United States Department of Agriculture

Forest Service

Southern Forest Experiment Station

Research Note

so-379
September 1995

Responses of Young Slash Pine on Poorly Drained to Somewhat Poorly Drained Silt Loam Soils to Site Preparation and Fertilization Treatments

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SUMMARY

Slash pines (*Pinus elliottii* Engelm. var. *elliottii*) were planted on poorly drained Wrightsville and somewhat poorly drained Vidrine silt loam soils in southwest Louisiana. Neither flat disking nor bedding increased pine growth and yield substantially after nine growing seasons, but broadcast application of triple superphoshate increased pine productivity on both soil types. On the Vidrine soil, slash pine diameter at breast height (d.b.h.), total height, volume per tree, and volume per acre averaged 4.4 inches, 24 ft, 1.7 ft^3, and 890 ft^3/acre, respectively, over all treatments. On the Wrightsville soil, values of these variables averaged 3.8 inches, 19 ft, 1 .O ft^3, and 350 ft^3/acre, respectively, over all treatments. The incidence of fusiform rust galls on the main stem, which are caused by *Cronartium quercuum* (Berk.) Miyabe ex Shirai f. sp. *fusiforme*, averaged 28 percent across both soils, which is below average for slash pine in the West Gulf Coastal Plain.

INTRODUCTION

Slash Pine (*Pinus elliottii* Engelm. var. *elliottii*) grows well on poorly drained to somewhat poorly drained soils in the lower Coastal Plain (Shoulders 1976). Slash pine performs better than loblolly pine (*P. taeda* L.) on these soils, especially in repeated rotations on unfertilized sites (Haywood 1994, Haywood and others 1990). Fusiform rust, which is caused by *Cronartium quercuum* (Berk.) Miyabe ex Shirai f. sp. *fusiforme*, causes mortality and degrade in slash pine plantations, reducing timber values and income (Anderson and others 1986, Busby and Haines 1988, Webb and Patterson 1984). Intensive cultural practices that increase the growth of slash pine seedlings may also increase the incidence of fusiform rust (Dinus and Schmidtling 1971, Tiarks 1983). However, when slash pine planting stock is resistant to fusiform rust, applications of phosphorus and nitrogen fertilizers may greatly increase yields on phosphorus-deficient soils (Haywood and others 1994, Shoulders and Tiarks 1990, Tiarks and Shoulders 1982).

In this study, slash pines were planted on poorly drained and somewhat poorly drained silt loams with and without phosphorus fertilization, disking, and bedding to determine the growth response of slash pine to amelioration on soils with poor internal drainage. After 6 years, the fertilizer treatment was ‘ineffective on the poorly drained Wrightsville soil but was effective on the somewhat poorly drained Vidrine soil (Haywood 1983a). However, phosphorus fertilization may not significantly affect the growth of pine trees for many years (Tiarks 1983). After 9 years, the fertilizer treatment was effective on both soils.

STUDY AREA

The 14-acre study area in Calcasieu Parish, Louisiana, previously supported a natural stand of longleaf pine (P. *palustris* Mill.). A dense cover of native grasses, scattered southern bayberry or waxmyrtle (*Myrica cerifera* L.), and blackberry (*Rubus* spp.) were in the understory.

The soil is a Wrightsville (Typic Glossaqualf, fine, mixed, thermic) and Vidrine (Glossaquic Hapludalf, coarse-silty over clayey, mixed, thermic) silt loam complex with a general slope of 0 to 1 percent (Haywood 1983a). Many solitary “pimple mounds” of Vidrine soil occupy about 16 percent of the area. The upper foot of these mounds is generally well drained, but both soil

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moisture and yellowish brown mottling increase with depth. A less permeable silty clay subsoil with distinct red mottling generally begins at a depth of 30 inches and slopes downward from under the mound, reaching its greatest depth under the Wrightsville silt loam depressions. A perched water table rests above the subsoil for 2 to 4 months in winter and spring. Vidrine-like silt loam occupies 49 percent of the area, surrounds the mounds, and may form ridgesconnecting them. This soil is not as well drained as the Vidrine soil of the mounds. Wrightsville silt loam occupies 35 percent of the area. It forms unconnected, meandering swales between the Vidrine mounds and Vidrine-like ridges, and these swales contain standing water during winter.

METHODS

The longleaf stand was clearcut harvested in 1971, and residual vegetation and logging debris were burned in September 1972. In October 1972, two fertilization and three site-preparation treatments were laid out in a randomized complete block 2 x 3 factorial design. There were four blocks, and each block contained six plots. Each plot was 0.4 acres in size. The two fertility levels were (1) unfertilized and (2) fertilized by broadcasting 500 lb of triple superphosphate per acre (101 lb P/acre) before mechanical treatment. The three site-preparation levels were: (1) no additional treatment after burning in September 1972, (2) burned and disked, and (3) burned, disked, and bedded. Treatments 2 and 3 were disked with a harrow, and the continuous beds in treatment 3 were formed using a bedding harrow equipped with a shaping roller.The beds were parallel to the general slope of the site. Bed centers were 10 inches high (furrow to crest) before settling and were spaced 8 ft apart.

Therefore, within each block the six combinations of treatments were as follows:

(1) burned only
(2) burned and disked
(3) burned, disked, 'and bedded
(4) burned and fertilized with triple superphosphate
(5) burned, disked, and fertilized with triple superphosphate
(8) burned, disked, bedded, and fertilized with triple superphosphate

Freshly lifted bare-root 1-O slash pine seedlings were uniformly graded and planted by hand on an 8-ft by 8-ft spacing in late February 1973. Two seedlings were planted at each location. If both survived, the less vigorous one was removed after two growing seasons.

After four growing seasons, each planting site within each 0.4-acre plot was assigned to one of two topography classes because soil drainage seemed to be influencing results more than the study treatments were.The topography classes were: (1) somewhat poorly drained Vidrine mounds and Vidrine-like ridges and (2) poorly drained Wrightsville depressions.

Survival and fusiform rust incidence were surveyed after five growing seasons. After nine growing seasons, slash pine survival, diameter at breast height (d.b.h.), total height, and the presence or absence of fusiform rust galls on the main stem were determined. Cubic-foot volumes of trees at least 4.5 ft tall were calculated using Lohrey's (1985) formula.

Data for the two topographic classes were analyzed separately because interaction between topographic classes and whole plot factors made it impractical to use a split-plot design with topographic classes as the subplot treatments to determine the influences of fertilization and site preparation on slash pine growth and yield. Each plot had sufficient numbers of planting locations in each topographic class, so no plots were excluded from the analyses. The number of planting locations on Wrightsville soil ranged from 44 to 138 per plot, and the number on Vidrine or Vidrine-like soil ranged from 138 to 228 per plot.

The survival, height, d.b.h., volume, and fusiform rust data for each topographic class were analyzed by analysis of variance (alpha = 0.05). The significance of mean differences associated with the two main effect levels (fertilization and site preparation) and the fertilization by site preparation interactions were determined by orthogonal trend comparisons.

RESULTS AND DISCUSSION

Vidrine Soils

Bedding did not influence slash pine survival, growth, and yield through nine growing seasons on the somewhat poorly drained Vidrine mounds and Vidrine-like ridges (table 1). Planting site occupancy averaged 78 percent and was this high partly because of the double planting. Across all fertilization and site preparation treatments, pine d.b.h., total height, volume per tree, and volume per acre averaged 4.4 inches, 24 ft, 1.7 ft^3, and 890 ft^3/acre, respectively.

Long-term responses of slash pine to mechanical site amelioration are often not statistically significant on somewhat poorly drained silt loam soils (Haywood 1980,

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Table 1.--Ninth-year results for slash pine (*Pinus* elliottii *Engelm. var.* elliottii) *planted on somewhat poorly drained Vidrine mounds and Vidrine-like ridges*

Site preparation and fertility combinations	Survival	D.b.h.	Total height	Volume Per tree	Volume Per acre	Fusiform infection
	Percent	*Inches*	*Ft*	Ft^3	Ft^3	*Percent*
Burned only[*]						
Fertilized	75	5.1	28.2	2.33	1,190	31
Unfertilized	81	3.7	20.4	0.99	546	28
Mean	**78**[†]	4.4	23.3	1.86	868	29
Burned and **disked**						
Fertilized	78	5.1	28.4	2.34	1,243	26
Unfertilized	80	3.8	21.6	1.17	637	31
Mean	79	4.4	24.0	1.75	940	28
Burned, **disked,** and bedded						
Fertilized	73	*4.9*	26.1	2.19	1,089	31
Unfertilized	80	3.9	21.4	1.17	637	30
Mean	78	4.4	23.8	1.68	863	31
All site preparation treatments						
Fertilized	**75b**[‡]	**5.0a**	**26.2a**	**2.29a**	**1,174a**	29a
Unfertilized	80a	**3.8b**	**21.1b**	1.11b	607b	30a
Mean of means	78	4.4	23.7	1.70	890	29

'Number of planting locations classed as the somewhat poorly drained Vidrine mounds and Vidrine-like ridges ranged from 136 to 228 per plot. Two trees were planted per location, and if both survived, the less vigorous one was removed after the second growing season.

†**Within** columns, none of the site preparation treatment means was significantly **different** (alpha = 0.05).

*Within columns, means for the two fertilization levels followed by the same letter are not significantly different (alpha = 0.05).

1983b). In some instances, growth responses of slash pine seedlings to mechanical site amelioration disappear once the trees are 10 to 15 years old (Tiarks 1983). In these studies, early added pine growth following mechanical site amelioration is attributed to competition control, increased fertility resulting from mixing of organic matter into the soil, and improved soil aeration.

A broadcast application of triple superphosphate before mechanical site preparation reduced slash pine survival but significantly increased d.b.h., total height, volume per tree, and volume per acre by 32, 24, 106, and 93 percent, respectively (table 1). The fertilizer was mixed into the soil on the **disked** and bedded plots but was left on the surface of the burned-only plots. The way in which the fertilizer was applied apparently had no effect on tree growth, and incorporation of phosphorus fertilizers had not been necessary in other studies **(Haywood** and others 1994, Shoulders and Tiarks 1990). It is likely that there will be greater differences between growth in the fertilized and unfertilized plots in later years (Tiarks 1983).

Wrlghtsvllle Soil

Both mechanical site preparation and fertilization reduced slash pine survival in the poorly drained **Wrightsville** depressions (table 2). After bedding, the soils settled for only 4 months before planting, and this period is often insufficient for poorly drained silt loams **(Haywood 1983a). There** were probably too many air pockets in the soil during the first growihg season following planting.

Certain combinations of fertilization and site preparation influenced slash pine growth and yield more strongly than others (table 2). Mean d.b.h., total height, volume per tree, and volume per acre in the burned, **disked,** bedded, and fertilized plots were **25, 24, 74,** and 48 percent greater, respectively, than the corresponding mean of means over all treatments. Mean **d.b.h.,** total height, volume per tree, and volume per acre in the burned and fertilized plots were 14, 11, 35, and 45 percent greater, respectively, than the corresponding mean of means over all treatments.

Table 2.—*Ninth-year results for slash pine (Pinus elliottii Engelm. var. elliottii) planted in the poorly drained Wrightsville depressions*

Site preparation and fertility combinations	Survival	D.b.h.	Total height	Volume Per tree	Volume Per acre	Fusiform infection
	Percent	*Inches*	*Ft*	*Ft³*	*Ft³*	*Percent*
Burned only[*]						
Fertilized	54	**4.1**[†]	**21.4**[†]	**1.38**[†]	**507**[†]	**34**[†]
Unfertilized	67	2.8	15.5	0.47	214	21
Mean	**60a**[‡]	3.4	18.4	0.92	360	28
Burned and disked						
Fertilized	42	3.6	18.8	1.05	300	20
Unfertilized	55	3.0	17.2	0.65	243	25
Mean	**48b**	3.3	18.0	0.85	272	22
Burned, disked, and bedded						
Fertilized	43	**4.5**[†]	**24.0**[†]	**1.77**[†]	**518**[†]	23
Unfertilized	59	3.4	18.9	0.80	321	**35**[†]
Mean	51b	4.0	21.4	1.29	419	29
All site preparation treatments						
Fertilized	**46b**[§]	4.1	21.4	1.40	439	25
Unfertilized	60a	3.1	17.2	0.64	260	27
Mean of means	53	3.6	19.3	1.02	350	26

[*]Number of planting locations classed as depressions ranged from 44 to 136 per plot. Two trees were planted per location, and if both survived, the less vigorous one was removed after the second growing season.

[†]Values differ significantly from all other values in the same column (alpha = 0.05).

[‡]Within columns, site preparation treatment means followed by the same letter are not significantly different (alpha = 0.05).

[§]Within columns, means for the two fertilization levels followed by the same letter are not significantly different (alpha = 0.05).

On silt loam soils where the mean depth to free water is less than 18 inches after winter rains, bedding improves aeration, increases soil drainage, and adds enough well-drained soil to increase slash pine tree growth (Haywood and others 1990). However, even when beds are laid out parallel to the general slope of the site, bedding can disrupt the natural drainage pattern on gently rolling silt loam soils. In these instances, water collects in depressions and affects tree development adversely. Probably because surface drainage was blocked naturally or artificially, bedding was not effective on the Wrightsville soil in this study. Although the burned, disked, bedded, and fertilized treatment combination gave the best results after nine growing seasons, the burned and fertilized treatment combination produced similar results. It would be difficult to recommend the added expense of disking and bedding in addition to the broadcast application of triple superphosphate.

To conclude, mechanical site preparation treatments were of little benefit on soils in either topographic class, but the broadcast application of triple superphoshate had positive long-term effects on slash pine growth regardless of soil drainage. The use of fertilizers containing phosphorus is a recommended practice on other soils as well (Haywood and others 1994, Shoulders and Tiarks 1990, Tiarks 1983).

Fusiform Rust

Percentages of rust infection have been increasing in slash pine stands in the West Gulf Coastal Plain (Hunt and Lenhart 1986). In this study, topographic class had little influence on the incidence of main-stem fusiform rust galls in surviving trees. After the fifth (data not shown) and ninth growing seasons, rust incidences averaged 22 and 28 percent, respectively (tables 1 and 2). However, the levels of infection observed in this study were low for slash pine in this region, probably because removal of the least healthy 2-year-old seedlings at each planting location favored seedlings that were initially free of fusiform rust.

Practices that increase pine growth may also increase the incidence of fusiform rust in slash pine plantings (Dinus and Schmidtling 1971, Tiarks 1983). Rust-related mortality can be significant in slash pine stands growing on silt loam soils, and fresh terminal leaders may develop new rust galls throughout the life of the stand (Haywood and others 1994). This would explain why the percentage of gall infections increased between the fifth and ninth growing seasons, whereas slash pine survival across both topography classes decreased from 79 to 89 percent (survival averages were weighted for differences in total number of planting locations within each topographic class).

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