FIELD EVALUATION OF EIGHT INSECTICIDES FOR CONTROL OF *NEODIPRION LECONTEI* ON RED PINE, *PINUS RESINOSA*, BY SIMULATED AERIAL SPRAY.

by

W. W. Hopewell

FOREST PEST MANAGEMENT INSTITUTE

CANADIAN FORESTRY SERVICE - ENVIRONMENT CANADA

25 PICKERING PLACE, OTTAWA, ONT., CANADA, K1G 3Z8

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ABSTRACT

Eight insecticides, including a molt inhibitor and a nuclear polyhedrosis virus preparation, were tested for control of the red-headed pine sawfly, *Neodiprion lecontei*. The formulations were applied as simulated aerial spray deposits to single red pine trees, *Pinus resinosa*, ca 2.4 metres in height. Phosphamidon and permethrin were the most active, the minimum effective deposits for both being <35 g AI/3 ℓ/ha for excellent foliage protection; aminocarb at 100 g AI/3.5 ℓ/ha and propoxur and fenitrothion at approximately 150 g AI/3 ℓ/ha resulted in good foliage protection; acephate at 240 g AI/4.8 ℓ/ha was ineffective. The molt inhibitor, EL-494, at 160 g AI/3 ℓ/ha also gave good foliage protection. Four formulations of a nuclear polyhedrosis virus, applied at nominal rates of 5.8 x 10^9 polynuclear inclusion bodies per hectare in 8.8 litres when larvae were in 3rd and 4th instar, gave some foliage protection. The virus formulated from a crude preparation was more effective than that from a purified form of the virus.

RÉSUMÉ

Huit insecticides, y compris un inhibiteur de mue et une préparation du virus de la polyhédrose nucléaire, ont été mis à l'essai contre le diprion de LeConte (*Neodiprion lecontei*). Chaque préparation a été appliquée lors de pulvérisations aériennes simulées, sur un pin rouge (*Pinus resinosa*) d'une hauteur d'environ 2,4 mètres. Le phosphamidon et la perméthrine sont les composés les plus actifs; une dose minimale inférieure à 35 g d'IA.3 l^{-1} .ha^{-1} donne une excellente protection du feuillage. L'aminocarbe, à 100 g d'IA.3,5 l^{-1} .ha^{-1}, et le propoxur et le fenitrothion, à environ 150 g d'IA.3 l^{-1} .ha^{-1} donnent aussi une bonne protection. L'acéphate, à 240 g d'IA.4,8 l^{-1} .ha^{-1} donne une bonne protection du feuillage. Quatre préparations de virus de la polyhédrose nucléaire, appliquées à des doses nominales de 5,8 x 10^9 virions polynucléaires .8,8 l^{-1} .ha^{-1}, alors que les larves en sont à leurs 3^e et 4^e stades, donnent une certaine protections. Les virus préparés à partir d'une souche brute sont plus efficaces que les virus purifiés.

INTRODUCTION

An apparatus and technique developed for application of simulated aerial spray deposits for field evaluation of insecticidal treatments for control of spruce budworm, *Choristoneura fumiferana*, Clem., has been in use for several seasons (Hopewell 1973, 1975, 1977: Hopewell and Nigam 1974; Nigam and Hopewell 1973). To broaden the base of data and the utility of this method for small scale field evaluation of insecticide formulations, several materials were field tested against red-headed pine sawfly, *Neodiprion lecontei*, (Fitch), in a heavily infested red pine, *Pinus resinosa*, plantation.

Eight insecticides were applied in 19 differenct treatments or formulations, including a solvent check. Five widely used pesticides *viz.*, fenitrothion, phosphamidon, acephate, aminocarb and propoxur were used in 10 treatments; a synthetic pyrethroid, permethrin (NRDC-143) in two, and an experimental molt inhibiting insecticide, EL-494 in two. Four formulations of a nuclear polyhedrosis virus (NPV) preparation were included in the study for comparison with each other and with reported promising results in earlier experimental aerial applications of the same virus (Kaupp and Cunningham 1977).

MATERIALS AND METHODS

1. Treatment Area and Tree Selection

The experimental area was located in Lot 27 Concession 5 of Beckwith township, County of Lanark, about 40 kilometres south of Ottawa. This was on poor quality abandoned farm land which had been planted to several species of trees over the past 12 to 15 years. The red pine varied greatly in height (0.5 to 8 m) due to variation in soil quality and age of trees. Trees selected for experimental use were *ca.* 2.4 m in height and had a minimum of four colonies of sawfly larvae per tree. The selected trees, spaced sufficiently to minimize interference with other test trees during treatment, setting up of equipment, etc., were flagged and numbered. The surrounding vegetation was tall grasses, milkweed, goldenrod, etc.

2. Experimental Design

It was planned to replicate each treatment as often as time and development of larvae allowed. Most treatments were replicated three times (3 trees each) but this was reduced to duplicates for the last four treatments because of the rapid development of larvae and unsatisfactory weather conditions. Applications were carried out as quickly as available manpower and weather conditions allowed so that larval development would be as nearly as possible the same for all treatments.

3. Formulations

The test formulations were prepared from the following active ingredients:-

1. Fenitrothion, technical, 96%. O,O-dimethyl O-(4-nitro-*m*-tolyl) phosphorothioate.

   Source: Sumitomo Chemical Co., Osaka, Japan.

2. Phosphamidon, technical, 93%. 2-chloro-N,N-diethyl-3-hydroxycrotonamide dimethyl phosphate.

   Source: Ciba Geigy, Canada Ltd., Cambridge, Ontario.

3. EL-494 (molt inhibitor), 50% WP. N-[[[5-4-bromophenyl)-6-methyl-2-2-pyrazinyl] amino] carbonyl]-2-6-dichlorobenzamide.

   Source: Eli Lilly and Company (Canada) Ltd., London, Ontario.

4. Permethrin, (NRDC-143). 3-phenoxybenzyl ± -*cis-trans* 2, 2-dimethyl-3-(2,2-dichlorovinyl) cyclopropane carboxylate.

   Source: Chipman Chemical Co., Stoney Creek, Ontario.

5. Acephate, (Orthene^R 75S). O,S-dimethyl acetophosphoroamido-thioate.

   Source: Chevron Chemical Company, Richmond, California.

6. Aminocarb, (Matacil^R 1.68 OSC). 4-dimethylamino-*m*-tolyl methyl-carbamate.

   Source: Chemagro Corp., Kansas City, Missouri.

7. Propoxur, (Baygon^R 1.68 OSC). o-isopropoxyphenyl methylcarbamate.

   Source: Chemagro Corp., Kansas City, Missouri.

8. NPV (Nuclear Polyhedrosis Virus): Prepared from infected red-headed pine sawfly larvae and standardized to contain a known number of polyhedral inclusion bodies (PIB) per millilitre.

Source: FPMI, Sault Ste. Marie, Ontario

The 16 formulations prepared from the above materials are listed in Table I.

4. Spray Application and Deposit Sampling.

The formulations were applied as simulated aerial spray to single trees using the apparatus and technique described earlier (Hopewell 1973, Fig. 1.). In brief, a portable shelter enclosing an area of 2.13 x 2.13 m was placed around each tree before spray application. The required volume for the nominal dosage to be applied was measured into the syringe and attached to the droplet producing unit (1.0 mℓ applied evenly over the enclosed 4.5 m^2 is equivalent to 2.2 ℓ/ha). The operator then raised the unit over the tree in the shelter and switched on spinning disc and feed motors. The unit was moved systematically over the enclosure during emission (approximately 1 mℓ/minute) while elapsed time was called at intervals to help the operator apply the fluid uniformly over the enclosed area.

Samples of depositing spray were taken in each tree quadrant, (north, east, south and west) on sampling units consisting of a 9 cm diameter petri dish and a 10 x 10 cm Kromekote[R] card. These sampling units were placed 1.8 m above ground level on staked holders approximately 0.5 m from the tree stem and clear of overhanging foliage. The deposit samples were returned to the laboratory for colorimetric assessment of deposit volume and drop count. Applications were made over the period 6 to 14 July, 1977.

5. Biological Assessment

Effect of treatments was assessed visually 7 to 10 days after treatment and again four months later. In the first observation the number of colonies and their condition were noted for larval mortality, etc. At the second observations, in late autumn, an estimate of percent defoliation of each test tree was made and these results were taken as the basic evidence for effectiveness of treatments. Percent defoliation was rated on a scale of 1 to 5 as follows:-

Rating	% defoliation
1	0 - 10
2	11 - 25
3	26 - 50
4	51 - 75
5	>75

RESULTS AND DISCUSSION

The results of the deposit assessment analyses of the samples from each quadrant of each treated tree, averaged for both volume (ℓ/ha) and density (number of drops/cm^2), are given in Table II. The standard deviations of the volume deposits are included to indicate the range of dosage to which colonies and/or their food may have been exposed. The results of the visual estimate of the defoliation of each tree are also included in Table II.

The larvae were very active at time of treatment and some colonies had developed to 3rd or 4th instar resulting in some defoliation on all test trees. Considering the more commonly used insecticides first, the resulting effectiveness of the various treatments are summarized below.

Fenitrothion. The one application level tested, *ca* 3 ℓ/ha of 4.9% AI averaging 157 g AI/ha reduced defoliation to the probable minimum attainable (5 to 10%) under conditions of treatment. It is likely that a lower dosage would also have been effective. Most larvae had disappeared one week after treatment.

Phosphamidon. Three tests with this material at concentrations of 5.0, 2.5 and 1.25% AI all resulted in minimum defoliation, hence the lower limit of effective dosage was not reached at an average 36 g AI in 2.9 ℓ/ha, 1.25% AI in formulation. No living larvae were found on any of the nine treated trees one week after treatment; many of the larval carcasses adhered to needles.

Aminocarb. Five percent AI in its oil soluble formulation at 218 g/ha (4.4 ℓ/ha) resulted in minimum defoliation; the second treatment using 2.5% AI and averaging 85g AI/ha (3.4 ℓ/ha) allowed slightly increased defoliation, indicating the minimum effective dosage to be *ca* 100 g AI/ha of the 2.5% formulation and perhaps less at 5% AI. No living larvae were found one week after treatment.

Propoxur (Baygon). The 5% formulation at a deposit average of 140 g AI/ha in 2.8 ℓ/ha resulted in minimum defoliation. However, the treatment using 2.5% AI formulation with 84 g AI/ha allowed significant increase in defoliation. Estimated minimum effective deposit was 125 to 150 g AI/ha.

Permethrin (NRDC-143). Both treatments with this material, with average deposits of 37 and 71 g AI/ha reduced defoliation to the minimum. It appears that the 2-litre volume per hectare of 1.7% AI formulation may be reduced or the concentration may be reduced and still give effective control when applied at the same volume. All trees were clear of living larvae one week after treatment.

Acephate (Orthene 75S). This material did not appear to be effective against the sawfly even at the maximum dosage applied, i.e., 242 g AI/ha in 4.8 litres. Observation two weeks after treatment showed colonies feeding normally, although there were signs of loss of numbers in some cases. This low order of effectiveness in these tests was unexpected. However, tests at this Institute on the toxicology of acephate have shown it to be not highly effective as a contact insecticide and, in addition, its activity decreases rapidly on exposure, especially if precipitation occurs (Dr. P. C. Nigam, personal communication). Field tests by Sundaram and Hopewell, 1976, showed acephate to have a half life of only 0.8 days on spruce foliage. These properties may well explain the results with these exposed larvae when contact toxicity would be of prime importance.

EL-494. This recently introduced experimental molt inhibiting compound was applied at two dosage levels in concentrations of 5 and 2.5%, both at volume application rates of 3 ℓ/ha, resulting in average deposits of 160 and 76 g AI/ha. These treatments resulted in estimated defoliation of 20 and 54%, respectively, compared with 81% on solvent treated trees and 48% on the untreated checks. Although there was no dramatic decrease in numbers of larvae or feeding observed in the 10-day post treatment observations, there seems to have been a significan decrease in defoliation at the 160 g AI/ha rate. It is probable that greater effect at these dosages would have resulted with earlier application, i.e., vs. 1st or 2nd instar larvae. In addition to observations on defoliation, 100 larvae were collected from each treatment (19 days post treatment) and reared until pupation or death. Mortality at the 160 and 76 g AI/ha dosages was 62 and 8% respectively, compared with 8% mortality in untreated checks. This confirmed the suspected effect at the higher dosage rate.

Nuclear Polyhedrosis virus (NPV). The four treatments carried out with virus material were primarily to compare effectiveness of different preparations. Unfortunately, sawfly development had progressed beyond the optimum stage for best results at time of application (77-07-14); also, because of limited time and unfavourable weather conditions, treatments were replicated only once. As was the case with EL-494 there was no visible effect on colony condition or feeding at time of the first observation 8 days post treatment. However, defoliation on all NPV trees was less than on trees treated with solvents only (81%) and untreated checks (48%). Average defoliation with NPV preparations II, IV, III and I were 18, 28, 38 and 52%, respectively. The No. II preparation was that made up from the crude concentrate and diluted to the required strength by solvent-carrier only and seemed to be superior to all others; the preparation containing the purified material in the same solvent carrier was least effective. The other two preparations, both containing molasses and one a sunlight protectant were intermediate in reducing defoliation. The variations in deposits of formulations and colony numbers between trees, combined with the small number of replicates in these preliminary tests, precludes any firm conclusions. The crude virus preparation without molasses appeared most active and the purified product the least. It is possible that earlier application before so much defoliation had already occurred would have resulted in greater effectiveness. Collections of larvae from each NPV treatment plus untreated checks were made for microscopic determination of infection and adult emergence (results to be published elsewhere by J. C. Cunningham).

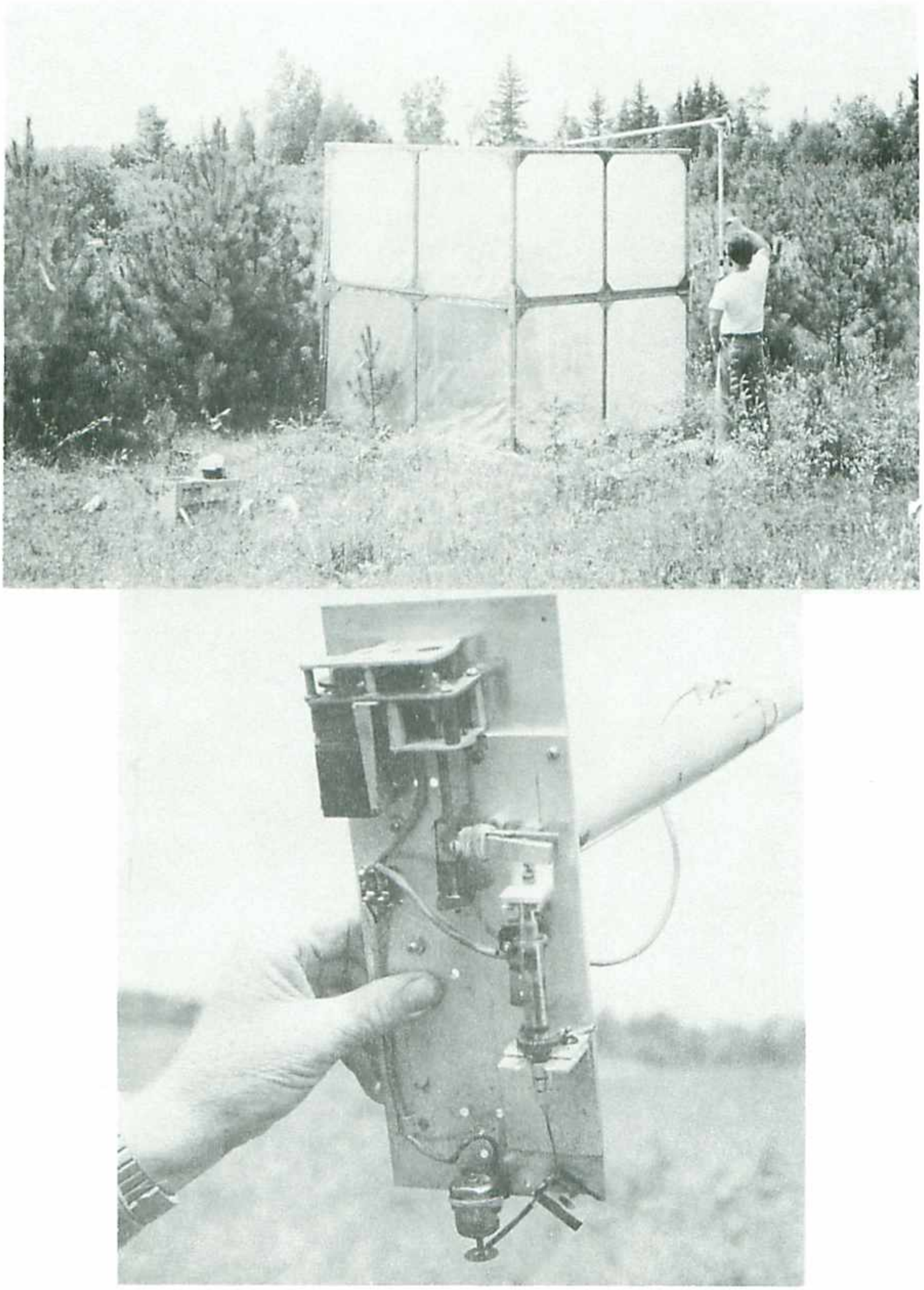

Fig. 1. Simulated Aerial Spray Deposit Device in Use.
Top: Distribution over area with tree in shelter.
Bottom: Closeup of liquid feed and droplet generator.

Photos: J. C. Cunningham

TABLE I

Formulations and Treatments--Red-headed Pine Sawfly Experiments

Lanark - 1977

Treatments				Spray Mixture		
Code No.	Active Ingredient	Application rate/ha g AI	ℓ	Composition*	% Volume	% AI-wt/vol
P-I	Phosphamidon	145	2.9	Phosphamidon (tech) 92%	4.5	4.9
				Arotex 3470	16.0	
				Fuel oil 2	34.5	
				Fuel oil 4	45.0	
F-I	Fenitrothion	145	2.9	Fenitrothion (tech) 96%	3.9	4.9
				Arotex	4.6	
				Fuel oil 2	46.5	
				Fuel oil 4	45.0	
EL-I	EL-494	145	2.9	EL-494 50WP	10 g	5.0
				Solvent mix 10% ethylene glycol-90% water to make	100 mℓ	
EL-II	EL-494	72	2.9	EL-494 50WP	5 g	2.5
				Solvent as above to make	100 mℓ	
143-I	Permethrin	49	2.9	ULV Conc. 50% AI	3.4	1.7
				Arotex 3470	24.2	
				Fuel oil 2	72.4	
143-II	Permethrin	22	1.3	As for 143 above		

* Dye solution (0.2%) was added to all mixes; automate red in oil-based and rhodamine B in water based.

TABLE I (Cont'd.)

Treatments				Spray Mixture		
Code No.	Active Ingredient	Application rate/ha g AI	ℓ	Composition*	% Volume	% AI-wt/vol
O-I	Acephate	145	2.9	Orthene 75S	6.7 g	5.0
				10% ethylene glycol in water to make	100 mℓ	
O-II	Acephate	65	1.3	As for O-I above		
M-I	Aminocarb	145	2.9	Matacil 1.68 OSC	29.8	5.0
				Arotex 3470	17.6	
				Fuel oil 2	52.6	
M-II	Aminocarb	72	2.9	Matacil 1.68 OSC	14.9	2.5
				Arotex	21.3	
				Fuel oil 2	63.8	
B-I	Propoxur	145	2.9	Baygon 1.68 OSC	29.8	
				Arotex	17.6	
				Fuel oil 2	52.6	
B-II	Propoxur	72	2.9	Baygon 1.68 OSC	14.9	2.5
				Arotex	21.3	
				Fuel oil 2	63.8	
P-II	Phosphamidon	72	2.9	P-I above diluted with dyed solvent Arotex 3470:F.O. 2 1:3		2.5

* See footnote page 11.

TABLE I (Cont'd.)

Treatments				Spray Mixture		
Code No.	Active Ingredient	Application rate/ha g AI	ℓ	Composition*	Volume	% AI-wt/vol
P-III	Phosphamidon	36	2.9	P-II above diluted 1:1 with dyed solvent	-	1.25
NPV-I	Nuclear Polyhedrosis Virus	-	8.8	Purified NPV (3.5×10^7 PIB/mℓ) Ethylene glycol:water 1:9	1.6 98.4	(5.6×10^5 PIB/mℓ)
NPV-II	NPV	-	8.8	Crude con. (3.6×10^8 PIB/mℓ) Solvent as for NPV-I	0.16 100.0	(5.8×10^5 PIB/mℓ)
NPV-III	NPV	-	8.8	Crude conc. Molasses Solvent as for NPV-I	0.16 25.0 75.0	(5.8×10^5 PIB/mℓ)
NPV-IV	NPV	-	8.8	Crude conc. Molasses IMC 90.001 (UV Protectant) Solvent as for NPV-I	0.16 25.0 3.0g 69.0	(5.8×10^5 PIB/mℓ)
Solvent		0	2.9	Arotex 3470 Fuel oil 2	25.0 75.0	

* See footnote page 11.

TABLE II

Average Deposits Applied to Single Trees and Treatment Groups[1]
Observed Post Treatment Defoliation

Active Ingredient Treatment Date	Spray Deposit Averages*			Defoliation Appraisal	
	ℓ/ha and SD	g AI/ha	Drops/cm²	Rating Number**	Est. Avg. % Defoliation
Fenitrothion	3.33±2.0		145	1	
F-I	2.90±1.6		75	1	
77-07-06	3.39±1.8		77	2	9
	3.21±1.6	157	99		
Phosphamidon	4.21±1.9		120	1	
P-I	4.12±1.3		124	2	
77-07-06	2.83±0.6		84	1	9
	3.72±1.4	186	109		
Phosphamidon	1.79±0.3		44	2	
P-II	3.73±2.2		65	1	
77-07-12	7.64±3.5		86	1	9
	4.38±3.3	110	65		
Phosphamidon	3.88±1.3		50	1	
P-III	1.98±0.6		31	1	
77-07-13	2.84±0.8		47	2	9
	2.90±1.2	36	43		

(1) All treatments in triplicate (3 trees) except NPV (2 trees).
* For Single tree, average of samples from each quadrant; treatment--mean of 12 quadrants
** Defoliation estimated visually--77-11-10 on a scale rating of 1 to 5.

TABLE II (Cont'd)

Active Ingredient Treatment Date	Spray Deposit Averages*				Defoliation Appraisal	
	ℓ/ha and SD		g AI/ha	Drops/cm^2	Rating Number**	Est. Avg. % Defoliation
Acephate	5.98	3.4		48	3	
O-I	4.06	1.0		35	3	
77-07-08	4.36	1.8		40	4	46
	4.84	2.3	242	41		
Acephate	2.06	0.8		21	5	
O-II	1.35	0.5		18	3	
77-07-08	1.20	0.4		14	5	71
	1.54	0.7	77	18		
Aminocarb	5.35	1.9		67	1	
M-I	4.48	1.8		54	1	
77-07-13	3.25	1.5		43	1	5
	4.36	1.8	218	55		
Aminocarb	1.92	0.9		37	2	
M-II	3.85	2.1		53	1	
77-07-13	4.42	2.4		56	2	14
	3.40	2.1	85	49		
Propoxur	2.80	1.2		42	1	
B-I	1.68	1.2		23	2	
77-07-13	4.00	1.4		64	1	9
	2.80	1.5	140	43		

* See Footnote, page 14
** See Footnote, page 14

TABLE II (Cont'd)

Active Ingredient Treatment Date	Spray Deposit Averages* ℓ/ha and SD	g AI/ha	Drops/cm^2	Defoliation Appraisal Rating Number**	Est. Avg. % Defoliation
Propoxur	3.05±1.3		41	3	
B-II	3.28±0.7		60	3	
77-07-08	3.78±0.5		50	2	31
	3.37±0.9	84	50		
Permethrin	2.23±2.2		34	2	
143-I	2.05±0.8		20	1	
77-07-08	2.20±1.1		26	1	9
	2.16±1.3	37	27		
Permethrin	4.58±1.8		63	1	
143-II	3.92±2.3		56	1	
77-07-08	4.10±2.4		44	1	5
	4.20±2.0	71	54		
EL-494-I	3.92±1.5		91	3	
EL-I	3.29±3.0		87	2	
77-07-07	2.34±1.2		34	1	20
	3.19±2.0	160	71		
EL-494-II	4.16±1.5		98	3	
EL-II	2.75±1.2		74	5	
77-07-07	2.22±1.0		56	3	55
	3.04±1.4	76	76		
Virus	8.3 ±2.8		97	2	
NPV-II	11.4 ±3.2		78	2	18
77-07-14	9.9 ±3.3	(5.8×10^9)†	88		

* See Footnote, page 14
** See Footnote, page 14

† Polyhedral inclusion bodies per hectare.

TABLE II (Cont'd)

Active Ingredient Treatment Date	Spray Deposit Averages*			Defoliation Appraisal	
	ℓ/ha and SD	g AI/ha	Drops/cm^2	Rating Number**	Est. Avg. % Defoliation
Virus	9.9±4.0		149	3	
NPV-IV	4.7±4.7		102	2	28
77-07-14	11.3±4.3	(6.6×10^9)†	126		
Virus	9.7±2.9		71	3	
NPV-I	10.7±3.6		64	4	50
77-07-14	10.2±3.1	(5.7×10^9)†	68		
Virus	10.0±6.5		88	3	
NPV-III	10.0±1.6		86	3	38
77-07-14	10.0±4.4	(5.8×10^9)†	87		
Check	3.7±2.6		63	5	
Solvent	2.7±0.7		106	5	
77-07-07	4.6±2.5		101	4	80
	3.7±2.1	0	90		
Checks				3	
				4	
				3	46

* See Footnote, page 14
** See Footnote, page 14
† See Footnote, page 16

SUMMARY AND CONCLUSIONS

Phosphamidon and permethrin appeared most effective against the red-headed pine sawfly, of those insecticides evaluated, with minimum effective deposits of less than 35 g/ha resulting in excellent protection against defoliation. Aminocarb at 100 g/ha and propoxur and fenitrothion at approximately 150 g/ha gave good foliage protection. Acephate was least effective, a dosage of 242 g/ha failing to give satisfactory results.

The experimental molt inhibiting compound EL-494 had no visible effect on sawfly larvae 10 days post treatment. However, average deposits of 160 g/ha in three litres formulation resulted in good foliage protection. Larvae collected from the 160 g AI/ha treatment and raised until pupation or death suffered 60% mortality, whereas mortality in larvae from the lower dosage was the same as that in the untreated check (8%).

Nuclear polyhedrosis virus was applied in 4 formulations, all at nominal application rates in the order of 5.8×10^9 polynuclear inclusion bodies per hectare. The visible effects on protection of trees from defoliation only, are reported here. Application too late in development of larvae, variations in infestation levels and too few treatment replicates precluded firm conclusions from these preliminary tests. However, all treated trees received some foliage protection, with formulations made up from the crude virus preparations appearing to give the most protection and the purified the least. Formulations containing molasses were intermediate in effect.

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REFERENCES

HOPEWELL, W. W. 1977. Field Evaluation of the Pyrethroid NRDC-143, Compared with Fenitrothion, Acephate and Chlorpyrifos-methyl as Simulated Aerial Spray Deposit for Control of the Spruce Budworm, *Choristoneura fumiferana*, Clem. Env. Canada, For. Serv. Chem. Cont. Res. Inst. Inf. Rept. CC-X-132 , 31 pp.

KAUPP, W. J. and J. C. CUNNINGHAM 1977. Aerial Application of a Nuclear Polyhedrosis Virus Against the Red-headed Pine Sawfly, *Neodiprion lecontei* (Fitch). Env. Canada, For. Serv., Chem. Cont. Res. Inst. Inf. Rept. IP-X-14, 26 pp.

HOPEWELL, W. W. 1975. Field Evaluation of Orthene[R], Phosvel[R], FMC 33297 and TH 6040, against *Choristoneura fumiferana*, Applied as Simulated Aerial Spray. Env. Canada, For. Serv., Chem. Cont. Res. Inst. Inf. Rept. CC-X-115, 29 pp.

HOPEWELL, W. W. and P. C. NIGAM 1974. Field evaluation of Orthene[R], Phoxim and fenitrothion against spruce budworm (*Choristoneura fumiferana*) applied as simulated aerial spray. Env. Canada, For. Serv., Chem. Cont. Res. Inst. Inf. Rept. CC-X-83, 14 pp.

HOPEWELL, W. W. 1973. Evaluation of commercial preparations of *Bacillus thuringiensis* with and without chitinase against spruce budworm. Section B. Env. Canada, For. Serv., Chem. Cont. Res. Inst. Inf. Rept. CC-X-59, 14 pp.

NIGAM, P. C. and W. W. HOPEWELL 1973. Preliminary field evaluation of Phoxim and Orthene[R] against spruce budworm on individual trees as simulated aircraft spray. Env. Canada, For. Serv., Chem. Cont. Res. Inst. Inf. Rept. CC-X-60, 15 pp.

SUNDARAM, K. M. S. and W. W. HOPEWELL 1976. Distribution, Persistence and Translocation of Orthene[R] in Spruce Trees after Simulated Aerial Spray Application. Env. Canada, For. Serv., Chem. Cont. Res. Inst. Inf. Rept. CC-X-121, 25 pp.