This article was listed in Forest Nursery Notes, Summer 2007

77. Stock type affects performance of shortleaf pine planted in the Ouachita Mountains through 10 years. Barnett, J. P. and Brissette, J. C. IN: Proceedings of the 12th biennial southern silvicultural research conference, p. 420-422. USDA Forest Service, Southern Research Station, General Technical Report SRS-71. Kristina F. Connor, ed. 2004.

STOCK TYPE AFFECTS PERFORMANCE OF SHORTLEAF PINE PLANTED IN THE OUACHITA MOUNTAINS THROUGH 10 YEARS

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Abstract—Shortleaf pine (*Pinus echinata* Mill.) seeds collected from several half-sib families were grown as both bare-root and container stock and outplanted on two sites in the Ouachita Mountains of Arkansas. When outplanted, the bare-root seedlings had greater mean height and root-collar diameter than the container seedlings. However, the container seedlings had greater mean root volume and more favorable shoot-to-root ratios than the bare-root stock. Survival of both stock types was excellent, exceeding 90 percent after 10 years. The container stock performed consistently better than the bare-root at each interval measured, but there were no statistically significant interactions between stock type and half-sib family at 3, 5, or 10 years.

INTRODUCTION

In the Ouachita and Ozark Mountains of Arkansas and Oklahoma, shortleaf pine (*Pinus echinata* Mill.) usually is planted on south- and west-facing slopes where soil moisture often is limited. One advantage of container-grown southern pine seedlings over bare-root planting stock is better performance on harsh, drought-prone sites (Barnett and Brissette 1986). Superior survival and growth of container seedlings on dry sites has been shown for longleaf pine (*P. palustris* Mill.) (Amidon and others 1982, Goodwin 1980) and for loblolly pine (*P. taeda* L.) (Goodwin 1980, South and Barnett 1986).

Shortleaf pine has not been compared in as many stock-type trials as the other southern pines. Ruehle and others (1981) compared container and bare-root shortleaf pine in an ectomycorrhizae study on two sites in the Ouachita Mountains. On the site with the best soil-moisture characteristics, the container seedlings survived better, grew taller, and had larger stem diameters than the bare-root stock. However, on the site with the drier moisture regime, container seedlings had poorer survival and growth. The authors concluded that the container seedlings, which were considerably smaller, required more intensive site preparation to perform as well as the larger bare-root stock. However, when we matched seedlings with less disparity in shoot size, first-year survival and growth were greater for container seedlings on two sites in the Ouachita Mountains (Brissette and Barnett 1989, 1992). We attributed the initial superior field performance of container seedlings to larger root systems and overall better shoot-to-root balance.

For reforestation, the use of half-sib family seed collections, rather than seed orchard mixes, has been increasing across the Southern United States for the past several years. One advantage of maintaining family identity is that it is possible to reduce variation in rates of seed germination and seedling growth in the nursery. Thus, nursery culture can be tailored to individual families, or groups of families, to grow seedlings of higher quality than possible when a bulked seed collection is sown. Similar growth advantages can be achieved when outplanting is by family as well. While producing and planting loblolly pine seedlings by family is now common, it is much less so for the other southern pines.

We designed this experiment to test whether stock type and half-sib family interact to affect field performance of shortleaf pine seedlings planted on typical reforestation sites in the Ouachita Mountains. Brissette and Barnett (1989, 1992) reported the 1st- and 3rd-year results of this study. This paper reports results through 10 years after planting, with emphasis on latter-year results.

MATERIALS AND METHODS

Family Selection and Seed Handling

Seed collections were made in the autumn of 1985 at the U.S. Department of Agriculture, Forest Service, Ouachita and Ozark seed orchard located near Mount Ida, AR. The seed orchard is organized by geographic sources. Separate blocks in the orchard consist of selections from the Ozark National Forest and the east and west sides of the Ouachita National Forest. Six half-sib families, two from each geographic source, were used in this study. Seed processing was done at the Forest Service's, Southern Research Station laboratory in Pineville, LA. The seeds were stratified for 35 days before sowing in the nursery.

Bare-Root Seedling Production

Staff of the Weyerhaeuser Company, Magnolia Forest Regeneration Center in southwest Arkansas grew the bare-root seedlings. The seeds were sown in mid-April 1986 using a Weyerhaeuser-designed precision vacuum seeder, which sowed eight parallel drills across the nursery beds. A germination rate of 90 percent was assumed, and enough seeds were sown to achieve a seedling density of about 23 per square foot. The two outside drills were planted with a seed orchard mix. The study families were assigned at random to the interior drills and rerandomized for each of seven replications; each replication was 50 feet long. In addition, seedlings were grown for several other

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Citation for proceedings: Connor, Kristina F., ed. 2004. Proceedings of the 12th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–71. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 594 p.

studies. Nursery cultural practices, such as fertilization and root pruning, were applied based on the best judgment of the nursery manager. Top pruning was not done. Seedlings were carefully hand-lifted on February 2, 1987, and kept in cold storage (approximately 38 °F) until planted.

Container Seedling Production

Container seedlings were grown at the Forest Service laboratory in Pineville, LA. The container volume was approximately 6.1 cubic inches, and density was about 46 per square foot. Containers were filled with a 1:1 peat-vermiculite medium and hand-seeded 1 week after the bare-root seeds were sown. The containers were in trays of 98; each tray held a single half-sib family, and there were 5 replications of each family.

The containers were kept in a greenhouse for 2 weeks until germination was complete. They were then moved to raised benches outside in full sunlight where the seedlings were grown and allowed to harden off. Except for having been grown outside, the seedlings received the cultural regime recommended by Barnett and Brissette (1986).

Planting Sites

The plantings were on two typical national forest sites in Arkansas; one on the Magazine Ranger District (RD) of the Ozark National Forest, about 18 miles southwest of Russellville, the other on the Winona RD of the Ouachita National Forest, about 40 miles southeast of Russellville and about 25 miles west of Little Rock. Although most of the Ozark National Forest is in the Boston Mountains, the Magazine RD is south of the Arkansas River and, therefore, in the Ouachita Mountains. Both sites are on gently rolling to rolling terrain with shallow, rocky soils. They had been clearcut harvested and site prepared as part of commercial operations. Both sites were ripped during site preparation. Ripping involves pulling vertical blades spaced about 8 feet apart through the soil to a depth of 18 to 20 inches. This is a process that has been shown to improve seedling water relations after outplanting and to increase height and diameter growth (Wittwer and Dougherty 1986). On the Magazine RD site, container seedlings were planted on December 10, 1986, and the bare-root stock on February 11, 1987. On the Winona RD site, container seedlings were planted on December 9, 1986, and the bare-root seedlings on February 11, 1987. A 25-seedling row plot in 6 blocks at each planting site represented each stock type by family combination.

Measurements and Analyses

We analyzed data for each site separately using analysis of variance. The design at both locations was a randomized block with six blocks and a factorial arrangement of treatments in split plots. Block and stock type were in the whole plots, and family and the stock type × family interaction were in the subplots. The experimental units were the 25-tree plots.

Response variables were both measured and calculated. After the first growing season, survival, total height, and groundline diameter were measured. At the end of three growing seasons, survival and total height were measured. After five growing seasons, survival, total height, and diameter at breast height (d.b.h.) were measured, and at 10 years, survival and d.b.h. were measured and basal area (BA) calculated. Because BA combines survival and growth, it is a measure of the degree of site occupancy.

Survival data were transformed using the arc sine of the square root of the proportional value. This transformation ensures that the proportions are close to normally distributed with homogeneous variance (Freese 1967). Three linear contrasts were used to determine differences in mean performance among the geographic sources: (1) east Ouachita vs. west Ouachita, (2) east Ouachita vs. Ozark, and (3) west Ouachita vs. Ozark.

RESULTS AND DISCUSSION

Early Results

When outplanted, the bare-root seedlings had greater mean height and root-collar diameter than the container seedlings (table 1). However, the container seedlings had

Table 1—The effects of stock type on field performance of shortleaf pine seedlings 3, 5, and 10 years after outplanting on two sites in the Ouachita Mountains

	3 years		5 years			10 years		
Site/stock type	Survival	Height	Survival	Height	D.b.h.	Survival	D.b.h.	BA[a]
	percent	*feet*	*percent*	*feet*	*inches*	*percent*	*inches*	*ft²/acre*
Magazine RD								
Bare-root	92b[b]	5.0b	92a	9.9b	1.3b	90a	3.7a	43.7a
Container	96a	5.6a	94a	10.6a	1.5a	92a	3.8a	47.3a
Winona RD								
Bare-root	93b	3.4b	91b	7.1b	0.9b	91b	3.3b	36.2b
Container	98a	4.1a	97a	7.9a	1.0a	96a	3.6a	44.3a

BA = basal area; RD = ranger district.

[a] Each stock type x family plot was 25 trees planted at 8- by 8-foot spacing. Plot basal area was divided by 0.04 to obtain the basal area per-acre values.

[b] At each site, values followed by the same letter are not significantly different ($P = 0.05$).

greater mean root volume and a more favorable shoot-to-root balance than the bare-root stock. After one growing season at both field locations, survival of all families from both stock types exceeded 94 percent. The container seedlings grew larger than the bare-root seedlings. Although container seedlings were planted 2 months earlier than the bare-root stock, the difference in planting date was expected to have limited effect on initial seedling performance. Soil temperatures were low enough that little root growth could occur during this winter period (Brissette and others 1988). Among families, groundline diameters differed on one site, and family and stock type interacted in their effects on height on the other site (Brissette and Barnett 1992).

Survival

After 3 years on both sites, survival of container seedlings was significantly greater than survival of bare-root stock. The interaction of stock type and family and differences among families were not significant for survival at either site at age 3 and older. Because there were no significant interactions of stock type and family, in subsequent evaluations we combined family data.

At ages 5 and 10, the small differences in survival on the Magazine RD site were not statistically significant, but survival remained at 90 percent or higher. However, the container seedlings maintained greater survival than the bare-root on the Winona RD site through year 10.

Growth

There were no significant interactions between stock type and family at either site at year 3 or subsequent measurements for height or d.b.h. Differences in growth occurred on the Magazine RD site through 5 years with container stock performing best. At 10 years, there were no differences in d.b.h. between container and bare-root treatments at the Magazine RD location.

As was the case with survival on the Winona RD site, d.b.h. of container-grown seedlings was significantly greater than of bare-root stock. Calculations of BA, which incorporate both survival and d.b.h., showed significant differences on the Winona RD area. Both heights and diameters show that growth was better at the Magazine RD location, indicating Winona RD was the poorer of the two sites. Stock type differences, however, were greater at Winona RD, confirming results from earlier studies that container stock outperforms comparable bare-root material on poor sites (Goodwin 1980, South and Barnett 1986).

Height differences among families were statistically significant, reflecting the fact that the two tallest families differed from the three shortest families.

CONCLUSIONS

High-quality bare-root or container shortleaf pine seedlings will survive well on prepared sites in the Ouachita and Ozark Mountains. However, container stock generally performs better than bare-root stock, especially on poorer sites where both survival and growth are reduced. The superior performance of container stock probably is due to larger root systems and better balanced seedlings.

Differences in seedling morphology suggest that half-sib families of shortleaf pine are different enough that maintaining family integrity during seedling production will improve overall quality of planting stock. Differences among families that were observed at planting were maintained throughout the 10 years of growth regardless of stock type. It is interesting to note that the seedlings grown from the more northern Ozark seed source consistently produced smaller plants than those from the two Ouachita sources.

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Proceedings of the 12th biennial southern silvicultural research conference

Author(s): Connor, Kristina F., ed.

Date: 2004

Source: Gen. Tech. Rep. SRS-71. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 600 p.

Station ID: GTR-SRS-071

Description: Ninety-two papers and thirty-six poster summaries address a range of issues affecting southern forests. Papers are grouped in 15 sessions that include wildlife ecology; fire ecology; natural pine management; forest health; growth and yield; upland hardwoods - natural regeneration; hardwood intermediate treatments; longleaf pine; pine plantation silviculture; site amelioration and productivity; pine nutrition; pine planting, stocking, spacing; ecophysiology; bottomland hardwoods - natural regeneration; and bottomland hardwoods—artificial regeneration.