EUCALYPTUS LEAF PATHOGENS IN SOUTH AFRICA: A NATIONAL PERSPECTIVE

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SUMMARY

Mycosphaerella molleriana is commonly regarded as the most important leaf spot pathogen in South Africa. In recent years, it has been found to occur in association with other leaf pathogens such as *Pseudocercospora eucalyptorum*, *Aulographina eucalypti* and *Phaeoseptoria eucalypti*, which are all regarded as important. Although the association between these fungi is poorly understood, the subsequent increased leaf spot is cause for concern. *M. molleriana* can be severely pathogenic on juvenile *E. nitens* foliage, whereas *M. molleriana*, *P. eucalyptorum* and *A. eucalypti* are noted on intermediate juvenile foliage. On older juvenile to young mature foliage, *M. molleriana* is less prominent, whereas *A. eucalypti* and *P. eucalyptorum* are more important. In addition to these pathogens, numerous other fungi have recently been found associated with leaf diseases of *Eucalyptus* spp. Amongst these is a presently unidentified rust disease which is also regarded as potentially significant.

Keywords: *Eucalyptus* leaf pathogens, interaction

INTROCUCTION

Despite the fact that numerous fungi have been recorded on Eucalyptus leaves worldwide (Crous et al., 1989a, b), very little attention has been given to their pathogenicity, epidemiology and control. In South Africa, pathogenicity has been established for some (Crous et al., 1989c, Crous, 1991), whereas the damage caused by others has been evaluated in plantations (Lundquist and Purnell, 1987; Knipscheer et al., 1990). Furthermore, pathogens such as Mycosphaerella molleriana (Th≠m) ú Lindau, Aulographina eucalypti (Cke. & Mass.) v. Arx & M≠ller, Pseudocercospora eucalyptorum Crous, Wingf., Marasas ú & Sutton and Phaeoseptoria eucalypti Hansf. are widely distributed in South Africa (Crous et al., 1988, 1989a; Crous et al., 1989e; Crous et al., 1991). These pathogens are also associated with severe leaf spotting symptoms on several Eucalyptus spp. (Crous et al., 1989a) and regarded as important in other countries (Magnani, 1965; Dick, 1982; Wall and Keane, 1984; Park, 1988; Crous et al., 1989e; Ferreira, 1989; Crous et al., 1990). Despite the fact that these fungi are pathogens in their own right, they also frequently occur in association with each other. Based on their distribution, pathogenicity and interaction, they are currently regarded as most important in South Africa.

The aim of this paper is to provide a brief review of the most important leaf pathogens of Eucalyptus in South Africa. The current status of these pathogens, both in terms of their taxonomy and impact is briefly outlined. Interactions between them are also considered.

IMPORTANT EUCALYPTUS LEAF PATHOGENS IN SOUTH AFRICA

Mycosphaerella molleriana

Mycosphaerella leaf blotch (MLB) was first recorded in 1929 in the Cape Province and subsequently found in Natal and Transvaal. Doidge (1950) identified the fungus as M. molleriana, and later (Doidge et al., 1953) wrote that MLB is "common and widespread", being "especially common on coppice growth in Natal and the Eastern Cape". In recent years, MLB has been recognised as a serious disease of E. nitens (Deane et Maid.) Maid. and E. globulus Labill. in the Eastern Cape and Eastern Transvaal, precluding the planting of E. globulus and certain progenies of E. nitens (Lundquist and Purnell, 1987).

Up to ten Mycosphaerella spp. have been described from Eucalyptus leaves, each having an unique distribution, host range and symptom expression (Park and Keane, 1982a, b, 1984). It was, therefore, important to determine the correct identity of the Mycosphaerella sp. occurring on Eucalyptus leaves in South Africa. Although Lundquist (1985) referred to M. molleriana, subsequent publications referred to the fungus as M. nubilosa (Cke.) Hansf. (Purnell and Lundquist, 1986; Lundquist and Purnell, 1987). Park and Keane (1984) also made mention of the fact that confusion existed between the identity of these two Mycosphaerella spp.

Initial surveys of forest plantations of the Cape, Transvaal and Natal led us to conclude that only one Mycosphaerella sp. is associated with MLB disease in South Africa (Crous et al., 1989d). The type material of M. nubilosa was therefore re-examined, and found to be identical to the fungus in South Africa. Morphological observations were supported with cultural studies, and ascospores of the South African fungus germinated with germ tubes at right angles to the long axis of the spore, typical of M. nubilosa (Park and Keane, 1982b). Furthermore, colonies grew slowly in culture, and were grey-green in colour, similar to observations for M. nubilosa (Park and Keane, 1982b). When the type material of M. molleriana was examined, it was found that it had been incorrectly measured, and that asci, as well as ascospores were identical to those of the South African material and the type of M. nubilosa.

M. molleriana was described from material collected by von Thümen in Portugal in 1881. Herbarium specimens of MLB on E. globulus were recently collected in Portugal by the second author. An examination of this material once again showed that it was similar to material collected in Australia by Cooke in 1892 (as Sphaerella nubilosa Cooke) and South African material. Additional collections and a comparison of all local material with that already lodged in PREM (National Collection of Fungi, Pretoria) and several other herbaria worldwide (BRIP, DAR, PDD-DSIR, IMI, K) showed that M. nubilosa is a synonym of the earlier described M. molleriana (Crous et al., 1991). The correct designation for the MLB fungus occurring in South Africa is, therefore M. molleriana, and not M. nubilosa.

Mycosphaerella infections are most common on E. nitens, which is planted at high-altitude sites in the Eastern Transvaal because of its frost tolerance (Purnell and Lundquist, 1986; Lundquist and Purnell, 1987). Although the host range of M. molleriana was observed to be significantly greater in South Africa than that reported in Australia by Park and Keane (1982b), the disease was only observed as serious on E. nitens and E. globulus. Lundquist and Purnell (1987) have shown that E. nitens seed sources from New South

Wales (NSW) are significantly more resistant than those from Victoria (VIC). This is probably because VIC provenances grow more vigorously, and remain in the juvenile leaf form longer than those from NSW (Purnell and Lundquist, 1986).

M. molleriana infects juvenile and intermediate foliage and causes extensive defoliation on subspecies of E. globulus and E. cypellocarpa L. Johnson in Australia (Dick, 1982; Park and Keane, 1982b). It has never been reported from lesions on mature foliage (Dick, 1982; Park and Keane, 1982b), although it can penetrate older leaves (Park, 1988). We have recently also found that M. molleriana occurs on mature foliage of E. grandis Hill: Maid., E. saligna Sm. and E. nitens. The fact that MLB is occurring more commonly on mature foliage, is cause for added concern.

The symptoms of MLB vary on different hosts. In general, lesion development starts with small areas on the leaf lamina appearing slightly swollen, becoming chlorotic or light green. Lesions become light brown, often surrounded by a red-purple prominently raised margin. Older lesions coalesce and cause a twisting of the leaf lamina (Crous, 1989). Park (1988) found that in Australia, premature defoliation usually occurred one to two months after symptom appearance. He further concluded that spraying for control is best during the active growing period, and possibly only after two or more consecutive days of rain.

The epidemiology of M. molleriana in South Africa must be studied in order to understand the infection process, preference for juvenile foliage and disease development. This data should then be used in selecting for resistance among E. nitens progenies, clones and hybrids.

Aulographina eucalypti

This pathogen has been known to occur on Eucalyptus leaves in South Africa for more than 40 years (Doidge, 1950). It is also known to have caused extensive defoliation on more than one occasion in Australia (Dick, 1982; Wall and Keane, 1984). In South Africa little is known of this pathogen besides its host range and distribution (Crous et al., 1989a).

Leaf spots induced by A. eucalypti are easily recognised by developing only half-way through the lamina, being circular and corky (Wall and Keane, 1984). The fungus also commonly occurs on leaf petioles, small branches, fruits and bark.

A. eucalypti invades healthy, actively growing leaves. Lesion development is very slow, and symptoms are more common on older than younger leaves. Wall and Keane (1984) found that A. eucalypti can sporulate for several months on leaf litter, and that litter is a potentially important inoculum source. Locally A. eucalypti has been observed causing extensive leaf spotting and defoliation on E. fastigata Deane et Maid. and E. fraxinoides Deane et Maid. Furthermore, it is also commonly found in association with other leaf pathogens, similar to the situation in Australia ans New Zealand (Dick, 1982; Wall and Keane, 1984).

Pseudocercospora eucalyptorum

A Cercospora-like fungus was recently found associated with angular, brown lesions on several Eucalyptus spp. in the Cape, and later in the Transvaal and Natal. Two Cercospora spp. have been reported from Eucalyptus leaves, viz. C. eucalypti Cke. & Mass and C. epicoccoides Cke. & Mass. (Crous et al., 1989e). An examination of the type collections of these fungi showed that they did not contain any Cercospora-like fungus, but rather a pycnidial Coelomycete.

Conidia from the Cercospora-like fungus collected in the Western Cape resembled those described for C. eucalypti, wheras collections from the Knysna area closely resemled those of C. epicoccoides (Chupp, 1953). Conidia from South African collections were found to be morphologically distinct when summer collections were compared with those collected in the winter. Cultural studies showed that conidia were of variable morphology, and that changes in relative humidity led to the production of conidia fitting the descriptions of either C. epicoccoides or C. eucalypti. From these studies we concluded that C. eucalypti and C. epicoccoides were synonymous. Because the material collected in South Africa, as well as that lodged in herbaria elsewhere in the world (CUP, IMI) showed pigmented conidia and conidiophores, it was found that the fungus would be more suitably placed in Pseudocercospora Speg. Due to the lack of type material, the Cercosporoid fungus associated with Eucalyptus leaves in South Africa was described as a new species, P. eucalyptorum (Crous, et al., 1989e).

P. eucalyptorum is found in most countries where eucalypts are grown commercially (Crous et al., 1989). In South Africa, this fungus occurs primarily on older leaves of young or older plantation trees. It has not, however, been found to induce premature leaf abscission, or to occur in nurseries (Crous, 1990c).

Symptom expression varies on different hosts, but is usually seen as angular or subcircular brown lesions, being discrete or confluent and confined by leaf veins (Crous et al., 1989d). Since this fungus was first recognised in South Africa in 1986 (Crous et al., 1989e), it appears to be occurring more commonly and on a wider range of Eucalyptus spp. This suggests that it warrants further attention.

Phaeoseptoria eucalypti Hansf.

P. eucalypti has only recently been recorded from South Africa (Wingfield, 1987; Crous et al., 1988). It is, however, widely distributed in countries where eucalypts are grown commercially (Knipscheer et al., 1990). It is distributed widely throughout South Africa, and occurs on mature trees, seedlings and clonal hedges (Crous et al., 1988).

Although juvenile leaves can be infected, symptom expression is mainly observed on older leaves. Lesions vary in appearance according to the susceptibility of the host, environmental conditions and leaf age (Crous, 1989). Symptoms observed on immature leaves after artificial inoculations vary from leaves with exuding black cirri of spores, to severe cases where leaf shrivelling can occur (Crous et al., 1989c). Intermediate leaves bear red-purple specks on the upper surface, while the lower surface is covered with black exuding spore masses. On older leaves a chlorotic or pale brown to reddish tinge develops on the upper surface, while the lower surface is covered with an black exudate of spores (Crous, 1989). Although pathogenicity trials have shown that it can reduce the growth rate of seedlings when conditions are ideal for the disease (Crous et al., 1989c), its relative importance must still be established in local nurseries and plantations.

Harknessia spp.

Several Harknessia spp. are known to occur on Eucalyptus leaves (Sutton, 1971, 1980; Nag Raj and Di Cosmo, 1981). Two Harknessia spp. occurring on this host in South Africa are Harknessia hawaiiensis Stev. & Young (Crous, 1990b) and H. eucalypti Cke. apud Cke. & Hark. (Crous et al., 1989a; Crous, 1990a). Whereas H. hawaiiensis has only been found on leaves in clonal hedges, H. eucalypti frequently occurs on leaves of young trees. Although the latter species occurs in the Transvaal, it seems to occur much more commonly in the Cape Province. Here, it has been associated with prominent leaf spotting of young E. andrewsii Maid., E. grandis, E. tereticornis Sm. and E. viminalis Labill trees. No infection studies have as yet

been done with any Harknessia sp., and their pathogenicity to Eucalyptus spp. must still be determined.

Leaf rust

No rust fungi are known to occur on Eucalyptus in its area of origin. There are however, early reports of a rust fungus (Melampsora eucalypti Rabh.) occurring on Eucalyptus globulus leaves in India, but these are unconfirmed, and without a valid description (Rabenhorst, 1881). More recently, a rust fungus identified as a species of Melampsora Cast. was reported from a Eucalyptus sp. in India (Upadhyay and Bordoloi, 1975), but no material was retained from this collection. Additional collections of a Melampsora sp. were made in India in 1984, and lodged at the International Mycological Institute (IMI 291489). An examination of this collection confirmed that a rust fungus was present (authors unpublished). Due to the absence of teleospores however, we were not able to confirm it as representative of the genus Melampsora.

In addition to the "Melampsora collection", a severe leaf and stem rust of Eucalyptus is known in Brazil (Ferreira, 1989). It has been determined that this rust is identical to guava rust caused by Puccinia psidii Winter, which is native on indigenous Myrtaceae (including Psidium L. and Syzygium Gaertn. spp.) in Brazil. In Brazil, P. psidii was first reported on eucalypts in 1944 (Joffily, 1944) and within 30 years it was recorded to cause significant losses on South African progenies of E. grandis plantation trees planted in Brazil (Ferreira, 1989). Eucalyptus rust is one of the most important diseases affecting the Brazilian forestry industry (Ferreira, 1989), and considerable concern surrounds the possibility of the entry of this fungus into South Africa.

In 1990, descrete lesions were noticed on young and old leaves of E. nitens in Natal. The lesions were angular, dark brown, and were colonised by creamy to pale yellow, distinctly raised rust pustules. These pustules, which gave the leaves a spotted appearance, occurred predominantly on the lower leaf surfaces (Knipscheer and Crous, 1990).

The rust on E. nitens in South Africa was compared with herbarium specimens of the rust from India, as well as P. psidii from Brazil. Unfortunately both the South African and Indian material consisted only of urediniospore pustules, which are insufficient for the identification of rust fungi. Repeated inoculations have been conducted with the South African material in an attempt to induce the teleospore stage, but these have not been successful. There is no similarity between the leaf rust of Eucalyptus in South Africa and P. psidii, which is also a stem pathogen.

Although the urediniospores of the South African and Indian collection proved to be similar in size, we feel that the South African material can be distinguished from the Indian collection by having shorter urediniophores.

At this stage little more can be done to identify the Eucalyptus rust in South Africa. No information is available to the possibility of alternate hosts, or its possible origin. It might be assumed that the rust has either adapted from indigenous hosts, or has been newly introduced into the country. The presence of a rust disease on Eucalyptus in South Africa should, however, be taken seriously, and the distribution of the disease monitored carefully.

INTERACTION BETWEEN LEAF PATHOGENS

Of the fungi discussed above, only M. molleriana is currently regarded as being of significant importance to the South African forestry industry. This is largely due to the drastic defoliation that it causes on plantation trees. In recent years, however, an interaction has been noted to occur between this fungus, A. eucalypti, P. eucalypti, P. eucalyptorum and Harknessia spp. Such interactions could result in compounding of damage caused by the pathogens when they occur alone.

In general, M. molleriana infects younger to intermediate foliage, while Phaeoseptoria, Aulographina, Pseudocercospora and Harknessia spp. are more frequently associated with symptoms on intermediate to mature foliage. At present, M. molleriana appears to be adapting to infect older foliage of several Eucalyptus spp., including E. nitens. The damage to both immature and mature foliage could result in severe tress to trees.

Research is required on the epidemiology of M. molleriana and its interaction with these other pathogens if any significant control program is to be implemented.

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