



Eucalyptus in a changing world

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CURRENT STATUS AND CONTROL STRATEGIES OF *EUCALYPTUS* DISEASES IN BRAZIL

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ABSTRACT

With the increasing eucalyptus plantation area in Brazil, outbreaks of several diseases in nurseries or the field have been reported in recent years. Eucalyptus canker (*Cryphonectria cubensis*), Ceratocystis wilt (*Ceratocystis fimbriata*), pink disease (*Erythricium salmonicolor*), eucalyptus rust (*Puccinia psidii*), and several leaf blights (*Cylindrocladium* spp., *Rhizoctonia* spp., *Mycosphaerella* spp., *Xanthomonas axonopodis*, *X. campestris*, and *Pseudomonas cichorii*) have been the most common diseases under field conditions. Selection of resistant clones, families, provenances or species is the best strategy for control. Artificial inoculations have been used to determine the level of resistance in germplasm to be used for planting and for crossing in breeding programs. The inheritance of resistance is currently being studied for several pathosystems.

INTRODUCTION

Eucalyptus cultivation in Brazil was limited only to a few thousand hectares until the decade of 1970, when eucalypts were considered to be practically immune to diseases. The increasing demand for forest products and the need to conserve the native forests, pushed the expansion of *Eucalyptus* plantations to about 3.0 million hectares. About one million hectares of this total are planted with 362 different clones, of both pure species and hybrids?, distributed in areas varying from 10 to 34,000 ha/clone. It is expected that within this year an additional 250,000 hectares of eucalypt forests comprising 55 clones will be planted, occupying areas varying from 10 to 9,000 ha/clone/company. The expansion of plantations to warmer and more humid regions conducive to infection by plant pathogens, the regional peculiarities of climate and soil, combined with the possible introduction of diseases from other countries, and adaptation of some local pathogens from native Myrtaceae to *Eucalyptus* species have resulted in the incidence of various fungal and bacterial diseases that cause significant losses in some highly susceptible clones. In spite of the risks, cloning has proved to be an excellent tool for disease control. The knowledge of *Eucalyptus* species and their interactions with different potential diseases is important to establish strategies to ensure stability of wood production.

This article summarizes the main eucalyptus field diseases and their control.

MAIN EUCALYPTUS DISEASES

Rust

Symptoms: Yellow colored powdery urediniosporic sporulation over the affected organs is the typical feature for rust diagnosis. In highly susceptible materials, infection causes deformation, necrosis, hypertrophy, mini-cankers and death of the apical meristems. Although the uredinal phase is more common and is the main form of pathogen dispersal, less frequently, teliospores can be produced during the warmer periods, on fully expanded leaves.

Causal agent: *Puccinia psidii*.

Control: The existence of high inter- and intra-species genetic variability for resistance to rust allows for disease control by planting resistant clones, progenies or species. *Corymbia citriodora*, *C. torelliana*, *Eucalyptus camaldulensis*, *E. microcorys*, *E. pellita*, *E. pilularis*, *E. propinqua*, *E. resinifera*, *E. robusta*, *E. saligna*, *E. tereticornis*, and *E. urophylla* are important sources of resistance. In regions, favorable to rust infection, planting of *E. grandis* seeds, (provenances: South Africa and Coff's Harbour 9583), *E. phaeotricha*, *E. cloeziana*, *E. globulus* and *E. nitens* should be avoided. There is, however, ample intra-species variability, which permits selection and cloning of resistant genotypes for planting. In *E. grandis*, resistance is dominant and controlled by a major gene (*Ppr-1*) (Junghans *et al.*, 2003). Thus, the rust can be controlled through use of resistant progenies, whose seeds are harvested from resistant homozygous mother-plants, as practiced by some forest industries in São Paulo and southern Bahia. It is also possible to select trees with rapid growth characteristics, which rapidly escape the disease by virtue of the microclimate in the upper canopy being unfavorable for disease development. Similarly, selection can be made from clones of *E. globulus* and related species that rapidly pass through the susceptible juvenile leaf stage to produce resistant adult leaves. In the case of highly susceptible genetic materials of high commercial value, the disease can be controlled by systemic fungicide spray such as triadimenol (Bayfidan 25 PM ou 25 CE) (0,5 g i.a./L) and azoxystrobin (Amistar 500 WG) (0,1 g i.a./L) at two-week intervals. In nurseries, especially in clonal hedges and mini hedges, the disease is

controlled by fortnightly spraying of triadimenol or azoxystrobin, using the above concentrations.

Cylindrocladium leaf blight

Symptoms: The lesions can develop at the base, at the apex, or at the leaf margins, and can cover a large portion of the leaf area, inducing severe premature defoliation of the lower, middle and apical thirds of the tree canopy during the first and second years after planting. It is believed that, when only the basal or middle third of the canopy is affected, the trees tend to recover. However, under disease favorable conditions, the apical portion is also defoliated, especially in highly susceptible materials, leading to reduced plant growth. Defoliation also allows for high light intensity penetration into the stand leading to growth of competing weeds. Disease symptoms can vary depending upon the species of *Cylindrocladium* and *Eucalyptus*. The leaf spots of *C. pteridis* are smaller, circular or elongated and light-gray progressing to light-brown in color (Ferreira *et al.*, 1995), while those of *C. candelabrum*, *C. floridanum*, *C. illicicola*, *C. parasiticum* and *C. scoparium* are larger, light to dark-brown with a gray-green halo (Alfenas *et al.*, 2004). In most *Eucalyptus* species, the lesions are light or pale brown, but in *E. cloeziana* they are dark brown.

Causal agents: *C. candelabrum*, *C. floridanum*, *C. illicicola*, *C. ovatum*, *C. parasiticum*, *C. pteridis* and *C. scoparium*.

Control: Considering the natural recovery of infected plants during subsequent periods climatically unfavorable to the disease, no control measure is currently used. However, because of high reduction of the photosynthetic area, a significant loss in volume is expected, which may justify adoption of control measures to reduce potential losses. In this case, planting blight-resistant progenies, provenance, species, and clones is the best control strategy. The determination of inheritance model and genetic base is essential for a breeding program to obtain resistant materials.

Rhizoctonia leaf blight

Symptoms: The disease is characterized by large and irregular leaf spots. In field plantations and clonal hedges, the infection starts on leaves of lower branches and progresses to the plant apex, causing intense leaf blight and defoliation (Silveira *et al.*, 2000). Depending on the disease intensity, whitish-mycelium-covered branches and leaves can be observed, with the possible presence of whitish or light to dark-brown sclerotia. Initially, the affected leaves show irregular light-gray to light-brown lesions of different sizes leading to blight of almost all leaves which become pale in colour. Initially, infected leaves remain attached to the plant, but tend to fall with time. Other marked characteristics of the disease are hanging leaves attached by the fungal hyphae, adhering to one another and connected by hyphae resembling a web (web-blight). The pathogen survives in soil, from which it disseminates by water splash to the surface of lower leaves, or by growing epiphytically up the trunk reaching

the higher portions of the canopy. In general, the fungus does not sporulate, and the most important features are sclerotia formation along the infected organs, right angle branching of hyphae and presence of a constriction at the first septum in the branched hyphae when observed under the microscope. The sexual phase of some isolates of *R. solani* (*Thanatephorus cucumeris*) can be produced under controlled conditions, but is rarely found in natural infections (Silveira *et al.*, 2000).

Causal agents: *Rhizoctonia solani* (AG1-1B) and binucleate species of *Rhizoctonia* not yet identified.

Control: Although there are no studies about the genetic variability for resistance, it is unlikely that resistant genotypes will be found within eucalypt species. However, artificial inoculations should be conducted to examine this hypothesis.

Bacterial leaf blight

Symptoms: At the initial phases of infection, the disease is characterized by water-soaked translucent leaf spots, resulting from water leakage into the intercellular spaces, and is followed by intense defoliation, girdling and mortality of the apical portion of highly susceptible materials. As the disease progresses, the lesions become necrotic and dry with perforations and deformation of the leaf blade. Its precise diagnosis requires laboratory examination, using exudation tests in which bacterial slime emanates from newly formed lesions.

Causal agents: Species of *Xanthomonas axonopodis*, *X. campestris*, *Pseudomonas cichorii*, and others (Gonçalves, 2003).

Control: Selection and planting of resistant genotypes.

Phaeophleospora leaf blight

Symptoms: Angular purple brown spots, distributed over both sides of mature leaves, result from exudation of conidial masses (csm), black sporulation resembling black mold. The disease is sometimes confused with the leaf spots caused by *Cylindrocladium*, plant bacterial infection or phosphorus deficiency, especially if observed on the upper leaf surface. However, typical sporulation of the pathogen is the major characteristic for diagnosing the disease. It generally occurs on old leaves of plants in the field or in the nursery.

Causal agent: *Phaeophleospora epicoccoides* (*Phaeoseptoria eucalypti* = *Kirramyces epicoccoides*), teleomorph *Mycosphaerella suttoniae* (Crous, 1998).

Control: No specific control measure has been used, but selection and planting of resistant genotypes may be effective.

Coniella leaf spot

Symptoms: Large, light-brown to pale leaf spots, with dark concentric halos formed by the exudation of spore mass. Typical conidiophores and conidia of the pathogen can be observed by microscopic examination of histological sections through the pycnidium. This fungus penetrates host tissues through wounds (leaf friction by the strong winds) insect (thrips, larval, and aphid) or mite injuries and also through the lesions caused

by other leaf pathogens as *Puccinia psidii* and *Cylindrocladium* spp. The photosynthetic area is reduced in case of high disease severity, but defoliation is not usually observed.

Causal agent: *Coniella fragariae*

Control: No specific control measures are employed, but planting of resistant clones is the best strategy of control.

***Aulographina* leaf spot**

Symptoms: Circular or elongated, dark-brown, corky spots over the main vein, petiole, and twigs (Ferreira, 1989). Superficial dark-brown to black, elongated, curved, or branched fruiting bodies with a longitudinal slit (hysterothecia) are formed over the lesions (Ferreira, 1989). Asci and the ascospores of the fungus can be observed by microscopic examination of histological sections of the ascomata.

Causal agent: *Aulographina eucalypti*.

Control: The disease does not cause important damage therefore, no specific control measures are being used.

***Mycosphaerella* leaf spot**

Symptoms: The fungus infects young leaves of *E. globulus*, *E. nitens* and *E. dunnii* and mature leaves of many other species, including *E. grandis*, *E. saligna*, *E. urophylla*, and their hybrids. The spots vary from circular to irregular circular shape and are light to pale brown, being darker on the lower leaf surface. Dark ascomata, asci and ascospores are formed on the lesions.

Causal agents: The disease is caused by various species of *Mycosphaerella*. Although it is not well known, it is believed that *M. parkii* (anamorph = *Stenella parkii*), *M. suberosa* (anamorph = not determined) and *M. suttoniae* (anamorph = *Phaeophleospora epicoccoides*) are the most common species on *Eucalyptus* in Brazil.

Control: No control measures have been adopted in Brazil, but for species such as *E. globulus*, *E. maidenii*, *E. dunnii*, and *E. nitens* it is possible to select faster growing clones, which rapidly pass to the less susceptible adult stage and, thus escape from the disease.

***Cryptosporiopsis* leaf spot**

Symptoms: The pathogen infects leaves on the basal third branches without causing significant defoliation. The lesions are light to grayish-brown of varying sizes, semicircular or circular. They are encircled by a dark halo and the center has a dark rust colored spot of up to 6 mm diameter (Ferreira *et al.*, 1998). Typical conidiophores and conidia can be observed microscopically in the histological sections of conidiomata. Like *Coniella fragariae* and *Hainesia lythri*, the fungus penetrates the host through wounds.

Causal agent: *Cryptosporiopsis eucalypti*.

Control: Since the disease does not cause significant economical losses, no specific control measures have been adopted. However, it is believed that planting of resistant genotypes may be the best strategy.

***Ralstonia* wilt**

Symptoms: The first symptoms appear on 4 to 8 month-old plants. Initially, the leaves show

wilting, becoming reddish, yellowish, and latter pale to dark brown in recently dead plants. Stem section of wilted plants, exudates bacterial pus as cream-colored drops.

Causal agent: *Ralstonia solanacearum* (= *Pseudomonas solanacearum*).

Control: Planting of resistant genotypes.

***Ceratocystis* wilt, die-back and canker**

Symptoms: "Die-back", canker, wood discoloration and wilt, leading to plant death.

Causal agents: *Ceratocystis fimbriata*.

Control: Planting of resistant genotypes.

***Eucalyptus* canker**

Symptoms: Infection may be observed on six-month old plants. When it occurs on young or adult plants of small stem diameter or on mini-stumps in clonal hedges, usually causes death by stem girdling. The canker can occur at any height of the stem, but usually occurs at the tree base (basal canker), causing superficial or deep lesions on the bark surrounded by callus. A typical canker is formed if the lesion is deep and localized at a specific point of the trunk, while in superficial lesions, not reaching the cambium, the plant responds by producing new tissues resulting in the trunk swelling and bark cracking at the infection point. The weakened trunk at this point can break, especially in regions of strong winds. Dark pycnidia and or perithecia produced on dead bark are the signs of the disease, essential for unequivocal diagnosis.

Causal agent: *Cryphonectria cubensis* (= *Diaporthe cubensis* = *Endothia eugeniae*).

Control: Planting of resistant species, provenances, families or clones. *Corymbia citriodora*, *C. torelliana*, *Eucalyptus cloeziana*, *E. pilularis*, *E. paniculata*, *E. pellita*, *E. urophylla*, *E. robusta*, *E. resinifera*, and *E. microcorys* are the more resistant species, while provenances of *E. grandis* and *E. saligna* are the most susceptible. However, there is a high intra-specific variability as to resistance, which allows for selection and cloning of resistant genotypes for planting. In clonal hedges, canker can be controlled by selective shoot harvesting that reduces the stress on the mini-stumps, avoiding predisposition to the disease.

Pink disease or rubellosis

Symptoms: Lesions and girdling on the stem and branches of 1 to 3-year old plants. A pink colored mycelium grows on young lesions. Epicormic shoots emerge from below the girdled portion of the stem. Later, the lesions dry out and lose the typical color, leaving behind cankers on the thicker non-girdled stem and branches. The stem may break and lose apical dominance. Pink to salmon colored mycelium, containing basidia and basidiospores may be observed on the lesions.

Causal agent: *Erythricium salmonicolor* (= *Corticium salmonicolor*).

Control: Selection and cloning of resistant genotypes.

***Coniothyrium* canker**

Symptoms: Small discreet necrotic lesions with a strong depression in the bark are formed along the trunk. The infection occurs through the younger tissues of the green stem. In highly

susceptible genotypes, the lesions coalesce causing extensive necrosis, generally followed by kinopocket formation (gummosis) and reduced plant growth, die back, and emission of epicormic shoots along the trunk, due to partial cambium death and stem girdling. The fungus produces globose and sub-stomatal pycnidia, containing conidiospores and conidia.

Causal agent: The disease, first described in South Africa, was attributed to *Coniothyrium zuluense* (Wingfield *et al.*, 1997). In Brazil the disease was found on *Eucalyptus grandis* and attributed to *Coniothyrium* sp (Ferreira 1997).

Control: In Brazil, it has not caused serious damage to the affected plants, thus no control measures have been adopted.

Cytospora canker

Symptoms: *Cytospora* is a weak parasite that generally infects physiologically weak plants. Typical pycnidial conidiomata, containing conidiospores and conidia of the fungus can be observed on the dead bark.

Causal agent: In Brazil, the disease has been attributed to *Cytospora eucalypticola*, teleomorph *Valsa ceratosperma* (Auer e Krugner, 1994).

Control: No specific control measures have been adopted.

Botryosphaeria canker

Symptoms: Infection occurs in young tissues, resulting in breakage with the forking of the main stem at the infection point, gum exudation, darkening, depression and bark cracking. Generally, the lesions are superficial and confined to the bark region, showing fructification of the pathogen. Pseudothecia containing asci and ascospores are formed on the lesions **Causal agent:** *Botryosphaeria ribis*.

Control: No specific control measures have been adopted.

SOURCES OF DISEASES RESISTANCE AND BREEDING STRATEGIES

Considering that a relatively small number of clones, possibly with narrow genetic base, are planted in some regions of Brazil, it is imperative to establish an inter-species breeding program to obtain new resistant genotypes. Predicting the eventual dry periods and predominance of high temperatures, drought resistant species, such as *E. camaldulensis*, should be considered for crossings. Other species, such as *E. pellita* (Papua New Guinea provenance) and *E. urophylla*, are excellent source of resistance to canker. The former is also an important source of resistance to leaf blights. On the other hand, *E. globulus* can be used as a gene source for reducing the lignin and extractive contents, increasing wood density, improving pulp yield and fiber quality, while *E. grandis* (Atherton or Coff's Harbour) has high adaptability and is suitable for high cellulose yield. Introgression of genes of *E. globulus* should be done from pollen obtained from elite mother-plant from southern part of Brazil, Uruguay, Spain, Chile, Portugal or Australia, where it is possible to cultivate these plants as a pure species. In the final composition,

hybrids should contain 50 to 75% genes of *E. grandis*, obtained by a series of crossing and back crossings, and selfings if necessary.

However, *E. deglupta*, *E. resinifera*, and *E. robusta* can also be tested, although little is known about their resistance to diseases, fiber quality, and adaptability. Since *E. globulus* and *E. pellita* have contrasting characteristics, for example, disease resistance, site adaptability and extractives and lignin content, they should contribute a maximum of 12.5% of genes in constituting inter-specific hybrids. Since wood lignin and extractives have essential functions in defense mechanisms, reduction of their concentrations can potentially result in higher susceptibility. Thus, in each generation of crosses, the resistant genotypes should be selected through artificial inoculation with specific pathogens of interest for each region. It is also essential to determine the resistance of commercial clones and its genetic basis, to different diseases such as stem canker, rust, leaf blights (fungal and bacterial), ceratocystis wilt, and bacterial wilt through artificial inoculations of controlled crossing progenies. When resistance is dominant, resistant homozygous mother-plants should be used for seed harvesting, since irrespective of the pollen origin, the progeny should be resistant.

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