Field Evaluation of Orthene®, Phoxim and Fenitrothion Against Spruce Budworm (*Choristoneura fumiferana*), Applied as Simulated Aerial Spray

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ABSTRACT

The efficacy of three insecticides, Orthene®, phoxim and fenitrothion for control of spruce budworm, Choristoneura fumiferana, Clem. on white spruce, Picea glauca, Moench, Voss, was compared in small scale field trials. All were tested as 10% formulations applied as simulated aerial spray at 40 fl.oz/acre to individual small trees. Variations in formulations and dosage, e.g., fenitrothion as emulsion and in oil solution, phoxim with and without an ultra violet inhibitor (UVI), Orthene at 60 and 90 fl. oz/acre, totalling 10 different treatments, each replicated six times. Orthene gave the best results with population reductions of 86 and 96% at applied rates of 4 and 6 oz A.I./acre: per cent defoliation was 5 and 3% respectively, compared with 24% on untreated check trees. The standard fenitrothion emulsion treatment gave 67% population reduction and 9% defoliation. Fenitrothion in oil solution and with a sticker Atplus® 526 was less effective (58% reduction and 9% defoliation). Phoxim was least effective; addition of UVI lowered its potency. Data on deposit characteristics are included.

Orthene, efficiently atomized to give good coverage (ca 50 drops/cm^2) could result in this material being highly effective at less than 4 oz. A.I./acre.

RÉSUMÉ

On a comparé l'efficacité de trois insecticides, l'orthène®, le phoxime et le fénitrothion pour la lutte à la tordeuse des bourgeons de l'épinette, Choristoneura fumiferana, Clem., infestant des épinettes blanches, Picea glauca, Moench, Voss. Les essais ont été faits sur le terrain et à petite échelle. Des mélanges contenant 10% d'insecticide ont été utilisés à raison de 40 oz liq. à l'acre; tous les insecticides ont été mis à l'essai et l'application s'est faite en simulant un arrosage aérien individuel de petits arbres. Les divers dosages et formules, par exemple: le fénitrothion en émulsion et en solution dans l'huile, le phoxime avec ou sans un inhibiteur de rayons U.V., l'orthène à 60 et à 90 oz liq./acre; le tout totalisant 10 traitements différents qui ont été répétés six fois chacun. C'est l'orthène qui a donné les meilleurs résultats, les réductions de populations ayant été de 86% et de 96% pour des taux d'application de 4 et de 6 onces d'ingrédient actif à l'acre. Les pourcentages de féfoliation ont été de 5 et de 3% respectivement, comparativement à 24% pour les arbres témoins non traités. Le traitement normal avec l'émulsion de fénitrothion a provoqué une réduction de population de 67% et une défoliation de 9%. Le fénitrothion en solution dans l'huile et mélangé à un agent adhésif, le Atplus® 526, a été moins efficace (réduction de population de 58% et défoliation de 9%). Le phoxime a été le moins efficace: l'addition d'un agent antirayonnement U.V. en a réduit les possibilités. Des

données sur les caractéristiques des dépots sont incluses.

L'orthène, atomisé de façon à se répandre adéquatement (env. 50 gouttelettes/cm^2) pourrait être très efficace à des concentrations inférieures à 4 onces liquides d'ingrédient actif à l'acre.

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Introduction

Preliminary field testing of phoxim (=Volaton®) and Orthene® by Nigam and Hopewell (1973) showed both materials to have promise for control of the spruce budworm, Choristoneura fumiferana. Both appeared at least as effective, at equivalent dosages, as fenitrothion: Orthene showed higher activity against later stages of the budworm.

More intensive comparative evaluation of these materials and standard fenitrothion emulsion (as used operationally) were carried out in 1974. The formulations were applied as simulated aerial sprays to individual small spruce trees naturally infested with budworm, by the same application technique as used in 1973. Some variations in formulations were also tested. Comparison of effectiveness was made on the basis of larval survival and foliage consumption.

Material and Methods

1. Treatment area and spruce budworm infestation

The work was carried out on a tree farm near Shawville, Quebec, on which a variety of species have been planted over the past 20 years. The trees selected for the tests were within an area of approximately one acre in a stand of uneven aged white spruce, Picea glauca, (Moench) Voss, ranging in height from 1.5 to 7.6 m. (5 to 25 feet). Infestation on these trees was generally moderate (i.e. 5 to 12 larvae per 45 cm* branch tip); whereas nearby mature trees were more heavily infested.

Trees 2.4 to 3 m (8 to 10 feet) high were selected and examined for budworm infestation. On each tree with adequate numbers of mined

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* Equivalent to standard 18 inch branch tip.

needles (2 to 10 per 45 cm branch tip) four branches were selected and tagged (45 cm from tip) one per quadrant at about the 1.8 meter level. Trees were numbered 1 to 71 (6 per treatment + 11 untreated checks).

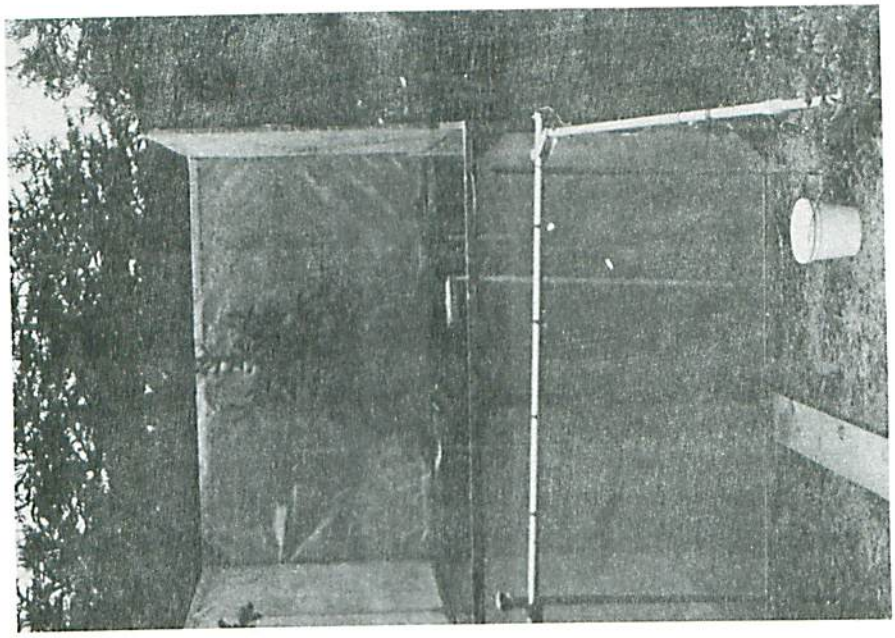
2. Experimental Design

There were 10 different treatments, coded A, B, C, D, E, F, G, H, J and K, to prevent sampling bias. Treatments were carried out successively, one at a time, until each had been replicated 6 times, every 7th tree being left as an untreated check. This procedure resulted in the treatments being well dispersed over the whole area as well as over the three day period required to complete the tests.

3. Application of Insecticides

The application of the simulated aerial spray was carried out as described by Hopewell (1973). A portable shelter enclosing an area of 2.1 x 2.1 m. (7 x 7 feet) was placed around each tree to shelter it during application (Fig. 1a, b). The nominal application rate for eight of the ten treatments was 2.924 l/ha (40 fl. oz./acre), i.e. 1.3 ml of the formulation emitted over the 4.55 $m.^2$ In the other two cases Orthene was applied at 4.39 and 6.58 l/ha (60 and 90 fl. oz/acre) and the emitted volumes were 2.0 and 3.0 ml respectively. Treatments were done on 5, 6 and 7 June, 1974, when budworm development was 3% L_3, 83% L_4 and 14% L_5. Application was suspended at times during mid-day when wind velocity was too great to allow even distribution of drops.

The average emitting time for 1.3 ml at a drive motor voltage of 7.5 and spinning disc voltage 6.0 was 77 seconds.



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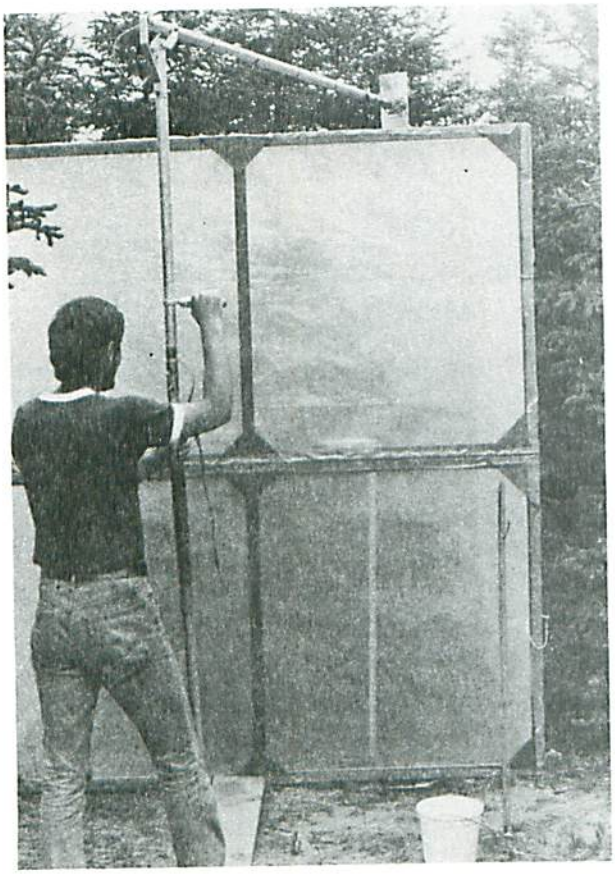
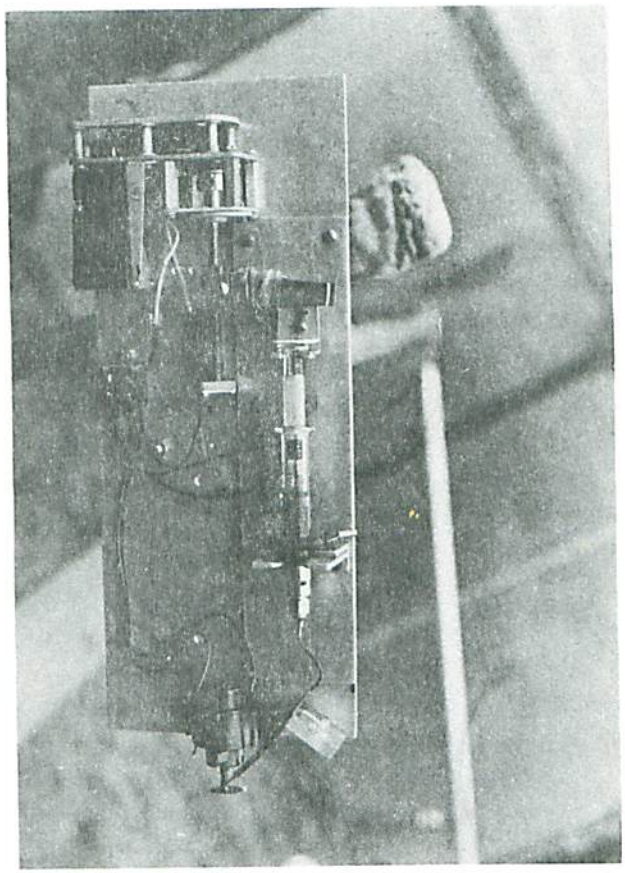


(a)



(c)

Fig. 1. Spray Application to Trees

(a) Application
(b) Shelter and deposit sampling units
(c) Closeup of droplet generator

4. Spray Deposit Sampling and Assessment

Samples of spray deposit were taken in each branch quadrant (N. S. E. W.) during application, approximately 0.5 m from the tree stem. The sample units consisted of a petri dish and a Kromekote card, mounted on staked holders 1.2 m (4 feet) above ground level and clear of overshadowing foliage (Fig. 1b). The samples were returned to the laboratory for analysis. Deposit volume (fl. oz/ac) was determined by colorimetric assessment of the deposit on petri dishes and its distribution from drops/cm^2 of drop stains on the Kromekote samples.

The assessment of effects of the spray treatments on larval population densities was made 7 days after application. Each 45 cm branch tip was clipped off and the larvae separated from the foliage by use of the apparatus and technique described by DeBoo et al (1973) and Martineau and Benoit (1973). Numbers of larvae in each instar were tallied. Twenty four branches were sampled for each treatment and 44 for untreated checks.

To assess the degree of foliage protection resulting from the various treatments, each tree was examined in the autumn and a visual estimate of the degree of defoliation made. The method followed was essentially that described by Fettes (1950) which quantifies defoliation into 10 classes. The five terminal current-year shoots on each of 4 branches, one in each quadrant, at the 1.5 m level were examined *in situ*. Observed defoliation classes were tallied, and branch, tree and treatment group averages were derived. Comparison of the effects of the different treatments was made on the basis of the infestation level of surviving budworm on the tagged

branches of treated trees (24 per treatment), and on degrees of defoliation as compared with that on check trees.

5. Insecticides and their Formulations

All formulations were made up to contain 9.6% (wt./vol.) active ingredient to allow direct comparison with the standard 10% technical (96% A.I.) fenitrothion emulsion used in the field. The details of the insecticides and their sources are as follows:

(i) Phoxim

Four preparations of phoxim, (phenyl-glyoxylonitrile 0,0-diethyl phosphorothioate), under the trade name Volaton were supplied by Chemagro Division of Baychem Corporation, Research and Development, Box 4913, Kansas City, Missouri. All were labelled as containing 1 lb. Volaton per U.S. gallon as follows:

Treatment Code

A	Volaton in oil (label data)
B	Volaton in corn oil "
C	Volaton in oil + 1% ultra violet inhibitor DOBP-N (UVI)
D	Volaton in oil + 5% " " "

These were diluted with summer oil and Automate Red dye as a tracer in the ratio of 80:19:1 by volume for use, i.e. 9.6% A.I. (wt./vol.).

(ii) Orthene

Supplied as technical grade water soluble powder containing 94% Orthene (0,S-dimethyl acetylphosphoramidothioate) by Chevron Chemical Company, Richmond, California. Sufficient material to make 50 ml of formulation was weighed in advance and prepared just before use in the field with a solvent containing water - 90%,

ethylene glycol - 9% and Rhodamine B solution - 1%, to give a solution containing 9.6% active ingredient. This formulation was applied at 3 nominal dosages of 4, 6 and 9 oz A.I./acre.

Treatment Code

F - 2.92 l/ha (40 fl. oz/acre)

G - 4.39 l/ha (60 " " ")

H - 6.58 l/ha (90 " " ")

(iii) Fenitrothion

Three formulations of fenitrothion, (0,0-dimethyl O-(4 nitro-m-tolyl) phosphorothioate), based on the technical product Sumithion®, supplied by Sumitomo Chemical Co., Osaka, Japan, and containing 96% active ingredient were prepared.

Treatment Code

E. The standard emulsifiable concentrate as used by Forest Protection Limited in large scale operational control of spruce budworm, was made up containing technical Sumithion 78%, Atlox 11% and Arotex 11% by volume. The emulsion was prepared before use in the field with water containing 1% Rhodamine B dye solution to give a formulation with 9.6% A.I. (wt./vol.).

J. An oil-based formulation made up to contain 10% technical Sumithion in summer oil: Arotex 1:1. (The technical material was not miscible with summer oil alone).

K. As for J above but with 1% Atplus® 526 spreader-sticker added.

Results and Discussion

The prespray count (24 May) of mined needles on the test trees averaged 6.4 mined needles per 45 cm branch tip. This was interpreted as constituting a moderate infestation. Prespray checks of budworm numbers and developmental stage were made on branch samples from trees adjacent to test trees. These data are given in Table I.

TABLE I

Record of Larval Development

Date	No. Branches	% in each instar				No. Larvae branch
		L_2	L_3	L_4	L_5	
31 May 74	10	14	83	3	0	8.1
3 June	24	7	88	5	0	7.7
4 June	40	1	28	68	3	8.2
6 June	11	0	3	83	14	6.9

Spray deposit volumes and drop densities have been averaged for the 6 trees in each treatment group and are given in Table II. The measured deposit densities exceeded the nominal application rates in most of the tests, (120% of nominal emitted dosage). This was probably a result of the operational technique or an inherent characteristic of the apparatus itself which precludes uniform distribution to the edges of the enclosed area. There is obviously an effect on deposit characteristics as a result of the physical characteristics of the formulation, since the same procedure was used for all. The formulation which differed most from all others was that of fenitrothion emulsion (E). In this case there was a much lower average deposit 2.19 l/ha = 30 fl. oz/acre - 75% recovery of emitted) although the number of drops/cm^2 (51) was highest of all. This indicates a more ready atomization

of the material into finer drops which may have evaporated more and left much of the material in droplets too small to be deposited under ambient conditions.

There is an apparent anomaly in the relationship of deposit volume to number of drops in the Orthene series. Although the volume increases as expected, i.e., with applied rates of 40, 60 and 90 fl.oz/acre, the corresponding numbers of drops do not. The average drop size of the 60 and 90 fl.oz/acre application is greater than that for the 40 fl.oz/acre. This may be due to reduction in rpm of the spinning disc from voltage drop in the batteries during the longer operating period for the higher dosages. It was observed also that there were almost no fine droplets in higher dosage deposits, so that with greater drop size in medium and high application rates, the effect of higher dosage was cancelled out by less efficient coverage.

TABLE II

Averaged deposits on each 6-tree Treatment Quadrant and Group

Treatment Code *	Fl.oz/acre					Drops/cm^2				
	N	E	S	W	Avg.	N	E	S	W	Avg.
A	52	45	66	66	58	40	32	47	57	42
B	45	72	43	50	52	46	46	50	42	46
C	61	37	45	71	54	46	21	33	41	35
D	48	48	54	51	50	34	30	53	41	40
E	21	35	20	42	30	31	59	42	73	51
F	57	36	28	36	39	35	34	19	22	28
G	65	55	62	55	59	34	28	33	27	30
H	115	101	77	100	98	46	41	29	36	38
J	47	32	68	41	47	34	26	46	40	36
K	34	25	56	29	36	30	29	46	45	37

* See Table III for key

The percent control of budworm was derived from the sampling data by comparison of the average budworm population of each treatment group with that on check trees (Table III). With the limited foliage samples available from the small test trees, population reduction from natural causes could not be monitored and Abbott's correction applied. In any case there was very little change in number of larvae per branch from prespray to final sampling (Tables I and III). Greatest population reduction occurred on all three Orthene treatments, i.e., 86, 96 and 95% on low, medium and high deposits, respectively. By comparison the standard fenitrothion emulsion, fenitrothion in oil, and in oil with Atplus 526 sticker gave 67, 57 and 59% reduction respectively. Apparently, the sticker additive did not improve activity of the oil-based fenitrothion, and oil based fenitrothion was not as effective as the standard emulsion formulation.

TABLE III

Total Surviving Budworm and Larval Instar for Each Treatment Group and Untreated Checks 7 days postspray

Treatment *	Instar L_4	L_5	L_6	Total	Avg/Branch	% Control
A - Phoxim	9	42	43	94	3.92	50
B - Phoxim - corn oil	8	41	34	83	3.45	56
C - Phoxim + 1% UVI	8	54	83	145	6.05	22
D - Phoxim + 5% UVI	9	43	62	114	4.75	39
E - Fenitrothion - emulsion	5	30	27	62	2.58	67
F - Orthene 4 oz/acre	1	12	12	25	1.05	86
G - Orthene 6 oz/acre	0	6	2	8	0.28	96
H - Orthene 9 oz/acre	0	6	1	7	0.35	95
J - Fenitrothion - oil base	4	40	36	80	3.32	57
K - Fenitrothion oil base + 526	3	28	45	76	3.18	59
Checks	18	104	220	342	7.78	0

* All applied at nominal 4 oz A.I./acre unless otherwise noted.

Of the 4 phoxim formulations tested, that with corn oil gave 56% population reduction and that in oil 50%, both somewhat below the fenitrothion emulsion standard (67%). The ultra violet inhibitor in both phoxim formulations appears to have definitely lowered their effectiveness in reducing the budworm populations, i.e., 22 and 39% reduction for 1 and 5% UVI respectively.

Post-treatment budworm development data (Table III) converted to percent in each larval stadium are given in Table V (Columns 3, 4, 5). The results suggest that budworm development was retarded by all phoxim formulations, those without UVI especially showing this activity, the number of L_4 being twice that in the checks whereas L_6 numbers were significantly lower than in the checks. Orthene formulations seem to have almost eliminated the L_4 and greatly reduced the proportion of L_6 as compared with the checks. This indicates a retardant effect on development of exposed survivors. The optimum deposit rate under the described conditions was in the 4.4 l/ha (6 oz/acre) range as there was no additional effect at 6.6 l/ha (9 oz/acre).

Observed defoliation percentages of the current year's growth on treated and check trees and their averages for each treatment group are given in Table IV).

All the data have been summarized in Table V, with treatment groups arranged in order of decreasing budworm population reduction. The highest reductions of 96, 95 and 86% in the Orthene medium, high and low application tests, respectively, correspond to lowest per cent defoliation of 3, 5 and 5% respectively as compared with 24% on check trees. The next greatest population reduction was by fenitrothion emulsion treatment with 67% and resulting in 9% defoliation. The average drop

TABLE IV

Percent Defoliation on Treated and Check Trees

(Averages for each tree and treatment group)

Treatment	Avg. % each tree						Group Avg.
A - Phoxim (oil)	16	6	4	9	0	0	6
B - Phoxim (corn oil)	8	1	14	23	0	8	9
C - Phoxim (oil + 1% UVI)	42	13	11	5	29	5	18
D - Phoxim (oil + 5% UVI)	6	10	10	12	30	4	12
E - Fenitrothion (emulsion)	5	4	31	4	2	9	9
F - Orthene (4 oz/acre)	5	3	3	3	10	5	5
G - Orthene (6 oz/acre)	5	3	3	6	1	2	3
H - Orthene (9 oz/acre)	12	1	3	3	3	-*	5
J - Fenitrothion (oil-based)	14	12	14	4	2	2	8
K - Fenitrothion (oil-based + 526)	2	6	26	14	10	4	10
Checks (includes 4 extra check trees)	14	30	28	9	38	30	
	29	11	18	4	50	20	
	22	16	40				24

* Not sufficient solution

TABLE V

Summary of Results (from averages of all data in each treatment group)

Treatment	Budworm reduction (%)	Defoliation (%)	Instar (%)* L_4	L_5	L_6	fl. oz/ac	Drops/ cm^2	Avg. drop** diam. (μ)
Orthene 6 oz/ac	96	3	0	75	25	58	30	139
Orthene 9 oz/ac	95	5	0	86	14	98	38	132
Orthene 4 oz/ac	86	5	4	48	48	44	28	130
Fenitrothion (emulsion)	67	9	8	48	44	28	51	90
Fenitrothion (oil + 526)	59	10	4	37	59	36	37	110
Fenitrothion (oil-based)	57	8	5	50	45	47	36	122
Phoxim (corn oil)	56	9	10	49	41	52	46	117
Phoxim (oil)	50	6	10	45	45	58	42	124
Phoxim (oil + 5% UVI)	39	12	8	38	54	50	40	120
Phoxim (oil + 1% UVI)	22	18	6	37	47	54	35	128
Checks	0	24	5	31	64	0	0	-

* Development class of survivors 7 days after treatment.

** Calculated average drop diameter from deposit (fl. oz/ac) and drops/cm^2.

diameter for each treatment group was derived from the deposit volume and drop density data. A possible explanation for variation in drop size of the 3 Orthene treatments has already been discussed. The mean drop sizes of all 4 phoxim treatments (all oil-based) and oil-based fenitrothion are of the same order, ranging from 120 to 128 microns. The addition of Atplus 526 to the oil-based fenitrothion seems to have improved its breakup characteristics (average drop diameter 110 microns).

Summary and Conclusions

1. Three insecticides, Orthene, phoxim and fenitrothion, in formulations all containing 10% active ingredient, were tested for effectiveness in controlling spruce budworm and reducing defoliation on white spruce. All were applied as simulated aerial spray deposit to individual trees 1.4 to 3 m (8 to 10 feet) in height at a nominal dosage rate of 2.92 l/ha (40 fl. oz/acre).

2. Orthene gave the greatest population reduction of any applied at 280 g/ha (4 oz A.I. per acre) rate (86%): applied at rates of 420 and 630 g A.I./ha (6 and 9 oz), reductions of 96 and 95% resulted. Per cent defoliation in these three treatments was also the lowest at 5, 3 and 5% respectively, compared with 24% on untreated check trees.

3. The fenitrothion emulsion formulation as used in operational control operations gave a population reduction of 67%, with the lowest deposit recovery of 196 g A.I./ha = 2.8 oz/acre (70% of emitted) but with the best deposit distribution of 51 drops/cm^2. This treatment resulted in 9% defoliation. Fenitrothion in oil base and oil base plus Atplus 526 sticker appeared to be less effective.

4. Phoxim was the least effective, with the corn oil formulation appearing best at 56% reduction vs. the summer oil formulation at 50%. The corresponding defoliations were 9 and 6% respectively. Ultra violet inhibitor reduced effectiveness of phoxim in both treatments giving population reduction of 22 and 39% and defoliation of 18 and 12% for the 1% and 5% UVI contents.

5. Orthene was most effective in eliminating younger instars; zero L_4 at medium and high application rates and a marked retardation of

development of survivors, i.e., 48, 25 and 14% L_6 at 280, 420 and 630 g/ha (4, 6 and 9 oz/acre) respectively, compared with 64% L_6 in checks.

6. Orthene, if more finely atomized to provide improved coverage of ca 50 drops/cm^2 could result in this formulation being highly effective at less than 280 g A.I./ha (4 oz./acre).

Acknowledgements

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