GROWTH OF YELLOW BIRCH SEEDLINGS FROM EIGHT PROVENANCES IN VARYING GROWING MEDIA

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By combining genetic selection with optimum greenhouse culture and using recommended nursery practices, yellow birch planting stock can be produced in 12 to 14 weeks.

A difficulty encountered in both natural and artificial regeneration of yellow birch (*Betula alleghaniensis* Britton) is variability in germination and early growth associated with seedbed and/or growing media (*1,4,8*). Numerous studies have demonstrated that yellow birch requires a specific combination of environmental factors for adequate germination and seedling growth (*11,12,13*). The use of greenhouse culture for raising tree seedlings permits some degree of control over environmental conditions (*10*). Hanover and Bongarten (*6*) caution, however, that in evaluating genetically diverse plant material under greenhouse conditions, one must be assured that seedlot X environment interactions are minimal if early evaluations and selections are to be reliable. In an environmentally sensitive and genetically variable species such as yellow birch, such a concern is of paramount importance. This study compares the growth of yellow birch seedlings from eight New England provenances under greenhouse conditions that varied in growing media and fertility level.

Materials and Methods

Seed procurement and handling. During fall 1978, seeds were collected from three average yellow birch trees within each of eight northern hardwood stands in Vermont and Massachusetts (table 1). Seeds were bulked by stand to represent eight provenances, dried at room temperature, and separated from. bracts by sieving. For each provenance, 150 unstratified seeds were weighed and tested for germination in moist petri dishes using a 24-hour photoperiod.

Experimental design and treatments. A split-plot greenhouse experiment was established to test the effects of two growing media and liquid fertilizer on the growth of yellow birch seedlings from eight provenances. Considering two media with and without liquid fertilizer additions, a total of four treatment combinations were tested across eight provenances.

Eight Spencer-Lemaire Hillson book containers, each containing four 164-cubic-centimeter (10 in)^3 cavities, were placed in each of 16 trays. The trays were arranged in four blocks (repli-

Table 1.—*University of Vermont accession number, location, germination percentage, and seed weight of eight yellow birch provenances used in this study.*

UVM number	Town and State	Latitude	Longitude	Elevation	Germination	Weight per 150 seeds
				Meters	*Percent*	*Grams*
0206	Underhill Cen, Vt.	44°32'	72°51'	523	33	.1792
0219	Jericho, Vt.	44°27'	73°00'	200	35	.1794
0221	Wolcott, Vt.	44°36'	72°25'	397	28	.1311
0224	Sutton, Vt.	44°44'	72°06'	535	47	.1636
0230	Jeffersonville, Vt.	44°35'	72°44'	665	68	.2440
0235	Granville, Vt.	44°03'	72°52'	400	45	.1509
0240	N. Shrewsbury, Vt.	43°34'	72°48'	523	40	.1420
0276	Chesterfield, Mass.	42°23'	72°50'	339	24	.1258

cations) each containing four trays. A single row of containers was placed around the perimeter of each block to minimize edge effects.

Two standard growing media, including base fertilizer components, were added to each of two trays in every block. Media 1 consisted of 6 parts sphagnum peat; 3 parts fine gravel; 2 parts sandy loam; 1 part sand; and 4,765 grams per cubic meter of 14-14-14 osm6cote, a slow release fertilizer. Media 2 consisted of 1.5 parts coarse perlite; 1 part sandy loam; 1 part sifted sphagnum peat; and the following nutrients: 5,935 grams per cubic meter of super phosphate (0-20-0), 10,460 grams per cubic meter of ground limestone, and 183 grams per cubic meter of fritted trace elements. The pH's of media 1 and 2 were 5.5 and 5.7, respectively.

On January 30, 1978, seeds from each of the provenances were randomly sown in one of the eight containers within each tray. Growing conditions included an 18-hour photoperiod (natural day length supplemented with fluorescent and incandescent lights) and an intermittent mist controlled by an evaporation leaf. Temperatures varied diurnally from 24° to 29° C. Three weeks after sowing, seedlings were thinned to one per cavity, resulting in one four-tree plot for each provenance in each tray.

Beginning 4 weeks after sowing, 15 milliliters of Ingestad solution, a balanced liquid fertilizer formulated by Ingestad (*7*) and modified by Pelham and Mason (*9*), was applied weekly to each seedling in one tray of each soil mix in each block. As a control, the nonfertilized seedlings received 15 milliliters of water per week through the 14th week. The experiment ended after 16 weeks of growth.

Measurements and data analysis. Height measurements were taken the 5th week after sowing and continued on a weekly basis through the 8th week, then every other week through the 16th week. Diameter at 1 centimeter above the soil surface was measured after 16 weeks of growth. All data were recorded as four-tree plot means. Data were analyzed using analyses of variance, and least significance differences (LSD) were used to determine the significance of differences between means. Growing media, fertilizer, and their interaction were considered as main treatments, while provenance and provenance X main treatment interactions were considered as subtreatments. Simple correlations were used to examine relationships among traits.

Results and Discussion

Seed weight and germination. Seed weight and germination percent, both parental characteristics, varied considerably among provenances (table 1). Weight of 150 seeds per provenance ranged from .1239 gram to .2440 gram and germination ranged from 24 percent to 68 percent. In general, provenances with heavy seed had the highest germination ($r = .82$, $P < .05$, 6 df). Seeds from provenance 0230 (Jeffersonville, Vt.) were heaviest and had the highest germination, while seeds from provenance 0276 (Chesterfield, Mass.) were lightest and had the lowest germination. The apparent relationship between seed weight and germination is not conclusive, however, because filled and empty seeds were not separated.

Provenance variation. Provenance differences in height and diameter were significant at all measurement ages. Diameter differences were somewhat less than those for height, but the relative performance of provenances was similar for the two growth traits ($r = .86$, $P < .01$, 6 df). After 5 weeks of growth, seedlings from provenance 0230 (Jeffersonville, Vt) were tallest, averaging 2.3 centimeters, while seedlings from provenance 0221 (Wolcott, Vt) were shortest, averaging 1.6 centimeters (table 2). With time, however, the pattern of relative height growth changed. By the age of 16 weeks, seedlings from prov-

Table 2.—*Relative height and diameter of greenhouse-grown yellow birch seedlings from eight New England provenances.*

UVM	*Relative height at age:*			*Relative diameter at age:*
accession no.	5 weeks	10 weeks	16 weeks	16 weeks
	Percent of experiment mean			
0206	94	87	88	89
0219	112	113	118	115
0221	84	86	86	90
0224	95	99	99	96
0230	116	104	100	108
0235	107	105	103	100
0240	02	102	99	105
0276	98	106	107	102
Mean (cm)	2.0	15.1	31.7	.29
LSD% (.05)	8.6	15.3	12.7	11.2

enances 0219 (Jericho, Vt) and 0276 (Chesterfield, Mass.) were tallest (37.5 and 34.0 cm), seedlings from provenance 0230 were average (31.7 cm), and seedlings from provenance 0221 were shortest (27.4 cm). Changes in relative provenance performance with time may have been due to a residual effect of seed weight on early growth rate. The relatively heavy seed of provenance 0230 may have given trees from that source an initial growth advantage, whereas the light seed of provenance 0276 may have been responsible for its relatively slow early growth. After 5 weeks of growth, seed weight was significantly correlated with mean provenance height ($r = .72$, $P < .05$, 6 df). With time, however, seed weight effects became unimportant.

Despite large genetic variability in seedling growth, no significant correlation was found between either height or diameter and latitude, longitude, or elevation of seed source. These results, although based on a relatively small sample of the species' natural range, are consistent with those of Clausen (*2,3*), who reported on a range-wide provenance test of yellow birch in Wisconsin.

Media and fertilizer effects. Growth of seedlings after the 8th week depended strongly on the specific combination of growing media and fertilizer treatment. Without the addition of Ingestad solution, seedlings in media 1 were significantly larger in height and diameter than those in media 2. However, when Ingestad solution was applied, media 2 produced significantly larger seedlings. Ingestad solution had no significant effect on the size of seedlings grown in media 1, whereas it did significantly increase the size of seedlings grown in media 2 (fig. 1). The best treatment, therefore, was media 2 with Ingestad solution, which produced seedlings averaging 37.8 centimeters tall and 0.32 centimeters in diameter after 16 weeks, the worst treatment was media 2 without Ingestad solution, which produced seedlings averaging 20.9 centimeters tall and 0.24 centimeters in diameter. Mean 16-week heights and diameters for seedlings grown in media 1, with and without Ingestad solution, were 33.8/0.29 and 34.5/0.30 centimeters, respectively.

The large media x fertilizer interaction was probably due to the base fertilizer levels contained in each growing media. Media 1 contained osmocote, a slow-release fertilizer, that apparently provided near optimum nutrient levels and/or ratios for yellow birch seedling growth. Media 2 contained only trace elements, super phosphate, and limestone as an added nutrient

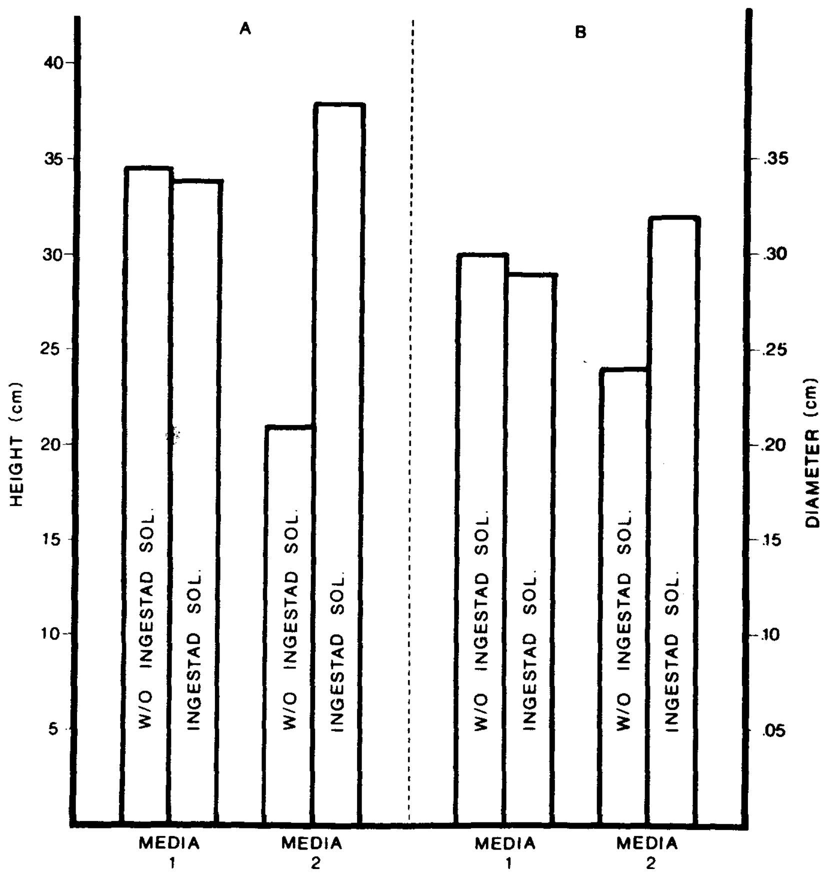

Figure 1.—*Height (A) and diameter (B) of yellow birch seedlings grown under greenhouse conditions in two growing media with and without Ingestad solution, a balanced liquid fertilizer.*

source. Because good growth in media 2 depended on the addition of liquid fertilizer, it appears that nutrient status, rather than a physical property, is a limiting factor in this media. Trees growing in media 2 without Ingestad solution had chlorotic leaves after 10 weeks of growth, suggesting that nitrogen was the primary limiting nutrient. Because growth in media 1 was independent of liquid fertilizer additions, it appears that the deficiency in that media is related to physical, as opposed to nutrient, factors. Algae growth was evident on the surface of media 1 suggesting that perhaps aeration and drainage conditions were sub optimum.

Combined provenance-treatment effects. Despite large and significant growth differences due to provenance and cultural treatments, provenance ranking by height and diameter remained essentially constant regardless of growing media and liquid fertilizer applications. This lack of interaction is encouraging from the standpoint of assessing the utility and reliability of using greenhouse culture as a tool in genetic testing. Our results suggest that, at least in making growth comparisons among New England provenances of yellow birch, accurate results can be obtained in greenhouses that use a diversity of soil and nutrient conditions.

Conclusions

The data accumulated thus far indicate that considerable gain in yellow birch seedling growth can be achieved by combining genetic selection with optimum greenhouse cultural practices. Sixteen-week old seedlings from provenance 0219 (Jericho, Vt.) were 18 percent taller than average when growth was evaluated over a range of growing media-fertilizer combinations. If seedlings from that provenance were grown in only the best soil-fertilizer combination (i.e., Ingestad solution in media 2), one could expect an 18 percent height advantage due to genetic selection, plus an additional 19 percent height advantage due to cultural practices, the end result being seedlings 37 percent taller than average or 43.5 centimeters tall at 16 weeks. Of course, as the germ plasma base for selection is expanded and cultural procedures become more refined, one may expect additional gain in growth rate. By combining genetic selection with optimum greenhouse culture, one can produce yellow birch planting stock in 12 to 14 weeks, instead of 2 years, using recommended nursery practices (*5*) and nonselected seed sources. Difficulties associated with the greenhouse-field planting transition and the maintenance of early genetic differences in growth rate must be addressed, however, before the full potential of such a growing system can be fully evaluated.

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