Genetic Variation in Stem Forking in Loblolly Pine

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Loblolly pine (*Pinus taeda* L.) is the most important commercial tree species in the southeastern United States, and is widely planted by landowners and forest product companies in the South (Schultz 1999). The NC State University Cooperative Tree Improvement Program has been breeding loblolly pine for more than 50 years with the objective of selecting and breeding loblolly pine trees with faster growth, disease resistance, and better stem straightness, but little attention has been paid to forking defects (McKeand et al. 2003, Li et al. 2000, McKeand and Bridgwater 1998). Forking defects include forked stems and major ramicorn or steep-angled branches (Schermann et al. 1997). Forked stems create large knots and irregular grain in lumber and also reduce the stem strength and timber uniformity. Ramicorn branches also produce large knots thus decreasing self-pruning and healing of branch scars (Barber 1964). Forking defects greatly decrease the wood quality, timber harvest and pulp yield, correspondingly reducing the economic value of the wood.

In this study, we examined the genetic and environmental components of stem forking in loblolly pine using data from the diallel progeny tests of the second-cycle breeding program of the Cooperative (see Xiang et al. 2003 for details). Overall, data from 268 test series (each series is 4 tests of 30 crosses in a specific geographic region) were used to investigate the variation of forking over geographic regions. Of the 268 test series, 123 had forking rates between 20% and 80% and were used for the genetic analyses. Genetic gains based on breeding values of half-sib families were estimated. A selection intensity of 20% within region was used for all seven test regions.

Forking across all 268 test series averaged 18%, and it ranged from 4% to 80% across different test series. Forking differed significantly across regions. The highest forking was in the Upper Gulf (24%), and the lowest was in Coastal Georgia & Florida (12%). High forking in the Upper Gulf and Piedmont regions could be explained by more cold damage or exposure to ice and snow, although we had no separate assessment of cold or ice and snow damage. A similar speculation can also be valid for Virginia and northern North Carolina in the northern distribution of loblolly pine populations with more frequent frosts and ice storms compared to the southern regions.

Based on variance components across the 123 test series with forking rates between 20% and 80%, the narrow-sense and broad-sense individual-tree heritabilities for forking averaged 0.05 and 0.06, respectively. Estimated average half-sib family-mean heritability for forking was 0.76 and ranged from 0.73 to 0.81 across the regions, while the average narrow-sense full-sib family-mean heritability was 0.59, ranging from 0.55 to 0.75. The average broad-sense full-sib family mean heritability was 0.71 ranging from 0.66 to 0.75. In contrast to individual tree phenotypic values, the mean of the family is much more precisely known from the proportion of

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the forking incidence. This analysis suggests that forking is under genetic control at the family level in loblolly pine but not at the individual tree level. Based on high family-mean heritability values, it seems likely that family-based selection against forking can provide good genetic gain.

Genetic correlations between forking and height were unfavorable and ranged from 0.12 to 0.29 across regions with the overall mean of 0.18. Correlation in the South Carolina Coastal Plain was relatively high (r_G=0.29) compared to other regions. The genetic correlation of forking and straightness showed more variation among different regions, ranging from 0.14 to 0.46. Overall, the genetic correlation of forking and straightness is favorable with the value of 0.33. The unfavorable genetic correlation between forking and height suggested that selection for height would result in a slight increase in forking. The favorable correlation between forking and straightness suggested that straight trees have a tendency not to fork, but we suspect that measurement crews tended to call most forked trees as below average for straightness, which may have caused positive correlation between forking and straightness.

The highest predicted genetic gain was in the Upper Gulf with 23% expected reduction in forking .The lowest gain was 12% expected reduction of forking in the SC Coastal Plain. Over all regions, half-sib family selection could reduce forking by 21%.The result showed that it should be possible to decrease forking defects in loblolly pine through family selection.

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