VARIATION IN HEIGHT GROWTH AND GROWTH CESSATION OF 55 YELLOW BIRCH SEED SOURCES

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Yellow birch (*Betula alleghaniensis* Britt.) is an important hardwood species in the Lake States, northeastern United States, and eastern Canada. Since it produces valuable timber, the species is a logical candidate for genetic improvement. An understanding of the variation pattern in a species is, however, basic to any improvement program.

In 1963 the Institute of Forest Genetics, Rhinelander, Wisconsin, initiated a study of natural variation in yellow birch. This paper describes variation in height growth and growth cessation in 2-year-old seedlings grown from the material collected for this study.

Methods

Seed was collected in 1963 and 1964 with the generous assistance of many cooperators in the United States and Canada. Most of the 55 sources used in the study (fig. 1, table 1) include seed of 10 or more trees per stand. Exceptions are sources 3068, 2958, 2996, and 3001 which represent seed of one, four, eight, and eight trees, respectively.

On March 24-26, 1965, three seed lots of each source were sown in flats and covered with moist peat. The flats were kept at 35° F. in a cooler for 4 weeks and then moved to a lathhouse. When germination was complete the seedlings were given supplementary light and grown under long days (18 hours) until transplanted. The seedlings were transplanted into four randomized complete blocks in the Hugo Sauer Nursery at Rhinelander on July 22-28, 1965.

Height growth of 20 seedlings in each plot was measured at the end of the first and second growing season. First-year height is probably confounded with the long-day treatment and the effects of the transplanting; hence only second-year height growth is considered here. To determine when the plants stopped growing during the second year height growth of five seedlings per plot was measured weekly from July 6, 1966, until shoot elongation had ceased.

Results and Discussion

The average hight growth of the 55 seed sources during their second year was 122.3 mm, but the individual sources varied from a low of 86.1 mm to a high of 164.0 mm (table 1). Thus, the West Virginia source (2969) and the Lower Michigan source (2961) grew almost twice as much as Nova Scotia source 3065, which was poorest. All but four sources performed better than the local source (3298). The differences between the sources were highly significant (table 2), but much block variation was also present. The best block, for example, averaged 43 percent more height growth than the poorest one. The differences between the blocks appear to be partially related to their relative proximity to a windbreak, but may also be due to soil differences or other environmental factors.

The seed sources stopped growing an average of 7.2 weeks after July 6, the date of the first measurement, but individual sources varied greatly in time of growth cessation. Source 3243 from eastern Newfoundland ceased growth one week earlier than the average, while the Kentucky source (3294) remained active 11/2 weeks later than the average (table 1). Thus, growth cessation of the sources took place over a period of about 21/2 weeks or from about August 11 to August 28. The 14 sources which ceased growth at the same time as, or later than, the local source (3298) were all of more southerly origin than the local source. The differences between the sources were highly significant (table 2), and again there was significant variation between the blocks.

Correlation analyses showed that height growth of 2-year-old seedlings is apparently not correlated with latitude, longitude, length of growing season, annual precipitation, and average July temperature of the seed sources; furthermore, height growth appears to vary in a random manner. Although some of the variation between the sources seems to be due to differences in growth rate, these differences do not follow any consistent geographic pattern. Second-year height growth is also uncorrelated with growth cessation, and surprisingly, with first-year height. Whether the pattern of variation in height growth of yellow birch is actually random should become apparent with future measurements.

Growth cessation, on the other hand, is inversely correlated with latitude, directly correlated with average July temperature, weakly correlated with length of growing season and annual precipitation, and independent of longitude (table 3). Generally speaking, northern sources stopped growing earlier than southern sources, indicating photoperiodic control of growth cessation. This result agrees with previous work by Wang and Perry (1958) who reported that photoperiod controlled cessation of shoot elongation in yellow birch and paper birch (*Betula papyrifera* Marsh.).

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Table 1. — Origin, mean second-year height growth, and mean growth cessation of 55 yellow birch seed sources

Source no.	State or province	Degrees of-- Lat.	Degrees of-- Long.	Elevation (ft.)	Growing season (days)	Height growth (mm)	Growth cessation 1/
3243	Newfoundland	47.2	53.4	50	110	117.9	6.15
3244	"	48.6	58.2	400	110	135.0	6.50
3241	Nova Scotia	46.6	60.5	100	120	146.0	7.10
3065	"	45.4	61.8	450	102	86.1	7.20
3242	"	44.8	65.2	650	130	117.8	7.05
3063	"	44.1	65.8	350	140	101.2	7.65
3068	New Brunswick	46.0	66.4	300	126	146.4	7.30
3066	"	47.4	65.2	300	130	131.4	6.85
3067	"	47.5	67.4	925	70	131.8	6.45
3001	Province of Quebec	49.2	65.1	300	135	95.6	6.25
2998	"	48.2	70.2	1000	107	108.4	6.40
2997	"	47.0	70.3	400	120	100.8	6.80
2999	"	47.4	72.6	1000	107	124.1	6.95
3000	"	47.5	75.0	1500	90	104.0	6.60
3002	Ontario	45.1	76.9	1000	115	136.3	7.20
3003	"	46.1	79.0	1000	115	117.2	6.95
3004	"	46.7	79.6	1000	115	119.8	6.95
3311	"	45.0	81.4	625	145	139.6	7.25
3309	"	47.5	84.8	1000	110	118.4	6.75
2977	Maine	44.8	68.6	250	142	109.8	7.30
2956	"	43.7	70.9	1000	130	96.5	7.25
2985	New Hampshire	44.0	71.4	1900	125	101.6	7.00
2986	"	43.5	71.4	1300	130	145.4	7.60
2982	Vermont	44.7	72.6	1250	115	124.5	7.25
2971	Massachusetts	42.7	73.2	1610	150	116.4	7.35
2980	New York	49.2	74.9	1620	111	130.6	7.40
2996	"	42.5	74.2	2100	135	129.4	7.35
2976	"	42.3	77.3	1300	145	150.6	7.75
2979	Pennsylvania	41.3	76.3	2300	150	132.3	7.35
3312	"	41.6	78.7	1800	120	158.4	7.75
2969	West Virginia	39.0	79.7	2200	145	164.0	8.15
3299	Virginia	37.8	79.1	3000	175	111.7	7.65
2959	North Carolina	35.7	82.3	5160	135	134.1	7.90
2973	Georgia	34.8	83.8	4700	185	111.2	7.35
2953	Tennessee	35.2	85.7	1740	180	115.0	7.90
2954	"	35.7	85.3	1420	185	90.2	7.50
3294	Kentucky	36.9	82.9	3600	180	142.5	8.55
2955	Ohio	39.5	82.5	830	165	131.0	7.65
2958	Indiana	38.3	86.5	700	165	118.7	7.35
2983	Illinois	41.9	89.4	680	164	112.3	7.45
3295	Iowa	42.4	93.1	1050	150	151.1	7.30
2961	Michigan	45.0	85.0	1000	110	163.8	7.55
2960	"	45.9	84.8	625	140	126.6	6.90
2978	"	46.7	87.9	1675	110	130.2	6.60
2987	"	47.0	88.7	1250	140	108.3	6.90
2968	Wisconsin	46.5	92.1	1150	140	123.6	6.80
3298	"	45.7	89.0	1710	110	96.1	7.45
3297	"	44.5	90.4	1100	130	125.1	7.50
2962	"	44.9	87.2	600	145	130.4	7.30
2963	"	43.1	88.4	900	165	114.0	7.00
2964	Minnesota	44.2	94.1	800	150	95.4	6.90
2965	"	47.2	95.2	1480	100	127.6	7.00
2966	"	47.6	92.5	1700	110	122.0	6.75
2967	"	47.8	90.2	1400	130	107.6	6.60
2957	Isle Royale, Michigan	47.9	89.1	750	120	101.2	6.65

1/ In weeks after date of first measurement, July 6, 1966.

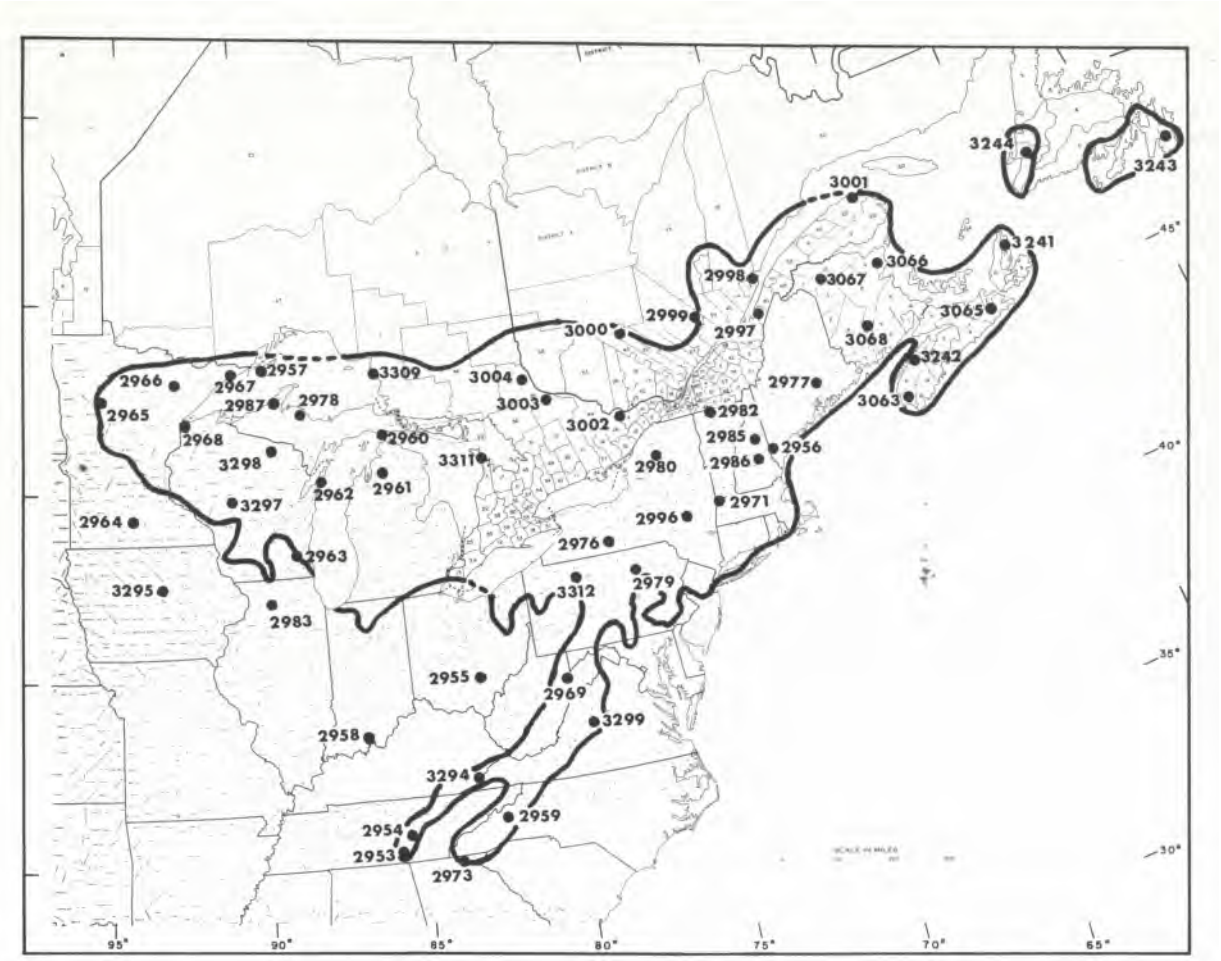

FIGURE 1. — Natural range of yellow birch adapted from maps in Fowells (1965) and Dansereau and Pageau (1966) and location of seed sources.

Table 2. — Analysis of variance of height growth and growth cessation of 55 yellow birch seed sources

Source of variation	Degrees of freedom	Variance ratio (F) Height growth	Growth cessation
Blocks	3	34.39**	29.13**
Sources	54	2.53**	2.21**
Error	162	--	

1/ The analysis is based on plot means.

** Significant at the 1-percent level.

Table 3. — Correlation between height growth and growth cessation of 55 yellow birch seed sources and environmental variables of the seed sources

Environmental variable	Height growth	Growth cessation
Latitude	-.1206	-.7824**
Longitude	.0176	.2157
Length of growing season	-.0523	.5606**
Annual precipitation	.0704	.5168**
Average July temperature	.1031	.6274**

Conclusion

This study provides no evidence of clinal variation in height growth of yellow birch. On the other hand, certain seed sources grew much better or worse than others during the second year in the nursery; it would, however, be premature to consider them ecotypes. Since variation in height growth appears to be random over the natural range of this species, the amount of variation present within more limited geographic areas should be considered. In the Lake States region, for example, the difference between the best and the poorest seed sources was 34 percent for Minnesota, 36 percent for Wisconsin, and 52 percent for Michigan. When the 14 Lake States sources are compared as a group, the southern Minnesota source (2964) is 20 percent shorter and the Lower Michigan source (2961) 37 percent taller than the Lake States average. Thus, much potential growth may be lost if a slow-growing seed source is used for reforestation purposes. More intensive studies of focal variation may be necessary in order to determine the pattern of variation associated with environment and to locate the fastest growing seed sources. Yellow birch exhibits much within-stand variation in fruiting characteristics (Clausen, 1967). If a similar pattern is present in growth characteristics, it is probable that certain trees will produce much faster growing progeny than others.

In contrast to the random variation observed in height growth, the study demonstrates that yellow birch exhibits clinal variation in growth cessation. This process is probably controlled to a high degree by photoperiod as it is in many other woody plants.

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