VARIATION AND HERITABILITY OF SEEDLING HEIGHT IN EAST TEXAS SYCAMORE AND RIVER BIRCH

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ABSTRACT. -- Ten families each of American sycamore (Platanus occidentalis L.) and river birch (Betula nigra L.) were planted in a randomized complete-block design. Survival for both species was excellent (> 90%). River birch seedlings averaged 72.25 cm tall after the first and 287.20 cm after the second growing season. Corresponding heights for sycamore were 44.48 and 210.47 cm. Narrow sense heritability estimates for first year heights computed by sib analysis were greater than unity, in both species, possibly due to maternal or confounding nursery effects. Second-year estimates for river birch were 0.22, for sycamore, 0.77. Simple correlation coefficients between first- and second-year heights were 0.418 and 0.532 for river birch and sycamore respectively.

THE "SILAGE SYCAMORE" CONCEPT was advanced by McAlpine et al (1966) as a means of increasing yields per acre. Generally, species with desirable wood properties, rapid growth, sprouting ability and thin bark are candidates for this system. River birch has many of these properties (Hicks, et al 1974), but little is known about the genetic parameters of the species or its potential for biomass yield. This study is designed to provide some of the needed answers. Sycamore was included in the study for comparison.

METHODS

A randomized complete-block plantation consisting of 4 contiguous blocks was established in January 1975. The site was an upper floodplain on a continuous-flow creek in Nacogdoches County, Texas. Half of each block was randomly assigned with either sycamore or river birch. Ten half-sib families of each species were randomly assigned to and planted in 9-tree square plots within blocks; thus 360 trees per species were planted. Trees were nursery grown to age 9 months when planted at 4x4 foot spacing as recommended by Steinbeck, et al (1972).

Seeds were collected from open-pollinated parent trees which were selected from natural stands near Nacogdoches, Texas on the basis of seed availability. Most resulting seedlings survived (> 90%)for both species) and their heights were measured

after the first and second field growing seasons. These data were analyzed by analyses of variance and simple correlation analysis. Henderson's (1953) method 3 was used in the Maximum Likelihood General Purpose Computer Program to extract variance components; these components were used to calculate narrow-sense heritabilities by the following formula:

$$h^2 = \frac{4(\sigma^2_f)}{\sigma^2_f + \sigma^2_{f \times b} + \sigma^2_w}$$

where h^2 = narrow sense heritability

σ^2_f = variance component among families

$\sigma^2_{f \times b}$ = variance component of family by block interaction

σ^2_w = variance component within families

REULTLi

At the end of the first growing season, river birch trees averaged 62% taller than sycamore, but this difference had diminished to 36% by the end of the second year (Table 1). If this trend continues to rotation age of 4 to 5 years, little or no difference may remain. Differences in height between the species were significant at the 1% probability level after both the first and second year.

Table 1. Averages and standard deviations for heights of syca more and river birch.

	River birch		Sycamore	
	cm			
first-year	72.2S	± 18.5	44.48	± 14.4
second year	287.20	± 57.1	210.46	± 67.2

Mean squares, degrees of freedom, and levels of significance for the analyses of variance within both species are presented in Table 2. The family effect is statistically significant for both species. The significant block effect for river birch implies that this species is sensitive to site variability although the apparent absence of a significant interaction effect implies that the family response to site variability may be more uniform than for sycamore; the interaction effect was significant for sycamore.

Table 2. Within-species analyses of variance for second-year river birch and sycamore.

	River Birch		Sycamore	
	degrees of freedom	Mean Squares	degrees of freedom	Mean Squares
Blocks	3	15255.33*	3	8772.64
Families	9	9802.92*	9	34258.28+
Block x Families	27	4047.67	27	7392.19*
Within plot	296	2849.91	261	3930.37

*P< 0.05
+P< 0.01

Heritability estimates were calculated for both first- and second-year heights. The first-year estimates were greater than unity and therefore unreasonable. Maternal or seedbed effects may have yielded these illogical values, thus they are not reported here. Second-year heritability estimates probably represent upper limits of genetic control due to the relatively homogeneous environment in which the replications of the study were planted. These estimates for river birch and sycamore were 0.2258 and 0.7666, respectively (Table 3). Roth (1971) found the heritability of river birch seedling height to be 0.388 using parent:offspring correlation analysis.

To evaluate the potential for early selection and progeny testing, the correlation coefficients of second-year with first-year heights were calculated. These values were 0.418 and 0.532 for river birch and sycamore, respectively. In both cases, first year height accounted for less than 30% of the variation in second-year height. Thus first-year progeny test evaluation for these species may not be practical. In subsequent years we plan to calculate similar correlation coefficients to determine the earliest age at which progeny test results may reliably be evaluated.

CONCLUSIONS

The results indicate the following:

1. River birch seedlings were taller than sycamore after two growing seasons in the field, although the relative difference between the two species was less than at 1 year.
2. Heritability estimates based on second-year height suggest that genetic gain from selection may be expected for both species, but progress would be more rapid for sycamore at a given selection intensity. Since our estimates are based on a few genotypes growing on a single site, their value in predicting genetic gain is limited; their main utility is in comparing the heritabilities of the two species.

Table 3. Expected mean squares, variance components and heritability estimates for river birch and sycamore.

Source	River Birch	Sycamore
Expected Mean Squares		
Blocks	$\sigma^2_w + k_4 \sigma^2_{f \times b} + 82.45 \sigma^2_b$	$\sigma^2_w + k_4 \sigma^2_{f \times b} + 69.49 \sigma^2_b$
Families	$\sigma^2_w + k_2 \sigma^2_{f \times b} + 33.02 \sigma^2_f$	$\sigma^2_w + k_2 \sigma^2_{f \times b} + 27.35 \sigma^2_f$
Families x Blocks	$\sigma^2_w + 19.00 \sigma^2_{f \times b}$	$\sigma^2_w + 16.23 \sigma^2_{f \times b}$
Within plots	σ^2_w	σ^2_w
Variance Components		
	$\sigma^2_f = 174.3069$	$\sigma^2_f = 982.4881$
	$\sigma^2_b = 135.9363$	$\sigma^2_b = 19.8648$
	$\sigma^2_{f \times b} = 63.0280$	$\sigma^2_{f \times b} = 231.2401$
	$\sigma^2_w = 2849.9059$	$\sigma^2_w = 3930.3718$
Narrow-Sense Heritability Estimates		
	$h^2 = 0.2258$	$h^2 = 0.7666$