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BURIED ORGANIC LAYER AFFECTS THE GROWTH OF SLASH PINE IN THE FLORIDA SANDHILLS

by
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ABSTRACT.-A technique for deep placement of organic matter within the soil, called sublayering. was tested as a means of improving Florida sandhill sites for slash pine (*Pinus elliottii* var. *elliottii* Engelm.). Single-tree plots were installed in four treatments: sublayering with peat moss, clearing, clearing plus sublayering, and no treatment. Survival was poor only on the cleared plots. Height-growth differences between treatments were significant at the 0.0 l level but did not show sublayering to be beneficial. Average 8-year height on untreated plots was 1.26 m, 1.44 m on cleared plots, 1.48 m on sublayered plots, and 2.48 m on cleared-sublayered plots. Root excavation showed proliferation of roots in the peat moss layer, but all roots had poor growth due to black root rot. Sublayering does not appear to be a good substitute for mechanical site preparation, though it may have value when applied along with it.

-Keywords: *Tiefdüngung*, soil amendments, sublayering, peat moss.

Site preparation benefits pine establishment and growth on droughty sites by increasing available soil moisture. Competing plants are removed or at least greatly reduced in number, so demands on the available moisture are fewer. In Europe the moisture regime of sandy soils has been improved in another way-by the deep placement of organic matter within the soil. The treatment, described by Egerszegi (1958), is called *Tiefdüngung* in German (Gyurkó and others 1958),—literally, deep manuring,-and has been rendered "sublayering" in a translation of an article by Papp (1958). Sublayering has been used to eliminate irrigation and shading in forest nurseries in the dry sandy regions of Hungary (Horvath 1960), to improve sandy forest soils in Germany (Buchholz and Neumann 1964), and to establish pines on sand dunes in Latvia (Bush and Kapost 1956). In Germany, it has been credited with increasing the yields of vegetables (Kunze 1% 1).

The experiment reported here was to test whether sublayering by inserting peat moss in the soil profile would improve Florida's sandhill sites for slash pine (*Pinus elliottii* var. *elliottii* Engelm.) by keeping soil moisture at a higher level during critical periods. It was also expected that treatment comparisons would clarify the role of soil moisture in the total effect attributed to mechanical site preparation.

METHODS

The study was established on the Chipola Experimental Forest, Calhoun County, Florida. The soil is Lakeland sand, uniform to a depth of 3.4 m, with an A horizon of brown sand (Munsell 10YR 5/3) about 9 cm deep. The subsoil (C horizon) is a yellowish-brown to a very pale-brown sand (Munsell 10YR 5/6 to 10YR 8/4). Below 3.4 m, the sands are different hues of brown that eventually blend into a layer of dark-brown sand (Munsell 7.5YR 4/2) at depths from 4 to 7 m.

The vegetation native to this site is primarily turkey oak (*Quercus laevis* Walt.) ranging in height from 0.9 to 3.5 m. There are a few scattered bluejack oaks (*Q. incana* Bartr.) of similar heights. Ground cover is mostly scattered clumps of wiregrass (*Aristida strictu* Michx).

The study plots are 2.4 m square; each tree with its site constitutes a plot and a treatment. Plot size had to be limited because of the difficulty

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in preparing the sublayered sites. Four treatments, replicated 16 times, were applied before planting in February 1962:

Untreated.The scrub oak and wiregrass vegetation was not disturbed.

Sublayered.—A layer of peat moss 3.8 cm thick and 0.5 m in radius was placed approximately 30 cm below the planting point at the plot center without disturbing the scrub oak and wiregrass. This was done by slanting a 3.8-cm metal tube in toward the planting point from points on a circle with a 1.2-m radius, extracting the soil, and packing the inner 0.5 m of the hole with peat moss. Repeating this procedure around the circle produced a buried layer of organic matter in a spoke-like pattern. Some roots were severed when the tube was introduced.

Cleared.-Sites were cleared of all vegetation with a grub hoe, and roots at the plot edges were severed with a spadelike blade to a depth of about 30 cm. The sites were kept bare and the roots severed at the plot edges through 1968.

Cleared and sublayered.-Sites were cleared as in the preceding treatment and, at the planting point, soil and roots were excavated to an 0.9 l-m diameter x 32-cm depth. The bottom of the hole was covered with enough peat moss to make a 3.8-cm layer when packed. The roots and part of the subsoil were discarded, the remainder of the subsoil returned to the hole, and the topsoil replaced. As in the previous treatment, the plots were kept bare and roots severed at the plot edges through 1968.

In March 1962, after treatment of the sites, two 1-O slash pine seedlings were planted about 10 cm apart at the center of each plot. After establishment seemed assured (in June 1962), the extra seedling was clipped off. Height measurements were taken through 1969, the eighth year in the life of the seedlings on the plots. Determinations of soil moisture were made in 1965 and of root distribution in 1965 and 1968.

An unquantified influence on the study trees was black root rot caused by ***Sclerotium bataticola*** Taub, and ***Fusarium oxysporum*** Schlecht. var. ***auriantiacum*** (Lk.) Wr., which was found to be "almost universally present" on slash pine in the area (Smalley and Scheer 1963) at the time the study was installed and was evident when roots were examined at the conclusion of the study.

RESULTS

Data on height of slash pine 8 years after planting were analyzed by analysis of variance, and differences by site treatment tested using the Duncan multiple range test (Duncan 1955; Kramer 1956). The cleared-sublayered treatment was significantly better than other treatments at the 0.01 level.

Seedlings on the cleared-sublayered plots grew faster than those on other plots during the first year after planting and increased their height advantage each year thereafter (fig. 1). Eight years after planting, heights averaged 2.48 m on cleared-sublayered plots, 1.48 m on sublayered plots, 1.44 m on cleared plots, and 1.26 m on untreated plots.

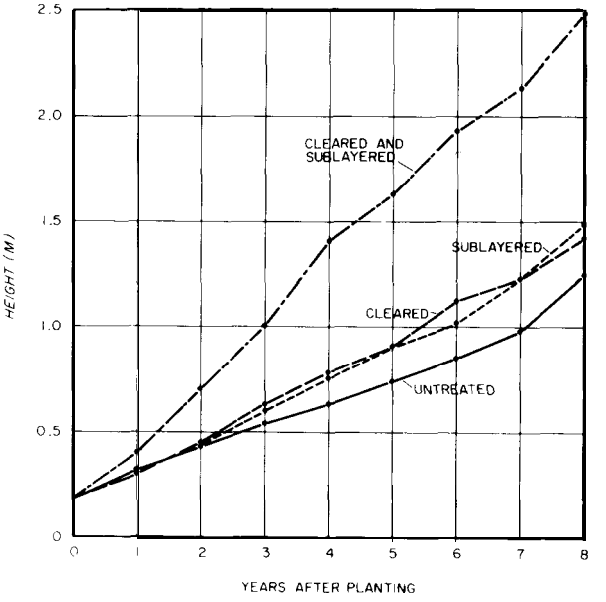

Figure I.-Height growth of slash pine by treatment.

Since the death of one seedling would have meant the loss of an entire plot, seedlings from the same planting stock, which had been held in the nursery bed, were planted in December to replace first-year losses. Two of the seedlings in the cleared plots died; one in the untreated. After replanting, survival of slash pine again was poorest among the cleared plots, where eight seedlings ultimately died. One tree of each of the other treatments died.

When excavated 8 years after being laid down, the layer of peat moss appeared to be altered very little. Soil moisture sampled gravimetrically after 17 days without rain was found to be higher at the layer of peat moss than above or below it, and higher in the peat moss layer than in the soil horizon from the same depth in plots that did not receive the sublayering treatments (table

I). Gyurkó and others (1958) also found moisture to be higher in the organic layer. (Furthermore, they found that where two layers had been installed, they were more moist than the sand between them.) Disregarding the layers of peat moss, soil moisture was slightly higher on the two types of cleared plots than on the plots with undisturbed vegetation.

Table I.---Soil moisture on plots. by treatment. Average of plots of three blocks

Depth sampled (cm)	Treatment			
	Untreated	Suhlayered	Cleared	Cleared-sublayered
		Percent		*of volume*
7.5	3.0	2.8	4.7	4.0
15.0	2.9	3.6	5.0	5.2
22.5	4.2	4.0	5.6	5.4
30.0	4.0	[1]24.3	5.3	[1]21.1
37.5	4.1	4.0	5.6	5.x

[1] Peat moss layer.

Bush and Kapost (1956) and Papp (1958) have reported enhanced root growth in the layer of organic_ matter, but root sampling of the study trees revealed no special concentrations of small roots (1.5 mm in diameter). Excavated plots showed a concentration of the larger roots in the layer of peat moss (fig. 2). The lack of small roots may have been the result of black root rot, which would tend to leave the stubs of roots while destroying the finer parts (fig. 3).

SUBSTITUTION OF SAND PINE

After the slash pines had grown on the plots 8 years, they were chopped out and sand pines (*P. clausa* var. *immuginata* Ward) were planted in their places. (Sand pine had been found to be much better suited to sandhill soils than was slash.) At that time the peat moss layers appeared to be nearly intact, so it was hoped that planting sand pine would allow at least partial comparison of the effect of sublayering on the two pines.

Growth of sand pine in the first few years after they were planted showed little effect from the layer of peat moss. At that time some of the peat moss was left. The pines were measured at 2 years and at 6 years, but only at the latter age was there a significant difference in heights among treatments (table 2). Unlike slash pine, sand pine

Table Z.-Height growth of sand pine planted after the slash pine

Planted age (years)	Treatment[1]			
	Untreated	Sublayered	Cleared	Cleared-sublayered
		meters		
2	0.34	0.37	0.27	0.34
6	2.26a	2.32a	1.71	2.38a

[1]Treatment means not followed by the same letter differ significantly at the 0.05 level.

had good survival under all treatments but did not excel in height under any one of them.

Nine years after the sand pine were planted, one sublayered plot and four cleared-sublayered plots were dug into. By that time the peat moss layers were found to be faint and thin, and the material powdery.

DISCUSSION

Sublayering by itself has not proved to be a good substitute for mechanical site preparation for planting slash pine. It did improve growth in this experiment only where combined with clearing. Growth was best on the cleared-sublayered plots, possibly because of the complementary effect of the treatments, but more probably the result of eliminating all roots when installing the treatment.

Sublayering did increase soil moisture in the region at the peat moss layer during a dry period. However, slash pine growth was not improved, so competition for moisture cannot be the only limiting effect on unprepared native sites.

Growth on cleared-sublayered plots, though the best of any of the four treatments, is still less than that noted on chopped sites in other studies. On a site preparation study installed nearby, the average height of 8-year-old slash pine on the chopped plots was 5.52 m. In the present study, the poorer growth may result from the repeated severing of pine roots at the edges of the plots.

Root excavation showed that black root rot is abundantly present-probably in most of the plots-so the effects of sublayering are weakened by the abnormal root growth of the trees; however, the effect of the rot may have been general because the disease was found under all treatments. The disease organisms are common to the area and slash pine is especially susceptible, so it

is doubtful that the study could have been conducted with slash pine free of the disease.

Even in the first few years after planting, when the layer of peat moss appeared to be sufficiently intact to have some effect, sand pine did not follow the pattern of slash nine. Most references to the period that the layer is useful concern short-term crops. Although Papp (1958) and Mar-ton (1970) did not study its persistence specifically, they believed the layer would be effective for at least 3 years.

Figure 2.-Excavated roots of representative saplings, showing treatment effects on (*A*) an untreated plot, (*B*) a sublayered plot showing the layer, (*C*) a cleared plot, and (*D*) a cleared-sublayered plot showing the layer. The roots are infected with black root rot, and most taproots terminate abruptly 0.5 to 0.6 m below the surface.

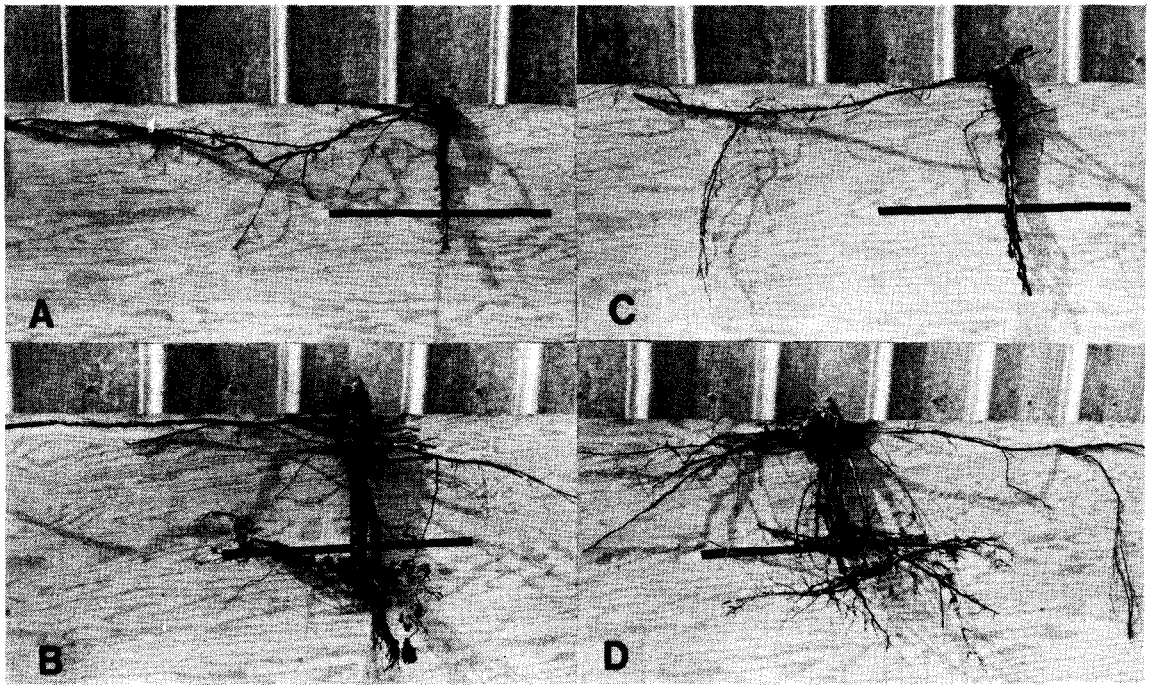

Figure 3.-The roots (fig. 2) removed from the soil show the pattern of growth on *(A)* an untreated plot. (*B*) a sublayered plot showing growth along the slanting organic layer, (C)a cleared plot, and (*D*) a cleared-sublayered plot showing the proliferation of roots at the organic layer. The black tape line is 0.6 m long and 0.3 m from the top of the board.

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