Genetic Parameters and Uniformity of Wood Properties of Full-Sib Families and Clones of Loblolly Pine

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With an increased proportion of the wood supply coming from intensively grown plantations, improvements in wood quality are becoming increasingly important. Genetic gains in wood quality may be achieved by control pollination and/or vegetative propagation. These strategies can increase the genetic quality of reforestation stock by eliminating pollen contamination and increasing selection intensity. While potential improvements have been estimated for growth and disease resistance (Frampton et al, 2000), insufficient information is available on potential improvements in wood properties of loblolly pine. The objectives of this study are to:

1) Determine if differences occur in wood properties between seedlings and rooted cuttings
2) Determine variation in wood properties among and within families for wood properties
3) Compare uniformity between seedlings and clones for wood properties
4) Determine site effects on wood properties
5) Determine if there are genotype by environment interactions for clones or families

In this study, we are analyzing wood properties from a 10 year-old field trial. The trial consists of full-sib seedlings and rooted cuttings (clones) from a factorial mating of 6 parents planted on two sites. This paper reports results from analysis of wood specific gravity on one of the two sites. The Monroe County, AL site is located in the upper coastal plain and is of old field origin.

The experimental design is a split-plot. There are two sites with six replications per site. Within each replication, the propagule types are separated into whole plots, with two trees per plot. In the seedling plots, there are 3 plots per family per replication (six seedlings per family per replication). In rooted cuttings plots there are 5-9 clones per family per replication, with each clonal plot consisting of two ramets.

Wood cores were collected using a 12-mm increment borer and electric drills from each study tree during March 2001. The specific gravity was determined using the gravimetric method (ASTM, 1985). Density was calculated using the following equations:

Basic Density (kg/m^3) = oven dry wood weight/ green volume

Green Volume (m^3) = (Saturated weight in air) – (Saturated weight in water)

A linear model was used to analyze wood specific gravity of rooted cuttings and seedlings. The model included female parent, male parent, clone, replication, type, and their interactions were applicable. The GLM procedure in SAS was used to analyze the wood specific

gravity data. Significant differences among means for propagule type, male parents and female parents were tested using Duncan's multiple range test within the GLM procedure. Individual, half-sib family mean, full-sib family mean, and clone mean heritabilities were estimated separately for rooted cuttings and seedlings. Linear models were generated for each propagule type using the GLM procedure. Variance components were then partitioned using the VARCOMP procedure.

There was no significant difference in mean specific gravity between rooted cuttings and seedlings (Table 1). However, there were differences in mean specific gravity for both half-sib and full-sib families. There were differences in the partitioning of variance in each propagule type (Table 2). In rooted cuttings, over one-third (35%) of the total variance was due to female parents, and 6% of the variance was due to males. The variance due to clones was 17%. The error variance was 37% in rooted cuttings, much lower than that of seedlings (73%). In seedlings, females contributed to 21% of the total variance, while males contributed to 3% of the variance.

Table 1.

Propagule Type	Mean Specific Gravity	Standard Deviation	Duncan's Test
Rooted Cutting	**0.409**	**0.025**	**A***
Seedling	**0.417**	**0.031**	**A**

* Same letter is not significantly different (p</= 0.05) using Duncan's multiple range test.

Table 2.

Variance Component	Rooted Cutting	• Seedling
Female	**35%**	**21%**
Male	**6%**	**3%**
Female*Male	**0%**	**0%**
Clone	**17%**	**-**
Replication	**2%**	**0%**
Rep*Fem	**0%**	**0%**
Rep*Male	**0%**	**3%**
Rep*Fem*Male	**0%**	**0%**
Rep*Clone	**3%**	**-**
Error	**37%**	**73%**

Heritabilities were higher for rooted cuttings than seedlings in all categories (Table 3). Replicating the genotype allowed for more variance to be partitioned into genetic components, leaving a smaller error variance. The reduction in error can also be seen in the variance components for rooted cuttings and seedlings.

Table 3.

Heritability	Rooted Cutting	Seedling
Individual	**0.20**	**0.12**
Half-sib Family Mean	**0.95**	**0.88**
Full-sib Family Mean	**0.97**	**0.94**
Clone Mean	**0.98**	**N/A**

With no significant difference in mean specific gravity between rooted cuttings and seedlings, rooted cuttings appear to be an alternative to seedlings with no negative effect on wood density. The use of clonal material also shows promise in making wood properties more uniform. As the best clones are selected, replication of fewer genotypes will reduce variation in density. Future results will provide more information on genetic parameters and uniformity of additional wood properties. This information is essential for estimating the amount of improvement in wood properties that can be realized by breeding programs and full-sib and clonal regeneration systems.

LITERATURE CITED

American Society for Testing and Materials. 1985. Standard test methods for specific gravity of wood and wood-based materials. D 2395-83. Annual Book of ASTM Standards. Volume 4.09 Wood. Philadelphia, PA.

Frampton, J., B. Goldfarb and B. Li. 2000. Early field growth of loblolly pine rooted cuttings and seedlings. Southern Journal of Applied Forestry, vol. 24, no. 2.