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Chemical Control Research Institute

Ottawa, Ontario

CONTROL METHODS RESEARCH

(Project No. CC-1)

Project Leader: J. A. Armstrong

AN ASSESSMENT OF THE EFFICACY OF EARLY APPLICATION OF FENITROTHION FOR THE CONTROL OF THE 2ND INSTAR LARVAE OF THE SPRUCE BUDWORM

(Study Ref. No. CC-1-001)

Report to the Canadian Forest Pest Control Forum
November 23 - 24, 1976

by

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November, 1976

AN ASSESSMENT OF THE EFFICACY OF EARLY APPLICATION OF FENITROTHION FOR CONTROL OF THE 2ND INSTAR LARVAE OF THE SPRUCE BUDWORM

by

A.P. Randall (CCRI)

and

R. Desaulniers (QDLF)

Large scale aerial spray trials utilizing multi-engine aircraft and incremental spray application techniques were conducted for the fifth consecutive year in Quebec in 1976 to develop improved control strategies for the spruce budworm. The objectives of the 1976 program were: (1) confirmation of adequate spray coverage (+20 drops/cm^2) from the emission of 0.88 ℓ/ha (12 oz/ac) of formulated insecticides, (2) the reduction of the 2nd instar larval population early in the budworm growth cycle, thereby preventing serious bud losses during the early bud developmental stage.

Two experimental blocks of 35,000 acres were established in a moderate (La Macaza) and high density (Bonaventure) spruce budworm density area. Treatment of each area was scheduled for two applications of 0.88 ℓ/ha (12 oz/ac) of oil-formulated fenitrothion containing 0.07 kg/ha (1 oz/ac) active ingredient against the 2nd instar larvae and one application of 0.07 kg/0.88 ℓ (1 oz AI/12 oz) formulation against the larger 4th and 5th instar larvae. Timing of spray application was aimed at the pre-needle and pre-bud mining stages for the 2nd instar larvae and, needle flare stage for the larger instars.

Pre and post spray population assessments were made on balsam fir and spruce host trees on the experimental and non-treated checks. Early larval population trends were established using NaOH extraction and field rearing techniques followed by the standard laboratory larval counting technique on 45 cm branch samples. Normal population decline curves were established from the untreated check trees and pre-spray larval data from the experimental block #118. From these data a corrected percentage population reduction for treatment of the experimental area was established using Abbott's formula.

RESULTS

Unfortunately, owing to shortages of funds and personnel, only one trial was completed (ie. the early phenological zone of La Macaza, Quebec) where the spruce budworm larval population was at a very low density. In spite of the low larval densities encountered the results were extremely interesting.

Analysis of the spray deposit data (colorimetric and drop counts/cm^2 indicated a relatively high spray deposition within and beyond the block boundaries. Application of spray formulation under ideal weather conditions (Fig. 1) shows a typical incremental deposit pattern downwind across the block of 10 drops/cm^2 for the first 3.22 km (2 mi.); 20+ drops for the next 3.22 km (2 mi.) and 30 to 50 drops/cm^2 for the remainder of the block and beyond the block boundary. Fig. 2 presents the cumulative deposit of the 1st and 2nd sprays, and Fig. 3 presents the cumulative deposit from the 1st, 2nd and 3rd sprays respectively.

Preliminary assessment of the biological results indicates an extremely favourable pattern of control of the 2nd instar larvae when the sprays are applied during the active emergence period of the larvae. Fig. 4 shows the typical emergence pattern for the 2nd instar larvae and subsequent larval population decline for the remainder of the season. Reduction of 2nd and subsequent spruce budworm larvae is graphically presented in Fig. 5 and in tabular form in Table I. Analysis of the data indicates that two applications of 0.07 kg/ha (1 oz/ac) active ingredient accounted for the greater part of the mortality figures and that 0.07 kg applied at the 4th instar stage was virtually ineffective as evidenced by the lower mortality values (Table 1).

Tentative assessment of foliage and bud protection within and outside of the experimental area shows a high order of new green foliage. Final assessment of the protection due to treatment, however, is more difficult to analyze because of the low population density of budworm larvae.

Cost/Benefit Analysis of Multiple Sprays

A preliminary assessment of costs of (a) triple applications at 0.070 kg AI/ha (1 oz/ac) vs. the current operational costs of (b) two applications of 0.140 kg AI/ha (2 oz/ac) is summarized below:

Ingredient	Comparative costs per application*			
	(a)		(b)	
	per hectare	per acre	per hectare	per acre
Sumithion[R]	40.87¢	16.54¢	81.74¢	33.08¢
Arotex[R]	1.33	0.54	2.67	1.08
#2 Fuel oil	1.73	0.70	0.86	0.35
#4 Fuel oil	2.17	0.88	1.83	0.74
Sub-Totals	46.11¢	18.66¢	87.10¢	35.25¢
Application cost	24.71¢	10.00¢	24.71¢	10.00¢
Total	70.83¢	28.66¢	111.81¢	45.25¢
Total cost for all applications	(X3) 212.49¢	85.98¢	(X2) 223.62¢	90.50¢

* based on emitted volume of 0.842 ℓ/ha (11.52 oz/ac) per application.

On the basis of the 1977 experimental proposal for triple application, other overriding factors would be:

1. more aircraft would be required for early multiple application;
2. conversely a shorter contract period for the aircraft to spray the area would be required.

FIG. 1. 12 OZ. PER AC.-1976 DC-6-1ST APPLICATION

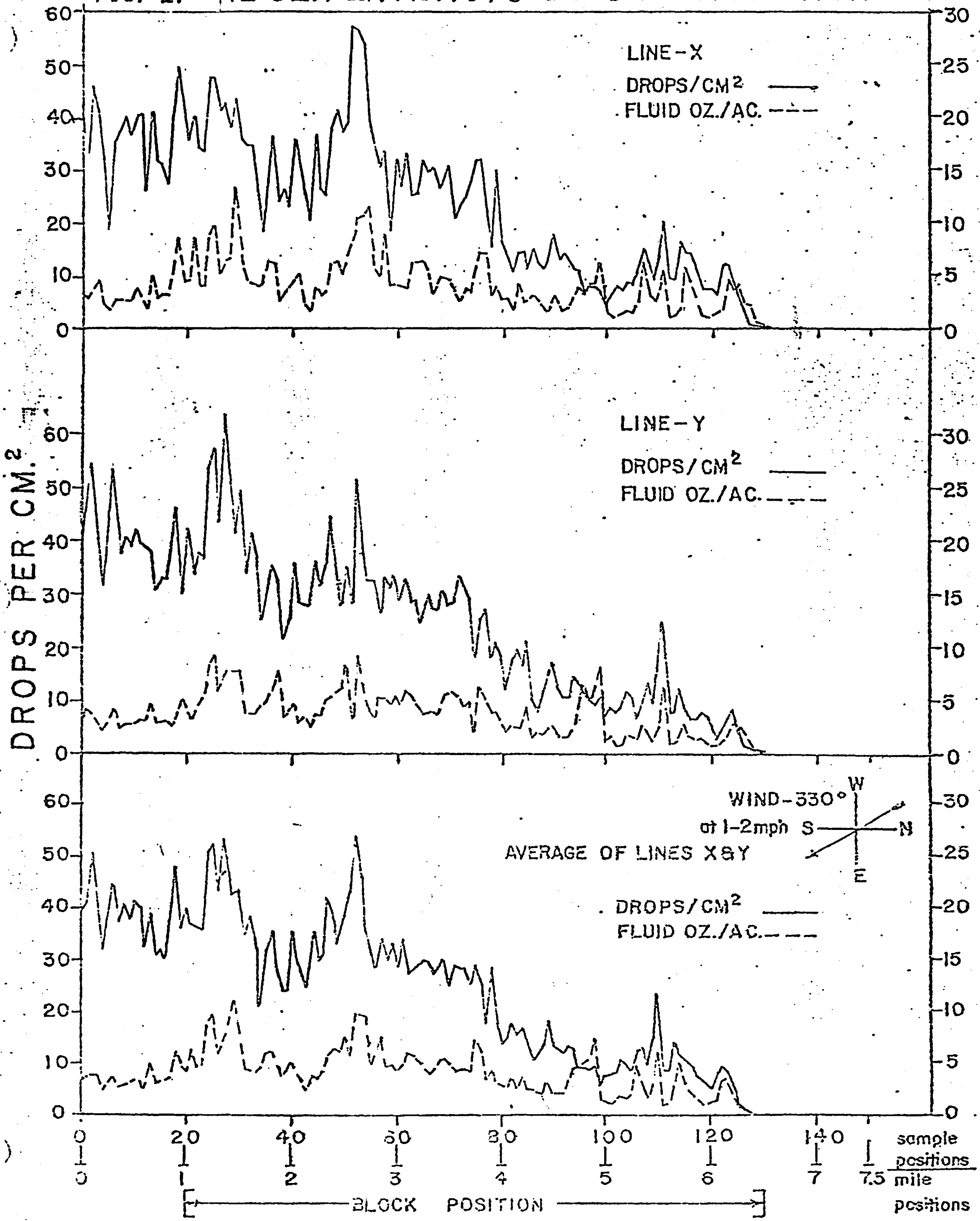


FIG. 2. CUMULATIVE OF 1st & 2nd APPLICATIONS

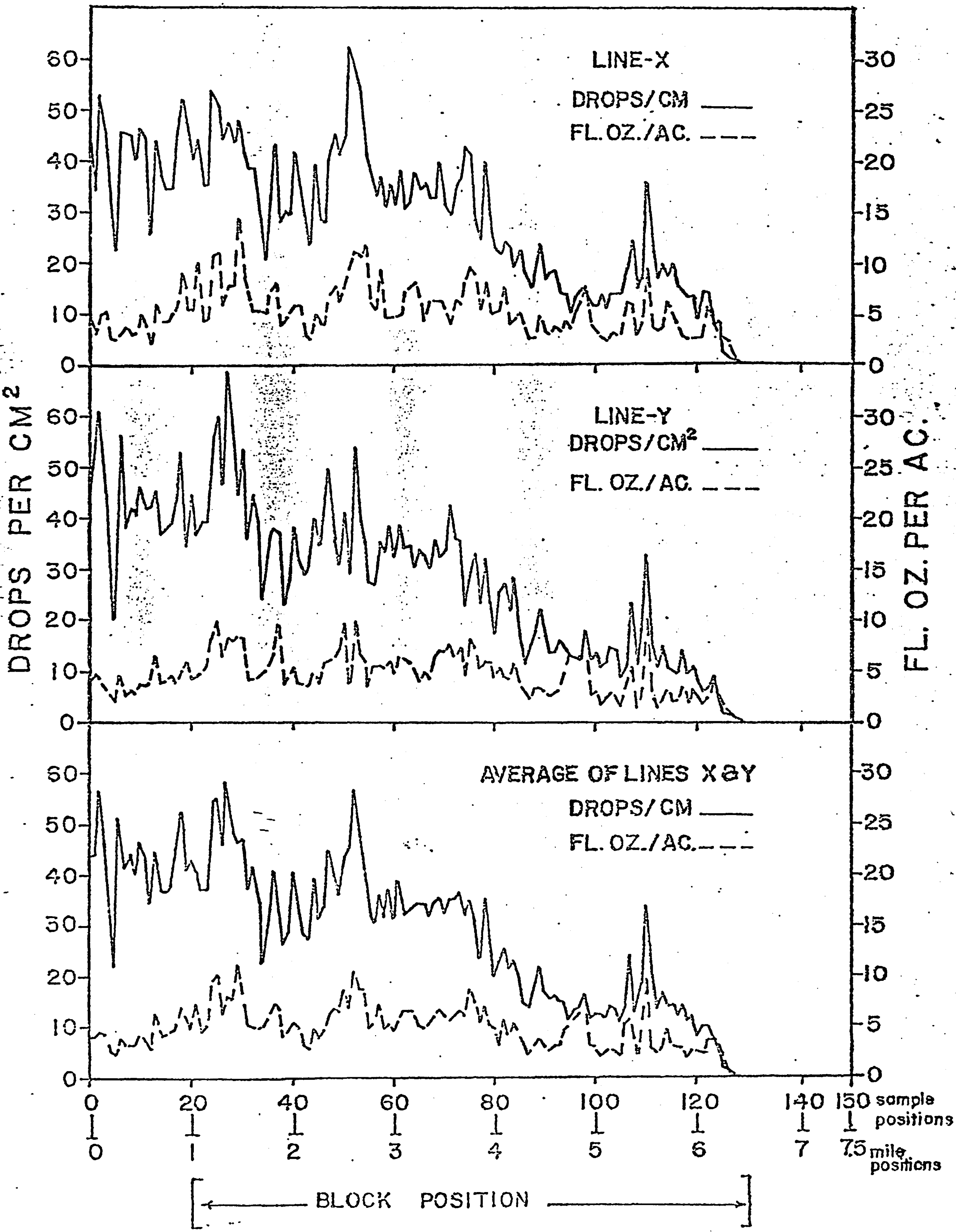
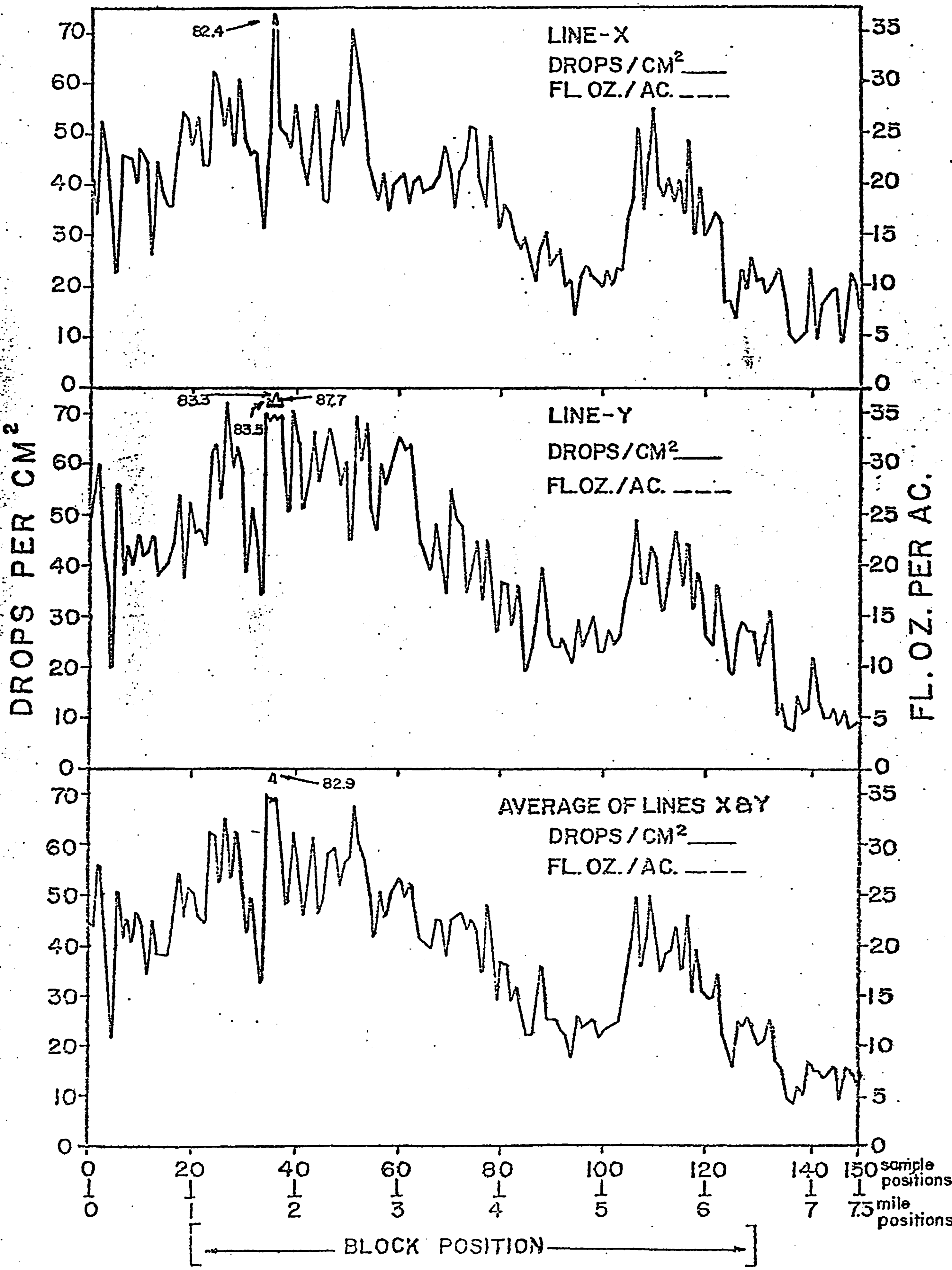


FIG. 3. CUMULATIVE OF 3 APPLICATIONS



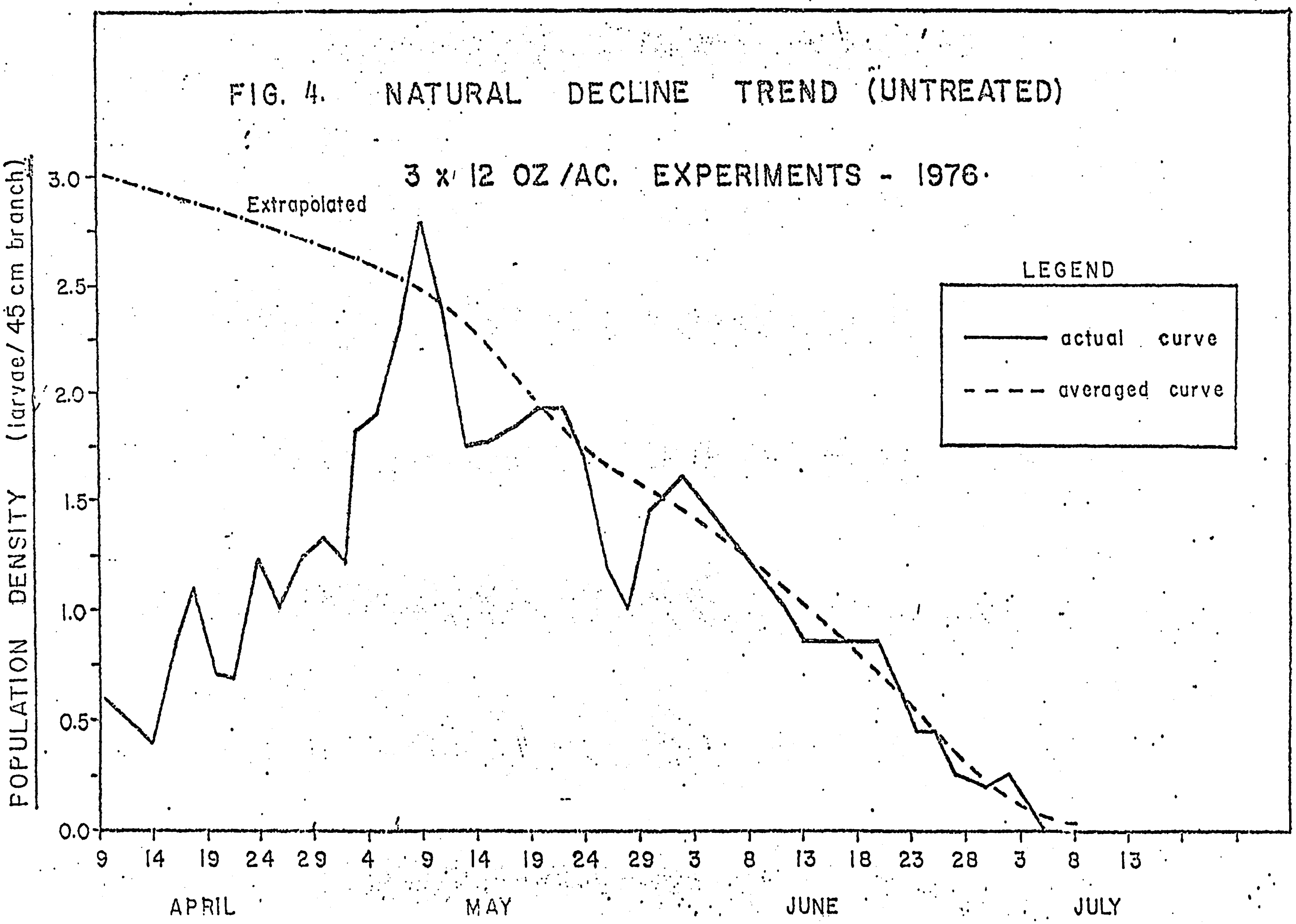


FIG. 4. NATURAL DECLINE TREND (UNTREATED)
3 x 12 OZ/AC. EXPERIMENTS - 1976
Extrapolated
LEGEND
actual curve
averaged curve
POPULATION DENSITY (larvae/ 45 cm branch)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
9 14 19 24 29 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13
APRIL
MAY
JUNE
JULY

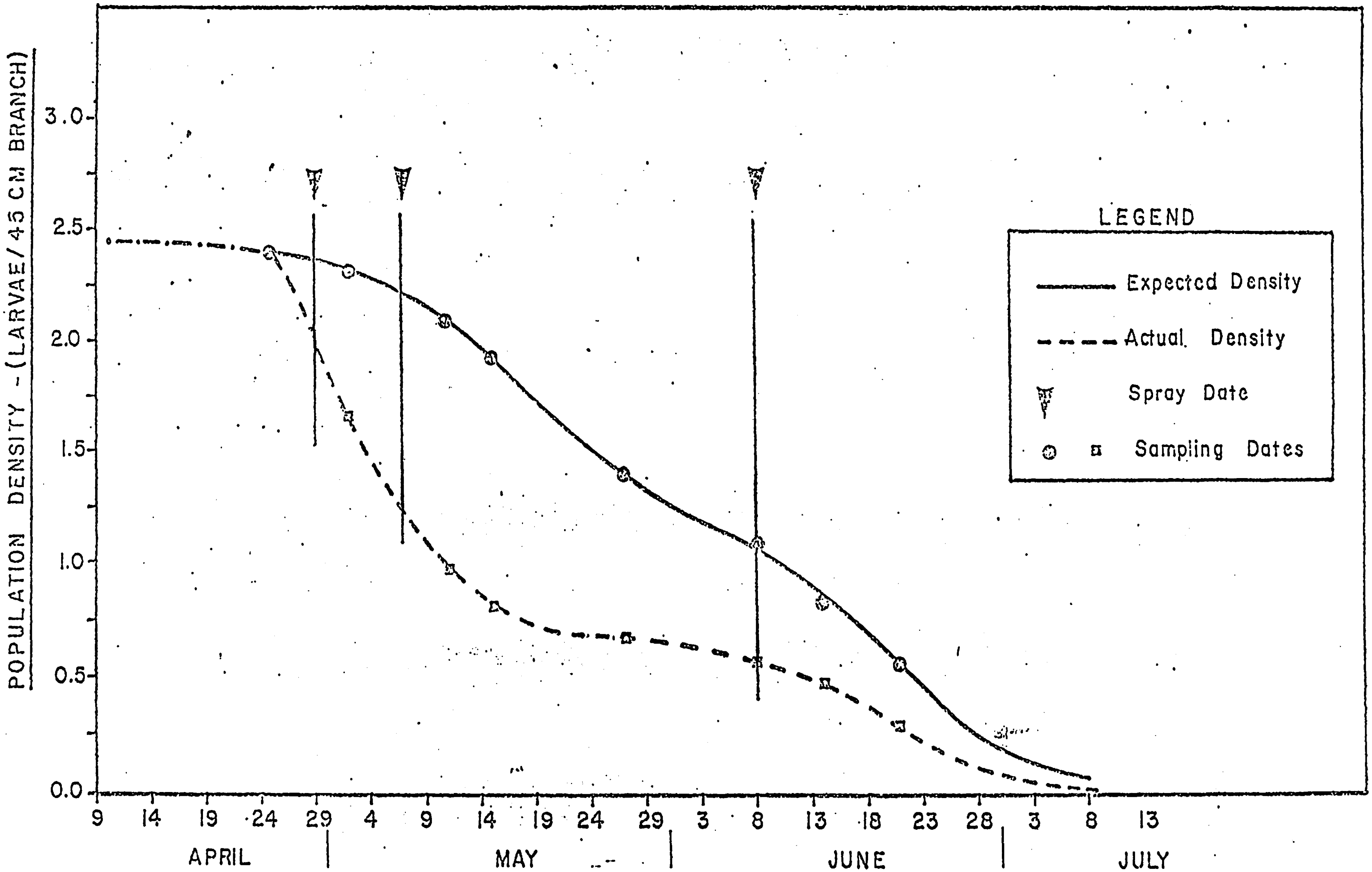


FIG. 5. EXPECTED SBW POPULATION DENSITY VS TREATED
LA MACAZA, QUE. 1976

Table I

2 nd Instar Larval Population Reduction due to treatment (Average for Block 118)

Application Date	Sampling Date	Pre-spray Density	S.B.W. Population: Expected Density at Spray Date	S.B.W. Population: Post-Spray Density Expected	S.B.W. Population: Post-Spray Density Observed	% Population Reduction *	% Larval Instar
1st Application Apr. 29th	May 1	2.475	2.450	2.450	1.700	30.6	2nd. 100%
	May 7		2.450	2.300	1.250	44.7	
2nd Application May 7th	May 11	2.400	2.300	2.150	1.000	53.5	2nd 100%
	May 15		2.300	2.000	0.850	57.5	
3rd Application June 8th	June 14	1.125	1.125	0.900	0.500	44.4	4th. - 28% 5th. - 27% 6th. - 38%
	June 21		1.125	0.575	0.250	56.5	

* Using Abbotts formulae $\left(\frac{\text{Expected} - \text{Observed}}{\text{Expected}}\right)$ X 100 = % Reduction due to Treatment.

STUDIES ON THE SYNTHETIC PYRETHROID, NRDC-143
FOR CONTROL OF THE SPRUCE BUDWORM

(Study Ref. No. CC-1-011)

Report to the Canadian Forest Pest Control Forum
November 23 - 24, 1976

by

J. A. Armstrong

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November, 1976

STUDIES ON THE SYNTHETIC PYRETHROID, NRDC-143 FOR CONTROL OF THE SPRUCE BUDWORM

by

J. A. Armstrong

The synthetic pyrethroid NRDC-143, known as permethrin, has been shown by Nigam (report to AFPCF, 1975) to be a good candidate material for control of the spruce budworm. Hopewell, in his report to the Forest Pest Control Forum, reported that effective budworm control could be achieved with an application of 0.07 kg/ha (1.0 oz AI/acre) and a deposit of from 0.025 to 0.06 kg/ha (0.36 to 0.85 oz AI/acre). Following the protocol used at CCRI, plans were made to do a series of aerial applications of NRDC-143 to assess its efficacy in terms of budworm mortality and foliage protection. Two sets of aerial applications were planned; one an oil solution to be applied to plots in the area of the Petawawa Forest Experiment Station and the other an aqueous emulsion to be applied to plots at Grand'Mére, Quebec. In this report only the sprays at PFES will be discussed.

Seven experimental plots, each 40 ha (100 acres) in size were selected for insecticide application. One block was to be treated twice with Fenitrothion, each application at 0.14 kg/ha (2.0 oz AI/acre). The remaining six to be treated with NRDC-143, were divided into two groups; an early application series to be treated when the larvae were in the L_2 - L_3 stage and a late application series to be treated when the larvae were predominantly L_4. The application rates in each series were to be 0.008, 0.017 and 0.035 kg/ha (0.125, 0.25 and 0.50 oz AI/acre). All applications were oil solutions (No. 2 fuel oil alone for the NRDC-143, No. 2 fuel oil plus Arotex for the fenitrothion) at 4.67 ℓ/ha (0.5 gals. (U.S.) per acre). Applications were made using the Institute aircraft fitted with Micronair AU 3000 spray units.

Budworm development and population decline information was collected from two untreated check plots. On the test and untreated plots upper and mid-crown branch samples were taken at each sample date and the population density was determined as the number of larvae per 45 cm (18 inch) branch tip. On each of the test plots a single pre-spray sample was taken and post-spray samples were taken at 2, 5, 9 and 14 days post-spray. At the time of complete pupation a defoliation survey was made.

Prior to spray application 1 m^2 collection sheets were set out under selected trees in the late application spray series plots. After the spray the sheets were examined and insects collected at 1 hr., 12 hrs,, 24 hrs. and 2, 5 and 9 days after treatment. Insects were identified to Order and Family. Immediately before each spray insecticide sample units consisting of kromekote cards and glass plates were set out in each plot. These units were collected 45 minutes after the completion of the spray. Colorimetric analysis of the spray deposit was completed at CCRI and droplet analysis was the responsibility of NAE.

All sprays were applied under suitable weather conditions with wind speeds between 0.90 and 4.5 m/s (2 and 10 mph) and stable to neutral weather conditions. The results of the spray applications are shown in Table I.

Table I

Effect of Permethrin (NRDC-143) Applications on Spruce Budworm Populations at PFES

Timing	Application rate oz ai/acre*	Deposit oz ai/acre	Population density, Larvae/18" branch Pre-spray	Post +2	Post +5	Post +9	Post +14	Percent pop'n reduction[1]	Percent defoliation[3]
L_2-L_3	0.125 (143)	0.125	9.7	4.9	7.2	4.4	3.3	4	12
L_2-L_3	0.250 (143)	0.09	9.2	5.4	7.5	4.5	3.2	5	12
L_2-L_3	0.50 (143)	0.05	6.4	5.0	2.7	3.1	2.2	15	12
L_4	0.125 (143)	0.08	5.2	3.0	2.3	2.7	1.9	0	10
L_4	0.250 (143)	0.06	9.7	2.9	3.3	1.6	1.1	63	13
L_4	0.50 (143)	0.18	16.2	17.3	17.5	9.6	7.7	22	35
L_2-L_4	2 x 2.0 (Fenit.)	1.13	2.7	2.1	1.9	2.9	1.5	0	10
	Untreated	-	6.9	6.0	4.5	3.4	1.2	83[2]	15
	Untreated	-	6.5	6.9	3.3	3.1	-	55[2]	-

* 0.125 oz AI/acre = 0.008 kg/ha.

[1] Percent reduction corrected using Abbott's Formula.

[2] Untreated check population reduction at last sample time.

[3] No difference between fir or spruce - data combined.

RESULTS

These data show no marked population reduction and no effective change in defoliation. The apparent lack of success can be attributed to the low initial populations (with one exception all were less than 10 larvae 45 cm (18 inch) branch) and the drastic population decline which occurred in the normal population (83% population reduction by 14 days post-spray). The results of these two factors was to mask the effect of the insecticide application in terms of insect mortality and foliage protection.

The deposit rates achieved were normal for a spray operation (average 40% deposit, ranging from 10 to 100%). On the more positive side assessment of all NRDC-143 trials completed by CCRI indicates that the material is effective against the spruce budworm and foliage protection can be achieved at an application rate of something between 0.035 and 0.07 kg/ha (0.5 and 1.0 oz AI/acre). As a result of photography problems NAE have not yet been able to complete the droplet analysis data.

A study of the ground collection sheets showed that the largest number of insects were collected from the plot with the highest percentage population reduction, 0.017 kg/ha (0.25 oz AI/acre) applied to L_4, with 9 Orders and 23 Families collected. In the fenitrothion plot 8 Orders (12 Families) were collected.

PLANTATION PEST CONTROL RESEARCH: SPRUCE BUDWORM

(Study Ref. CC-1-012, CC-1-025)

Report to the Canadian Forest Pest Control Forum
November 23 - 24, 1976

by

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November, 1976

PLANTATION PEST CONTROL RESEARCH: SPRUCE BUDWORM

by

R. F. DeBoo

Two synthetic pyrethroids (FMC 33297, NRDC 143) were selected for experimental aerial application as part of the Institute's program for field bioassay of candidate insecticides for control of spruce budworm (Choristoneura fumiferana). Results of ground spray applications by mist-blower during 1975 indicated that dosages of less than 70 g AI/ha were very effective in inducing high mortality of budworm larvae and in providing excellent protection of foliage of host trees.

Aerial sprays were applied to selected white spruce compartments of the Grand'Mere Plantations with permission of the proprietor, Consolidated-Bathurst Ltd. Dosages and volumes for experimentation were determined after consultation with technical representatives of FMC Canada and Chipman Chemicals. The major objectives of the study were (1) to determine the efficacy of a range of dilute aqueous solutions applied as single-spray treatments by small agricultural spray aircraft vs. fourth-instar larvae for (2) comparison with similar oil-based sprays (see report by J.A. Armstrong, Study Ref. CC-1-011).

Preliminary results (Table I) indicate that the range of dosages evaluated for the synthetic pyrethroids may be up to 10 times as effective as a conventional application of fenitrothion. Poor spray deposition (due to evaporation and drift), non-vigorousness and low density of spruce budworm populations, and unexpected heavy refoliation of host trees during 1976, hindered interpretations of dosage-mortality-defoliation relationships. Data acquired at Grand'Mère are under analysis for presentation as a Canadian Forestry Service Report at a later date.

Preliminary Results of Experimental Aerial Applications of Synthetic Pyrethroids for Control of Spruce on White Spruce, Grand'Mère Plantations, Quebec, 1976

(Applied by Cessna AgTruck equipped with 4 Micronair AU3000 Spray Atomizers at 0.5 U.S. gal aqueous spray mix/acre)

Treatment[1]	Amount AI/ac	Acreage Treated	Spray Date	Larval Development at Spray Date	Larval Population Density (Avg No. per 18" branch tip)		% Population Reduction[2]	% Defoliation[3] (Mid. Crown)
					Pre-spray (+2 days)	Post-spray (-9 days)		
NRDC 143	0.25 oz	424	June 4	68% L4	8.8	1.4	72	4
NRDC 143	0.50 oz	225	June 3	63% L4	5.5	1.3	59	2
FMC 33297	0.50 oz	160	June 2	52% L4	16.2	3.5	62	8
FMC 33297	1.0 oz	180	June 3	63% L4	12.2	3.0	57	3
Fenitrothion	4.0 oz	175	June 2	52% L4	5.3	0.8	72	3
Untreated Check	-	ca.200	-	-	5.0	2.9	(42)*	7

[1] Replications/treatment:

NRDC 143 @ 0.25 oz AI/ac - 3
NRDC 143 @ 0.50 oz AI/ac - 2
FMC 33297 @ 0.50 oz AI/ac - 2
FMC 33297 @ 1.0 oz AI/ac - 1
Fenitrothion @ 4.0 oz AI/ac - 1
Untreated Check - 5

[2] Corrected by Abbott's Formula.

[3] Based on examinations of 1976 shoot condition - Fettes method.

* Natural population decline June 1-12.

NOTE: 1 oz (wt) = 70 g; 1 oz (liquid) = 29.57 ml; 0.5 gal = 1.9 litre; 1 acre = 0.4 hectare

AERIAL APPLICATION OF A NEW FORMULATION OF *BACILLUS THURINGIENSIS* WITH AND WITHOUT ORTHENE® AGAINST THE SPRUCE BUDWORM, *CHORISTONEURA FUMIFERANA*

(Study Ref. No. CC-1-015)

Report to the Canadian Forest Pest Control Forum
November 23 - 24, 1976

by

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Ottawa, Ontario

November, 1976

AERIAL APPLICATION OF A NEW FORMULATION OF *BACILLUS THURINGIENSIS* WITH AND WITHOUT ORTHENE® AGAINST THE SPRUCE BUDWORM, *CHORISTONEURA FUMIFERANA*

by

O.N. Morris and J.A. Armstrong

The 1976 field studies on the effectiveness of *Bacillus thuringiensis* in combination with a chemical insecticide involved (a) assessment of those plots sprayed in 1975 to determine long term effectiveness of B.t. treatments and (b) application of a new formulation of B.t. developed at C.C.R.I.

Long Term Studies

In the long term study, the treatment rate applied in 1975 to 5 plots ranging in size from 194 - 362 hectares was 20 Billion International Units of B.t. activity with or without 42 g of active ingredient of acephate/ha. In the year of application, population reduction on plots sprayed with B.t. + acephate ranged from 97 - 99% (86 - 90% on B.t. alone plots). Foliage protection, however, was generally not satisfactory partly due to high budworm densities (défoliation about 70% generally).

In the second year of assessment (without further treatment), population declines were greater and defoliation and oviposition were significantly lower in treated than in untreated check plots, indicating long term effectiveness of the treatments. Egg mass densities in the second year indicated that there would be no significant defoliation in the third year in treatment plots.

The data indicated that large scale testing of B.t. - chemical insecticide combinations is now warranted.

New Formulation

During the past three years, a new water based formulation of B.t. was developed at C.C.R.I. The formulation contained (1) sodium carboxy-methyl cellulose, a water soluble cellulose ether widely used in industry to improve film forming, suspending, stabilizing, emulsifying and adhesive properties of liquids; (2) polyvinylpyrrolidone (PVP), a water soluble polymer characterized by its unusual complexing and colloidal properties and its physiological inertness. PVP is also an excellent film former and acts as a humectant; and (3) Uvinul DS49 a commercial sunlight screen, high water soluble.

The formulation was applied against larval budworm densities ranging from 12 to 20 larvae per 45 cm branch of white spruce and from 6 to 8 per 45 cm branch of balsam fir. Pre-spray densities per 100 buds were almost identical in all treatment and check plots. All plots were sprayed at 9.4 ℓ/ha.

The results indicated a high degree of success in term of spray and deposit efficiency. In Plot 1, for example, which was sprayed at 30 BIU of B.t. + 42 g acephate/ha, the mean number of drops/cm^2 at 50 sampling sites was 87.7 with 23% of the emitted volume reaching ground surface. The number of viable spores per hectare deposited was 6.7×10^9. This deposit rate is 4-5 times the previous deposit rates achieved with aerially applied water suspensions of B.t.

In spite of the highly increased deposit efficiency, budworm population reduction was not acceptable (14% on white spruce and 0 on balsam fir) for two reasons. Firstly the populations crashed on the check plot so that the difference between treated and untreated plots was not statistically significant. Secondly, the encapsulating effect of the PVP was so efficient as to inactivate the toxicity of the crystal component of the B.t. Defoliation was low on all plots (4% on treated and 17% on the check). For the same reasons, it was not possible to determine the effectiveness of the sunlight screen for B. thuringiensis.

In conclusion, the new formulation was shown to be highly successful in terms of spray and deposit efficiency, but an adjustment in its components will have to be made to improve its compatibility with the microorganism.

FIELD TESTS OF CANDIDATE INSECTICIDES APPLIED AS SIMULATED SPRAY DEPOSITS FOR CONTROL OF SPRUCE BUDWORM

SHAWVILLE - 1976

(Study Ref. No. CC-1-021)

Report to the Canadian Forest Pest Control Forum
November 23 - 24, 1976

by

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November, 1976

FIELD TESTS OF CANDIDATE INSECTICIDES APPLIED AS SIMULATED SPRAY DEPOSITS FOR CONTROL OF SPRUCE BUDWORM

by

W.W. Hopewell

The 1976 field work at Shawville was confined mainly to more intensive testing of the efficacy of the pyrethroid NRDC-143 (referred to as FMC-33297 in 1975 tests) for control of spruce budworm on white spruce. The material was applied at several concentrations and application rates to small white spruce (3-4 m) with a natural infestation of budworm. There were two series of tests: in Series 1, application was made early in the season before or about the time larvae were at the needle mining stage. The objective was to determine the persistence of the material and if there would be any effective control by this early treatment. In the Series II tests, application was made when budworm were primarily 4th and 5th instar. Fenitrothion was used as the reference insecticide and some tests using acephate (Orthene®) and chlorpryrifos-methyl (Reldan® or Dowco-214) were also included.

Methods and Materials

The formulations were applied to individual small white spruce trees as a simulated aerial spray deposit (Hopewell, 1975 - Report CC-X-115, Hopewell & Nigam 1975, Report CC-X.83).

Each test was in triplicate. Deposit samples were taken in each quadrant adjacent to a tagged branch which was later clipped off, larvae separated, counted and larval stage recorded. Effect of treatment was judged by comparison with budworm infestation on check trees. The formulations tested are listed below.

Formulations - Shawville-1976

The 17 formulations tested were made up from the following original concentrate preparations as received from commercial sources.

1. NRDC-143(A). Chipman Chemical Co. Stoney Creek, Ontario. A concentrate containing 500 g AI/ℓ for dilution with oil. Diluted with Arotex: F.0.2, 1:3 to give formulations 143A, I, II, III, IV, V and VI containing 3.4, 5.6, 1.7, 2.8, 0.8 and 1.4% AI respectively.
2. NRDC-143(B) FMC of Canada Ltd. Burlington, Ontario. A concentrate containing 800 g AI/ℓ. Diluted with same Arotex: F.0.2 mix to give same percent active as above for Chipman formulation - designated "B".
3. Orthene® 75S (acephate) Chevron Chemical (Canada) Ltd. Oakville, Ontario.
   A water soluble powder containing 75% active ingredient. Diluted to 10% and .5% AI with water (0-I and 0-II resp.).
4. Fenitrothion (Sumithion®) technical 96% AI Sumitomo Chemical Co. Osaka, Japan. An emulsifiable concentrate made up which was diluted to 10% AI for use (F-I).

Also an oil solution containing 18% AI (F-II).

5. Chlorpryrifos-methyl (Reldan®) Dow Chemical Co. diluted to 10% AI- (D-I).

   The 17 formulations as listed above were tested in 32 individual tests, each of which was replicated on 3 individual trees. For the series of early applications (6 to 13 May) only the Chipman sample of NRDC-143 was available; in the later tests parallel tests were carried out with the FMC formulation.

Results and Discussion

A summary of the results from the early series of tests, an average for the 3 trees in each test, is given in Table I.

TABLE I

Summary of Results from Early Application Tests (May 6-13, 1976)

Test No.	Formulation	Deposit			% Control
		ℓ/ha	g AI/ha	drops/cm^2	
1	143-I A	2.88	98	39	68
2	143-II A	1.06	59	34	27
3	143-III A	3.24	55	35	48
4	143-IV A	3.30	92	27	66
5	143-V A	6.28	50	74	44
6	143-VI A	6.51	91	76	46
7	O-I	4.62	462	18	37
8	O-I	1.81	181	7	20
9	O-II	1.92	96	6	5
10	F-I	1.30	234	12	52
11	F-I	0.60	108	16	62
12	F-II	2.10	210	36	18

Checks - Avg. infestation/branch 5.75 - bud infestation rate 15.14%

Results from early application were quite variable from branch to branch and tree to tree. However, NRDC-143 does have some carry over effect with deposits of 100 g AI/3ℓ/ha giving approximately 70% control, which was of the same order of effectiveness as fenitrothion in oil solution (tests 10 & 11) at deposit rates of the order of 200 g AI/ℓ/ha. Early application of acephate (tests 7, 8, 9) was ineffective as was fenitrothion emulsion (test 12). There is some uncertainty about the validity of these early applications on individual trees since there might be some re-infestation or transfer of budworm to the small trees from surrounding large ones.

A summary of results from the mid-season tests, with application during the period May 27 to June 5 when budworm were predominantly 4th and 5th instar (30% 6th by June 5) is given in Table II.

TABLE II

Summary of Results from mid-season application (May 27-June 5)

Test No.	Formulation	Deposit ℓ/ha	Deposit g AI/ha	Deposit drops/cm^2	% Control
13	143-I A	1.55	53	17	35
14	143-I B	1.53	52	21	34
15	143-II A	1.20	67	14	16
16	143-II B	2.28	128	23	85
17	143-III A	1.48	25	13	38
18	143-III B	1.38	23	13	0
19	143-III A	3.06	52	25	45
20	143-III B	3.42	58	30	44
21	143-IV A	3.37	94	33	53
22	143-IV B	2.43	68	29	69
23	143-V A	4.29	34	49	46
24	143-V B	2.68	21	34	25
25	143-VI A	2.24	31	32	56
26	143-VI B	7.05	99	69	79
27	0-II	1.54	77	16	68
28	F-II	2.30	230	37	53
29	F-I	1.37	247	10	65
30	D-I	7.65	765	62	79
31	D-I	4.47	447	43	56
32	D-I	2.19	219	26	72

Checks Avg. 8.70 budworm per branch - Bud infestation 14.95%

The general results indicated by the test data in Table II were:

1. There was no significant difference between the two NRDC-143 formulations from the two commercial sources.
2. A deposit of approximately 100 g AI/ha of NRDC-143 was required to give control equivalent to a deposit of 250 g AI/ha of fenitrothion.
3. The 5% AI formulation of acephate (Orthene® 75S) applied at 1.5 ℓ/ha (77 g AI/ha) was equivalent in effect to fenitrothion at 250 g AI/ha.
4. The oil solution formulation of fenitrothion was more effective than the emulsion in both the early and late applications: the emulsion would be ineffective for early application.
5. The three tests with Dowco 214 (chlorpryrifos-methyl) showed it to be approximately equivalent in effectiveness to fenitrothion.

The data are being checked more thoroughly for correlation between deposits, (i.e. drop size and coverage, active ingredient content and deposit) and budworm control for individual test branches. The budworm infestation level in this area was less than half that of 1975 and weather conditions for budworm development during the test period were excellent so that a high percent control would be more difficult than at most other times. Defoliation assessment is not yet completed.

INSECT TOXICOLOGY

(Project No. CC-2)

Project Leader: P. C. Nigam

SUMMARY OF LABORATORY EVALUATION OF INSECTICIDES AGAINST VARIOUS SPECIES OF FOREST INSECT PESTS DURING 1976

(Study Ref. No. CC-2-006)

Report to the Canadian Forest Pest Control Forum
November 23 - 24, 1976

by

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Environment Canada
Ottawa, Ontario

November, 1976

SUMMARY OF LABORATORY EVALUATION OF INSECTICIDES AGAINST VARIOUS SPECIES OF FOREST INSECT PESTS DURING 1976.

by

P. C. Nigam

Forty-two insecticides, and their formulations, were tested for contact, stomach and residual toxicity using modified Potter towers. Sixteen of these were new insecticides and formulations. The results are summarized under contact, stomach and residual toxicity studies. Unless otherwise specified, mortality counts were made 72 hours after treatment.

CONTACT TOXICITY

Insecticides were tested for contact toxicity against insects from British Columbia, Ontario and Quebec. The results are summarized by the area of origin and by species. Insect collections were provided by the staff of the Forest Insect and Disease Survey; personnel of the Insect Toxicology Section, Chemical Control Research Institute and from the Insect Pathology Research Institute, Sault. Ste. Marie for the laboratory culture. Insecticides are arranged in descending order of toxicity on the basis of 100% mortality.

BRITISH COLUMBIA

Bruce Spanworm - *Operophtera bruceata* (Hulst.)

Eight insecticides were tested against the fourth instar larvae of the bruce spanworm. The corrected percentage mortality ranged from 73% to 97%.

NRDC 143 > Fenitrothion = Bay 9306 > Malathion > Matacil > Phosphamidon > Dimethoate > Orthene

Douglas Fir Tussock Moth - *Hemerocampa pseudotsugata* McDunnough

Orthene was tested against the fourth instar larvae of the douglas fir tussock moth. The corrected percentage mortality was 89% at 0.224 $\mu g/cm^2$.

Rusty Tussock Moth - *Orgyia antiqua labia* (Linnaeus)

Seven insecticides were tested against the fourth instar larvae of the rusty tussock moth. The corrected percentage mortality ranged from 20% to 97%.

NRDC 143 > S 5602 > Carbaryl > Dylox > DDT = Malathion > Orthene

ONTARIO

European Snout Weevil - *Phyllobius oblongus* (Linn.)

Nine insecticides were tested against the adults of the European snout weevil. The corrected percentage mortality ranged from 66% to 94%.

NRDC 143 > DOWCO 214 > Dimethoate > DDT > Phosphamidon = Dursban > Methoxychlor > Gardona > Diazinon

White Pine Weevil - *Pissodes strobi* (Peck)

Three insecticides were tested against the adults of the white pine weevil. The corrected percentage mortality, at 24 hours, ranged from 40% to 96%.

FMC 33297 = FMC 40963 > NRDC 143

Spruce Budworm - *Choristoneura fumiferana* (Clemens) - Laboratory Reared Larvae

Seven insecticides were tested against second instar larvae of the spruce budworm. The corrected percentage mortality ranged from 51% to 97%.

Fenitrothion = NRDC 143 > Phosphamidon = Matacil Tech. > Bay 9306 > Orthene > DDT

Five insecticides were tested against third instar larvae of the spruce budworm. The corrected percentage mortality ranged from 59% to 97%.

Bay 9306 = NRDC 143 = Matacil Tech. > Fenitrothion = Phosphamidon

Twelve insecticides were tested against the fifth instar of the spruce budworm. The corrected percentage mortality ranged from 63% to 99%.

PP 383 > NRDC 143 > S 5602 = S 3206 > Bay 9306 = FMC 40963 = RU 11483 > FMC 33297 > Fenitrothion > RHC 367 > Bay 8629 > Mobil 9087

Four insecticides were tested against the laboratory reared pupae of the spruce budworm. The corrected percentage mortality ranged from 25% to 97%.

NRDC 143 > Phosphamidon > Fenitrothion > DOWCO 214

Jack Pine Sawfly - Neodiprion pratti banksiannae Rohwer

Two insecticides were tested against the fourth instar larvae of the jack pine sawfly. The corrected percentage mortality was:

97% for Bay 9306 at 0.011 $\mu g/cm^2$ and
89% for S 5602 at 0.034 $\mu g/cm^2$.

Fenitrothion was tested against the fifth instar larvae of the jack pine sawfly. The corrected percentage mortality was 72% at 0.022 $\mu g/cm^2$.

QUEBEC

Swaine Jack Pine Sawfly - Neodiprion swainei Middleton

Thirteen insecticides were tested against the fourth instar larvae of the Swaine jack pine sawfly. The corrected percentage mortality ranged from 36% to 97%.

NRDC 161 > CGA 18809 = WL 43467 > Fenitrothion > Dimecron > SAN 279 > WL 41706 = SAN 197 > WL 43775 > CGA 15324 > CGA 15234 > CGA 19795 > EL 222

Red-headed Pine Sawfly - Neodiprion lecontei (Fitch)

Twelve insecticides were tested against fourth instar larvae of the red-headed pine sawfly. The corrected percentage mortality ranged from 10% to 97%.

NRDC 161 > CGA 18809 = WL 43467 > SAN 197 = SAN 279 > WL 43775 > Dimecron > WL 41706 > CGA 15324 > CGA 15234 > CGA 19795 > EL 222

Two insecticides were tested against the fifth instar larvae of the red-headed pine sawfly. The corrected percentage mortality was:

82% for CGA 18809 at 0.014 $\mu g/cm^2$ and
97% for NRDC 161 at 0.018 $\mu g/cm^2$.

Spruce budworm - Choristoneura fumiferana (Clemens) - Field Collected Larvae

Nine insecticides were tested against the fifth instar of spruce budworm. The corrected percentage mortality ranged from 29% to 98.5%.

NRDC 161 > Bay 9306 > S 3206 > S 5602 > NRDC 143 > Fenitrothion = CGA 15324 > Imidan 1E > CGA 19795

Four insecticides were tested against the sixth instar of the spruce budworm larvae. The corrected percentage mortality ranged from 83% to 97%.

NRDC 161 > PP 383 > NRDC 143 > Bay 8629

Adults from field collected material :

Eight insecticides were tested against the adults emerged from field collected pupae and late instar larvae of the spruce budworm. The corrected percentage mortality, at 24 hours, ranged from 46% to 95%.

NRDC 143 > Guthion = Matacil Tech. > Fenitrothion > Phosphamidon > Bay 9306 > Orthene > DDT

STOMACH TOXICITY

Seven insecticides were tested against fifth instar larvae of laboratory reared spruce budworm. The toxicity of the treatments were evaluated after 72 hours. The corrected percentage mortality ranged from 78% to 97%.

DOWCO 214 > RH 218 > NRDC 143 > CGA 19795 > Bay 9306 > Phosvel > Mobil 9087

RESIDUAL TOXICITY

The insecticides were tested for residual toxicity by spraying potted jack pine, balsam fir and white spruce trees in the spraying chamber. The sprayed host plants were then exposed to weathering conditions for up to ten days. The insects used for bioassay of residues were either reared in the laboratory or collected in the field and maintained in the laboratory until their release on the insecticide treated foliage. A change in technique for bioassay of insecticide residues was introduced this year for all white spruce and jack pine trees. The insects were released on clipped foliage that was obtained after a particular period of weathering of the treated trees. The clipped foliage was placed, together with the insects, inside a clear plastic dish equipped with a perforated plastic lid. The dishes were kept in an environmental chamber that was maintained at 24°C and 70% R.H. with a 16 hour photoperiod. The residue of the insecticide bioassayed on the same day of spraying (i.e. 4 ± 2 hr. after spraying) are referred to as 0-day and these host trees were not exposed to weathering. The insecticides are arranged in descending order of residual toxicity at 0 and 10 days of residual life, except in the case of spruce budworm adults, where it is 0 and 1 day after treatment. The corrected percentage mortality, 72 hours after release of insects (for all insecticides except PH60-40), is given in brackets. The corrected percentage mortality for PH60-40 is reported for 10 days after insect addition.

Spruce Budworm - Choristoneura fumiferana (Clemens)

Residual toxicity of fifteen insecticides was tested against the spruce budworm. Of these, thirteen were tested against fifth instar, one against fourth instar, two against second instar larvae, and eight against the spruce budwrom adult.

Two percent aminocarb and phoxim, and five percent Orthene were tested at the rate of 9.4 ℓ/ha (1 gal/ac) against fifth instar larvae using balsam fir as hosts. All were repeat runs from previous years.

Bay NTN 9306, chlorpyrifos-methyl, FMC 33297, NRDC 143, S 5602, phosmet (Imidan 1E and Imidan 2S), were all sprayed as a solution of 2% active ingredient at a rate of 9.4 ℓ/ha (1 gal/ac) on white spruce for bioassay with fifth instar larvae. Bay NTN 9306, S 5602, and Imidan 2S were tested as new materials, whereas the other insecticides were repeats from previous years.

First attempt to study residual toxicity against second instar spruce budworm was made. Treated white spruce was in the development stage where approximately half of the new buds were about to shed their protective bud caps and the other half of the buds were open. Phosphamidon and fenitrothion, each at 6, 9, 12, 18, 24, 36 and 48% active ingredient were applied at the rate of 0.14, 0.21 and 0.28 kg of active ingredient in 0.58, 1.17 and 2.34 ℓ per hectare (2, 3, and 4 oz. of active ingredient in 8, 16, and 32 U.S. fl. oz. per acre). The insecticides are arranged in descending order of residual toxicity, giving the ounces of active ingredient in the total volume per acre applied. The corrected percentage mortality is given in brackets and it is the average of all weathering periods observed 72 hours after insect addition.

This is the second season that a study of residual toxicity against the spruce budwrom adult was carried out. In the adult Series I, aminocarb, azinphosmethyl (Guthion), Bay NTN 9306, and DDT were applied to white spruce at the rate of 0.14 kg active ingredient in 1.46 ℓ per hectare (2 oz. active ingredient in 20 U.S. fl. oz. per acre). Bay NTN 9306, azinphosmethyl (Guthion), and aminocarb were tested for the first time against the adult moth. DDT, at the concentration of 5% @ 9.4 ℓ/ha (1 gal/ac) was tested once before in 1974. In spruce budworm Series II another four insecticides, namely: phosphamidon, fenitrothion, NRDC 143, and Orthene were applied to white spruce at the rate of 0.14 kg active ingredient in 1.46 ℓ per hectare (2 oz. active ingredient in 20 U.S. fl. oz. per acre). The first two insecticides were repeats from last year, NRDC 143 and Orthene were tried for the first time against the adult. There was high control mortality in the adults and results after 24 hours are not significant.

A special test, involving the evaluation of residual toxicity of PH60-40 against fourth instar laboratory reared spruce budworm was conducted during the winter in the greenhouse. Potted white spruce trees were gradually brought out of dormancy and placed inside the greenhouse. When the new shoots reached the desired length, the trees were sprayed in a spray-tower with 0.5, 1.0, and 2.0% PH60-40 solution at a rate of 9.4 ℓ/ha (1 gal/ac). The trees were then placed inside the greenhouse and thus were not exposed to the usual weathering. Foliage was clipped at 0 (4 ± 2 hrs.) 1, 3, 5, and 10 days after insecticide application, placed into plastic dishes that had a perforated lid, and the larvae were released on top of the treated foliage.

<u>Fifth Instar Spruce Budworm on Balsam Fir</u>

0 day - Orthene (100) > aminocarb = phoxim (98)
10 day - aminocarb (69) > Orthene (56)

Phoxim was tested up to 5 days of weathering only where the corrected mortality stood at 4%.

<u>Fifth Instar Spruce Budworm on White Spruce</u>

0 day - chlorpyrifos methyl = S 5602 (100) > FMC 33297 (92) >
Bay NTN 9306 = NRDC 143 (77) > Imidan 1E (43) > Imidan 2S (8).
10 day - chlorpyrifos methyl (65) > S 5602 (35) > NRDC 143 (23) >
FMC 33297 (4) > Bay NTN 9306 (2) > Imidan 1E = Imidan 2S (0)

<u>Fourth Instar Spruce Budworm on White Spruce</u>

0 day - 0.5% PH60-40 (46) > 2% PH60-40 (31) > 1% PH60-40 (29)
10 day - 2% PH60-40 (69) > 0.5% PH60-40 (39) > 1% PH60-40 (30)

<u>Second Instar Spruce Budworm on White Spruce</u>

(Note: 1 oz/ac = 0.070 kg/ha - 1 U.S. fl. oz/ac = 0.073 ℓ/ha)

0 - 10 day average - fenitrothion 4 oz. a.i. in 8 U.S. fl. oz./acre =
fenitrothion 4 oz. a.i. in 16 U.S. fl. oz./acre =
fenitrothion 2 oz. a.i. in 8 U.S. fl. oz./acre (42) >
fenitrothion 4 oz. a.i. in 32 U.S. fl. oz./acre =
fenitrothion 2 oz. a.i. in 16 U.S. fl. oz./acre =
phosphamidon 3 oz. a.i. in 8 U.S. fl. oz./acre =
phosphamidon 4 oz. a.i. in 8 U.S. fl. oz./acre =
phosphamidon 3 oz. a.i. in 16 U.S. fl. oz./acre =
fenitrothion 3 oz. a.i. in 16 U.S. fl. oz./acre (29) >
phosphamidon 4 oz. a.i. in 32 U.S. fl. oz./acre =
phosphamidon 2 oz. a.i. in 8 U.S. fl. oz./acre (26) >
phosphamidon 4 oz. a.i. in 16 U.S. fl. oz./acre (23) >
fenitrothion 2 oz. a.i. in 32 U.S. fl. oz./acre =
fenitrothion 3 oz. a.i. in 8 U.S. fl. oz./acre =
phosphamidon 2 oz. a.i. in 16 U.S. fl. oz./acre (19) >
phosphamidon 2 oz. a.i. in 32 U.S. fl. oz./acre =
fenitrothion 3 oz. a.i. in 32 U.S. fl. oz./acre (16) >
phosphamidon 3 oz. a.i. in 32 U.S. fl. oz./acre (9)

Spruce Budworm Adult, Series I on White Spruce

0 day - azinphosmethyl (100) > Bay NTN 9306 (21) > aminocarb = DDT (4)
1 day - azinphosmethyl = Bay NTN 9306 (50) > aminocarb = DDT (33)

Spruce Budworm Adult, Series II on White Spruce

0 day - NRDC 143 = Orthene = fenitrothion (100) > phosphamidon (50)
1 day - NRDC 143 = Orthene (100) > fenitrothion = phosphamidon (0)

Jack Pine Sawfly - *Neodiprion pratti banksianae* Rohwer

One percent concentrations of three insecticides: FMC 33297, NRDC 143, and chlorpyrifos-methyl (DOWCO 214), applied to jack pine at the rate of 9.4 ℓ/ha (1 gal/ac), were tested for residual toxicity against fourth instar jack pine sawfly. All three insecticides represent a repeat from the previous year.

0 day - FMC 33297 = NRDC 143 = chlorpyrifos methyl = (100%)
10 day - FMC 33297 (47) > NRDC 143 (33) > chlorpyrifos methyl (O)

INSECTICIDES TESTED IN 1976

NO.	INSECTICIDE	FORMULATION % A.I.	TYPE	SOURCE
1	Bay NTN 8629	45	Organophosphate	Chemagro
2	Bay NTN 9306	64,65	Organophosphate	Chemagro
3	Bay 77488	89	Organophosphate	Chemagro
4	CGA 15234	50 EC		Ciba-Geigy
5	CGA 15324	50 EC		Ciba-Geigy
6	CGA 18809	99.8	Organophosphate	Ciba-Geigy
7	CGA 19795	40 EC		Ciba-Geigy
8	DDT	100	Chlorinated hydrocarbon	Math. Col. & Bell
9	Diazinon®	97.3	Organophosphate	Ciba-Geigy
10	Dimecron®	100	Organophosphate	Ciba-Geigy
11	Dimethoate (Cyanamid tech)	94.4	Organophosphate	Cyanamid Co.
12	DOWCO 214®	30, 95.6	Organophosphate	Dow Chemical Co.
13	Dursban®	48	Organophosphate	Dow Chemical Co.
14	Dylox® tech.	98	Organophosphate	Chemagro
15	EL 222	12.5 EC	Chlorophenyl	Elanco (Eli Lilly)
16	Fenitrothion	97, 98.7	Organophosphate	Sumitomo
17	FMC 33297	40 &10 EC	Pyrethroid	FMC Corp.
18	FMC 40963	5 EC	Pyrethroid	FMC Corp.
19	Gardona®	94	Organophosphate	Shell
20	Guthion®	22	Organophosphate	Chemagro
21 (a)	Imidan 1E	12.5	Organophosphate	Stauffer
(b)	Imidan 2S	25	Organophosphate	Stauffer
22	Malathion	50 EC	Organophosphate	Chevron

INSECTICIDES TESTED IN 1976 (CONT'D.)

NO.	INSECTICIDE	FORMULATION % A.I.	TYPE	SOURCE
23	Matacil®, tech.	17,34,99	Carbamate	Chemagro
24	Methoxychlor	88	Chlorinated hydrocarbon	DuPont
25	Mobil 9087, tech.	85		Mobil
26	NRDC 143	25,50	Pyrethroid	Chipman
27	NRDC 161	2.5	Pyrethroid	Procida
28	Orthene®	94	Organophosphate	Chevron
29	Phosphamidon	93.9	Organophosphate	Ciba-Geigy
30	Phosvel	92	Organophosphate	Velsicol
31	PH60-40	25	Urea	Thompson--Hayward
32	PP 383	93		Chipman
33	RH 218	88	Chlorinated hydrocarbon	Rohm & Haas
34	RHC 367	100		Rohm & Haas
35	RU 11483	100	Pyrethroid	McLaughlin, Gormley, King Co.
36	S 3206	20 EC	Pyrethroid	Sumitomo
37	S 5602	20 EC	Pyrethroid	Sumitomo
38	SAN 197	50 EC		Sandoz-Wander
39	SAN 279	50 EC		Sandoz-Wander
40	WL 41706	95, 30 EC	Pyrethroid	Shell
41	WL 43467	96, 40 EC	Pyrethroid	Shell
42	WL 43775	94, 30 EC	Pyrethroid	Shell

INSECTS USED IN 1976

INSECT	AREA OF ORIGIN	INSTAR	NO. USED
	CONTACT TOXICITY		
Bruce Spanworm	British Columbia	IV	1,890
Douglas Fir Tussock Moth	British Columbia	IV	420
Rusty Tussock Moth	British Columbia	IV	1,770
European Snout Weevil	Ontario	Adult	2,730
Red-headed Pine Sawfly	Quebec	IV	5,250
Swaine Jack Pine Sawfly	Quebec	IV	3,360
Spruce Budworm	Ottawa Valley, Quebec	V	4,410
Spruce Budworm	Ottawa Valley, Quebec	VI	1,050
Spruce Budworm	Ottawa Valley, Quebec	Adult	3,150
Jack Pine Sawfly	Lanark, Ontario	IV	630
Jack Pine Sawfly	Lanark, Ontario	V	210
White Pine Weevil	Northern Ontario	Adult	630
Spruce Budworm	Lab. reared (Sault) Ont.	II	6,090
Spruce Budworm	Lab. reared (Sault) Ont.	III	1,680
Spruce Budworm	Lab.reared (Sault) Ont.	Pupae	840
	STOMACH TOXICITY		
Spruce Budworm	Lab. reared (Sault) Ont.	V	3,990
	RESIDUAL TOXICITY		
Spruce Budworm	Ottawa Valley, Quebec	V	3,540
Spruce Budworm	Ottawa Valley, Quebec	Adult	4,500
Spruce Budworm	Lab. reared (Sault), Ont.	II	13,230
Spruce Budworm	Lab.reared (Sault), Ont.	IV	600
Jack Pine Sawfly	Lanark, Ontario	IV	1,200

ENVIRONMENTAL IMPACT

(Project No. CC-3)

Project Leader: C. H. Buckner

SUMMARY REPORT OF STUDIES ON THE IMPACT OF INSECTICIDES ON FOREST ECOSYSTEMS

(Study Ref. No. CC-3-014)

Report to the Canadian Forest Pest Control Forum
November 23 - 24, 1976

by

C. H. Buckner

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Chemical Control Research Institute
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Environment Canada
Ottawa, Ontario

November, 1976

SUMMARY REPORT ON STUDIES ON THE IMPACT OF INSECTICIDES ON FOREST ECOSYSTEMS

by

C.H. Buckner, B. B. McLeod and P. D. Kingsbury

The Ecological Effects team of the Chemical Control Research Institute carried out a surveilliance monitoring of operational spruce budworm control programs in New Brunswick and Quebec in 1976. The extent of the monitoring operations carried out is presented in Table I.

Table I

Surveilliance Monitoring of Operational Insect Control Programmes in New Brunswick and Quebec in 1976

Area	Insecticide treatment	Ecological component monitored		
		birds	small mammal	aquatics
Quebec	fenitrothion	x		x
New Brunswick	fenitrothion	x	x	x

In addition to the operational insec control programmes, numerous studies were carried out to provide data and information on specific trials and formulations in 1976 (Table II).

Table II

Experimental applications of pesticides monitored for ecological impact in 1976

Area	Experimental Trials	Dosage rate* (kg/ha)	Ecological component monitored
New Brunswick	phosphamidon	0.070 x 3	birds
	phosphamidon	0.210	birds
	"	0.210 x 2	birds
	"	0.280	birds
	"	0.280 + 0.140	birds
	Sevin®-4-Oil	1.121	birds
	"	0.560 x 2	birds
	Orthene®	0.560	birds
	"	0.280 x 2	birds
	Matacil®	0.070 x 2	birds, aquatics
	"	0.070 x 3	birds
	Dylox®	0.560 x 2	honey bees
Quebec	fenitrothion	0.210 x 2	birds, aquatics, honey bees
	phosphamidon	0.140	birds
	"	0.280	birds
	"	0.140 x 2	birds
	NRDC-143	0.140	aquatics
Ontario	fenitrothion	0.280 x 2	birds, aquatics, ground insects, honey bees
	NRDC-143	0.035	aquatics
	"	0.070	aquatics
British Columbia	Orthene®	1.121	birds, aquatics
	Dimilin®	0.140	birds, aquatics
	"	0.035	aquatics

* 0.070 kg/ha = 1 oz/acre.

Additional studies and surveys were carried out in areas where emergency situations occurred involving accidents and insecticides.

RESULTS

Monitoring Control Operations: In Quebec, operational treatments of fenitrothion at emitted dosage rates of 0.140 kg/ha (2 oz/ac) applied twice did not affect the avian component. In New Brunswick, 4 operational blocks were monitored where fenitrothion was applied twice at the emitted dosage rate of 0.210 kg/ha (3 oz/ac) and no bird mortality was recorded. Small mammal populations were also not affected by these operations.

Ecological Monitoring of experimental trials: Phosphamidon was applied to forest ecosystems at dosage rates ranging from 0.070 kg/ha (1 oz/ac) to 0.280 kg/ha (4 oz/ac). Analysis of the data to date indicates this insecticide to be hazardous to small forest songbirds, particularly the kinglets and warblers, at rates in excess of 0.140 kg/ha (2 oz/ac). A moderate reduction of kinglets was observed in trials using 0.210 kg/ha (3 oz/ac) and a considerable reduction of kinglets and some warblers occurred at 0.280 kg/ha (4 oz/ac). Phosphamidon when applied as an adulticide at 0.070 kg/ha (1 oz/ac) every second day for 3 applications did not cause any mortality.

Experimental trials using Sevin® 4-oil at 0.560 kg/ha (8 oz/ac) and 1.121 kg/ha (16 oz/ac) did not reduce bird populations. Orthene®, sprayed at 0.280 kg/ha (4 oz/ac), 0.560 kg/ha (8 oz/ac) and 1.121 kg/ha (16 oz/ac) also did not reduce small forest songbird populations. Matacil® was used as a adulticide in New Brunswick and applied at 0.070 kg/ha (1 oz/ac) in 3 treatments. No dead birds were found but a fledgling purple finch was observed exhibiting symptoms similar to those resulting from pesticide intoxication. Bird populations were not affected by the Dimilin® trials. Fenitrothion was applied twice to a forest ecosystem at 0.280 kg/ha (4 oz/ac) and preliminary analysis of the data does not indicate a measurable effect upon birds. NRDC-143, when applied at 0.140 kg/ha (2 oz/ac), caused considerable mortality to aquatic insects and plankton and resulted in a light impact to native fishes in the lake. Trials employing 0.035 kg/ha (½ oz/ac) resulted in a considerable knockdown of terrestrial and aquatic insects in a treated lake and stream. Analysis of these data is not complete at this date. The Dylox® trials involving honey bees were inconclusive.

Special Investigations: Accidental bird, mammal and fish mortality was reported from several areas of Quebec. All reports were investigated, and reports of damages alleged to be a result of the insect control operations were proved to be unfounded.

STUDIES ON THE

DISTRIBUTION, PERSISTENCE AND FATE OF

PESTICIDES IN FOREST ENVIRONMENTS

(Study Ref. No. CC-3-018)

Report to the Canadian Forest Pest Control Forum
November 23 - 24, 1976

by

K. M. S. Sundaram

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Ottawa, Ontario

November, 1976

STUDIES ON THE DISTRIBUTION, PERSISTENCE AND FATE OF PESTICIDES IN FOREST ENVIRONMENTS

by

K. M. S. Sundaram

Among the various methods available for the control of forest pests, chemical pesticides are still by far the most effective and economical in large scale control programs. The demand for contemporary pesticides which are readily biodegradable and less hazardous to the environment at large, is constantly increasing and the volume of scientific research is expanding in this area. In recent years phosphamidon, Matacil®, Zectran®, Dylox®, dimethoate, fenitrothion and pyrethroids have been used operationally and experimentally as broad spectrum insecticides in combatting insect pests in Canadian forest spraying programs. The environmental effects of these insecticides, their fate and persistence, especially in forest areas, are not yet fully explored; hence it is essential that the spray programs be monitored in all the forest components at varying intervals of time for determining the toxicities of intact insecticides and their degradation products to evaluate their distribution, persistence, and ultimate fate in various forest components and their overall impact on non-target species inhabiting the forest ecosystem.

The pesticide chemistry section of this Institute plays a vital part in meeting these requirements and its primary objectives include:

1. Research to develop, evaluate and improve methodology and cleanup procedures for newer pesticides.

2. Definition of procedures for sampling, formulating and determining quantitative measurement of pesticide residues and breakdown products in various forest substrates such as soil, water, air, flora and fauna to a high degree of sensitivity up to nanogram levels.

3. Active collaboration in multi and interdisciplinary mission oriented research programmes of the scientists in the Forestry Directorate, other government departments, universities and chemical companies.

4. Analysis of samples for specific projects undertaken by various research groups within and outside the Institute such as EPS, CWS, FICP programs, MFRC, LFRC and provincial governments.

All analyses require the use of GLC, TLC, IR, UV and radiochemical techniques for the detection, quantitation and characterization of degradation products.

Recently the Pesticide Chemistry Section devoted considerable time to the analysis of chlorinated hydrocarbons such as DDT and its metabolites (p,p'-DDT, o,p-DDT and DDE) and methoxychlor inter alia in various forest flora and fauna including wildlife and game birds collected from different DDT sprayed areas all over Canada, to study and monitor their persistence characteristics and distribution patterns for quantitative evaluation of their toxicities causing possible biological and ecological damages. It is observed that the concentration of the residues in a system, within limits, is a function of the concentration in the environment and although the half-lives of some of the residues are high, the toxicants appear to disappear from the environment.

Similar intensive studies on organophosphorus insecticides such as fenitrothion and phosphamidon in various parts of the ecosystem such as air, water, soil, foliage, animal tissues, insects etc. have been completed. Current studies show that these organophosphates are readily degradable, biologically and chemically, thus having low half-lives compared to organochlorine compounds. In addition, their low persistence in the various components of the environment minimize biological magnification thus reducing pollution and ecological hazards.

The persistence and fate of an experimental dose of 0.560 kg/ha (8 oz AI/acre) of Orthene® has been followed during the year in coniferous foliage, forest soil, honeybees and water. Foliage samples collected relatively large amounts of the insecticide, ca 13 ppm from aerial spraying, while only small amounts were found in soils (0.4 - 0.8 ppm) and natural waters (0.7 - 0.02 ppm).

The parent compound decreased rapidly in foliage ($T_{\frac{1}{2}}$ ca 2.5 days) primarily due to environmental factors. No significant amounts of the metabolite, Ortho 9006® were found in the samples analysed.

Similar research studies on the fate and persistence of Matacil® have been completed, and demonstrated that the insecticide is labile, environmentally safe and effective in budworm control.

At the request of chemical companies and with their collaboration, an interesting and exploratory research project to study the uptake, translocation and metabolism of C-14 labelled Matacil^{R}, phosphamidon and Orthene® in coniferous trees has been started at the beginning of this year, and considerable progress has been made. The preliminary results gathered so far not only support some of our earlier findings on their distribution and persistence within the tree but also throw some light on the systemic behaviour of these toxicants and their metabolites.

An exploratory research project on the fate of Dylox® in forest environments is under way in collaboration with MFRC and it is expected that this insecticide would be equally effective in controlling the spruce budworm in Canadian forests.

In providing analytical service facilities, the section has considerably expanded its service capacity to meet the increasing demand.

During the year, formulation, spray mixtures, water, air, soil, foliage, birds, mammals, insects, and fish samples were received from various scientists in EMS, EPS, CWS, Provincial Governments, FICP, NCC, various chemical companies etc. for residue analysis. The insecticide residues analysed were fenitrothion, phosphamidon, Orthene®, Dylox®, dimethoate, Matacil®, carbaryl, DDT and methoxychlor. New methodologies and techniques have been developed for extraction and analysis of the insecticides and their breakdown products from various substrates of the forest environment. In addition to providing service, the section has collaborated actively in various mission-oriented, problem-solving research projects carried out at the Institute and other Forestry establishements such as MFRC, PFRC and LFRC, as well as the National Capital Commission and USDA.

TREE PHYSIOLOGY AND PATHOLOGY

(Study Ref. No. CC-3-013 and CC-3-023)

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by

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TREE PHYSIOLOGY AND PATHOLOGY

by

Raj Prasad

A. Development of systemic pesticides for control of forest pests.

Systemic pesticides cause minimal contamination to forest environments and are thus one of the best methods for combatting forest pests. The purpose of this research is to develop or modify materials and methods to increase the efficacy of pesticides.

(a) Field Dutch Elm Disease (DED) Studies

Since a curative method for control of diseased elms is hard to achieve, much of the research efforts were concentrated on preventive methods. During the past six years different approaches were tried such as foliar, bark and soil application - but the most effective method was found to be the trunk injection by using benomyl derivatives - Lignasan® Phosphate or Chloride. Because of its enclosed nature, this system is very safe and causes minimal harm to the environment. Experiments were first conducted with high pressure apparatus but later a small, portable, hand-operated apparatus equipped with pressure gauge, plastic valves and injectors, was developed, using low pressure (138-207 kPa (20-30 psi)). This apparatus proved very effective and easy to use. Also by using a lower volume of higher concentration, the time of application was greatly reduced and thus the whole operation was more economical.

Preliminary research was first carried out with smaller trees (d.b.h. 20.3 - 30.5 cm (8-12 inches)) with very good distribution of pesticide throughout the branches and leaves. Protection of these trees was achieved by inoculation with the Dutch elm disease into treated and untreated (check) trees. None of the treated trees contracted the disease, while 85% of untreated trees were infected. This year's research involved testing of this modified method on large trees (76.2 - 127.0 cm (30-50 inches)) in co-operation with the City of Ottawa, and the distribution throughout the crown was found to be as good as with any other method. It is suggested that this apparatus and the method of treatment be patented and offered to homeowners and public for use.

Due to a great public interest, this method was demonstrated on three television stations and reported by local newspapers.

(b) Screening of Systemic Fungicides for DED Control

This year again, twenty new fungicides were screened against the Dutch elm disease pathogen, (*Ceratocystis ulmi*). The following compounds were found to be fungitoxic and promising:- Hymexafol F319; EL-222 E.C.; Terraclor W.P.; Rovral EFA 2043; Nystatin; PP 588.

(c) Herbicide Screening for Control of Unwanted Tree Roots

Tree roots, by blocking sewer and drainage lines, and by causing cracks in swimming pools and foundation walls bring about expensive damages in urban areas every year. CCRI initiated yearly herbicide screening to find the best means of chemical control of such unwanted roots. Out of several arboricides (silvicides) tested the following appeared promising for further tests:- picloram, 2, 4, 5-T and Vapam.

B. Environmental Impact of Pesticides

To control the outbreaks of spruce budworm (*C. fumiferana*) the insecticide fenitrothion is extensively used as foliar sprays in Canadian forests. Because about 30% residues persist on conifer foliage two weeks after spray applications, studies were initiated to determine the fate of fenitrothion in the forest ecosystem.

(a) Fate, Persistence and Translocation of C^{14} - Fenitrothion in Conifers

An investigation was carried out to determine the fate and persistence of C^{14} - labelled fenitrothion in four-year-old seedlings of balsam fir (Abies balsamea) and white spruce (Picea glauca) in the greenhouse.

The insecticide disappeared rapidly from the surface of conifer tissue while the absorbed residues were more peristent. An in vitro study carried out on glass surfaces demonstrated that rapid disappearance of the pesticide was probably due to volatilization. TLC analysis of the conifer extracts was consistent with this dissipation mechanism since C^{14} - ring metabolites were present for the most part only in trace amounts.

Autoradiographic tracing studies demonstrated the ability of C^{14} - fenitrothion to be translocated acropetally into the young foliage of fir and to a lesser extent in spruce. That this took place via the xylem vessels (apoplastically) was confirmed by histoautoradiography.

These results were taken as evidence for the systemic potential of fenitrothion for spruce budworm control.

(b) Fate, Persistence and Translocation of C^{14} - Fenitrothion in Jack Pine (Pinus banksiana)

The collăborative research study with the Laurentian Forest Research Centre (Dr. McLeod) was completed. No evidence of presence of toxic substrates of fenitrothion which were lethal to sawfly larvae (Neodiprion swainei) was found on treated jack pine foliage.

Employing modern analytical techniques - autoradiography, liquid scintillation spectrometry, gas-liquid and thin-layer chromatography - detailed examination of fenitrothion C^{14} tissue showed no direct evidence of systemic action except that radioactivity (silvergranules) was present in the hypodermis and xylem regions. It seemed that the cause of the sawfly mortality was related to extreme sensitivity of the parasite to minute quantities of residues of fenitrothion deposited after extensive spray operations.