FIELD EVALUATION OF ORTHENE(R), PHOSVEL(R), FMC 33297 AND TH 6040, AGAINST *Choristoneura fumiferana*, APPLIED AS SIMULATED AERIAL SPRAY

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ABSTRACT

Several formulations and treatment variations of Orthene® (acephate), Phosvel® (leptophos), FMC 33297 (NDRC 134) and TH-6040 (PH-6040) applied as simulated aerial spray deposit on individual white spruce trees for control of spruce budworm, Choristoneura fumiferana, were evaluated in field tests. Effectiveness was based on comparison with that of fenitrothion emulsion as used operationally and DDT as reference standards.

Orthene® treatments gave excellent reduction of budworm populations (up to 90%) at 300 g AI/3 ℓ/ha (4.25 oz/42 fl.oz/acre) at a drop coverage ranging from 18 to 55/cm^2. A commercial field preparation of Orthene®, 75S (soluble powder) was especially active; a deposit of 84 g/ha at 15 drops/cm^2 gave population reductions of 90%, and a reduction in defoliation of 70%, compared with untreated checks. Early application of 245 g AI/ha applied to old foliage about time budworm was in second and third instars resulted in 72% reduction in subsequent budworm population and good foliage protection. A surfactant, Atplus®555, added to Orthene® formulations did not appear to increase effectiveness but did result in dispersal of the formulation into finer droplets and more efficient coverage.

FMC 33297 was the most active of all compounds tested when 25g/2ℓ/ha (0.4 oz/27 fl.oz/acre) resulted in 81% budworm mortality. However, mortality was not increased at deposit rates up to 155 g/ha. Knockdown of larvae by FMC 33297 was good even at the lowest dosage tested (13g/2 ℓ/ha) and foliage protection ranged from 40 to 66 percent.

Phosvel® at 350 to 450 g/ha gave budworm mortality of 80%, similar to that of the standard fenitrothion emulsion at 210 to 300 g/ha. The TH-6040 material, representative of a new class of insect growth disruptors, was ineffective at all dosages up to 345 g AI/ha. Budworm development had progressed beyond the optimum of peak fourth and fifth instars for some of the tests.

RÉSUMÉ

On a évalué sur le terrain quelques préparations et variations des méthodes de traitement à l'Orthène(R) (acéphate), au Phosvel(R) (leptophos), au EMC 33297 (NDRC 134) et au TH-6040 (PH-6040) appliqués sur des épinettes blanches individuelles par pulvérisation aérienne simulée pour lutter contre la tordeuse des bourgeons de l'épinette, Choristoneura fumiferana. On a mesuré l'efficacité des divers traitements par comparaison avec celle d'une émulsion de fénitrothion telle qu'employée en pratique et le DDT.

À une dose de 300 g d'ingrédient actif par 3 ℓ et par ha (4.25 oz/42 oz (liquides)/acre) et une dispersion de 18 à 55 gouttes par centimètre carré, les traitements à l'Orthène ont donné une excellente réduction des populations de tordeuses de bourgeons (jusqu'à 90 %). Une préparation commerciale d'Orthène, le 75S (poudre soluble), a été particulièrement active, une application de 84 g/ha à raison de 15 gouttes par centimètre carré a réduit la population de tordeuses de 90 % et la défoliation de 70 % comparativement à des arbres témoins. Une application précoce sur de vieux feuillages de 245 g d'ingrédient actif par hectare au moment environ où les tordeuses étaient dans leurs deuxième et troisième phases de développement a eu pour effet de réduire de 72 % la population suivante de tordeuses et de bien protéger le feuillage. L'addition aux formules d'Orthène d'un agent tensio-actif, l'Atplus(R) 555, n'a pas semblé en augmenter l'efficacité mais a permis d'obtenir des gouttelettes plus fines et une application plus uniforme.

Le FMC 33297 a été le plus actif de tous les composés éprouvés, une dose de 25 g/2 ℓ.ha (0.4 oz/27 oz liquides/acre) ayant entraîné 81 % de mortalité chez les tordeuses. Toutefois, une augmentation de la dose jusqu'à 155 g/ha n'a pas augmenté davantage le taux de mortalité. Ce composé a eu un bon effet de "choc" sur les larves même aux doses expérimentales les plus faibles (13 g/2 ℓ.ha), et la protection du feuillage a varié entre 40 et 60 %.

Le taux de mortalité (80 %) des tordeuses de bourgeons obtenu avec le Phosvel lorsque les doses variaient de 350 à 450 g/ha était similaire à celui que donnait l'émulsion étalon de fénitrothion entre les doses de 210 et 300 g/ha. Le TH-6040, représentatif d'une nouvelle classe d'inhibiteurs de la croissance des insectes, s'est révélé inefficace à des doses inférieures à 345 g d'ingrédient actif par hectare; au cours de certains essais, le développement des larves s'est poursuivi au-delà de l'optimum des quatrième et cinquième stades.

INTRODUCTION

Field testing of the efficacy of various formulations as candidate insecticide treatments for aerial spray control of spruce budworm, *Choristoneura fumiferana*, was continued in 1975 in small scale tests in which the materials were applied to individual small trees as a simulated aircraft spray deposit (Hopewell and Nigam, 1974; Hopewell, 1973; Nigam and Hopewell, 1973).

Previous tests had shown Orthene(R), common name, "acephate", (O,S-dimethyl acetylphosphoramidothioate) to be very effective against budworm larvae. In the 1975 tests it was planned to examine (1) variations in formulation, (2) timing of treatments and (3) improved coverage by smaller drops as possibilities for reducing the required effective application rates and making this material more economically attractive for large scale use.

The three other compounds selected for testing were (1) Phosvel(R), common name, "leptophos", O-(4-bromo-2,5-dichlorophenyl)O-methyl phenylphosphonothioate, a wide spectrum insecticide used extensively for control of agricultural pests; (2) FMC 33297 (NRDC 143) a new synthetic pyrethroid insecticide, 3-phenoxybenzyl (±)-*cis-trans*-2,2-dimethyl-3-(2,2-dichlorovinyl) cyclopropane carbonylate, of low acute mammalian toxicity and a high level of activity against a broad spectrum of insect pests; and (3) TH 6040, 1-(4-chlorophenyl)-3-(2,6-difluorobenzoyl)-urea, representative of a new class of insect growth disruptors which interfere with cuticle deposition and has been tested against a lepidopterous larvae by Pree, 1976.

Effectiveness of the formulations and treatments were compared with results from parallel tests using the standard fenitrothion, O,O-dimethyl O-(4-nitro-m-tolyl) phosphorothioate, emulsion formulation as used operationally for spruce budworm control in eastern Canada, and with a p,p'-DDT oil solution formulation.

MATERIALS AND METHODS

1. Treatment area

The work was carried out on a tree farm near Shawville, Que., on which a variety of species have been planted over the past 20 years. The trees selected for the tests (2.5 to 3 m in height) were within an area of approximately one hectare in a stand of uneven aged white spruce, *Picea glauca* (Moench) Voss, ranging in height from 2 to 8 m. The test trees were numbered and four branches, one from each quadrant, selected and tagged (45 cm from tip) at about 1.8 m above ground level. The area around each test tree was cleared, if necessary, by trimming interfering foliage from adjacent trees.

2. Budworm Development and Infestation

Development and infestation levels were monitored during the operational period by checking 10 standard 45 cm branches every other day, if possible. The sample branches were taken from trees adjacent to test trees throughout the test area. The larvae were separated from the foliage using the apparatus and technique described by DeBoo et al (1973) and Martineau and Benoit (1973) and total budworm and development stage determined and recorded.

3. Experimental Design

On advice from Dr A.L. Wilson, Applied Statistics and Scientific Computing Branch, D.O.E., a fully nested experimental design was followed to allow easier handling of the data. Each test treatment had the same number of check tree replicates as treatment replicates and the number of replicates was to be as many as practicable.

The six different insecticidal compounds used in the tests were made up in a total 13 formulations, on which 26 individual tests were carried out. Each test was replicated 4 times. The four check trees taken for each test were from the same geographical area of the relative tests and were checked at the same time as treated trees, i.e. ca 9 days post-treatment. Maximum and minimum temperatures and precipitation records were kept over the active field work period (6 May to 18 June).

4. Formulations and Treatments

TABLE I

Formulations Tested - Shawville, 1975

Code	Composition (*)
O-I	Orthene 10% AI (wt/vol) from technical, in aqueous solution.
O-II	As for O-I but with 0.2% G-1249 (now Atplus 555)* added.
O-III	Orthene 10% AI from preparation 75S, a soluble powder for field use.
P-I	Phosvel 10% AI from 2.7 lbs/gal conc. diluted with F.O.#2: Arotex 1:1.
F-I	FMC 33297** 0.62% AI in F.O.: Arotex 1:1.
F-II	FMC 33297 1.25% AI in F.O.: Arotex 1:1.
F-III	FMC 33297 2.5% AI in F.O.: Arotex 1:1.
F-IV	FMC 33297 5.0% AI in F.O.: Arotex 1:1.
TH-I	Thompson-Hayward 6040*** 4.0%
TH-II	Thompson-Hayward 6040 2.0%
S-I	Fenitrothion 10% AI - emulsion from concentrate as used operationally in New Brunswick.
S-II	Fenitrothion 10% technical in F.O.: Arotex 1:1 solution.
D-I	p,p'-DDT 10% in F.O.: Arotex 1:1 solution.

(*) Note: 0.1% dye was added to each for purposes of deposit assessment: Automate red for oil-based and Rhodamine B for water-based mixes.

* Surfactant - supplied by Atlas Chemical Industries Limited.

** All made up from 4 lb. AI/gal conc. diluted to required strength.

*** From Dimilin 5% P7321 K Duphar diluted with F.O.: Arotex.

The formulations as listed in Table I were tested in 26 treatments as given in Table II.

TABLE II

Tests and Treatments - Shawville, 1975

Test Code	Formulation	Treatment
(Orthene)		
O-3	O-I	280 g AI/2.9 ℓ/ha (4 oz/40 fl.oz./acre) on old foliage. Larvae L_2.
O-5	O-II	" " "
O-7(*)	O-I	280 g AI/2.9 ℓ/ha
O-8	O-I	140 g AI/1.45 ℓ/ha
O-9	O-II	280 g AI/2.9 ℓ/ha
O-10	O-II	140 g AI/1.45 ℓ/ha
O-11	O-III	280 g AI/2.9 ℓ/ha
O-12	O-III	140 g AI/1.45 ℓ/ha
(Phosvel)		
P-1	P-I	280 g AI/2.9 ℓ/ha - Control assessment made 96 hours post-spray.
P-2	P-I	140 g AI/1.45 ℓ/ha applied twice at 2 day interval.
P-3	P-I	280 g AI/2.9 ℓ/ha
(FMC 33297)		
F-1	F-I	7 g AI/1.45 ℓ/ha (0.1 oz AI/20 fl.oz./acre)
F-2	F-II	17.5 g AI/1.45 ℓ/ha
F-3	F-III	35 g AI/1.45 ℓ/ha
F-4	F-III	70 g AI/2.9 ℓ/ha
F-5	F-IV	70 g AI/1.45 ℓ/ha
F-6	F-IV	140 g AI/2.9 ℓ/ha
(TH-6040)		
TH-1	TH-I	371 g AI/9.4 ℓ/ha (5.3 oz AI/1 gal (US)/acre)
TH-2	TH-I	124 g AI/4.7 ℓ/ha (2.6 oz AI/0.5 gal/acre)
TH-3	TH-I	91 g AI/2.35 ℓ/ha (1.3 oz AI/0.25 gal/acre)
TH-4	TH-II	124 g AI/9.4 ℓ/ha (2.6 oz AI/1 gal/acre)
TH-5	TH-II	91 g AI/4.7 ℓ/ha (1.3 oz AI/0.5 gal/acre)
TH-6	TH-II	42 g AI/2.35 ℓ/ha (0.6 oz AI/0.25 gal/acre)
(DDT)		
D-1	D-I	280 g AI/2.9 ℓ/ha (4.0 oz AI/40 fl.oz./acre)
Fenitrothion		
S-1	S-I	280 g AI/2.9 ℓ/ha (4.0 oz AI/40 fl.oz./acre) emulsion
S-2	S-II	280 g AI/2.9 ℓ/ha (4.0 oz AI/40 fl.oz./acre) oil soln

(*) All tests except O-3 and O-5 were done as soon as possible after larval development reached mainly L_4 and L_5 stadia.

5. Spray Application and Deposit Sampling

Application of the simulated aerial spray was carried out by use of the apparatus and technique described by Hopewell, 1973. A portable shelter enclosing an area 2.1 x 2.1 m (7 x 7 feet) was placed around each tree during application (Fig. 1 a,b). The required volume for the nominal dosage to be applied was measured into the syringe, e.g. 2.9 ℓ/ha (40 fl.oz./acre) required 1.3 ml emitted over the enclosed 4.55 m^2. The operator then raised the unit over the tree in the shelter and switched on the spinning disc and feed motor. The unit was moved systematically over the enclosure during emission while elapsed emitting time was called out at intervals to allow better judgment of uniformity of emission over total enclosed area.

Deposit was sampled in each tree quadrant, (north, south, east, west) on sampling units consisting of a 9 cm diameter petri dish and a 10 x 10 cm Kromekote(R) card. These units were placed on staked holders 1.2 m above ground level, approximately 0.5 m from the tree stem and in close proximity to the branch tagged for post-treatment biological assessment. The deposit samples were returned to the laboratory for colorimetric assessment of deposit and drop count.

6. Sampling of Larval Knockdown following Treatment

An added observation of treatment effects in the 1975 tests was a count of budworm larvae which dropped to the ground. Two trays (32 x 42 cm) were placed under the north and south quadrant of each tree before treatment and a count of living and dead larvae on the trays was made 24 hours post-treatment.

7. Biological Assessment

The assessment of effect of treatments on the larval population densities was made 9 ± 2 days post-treatment. The 45 cm tagged branch from each quadrant was clipped off and the larvae separated from the foliage using the apparatus and technique described by DeBoo et al (1973) and Martineau and Benoit (1973). The surviving budworm were counted and identified as to larval stage. The 4 replicates of each spray treatment gave 16 branch samples on which the average number of survivors per branch was determined and compared with that on the 16 from the 4 representative check trees. Percent mortality due to treatment was calculated by Abbott's method, using the monitoring data as a measure of natural mortality.

8. Defoliation Assessment

The degree of foliage protection was assessed in late autumn as an additional factor of treatment effect. The method followed was essentially that described by Fettes (1950) which quantifies defoliation into 10 classes. Five terminal current year shoots on each of 4 branches, one in each quadrant and adjacent to the branch sampled for surviving budworm, were examined visually in situ. Defoliation class of each shoot was judged by an experienced observer and tallied; the branch, tree and treatment group averages were derived from these data.

RESULTS AND DISCUSSION

The first two tests with Orthene 10% (O-3 and O-5), one with the surfactant, Atlas G.1249, were applied at the time of emergence of L_2 and the budworm was in the needle-mining stage, i.e. no significant new bud development so that application was to old foliage (15 May). From then on, development was very rapid due to unusually warm weather and the main treatment period was from 28 May to 2 June inclusive. (See Figs. 2 and 3 for meteorological data). The monitoring data on budworm development and infestation levels are given in Table III and Figs. 4 and 5. The broken part of the infestation line (Fig. 5) is considered to be close to the true maximum infestation level since it is generally recognized that there is a large sampling error in larval count in the L_2 and L_3 stadia. The data from 1 June on, show the natural mortality and these data were used to calculate the corrected percent control by Abbott's formula (Abbott, 1925).

TABLE III

Budworm Development and Infestation Record Through Testing Period
(Percent in each stage and average number per branch)

Date	L_2	L_3	L_4	L_5	L_6	PP	P	Larvae/branch
20 May	37	59	4					10.8
22 May	11	63	24	2				10.9
26 May	5	26	42	27				19.7
28 May	3	15	40	34	8			23.3
30 May	1	15	17	30	37			25.0
1 June	1	8	23	22	46			25.9
3 June		2	21	26	49	2	<1	23.3
6 June		6	26	18	46	3	1	13.9
8 June		2	15	20	40	15	8	11.7
10 June		3	17	16	33	11	23	14.9
14 June		1	3	6	14	6	70	7.1

The deposit data for each treated tree and treatment dates are given in Table IV. The total larval drop on the 8 trays per treatment, 24 hours post-spray, are included in Table IV.

TABLE IV

Averaged Deposit on Sampling Units for all Treatments and 24 Hour Larval Drop

Test	Date	Avg. Deposit/ha* litres	Avg. Deposit/ha* g AI	Drops/cm²	Calc. Avg. Drop Diam. (μ)	Larval Drop** Total
O-3	15-5	2.6	245	12	160	-
O-5	15-5	1.2	119	11	129	-
O-7	28-5	3.1	300	18	149	85
O-8	28-5	1.4	133	11	134	63
O-9	28-5	3.1	294	55	102	59
O-10	28-5	0.6	56	13	95	48
O-11	28-5	0.9	84	15	104	44
O-12	28-5	0.7	70	12	105	41
P-1	29-5	3.4	329	26	136	54
P-2	29-5+ 2-6	3.6	350	37	124	18
P-3	29-5	4.8	462	81	104	24
F-1	29-5	2.1	13	26	116	57
F-2	29-5	2.1	25	28	113	69
F-3	29-5	2.0	49	36	103	33
F-4	2-6	2.3	62	19	132	78
F-5	2-6	1.2	60	17	112	28
F-6	2-6	3.2	154	33	123	70
TH-1	1-6	8.9	343	78	130	0
TH-2	1-6	4.3	168	33	136	1
TH-3	1-6	2.1	84	26	116	2
TH-4	1-6	8.1	154	80	125	0
TH-5	1-6	4.1	77	44	121	1
TH-6	1-6	3.1	63	31	125	0
D-1	30-5	3.1	300	34	121	18
S-1	30-5	2.1	203	23	121	57
S-2	30-5	3.1	294	23	137	52

Conversion factors:

1 ℓ/ha ≡ 13.7 fl.oz. (US)/acre
70 g/ha ≡ 1 oz./acre

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* Average on 4 samples per tree x 4 replicates = 16 samples.

** Total on the 2 trays under each of 4 replicates. It was noted that in some cases ants were active in removing larvae from trays - hence variable results.

The main observations from the data in Table III were:

(1) In most cases the actual deposit was close to the nominal applied dosage; however, there are exceptions. In the Orthene series the formulation with the additive Atplus 555, (tests O-5, O-9, O-10), dispersed more readily into finer drops and except for O-9, recovery is much lower than the emitted dosage, indicating that much of the material was in drops too fine for good deposition or easily carried away by very light breezes. The average calculated drop diameter of deposited spray was smaller than those without the additives. This was also characteristic of tests O-11 and O-12 in which the 10% Orthene formulation applied was made up using the 75S commercial formulation (75% Orthene soluble powder).

(2) Good knockdown of larvae occurred on trees treated with Orthene, FMC 33297 and fenitrothion. In this respect the FMC product was much more active on the basis of the amount of active ingredient deposited and there was little change in total knockdown as deposit of active ingredient increased.

(3) Phosvel was of intermediate activity in larval knockdown and the double application (Test P-2) of 140 g/ha oz./acre) twice had less knockdown effect than one 280 g/ha (4 oz./acre) application rate.

(4) DDT was similar to Phosvel in knockdown effect and

(5) TH-6040 had no knockdown activity.

The results of the biological assessment of the four sample branches from each of the 4 trees in each treatment for number and development stage of surviving budworm are given in Table V. These were taken 9 ± 2 days after treatment except for tests O-3 and O-5 in which treatment was applied to old foliage on 15 May and observations taken 24 days post-treatment. The percent control of budworm was calculated from the average number of survivors per standard branch length, as shown in the table, compared with untreated checks and corrected for natural mortality.

TABLE V

Numbers and Development Stage of Surviving Budworm, Assessed 9 Days Post-Treatment

Test No	Tree No	Instar 3	Instar 4	Instar 5	Instar 6	Pre-Pupae	Pupae	Total Alive	Avg. No. Survivors per branch
O-3	2		1	4				5	
	6	1	12	9	29		1	52	
	10			2	6			8	
	11		6	5	20	1		32	6.1
O-5	7		4	8	12	1	3	28	
	8	3	7	15	52	2		79	
	12	1	3	6	11			21	
	13	1	4	6	4			15	8.9
O-7	15		3	4	5			12	
	18		1		1			2	
	19		2		7			9	
	20		0	0	0			0	1.4
O-8	16		8	5	15	3		31	
	21	2	9	4	21			36	
	22		4					4	
	23		2	1	15			18	5.6
O-9	25		1					1	
	26		3		3			6	
	42		2		2		1	5	
	43	1	2	2	4	3	1	13	1.6

TABLE V Cont'd

Test No	Tree No	Instar 3	Instar 4	Instar 5	Instar 6	Pre-Pupae	Pupae	Total Alive	Avg. No. Survivors per branch
O-10	27				1			1	
	28			2	15			17	
	29	2	2	6	15		3	28	
	30		3	6	24		3	36	5.1
O-11	32		1	1	8	3	1	14	
	33		1	3	8	1		13	
	34				2			2	
	35		0		0			0	1.8
O-12	36			1	3			4	
	37		2	3	14	2	1	22	
	38		3		10	2		15	
	39		1		5			6	2.9
Checks	9		16	9	26	1		52	
	17	3	19	30	48	1		101	
	24	3	8	6	19	1	1	38	
	31		5	6	33	4	3	51	15.1
P-1	14		)						
	45		)	DATA NOT AVAILABLE					
	46		)						
	47		)						
P-2	48		5	5	5		2	17	
	49			4	11	7	8	30	
	50		1					1	
	51		2	2	5	1	3	13	3.8
P-3	67		1	2	5	1	4	13	
	68			1	6			7	
	69	1	1	2		2	6	12	
	70		3	1	3	1		8	2.5
Checks Phosvel	24	3	8	6	19	1	1	38	
	31		5	6	33	4	3	51	
	52		6	9	8	5	8	36	
	76		1	13	33	4	6	57	11.4

TABLE V Cont'd

Test No	Tree No	Instar 3	Instar 4	Instar 5	Instar 6	Pre-Pupae	Pupae	Total Alive	Avg. No. Survivors per branch
F-1	53		7	7	20	9	2	45	
	54	1	3	4	12	1	2	23	
	60		4	1	9	1		15	
	61		1	1	6		1	9	
									5.8
F-2	55		2	1	5	1		9	
	56		1		8			9	
	57			2	1			3	
	62	1	4	8				13	
									2.1
F-3	58		4	6	6	5	1	22	
	63	1	4	1	1			7	
	64	2	5	3	5			15	
	65	1	2	2	8		1	14	
									3.6
F-4	148		2		3		11	16	
	149		5	2	1			8	
	150		1		3		5	9	
	151		1		3	1	6	11	
									2.8
F-5	152		3	2	1	3	5	14	
	153		2		1		9	12	
	154	1	5	5	6		15	32	
	155		3	3	2		13	21	
									4.9
F-6	156		2	1	1		2	6	
	157		1	4	2	1	8	16	
	158	1	1	2	1		4	9	
	159		0	0	0		0	0	
									2.6
Checks		3	8	6	19	1	1	38	
			5	6	33	4	3	51	
			6	9	8	5	8	36	
			1	13	33	4	6	57	
									11.4
TH-1	105		15	13	44	11	14	97	
	106		6	9	19	10	8	52	
	131	2	4	10	11	8	40	75	
	132			1	7	2	6	16	
									15.0

TABLE V Cont'd

Test No	Tree No	Instar 3	4	5	6	Pre-Pupae	Pupae	Total Alive	Avg. No. Survivors per branch
TH-2	107		9	4	22	5	11	51	
	108		14	8	17	4	16	59	
	133		8	7	8	3	6	32	
	136	1	2	6	17	6	21	53	
									12.2
TH-3	110		10	6	12	10	19	57	
	111		11	3	22	2	16	54	
	138		4	7	4	3	12	30	
	139		3	13	29	10	39	94	
									14.7
TH-4	112		2	6	18	9	7	42	
	122		8	7	24	7	14	59	
	140		4	3	21	12	21	61	
	141		6	4	11	3	32	56	
									13.6
TH-5	123		6	7	36	9	29	87	
	124	2	5	19	22	11	11	70	
	142		3	3	8	6	10	30	
	143	1	5	6	22	8	14	56	
									15.2
TH-6	125		7	3	33	10	14	67	
	126		5	8	22	3	13	51	
	144		6	10	17	3	23	59	
	145		6	5	12	7	37	67	
									15.2
TH-Checks	130		7	15	23	9	24	78	
	137		11	9	25	13	14	72	
	160		2	7	11	6	23	49	
	52		6	9	8	5	8	36	
									14.7
D-1	80			2	8			10	
	81		1	2	1			4	
	82		1		1			2	
	83		2	2				4	
									1.0
S-1	71	1	1	2				4	
	72		2	1	8	1	1	13	
	73				1		1	2	
	74		1	1	8		1	11	
									1.9

TABLE V Cont'd

Test No	Tree No	Instar 3	Instar 4	Instar 5	Instar 6	Pre-Pupae	Pupae	Total Alive	Avg. No. Survivors per branch
S-2	75		3	3	5		1	12	
	77		4	2	5	1	1	13	
	78		7	1	5		1	14	
	79		3	4	7			14	
									3.3
Checks	24	)	As for F 1-6 and P 1-3					38	
D-1	31	)						51	
S-1-2	52	)						36	
	76	)						57	
									11.4

A summary of results, including defoliation data, is given in Table VI.

Orthene:

Highest mortality of 94, 93 and 92 percent resulted from Orthene tests 7, 9 and 11 respectively. Tests 7 and 9 both had average deposits of approximately 300 g AI/3 ℓ/ha. The difference between the two deposits was drop size, O-7 and O-9 having 18 and 55 drops/cm^2 respectively (Table IV). The better coverage at this dosage did not increase budworm mortality. Both tests using the 75S field formulation as base (O-11, O-12) gave good budworm mortality of 92 and 87%, with active ingredient deposits of 84 and 70 g/ha respectively, and 15 and 12 drops/cm^2. Percent recovery of emitted spray was low as a result of breakup into very fine drops (average drop diameter of deposited spray 105 μm) but activity against budworm seems much higher than other Orthene formulations. The addition of Atplus 555 resulted in a formulation more readily dispersed into fine drops in all cases where it was compared directly with the aqueous solution of Orthene without an additive (tests O-3 vs O-5, O-7 vs O-8, O-9 vs O-10, Table IV) the average diameter of deposited drops being smaller in each case where the additive was used. In the two tests where application was made early with budworm larvae in 2nd and 3rd instar, the results were variable between replicates (tests O-3, O-5, Table V). However, there was a significant average reduction in budworm infestation giving mortality of 72 and 60% with measured deposits of 245 and 120 g AI/ha for tests O-3 and O-5 respectively. The additive Atplus 555, if improving effectiveness at all, was not sufficient to double it, as is evident from larval mortality and foliage protection. Significant foliage protection resulted from all Orthene tests except the 120 g AI/ha applied early to old foliage, and equalled or surpassed the results from the standard fenitrothion emulsion deposited at 210 g AI/2.1 ℓ/ha.

Phosvel, at approximately 350 g AI/ha (5 oz/acre) gave control equivalent to the standard fenitrothion emulsion at 200 g/ha or oil solution at 300 g/ha. The double application at a rate of 140 g/ha applied twice at a 4 day interval (Test P-2) was not as effective as the total dosage applied at one time. In operational work the double application would tend to give more even distribution on the target area and eliminate missed areas. However, this did not apply in these tests. This is shown in reduced mortality and foliage protection. In test P-1, biological assessment was made 96 hours post-treatment, but the data were inadvertently recorded incorrectly so that effectiveness must be judged on the basis of foliage protection only. The deposit of 330 g AI/ha resulted in a 60% reduction in defoliation compared with that on the checks (Table VI).

FMC 33297 was the most active of all on the basis of budworm mortality per unit of active ingredient per hectare, the highest being 81% budworm mortality at a deposit of 26 g/2 ℓ/ha (0.4 oz/30 fl.oz./acre). All FMC 33297 tests gave fairly good budworm mortality and foliage protection (Table VI). With later instars (tests F-4, 5, 6, Tables IV and VI) about 20 g AI/2.25 ℓ/ha seems optimum with no advantage showing at double the active ingredient content in approximately equal volume (Test F-6). Best results were obtained in test F-2 with a formulation containing 1.25% AI applied at 17.5 g AI/1.45 ℓ/ha (0.25 oz AI/20 fl.oz. /acre). This treatment gave 81% budworm mortality and 66% reduction in defoliation and was applied when majority of budworm were in 4th and 5th instars.

TH-6040 showed little or no budworm mortality or knockdown. However, time of application with majority of larvae in 4th, 5th and 6th instars (22, 22 and 40% respectively) may have been too late in budworm development to expect results from this type of material which must be ingested to disrupt cuticle formation.

DDT at 295 g/3 ℓ/ha (4.2 oz AI/42 fl.oz./acre) induced 91% budworm mortality and 80% reduction in defoliation compared with untreated checks.

TABLE VI

Summary of Percent Budworm Mortality and Defoliation Observations for each Test

Test	Spray Deposit Avg. g/ha	% Larval Mortality (Corr.)	Defoliation Avg. (%)	Defoliation % Reduction vs Check
Orthene				
O-3	245	72	20	67
O-5	120	60	50	17
O-7	300	94	8	87
O-8	133	75	23	62
O-9	295	93	16	73
O-10	56	77	24	61
O-11	84	92	18	71
O-12	70	87	19	68
Checks		-	60	0
Phosvel-1	330	-	18	60
P-2	350	70	32	30
P-3	460	81	11	76
Checks			41	0
FMC-1	13	49	31	33
F-2	26	81	16	66
F-3	50	68	20	56
F-4	62	70	39	26
F-5	60	47	26	44
F-6	155	70	28	40
Checks		-	41	0
TH-6040				
TH-1	345	0	48	33
TH-2	170	0	59	18
TH-3	85	0	66	8
TH-4	155	0	66	8
TH-5	75	0	58	20
TH-6	65	0	68	6
Checks		-	72	0
Fenitrothion				
S-1	205	83	13	71
S-2	295	71	12	73
Checks				
DDT-1	295	91	6	86
Checks		-	45	0

The percent of surviving budworm in each development stage was calculated from the data in Table V and compared with that of the corresponding checks to determine if any change in larval development occurred as a result of the treatments, especially with respect to the TH-6040 compound. These data are given in Table VII. Data from all tests with each insecticide have been pooled for comparison with its checks. There is no indication that the TH-6040 compound interfered in any way with development since the general development distribution is the same as that in the checks. The only one which was outstandingly different from check population was from the DDT treatment where none advanced to the pre-pupal or pupal stage.

TABLE VII

Percent of Survivors in each Development Stage
Totals for each Insecticide

Insecticide	L_3	L_4	L_5	L_6	PP	P	Total Number Budworm
Orthene	2	16	17	58	3	2	535
Checks	2	20	21	52	3	2	242
Phosvel	1	13	17	35	12	23	101
Checks	2	11	19	51	8	10	182
FMC 33297	3	22	19	36	3	18	293
Checks	2	11	19	51	8	10	182
TH-6040	1	11	12	33	12	31	1327
Checks		11	17	28	14	29	235
DDT							
D-1		20	30	50			20
Checks	2	11	19	51	8	10	182
Fenitrothion							
S-1	3	13	13	57	3	10	30
S-2		32	19	41	2	6	53
Checks	2	11	19	51	6	10	182

SUMMARY AND CONCLUSIONS

1. Orthene formulations again gave excellent reduction of spruce budworm populations on white spruce, up to 94%, when applied at 300 g/3 ℓ/ha (4.25 oz AI/42 fl.oz./acre) at a drop coverage of 18 to 55/cm^2. The 75S-based formulation seemed particularly active since the average measured deposit of 84 g/ha at 15 drops /cm^2 gave control in the order of 90%. This formulation dispersed more readily into smaller drops (average 105 micron diameter in sampled deposit) which resulted in a much lower percent recovery of emitted spray.

2. Early application of Orthene to old foliage about the time L_2 are emerging from hibernacula, at a measured deposit of 245 g/ha resulted in significant budworm control of 72% and good foliage protection. The 75S-based formulation should be tested for early application to determine if it is superior to the regular aqueous solution.

3. Phosvel at 350 to 450 g/ha, resulted in budworm mortality in the order of 80%, which is similar to that of the standard fenitrothion emulsion at 210 to 300 g/ha. Total application of 350 g/ha (5 oz/acre) applied at 140 g/ha twice at a 4 day interval did not give as good results in budworm mortality (70%) or foliage protection (30% reduction) as one application of 460 g/ha which gave 81% budworm mortality and 76% reduction in defoliation.

4. FMC 33297 was the most active of all tested, as an average deposit

of 26 g/ha (0.4 oz AI/acre) resulted in 81% budworm mortality. However, mortality was not increased by deposit rates up to 155 g/ha (2.2 oz/acre). Knockdown of larvae was good even at the lowest dosage tested, 13 g AI/2 ℓ/ha (0.2 oz/30 fl.oz./acre), and foliage protection ranged from 40 to 66% over that in untreated checks in the FMC series.

5. The Thompson-Hayward product 6040 was ineffective on all counts; no knockdown, no budworm mortality or foliage protection. In addition, there was no indication of any interference with budworm development. Application was made when larval stages L_4, L_5 and L_6 accounted for 22, 22 and 40% respectively of the budworm and development may have progressed beyond the stage when effect of this cuticle growth disruptor would be evident.

6. An overall higher percent of defoliation occurred than in the 1974 tests on account of (1) a higher infestation level and (2) budworm development had reached a more advanced development stage at time of application and much foliage damage had already occurred.

7. Addition of Atplus 555 to the Orthene formulation resulted in easier breakup of solution into finer drops and more efficient coverage in drops/cm^2 but did not increase toxic activity of Orthene to spruce budworm.

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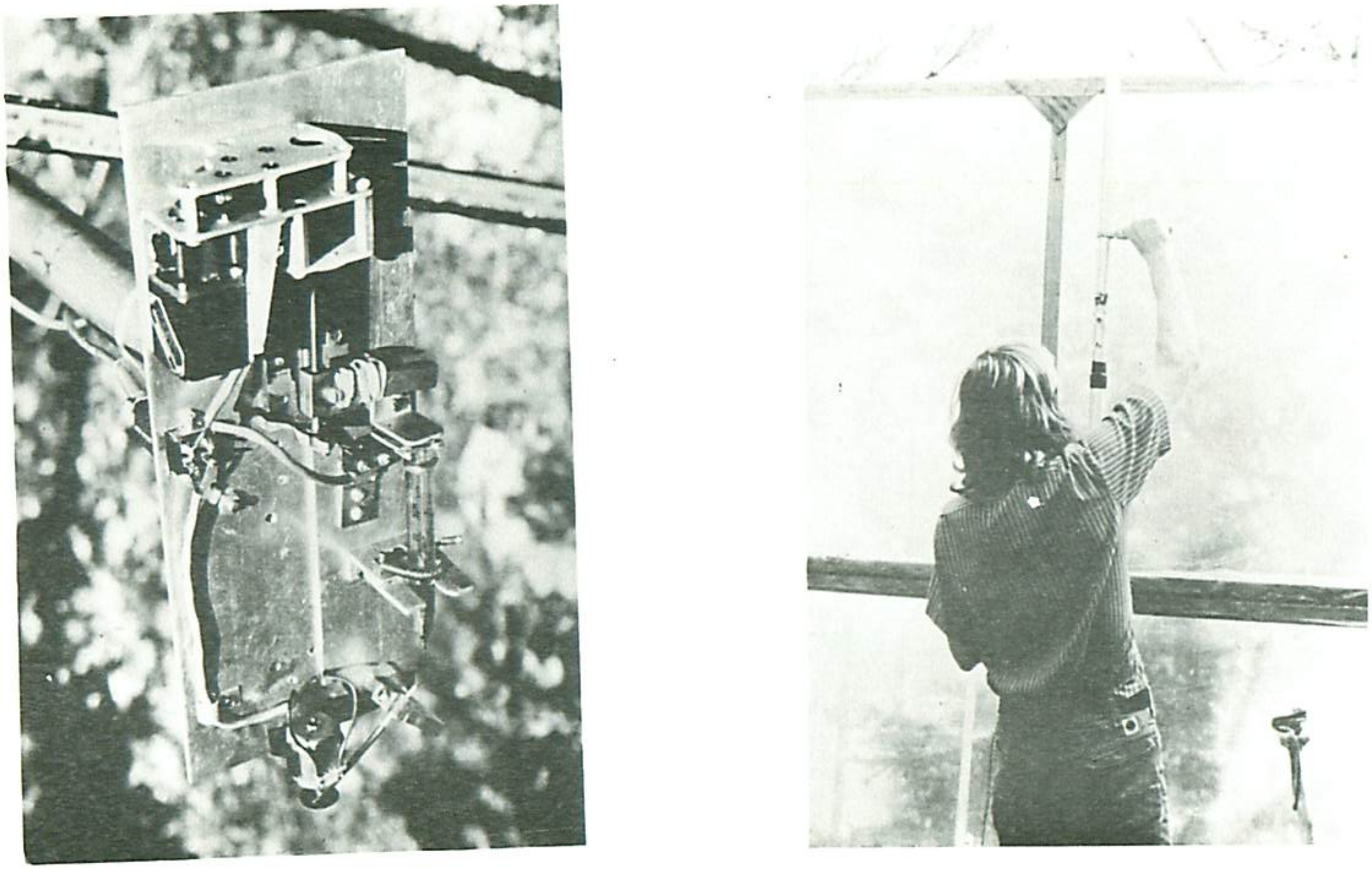

(a) Droplet emitting unit.

(b) Spray Application.

Fig. 1. Simulated Aerial Spray Deposit Treatment to Individual Sheltered Trees.

Photos courtesy of P. Jones, FMC of Canada, Limited.

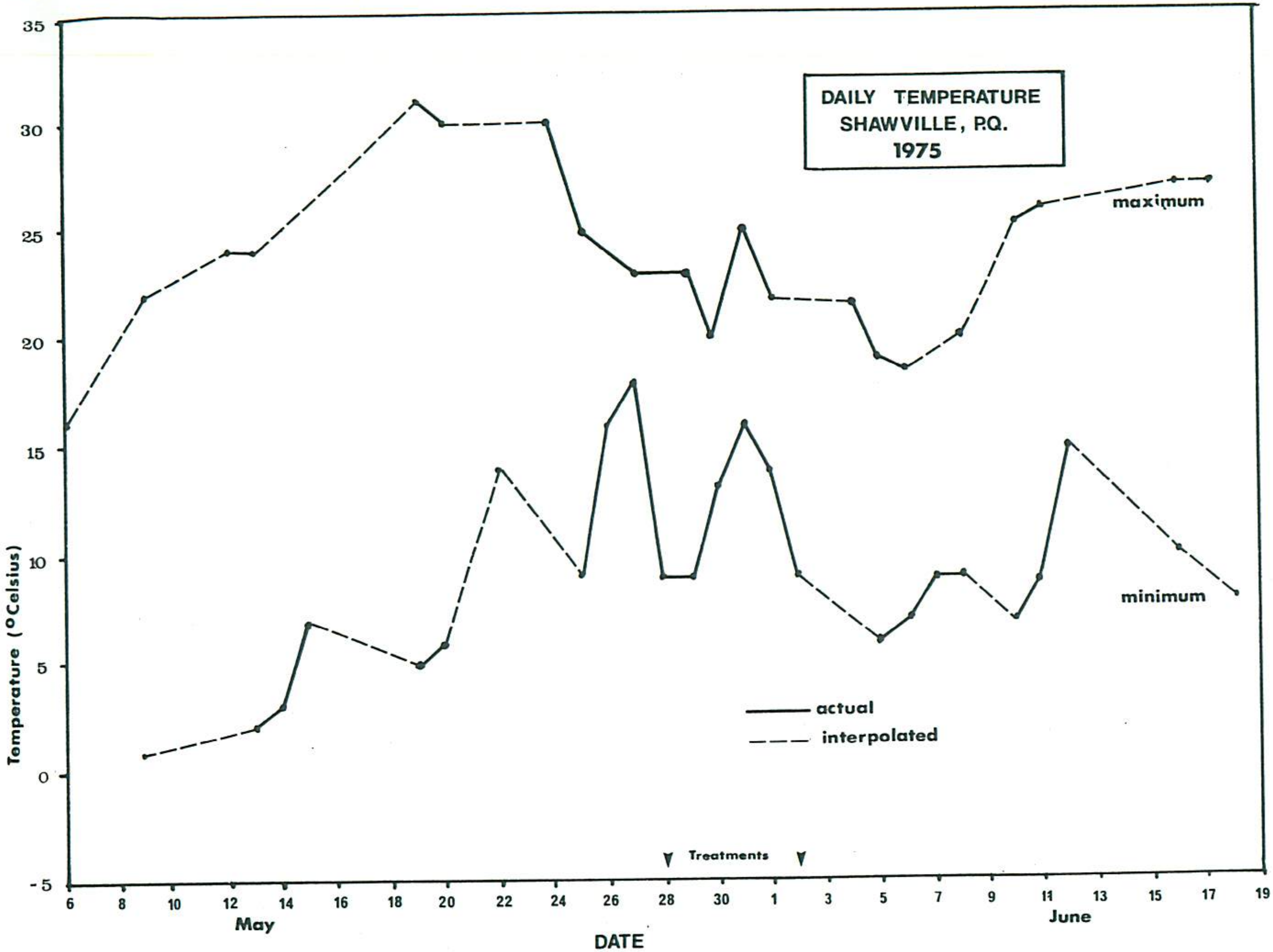

Fig. 2. Daily Maximum and Minimum Temperatures at Field Plot.

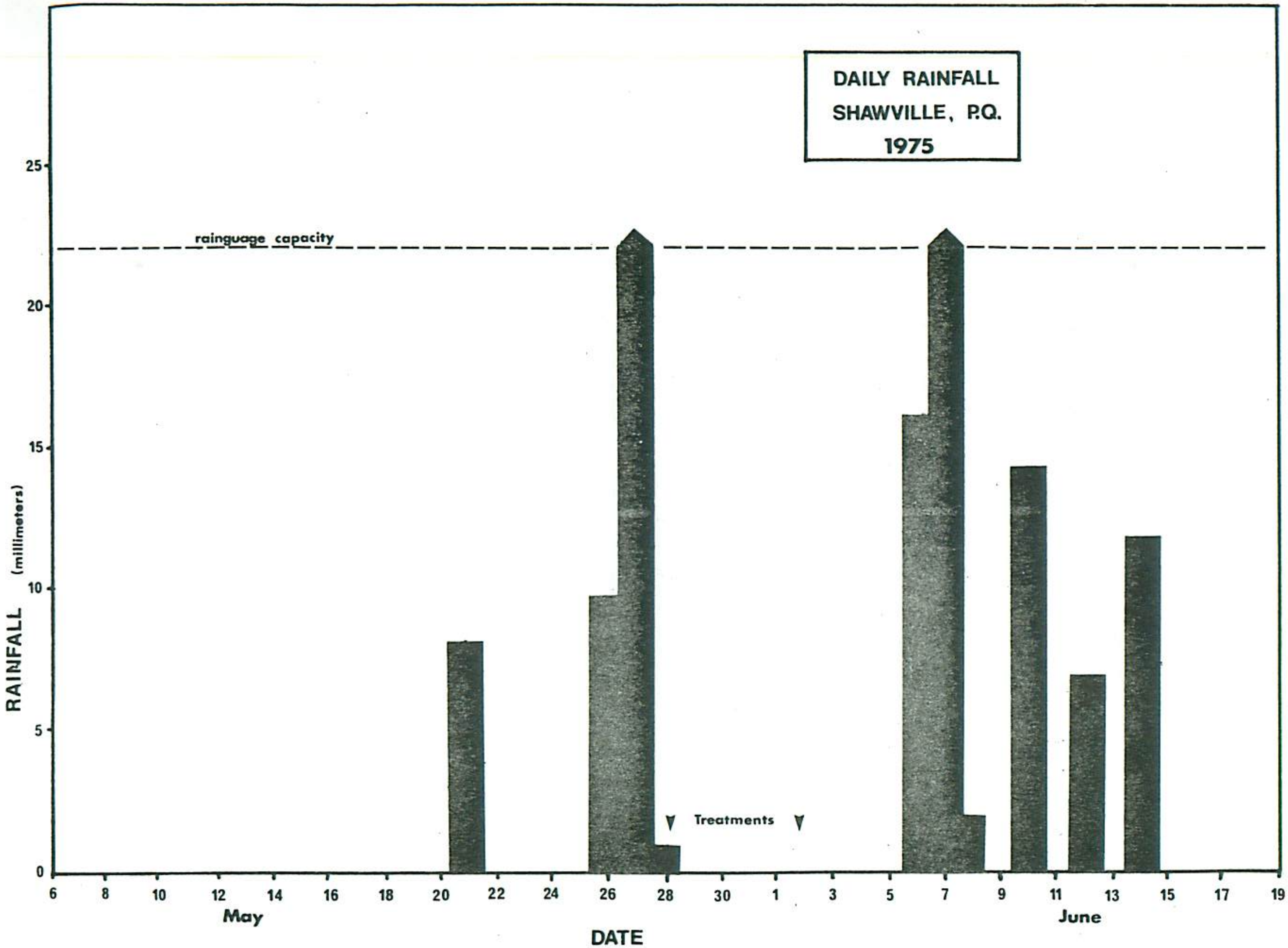

Fig. 3. Precipitation on Plot During Test Period.

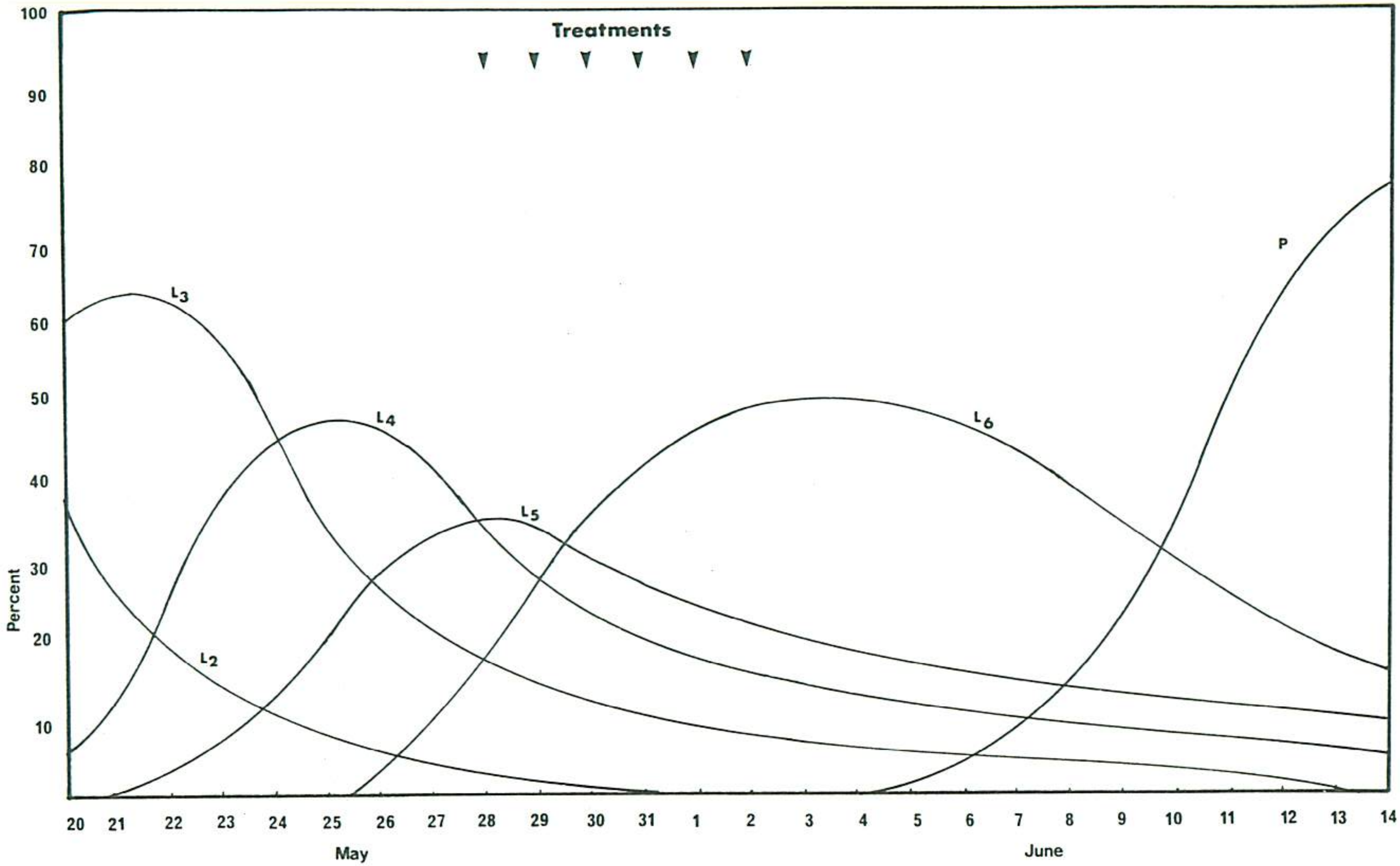

Fig. 4. Larval Development Distribution at Shawville, Que. 1975.

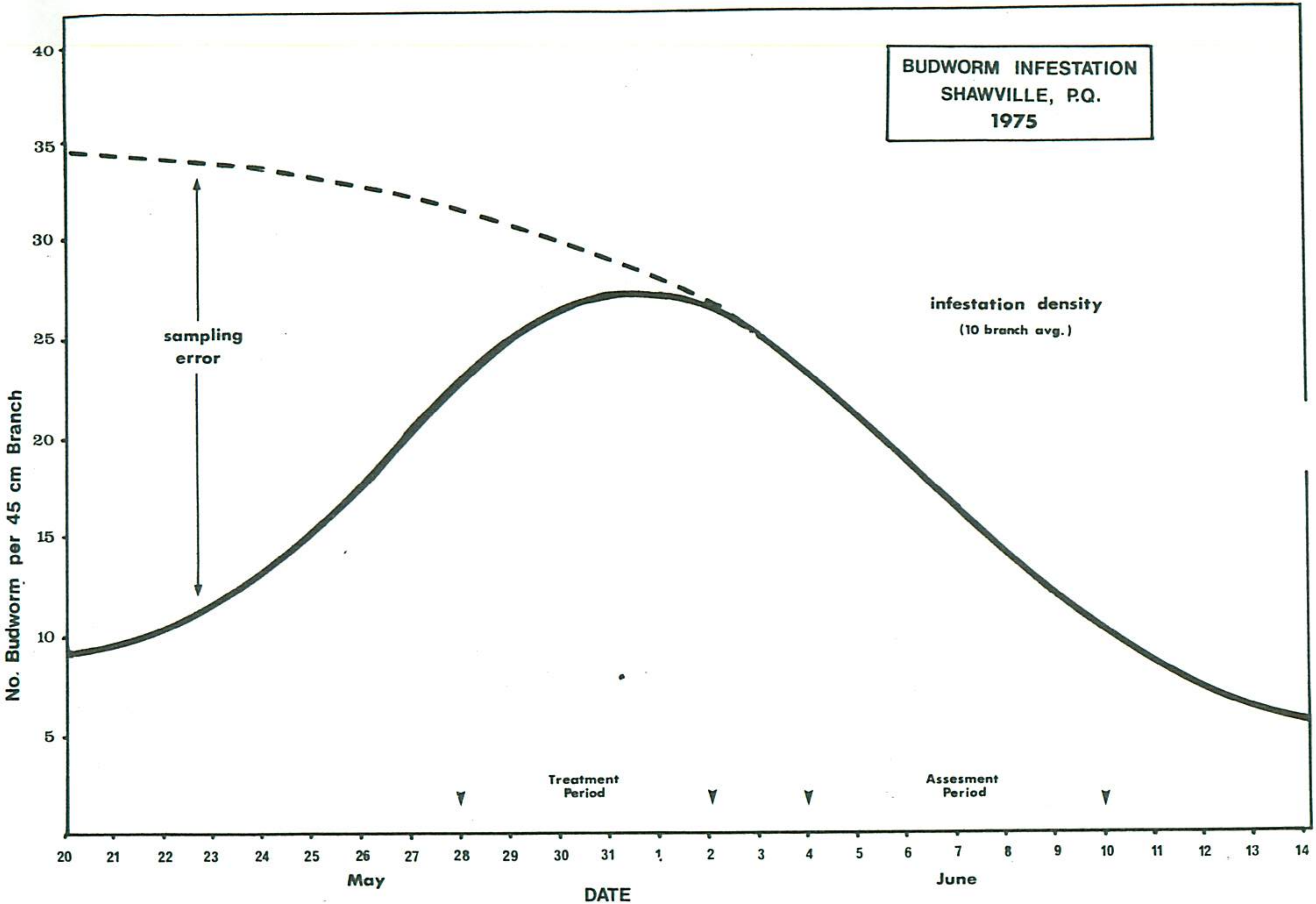

Fig. 5. Average Budworm Infestation Level in Study Area, Shawville, P.Q. 1975.