Auger Hole Shape, Size, and Tree Placement Affect Survival and Root Form of Planted Ponderosa Pine in South Central Idaho[1]

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Abstract.-- Ponderosa pine seedlings (2-0) were planted in 4- and 6-inch cylindrical auger holes and in 8-inch holes tapering to 4 inches at the bottom. Fifth-year mean survival of trees planted in the tapered holes was higher than three of four other treatments. The size of the planting hole as well as tree placement in the center or on the side of the hole did not affect survival. Mean seedling height after five growing seasons was unaffected by planting hole size, shape, or tree placement. Planting hole shape and tree placement impacted root system form while planting hole size did not.

INTRODUCTION

A tree depends on an adequate root system for acquisition of moisture and nutrients as well as for physical support. After establishment, planted ponderosa pine (Pinus ponderosa Dougl. ex Laws.) seedlings often have root morphologies drastically different from those grown from seed in place. Soil characteristics, nursery cultural practices, and planting methods of bareroot stock can all have a great influence on the form a root system may take. Root system parameters -- affected by various cultural and planting practices -- include symmetry, balance, constriction, coiling, and taproot development. Trees seeded in place tend to be strongly taprooted in comparison to artificially regenerated trees, which have more of a thick branched root system (Long 1978), and bareroot seedlings have fewer laterals than naturals (Stein 1978). Differences in planting tool, initial size of seedlings, and microsite have also been suggested as possible sources of variation on root system form and tree performance (Lyon 1971, Sutton 1969, Little and Somes 1964, and Rudolf 1950).

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Bareroot planting stock with large root systems is especially susceptible to root deformations such as a bent or J-rooted tap root (Stein 1978). A larger sized planting hole may help the planter to keep the roots straight and vertical. Also, the planting hole shape or tree placement within the hole can effect root system form. The important question is, can planting hole size, shape, and tree placement impact the root system enough to also affect the seedling survival and growth?

The standard U.S.D.A. Forest Service practice in the Intermountain Region is to plant a tree in the center of a 4-inch straight-sided hole, augured to a depth sufficient to accommodate the full length of the seedling's root system. In this study we varied the planting hole size, shape, and the placement of the tree to observe the effects on bareroot ponderosa pine seedling survival and growth. The objectives of the study were:

1. To determine if tree survival and growth is greater in 6-inch auger holes than in 4-inch holes.

2. To determine if survival and growth differ between side-hole and center-hole planted trees.

3. To determine if a beveled planting hole results in better tree survival and growth than straight-sided holes.

METHODS

The study was installed on the Mountain Home Ranger District of the Boise National Forest. In mid May 1983, bareroot 2-0 ponderosa pine seedlings were planted on a Pseudotsuga menziesii/Carex geyeri habitat type (PSME/CAGE; Douglas-fir/Elksedge) (Steele and others 1981) at about 4,900 ft of elevation. The soil is a clay-loam of basaltic origin. The site has an easterly aspect and a slope of 10 to 20 percent. Seedling root systems were 12 inches in length. Experienced planters planted the trees in the middle of 2- by 2-ft hand scalps.

Planting holes were drilled using one of three auger bits. Two of them made cylindrical holes with 4- and 6- inch diameters. The third bit tapered from 8 inches at the top to 4 inches at the bottom and was developed at Lucky Peak Nursery near Boise, ID. Figure 1 explains the five treatments which were randomly arranged in each of 10 blocks.

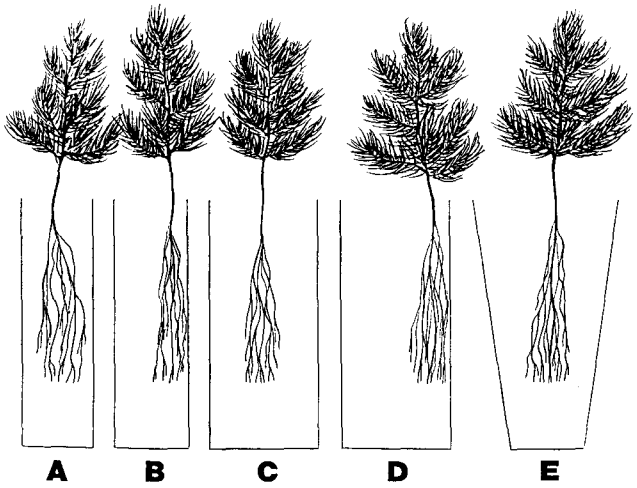

Figure 1.--Five planting hole configurations: (A) 4-inch straight-sided with tree placement in the center, (B) 4-inch straight-sided hole with tree placement on the side, (C) 6-inch straight-sided hole with tree placement in the center, (D) 6-inch straight-sided hole with tree placement on the side, and (E) 8-inch hole tapering to 4 inches at the bottom, with tree placement in the center.

Each treatment consisted of a row of 10-trees. Planting spots were 6 feet apart between rows and within rows, and planting holes were augered to a 14-inch depth. The times required to auger and plant each row were recorded during plot establishment. Survival and total height of each tree were measured after planting and then after the first, second, third, and fifth growing seasons. Finally, after 5 years of growth, several trees from each treatment were excavated to examine the root systems.

RESULTS AND DISCUSSION

Mean fifth-year survival of seedlings planted in the tapered holes was higher .05) than in the 4-inch hole with side placement, the 6-inch hole with the side placement, and the 6-inch hole with center placement (table 1 and fig. 2). Survival of the seedlings planted in the 4-inch hole with center placement was intermediate. After five growing seasons, mean heights are close for all five treatments (table 1).

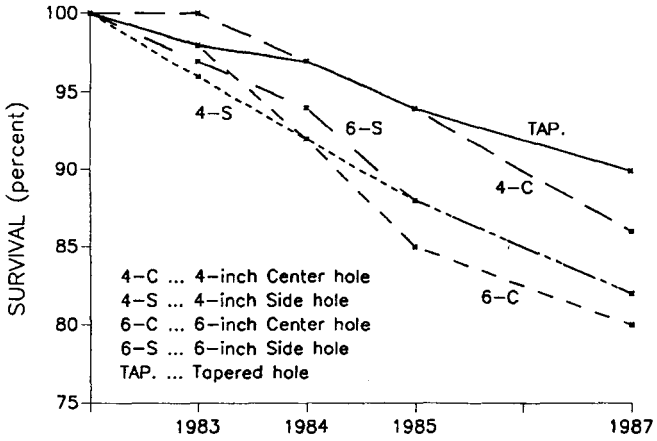

Figure 2.--Five-year survival of ponderosa pine seedlings in planting holes of different configuration. Based on first, second, third, and fifth year measurements.

These results are comparable to Buchanan's (1974) study in which after two growing seasons he found no difference in survival between ponderosa pine planted in the center of the hole and planted on the side of the hole. Little and Somes (1964) saw that center-hole planting of southern pines resulted in more spreading root systems than did slit planting. However, they still frequently found the roots of the center-hole seedlings to be in a single plane, and often the taproots were deformed.

After five growing seasons since planting, the shapes of the root systems tended to be similar within each treatment but varied between treatments. Generally, we found the straightest taproots on the trees that were

Table 1.--Mean auger and planting times per 10-tree row and fifth-year seedling mean heights and survival. Values followed by the same letter are not significantly different at the 95 percent level of confidence

Auger hole sizes (inches)	Tree placement	Augering time (sec)	Planting time (sec)	5th year height (cm)	5th year survival (percent)
4	Centerhole	45.6 a	195.1 b	57.3	86 ab
4	Sidehole	45.2 a	154.9 a	57.7	82 a
6	Centerhole	87.7 b	255.3 d	59.3	80 a
6	Sidehole	96.0 bc	191.5 b	57.0	82 a
4 - 8	Centerhole	81.8 b	232.2 c	62.2	90 b

planted on the side of the planting hole (fig. 3). However, the root systems of the side-hole trees have tended to remain in a single plane. The center-hole planted trees had root systems that spread more in all directions, but most had a slight bend in the taproot (fig. 4).

Overall, the trees planted in the tapered holes produced a spreading bell-shaped root system (fig. 4) with the most laterals of any treatment, but it is still much different from that of a seeded-in-place tree. The center-placed root systems in the straight-sided holes were also bell shaped, but most of the roots were directed downward. The planting hole size did not seem to affect the root system size, shape, or symmetry.

How these initial differences in root system morphologies will influence future growth and survival of the stand is unclear. However, none of these deformations are considered serious. I expect normal tree growth and development.

Several investigators have studied root deformations. Greene (1978) found that once established, root deformities tend to persist, but in time, root systems can partially mend themselves. Chavasse (1978) states that it is difficult to satisfactorily distribute roots during normal planting operations. Eis (1978) reported that the lifetime configuration of a root system is established early, and Long (1978) found that differences due to cultural practices were evident after 4 to 7 years. In contrast, Van Eerden (1982) reported that some deformed root systems repair themselves in time and increasingly acquire a normal or natural growth habit. According to Bibelriether (1966), this takes about 30 to 40 years. While Long (1978) found a weak correlation between root system deformation and tree growth, others found little evidence to connect them.

The 4-inch planting hole took less time to auger than the other holes (table 1). The 6-inch holes took twice as long as the 4-inch holes to auger. Tapered holes were slightly faster than the 6-inch holes. Side-hole planting went faster than center-hole planting and the 4-inch holes took less time to plant than the 6-inch and tapered holes.

Total planting time consisted of the time it takes to auger the hole plus the time to plant the tree. Of the five treatments, the 4-inch hole with the tree placed on the side was the fastest (fig. 5). The next fastest treatment was the 4-inch hole with center placement. Planting times for the center-placed trees in the 4-inch hole and the side hole placement in the 6-inch holes were very close, but because augering of the 6-inch hole took longer, total time was shorter for the 4-inch center treatment. Finally, the 8-inch hole, tapering to 4 inches, had a total planting time that was only less than the treatment with a 6-inch hole and center placement of the tree.

SUMMARY

Of the five treatments studied, the seedlings planted in the tapered holes survived best. Neither the size or shape of the planting hole, nor the tree placement influenced height growth in the first five growing seasons.

Side-hole placement tended to cause a flattened root system on one side, but all had straight tap roots after five growing seasons.

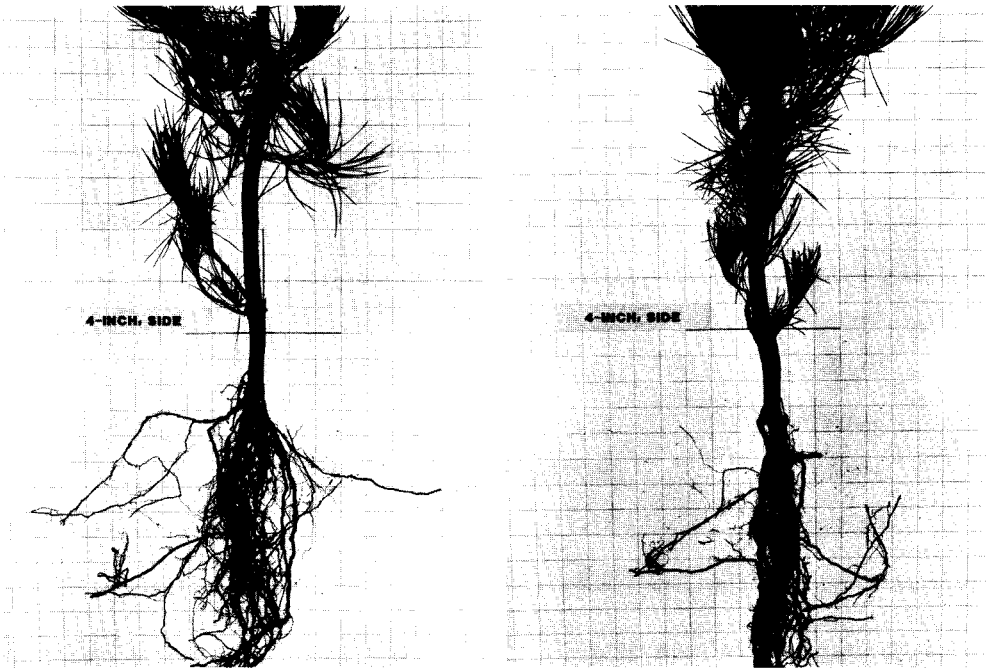

Figure 3.--A representative seedling root system that was excavated after five growing seasons. The two photos are of the same tree that was planted in the side-hole fashion. The root system in the second photo is rotated 90 degrees from the first and illustrates the somewhat flattened configuration of side-hole planted trees.

Figure 4.--These are representative seedling root systems that were excavated after five growing seasons. All three trees were planted in the center of the planting hole. The root system on the left came from a 4-inch hole, the one in the center came from a 6-inch hole, and the seedling on the right was planted in a 4- to 8-inch tapered hole.

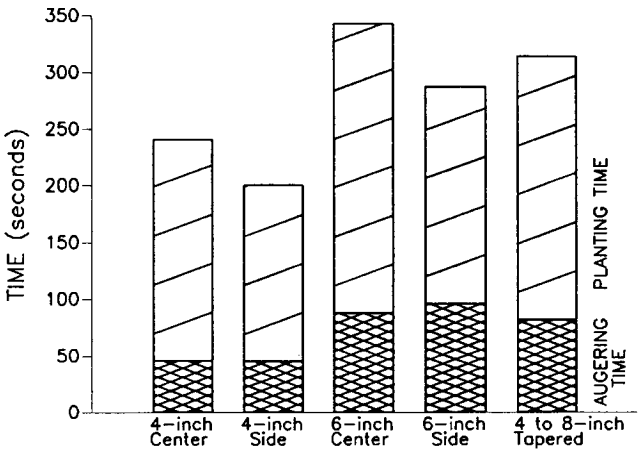

Figure 5.--Planting times required to drill holes and plant ponderosa pine seedlings in 4-, 6-, or 4- to 8-inch holes with tree placement either in the center or on the side.

Seedlings planted in the center of the hole often still had a bend in their taproot 5 years after planting. Overall, trees in tapered planting holes had the most spreading root systems. Seedlings in the center of straight-sided holes had the most fibrous root systems, but most of them were directed downward. Differences in root form are not expected to affect future height growth.

Large planting holes took longer to auger. Seedling placement on the side of the planting hole was quicker than planting in the center.

Applicablity of the results presented here may vary depending on the size of the planting stock, site quality, and especially soil type.

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