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PERFORMANCE OF LOBLOLLY, SLASH, AND POND PINES ON A POORLY DRAINED SITE WITH FERTILIZATION AT AGES 11 and 14

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Abstract.--Slash pine has outgrown both loblolly and pond pine on a poorly drained, wet savannah. All three pines responded to phosphate, phosphate with lime, and nitrogen fertilizations. None of the three responded to lime alone. The study indicated that calcium for loblolly pine, magnesium for slash pine, and nitrogen and calcium for pond pine may have been as or more limiting to growth than phosphorus. Correcting nutrient deficiencies 11 to 14 years after planting can raise the productivity of a site from very low to average.

Additional keywords: Phosphorus, magnesium, calcium, nitrogen, growth responses.

BACKGROUND

Wet savannahs, a major wetland type of the lower Atlantic Coastal Plain (Ralston 1965), occur in broad, flat to slightly depressed areas at the upper reaches of small coastal streams. These savannahs are typically poorly drained with water tables close to the soil surface; during periods of heavy rainfall, they may be flooded for several weeks. Prior to fire protection, these areas burned rather frequently because of the inflammability of the grassy fuels. Repeated burning resulted in open, savannah-like areas dominated by grasses and sedges with only a few scattered pine trees.

ORIGINAL STUDY

A study was established in 1960 in one of these wet savannahs[2/] to compare the performance of loblolly (*Pinus taeda* L.), slash (*P. elliottii* var.*elliottii* Engelm.), pond (*P. serotina* Michx.), and longleaf (*P. palustris* Mill.) pines under natural growing conditions. Plots (0.083-acre in size) were planted to each of the four species in two 4 x 4 latin squares in January 1960. The soil on the study site was a Bladen clay loam (Typic Albaquult, clayey, mixed, thermic). The results through the 10th year have been reported by Hatchell and Langdon (1972). Briefly, slash pine survived better (80%) than loblolly (68%), pond (68%), or longleaf (41%) pine; slash pine had also grown better (11.8 feet) than loblolly (8.2 feet), pond (7.5 feet), or longleaf (2.5 feet for those in active height growth). However, even the slash pine height growth was poor, only slightly more than a foot per year or about a 50-foot site index class (50-year basis).

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We knew that aeration of the soil was poor, and work of others lead us to suspect that insufficient phosphorus was available to the trees. Indeed, our foliar analysis at 10 years of slash pine (.043%) and loblolly pine (.049%) was well below the level that Pritchett (1968) and Wells and Crutchfield (1969) had found to indicate a phosphorus deficiency. The questions that these results raised were: Would these trees at 11 years respond to phosphorus fertilization? Were other nutrients limiting? Would the growth responses be great enough to be economically feasible?

CURRENT STUDY

At stand age 11, we revised our study objectives in an attempt to answer some of the questions just posed. Four fertilization treatments were set up with fertilizers being applied at ages 11 and 14 as follows:

Treatment	Fertilizers applied at age 11 (rate per acre)	Fertilizers applied at age 14 (rate per acre)
A	None	None
B	572 pounds normal superphosphate (50 lbs. elemental P and 102 lbs. elemental Ca.)	None
C	4000 pounds dolomitic limestone (approx. 872 lbs. elemental Ca. and 483 lbs. elemental Mg)	248 pounds triple superphosphate (50 lbs. elemental P and 35 lbs. elemental Ca)
D	572 pounds normal superphosphate (50 lbs. elemental P) + 4000 pounds dolomitic limestone (approx. 872 lbs. elemental Ca and 483 lbs. elemental Mg)	300 pounds ammonium nitrate (100 lbs. elemental N)

Fertilizers were broadcast over the entire treatment plot (.083-acre). A 25-tree measurement plot (.021-acre) was established within the treatment plot; trees within 18 feet (2 rows) of the plot edges were not measured. All soil and tree samples and measurements were taken on the 0.021-acre plot. Trees were measured at ages 11, 14, 16, and 17, and the soil and foliar samples were collected in the winter at ages 14 and 16. Foliar samples were collected from the first flush of the previous spring from branches near the top of the tree as recommended by Wells (1969).

RESULTS

Slash pine has grown better on this site in the 17 years since planting than either loblolly or pond pine (table 1). Slash pines were about 1 inch larger

in diameter, and 7 feet taller than loblolly or pond pine. They contained between 500 and 600 more cubic feet of total volume per acre. Loblolly and pond pine have performed about equally on this site, with pond pine having a slight edge.

Table 1.--Average diameter, height, and volume yields at age 17 of loblolly, slash, and pond pine growing on a wet savannah site.

Species	Average diameter at age 17	Average height at age 17	Average total volume inside bark at age 17
	(inches)	(ft.)	(cu. ft./acre)
Loblolly pine	3.0 a	20 a	413 a
Slash pine	4.1 b	27 b	1012 b
Pond pine	3.3 a	20 a	517 c

Note: Within columns, means followed by the same letter are not significantly different at the 5-percent level.

Slash pine responded better to the fertilization treatments in terms of height and volume growth than did the other two pines (table 2). In the first 3 years after treatment all three species responded to phosphate (B) and phosphate plus lime (D). Slash pine did not appear to respond when lime was applied without phosphate (C), but when it was combined with phosphorus, an additional response was evident. On the other hand, lime alone appeared to suppress the growth of loblolly and pond pine, and when lime was applied with phosphate (D), no additional response over the phosphate fertilization (B) was detected. In the second 3 years all three species responded to the nitrogen fertilization at age 14 when it was applied over the phosphate plus lime treatment (D). There is some evidence in the data that loblolly and pond pine might have responded more to the nitrogen fertilization if it had been applied to the phosphate treatment (B), but this is mainly conjecture.

In an attempt to ferret out the nutrient responses of the three species, correlation analyses were made of foliar nutrient uptake and periodic volume growth (total cubic foot volume, inside bark). These analyses (table 3) showed that growth of loblolly pine was correlated with percent K and Ca in the foliage; growth of slash pine, with percent K and Mg; and growth of pond pine, with N. These results indicated that the three pines were responding to different nutrients, and of those applied (P, Ca, Mg, and N), there was no significant linear correlation of growth with percent P in the foliage, the principal nutrient suspected to be limiting. However, as shown by the following

Table 2.--Periodic diameter, height, and volume growth of loblolly, slash, and pond pine between ages 11 and 17 growing on a wet savannah site and fertilized at ages 11 and 14

Species	Fert. treatment	Periodic Diameter Growth			Periodic Height Growth			Periodic Volume Growth		
		Ages 11-14	Ages 14-17	Ages 11-17	Ages 11-14	Ages 14-17	Ages 11-17	Ages 11-14	Ages 14-17	Ages 11-17
		------(inches)-------			------(feet)-------			(cubic feet, i.b.)		
Loblolly pine	A	0.50a	0.45a	0.95a	3.7a	3.1a	6.8a	74a	85a	159a
	B	1.05a	0.90ac	1.95ac	5.3a	8.2b	13.5a	150a	318a	467a
	C	0.45a	0.80ac	1.25ac	2.6a	4.4a	7.0a	40a	120a	160a
	D	1.05a	1.45bc	2.50bc	5.9a	10.0b	15.9a	157a	519a	675a
Slash pine	A	0.65a	0.60a	1.25a	4.9ab	4.7a	9.6a	190a	240a	430a
	B	1.05b	0.95a	2.00bc	6.8ab	9.0c	15.8b	254a	515b	768a
	C	0.60a	0.85a	1.45ac	4.3a	7.5b	11.8a	194a	488a	682a
	D	1.05b	1.10a	2.15b	8.0b	10.7d	18.7b	456a	1036c	1490b
Pond pine	A	0.75a	0.55a	1.30a	2.7a	3.0a	5.7a	62a	78a	140a
	B	1.45a	1.00ac	2.45b	6.4b	9.1b	15.5b	252a	460ab	712a
	C	0.65a	0.70a	1.35a	2.8a	5.0ab	7.8ab	56a	116ab	173a
	D	1.35a	1.40bc	2.75b	5.6b	9.4b	15.0b	216a	622b	838a

Note: The means in a column (for a given species and Y-variable) with the same letter are not significantly different at the 5-percent level.

regressions, other nutrients on this site were apparently as deficient as P--namely, Ca for loblolly pine, Mg for slash pine, and N and Ca for pond pine:

(1) Periodic volume growth, loblolly pine = 192 + 4677 (%Ca) - 8544 (%P)

$R^2 = .8570$

(2) Periodic volume growth, slash pine = 266 + 16549 (%Mg) - 11943 (%P)

$R^2 = .7412$

(3) Periodic volume growth, pond pine = 8185 - 6072 (%N) - 6263 (%Ca)

$R^2 = .7695$

These soils appear to be quite low in exchangeable Ca and Mg (both cations ranged between 0.2 to 1.5 milliequivalents/100 grams) which may account for the high correlations in uptake of these nutrients with growth. In McCarthy and Davey's (1976) study in which they fertilized loblolly pine on a pocosin site with lime and calphos (a lime-phosphate-kaolin mixture), they observed responses to the lime and phosphorus which seemed to parallel ours.

CONCLUSIONS

The conclusions reached from this study are that on wet sites such as these more than one nutrient may be limiting growth and that correcting these nutrient deficiencies at ages 11 and 14 can convert a very low productive site to one that is at least average in productivity. On these wet sites slash pine may be the best choice of species. More trials should be made on these sites with all three of these pines. Although not included as a variable in this study, soil aeration has been shown to play an important role in tree nutrition. Further research is also needed on these soils to study the complex nutritional and soil aeration interactions with growth of loblolly, slash, and pond pine.

Table 3.--Correlation of foliar nutrients and periodic (ages 11-17) volume growth of loblolly, slash, and pond pine growing on a wet savannah site and fertilized at ages 11 and 14.

Foliar nutrient	Correlation of foliar nutrients and periodic (ages 11-17) volume growth of:		
	Loblolly	Slash	Pond
	------Correlation coefficient (r)[a/]-------		
Nitrogen (N)	-.180 NS	-.516 NS	-.686 *
Phosphorus (P)	-.232 NS	-.179 NS	+.034 NS
Potassium (K)	-.791 **	-.805 **	-.286 NS
Calcium (Ca)	+.730 **	+.509 NS	+.013 NS
Magnesium (Mg)	+.024 NS	+.700 **	+.076 NS
Manganese (Mn)	-.060 NS	+.429 NS	-.130 NS

a/ Levels of significance: NS = nonsignificant, * = 10% level, ** = 5% level,

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