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Time of Germination: A Factor in Rate of Growth of Accelerated Transplants of Black Spruce (*Picea mariana* (Mill) B.S.P.)

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*Cotyledonous black spruce (*Picea mariana *(Mill) B.S.P.) seedlings, initiated in "cigarette" germination plugs, were planted in peat cubes over a range of dates in the greenhouse. Following midsummer transplanting, bareroot trees were sampled in the fall of each production year. Rate of growth through the first and second year in the nursery is related to time of germination. Second-year growth is related to size of stock after the first season in transplant beds. Rate of growth in terms of daily dry weight increment was found to be related to time of germination through both the first and second seasons in the nursery. Second-year growth was also related to stock size at the end of the first season.* (Tree Planters' Notes 37(1):20-24; 1986)

In a 2-year bareroot transplant system for black spruce (*Picea mariana* (Mill) B.S.P.), uniform early germination and rapid early growth are essential. The size of transplants after one and two seasons in nursery beds varied directly with the duration of growing period since the time of germination (6). The results were attributed primarily to an extended growing season.

An additional factor is the rapid growth achieved through the season by plants from early germinated seedlings. In an accelerated transplant system, that is, greenhouse-initiated seedlings for transplanting as eventual bareroot shipping stock, time and space are important considerations in both quality and cost of seedlings. Pre-germination of seed may save several days of greenhouse operations and ensure full initial stocking of uniformly developed plants.

This report relates rate of growth in terms of plant dry weight production and time of germination in a 2-year accelerated transplant system.

Methods and Materials

Mean plant data--root collar diameter, plant height, oven-dry weight of roots and shoots, and shoot to root ratio--have been published (6). Total plant dry-weight data are presented here in relation to the duration of growth during the two growing seasons.

Stratified seed was sown in "cigarette" plugs of commercial peat moss rolled with cellulose tea bag material for "paper" (6). Seed was germinated under optimum conditions recommended by Fraser (1). After they shed their seed coats, the cotyledonous seedlings were planted in peat cubes 2.5 centimeters square and grown in a greenhouse for 6 to 14 weeks (depending on date of germination), and then removed for 2 weeks of conditioning. Plants were transplanted in July of 1975 by hand in normal nursery beds at Orono Forest Station, Orono, ON (lat. 43°59' N. long. 78°37' W.).

Seed were germinated over a range of dates from February 15 to June 11. From 400 to 3,000 cotyledonous seedlings were planted at each sowing time and grown in trays of approximately 400 cubes each. Trees of each tray, identified by time of planting, formed separate plots in the nursery bed. The stock was treated according to standard nursery procedures through the remainder of 1975 and 1976.

Samples were lifted in the fall of each production year; about 20 bareroot transplants were taken in a line across each bed. For each assessment, measurements of height and root collar diameter were made on each tree. Roots were separated from tops at the root collar. Both were oven dried at 105 °C for 24 hours to determine the mean dry weights of plant samples.

Results

First-year growth in terms of total plant ovendry weight is represented by the slope of lines from date of sowing to weight of 1-year-old plants harvested in the fall of the first season in the nursery (fig. 1). Germinates from successive sowings exhibited lower rates of increase in plant dry weight.

In the second season, all plants experienced a full growing season from flushing in May to lifting of samples in November. Growth through the season exhibited similar relationships of increase in dry weight relative to germination date in the first year (fig. 2).

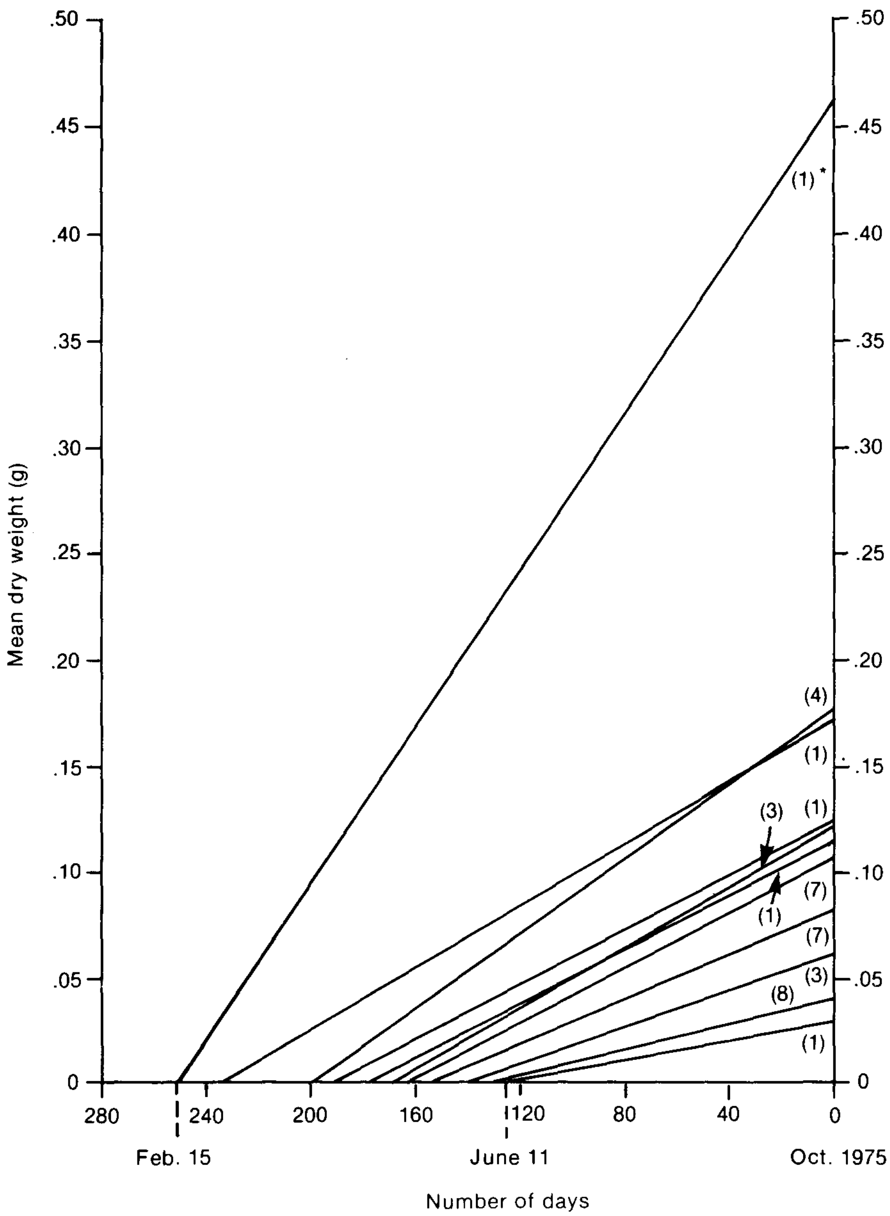

Figure 1—*First-year mean plant dry weight (g) related to duration of growing season in days prior to fall sampling. Numbers in parenthesis indicate number of 20-tree samples included in data.*

A first-year growth rate per day was calculated for each of 37 samples (table 1). First-year dry plant matter production (Y), measured in milligrams per day, correlated highly (r = 0.834) with time, in days, from germination to sampling (X), using the equation Y = -0.912 + 0.009X (fig. 3). The equation accounted for 69.9 percent of the variability in average growth rate. Mean daily growth rates through the first season varied from 0.24 milligram per day for seedlings germinated in June to 1.85 milligrams per day for those germinated in February (table 1).

Similarly, daily growth in the second year, calculated as second-year minus first-year mean dry weight over 180 days for the 36 samples available in the second year, correlated highly with total growing time over the 2 years (Y = -40.095 + 0.150X), accounting for 70 percent of growth variability (r = 0.837) (fig. 3). Second-year growth increments varied from 5.25 milligrams per day for plants from late germination in the first year to 27.00 milligrams per day for plants from earliest germination, associated with cumulative duration of growth of 308 to 432 days, respectively.

Second-year dry-weight increment also correlated highly with first-year mean plant dry weight (r = 0.820). The equation Y = 1 .061 + 9.595X, where Y is total dry-weight increment and X is dry weight of 1-year-old plants, accounted for 67.2 percent of the

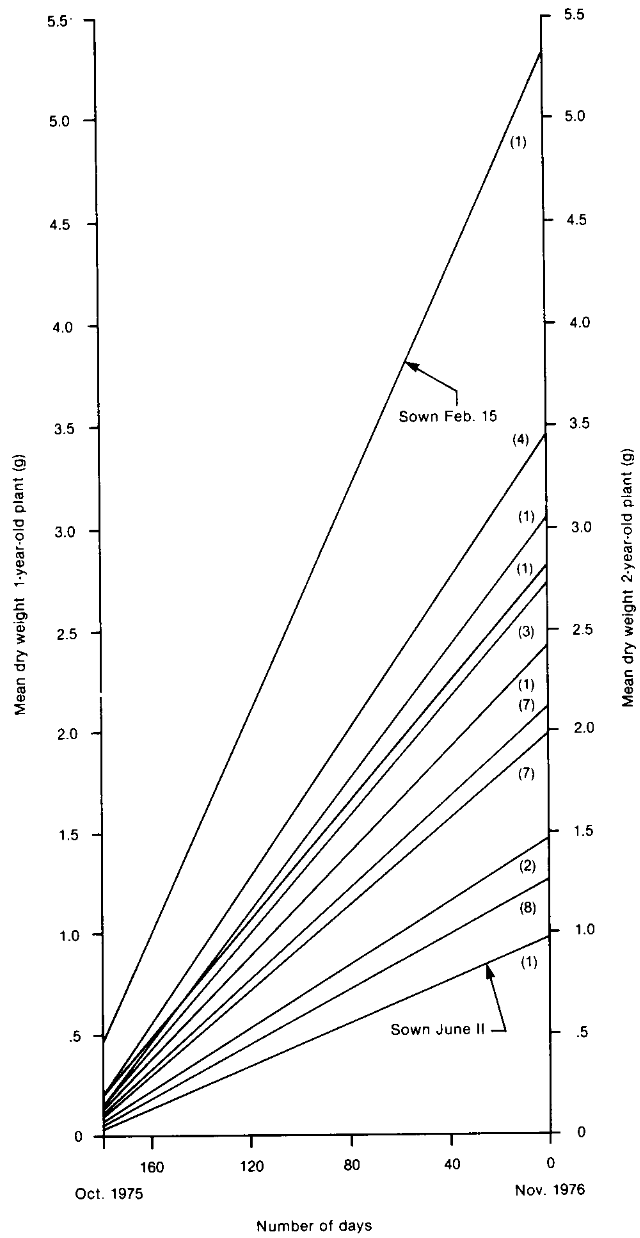

Figure 2—*Second-year mean plant dry weight (g) related to duration of growing season in days prior to fall sampling. Numbers in parentheses indicate number of 20-tree samples included in data.*

variability in mean second-year growth.

In each of the regressions, second- and third-order relationships were tested. In some instances these explained somewhat more of the variability in data. However these regressions were considered to be unduly influenced by limited information in the early weeks of the study. Therefore the linear regressions noted above were considered more appropriate for analysis of results.

Discussion

First-year growth of black spruce in nursery beds was not proportional to duration of growing season alone. Plants from seed germinated in February grew at mean daily rates that were five to eight times those of plants germinated in late May to early June. This increase was associated with a 100-percent increase in duration of growing season. During the second season, a three- to fivefold increase in daily growth was associated with a 40-percent increase in cumulative duration of growth over 2 years.

Scarratt and Reese (5) published growth progressions for jack pine (*Pinus banksiana* Lamb.) container stock to establish the time required to produce shippable stock for different sowing dates. Their data indicated faster rates of growth for seedlings that were germinated early. In fact, their oven-dry weight for 3- to 4-month-old first-year jack pine sown early exceeded that of

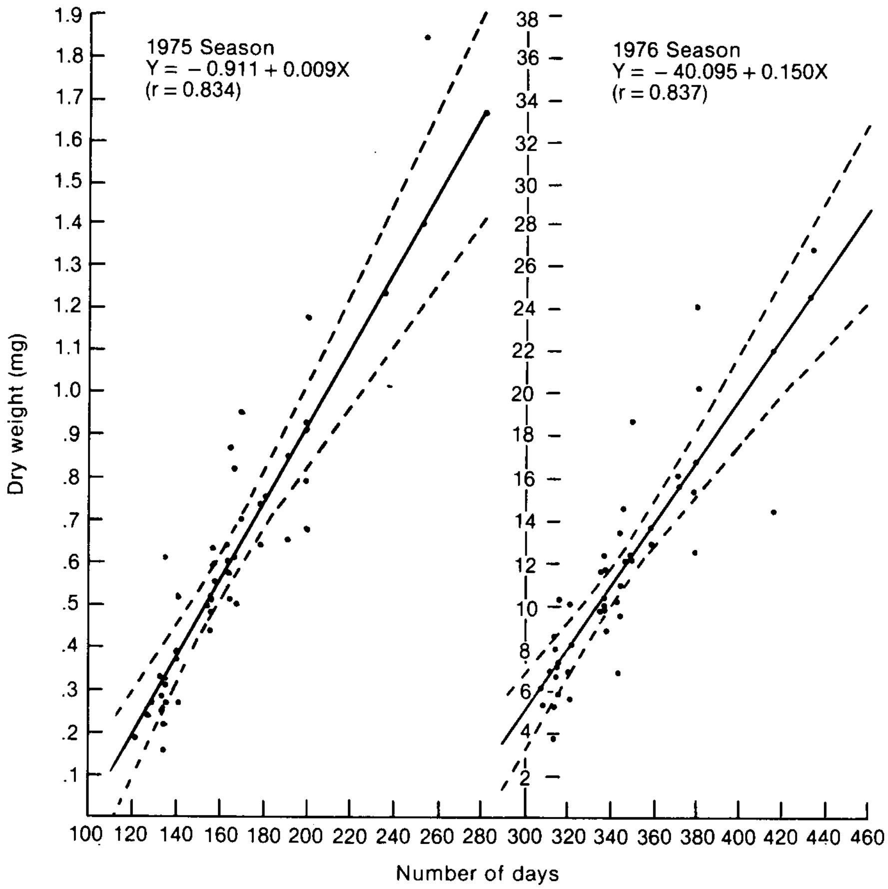

Figure 3—*Mean daily growth (mg) related to duration of growing season (days) with 95 percent confidence limits (2).*

overwintered 2-year-old plants sown late in the first year. Similar growth predictions have been developed for container stock of other species.* Hallett (3) showed different growth patterns for fall-sown black spruce container stock than for stock sown in the early spring.

*Sadreika, V. Forestry Resources Bureau, Ontario Ministry of Natural Resources, Toronto (personal communication).

Second-year growth of black spruce transplants in this study was directly proportional to size of plant at the end of the first season. June germinates grew into 1-gram plants in 2 years whereas February germinates weighed 0.5 gram at the end of the first season and 5 grams after the second season. Factors influencing the size of 1-year-old plants apparently have an important influence on the quality of 2-year-old bareroot shipping stock.

One important component contributing to early vigor is pregermination of seed. If seed are germinated before they are planted in the greenhouse, plants can take full advantage of the growing degree days during the early part of the growing season, when growth is most vigorous. The time saved depends on the pregermination system employed. Use of day-old germinates saves up to a week of greenhouse time; use of cotyledonous seedlings or young trees may save from 4 to 8 weeks. Germination of seed and early plant development can be accomplished in a fraction of the space required for later plant growth. Use of pregerminant seed or cotyledonous seedlings planted in a greenhouse production system produce better stocking.

A heated greenhouse provides an advantage in terms of growing degree-days over a "Finn house" in which auxiliary heat is provided only to prevent freezing. Insulated plastic nursery bed shelters (7) provide less of an advantage in terms of growing conditions but represent lower capital costs and no cost of heat energy. In each case, sowing pregerminated seed provides more uniform plant development and full initial stocking.

The influence of first-year plant size on rate of subsequent growth is a factor to be considered in production of other stock products. In container production, valuable

Table 1—*Daily rates of growth relative to date of sowing*

Sowing date	No. of trays	First-year assessment (1975): Length season (days)	Mean plant dry wt (g)	SD	Daily growth (mg)	Second-year assessment (1976): Cum. length 2 seasons* (days)	Mean plant dry wt (g)	SD	2nd year growth increment (g)	Daily growth (mg)
Feb 15	1	252	0.465	—	1.85	432	5.325	—	4.860	27.00
Mar 2	1	234	.172	—	0.74	414	2.798	—	2.626	14.59
Apr 1/2	4	199	.178	0.043	0.89	379	3.429	0.891	3.251	18.06
Apr 9	1	191	.124	—	0.65	371	3.033	—	2.909	16.16
Apr 22	1	178	.114	—	0.64	358	2.418	—	2.304	12.80
May 1	3	169	.121	.039	0.72	349	2.713	.703	2.592	14.40
May 5/7	7	164	.107	.023	0.65	344	2.108	.483	2.001	11.12
May 13/15	7	156	.083	.010	0.53	336	1.993	.226	1.910	10.61
May 27	3	141	.055	.018	0.39					
	2					321	1.466	.576	1.411	7.84
Jun 4/7	8	134	.041	.018	0.31	314	1.254	.346	1.213	6.74
Jun 11	1	128	.031	—	0.24	308	.976	—	.934	5.25

*Duration of 1975 season + 180 days in 1976.

greenhouse space is often used for two or more changes at different times in the season. Little is known of the effect of time of germination on vigor of outplanted trees. Similarly, production of seedling stock is based on variable germination times through the first season in nursery beds. Later germinates with reduced vigor and a shorter growing season produce smaller 1-year-old plants. This contributes to the variability common in beds of black spruce and adds to the reduced yield and increased cost due to culling.

In the 2-year accelerated transplant system for black spruce described here, trees from early sowings grew to a size comparable to 3-year-old bareroot nursery stock standards in Ontario (4). Rapid early growth due to early germination formed a major component of this success. Pregermination of seed is one economical means of improving on germination time in this or any stock system, thereby reducing the space and heating energy required for growth during the coldest period in the production schedule.

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