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Dutch elm disease vector population low in sanitation area

Calculations relevant to field applications of Bacillus thuringiensis

Root initiation of lodgepole pine and white spruce under varying light conditions

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ENTOMOLOGY

Dutch Elm Disease Vector Populations are Low within Fredericton, N.B., Sanitation Area.—Sanitation, the annual removal of potential elm bark beetle breeding material (newly dead elm wood) is the basic recommendation to municipalities for control of Dutch elm disease. The elm bark beetles transmit spores of *Ceratocystis ulmi* (Buism.) C. Moreau, the causal fungus of Dutch elm disease, from diseased to healthy elms. Therefore, a reduction in the beetle population can effectively reduce the incidence of the disease, and the success of sanitation programs is expressed in terms of the number of elms infected each year. Little effort has been made to monitor beetle populations, and consequently, information on beetle density within sanitation areas is lacking. Fredericton was deemed an ideal location to obtain such information aboutt the native elm bark beetle [*Hylurgopinus rufipes* Eichh.] because a 24-year sanitation program has left the City with a healthy elm population, while up to 75% of the elms in the surrounding area are dead or infected (Van Sickle and Sterner. Plant Dis. Reptr. in Press).

Between 2 May and 3 October 1975, 10-cm-wide, sticky-coated bands of polyethylene, as described by Gardiner (Can. For. Ser. Info. Rep. 0-P-2, 1973), were in place around the bole of single elms at six locations in Fredericton and on 18 elms 5 to 28 km outside of the City, where disease incidence is high. The trees ranged from 28 to 113 cm dbh. The traps, designed to catch beetles crawling up or down the bole, were attached to apparently disease-free trees at a height of about 4.5 m.

In Fredericton, beetle catches per unit trap area were significantly lower (t-test, .05 level) than in the outside areas, indicating that sanitation has restricted the beetle population (Fig. 1). The highest number of beetles captured during the season on a single tree was 37 in Fredericton, compared to 592 on one outside tree. Ninety-five percent of all beetles collected were trapped after 25 July, and 83% of these were on the upper portion of the trap, indicating that the beetles were moving downward. The largest catches were made on eight elms outside Fredericton that became infected during the season. This suggests that infected and dying trees are more attractive to the beetles than healthy trees.

The catches within Fredericton may be an indication of the migration of beetles from the heavily infested surrounding area (as close as 0.8 km) rather than a measure of the residual population. Recent research has shown that massive, long-distance movement (3 to 8 km) of beetles in search of overwintering sites occurs in late summer and fall. After overwintering in the bark on the lower trunks of living elms, many beetles emerge in the spring to feed, still carrying viable spores (Gardiner, GLFRC Res. Newsletter 5:5-6, 1975; Gardiner Pers.

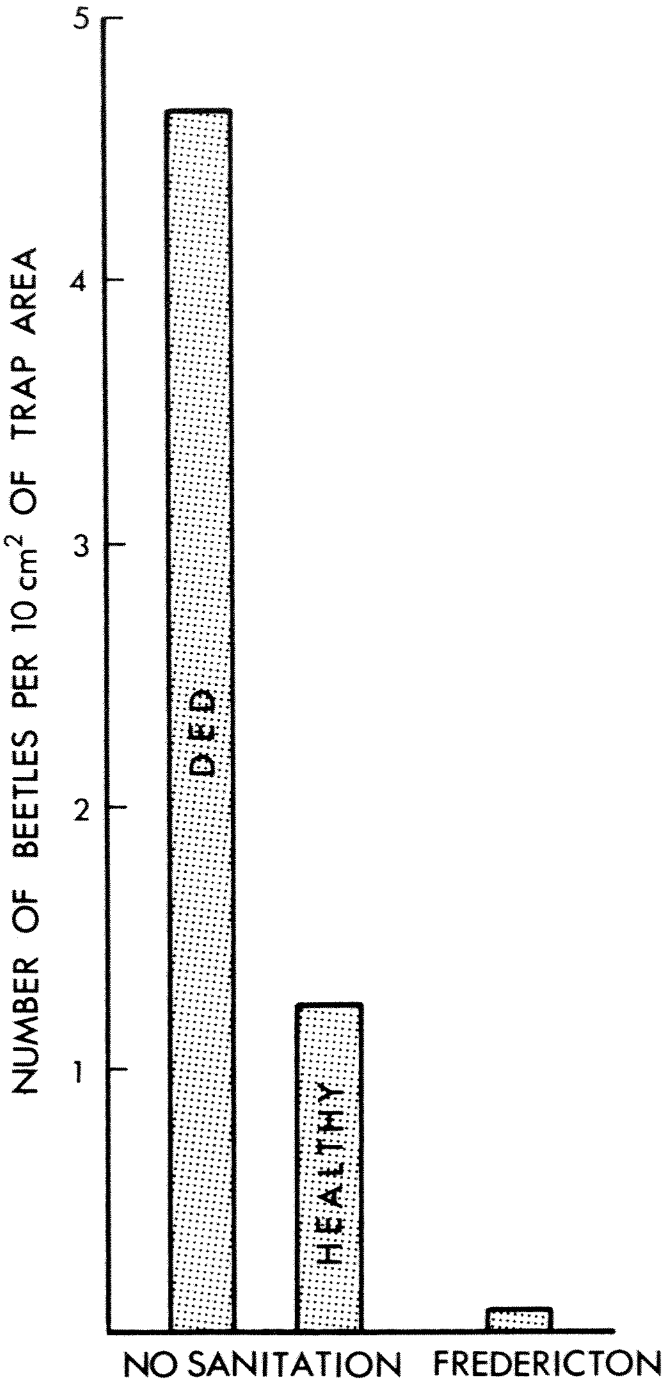

Figure 1. Number of native elm bark beetles trapped, per unit of trap area, on diseased (DED) and healthy elms in area of no sanitation and on healthy elms within the Fredericton sanitation area.

Commun. 1976). This suggests that municipalities, such as Fredericton, practicing sanitation in the midst of areas of high infection, should consider supplemental measures to prevent overwintering of beetles within the control area. An effective spray program could be integrated with sanitation until beetle populations in outlying areas subside. Gardiner (op. cit. 1975) is currently testing fall application of insecticide sprays to the lower trunk of elms.—T. E. Sterner, Maritimes Forest Research Centre, Fredericton, N.B. E3B 5G4.

Some Calculations Relevant to Field Applications of *Bacillus thuringiensis*.—Data have recently become available that permit some calculations relevant to the field use of *Bacillus thuringiensis* (B.t.) against forest pests, particularly, spruce budworm.

We have found by force feeding, that the LD_{50} for pure crystals of *B.t.* strain HD-1 against newly moulted VIth instar spruce budworm larvae is 0.04 $\pm$ 0.01μg/larva. Abbott Laboratories states that Dipel WP contains 2,000 spores and the same number of crystals per international unit (IU) and that there are 16,000 IU/mg. Thus the LD_{50} found by us is equal to 1280 crystals or 0.6 IU. The LD_{90} dose is approximately 0.22 μg/larva or 7,000 crystals equivalent to 3.5 IU.

Morris reported at the Symposium on Microbial Control of Spruce Budworm sponsored by Abbott Laboratories in Montreal, January 1976, that when *B.t.* was sprayed at 8/BIU in 0.5 gal of water/acre, spray droplets 100μ in diameter contained 288 particles, 144 of which were spores and 144 were presumably crystals, equivalent to 0.07 IU/drop. Smaller droplets had proportionately fewer particles. A VIth instar spruce budworm larva would therefore have to eat the equivalent of 9-10 100μ drops in order to ingest an LD_{50} dose or 48 100μ drops to ingest an LD_{90} dose. At a reasonable droplet frequency of 30/cm^2 this is equivalent to eating 0.3 cm^2 of foliage to obtain an LD_{50} dose and 1.6 cm^2 of foliage to get an LD_{90} dose. Since many of the droplets are smaller than 100μ even larger areas of foliage will be required. Foliage consumption of this magnitude must require at least several hours of feeding.

Our experience with assays using dipped foliage suggests that at low dosages feeding inhibition alternates with feeding periods as the effect of the toxicant wears off. If the larva has access to clean foliage when the inhibition wears off, the insect survives, but if the foliage remains toxic the larva eventually succumbs. The residual life of toxicant on foliage in the field is often relatively short due to the frequency of rain showers during spray season, and the net effect of the low dosages used may be to protect the insect from the full effect of the *B.t.* applied. Some foliage protection would occur.

Food consumption and LD_{50} both are directly related to body weight. While the regression equations for food consumption and toxicity with body weight may differ it is probably reasonable to assume that it will take as long for a IIIrd or IVth instar budworm to get a toxic dose if it is feeding in an exposed position as for a VIth. If it is mining in a bud the likelihood of ingesting an LD_{50} or LD_{90} dose is even smaller.

We are led therefore, to suggest that the dosages reaching the target site for spruce budworm control when sprayed at the recommended 8 BIU/acre are marginal and that much of the observed variability in effectiveness may be ascribed to the marginal nature of these dosages. Our data on the relative toxicological effect of crystals vs spore:crystal mixtures (to be published elsewhere) indicate that the presence of spores will not materially affect these conclusions.—P. G. Fast, Insect Pathology Research Institute, Sault Ste. Marie, Ont.

SYLVICULTURE

Root Initiation of Lodgepole Pine and White Spruce Seedlings Grown Under Varying Light Conditions.—It has been suggested that root growth of conifer seedlings is directly related to photosynthetic activity of the seedlings (Keller, Forstwiss. Centralbl. 85:65-79, 1966; Etter and Carlson, Can. J. Plant Sci. 53:395-399, 1973). The effect of light on hormone transport and metabolism has been demonstrated (Yamaki and Fujii, Biochemistry and Physiology of Plant Growth Substances, Runge-Press Ltd., 1968, pp. 1025-1036; Zenk, *op. cit.*, pp. 1109-1128), and therefore it is postulated that root initiation is the function of light effects on both the photosynthetic mechanism and hormone levels. Stimulation of root initiation by varying light conditions was the subject of two preliminary studies reported here.

In the first experiment bare-root dormant (dormant buds and inactive roots) 2-0 lodgepole pine [*Pinus contorta* var. *latifolia* Engelm.] and 3-0 white spruce [*Picea glauca* (Moench) Voss)] seedlings, fall-lifted and stored at $-1°C$ for 2 months, were potted in sand. The seedlings were covered with a black plastic hood that blocked out all light for 0, 10, 20, and 30 d in various combinations with periods of light. In all combinations the dark period preceded the light period. The following greenhouse conditions were maintained: a minimum light intensity of 10 500 lux and day length of 18 h using artificial lighting, air temperature of 15°–30°C, and sand temperature 18.5° $\pm$ 1°C. In the second experiment similar spotted seedlings were maintained in the greenhouse for 30 d in full light (minimum of 10 500 lux) during the daytime (18-h photoperiod), half light (minimum of 5250 lux), or in complete darkness. One-half light was attained by using screening that intercepted 50% of the incident light and complete darkness was attained by using black plastic. Greenhouse conditions remained as described above. In the first experiment groups of seedlings were excavated after 10, 20, or 30 d at the completion of the treatment and new unsuberized root tips were counted. In the second experiment new root tips were counted after 30 d. The data are recorded as averages of 50 seedlings per treatment in the first experiment and of 40 seedlings per treatment in the second experiment. The data were analyzed using ANOVA for single classification.

Data from the first experiment (Table 1) indicate that light stimulated root initiation in lodgepole pine within 10 d after planting. The initial 10-d dark period suppressed root

TABLE 1

Effect of varying periods of light on root initiation of lodgepole pine and white spruce seedlings

Light regime (days dark + days light)	*Lodgepole pine* Plants with new roots %	New roots per plant[1]	*White spruce* Plants with new roots %	New roots per plant[1]
0 + 10	94	27.8 b[2]	94	11.1 b
0 + 20	100	12.8 c	98	7.6 bc
0 + 30	96	33.9 a	98	16.7 a
10 + 0	0	0 d	90	6.4 c
20 + 0	0	0 d	78	5.0 c
30 + 0	28	1.6 cd	66	5.0 c
10 + 10	22	1.3 cd	86	6.1 c
20 + 10	22	1.5 cd	84	5.2 c
10 + 20	50	13.7 c	100	20.7 a

[1] Average of 50 plants.
[2] The small letters indicate Duncan's Multiple Range groupings of treatments which do not differ significantly at the 5% level.

initiation over the following 10–20 d: after 10 d of dark and 10 d of light 22% of the seedings had new root tips (1.3/plant) compared with 94% for the 0 + 10 treatment and 27.8 new tips per plant. Comparisons of data for the 10 + 20 and and 0 + 20 treatments with the 0 + 10 treatment are similar. While root initiation in white spruce did not seem dependent on light, as 94% of the seedlings had new root tips after 10 d of light and 90% had new root tips after 10 d of darkness, there was a significant difference in the number of new roots produced. The apparent decrease in the percentage of white spruce seedlings with new roots from the 10-d dark and 0-d light treatment (90%) to the 30-d dark and 0-d light treatment (66%) could not be explained. However, the numbers of new roots produced were not significantly different.

Data from the second experiment confirm that lodgepole pine seedling root initiation responds to a light stimulus. The stimulation is not necessarily due to photosynthetic activity

TABLE 2

Effect of the amount of light on root growth of lodgepole pine and white spruce seedlings

Light regime for 30 d	*Lodgepole pine* Plants with new roots %	New roots per plant[1]	*White spruce* Plants with new roots %	New roots per plant[1]
Full light (10 500 lux)	95	37.4 a[2]	93	11.5 a
1/2 light (5250 lux)	95	29.0 b	85	13.2 a
No light	45	6.1 c	98	5.3 b

[1] Average of 40 plants.
[2] The small letters indicate Duncan's Multiple Range groupings of treatments which do not differ significantly at the 5% level.

since the number of new root tips per plant did not vary greatly under full and half light conditions. This experiment also confirms that white spruce differs from lodgepole pine in root initiation under dark conditions (98% and 45% respectively). The species are similar in that both responded positively to light in terms of numbers of roots per plant.

The data presented in this report suggest that root initiation is related to a light stimulus but not dependent on photosynthetic activity. As root growth may be related to photosynthetic activity (Keller, *op. cit.*; Etter and Carlson *op. cit.*), these experiments point out a difference between root growth and root initiation. The latter appears to be related to a hormonal response. Clarification of the effect of the two mechanisms on root initiation and growth will require further study.—L. W. Carlson, Northern Forest Research Centre, Edmonton, Alberta.

RECENT PUBLICATIONS — JULY-AUGUST 1976

15 **Arif, Basil M. 1976.** Isolation of an entomopoxvirus and characterization of its DNA. *Virology* 69:626-634.

12 **Bramhall, G. 1976.** Accuracy of thermistor method for measuring wood temperature. *For. Prod. J.* 26(2): 37-38.

1 **Chalupa, V., D. J. Durzan and C. Vithayasai. 1976.** Growth and metabolism of cells and tissue of jack pine (*Pinus banksiana*). 2. The quantitative analysis of the growth of callus from hypocotyls and radicles. *Can. J. Bot.* 54:446-455.

10 **Corns, Ian G. W. and George H. La Roi. 1976.** A comparison of mature with recently clear-cut and scarified lodgepole pine forests in the lower foothills of Alberta. *Can. J. For. Res.* 6:20-32.

1 **Durzan, D. J., V. Chalupa and A. J. Mia. 1976.** Growth and metabolism of cells and tissues of jack pine (*Pinus banksiana*).1. The establishment and some characteristics of a proliferated callus from jack pine seedlings. *Can. J. Bot.* 54:437-445.

1 **Durzan, D. J. and V. Chalupa. 1976.** Growth and metabolism of cells and tissue of jack pine (*Pinus banksiana*).3. Growth of cells in liquid suspension cultures in light and darkness. *Can. J. Bot.* 54: 456-467.

1 **Durzan, D. J. and V. Chalupa. 1976.** Growth and metabolism of cells and tissue of jack pine (*Pinus banksiana*).4. Changes in amino acids in callus and in seedlings of similar genetic origin. *Can. J. Bot.* 54:468-482.

1 **Durzan, D. J. and V. Chalupa. 1976.** Growth and metabolism of cells and tissue of jack pine (*Pinus banksiana*).5. Changes in free arginine and Sakaguchi-reactive compounds during callus growth and in germinating seedlings of similar genetic origin. *Can. J. Bot.* 54: 483-495.

1 **Durzan, D. J. and V. Chalupa. 1976.** Growth and metabolism of cells and tissue of jack pine (*Pinus banksiana*).6. Free nitrogenous compounds in cell suspension cultures of jack pine as affected by light and darkness. *Can. J. Bot.* 54:496-506.

1 **Durzan, D. J. and G. Bourgon. 1976.** Growth and metabolism of cells and tissue of jack pine (*Pinus banksiana*).7. Observations on cytoplasmic streaming and effects of L-glutamine and its analogues on subcellular activities. *Can. J. Bot.* 54:507-517.

8 **D'Aoust, André L. 1976.** Effets d'un engrais chimique sur la croissance de semis d'épinette noire en godets. *Can. J. For. Res.* 6:13-19.

9 **Fogal, W. H. and D. P. Webb. 1976.** Cellulose content of food and faeces of *Diprion similis* as an internal marker for determining food consumption and digestibility. *Can. J. Zool.* 54:571-575.

9 **Foster, N. W. and I. K. Morrison.** Distribution and cycling of nutrients in a natural *Pinus banksiana* ecosystem. *Ecol.* 57(1):110-120.

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8 **Gagnon, J. D. and K. Hunt. 1975.** Effets de la fertilisation sur le poids spécifique et le rendement en pâte Kraft du sapin baumier. *Naturaliste can.* 102: 845-852.

15 **Grant, G. G. 1976.** Courtship behavior of a phycitid moth, *Vitula edmandsae*. *Ann. Ent. Soc. Amer.* 69(3): 445-449.

13 **Johnston, J. S. and A. St-Laurent. 1975.** Forces to delimb whole trees. *Pulp Pap.* August 1975.

12 **Keays, J. L. 1975.** Projection of world demand and supply for wood fiber to the year 2000. *Applied Polymer Symposium* 28:29-45.

12 **Keays, J. L. 1975.** Full forest harvesting. The source of tomorrow's chips. *American Paper Industry*, March 1975.

12 **Kellogg, R. M., E. Thykeson, and W. G. Warren. 1975.** The influence of wood and fiber properties on kraft converting-paper quality. *Tappi* 58(12):113-116.

12 **Kirbach, E. and S. Chow. 1976.** Chemical wear of tungsten carbide cutting tools by western red cedar. *For. Prod. J.* 26(3):44-48.

9 **Lyons, L. A. 1976.** Mating ability in *Neodiprion sertifier* (Hymenoptera: Diprionidae) *Can. Ent.* 108:321-326.

15 **Macdonald, Linda M. and J. Weatherston. 1976.** Gas chromatography and the structural elucidation of lepidopteran pheromones. *J. Chromatography* 118: 195-200.

12 **Mackay, J. F. G. 1976.** Delayed shrinkage after surfacing of high-temperature kiln-dried aspen dimension lumber. *For. Prod. J.* 26(2):33-36.

12 **Mackay, J. F. G. 1976.** Effect of moisture gradients on the accuracy of power-loss moisture meters. *For. Prod. J.* 26(3):49-52.

12 **Mackay, J. F. G. 1975.** Properties of northern aspen discolored wood related to drying problems. *Wood Fiber* 6(4):319-326.

7 **Magasi, Laszlo, P. 1976.** Incompatibility factors in *Polyporus abietinus*, their numbers and distribution. *Mem. New York Bot. Garden* 28(1): 163-173.

13 **Nanassy, A. J. and D.P.C. Fung. 1976.** ESR study of flame retardancy in wood. *Wood Sci.* 8(3): 188-193.

11 **Owens, John N. and Marje Molder. 1976.** Bud development in sitka spruce. I. Annual growth cycle of vegetative buds and shoots. *Can. J. Bot.* 54: 313-325.

15 **Percy, Jean E. 1975.** Development and ultrastructure of cells of the sex pheromone gland in the white-marked tussock moth, *Orgyia leucostigma* (J. E. Smith) (Lepidoptera: Lymantridae). *Int. J. Insect Morphol. & Embryol.* 4(6):567-579.

13 **Rak, J. 1976.** Leaching of toxic elements from spruce treated with ammoniacal solutions of copper-zinc-arsenic preservatives. *Wood Sci. Techn.* 10:47-56.

10 **Raske, A. G. and J. K. Robins. 1975.** Wood borer control in spruce logs with p-dichlorobenzene and plastic sheeting (Coleoptera: Cerambycidae). *J. Entomol. Soc. Brit. Columbia* 72:15-17.

10 **Sims, H. P. 1976.** The effect of prescribed burning on some physical soil properties of jack pine sites in southeastern Manitoba. *Can. J. For. Res.* 6:58-68.

12 **Smith, Roger S. 1975.** Respiration methods to follow wood decay and evaluate toximetric potential of wood preservatives. *Material und Organismen* 10: 241-253.

15 **Sohi, S. S. and G. G. Wilson. 1976.** Persistent infection of *Malacosoma disstria* (Lepidoptera: Lasiocampidae) cell cultures with *Nosema* (Glugea) *disstriae* (Microsporida: Nosematidae). *Can. J. Zool.* 54:336-342.

9 **Stanek, W. and T. Silc. 1976.** An instrument and technique for collecting peat core samples in peatland surveys. *Can. J. Soil Sci.* 56:59-61.

7 **Strunz, George M. and Pavle I. Kazinoti. 1976.** Butenolides from citraconic anhydride and acetophenone: rearrangement to a 2, 3-dihydro-3-furanone related to bullatenone. *Can. J. Chem.* 54:415-417.

12 **Troughton, G. E. and S. Chow. 1975.** Effect of fortifier addition on the curing reactions of urea-formaldehyde adhesives. *Holzforschung Bd.* 29 (1975) H. 6.

7 **Varty, J. W. and W. N. Yule. 1976.** The persistence and fate of phosphamidon in a forest environment. *Bull. Environ. Contamination Toxicol.* 15(3):257-264.

15 **Weatherston, J., J. E. Percy and L. M. MacDonald. 1976.** Field testing of *cis*-11-tetradecenal as attractant or synergist in Tortricinae. *Separatum Experientia* 32:178-179.

9 **Webb, Paul D. 1976.** Effects of cold storage duration on bud dormancy and root regeneration of white ash (*Fraxinus americana* L.) seedlings. *Hort. Sci.* 11(2):155-157.

10 **Wong, Horne R. 1976.** American species of *Pristiphora* south of the United States. *Ann. Ent. Soc. Amer.* 69(3):525-526.

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