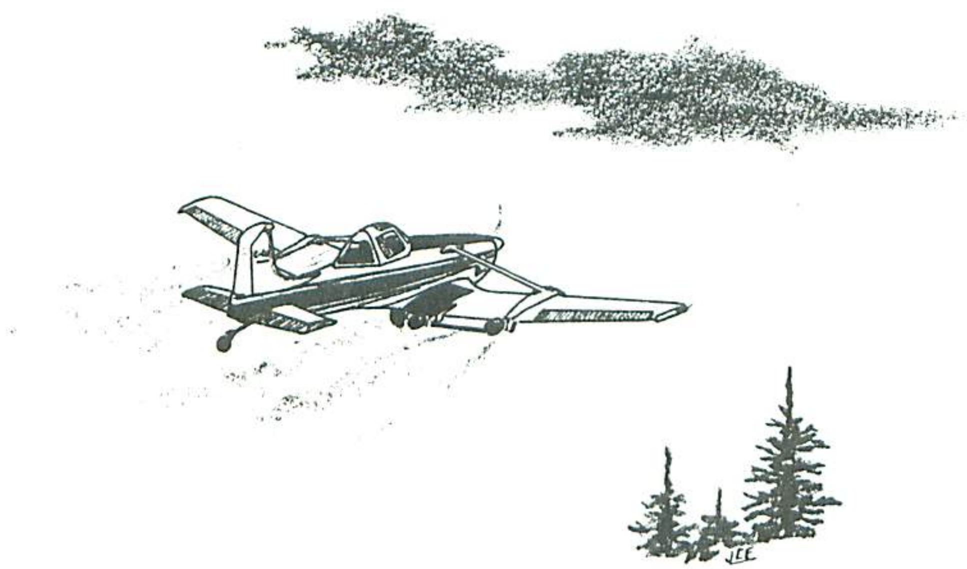
PLANTATION RESEARCH: XV. EXPERIMENTAL AERIAL APPLICATIONS OF METHOMYL, PHOXIM AND TRICHLORFON FOR CONTROL OF *CHORISTONEURA FUMIFERANA* ON WHITE SPRUCE IN QUEBEC, 1975

by

R. F. DeBoo



CHEMICAL CONTROL RESEARCH INSTITUTE
CANADIAN FORESTRY SERVICE - DEPARTMENT OF THE ENVIRONMENT
OTTAWA, ONTARIO

INFORMATION REPORT CC-X-105
DECEMBER, 1975

TABLE OF CONTENTS

ABSTRACT

Experimental aerial applications of methomyl (0.37 kg/ha), phoxim (0.42 kg/ha) and trichlorfon (1.12 kg/ha) to white spruce (*Picea glauca*) plantations near Grand'Mère, Québec, indicated that single aqueous spray treatments under conditions of extreme population densities of the spruce budworm (*Choristoneura fumiferana*) may be inadequate to induce the high degree of foliage protection required for valuable stands. Methomyl sprays induced the best levels of larval population reduction (88%) and defoliation (39%). Results of applications of phoxim (53% reduction, 71% defoliation) and trichlorfon (52% reduction, 59% defoliation) were considered unacceptable.

RESUME

Des expériences d'épandage aérien de méthomyl, de phoxime et de trichlorfon à raison de 0,37, 0,42 et 1,12 kg/ha respectivement sur des peuplements d'épinette blanche (*Picea glauca*) près de Grand-Mère, au Québec, amènent à croire qu'un traitement unique avec une préparation aqueuse ne suffit pas à assurer la protection voulue du feuillage des peuplements précieux contre les proliférations de la tordeuse des bourgeons de l'épinette (*Choristoneura fumiferana*). Le méthomyl a été le plus efficace pour ce qui est de la répression des larves (88%) et de la défoliation (39%). Le phoxime (répression de 53%, défoliation de 71%) et le trichlorfon (répression de 52%, défoliation de 59%) ont donné des résultats jugés inacceptables.

INTRODUCTION

Recent infestation levels of the spruce budworm, *Choristoneura fumiferana* (Clem.), have had serious impact on the growth and survival of its host trees in eastern Canada. Many high-value stands on both private and public lands have been devastated, particularly in portions of south-western Quebec, by annual severe defoliation by the budworm. Estimates by the Quebec Department of Lands and Forests (R. Desaulniers, personal communication) have indicated that more than 2 million hectares of productive forest have been lost in this important region of Quebec to date. Subsequent damage to these forests, as well as social and economic implications of the current budworm outbreak, are at best speculative at present. However, the need to protect surviving stands here, in other regions of Quebec, as well as in other provinces of Canada threatened by the budworm problem, never has been more evident. Included in the area requiring optimal protection are municipal, provincial and national park systems, private recreation and resort areas, plantations and farm woodlots.

Consistent with the policies of the Canadian Forestry Service and the role of the Chemical Control Research Institute, field studies on the application of insecticides for protection of high-value stands from budworm defoliation was continued during 1975 in white spruce, *Picea glauca* (Moench) Voss, plantations near Grand'Mère, Quebec. Whereas research during previous years was centered primarily on insecticide sprays by mistblower (DeBoo and Campbell 1972, 1974 a,b), the major objective of the 1975 study was to evaluate the efficacy of selected dosages of methomyl (Lannate®), phoxim (Volaton®), and trichlorfon (Dylox®) when applied as aqueous mixtures by fixed-wing aircraft.

Rates of application and formulations of insecticides selected were based on previous results and on recommendations from technical representatives of the manufacturers. Although mention of trade names implies neither endorsement nor recommendation by the Canadian Forestry Service, the evaluation of proprietary pest control products is consistent with the federal role in pest management: To provide a selection of effective, practical and environmentally acceptable spray ingredients and application techniques for the protection of valuable forest trees and stands. This report, therefore, is presented for consideration by regulatory authorities and resource managers as background information for the development of recommendations in forest pest management.

MATERIALS AND METHODS

Research Study Area

The Grand'Mère Plantations (Gagnon 1972, DeBoo and Campbell 1974b) were selected for establishment of the experimental spray study in consultation with the proprietor, Consolidated-Bathurst Ltd. A total of 9 plantation blocks, covering 416 hectares (1040 acres), were selected for the aerial spray experiments. The study blocks were selected from plantations near the Grandes-Piles provincial tree nursery and north of St. Timothée to plantations south of the airstrip facility near Lac-a-la-Tortue (Fig. 1). Trees selected for treatment were predominantly white spruce ranging from 6 to more than 18 meters in height and numbering 2,000 or fewer per hectare due to past commercial thinning operations.

Spruce Budworm Population Density

Data on population densities of the spruce budworm indicated that numbers had been increasing since 1968 (DeBoo and Campbell 1974b). Based on 45-cm branch tip samples, average number of larvae were:

1968	-	15.5		- moderate infestation
1970	-	20.8		- moderate infestation
1974	-	55.0		- severe infestation
1975	-	>55	(predicted)	- severe infestation

Insecticides

Three insecticides were selected for experimental application to the white spruce plantations at Grand'Mère. Spray mixtures of methomyl and phoxim were applied as part of the Institute's sequential program of evaluation of insecticides from laboratory to field conditions.

Trichlorfon was included as part of concurrent evaluations of dosages by several other forest protection agencies in eastern Canada. Details on nomenclature, formulations and dosages are summarized in Table I.

Application Equipment

A Cessna Agtruck was contracted from Modern Airspray Ltd., St. Jean d'Iberville, for the aerial applications. The aircraft was equipped with four Micronair® AU3000 spray atomizers (Fig. 2) and calibrated to emit 4.68 litres/hectare (0.5 gal/ac.) at an effective swath of approximately 65 m and speed of 160 km/hr.

Support equipment at the Lac-à-la-Tortue airstrip included a laboratory trailer, storage compound and meteorological, mixing and loading equipment (Fig. 3).

Experimental Design

Nine plantation blocks were selected from the priority stands designated by Consolidated-Bathurst. Two plantations (42, 124 ha) were selected for treatment by methomyl, two for treatment using trichlorfon (72, 90 ha), three for treatment using phoxim (40, 24, 24 ha), and two representative plantations (40, 45 ha) were reserved as untreated check blocks for comparative purposes and to monitor development and natural population decline of larvae of the spruce budworm.

Spray Applications

All sprays were planned for that timespan near the peak occurrence of the 4th larval instar (L_4). Aerial spray treatments were applied from June 3 to June 10, being interrupted during the period June 5-9 by continuous rainfall and high winds. Accordingly, the applications of phoxim were approximately one week late due solely to this period of inclement weather (Table II, Figure 4).

Spray mixtures were prepared at the Lac-a-la-Tortue airstrip for immediate application to the designated plantations. Treatments were applied during early morning and evening periods (ca. 0445-0830, 2000 - 2130 hours) when conditions of humidity and wind were considered to be suitable (Table II). A ground support crew was on site during each application to monitor meteorological conditions and spray deposit, and to assist the pilot of the aircraft in the accurate delivery of each swath using red and white meteorological balloons as guidance markers.

Evaluation of Spray Treatments

Prior to treatment, sampling stations along two transects at right angles to spray swaths were located in each plantation for estimates of budworm population densities, spray deposits near ground level, and defoliation levels at the end of the larval feeding period. Two 45-cm branch tips were collected randomly from the mid-crown section of each sample tree for estimates of larval densities once before treatment (-1 to -2 days) and once after treatment (+5 to +9 days). A minimum of 10 sampling stations were located along each transect.

Kromekote® cards and glass microscope slides were located on staked platforms (ca. 0.3 m above ground level) in openings near each branch sample tree immediately before each spray. The slides and cards were collected within two hours of treatment for estimates of droplet size and number and of spray volume deposits using colorimetric techniques and the Flying Spot Scanning system developed by Slack (1972). Rhodamine B (liquid), a fluorescent dye tracer, was added to all spray mixtures at 0.5% (volume) to facilitate analysis of spray deposition on cards and slides.

Estimates of branch defoliation at mid-crown levels were obtained through visual examinations of shoot condition (Fettes 1951) of 2 randomly-selected branches from each sample tree. Estimates of tree-top condition were obtained by binocular examination of foliage on these same trees.

The Spruce Coneworm

Special emphasis was placed on obtaining indices of population densities of the spruce coneworm, *Dioryctria reniculelloides* (Matuura and Monroe 1973), during routine acquisition of counts of larvae from spruce branches. This information was used to document interspecies relationships, comparative population densities and survivorship after insecticidal treatments.

Table I

Insecticide nomenclature, commercial formulations, mammalian toxicity, and rates of application at Grand'Mère, 1975

Common Name:	methomyl	phoxim	trichlorfon
Trade Name^{R}:	Lannate	Volaton	Dylox
Formulation:	20L	4SC	4.8 LS
Mammalian Toxicity[1]:	Rb = >1000	R = >1126	R = >2000
Application Rates[2]:			
Dosage (A.I.)	0.37 Kg/ha	0.42 Kg/ha	1.12 Kg/ha
Spray Volume	4.68 ℓ/ha	4.68 ℓ/ha	4.68 ℓ/ha

[1] From Kenaga and End (1974); Acute dermal toxicity in mg/Kg bodyweight, Rb = Rabbits, R = Rats

[2] Chevron Sticker added at 50 mℓ/100 liters (0.5 pint/100 gal.).

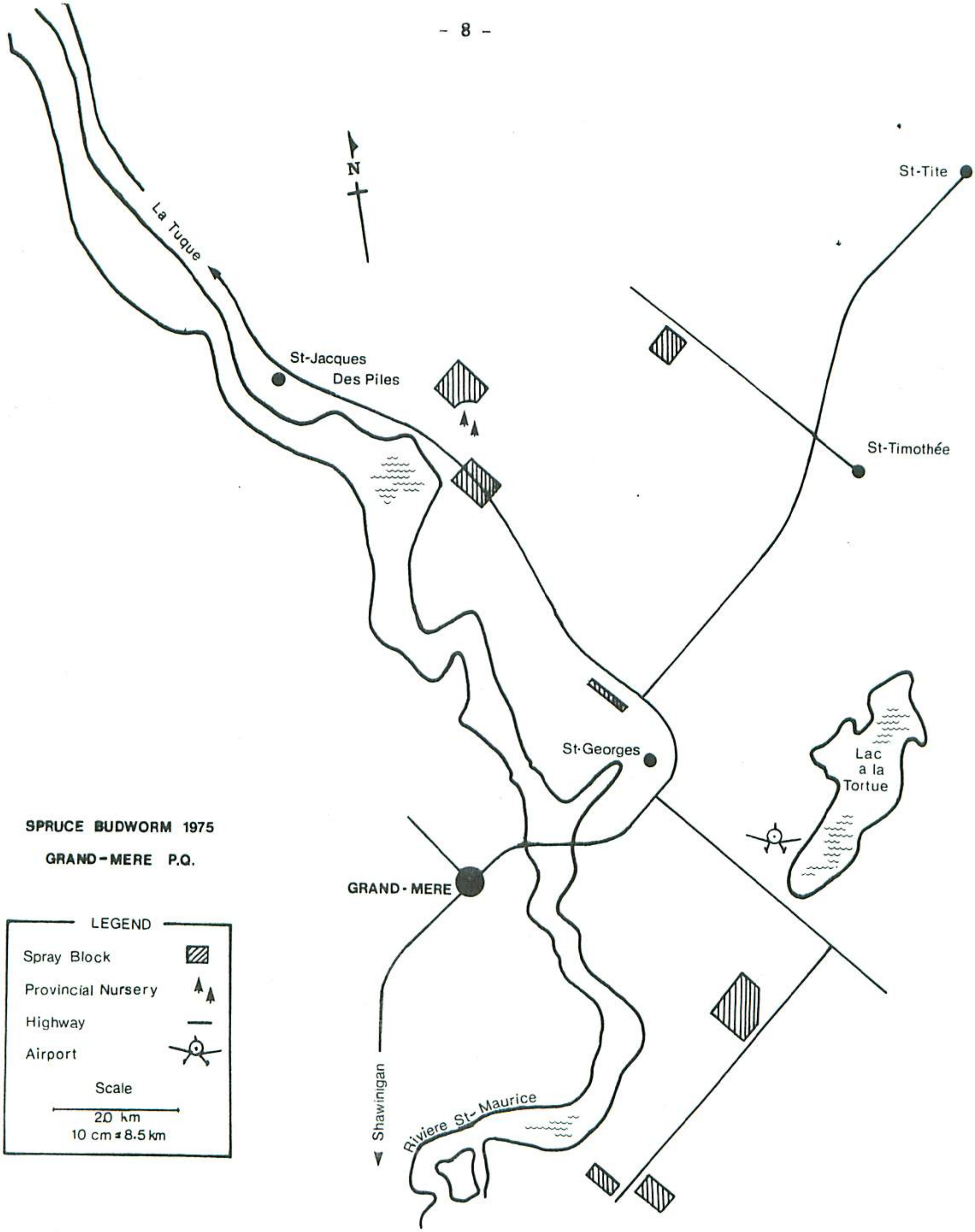


Figure 1 Location of treatment areas - Grand'Mère Plantations, 1975.

Figure 2. Cessna Agtruck with Micronair AU3000 spray atomizers.

Figure 3. Spray mixing-loading facility at Lac-à-la-Tortue airstrip.

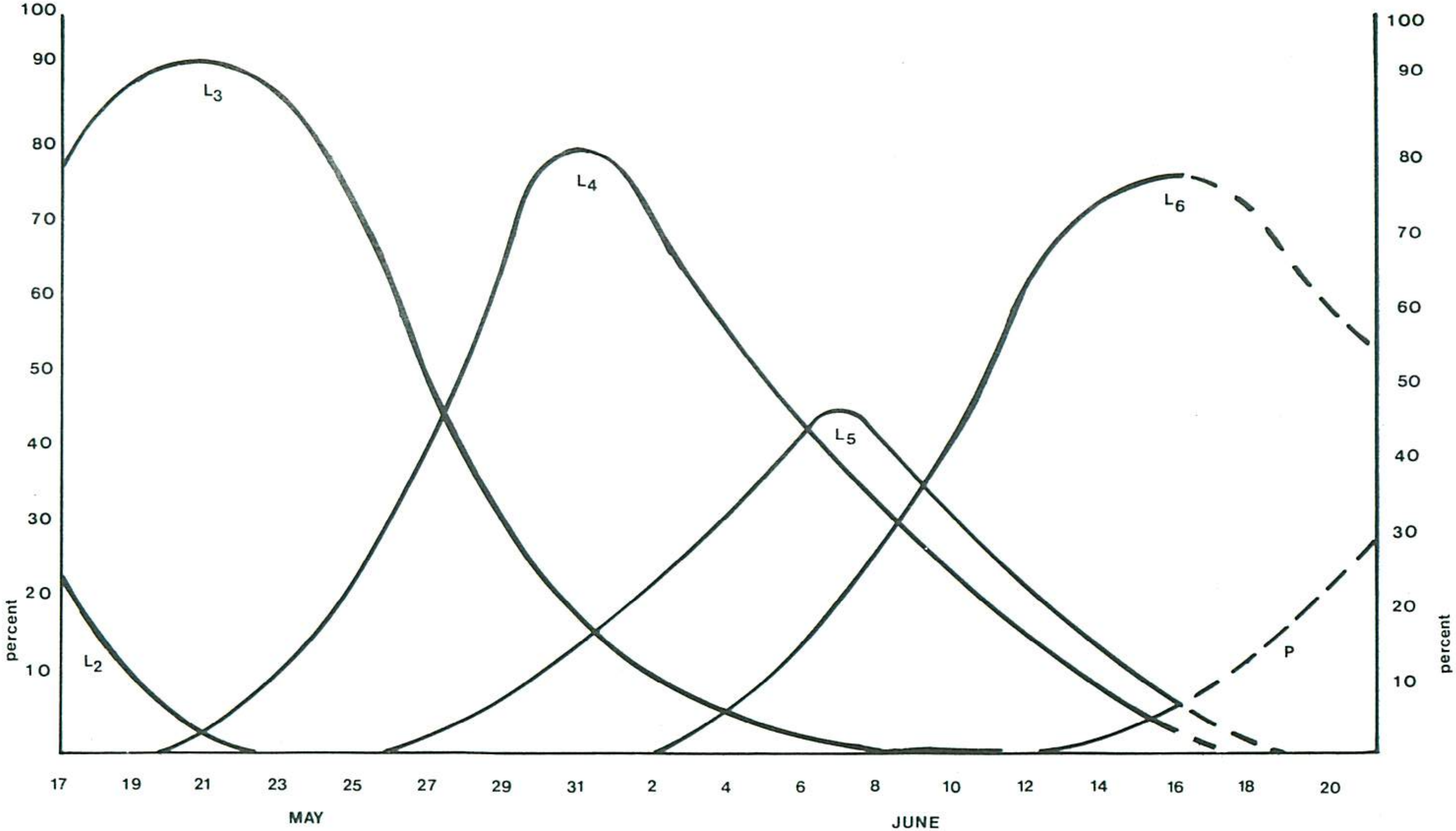


Figure 4. Larval development of the spruce budworm - Grand'Mère Plantations, 1975.

RESULTS AND DISCUSSION

Evaluation of the results of the spray study indicated that the very high population densities of the spruce budworm at Grand'Mère during 1975 would have required special tactics for optimum protection of tree foliage. Each of the three conventional spray treatments provided significant mortality of larvae populations in the selected plantation compartments, but none provided the required level of foliage protection.

Methomyl

The applications of methomyl on June 3 provided the highest degree of larval mortality and foliage protection of the three treatments in the study. Very heavy "knockdown" of larvae occurred within two hours of application as evidenced by the thousands of larvae which were hanging by silk strands from the host trees. This phenomenon was also observed after mistblower sprays during previous years (DeBoo and Campbell 1972, 1974b).

A marked difference was observed between morning (Replicate 1) and evening (Replicate 2) sprays. Very superior foliage protection was obtained in treatment Replicate 1 (Table III) due to meteorological influences which permitted better droplet deposit through tree crowns. Less than 10% of the spray emitted was collected near ground level in Replicate 2, whereas nearly 30% of the spray reached ground level in Replicate 1. Also, more uniform swath patterns were attained in Replicate 1 as the spray block layout was such that better guidance of the aircraft was possible using the tethered weather balloons. The overall results of methomyl, with due considerations for marginal spray deposition, excessive numbers of budworm larvae, and their advanced state of development, clearly demonstrated the efficacy of this insecticide at low dosages vs. spruce budworm larvae, and corroborated the results of previous experimentation using groundspray equipment.

Trichlorfon

Results of the aerial applications of trichlorfon indicated that only about 50% mortality of larvae of the spruce budworm 9 days after could be attributed to the treatment. An average of nearly 60% defoliation occurred in these sprayed areas (Table III).

Although analyses of spray deposits showed that slightly more than 50% of the spray emitted was collected near ground level (equivalent to approximately 0.56 kg AI/ha), the single-spray applications of trichlorfon did not, in effect, control the very severe budworm infestations (85 larvae/45-cm branch tip) near Grand'Mère during 1975.

Phoxim

A five-day period of near continuous rain and high wind postponed the application of phoxim from near the peak occurrance of the 4th-larval instar to past the peak of the 5th-instar (Table II). At that time (June 10), serious defoliation had already occurred, and many larvae were dropping from the branches in search of a new food supply. Also, poor deposition of spray droplets (Table IV), coupled with the late application date, essentially negated all possibilities for the success of this treatment. Evaluations of defoliation in the phoxim-treated plantations indicated no difference from those levels of defoliation in the untreated check areas.

Aerial Application of Aqueous Spray Mixtures

The aerial application of aqueous sprays without anti-evaporant/ anti-drift adjuvants may be subject to considerable loss in volume soon after emission from the aircraft spray system. The variable results of volume deposits (Table IV) were indicative of evaporation, and drift losses with aqueous sprays dispersed as small droplets. The exceptionally high recovery of deposit during the trichlorfon treatment (>50%) was due to the smaller quantities of water used in the spring mixture and to the excellent weather conditions during the time of application. Deposit recovery at ground level may at best be in the range of 10-20% of emitted volume rates as evidenced by the deposits for methomyl and phoxim.

Spruce Budworm Population Densities

Population densities of the spruce budworm (at peak L_4) averaged approximately 90 larvae/45 cm branch tip during 1975 at the Grand'Mère Plantations. This extremely severe population outbreak was nearly twice the damaging density which had occurred in 1974 (DeBoo and Campbell 1974b). Accordingly, larval feeding impact on the already weakened trees was very evident by peak L_4 time, the period selected for spray application. Defoliation of many branches was complete and larvae had commenced dropping in search of a new food supply. By June 10 most untreated and many treated trees harboring high population densities were covered with the silk strands of starving larvae.

The Spruce Coneworm

Observations on larval populations of the spruce coneworm, a species commonly associated with the spruce budworm, indicated that the ratio of budworm to coneworm was 4:1 at Grand'Mère during 1975. The ratio of budworm/coneworm larval survivorship after spray treatment was approximately 3:2, indicating that the coneworm may be less susceptible to insecticide treatment. Also, at high population densities, as at Grand'Mère the feeding of 10-20 surviving coneworm larvae/45 cm branch

branch tip may cause considerable defoliation which cannot be related to pre- and post-treatment population densities of the budworm alone. It was suspected that coneworm, therefore, may have significantly confounded the anticipated relationships between spray efficacy vs. the target insect (spruce budworm) and resultant levels of foliage protection. Estimates by the author suggest up to 50% of observed defoliation, especially in insecticide-treated plantations, could be attributed to the spruce coneworm at Grand'Mère during 1975.

A separate (unpublished) report[1] on budworm-coneworm observations during the period 1973-1975 has been prepared for distribution upon request.

---

1 Nicholson, S.A., and R. F. DeBoo. 1976. Budworms and coneworms: Larval population densities and consequences of simultaneous defoliation to host trees. Environ. Can., Chem. Contr. Res. Inst. File Rep. No. 35, 11 pp.

Table II

Experimental aerial applications of insecticides for control of spruce budworm on white spruce, Grand'Mère, Quebec, 1975: Larval development and meteorological conditions at time of treatment.

Treatment	Replicate	Hectares Treated	Spray Date	Larval Development at Spray Date	Meteorological Conditions during Spray: Temp °C	RH %	Wind (Km/hr)	Sky
Methomyl	1	42	June 3 (am)	60% L_4; 30% L_5	13.0	80	0-3	overcast
	2	124	June 3 (pm)	60% L_4; 30% L_5	14.5	83	calm	overcast
Trichlorfon	1	72	June 4 (am)	52% L_4; 37% L_5	12.0	91	calm	overcast
	2	90	June 4 (am)	52% L_4; 37% L_5	14.0	89	calm	overcast
Phoxim	1	40	June 10 (am)	30% L_5; 47% L_6	8.5	91	calm	clear
	2	24	June 10 (am)	30% L5; 47% L_6	9.0	92	0-3	clear
	3	24	June 10 (am)	30% L_5; 47% L_6	9.5	80	3-6	clear

Table III

Results of experimental aerial applications of insecticides for control of spruce budworm on white spruce, Grand'Mère Plantations, 1975: Larval mortality and foliage condition.

Treatment	Replicate	Average No. Larvae/45-cm Branch Tip		Corrected % Population Reduction[1]	Tree Crown Defoliation (%)	
		1 day Prespray	9 days Postspray		Top 1/3	Mid 1/3
Methomyl	1	80	5	-	6	25
	2	79	4	-	22	52
	Avg.	80	4	88	14	39
Untreated Check	Avg.	86	37	-	57	80
Trichlorfon	1	68	13	-	29	64
	2	100	8	-	42	54
	Avg.	85	10	52	35	59
Untreated Check	Avg.	83	21	-	57	80
Phoxim	1	78	8	-	42	72
	2	56	4	-	44	84
	3	34	3	-	18	56
	Avg.	56	5	53	35	71
Untreated Check	Avg.	74	14	-	57	80

[1] Corrected by Abbott's Formula (1925).

Table IV

Results of experimental aerial applications of insecticides for control of spruce budworm on white spruce, Grand'Mère Plantations, 1975: Droplet size and density and spray volume collected near ground level.

Treatment[1]	Volume median diameter (µm)	No. droplet/cm^2 Avg.	Range	% of Vol. emitted collected near ground	Avg. Vol. Collected ℓ/ha
Methomyl	122	12	0-45	16	0.73
Trichlorfon	126	33	5-98	53	2.48
Phoxim	115	6	1-47	10	0.48

[1] See Table 1 for emitted rates of application.

SUMMARY AND CONCLUSIONS

The aerial applications of insecticides at Grand'Mère during 1975 indicated that single spray treatments under conditions of extreme population densities of the spruce budworm may be insufficient to induce the high degree of foliage protection required for valuable stands. The results supported the conclusion that two or more applications and higher spray volumes for better coverage may be required for control of L_4 and earlier larval stadia. Similarly, recent work by Robertson *et al.* (1976)[1] has indicated that higher dosages of active ingredient may be necessary for sprays vs. L_2 and L_3 larvae.

Of the three insecticides evaluated, the methomyl treatment induced the greatest percentages of population reduction and foliage protection. A better treatment under the circumstances at Grand Mère most likely would have been two sprays of ca. 0.2 kg AI/ha at 4.68 ℓ/ha per application (i.e. 2 oz. AI/64 oz. spray mixture/ac.). Likewise, oil-base spray mixtures, to reduce evaporation losses, would have provided superior droplet deposition.

Although good spray deposition was attained with the trichlorfon treatment, resulting levels of both larval mortality and foliage protection were considered unsatisfactory. As for methomyl, different tactics including two or more applications vs. larval populations prior to the peak occurrence of L_4, might have produced better results.

---

1 Toxicological studies on *C. occidentalis*. Preliminary studies by P.C. Nigam, Chemical Control Reseach Institute (personal communication), indicates this to be the case also for *C. fumiferana*, particularly vs. L_2 larvae.

The applications of phoxim failed primarily because of the late timing (vs. L_5 and L_6) caused by the prolonged period of inclement weather. Studies of phoxim should be repeated at a future date under more acceptable overall experimental conditions.

Careful monitoring of larval population densities of the spruce coneworm during the work at Grand'Mère has indicated that this species may occupy a significant position in the defoliation of host trees inhabited jointly with the spruce budworm. Approximately 20% of the total defoliator complex was coneworm at Grand'Mère during 1975. This percentage doubled after about 10 days in surviving populations inhabiting those stands selected for spray treatment. Initial observations indicated that populations of spruce coneworm may be less susceptible to certain insecticidal treatment than spruce budworm. Should this be the case, it was suggested that field studies on pesticide efficacy for control of spruce budworm larvae should recognize all defoliating species present, especially for long-established infestations on white spruce.

ACKNOWLEDGEMENTS

Sincere thanks and appreciation are extended to L. M. Campbell and S. A. Nicholson of C.C.R.I. and to D. F. Dyer and Bao Truong, summer students, for their important contributions to the study. Mr. John Conway of Consolidated-Bathurst Ltd. and Mr. Marc Michaud of Quebec Lands and Forests generously provided the facilities and logistical support during field operations. The important contribution of Mr. Jean Tardif of Modern Airspray Ltd. during aerial spray applications is gratefully acknowledged. Mr. R. W. Evans of DuPont Canada Ltd. and Dr. K. A. Howard of Chemagro Ltd. provided quantities of insecticides and important technical information. Thanks also are extended to J. A. Armstrong, W. W. Hopewell and G. W. Taylor for their valuable comments in the review of the manuscript.

LITERATURE CITED

ABBOTT, W. S. 1925. A method of computing the effectiveness of an insecticide. *Jour. Econ. Ent.* 18: 265-267.

DeBOO, R. F., and L. M. CAMPBELL. 1972. Plantation research: V. Mistblower applications of dilute insecticide solutions for control of *Choristoneura fumiferana* on white spruce in Quebec, 1972. Environ. Can., For. Serv. Inf. Rep. CC-X-21, 17 pp.

DeBOO, R. F., and L. M. CAMPBELL. 1974a. Evaluation of commercial preparations of *Bacillus thuringiensis* with and without chitinase against spruce budworm. Part C. Assessment of effectiveness by mistblower and aerial application, Spruce Woods, Manitoba. Environ. Can., For. Serv. Inf. Rep. CC-X-59, 31 pp.

DeBOO, R. F., and L.M. CAMPBELL. 1974b. Plantation research: XII. Experimental applications of insecticides by mistblower for control of *Choristoneura fumiferana* on white spruce in Quebec, 1974. Environ. Can. For. Serv. Rep. CC-X-88, 24 pp.

FETTES, J.J. 1951. Investigations of sampling techniques for population studies of the spruce budworm on balsam fir in Ontario. Ph.D. Thesis, Univ. of Toronto, 212 pp.

GAGNON, J.D. 1972. Grand'Mère Plantations, an example for future reforestation. Environ. Can., For. Serv. Inf. Rep. Q-X-30, 27 pp.

KENAGA, E.E., and C.S. END. 1974. Commercial and experimental organic insecticides. Ent. Soc. America Special Publ. 74-1, 77 pp.

MUTUURA, A., and E. MUNROE. 1973. American species of *Dioryctria* (Lepidoptera:Pyralidae). II. The Schuetzeella group and the taxonomic status of the spruce cone moth. *Can. Ent.* 105: 653-668.

ROBERTSON, J. L., N. L. GILLETTE, M. LOOK, B.A. LUCAS, and R. L. LYON. 1976. Toxicity of selected insecticides applied to western spruce budworm. *Jour. Econ. Ent.* 69: 99-104.

SLACK, W. E. 1972. The NAE flying spot scanner/analyser. Nat. Aeronaut. Estab. Quart. Bull. No. 1972 (3), 9 pp.