bi-monthly research notes

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ENTOMOLOGY

Sex Attraction in the Eastern Hemlock Looper.—The eastern hemlock looper [*Lambdina fiscellaria fiscellaria* (Guenée)] is an important pest of balsam fir forests in Newfoundland and its cyclic outbreaks have caused extensive tree mortality. Between outbreaks looper numbers decrease to such a low, endemic level that it is very difficult to measure population levels. Sex pheromones are potentially useful in population density surveys and in monitoring the effectiveness of control programs (Jacobson, M., Insect sex attractants. Wiley, New York. 1965). Accordingly, the presence of a sex pheromone in the eastern hemlock looper was investigated.

Sixteen masonite board traps, measuring 2 x 2 ft, coated with Tanglefoot (The Tanglefoot Company, Grand Falls, Michigan) were secured to trees within a balsam fir stand infested by the hemlock looper. A small screen cage, measuring 3 x 1 x 0.5 inches, designed to hold bait, was wired to the center of each board. The 16 traps were divided into four equal groups; the first was baited with six, 1- to 3-day old virgin males; the second with six, 1- to 3-day old virgin females; the third with a piece of cotton soaked in benzene; and the fourth with a piece of cotton impregnated with a "slush" of benzene in which abdomen tips of six 1- to 3-day old virgin females were crushed. Adults were obtained from field collected pupæ that were sexed and reared separately. All cages contained a piece of cotton soaked in 5% sugar solution. The experiment began on September 11 when both sexes of the adults were present in the field. Moths caught in each trap were counted, sexed and removed on September 17 and the traps were replenished, and checked again on October 15. For comparison traps baited with virgin males were used as a check on those baited with virgin females, and the benzene baited traps on those with abdomen tips of virgin females crushed in benzene (ATVF). Statistical analysis was done by using a chi² test on the proportion of the sexes caught.

Traps baited with virgin females and with ATVF caught more adults than their respective controls (Table 1).

Traps with virgin females caught, on the average, 2.3 times as many adults as the control. There was a highly significant difference in the male to female ratio between traps with virgin females and with virgin males (chi² = 43, d.f. = 1; $P<0.001$).

TABLE 1
Number and sex of eastern hemlock looper adults caught in baited traps between September 11 and October 15, 1969

Trap Groups With	Sex	Moth Trapped Total	No per trap Min	Max	Avg	Sex Ratio (male:female)
Virgin males	Male	265	6	95	66.3	1.6:1.0
	Female	165	4	69	41.3	
Virgin females	Male	707	17	340	176.8	2.6:1.0
	Female	277	10	82	69.3	
Benzene	Male	202	10	68	50.5	1.5:1.0
	Female	135	5	41	33.8	
ATVF[a]	Male	1,046	24	347	261.0	3.5:1.0
	Female	299	11	82	74.8	

[a] Abdomen tips of virgin females crushed in benzene.

The male to female ratio among pupæ in the field just prior to emergence was 1.1:1.0 (n = 1632).

Traps with ATVF caught 4.0 times as many adults as their respective controls. The difference in the sex ratio between these two groups of adults was also significant (chi² = 177; d.f. = 1; $P<0.001$).

The highest number of moths was caught by traps baited with ATVF. The higher attractancy of these traps over those baited with virgin females is possibly caused by synergism between the solvent and the attractant. Increased attractancy as a result of synergism has been noted before (Borden, Silverstein and Brownlee. Can. Entomol. 100:597-603. 1968).

The sex ratio among the adults caught by traps baited with virgin males and with benzene are virtually the same; 1.6:1.0 and 1.5:1.0 respectively. However, they differ from the 1.1:1.0 (n=1632) ratio determined from pupal collections. This difference is probably caused by the flight behavior of the adults; male moths are more active than the gravid, heavier females.

The fact that the male to female ratio of the adults caught by traps baited with virgin females and ATVF was significantly greater than those of their respective controls gives evidence that further studies on isolation, identification and synthesis of the sex pheromone of this economically important pest, appear warranted. The result of these studies may provide a valuable tool for detection surveys, and also in the forecasting and in the evaluation of success of control measures.—Imre S. Otvos, Newfoundland Forest Research Centre, St. John's, Nfld.

Juvenile Hormone-Like Activity of Thujic Acid, an Extractive of Western Red Cedar.—Western red cedar [*Thuja plicata* Donn] has long been suspected of having insecticidal properties. Experiments at the University of Massachusetts (1955) showed the toxicity of methyl thujate to larvæ of black carpet beetles, furniture carpet beetles and case-making moths. (Barton and MacDonald, Can. Forest. Serv. Pub. No. 1023, revised 1971). Also, the use of cedar shavings as litter to control mites in poultry and in colonies of mice (Hansen, New Wood-Use Series, Circ. 20, Univ. Wash., 1952) further indicates the insecticidal activity of western red cedar extractives. In a current study of neutral cedar extractives, methyl thujate as well as other components from cedar wood have been tested for juvenile hormone-like activity. The results with one of these, thujic acid, is now reported.

Thujic acid (Fig. 1) is present in western red cedar heartwood in amounts of 0.08% of the moisture-free wood. It is a steam-distillable acid and unlike its methyl ester, which is mainly responsible for cedar's fragrant odor, has no smell. Because of its natural transformation into the isomeric p-isopropyl benzoic acid (cumic acid — Barton and MacDonald, Bi-mon. Res. Notes 27:41-42, 1971) in moist cedar wood, cumic acid will also be tested for hormone activity later.

Juvenile hormone (JH)-like activity of thujic acid was tested in a preliminary experiment using *Tenebrio* bioassay as described by Bowers and Thompson (Science 142:1469-1470, 1963). A 50/50 (w/w) mixture of thujic acid and peanut oil was injected into ten fresh *Tenebrio molitor* pupæ in the amount of 1.0 μl/pupa. Injected pupæ, along with ten controls, were maintained at 22C. At this temperature, controls emerged into normal adults in 8 days. Injected insects, however, exhibited various kinds of deformities. They were unable to shed the pupal cuticle which broke at various places. Legs became partially mobile, but the broken pupal cuticle stuck to the pupal-adult intermediate with its trachea still lodged in the spiracles of the new cuticle. This was always accompanied by the retention of pupal wings, similar to the observations of Wellington and Lawko (J. Invertebr. Pathol. 14:287-288, 1969) and Zeikus and Steinhaus (J. Invertebr. Pathol.

11:8-24, 1968). All these insects also retained a varying number of lateral abdominal structures called gin traps. Gin traps are pupal characters and are not retained in the normal adult and thus constitutes definitive evidence for JH-like activity of thujic acid (Fig. 2). The figure shows the maximum JH-like effect elicited by injection of 1.0 μl of 50/50 thujic acid and peanut oil.

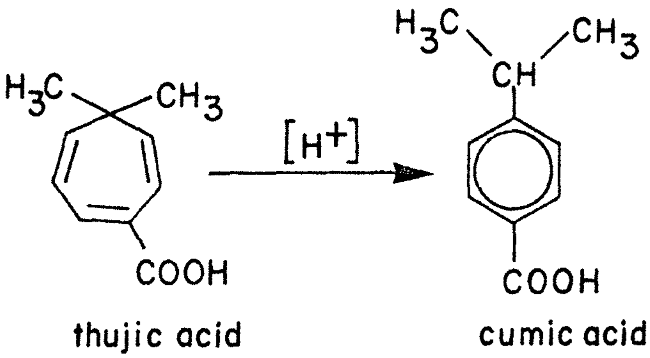


Figure 1. Transformation of thujic to cumic acid.

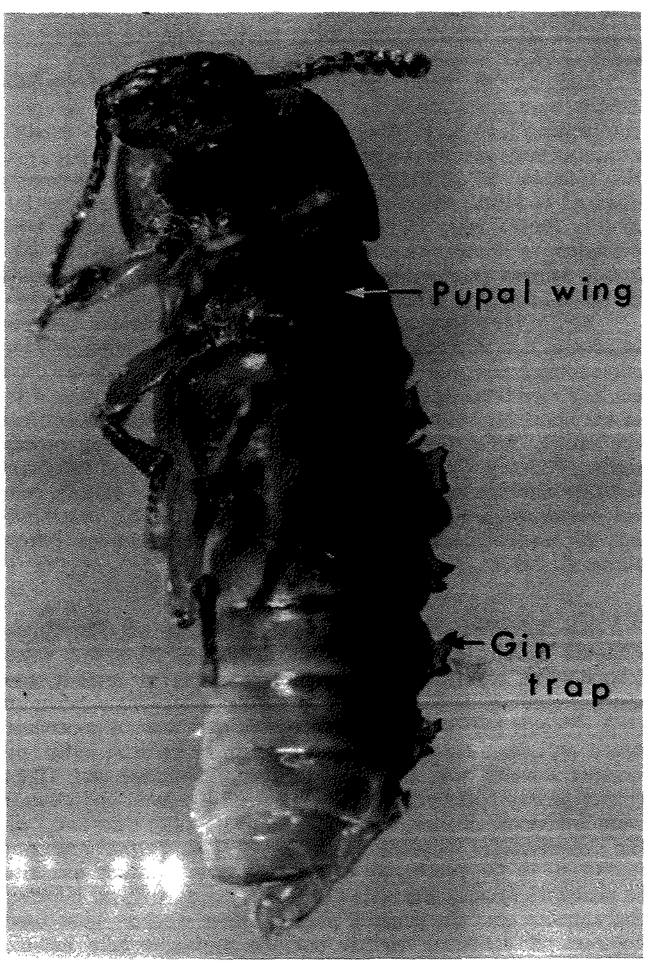
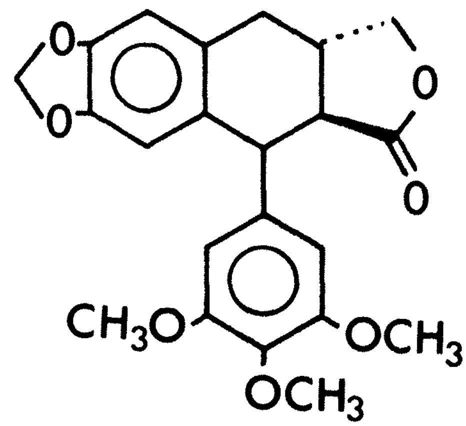


Figure 2. Pupal wings and gin traps of a pupal-adult intermediate.

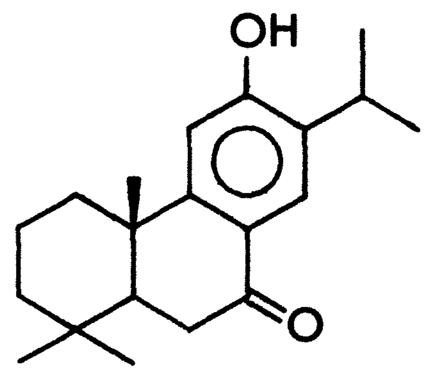
The variability in the number of retained gin traps probably indicates a variability in the dose delivered to each insect. Thujic acid mixed with peanut oil forms a very viscous fluid which is hard to inject into the pupa through a fine (thin) needle. Nevertheless, the observations clearly showed a JH-like effect caused by thujic acid in *Tenebrio*.—George M. Barton, B.F. MacDonald, Western Forest Laboratory, Vancouver, B.C., and Tara S. Sahota, Pacific Forest Research Centre, Victoria, B.C.

FOREST PRODUCTS

Deoxypicropodophyllin and Sugiol from *Thuja plicata* Bark—Two extractive components, previously found in other plant sources, have been identified in western red cedar [*Thuja plicata* Donn] bark as deoxypicropodophyllin, a lignan, and sugiol, a phenolic dipterpene. A third component, xanthoperol, also a phenolic dipterpene, was not isolated but was identified only by chromatographic techniques (Fraser and Swan, J. Chromatog. 38:141-2, 1968).



I



II

Western red cedar bark that had been extracted with petroleum ether was benzene extracted. The latter was fractionated into neutral, acidic and phenolic fractions by standard methods. The neutrals were separated chromatographically on an argentous silica gel column to give a 0.02% yield (oven-dry bark basis) of a substance suspected to be deoxypicropodophyllin (I). This was deduced from the p.p. of 170-171°, the positive Gæbel test, and spectra (i.r., n.m.r., mass) consistent with the proposed structure. Its identity was proved by synthesis of I from podophyllotoxin by the method of Hartwell and Schrecker (J. Amer. Chem. Soc. 75:2138-2149, 1953) and comparison of the two samples.

The interesting point about the isolation of I is that it is the only lignan obtained from cedar bark. However, the heartwood contains large amounts of an interesting series of lignans with important effects on the properties and uses of the wood (MacLean, Forest Prod. J. 20:48-51, 1970). The basic structure of compound I and the heartwood lignans is the same, but important differences are the lack of free phenolic groups in I, its methylene dioxy and trimethylpyrogallol substituted rings in the latter, respectively. These data, together with the lack of tropolone derivatives in the bark, show that the phenolics biosynthesis pattern in the heartwood is quite different from that of the bark.

Another compound isolated from the phenolic fraction of this bark, sugiol (II), confirmed this observation since it is not in the heartwood either. Sugiol, m.p. 293-294°, was isolated in 0.01 percent yield by silica gel column chromatography of the benzene-solubles phenolic extract. The i.r., n.m.r., and mass spectra of II and its acetate derivative were consistent with the structure. It was proved by comparison with an authentic sample kindly donated by Prof. Y.L. Chow, Simon Fraser University. —H.H. Quon, Simon Fraser University, Burnaby, B.C. and E.P. Swan, Western Forest Products Laboratory, Vancouver, B.C.

PATHOLOGY

Root Rot in White Spruce Planted in Areas Formerly Heavily Attacked by *Polyporus tomentosus* in Saskatchewan. —*Polyporus tomentosus* Fr. parasitizes and kills trees over 40 years of age in natural white spruce [*Picea glauca* (Moench) Voss] stands in Saskatchewan (Whitney, Can. J. Bot. 40:1631-1658, 1962) and elsewhere in Canada (Martineau and Ouellette, *In* Annu. Rep. Forest Insect Dis. Surv. p. 43-44, 1966). It has also killed planted white spruce in eastern Canada (Martineau and Ouellette, *loc. cit.*; Stiell, Can. For. Serv. Pub. No. 1258, 16 p., 1970) and in the United States (Myren and Patton, Can. J. Bot. 49:1033-1040, 1971). *Polyporus tomentosus* var. *circinatus* Fr. has been associated with mortality in planted slash pine (*Pinus elliottii* Engelm.) in the southeastern United States (Ross, Plant Dis. Rep. 50:527, 1966).

Healthy roots are infected when they contact diseased roots, and *P. tomentosus* has been isolated from stump roots of trees cut 16 years previously (Whitney, *loc. cit.* 1962), indicating a source of inoculum that persists for a considerable period following logging. There is speculation concerning the fate of young trees planted on areas containing diseased root material.

In 1954, 23 white spruce seedlings 6 to 8 years old, about 30 cm high, and free from root rot, were inplanted near Candle Lake, Saskatchewan, around the bases of three large white spruce 50 to 60 years old, growing in a group and heavily diseased with *P. tomentosus* (Plot 1). The seedlings were planted so that about one-half were in an area where dead roots contained *P. tomentosus* and the others were in the comparatively disease-free area near the large trees. The seedlings were shaded by the surrounding stand. In 1955, four similar seedlings were planted around the base of a 40-year-old dominant white spruce that was also severely affected by *P. tomentosus* (Plot 2). Seedlings on this plot, about 1 mile from Plot 1, were partly shaded.

In 1967, one seedling on Plot 1 was dead. *P. tomentosus* was isolated from the decay in its roots and lower stem, and a sporophore of *P. tomentosus* was attached to one root.

In 1970, all seedlings were removed from both plots and examined for root rot. The seedlings were spindly because of shading; most seedlings on Plot 1 had been browsed. Average height was 99 cm (Plot 1) and 102 cm (Plot 2). On plot 1, one additional seedling was heavily diseased with *P. tomentosus* root rot. All the needles were chlorotic, branches in the lower crown were dead, and the wood of all main roots had the typical reddish brown stain or white-pocket decay from which *P. tomentosus* was isolated. The stain extended 10.2 cm up the stem and most root bark was dead. No other seedlings on Plot 1 were infected by this fungus, but in the area of this plot comparatively free from diseased roots from the older trees, *Armillaria mellea* (Vahl ex Fr.) Kummer had infected two seedlings, one of which had died.

On Plot 2, one seedling was dead in 1970, and another was chlorotic with a much stunted leader, and branches in the lower half of the crown were dead. Both seedlings had the reddish brown stain and white- or yellow-pocket decay throughout the root wood and base of the tree. The stains from which *P. tomentosus* was isolated extended 15 and 22 cm up the stem of the dead and living seedling, respectively. In the heavily diseased but still living seedling, 80 – 90% of the root bark was dead. The last six annual rings were very close together indicating that the root rot had reduced growth. A heavily decayed root (white-pocket decay) from the large diseased tree was pressed against the base of this seedling and it could have been the source of infection,

Although the number of trees was very small, and the conditions were unfavorable for white spruce seedlings (shade and competition from large trees), *P. tomentosus* is evidently capable of killing large seedlings planted near diseased trees. On one area, two trees out of 22 (9%) planted 16 years earlier were heavily diseased or killed, while on the other, these figures were two out of four (50%), after 15 years. Diseased roots of overstory trees provided an abundance of *P. tomentosus* inoculum in the soil; and in at least one seedling, the root system which was touching a diseased root was infected.

This study was conducted with seedlings inplanted between large trees that were infected with *P. tomentosus*. Whether infected roots remain effective as inoculum when diseased stands are clear cut and seedlings are free from overstory competition should be investigated. However, since suppressed and non-suppressed trees are equally susceptible to *P. tomentosus* in inoculation experiments (Whitney, Can. J. Bot. 44:1711-1716, 1966), and inoculum remains viable in infected roots up to 16 years after cutting, root rot could cause losses in white spruce planted on previously heavily diseased areas.—R.D. Whitney, Great Lakes Forest Research Centre, Sault Ste. Marie, Ont.

An Effective Method for the Isolation of Fish-Toxic Organic Solutes from Pulp Mill Effluents.—Bleached kraft effluents are highly complex, dilute solutions of organic and inorganic compounds. Isolation of the fish-toxic components of such effluents previously has not been an easy task. A procedure based on conventional methods of partition between water and organic solvents was used by Maenpaa, Hynninen and Tikka (Paperi ja Puu 50:143-150, 1968). The neutral organic compounds were first removed from sulphite or sulphate mill wastes and then the organic acids recovered for analysis. This method does not lend itself to the processing of large samples and may give rise to problems because the resin acid soaps are partitioned between the aqueous and the organic phases. Other workers have used columns of activated carbon but the problems here include irreversible absorption or chemical transformation by hydrolysis or oxidation catalyzed at the surface of the carbon particles.

Organic micropollutants have been recovered from brackish water samples by Calder and Fritz (Ames Laboratory, U.S. Atomic Energy Commission, news release of December, 1970) using a bed of polyacrylate resin (Amberlite XAD-7) manufactured by Rohm and Haas. Organic solutes were absorbed on the surfaces of the microspheres by weak forces of attraction and subsequently eluted by successive washes with 0.05N solutions of hydrochloric acid, sodium bicarbonate, sodium hydroxide and finally with methanol. Using a gas chromatograph-mass spectrometer combination, 42 micropollutants were detected. This method does not have the disadvantages associated with use of activated carbon columns and is readily adaptable to processing large samples. Recently, Button (Pap. Trade J. 155:84-85, 1971) has described the Rohm and Haas color-removal process for treating kraft bleaching wastes using Amberlite XAD-8 polyacrylate resin. We describe now a simple and effective procedure, applicable on any scale, which has allowed us to quantitatively recover the toxic organic fractions from kraft mill wastes.

In February 1971, the Western Forest Products Laboratory and Sweltzer Creek Field Station of the International Pacific Salmon Fisheries Commission embarked on a joint study of the chemical identity of kraft mill effluent components which can cause mortality in exposed juvenile Pacific salmon. Our method for the isolation of the toxic substances is a variation of the procedure used by Calder and Fritz. The resin Amberlite XAD-2 (polystyrene type) was pre-extracted with methanol to remove low-molecular-weight contaminants. Then a 5-gallon sample of waste was passed through a bed of the resin (dimensions 40 x 1.725 inches) and the effluent was collected and biossayed against sockeye salmon fry [*Oncorhynchus nerka*]. The column was washed with 5 litres water followed by 5 litres (*ca.* 4 bed volumes) of 0.05 N sodium hydroxide solution and again by 5 litres water. The alkaline extract and succeeding aqueous wash were combined, neutralized and bioassayed after dilution to the same concentration as the original waste sample. The column was then stripped with 3 litres methanol and finally washed thoroughly with water in preparation for the next cycle. The methanol was evaporated under reduced pressure and the residue dissolved in 100 ml water. An aliquot of this solution was diluted to its original concentration for bioassay.

Bioassays were conducted in 5-qt plastic buckets, each containing five sockeye fry exposed for 4 days. Effluent-water mixtures were aerated with oil-free compressed air to keep dissolved oxygen near saturation at the bioassay temperature which ranged from 41 to 45 F.

TABLE 1

Recovery of Toxicity from Kraft Mill Effluents

Sample number	Identity	Original bioassay*	Methanol extract bioassay*
8	Brown stock wash	100[48](8)	100[24](10) 20[48](5)
51	" " "	100[72](10)	100[24](10)
25	First caustic extr	100[96](25)	100[48](30)
50	" " "	100[72](10)	100[24](10)
11	Biobasin inlet	100[24](25)	80[48](25)
20	" "	100[24](10)	100[24](10)
27	" "	60[24](25)	100[24](25)
45	" "	0[96](100)	0[96](100)
7	Biobasin outlet	100[24](100)	100[48](100)
12	" "	60[48](100)	100[24](100)
29	" "	40[96](65)	100[24](100)
44	" "	0[96](100)	0[96](100)

* Percent mortality [time in hours] (concentration percent).

To date, 35 samples of mill effluents have been processed. These represent wastes entering and leaving the aerated stabilization basin at the mill over a 7-month period, besides a few samples from various sewers within the plant. Some typical bioassay results are shown in Table 1. With XAD-2 resin, we have always found that the toxicity was recovered almost quantitatively in the methanol fraction. This was not the case in our experiments with Amberlite XAD-7 resin, as used in the method of Calder and Fritz, in which the toxicity became distributed among the various washes.

For completion of color removal from the methanol fractions, we have found it necessary to extract them with ether in a liquid-liquid extractor. The pale yellow oils thus recovered may then be chemically separated by various techniques to identify the compounds responsible for the toxicity. These experiments will be discussed in detail elsewhere.—I.H. Rogers, Western Forest Products Laboratory, Vancouver, B.C.; J.A. Servizi and R.W. Gordon, Sweltzer Creek Field Station, International Pacific Salmon Fisheries Commission, Cultus Lake, B.C.

SILVICULTURE

Survival of 2–0 and 3–0 Jack Pine Seedling Outplantings in Southeastern Manitoba.—A survey of jack pine plantations in Manitoba in 1969 indicated poor survival of 3–0 jack pine nursery stock (Carlson, unpublished data). This survey also showed that in 1969 shoot/root ratios of the 3–0 jack pine stock were high, average 5.61:1. Survival of 2–0 stock seemed better and the shoot/root ratio was considerably lower, average 3.54:1. In the spring of 1970 experimental plots were laid out to compare first year survival of 2–0 and 3–0 jack pine with reference to shoot/root ratios.

Three planting sites were chosen in southeastern Manitoba, near Whitemouth, Richer, and Marchand. The site at Whitemouth was a fresh mesotrophic type 7 (Mueller-Dombois, Can. J.Bot. 42:1417, 1964), the site at Richer was a moist oligotrophic type 4, and the site at Marchand was a dry oligotrophic type 2. Before planting the sites had been barrel scarified. Six replicates of approximately 100 seedlings each for each type of planting stock were laid out at each site. All seedlings were hand planted by local planting crews. The seedlings were planted in Whitemouth and Marchand areas on 6 May and in the Richer area on 7 May. Final data on survival were taken in late August as were new growth data from the Marchand planting. The shoot/root ratios were obtained from 100 of each class of seedling at the time of planting.

Survival of 2–0 jack pine seedlings was significantly better than 3–0 jack pine seedlings after 4 months (Table 1). There were also significant differences in shoot/root ratios and the

TABLE 1

Survival of 2–0 and 3–0 jack pine seedling outplants, southeastern Manitoba, 1970

Site	Survival %		New Shoot Growth per Seedling in mm	
	2–0	3–0	2–0	3–0
Whitemouth	98.9**	77.8	—	—
Richer	98.6*	75.9	—	—
Marchand	98.3**	75.9	30.97**	12.71
Shoot/Root Ratios (Avg) Dry wt of shoot/ Dry wt of root)	2.94	4.49**		

* Significantly greater at the 5% level of confidence.

** Significantly greater at the 1% level of confidence.

amount of new shoot growth. Shoot/root ratio of 2–0 jack pine was only a little more than half that of the 3–0 stock. Growth of the 2–0 seedlings was more than double that of the 3–0 seedlings. These data also show that the effect of the site on survival in 1970 was minimal in southeastern Manitoba.

The much better survival of 2–0 jack pine was possibly related to a more even balance of shoot and root than in the 3–0 stock, and which may account for the increased growth. Plants with large tops may dry out faster or require more energy for shoot production and leave little for root regeneration which is thought to be the most critical requirement for survival. These data suggest that cultural practices, such as root pruning and fertilizing at nurseries, should be designed to produce a more "balanced" plant rather than a large plant.—L. W. Carlson, Northern Forest Research Centre, Edmonton, Alta.

Copper Toxicity in Container Seedlings Grown in Copper-Bottomed Flats.—Maximum root growth is desirable for balanced container seedlings, but that growth should be inside the container. Roots which grow out of containers are of no value as they will be distorted, injured, or removed at planting.

In containers like the Walters' bullet or the BC/CFS styroblock, protruding roots dry and wither away (Matthews, Can. Dep. Environ., Can. Forest. Serv. Inf. Rept. BC-X-58, 1971). From containers which rest directly on an impermeable tray, roots tend to grow across the bottom of the tray. The resulting tangled mat of roots, besides being useless, causes difficulty in removing individual containers for planting.

One recommended method of preventing such proliferation of roots is to coat the bottom of the tray with copper paint or foil (Anon, 1967 and 1968, Ont. Dept. Lands and Forests, Provisional instructions for growing and planting seedlings in tubes. Restricted Distribution). While effective for the purpose, the mechanism is one of poisoning the root tips that reach the copper.

To test the influence that such root poisoning has upon growth, lodgepole pine [*Pinus contorta* Dougl. var. *latifolia* Engelm.] seedlings were grown in Ontario-type tubes in trays with or without copper-painted bottoms. Copper was applied by spray can and control trays were sprayed with non-metallic paint. Seedlings were grown for 10 weeks in the greenhouse at 70 F ± 5° with 18 hour photoperiods. They were watered as required and received weekly applications of one of two types of fertilizer solution after the third week from germination. After washing and measuring heights and dry weights of the three replications of 100 seedlings, samples were pooled and the copper content of shoots and of roots was determined chemically. Results are in Table 1.

Copper content in roots of seedlings from treated trays was more than ten times that of untreated seedlings.

TABLE 1

Influence of copper-bottomed trays on growth of tubed lodgepole pine seedlings

Treatment		Growth Parameters			Root Weight (mg)			Copper Content (ppm)	
Fertilizer	Copper tray	Height (cm)	Total Wt (mg)	Net Wt[1]	Total	Inside tube	Outside tube	Roots	Shoots
1	yes	7.16	123	123	25	25	—	106	6
1	no	7.63**	142**	134**	29*	21	8	9	4
2	yes	5.76	82	82	19	19*	—	219	13
2	no	6.16**	100**	91*	23*	14	9	12	8

*, ** significantly greater by t-test.

[1] without weight of roots that grew outside the tube.

For both types of fertilizer tested, height and total weight were significantly reduced in the copper-treated trays, whether of not the weight of roots outside the tubes was included. However, because no roots grew outside the tube, the weight of roots within the tube tended to be greater with copper-bottomed trays. This difference was significant for one treatment combination.

Despite high copper content, seedlings reared on copper-bottomed trays have given good field survival. The inhibitory influence is probably confined to the rearing phase, producing smaller seedlings than would otherwise be the case. However, recent evidence showed that larger container seedlings perform significantly better than smaller ones upon outplanting (Endean and Hocking, unpublished data), and this improved performance was highly correlated to large shoots but not to roots. Thus any treatment that inhibits shoot growth should be avoided. The retention of roots within the tube may be achieved without inducing toxicity by the air root-pruning method that operates for the BC/CFS styroblock.

For seedlings in discreet containers (rigid or polyethylene film tubes), trays with an open-mesh bottom (made of expanded metal, hardware cloth, or synthetic fiber) have the same effect (Mitchell and Hocking, 1972, unpublished). Trays must be placed on racks (wooden slots, chicken wire, etc.) that permit adequate air circulation to dry out protruding roots. The potential for zinc toxicity from galvanized materials is not realized owing to the wide separation of wires and limited root contact.—Drake Hocking, Northern Forest Research Centre, Edmonton, Alta

Effects of Stratification of Alberta White Spruce and Lodgepole Pine Seeds on Emergence in Operational Seedbeds.—Recent testing of geographically distinct seedlots of Alberta white spruce indicates that seedlots differ in their requirements for stratification, some germinating better without stratification (Hellum, Can. Dep. Forest. Rural Develop., Forest Br., Pub. No. 1243, 1968; Shivanagi and Hocking, unpublished). The Alberta variant of white spruce differs from the principle species type, which is consistent in its stratification requirement (Santon, North. Forest Res. Centre, Inform. Rep. PS-X-17, 1970). However, there are persistent verbal reports that stratified seed "does better" in the seedbed (Chedzoy, pers. comm.). The following experiment was designed to test the influence of stratification in operational nursery seedbeds.

At the Alberta Tree Nursery (Oliver, Alberta), seed of Alberta white spruce [*Picea glauca* (Moench) Voss. var. *albertiana* (S. Brown) Sarg.] is routinely stratified for seedbed use while seed of lodgepole pine [*Pinus contorta* var. *latifolia* Engelm.] is sown non-stratified. Subsequent inventories of seedling stands show inconsistent results.

In 1969, each operational seedlot sown at Oliver was matched with an adjacent experimental sowing of the same seedlot with opposite stratification treatment. For stratified treatments, seeds were stratified for 90 days at 35 F in moist peat moss. Operational sowing rates were established by nursery personnel; experimental treatments were sown at the same rates. Seeds were sown in five rows, lightly covered with sand, and shaded with snowfencing. According to normal practice, irrigation was applied "as required" by nursery staff.

Immediately after sowing, six randomly selected plots were marked out for each seedlot treatment. Weekly observations were made throughout the growing season to record new emergence and seedling stand.

Data for stratified and non-stratified seeds of each seedlot were compared by the t-test. Early emergence (20 June count) was better for stratified seeds of most white spruce seedlots, probably accounting for the observation that stratified seed "does better". However, this trend was steadily eroded as emergence continued throughout the summer. Final seedling stands (23

TABLE 1

Emergence and survival of stratified and non-stratified seeds in operational nursery seedbeds

Species	Forest	Seedlot	Laboratory Germination (%)	Sowing rate (seeds per lineal ft)	Nursery seedbed stand[1] (Seedlings per lineal foot)	
					Stratified	Non-stratified
White spruce	Footner Lake	67-51	30	30	2.0	14.7*
		67-31	88	30	18.5*	3.8
		3-1-68	85	30	5.2	9.7*
	Peace River	7-2-68	93	32	5.7	11.8*
		5-1-68	90	32	21.2*	17.0
	Athabasca	67-67	47	30	1.8	15.2*
		67-35	43	30	22.3*	2.7
		67-34	54	30	22.3*	5.7
		67-33	58	30	25.0*	2.8
	Slave Lake	7-1-68	71	34	6.7	10.2*
		5-2-68	84	34	12.3	20.2*
		4-1-68	84	34	7.3	20.3*
		2-2-68	81	34	14.2	12.8*
	Lac La Biche	3-1-68	96	30	29.3*	10.0
		3-3-68	91	34	18.1	26.7*
	Grande Prairie	2-3-68	87	30	17.8*	7.0
	Whitecourt	5-3-68	92	30	20.2*	6.0
	Edson	60-35	81	29	0.0	12.0*
		67-1	63	28	0.0	13.1*
	Bow	103-13	96	32	19.3	21.1
Lodgepole Pine	Peace River	60-79	54	55	6.6	15.5*
		64-32	75	56	2.7	8.0*
	Edson	67-69	32	51	2.8	2.5
		67-65	61	60	2.7	15.0*
		66-3	78	56	12.1	13.3
	Bow	5-1	90	34	16.1	19.2*
		66-15	91	55	19.0	29.1*
		66-2	67	32	10.3	11.7

* Indicates significantly greater by t-test (P = .05).

[1] Basis: mean of six 1-foot plots.

September count, Table 1) were significantly superior in more non-stratified seedlots than in stratified seedlots, both for white spruce and lodgepole pine. For lodgepole pine, trends and significant differences all showed that non-stratified seed gave a superior stand of seedlings. These data support normal practice.

The results for white spruce are more complex. Significantly superior stands occurred in scattered plots from both stratified and non-stratified seed. Large and unexplained losses of germinative capacity occurred relative to previous laboratory tests, in both treatments.

Pooled data from white spruce seedlots of similar geographic sources revealed no trends in response to stratification relatable to seed source. This supports conclusions from the studies cited earlier and differs from several other tree species, where there are well-defined clinal responses to stratification of seed from provenances widely separated in latitude (e.g. Allen, Forest Chron. 36:18-29, 1960; Mergen, Ecology 44:716-727, 1963; Wilcox, Forest Sci. 14:16-19, 1968). The lack of a clinal response in white spruce might be explained in part by the existence of closely-related species and the distribution of varieties or hybrids.

Besides the effects of local population adaptations, many other factors can affect seed dormancy and the need for stratification: seed "ripeness" or stage of maturity; handling and exposure of cones during transport and storage; temperature and other factors during extraction of seed; and storage time and temperature of extracted seed (Allen, Forest Chron. 34:266-298, 1958). That these other factors played an important role in our experiment is shown by the large differences among seed lots from the same forest regions. Still other factors such as cycles of light, temperature and moisture can affect emergence in the seedbed, but these were evenly distributed over the plots containing treatment pairs.

Until more is known of the effect of these factors and until better control over them is developed, every seed lot of Alberta white spruce can be expected to differ in its stratification requirements. Therefore, it seems practical to abandon stratification except where a need is demonstrated by tests for stratification requirements. Differences found in seedbed emergence were sufficiently large to justify such testing.—Drake Hocking, Northern Forest Research Centre, Edmonton, Alta.

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