Quantitative Trait Inheritance in a Forty-Year-Old Longleaf Pine Partial Diallel Test

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A longleaf pine (*Pinus palustris* Mill.) 13 parent partial diallel field experiment was established at two locations on the Harrison Experimental Forest in 1960. Parent trees were randomly selected from a natural population growing on the Harrison Experimental Forest, near Gulfport, Miss. Distance between trees chosen as parents ranged from 13 to 357 m. Following planting, brown-spot needle blight was controlled through the application of Bordeaux mixture three times per year for three years and competing vegetation was controlled with cultivation and mowing, resulting in good initial survival (first year survival was 94%) and early emergence from the grass stage (mean height at age 5 was 3.7 m). Analyses of genetic parameters for ages one through seven were reported by Snyder and Namkoong (1978) and results for age 17 were analyzed by Rousseau (1980). At age 40, the trees averaged 24.1 m (79.1 ft) tall with a dbh of 26.8 cm (10.6 in) and had a survival rate of 48%. Basal area across the two plantations averaged 23.4 m^2/ha (102 ft^2/ac). Measurements for ages 7, 17, 30, and 40 were analyzed for this report.

Maternal and reciprocal effects were not found to be significant in earlier analyses (Snyder and Namkoong 1978) and were not included in this analysis. Also, no selfs survived to age forty. Only families that had a minimum of two plots per plantation, with at least three trees per plot were included in the current analysis. Of the original 78 full-sib crosses, only 55 families met the above criteria. Single tree narrow-sense heritabilities are reported in Table 1 and the ratios of non-additive to additive genetic variance are listed in Table 2. Heritabilities are low to moderate in value and remained stable over ages except for several notable exceptions.

Table 1. Single tree narrow-sense heritabilities.

Trait	Age 7	Age 17	Age 30	Age 40
Height	0.13	0.06	----	0.15
DBH	0.07	0.14	0.10	0.11
Volume	----	0.12	----	0.13
Survival	0.06	0.06	0.08	0.07

Table 2. Ratios of non-additive to additive genetic variances.

Trait	Age 7	Age 17	Age 30	Age 40
Height	0.1092	2.1448	----	0.3162
DBH	0.1911	1.1514	1.4618	1.2866
Volume	----	1.2957	----	1.0407
Survival	0.5568	0.7969	0.5510	2.8292

The ratio of dominant to additive genetic variance varied over ages for the traits studied, tending to be considerably larger at age 17 than at age 7, and except for height, remained high at age 40. This result was due to the specific combining ability (SCA) variance increasing faster from age 7 to 17 than did the general combining ability (GCA) variance, and remaining higher at older ages. These results indicate that, for longleaf pine, breeding programs should focus on SCA as well as GCA.

Overall, the ratio of non-additive to additive genetic variance was higher than observed in other southern yellow pines, and contributed to the low to moderate heritabilities for the traits investigated. The increasing importance, with increasing age, of non-additive genetic variance has also been reported in black spruce (*Picea mariana* Mill.) (Boyle 1986, Mullin and Park 1994) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco (Yanchuk 1996).

Additive genetic correlations for heights and diameters among different ages are reported in Table 3. At age seven, heights showed a much stronger correlation to age 40 values than did diameters. At age 17 and older, all correlations were high.

Table 3. Genetic correlations between selected ages.

Ages (years)	Height	Diameter
7 to 40	0.61	0.26
17 to 40	0.92	0.84
30 to 40	----	0.97

At age 30, fifteen families were destructively sampled to measure unextracted wood specific gravity (SG), modulus of elasticity (MOE), and modulus of rupture (MOR) from juvenile and mature samples. Specific gravity for juvenile samples averaged 0.56 with family means ranging from 0.51 to 0.62. Specific gravity for mature samples averaged 0.62 with family means ranging from 0.59 to 0.65. Family differences for juvenile and mature SG, and mature MOE were significantly different. Trees that had been damaged by hurricane Camille (age 9) had significantly higher unextracted juvenile wood SG (0.58) than did undamaged trees (0.51).

Twelve-mm bark-to-bark core samples are currently being collected to estimate genetic parameters of selected wood quality traits. Near infrared spectroscopy will be used to estimate SG, clearwood MOR, clearwood MOE, fiber length, and microfibril angles. Fiber length and earlywood to latewood ratios will also be measured. Chemical properties to be analyzed include alcohol-toluene extractives, holocellulose, Klason lignin, and hemicellulose.

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