluster
Methoxychlor 25% E.C.	498 ml	0.2
Methoxychlor 25% E.C.	498 ml	
+ surfactant	30 ml	0.5
Naled 9.6 E.C.	124 ml	0.1
Naled 9.6 E.C.	124 ml	
+ surfactant	30 ml	0
Permethrin 50% E.C.	19 ml	0
Permethrin 50% E.C.	19 ml	
+ surfactant	30 ml	0

larval infestations significantly 9 days after treatment in the pink bud stage (Table 2). There were no differences in control among the 3 dosage rates tested.

In the first experiment we obtained excellent control with sprays containing surfactant only. For this reason we suspected an interaction between surfactant and insecticides in the remaining treatments in that trial. However, the results of the third trial using sprays with and without surfactant showed no interaction (Table 3). There was also no significance between larval counts from the untreated control and those from trees sprayed with surfactant only.

The variable results obtained with surfactant sprays may be due to a difference in larval age groups between the first trial and the third trial. In the first trial there was a higher proportion of early-instar larvae which might have been more sensitive to surfactant sprays. However, the relatively light defoliation of trees treated with surfactant only in the first trial is unexplained. Further studies are therefore required to reach any valid conclusions on the efficacy of surfactant sprays for control of winter moth and Bruce spanworm.

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