Improved Quality Pine Seedlings: What To Expect at Early Ages

Genetically improved seedlings have helped increase growth rates of forest tree species around the world. Some of the most sophisticated pine tree improvement programs are in the southeastern United States. Covering this region are three tree improvement cooperatives that have been working on genetically improving pine for over 50 years. About 14 million dollars are spent annually to breed, test, select, and produce improved loblolly and slash pine. The results have been impressive: every analysis shows that the returns on the investment of planting genetically improved loblolly and slash pine are very good (McKeand et al. 2007)

Today, more than 75 percent of the United States tree planting occurs in the southeastern United States, and more than 95 percent of the loblolly and slash pine seedlings planted are genetically improved. By 2000, 59 percent of all the loblolly pine plantations in the South were being planted with open-pollinated (OP) seedlings in single-family blocks (McKeand et al. 2006).

A "single family" is a group of seedlings produced from the seed of one specific, select individual (genotype) within a seed orchard. Family seed is sown separately in the nursery and planted separately in the field. In contrast, a seed orchard mix is a collection of cones from a number of individuals in a seed orchard. A seed orchard mix includes many OP families and so contains a greater degree of genetic variability than a single OP family does.

Although reduced genetic variation is of some concern for OP family plantings, there have been no reported problems associated with single-family plantings, as long as the seedlings are planted in the correct climatic zones (Schmidtling 2001). Stands established from an OP single family tend to be more uniform than stands from a seed orchard mix.

Today, about 800 million loblolly pine seedlings are planted every year in the southern United States, and most of those seedlings are open-pollinated. The genetic improvement level of loblolly pine has risen considerably, with the standard being either 1.5 generation (i.e. first-generation orchard thinned down to only the best genetically superior stock) or second-generation seedlings (Rousseau 2010). However, we have begun to see more third-generation or third-cycle seedlings being offered. In addition to the typical open-pollinated seedlings, we have also begun to see the emergence of full-sib and varietal pine seedlings.

Full-sib seedlings are the result of crossing two highly select individuals, which takes advantage of the known genetic quality of both parents. Full-sib seedlings were previously used only for research, as they were too expensive and time-consuming to produce in great quantities. However, today full-sib seedlings are being produced through an operational scale process known as mass control pollination (MCP) (Figure 1). MCP production is still expensive, so seedlings cost about $120 to $140 per 1,000; OP seedlings cost about $50 to $75 per 1,000.

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Figure 1. Mass control pollinations taking place in a seed orchard (left). Here a worker applies pollen from a single selection inside the bag to a selected female, making a full-sib cross.

Figure 2. Seed orchard photo showing bags that exclude out outside pollen sources (right). Eventually the bags will decompose, allowing the mass control pollinated cones to mature. Photos by MeadWestvaco.

Varietal pine is the top genetic level of pine tree improvement today. The term varietal was given to the development of pine clones (Rousseau 2010). Varietal pine seedlings are produced through either hedging or somatic embryogenesis. Hedging is a simple technique where young seedlings are cut back to produce numerous growing tips that are harvested and propagated into seedlings. Somatic embryogenesis is a technique where an embryo is removed from the seed and placed into a system that allows it to multiply. These embryos are grown on a specialized media to form seedlings that are identical copies of the original. In this process it is possible to place the resulting embryos in liquid nitrogen (cryopreservation) until the genetic testing is complete. Although these techniques are expensive, they do provide the grower with the highest quality genetic material available. Seedlings produced with this method cost about $435 per thousand.

No matter what type of improved pine you use, you should understand how that pine will perform on the planting site. At first, seed orchard mixtures were used to provide a sort of genetic buffer to the variety of sites being planted across the South. Later, with more information about how seedlings perform on different types of sites, single-family plantings became the norm. However, each year more acreage is planted to MCP and varietal seedlings. Before planting, landowners should be fully aware of how these advanced genetic seedlings perform in their general area in order to realize the genetic potential.

With this understanding Mississippi State University Department of Forestry examined differences among selected open-pollinated second-generation seedlings, a selected MCP family, and varietal loblolly pine seedlings.

Comparison of Loblolly Pine Genetic Types

Test Establishment

The test site is located on the Mississippi Agriculture and Forestry Experiment Station located in north Mississippi near Holly Springs. The soil is a combination of a Loring silt loam and a Cahaba-Providence complex. The test site was primarily in bermudagrass, as it was previously used for cattle grazing and hay production. Site preparation included a sub-soiling in March of 2007 to a depth of 14 inches on 12-foot intervals and a March 2007 glyphosate banded treatment directly over the sub-soiled rows. The test was hand-planted in April 2007 at a spacing of 12 by 9 feet (i.e. 403 trees per acre). At the time of planting a single 20mg SilvaShield tablet was placed directly into the planting hole to control pine tip moth. In May 2008 the test received a broadcast application of Oustar.

The three types of planting stock included a single MeadWestvaco select second-generation OP family, a single MeadWestvaco select MCP family, and ArborGen Varietals. The seedlings of both the open-pollinated and MCP families were 1-0 bareroot stock, while the varietals were containerized stock. The MeadWestvaco second-generation OP and MCP families were selected based on their known performance in southwest Tennessee. The varietal plots were a mixture of 57 different varieties, making it difficult to directly compare the performance of any single variety to the second-generation OP and MCP plots. The field design is a randomized complete block where the seedlings of the 3 genetic types were planted in 100 tree blocks across the site and replicated 6 times. Thus, 600 trees of each type of planting stock were measured and evaluated through the 2010 growing season.

Table 1. Average total height and dbh of the three genetic types from age 1 to age 4 tested on the MAFES site near Holly Springs, MS

Genetic Type	Total Height (ft)				DBH (in)	
	Age 1	Age 2	Age 3	Age 4	Age 3	Age 4
Single 2nd-Gen. OP	1.9	5.0	9.6	14.7	1.7	3.1
MCP	2.0	5.4	10.4	15.8	2.0	3.5
Varietal	1.9	4.9	9.6	14.2	1.5	2.7

Early Results of the Three Genetic Types

Test survival was 93 percent at the end of the first growing season. Survival was certainly good, but the heavy bermudagrass competition and the drought played a major role in seedling mortality. The varietal seedlings had the lowest age-one survival, at 87 percent. This was probably because at planting, they had smaller root systems than stock of the second-generation and MCP seedlings. By age four, test survival was 92 percent. There were no major trends in survival differences among the three genetic types at age four. The slight change in test survival between age one and four suggests that proper site preparation and weed control is critical to plantation success.

Total height was measured each winter to determine early-age performance and later correlate that to more mature performance. Following the first growing season, there was very little difference among the three genetic types (Table 1). This lack of differences may have been because the trees struggled to compete for water during a very dry growing season. By age two, the MCP seedlings were the tallest, at 5.4 feet, followed by the second-generation open-pollinated seedlings and the varietal seedlings. At age three the MCP seedlings were still the tallest, at 10.4 feet, followed by the second-generation open-pollinated seedlings and the varietal seedlings, at 9.6 feet. The MCP seedlings remain the tallest at age four at 15.8 feet. The second-generation open-pollinated seedlings were 1.1 feet shorter at 14.7 feet, and the varietal seedlings were 1.6 feet shorter at 14.2 feet. Diameter at breast height (DBH) also followed the same trend as seen in total height, where the MCP seedlings were the largest at ages three (2 inches) and four (3.5 inches) (Table 1).

On average, trees grew about 3 feet between age one and two, about 4.5 feet between age two and three, and more than 5 feet between age three and four. As expected, height growth followed the same pattern as total height. MCP seedlings grew most rapidly.

As expected, MCP seedlings performed better than second-generation OP seedlings. The MCP material was genetically better, and the results show its superiority at least through age four. The test did not include a single highly selected variety, which would have made a more valid comparison to the other two genetic types. However, 57 individual varietals were used because it would be difficult to impossible to select the one varietal best for northern Mississippi sites.

The varietal seedlings ranged from 11 to 17 ft. tall. This variation was expected. Varietal 329 was one of the three tallest varieties from age two to age four. Although varietal 228 was not among the tallest varietal at age two, it was the tallest varietal at ages three and four (Table 3). Varietal 228 was 1.2 ft. taller than the MCP seedlings. However, the DBH of 228 averaged 3.1, making it smaller than the average DBH of the MCP seedlings, which was 3.5 inches (Table 2).

Table 2. Comparison of total height between the MCP type and selected varietal types from age two to age four on the MAFES site near Holly Springs, MS

Genetic Type	Total Height (ft)		
	Age 2	Age 3	Age 4
MCP	5.4	10.4	15.8
Top 3 Varietal	6.2	11.2	16.4
Best Varietal	6.3 (329)[1]	11.6 (228)	17.0 (228)

[1] Number within the parentheses represents the specific varietal number of the top performer

Conclusion and Management Implications

This specific MCP family easily outperformed the second-generation OP family, with faster growth through age four. The MCP family performed as well as the top-performing varieties. However, landowners must recognize the fact that this is only one test and that it may not apply to their property. In addition, form and wood characteristic traits are extremely important to the sawtimber market. To date, these traits have yet to be adequately measured but will be included as the test ages.

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