Performance of Loblolly and Slash Pine Nursery Selections

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Abstract. Select loblolly pine seedlings averaging 126 percent taller than controls at planting were 10.8 ft or 45 percent taller than controls at age 10, and total stem-wood volume of the average selected tree was 3.4 times greater than controls. Select slash pine seedlings with an initial superiority of 104 percent over the controls were 5.2 ft or 20 percent taller than controls at age 10, and the total stem-wood volume of the average select tree was 1.8 times greater than controls. Select loblolly and slash trees had less within-plot variation in diameter and height at age 10 than did their controls. The control loblolly had more variation in height than did the control slash, but the selects of the two species had comparable variation. Select trees in comparison with controls did not show significant differences with respect to percent infection from fusiform rust, stem forking, cone production, or seedling survival, but select loblolly stems had significantly more sweep than control loblolly. ***Forest Sci. 18:308–313.***

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A LARGE proportion of the tree breeding work in the southern pine region is devoted to loblolly pine (*Pinus taeda* L.) and slash pine (*P. elliottii* Engelm.) because of their importance as raw material for the lumber, pulpwood, and plywood industries. In a breeding program several methods are used to select superior phenotypes: nurserybed selection, field selection, and geographic race selections. Most tree improvement programs by private companies, State, and Federal Agencies have used field selections as the first step in their genetic programs. The results of this study and others such as that of Zarger (1965) indicate that nurserybed selection may be an efficient way of identifying exceptionally fast-growing trees.

This paper reports the 10-year results of a nursery selection study for fast growth of loblolly and slash pine. First-year height in the nursery beds was the only criterion used for selecting outstanding seedlings. Because undesirable traits that may be associated with fast growth are of concern to silviculturists, geneticists, and pathologists, measurements were also taken to determine if undesirable characteristics, such as high incidence to disease, poor stem form, low seedling survival, or low seed production, were correlated with fast growth.

Methods

The planting stock was 1–0 loblolly and slash pine seedlings lifted after the 1954, 1955, and 1957 growing seasons from the Manchester State Forest Nursery, Sumter, South Carolina.[1] Selections were made in the nurserybed on the basis of the exceptionally large size of select seedlings rela-

[1] Nursery owned and operated by the South Carolina State Commission of Forestry.

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TABLE 1. Ten-year development of loblolly and slash pines grown from selected and control seedlings.

Variable	Loblolly pine		Slash pine	
	Control	Select	Control	Select
Survival, percent	86	81	74	76
Diameter breast height, inches	3.5	5.7**	4.2	5.1
Total height, feet	24.0	34.8**	26.5	31.7**
Volume of average tree, cu ft	.73	2.46**	.94	1.69*
Mean volume of 2 tallest trees, cu ft	1.75	3.57*	1.71	2.63*
Coefficient of variation of:				
Diameter breast height, percent	41.0	18.3**	32.5	19.2*
Height, percent	28.2	11.4**	20.1	13.8**

* Select significantly different from control of same species at 5-percent level.

** Select significantly different from control of same species at 1-percent level.

tive to surrounding seedlings. The minimum size for selects was 8 inches in height and a root collar diameter of 3/16 inch. Selection intensity was approximately 1: 10,000 for both species. Each year 24 seedlings of each species were selected, and an equal number of average-sized seedlings present in the nurserybed at time of selection were used as controls for evaluating the performance of select seedlings. Mean heights of loblolly pine seedlings immediately after outplanting were 12.0 inches for selects and 5.3 inches for controls, and respective heights of select and control slash pine seedlings were 11.6 and 5.7 inches.

Plantings were made in December during each of the three years on an open site on the Santee Experimental Forest in South Carolina. The site had been cleared during the early 1940's and then abandoned after several years. The trees and shrubs which invaded were cleared from plots and adjacent isolation strips prior to planting. The texture of the surface 6 inches of soil is loamy sand to sandy loam, and soil texture varies but a little to a depth of 36 inches.

Two blocks of select and control loblolly and slash pine seedlings were established each year in a randomized, complete block design. Twelve seedlings per plot were hand-planted at a 6 × 6-ft spacing, in 0.01-acre plots; no buffer zone was left between plots planted the same year. Isolation strips established between plantings were rapidly invaded by pines and hardwoods, which have maintained competitive stands of equivalent ages on the perimeter of plantings.

Survival and height were measured the first year after planting and at periodic intervals through the 10th year. Total cubic-foot volume of entire stems, less bark, was computed at age 10 from MacKinney and Chaiken's (1939) equation. Fusiform rust (*Cronartium fusiforme* Hedgec. & Hunt ex Cumm.) on stem and branches was recorded during each inventory. When the stands were in their 10th to 13th growing seasons, stem sweep, stem forking, and cone production were assessed.

Data for the three plantings was pooled to provide six blocks for analysis of variance. Separate analyses for loblolly and slash pines were made to test select versus control seedlings of each species. Data involving proportions—percent survival and percentage of trees having fusiform rust, stem sweep, forking, and cones—were transformed by arcsin $(\text{percentage})^{\frac{1}{2}}$ transformation.

Results and Discussion

Loblolly and slash pine seedlings developed very similarly with respect to survival, height, diameter, volume growth, fusiform rust incidence, and forking. The most consistent differences between the two species

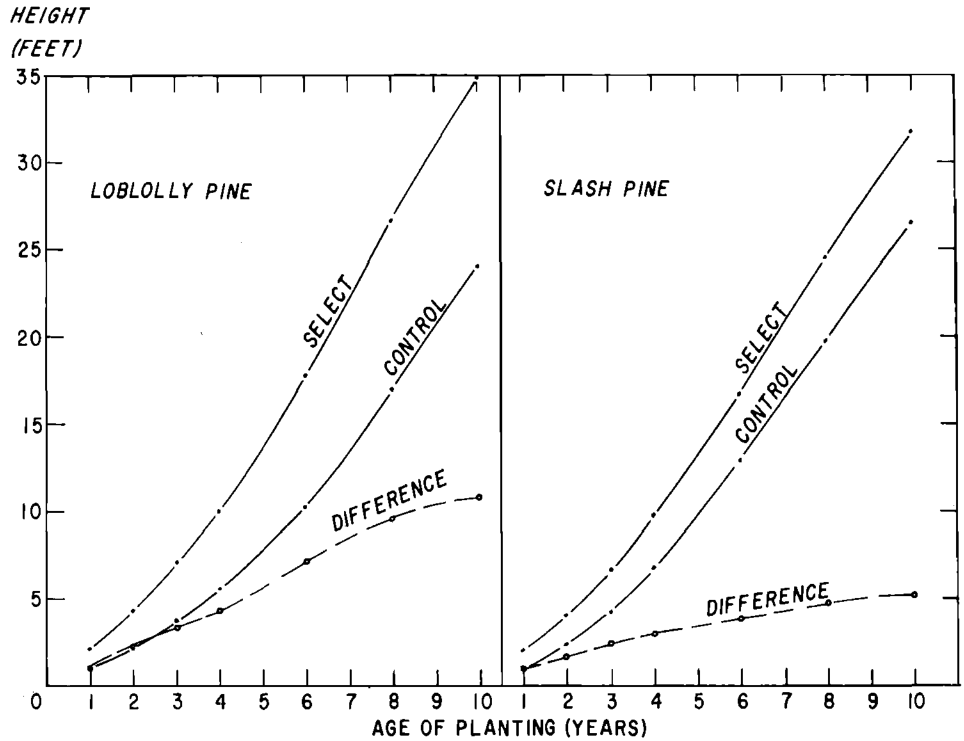

FIGURE 1. *Pattern of height growth behavior of select and control trees of loblolly and slash pine for 10 years following planting.*

were in stem sweep, cone production, and variability in height growth. The relative performance of select and control seedlings at age 10 was consistent among the six blocks.

Survival. Average survival in all plots planted during the three-year period was 79 percent. Survival did not differ significantly by species or by selection (Table 1). The select trees of both species survived as well as controls. These results agree with other nursery selection studies for both loblolly (Zarger 1965) and slash pine (Foulger 1960). In a Florida slash pine study (Bengtson 1963), the select seedlings had lower survival, but this was attributed to a droughty period after planting which was compounded by micro-site differences.

Growth. Height growth of select loblolly and slash seedlings has been substantially greater than control seedlings from first to tenth year (Fig. 1 and Table 1). Absolute differences between the selects and controls continued to increase for 10 years, although at a slower rate after age 8. However, relative differences have decreased since planting. For slash pine the initial superiority of 104 percent for the selects dropped to 20 percent at 10 years, and for loblolly the drop was from 126 percent to 45 percent.

At 10 years old, select loblolly pine trees were significantly larger than their controls in both diameter and height (Table 1). Select slash pines were also larger in height but diameter differences were significant at a lower level ($P < 0.10$). Total cubic volume of stem-wood of the average tree (tree of average diameter and height) and of the two tallest trees on each plot (representing the tallest 200 trees on an acre basis) were the measures used to compare the select and control seedlings of each species (Table 1). On the average tree basis, cubic volume of selects was 3.4 times that of the controls for loblolly, and 1.8 times that of its controls for slash. On the basis of the two tallest trees per plot, the cubic-volume ratios of selects and controls were lower than in the preceding comparison. For loblolly the ratio dropped from 3.4 to 2.0, and for slash, from 1.8 to 1.5. The greater reduction in the ratio for loblolly pine compared to slash pine is a reflection, in part, of the greater inherent variability of control loblolly seedlings than control slash seedlings. Within-plot variation in height and diameter at age 10, as revealed by the coefficient of variation, was in the following descending order: control loblolly, control slash, select slash, and select loblolly (Table 1). The coefficient of variation for height was 28.2 percent for control loblolly versus 11.4 percent for select loblolly, and 20.1 percent for control slash versus 13.8 percent for select slash. Bengtson (1963) also found that select slash pine seedlings showed a lower coefficient of variation for height at age 8.

Theoretically, nursery selection should identify not only superior growth rates for a group of seedlings but also for individual trees. Hence, the average volume of the two largest selects per plot is compared with the average volume of all controls. For loblolly the selects had 4.9 times more volume than their controls, and for slash the volume of the selects was 2.6 times their controls.

The differences in growth rate of loblolly and slash pines due to nursery selection are much larger than those observed in other studies. Our seedlings were selected at a rate of about 1:10,000. Hunt (1967) and Zarger (1965) selected their loblolly pine seedlings at ratios of 1:44,000 and 1:250,000, respectively, but their select and control trees differed by only 1.9 feet or 20 percent by volume after 9 years. Hunt (1967), Bengtson (1963), and Foulger (1960) selected their slash pine seedlings at higher ratios: 1:146,000; 1:23,000; and 1:25,000 (estimated), respectively; but, again, less differences (or no differences, Foulger 1960) were observed in comparable periods of time. Apparently, extremely high selection intensities do not assure success because results can vary with any one of the many factors (for example, different seed lots, nursery practices, outplanting sites, spacing, and plot size) which differ among experiments.

TABLE 2. Percentage of young loblolly and slash pine trees showing fusiform infection of branches or stems, stem sweep or forking, or cone production.[1]

Attribute	Loblolly pine		Slash pine	
	Control	Select	Control	Select
Fusiform branch infection	18	20	10	16
Fusiform stem infection	16	18	17	21
Stem sweep	49	79*	32	27
Stem forking	7	8	7	10
Cone production	11	17	0	3

[1] Fusiform infection was recorded at each inventory through the 10th growing season, and dead trees which were infected are included. Stem sweep, forking, and cone production were recorded during 10th to 13th growing season.

* Significantly different from control of same species at 5-percent level.

In our study the close spacing, small plot size, and arrangement of plots (3 rows of 4 trees each spaced 6 ft apart, without border rows between plots) possibly could have exaggerated competitive effects. If such competition between plots had been apparent, we should have noticed, in plots having relatively slower growing trees compared to the plots on its perimeter, a tendency for trees to be smaller near plot margins and bigger in the interior; but, trees did not appear to vary in size depending on their within-plot location.

The value of comparisons of volume growth in young plantations is limited because of the possibility of changes in growth rate of individual trees with age. However, our 10-year test period for loblolly and slash pines covers a substantial proportion of rotation lengths of about 20 years now used by many forest managers. Also, information reported recently indicates that, in general, relative growth rates might not change with time. In the oldest seedling-grade study on record, the largest seedlings produced greater volumes at 34 years (Wakeley 1969). In another study, Wakeley (1971) showed that loblolly and slash pines which were tallest at early ages tended to remain tallest at age 30. Therefore, it is reasonable to assume that the volume superiority of our selected seedlings will still be apparent far beyond 10 years.

Disease Resistance, Stem Form, and Cone Production. Five other traits possibly associated with growth rate—fusiform infection of branches and main stem, stem sweep, forking, and cone production—were evaluated. Comparisons of selects and controls of each species revealed that the only significant difference was with respect to stem sweep of loblolly pine (Table 2). Select loblolly pines had 79 percent of trees with sweep, compared to only 49 percent for controls. Other studies have shown that fusiform infection is not closely related to fast growth, and that there are inherent differences among trees of both species in resistance to infection (Kinloch and Stonecypher 1968). Nursery selection had no detectable effect on early cone production. An average of approximately 15 percent of loblolly trees had produced cones at ages 10 to 13, whereas only one slash pine produced cones. Although wood specific gravity and other properties were not sampled, the current results of tree breeding indicate that wood quality generally is not seriously impaired by fast growth (Zobel *et al.* 1969).

Conclusions

Nurserybed selection appears to be useful as an initial step in picking out fast-growers to be followed by breeding for further improvement in growth and for other desired traits. Nurserybed selection, whereby millions of trees can be rapidly screened, can supplement field selections made in plantations or natural stands.

Select loblolly and slash pines that had produced more cubic volume of wood than their controls showed no appreciable differences in resistance to disease, stem form, or seed-producing ability. Correlation among traits is important in breeding, particularly when traits may complement each other.

Although phenotypic growth superiority has been demonstrated, genetic growth superiority has yet to be proven. The next logical step would be to conduct controlled crosses among the fast-growing selects and controls that have other desirable traits and to install progeny tests to determine the crosses that have inherent growth superiority and other desired traits. There was ample variation in fusiform infection, stem form, and fruitfulness among fast-growing loblolly and slash pines to make further selections among them possible. If there were a larger population of nurserybed selections, trees that possess desirable traits could be easily identified. Ultimately, such a program could result in greatly increased net returns because of an increase in growth per tree combined with higher survival of disease-resistant planting stock and of high-value trees from improvement in form.

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