RESULTS OF AERIAL TREATMENTS WITH *BACILLUS THURINGIENSIS* AGAINST SPRUCE BUDWORM, *CHORISTONEURA FUMIFERANA*, DURING 3 CONSECUTIVE YEARS

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Résumé

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Un bloc de 40 ha compsé principalement de sapin baumier (*Abies balsamea* L. (Mill.) a été traité avec une préparation de *Bacillus thuringiensis* (*B.t.*) en 1976, 1977 et 1978 respectivement. Ces traitements n'ont permis qu'une défoliation de la pousse annuelle de 28, 46.5 et 15.2% les 3 années du traitement. En 1979, aucun traitement ne fut réalisé et la défoliation de la pousse annuelle a atteint 19.3%. Dans les zones non-traitées la défoliation de la pousse annuelle fut de 96, 97 et 96% de 1976 à 1978. En 1979, la défoliation fut de 69.6% suite à une mortalité élevée des larves par inanition après ces années de défoliation sévère. Des traitements consécutifs par *B.t.* peuvent donc maintenir les conditions d'un peuplement à un haut niveau même si ce territoire est entouré par une épidémie de la tordeuse.

Since 1971, several aerial treatments using *Bacillus thuringiensis* (*B.t.*) have been carried out against the spruce budworm (Smirnoff *et al.* 1973, 1974, 1976; Smirnoff and Hardy 1978) to evaluate its potential in protecting foliage of balsam fir (*Abies balsamea* (L.) Mill.). However, *B.t.* treatments were not applied for 3 consecutive years to plots reinfested yearly by spruce budworm. Two objectives were considered: first, could repeated *B.t.* treatments maintain the live foliage protected by previous treatments? Second, could *B.t.* treatments help keep trees alive and help stands severely defoliated for the last 3 or 4 years to recover?

In 1976, a 40 ha block was established near St. Gabriel de Ferland, Chicoutimi County, Quebec, in a spruce budworm infested stand which had been moderately damaged in 1973 and severely damaged in 1974 and 1975. The treatment block was composed of 80% 50-year-old balsam fir, 9 to 15 m high with white spruce (*Picea glauca* (Moench) Voss.), black spruce (*Picea mariana* (Mill.) B.S.P.), and paper birch (*Betula papyrifera* Marsh.) as companion species. Three sample plots were established in the block prior to treatment and two in the untreated area. Each plot was composed of transects perpendicular to flight lines in which five co-dominants, 20 m apart, were marked.

Larval populations before and after treatment were determined by the number of larvae on one 45 cm branch tip (larvae/45 cm) sampled in the upper mid-crown of each marked tree. Two samples were collected prior to treatment, when larvae were in instars 2 and 3, and three after treatment, of instars 4 and 5 and pupae. Each year, 75 measurements were then taken in treated and 50 were taken in untreated plots. Larval mortality was estimated by the difference between pretreatment and posttreatment larval population levels. Defoliation of current shoots was determined by the method of Fettes (1950). This method scales different degrees of defoliation from 1 to 12 (0 to 100%). Twenty shoots per branch were evaluated and an average value was estimated.

The formulation used was composed of 50 parts of *B.t.* concentrate[1]; 20 parts, 70% sorbitol solution; 30 parts, water; 3.0 ml/ha of Chevron sticker, 10,000 nephelometric units of chitinase/ha, and 0.1% nigrosine was used as dye.

In 1976, treatment was carried out using a Sikorsky S-55-T helicopter equipped with booms and 4×80 μm mesh Beecomists® spray heads. In 1977 and 1978, a Grumman AgCat aircraft was used. The AgCat spray system was composed of 39,

[1]Thuricide 32B (32×10^9 I.U./U.S. gal, 8.4×10^9 I.U./l.), Sandoz, Inc., San Diego, California, U.S.A.

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80-degree flat fan nozzles (T8004) placed at a 45-degree angle in the wind. The final rate of dispersion was 4.7 l./ha.

Spray deposits were monitored with 10×10 cm Kromekote papers and also with petri dishes containing nutrient agar medium distributed 10 m apart on a road crossing the block, perpendicular to flight lines. Petri dishes were incubated for 17 h at 28°C and colonies were counted with a standard colony counter. Kromekote cards were photographed and analyzed by electronic scanner at the National Aeronautical Establishment, National Research Council, Ottawa.

Treatments were carried out under similar meteorological conditions (av. temp. 8.3°C and R.H. over 85% for the 3 years). Although each year's treatment was part of a 3-year experiment, the similarities (same treatment block, same methods of sampling, comparable meteorological conditions, etc.) made each treatment an experiment in itself. Thus, each year's treatment can be considered a replicate of the others.

Deposit in colonies/cm^2 on agar plates was 35.0, 29.5, 36.3 in 1976, 1977, and 1978. Analysis of Kromekote papers revealed a similar uniformity in the results with 25.1 to 20.3 droplets/cm^2 and 3.9 to 3.4 l./ha deposited during all 3 years' treatments.

Larval mortality was 80.0, 66.4, and 70.8% in 1976, 1977, and 1978. Treatment efficiency as determined by the Abbott formula (Abbott 1925) was 62.0, 59.8, and 54.9% in 1976, 1977, and 1978. In untreated plots, larval mortality was 48.0, 16.4, and 15.2% in 1976, 1977, and 1978. It should be noted that the 40 ha treated block was yearly re-infested from surrounding spruce budworm populations.

Current defoliation in the untreated block in 1976, 1977, and 1978 was 96%, 97%, and 96%. In the treated block current defoliation was only 28%, 36%, and 15%. Obviously the *B.t.* treatment resulted in a significant reduction in defoliation in all 3 years. As a result, treated trees retained a relatively high growth potential compared with untreated trees. For example, 50 branches[2] were collected from the treated and untreated blocks in 1979. Branches from the treated block had an average of 182 current shoots/branch weighing 28 g/shoot. Untreated branches had an average of 27 shoots weighing 7 g. The difference in growth potential was significant.

The study area was not treated with *B.t.* in 1979 but *budworm* density and defoliation were monitored in the previously treated block and the untreated block. There was no significant difference in budworm density: 7.1 larvae/45 cm branch tip in the treated block and 8.5 larvae/45 cm in the untreated. However there was a significant difference in current defoliation: 19% compared with 70%. The cause can be related to the significant difference in the amount of current foliage on the trees as noted above. Thus a few larvae feeding on a small amount of current foliage in the untreated block were able to cause a significant level of defoliation, 70%. The treated trees with a much larger amount of current foliage were able to withstand the feeding pressure, 19% defoliation.

During 1979, it was established, from the analysis of 200 trees located in two 0.1 ha survey plots, that no tree mortality occurred in the block treated the 3 previous years while in untreated plots 20% of the trees in 1979 showed signs of advanced deterioration (upper half of the crown already dead and dry).

In conclusion, treatment with *B.t.* 3 consecutive years can maintain stand condition at a high level of vitality despite yearly re-infestation of the block.

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[2]For the purpose of comparison, figures were statistically corrected for a 100 cm branch. Fifty full length branches were examined in treated and untreated plots.

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