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A Study of the Growth, Yield, and Pest Resistance of Shortleaf X Slash Pine Hybrids

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SUMMARY

At age 10, shortleaf x slash pine hybrids performed relatively poorly when compared with loblolly pine in 10 plantings throughout the southern pine region. The hybrids excelled only in resistance to fusiform rust. Over all plantings, loblolly averaged about 5 feet taller than the hybrids and had almost twice as much volume. The hybrids' rust resistance may make it a valuable source of germ plasm for breeding programs aimed at producing varieties of slash pine with a broad genetic base for resistance.

INTRODUCTION

Hybrids involving the southern pines are being developed in the northeastern part of the Southern pine region (Little and Trew 1967, 1977, pitch x loblolly), and in central Georgia (LaFarge and Kraus 1960, loblolly x shortleaf). The pitch x loblolly hybrid is to be planted on sites in and near Pennsylvania and West Virginia where climate and soils are unsuitable for loblolly pine, and the loblolly x shortleaf hybrid is being developed primarily for its rust resistance in the high rust hazard areas of the Southeast. A third hybrid, shortleaf x slash pine, has been suggested as an alternative to loblolly pine on high rust hazard Piedmont and Upper Coastal Plain sites in Georgia and Alabama (Wells et al. 1976). So far, shortleaf x slash pine hybrids have been adequately tested only for performance in comparison to the parent species.

The present study was designed to test the shortleaf x slash hybrids against loblolly pine, as well as the parent species, over the long term at several locations throughout the southern pine region.

METHODS

The shortleaf female parents of the hybrids are located in a geographic seed-source plantation on the Harrison Experimental Forest in south Mississippi. About 10 trees each from Louisiana, Texas, Arkansas, and Oklahoma seed sources were used as female parents for a "western hybrid" and about the same number from Alabama, Georgia, South Carolina, and Tennessee were used for an "eastern hybrid". Eastern and western shortleaf parents were pollinated in 1964 with a pollen mix from approximately 25 slash pine in a southern Mississippi plantation. The slash pine were of northern Florida origin. Seed from the four eastern sources were mixed together as were seed from the four western sources. Hybrid stock was grown at the Harrison Experimental Forest in southern Mississippi in the spring of 1966. Seed from natural stands-slash pine from southern Mississippi and shortleaf from southeastern Louisiana were included in the test.

Shortleaf pine and loblolly pine from near each planting site were also included in each planting. All stocks were grown either in nurseries near the planting sites or at the U.S. Forest Service Ashe Nursery near Brooklyn, Mississippi, about 40 miles north of the Harrison Experimental Forest.

A randomized complete block field design was used with trees planted at 12 X 12 foot spacing in 49-tree plots with a single isolation row around each plot. Large plots with buffer rows were used to eliminate between-plot competition, and the trees were widely spaced to eliminate thinning for many years. The interior 25 trees were measured periodically. Each block consisted of the following sources of stock: (A) shortleaf x slash, western source; (B)

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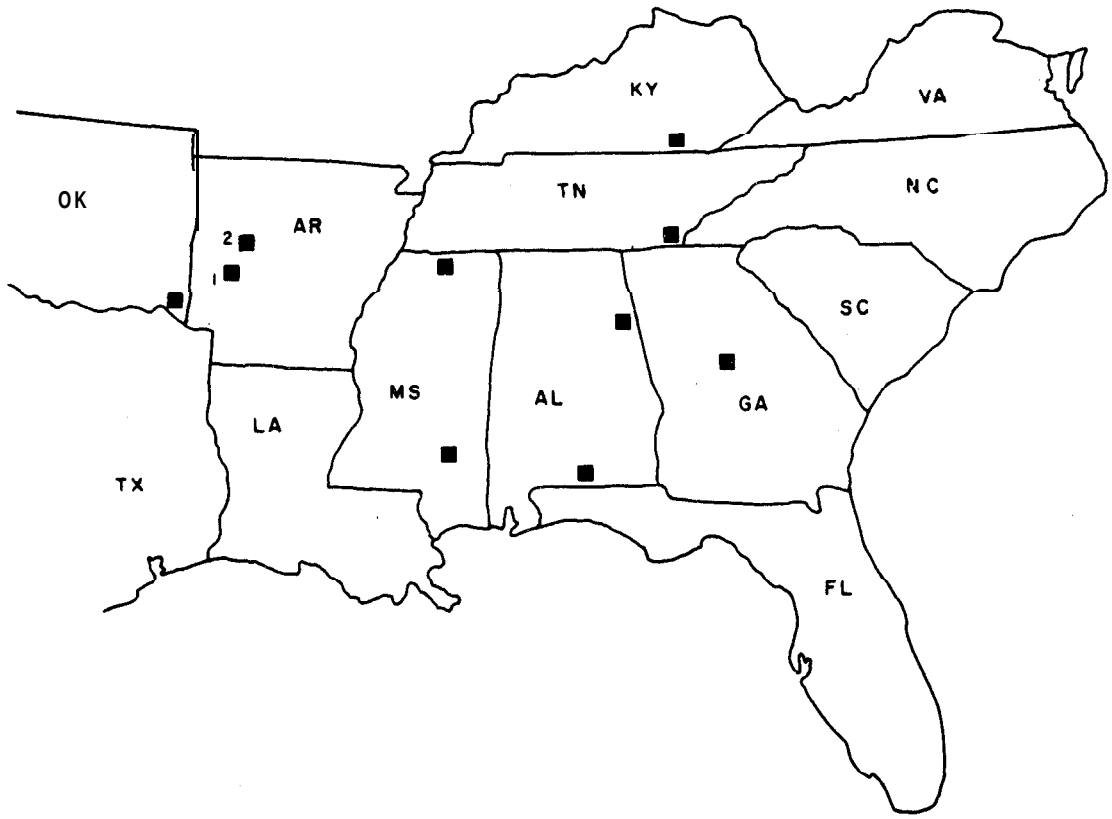

Figure 1.—*Planting* locations. *The Oklahoma and Arkansas 2 (Yell County) plantings were established In 1966–67; the others in 1968–69.*

shortleaf x slash, eastern source; (C) shortleaf control, St. Helena Parish, Louisiana; (D) shortleaf control, local source; (E) slash control, southern Mississippi; and (F) loblolly control, local source. These 6 sources were replicated in 5 blocks at each of 10 planting locations.

Ten plantings were established in the 1968-67 planting season, one near Oklahoma State University and nine on National Forests. Planting survival, generally low, ranged from complete failure in Polk County, Tennessee, and McCreary County, Kentucky, to an average survival of 77 percent in McCurtain County, Oklahoma. Unusually low temperatures immediately after establishment at the northern locations and a generally dry spring were the major causes of poor survival in 1967. Because of mild temperature, neither stocks produced in the Harrison Experimental Forest nursery nor the local checks at two more northerly nurseries hardened for winter sufficiently to survive planting.

Because of the poor survival, eight plantings of the same seedlots in the same design were reestablished in the 1968-69 season. All seedlings including local stocks were grown in the Ashe Nursery. Planting survival was good and with the two plantings from the 1966-67 season that were retained—in McCurtain County, Oklahoma and Yell County, Arkansas-the study was established as designed. (fig. 1).

Data were collected on survival, height, diameter, and fusiform rust incidence after 3, 5, and 10 years in the 1968-69 plantings and after 3, 6, and 12 years in the 1966-67 plantings. Analysis of variance and Duncan's Multiple-Range Test was used to test for differences among sources.

RESULTS

Planting Survival.-Planting survival was above 90 percent for four of the eight plantings established in the winter of 1968-69 and above 80 percent in all but one other. Only the northern Mississippi planting had fairly low survival-81 percent. Relatively few genetic differences in survival were expressed under these non-stressful conditions. In lower-sur-

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Table 1.—*Survival at 10 years of hybrids and check species in six plantings east of the Mississippi River and at 12 years in hvo plantings west of the River*

Hybrid or check species	Eastern planting location							Western planting location		
	KY	TN	N MS	N AL	N GA	SAL	Avg	OK	AR	Avg
	percent									
Local loblolly	91	88	90	94	77	94	89d[1]	88	99	94'
South MS Slash	41	88	69	74	62	66	67b	68	30	49
Western hybrid	64	81	56	71	74	83	68b	58	42	50
Eastern hybrid	66	56	33	61	61	58	56a	42	30	37
SE LA shortleaf	64	87	58	93	93	96	81c	60	50	55
Local shortleaf	90	84	67	69	85	97	85cd	68	62	85

'Means opposite the same letter are not significantly different at the 0.05 percent level.
[2]Statistical analysis not done because local loblolly and shortleaf were grown in different nurseries.

Table *P.-Average volume per acre* al *10 years-hybrids and check species in six plantings east of the Mississippi River*

Hybrid or check species	Eastern planting location						
	KY	TN	N MS	N AL	N GA	S AL	Avg
	ft^3/acre						
Local loblolly	339	279	935	333	778	1302	661e[1]
South MS Slash	57	115	452	208	426	676	322c
Western hybrid	107	79	324	176	615	1035	389d
Eastern hybrid	77	78	191	149	443	507	241a
SE LA shortleaf	67	51	205	137	547	948	325c
Local shortleaf	107	93	287	114	345	855	297b

[1]Means opposite the same letter are not significantly different at the 0.05 percent level.

vival areas, the hybrid made with eastern shortleaf averaged only 64 percent planting survival while the western hybrid averaged 81 percent.

Interpretation of survival results in the two 1966-67 plantings was complicated by variations in stock sources. The Yell County, Arkansas planting had 98 percent survival of the trees grown at the U.S. Forest Service Ashe Nursery, but only 47 percent of the stock from the Harrison Experimental Forest survived.

Post-Establishment Survival.-Between establishment and measurment at 10 or 12 years, the plantings in northern Arkansas and southern Mississippi suffered heavy nonrandom mortality from weed competition and fire respectively, and were abandoned. In the other plantings, the hybrids generally suffered more mortality than local shortleaf or loblolly (table 1), particularly in the Oklahoma and Yell County, Arkansas plantings. Many of the hybrids that did not survive were dwarfs. Dwarfing has been previously reported in hybrids between slash and shortleaf pines (Schmitt 1969). The planting in northern Alabama showed height distribution of the eastern hybrids at 6 years (fig. 2A) skewed more towards the shorter height classes than in the non-hybrid stocks. At 10 years (fig. 2B) many of these short trees had died. As seedlings destined to be dwarfs are hard to recognize during nursery operations, culling is impractical. If some mortality from this cause is expected, slightly increased planting density could easily make up the difference.

Slash pine, in a response to cold climate, also suffered greater than average mortality between establishment and age 10 in the northern and mid-latitude plantings. Mortality was most pronounced in the most northern plantings (Kentucky, Tennessee, North Georgia) and trees of any size, large or small, were affected at random.

The local loblolly and shortleaf generally had higher survival than the hybrids or slash pine, both at establishment and after 10 or 12 years in the field.

Height.-Local loblolly was the fastest-growing stock in the test. It ranked first in 10th or 12th year dominant-codominant height in seven of eight plantings (fig. 3). Only the Oklahoma planting of slash pine ranked higher.

The shortleaf stocks generally grew slowest in all plantings with the two hybrids stocks and slash pine intermediate, but in Oklahoma local shortleaf grew faster than the hybrids.

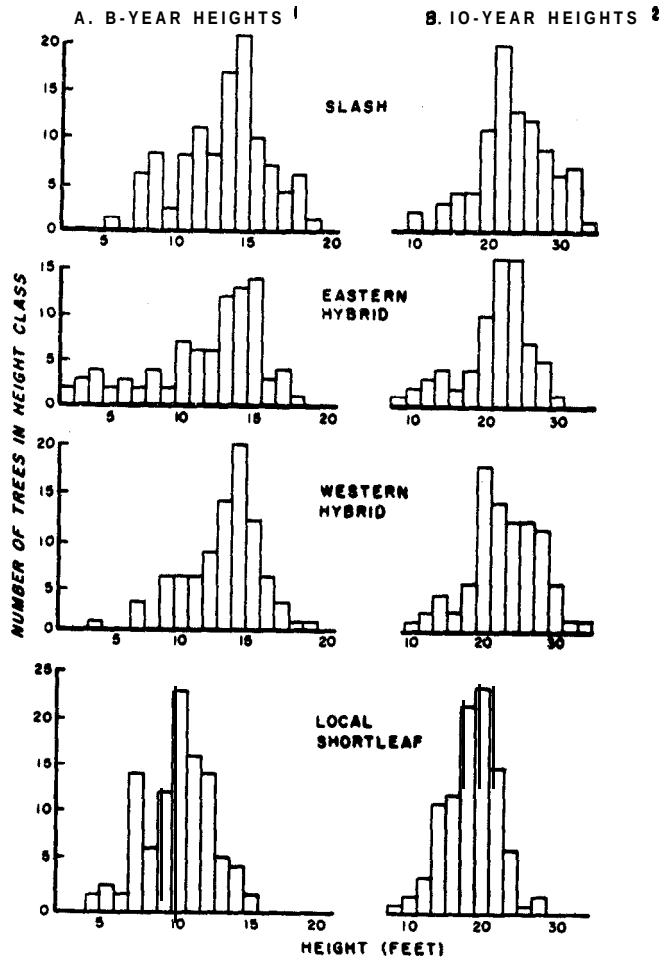

Figure *P.-Frequency distribution of* ***heights at*** *6* ***(Col.*** *A) and 10* ***(Col.*** *B) years in* ***Cleburne County,*** *(northern) Alabama planting.*

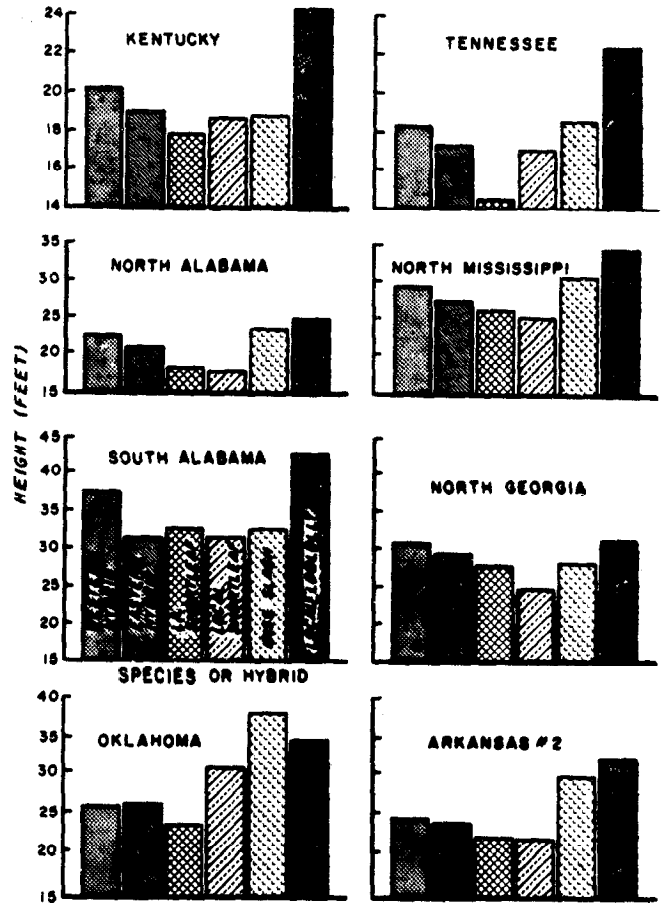

Figure 3.—*Height over age In six 1968–69 plantings* and two. *1966–67 plantings (Oklahoma and Arkansas 2).*

The hybrids made with western shortleaf averaged about 2 feet taller than those of eastern shortleaf in the eastern plantings, but the hybrid groups were about the same height in the western planting.

Volume.-A conic formula was used to compute total bole volume per plot.

$$\text{volume} = \frac{1}{4}\,\frac{\pi\, d^2 h}{144 \times 3}\, n$$

where:

n = number of trees surviving on each plot
d = average plot dbh in inches
h = average plot height in feet

Plot volumes were then converted to a per acre basis. Analysis was confined to the six eastern plantings where nursery source was held constant.

The formula combines growth rate and survival. Since local iobioiiy performed well in both these respects, its advantage over the hybrids and other check species was even greater than in either of the component traits taken singly. Local loblolly, first in volume in each planting, showed, over all plantings, about twice as much volume as the hybrids and other check species (table 2).

***Rust Resistance.*—Only** three plantings had enough rust infection to demonstrate differences in resistance among hybrids and check species; only one planting-Jones County, Georgia-had over 65 percent stem plus branch infection on the susceptible slash and iobloiiy pine (table 3).

in two of the three **plantings—Covington,** Alabama and Jones County, Georgia-the slash and lobioliy pines were most heavily infected, the shortleaf had negligible infection, and the two hybrids were lightly infected. in the Cieburne County, Alabama planting, however, the hybrids had almost as much infection as slash and lobioiiy pines. This is most unusual because in other trials (Wells et al. 1978) the shortleaf x slash pine hybrids have reacted as they did in the Covington County, Alabama and Jones County, Georgia plantings in the present

Table *3.-Trees with stem or branch galls in three plantings*

Hybrids or check species	Planting location			
	Covington, AL	Jones County, GA	Cleburne County, AL	Avg
	percent			
Local loblolly	23.8	69.4	16.5	37.2
South MS Slash	5.3	63.9	39.7	36.3
Western hybrid	0.8	9.6	26.5	12.4
Eastern hybrid	0.9	11.2	18.7	10.3
SE LA shortleaf	0	4.3	0	1.4
Local shortleaf	0	1.0	0.8	0.6

study-their infection rate has been much closer to the nearly immune shortleaf pine than to the susceptible slash and loblolly pine.

In practical terms, the hybrid can be considered very resistant. Combining stem plus branch infections was necessary in the present study to get infection rates high enough for a definitive test. Not enough stem infection occurred on the hybrids to demonstrate adequately differences in resistance among the hybrids and checks.

DISCUSSIONS AND CONCLUSIONS

The hybrids have not performed well in this study. Their survival, both immediately after planting and in the long run, has not been as good as the check species and their growth rate is unimpressive, particularly when compared with loblolly. Loblolly is most often the species recommended for planting above the flatwoods on coastal plain and piedmont sites in the Southeast.

The hybrids have good rust resistance, but resistant loblolly is also available, either from natural populations or, increasingly now, from orchards selected for other traits as well. The shortleaf x loblolly hybrid is another alternative source of rust resistance (La Farge and Kraus, 1980) for the southeastern United States.

Perhaps the best use of the shortleaf x slash hybrid would be as a source of variation in a breeding program. It's rust resistance derives from a source -shortleaf pine-that is not ordinarily present in natural evolving populations of slash pine. Genetic diversity is necessary in advanced generations of breeding programs and incorporating highly diverse germ plasm, such as this, into a slash pine breeding program might be worthwhile. Development of rust resistant slash pine is a high priority need of the Florida Cooperative (Goodard et al. 1981) and presumably other planters of slash pine, so an improved variety is readily marketable.

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