GERMINATION AND EARLY GROWTH OF WHITE SPRUCE ON ROTTEN WOODS AND PEAT MOSS IN THE LABORATORY AND NURSERY

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NORTHERN FOREST RESEARCH CENTRE
EDMONTON, ALBERTA
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ABSTRACT

Rotten spruce wood proved superior for growth of white spruce during the first 85 days of growth in laboratory and nursery compared to rotten woods of aspen and birch, *Sphagnum* peat, and perlite. Rotten woods of aspen and birch as well as peatmoss appeared suitable for germination and growth only for reasons of available moisture. After four years of growth in the nursery, seedlings grown on peatmoss proved on the average to be 32 times heavier than seedlings grown on any of the other seedbeds. The early advantage of the spruce wood seedbed was therefore of little consequence to seedling establishment in the absence of alternate sources of nutrients. The considerable amount of second year germination on rotten woods in the nursery may be of significance to seedling establishment of white spruce in nature, especially when compared with the virtual lack of second year germination on peatmoss or mineral soil.

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INTRODUCTION

Rotten wood is a very important seedbed material in temperate coniferous forests. Between 15% and 30% of the forest floor may be covered with rotten wood at a given time (Day and Duffy, 1963; McFee and Stone, 1966) because this material is incorporated so slowly into the soil profile. In undisturbed forests of Central Canada, where white spruce (Picea glauca (Moench) Voss) generally follows trembling aspen (Populus tremuloides Michx.) in the forest succession, up to 90% of all natural white spruce reproduction may be on rotten wood seedbeds (Phelps, 1948). Such seedbeds function more as moisture reserves (Place, 1955) than as sources of nutrients, although little is known of their nutrient status (McFee and Stone, 1966). Because rotten wood seedbeds are raised slightly above the forest floor, small tree seedlings established on rotten wood are less likely to be smothered by leaves and grass than on the adjacent forest floor (Rowe, 1955).

This study evaluates the rotten wood from several tree species as substrates for germination and early growth of white spruce seedlings, and compares these substrates with peatmoss and perlite. Comparisons were made with peatmoss because it is a very common seedbed in boreal forests and because it is frequently used as a rooting medium in container seedling production. Perlite was included to permit comparisons with an inert material.

METHODS

Laboratory

All seeds for this study phase were collected in August 1964 from a 35-year-old white spruce tree in Riding Mountain National Park, Manitoba (50°38'N, 99°55'W). Two independent tests were conducted, each lasting 85 days. In both tests, 144 seeds were sown in each of two samples of perlite peatmoss and rotten woods of three tree species.

Rotten wood of white spruce, trembling aspen, and paper birch (*Betula papyrifera* March.) was collected near Chisholm, Alberta, about 100 miles north of Edmonton. Collections were taken from one log per species in February 1966. The peatmoss containing both *Sphagnum magellanicum* Brid. and *S. recurvum* P. Beauv., was collected from the same vicinity as the rotten wood. The rotten woods and peatmoss were air dried, crushed, and passed through a 5mm screen, with the intent to make all seedbeds similar in texture; differences in growth and morphology could be more easily attributed to the influence of nutrients. The wood was so well decayed in the field it could be easily crushed between the fingers. All woods were similar in their N and P contents with less than 5 pounds available N per acre and less than 12 pounds available P per acre. The rotten woods differed in K contents ranging between 132 and 276 pounds available K per acre, rotten wood of birch containing the most. Peatmoss and rotten woods of aspen and spruce had a pH of about 4.0 while that of rotten birch wood was 6.5[1].

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[1] N.P.K. and pH determinations were kindly made by Mr. D. L. Laverty, Agricultural Soil and Feed Testing Laboratory, Alberta Department of Agriculture, Edmonton, Alberta.

The seedbed materials and seeds were placed in plastic containers 15 cm x 35 cm x 10 cm deep[2]. Distilled water was added twice weekly and all excess water was drained off. Thiram fungicide was dusted very lightly over all seedbeds prior to seeding. Seedlings received about 500 ft-c of natural daylight over an 8-hour day during the summer test. Supplemental fluorescent lighting (12 hours per day) was added to maintain the same light intensity during the winter test. Temperatures fluctuated between 20°C and 30°C during both tests.

Nursery

The seeds for this phase of the study were collected in 1964 from a stand of white spruce in southwestern Alberta (51°41'N; 115°18'W).

The study was run for four years (between May 1967 and August 1970) at the Kananaskis Forest Experiment Station (51°N, 115°W) in southwestern Alberta. Seedbed materials and textures were the same as those used in the laboratory phase, all collected from the same logs except for the *Sphagnum* peat which was collected locally. Mineral soil seedbeds were added for comparison.

The organic seedbed materials were placed in holes 24 x 24 inches in area and 12 inches deep, sloping to a centre 15 inches deep dug into the nursery soil. All pits were lined with thick polyethylene (6-mil) with a central drain hole. Fourteen pits were dug: three each for rotten spruce wood, rotten aspen wood, rotten birch wood, and peat and two pits for perlite. The three mineral soil plots were 12 x 24 inches in area.

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[2] Merrygro Ltd., Unionville, Ontario

Sample plots were located in nursery beds in two rows, and in the organic seedbed materials at random. Soil plots were located between organic seedbeds and perlite. Pits were bordered with 1 x 4 inch lumber pieces set on edge to prevent contamination of the seedbeds with adjacent soil. The entire layout was shaded with snowfencing and watered periodically through the four years.

Cold stratified seeds (60 days @ 34°F) were seeded wet by hand to the density of 200 seeds per square foot of seedbed for all seedbed types. Beds were seeded in early May 1967. A total of 12,400 seeds were used.

Areas of seedbed 12 x 12 inches were excavated each year to give information on germination, growth, and survival over the four-year period.

Germination varied from a low of 50% on birch wood to a high of 58% on peatmoss. This difference proved statistically significant, but the practical consequence is probably minor.

Less than 10% mortality was recorded among seedlings grown on spruce and aspen wood as well as on peatmoss while there was 30% mortality on perlite and 31% on birch. Mortality on perlite occurred between the 75th and 85th day of the experiment and might be attributed to the exhaustion of food reserves in endosperm and cotyledons of earliest germinants.

RESULTS

Laboratory

Data from both tests were combined (as shown in Table 1) and comparisons were based on a 1-in-20 chance of error.

TABLE 1. CHARACTERISTICS OF GERMINATION, SURVIVAL, AND GROWTH OF WHITE SPRUCE GERMINANTS AS AFFECTED BY SEEDBED TYPE OVER AN 85-DAY PERIOD IN THE LABORATORY. (Each value represents an average of 100 measurements except for the percentages given which are based on actual germination and survival counts.)

Measure	Rotten wood of				
	Spruce	Aspen	Birch	Peatmoss	Perlite
Germination (%)	54.2	56.2	50.2	58.0	56.4
Survival (%)	93.8	90.8	69.0	90.5	70.0
Total Dry Weight (mg)	6.8	5.8	5.7	5.7	5.6
Root (mg)	2.1	1.7	1.7	1.1	1.2
Shoot (mg)	4.7	4.1	4.0	4.6	4.4
Root/Shoot ratios	0.4	0.4	0.4	0.2	0.3
Taproot (mm)	59.2	56.7	58.4	50.7	34.6
Hypocotyl (mm)	29.5	29.1	25.5	30.2	24.6
Cotyledons (mm)	21.3	11.9	11.2	12.2	11.8
No. of Lateral roots per germinant:					
Shorter than 5 mm	12.1	8.6	8.9	7.6	5.8
Longer than 5 mm	2.3	2.0	1.4	22.1	0.1

Continued growth was therefore assumed to be dependent on an external supply of nutrients. The mortality among seedlings on rotten birch wood (31%) was spread over the 85 days. This, and the low total germination on birch, are interpreted as a possible presence in the seedbed of an inhibitor to white spruce germination and early growth.

Total dry weight was significantly higher for seedlings grown on rotten wood of spruce than on any other medium tested. The fact that Rowe (1955) found that white spruce seedlings "preferred" the rotten wood of its own species for germination and early growth in the field, to that of aspen, is supportive evidence for the superior nature of rotten spruce wood as a seedbed compared to the other three organic media tested. The rotten woods, peatmoss, and perlite all produced seedlings of comparable but significantly lighter weight. The seedlings grown on rotten spruce wood also had greater total root weight, significantly more short roots, and slightly more long roots than seedlings on other media (except peatmoss). In addition to these observations, greater root branching, and the observed clubshaped tips of short roots suggest the possibility of mycorrhizal associations which might explain the greater total dry weight for seedlings on spruce wood than on the other media. The lack of a difference between seedlings on perlite and seedlings on aspen or birch wood or peatmoss suggests that rotten spruce wood contribute little but water to the survival of white spruce seedlings during the first year of growth. Variation observed in K contents among seedbeds apparently had no measurable effect on initial seedling growth or morphology for the duration of this study.

Seedlings grown on peatmoss had more roots longer than 5 mm than seedlings grown on rotten woods, quite low root-to-shoot ratios and root growth in such peatmoss was stringy, weak, and fragile. Seedlings grown in rotten woods were more robust and with more abundant short root growth. From results it may be suggested that seedlings grown on peatmoss would be more vulnerable to damage from drought than would seedlings grown on rotten wood seedbeds.

Dry weights of white spruce seedlings, grown in a fertilized nursery soil in Ontario, reported on by Armson (1965), were two to three times heavier than those obtained in this study. Therefore, although rotten spruce wood did produce heavier and more vigorous white spruce seedlings than did rotten woods of birch or aspen or even peatmoss, spruce wood is of sub-optimal value during the first 85 days of growth after germination.

Nursery

Significant amounts of germination were recorded over the first two years after seeding on rotten woods and perlite (see Figure 1) but not on mineral soil. Reasons for low germination on peatmoss was attributed to seeds being buried because of the somewhat lower compaction of this than other seedbeds. Mineral soil showed no added germination in the second year, presumably due to a relatively compacted seedbed surface permitting many seeds to wash away or get buried during heavy rains. The large difference between second-year germination on rotten woods as opposed to mineral soil is probably of significance under field conditions. No germination was observed in the third or fourth year after seeding.

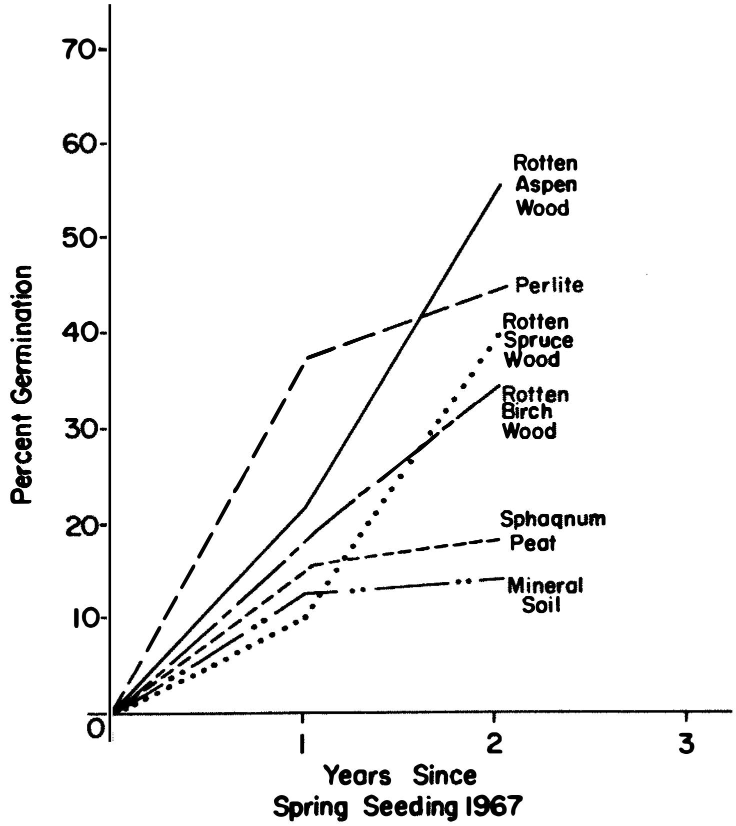

Fig. 1. Rate of germination for white spruce in the first and second year after seeding is dependent on seedbed type.

Figure 2 illustrates, for the first year, the same relation among seedbeds in the nursery as was found in the laboratory phase. Peat and perlite produced shorter and lighter plants after one growing season than did rotten woods. In subsequent years, however, peat proved to be far superior to rotten woods for height growth and dry matter production. Mineral soil produced larger and heavier plants in four years than rotten woods and perlite but significantly less than peatmoss. Seedling growth between the third and fourth year on mineral soil was negligible in this study. This was probably due to inadequate sample where only five seedlings were available for measurement.

While the root-to-shoot ratios for seedlings on rotten woods, mineral soil and perlite remained fairly constant between 0.4 and 0.6 throughout the four-year period, they dropped steadily from 0.6 to 0.2 for seedlings grown on peat from the first to the fourth year. The seedlings on peat became increasingly top heavy with time. The effects of peat on root-to-shoot ratios as measured in the first year (laboratory phase), is therefore accentuated as time passes.

CONCLUSIONS

These two phases of the study of white spruce seedling growth on rotten woods and native peat showed that rotten wood of spruce provided short term advantage in growth to white spruce seedlings, but that the advantage was lost in subsequent years. If seedling roots do not grow out of their rotten wood media within the first year of growth, the early advantage of seedbed moisture on rotten spruce wood is lost for lack of new plant growth. Conversely, to grow white spruce seedlings on unfertilized peat would retard growth slightly in the first year compared with rotten spruce wood, but that trend was completely overcome in the subsequent three years when a plant nearly 32 times heavier was produced on peatmoss other than on rotten woods of any kind. The continual germination of seeds on rotten wood seedbeds over two years in the nursery gave proof that seed losses in seeding operations on mineral soil were mostly due to seed burial or physical damage in nature.

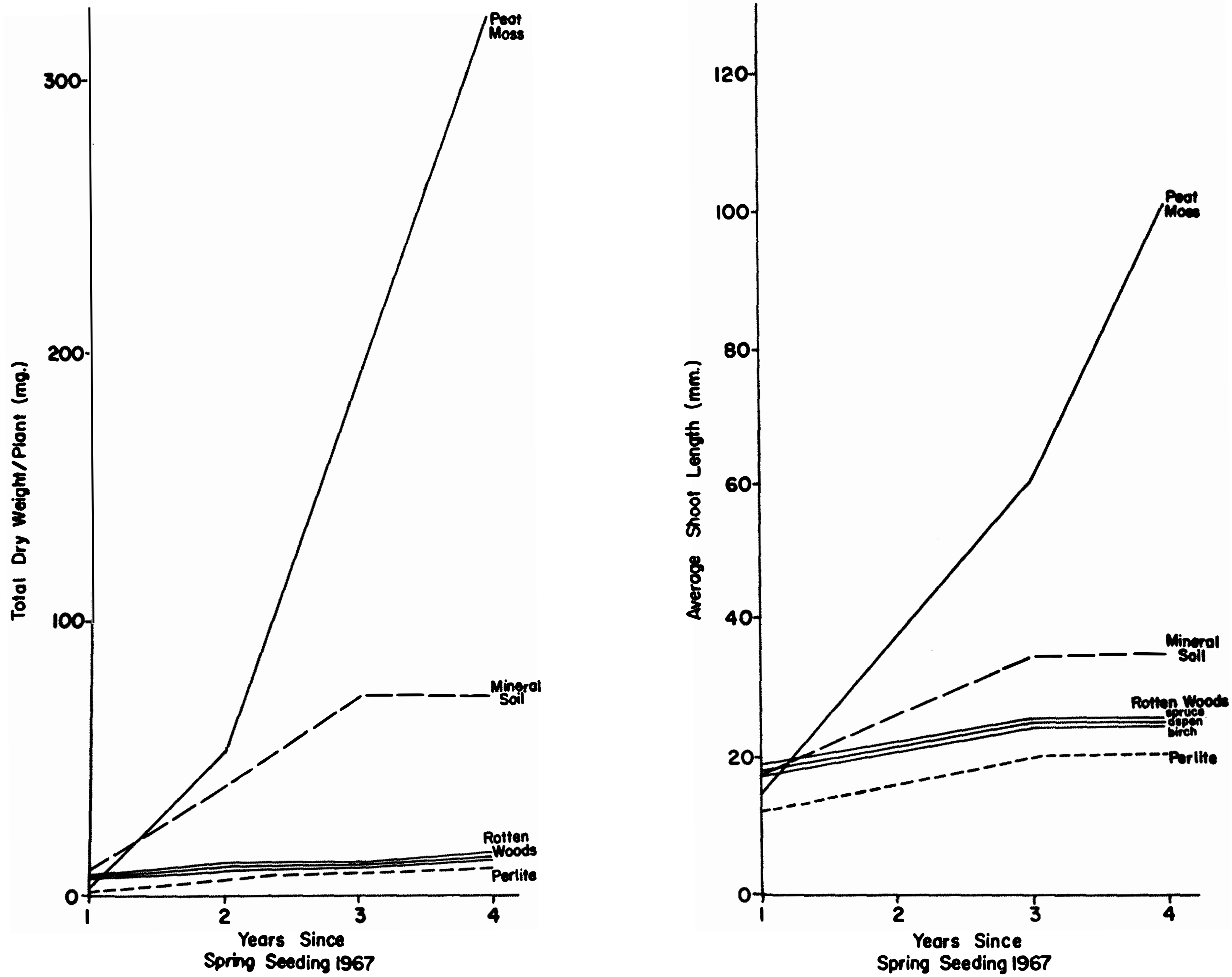

Fig. 2. Total dry weight production/plant and height growth for white spruce seedlings grown on rotten woods, peatmoss, and perlite over a 4-year period in the nursery. (Each point is based on between 10 and 20 observations except for mineral soil, fourth year only, when five plants were available).

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