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Noninvolvement of Mixed Function Oxidases in Dimilin®
Metabolism

Influence of Formulation on Droplet Size, Deposit Concentration,
and Persistence of Fenitrothion in Conifers Following a Simulated
Aerial Application

Effectiveness of Moulting-inhibiting Insect Growth Regulators in
Controlling the Oak Leaf Shredder

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ENTOMOLOGY

Noninvolvement of Mixed Function Oxidases in Dimilin® Metabolism.—Metabolism and consequent detoxification of chemical insecticides is frequently by hydrolysis and hydroxylation, with the latter step mediated by microsomal mixed function oxidases. Synergists such as piperonyl butoxide and SKF-525A (Fig. 1), relatively nontoxic themselves, inhibit the

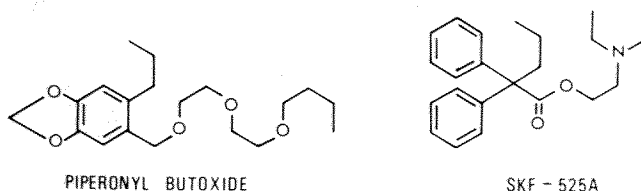


Figure 1. Insecticide synergists tested for enhancing Dimilin® toxicity to spruce budworm.

mixed function oxidases and thus greatly enhance the effectiveness of insecticides such as pyrethrins, chlorinated hydrocarbons, carbamates, and some organophosphates (Cassida, J. Agric. Food Chem., 18:753-773, 1970).

sation of N-acetyl glucosamine units (Eck, Insect Biochem., 9:295-300, 1979; Mayer et al., Insect Biochem., 10:549-556, 1980). Like many insecticides, the metabolic breakdown of this IGR involves hydrolysis and hydroxylation (Chang, J. Econ. Entomol., 71:31-39, 1979). It was therefore of interest to determine whether inhibition of the mixed function oxidases could enhance the activity of Dimilin® against the spruce budworm, which has been shown to be relatively refractory to this IGR (Retnakaran et al., J. Insect Physiol., 26:385-390, 1980).

Dimilin® was incorporated in the diet with and without the synergists and its activity was tested on fourth, fifth, and sixth instar larvae. Based on the use pattern, a relatively high concentration of synergist was chosen for this study (Metcalf, Ann. Rev. Entomol., 12:229-256, 1967). The EC₅₀ for each treatment on an instar was determined by using five different concentrations and testing each level on 100 larvae (Retnakaran, J. Econ. Entomol., 73:520-524, 1980). The results (Table 1) show clearly that neither synergist has any effect on the EC₅₀ values for Dimilin® against the spruce budworm. It was therefore concluded that the low activity of Dimilin® cannot be attributed to its detoxification by mixed function oxidases in this insect. Also, since the addition

TABLE 1
Effect of synergist on Dimilin® activity on spruce budworm larvae

Treatment	EC ₅₀ and 95% confidence limits (within brackets) in ppm for the last three larval instars.		
	Fourth	Fifth	Sixth
1. Dimilin®	6.8 (4.7-11.8)	15.9 (11.9-25.4)	0.2 (0.1-0.5)
2. Dimilin® + 20 ppm Piperonyl butoxide	8.8 (5.4-16.5)	12.5 (10.0-17.2)	0.4 (0.1-0.7)
3. Dimilin® + 20 ppm SKF-525 A	7.9 (5.4-13.9)	12.3 (10.2-15.9)	0.4 (0.2-1.5)

Dimilin® (1-[4-chlorophenyl]-3-[2,6-difluorobenzoyl]-urea) is a moult-inhibiting insect growth regulator (IGR) that inhibits either directly or indirectly the terminal step in chitin synthesis involving the polymeri-

of synergists did not decrease the level of activity, there is no metabolic activation of Dimilin® by these enzymes.—Arthur Retnakaran, Forest Pest Management Institute, Sault Ste. Marie, Ont.

Influence of Formulation on Droplet Size, Deposit Concentration, and Persistence of Fenitrothion in Conifers Following a Simulated Aerial Application.—

Fenitrothion (0,0-dimethyl 0-[3-methyl-4-nitrophenyl] phosphorothioate) has been used for spruce budworm (*Choristoneura fumiferana* [Clem.]) control in eastern Canada since 1963 and to date about 9×10^6 kg of the material has been sprayed over 31×10^6 ha of forest (Nigam, CANUSA Newsl. 11, 1980). Usually the insecticide is applied by aircraft at the rate of 2×0.210 kg active ingredient (AI)/ha either as an aqueous emulsion or as an oil formulation. The former is a heterogeneous system with the toxicant dispersed in water, whereas the latter is a homogeneous solution with the insecticide dissolved in a petroleum distillate.

When selecting solvents for use in pesticide dispersion, it is necessary to consider not only their capacity to dissolve the AI and their compatibility with other cosolvents, but also their influence in producing desirable droplet and deposit densities (droplets/cm² and g AI/ha respectively) on target surfaces. These parameters represent the degree of coverage over the sprayed area (Courshee et al., Proc. 4th Int. Agric. Avait. Congr. Kingston, Canada, pp. 288-296, 1969) and therefore play a significant role in influencing efficacy of the spray formulations. The cosolvents and emulsifiers in a formulation also affect the rate of evaporation of the AI from target matrices (Sundaram and Sundaram, Can. For. Serv. Res. Notes 1:18-21, 1981).

In a preliminary study, Randall (Can. For. Serv., For. Pest Control Forum Rep., 1974) observed that

fenitrothion formulations containing different amounts of petroleum distillates enhanced the droplet density and pesticide coverage. In this paper a comparative account is given between foliar persistence of fenitrothion residues in relation to the droplet size spectrum produced by different formulations of fenitrothion when single conifer trees were sprayed using a simulated aerial application method. The formulations used in the study were: 1) an aqueous emulsion and 2) fenitrothion in either of the two petroleum distillates Arotex® or fuel oil No. 2, or a combination of these two. The objective was to find the additives most effective in enhancing foliar deposits and persistence.

The study was conducted at a tree farm near Shawville, Que. Nine white spruce trees (*Picea glauca* [Moench] Voss) nearly uniform in size and shape, about 2.8 m in height and with abundant foliage and ample growing space were selected, tagged with plastic ribbon, and numbered T1 to T9. T1 to T8 were divided into four pairs and each pair was sprayed separately with one type of the four fenitrothion formulations shown in Table 1. T9 served as the untreated check. Prior to application, a portable polyethylene shelter 3 m in height and surrounding a ground surface area of 4.6 m² was erected around each tree as a windscreen. A measured 1.5 mL of the formulation was sprayed on each tree using a device and technique developed by Hopewell (Chem. Cont. Res. Inst. Inf. Rep. CC-X-59, 1974) for applying measured amounts of simulated aircraft spray to individual small trees.

TABLE 1
Composition of formulations and deposit data for each application⁺

Formulation	Composition of formulations (wt %)	Trees sprayed	Fenitrothion deposited (g/ha) ⁺⁺			No. of drops*/cm ² (Mean \pm SD)	Droplet diameter (μ m)	
			GLC	Colorimetry	Spot counting		VMD	NMD
F1	Fenitrothion** 10 Arotex® [°] 89, Automate B Red Δ 1	T1 & T2	175	156	146	37 \pm 5	118	65
F2	Fenitrothion 10, Fuel oil ^{°°} 89, Automate B Red 1	T3 & T4	238	227	221	49 \pm 4	136	78
F3	Fenitrothion 10, Arotex® 30, Fuel oil 59, Automate B Red 1	T5 & T6	215	199	189	44 \pm 4	130	72
F4	Fenitrothion 10, Atlox® [†] 1, Arotex® 2, Water 86, Rhodamine B $\Delta\Delta$ 1	T7 & T8	195	186	180	34 \pm 3	149	82

⁺ Application rate = 1.5 g of formulation (density 1.02)/tree corresponding to 330 g AI/ha, i.e., 20% more than the normal application rate of 280 g AI/ha. F3 and F4 are the two conventional formulations used in spruce budworm control programs in Canada.

⁺⁺ Experimental error: GLC <2%, colorimetry <6%, spot counting <13%.

^{*} Average of eight readings.

^{**} Technical material supplied by Sumitomo Chemical Co.

[°] Arotex® 3470 supplied by Texaco Oil Co.

Δ Automate B Red supplied by Morton Williams Ltd.

^{°°} Fuel oil No. 2, supplied by Texaco Oil Co.

[†] Atlox® 3409 emulsifier supplied by Atlas Chemical Ind.

$\Delta\Delta$ Rhodamine B supplied by Allied Chemicals.

Four formulations were investigated: fenitrothion in Arotex® (F1), in fuel oil (F2), in Arotex®-fuel oil mixture (F3), and in water-Atlox®-Arotex® emulsion (F4). These mixtures were made up in 100 mL Erlenmeyer flasks a few hours prior to application and stored at 2°C.

Spray applications were carried out during the 2nd week of May before the new shoots had begun to expand and while they were still covered by bud caps. Kromekote card-glass plate (collection) units (Randall, Bi-mon. Res. Notes 36:23, 1980) were used for droplet size and deposit assessments. Gas-chromatography (GC) was used to measure the active ingredient (Sundaram, Chem. Cont. Res. Inst. Inf. Rep. CC-X-64, 1974) and colorimetry to measure the dye tracer (Armstrong and Randall, Proc. 4th Int. Agric. Aviat. Congr. Kingston, Canada, pp. 196-202, 1969). Four collection units were placed on the ground equally spaced around each tree and away from overhanging foliage. They were collected about 20 min. after the spray application and transported to the laboratory in styrofoam coolers. Samples of foliage (7-cm branch tip from each quadrant of the tree at mid-crown level, excluding new growth and buds) were taken 1 day prior to treatment and at the following hours after treatment on the first day—0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0,

6.0, 8.0, 10.0, 24.0 ; and on the following days thereafter—2, 4, 7, 10, 15, 20, 30, 45, 60, 90, 120, 150, and 370. The foliage samples from the two trees treated with the same formulation were cut into small pieces, mixed well, put in plastic bags, stored in coolers containing dry ice, and transported immediately to the laboratory for analysis.

In the laboratory, fenitrothion present on the surface of the foliage (surface residues) was removed by washing 10 g aliquots of foliage with 4 x 30 ml ethyl acetate in a stoppered measuring jar (250 mL). Fenitrothion residues that had penetrated the cuticle (tissue residues) were extracted by Sorvalling the same foliage with 2 x 50 mL of ethyl acetate. Washings and extracts were separately partitioned, cleaned by adsorption chromatography, and quantified by FPD gas-chromatography as described by Sundaram (1974). The deposits on glass plates were removed by washing with 5 x 2 mL of toluene (Automate B Red) or methanol (Rhodamine B). The eluant was centrifuged to remove dirt particles that had settled on the plates and was analysed by colorimetric and GC techniques. The Kromekote cards were examined under magnification and the spots recorded. The resulting counts were grouped according to size and from these the droplet size

TABLE 2
Fenitrothion concentration* (ppm) in spruce foliage

Time after application	Formulation sprayed											
	F1			F2			F3			F4		
	Sur.	Tis.	Tot.	Sur.	Tis.	Tot.	Sur.	Tis.	Tot.	Sur.	Tis.	Tot.
0.5 h	65.5	0.7	66.2	79.1	0.5	79.6	74.2	0.6	74.8	73.8	0.3	74.1
1.0 h	64.6	1.1	65.7	78.5	0.9	79.4	72.9	1.3	74.2	70.6	0.5	71.1
1.5 h	64.0	1.4	65.4	76.5	1.6	78.1	70.8	1.5	72.3	68.4	0.7	69.1
2.0 h	60.4	1.6	62.0	74.5	2.1	76.6	69.6	1.9	71.5	66.3	0.9	67.2
2.5 h	56.3	2.1	58.4	71.5	3.2	74.7	66.5	3.0	69.5	64.3	1.4	65.7
3.0 h	54.6	2.3	56.9	69.0	3.7	72.7	64.9	3.3	68.2	61.7	1.7	63.4
4.0 h	51.3	2.4	53.7	66.4	3.9	70.3	63.1	3.5	66.6	57.3	1.8	59.1
6.0 h	48.4	2.5	50.9	63.9	4.0	67.9	62.3	3.6	65.9	53.5	1.9	55.4
8.0 h	46.0	2.6	48.6	61.3	4.1	65.4	58.6	3.6	62.2	51.4	2.2	53.6
10.0 h	44.9	2.6	47.5	60.8	4.2	65.0	56.1	3.8	59.9	49.4	2.6	52.0
1 d	44.2	2.4	46.6	56.6	4.2	60.8	52.6	3.7	56.3	46.2	2.9	49.1
2 d	39.8	1.9	41.7	49.8	3.8	53.6	47.8	3.4	51.2	42.6	2.6	45.2
4 d	36.4	1.7	38.1	45.2	3.5	48.7	41.9	3.1	45.0	36.8	2.2	39.0
7 d	30.9	1.5	32.4	39.9	3.2	43.1	36.1	2.7	38.8	29.3	1.8	31.1
10 d	26.6	1.2	27.8	35.9	2.9	38.8	31.2	2.5	33.7	28.8	1.3	30.1
15 d	17.6	1.1	17.7	29.6	2.7	32.3	23.9	1.9	25.8	19.6	1.1	20.7
20 d	13.4	1.0	14.4	24.8	2.4	27.2	19.2	1.4	20.6	14.9	0.8	15.7
30 d	10.9	0.8	11.7	19.9	1.9	21.8	16.1	1.0	17.1	11.7	0.7	12.4
45 d	5.7	0.7	6.4	9.8	1.4	11.2	7.7	0.8	8.5	6.4	0.5	6.9
60 d	2.7	0.5	3.2	5.6	1.1	6.7	3.9	0.6	4.5	3.0	0.4	3.4
90 d	2.0	0.3	2.3	3.4	1.0	4.4	2.7	0.4	3.1	2.2	0.3	2.5
120 d	0.6	0.3	0.9	2.8	0.8	3.6	1.8	0.4	2.2	1.4	0.2	1.6
150 d	0.5	0.2	0.7	2.2	0.6	2.8	1.5	0.3	1.8	1.0	0.2	1.2
370 d	0.3	0.1	0.4	1.4	0.2	1.6	0.9	0.2	1.1	0.6	0.1	0.7
370 d**	T	T	T	T	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.3

Sur. = Surface residue

Tis. = Tissue residue

Tot. = Total residue

* = MDL 0.1 ppm; mean of two determinations with S.D. < 10%

** = New foliage of the following year

T = Trace amounts (< 0.1 ppm)

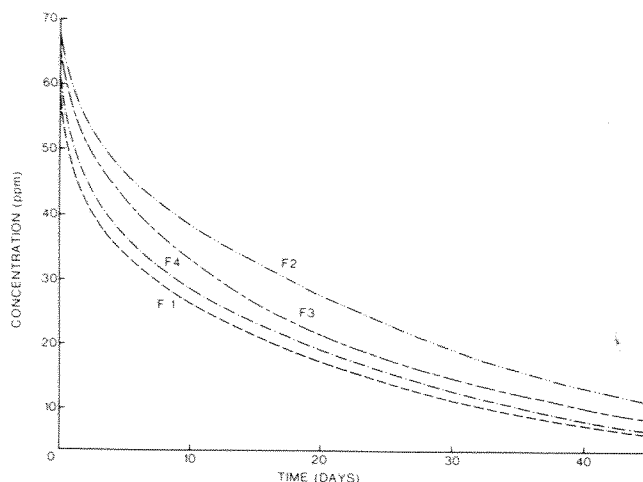


Figure 1. Rate of dissipation of fenitrothion from spruce foliage.

spectrum was calculated using the spread factor values (Rayner and Haliburton, *Rev. Sci. Instr.* 26:1124-1127, 1955). Deposit densities (g AI/ha) were calculated from the droplet size spectrum.

Composition of the formulations and deposit data from the sampling units are given in Table 1. Data in Table 2 and Fig. 1 represent the dissipation rates of foliar residues as well as the long-range foliar persistence of fenitrothion. Foliar samples collected from the untreated check tree did not show any detectable levels of fenitrothion (minimum detection limit [MDL] = 0.1 ppm).

Fenitrothion deposits from the collection plates (Table 1), determined by colorimetric and spot counting methods, were respectively 7 and 11% lower than the GC method results. The lower value obtained by colorimetry is probably a result of adsorption of the dye by dirt particles that were removed by centrifugation prior to analysis. The lower recovery of deposits by the spot counting method can be attributed partly to the low magnification used (minimum detectable drop diameter = 40 μ m), and partly to the error in the measurements of spread factor. From the data in Table 1, it is apparent that deposit levels are related to the physicochemical characteristics of the formulations. Formulation F1, containing a light petroleum distillate, Arotex®, gave small droplets with a low volume-median diameter (VMD) and number-median diameter (NMD) (Table 1). Droplet and deposit densities were also low because of the low impaction efficiency of the small droplets on the flat collection plates.

The emulsion formulation F4 produced larger droplets on the Kromekote card (a VMD of 149 μ m and NMD of 82 μ m), but the droplet density was low, indicating that the presence of polar adjuvants (water and the emulsifier Atlox® 3409) contributed to the cohesive forces within the spray liquid, resulting in a spectrum of larger droplets. The two formulations, F2 and F3, containing fuel oil were more readily dispersed, yielding smaller droplet diameters and higher droplet and deposit densities compared to formulations F1 and F4. This

dispersion suggests that the presence of fuel oil in a spray mix enhances the pesticide coverage and efficacy.

Initial concentration of fenitrothion on and in conifer foliage (total residue) in 0.5-h samples ranged from 66.2 to 79.6 ppm (Table 2); formulation F1 yielded a lower total residue than F2, F3, or F4. These results indicate that the appropriate selection of solvent mixtures and emulsifiers not only optimizes the droplet sizes and coverage but also enhances the foliar deposition and stability of the AI on conifer needles. Among the three oil formulations (F1 to F3), the conventional formulation F3 compared favorably with F2 in foliar deposition and persistence, although the latter posed problems in miscibility; the mixture separates into two phases unless shaken vigorously prior to application and sprayed immediately. The Arotex®-fenitrothion mixture (F1) gave comparatively low foliar deposition, probably because of low impaction efficiency of the smaller droplets produced. With the emulsion formulation F4, the total residues were not much different from F2 or F3.

The dissipation rates (Table 2) show that fenitrothion is rapidly lost initially from the foliage. Within the first 10-h period, about 20-30% of the total residues were lost with all formulations. This rapid loss is primarily a result of volatilization of the AI into the surrounding mobile air mass. It is apparent that this rate of evaporation is influenced to some extent by the additives in the formulations. Formulation F1, containing a light petroleum distillate of high volatility, low density, and low viscosity, caused a high initial rate of evaporation (~30% in 10 h) of the AI. The influence of the small droplet spectrum produced also contributes to this high rate of loss. In the case of F4, the hydrophobic and codistillation factors played a combined role (Gould, ed., *Pestic. Formul. Res.*, Amer. Chem. Soc., Washington, D.C., 1969) in the high rate of initial loss. Formulations F2 and F3 showed lower rates of loss (~20% in 10 h) than F1 and F4, and the lower rates can be attributed to the low vapor pressure and high viscosity of the fuel oil content in the formulations.

From day 1 onwards, the total residues showed a gradual decrease with time (Table 2, Fig. 1). The rate of dissipation of the AI was appreciably lowered by the fuel oil content of the formulation. F3, containing 59% fuel oil, showed a lower rate of loss than F1 and F4, both of which had no fuel oil additive. F2, containing 89% fuel oil, showed the lowest rate of dissipation of the four formulations studied.

Following impaction of droplets on conifer needles, the tissue residues (i.e., excluding the surface residues) of fenitrothion (Table 2) gradually increased with time, reached a maximum value within 24 h, and declined gradually over a period of several months. The conifer surface containing the waxy lipophilic cutin, a polymeric material composed of long-chain fatty acids and alcohols (Kolattukudy, *Science*, 208:990-1000, 1980), has a strong affinity for the deposited fenitrothion molecules (Sundaram, *Chem. Cont. Res. Inst. Inf. Rep.* CC-X-65,

1974). The AI, being lipophilic, is slowly partitioned between the solvent and the cutin components, and is gradually diffused into the cutin, forming tissue deposits. Tissue residues in the 10–24 h interval for the formulations F2 and F3 were higher than those for F1 and F4. The high viscosity of the fuel oil in F2 and F3 appears to have facilitated the penetration process compared to the lighter solvent Arotex® in F1 and the aqueous component in F4. In the case of the aqueous emulsion formulation F4, the tissue residue in 10 h was the same as the values observed in F1; however, the rate of penetration during the 10-h period was slower than in F1, as evident from the consistently lower tissue:total residue ratio. The insecticide molecules present in F4 were hydrated because of the presence of the aqueous component, consequently retarding penetration through the cuticular layer. Gradual loss of the water increased the lipophilicity of the droplet, thus facilitating penetration.

After day 1, the tissue residues showed a gradual decrease with time (Table 2). The rate of loss between days 1 and 150 indicates that the high concentration of fuel oil in F2 largely contributed to the retention of fenitrothion in tissues for longer periods compared to the other formulations.

Results in Table 2 indicate that fenitrothion persisted as long as 370 days in small but significant amounts, ranging from 0.3 ppm (F4) to 1.5 ppm (F2), depending on the type of formulation used. The oil formulations F2 and F3 enhanced the persistence of the chemical compared to the emulsion formulation. The persistent fenitrothion molecules, being lipophilic in nature, are stored in cuticular waxes (Yule and Duffy, Bull. Environ. Contam. Toxicol. 8(1):10–18, 1972; Sundaram et al., Chem. Cont. Res. Inst. Inf. Rep. CC-X-85, 1975) and resist a rapid loss from evaporation or foliar leaching. New foliage not exposed to the insecticide spray contained low but detectable levels of fenitrothion (0.1–0.3 ppm), suggesting that the chemical is translocated. However, it might have been leached from the upper canopy by rain. Even if the cause is translocation, the levels involved are extremely low compared to the high foliar deposit. The high dosage rates, combined with the spray application technique used in the present study, resulted in deposit levels much higher than those encountered normally in an aerial spray operation involving dosage rates of 0.14–0.28 kg AI/ha. Consequently, foliar translocation (if any) and persistence levels in a normal spray operation would be very much lower than those observed in the present study.

In conclusion, this study indicates the following:

1. Solvents and additives in spray formulations influence droplet size and deposit levels.
2. They also affect the rate of tissue penetration into the foliar cuticle, the rate of dissipation, and foliar persistence.
3. Fuel oil has definite advantages over Arotex®, as it yields the desired spectrum of smaller droplets, high droplet density, high foliar deposits (both tissue and

total), and a low rate of dissipation.

4. Irrespective of the nature of additives in the formulation, a large amount of the AI was rapidly lost from the foliage with all formulations.
5. Fenitrothion shows a long-term foliar persistence in extremely low concentrations. Generally speaking, oil formulations appear to enhance persistence.
6. Although some new foliar shoots exhibited low but detectable levels of fenitrothion, it is not known if these resulted from translocation or from external contamination because of leaching of the AI from older needles. The levels involved are too low to contribute significantly to bioefficacy.—K.M.S. Sundaram and A. Sundaram, Forest Pest Management Institute, Sault Ste. Marie, Ont.

Effectiveness of Moulting-inhibiting Insect Growth Regulators in Controlling the Oak Leaf Shredder.—

The oak leaf shredder (or oak leafminer) (*Croesia semipurpurana* Kft.) is a pest of several species of oak, particularly red oak (*Quercus rubra* L.) in southern Ontario and can completely defoliate mature trees. Orthene® has been used to control this insect (Howse and McDowall, Surv. Bull., Great Lakes Forest Res. Cent., 1980). In June 1981, field trials were conducted to investigate whether Insect Growth Regulators (IGRs) have potential for control of this species.

Although the first instars of this insect tend to mine buds, the later three larval instars feed openly on fully flushed leaves (Beckwith, Ann. Entomol. Soc. Amer. 56:741–744, 1963). Such open feeders are in general easily controlled with IGRs (Granett and Dunbar, J. Econ. Entomol. 68:99–102, 1975; Retnakaran et al., Can. Entomol. 111:841–846, 1979). Initially we attempted to rear the insect on artificial diet or maintain it on potted oak trees in order to conduct laboratory and greenhouse trials with the test materials. All attempts were unsuccessful and therefore we conducted field trials near Sault Ste. Marie, Ont., on 3–4.5 m high red oak trees infested with the oak leaf shredder.

A 1% suspension (active ingredient, wt/vol) of either Dimilin® or BAY SIR-8514 in Sunspray 7-N oil was sprayed to run-off with a mistblower. The oil by itself sprayed on four trees infested with the oak leaf shredder did not have any deleterious effects on the insect. Each IGR was tested on 10 trees; the controls were untreated trees. Prespray density was estimated by collecting two 46-cm branch tip samples/tree and counting the number of larvae under a magnifier. To estimate the post-spray density, the same number of samples were taken when the insects in the control trees started pupating. The results indicated complete control in both treatments with excellent foliage protection (Table 1).

Unlike other tortricids such as the eastern and western spruce budworms that are refractory to Dimilin® (Granett et al., Entomol. Exp. and Appl. 28:295–300, 1980; Retnakaran et al., J. Insect Physiol. 26:385–390, 1980), the oak leaf shredder apparently can be readily

TABLE I
Effect of mistblower application of two moult-inhibiting insect growth regulators on
oak leaf shredder larvae infesting red oak near Sault Ste. Marie, June 1981.

Plot No.	Treatment (1% w/v in 7-N oil)	No. of trees treated	Population density		% population reduction*
			Pre-spray (No./46-cm branch tip)	Post-spray (No./46-cm branch tip)	
1	Dimilin®	10	8.6	0.05	99.4
2	BAY-SIR-8514	10	11.7	0	100.0
3	Control	10	7.8	7.9	—

$$*\% \text{ population reduction} = \left(1 - \left[\frac{\text{Post-spray density in treatment}}{\text{Pre-spray density in treatment}} \times \frac{\text{Pre-spray density in control}}{\text{Post-spray density in control}} \right] \right) \times 100$$

controlled by this IGR. Further field trials are under consideration.—Arthur Retnakaran and William Tomkins, Forest Pest Management Institute, Sault Ste. Marie, Ont.

- 8 **Winston, D.A., and B.D. Haddon. 1981.** Effects of early cone collection and artificial ripening on white spruce and red pine germination. *Can. J. Forest Res.* 11:817–826.
- 6 **Zoltai, S.C., and C. Tarnocai. 1981.** Some non-sorted patterned ground types in northern Canada. *Arct. and Alp. Res.* 13:139–151.

RECENT PUBLICATIONS — JANUARY–MARCH 1982

- 8 **Alemdag, I.S., and K.W. Horton. 1981.** Single-tree equations for estimating biomass of trembling aspen, largetooth aspen, and white birch in Ontario. *For. Chron.* 57:169–173.
- 4 **Blais, J.R., R.F. DeBoo, and M. Auger. 1981.** Comparison of early and late timing of spray applications for control of spruce budworm in Quebec. *Can. J. Forest Res.* 11:538–544.
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- 7 **Funk, A., and R.B. Smith. 1981.** *Potebniamyces gallicola* n. sp., from dwarf mistletoe infections in western hemlock. *Can. J. Bot.* 59:1610–1612.
- 4 **Smirnov, W.A. 1981.** Activités bactéricides du colorant Erio acide rouge XB 400 vis-à-vis *Bacillus thuringiensis*. *Can. J. Microbiol.* 27:952–955.
- 9 **Sohi, S.S., Jean Percy, J.C. Cunningham, and B.M. Arif. 1981.** Replication and serial passage of a multicapsid nuclear polyhedrosis virus of *Orgyia pseudotsugata* (Lepidoptera: Lymantridae) in continuous insect cell lines. *Can. J. Microbiol.* 27:1133–1139.

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