Survival, growth of loblolly, pitch, shortleaf pines established by different methods in New Jersey

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There has long been confusion about how much care should be practiced in tree planting. Long ago pathologists pointed our that planted trees were more susceptible than natural stands to disease, especially to root rots (2, 1). Others have shown that two-thirds of the planted trees in some areas had root systems severely deformed in planting (4); that these deformities may cause increased mortality *(9, 3, 11),* and that they may reduce growth in height by as much as 20 percent (9). However, Wakeley (12) considered apprehension over ill effects from slit planting of southern pines unwarranted, and Schantz-Hansen (10) reported that five different methods of planting red, white, and jack pines on sandy sites produced no important differences in tree survival or root development in Minnesota.

In the Northeast, most available evidence on the effects of establishment practices on seedling survival, tree form and growth, and disease infection come from observation. To obtain more reliable information, the Northeastern Station started an experiment with three species of pines in southern New Jerseytesting direct seeding and three planting procedures at two ages. The effects of establishment methods on early survival and growth of seedlings are described in this article.

Study Methods

Each of three species-loblolly, shortleaf, and pitch pine-was direct-seeded and planted as 1-0 and 2-0 stock, and the planting done in three ways: Center hole, good slit, and poor slit. Centerhole planting called for digging holes and spreading the roots out in a position similar to that in the nursery. Planting bars were used in slit planting. Good slits were made deep enough to accommodate the length of the taproots. Poor slits were made shallow enough so that roots were bent in an L or J shape. Direct seeding was done by spading spots, dropping 12 sound seeds per spot, lightly covering them with soil, and protecting each spot with a hardware-cloth cone.

Two sites were selected-one in the Wharton State Forest and one in the Lebanon State Forest, both in Burlington County. Both sites had been covered by oak-pine stands, which had been cut or killed, and woody regrowth has since been controlled. In both areas the soils are sandy.

In each area, two 0.1-acre plots were laid out for each of the 21 treatment combinations. In each plot there were 121 seed spots or seedlings planted at 6-foot spacing, but only the inner 49 trees or spots were subsequently measured.

In the Wharton area, direct seeding and planting of 1-0 stock were done in the winter or spring of 1961, and 2-0 stock was planted the following spring. In the Lebanon area, direct seeding and the planting of 1-0 stock were done in the winter and spring of 1965, and the 2-0 seedlings were planted in 1966 (earlier seedings and plantings had been killed by a 1963 wildfire). Within an area, the same seed lots provided the seeds for all treatments within a species. Pitch pine and shortleaf pine seeds were collected in southern New Jersey, while loblolly pine seeds came from Maryland's Eastern Shore through collections by the Maryland Forest Service. All planted seedlings were grown by the New Jersey Bureau of Forestry in its Washington Crossing Nursery.

Results

Stocking or Survival

For the most part, the method of establishment and the age of stock had relatively little effect on the stocking within plots in March 1971. For example, in the Wharton area, 68 percent of both the 1-0 and the 2-0 stock was

living in 1970, while comparable values in the Lebanon plots were 90 and 85 percent respectively. By planting method, the survival of trees in the two areas was as follows:

Method	*Wharton Plots*	*Lebanon plots*
Center hole	74 percent	87 percent
Good slit	63 percent	89 percent
Poor slit	67 percent	86 percent

In the Wharton plots, 70 percent of the seeded spots were stocked.

The exception was the direct-seeded Lebanon plots, in which only 20 percent of the spots were stocked in March 1971. The low stocking there is attributed primarily to adverse weather during 1965, when rainfall during May, June, and August was far below normal. In contrast, the same treatment on the same plots had produced a stocking of 81 percent at the end of the second growing season after the 1961 seeding (during a period of more plentiful rainfall). Evidently, establishment by planting is far more successful than direct seeding during some drought years on the study sites.

Height and Height Growth

Seedlings from direct seeding were generally shorter than planted seedlings in March 1971 (tables 1 and 2), partly because they are a year younger. But even when only growth since establishment is considered, direct-seeded trees still generally grew less than trees planted as seedlings. In annual growth since seed sowing, direct-seeded seedlings did about as well as those of the poorer planting methods.

The different planting methods gave no consistent difference-either in current height or in height growth. For all seedlings undamaged by windfalls and not suppressed by oaks, the means of the values in tables 1 and 2 are 8.8 feet for center-hole planting, 8.6 for good-slit, and 8.6 feet for poor-slit planting.

Age of stock did affect current height and height growth since seed sowing. In both of these measures, 1-0 stock tended to have the same or slightly greater values than 2-0 stock comparably planted (for example, see tables 1 and 2.) Means of the values in tables

TABLE 1.—*Results from Wharton plots after the 1970 growing season*

Species	Establishment method	Survival or stocking	Avg. hgt. of surviving seedlings[1]	Avg. hgt. of tallest 5 trees per 0.1-acre plot	Max. hgt. of surviving seedlings
		Percent	*Feet*	*Feet*	*Feet*
Loblolly pine	Direct seeding	59	9.1(9.3)	12.8	44.4
	Planting 1-0 stock:				
	Center-hole	57	11.9	14.8	16.3
	Good-slit	60	10.8	14.4	16.9
	Poor-slit	67	10.5(10.6)	14.1	16.3
	Planting 2-0 stock:				
	Center-hole	63	10.8(10.9)	14.8	16.8
	Good-slit	45	9.5(9.6)	11.8	12.7
	Poor-slit	50	9.9(10.0)	12.7	15.8
Pitch pine	Direct seeding	82	8.4	11.0	13.0
	Planting 1-0 stock:				
	Center-hole	71	10.1	12.3	13.0
	Good-slit	64	10.1	11.8	14.3
	Poor-slit	77	8.9(9.2)	11.2	12.6
	Planting 2-0 stock:				
	Center-hole	89	9.1	11.0	12.0
	Good-slit	74	9.6	11.4	13.2
	Poor-slit	62	8.7	11.0	12.3
Shortleaf pine	Direct seeding	69	8.1(8.4)	10.8	12.1
	Planting 1-0 stock:				
	Center-hole	81	9.6(10.0)	12.9	16.1
	Good-slit	68	9.3(9.4)	11.9	12.9
	Poor-slit	69	9.9(10.0)	12.6	15.4
	Planting 2-0 stock:				
	Center-hole	86	8.8(9.1)	11.7	12.9
	Good-slit	67	8.3(8.5)	10.5	11.8
	Poor-slit	79	10.0	12.4	13.8

[1]Values in parentheses do not include occasional seedlings badly damaged by windfalls or suppressed by oak sprouts.

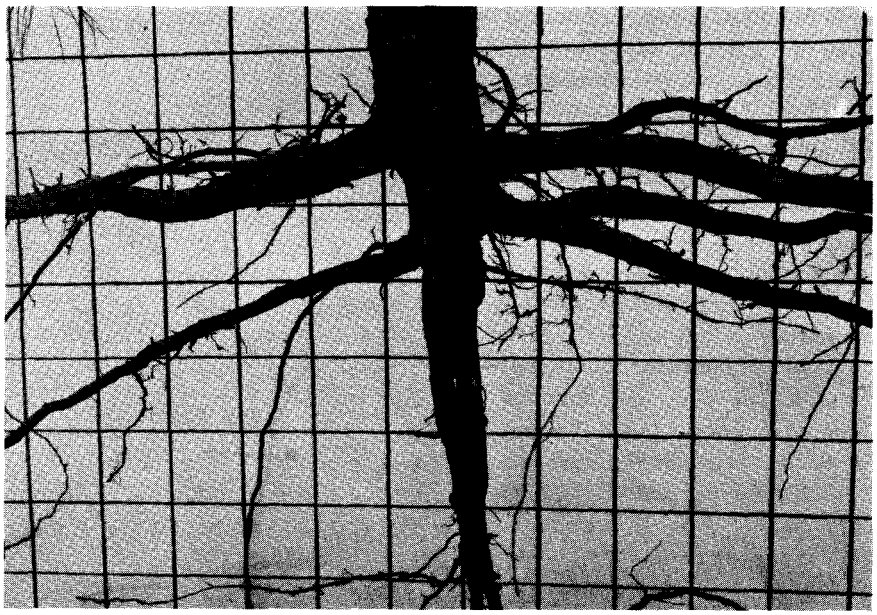

Figure 1.—A portion of the root system of a loblolly pine planted as a 2-0 seedling is a poor slit 5 years before. Note that the root system has largely recovered from planting distortions, and that twin taproots have even developed. However, the original taproot has apparently become the lower lateral on the left side, and the upper large lateral on the right side is bent toward the right.

TABLE 2.—*Results from the Lebanon plots after the 1970 growing season*

Species	Establishment method	Survival or stocking	Avg. hgt. of surviving seedlings	Avg. hgt. of tallest 5 trees per 0.1-acre plot	Max. hgt. of surviving seedlings
		Percent	*Feet*	*Feet*	*Feet*
Loblolly pine	Direct seeding	15	5.7	7.7	9.8
	Planting 1-0 stock:				
	Center-hole	81	8.6	11.8	12.7
	Good-slit	89	8.9	12.4	15.4
	Poor-slit	86	9.9	12.8	13.5
	Planting 2-0 stock:				
	Center-hole	80	7.8	10.6	11.7
	Good-slit	89	8.6	11.4	12.6
	Poor-slit	77	8.6	11.4	12.9
Pitch pine	Direct seeding	21	5.1	6.2	8.8
	Planting 1-0 stock:				
	Center-hole	95	8.1	10.3	12.3
	Good-slit	95	8.4	10.6	11.5
	Poor-slit	93	7.5	9.7	11.2
	Planting 2-0 stock:				
	Center-hole	83	6.1	7.7	8.7
	Good-slit	74	5.6	7.4	8.4
	Poor-slit	81	5.5	7.3	8.8
Shortleaf pine	Direct seeding	23	4.0	5.0	6.8
	Planting 1-0 stock:				
	Center-hole	86	7.1	10.0	11.8
	Good-slit	89[1]	7.4[1]	10.1	11.0
	Poor-slit	95	7.8	10.7	11.7
	Planting 2-0 stock:				
	Center-hole	98	6.9	9.3	10.2
	Good-slit	97	6.1	8.6	11.0
	Poor-slit	83	5.1	7.2	8.5

[1]Excluding one tree cut by vandals for a Christmas tree.

1 and 2 for all seedlings undamaged by windfalls and not suppressed by oaks are 9.2 feet for 1-0 stock and 8.1 feet for 2-0 stock. Mean values for annual growth in height since seed sowing are 1.1 foot for 1-0 stock and 0.9 foot for 2-0 stock. However, annual growth of 2-0 stock since establishment has been more nearly the same as that of 1-0 stock: mean values of 1.1 and 1.2 feet respectively.

In spite of the somewhat heavier soil on the Wharton plots, the Lebanon seedlings have grown faster. Current heights of the Lebanon seedlings are only about 2 years behind those of seedlings on the Wharton site, even though the Lebanon trees are 4 years younger.

Root Systems

Because planting method had so little effect on the survival and growth of seedlings, some root systems were excavated in the spring of 1971 to determine whether the roots had largely recovered from planting distortions. One seedling of, average height for the species and treatment was selected in each study area in the plots planted with 2-0 stock by the poor-slit method. Although it would have been desirable to excavate more seedlings, the task is tedious and time-consuming, and the six seedlings excavated, two for each species, are considered indicative. The author assumes that if the root systems of 2-0 stock planted by the poor-slit method had largely recovered, root systems of trees planted by other methods and those of 1-0 stock would also have recovered, because earlier excavations (7) showed that 2-0 stock in poor slits suffered the most" distortion.

In excavating the 1971 seedlings, the methods used were similar to earlier ones: dry-excavation by digging a deep hole on one side, and using screwdrivers and hands to loosen the roots and pull the sandy soil into the hole. No attempt was made to obtain complete root systems, but an attempt was made to remove almost intact that portion of the root system within 3 feet of the stem and within the upper 4 feet of soil.

Figure 2.—Most of the root system of a pitch pine planted as a 2-0 seedling in a poor slit 5 years before. Note the U-turn that one large root makes close to the stem—a result of distortion in planting. Close examination of excavated root systems showed many more distortions than are easily seen in these figures.

All the excavated seedlings had developed spreading root systems, indicating that root systems had largely recovered from planting damage. Most root systems still had few roots on one side (figs. 1-3), and intertwined roots near the taproot and soil surface were still common (figs. 2-3). In all of the root systems, severe bending of one or more roots was still noticeable 5 or 9 years after planting (figs. 1-3). Some of the roots twisted around the taproot were being overgrown by the taproot (fig. 3). However, in development of both taproots and spreading lateral roots, the trees showed markedly better root systems than those reported in the earlier publication (7).

Discussion

Direct seeding in the New Jersey Pine Barrens can provide good stocking of pine seedlings in years with favorable soil moisture for germination, for initial establishment, and for survival through the second growing season. This conclusion was reached in earlier studies (6) and is substantiated here. Under unfavorable moisture conditions, and especially on sites where conpeting sedges or other plants have not been eliminated, direct seeding will not provide as good stocking of pine seedlings as planting.

In some prior studies, volunteer pines frequently equalled or excelled planted trees in height growth, so the author expected that the direct-seeded seedlings of this study might compare favorably in growth rate with the planted trees. However, current results favor the planted stock, and these results are similar to others previously reported *(5, 8).*

At the start of the study, appreciable differences in survival and growth were

expected to develop among trees established by different planting methods, However, ill effects, such as those reported by Rudolf (9), Brown and Carvell (3), or Ursic (11), did not develop. This study tends to confirm both Wakeley's (12) conclusion and the results SchantzHansen (10) obtained in Minnesota.

Although results from the present study should not be interpreted as applicable to heavy soils or indicative of longterm effects on susceptibility to root disease, they do suggest that 1-0 stock should be used in planting similar sites in southern New Jersey. Trees from the 1-0 stock are now taller, and have usually grown slightly faster since seed sowing, than trees planted as 2-0 stock.

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Figure 3.—Part of the root system of a shortleaf pine planted as a 2-0 seedling in a poor slit 9 years before. Note severe U-turn of one root on the left side, and the twisted lateral root being overgrown by the taproot (below center).