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Root Systems

of direct-seeded and variously planted loblolly, shortleaf, and pitch pines

by s. little
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the authors . . .

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The Root Problem

THOUGH tree planting has long been a major forestry practice in the Northeast, it has resulted in relatively few wholly successful stands. Survival has often been low. Where survival has been high, the trees in some plantations have been slow-growing or misshapen. Even when planted trees do grow well for a while, they commonly are short-lived: scattered trees die from no apparent cause, or a swath of trees may go down in a wind storm. Attrition of this sort tends to continue until the stand is largely destroyed or is removed in a salvage cutting. Only in occasional instances or in certain places do plantations give promise of growing as well as the best natural stands.

Poor performance of plantations may be due to one or more of several causes: low-quality stock, wrong species, wrong seed source, unsuitable site, and nursery and planting practices that are geared more to cost than to quality considerations. Though most states now are taking steps to provide good stock of suitable species and source, and to match species and site, relatively little attention has been paid to practices that may greatly influence disease susceptibility, and hence plantation longevity and growth.

Pathologists pointed out long ago that planted trees were more susceptible than natural stands, especially to root rots (Boyce 1938, Baxter 1943). Other authors have shown that, on two-thirds of the planted trees in some areas, the root systems may be severely deformed in planting (Gruschow 1959); that these root deformities may cause increased mortality (Rudolf 1939, Brown and Carvell 1961, Ursic 1963); and that they may reduce height growth by as much as 20 percent (Rudolf 1939).

In the Northeast, most evidence of the effects of planting practices on seedling survival, tree form, growth, and disease infection has been observational. To obtain more reliable information on those effects, the Northeastern Forest Experiment Station in 1960 started a long-term experimental study with three pine species in southern New Jersey. The study was designed to compare direct seeding with several planting procedures in terms of tree performance through the period of a stand rotation. As part of the study, sample seedlings were excavated in 1962 to determine the early effects of the treatments on root systems. This paper describes and pictures the root systems, and the differences among them that relate to the method of seedling establishment.

Study Methods

The three species used were loblolly, shortleaf, and pitch pines. Each was direct-seeded and planted as 1-0 and 2-0 stock, and the planting was done in three ways: center hole, good slit, and poor slit. Thus there were 21 species-treatment combinations.

Center-hole planting called for digging holes, usually with a spade, and spreading the roots out in a position similar to their position in the nursery. In slit planting, planting bars were used. Good slits were made deep enough to accommodate the length of the taproots, and planters were instructed to maneuver the roots so that they hung vertically. Poor slits were deliberately made shallow enough (to simulate careless planting) 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.

The same seed lot provided seedlings for all treatments within a species. The pitch pine seeds were collected in the Lebanon State Forest and the shortleaf pine seeds in the Wharton State Forest in 1959. Loblolly pine seeds from the 1958 crop on the Eastern Shore were provided by the Maryland Department of Forests and Parks. The New Jersey Department of Conservation and Economic Development extracted the pitch and shortleaf pine seed, and grew all the required seedlings at their Washington Crossing Nursery. These seedlings were started in 1960.

Two sites were selected for field tests — one in the Wharton State Forest and one in the Lebanon State Forest. Both sites had been occupied by oak-pine stands, but the Lebanon area had recently been cut over, and the Wharton area had been subjected to a killing wildfire. (Regrowth in both areas has since been controlled by cutting and silvicides.) The soils of both areas are sandy. Those at the Lebanon site are gradational between the Lakeland and Lakewood series, which differ primarily in depth of the leached A_2 horizon. The soils of the Wharton site are somewhat heavier and less leached, and are considered to be of the Sassafras series.

At each site two 0.1-acre plots were laid out for each of the 21 treatment combinations. Each plot provided for 121 seed spots or planted seedlings at 6-foot spacing. Only the inner 49 trees were to be measured; the outer two rows all around were regarded as isolation strips.

All plots that were to be direct-seeded were seeded in March 1961, and plots that were assigned 1-0 seedlings were planted that spring. Plots assigned 2-0 stock were planted the next spring — 1962. Sufficient stock was available both years to permit culling out most of the smaller and damaged seedlings.

In November 1962, one seedling that appeared typical of those in each plot was excavated from the isolation strip. Dry excavation methods were employed: a fairly deep hole was dug on one side of the seedling, with shallower ones on the other sides, and screwdrivers were used to loosen the roots and pull the sandy soil into the holes. Care was taken to remove the root system as intact as possible. In all, 84 seedlings — 1 per plot or 4 per treatment combination — were excavated.

Results

Seeded Seedlings

All direct-seeded seedlings had relatively normal root systems. Taproots usually had penetrated nearly vertically into the soil. Laterals had developed on all sides and had grown away from the taproots almost at right angles (fig. 1).

There was one striking exception, a shortleaf pine seedling in which the tip of the taproot had died and a lateral had taken over (fig. 2). Surprisingly, this root had penetrated to a depth of 37.5 inches — a greater depth than had been reached by the taproot of any other direct-seeded seedling that was excavated. By develop-

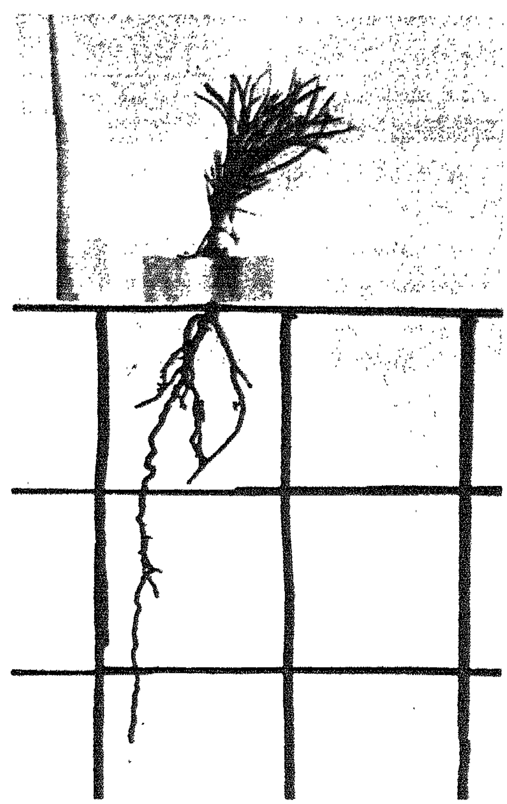


Figure 1.—Typical seeded seedling of pitch pine excavated at the end of two growing seasons. (3-inch grid.)

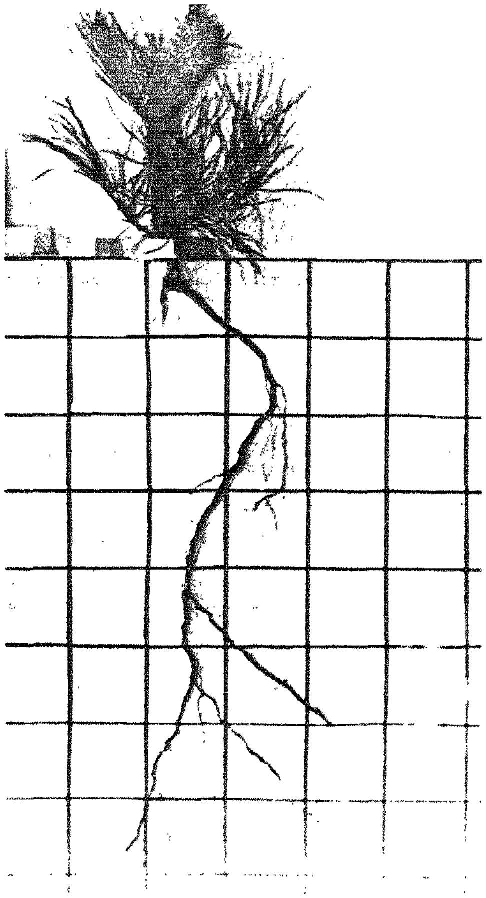


Figure 2.—A direct-seeded 2-year-old shortleaf pine seedling on which the taproot soon died, possibly because of insect injury, and was then replaced by a lateral root. (3-inch grid.)

ment of lopsided growth rings, this seedling could easily mask the crook in its main root by the time root diameter at that point has reached 6 inches.

Planted Seedlings

The roots of planted seedlings differed from those of seeded seedlings in several ways. One of the most notable differences was the occurrence in the planted trees of twisted, intertwined roots in the upper 3 inches or so of the root systems. This condition was not found in the direct-seeded trees.

Such intertwined roots characterized 94 percent of the excavated planted seedlings. They were most conspicuous on seedlings planted in poor slits as 1-0 stock (fig. 3), but some occurred also on similar seedlings planted in center holes or good slits. On 2-0

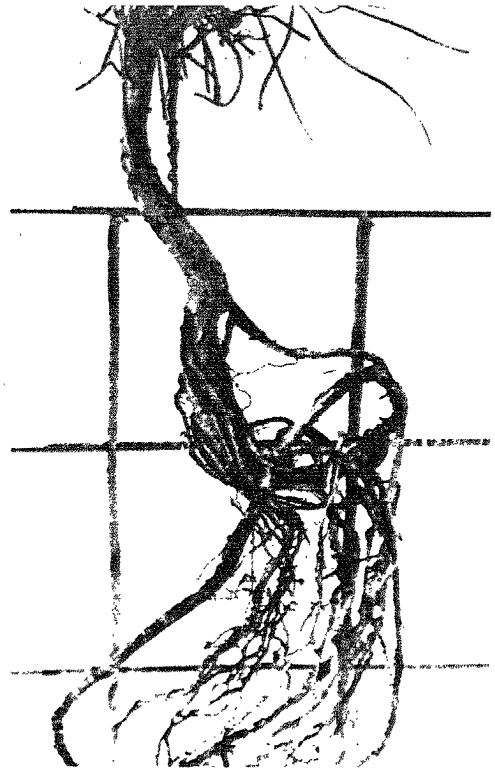


Figure 3. — Intertwined roots of a shortleaf pine seedling two growing seasons after planting as 1-0 stock in a poor slit. (3-inch grid.)

stock intertwined roots, although usually present, were not so conspicuous — probably because these trees had had 1 year less for growth since planting.

Nearly all the seedlings planted in slits had root systems that were developing only in one plane. This was particularly true of those in poor slits. However, even in good slits, only two excavated seedlings — one pitch pine and one shortleaf pine — were developing relatively normal root systems. Both of these seedlings had been planted as 1-0 stock and were still small.

Planting in slits tended to produce J- or L-shaped taproots. Although deformities of this kind were deliberately induced in the poor-slit method, 25 percent of the seedlings excavated from good-slit plantings also had J- or L-shaped taproots. In these cases, the planters evidently had not taken sufficient care to have the taproots hanging free in the holes before closing them. Of course, where good-slit planting was properly done, root systems were more nearly normal in appearance (fig. 4).

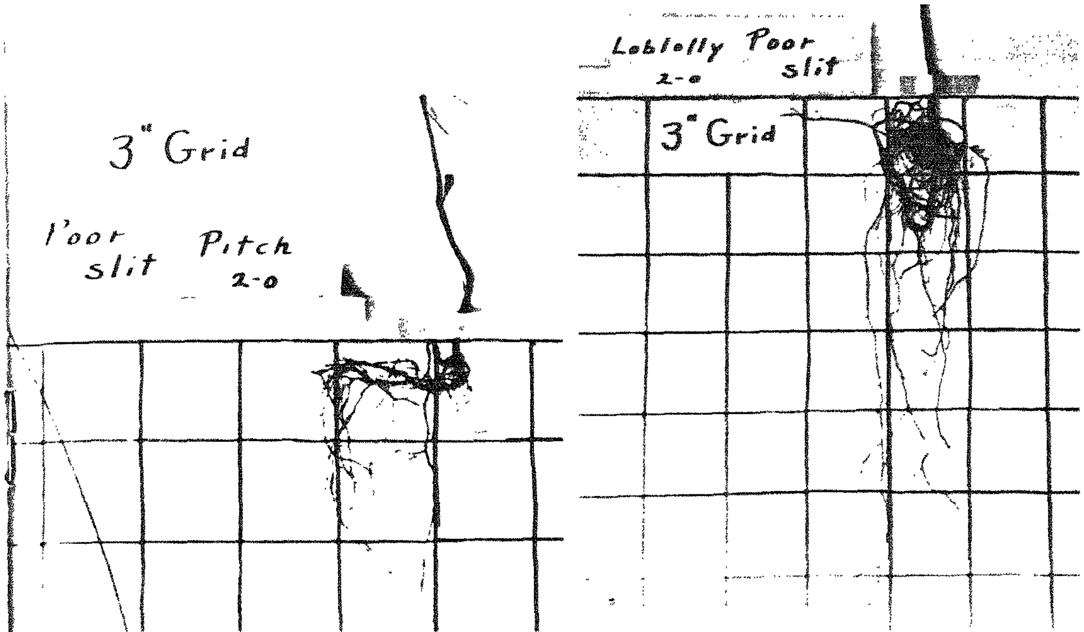
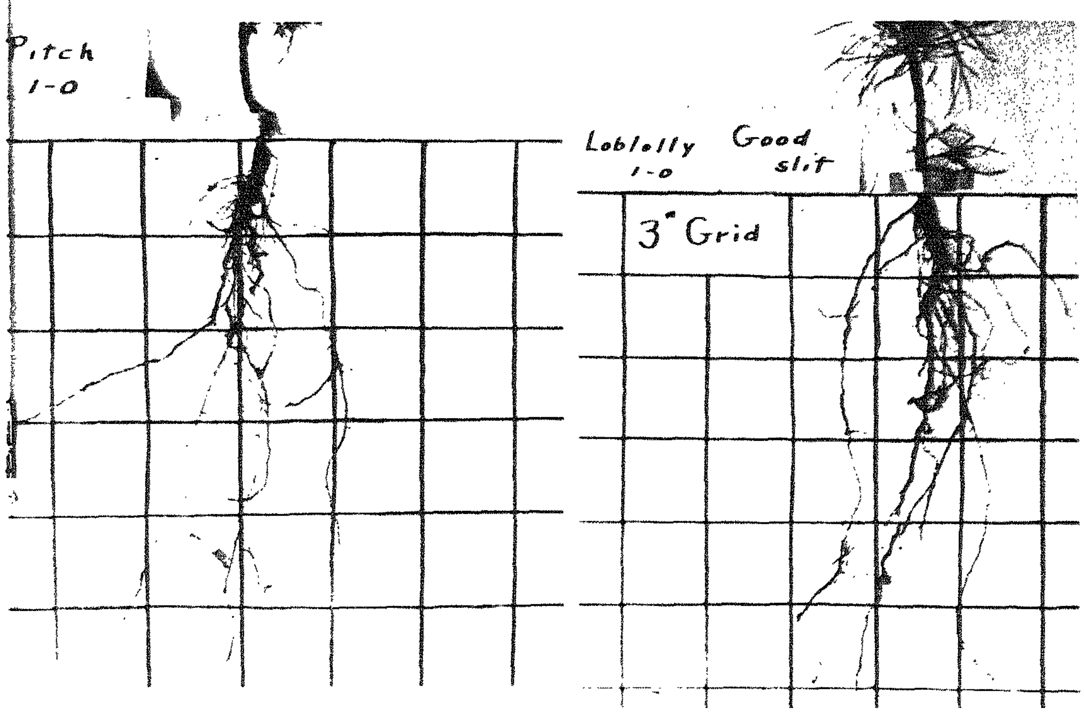


Figure 4. — Contrast in the root systems resulting from poor-slit and good-slit planting. Above: pitch and loblolly pine seedlings planted as 2-0 stock in poor slits. Below: the same species planted as 1-0 seedlings in good slits.



The 1-0 seedlings showed greater flexibility in recovering from poor planting than did the 2-0 stock. Ursic (1963) has already observed and described the recovery of root systems in 1-0 loblolly pines from U-root planting. In our study the roots of all the excavated 1-0 seedlings that had been planted in poor slits had reacted either by the taproot itself growing in an abrupt turn downward from the end of the J or L (fig. 5) or, in some cases,

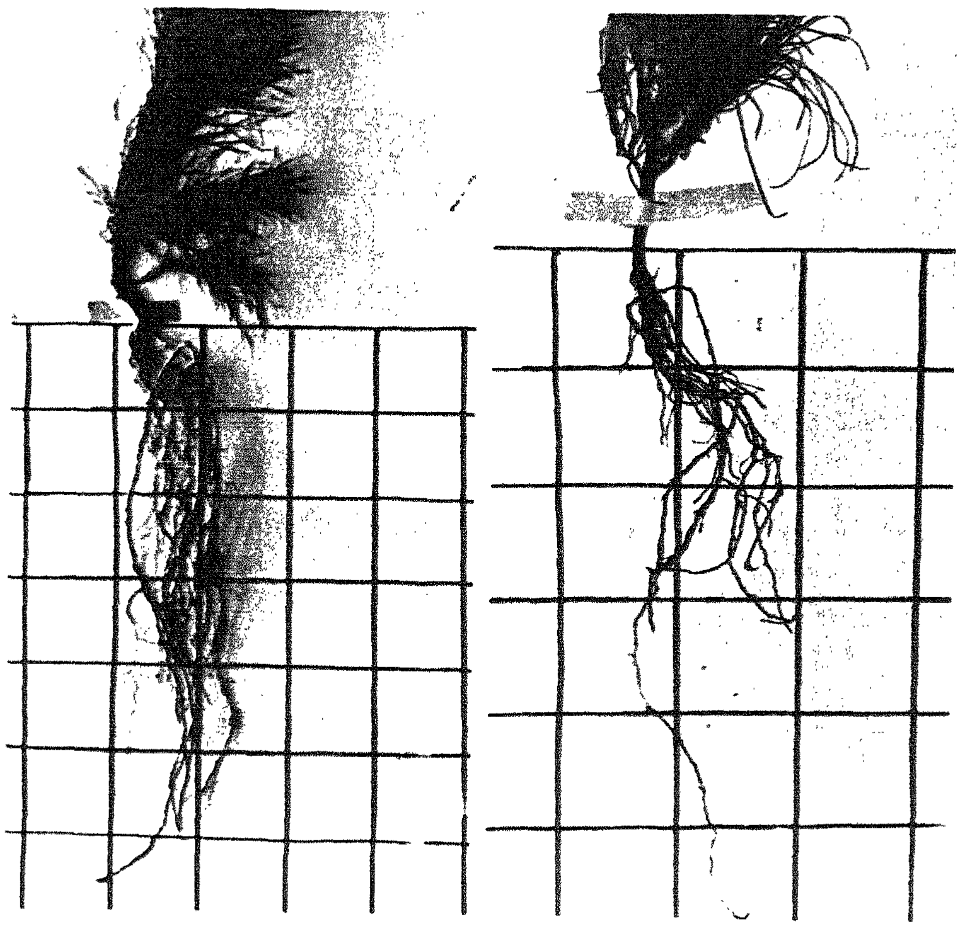


Figure 5.—Recovery of taproots in two growing seasons after 1-0 seedlings were planted in poor slits with taproots in an L or J position. Note the U-turn in the taproot of the shortleaf pine seedling (left) and the L-turn in that of the loblolly pine (right).

by another root replacing it. When the latter happened, most of the development of the replacement root seemed to have occurred since planting. In part because of less elapsed time, the 2-0 seedlings planted in poor slits had made less recovery. In some, as in one shortleaf pine planted with most of its root system above the base of the stem, a new taproot had scarcely started.

Center-hole planting resulted in more spreading root systems than slit planting (fig. 6 compared to figs. 4 and 5). Theoretically, planting in center holes should result in nearly normal root systems with laterals spreading in all directions and taproots growing downward without marked deformities.

However, the desired objective was not achieved. In nearly half of the excavated seedlings from center-hole planting most of the roots were in one plane, and in many others one side had few or no roots. Frequently, too, the taproots were deformed: either they had a J or L shape or they had been spread out like lateral roots in the planting. Though the amount of distortion of taproots was not so great as in poor-slit planting, and though root systems were more spreading than in either type of slit planting, root distribution in the center-hole planting still was far from normal. In view of the difficulty in distributing the flexible, bare roots in their natural positions, this is understandable.

To achieve proper placement of roots in center-hole planting, the root system should not be pressed against one side of the hole: the taproot should hang vertically, and lateral roots should be spread out on all sides. This is slow, tedious work. Planters, by and large, will not take the requisite time and care in separating and placing the roots in the hole.

Surprisingly, the three methods of planting caused little difference in the depth of taproot penetration in 1962, although differences did occur between ages of stock and between planted and direct-seeded seedlings. As might be expected, the greatest depth of taproot penetration was by seedlings planted as 1-0 stock, the average values being 21 or 22 inches for the slit treatments and 24 inches for the center-hole method. Average values for seedlings planted as 2-0 stock by comparable methods were 4 to 11 inches less than for the 1-0 seedlings, mainly because these seedlings had

had one less growing season in the field since planting. The average taproot penetration by seeded seedlings approached that of 2-0 stock, but these were 1 year younger from seed than either the 1-0 or 2-0 planted seedlings.

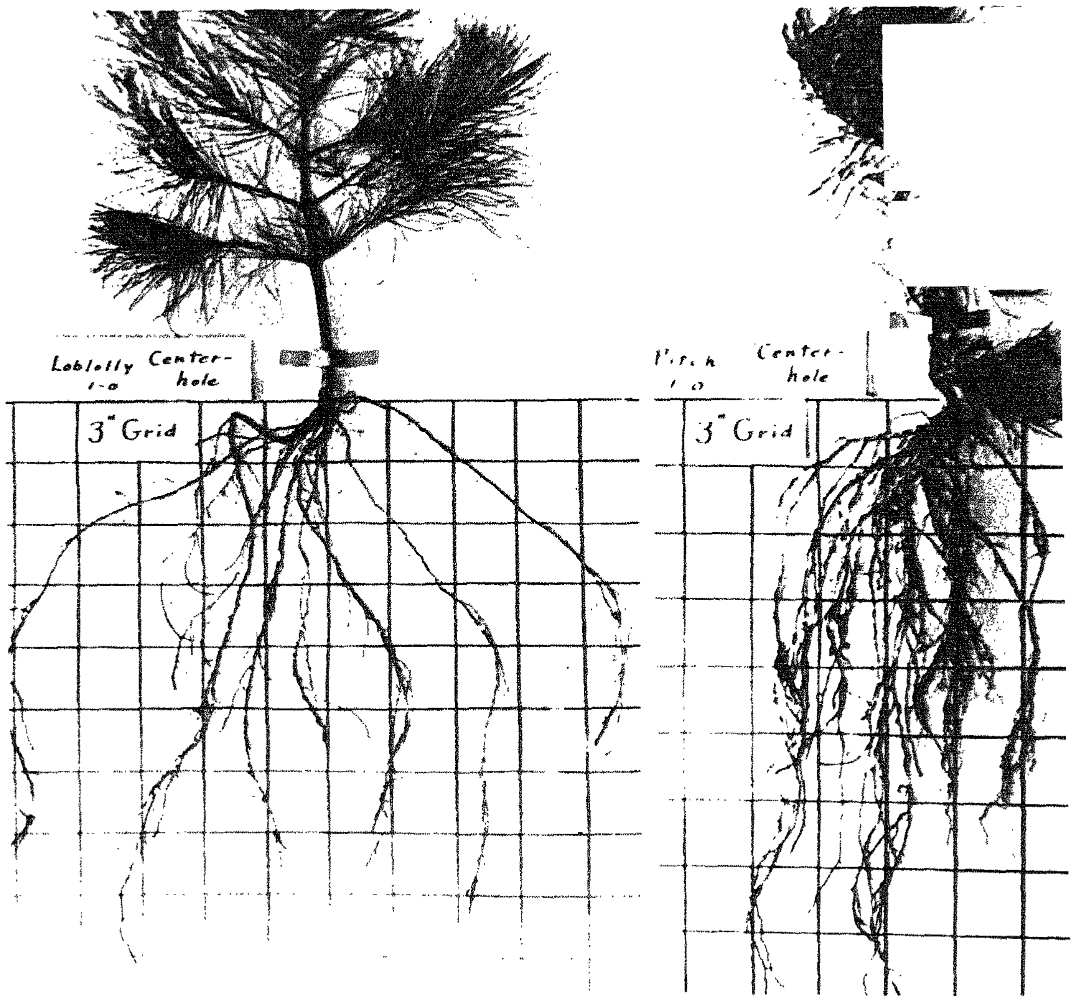


Figure 6.—Seedlings planted in center holes as 1-0 stock, photographed two growing seasons later. Note that the root systems are more spreading than those of slit-planted seedlings, but that, as shown in the loblolly pine seedling, root systems did not escape distortion.

Discussion

Although the seeded seedlings of this study were younger and smaller, their root systems were in marked contrast to those of the planted seedlings. The seeded seedlings did not exhibit the one-plane pattern of root distribution found in the root systems of planted trees, and they did not have distorted taproots and intertwined laterals.

Intertwined roots near the surface, common on most of the planted seedlings, warrant emphasis because they are a possible source of disease infections. Even though Station pathologists found indications of infection on only one of the excavated root systems, the intertwined roots, as they grow, will strangle each other and provide dead material for invasion by wood-decaying fungi. Gruschow (1959) observed rotten roots on several loblolly pines 3 years after planting with J-shape or balled root systems. Ursic (1963) found twisted roots on planted loblolly pines and considered the twisting as potentially more serious than U-root planting.

The extent to which the planted seedlings can overcome distortions in their root systems remains to be seen. Bilan (1960) investigated slit-planted 1-0 loblolly pines in Texas and reported that during the first growing season most of the growth in lateral roots continued to be in the plane of the slit. Stevens (1931) reported a similar bunching of roots in one plane on white pines 3 years after planting. Certainly in our study, the more severely distorted root systems of stock planted in poor slits offer much less promise of ultimate recovery than do those planted by the other two methods.

The greater recovery in root systems of 1-0 seedlings than of 2-0 seedlings seems of great importance. To minimize planting damage, the use of small stock and sufficient care in planting seem necessary. In either center holes or good slits, properly planted 1-0 seedlings might develop root systems near enough to the normal pattern that root rots would not become very damaging. Survival and top growth of such seedlings should also be much better than in poorly planted trees — better especially than in 2-0 stock, in which the roots are more likely to be wedged into a ball and the taproots bent into J, L, or U shapes.

These conclusions are not considered in conflict with Wakeley's (1954) statement that apprehension over ill effects from slit planting of southern pines is unwarranted. His observations were based on excavated roots and on the evident vigor of thousands of acres of pulpwood-size pines. Presumably the use of 1-0 seedlings and careful, closely supervised planting accounted for the good results he observed. Because of continued pressure to reduce costs, present-day crews may not be turning out such good-quality plantings. This inference is supported by Gruschow's (1959) survey in southeastern Virginia, where he found that only about a third of the planted seedlings appeared to be developing normal root systems.

Summary

A study was started in 1960 to compare the development of direct-seeded and planted pitch, shortleaf, and loblolly pines in southern New Jersey. The planting included 1-0 and 2-0 stock; and center-hole, good-slit, and poor-slit planting. All seeds and seedlings of each species came from one lot of seed. The direct seeding and planting of 1-0 stock were done in the spring of 1961; and 2-0 stock was put in 1 year later. In November 1962, one seedling from each plot (four of each species-treatment combination) was excavated to determine the early effects of establishment methods on root systems.

Seedlings starting in place from direct seeding had normal root systems: taproots usually penetrated vertically; laterals grew away from taproots almost at right angles and on all sides.

Seedlings planted in slits usually had one-plane root systems. Those in poor slits, which had been planted with J-, L-, or U-shaped taproots, had reacted either by the new growth of the taproot turning abruptly downward, or by another root developing to replace the taproot. Seedlings planted in good slits exhibited much less distortion of root systems, but this method did not provide the spreading root systems of center-hole planting.

In all planting methods, intertwined roots were found near the soil surface. This condition was especially conspicuous on stock planted in poor slits. Presumably some of these intertwined roots will strangle each other to death and thus provide entry for wood-decaying fungi.

Root systems of 1-0 stock showed much greater recovery from planting distortions than did those of 2-0 stock. In establishing plantations by planting, carefully planted 1-0 stock would seem to offer the most promise of developing into stands that would be relatively safe from root-rot damage. Whether they would be as resistant as stands from direct seeding is still an unresolved question.

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