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AERIAL APPLICATION OF *BACILLUS THURINGIENSIS* - FENITROTHION COMBINATIONS AGAINST THE SPRUCE BUDWORM, *CHORISTONEURA FUMIFERANA* (CLEM.)

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CHEMICAL CONTROL RESEARCH INSTITUTE
OTTAWA, ONTARIO
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ABSTRACT

Mixtures of commercial formulations of *Bacillus thuringiensis* Berliner + a low dosage of fenitrothion and an operational dosage of fenitrothion were applied to white spruce and balsam fir against the spruce budworm (*Choristoneura fumiferana* Clem.). The effects of the treatments were assessed 8, 17 and 30 days after treatment. Dipel + the low dosage fenitrothion was effective in reducing the budworm population on balsam fir only; Thuricide + the low dosage fenitrothion and the operational dosage of fenitrothion gave good foliage protection to balsam fir. None of the treatments resulted in a population reduction or foliage protection to white spruce. The egg mass survey at the end of the field season forecast a reducted budworm population on the Thuricide + low dosage fenitrothion plot only.

The overall results indicated that Thuricide + low dosage fenitrothion was effective in protecting the forest trees from excessive defoliation in the year of application and probably in the succeeding year as well.

RESUME

Des mélanges commerciaux de *Bacillus thuringiensis* Berliner additionnés d'une faible dose de fénitrothion et une dose courante de fénitrothion ont été appliqués sur des épinettes blanches et des sapins baumiers contre la tordeuse des bourgeons de l'épinette (*Choristoneura fumiferana* Clem.). Les effets des traitements ont été évalués 8, 17 et 30 jours aprés l'application. Le Dipel additionné d'une faible dose de fénitrothion a réussi à réduire la population de tordeuses des bourgeons sur le sapin baumier seulement; le Thuricide additionné d'une faible dose de fénitrothion et la dose courante de fénitrothion ont réussi à protéger les aiguilles du sapin baumier. Pour l'épinette blanche, aucun des traitements n'est parvenu à réduire la population de tordeuses ni à protéger les aiguilles. Le relevé des oeufs fait à la fin de l'expérience a permis de prévoir une réduction de population des tordeuses dans la seul bloc où on avait appliqué du Thuricide additionné d'une faible dose de fénitrothion.

Les résultats général ont montré que le Thuricide additionné d'une faible dose de fénitrothion peut protéger les arbres d'une défoliation excessive durant l'année de l'application, et probablement aussi l'année suivante.

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Presently available information indicates that the simultaneous or sequential application of *Bacillus thuringiensis* (B.t.) and low doses of chemical insecticides is a promising approach to the integrated control of some Canadian forest insect pests (Morris 1972a; Morris 1972b). Morris (1972b) has presented laboratory and field data indicating that the application of mixtures of low doses of fenitrothion, an organophosphorous insecticide, and commercial B.t. increased total spruce budworm larval and pupal mortality as well as incidence of bacterial septicemea, reduced the rate of pupation, and reduced the defoliation of white spruce, *Picea glauca* (Moench) Voss, compared with fenitrothion or B.t. separately or with untreated checks. The field tests in this case were carried out with back-pack mist-blowers.

In 1973, aerial application trials were designed to test the validity of our previous findings and to determine the feasability of adding this combination to our arsenal of weapons against the spruce budworm.

MATERIALS AND METHODS

The test plots consisted of mixed white spruce and balsam fir *Abies balsamea*(L.) Mill. stands located on the Petawawa Forest Experiment Station, Chalk River, and in Algonquin Park, Ontario. The 30-50 ft high trees had been infested by spruce budworm for the previous 2-3 years. The test plots at Petawawa varied in size from 60-90 acres (Fig. 1) and the two located in

Algonquin Park were both 100 acres.

Twenty-five white spruce and 25 balsam fir in each Petawawa plot were selected for periodic biological assessment of efficacy of treatment. There were no white spruce in the Algonquin Park plots so 48 balsam firs per plot were chosen there. The ground at all sampling sites was cleared, and deposit sample collecting units consisting of a Kromekote card, 2 glass slides and 2 Millipore filter membranes each were installed. Canvas mats were placed under selected trees to collect fallen non-target-organisms.

The Branstead weather station tower at Petawawa fitted with temperature sensors at the 6 ft. and 24 ft. levels was used to measure the temperature differential. The existing wind speed and direction indicator at the 24 foot level, along with the temperature sensors, provided the necessary information for meteorological control of each Petawawa spray application and for calculation of the stability ratio (Yates et al 1967). Meteorological data necessary for the control of the sprays in Algonquin Park were obtained from sensors mounted at 18 and 80 feet on a high tower situated in the area of the spray blocks. At each sensor position, wind speed and direction, turbulence, temperature and relative humidity were measured. A stability ratio was determined using the temperature differential between 18 and 80 feet and the wind speed at 80 feet. To permit a direct comparison of stability ratios from Petawawa with those from Algonquin Park a correction factor was applied to account for the variation in height differences of the temperature sensors.

The requirements for spray application were that temperature differentials should indicate inversion conditions (the lower temperature less than the upper temperature) and that the wind speed was less than 6 mph.

Table 1 shows average wind speeds, stability ratios, and temperatures for each spray application period. Information on turbulence and relative humidity for the Petawawa sprays was not available. Applications of sprays were made in 200 ft swaths by Stearman and Pawnee aircraft fitted with 4 micronair AU 3000 emission units. The Thuricide 16 B used in the formulations (Table 2) was supplied by International Minerals and Chemical Corp., Libertyville, Illinois and Dipel wettable powder was supplied by Abbott Laboratories, Chicago. The sprays were applied May 31 - June 3 in late evening (8:00 - 9:00 pm) or early morning 5:00 to 6:00 am).

Deposit units were collected 20-30 minutes after spray. The Kromekote cards were analysed for droplet size and density (and volume in the case of the operational fenitrothion spray). Volume deposit analysis of bacterial and sub-lethal fenitrothion sprays were estimated by fluorometric analysis using a tracer dye, Brilliant Sulfoflavine (Chemical Developments of Canada Ltd., Toronto). This dye was previously shown in the laboratory to be compatible with the bacteria. Deposits of viable bacterial spores were estimated by counting the number of bacterial colonies developing on the Millipore filter membranes after they were placed on agar media and incubated at 29°C for 24 hours.

Two 18" branch tips were collected from middle and upper crowns of each sample tree at intervals of 0 (pre-spray, May 12-16), 8 (June 6), 17 (June 19-21) and 30 (June 28-July 3) days post-spray. The number of dead and live insects taken from the foliage was recorded for each sample period (Fettes, 1951). Larvae had developed mostly to the 4th instar at spray time. Data were collected throughout the sampling season for determining the effects of treatments on larval mortality, incidence of introduced and naturally occurring pathogens, population reduction, mortality of non-target arthropods, feeding activity, current year's defoliation, moth emergence and oviposition (Morris and Hildebrand 1973).

RESULTS AND DISCUSSION

Meteorological conditions were good for all applications, except for Dipel alone and Thuricide + fenitrothion treatments as indicated by the negative stability ratios (Table 1).

Wind speeds were within the desired ranges, except for sub-lethal fenitrothion and Dipel + fenitrothion combination where wind speeds at time of spray were approaching the upper limits (6 mph.). An average 6 mph wind can be expected to cause unsatisfactory deposits of spray on a small block.

The volumes of spray suspensions depositing at ground level varied from 4.3 to 21.8 fluid oz. U.S. per acre between plots (Table 3). Density of coverage as indicated by the number of droplets/cm^2 varied from 12 to 37 for all plots. There was no direct relationship between volume deposited and number of viable spores deposited per unit area for either the Dipel or Thuricide applications. For example, the ratio of Thuricide alone/Thuricide + Fenitrothion was 2.5 in terms of volume deposit but 7.8 in terms of viable spore deposit. It is evident that viable spore deposit by itself is not an accurate criterion for deposit measurement especially since both spores and crystals are the active ingredients in the presently available commercial products and it is known that the mixture of the two ingredients is more pathogenic for spruce budworm than either ingredient alone (Yamvrias and Angus 1970).

Larval development pre- and post-spray are illustrated in Fig. 2. Development at the time of spray is summarized in Table 4. There was little difference in the development stage between populations on white spruce and those of balsam fir.

The data (Table 5) show that mortality on balsam fir was always lower than on white spruce for all treatments in which both tree species were studied. Thuricide alone treatment consistently showed lowest mortality on balsam for all sample periods but, on the whole, larval mortality, as judged by recovery of dead insects on sample branches, was low. It must be pointed out, however, that larval fall and wind distribution of dead or dying insects could account for the apparently low mortality. Among dead larvae recovered, the incidence of bacterial septicemia and of naturally occurring pathogens were low on white spruce and balsam fir (Table 6 and 7).

Results of populations reduction studies (Table 8) show Dipel and Dipel + fenitrothion as the most infectious materials with the latter showing a slightly additive effect (11.8%). Population reductions on white spruce were insignificant for all treatments. Dipel alone was considerably more effective in reducing spruce budworm populations on balsam fir than was Thuricide alone at nearly identical deposit rates (21.1 and 21.8, respectively) or fenitrothion sprayed at the operational or sub-lethal dosages. Population reductions on balsam fir by the sub-lethal and operational dosages of fenitrothion were almost similar (60% and 55%, respectively) and similar to reductions by the same sub-lethal dosage sprayed one year before against spruce budworm at Rankin, Ontario (Morris _et al._ 1972c).

Results of the mat collections (Table 9) indicate that fenitrothion at 4 oz. per acre was the only treatment causing a substantial increase in mortality of non-target arthropods compared with the untreated check. The mortality rate was less than twice that of the untreated check. The difference occurred only on white spruce. Data by Varty et al. (1971) and Carter and Brown (1973) strongly suggest that fenitrothion sprays in New Brunswick forests have substantially reduced spruce budworm parasites and some predacious arthropod components of the soil fauna.

Data on feeding activity based on the ratio of frass drop rate to population density (Table 10) show that Thuricide + fenitrothion, Dipel alone, and fenitrothion operational caused the lowest feeding activity on balsam fir while Dipel + fenitrothion caused the lowest feeding on white spruce in treated areas. These results should normally reflect in foliage protection, however, when pre-spray population densities were calculated in defoliation estimates it was evident that only Thuricide + fenitrothion and fenitrothion operational gave acceptable control on balsam fir but not on white spruce (Table 11), with fenitrothion treatment slightly the superior of the two.

Results of the pupal rearing experiments (Table 12) show that, with the possible exception of the low-dosage fenitrothion, the treatments had practically no effect on pupal weights or moth emergence. There were little or no reductions in fecundity or egg viability due to the treatments.

The egg mass survey at the end of the season indicated that there would be a very low budworm population during the year following treatment in the plot treated with Thuricide + fenitrothion and a relatively high population in the plot treated with fenitrothion operational dosage.

SUMMARY AND CONCLUSIONS

White spruce and balsam fir trees infested with spruce budworm were sprayed with mixtures of Thuricide 16B or Dipel wettable powder and fenitrothion, an organophosphorous chemical insecticide. Branch samples were taken at intervals of 0 (pre-spray), 8, 17, and 30 days post-spray, pupal rearing and egg mass surveys were conducted to supply information on the effect of the treatments on deposit and distribution of sprays, spruce budworm population reduction, larval development, mortality of non-target organisms, feeding activity, larval mortality, incidences of naturally occurring and introduced pathogens, defoliation, adult emergence, fecundity and egg viability.

The following conclusions were drawn from the results:

1. Meteorological conditions at the time of spray ranged from good to poor, ground deposits were generally unsatisfactory.
2. There was no direct relationship between the volume of B.t. suspension and the number of viable spores deposited.
3. Dipel + fenitrothion at 1/16th the operational dosage was effective in reducing budworm population on balsam fir (but not on white spruce) and was more effective than an operational dosage of fenitrothion alone.
4. With the possible exception of fenitrothion at the operational dosage, the sprays appeared to have had no detrimental effect on non-target arthropods.
5. Thuricide + low dosage fenitrothion and fenitrothion operational dosage gave good foliage protection on balsam fir but not on white spruce.

6. The egg mass survey forecasted a very low budworm population on the Thuricide + fenitrothion plot and a high population on the fenitrothion operational plot for the next year.
7. The overall results indicate that Thuricide + fenitrothion sub-lethal dosage was the most effective treatment in protecting the forest in the year of treatment and probably in the subsequent year.

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TABLE 1

Meteorological Conditions at Time of Spray Applications

	Date	Wind Speed mph. (Direction)	Stability[1] Ratio	Turbulence[2]	Dry Bulbs Temp. °C		Relative Humidity	
					Low	High	Low	High
Sub-lethal fenitrothion	June 3	6.0 (S)	+1.6	-	19.5	20.8	-	-
Dipel alone	May 31	2.7 (WSW)	-7.5	0.218	12.5	12.5	63	69
Dipel + fenitrothion	June 3	6.0 (S)	+3.6	-	17.6	18.2	-	-
Thuricide alone	May 29	3.0 (WNW)	39.2	0.114	11.3	12.8	64	57
Thuricide + fenitrothion	June 4	3.0 (S)	-1.1	-	20.3	20.2	-	-
Fenitrothion operational	May 31	4.0 (N)	+0.3	-	6.6	6.5	-	-

[1]Stability ratio = $\frac{\text{Temperature differential}}{(\text{Mean Wind speed, cm/sec})^2} \times 10^5$.

[2]Determined from calculation of the frequency and amplitude of the vertical movement of the bi-vanes.

TABLE 2

Summary of Formulations Used in *Bacillus thuringiensis* - Fenitrothion Aerial Sprays - Petawawa 1973[1]

Treatments	Area Sprayed (Acres)	Thuricide 16B (gallons-U.S.)	Dipel (lbs)	Fenitrothion oz. A.I.	Chevron Sticker (ml)	Brilliant Sulfo-Flavine Dye (gm)	Water (gallons-U.S.)	Molasses (gallons-U.S.)
Sub-lethal fenitrothion	100	-	-	25	400	190	25	25
Dipel alone	100	-	50	-	400	190	25	25
Dipel + fenitrothion	60	-	30	15	240	114	15	15
Thuricide alone	100	25	-	-	-	190	25	-
Thuricide + fenitrothion	75	18.9	-	18.8	-	142.5	18.8	-
Fenitrothion operational	100	-	-	400	-	-	-	-

[1]Application made at 0.5 gallon U.S. per acre except Fenitrothion operational at 0.25 gallon U.S. per acre.

TABLE 3

Deposit Rates on Plots Treated with *Bacillus thuringiensis* - Fenitrothion

Treatments	Fluid oz/acre Deposited	Percent Deposited	Drops/cm^2	No. Viable Spores per acre
Sub-lethal fenitrothion[1]	10.5	16.4	12.0	-
Dipel alone	21.1	33.0	15.0	9×10^8
Dipel + fenitrothion	17.4	27.2	18.2	2×10^8
Thuricide alone	21.8	34.1	36.7	13×10^8
Thuricide + fenitrothion	8.7	13.6	16.9	1.7×10^8
Fenitrothion operational[2]	4.3	13.4	24.7	-

[1]Applied at 0.25 oz. A.I./acre

[2]Applied at 4.0 oz. A.I./acre. Fenitrothion sub-lethal and operational sprays deposited at ground level at 0.03 and 0.5 oz. A.I./acre, respectively.

TABLE 4

Larval Development at Petawawa 1973 at Time of Spray

Tree Species	Total No. Larvae	Larvae Recovered - Percent by Instars				
		II	III	IV	V	VI
White Spruce (WS)	376	1.3	19.1	41.8	34.8	2.9
Balsam Fir (BF)	186	3.2	17.2	48.4	22.6	8.6
WS + BF	562	2.0	18.5	44.0	30.8	4.8

TABLE 5

Larval Mortality on Balsam Fir and White Spruce Sprayed with *Bacillus thuringiensis* - Fenitrothion Combinations

Treatments	Cumulative Totals Collected (dead and alive)								Percent Mortality (Uncorrected)							
	Pre-spray		8 Days Post-spray		17 Days Post-spray		30 Days Post-spray		Pre-spray		8 Days Post-spray		17 Days Post-spray		30 Days Post-spray	
	BF*	WS*	BF	WS	BF	WS	BF	WS	BF	WS	BF	WS	BF	WS	BF	WS
Sub-lethal fen.[1]	357	253	253	235	326	411	358	510	11.8	4.3	25.3	12.3	20.0	9.3	20.0	7.5
Dipel alone	4748	-	1886	-	2517	-	2752	-	6.4	-	20.6	-	17.2	-	16.2	-
Dipel + fen.[2]	603	724	187	1446	308	815	329	1013	7.5	2.5	10.7	3.9	9.1	8.7	10.0	8.1
Thuricide alone	2393	-	1570	-	2384	-	2733	-	3.3	-	6.6	-	5.2	-	5.3	-
Thuricide + fen.[2]	507	656	244	1163	364	1398	446	1531	18.7	8.2	11.1	6.5	9.6	7.2	9.1	6.9
Fen. operational[3]	694	1108	511	1344	611	1781	678	1997	5.2	3.9	20.5	14.8	17.8	13.4	16.2	12.2
Untreated check A[4]	442	1471	231	1018	426	2600	508	2877	5.9	5.8	1.3	5.0	2.8	3.7	3.5	3.6
Untreated check B[4]	1562	-	1806	-	2694	-	3249	-	2.0	-	11.6	-	9.4	-	9.8	-

[1]Applied at the rate of 0.25 oz. active ingredient/acre.

[2]Applied at the rate of 0.25 oz. active ingredient as emulsifiable concentrate mixed in water suspension of *Bacillus thuringiensis.*

[3]Applied at the rate of 4.0 oz. active ingredient/acre.

[4]Check B compared with Dipel alone and Thuricide alone treatments. Check A compared with all other treatments.

* WS, BF = White Spruce, Balsam Fir

TABLE 6

Incidence of Pathogens among Larvae from Balsam Fir Trees Sprayed with *Bacillus thuringiensis* - Fenitrothion Combinations

Treatments	Total[2] Larvae Collected	Total[2] Number Dead	Percent Infected With					
			BT		NPV*		Microsporidia	
			Total	Cadavers	Total	Cadavers	Total	Cadavers
Pre-spray[1]	2603	244	0.0	0.0	0.0	0.0	0.0	0.0
Sub-lethal fenitrothion	358	70	0.0	0.0	0.0	0.0	2.0	9.2
Dipel alone	2752	446	7.2	44.2	0.0	0.0	0.0	0.2
Dipel + fenitrothion	329	33	0.5	4.5	0.0	0.0	0.5	4.5
Thuricide alone	2733	955	1.8	35.2	0.0	0.0	0.3	2.6
Thuricide + fenitrothion	446	41	1.8	19.5	0.0	0.7	1.6	7.3
Fenitrothion operational	678	110	0.0	0.0	0.0	0.0	0.6	4.2
Untreated check A	508	18	0.0	0.0	0.0	0.0	0.0	0.0
Untreated check B[3]	1924	389	0.0	0.0	0.0	0.0	0.4	1.8

[1]Collected from all plots.

[2]Collected from all pest-spray samples.

[3]Untreated Check B compared with Dipel alone and Thuricide alone. Check A with all other treatments.

* NPV = nuclear polyhedrosis virus

TABLE 7

Incidence of Pathogens Among Larvae from White Spruce Trees Sprayed with *Bacillus thuringiensis* - Fenitrothion Combinations

Treatments	Total[2] Larvae Collected	Total[2] Number Dead	Percent Infected With					
			BT		NPV *		Microsporidia	
			Total	Cadavers	Total	Cadavers	Total	Cadavers
Pre-spray[1]	4212	2212	0.0	0.0	0.0	0.0	0.0	0.0
Sub-lethal fenitrothion	511	38	0.0	0.0	0.0	0.0	0.4	4.8
Dipel + fenitrothion	1013	82	0.7	8.5	0.0	0.0	0.3	3.4
Thuricide + fenitrothion	1531	105	2.5	32.8	0.0	0.0	0.3	4.2
Fenitrothion operational	1997	224	0.0	0.0	0.0	0.0	0.4	3.5
Untreated check	2877	103	0.0	0.0	0.0	0.0	0.0	0.0

[1]Collected from all plots.

[2]Collected from all post-spray samples.

* Nuclear polyhedrosis virus

TABLE 8

Corrected Percentage Population Reduction on Balsam Fir and White Spruce
Due to Treatment - *Bacillus thuringiensis* - Fenitrothion Sprays 1973[1]

Treatments	Pre-Spray[2]		8 Days Post-Spray		17 Days Post-Spray		30 Days Post-Spray	
	BF	WS	BF	WS	BF	WS	BF	WS
Sub-lethal fenitrothion	6.8	5.8	36.5	0.0	58.4	0.0	59.5	0.0
Dipel alone	51.7	-	47.8	-	75.0	-	75.5	-
Dipel + fenitrothion	11.6	15.3	61.0	25.2	61.0	0.0	87.3	6.4
Thuricide alone	25.7	-	7.2	-	35.3	-	29.4	-
Thuricide + fenitrothion	9.4	11.6	40.3	0.0	58.9	0.0	11.7	0.0
Operational fenitrothion	12.9	24.2	29.0	0.0	65.0	0.0	54.6	0.0
Untreated check A[3]	8.3	25.6	33.3	-	47.1	-	69.4	-
Untreated check B[3]	33.3	-	7.2	25.7	46.9	57.0	79.5	79.7

[1]Corrected by Abbott's formula (1925). Thirty days after spray.

[2]Average number larvae per 18" branch tip.

[3]Untreated check B compared with Dipel alone and Thuricide alone. Check A used for all other treatments.

TABLE 9

Mortality of Non-Target Arthropods in Treated Plots

Treatments	No. Non-Target Arthropods[2] per Sq. Ft. of Mat	
	B. Fir	W. Spruce
Sub-lethal fenitrothion	0.56	0.61
Dipel alone	0.63	-
Dipel + fenitrothion	0.67	0.59
Thuricide alone	0.28	-
Thuricide + fenitrothion	0.44	0.44
Fenitrothion operational	0.33	1.44
Untreated check A	0.44	0.81
Untreated check B[2]	0.25	-

[1]Calculated from post-spray samples only.

[2]Untreated Check B compared with Dipel alone and Thuricide alone treatments.

TABLE 10

Effect of Treatments on Feeding Activity - *Bacillus thuringiensis* - Fenitrothion Aerial Spray Trials

Treatments	Population Index[1]		Wt. (mg) Frass[2] per Sq. Ft.		Ratio Wt./Density	
	B. Fir	W. Spruce	B. Fir	W. Spruce	B. Fir	W. Spruce
Sub-lethal fenitrothion	3.19	3.92	2004	928	628	237
Dipel alone	19.8	-	5931	-	299	-
Dipel + fenitrothion	4.59	2.55	4642	382	1011	149
Thuricide alone	14.6	-	10065	-	743	-
Thuricide fenitrothion	4.49	10.14	905	1483	201	146
Fenitrothion operational	6.35	16.13	813	8287	127	513
Untreated check A	5.27	15.33	116	883	22	58
Untreated check B[3]	18.86	-	15682	-	831	-

[1] Number larvae per 18" branch tip for all samples.

[2] Nine to 36 sq. ft. canvass matting were placed under sample trees.

[3] Untreated check B compared with Dipel alone and Thuricide alone. Check A used for other treatments.

TABLE 11

Defoliation Estimates on Plots Treated with *Bacillus thuringiensis* - Fenitrothion Combinations

Treatment	Pre-Spray[1] Pop. Density		Percent Current Year's Defoliation 30 Days Post-Spray		Ratio Percent Defoliation/ Pre-Spray Density	
	WS	BF	WS	BF	WS	BF
Sub-lethal fenitrothion	5.8	6.8	70.2	73.6	12.1	10.8
Dipel alone	-	51.7	-	84.6	-	1.6
Dipel + fenitrothion	15.3	11.6	55.3	54.2	3.6	4.7
Thuricide alone	-	25.7	-	89.5	-	3.5
Thuricide + fenitrothion	11.6	9.4	57.0	26.8	4.9	2.9
Fenitrothion operational	24.2	12.9	61.9	25.4	2.6	2.0
Untreated check A	25.6	8.3	60.1	42.8	2.4	5.2
Untreated check B[2]	-	33.3	-	89.5	-	2.7

[1]Number of larvae for 18" branch tip. WS, BF = white spruce, balsam fir

[2]Untreated check B compared with Dipel alone and Thuricide alone treatments. Check A with other treatments.

TABLE 12

Effect of Treatments on Moth Emergence and Oviposition - *Bacillus thuringiensis* - Fenitrothion Spray, 1973

Treatments	Total Pupae Caged		Average Pupal Weights (mg)		Percent Moth Emergence			Average No. Egg Masses/Female		Average No. Egg Masses per 100 sq. ft. Foliage	
	Males	Females	Males	Females	Males	Females	Totals	Total	Viable (emerged)	WS	BF
Sub-lethal fenitrothion	205	233	60	77	65.3	30.5	46.8	2.3	2.1	66	42
Dipel alone	216	218	50	64	80.0	56.0	68.0	1.6	1.2	-	63
Dipel + fenitrothion	200	220	62	86	92.5	71.8	81.7	2.4	2.2	106	39
Thuricide alone	240	220	70	93	97.0	83.0	90.0	3.1	2.8	-	134
Thuricide + fenitrothion	290	200	68	90	92.8	63.0	80.6	1.5	1.5	71	26
Fenitrothion operational	254	189	69	90	89.4	57.1	77.4	2.5	2.4	195	70
Untreated check	235	185	73	120	83.4	56.2	71.4	1.9	1.7	269	79

[1]WS, BF = white spruce, balsam fir

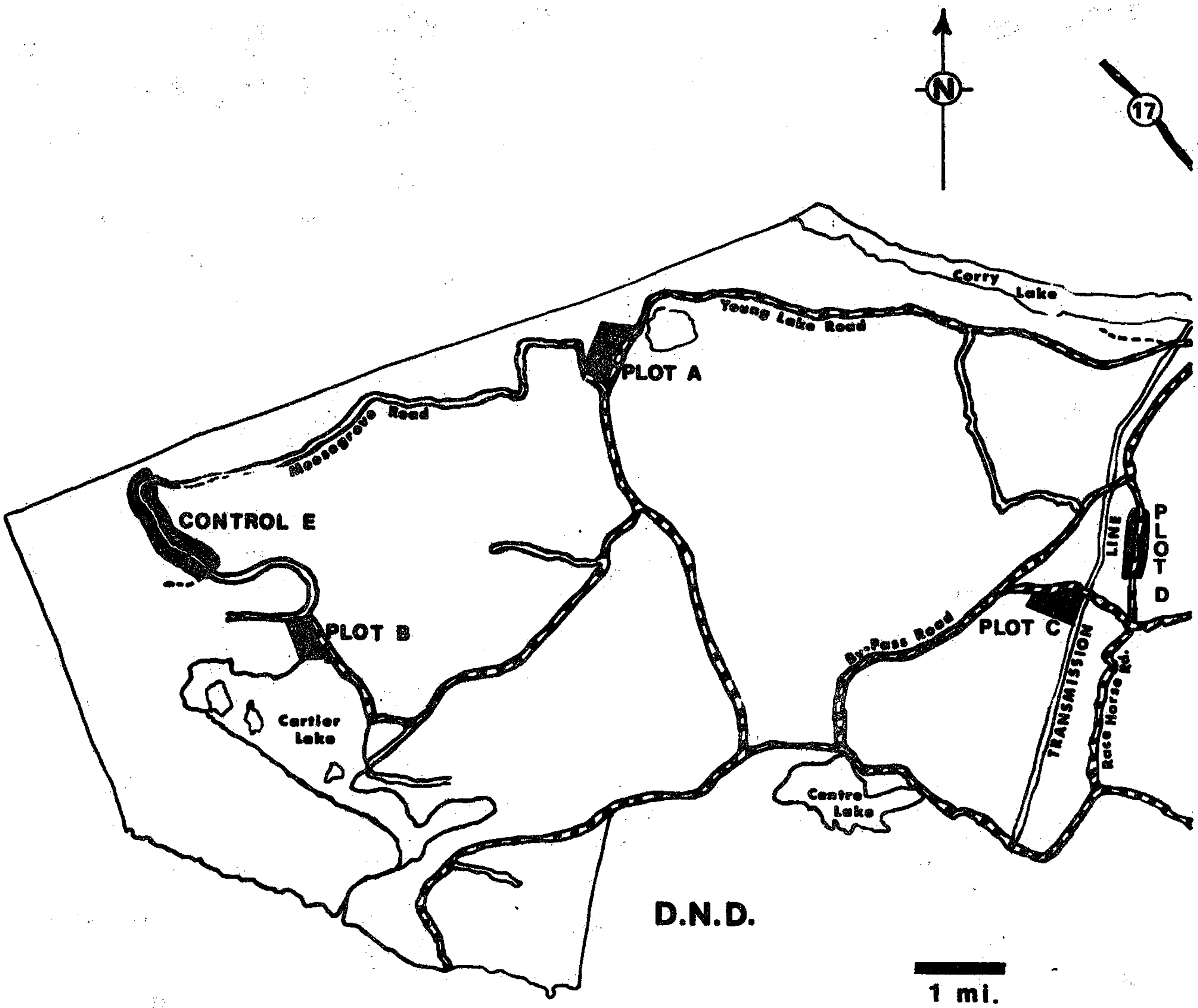

FIG. 1 Bacillus thuringiensis - Fenitrothion Aerial Spray Plots Petawawa Forestry Experimental Station 1973

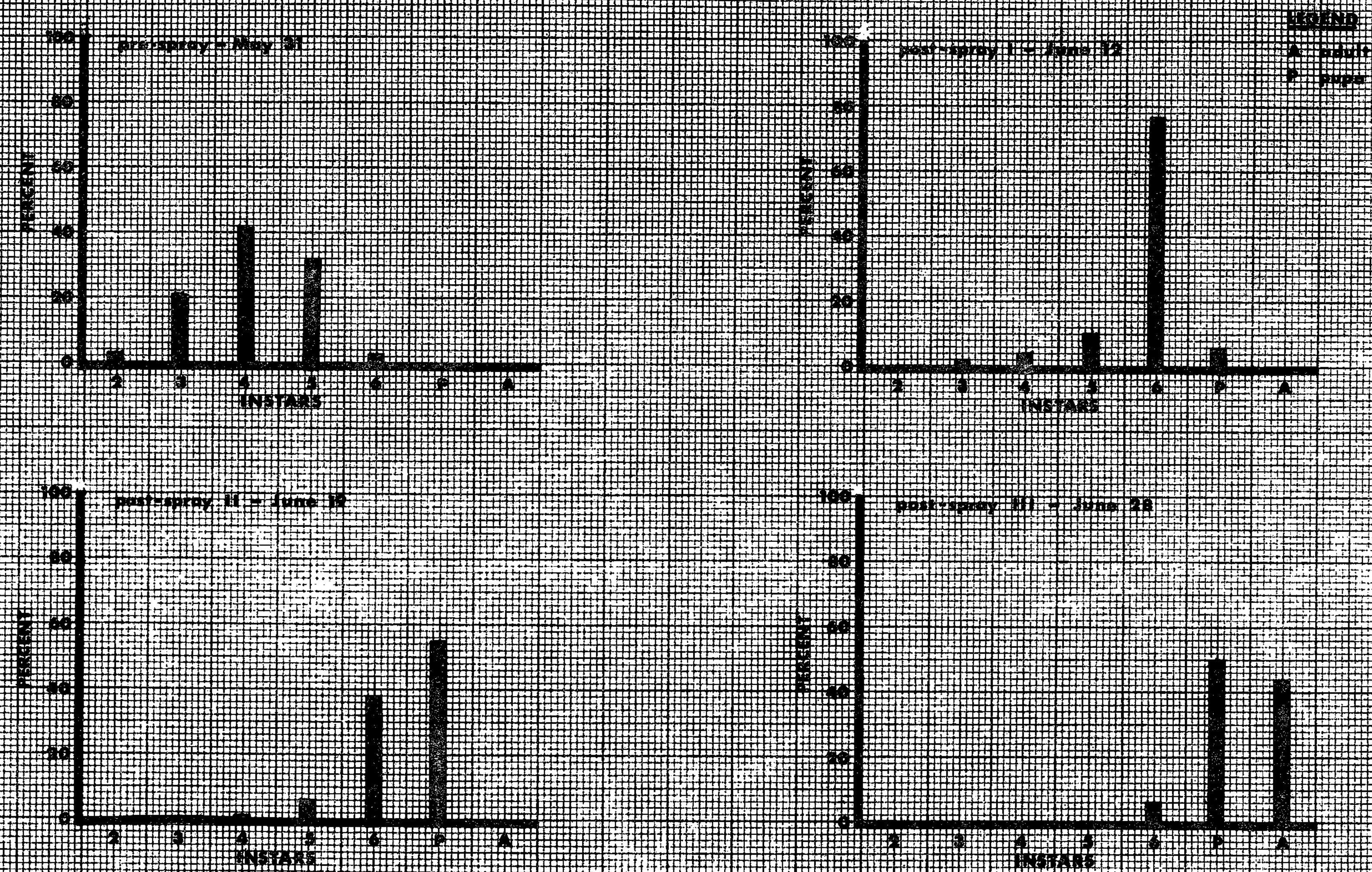

FIG. 2 Spruce Budworm development on key dates on 25 White Spruce and 25 Balsam Fir - Petawawa 1973