GEOGRAPHIC PATTERNS OF VARIATION IN GROWTH OF SWEETGUM IN EAST TEXAS

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Abstract.--Two groups of open-pollinated sweetgum progeny tests from 202 selections were planted in east Texas. Study A consisted of three tests and was established in northeast Texas and southeast Texas. This study contained seedlings from 100 families representing 12 counties in east Texas. Significant provenance differences were observed for height and diameter but not for survival and volume. The planting location by family within provenance interaction was significant for survival, diameter and volume. Two other tests (Study B) were established in east-central Texas and southeast Texas and contained seedlings from 102 families representing east Texas, south Arkansas and west Louisiana. The provenance effect was significant for survival and volume, and the family within provenance term was highly significant for all traits. There were no important genotype by environment interactions. The data indicate that sweetgum seed should be collected from Polk, Tyler, Newton and Jasper Counties for use in east Texas.

Additional keywords: *Liquidambar styraciflua*, progeny tests, heritability.

Sweetgum (*Liquidambar styraciflua* L.) is a southern bottomland species and occurs mostly on rich, moist, alluvial soils (Harlow and Harrar 1969). The range of sweetgum extends from Connecticut southward throughout the eastern United States to central Florida and east Texas, as well as scattered locations in Central America (Fowells 1965). Besides being an important commercial hardwood species in the United States, sweetgum is a desirable ornamental because of its attractive shape and brilliant autumn leaf coloration. The North Carolina State University-Industry Hardwood Research Cooperative, the Western Gulf Forest Tree Improvement Program-Hardwood and the Texas Forest Service Urban Tree Improvement Program have active tree improvement programs underway with sweetgum, and selected trees have been accepted for use in breeding arboretums and seed orchards (North Carolina State University 1984, Byram et al. 1984). Sweetgum is an intolerant species and large, pure even-aged natural stands are not uncommon. It appears

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that sweetgum is relatively slow to establish itself; however, once established growth is relatively fast on many bottomland sites.

The objectives of this study were to examine the amount of genetic variation present in stands of sweetgum in east Texas and develop seed movement guidelines. Estimated genetic gains from family selection are also described.

METHODS

Study A

Open-pollinated seed from 110 sweetgum selections representing 12 counties and six provenances throughout east Texas were collected in 1969 and 1970. The seedlings from these selections were grown in 1970 and 1971 in three replications at Indian Mound Nursery located near Alto, Texas. One progeny test containing 100 families was established in early spring, 1971 in Jasper County, Texas (Figure 1). Two other progeny tests containing 110 families were planted in 1972 at Harrison County and Montgomery County. All seedlings were root pruned to eight inches before planting.

Data from the 100 common families among the three plantings were used in the analysis. The field design for all tests was a six-replication, randomized complete block with four-tree family row plots. Spacing was 10 by 10 feet. A single border row was used at each location to offset edge effects; however, the border row was partially destroyed at the Harrison County location.

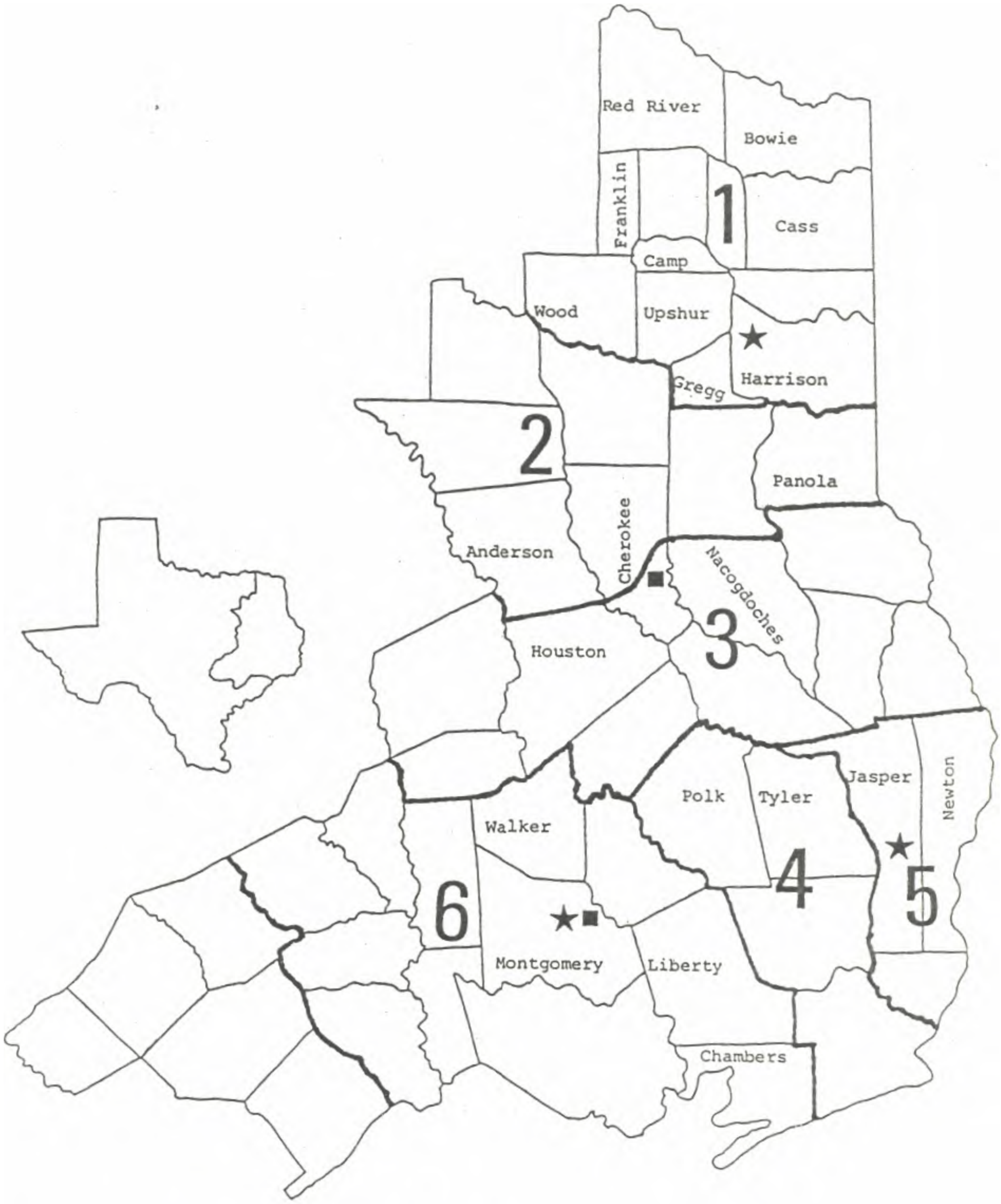
Study B

Open-pollinated seed were collected in 1972 from 106 sweetgum selections representing 16 counties and six geographic areas of seed collection from east Texas as well as two counties each from south Arkansas and west Louisiana. As in Study A, these seedlings were grown at Indian Mound Nursery. Two progeny tests containing 104 families each were established in 1974 in Cherokee County and Montgomery County (Figure 1). Data from 102 families in common between the two locations were used for the analysis. The field design was the same as that used for Study A.

Site Description and Cultural Treatments

The Harrison County planting was cleared, previously forested land of silty loam soil. The Cherokee County planting site was sandy loam soil and was also cleared, previously forested land. Both sites in Montgomery County were cut over areas on clay loam soils that were previously planted in pine and abandoned one year after planting. The test in Jasper County was an old clearcut on a sandy clay loam soil.

Weeds and sprout competition were controlled in all tests by disking during the first three years and by mowing thereafter. The



★ = plantation locations for Study A

■ = plantation locations for Study B

Figure 1.--Seed collection and plantation locations in east Texas for the sweetgum progeny tests.

Table 2.--Combined analysis of variance for survival, height, diameter and volume of three sweetgum progeny tests (Study A).

Source of Variation	df	Mean squares for Sur.	Ht.	Dia.	Vol.
Location	2	75505.83**	272.03**	76.90	3316.45**
Replication(Loc.)	15	2269.04**	22.36**	56.40**	369.28**
Provenance	5	1672.49	8.78**	20.45*	84.41
Family(Provenance)	94	697.31	1.44**	3.00	27.76
Loc. x Provenance	10	1045.40	0.75	4.38	46.79
Loc. x Family(Prov.)	188	840.82**	0.93	2.58*	26.94**
Rep.(Loc.) x Prov.	75	421.17	0.92	2.87*	21.45
Error	1332	374.19	0.79	2.08	19.03

*Significant at 0.05 level of significance
**Significant at 0.01 level of significance

Table 3.--Provenance means for the combined analysis for the ten-year-old sweetgum progeny tests in east Texas.

Provenance	Height (m)	Diameter (cm)	Volume (dm^3)
Study A			
1	5.8	7.0	7.5
2	5.8	7.0	7.5
3	6.0	7.4	8.3
4	6.2	7.5	8.7
5	6.1	7.6	8.7
6	5.7	7.0	7.3
Study B			
1	7.3	10.2	20.8
2	7.7	10.9	23.1
3	7.2	9.9	17.9
4	8.1	11.7	29.6
5	8.0	11.1	26.7
6	7.7	10.8	21.1
15 (La.)	7.9	10.9	24.3
18 (Ark.)	7.8	10.9	24.0

Family within provenance differences could only be detected for height. Family heritability and gain estimates for height was 0.35 (SE=0.16) and 0.16 m (3%), respectively. The planting location by family within provenance interaction was significant for survival, diameter and volume. This indicates that family rankings for these traits differed among the plantations. The results from Study A indicate that sweetgum seed can be collected from any area within these boundaries and planted in east Texas without a loss in survival and volume growth. Height and diameter growth can be significantly increased by collecting seed from trees in provenances four and five. They also indicate that any family differences in survival, diameter and volume growth are masked by the significant interactions.

Study B

Survival was good (84 percent) for the average of the two 102-family progeny tests at Cherokee County and Montgomery County. Average volume was 23.1 dm^3, which was larger than that for any of the three tests in Study A (Table 1).

Results from an analysis of variance for these two plantings revealed no differences between the planting locations (Table 4). Survival and volume varied significantly among provenances. As shown in Table 3, trees from provenances four and five were clearly the largest. These same geographic areas produced the tallest trees in Study A.

Table 4.--Combined analysis for survival, height, diameter and volume at age ten of two sweetgum progeny tests (Study B).

Source of Variation	df	Mean squares for Sur.	Ht.	Dia.	Vol.
Location	1	267.28	2.30	5.58	1232.73
Replication(Loc.)	10	2079.18**	51.96**	124.03**	3050.05**
Provenance	7	1593.10**	15.45	36.15	1585.87*
Family(Provenance)	94	728.72**	3.72**	8.44**	321.11**
Loc. x Provenance	7	74.33	3.74	9.45	274.48
Loc. x Family(Prov.)	94	364.52	1.62	3.96	125.41
Rep.(Loc.) x Prov.	70	386.15	2.58	5.05	190.15
Error	894	371.24	2.04	3.96	164.83

* Significant at 0.05 level of significance
** Significant at 0.01 level of significance

In this study, the family within provenance term was highly significant for survival, height, diameter and volume. There were no significant genotype x environment interactions for these plantings, indicating consistent family rankings between the tests. Selected families as well as provenances performed well at both locations. This study indicates that a single breeding population can be used in central and southeast Texas.

Family heritability and gain estimates were calculated for all four traits (Table 5). Estimates ranged from h^2=0.50 for survival to h^2=0.54 for volume. Genetic gain by selecting the best 15 families out of 102 for survival, height, diameter and volume were 6.15 percent (7%), 0.47 m (6%), 0.71 cm (7%), and 4.72 dm^3 (20%), respectively. These gains appear to be sufficient for use in an operational tree improvement program.

Table 5.--Family heritabilities (h^2) and estimated genetic gains for the combined analysis of two sweetgum tests (Study B).

Variable	Family $h^2 \pm$ SE	Gain
Survival	0.50±0.16	6.15%
Height	0.51±0.14	0.47 m
Diameter	0.53±0.16	0.71 cm
Volume	0.54±0.14	4.72 dm^3

CONCLUSIONS

The results from Study A indicated that the geographic area of seed collection within east Texas affected height and diameter growth but not survival or volume. Individual family differences could only be detected for height (h^2=0.35). There was also a significant location by family interaction for survival, diameter and volume. The results from Study B revealed a significant effect of geographic area of seed collection on survival and volume as well as significant family differences for all traits. Growth traits appeared to be moderately inherited in sweetgum (volume h^2=0.54). By selecting the 15 best families, expected genetic gains were six percent for height, seven percent for survival and diameter, and 20 percent for volume growth.

Based on these studies, it appears that sweetgum seed should be collected from Jasper, Newton, Polk and Tyler Counties for use in east Texas.

LITERATURE CITED

Byram, T. D., Lowe, W. J., McKinley, C. R., Robinson, J. F., Stauder, A. F. and van Buijtenen, J. P. 1984. 32nd progress report of the cooperative forest tree improvement program. Forest Genet. Lab., Texas Forest Service Cir. 269. 27 p.

Fowells, H. A., ed. 1965. Silvics of forest trees of the United States, USDA Agric. Handb., No. 271, 762 p.

Harlow, W. M. and Harrar, E. S. 1969. Textbook of dendrology. McGraw-Hill Book Co., N. Y. 512 p.

Hicks, C. R. 1973. Fundamental concepts in the design of experiments. Holt, Rinehart and Winston, N. Y. 349 p.

North Carolina State University. 1984. Twenty-first annual report, N. C. State University - Industry Cooperative Hardwood Research Program Sch. Forest Resor., Raleigh, N. C. 61 p.

SAS Institute, Inc. 1982. SAS user's guide: statistics, 1982 ed. Cary, N. C. 584 p.