MANAGEMENT INTENSITY AND GENETICS AFFECT LOBLOLLY PINE CROWN CHARACTERISTICS

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ABSTRACT

The development of elite loblolly pine (*Pinus taeda* L) genotypes may lead to reduced planting densities as a means of reducing establishment costs. However, this can lead to undesirable crown and branch characteristics in some genotypes. Selecting appropriate genetic material, combined with appropriate silvicultural management, is essential to realizing potential genetic gains. A study was established in 2008 to examine the performance of two loblolly pine varieties, a "crop tree" ideotype and a "competitor" ideotype, at different initial tree spacings and management intensities. After two growing seasons, genetics were already affecting crown morphology. The crop tree ideotype was, on average, taller, had longer and wider crowns, greater crown volume, and less acute branch angles. Management intensity had greater impact on crown characteristics than genotype. Intensive management resulted in trees that averaged over 1.1 ft (~24%) taller with wider crowns (0.7 ft, 30%), longer crowns (0.9 ft, 32%), and greater crown volume (5.5 ft^3, 133%) relative to non-intensive management. Differences due to management intensity were related to reduced crowding from competing vegetation and lower incidence of damage from pine tip moth and sawfly.

INTRODUCTION

Due to increasing population, demand for wood products continues to increase. Numerous improvements have been made in the management of loblolly pine, and large increases in growth have been reported in recent years (Borders and Bailey 2001). Such improvements have come about due to improvements in management practices, seedling quality, mechanical and chemical site preparation, density management, and fertilization (Jokela and others 2004).

Researchers have also used genetic tree improvement as a means for increasing productivity of loblolly pine forests, resulting in a steady progression of improved yields over the past five decades. Genetic manipulation of trees through breeding and selection has improved wood quality, growth rates, and disease resistance of loblolly pine (Fox and others 2007). These improvements were attained by utilizing offspring from high quality female parent trees that have been tested in open-pollinated half-sib family blocks (McKeand and others 2006). Further improvements have been made using controlled pollination, a technique allowing selection of both parents which results in potentially superior full-sib offspring for planting. While controlled pollination was originally used in the breeding and testing phases of tree improvement programs, the forest industry has now adopted Mass Controlled Pollination (MCP) techniques as a means of producing full-sib seedlings. MCP allows the capture of a greater amount of genetic variation, theoretically, resulting in faster growth rates, better tree form, and increased disease resistance on an operational scale (Bramlett 1997).

Clonal forestry has the potential for even greater genetic gains (Mckeand and others 2003), and may be obtained by the utilization of somatic embryogenesis (Pullman and others 2002). Somatic embryogenesis method uses the results from full-sib progeny tests to determine which specific parents will be crossed to recreate a similar selected full-sib family. From a specific cross, embryos are harvested, and developed into plants that can be clonal tested. Each individual embryo is a clone (today known as a variety) (Wright and Dougherty 2006). A number of varieties can then be included into a set of varietal tests to determine selections for operational deployment. Like any other genetic tests these varietal can be specifically selected for characteristics that coincide with a targeted product. For example, phenotypic characteristics desirable for sawtimber might include superior stem form, good self-pruning ability, and wood characteristics needed for quality structural grades (Wright and Dougherty 2006). The development of elite loblolly pine varietals may lead to reduced planting densities thus reducing establishment costs. Combining appropriate select genetic material, with a corresponding level of silvicultural management, is essential to realizing potential genetic gains (McKeand and others 2003).

A study was established in 2008 to examine the performance of two loblolly pine varieties, one selected as a sawtimber "crop tree" ideotype and the other as a "competitor" ideotype, at different initial tree spacings and management intensities. The overall objective of the study was to compare the performance of the two ideotypes across different stem densities and management intensities. The specific objective of this analysis is to compare treatment effects on stem and crown form of two contrasting loblolly pine varieties.

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METHODS

The study is located on Mississippi State University's Coastal Plain Branch Experiment Station near Newton, Mississippi (32˚20'19"N 89˚05 51"W). Soils on the site are classified as a Prentiss, very fine sandy loam with an approximate site index for loblolly pine of 88 feet at base age 50. The site had previously been in agricultural production resulting in somewhat compacted soils. The site received a broadcast application of Glyphosate (64 ounces per acre) in September 2007, and was sub-soiled to a depth of approximately 14 inches in October of 2007. The site received a second broadcast application of Glyphosate (32 ounces per acre) in March of 2008 prior to being hand planted with containerized seedlings in late April/early May of 2008.

Treatments consisted of two levels of management intensity, two genetic varieties of loblolly pine, and three initial planting spacings. The two levels of management intensity included a standard intensity (low) and a high intensity (high). In addition to the chemical site preparation and sub-soiling described above, both high and low intensity plots received herbaceous competition control in year 1 through a broadcast application of Oustar® (10 ounces per acre). Additional management input applied to high intensity plots included tipmoth control in the form of a single SilvaShield™ tablet (Bayer Environmental Science) in the planting hole at time of planting, PTM™ insecticide (BASF Corp.) injected 3-6 inches deep into the soil adjacent to each tree (0.05 ounces per tree) in years 2 and 3 for additional tipmoth control, herbaceous competition control in year two (1 ounce per acre of Escort®, 16 ounces per acre of Arrow®, 32 ounces per acre of Goal®), and mowing competing vegetation in year 3.

Two varietal genotypes of loblolly pine were included in the study based on their putative divergent crown architectures. The varieties, produced by ArborGen, LLC, included one considered to be a competitor ideotype (comp) characterized by a wider crown form, and another considered to be a crop tree ideotype (crop) with a more narrow, compact crown form. The three initial tree spacings were 6 x 14 ft (519 tpa), 9 x 14 ft (346 tpa), and 16 x 14 ft (194 tpa).

The study was set up as a 2x2x3 factorial design with split plots. Main effects treatments included the two levels of management intensity and the two genetic varieties, with main effects treatment plots split by the three initial planting spacings. Trees within the spacing subplots were planted in 64-tree blocks (8 x 8 trees) with the inner 36 trees constituting the measurement plots. Each treatment combination was replicated four times.

Initial heights were recorded following planting in May 2008. Age-one heights were recorded in December 2008. Year-two measurements, taken at the end of the 2009 growing season, consisted of ground line stem diameters, height to the base of the live crown, and total height on all trees. Crown and branch measurements were recorded on trees within an inner 16-tree (4 x 4 tree) measurement plot. Branch angle, branch length, and branch diameter one inch from the main stem were recorded on the two longest branches in the first primary whorl from the base of the tree. Height was measured using a height pole and recorded to the nearest one tenth of a foot. Branch diameter was measured using a caliper and recorded to the nearest one tenth of an inch. Branch angle was measured using a protractor to judge the angle of the branch adjacent to the main stem. Branch angle was recorded to the nearest five degrees. Crown diameter was the average of measurements taken in two directions. For this analysis, we tested for spacing, management intensity and varietal differences in crown characteristics following the second growing season. All reported differences are based on a critical value of alpha=0.05.

RESULTS AND DISCUSSION

Results for year-two crown widths show there were significant differences by variety and management intensity, but not by spacing. Mean crown width of the crop tree ideotype (2.7 feet) was nearly one half of a foot greater than the competitor ideotype (2.3 feet) (Figure 1). Mean crown widths on the high intensity management plots were 0.8 feet wider than on the low intensity management plots (Figure 2).

Significant differences in mean branch length occurred with management intensity. Mean branch length on high intensity plots averaged 2.1 feet compared to 1.5 feet on low intensity plots (Figure 3). The crop tree ideotype did have slightly longer (0.1 feet) mean branch lengths than the competitor ideotype but the difference was not significant.

Branch diameters also differed significantly by management intensity, with mean branch diameters on high intensity management plots (0.36 inches) larger than on low intensity plots (0.30 inches) (Figure 4). The crop tree ideotype again had slightly larger mean branch diameters than the competitor ideotype but the difference was not significant (Figure 5).

High intensity plots where expected to have wider crowns, longer branches, and larger branch diameters than low intensity plots, as higher intensity management typically produces more growth compared to low or non-managed sites. Crown widths, branch lengths, and branch diameters on high intensity plots were all significantly greater than on low intensity plots. This was likely due to reduction of competing vegetation and lower incidence of damage from pine tip moth and sawfly in high intensity management plots allowing for greater crown development.

Analysis of branch angles in year two showed a significant difference by genetic variety. The mean branch angle of the crop tree ideotype was 49˚ while the competitor ideotype had a mean branch angle of 46˚ (Figure 6). There were no differences in mean branch angle by management intensity or initial spacing.

The results of crown and branch measurements indicate genetics are already playing a role in crown characteristics. The crop tree ideotype was, on average, taller, had longer and wider crowns, greater crown volume, and wider branch angles than the competitor ideotype. Initial observations concerned us if the crop tree ideotype selected was actually performing as a crop tree. However, according to Cannell (1978), the crop tree ideotype being tested here is performing as a crop tree. Crop trees are efficient users of locally available resources and do not compete strongly with neighboring trees. These characteristics enable the crop tree ideotype to produce greater yields than trees of a competitor ideotype in intensively managed monocultures. In fact, the crop tree ideotype in this study outperformed the competitor ideotype by 15 percent for mean height at the end of the year 2 (Roberts and others [in press], these proceedings). These early results indicate that the varietal material retains its inherent ability to exhibit those selected stem and crown characteristics regardless of spacing.

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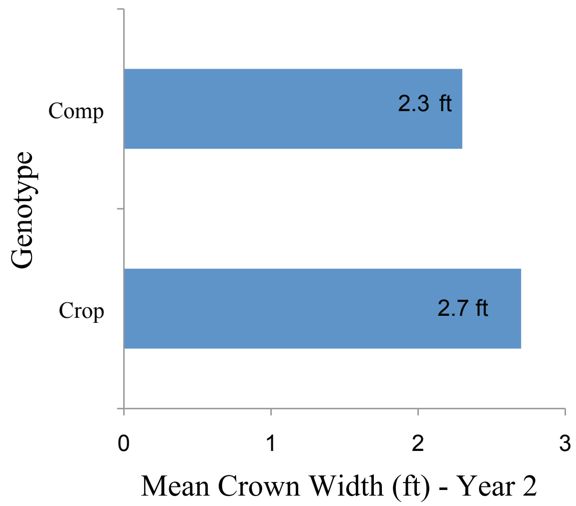

Figure 1—Mean year-2 crown widths for contrasting loblolly pine crown ideotypes planted in a spacing by management intensity trial in central Mississippi.

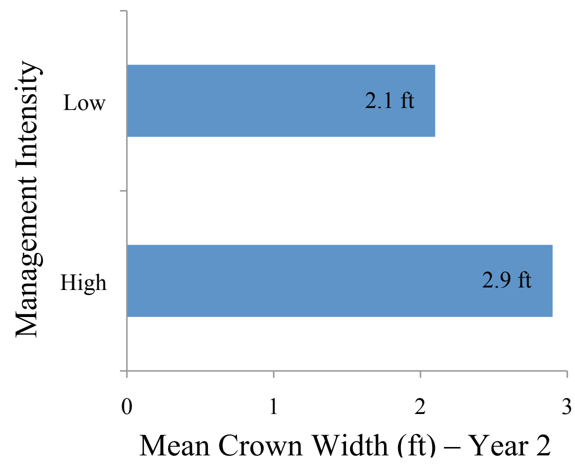

Figure 2—Mean year-2 crown widths for loblolly pine varietal seedlings managed at different management intensities in central Mississippi.

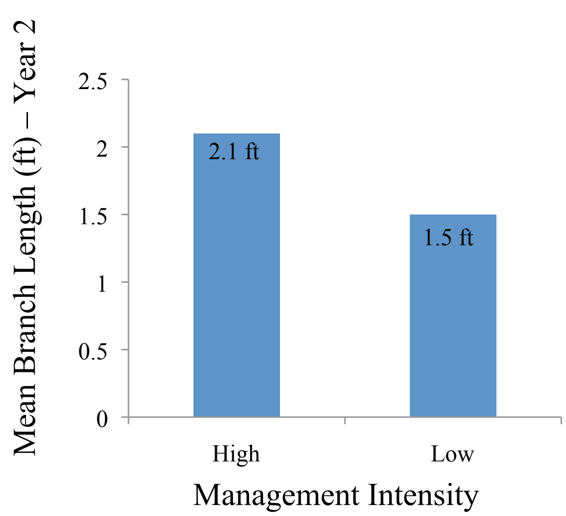

Figure 3—Mean year-2 branch lengths for loblolly pine varietal seedlings managed at different management intensities in central Mississippi.

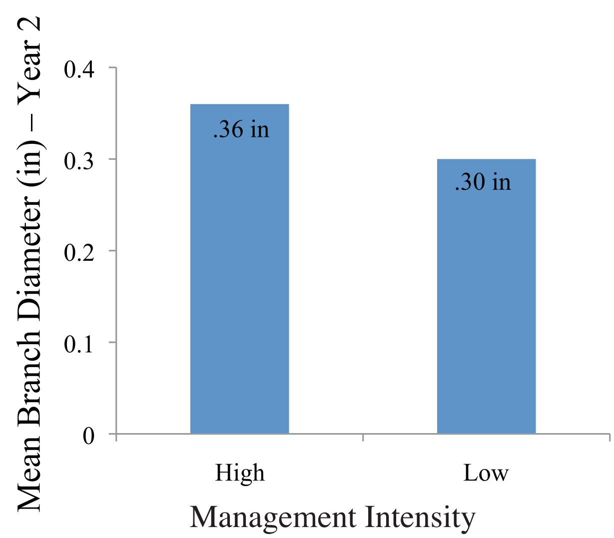

Figure 4—Mean year-2 branch diameters for loblolly pine varietal seedlings managed at different management intensities in central Mississippi.

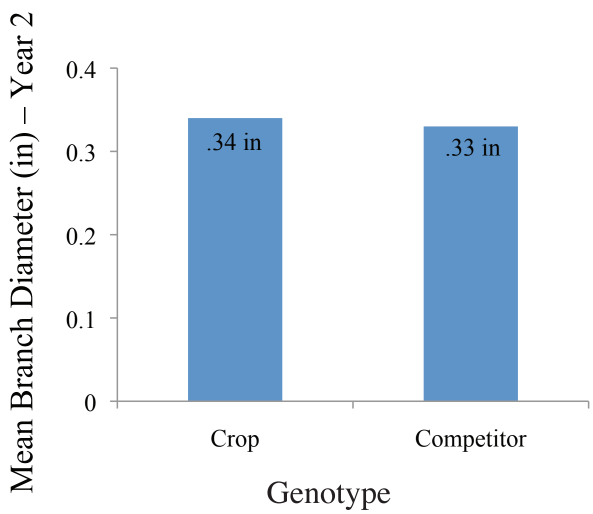

Figure 5—Mean year-2 branch diameters for contrasting loblolly pine crown ideotypes planted in a spacing by management intensity trial in central Mississippi.

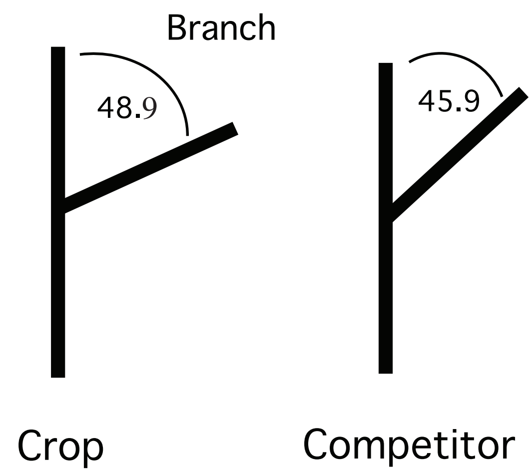

Figure 6—Mean year-2 branch angles for contrasting loblolly pine crown ideotypes planted in a spacing by management intensity trial in central Mississippi.