# COMPARISON OF ADVANCED GENETIC LOBLOLLY PINE PLANTING STOCK

R.J. Rousseau[1], S.D. Roberts[2], and B.L. Herrin[3]


## ABSTRACT

Forest landowners have several options when it comes to selecting planting stock for loblolly pine plantations. The majority of plantations established over the past two decades have been planted with 2nd-Generation open-pollinated (2nd-Gen) seedling stock. Today, landowners can increase their yields using more sophisticated planting stock such as Mass Control Pollinated (MCP) or Varietal (clonal) stock. Substantial gains have been estimated when using either MCP or Varietal stock. Forest biotechnology firms are currently producing loblolly pine varietal planting stock for deployment in the southeastern US. Currently, however, the cost of varietal planting stock is considerably higher than that of both standard open-pollinated and MCP seedlings. Landowners need to know if the increased gains from the improved genetic material will be great enough to offset increased plantation establishment costs. In 2007, a Loblolly Pine Genetic Level Study was installed in northern Mississippi to examine differences in growth and form among 2nd-Gen, MCP, and Varietal planting stock. Third-year measurements showed that on average, MCP trees were significantly taller than either the Varietal or 2nd-Gen stock types. However, the top five performing varieties averaged nearly 0.5 feet taller than the MCP trees, and 1.0 feet taller than the 2nd-Gen stock. Results from fourth-year measurements will be presented.


## INTRODUCTION

Genetics has played a major role in increasing growth rates of forest tree species around the world. Some of the most sophisticated pine tree improvement programs are found 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. Approximately 14 million dollars are spent annually to breed, test, select, and produce improved loblolly and slash pine. The results have been impressive with every analysis showing that the returns on investment from planting genetically improved loblolly and slash pine are very high (McKeand et al. 2007)

Today, over 75% of the United States tree planting occurs in the southeastern United States with over 95% of the loblolly and slash pine seedlings being genetically improved. By 2000, 59% 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 defined as seedlings produced from the seed of one specific highly selected individual (genotype) within a seed orchard. Family seed are sown separately in the nursery and planted separately in the field. This is in contrast to a seed orchard mix, where cones from a number of individuals in a seed orchard are collected and mixed together. This mixture of seed is grown in the nursery and planted in the field as a seed orchard mix. Thus, a seed orchard mix would contain a number of OP families which results in a greater degree of genetic variability in comparison to a single OP family. 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 a seed orchard mix. Increased stand uniformity is the result of using only one selection and allowing that selection to exhibit its genetic superiority in the resulting offspring (seedlings).

Currently, approximately 800 million loblolly pine seedlings are planted annually in the southern United States, with a great majority of these seedlings being open-pollinated. The genetic improvement level of loblolly pine has risen considerably, with the standard being either 1.5 generation (i.e. 1st-generation orchard thinned down to only the best genetically superior stock) or 2nd-Generation seedlings (Rousseau 2010). However, we have begun to see more 3rd-generation or 3rd-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 selected 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). The increased cost of MCP production results in a higher seedling cost ranging from $120 to $140 per thousand, as compared to OP seedlings that range from $50 to $75 per thousand.

Varietal pine represents 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

Randall J. Rousseau, Associate Extension/Research Professor, Scott D. Roberts, Professor, B. Landis Herrin, Research Assistant, Department of Forestry, Mississippi State University, Mississippi State, MS 39762-9681.

juvenile seedlings are cut back to produce numerous growing tips that are harvested and propagated into seedlings. Somatic embryogenesis is a technique where embryos are removed from the seed and placed into a system that allows it to multiply. These embryos are grown on a specialized media to form a seedling, which is an identical copy 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 not cheap, as reflected in the seedling cost of $435 per thousand, they do provide the grower with the highest quality genetic material available.

No matter what type of improved pine selected, it is imperative to understand how that material will perform on that particular planting site. Initially, seed orchard mixtures were used to provide a sort of genetic buffer to the variety of sites being planted across the South. Later, with an increased understanding of progeny performance from each seed orchard selection as well as the type of sites these selections performed well on, single family plantings became the norm. However, each year an increasing amount of acreage is being planted to MCP and varietal seedlings. Each landowner should be fully aware of the performance of these advanced genetic seedlings in their general area prior to planting in order to realize the genetic potential.

With this understanding Mississippi State University Department of Forestry installed a test to examine differences among selected open-pollinated 2nd-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 Bermuda grass as it was previously used for cattle grazing as well as 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 x 9 feet (i.e. 403 trees per acre). In addition, 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 2nd-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 2nd-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 2nd-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 has been measured and evaluated through the 2010 growing season.

## RESULTS

Test survival was 93 percent at the end of the first growing season. Although survival was certainly good, the heavy Bermuda grass 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 due to the smaller root system of the type of containerized seedlings used in comparison to the bareroot stock of the 2nd-Generation and MCP seedlings. By age four there was little change to test survival, which dropped to 92 percent. Survival differences among the three genetic types at age four showed no distinguishable trend. The slight change in test survival between age one and four emphasizes the fact that proper site preparation and herbaceous competition 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. At the end of the first growing season there was very little difference among the three genetic types (table 1). The lack of significant genetic differences may have been the result of intense herbaceous (i.e. Bermuda grass) competition outcompeting all the genetic sources for moisture during a very droughty first growing season. By age two, the MCP seedlings were the tallest at 5.4 feet, followed by the 2nd-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 2nd-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, with the 2nd-Generation open-pollinated seedlings 1.1 feet shorter at 14.7 feet, and the varietal seedlings 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 (2.0 inches) and four (3.5 inches) (table 1).

Height growth increased on a yearly basis from approximately 3 feet between age one and two, to over 4.5 feet between age two and three, to over 5 feet between age three and four. As expected height growth followed the same pattern as total height, with MCP seedlings exhibiting the most rapid growth.

The superior performance of the MCP seedlings to the 2nd-Generation OP seedlings was expected, since both parents are selected. This higher genetic level resulting from a specific mating has manifested itself through greater diameter and height performance, at least through age four. It is unfortunate that the test did not include a single highly selected varietal, which would have made a more valid comparison to the other two genetic types. However, the inclusion of the 57 individual varietals provides an insight to difficulty of selecting the one correct varietal that would be best for this northern Mississippi site or for that case any particular site.

Age-four height of the varietal seedlings indicated a wide variation in performance, ranging from 11.0 to 17.0 ft. This variation is expected when 57 varieties are being evaluated. Varietal 329 is among 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 2). In comparison to the MCP seedlings, varietal 228 was 1.2 ft. taller. However, DBH of 228 was a little smaller than the MCP seedlings averaging 3.1 in., in comparison to the average DBH of the MCP seedlings of 3.5 inches (table 2).

## CONCLUSION AND MANAGEMENT IMPLICATIONS

The comparison of the MCP family to the select 2nd-Generation OP family is certainly valid and indicates that this specific MCP family easily outperforms the 2nd-Generation OP family, with faster growth through age four. In addition, the MCP family performed equally well with 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.

## LITERATURE CITED

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**Table 1—Mean total height and dbh of the three genetic types from age one to age four tested on the MAFES site near Holly Springs, MS**

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

[1] – Different letters following the means represents significant differences at the 0.05 level

**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**

| | ----------Total Height---------- (ft) | | |
|---|---|---|---|
| Genetic Type | 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

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 thus making a full-sib cross; Seed orchard photo showing bags that isolate those selections from any outside pollen source, eventually the bags will decompose allowing the mass control pollinated cones to mature (right). Photos by MeadWestvaco.