LARGER SWEETGUM SEEDLINGS ARE MORE VIGOROUS TWO YEARS AFTER PLANTING

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In the spring of 1964, a study was established near Tillery, N.C., to test the effects of seedling size and spacing on the survival and growth of planted sweetgum *(Liquidambar styraciflua).* The study was a cooperative project of the Albemarle Paper Manufacturing Co. and the North Carolina State-Industry Cooperative Hardwood Research Program. Results presented here cover survival and total height development during the first two growing seasons after outplanting.

These results are neither unusual nor unexpected. As reported for sweetgum plantings elsewhere *(6,* 1), survival is generally satisfactory and height development by seedling-size class follows the pattern for sycamore (3), yellow-popular (2, 5), and cypress (4). Survival and development results are reported in some detail here mainly because so little data on these variables is available for sweetgum.

Site

The planting area used was a cleared woods site in the isolation strip of Albemarle's loblolly pine seed orchard at Tillery. The soil is a Warne fine sandy loam with a 0 to 1 percent slope, and is closely related to the Altavista and Roanoke series. Occurring normally in intermediate terraces, the Warne series is a deep soil with a subsoil that is plastic when wet and very hard when dry.

The specific study area has a 50-year site index of about 95 for loblolly pine. It was logged to loblolly pine seed trees in 1953, and the seed trees were removed in 1961. Because it is part of an isolation strip for a pine seed orchard, in 1962 it was cleared and windrowed with a KG blade, and in 1963 it was disked prior to planting.

Planting Stock

A local seed source-from Halifax and Bertie Counties, N.C.-was used for the sweetgum planting. Seeds were collected in the fall of 1962. The seed was planted at the Riegel Paper Corporation's forest tree nursery, Lumberton, N.C., with a nursery spacing of about 20 to 25 per square foot; conquently, there was much variation in the height and root-collar diameter of the individual seedlings. The very smallest seedlings in height and diameter were culled at the time of lifting and bundling.

Just before planting, the seedlings were sorted into four size classes based on root-collar diameter and stem length. Root-collar diameter, classed as Small and Large, was differentiated by the mean. diameter of the seedlings; the break was at 0.38 inches. In similar manner, seedling height classes

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Figure 1.—Early in its third growing season after outplanting, this sweetgum is 5.4 feet in height. At time of planting, the seedling was classed as Large-Tall.

Tall and Short, were separated on the basis of mean stem length. There proved to be relatively little difference between average stem lengths for the Tall and Short seedlings, which has undoubtedly influenced the results of second-year total height analyzed on the basis of height class at time of planting.

Study Design

Study design consists of a series of replicated plots using the four seedling-size classes planted at ix different spacings. Treatments, consisting of size, class and spacing, were completely random ized within the planting area. Some 41 plots were installed in total; of these, 17 were planted at the six different spacings but with ungraded seedlings, and are not used in the analyses of survival and twoyear height development that follow. Seedling-size grades on the 24 analysis plots were:

1. Large-Tall
2. Small-Tall
3. Large-Short
4. Small-Short

There are, thus, six plots of each grade. Original numbers of seedlings per plot ranged from 49 to 119, depending on the different spacings used. Effects of spacing, incidentally, are not considered here; there is as yet no apparent competition for growing space between seedlings, even at the closest spacing (5 X 5 feet) .

Figure 2.—Stem diameter development of sweetgum early in its third growing season after outplanting.

Results

After two years in the field, the plantation is well established, and individual seedling development has been adequate, compared to that of other species of the same age on- similar sites. Individual seedlings blend in with the color and shape of annuals and incidental sprouts, however, and the plantation is not as spectacular as a two-year-old pine planting would be. Actual results in terms of survival and total height development are presented in the following sections.

Survival.-Overall survival of the 24 plots, ignoring seedling-size class, is 90.9 percent after two growing seasons in the field. Individual plot survivals range from 70.3 percent to 100 percent, with mean survival by seedling-size class as follows:

Large-Tall	*Small-Tall*	*Large-Short*	*Small-Short*
94.5%	*92.2%*	*90.8%*	*85.9%*

An analysis of variance, using square root transformation for plot survival data, indicates no significant differences between survival after two years based on seedling sizes at time of planting. There apparently are no particular problems connected with establishing sweetgum plantations except, perhaps, in situations where animal damage is severe.

Figure 3.—As of June 1, height growth in the 1966 growing season was 0.8 foot on this 3.6-foot sweetgum. Man's finger is at point of termination of 1965 growth.

Height development.-After two years in the field, total height differences between seedling grades are small but readily apparent. Mean total height for the four size classes ranges from 2.74 to 3.29 feet, for the Small-Short and Large-Tall classes, respectively. The effect of seedling grades on total heights after two years is shown in table 1.

TABLE 1.—*Second-year mean heights, by plots.*

[SEEDLING SIZE]

	Large-Tall	Small-Tall	Large-Short	Small-Short
	Ft.	*Ft.*	*Ft.*	*Ft.*
	3.35	2.62	3.23	2.54
	3.28	2.88	3.34	2.69
	2.99	2.76	2.88	2.95
	3.37	3.01	3.00	2.82
	3.41	3.15	2.70	2.52
	3.34	2.70	2.88	2.93
Mean:	3.29	2.85	3.00	2.74

[ANALYSIS OF VARIANCE]

Source	*df*	*MS*	*F*
Total	23		
Size class	3	.3387	8.66 **
Root-collar diam.	1	.7350	18.80 **
Initial stem length	1	.2360	6.04 *
Diam. x length	1	.0450	1.15 NS
Error	20	.0391	

* Level of significance—0.025
** Level of significance—0.005
NS Non-significant, at 0.10 level

As indicated by the above analysis of variance, seedling-size class at time of planting had a highly significant effect on total height development after two years in the field. The two components of seedling-size class, root-collar diameter and initial stem length, are both shown to be significant in two-year height, but root-collar diameter is apparently the more important of the two.

A Tukey Test comparing mean heights after two growing seasons in the field for the four treatments at the 1% level of significance gave the following results:

Large-Tall	*Large-Short*	*Small-Tall*	*Small-Short*
3.29	*3.00*	*2.85*	*2.74*

Mean height values not underscored by the same line are significantly different at the 1 percent level from each other. Thus, it is seen that Large-Tall seedlings performed better than either Small-Tall or Small-Short. Performance of Large-Tall seedlings was not, however, significantly different (at the I percent level) from Large-Short, nor were LargeShort seedlings different from Small-Tall or SmallShort.

The evidence strongly suggests that taller seedlings with larger root-collar diameters should be preferred when planting sweetgum, and that initial root-collar diameter is somewhat more important in two-year height development than initial seedling height.

Discussion

The foregoing observations and analyses clearly indicate the importance of seedling size on early development of planted sweetgum. If seedlings are sorted into rough grades based on root-collar diameter and stem length, those of larger root-collar girth can be expected to show greater early height development. Initial stem length, while exerting a significant effect on development after two years, is not as important as root-collar diameter.

Analysis of the effect of seedling grades on survival after two years indicated no significant differences between the size classes. It is conjectured, however that initial seedling size-in terms of girth and height-could be important to survival in planting situations where wildlife pressures are heavy: the larger seedlings should be able to withstand or sprout back after deer or rabbit browsing somewhat better than smaller plants.

There are, after two years, differences in appearance between seedling-size grades that are real but difficult to quantify. The seedlings that were larger at planting time, particularly in terms of root-collar diameter, are bulkier and apparently more vigorous in general than the smaller seedlings -in addition to being taller.

Two-year height development is not, of course, the ultimate criterion for evaluation of a sweetgum plantation. Total heights may level out over additional growing seasons, or present rankings may even be reversed. Measurements of the Tillery plots in years to come will indicate the pattern of height development and, ultimately, volume production as well. There would seem to be, however, a real advantage in vigorous early development, and additional vigor can be achieved through use of larger planting stock. Subsequent research should be initiated to define more precisely optimum total size of seedlings and in addition optimum sizes of root system, stem, and root-stem ratio.

In spite of the limitations of this study, the results reported here indicate unquestionably the importance of initial seedling size on early development of sweetgum and the necessity of accounting for this in research dealing with plantation establishment and growth. Further, there is clear indication of the need for nursery practices, such as lower seedbed densities, that will produce seedlings of acceptably large root-collar diameters and heights at time of planting.

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