GERMINATION AND EARLY GROWTH OF SWEETGUM SEED SOURCES IN THE NURSERY[1/]

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ABSTRACT.—Seed from 4 half-sib sweetgum families in each of 33 provenances was sown in nursery beds. Germination percent and first-year height differed significantly among sources. Both variables were highly correlated with seed weight, but were not related to latitude or longitude of the seed source.

Sweetgum or red gum (Liquidambar styraciflua L.) is native to central and southwestern West Virginia, but generally is not an important stand component. It grows well as an ornamental in the northern portion of the state. Sweetgum has an extensive range, growing in the area bounded by extreme southwestern Connecticut in the north, west to southern Illinois, southwest to eastern Texas, and east to central Florida (Little 1978). It is an excellent pulping species for fine papers, corrugated board, and rayon, and is used for any product where hardwood pulp is acceptable. Round wood is used for lumber, veneer, and plywood (Martindale 1958). It is a useful ornamental species, providing shade and fall coloration varying from yellow to crimson.

Wilcox (1968), in reporting the results of a sweetgum seed source study in Mississippi, noted that the length of stratification time required to produce uniform germination varied clinally, increasing from south to north. Based on his observations of 3-year-old half-sib families, he concluded (1970) that mass selection would probably be useful in obtaining genetic improvement in form and growth rate.

As part of the NE-27 Regional Genetics project, a range-wide sweetgum provenance study has been initiated under the direction of Dr. Kim Steiner of Pennsylvania State University. While the study was originated primarily as a vehicle for selecting sources and/or clones for ornamental planting, another of our purposes is to test sweetgum sources for forest planting. Sufficient seed was available for establishing large plots and, rather than grow the large number of seedlings in scarce greenhouse space, a planting was made in the West Virginia Division of Forestry tree nursery near Parsons, West Virginia. The information reported here is from that planting.

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MATERIALS AND METHODS

Seed was collected by a number of collaborators and sent to Steiner for processing. After one year's storage, we received seed which represented 33 provenances with 4 mother trees per provenance (Table 1; Figure 1). Weight of seed was determined for 100 seeds per seed lot. First-year greenhouse germination of several sources had been quite low and it was recommended that we should expect a minimum of 16% germination from some seed lots.

Half-sib seed lots were divided into three replications, soaked for 24 hours, and then put into plastic bags. Seeds were stratified for 40 days at 35-40° F. prior to planting.

Table 1.--Location of sweetgum provenances.

Number	County and State	Latitude (deg.)	Longitude (deg.)
033	Jasper, GA	33.2	83.7
053	Jones, NC	34.8	77.1
061	Fairfield, SC	34.4	81.4
077	Dorchester, MD	38.5	76.1
081	Dovington, AL	31.1	86.6
085	Marshall, MS	34.9	89.6
097	Jefferson, IL	38.2	88.9
101	Tipton, TN	35.5	89.6
105	Humphreys, TN	35.9	87.8
109	Coffee, TN	35.5	86.0
117	Campbell, TN	36.3	84.2
121	Floyd, IN	38.3	85.8
125	Vanderburg, IN	37.9	87.6
129	Hopkins, KY	37.2	87.7
229	Choctaw, MS	33.3	89.1
241	Greenwood, SC	34.1	82.2
245	Madison, MO	37.5	90.3
257	Murray, GA	34.8	84.7
285	Bucks, PA	40.2	74.9
297	Burlington, NJ	40.0	74.6
313	Middlesex, NJ	40.5	74.4
377	Jackson, IL	37.7	89.3
381	Henri, VA	37.6	77.5
385	Lancaster, VA	37.8	76.5
445	Laurence, AL	34.3	87.3
461	Delaware, PA	39.8	75.5
457	Montgomery, AR	34.7	93.8
473	St. Louis, MO	37.1	89.6
481	Union, IL	37.5	89.3
489	Scott, MO	37.1	89.6
545	Shelby, TN	35.3	90.1
549	Hardin, TN	35.3	88.3
553	Hardeman, TN	35.4	89.0

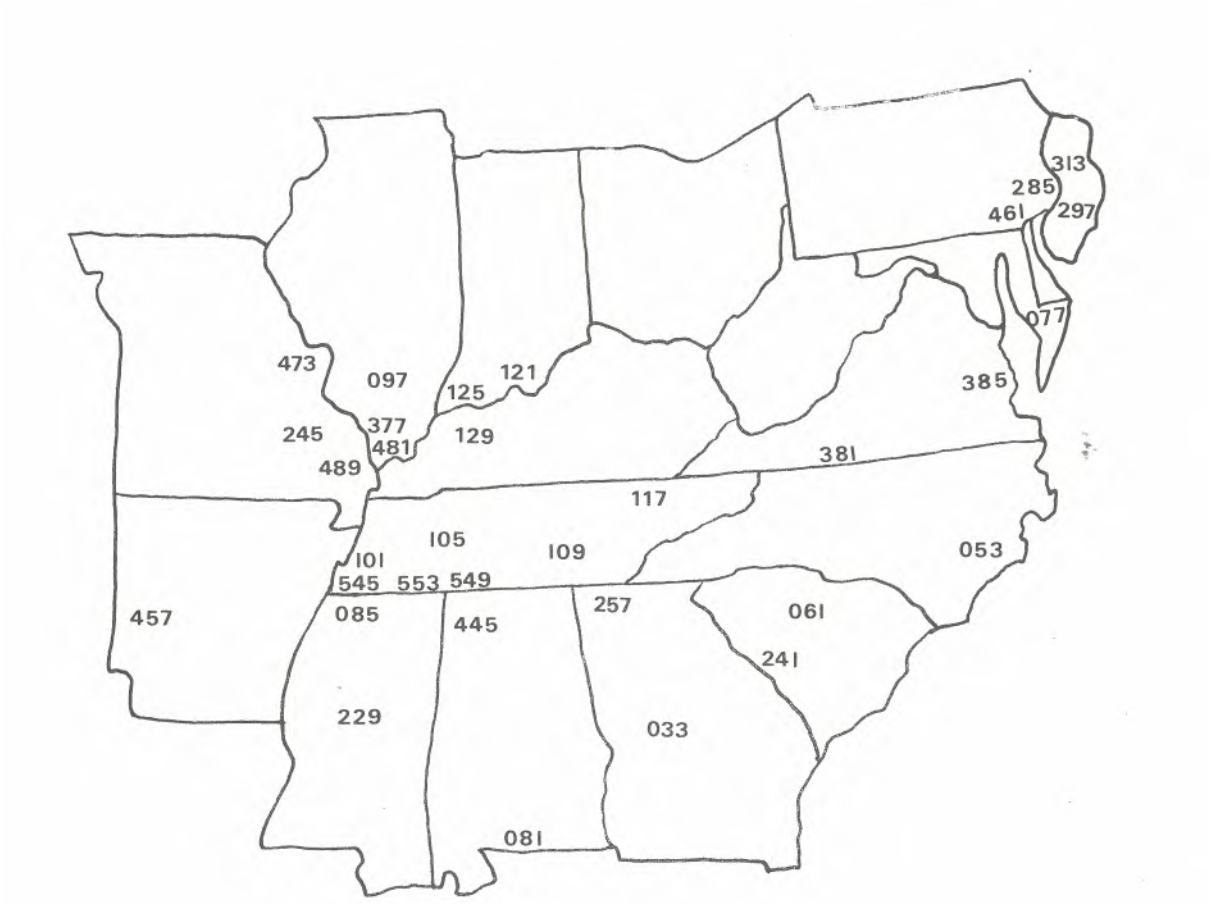

Figure 1.--Location of sweetgum seed sources.

Seeds were sown on May 7-8, 1979, in 3k-foot-long rows across the standard seed beds. Approximately 100 seeds were planted per family per replication. Families were planted randomly in each replication, with 8 inches between rows. Seed was covered with 1/4 inch of sand. As each replication was completed, the bed was rolled with a hand drum roller, mulched with straw to a depth of approximately two inches, and watered. Germination began within two weeks of sowing, and the mulch was then removed.

By the end of the second week it was obvious that differential germination was occurring. Germination counts were initiated on May 25th, and for the next five weeks, counts were made at approximately weekly intervals, varying slightly as time, distance, and weather allowed. The last germination count was made on July 3, 1979, when germination was virtually complete.

Nursery culture was that which. was normally carried out for other hardwoods and was performed in rotation with other beds. Seedling growth and development is, therefore, what might be expected under standard nursery conditions, with one exception: The predicted germination rate was much lower than the actual germination and consequently the seed beds were far too dense, i.e. approximately 50 seedlings per square foot instead of the 10 desired.

Seedling height was measured on November 6, 1979. Selection of seedlings for measurement was done methodically, starting six inches from the edge of the bed and measuring the tallest seedling in each 3-inch space across the bed. Leaf color was observed„. but there were no detectable color variants by mother tree.

RESULTS

Average seed weight by provenance varied from 3.9 to 6.6 mg per 100 seeds. Individual family weights varied from 1.5 to 7.6 mg per 100 seeds. Germination began less than two weeks after planting and was essentially complete in five weeks. Generally, the earliest germination occurred in the sources from western Tennessee and the lower Ohio River valley. The most complete germination occurred in the Pennsylvania and New Jersey sources in the east, and in several scattered provenances in the western part of the range. The provenances which germinated earliest were not necessarily those which had the most complete germination (Table 2). Differences in

Table 2.--Percent germination of selected provenances on May 25, compared to total percent germination on July 3. The value of Spearman's rank correlation for germination on these two dates is 0.21*, indicating a low, but positive, correlation.

May 25			July 3		
Rank	Provenance	% Germ.	Rank	Provenance	% Germ.
1	097	42.2	1	257	88.6
2	125	39.3	2	461	87.0
3	553	38.3	3	473	86.2
4	121	36.7	11	097	76.7
12	257	20.8	18	553	72.7
20	461	15.1	22	121	67.5
22	473	13.8	24	125	65.1
33	445	2.0	27	445	61.8

cumulative germination among provenances and families were highly significant on all six observation dates. Germination percent at each date varied directly with seed weight, but the size of the correlation decreased with time (Table 3).

Table 3.--Correlations between seed weight, seedling height, and percent germination on six dates, based on provenance means. (**significant at 1% level; *significant at 5% level)

	Percent Germination						Height
Date:	5/25	6/1	6/11	6/18	6/26	7/3	11/6
Seed Weight	.67**	.75**	.62**	.51**	.50**	.50**	.74**
Height on 11/6	.70**	.79**	.41*	.19	.17	.18	--

There is an interesting relationship between height at the end of the growing season and the weekly germination percentages. The correlation between height and percent germination is highly significant for the first two weekly counts, significant at the .05 level the third week, and becomes non-significant thereafter. Average height of provenances is also positively correlated with seed weight.

Analysis of variance indicates that differences in height among provenances and families are highly significant, with the Tennessee provenance 549 being the tallest at 45.9 cm, followed by Mississippi 229 at 45.8 cm. The Pennsylvania 285 provenance has the shortest seedlings, 28.6 cm, and Missouri 245 is the next shortest provenance, averaging 29.2 cm. Partitioning the sums of squares shows that 40% of the variation is attributable to provenance, 25% to family differences, and the remaining 34% is in the error term (Tables 4 and 5).

Table 4.--Analysis of variance for seedling height.

Source	D.F.	Mean Square	F Value	Component of Variance
Replication	2	556.9	36.02**	--
Provenance	32	269.8	17.45**	18.33
Tree:Prov.	99	49.9	3.23**	11.48
Error	260	15.5	--	15.46

Table 5.--Mean heights of selected sweetgum seed sources.

Rank	Source	Height(cm)	Rank	Source	Height(cm)
1	549	45.9	25	381	37.7
2	229	45.8	26	061	37.1
3	081	45.5	27	033	37.1
4	125	45.2	28	445	35.7
5	085	44.9	29	297	34.9
6	101	44.9	30	313	32.6
7	377	44.5	31	077	32.4
8	473	44.1	32	245	29.2
9	097	44.0	33	285	28.6

DISCUSSION

While we recognize that seedbed data is generally a weak selection tool, it is important as a basis for future evaluations, and can provide some estimate of the amount of variation present in a species.

Seed weight varied considerably among sources. Generally the variation within provenances was less than that among provenances, but in a few cases within-source variation was large, e.g. Georgia provenance 033 and Tennessee provenance 137. One might suspect that the low seed weights of some families in these provenances was due to empty seed, but germination percentages for the families in question was usually average or above.

The positive correlation between early germination and height was not surprising, since early germinators probably have a longer growing season, but the fact that the correlation became non-significant as germination reached the maximum suggests that total germination percent has little relationship to first-year height. The relationship between seed weight and germination is also interesting. The heaviest seed lots tended to germinate most rapidly, but not necessarily most completely. The correlation between seed weight and first-year height supports the generalization that seedling height is strongly influenced by seed weight in sweetgum, as it is in white spruce and slash pine (Burgar 1964; Shoulders 1961). Plantations established using the seedlings from this study will provide information about the degree to which differences in seed weight and early germination may affect height at later ages.

The significant variation in height among provenances is important for breeding programs, but this variation does not appear to be related to the latitude of the seed source. The tallest provenances are those from the Mississippi valley region and the lower Ohio valley. The large component of variance due to provenance is in agreement with Sprague and Weir's (1973) finding that fourth-year sweetgum height differences among stands are greater than differences due to mother trees within stands. If this pattern of variation persists at later ages, selection for growth rate should be based on the identification of superior provenances and the selection of outstanding trees within these provenances.

SUMMARY

Differences in germination due to provenance and to mother tree were significant for each of six observation periods during the germination season. Seedlots having high early germination do not necessarily have high total germination. Percent germination is positively correlated with seed weight. First-year height is positively correlated with seed weight and with rapid germination.

Both mother tree and provenance have significant effects on seedling height, but the component of variation due to provenance is larger. Neither first-year height nor percent germination is correlated with latitude or longitude of the seed source.

LITERATURE CITED

Burgar, R. J. 1964. The effect of seed size on germination, survival, and initial growth in white spruce. For. Chron. 40:93-97.

Little, E. L. Jr. 1978. Checklist of United States trees. USDA Forest Service Ag. Handbook 541. Washington, DC. 375 p.

Martindale, D. L. 1958. Silvical characteristics of sweetgum. USDA For. Serv. Sta. Pap. SE-90.

Shoulders, E. 1961. Effect of seed size on germination, growth, and survival of slash pine. J. For. 59:363-365.

Sprague, J. and R. J. Weir. 1973. Geographic variation in sweetgum. Proc. 12th Southern For. Tree Impr. Conf., p. 169-180.

Wilcox, J. R. 1968. Sweetgum seed stratification requirements related to winter climate at seed source. For. Sci. 14:16-19.

_____. 1970. Inherent variation in south Mississippi sweetgum. Silv. Gen. 19:91-94.