Repeatability for Oleoresin Yield Determinations in Southern Pines

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Flow of constitutive oleoresin is believed to be a major component of tree defense against attack by the southern pine beetle (*Dendroctonus frontalis* Zimmermann). Pines that exude large quantities of oleoresin are considered to be most capable of preventing or obstructing colonization by this destructive insect herbivore (Hodges et al. 1979; Cook and Hain 1987; Strom et al. 2002). We evaluate a tree's capacity to resist attack by assessing resin yield over a fixed time interval from one or more small wounds made on a tree's bole at or near breast height. These wounds are administered so as to sample resin from a zone proximal to the bark, the region containing tissues directly affected by *D. frontalis* during an attack. For resin yield measured in this way, it is desirable to determine the relative contribution of variation among multiple measurements taken from individual trees compared to phenotypic variation existing in populations.

Repeatability (r) is a population parameter that provides information pertinent to this issue. It is by definition, a measure of the correlation between multiple measurements taken on the same individual and represents the fraction of the total variation in populations attributable to variation among individuals. In quantitative genetics, estimates of repeatability are routinely used to obtain upper bounds for broad sense heritability, and to determine the appropriate number of measurements needed per individual to provide accurate estimates of individual trait means and breeding values (Falconer and MacKay 1996; Mrode 1996).

To acquire information about the distribution of variation for oleoresin yield within stands of three southern pine species, we estimated repeatability for measurements taken in the vicinity of breast height for this trait. Resin samples were collected from eight populations located in the central Gulf region of southern United States. Although our primary interest is focused on values for loblolly pine (*Pinus taeda* L.), we also obtained estimates for two populations of longleaf (*Pinus palustris* Mill.) and for a single population of slash (*Pinus elliottii* Engelm. var. *elliottii*) pine. Estimates from these populations primarily occur in the interval r = 0.5 to 0.7,

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indicating moderately high repeatability. These results suggest that for oleoresin yield in populations growing on average and better sites, greater variation is likely to be found among trees as opposed to within trees.

For traits in which it is possible to take multiple measurements on each tree, variation among tree means can be partitioned into true variance among trees plus an error variance that depends on variation among measurements within trees and the number of measurements per tree. Error variance of this type decreases with increasing repeatability and also with increasing numbers of measurements per individual. If repeatability values are close to one, a single measurement per tree is sufficient to produce low error variance, but with low repeatabilities, additional measurements are required to reduce this error variance to appropriate levels. For the range of repeatabilities we observed for breast-height resin yield, two or three measurements per tree suffice to provide satisfactory reduction of error variance for most estimation purposes.

Tree resin defense is almost always evaluated from samples collected at or near breast height. This practice is dictated by logistical convenience; however initial attacks by the southern pine beetle most frequently occur at bole heights of three to five meters (Coster et al. 1977). Such attack behavior makes it desirable to obtain a method for assessing resin yield in this upper bole region from measurements taken near breast height. Because of this need, we developed equations for predicting tree resin yields at a bole height of 4.5 meters from yield assessments made at a height of 1.5 meters. An allometric approach combined with regression methods was employed to produce linear prediction equations based on logarithms for the two resin yield variables. Data collected from resin samples taken from two loblolly pine populations located in central Louisiana were used to estimate equation parameters. Equations for both populations provided reasonable fits to the sample data (R^2 = 0.68, 0.76), and in each population, regression coefficients were found to be significantly greater than zero and significantly less than one (b = 0.592, 0.845). Corresponding intercept estimates for the two populations were also in the interval, zero to one (a = 0.299, 0.111), with only the value for the first population being significantly greater than zero. Under a hypothesis of equivalent tree resin yields at the two heights, estimates for the regression coefficients would not be expected to differ from a value of b = 1.0, and intercept terms would not be expected to differ from a value of zero. Our results indicate that resin yields at the two heights, although correlated (r = 0.72, 0.84), are not equivalent across the entire range of resin yields observed at a height of 1.5 meters, especially in the portion of the range consisting of high yield values. As a consequence, high resin yielding trees appear to be somewhat more resistant when evaluated at a height of 1.5 meters than they actually are, since their resin yields tend to be lower at a height of 4.5 meters.

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