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Response of Newly Established Slash Pine to Cultivation and Fertilization

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SUMMARY

Response of newly established slash pine to fertilization is increased if herbaceous plants are controlled. To find the amount of cultivation required in Louisiana, fertilized and unfertilized rows of planted pines were hand-hoed in a wedge-shaped pattern. By using this technique, the amount of cultivation was varied from none to complete.

Slash pine growth was linearly related to amount of cultivation for both fertilized and unfertilized trees. Pine response to cultivation or fertilization was much greater when both cultural practices were applied.

Additional keywords: Weed control, tree form, herbaceous competition.

INTRODUCTION

Fertilizer applications to newly planted slash pine can increase early growth. However, field observations indicate the effect of fertilizer is often negated by herbaceous plant competition because the herbaceous plants respond better than pine to added nutrients. Smith and Schmidtling (1970) reported that disking alone increased the height of slash pine by 2 feet at age 5 and that fertilization of cultivated plots increased growth by another 5 feet. Combined cultivation and fertilization on an old field site increased the height of 4-year-old slash pine by 2.1 feet (Westberg 1951). We established an experiment to find the response of slash pine to varying degrees of cultivation by hoeing and to fertilization with nitrogen, phosphorus, and potassium.

METHODS

The study was established on a site in Central Louisiana that had been clearcut, chopped, and burned. Vegetation, mainly grasses and forbs, had completely occupied the site. The soil was a Beauregard silt loam (Plinthaquic Paleudult, fine-silty, siliceous, thermic), was low in fertility, and had slow internal drainage. Analysis of soil samples, taken from 0 to 6 inches, showed 2.1 percent organic matter (wet oxidation without external heat, Jackson 1958), 0.04 meq/100 g of potassium (1*N* NH40Ac extraction, Chapman 1965b), and 1.1 mg/kg of available phosphorus (Bray #1 with a 15-minute shaking time, Jackson 1958).

Slash pine seedlings 1-0 bare rooted nursery stock were graded for uniformity and hand-planted in February 1974 at 1.5 foot intervals in eight rows 150 feet long and 10 feet apart. In April 1974, four of the rows were selected at random and fertilized with 200 pounds N, 200 pounds P_2O_5, and 70 pounds of K_2O per acre.

The amount of cultivation was varied from none to complete by hand-hoeing a wedge-shaped pattern along each row. Thus, the amount of cultivation applied to each row increased from none at one end to a 10-foot wide strip at the other end. The rows were hand hoed four times the first year. In the following 3 years, hoeing was repeated as necessary to keep the competition from reoccupying the site. Care was taken to avoid injury to the pine roots.

Heights of all trees were measured at the end of the first and fourth growing seasons. At the end of the first season, every other tree was cut off

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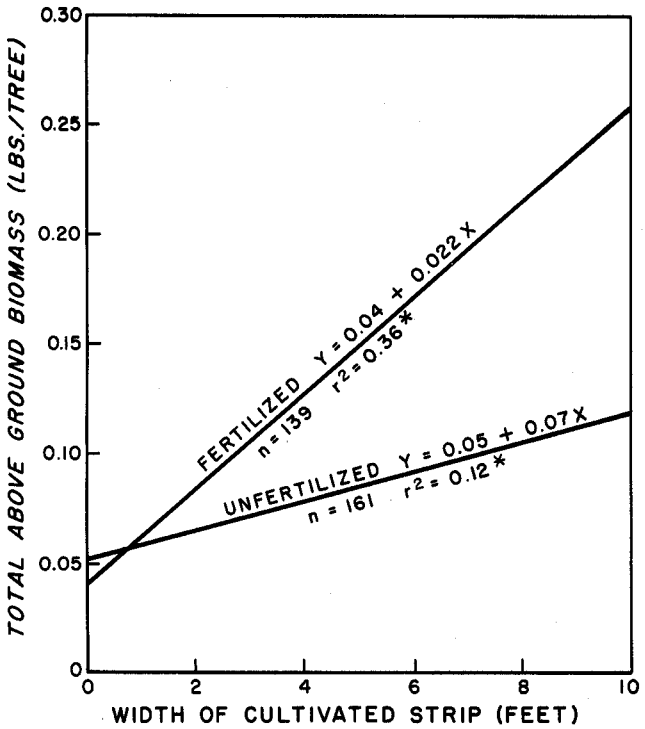

Figure 1.—*Effect of fertilization and varying amounts of cultivation on the above ground biomass of 1-year-old slash pine (*P<0.05).*

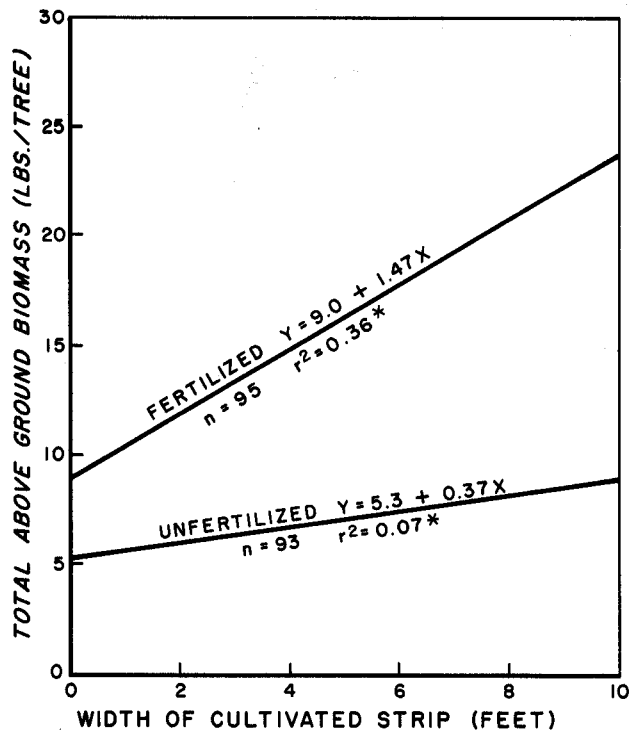

Figure 2.—*Effect of fertilization and varying amounts of cultivation on the above ground biomass of slash pine 4 years after establishment (*P<0.05).*

at the root collar and ovendried and weighed. At the end of the second growing season, every other tree was removed, leaving the effective spacing for the third and fourth growing season at 6×10 feet. All of the remaining trees were cut off at the root collar at the end of the fourth growing season. Needles and branches were removed, shredded with a leaf mulcher, and the wet weight was recorded. A subsample was taken and dried to determine moisture content for calculation of dry weight of needles and branches. The entire main stems were immersed in water for volume measurements, then dried and weighed.

To determine the relationship between cultivation and tree growth, linear, quadradic, and cubic regression equations were calculated using width of the cultivated strip and ovendry top weights for the first year's growth. The level of significance was preset to 0.05. As only the linear model was significant, linear regression equations between the width of the cultivated strip and the fourth year measurements of height, root collar diameter, main stem volume, ovendry weight, and weight of the needles and branches were calculated.

Separate regressions were calculated for fertilized and unfertilized trees to find if the cultural treatments had affected tree form. Height was used to predict root collar diameter while log of height-by-diameter-squared (HD^2) was used to predict log of volume of the main stem, log of the weight of needles and branches, and log of the total biomass. The residuals from these equations were then regressed against the width of the cultivated strip to see if competition control affected the relationships.

RESULTS

The top, dry weight had increased proportionately to the area hoed after the first growing season (fig. 1). The top weight of unfertilized trees increased from 0.05 to 0.12 pounds/tree as the width of the cultivated strip increased from 0 to 10 feet (fig. 1). Cultivation increased dry weight of the tops from 0.04 to 0.26 pounds/tree in fertilized rows.

After 4 years, hoeing increased top dry weight production from 5.3 to 9.0 pounds/tree on the unfertilized rows, and from 9.0 to 23.7 pounds/tree

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on the fertilized rows (table 1). The intercept values were significantly different (fig. 2), so 4 years after planting, fertilizing uncultivated trees had increased biomass production by 70 percent. Fertilization alone was equal to cultivation alone. The two combined produced a 347 percent increase in total biomass or 207 percentage points more than expected if the two treatments had been additive.

The response to increasing width of cultivation was linear for both periods reported (figs. 1 and 2) and for both fertilized and unfertilized trees. Thus, the amount of cultivation required to maximize slash pine growth planted at a 10-foot spacing or less was 100 percent of the plantation, even during the establishment year. Because of large tree to tree variation, the regression equations accounted for only a small part of the variability. Graphs and statistical analysis of residuals from the regression equations indicated the remaining variation to be random.

Root collar diameters, volume of the main stem, and weight of needles and branches also increased linearly as cultivation increased from none to complete. The linear regression equations, calculated from data representing the continuously varying amounts of cultivation were used to predict the parameters of tree growth at no cultivation, and at complete cultivation (at 10 feet). The accumulative growth of the trees representing the combinations of no cultivation and cultivation, and fertilizer and no fertilizer are shown in table 1.

On the fertilized trees, cultivation increased both the height and root collar diameter. However, on the unfertilized rows of trees, cultivation increased the root collar diameter but not the height. To establish if this difference was real, we regressed root collar diameters against heights of fertilized and unfertilized trees separately (table 2). We then fitted the residuals from these equations against width of the cultivated strip. Residuals of unfertilized, but not of fertilized trees were significantly related to width of cultivation (r^2=0.29 and 0.03, respectively).

To find if other changes in tree form might have occured, height-times-diameter-squared relationship was used to predict volume of the main stem, total ovendry weight, and the weight of the needles and branches (table 2). All of the equations were significant. When the residuals from these prediction equations were plotted against the width of the cultivated strip, no trend was discernible. Also, equations fitted for the relationships using fertilized or unfertilized trees were not significantly different. Thus, the cultivation or fertilizer treatments did not affect the relationship between height-times-diameter-squared and any other measured parameter.

DISCUSSION AND CONCLUSIONS

After 4 years, fertilization alone and complete competition control alone were about equally effective

Table 1.—*Four-year growth of slash pine as affected by cultivation and fertilization. Values for cultivation are estimated by regression and represent no weed control and complete control*

Cumulative growth after 4 years	Unfertilized		Fertilized	
	Uncultivated	Cultivated	Uncultivated	Cultivated
Rcd, in	2.7 a[1]	3.6 b	3.6 b	5.1 c
Ht, ft	8.5 a	9.2 ab	10.5 b	14.4 c
Volume of main stem, cu. in.	214 a	330 b	354 b	921 c
Total biomass, lbs/tree	5.3 a	9.0 b	9.0 b	23.7 c
Weight of needles and branches, lbs/tree	2.6 a	4.6 b	4.2 b	11.3 c

[1]Values in the same row followed by the same letter are not significantly different (P=0.05).

Table 2.—*Equations used to model relationships among tree variables*

Treatment	Equation	r^2
Fertilized	[1]Rcd = 0.461 + 0.026 height	0.72[2]
Unfertilized	Rcd = 0.370 + 0.026 height	0.74
All	Volume = 0.516 (Rcd² × height)$^{0.886}$	0.94
All	needle + branch wt = 0.0137 (Rcd² × height)$^{0.788}$	0.88
All	Total biomass = 0.0142 (Rcd² × height)$^{0.851}$	0.95

[1]RCD = root collar diameter. Biomass in pounds, Rcd and height in inches, volume in cubic inches.
[2]All equations are significant (P = 0.05).

in improving biomass production. When both treatments were applied, they interacted to increase biomass by 347 percent. Baker (1973), in a study on the Florida sandhills, found the response to cultivation and fertilization was additive rather than synergistic as reported here.

Complete cultivation is necessary for maximum early growth of the pines. However, in practice, complete control is not advisable on slopes where erosion would be a problem. The minimum amount of ground cover that would control erosion should be left between trees.

With maximum cultivation, fertilized trees were about a foot taller after 3 years than unfertilized uncultivated trees were after 4 years. Therefore, cultivated and fertilized trees had gained more than one year's growth over untreated pines. We speculate that removal of herbaceous competitors and fertilization will not affect growth rates after crown closure. Crowns of fertilized-cultivated pines were closing after four growing seasons while those of untreated pines were not. As crown closure had not occurred in untreated rows, the difference in accumulated dry weight should continue to increase between the cultivated-fertilized trees and untreated trees, thus shortening the rotation interval by more than the 1 year measured so far for treated pines.

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