Field Performance of Shortleaf Pine Half-Sib Families Though 10 Years in the Ouachita Mountains of Arkansas

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Abstract:-- Shortleaf pine (*Pinus echinata* Mill.) seeds collected from six half-sib families were grown as both bareroot and container stock and outplanted on two sites in the Ouachita Mountains of Arkansas. Survival and growth were measured at years 1, 3, 5, and 10 after planting. Stock-type and family interacted to affect height at year 1 on one site. There were no other interactions through 10 years. Container stock performed consistently better than bareroot at each interval measured. There were differences among half-sib families for diameter and height on both sites for some measurement periods. Family ranks for total height early in the experiment correlated with 10 year performance on both sites.

Keywords: Artificial regeneration, container, bareroot, half-sib family, *Pinus echinata*.

INTRODUCTION

In the Ouachita and Ozark Mountains of Arkansas and Oklahoma, shortleaf pine (*Pinus echinata* Mill.) is usually planted on south- and west-facing slopes where soil moisture is often limited. One advantage cited for container-grown southern pine seedlings compared to bareroot 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 et al. 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 et al. (1981) compared container and bareroot shortleaf pine in an ectomycorrhizae study on two sites in the Ouachita Mountains. The container seedlings survived better and grew taller and to a larger diameter than the bareroot stock on the site with the best soil moisture characteristics. However, on the site with the drier moisture regime, the container seedlings were poorer than the bareroot seedlings in both 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 bareroot stock. However, when we matched seedlings with less disparity in shoot size, survival and growth were greater for container seedlings on two sites in the Ouachita Mountains for up to 10 years after planting (Barnett and Brissette in press). We attributed the initial superior field performance of the container seedlings to larger root systems and overall better shoot-to-root balance.

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The use of half-sib family seed collections, rather than seed orchard mixes, for reforestation has been increasing across the southern United States for several years. One advantage of maintaining family identity is that variation in rates of seed germination and seedling growth in the nursery can be reduced. 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 advantages in growth may be achieved when outplanting is by family as well. While the practice of producing and planting seedlings by family has become commonplace for loblolly pine, it is used little for the other southern pines.

This experiment was designed 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. We recently reported results of this study through 10 years with an emphasis on the stock-type comparison (Barnett and Brissette in press). This paper focuses on half-sib family performance.

MATERIALS AND METHODS

Seeds were collected at the USDA Forest Service Ouachita and Ozark seed orchard near Mount Ida, Arkansas. The seed orchard has three blocks, each representing a geographic subregion. One block contains selections from the eastern half of the Ouachita National Forest, another from the western portion of that forest, and the third from the Ozark National Forest. Trees in the orchard are numbered such that the 100s are east Ouachita, 200s west Ouachita and 300s Ozark. Seeds for this study were from two families in each block, selected based on survival in a number of progeny tests (Brissette and Barnett 1989).

The staff of the Weyerhaeuser Company Magnolia Forest Regeneration Center in southwest Arkansas grew the bareroot seedlings. Seeds were sown April 16, 1986, with a Weyerhaeuser-designed precision seeder that accommodated sowing individual lots of seeds in each row along a nursery bed. Seeds from an orchard mix were sown in the two outside rows with the families sown on the interior of the nursery bed. Families were assigned randomly to the rows and re-randomized for seven replications along the bed. 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 hand lifted February 2, 1987, and kept in cold storage (approximately 3 ºC) until they were planted.

Container seedlings were grown at the USDA Forest Service laboratory in Pineville, Louisiana. The containers were hand seeded April 23, 1986, into Ray Leach “Stubby” cells filled with a 1:1 peat-vermiculite medium. The volume of each cell was approximately 115 cm^3. One tray held 98 cells at a density of about 500 per m^2. Each tray was sown with a single family, with five replications of each family. Following germination in a greenhouse the trays were moved to raised benches outside in full sunlight where the seedlings were grown and hardened off.

The two planting sites were typical of sites artificially regenerated on the national forests in Arkansas at that time. One site was on the Magazine Ranger District of the Ozark National Forest and the other on the Winona Ranger District of the Ouachita National Forest. Both sites are physiographically in the Ouachita Mountains, in areas gently rolling to rolling with shallow, rocky soils. They were clearcut and site prepared as part of a commercial operation. Both sites were ripped following the contours during site preparation. Container seedlings were planted December 9 and 10, 1986 on the Magazine and Winona sites, respectively. Bareroot stock was planted February 11, 1987 at both sites.

A split-plot, randomized block experimental design with six blocks was used at each site. At both sites, slope position was the blocking variable. Stock type was in the whole plots with 5 degrees of freedom for error (dfe). Family and stock type by family interaction were in the subplots with 50 dfe. Because the families followed in this study were purposely, not randomly, chosen from among those available in the seed orchard, family was considered a fixed effect. Experimental units were 25 tree row plots. Analysis of variance (ANOVA) was used to test for the stock type x family interaction, and for stock type and family main effects for a number of response variables. When the family main effect was significant ($p=0.05$), family means were separated by the Waller-Duncan Bayes Least Significant Difference (BLSD) procedure (Petersen 1985). Data analysis was separate for each site.

The experiment was evaluated at 1, 3, 5, and 10 years after planting and a range of response variables were measured as the trees grew. Survival was measured at each inventory. Ground line diameter was measured at year 1. Diameter breast height (dbh) was measured at years 5 and 10. Total height was measured at years 1, 3, and 5. Quadratic mean diameter (QMD) and plot basal area (BA) were determined at year 10. In addition, families within each stock type x block combination were ranked for each response variable and correspondence between early performance (years 1 and 3) and 10-year performance was tested using Spearman's Coefficient of Rank Correlation (Steele and Torrie 1980).

RESULTS AND DISCUSSION

When outplanted, the bareroot seedlings were larger, both in root collar diameter and shoot length, than the container seedlings but the container stock had greater mean root volume and a more favorable shoot-to-root ratio than the bareroot seedlings (Brissette and Barnett 1989). Overall survival exceeded 94 percent at both sites the first year after planting and remained at 90 percent or higher through year 10 (Barnett and Brissette in press). Neither the stock type x family interaction nor the main effect of family influenced survival at any measurement period. However, the stock type main effect was significant on the Winona Ranger District planting site at each measurement. Container-grown seedlings consistently survived better than bareroot seedlings on that site.

With respect to the measures of growth, diameter and height, there was a stock type x family interaction in total height one year after planting at the Winona site. The family tallest when grown in containers was the second shortest from bareroot (Brissette and Barnett 1989). There were no other interactions between stock type and family through 10 years.

The main effect of half-sib family was significant for diameter and/or height at each site at some measurement periods. On the Magazine site, families differed in diameter at years 1 and 5, while there were no differences in diameter among families at the Winona site (Tables 1, 2). At year 1, the diameter of Family 322, the largest at the Magazine site, was 12 percent greater than Family 219, the smallest, and 5 percent more than the overall mean.

Site	Response variable	Year	Stock Type x Family	Stock Type	Family
Magazine	Survival	1	0.5	0.1	0.3
		3	0.3	0.2	0.6
		5	0.1	0.3	0.5
		10	0.1	0.3	0.7
	Diameter	1	0.1	0.002	0.02
		5	0.9	0.03	0.02
		10	0.9	0.4	1.0
	Height	1	0.3	0.0002	0.2
		3	0.9	0.008	0.0001
		5	0.7	0.008	0.0001
	Basal Area	5	0.3	0.02	0.054
		10	0.3	0.2	0.7
Winona	Survival	1	1.0	0.005	0.9
		3	0.9	0.03	0.9
		5	0.9	0.02	0.9
		10	0.6	0.048	0.9
	Diameter	1	0.7	0.0006	0.2
		5	0.9	0.004	0.1
		10	0.9	0.0001	0.2
	Height	1	0.048		
		3	0.7	0.004	0.03
		5	0.9	0.003	0.054
	Basal Area	5	0.8	0.008	0.2
		10	1.0	0.0001	0.4

Table 1. Significance levels (probability of greater F) from analyses of variance for survival and growth of shortleaf pine half-sib families grown as bareroot and container stock and planted on two sites in the Ouachita Mountains.

After 5 years, the difference between largest (202) and smallest (342) families at Magazine was 15 percent, while diameter of the largest family was still 5 percent greater than the overall mean. Container seedlings had larger diameters at years 1 and 5 at Magazine and years 1, 5, and 10 at Winona (Table 1, Barnett and Brissette in press).

There were differences among families in total height at both sites (Tables 1,2). At the Magazine site, family affected height at both 3 and 5 years after planting. The difference between the tallest and shortest families was 14 percent both times. At year 3, Family 202 was 7 percent taller than the mean, while at year 5 the tallest (still 202) was 6 percent taller than the mean. At the Winona site, differences among families were only significant at year 3. Family 115, the tallest, was 12 percent taller than Family 322, the shortest, and 5 percent taller than the overall mean. Through the 10 years of the study, container seedlings were consistently taller than bareroot seedlings at both sites (Table 1, Barnett and Brissette in press).

Family	Planting Site				
	Magazine				Winona
	Ground line diameter, yr 1 ---(mm)---	DBH, yr 5 ---(cm)---	Total height, yr 3 ---(cm)---	Total height, yr 5 ---(m)---	Total height, yr 3 ---(cm)---
103	5.4 bc[1/]	3.6 abc	162 bc	3.2 a	113 abc
115	5.7 ab	3.8 ab	170 ab	3.2 a	120 a
202	5.3 bc	3.9 a	173 a	3.3 a	118 ab
219	5.2 c	3.7 abc	159 cd	3.2 a	114 abc
322	5.8 a	3.5 bc	152 d	2.9 b	107 c
342	5.4 bc	3.4 c	152 d	3.0 b	109 bc
Mean	5.5	3.7	161	3.1	114

Table 2. Significant ($p < 0.05$) differences among half-sib families on two planting sites in the Ouachita Mountains. [1/] Within a column, values followed by the same letter are not significantly different.

Plot basal area integrates both survival and growth performance. Basal area was determined at years 5 and 10, and family had no effect on BA at either site (Table 1). Container seedlings had greater BA than bareroot stock at both sites at age 5 and at Winona at age 10 (Table 1, Barnett and Brissette in press).

Spearman rank correlation coefficients were significant at both sites. At the Magazine site, family rank for year 1 total height correlated with family rank for year 10 BA (Table 3). At Winona, family ranks between year 3 total height and both 10 QMD and BA at year 10 were highly correlated (Table 3).

Site	Early Performance	Age 10 performance	
		QMD[1/]	Plot Basal Area
Magazine	Ground line dia, yr 1	-0.025 (0.9)	0.002 (1.0)
	Total height, yr 1	0.271 (0.1)	0.425 (0.01)
	Total height, yr 3	0.028 (0.9)	0.314 (0.06)
Winona	Ground line dia, yr 1	0.164 (0.3)	0.166 (0.3)
	Total height, yr 1	0.253 (0.1)	0.295 (0.08)
	Total height, yr 3	0.662 (<0.0001)	0.619 (<0.0001)

Table 3. Spearman rank correlation coefficients (r) and probabilities (in parentheses) for half-sib family performance at years 1 and 3 with performance at year 10 on two sites in the Ouachita Mountains. [1/] QMD = quadratic mean diameter of the surviving trees.

CONCLUSIONS

If quality seedlings are planted, either bareroot or container-grown shortleaf pine will survive well on prepared sites in the Ouachita Mountains. Interactions between half-sib family and stock type might impact initial field performance on some sites. However, it is unlikely that such interactions will persist. Consequently, over the long term, family performance is consistent regardless of how seedlings are produced. Container stock generally performs better than bareroot, especially on poorer sites where both survival and growth are less.

Among half-sib families, the largest in diameter or tallest in height have a 12-15 percent advantage over the poorest performers and a 5-6 percent edge over the mean. Spearman rank correlation coefficients indicate that once established there is some stability in relative performance among families.

These results suggest that there are enough differences among half-sib families of shortleaf pine that maintaining family integrity during seedling production will improve overall quality of planting stock. In addition, some improvement in growth can be achieved by selecting the best performing families. On the other hand, planting diverse families will not result in a marked reduction in overall field performance. All appropriate management alternatives should be considered when planning to artificially regenerate sites in the Ouachita Mountains with shortleaf pine.

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