Comparing Planting Tools for Container Longleaf Pine

Daniel J. Leduc, James D. Haywood, and Shi-Jean Susana Sung

Information Technology Specialist, Supervisory Research Forester;Research Plant Physiologist, respectively, USDA Forest Service, Southern Research Station, Alexandria Forestry Center, Pineville, LA

Abstract

We examined if compressing the soil to make a planting hole with a custom-built, solid round dibble versus coring the soil with a commercially available tube dibble influenced container-grown longleaf pine seedling development differently. Seventeen months after planting, the planting tool did not significantly affect root collar diameter, shoot or root mass, root-to-shoot ratio, or root system length. Seedlings planted with the solid round dibble, however, had significantly greater numbers of first-order lateral roots and better root system architecture. The light soil texture on the study site was likely an influencing factor in the relative performance between the two planting tools.

Introduction

More than 1 billion conifer seedlings are produced yearly in southern nurseries in the United States for outplanting on forest sites, of which 96 percent are bare root and 4 percent are container stock (McNabb and Enebak 2008). Longleaf pine (*Pinus palustris* Mill.) is the exception, in which only 30 percent of the 33 to 69 million seedlings produced annually is bareroot, and 70 percent is container stock (South and others 2005, McNabb and Enebak 2008). Because of this preference for longleaf pine container stock, research continues across the region to examine the effects of size and type of containers on seedling quality, both in the nursery and after outplanting (e.g., Barnett and McGilvray 2002, South and others 2005, Sword Sayer and others 2009). Naturally regenerated southern pine seedlings develop long lateral roots providing a widespread support system, while the roots from containers seedings are forced downward into the planting hole (Ruehle 1985). Using copper-coated containers can change seedling root morphology by promoting more taproot growth and inhibiting the downward growth of lateral roots, thereby resulting in better distribution of fibrous roots within the container cavity (Barnett and McGilvray 2002). Currently, at least one study is underway to determine if copper-coated containers result in long-term improvement of longleaf pine plantations (Haywood and others 2007).

Planting tools used in container studies vary. South and others (2005) used augers to plant seedlings while Sword Sayer and others (2009) used solid round dibbles or punches. In both cases, however, the research focus was on container type and size; little research has been done to examine planting tools used to plant longleaf container pine seedlings in the West Gulf Coastal Plain. Jones and Alm (1989) and Johnson and others (1998) evaluated planting tools, but their emphasis was on planting errors, seedling survival, and height growth rather than on the direct effects the tools might have on root system development. We hypothesized that the tool used for planting container-grown seedlings affects root system architecture just as much as the container type does. The objective of this study was to compare shoot and root development of seedlings planted with a solid, round dibble, which compresses the soil to make a planting hole versus seedlings planted with a tube dibble, which cores the soil.

Methods

We compared two planting tools (figure 1). The solid-steel, round dibble has a 13.8 cm (5.4 in) long blunt-tipped bit that is 3.5 cm (1.4 in) in diameter at the hilt and the tube dibble has a hollow steel bit 14.7 cm (5.8 in) long with a 2.5 cm (1.0 in) inside diameter and a 3.8 cm (1.5 in) outside diameter at the hilt. The solid round dibble was custom made for planting container seedlings and makes the planting hole by compressing the soil. The tube dibble is sold under several trade names including "Container Seedling Dibble" (Alabama Evergreens, Danville, AL) and makes the planting hole by excavating a soil core.

The longleaf pine seeds came from a Florida source and were supplied by Louisiana Forest Seed Company (Woodworth, LA). Seeds were sown in May 2007 in Copperblock™ Styroblocks (Beaver Plastics model number 112/105, 3.2 cm [1.3 in] diameter with 11.6 cm [4.6 in] depth). Seedlings were grown at the Forest Service, Alexandria Forestry Center (Pineville, LA) using protocols adapted from Barnett and McGilvray (1997, 2000) and described in Sword Sayer and others (2009).

The field site was established on the Palustris Experimental Forest (31° 10' 3"N, 92° 39' 53"W). The site was prescribe-burned in May 2004. The elevation is 72 m (236 ft) above sea level. The growing season (March-November) rainfall for 2008 was 105.4 cm (41.5 in) with average January and July temperatures in 2008 of 9 °C (48 °F) and 28 °C (83 °F), respectively. Previous vegetation was mostly grass, forb, scattered hardwood, and pine brush as described by Duval (1962) and Pearson (1987). The soil is a Malbis fine sandy loam (fine-loamy, siliceous, subactive, thermic Plinthic Paleudults); soil bulk density was determined in August 2009 by collecting 5 soil cores in a systematic pattern (4 corners and center) of the 100 m² (1,076 ft²) study area.

A 10 x 10 m (33 x 33 ft) area was rotary mowed and a fire-exclusion strip was established by tilling around the perimeter. Single-tree plots were established in a completely randomized experimental design. One hundred planting spots were marked with vinyl flags at a 1 x 1 m (3.3 x 3.3 ft) spacing and each was randomly assigned to one of the planting tools so that 50 container seedlings were planted with a solid round dibble and 50 with a tube dibble. Experienced tree planters planted seedlings in November 2007. As standard practice, the grass on the planting spot was scuffed off with a boot and the hole for the seedling was closed with the heel of a boot. After planting, the top of the root plug was either flush or slightly above the soil surface. No additional treatments were applied to the site.

Figure 1. The tool on the left is the solid round dibble with a bit made in the shape of a container cavity, such as those used for growing the seedlings in this study. The tool on the right is a tube dibble that is available commercially from several sources. Both tools are leaning on a Copperblock™ Beaver Plastics Styroblock, model number 112/105, which was the type of container used to grow the longleaf seedlings in this study.

Only one seedling of each planting treatment died during the study period; so, we did not further investigate survival. We measured root collar diameter (RCD) 1 week after planting. The initial average RCDs were 7.2 mm (0.28 in) and 7.3 mm (0.29 in) for the hollow tip and solid tip, respectively, and the differences were not significant ($p = 0.65$). In April 2009, 17 months after planting, all seedlings were excavated at a 15 cm (5.9 in) radius from the stem, washed, and evaluated. We measured oven-dried shoot and root mass, RCD at harvest, RCD growth, root-to-shoot ratio, and the length of the longest vertical root (tap root and sinker root combined). The number of first-order lateral roots (FOLRs) (primary lateral roots with diameter greater than 1 mm [0.04 in]) egressed from the root plug were counted. We placed each seedling's root system on a diagram divided into quadrants with a solid black central circle that delineated the outside wall of the root plug before outplanting (figure 2). Quadrants with at least one end of an egressed FOLR present were counted for each seedling.

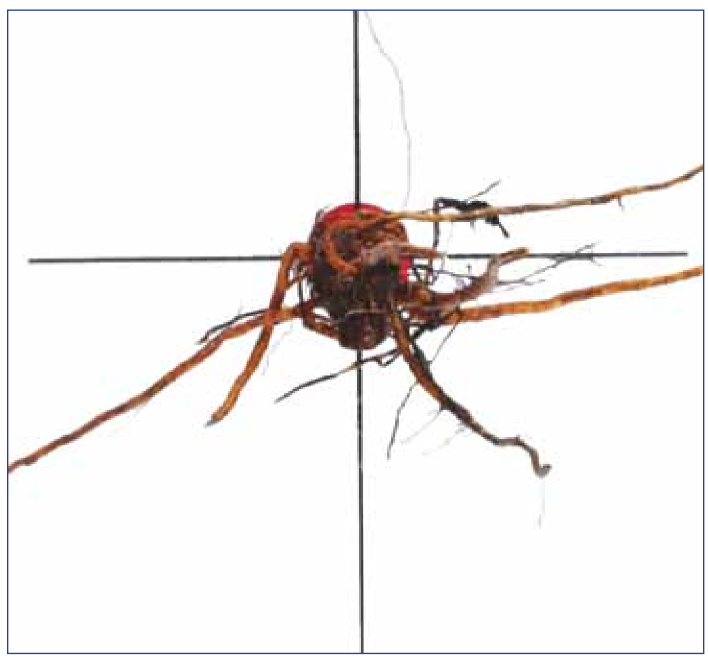

Figure 2. A typical longleaf pine seedling being evaluated for the distribution of egressed roots by quadrant, 17 months after planting. Roots were considered egressed if they were greater than 1 mm (0.04 in) in diameter and exceeded the boundaries of the solid black central circle that delineated the outside wall of the seedling plug before outplanting. A root is considered in the quadrant where it ends.

Differences between the continuous, normally distributed variables were evaluated with a two-tailed t-test at an α level of 0.05 with PROC TTEST (SAS Institute Inc. 1991), and the count variables (egressed FOLRs and quadrants) were compared using a nonparametric Wilcoxon two-sample test with PROC NPAR1WAY (SAS Institute Inc. 1991). The null hypothesis for all variables was that no difference was evident in seedling development between planting tools.

Results and Discussion

We observed no significant differences in seedling development variables between the two planting tools, although seedlings planted with the solid round dibble tended to be slightly larger (table 1). Our results agree with Johnson and others (1998) and Jones and Alm (1989) that no survival or aboveground growth differences are associated with the planting tool. We hypothesized that soil compression from using the solid round dibble would inhibit lateral and vertical root egress from the root plug as compared with seedlings planted into a hole created by removing a soil core with a tube dibble. The number of egressed FOLRs and quadrant counts were significantly greater, however, for seedlings planted by a solid round dibble than by a tube dibble (table 2). This unexpected result may be because the solid round dibble size more closely matched that of the planted plug or that the compressed soil expanded after planting and resulted in a tighter plug-to-soil interface favoring FOLR egression, or that compression was short-term and inconsequential in this soil type.

Soil texture is likely an influencing factor as well. Barnett (1978) found that loblolly pine seedlings survived better in a heavy silt loam when planting holes were cored rather than dibbled. Similarly, survival and height growth of lodgepole pine (*Pinus contorta* Dougl. Ex Loud.) in a compacted clay loam was best when a soil core was removed for planting (Bohning 1981). In both studies, seedling survival in light-textured soils (bulk density < 1.6 g/cm^3 [100 lb/ft^3]) was as good or better in dibbled holes (Barnett and Brissette 1986). Barnett (1978) suggested that using the solid dibble compacts the soil and could reduce the ability of the root system to penetrate the sides of the hole, but provides no reason for the better performance of the dibble in light-textured soils. The soil bulk density in our study plots was 1.48 g/cm^3 (92 lb/ft^3) suggesting it was too light-textured for negative compaction effects to occur by the dibble.

Conclusions

In Sword Sayer and others (2009), the development of FOLRs and root system architecture were considered important in predicting seedling access to surface soil resources, growth, and the future stability of saplings and trees in high, sustained winds. Although the tool differences were slight, better root system development may result after outplanting when a solid round dibble is used to plant copper-coated container seedlings in light-textured soils. These results may or may not apply to other container types or soils.

Table 1. Mean growth variables for longleaf pine seedlings planted with a tube or solid round dibble and the t-test statistics.

Variable	Tube dibble	Solid round dibble	T-statistic	Probability > |t|
Shoot mass (g/oz)	13.6/0.48	14.2/0.50	– 0.71	0.4805
Root mass (g/oz)	12.8/0.45	13.1/0.46	– 0.33	0.7402
RCD (mm/in)	18.8/0.74	19.3/0.76	– 1.02	0.3120
RCD growth (mm/in)	11.6/0.46	12.0/0.47	– 0.81	0.4177
Root/shoot ratio	0.95	0.96	– 0.33	0.7388
Length of the longest root (cm/in)	30.2/11.9	30.4/12.0	– 0.15	0.8811

RCD = root collar diameter.

Table 2. Mean root system architecture variables for longleaf pine seedlings planted with a tube or solid round dibble and the Z-test statistics from the nonparametric Wilcoxon test.

Variable	Tube dibble	Solid round dibble	T-statistic	Probability > |Z|
FOLR count	3.2	4.4	– 2.491	0.0127
Number of quadrants[a]	1.6	2.1	– 2.392	0.0168

FOLR = first-order lateral roots.

[a] Number of quadrants into which at least one FOLR root ended that had egressed from the root plug.

References

Barnett, J. P. 1978. Advances in container production of planting stock. In: Hollis, C. A.; Squillace, A. E., eds. Proceedings Fifth North American Forest Biology Workshop: Theme—Physiological and genetical implications of forestry on difficult sites. Asheville, North Carolina, U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 167–175.

Barnett, J.P.; Brissette, J.C. 1986. Producing southern pine seedlings in containers. Gen. Tech. Rep. SO-GTR-59. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 71 p.

Barnett, J.P.; McGilvray, J.M. 1997. Practical guidelines for producing longleaf pine seedlings in containers. Gen. Tech. Rep. SRS-GTR-14, Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 28 p.

Barnett, J.P.; McGilvray, J.M. 2000. Growing longleaf pine seedlings in containers. Native Plants Journal. 1(1): 54–58.

Barnett, J.P.; McGilvray, J.M. 2002. Copper-treated containers influence root development of longleaf pine seedlings. Proceedings of workshops on growing longleaf pine in containers—1999 and 2001. Gen. Tech. Rep. SRS-GTR-56. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 24–26.

Bohning, R. 1981. Core dibble reduces impact of soil compaction on seedling growth. Forestry Report No. 24. Edmonton, Alberta, Canada: Canadian Forestry Service, Northern Forest Research Center: 15.

Duval, V.I. 1962. Burning and grazing increase herbage on slender bluestem range. Journal of Range Management. 15(1): 14–16.

Haywood, J.D.; Sword Sayer, M.A.; and Sung, S.S. 2007. Study plan and establishment report: Long-term comparison of root and stem growth of outplanted longleaf pines grown in six kinds of container. Unpublished report. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 15 p.

Johnson, R.; Pancake, D.; Hainds, M.; and Gjerstad, D. 1998. The effects of planting tool on planting productivity and survival of longleaf pine bare-root seedlings. In: Waldrop, T.A., ed. Proceedings of the ninth biennial southern silvicultural research conference; 1997 February 25-27; Clemson, SC. Gen. Tech. Rep. SRS-GTR-20. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 99–102.

Jones, B.; Alm, A.A. 1989. Comparison of planting tools for containerized seedlings: two-year results. Tree Planters' Notes. 40(2): 22–24.

McNabb, K; Enebak, S. 2008. Forest tree seedling production in the southern United States: the 2005–2006 planting season. Tree Planters' Notes. 53(1): 47–56.

Pearson, H.A.; Grelen, H.E.; Parresol, B.R.; Wright, V.L. 1987. Detailed vegetative description of the longleaf-slash pine type, Vernon District, Kisatchie National Forest, Louisiana. In: Pearson, H.A.; Smeins, F.E.; Thill, R.E., compilers. Ecological, physical, and socioeconomic relationships within southern National Forests: Proceedings of the southern evaluation project workshop; 1987 May 26-27; Long Beach, MS. Gen. Tech. Rep. SO-68. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 107–115.

Ruehle, J.L. 1985. The effect of cupric carbonate on root morphology of containerized mycorrhizal pine seedlings. Canadian Journal of Forest Research. 15(3): 586–592.

SAS Institute Inc. 1991. SAS/STAT User's Guide, Version 6, Fourth Edition, Volume 2. SAS Institute Inc., Cary, NC. 846 p.

South, D.B.; Harris, S.W.; Barnett, J.P.; Hainds, M.J.; and Gjerstad, D.H. 2005. Effect of container type and seedling size on survival and early height growth of *Pinus palustris* seedlings in Alabama, U.S.A. Forest Ecology and Management. 204(2–3): 385–398.

Sword Sayer, M.A.; Haywood, J.D.; and Sung, S.S. 2009. Cavity size and copper root pruning affect production and establishment of container-grown longleaf pine seedlings. Forest Science. 55(5): 377–390.