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ENTOMOLOGY

A Testis-sampling Technique for Holo- and Hemi-metabolous Insects.—Studies of endophenotypic variation in insects – within individuals or populations – generally involve the removal of the reproductive organs and ensuing death of the donor. This technique allows only a static analysis of events that have taken place during meiosis and requires extrapolation to assess their future role either in natural populations or in laboratory matings involving sibs of the dissected insects. Unlike exophenotypes, we have no direct method of following chromosomal mutations through several generations.

With the possible involvement of chromosomal mechanisms in the genetic control of populations, it has become necessary to find a direct method of meiotic assay which does not hinder the reproductive capacity of the insect and permits it to be used for breeding after the analysis. This would allow unambiguous observation of the behavior and fate of such meiotic abnormalities as aneuploidy, translocations, and inversions, both in parent and offspring.

Such a sampling method has been devised for two insects, the spruce budworm [*Choristoneura fumiferana* (Clem.)] and the desert locust [*Schistocerca gregaria* Forsk.]. Because of their very different patterns of metamorphosis, the technique employed is different for each insect.

(a) Schistocera gregaria

Adult males were labelled and coded immediately after the final ecdysis and were subsequently sampled at a known age. After the insect was anaesthetized with CO_2, the testis was exposed by making a lateral incision along the length of the fourth and fifth abdominal pleurites, 10–15 follicles were teased away from the testis, and then removed by cutting close to their base. These samples were fixed in 3:1 alcohol-acetic acid and refrigerated before chromosomal assay. Up to 30 insects could be sampled per hour.

The incision was sealed with low melting point dental wax. The open structure of the testis with 70–90 follicles allowed at least two further samples to be taken. Chromosome assay can be completed before the insect has attained sexual maturity (as determined by pigmenentation patterns).

Males that have been subjected to this technique are still fertile and, when involved in matings, their female partners produce normal quantities of fertile eggs. This technique has facilitated a direct disruptive selection program for high and low chiasma frequency and an analysis of temporal variation in chiasma frequency at different temperature regimes within the individual. Over 400 males have been sampled in this manner and so far none have died within 4 weeks of the operation.

(b) Choristoneura fumiferana

In this species, the production of secondary spermatocytes is at peak in the fifth larval instar. The paired testes are visible through the integument as dark oval bodies. Unlike *Schistocerca*, the four testicular follicles are enclosed by a two-layered testis wall and consequently only whole testes can be successfully removed.

Fifth-instar larvae were anaesthetized with diethyl ether. (In this species, CO_2 cannot be used since it causes the body cavity to swell and any incision results in a massive, usually lethal, loss of haemolymph.) A dorso-lateral incision was made above the position of the testis as soon as spiracular movement had ceased. The turgidity of the body cavity pushed the testis partially through the incision and facilitated testis removal with either fine forceps or by suction using a micro-syringe, after excision of the vas deferens. Contrary to Retnakaran (Annal. Entomol. Soc. Amer. 63: 851-859, 1970), we have found that the vasa deferentia are present in the fifth-instar larva and can be traced from the posterior tip of the testis to the ectodermal reproductive anlage on the last abdominal segment. This has precluded the possibility of testis transplants between *Choristoneura* species.

After testis removal, the incision was left unsealed since, upon recovery from the anaesthetic, there was no excessive loss of haemolymph. The larvae were returned to feeding cups to complete larval development and pupation. The emerging adults were mated to females in single-pair mating cages. Mating success and egg hatchability were not affected by removal of a testis from the male parent. In this species, the operation is more difficult because of the delicate nature of the donor and post-operative mortality was 25%.

This direct sampling technique can reduce the rearing program needed to assess the meiotic effects of physico-chemical treatments or the behavior of supernumerary chromosome material in laboratory-reared populations and their fate in future generation.—D. D. Shaw and M. G. Morgan, Maritimes Forest Research Centre, Fredericton, N.B.

Differences between two Species of Birch in Attack and Susceptibility to Defoliation by the Birch Casebearer.—The birch casebearer [*Coleophora fuscedinella* Zeller] was discovered in Newfoundland in 1953, and by 1971 it had become the most important pest of birch throughout the Island. Adults of the casebearer emerge in July and lay eggs on the underside of leaves. The insects overwinter as a second-instar larvae in the tree crown, attached to branch crotches or to the base of buds. Larvae begin to feed in the spring when the buds are flushing, and continue to feed till pupation in mid-June. Larvae feed by attaching their cases to the leaf and mining the leaf as far as they can reach without detaching themselves from the cases. After a larva has consumed all the food it can reach, it detaches its case and moves to a different area of the leaf to feed. This feeding habit creates somewhat reactangular brown patches on the leaf. Feeding causes defoliation by destroying the photosynthetic materials of the leaf. Feeding by large numbers of larvae causes individual leaves and ultimately the whole tree, to appear brown.

Preliminary surveys indicated differences in the intensity of defoliation between *Betula papyrifera* Marsh. [white birch] and *Betula cordifolia* Regel [mountain white birch]. Both occur in Newfoundland (Brittain and Grant, Can. Field-Natur. 81: 251-262, 1967), and both are common in western and central Newfoundland. This report presents data that quantifies the difference in birch casebearer abundance, as reflected by intensity of defoliation, number of eggs laid, and number of overwintering larvae.

Data were collected from 10 trees of each species, 15-25 ft (4.6-7.6 m) in height in a stand near Cormack in western Newfoundland. Starting 100 ft (30.5 m) from the stand edge, the first 10 trees encountered of each species in a 50-ft (15.2 m) wide strip were chosen; but only one tree per clump. Randomly selected leaves from the peripheral 10 inches (25.4 cm) at mid crown of each tree were used to obtain defoliation estimates (20 leaves), and number of eggs per leaf (10 leaves). The number of overwintering larvae was expressed as the average number on four branch crotches in the fall. Branch crotches were located near the stem, and one each per quarter of crown height.

Results of the study are summarized in Table 1. Estimated defoliation on *B. papyrifera* was about six times more severe than for *B. cordifolia.* The feeding pattern of individual larvae on *B. papyrifera* consisted of many large feeding areas which tended to be contiguous, on *B. cordifolia* large feeding areas were scarce and tended to be scattered. This difference in feeding pattern caused severely attacked *B. cordifolia* trees to appear mottled, quite different from the uniform brown appearance of severely attacked *B. papyrifera.*

The number of eggs per leaf and number of overwintering larvae per branch crotch on *B. papyrifera* was about two and one-half times greater than on *B. cordifolia.* Means were compared with Student's *t* test, and both differed significantly at the 1% level.

TABLE 1
Difference in defoliation and birch casebearer numbers between *Betula payrifera* and *B. cordifolia*

	B. papyrifera			*B. cordifolia*		
	Avg	S.D.	Range	Avg	S.D.	Range
Percent defoliation	29	–	11-55	5	–	1-7
No. eggs per leaf	16.7	10.4	0-52	6.1	4.8	0-19
No. larvae in branch crotches	27.7	19.6	5-94	11.9	7.9	3-51

These differences in intensity of defoliation and insect numbers indicates that *B. cordifolia* is much less likely to be damaged by the birch casebearer. The difference in insect numbers indicates that birch trees must be correctly identified when sampling to obtain estimates of casebearer abundance or estimates of potential defoliation.—A. G. Raske, Newfoundland Forest Research Centre, St. John's, Nfld.

PATHOLOGY

Corky Root Disease of Douglas-fir Seedlings: Post-Plant Nematicide Trials to Control ***Xiphinema bakeri.***—Since 1963, corky root disease (Bloomberg, Bi-Mon. Res. Notes 24:8, 1968) has ruined about 1.5 million Douglas-fir [*Pseudotsuga menziesii* (Mirb.)] Franco seedlings in coastal British Columbia forest nurseries. The nematode *Xiphinema bakeri* Williams is the primary pathogen (Bloomberg and Sutherland, Ann. Appl. Biol. 69:265-276, 1971). Corky root can be controlled by pre-plant application of nematicides (Bloomberg and Orchard, Ann. Appl. Biol. 64:239-244, 1969) or by bare fallowing accompanied by frequent disking of infested areas during the hot, dry, late summer - early fall period.

Although pre-plant controls are satisfactory, post-plant ones are needed to eradicate the nematode on seedbed seedlings and transplants. Generally, nematicides are injected or drenched into the soil. Recently attention has focused on systemic materials that can be applied to plant foliage and then translocated to the roots to act as nematicides. The objective of the two experiments reported herein was to determine the usefulness of two soil-applied nematicides (Diazinon and Nemagon) and a promising systemic (Vydate) (Radewald et al., Plant Dis. Rep. 54: 187-190, 1970; Birchfield, Plant Dis. Rep. 55: 362-365, 1971; Abawi and Mai, Plant Dis. Rep. 55: 617-620, 1971; Miller, Plant Dis. Rep. 56: 255, 1972) for post-plant of control *X. bakeri* on Douglas-fir.

Experiment 1

In March 1972, a sandy loam, *X. bakeri*-infested soil from the Campbell River nursery was thoroughly mixed, and put into plywood boxes (each 34 x 8 x 8 inch; 86.4 x 20.3 x 20.3 cm) lined with plastic sheeting. Thirty, 1-yr-old corky-root-diseased Douglas-fir from Campbell were selected for uniformity of size and disease severity and transplanted into each box with three equally-spaced rows of 10 seedlings each. The nematicides and their equivalent application rates (formulated as water-based emulsions) were: a) Diazinon® [0,0-diethyl 0-20 isopropyl-4-methyl-6-pyrimidyl phosphorothioate] at 35, 50 or 75 lb. a.i. per 120 Imp gal (546 l) of water per acre (39, 56 and 84 kg per hectare) applied as a soil drench; b) Nemago® (1,2-dibromo-3-chloropropane) at 20, 40 or 60 lb. a.i. per 600 Imp gal (2,728 l) of water per acre (22, 45 and 68 kg per hectare) dribbled into 2.5 inches (6.4 cm) deep soil trenches on either side of each seedling row; after treatment, the trenches were filled with soil, and c) Vydate® [S-methyl 1-(dimethyl carbamoyl)-N-[(methyl carbamoyl) oxyl] thioformimidate] at 2, 4 or 6 lb. a.i. per 100 Imp gal (455 l) of water per acre (2.2, 4.5 and 6.7 kg per hectare) sprayed onto seedling shoots and soil surface. The nematicides, one per box, were applied 1 week after transplanting when the seedlings were still dormant. Vydate was also applied, 35 days after transplanting, to other seedlings that had broken dormancy. No water was applied to Vydate-treated foliage for 5 days after treatment; otherwise, all seedlings were watered as needed and greenhouse temperatures ranged from 98 to 64 F (41 to 11 C). Each treatment and control (distilled water) was replicated four times in a completely random design.

From 21 Aug to 28 Sept (145 to 183 days after transplanting), the seedlings were removed from the soil, the nematodes were obtained from the roots (Bloomberg et al., Bi-Mon. Res. Notes 26: 14-15, 1970), the second year's shoot growth was measured, and fresh weights were obtained for it and the roots. The data were transformed (natural log) for analysis of variance, and treatment means were compared, using the Newman-Keuls test (Miller, Simultaneous statistical inference, McGraw-Hill, New York).

The results showed that Nemagon was the only nematicide that produced a significant ($P = .05$) treatment effect; consequently only results for the Nemagon treatment are given in Table 1. Numbers of *X. bakeri*/g of root decreased as Nemagon rates increased up to 40 lb. per acre, but there was no significant ($P = .01$) difference between the 40 and 60 lb. per acre rates (Table 1). Nemagon also caused a reduction in root weight, i.e., it was apparently phytotoxic, whereas shoot weight and length were not affected. Although Nemagon has been reported (Ferris and Leiser, Plant Dis. Rep. 49: 69-71, 1965) to be phytotoxic to unthrifty, field-grown spruce, we observed no phytotoxic symptoms such as chlorosis or death on Douglas-fir seedlings.

TABLE 1
Effect of Nemagon (Experiment 1) and Vydate (Experiment 2) on numbers of *Xiphinema bakeri* nematodes and seedling growth [a]

Material and application rate (lb. a.i./acre)	No. nematodes /g fresh root	Fresh wt roots (g)	Second yr shoot wt (g)	Second yr shoot length (cm)
Nemagon				
0	33a	1.8b	0.36a	38a
20	17b	1.7ab	0.49a	44a
40	7c	1.5a	0.69a	51a
60	7c	1.6ab	0.51a	46a
Vydate				
Healthy seedlings				
0	49b	2.6a	0.38ab	33b
2	27a	2.4a	0.40ab	42a
4	23a	2.5a	0.44a	42a
6	35ab	2.0b	0.37b	39a
Diseased seedlings				
0	62b	1.5b	0.27b	35b
2	37a	1.9a	0.36a	44a
4	42a	1.9a	0.34a	41a
6	52ab	1.2c	0.29b	40a

[a] Values for Experiment 1 are means of 4 replicates, those for Experiment 2 are means of 30 replicates; means followed by a letter in common do not differ significantly ($P = .01$) for nematodes per g of root in the Nemagon treatment, $P = .05$ for all other differences).

Experiment 2

On 12 April 1972, 1-yr-old corky root diseased (from Campbell River) and healthy (container grown) Douglas-fir were transplanted, one seedling per 6 inches (15 cm) pot, into

X. bakeri infested Campbell River soil. After breaking dormancy (8 May), each seedling shoot was immersed three consecutive times into a Vydate solution and the seedling laid horizontally until dry. Seedlings were then arranged in a completely random design on a greenhouse bench, with each treatment (2, 4 or 6 lb. a.i. per 100 Imp gal of water per acre) and control (distilled water) replicated 30 times. Seedlings were not watered for 5 days after treatment; thereafter, water was applied only to the soil surface. The experiment was evaluated (1 – 12 Oct), using the same techniques as described for Experiment 1, except no data transformation was needed for the analysis of variance.

Foliage application of Vydate showed that (disregarding application rate) there was no overall difference ($P = .05$) between the number of *X. bakeri* nematodes on roots of healthy (34 per g) and diseased (49 per g) seedlings, i.e., Vydate nematode control was as good on diseased as on healthy plants. However, Vydate did reduce *X. bakeri* populations on both diseased and healthy seedlings (Table 1), especially at the 2 and 4 lb. application rates. The 6 lb. rate of Vydate reduced root weight of diseased and healthy seedlings. There was no clear-cut trend between seedling shoot weight and Vydate concentration, but the nematicide treatment did increase shoot length. No seedlings died or exhibited any shoot symptoms of phytotoxicity. We do not know why Vydate gave some control of *X. bakeri* here, but not in the first experiment.

Recent evidence (Sutherland and Sluggett, 1972, unpublished) indicates that corky root development depends upon the combined effects of *X. bakeri* root feeding and low soil fertility. Future nematicide tests should determine the value of applying both a nematicide and fertilizer to disease infested nursery areas. Our results indicate that both Nemagon, which has a low mammalian toxicity, and Vydate should be included in such trials.—S. Ilnytzky and Jack R. Sutherland, Pacific Forest Research Centre, Victoria, B.C.

Association of Some Physical and Chemical Properties of Nursery Soils with Corky Root Disease.—The nematode *Xiphinema bakeri* Williams is the "primary" pathogen of corky root disease because its feeding precedes root invasion by the soil-borne fungi *Cylindrocarpon destructans* (Zinnsm.) Schalten and *Fusarium oxysporum* Schletcht. (Bloomberg and Sutherland, Ann. Appl. Biol. 69: 265-276, 1971). Sutherland and Sluggett (Can. J. Forest Res., in press) found diseased seedlings and soil from a disease-infested area in the Campbell River nursery contained statistically lower amounts of several nutrients than their healthy counterparts, which suggested that disease development depends upon the combined effects of nematode feeding and low soil fertility. Related to this latter factor is the field observation that the disease prevails on the sandiest soils within infested fields. Because the implication of soil fertility had been studied only at the Campbell River nursery, the present study was made to determine some physical and chemical properties of Green Timbers and Haney (Alouette Lake) nursery soils where the disease has also occurred.

In August 1972, 10 randomly selected soil cores, taken to a 6-inches (15 cm) depth, were collected and bulked from adjacent 50 x 50 ft (15.2 x 15.2 m) plots with and without corky root disease. When sampled, Haney field 1 and Green Timbers field 4 were in bare fallow and Green timbers field 7 was in 2-0 Douglas-fir. The 4-5 lb. (1-5-2.0 kg) samples were air dried, sieved (10 mm sieve) and passed through a sample splitter, after which subsamples were analyzed for: texture (Bouyoucos, Soil Sci. 23: 343-353, 1927); total N by micro-Kjeldahl; P by acid fluoride extraction; exchangeable K, Mg, and Ca by ammonium acetate extraction; pH and conductance (soluble salts) by saturated soil paste; cation exchange capacity (CEC) by ammonium saturation; and total organic carbon by Leco carbon analyzer. These methods use the standard procedures for this laboratory (McMullan, Can. For. Serv. Inf. Rept. BC-X-50, 1971; McMullan, Can. For. Serv. Inf. Rept. BC-X-67, 1972).

Table 1 shows that corky root soils contained more sand and less silt and clay than non-corky root soils. The results also confirm our earlier Campbell River observation (Sutherland and Sluggett, Can. J. Forest Res., in press) that corky root soils are less fertile than disease free soils, e.g. they contained less N, K, Mg, and Ca and had lower CEC and carbon content values than non-corky root soils. Phosphorus and acidity (pH) levels of the two soils were similar and the conductance reading indicated that neither soil contained harmful amounts, 4000 to 8000 micromhos/cm for most plants, of soluble salts (Bower and Wilcox, pp. 933-940, in Methods of Soil Analysis, part 2, C. A. Black, Ed., Vol. 9 of Agron. Mono., 1965). The lower fertility levels of corky root soils are probably attributable to their lower clay and organic carbon contents, two factors influencing CEC (Lyon et al. The nature and properties of soils, MacMillan, New York, 1952). Their higher sand content likely results in greater available pore space, which favors nematode population build-up. We do not know why these areas of sandy soil occur, but perhaps they are exposed areas of interglacial sand (Fyles, *In* Day et al., Rep. No. 6, B.C. Soil Surv., 1959).

TABLE 1
Some physical and chemical properties of soil from corky root and non-corky root nursery areas[a]

	Non-corky root areas	Corky root areas	Adequate nutrient levels[b]
Physical properties			
Sand, %	58 ± 3.5	67 ± 3.3	—
Silt, %	14 ± 2.1	9 ± 0.9	—
Clay, %	28 ± 1.7	23 ± 2.4	—
Chemical Properties			
N (total), %	.59 ± 0.20	.36 ± 0.05	.20
P, ppm	14 ± 5.4	15 ± 3.7	100
K, ppm	86 ± 7.3	51 ± 14.2	78
Mg, ppm	55 ± 25.9	28 ± 8.5	170
Ca, ppm	625 ± 285	497 ± 207	1000
pH	5.7 ± 0.4	5.5 ± 0.3	—
conductance[c]	637 ± 115	425 ± 77	—
CEC[d]	44 ± 5.3	36 ± 1.2	—
Carbon (total organic), %	4.3 ± 1.3	3.2 ± 0.4	—

[a] Value are means of three samples, ± SE of the mean.
[b] For Douglas-fir nursery seedlings (van den Driessche, B.C. For. Serv. Res. Note No. 48, 1969).
[c] Micromhos/cm.
[d] Cation exchange capacity = meq/100 g air-dry soil.

The adequate nutrient level values (Table 1) indicate that N is adequate in both corky root and disease free soils while P, Mg, and Ca are deficient in both soils and K is adequate in "healthy" but not corky root soils. Such comparisons may be misleading because they do not consider the minimum nutrient levels at which seedlings can grow and still not exhibit deficiency symptoms. For example, 170 ppm Mg is adequate for seedling growth and even a 55 ppm in non-corky root soils (Table 1) growth may be uneffected, but the low (28 ppm) Mg levels in corky root soils may be critical, especially when seedlings are subjected to the additional stress of *X. bakeri* nematode root feeding.

Because past cultural and cropping practices have varied widely within and among nurseries, it may not be possible to pin-point specific nutrient deficiencies for corky root soils. Probably their only common characteristics are that they are sandier and less fertile than their "healthy" counterparts. Fallowing increases the organic matter and nutrient content of corky root soils would help seedlings offset the effects of *X. bakeri* feeding.—Jack R. Sutherland, L. J. Sluggett, and W. Lock, Pacific Forest Research Centre, Victoria, B.C.

Chemotherapy Trials on Sweetfern Blister Rust Cankers.—Despite early reports of successful control of white pine blister rust [*Cronartium ribicola* J. C. Fischer] on western white pine [*Pinus monticola* Dougl.] with the antibiotics cycloheximide and phytoactin (Moss et al. J. Forest. 38: 691-695, 1960), later results were variable and discouraging (Dimond, J. Forest, 64: 379-382, 1966) and even the best levels of control were too low for an effective control program. Similar chemical tests have not been reported for sweetfern blister rust incited by *Cronartium comptoniae* Arth. This is the major stem rust fungus attacking hard pines in the Maritime Provinces (Van Sickle, Plant Dis. Rep. 53: 369-371, 1969). With most stem rusts, such as *C. ribicola,* once the aeciospores are released, the bark cracks, the cambium and underlying wood die, and the tree is eventually girdled. With *C. comptoniae*, however, the cambium is not killed even after several years of infection, rather it produces an abnormal xylem in characteristic wavy patterns. Thus, testing of chemicals to control sweetfern blister rust cankers seemed justified, as even trees with most of their circumference infected might revert to normal growth if the fungus could be inhibited.

On 11 June 1969, when aecia were obvious, 60 infected lodge-pole pine [*Pinus contorta* Dougl.] averaging 4.2 in. (10.7 cm) dbh were selected in a 20-year-old plantation near Lawrencetown, N.S. All trees were dominants or codominants with a bole canker within 6 ft (182.9 cm) of the ground (average canker length, 2.7 ft (82.3 cm); range, 1.1 – 6.0 ft (33.5 – 182.9 cm); average proportion of bole circumference affected, 0.6; range, 0.1 – 1.0). Six groups of trees were randomly selected and each group given one of six treatments applied on 16 July 1969: (1) control – five trees were sprayed with water only, five received no treatment; (2) 5.0% sodium arsenite solution in water; (3) number 1 stove oil; (4) phytoactin L-440 at 200 ppm in stove oil; (5) 11% dimethyl sulfoxide (DMSO) in water; and (6) cryptosporiopsin (Stillwell et al. Can. J. Microbiol. 15: 501-507, 1969) at 400 ppm in DMSO and water. Solutions were applied to the point of run-off to the basal 6 ft of each bole from a hand-operated garden-type sprayer (except treatment 2 which was brushed on to prevent drift). Trees received an average of 1.6 qt Imp (1.8 l) of solution in treatments 2, 3, and 4, and 0.25 qt (0.3 l) in treatments 5 and 6. All trees were reexamined in 1970, 1971, and 1972 during the period of peak aecia production (about mid-June). The active area of each canker was estimated by measuring the lineal extent of aecia on each of the cardinal faces of the tree. To compare treatments, the total for each canker for each year was expressed as a proportion of the corresponding 1969 measurement before treatment.

Even 1 year after treatment, considerable tree mortality had occurred (Table 1). Most trees were of low vigor, having been infected for 10 – 15 years and subsequently attacked by wood-boring beetles, and some chemicals were phytotoxic at the concentrations tested. Treatment with 5% sodium arsenite killed all 10 trees, which was unexpected as Brown and Rowan (U.S. Dep. Agr., Forest Serv. Res. Note SE-75, 1967) applied higher concentrations to southern pines without phytotoxicity.

Reduced sporulation was evident, but it was insufficient for effective control. Although the sample size was too small for meaningful statistical analysis, the range of values obtained and the differences between means are useful in comparing treatments (Table 1). A substantial decrease in aecia production occurred after treatment with fuel oil and phytoactin, and a slight reduction followed spraying with cryptosporiopsin and DMSO, but in no case did the antibiotics result in a significant improvement over the carrier alone (t-test, $p = 0.05$).

No obvious explanation can be given for the apparent stimulation of aecia production during the first 2 years after the single application of water (Table 1). Perhaps it enhanced the cross-fertilization of the pycnia. Further study of this phenomena is required to determine any cause-effect relationship or its possible role in the initiation of epidemics.

Results indicate little promise of an economical eradication of sweetfern blister rust cankers form severely infected trees using the chemicals tested. Greater benefit, however, may arise from treating younger, recently infected trees, with lower concentrations of solvents but higher concentrations of cryptosporiopsin which showed the most promise and least phytotoxicity. Two or more applications made in consecutive years may also enhance the degree of control.

I thank P-L Biochemicals Inc., Milwaukee, Wisc., U.S.A. for donating the phytoactin and M. A. Stillwell of this Research Center for the cryptosporiopsin.—G. A. Van Sickle, Maritimes Forest Research Centre, Fredericton, N.B.

SILVICULTURE

Effects of Different Phosphatic Fertilizers on the Growth of Spruce Seedlings in a Greenhouse.—Commercially available phosphatic fertilizers differ widely in their physical and chemical properties. However, in Newfoundland few attempts have been made to determine their effects on the growth of trees. In 1968, the Newfoundland Forest Research Centre initiated greenhouse studies to obtain information on the relative effectiveness of a number of phosphatic fertilizers when applied to two common Newfoundland forest soils. Results are presented below.

Bulk soil samples, including organic and mineral materials, were collected from the upper 9 inches (5.1 cm) of the profile beneath a semi-mature black spruce [*Picea mariana* (Mill.) B.S.P.] stand near Badger in central Newfoundland and a semi-mature balsam fir [*Abies balsamea* (L.) Mill.] stand near Deer Lake in western Newfoundland. Each soil sample was air-dried, passed through a 2 mm sieve and thoroughly mixed. Fifteen six-inch plastic containers were filled with soil from each of the two stands. Nitrogen as ammonium nitrate and potassium as potassium chloride (reagent grade) were applied in powder form to all containers at rates of 300 and 200 ppm respectively. Four commercial grade phosphatic fertilizers, basic slag, rock phosphate, potassium metaphosphate, and ordinary superphosphate were each applied in powder form to 6 containers (3 of each soil)at a rate of 100 ppm of phosphorus. The particle size of basic slag and rock phosphate was -100 mesh and of potassium metaphosphate and

TABLE 1

Aecia production by *Cronartium comptoniae* on lodgepole pine after treatment in 1969

Treatment	1970 Aecia production[a] Mean	1970 Aecia production[a] Range[b]	1970 % tree mortality	1971 Aecia production Mean	1971 Aecia production Range	1971 % tree mortality	1972 Aecia production Mean	1972 Aecia production Range	1972 % tree mortality
DSMO + Water	0.69	0-1.36	0	0.90	0.13-1.46	20	0.54	0.28-1.33	20
DMSO + Water + Cryptosporiopsin	0.74	0.15-1.32	0	0.69	0-1.36	10	0.46	0-1.00	20
Fuel Oil	0	0	30	0.02	0-0.10	50	0.03	0-0.14	60
Fuel Oil + Phytoactin	0.01	0-0.05	30	0.04	0-0.23	50	0.10	0-0.35	60
Water only	1.43	0.92-2.23	20	1.56	1.00-2.38	20	0.87	0.42-1.31	20
None	0.80	0.50-1.17	0	0.98	0.41-1.59	0	0.68	0-1.21	0

[a] Expressed as a proportion of the corresponding measurement for each canker taken before treatment.

[b] Range of individual measures from each 4 – 10 trees (only measurements from living trees were averaged).

ordinary superphosphate -60 mesh. Six containers received no phosphorus and served as controls. Soil and fertilizer in each pot were thoroughly mixed.

Four sitka spruce seedlings (2 + 0) were planted in each of the containers of soil from Badger and two black spruce seedlings (2 + 2) in each of the containers of soil from Deer Lake. Seedlings were grown in a greenhouse at 25 C until noticeable differences in growth were observed between treatments. This required a period of 18 months for the sitka spruce and 12 months for the black spruce seedlings. After harvesting, the aerial parts of the seedlings were oven-dried at 70 C, weighed, and ground in a small Wiley mill. Total phosphorus in the ground samples was determined by the Dickman and Bray method (Ind. Eng. Chem., Anal. Ed. 12:665-668, 1940). Data on the analysis of the two soils are given in Table 1. Data for dry matter production and phosphorus uptake by sitka spruce and black spruce seedlings for each soil and each fertilizer treatment are presented in Table 2.

TABLE 1
Analysis of soil samples from upper 9 inches (5.1 cm) prior to fertilizer application

Soil	pH	Organic matter %	C/N ratio	Cation exchange capacity (meq/100g)	Available nutrients (lb./acre) N	P	K	Ca	Mg
Badger [1]	5.1	4.9	19.4	8.9	15.6	T[3]	96.0	64.0	52.0
Deer Lake [2]	4.5	3.5	18.7	9.8	15.6	5.0	104.0	88.0	50.4

[1] Mini humo-ferric podzol, sandy loam.
[2] Orthic humo-ferric podzol, sandy loam.
[3] Trace.

TABLE 2
Effects of four different sources of phosphorus on dry matter production and phosphorus uptake by sitka spruce and black spruce seedlings growing on two types of soils. [1]

Treatment	Sitka spruce on Mini humo-ferric podzol: Dry matter (g/pot)	P uptake (mg/pot)	Black spruce on Orthic humo-ferric podzol: Dry matter (g/pot)	P uptake (mg/pot)
1. Control	2.7a[2]	1.5	3.9a	5.3a
2. Basic slag	2.9a	2.2	7.6b	9.7a
3. Rock phosphate	3.5a	2.4	10.2c	8.8a
4. Potassium metaphosphate	4.8b	4.9	13.9d	17.4b
5. Ordinary superphosphate	6.3c	5.2	13.4d	19.4b
L.S.D. at 5% level	1.3	N.S.[3]	2.5	7.3

[1] The data are based on the means of three replicates.
[2] a, b, c and d – values followed by the same letter do not differ significantly at 5% level of probability.
[3] N.S. – No significant difference.

The superphosphate and potassium metaphosphate treatments produced significantly more sitka spruce dry matter than the basic slag, rock phosphate, and control treatments on a moderately acid mini humo-ferric podzol (Table 2). Superphosphate was superior to potassium metaphosphate. This result is attributed to high water solubility of the phosphorus present in superphosphate and its availability to the sitka spruce seedlings. In addition the seedlings may have responded to sulphur which is present in superphosphate as calcium sulphate. Phosphorus in rock phosphate and basic slag is insoluble in water, and thus unavailable to seedlings. Benzian (Proc. Fert. Soc. Lond. 94: 3-35, 1966) tested three phosphate fertilizers on moderately acid soils under nursery conditions with similar results. Phosphorus uptake by sitka spruce showed a similar pattern to that observed for dry matter production, but all differences were non-significant.

Superphosphate and potassium metaphosphate treatments produced significantly more black spruce dry matter and greater uptake of phosphorus than the rock phosphate, basic slag and control treatments on a strongly acid orthic humo-ferric podzol soil. Increased availability of phosphorus from superphosphate results from its high water solubility; the availability of phosphorus from potassium metaphosphate is a result of greater dissolution caused by hydrolysis and strong acidity in the soil. Rock phosphate and basic slag also significantly increased dry matter production over the control, although not to the same extent as did superphosphate and potassium meta-phosphate. This result is also attributed to the highly acidic nature of the soil which caused some dissolution of phosphorus from these two fertilizers.

This experiment suggests that superphosphate and potassium metaphosphate may be the best types of fertilizer for use on the soils tested. However, before these fertilizers can be recommended for operational use, their long term effectiveness in comparison with rock phosphate and basic slag needs to be determined under field conditions.—N. D. Bhure, Newfoundland Forest Research Centre, St. John's, Nfld.

Errata: Vol. 28, No. 6
p 40, col 2, line 17 under Silviculture; should be (1.6 cm).
p 40, col 2, line 18 under Silviculture; should be (2.0 cm).
p 40, col 2, line 19 under Silviculture; should be (2.1 – 3.1 m).
p 41, col 1, line 1 under Table 1; should be (7.6 cm).
p 41, col 1, line 6 under Table 1; should be (58.4 x 38.1 x 10.6 cm).

(Continud from back cover)

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