INHERITANCE OF SPROUT GROWTH IN AMERICAN SYCAMORE (*Platanus occidentalis* L.)

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Abstract.--A 4-year-old progeny test of 64 wind-pollinated sycamore families was harvested and stumps were permitted to sprout. After four years, sprouts were measured and heritabilities calculated for growth. The plantation averaged 2.49 sprouts per clump; dominant sprouts averaged 7.89 m tall and 5.21 cm in diameter at 30 cm. Total dry weight production of the 0.23 ha plantation was 8,284 kg/ha/year during the sprout rotation. Narrow-sense heritabilities were: height, 0.16; diameter of dominant sprout, 0.20; number of sprouts per clump, 0.05; sprouting capacity expressed as total dry weight of all sprouts in a clump, 0.17. Family averages in dry weight per clump varied widely: the best family was 46% greater than the plantation average, the poorest family equaled only 48% of the plantation average.

Additional keywords: Coppice, additive variance, heritability, hardwoods, short rotations, silage sycamore, Georgia, energy plantations, whole-tree utilization.

In the 13 years since the "silage sycamore" concept was proposed (McAlpine et al. 1966), considerable attention has been given to the concepts of coppice regeneration of hardwoods with complete tree utilization for fiber products or energy production. Numerous studies have shown that application of this concept can produce high yields of fiber very soon after plantation establishment (Wood et al. 1976; Steinbeck and Brown, 1976). Young (1967) demonstrated that dense natural stands of hardwoods in the Northeast can also produce high yields of wood fiber. Utilization studies have reported generally acceptable paper and other reconstituted wood products can be manufactured from relatively small, whole trees (Steinbeck and Brown 1976). Economic analyses have shown that the concept is most profitable for fiber products with good sites, wide spacing and cutting cycles of 4 or 5 years (Dutrow and Saucier 1976).

Informal observations on clones of sycamore in a nursery revealed obvious differences among clones in growth and sprouting characteristics. Certain clones tended to have one or two dominant sprouts on each stump, while other clones characteristicly had 3 to 6 sprouts per clump competing for dominance. In a breeding program, the size and nature of genetic variation in sprouting characteristics under intensive culture would be important. The present study was developed to quantify heritabilities of key expressions of sprouting in young sycamore.

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METHODS

In 1968, seedlings of 64 wind-pollinated families were planted in an overflow bottom of the Oconee River in Greene County, Georgia, at a spacing of 1.2m x 1.2m (4'x 4') in 4-tree plots. Weed competition during the first year was controlled by mowing. Fertilizer was applied twice during the first four years, once as 12-12-12, once as ammonium nitrate. After four growing seasons, the plantation was clearcut to a stump height of 15 cm (6"). Stumps were permitted to sprout, and again after four growing seasons the plantation was measured. Measurements included height and diameter of each major sprout and a count of the number of sprouts originating from each stump. Using regression equations developed by Saucier, et al 1/, estimates were developed for all sprouts in each clump for total dry weight and total green weight. For a description of methodology of the earlier phase of the study, genetic assumptions and limitations, see Webb, et al. 1973.

Table 1.--The analyses of variance and construction of heritabilities

Source	df	E(ms)
Replication	5	$\frac{\sigma_w^2}{k} + \sigma_{rf}^2 + f\sigma_r^2$
Family	63	$\frac{\sigma_w^2}{k} + \sigma_{rf}^2 + r\sigma_f^2$
RxF	315	$\frac{\sigma_w^2}{k} + \sigma_{rf}^2$
Total	383	
Within plot	993	$\frac{\sigma_w^2}{k}$

k = harmonic mean number of trees per plot = 2.8098

Assumption: half-sib family component $\sigma_f^2 \hat{=} \frac{1}{4}\sigma_A^2$

Narrow sense heritability:

$$h^2 = \frac{4\sigma_f^2}{\sigma_w^2 + \sigma_{rf}^2 + \sigma_f^2}$$

1/ Personal communication, J. Saucier, A. Clark III, and R.G. McAlpine, USDA Forest Service, Southeastern Forest Experiment Station, Athens, GA.

RESULTS

The general growth of sprouts over the entire plantation was excellent. After four growing seasons, height averaged 7.89 m (25.9') and diameters of dominant sprouts at 30 cm (1') averaged 5.21 cm (2.05"). The plantation produced a total of 33,139 kg/ha (14.8 T/acre), or an average annual rate of 8,284 kg/ha/yr. (3.7 T/acre/yr). Wind-pollinated families demonstrated highly significant differences in sprout growth when expressed in terms of height, diameter, dry weight and green weight (table 2).

Table 2.--Key statistics summarizing inheritance of sprouting capacity.

Statistic	Height	Diameter	Total dry weight	Total green weight	Number of sprouts per clump
Heritability, narrow-sense	0.16	0.20	0.17	0.17	0.05
Family F-test[a/]	1.58**	1.85**	1.74**	1.74**	1.37 N.S.
Variance components					
Half-sib family, σ_f^2	1.0400	0.020623	2.9449	18.5619	0.020039
Rep. x family, σ_{rf}^2	3.0870	0.016070	0.6399	4.6266	0.697314
Within plot, σ_w^2	21.7456	0.365852	65.0196	407.3690	0.813578

a/ df 63,315

The expression of sprouting capacity that had the widest range of variability was total dry weight of all sprouts in a clump. This is a function of height, diameter, and number of sprouts per clump. The individual clump variation in dry weight ranged from less than 2 kg per clump to over 23 kg per clump (fig. 1). Family averages ranged from a low of 2.58 kg (5.68 lb) per clump to a high of 7.18 kg (15.84 lb) per clump. Stated another way, the poorest family in the plantation produced dry matter at a rate equal to only 48 percent of the plantation average. However, the best family produced dry matter at a rate 46 percent greater than the plantation average.

When sprouting was expressed in number of sprouts per clump, the total range of.variability was very narrow, 6 sprouts per clump or less (fig. 2). The F-test for families was non-significant, and narrow-sense heritability was only 0.05 (table 2). However, informal observation of sycamore clones in the nursery suggested a high broad-sense heritability for number of sprouts per clump. This apparent descrepancy suggests that the factors controlling this aspect of sprouting express dominance rather than additive gene action.

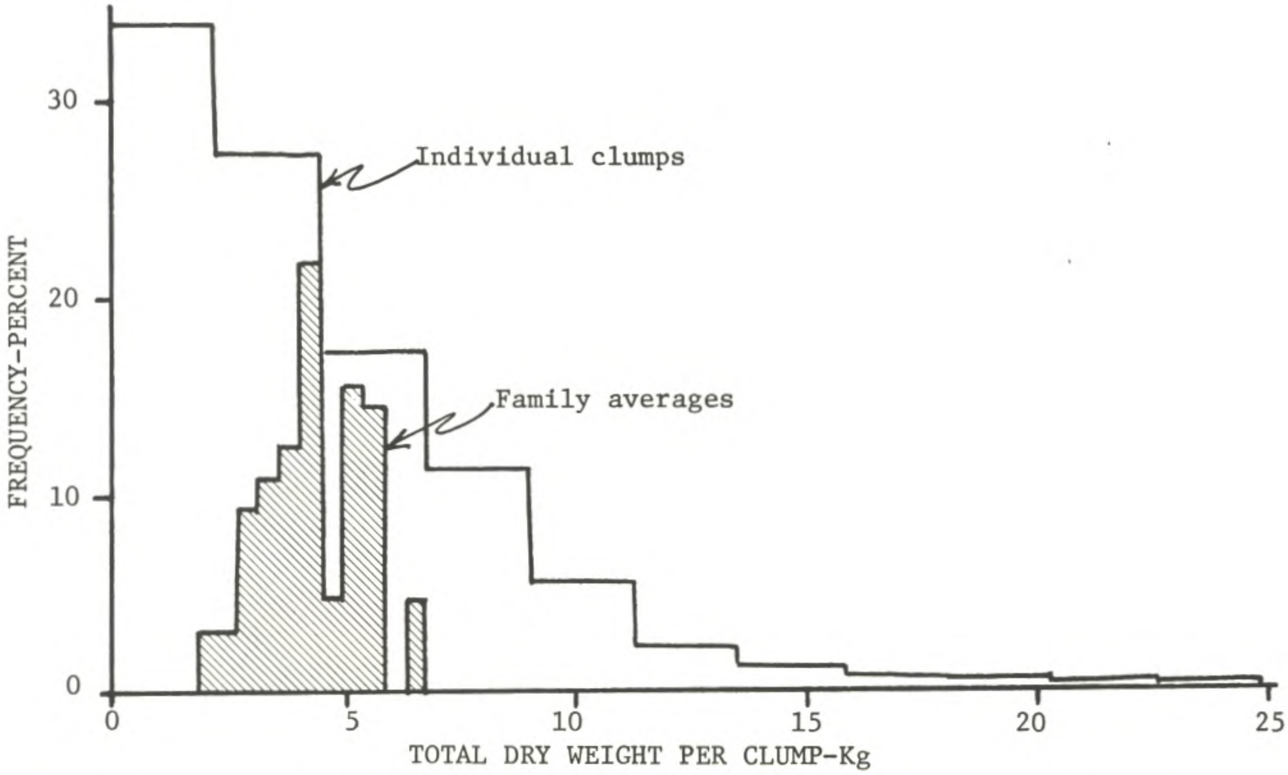

Figure 1: Total dry weight per clump: frequency distribution of 1215 sprout clumps compared with 64 family averages.

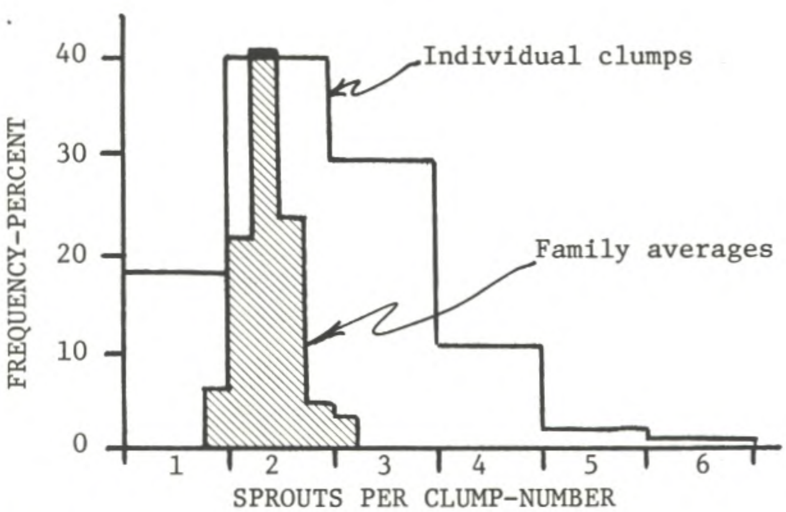

Figure 2: Number of sprouts per clump: frequency distributions of 1215 sprout clumps compared with 64 family averages.

CONCLUSIONS AND RECOMMENDATIONS

This small plantation, in a single location, again demonstrates the capacity of sycamore sprouts to yield large quantities of usable dry matter on a good site under intensive culture on short rotations. Furthermore, there is adequate additive genetic variance in the growth capacity of sprouts to reward an applied breeding program designed to increase productive capacity under intensive culture. More work, however, is needed to define the relative importance of additive genetic variance and dominance variance in factors affecting competition among sprouts originating from the same stump.

Once a decision is made concerning the proposed rotation length, 4 to 6 years versus 10 to 15 years, then decisions can be made about relative emphasis on number of sprouts per clump, total dry weight per clump, and upon using seedlings or cuttings. This plantation of sprouts is now 6 years old; competition is becoming very intense and smaller sprouts are dying out.

The following recommendations are offered for an applied breeding program: If rotations are projected to be short, 4 to 6 years, selection should favor those families that maximize total dry weight per clump, and seedlings can be used to establish operational plantations. These families will probably have an above average number of sprouts per clump. However, if rotations are projected to be longer, 10 to 15 years, selection should favor those families that maximize total dry weight, but on only 1 or 2 stems per clump. This strategy would minimize loss of production through mortality of suppressed sprouts. To achieve this sprouting pattern, it may be necessary to plant cuttings instead of seedlings to utilize the apparent broad-sense heritability of number of sprouts per clump.

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