SESSION V

POTPOURRI

MODERATOR: R. E. SCHOENIKE

COMPARISONS WITHIN AND BETWEEN POPULATIONS OF PLANTED SLASH AND LOBLOLLY PINE: A SEED SOURCE STUDY

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Abstract.--Six slash pine seed sources and six loblolly pine seed sources were planted at eight planting locations in the Atlantic Coastal Plain and Piedmont of Florida, Georgia, and South Carolina in 1958-59.

Loblolly pine was significantly more productive than slash pine, producing 61-49% more volume and 54-46% more weight of wood than slash pine. The species did not differ in percent fusiform rust infection, but slash pine was higher than loblolly pine in measures related to severity of infection. Slash pine was higher in unextracted wood specific gravity than loblolly pine. Differences in height were not significant, but loblolly was larger in diameter and had higher survival than slash pine. Differences among seed sources were generally minor in both species.

Additional keywords: *Pinus elliottii* var. *elliottii*, *P. taeda*, productivity, species comparisons, seed source, fusiform rust, specific gravity.

INTRODUCTION

This study was established by Continental Can Company in 1958. The Company planted both slash and loblolly pine, but there was no general agreement on where to draw the line - here slash will be most productive, but there loblolly pine will do better. We could find no clearcut answer to this question in the literature, and since it was a question with significant long-term management implications, this study was established in an attempt to provide an answer.

There were two major objectives: first, to compare the performance of slash pine (*Pinus elliottii* Engelm. var. *elliottii*) and loblolly pine (*Pinus taeda* L.) by testing known sources of both species on the same sites. Second, to determine whether the variation within the species was of sufficient magnitude to have practical as well as statistical significance when both species were represented by seed sources selected from and tested within a relatively restricted area.

MATERIALS AND METHODS

Each species was represented by six seed sources (Table 1). All of the seed came from large commercial collections. Most of the seedlings were grown in a single bed chosen for its uniformity in Continental Can Company's nursery near Statesboro, Ga.

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Table 1.--Slash and loblolly pine seed sources

Slash Pine	Loblolly Pine
Baker Co., Fla.	Laurens Co., S.C.
Nassau Co., Fla.	Allendale Co., S.C.
Wayne Co., Ga.	Warren Co., Ga.
Jeff Davis Co., Ga.	Randolph Co., Ga.
Allendale Co., S.C.	Glynn, Camden, & McIntosh Co., Ga.
Emanuel & Bulloch Co., Ga.	Emanuel & Jefferson Co., Ga.

The Nassau Co., Fla. and Wayne Co., Ga., slash pine seed sources and the Randolph Co., Ga., and Glynn-Camden-McIntosh Co., Ga., loblolly pine seed sources came from other nurseries. Nursery effects upon survival and early height growth have been well established (Wakeley, 1962; Snyder and Allen, 1962). Therefore, for these seed sources, survival and growth data are confounded with nursery effects and the results cannot be considered a true measure of their potential. However, the results for specific gravity, fusiform rust infection, branchiness, and stem straightness should he independent of nursery effects.

Field planting took place during the winter of 1958-59. A 49-tree plot was used (seven rows of seven trees); spacing was 2.13 meters in the row and 2.74 meters between the rows (7' x 9').

For both species, a complete replication was made up as follows:

One plot for each of the six seed sources representing that species (one of these six is the tester in plantings of the other species).

One plot of the tester of the other species.

For convenience in planting, an eighth plot was added, using nursery run seedlings of the tester source of the predominating species.

There were four replications at all planting locations, and both species are represented in each replication at every location by means of the tester lots.

Slash pine sources were planted at five locations in the lower and middle Atlantic Coastal Plain, and loblolly pine at seven locations in the Atlantic Coastal Plain and Piedmont regions (Figure 1). All sources of both species were planted at four of the locations.

At the end of the first, third, and fifth seasons in the field, data on height, mortality, and fusiform rust infection were collected. At the end of the ninth season, data were collected on height, diameter at breast height, mortality, branchiness (the number of branches 2.54 cm. (one inch) or more in diameter between the 1.5 and 3.0 meter level above the ground), and straightness (based on an assessment of the basal seven meters of the bole; "straight" trees were those whose boles were straight enough to permit

Figure 1. Planting locations

their utilization for any purpose; "crooked" trees were those with one or more forks, three or more ramicorn branches, more than 13.2 cm. sweep per seven meters, more than three crooks per seven meters, or more than one spiral per seven meters). Data on fusiform rust infection was recorded in this fashion; on all infected trees, the number of fusiform bole galls was counted (to a maximum of 10), the number of fusiform branch galls was counted (to a maximum of 20), and trees so severely infected with fusiform rust that they appeared unlikely to survive until the time of the next measurement were recorded separately. Trees in this category were those with bole galls covering 50% or more of the circumference of the bole or with one or more smaller bole galls which also showed signs of dying. This was a subjective evaluation, of course, but it permitted a more realistic assessment of the effects of fusiform rust in trees of this age than percentage of infection or gall counts alone.

Wood samples were taken at the end of the eighth season in the field. Ten randomly selected trees per plot were sampled, eight with single bark-to-pith cores, and two with two cores per tree. The cores were taken with a ten-millemeter increment borer, and only the unextracted specific gravity was determined.

Analyses of variance were carried out for all variables. The computer program which made the analyses generated the corresponding tables of means. Duncan's multiple range procedure was used to test for significant differences (at the .05 level of significance) among the ranked means. Percentage data was transformed by the arcsin sq. root of % transformation, and count data by the sq. root of (x+1)/2 transformation (where X is the count) before analysis.

RESULTS AND DISCUSSION

The most important result of this study was that loblolly pine was significantly more productive than slash pine in the volume 1/ and dry weight of wood produced per unit area.

In slash plantings, the loblolly tester produced 61% more volume and 54% more weight of wood than the average of the slash seed sources (Table 2). In loblolly plantings, the average of the loblolly seed sources was 49% higher for volume and 46% higher for weight than the slash tester (Table 2). In both cases, the comparisons are made on the basis of seed sources from a single nursery, i.e., excluding seed sources of either species which came from other nurseries (those whose survival and growth were poor).

Only at one location was slash pine more productive than loblolly pine. At the Baker Co., Fla., location, which was on a very poorly drained flatwoods site, slash seed sources produced an average of 24% more volume and 31% more weight of wood than the average for loblolly seed sources.

These large differences in volume and weight were the combined result of several smaller differences between the species:

1/ Total cubic volume inside bark.

Table 2. Slash pine seed source means for unextracted wood specific gravity, growth variables, and volume and weight of wood

Seed Source	Specific Gravity	DBH (cm.)	Height (mt.)	Crooked Trees	Branches per Tree	Percent Survival	Hectare (cu. mt.)	Hectare (1,000 kilos)
Baker Co. Fla.	.420 a	11.4 a	7.9 a	5.5 a	1.3 a	79.0 a,b	43.9 a	18.1 a
Nassau Co. Fla.	.417 a	10.5	7.0 c,d	8.4 a,b	1.3 a	43.9	17.9 b	7.5 b
Wayne Co. Ga.	.414 a	10.4	7.0 d	10.3 a,b	1.1	67.0 b	28.6 a,b	11.7 a,b
Jeff Davis Co. Ga.	.419 a	11.5 a	7.9 a	6.1 a,b	1.4 a	79.1 a,b	45.1 a	18.5 a
Eman. & Bull. Co. Ga. Sl. Tester	.414 a	11.3 a	7.9 a	7.6 a,b	1.3 a	77.4 a,b	43.4 a	17.6 a
Eman. & Bull. Co. Ga. Nur. Run	.414 a	11.0 a	7.5 b,c	6.3 a,b	1.4 a	74.9 a,b	36.7 a,b	14.8 a
Allendale Co. S.C.	.419 a	11.2 a	7.7 a,b	7.6 a,b	1.3 a	78.4 a,b	42.4 a	17.6 a
Eman. & Jeff. Co. Ga. Lob. Tester	.393	12.7	8.2 a	12.3 b	2.5	83.3 a	68.2	26.6
Means	.414	11.3	7.6	7.9	1.4	73.8	41.0	16.6

Means not marked by a common letter differ at the .05 level of significance.

(1) Loblolly seed sources had significantly higher survival than slash pine (Tables 2 and 4). When the two species were compared on the basis of seed sources from a single nursery, loblolly sources averaged 5% better survival than slash sources.

(2) In diameter at breast height, loblolly was significantly larger (1.0 to 1.5 cm.) than slash pine (Tables 2 and 4).

(3) In total height, the difference between the species was not significant, but on the average loblolly pine was slightly taller than slash pine. And height differences were greatest on the better sites (Tables 2 and 4).

Also, there was no evidence that slash pine had faster early height growth than loblolly pine, although this has often been cited as a reason for the supposed superiority of slash pine. In the slash plantings, the loblolly tester was taller than the average for the slash sources at the end of the first season, and taller than any slash source from the third season on. In the loblolly plantings, the slash tester never has ranked higher than sixth. Finally, the trend of height growth with age gives no indication that slash height growth is increasing faster than loblolly - thus there is no indication that the slash pine is likely to catch up to the loblolly pine.

It should be noted that tipmoth attacks (Ryacionia frustrana Comst.) were never serious in these tests. Attacks at the end of the first season were light (4% in slash, 18% in loblolly) and had little effect on height growth of either species. After the first season, attacks were so light and had so little apparent effect on growth that they were not recorded.

There were other differences between the species:

(1) Loblolly had significantly more branches per tree than slash pine, but differences were small, one-half to one branch Der tree for the 1.5 meter section of the bole that was evaluated (Tables 2 and 4).

(2) Slash pine was significantly higher than loblolly pine in unextracted wood specific gravity, but again differences were small (.015 to .024), and this difference was completely overcome by the superior volume growth of the loblolly pine (Tables 2 and 4).

In addition, at Piedmont locations beyond the natural range of slash pine (Hancock and Saluda Co.) the specific gravity of the slash tester (.366) was lower than the average for loblolly sources at those locations (.373).

(3) In the percentage of crooked trees, the difference between the species was not significant, although slash sources averaged 3% to 4% fewer crooked trees than loblolly sources (Tables 2 and 4).

(4) In percentage infection, and mortality from fusiform rust (Cromartium fusiforme Hedgc. and Hunt ex.Cumm.), differences between the species were not significant.

But in measures of fusiform rust infection related to severity of infection (total number of galls per tree, number of bole galls per tree, percentage of trees with bole galls, and percentage of severely infected trees), slash pine was significantly higher than loblolly pine, and differences between the species were greatest at those locations where infection rates were highest (Tables 6 and 8). This suggests that even when the infection rate is the same for both species, slash pine is more likely to be severely infected than loblolly pine. It also suggests that future mortality among infected trees will be higher in slash pine than in loblolly pine. This increased mortality in slash pine is expected to accentuate differences in productivity between the species in the future.

Few meaningful differences were found among seed sources of either species in this study.

The most likely reason is that only a few sources of either species were included in this study, and these came from a restricted part of the species range. The only notable exception was the high percentage of crooked trees in the Glynn-Camden-McIntosh Co. loblolly seed source, which had an average of 29% crooked trees in comparison with an average of 11% for all seed sources in the loblolly plantings (Table 4).

Other authors, however, have reported differences in productivity among seed sources in both species. In slash pine, Gansel, et al.(1971) found significant differences in height growth among slash pine seed sources. Among those reporting significant differences among loblolly pine seed sources are Zarger (1961), Kraus (1969), Lantz and Hofmann (1969), Wells (1969), and Rink and Thor (1971).

In slash pine, no differences among seed sources in susceptibility to fusiform rust have been reported (Snyder, et al., 1967; Gansel et al., 1971). But in loblolly pine, other studies have shown considerable variation in susceptibility to fusiform rust (Wells and Wakeley, 1966; Wells and Switzer, 1971). In particular, the southeastern Louisiana loblolly source has shown a high degree of rust resistance and good growth through age 15, and has been recommended for plantings in the Coastal Plain and Piedmont of Mississippi, Alabama, and Georgia (Wells, 1969).

Thus it seems that there are significant differences among seed sources of both species whenever the sources tested are from areas where environmental factors differ significantly.

Location effects were significant in all analyses, and there were three general patterns of response.

(1) Unextracted wood specific gravity was highest in the southern Coastal Plain, decreased at locations in the northern Coastal Plain, and was lowest at Piedmont locations (Tables 3 and 5). This pattern has been reported in several studies in natural stands (Goddard and Strickland, 1962; Zobel, et al., 1960).

(2) For volume and weight of wood, diameter, height, and number of branches per tree, values were highest at locations on abandoned fields (those in Saluda Co., Hancock Co., Bleckley Co., Bulloch Co., and Jasper Co.) than at locations on prepared sites (those in Baker Co., Long Co., and Appling Co.). This seemed to be a response to site quality factors rather than a geographic effect (Tables 3 and 5).

Table 3. Location means for unextracted wood specific gravity, growth variables, and volume and weight of wood for slash pine locations

Locations	Specific Gravity	DBH (cm.)	Height (mts)	Percent Crooked Trees	Branches per Tree	Percent Survival	Volumes per Hectare (cu. mt.)	Weight per Hectare (1,000 kilos)
Baker Co. Fla.	.422 a,b	8.6a	6.4 a	9.3 a	0.6 a	85.6 a	23.1 a	9.8 a
Long Co. Ga.	.431 a	9.3 a	6.6 a	7.9 a	0.8 a	73.4 b	24.6 a	10.6 a
Appling Co. Ga.	.419 b	9.3a	6.8 a	0.7	0.9 a	84.4 a	27.1 a	11.3 a,b
Bulloch Co. Ga.	.397 c	15.9	10.1	22.5	3.2 b	70.3 b	92.2	36.4
Jasper Co. S.C.	.399 c	13.2	8.3	6.0 a	2.6 b	47.6	37.8	15.0 b
Means	.414	11.3	7.6	7.9	1.4	73.8	41.0	16.8

Means not marked by a common letter differ at the .05 level of significance.

Table 4. Loblolly pine seed source means for unextracted wood specific gravity, growth variables, and volume and weight of wood

Seed Source	Specific Gravity	DBH (cm.)	Height (mt.)	Percent Crooked Trees	Branches per Tree	Percent Survival	Volumes per Hectare (cu. mt.)	Weight per Hectare (1,000 kilos)
Laurens Co. S.C.	.387 a	12.6 a	7.9 a,b	7.4 a,b	3.4 a,b	76.4 a,b	51.2 a,b	19.7 a,b
Allendale Co. S.C.	.386 a	12.5 a	7.9 a,b	9.5 a,b	3.5 a,b	75.3 a,b	51.5 a,b	19.7 a,b
Warren Co. Ga.	.388 a	12.5 a	8.1 a,b	5.8 b	3.3 b	79.3 a	56.4 a	21.6 a
Eman. & Jeff. Co. Ga. Lob. Tester	.382 a	12.9 a	8.2 a	9.5 a,b	3.1 a	78.2 a	58.9 a	22.3 a
Eman. & Jeff. Co. Ga. Nur. Run	.383 a	12.9 a	8.2 a	9.8 a,b	3.1 a	74.2 a,b	55.8 a,b	21.2 a
Randolph Co. Ga.	.382 a	11.9 a,b	7.2 b	12.2 a	3.3 a,b	70.0 b	41.8 c	15.7 b,c
G-C-M Co. Ga.	.379 a	12.3 a,b	7.8 a,b	29.2	2.6	69.8 b	46.0 b,c	17.2 b,c
Eman. & Bull. Co. Ga. Sl. Tester	.399	11.5 b	7.5 a,b	7.8 a,b	1.8	71.6 a,b	36.6 c	14.3 c
Means	.386	12.4	7.9	10.7	3.0	74.5	49.8	19.0

Means not worked by a common letter differ at the .05 level of significance.

Table 5. Location means for unextracted wood specific gravity, growth variables, and volume and weight of wood for loblolly pine locations

Location	Specific Gravity	DBH (cm.)	Height (mt.)	Percent Crooked Trees	Branches per Tree	Percent Survival	Volumes per Hectare (cu. mt.)	Weight per Hectare (1,000 kilos)
Baker Co. Fla.	.397 c	7.7 a	5.3	11.0 a	0.9 a	90.2 a	18.6 a	7.4 a
Long Co. Ga.	.412 c	9.0 a	6.3 c	12.6 a	1.3 a	83.9 b	28.1 a,b	11.6 a,b
Appling Co. Ga.	.389 b,c	9.3 a	6.6 c	1.5	1.5 a	93.1 a	29.9 a,b	11.7 a,b
Jasper Co. S.C.	.386 b	15.1 b,c	9.6 a	15.5 a	3.1	56.0 c	68.2 d	26.2 d
Bleckley Co. Ga.	.371 a	16.2 b	8.5 b	16.5 a	8.1	35.7	40.9 b,c	15.2 b,c
Hancock Co. Ga.	.371 a	14.2 c	8.7 b	8.7 a	4.2 b	62.4 c	55.1 c,d	20.4 c,d
Saluda Co. S.C.	.374 a	15.6 b	10.2 a	14.5 a	4.7 b	83.4 b	107.3	40.2
Means	.386	12.4	7.9	10.7	3.0	74.5	49.8	19.8

Means not marked by a common letter differ at the .05 level of significance.

Table 6. Slash pine seed source means for measures of fusiform rust infection

Seed Source	Percent Mortality	Percent Infection	No. bole Galls per Tree	No. Branch Galls per Tree	Total No. Galls per Tree	Percent Bole Galls	Percent Branch Galls	Percent Severely Infected
Baker Co. Fla.	8.2 a	46.4 a,b	0.9 a	2.5 a	2.8 a	17.2 a	38.3 a	9.2 a
Nassau Co. Fla.	2.4 b	39.7 a,b	0.9 a	2.0 a,b	2.3 a	21.4 a	33.6 a	8.2 a
Wayne Co. Ga.	4.1 b,c,d	43.6 a,b	0.9 a	2.1 a	2.4 a	22.7 a	38.7 a	9.9 a
Jeff Davis Co Ga.	6.4 a,d	49.1 a	0.9 a	2.2 a	2.5 a	20.9 a	37.1 a	9.1 a
Eman. & Bull. Co. Ga. Sl. Tester	8.2 a	49.8 a	0.9 a	2.2 a	2.5 a	21.8 a	44.5 a	8.9
Eman. & Bull. Co. Ga. Nur. Run	3.0 b,c	48.8 a	0.8 a,b	2.2 a	2.5 a	21.6 a	43.9 a	9.5 a
Allendale Co. S.C.	8.2 a	41.4 a,b	0.9 a	2.1 a	2.4 a	22.5 a	38.6 a	10.8 a
Ema. & Jeff. Co. Ga. Lob. Tester	5.1 a,c,d	36.5 b	0.7 b	1.5 b	1.7	12.6 a	32.0 a	3.7
Means	5.5	44.4	0.9	2.1	2.4	19.9	38.3	8.5

Means not marked by a common letter differ at the .05 level of significance.

(3) For all measures of fusiform rust infection, values were highest at locations on abandoned fields, and lower at locations on prepared sites (Tables 7 and 9). It has long been recognized that plantations or natural stands on abandoned fields are more severely infected than those on undisturbed sites in the same area (Siggers, 1955).

There was also an indication of a geographic effect, since the extreme north and south locations were significantly lower in most measures of fusiform rust infection than locations in the center of the test area.

In summary, this study showed that loblolly pine was significantly more productive than slash pine in the volume and weight of wood produced in the area where the study was conducted. These results are based on measurements at the end of the ninth season, and these species aren't usually harvested before an age of 20-30 years. Thus, the results and conclusions are tentative, and must be confirmed by future measurements before they can be considered final.

However, evidence from the data on height growth and fusiform rust infection is such that there is little indication that any major reversal will take place; it seems more likely that differences in productivity will be greater in the future.

The difference in productivity is certainly large enough to have considerable economic importance. It favors the use of loblolly pine on well drained sites over a large part of the southeastern Coastal Plain, although slash pine will be more productive on poorly drained sites.

It is suggested that forest land managers within that part of the natural range of slash pine covered by this study may obtain an economically important increase in productivity by planting the appropriate source of loblolly pine, instead of slash pine, on the better drained sites.

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Table 7. Location means for measures of fusiform rust infection for slash pine locations

Location	Percent Mortality	Percent Infection	No. Bole Galls per Tree	No. Branch Galls per Tree	Total No. Galls per Tree	Percent Bole Galls	Percent Branch Galls	Percent Severely Infected
Baker Co. Fla.	1.4 a	1.3	0.5	0.5	0.5	0.1	0.7	0.0
Long Co. Ga.	4.1	36.6 a	0.6 a	1.1	1.2	11.8 a	31.5 a	4.3
Appling Co. Ga.	2.3 a	30.9 a	0.6 a	0.9	1.0	7.3 a	27.2 a	2.2
Bulloch Co. Ga.	6.2	81.4 b	1.3	5.2 a	6.0 a	47.8	72.2 b	20.7
Jasper Co. S.C.	21.3	87.7 b	1.6	5.3 a	6.4 a	63.3	81,2 h	39.3
Means	5.5	44.4	0.9	2.1	2.4	19.9	38.3	8.5

Means not marked by a common letter differ at the .05 level of significance.

Table 8. Loblolly pine seed source means for measures of fusiform rust infection

Seed Source	Percent Mortality	Percent Infection	No. Bole Galls per Tree	No. Branch Galls per Tree	Total No. Galls per Tree	Percent Bole Galls	Percent Branch Galls	Percent Severely Infected
Laurens Co. S. C.	1.6 a	42.4 a,b	0.7 a,b	1.8 a	2.0 a	15.3 a,b	38.3 a,b	2.5 a
Allendale Co. S. C.	2.5 a	45.6 a,b	0.7 a,b	1.8 a	2.1 a	14.5 a,b	41.4 a,b	3.3 a
Warren Co. Ga.	2.6 a	43.1 a,b	0.7 a,b	1.7 a	1.9 a	13.4 a,b	39.7 a,b	2.1 a
Eman. & Jeff. Co. Ga. Lob. Tester	4.5 a	42.9 a,b	0.8 a,b,c	1.8 a	2.0 a	15.7 a,b	39.8 a,b	2.6 a
Eman. & Jeff. Co. Ga. Nur. Run	1.9 a	48.9 a	0.8 a,c	2.0 a	2.2 a	18.9 a,c	43.4 a	2.3 a
Randolph Co. Ga.	4.4 a	44.7 a,b	0.8 a,b,c	1.9 a	2.2 a	16.6 a,b	38.0 a,b	3.1 a
G-C-M Co. Ga.	2.1 a	37.8 b	0.7, a,b	1.6 a	1.8 a	12.8 a	32.0 b	2.2 a
Eman. & Bull. Co. Ga. Sl. Tester	4.8 a	46.6 a	0.9 c	1.7 a	2.1 a	22.8 c	38.6 a,b	8.5
Means	3.0	44.0	0.8	1.8	2.0	16.2		3.1

Means not marked by a common letter differ at the .05 level of significance.

Table 9. Location means for measures of fusiform rust infection for loblolly pine locations

Location	Percent Mortality	Percent Infection	No. Bole Galls per Tree	No. Branch Galls per Tree	Total No. Galls per Tree	Percent Bole Galls	Percent Branch Galls	Percent Severely Infected
Baker Co. Fla.	1.5 a, b	2.8	0.5 a	0.5	0.5	0.4	2.1	0.1 a
Long Co. Ga.	1.2 a,b	20.6 a	0.6 a	0.8 a	0.9 a	4.6 a	18.7 a	1.5 b
Appling Co. Ga.	1.0 a	18.4 a	0.6 a,b	0.8 a	0.8 a	4.6 a	16.0 a	0.7 a,b
Jasper Co. S.C.	7.4 c	83.9 b	1.2 d	4.3	5.0	49.8 c	77.2 c	21.7
Bleckley Co. Ga.	3.1 b	79.4 b	1.1 c,d	3.7 b	4.3 h	41.0 b,c	74.6 b,c	6.2 c
Hancock Co. Ga.	6.4 c	77.4 b	1.0 c	3.4 b	3.9 b	34.2 b	70.1 b	6.1 c
Saluda Co. S. C.	2.8 a,b	40.1	0.7 b	1.2	1.3	12.8	34.9	0.1 a
Means	3.0	44.0	0.8	1.8	2.0	16.2	39.0	3.1

Means not marked by a common letter differ at the .05 level of significance.

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