

Breeding *Eucalyptus* for Disease Resistance

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Abstract

Eucalyptus plantations cover about 1.5 percent of the agricultural area in Brazil, and contribute to 4 percent of GDP and 3 percent in exports of forest products. Technological and research advances in silviculture and genetic improvement have increased productivity up to 80 m³ of wood/ha/year, with an average of 35 to 45 m³/ha/year. The greatest challenge to the introduction and commercial use of exotic species is the adaptation of species to climatic conditions. Even when maladapted species are able to survive, they are subjected to continuous stress that limits the expression of their maximum genetic potential. The incidence of insects and diseases frequently represent another limiting factor, because the exotic tree species have not co-evolved with most of the local insect and pathogen pests. In recent decades, the expansion of *Eucalyptus* plantations in Brazil has been frequently associated with frequent disease outbreaks. Prominent diseases, such as Ceratocystis wilt, Ralstonia wilt, rust, and bacterial/fungal leaf blights, have limited the establishment and growth of plantations that contain susceptible species or clones in regions favorable to disease establishment. Plantations of hybrid clones or elite-resistant varieties represent the most efficient strategy for disease control. In general, fungicide application is restricted to control of nursery diseases, and rarely for rust control in the field. *Eucalyptus* clonal forests offer potential to establish homogeneous, disease-free stands of high yield. Currently, the hybrid clones of *E. urograndis* (*E. urophylla* S.T. Blake x *E. grandis* Hill ex Maiden) are among the most planted material in Brazil because of their high adaptability, wood quality for pulping, and resistance to Chrysoporthe canker. Other interspecific hybrids have been developed in an attempt to incorporate specific traits from other species, such as drought and frost tolerance, disease resistance, and high pulp yield. Primary breeding strategies are based on selecting species/provenances, coupled with individual genetic selection within populations, to capture the natural variability among and within populations. The recurrent selection method and its variants are applied to genetic improvement of *Eucalyptus* to obtain new clones of interspecific and intraspecific hybrids. Backcrosses, mutation induction, and polyploidy have also been applied to develop new genotypes. These strategies help ensure the sustainability of commercial plantations and the continual contributions from the improvement program through the selection in advanced generations and superior clones. With interspecific breeding to incorporate contrasting traits, it is usually necessary to make continued backcrosses to the species of interest as the recurrent donor to recover the desired forest features and industrial properties. For each breeding generation, it is essential to perform disease screening under controlled conditions to select disease-resistant genetic materials for commercial cloning or identifying sources of resistance for other crosses. For disease-resistance evaluations, reliable inoculation protocols are essential. In recent years, approximately 90 percent of elite-clones were susceptible to at least one of the main diseases tested using artificially inoculations under controlled conditions. Determining the genetic basis and the mode of inheritance of disease resistance is an essential step to obtain disease-resistant plant material for the breeding program. The breeding strategy varies according to the inheritance model. To reduce losses caused by rust (*Puccinia psidii*), efforts have been conducted to select and plant rust-resistant clones and determine the mode of inheritance. In *E. grandis*, the segregation pattern of resistance to rust is controlled by one locus with major effect, *Ppr-1* (*P. psidii* resistance, gene 1), which is tightly linked to RAPD marker AT9-917. Controlled inoculations of other families allowed the identification of a homozygous, rust-resistant mother parent of *E. grandis*, currently used to obtain rust-resistant progenies, regardless of pollen source. Screen tests for resistance to Ceratocystis wilt (caused by *Ceratocystis fimbriata*) showed a continuous variation in resistance, ranging from highly susceptible to highly resistant, indicating a pattern typical of horizontal resistance. Additional studies are needed to determine the genetic basis, the new sources of resistance, and the inheritance patterns of resistance of *Eucalyptus* spp. to other diseases. Furthermore, a better understanding of the population genetic structure of pathogens is needed to determine the role of pathogen variability in disease resistance that is targeted by the breeding strategies.

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