VARIATION OF SWEETGUM FIBER LENGTH WITHIN AND BETWEEN UPLAND AND BOTTOMLAND SITES[1]

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ABSTRACT

A total of 79,550 fibers were measured from sample trees representing upland and bottomland sites in Louisiana. These sites represent three separate geographic areas within the state. In all sample years, average fiber length was significantly longer in trees from upland sites in Area 2, significantly shorter in trees from upland sites in Area 3, with sites in Area 1 being significantly different in only two sample years. Thus the magnitude and nature of variation between upland and bottomland sites appear to be geographically isolated.

Keywords: sweetgum, fiber length, upland, bottomland.

INTRODUCTION

Sweetgum (*Liquidambar styraciflua*), in terms of where and how it grows, its uses, and the quantities utilized, is perhaps the most important hardwood species in the United States (Johnson and McElwee 1967; Randel and Winstead 1976). With progressive technology, utilization of the species has changed from a status of general hardwood comsumption to the present usage for face, box, and commercial veneer, factory lumber, small dimension stock for furniture, and hardwood pulp (Putnam et al. 1960). Some major industries now consider sweetgum as a separate resource in their reconnaisance and harvesting operations (Haller 1980).

Because the quality of growth may be as variable as the range of sites on which it occurs, the amount of basic information for the species should be increased. Sweetgum fibers are 1.47 to 2.13 mm long (Jett and Zobel 1975; USDA Forest Service 1964) with an average of 1.82 ± 0.12 mm (Panshin and deZeeuw 1970). Compared to conifers, sweetgum has relatively short fibers; therefore, variation in fiber length may be particularly important to breeding programs, and identification of variation in natural stands may be essential to successful selection for improved qualities.

Johnson and McElwee (1967) reported highly significant differences in mean

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fiber length among sweetgum trees in the same stand and among all stands in the same provenance. Hunter and Goggans (1969) found mean fiber length in sweetgum to vary significantly between quarter-degree latitude areas, whole-degree latitude areas, and physiographic and rainfall provenances.

Webb (1964), in his extensive study of sweetgum across the Southeast, found that differences between trees within stands was the most significant source of variation. Differences among stands were small but sites with the more rapid growth had longer fibers.

The objective of this study was to determine if fiber length in sweetgum varies between trees within a site, either among similar physiographic sites, or between upland and bottomland sites.

MATERIALS AND METHODS

Field sampling

A total of six sites from three areas (geographic regions) in Louisiana were sampled in the study, with one upland site and one bottomland site included in each area. Three dominant or co-dominant trees were selected (total of 18 trees) from each site. Selection of sample trees was with restrictive guidelines outlined in Ezell (1977).

Before felling, the directional axes were determined with a compass and marked on each bole. After felling, discs were tagged along one directional axis and removed at 1.2-m intervals starting at a height 15.24 cm above the ground and proceeding to the tops of the trees. Discs were immediately sealed in polyethylene bags and refrigerated within hours to restrict moisture loss, inhibit discoloration, and prevent decay. A complete description of field and laboratory sampling procedures may be found in Ezell (1977).

Laboratory sampling

All fiber length measurements were completed on sample sections taken from the western directional axis of each disc. Growth rings were identified along a fresh surface (prepared with razor blade or sharp knife) on the cross-sectional plane.

Growth rings formed in the years 1974, 1970, 1965, 1960 and subsequent intervals of five years were used for sample measurements. A portion of the isolated growth ring was sliced along the radial plane in order to eliminate the bias of differential sample points within the ring (Taylor 1963).

Samples were macerated in Jeffrey's Solution, stained with Safranin-O, and measured on a microprojector. A specially etched glass slide was employed in all fiber length measurements (Hart and Swindel 1967). The bias of selecting longer fibers was thereby eliminated.

Calculations based on preliminary measurements were undertaken to determine the sample size necessary to ensure 95 percent confidence. Twenty-five fibers were adequate to ensure this confidence for each sample ring. A total of 79,550 fibers were measured in the study.

RESULTS AND DISCUSSION

Comparison of trees within a site was accomplished with an evaluation of whole-tree average fiber length with their respective standard deviations (Fig. 1).

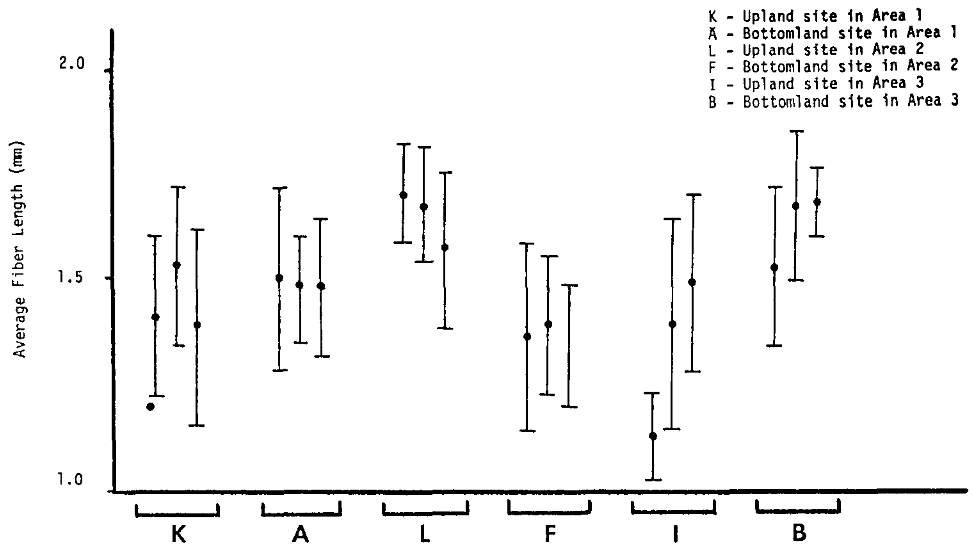

FIG. 1. Average tree fiber length with one standard deviation for all trees.

This method of comparison was best due to the fact that even though the trees were morphologically similar, differences in ages created a variation in sample size.

This analysis revealed that there is only one occurrence of significant difference between trees from the same site (Trees 1 and 3 from the upland site in Area 3). Using a significance level of 0.05, one would expect to find a difference at least one time in twenty by chance. Thus, with eighteen samples examined, one significant difference is not surprising.

The tree that had significantly lower values in Area 3 had an unusually low whole-tree average fiber length. Since the identical sampling scheme was applied to all trees, the shorter fibers in this tree appear to be the result of natural biological variation. This variation also seems to be a function of the individual tree rather than the site, since the other two trees had means comparable to the other intensively sampled trees. It is therefore possible to theorize that the shorter fibers are a result of genetic factors as described by Smith (1967). Conversely, genetic factors could produce a tree of significantly longer fibers, but no such tree was found in this research.

These results represent a deviation from previous reports. Johnson and McElwee (1967) and Webb (1964) both had highly significant differences between trees from the same stand. The sampling schemes involved could account for differences in results. First, this study utilized more samples from each tree than earlier efforts. Second, the other studies sampled more trees in each stand. Third, earlier studies sampled stands over a wider geographic area than the present study. In addition, it appears that the study area (i.e. Alabama or Georgia vs. Louisiana) could be as important as any differences in sampling scheme. If the latter is true, results of this study indicate that fiber length in sweetgum varies along longitudinal in addition to latitudinal gradients.

TABLE 1. *Analysis of variance of fiber length in intensively sampled trees.*

	1935			1940			1945		
	df	ms	F	df	ms	F	df	ms	F
Area	2	0.0971	5.00	2	0.0599	4.76	2	0.0330	
Error (a)	5	0.0194		6	0.0126		6	0.0845	0.39
Sub-Area	1	0.0223	1.06	1	0.0405	3.72	1	0.0033	
A×SA[1]	2	0.2164	10.30**	2	0.4384	36.96**	2	1.3831	0.29
H (A×SA)[2]	30	0.0298	1.42	41	0.0397	3.35**	59	0.0646	119.52**
Error (b)	29	0.0210		48	0.0119		67	0.0116	5.58**
	1950			1955			1960		
	df	ms	F	df	ms	F	df	ms	F
Area	2	0.1322	1.13	2	0.0033	0.02	2	0.0932	0.34
Error (a)	6	0.1170		6	0.1606		6	0.2735	
Sub-Area	1	0.0017	0.08	1	0.0559	3.33	1	0.0002	0.01
A×SA	2	1.9188	88.40**	2	1.6626	99.08**	2	2.2463	100.81**
H (A×SA)	69	0.0665	3.06**	82	0.0718	4.28**	93	0.0896	4.03**
Error (b)	104	0.0217		138	0.0168		172	0.0223	
	1965			1970			1975		
	df	ms	F	df	ms	F	df	ms	F
Area	2	0.0130	0.04	2	0.0515	0.14	2	0.1150	0.29
Error (a)	6	0.3549		6	0.3606		6	0.3973	
Sub-Area	1	0.0005	0.02	1	0.1169	4.90*	1	0.0758	2.86
A×SA	2	2.4955	111.57**	2	3.0969	129.74**	2	2.5138	94.79**
H (A×SA)	116	0.1178	5.27**	132	0.1368	5.73**	136	0.1117	4.21**
Error (b)	198	0.0224		247	0.0239		256	0.0265	

[1] Area × Sub area.
[2] Height (Area × Sub area).
** Significant at .01 level.

Analysis of variance revealed that there are highly significant differences ($P < .01$) in average fiber length between upland and bottomland sites (sub-areas) within areas for every sample year of deposition examined (Table 1). This highly significant variation extended to include sampling heights for all but one sample year (1935). A series of specific comparisons revealed that fiber length was significantly different between sites within an area in only two of the three areas (Table 2). In all sample years, average fiber length was significantly longer in trees from upland sites from Area 2, significantly shorter in trees from upland sites in Area 3, but sites in Area 1 were significantly different in only two sample years. Even when differences were significant in Area 1, the magnitude of the differences was small in comparison to the differences in Areas 2 and 3.

Analysis of variance among all similar sites (denoted as areas) failed to reveal any significant difference in any sample year examined (Table 1). Thus, the inference can be drawn that fiber length variation in this study is geographically isolated. The inference is further supported by the results from specific comparisons (Table 2). No significant differences could be found in a comparison of all upland sites vs. all bottomland sites due to the fact that fiber length did not fluctuate much in this respect. However, failure to detect significant differences between areas is due primarily to the nature of the variation displayed in the specific comparisons.

TABLE 2. *Specific comparison of average fiber length between sites within an area.*

Year	Area	Upland	Bottomland	LSD[a]
1935	1	1.42	1.53	.23
	2	1.77	1.53	.10*
	3	1.17	1.56	.24*
1940	1	1.51	1.48	.09
	2	1.72	1.50	.05*
	3	1.39	1.71	.08*
1945	1	1.55	1.51	.03*
	2	1.77	1.29	.02*
	3	1.33	1.76	.03*
1950	1	1.56	1.54	.07
	2	1.76	1.36	.06*
	3	1.42	1.85	.08*
1955	1	1.59	1.57	.05
	2	1.73	1.44	.04*
	3	1.41	1.79	.05
1960	1	1.60	1.61	.05*
	2	1.76	1.40	.04*
	3	1.49	1.80	.05*
1965	1	1.57	1.63	.05*
	2	1.77	1.44	.05*
	3	1.46	1.76	.05*
1970	1	1.57	1.57	.05
	2	1.76	1.40	.04*
	3	1.42	1.68	.05*
1974	1	1.58	1.62	.05
	2	1.73	1.41	.04*
	3	1.43	1.65	.05*

[a] Least significant difference.
* Denotes significance at .05 level.

These results differ from those of Hunter and Goggans (1969), Johnson and McElwee (1967), and Webb (1964), all of whom noted significant differences between geographic areas. The explanation for differences between the present and earlier studies could lie within the results of earlier work. If sweetgum fiber length does vary between geographic regions, as stated earlier, the lack of variation in Louisiana could be one more expression of total variation in the species.

In summary, fiber length in sweetgum used in this study did not vary greatly between trees in the stand or between geographic areas. Overall, fiber length does vary significantly within the tree (Ezell and Schilling 1979) and between some upland and bottomland sites in the same area. However, the magnitude and nature of variation between upland and bottomland site appear to be geographically isolated.

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