UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Chapter One
Impact and Importance of Diseases in Exotic Plantations in Ethiopia and Other African Countries-Literature Review

INTRODUCTION

The demand for forest products has increased considerably over the past 100 years. The result has been the near depletion of indigenous wood sources. This increasing demand for timber and fuel energy has necessitated the establishment of large areas of plantation forests. Plantation forests can be developed using either exotic or native tree species. However, there is a growing worldwide trend towards the establishment of plantations of exotic tree species, especially in the tropics and subtropics (Evans 1984, Turnbull 1991, Persson 1995). These provide a source of energy, paper and pulp and wood extracts such as tannins. Plantations also play a substantial role in agroforestry development, the reduction of soil erosion, run-off control, combating desertification, rehabilitation of degraded land, fodder and they provide shade and shelter (Evans 1984).

The establishment of exotic plantation forestry has grown substantially worldwide. It is estimated that approximately 78 million hectares of exotic plantations exist today (Vercoe 1995). The most commonly planted species are *Pinus radiata* D. Don, *P. patula* Schiede & Deppe, *Eucalyptus grandis* Hill ex Maid and other *Eucalyptus* hybrids and species, Australian *Acacia* spp. and *Tectona* spp. Plantations of *Eucalyptus* spp. alone covers about 10 million ha worldwide (Eldridge *et al.* 1997). The largest exotic plantation forestry countries are Chile, Brazil, Indonesia, South Africa, Australia and New Zealand (Vercoe 1995). In these countries, plantations are utilized mainly for the paper and pulp industries and for sawn timber, forming multi-billion dollar industries.

Many countries in Africa grow large areas of exotic plantations of *Eucalyptus*, *Pinus, Cupressus* and *Acacia* spp., to provide fuel and timber as well as for the production of paper and pulp for the local and especially for the export markets (Evans 1984, Vercoe 1995). Exotic plantations in South Africa for example cover approximately 1.5 million ha, of which *E. grandis* and *P. patula* are the dominant species (Denison & Kietzka 1993, Anonymous 1998). In Kenya, almost all wood required for fuel-wood and industrial purposes are obtained from plantations of exotic species, which include *P. patula, Cupressus lusitanica* Mill. and different *Eucalyptus* spp. (Ciesla, Mbugua & Ward 1995).

Exotic trees are commonly used as plantation species in Ethiopia. The establishment of exotic plantation forestry in this country commenced with the introduction of *Eucalyptus* species, approximately 110 years ago, around 1890 (Persson 1995). Since then, a number of other exotic tree species including *Pinus* spp., *Acacia* spp., and *Cupressus* spp. have been introduced and planted in different parts of the country. Plantations of exotic tree species cover more than 200 000 ha of land (Anonymous 1994, Vercoe 1995).

To meet the increasing demands for wood and wood products, both natural forests and plantation forests have to be protected. Threats against these wood sources include fire, indiscriminate cutting, encroachment, pests and diseases. The occurrence of pathogens on woody plants is a common phenomenon on trees growing in natural forests, plantations and ornamentals and has resulted in serious losses to forestry programmes worldwide (Manion 1981, Wingfield 1990).

In many countries exotic plantation forestry has been highly successful, largely because these trees have been removed from their natural enemies, found in their areas of origin. This might account specifically to the success of *Eucalyptus* spp. in Africa (Wingfield 1990, Persson 1995, Bright 1998). Exotic plantation species, though separated form their natural enemies, have on the other hand, been planted in a new environment. They can thus be exposed to potentially new pests and diseases, to which they do not have a natural resistance (Wingfield 1990). This situation may increase the disease risk associated with exotics (Wingfield 1987a). Despite being isolated from their natural enemies, a number of serious disease problems have emerged on exotic species in most countries where they have been planted (Wingfield 1990). Both native pathogens originating from endemic hosts as well as accidentally introduced pathogens cause damage in plantations (Wingfield, Swart & Kemp 1991). A large number of new and emerging tree disease have been recorded in the last decade. This may be attributed to the increased movement of people and plant material between countries (Palm 1999, Wingfield & Roux 2000a, Wingfield *et al.* 2001, Allen & Humble 2002).

Pathogenic fungi pose an enormous threat to trees planted in monoculture, due to the uniform age of the trees and the reduced diversity of plantations (Hodges 1979, Wingfield 1990). It is generally believed that monocultures are more vulnerable to disease and pest damage. The damage to monocultures could be serious because risk is not spread widely. Monocultures are also believed to facilitate the emergence of new and more virulent forms of pathogens (Hodges 1979, Heybroek 1980, Libby 1982, Leakey 1987, Roberds, Namkoong & Skrøppa 1990, Persson 1995). On the other hand, it has been shown that the susceptibility of monoculture to disease has been very much generalised and unbalanced. Choice of species and provenances and site selection has more influence than effect of stand composition on incidence of disease in plantations (Chou 1981).

Similarly, pathogens with wide host ranges for example *Armillaria* spp. (Raabe 1962) and *Phytophthora cinnamomi* Rands (Newhook & Podger 1972) could have a devastating effect even in mixed stands.

Fungal tree diseases, especially, have had a major impact on woody hosts world-wide. This includes those caused by both introduced and native pathogens. Chestnut, which was one of the major forest species in North America, has been nearly eliminated by the Chestnut blight fungus, *Cryphonectria parasitica* (Murr.) Barr (Hepting 1974, Anagnostakis 1987, 1988). Similarly, Dutch elm disease caused by *Ophiostoma ulmi* (Busim.) Nannf. and *Ophiostoma novo-ulmi* Brasier has devastated native elm trees in Europe and North America (Gibbs 1978, Brasier 1990). *Cronartium ribicola* Fischer, the cause of White pine blister rust has had a dramatic impact on White pines in America (Ziller 1974). Similarly, Dothistroma needle blight caused by *Dothistroma pini* Hulbury (syn. = *D. septospora*), which was initially identified in the United States of America, occurs in eastern and southern Africa, Chile, Australia and New Zealand and causes devastating damage on exotic *P. radiata* plantations in these countries (Ivory 1968, Gibson 1972, Lundquist & Roux 1984). Pathogens of native plants have also developed the capacity to infect exotic plantation species. For example, rust caused by *Puccinia psidii* G. Winter, a pathogen on native Mytraceae in South and Central America, suddenly appeared on various exotic *Eucalyptus* spp. planted in this region (Coutinho *et al.* 1998).

This review focuses on the importance and impact of pathogens on exotic plantations in some African countries. Special consideration is given to the disease situation in plantations of Ethiopia. Hence, in the following sections, some of the most important diseases of the major exotic plantation species in Africa are discussed. Special emphasis is given to species of *Eucalyptus, Pinus, Cupresses* and Australian *Acacia,* because they are dominant in the plantations of Ethiopia and other African countries.

NURSERY DISEASES

As a result of the use of non-sterilised growth medium and water in many African nurseries, diseases cause significant losses in production. Nursery diseases reduce germination, cause seedling death and enhance malformation and stunting. These result in seedling rejection and lower field survival rates. The most commonly observed disease symptoms include damping-off, root rot, blight, stem cankers and leaf spots (Darvas, Scott & Kotze 1978, Sharma, Mohanan & Florence 1984).

Nursery plants are predisposed to nursery diseases by environmental and management factors. Control of nursery diseases relies heavily on sound sanitation and management. Nursery diseases are commonly spread by infected seed, water and planting media. Mechanical and insect wounds are other factors increasing disease risks. Watering and weeding regimes, spacement and nutrition all impact on nursery health (Bloomberg 1981, Anderson, Belcher & Miller 1984, Dwinell, Barrows-Broaddus & Kuhlman 1985). Available reports of diseases in African nurseries have been summarised in Table 1 and will not be discussed individually.

DISEASES OF PLANTATION *PINUS* SPP. IN AFRICA

Plantations of *Pinus* spp. have been established especially in South, East and Central Africa (Gibson 1979). The most commonly planted species are *P. patula, P. radiata, P. caribea* L., *P. elliottii* Englam and *P. taedea* L. (Gibson 1975, Evans 1984). These trees are grown mostly for industrial purposes, sawtimber, pulpwood and plywood veneers (Evans 1984, Ivory 1987).

Root diseases

***Armillaria* spp**. include some of the most prominent causes of death and decay of coniferous trees and shrubs in natural forests, native and exotic plantations, and gardens world-wide (Wargo & Shaw 1985, Ivory 1987, Shaw & Kile 1991). *Armillaria* spp. have a wide host range and occur in both tropical and temperate areas of the world (Ivory 1987, Shaw & Kile 1991). Reports indicate that *Armillaria* spp. are dominant in deciduous forests as secondary pathogens attacking trees weakened by biotic or abiotic stress. Such stress includes defoliation by insects, frost, drought, foliage diseases, stem cankers, water logging, soil compaction and air pollution (Wargo & Shaw 1985). *Armillaria* spp. can, however, also be aggressive primary pathogens, frequently killing healthy trees of all ages (Wargo & Shaw 1985).

A typical sign of *Armillaria* root rot in forests and plantations are the concentration of dead and dying trees in circular patches. Infections of trees take place through the roots, resulting in root rot and eventual tree death. Root death results in yellowing and wilting of crowns, resin exudation around the root collar and basal areas of stems and well developed white mycelial mats under the bark of infected trees (Bottomley 1937, Lückhoff 1964, Ivory 1987). The wood beneath the fungal mycelium has a soft, wet, stringy, white rot. Under favourable conditions rhizomorphs will form (Ivory 1987, Shaw & Kile 1991). It has been reported that *Armillaria* spp. colonise the stumps of indigenous trees and serve as a source of inoculum for the infection of exotic tree species especially, *Pinus* spp. (Kotze 1935, Bottomely 1937, Lückhoff 1964, Gibson 1970, Ivory 1987).

Armillaria mellea (Vahl:Fr.) Kummer *sensu lato* and *A. heimii* Pegler are names commonly used for the causal agents of Armillaria root rot in Africa (Ivory 1987, Coetzee 1997). Mohammed (1994) assumed that *A. mellea* is the cause of *Armillaria* root rot in temperate regions of Africa. However, recent reports have indicated that *A. heimii*, *A. mellea sensu stricto*, *A. mellea* (Vahl.:Fr.) P. Kumm. sub sp. *africana* Mohammed, *A. mellea* (Vahl.:Fr.) P. Kumm. var. *cameruensis* Henn. and *A. fuscipes* Petch occur in African plantations (Gibson 1975, Pegler 1977, Ivory 1987, Masuka 1989, Mwangi, Lin & Hubbes 1989, Abomo-Ndongo & Guillaumin 1997, Coetzee *et al.* 2000).

Armillaria root rot has been reported in *P. patula*, *P. elliottii*, *P. oocarpa* Shchiete and *P. radiata* plantations in Zimbabwe, Uganda, Kenya, Tanzania, Malawi and South Africa (Lee 1970, Gibson 1975, Ivory 1987, Masuka 1989, Mwangi *et al.* 1989, Abomo-Ndongo & Guillaumin 1997, Coetzee *et al.* 2000). In South Africa, *Armillaria* root rot is known in plantations of several pine species including *P. patula, P. caribea* and *P. elliottii*. (Kotze 1935, Bottomley 1937, Lückhoff 1964). Despite this, the identity of *Armillaria* found in South Africa was not determined until recently. Initially it was arbitrarily called *A. mellea* (Lundquist 1987) and later the pathogen was assumed to be *A. heimii* (Wingfield & Knox-Davies 1980a). Coetzee *et al.* (2000), however, showed that the isolates obtained from plantations in South Africa are clearly different from both *A. mellea* and *A. heimii* and rather represents *A. fuscipes*.

In Zimbabwe, *Armillaria* root rot was considered to be one of the most serious threats to *Pinus* plantations in that country. Affected species included *P. elliotii* and *P. oocarpa* (Masuka 1989). Mwenje & Ride (1996) characterized the *Armillaria* isolates from Zimbabwe into three morphological groups, namely groups I, II, and III. Coetzee *et al.* (2000) showed that most *Armillaria* isolates from Zimbabwe (Harare area) resemble neither *A. fuscipes* that is found in South Africa, nor *A. mellea*, but represents *A. heimii*.

In Kenya Armillaria root rot is widely spread in plantations, indigenous forests and cash crops (Mwangi *et al.* 1994). It was isolated from *P. patula, P. elliottii* and *P. radiata* (Abomo-Ndongo & Guillaumin 1997). Mewnje and Ride (1996) showed that both *A. mellea* and *A. heimii* are found in Kenya.

Sphaeropsis sapinea (Fr.:Fr.) Dyko and Sutton (syn. *Diplodia pinea* (Desm.) Kickx) has a world-wide distribution and is associated with a wide range of disease symptoms (Punithalingam & Waterston 1970, Gibson 1979, Swart, Knox-Davies & Wingfield 1985, Swart, Wingfield & Knox-Davies 1987). It was reported to cause serious root disease on *P. taeda* and *P. elliotii* in South Africa and Swaziland (Wingfield & Knox-Davies 1980a, Swart *et al.* 1985, Swart *et al.* 1987). The above ground symptoms of *S. sapinea* infection include discoloration of the root collar, foliage chlorosis, needle fall, exudation of resin and death of tree tops. It also causes dark blue radial lesions in young roots, which extend into the lateral root and even up to the trunks of trees (Wingfield & Knox-Davies 1980a, Swart *et al.* 1985). This root disease is associated with stress such as overstocking, drought and poor site conditions (Wingfield & Knox-Davies 1980a, Swart *et al.* 1987).

Rhizina undulata Fr. (= *R. inflata* (Schaff.) Krast) is a fire associated pathogen that causes root rot of *Pinus* and other conifers (Morgan & Driver 1972, Lundquist 1984a, Wingfield, Swart & Von Broembsen 1988). It is found in Europe, North America, Africa and Asia (Gibson 1979). According to Germishuizen (1984), *Rhizina* root rot caused serious losses to *Pinus* plantations in South Africa. It was also reported to occur in Swaziland (Germishuizen 1979). Studies indicated that slash burning, which was conducted to remove logging debris, induced infection by *R. undulata* (Morgan & Driver 1972, Germishuizen 1984, Ivory 1987).

***Phytophthora* spp.** are known to cause serious damage to woody plants in many parts of the world and have a wide host range (Zentmyer 1980, Tidball & Linderman 1990, Strouts & Winter 1994, Erwin & Ribeiro 1996). *Phytophthora* spp. are important pathogens in forestry nurseries (Von Broembsen & Donald 1981) and in sites that are wet or with poor soil nutrients (Erwin & Ribeiro 1996). In South Africa, *P. cinnamomi* is associated with root rot and death of several *Pinus* spp., especially *P. patula,* both in nurseries and plantations (Von Broembsen 1984, Wingfield & Knox-Davies 1980b, Linde, Kemp & Wingfield 1994a). Other *Pinus* spp. affected includes *P. pinea* L., *P. radiata, P. elliottii* and *P. patula* (Wingfield & Knox-Davies 1980b, Von Broembsen 1984, Ivory 1987).

***Pythium* spp.** are not considered as important pathogens of mature pine trees (Markes & Kassaby 1974). Yet, some *Pythium* spp. cause death of young *Pinus* seedlings planted out in the field (Linde, Kemp & Wingfield 1994b). Some reports from South Africa indicate that a number of *Pythium* spp. are associated with death of *P. patula* established on previously cultivated lands. *P. irregulare* Buisman was consistently isolated from dying plants as well as from the soil in *Pinus* plantations and is considered as a major cause for the failure of *P. patula* planted on previously cultivated land (Linde, Kemp & Wingfield 1994c).

Helicobasidium compactum Boedijn causes purple root rot and is found in Asia, Europe, Australia and Africa. It was reported from several Central and Southern Africa countries (Gibson 1979). It infects the roots of a wide range of plants including both hardwoods and conifers (Browne 1968). *H. compactum* is associated with root and collar rot of *Pinus* spp. (Bottomley 1937, Gibson 1979) in Zimbabwe, Nigeria, Kenya, Malawi, Tanzania (Browne 1968, Gibson 1975) and South Africa (Bottomley 1937). It causes stunting of terminal shoots, yellowing of needles, wilting and death of trees (Bottomley 1937). Infection by *Helicobasidium* is also associated with collar constriction. It is possible to find purplish brown fungal growth at the base of the tree and at the lowest parts of the branches (Bottomley 1937).

Pseudophaeolus root and collar disease, caused by *Pseudophaeolus baudonii* (Pat.) Rev. (syn. *Phaeolus manihotis* Heim, *Polyporus baudoni* Pat.) is distributed throughout central and Southern Africa (Gibson 1979, Rattan & Pawsey 1981). This pathogen attacked *Pinus* spp. in Congo Brazzaville (Rattan & Pawsey 1981), Ghana (Ofosu-Asiedu 1975) and South Africa (Lückhoff 1955, 1964, Van Der Westhuizen 1973, Lundquist 1987, Wingfield 1987b). Infection spreads by means of root contact. The white to yellow mycelial fans found beneath the bark at the base of trees is used to distinguish the disease. It also produces large yellow fruiting structures on the roots near the base of infected trees (Van Der Westhuizen 1973, Ivory 1987, Wingfield 1987b).

Stem diseases/canker

Sphaeropsis sapinea is arguably the most common stem pathogen on *Pinus* spp. in Africa. Apart from causing root rot, *S. sapinea* is best known for the stem disease it causes on *Pinus* spp. It is known to be an opportunistic pathogen (Marks & Minko 1969, Swart *et al*. 1985) that subsists in cones and stems of healthy pine trees as endophytes (Smith *et al*. 1996a). Disease symptoms are

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

only expressed when trees are under stress (Zwolinski, Swart & Wingfield 1990a, Smith *et al.* 1996a).

Sphaeropsis sapinea is known in pines wherever they are native and has been recorded from most countries where these trees are grown as exotics (Currie & Toes 1978, Gibson 1979, Palmer & Nicholls 1985). It has been associated with a wide range of disease symptoms, both in nurseries and on mature trees in the plantation. Plantation related symptoms include collar rot, shoot blight (Gibson 1979, Wingfield & Knox-Davies 1980b), blue stain, stem and branch cankers (Marks & Minko 1969, Wright & Marks 1970) and root disease (Punithalingam & Waterston 1970, Gibson 1979, Palmer, McRoberts & Nicholls 1988).

In Africa, *S. sapinea* has been recorded as a pathogen of *Pinus* spp. in countries such as Malawi, South Africa, Swaziland, Zimbabwe and Tanzania (Gibson 1964, Lee 1970). *Pinus radiata* and *P. patula* are especially susceptible to infection (Swart *et al.* 1987, Wingfield 1990). In South Africa, a close association with hail damage has been shown (Swart *et al.* 1987). In summer rainfall areas of the country, where hail damage is frequent, the planting of *P. radiata* was abandoned (Wingfield 1990). Similarly, *P. elliottii* replaced *P. patula* in hail prone areas due to the susceptibility of *P. patula* to infection (Lundquist 1987).

It was estimated in 1986 that infection by *S. sapinea* in South Africa has resulted in more than nine million Rand of loss per annum (Zwolinski *et al.* 1990a). Infection by *S. sapinea* not only results in death of trees, but reduces profit through the reduction of increment (Wright & Marks 1970), the loss of marketable volume (Currie & Toes 1978, Zwolinski *et al.* 1990a) and blue stain of timber (Laughton 1937, Da Costa 1955, Eldridge 1961). South African exports of saw logs often loose as much as half their marketable volume due to blue stain of timber (Zwolinski, Swart & Wingfield 1990b).

Needle diseases

Dothistroma needle blight, caused by *Dothistroma pini* Hulbury (=*Dothistroma septospora* Dorog. Morelet) is one of the most important needle diseases of exotic *Pinus* spp. *Dothistroma* needle blight was first recognized as a serious disease of ornamental, windbreak and Christmas trees in the United States of America. The disease was also reported from several other countries, including East and Southern Africa, Chile, Australia and New Zealand in exotic *Pinus* plantations (Ivory

1968, Gibson 1972, Peterson 1977, Lundquist & Roux 1984). According to Ivory (1968), three varieties of *Dothistroma* are found on needles of *Pinus* spp. in different parts of the world. These varieties are *D. pini* Hulbery var. *keniensis* Ivory, *D. pini* var. *pini* and *D. pini* Hulbery var. *linearis* Thyr & Shaw. Of these three varieties only *D. pini* var. *keniensis* has been reported from Africa, whereas *D. pini* var. *pini* is distributed in different parts of the world and *D. pini* var. *linearis* is mainly found in the United States of America and Canada.

In Africa, Dothistroma needle blight was first observed in Tanzania (Gibson, Christensen & Munga 1964, Ivory 1968) and later in Kenya, Zimbabwe, Malawi and Uganda (Gibson 1964, Ivory 1968). The disease spread very fast in *P. radiata* plantations, causing defoliation and stunting of trees (Gibson *et al.* 1964). Because of Dothistroma needle blight, the planting of *P. radiata,* has been mostly abandoned or severely restricted in African countries such as Kenya, Malawi and Zimbabwe (Ivory 1968, Lee 1970, Gibson 1972, Ciesla, Mbugua & Ward 1995). In many other countries, *P. radiata* has been substituted by *P. patula*. Lundquist & Roux (1984) reported the occurrence of *D. pini* in South Africa. It is, however, only found in a very small area of the country and is not considered to be economically important (Lundquist & Roux 1984, Wingfield & Roux 2000b).

Dothistroma needle blight first appears on the lower branches of young trees (Gibson *et al.* 1964, Wingfield & Roux 2000a). Early infection of needles produce yellow bands that later develop a reddish tint as the disease develops. Following this chlorosis, necrosis of the needles appears, first at the base of the tree, later spreading higher up the tree. In favourable conditions, the disease results in severe defoliation, to the extent that only the needles at the extremes of the branches remain (Gibson *et al.* 1964). Black fruiting bodies commonly appear on the dead epidermis in the red bands (Gibson 1964, Wingfield & Roux 2000a). In severe cases infection may result in malformation and tree death. Dothistroma needle blight is more severe in younger trees less than ten years in age (Gibson 1972).

In Tanzania, death of pine trees associated with Dothistroma needle blight was not experienced in areas where the rainfall was below 1500 mm/annum. In these areas only the diameter and height growth was reduced considerably (Christensen & Gibson 1964). A study conducted in Kenya on the effect of defoliation by *D. pini* on the increment rates of *P. radiata,* showed that diameter growth is considerably reduced. Nearly all growth of trees is inhibited when 75% of the foliage is affected (Christensen & Gibson 1964, Gibson *et al.* 1964).

Cercospora needle blight is the other needle disease recorded on various *Pinus* spp. in several African countries (Gibson 1972, 1979, Ivory & Wingfield 1986, Ivory 1987) including Madagascar, East Africa, South Africa, Swaziland, Zambia and Central Africa (Gibson 1964, 1979, Ivory & Wingfield 1986, Ivory 1994). *Cercospora* needle blight is caused by *Cercoseptoria pini-densiflorae* (Hori. & Nambu) Deightn (Telemorph= *Mycosphaerella gibsonii* H. Evans). In South Africa it infects *P. patula* and *P. radiata* (Ivory & Wingfield 1986, Wingfield & Roux 2000a). The disease causes severe defoliation on young pine seedlings in nurseries and plantations. The fungus initially infects old needles and in severe cases, it also attacks young needles (Wingfield & Roux 2000a). Infection causes light green bands on the needles, which later change to yellow, brown and finally to a grey colour. Fruiting bodies are seen on dead needles and are "brush like" and grey in appearance (Wingfield & Roux 2000a).

DISEASES OF PLANTATION *EUCALYPTUS* SPP. IN AFRICA

In Africa, the production of *Eucalyptus* trees takes place either by the raising of seedlings from seed, the production of cuttings or by tissue culture (Leakey 1987, Denison & Kietzka 1993). In South Africa alone, approximately 500 000 ha are planted to a variety of *Eucalyptus* spp. and clones (Anonymous 1998). Other African countries also depend on *Eucalyptus* spp. for export income and importantly, as a substitute for indigenous trees. *E. grandis*, *E. saligna* Sm., *E. globulus* Labil., *E. camaldulensis* Dhen., *E. citriodora* Hook and *E. urophylla* Blake are the most commonly planted species (Gibson 1975, Evans 1984). Several pathogens pose a threat to *Eucalyptus* planting on the continent. The most important of these are presented in the following section.

Root diseases

Phytophthora spp. are among the most common pathogens of *Eucalyptus* spp. (Marks & Kassaby 1974, Heather, Pratt & Chin 1977, Zentmyer 1980). In South Africa, *P. cinnamomi* results in death and stunting of *E. fastigata* Deane and Maid., *E. smithii* R. T. Baker and *E. fraxinoides* Deane and Maid. (Wingfield & Knox-Davies 1980b). Hence, as Linde *et al.* (1994a) indicated, the susceptibility of these species has necessitated planting of other *Eucalyptus* spp. not prone to *P. cinnamomi* root disease. Recently *P. nicotianae* Breda de Haan has been isolated from diseased and dying *E. nitens* trees in the Kwazulu Natal Midlands of South Africa (Maseko *et al.* 2001).

Another Oomycetous root pathogen, ***Pythium splendens*** H. Braun, has been reported to cause mortality of young *E. grandis* in South Africa (Linde, Wingfiled & Kemp 1994d). This fungus has caused a root and root collar disease on established *E. grandis* in the warmer sub-tropical areas of the country (Linde *et al.* 1994d). The disease is characterised by reddening of the leaves, rapid wilting as well as girdling of the roots and root collars and consequent death of trees.

Lasiodiplodia theobromae (Pat.) Griff. and Maubl. (telemorph *Botryosphaeria rhodina* (Cooke) Von Arx.), has been reported from the Republic of Congo in association with rot of *E. grandis* roots (Roux *et al.* 2000a). The root collars and the stems above soil level exuded kino and developed small cankers. The disease spreads from the roots to the root collars and rest of the stem. The cankers associated with this disease caused a complete girdling, wilting and death of branches (Roux *et al.* 2000a).

In Kenya, **Armillaria** root rot has been reported on *E. microcorys* F. Mull and *E. saligna* (Mwangi *et al.* 1989, Onsando, Wargo & Waudo 1997). In South Africa, *Armillaria* root rot has been recorded on *Eucalyptus* sp. planted on a site cleared of indigenous forest (Bottomley 1937, Kotze 1935, Lückhoff 1964), while in Malawi Armillaria root rot was found associated with *E. saligna*, *E. microcorys* and *E. pilularis* Sm. (Lee 1970). Ivory (1987) reported that *Armillaria* spp. also infects *E. pilularis* Sm. in Zimbabwe.

Ganoderma species cause root and butt rot on several woody plants including *Eucalyptus* spp., worldwide (Browne 1968). In Zimbabwe *E. grandis* trees were infected by this pathogen (Masuka 1990, Masuka & Nyoka 1995). The causative agent was identified as *G. sculptrutum* Llyod (Masuka & Nyoka 1995). Infected trees showed longitudinal bark splitting, stem swelling and gummosis, with dark to black lesions on the affected roots. Affected trees developed epicormic shoots and trees died from the crown downwards (Masuka & Nyoka 1995). Basidiocarps of the fungus may be found at the base of the stems or attached to lateral roots (Masuka & Nyoka 1995). Infection causes death of trees in patches or death of trees in a line, with the most recently killed trees at the edges of the patches (Masuka & Nyoka 1995).

Polyporus baudonii Pat. Ryv., also known as *Pseudophaelus baudonii* (Pat.) Ryv. and *Phaeolus manihotis* Heim is found in several African countries on many woody plants (Browne 1968, Gibson 1979, Ivory 1987). This fungus is known to cause root rot on *Eucalyptus* spp. in South Africa and Ghana (Van der Westhuizen 1973, Ofosu-Asiedu 1975, Wingfield & Roux 2000a). *P. baudonii* attacks roots and root collars of susceptible trees. Leaf chlorosis, unseasonal leaf shedding as well as die-back of small branches at one side of the crown are characteristic symptoms of infection. The bark of the infected trees also changes colour and becomes cracked and charred as if it has been burnt by fire (Ofosu-Asiedu 1975).

Stem disease/canker

Cryphonectria canker caused by *Cryphonectria cubensis* (Burner) Hodges is considered to be one of the most serious canker diseases of *Eucalyptus* spp. in the tropics. It has been reported from different countries in Central and South America, Africa, Asia and Australia (Boerboom & Maas 1970, Hodges, Geary & Cordell 1979, Sharma, Mohanan & Florence 1985, Florence, Sharma & Mohanan 1986, Hodges, Alfenas & Ferreria 1986, Wingfield, Swart & Abear 1989, Conradie, Swart & Wingfield 1990). In Africa, Cryphonectria stem canker has been reported on *Eucalyptus* from Northern Africa (Gibson 1981), Cameroon (Sharma *et al.* 1985), South Africa (Wingfield *et al.* 1989, Conradie *et al.* 1990), and the Republic of Congo (Brazzavile) (Roux *et al.* 2000b).

Cryphonecria canker has been reported on many different *Eucalyptus* spp. In Africa these include *E. grandis* in South Africa, *E. grandis* and *E. urophylla* in the Congo (Sharma *et al.* 1985, Conradie *et al.* 1990, Roux *et al.* 2000b). It is not known which species were affected in Cameroon and North Africa. Typical symptoms of Cryphonectria canker in South Africa differ from those found in other parts of Africa and the world. In South Africa, the disease is characterised by the formation of swollen, cracked, basal cankers and root/collar rot (Wingfield *et al.* 1989, Conradie *et al.* 1990). Young trees die readily from root and root collar infections, while older trees tend to become stunted (Wingfield *et al.* 1989, Conradie *et al.* 1990). In the Congo, Cryphonectria canker is characterised by the more typical target shaped stem cankers found on above grounds parts of the trees such as those described from other parts of the world (Roux *et al.* 2000b). These stem cankers commonly coalesce to girdle and kill and can occur over the length of the stem, often around branch knots (Sharma *et al.* 1985, Wingfield & Roux 2000a). Long-necked fruiting bodies, with orange spore masses, form abundantly in the cracks and the basal cankers (Wingfield & Roux 2000a). In South Africa the disease has lead to the abandonment of some clones in subtropical areas of the country (Wingfield 1990).

Cryphonectria eucalypti Venter & M.J Wingfield, previously known as *Endothia gyrosa* (Schew) Fr. represents a newly described fungus, which is known to occur only in South Africa and

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Australia (Venter *et al.* 2001). In South Africa it is commonly known as a pathogen of minor concern (Van der Westhuizen *et al.* 1993, Wingfield & Roux 2000a). Symptoms of infection are commonly characterised by the formation of superficial cracks in the bark of trees. These cankers commonly form in bands and may occur over the length of tree stems, although they are often most concentrated towards the bases of trees (Van der Westhuizen *et al.* 1993, Wingfield & Roux 2000a, Venter *et al.* 2001). Orange fruiting bodies are common between the cracks on infected stems. In some cases, these cracks provide entry sites for opportunistic pathogens such as *Botryosphaeria* spp. In some parts of South Africa, the pathogen has been associated with cankers and death of young stressed trees (Venter *et al.* 2001).

Coniothyrium canker is a relatively newly discovered and important stem canker disease of *Eucalyptus* spp. This disease was first observed in 1988 in South Africa (Wingfield, Crous & Coutinho 1996). The causal agent was described as *Coniothyrium zuluense* Wingfield, Crous & Coutinho (Wingfield *et al.* 1996). The disease most typically damages *E. grandis* propagated from seed. It is also reported to affect several *E. grandis* clones and hybrids of *E. grandis* with *E. urophylla* and *E. camaldulensis* (Wingfield *et al.* 1996) in the warmer, humid areas of South Africa. The disease is characterised by discrete necrotic lesions on young green bark. At later stages, it forms large necrotic patches, which may spread over most of the stem. In severe cases, the trees produces epicormic shoots as a result of infection. In advanced stages of disease, infection may lead to top die-back and subsequent reduction in height growth (Wingfield *et al.* 1996, Wingfield & Roux 2000a).

Botryosphaeria spp. and their anamorphs in the genera *Fusicoccum*, *Lasiodiplodia*, *Sphaeropsis* and *Microphomopsis* have one of the widest host ranges known for any group of pathogens. Amongst these hosts are many species of *Eucalytpus*. In Africa, confirmed reports of *B. rhodina* (anamorph: *Lasiodiplodia theobromae*) on *Eucalytpus* spp. have been made from South Africa (Smith, Kemp & Wingfield, 1994), the Republic of Congo (Roux *et al.* 2000b), Uganda (Roux *et al.* 2001a) and Malawi (Gibson 1964). Recently, a new *Botryosphaeria* sp., namely *B. eucalyptorum* Crous, H. Smith et M. J. Wingfield has been described on *Eucalyptus* in South Africa. This *Botryosphaeria* sp. is reported to be associated with cankers of the main stems of *E. grandis* and *E. nitens* (Deane Et maid.) Maid. (Smith *et al.* 2001).

Symptoms of infection by *Botryosphaeria* spp. range from leaf spots, to stem cankers, tip and shoot blight and root rot (Davison & Tay 1983, Barnard *et al.* 1987, Shearer, Tippett & Bartle 1987, Smith *et al.* 1994). Stem cankers are characterized by cracking of the bark and the exudation of resin (Smith *et al.* 1994). When the bark is removed, extensive resin formation is observed in the cambium and wood (Smith *et al.* 1994). Trees often recover from current infections, resulting in dead, discoloured heart wood (Smith *et al.* 1994, Roux *et al.* 2000b), and such trees continue to grow until the next infection cycle.

Stress is known to be a major factor contributing to development of diseases caused by *Botryosphaeria* spp. on *Eucalyptus* spp. (Smith *et al.* 1994). According to Smith *et al.* (1994), plantations situated on marginal land are especially prone to infection by *B. dothidea* (Moug.) Ces. De Not. This pathogen is frequently associated with damage from hot and cold winds, late frost, drought, mechanical damage from hail, insect feeding or silvicultural practices (Schoeneweiss 1979, Ramos *et al.* 1991, Smith 1995, Wingfield & Roux 2000b).

B. dothidea occurs as latent endophytic infections in several *Eucalyptus* spp. (Bettucci & Saravay 1993, Fisher *et al.* 1993, Smith *et al.* 1996a, Smith, Wingfield & petrini 1996b). In South Africa, *B. dothidea* was reported to be found as a latent pathogen in *E. camaldulensis*, *E. grandis*, *E. nitens* (Deane et Maid) Maid. and *E. smithii* R. T. Bak. (Smith *et al.* 1996a, 1996b). It causes asymptomatic endophytic infections in the leaves and in the xylem of *E. grandis* and *E. nitens*. Symptoms appear only when environmental conditions favour disease development (Bettucci & Saravay 1993).

Cytospora spp. and their *Valsa* telomorphs are commonly isolated from *Eucalyptus* spp. in association with cankers. *Cytospora australiae* Speg, *C. eucalypticola* Van der Westhuizen and *C. eucalyptina* Speg., have been reported to cause cankers on *Eucalyptus* spp. in South Africa (Van der Westhuizen *et al.* 1993, Wingfield & Roux 2000a). *Cytospora* spp. were also reported in association with stem cankers of *Eucalyptus* spp. in Congo and Uganda (Roux *et al.* 2000b, Roux *et al.* 2001a). In Malawi, Cytospora cankers were observed on *E. saligna*, *E. citriodora* and *E. maculata* Hook (Lee 1970). These opportunistic pathogens are mainly isolated from trees under severe stress due to drought, or trees planted in wet swampy areas with poor drainage. Mechanical wounds are also common sites of infection (Shearer *et al.* 1987, Old, Yuan & Kobayashi 1991, Roux *et al.* 2001a). It is assumed that these fungi are endophytes (Smith 1995, Wingfield & Roux 2000b) although this matter has not been comprehensively investigated.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

In tropical areas of the world, woody plants including *Eucalyptus* and *Acacia* spp. suffer from a canker disesase commonly known as **pink disease**. In South Africa, *E. macarthurrii* Deane & Maiden is attacked by the pink disease pathogen, *Erythricium salmonicolor* (Berk & Broome) Burds. [syn. *Corticium salmonicolor* Berk. & Br., *Phanerochaetea salmonicolor* (Berk. & Br.) Julich] (Wingfield & Roux 2000b, Roux *et al.* 2001c). Infection by *E. salmonicolor* causes the inner tissue of the bark, mainly the phloem and the cambium to become brown and eventually die. Later, epicormic shoots develop just below the cankered region. These epicormic shoots also die due to downward spread of infection and a wilting of young shoots (Sharma *et al.* 1988). Apart from South Africa, pink disease has been reported from *Eucalyptus* spp. in Nigeria and the Democratic Republic of Congo (Gibson 1964).

Leaf diseases

Leaf diseases can have a serious impact on the growth of trees. Many fungi have been recorded on *Eucalyptus* leaves (Gibson 1975, Lundquist & Baxter 1985, Crous, Knox-Davies & Wingfield 1989a). In severe cases these fungi may result in complete defoliation of trees and seriously impact on tree growth.

Cylindrocladium leaf blight, caused by several species of *Cylindrocladium* is one of the most devastating leaf diseases of *Eucalyptus* spp. *Cylindrocladium* leaf blight has been reported from several countries, especially in the tropics. Reports from Africa include those from South Africa (Crous, Phillips & Wingfield 1991) and the Republic of Congo (Brazzaville) (Roux *et al.* 2000b). Cylindrocladium leaf blight caused by *C. theae* (Petch) Subramanian was observed on *Eucalyptus* in the Congo in 1998 (Roux *et al.* 2000b). Lesions initially develop at the edges of leaves and gradually affect the entire leaf. The disease was also observed on twigs and branches. Leaves die on one or two branches and in severe cases the entire tree can be defoliated (Roux *et al.* 2000b). In South Africa, *C. colhounii* Peerally var. *macroconidialis* Crous, Wingfield & Alfenas var. nov. and *C. pauciramosum* C. L. Schoch et Crous have been recorded on *Eucalyptus* (Crous, Philips & Wingfield 1993, Schoch *et al.* 1999).

Mycosphaerella leaf blotch disease (MLB) on *Eucalyptus* is associated with 30 species of *Mycosphaerella* Johnson (Crous 1998, Carnegie 2000, Hunter *et al.* 2002) and has a world-wide distribution including the tropics, subtropics, temperate and Mediterranean areas (Lundquist & Purnell 1987, Crous *et al.* 1989a, Carnegie & Keane 1994). Infections of *Eucalyptus* spp. by

Mycosphaerella spp. often show high host specificity (Crous & Wingfield 1996). For example, *M. cryptica* (Cooke) Hansf. is responsible for foliage damage on both juvenile and mature trees of *E. nitens* (Carnegie 1991), whereas *M. molleriana* Lindau. is the main cause of such foliage damage on *E. globulus* and *E. maidenii* F. Muel. (Lundquist & Purnell 1987).

Leaf spot fungi in the genus *Mycosphaerella* result in severe leaf necrosis, premature defoliation and loss of growth in *Eucalyptus* plantations (Crous *et al.* 1989a). In Africa, *M. molleriana* is responsible for leaf spot and defoliation on both juvenile and mature trees of *E. globulus* (Dungey *et al.* 1995, Lundquist & Purnell 1987). *M. molleriana* has resulted in an inability to establish *E. globulus* and *E. maidenii* in South Africa (Wingfield 1990). Similarly, planting of *E. nitens*, the most promising tree species for afforestation of frost prone areas is restricted because of attack by *Mycosphaerella* spp. (Lundquist 1985, Wingfield 1990). *Mycosphaerella* leaf blotch has also been reported from Uganda (Roux *et al.* 2001a), Zimbabwe and Kenya (Gibson 1964) as well as from Malawi (Lee 1970).

Mycosphaerella nubilosa (Cooke) Hansf. (Syn. *Sphaerella nubilosa* Cooke) is another *Mycosphaerella* sp. found in South Africa and Zambia. This fungus is the cause of leaf spot and blight of *E. globulus, E. maidenii, E. regnans* F. Mueller, *E. viminalis* L. and several other *Eucalyptus* spp. (Gibson 1975, Park & Keane 1982, Lundquist & Baxter 1985, Lundquist & Purnell 1987). Recently five new *Mycosphaerella* spp., namely *M. juvenis* Crous et M.J. Wingf. (Anamorph: *Uwebrauni juvenis* Crous et M.J. Wingf.), *M. africana* Crous et M.J. Wingf., *M. ellipsoidea* Crous et M.J. Wingf. (anamorph: *Uwebrauni ellipsoidea*), *M. crystallina* Crous & M.J. Wingf., and *M. lateralis* Crous et M.J. Wingf. (anamorph: *Uwebrauni lateralis* crous et M.J. Wingf.) were described in association with different *Eucalyptus* spp. in South Africa (Crous & Wingfield 1996). In South Africa, *M. marksii* Carnegie & Keane has also been reported from *E. grandis* and *E. nitens* (Crous & Wingfield 1996).

Phaeoseptoria eucalypti Hansf. Emand [syn=*Kirramyces epicoccoides* (Cooke & Massee)] J. Walker, B. Sutton & Pascoe, which is now more correctly known as *Phaeophleospora epicoccoides* (Cooke & Massee) Crous, F.A. Ferreira & Sutton, (Crous, Ferreira & Sutton 1997), has been recorded in Malawi, Zambia and South Africa (Chipompha 1987, Wingfield 1987a, Crous, Knox-Davies & Wingfield 1988, Shakacite 1991). It causes discrete leaf spots on several *Eucalyptus* spp. (Crous, Knox-Davies & Wingfield 1989b). High levels of infection have been reported on *E. camaldulensis, E. globulus, E. saligna, E. grandis* and *E. tereticornis* Sm. (Chipompha 1987, Crous *et al.* 1988), whereas the infection levels recorded on *E. grandis* have tended to be low. Infection is commonly observed on the older leaves and lower branches of trees (Crous *et al.* 1989b). Infected leaves initially develop numerous minute spots with purple margins. As infection develops the spots enlarge slightly. Black masses of spores are found on the under surfaces of the spots. In severe cases, infection leads to defoliation (Sharma *et al.* 1984, Chipompha 1987, Crous *et al.* 1988). According to these authors, the disease also affects seedlings in nurseries. Nichol, Wingfield & Swart (1992) indicated that plantation establishment conditions such as site preparation and fertilisation influence the susceptibility of *Eucalyptus* spp. to infection by *P. eucalypti.*

Two ***Pestalotiopsis*** spp. have been reported from *Eucalyptus* leaves in African countries. *Pestalotiopsis disseminata* (Thum.) Steyaert is reported to cause brown leaf blight on *E. citriodora*, while *P. funerea* (Desm.) Steyaert (syn.=*Pestalotia funerea* Desm.) has been reported to cause leaf spots on *E. globulus* (Doidge *et al.* 1953, Lundquist & Baxter 1985).

Aulographina eucalypti (Cooke & Massee) Von Arx and Muller [anamorph: *Thyrinula eucalypti* (Cooke & Mass.) Swart] was recorded in South Africa on several *Eucalyptus* spp. including *E. globulus*, *E. grandis* and *E. nitens* (Crous *et al.* 1989b). It causes circular necrotic lesions on the upper or lower leaf surfaces (Doidge *et al.* 1953, Lundquist & Baxter 1985) and may result in extensive defoliation (Crous *et al.* 1989b). This disease is also known as corky leaf spot because of the distinct raised, corky spots, often with concentric rings.

Pseudocercospora eucalyptorum Crous, Wingfield, Marasas and Sutton (Crous *et al.* 1989c), *Coniothyrium ovatum* Swart (Crous *et al.* 1988), *Fairmaniella leprosa* (Fairm.) Petrak and Syd. (Crous, Knox-Davis & Wingfield 1989d) and *Harknessia eucalypti* Cke. Apud Cke. & Hark. (Crous *et al.* 1989d) are among the other leaf pathogens recorded on several *Eucalyptus* spp. in South Africa. *Harknessia eucalypti, Pestalotiopsis* sp., *Botrytis* sp. and *Melanconium eucalypticola* Hansf. were reported from Zimbabwe in association with *Eucalyptus* spp. (Gibson 1964). *Harknessia* sp. and *Cryptosporiopsis* sp. have also been recorded on *Eucalyptus* spp. in Uganda (Roux *et al.* 2001a). *Conniella fragariae* (Oud.) Sutton was reported as the cause of leaf spot on *Eucalyptus* in Congo (Roux *et al.* 2000b). These diseases were not considered to be of great economic importance.

Wilt diseases

Wingfield (1990) indicated that the number of diseases affecting forest trees can be expected to increase significantly in the future. A large number of pathogens that have as yet, not appeared in a country, could result in devastation. For example Roux *et al.* (2000a) discovered an important new wilt and die-back disease of *Eucalyptus* in the Congo in 1998. The causal agent of this disease was identified as ***Ceratocystis fimbriata*** Ell. and Halst (Roux *et al.* 2000a). *Ceratocystis* spp. are well known causal agents of wilt disease and are amongst the most serious pathogens of woody plants in the world (Kile 1993). They range from weak pathogens to aggressive primary pathogens (Kile 1993).

The occurrence of *C. fimbriata* as a pathogen of *Eucalyptus* spp., in the Republic of the Congo, was the first record of a *Ceratocystis* sp. causing a vascular wilt on *Eucalyptus* spp. in the world. Infection by this pathogen led to a serious wilt disease of *E. urophylla* X *E. pellita* F. Muell (UP) and *E. tereticornis* Sm. X *E. grandis* (Roux *et al.* 2000a). Ceratocystis wilt has also recently been found in Uganda (Roux *et al.* 2001a). Plantations of *E. grandis* trees showed the development of epicormic shoots, dead tops and tree death (Roux *et al.* 2001a). Close examination of the main stems of the affected trees revealed extensive brown to blue streaking of the xylem. As was the case in the Congo, *Ceratocystis* wilt in Uganda resulted in high levels of mortality (Roux *et al.* 2001a). The most typical symptoms of this disease is the irregular (streaks) dark brown discoloration of the xylem (Roux *et al.* 2001a).

Bacterial wilt of *Eucalyptus* spp. caused by ***Ralstonia solanacearum*** Yabuuchi *et al.* (syn.: *Pseudomonas solanancearum*) was first described from Brazil (Hayward 1964, Ciesla, Diekmann & Putter 1996). The first report of bacterial wilt of *Eucalyptus* in Africa was in the mid 1990's, from South Africa (Coutinho *et al.* 2000). Its occurrence was also reported from the Republic of Congo and Uganda (Roux *et al.* 2000a, 2001a). The isolates found in Congo belong to Biovar 3, similar to the bacteria found in South Africa (Roux *et al.* 2000a, Coutinho *et al.* 2000). *Ralstonia solanacearum* survives in soil or on plant debris. This bacterial pathogen affects several different *Eucalyptus* spp., which include *E. urophylla, E. camaldulensis, E. grandis,* and *E. saligna. R. solanacearum* causes root disease and cracking around the root collars of infected trees (Roux *et al.* 2000a). The disease also causes extensive xylem discoloration and black streaks are present in the discoloured xylem (Hayward 1964, Roux *et al.* 2000a). A creamy to white bacterial ooze appears on the surface of cut stems (Roux *et al.* 2000a).

DISEASES OF PLANTATION *CUPRESSUS* SPP. IN AFRICA

Trees in the *Cupressaceae* are widely planted in African countries as a source of sawn timber (Nsolomo, Madoffe & Maliondo 2000). In Africa, information on the diseases affecting the *Cupressaceae* is very limited, despite the fact that mortalities are commonly experienced.

The best described disease of the *Cupressaceae* in Africa is **Seiridium canker**. This destructive canker disease is caused by *Seiridium* spp. and is described world wide as a devastating disease in plantations and on ornamental cypresses (Graniti 1986). *S. cardinale* (Wagener) Sutton, *S. unicorni* (Cke and Ell.) Sutton & Gibson and *S. cupressi* (Guba) Boesewinkel are the three *Seiridium* spp. involved in causing stem canker on *Cupressaceae* (Boesewinkel 1983, Graniti 1986, Barnes *et al.* 2001). All three species have been found in Africa, although the taxonomy of these fungi has been a matter of substantial debate.

Seiridium canker has been reported from Kenya, North and South Africa (Rudd Jones 1953, Nattras Booth & Sutton 1963, Graniti 1986, Wingfield & du Toit 1986). The disease results in twig and branch cankers characterized by reddening or browning of the living bark. Infection results, in necrosis of tissue and gradually leads to girdling of the branches and stems of plants. This eventually results in death, first of the branches and then entire trees (Graniti 1986, 1998).

Seiridium canker, caused by *S. cupressi* (syn= *Rhynchosphaeria cupressi*) has resulted in serious losses in Kenya (Rudd Jones 1953, 1954a, 1954b, Gibson 1964). In this country, damage to fast growing *C. macrocarpa* Hartw. has resulted in termination of the planting of this tree. It has been substituted by slow growing, but less susceptible, *C. lusitanica* Mill. (Gibson 1964). Apart from Kenya, Seiridium canker has also been reported from Malawi, South Africa, Tanzania and Uganda (Gibson 1964, Graniti 1986, Wingfield & du Toit 1986).

Other diseases of *Cupressaceae* reported from Africa include stem gall, caused by *Agrobacterium tumefasciens* (Smith & Towsend 1907) Conn 1942 from Uganda and Kenya (Gibson 1964) and *Rhizoctonia lamellifera* Small. from *C. lusitanica* in Kenya (Gibson 1964). A serious stress-related disease caused by *Sphaeropsis sapinea f.* sp. *cupressi* Solel *et al.* has also been reported from South Africa (Linde, Kemp & Wingfield 1998). In Kenya, Armillaria root rot is found in association with *Cupressus lusitanica* (Mwangi *et al.* 1989, Onsando *et al.* 1997).

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

DISEASES OF PLANTATION *ACACIA* SPP. IN AFRICA

A number of Australian *Acacias*, commonly known as wattles, have been introduced into Africa. *A. mearnsii* de Wild., *A. decurrens* Wendl., *A. mangium* Wild. and *A. auriculiformis* A. Cunn. Ex Benth are the major species planted in Africa (Anonymous 1978, Kihiyo & Kowero 1986, Khasa, Jallee & Bousquet 1994). Mostly, *Acacias* are used to extract tannin, for timber, pulp production, to promote biological nitrogen fixation and some are used for sand dune stabilization (Anonymous 1978, Kihiyo & Kowero 1986, Ngulube 1988, Khasa *et al.* 1994). Roux, Kemp & Wingfield (1995) provided an extensive review of the diseases of *A. mearnsii* in South Africa. The current treatment will, therefore, only briefly mention the major diseases of this tree in South Africa and will focus on diseases of other *Acacia* spp. and other African countries.

Root diseases

Phytophthora spp. are commonly associated with root diseases of Australian *Acacia* spp. *Phytophthora nicotianiae* (Dastur) Waterhouse [*P. parasitica* (Dastur)] was first reported from *A. mearnsii* in South Africa in the 1960's (Zeijlemaker 1971). The disease caused by *P. nicotianiae,* is commonly called black butt disease and results in collar rot of infected trees (Zeijlemaker 1971). The disease derives its common name from the resultant black discoloration and cracking of the bark at the bases of trees (Zeijlemaker 1971, Roux 2002). Infection may result in the death of trees, in a reduction of bark yield as well as a reduction in the quality of the thickest most valuable bark at the bases of trees (Sherry 1971, Haigh 1993, Roux & Wingfield 1997). More recently Roux & Wingfield (1997), isolated other *Phytophthora* spp. from black butt and root disease symptoms of *A. mearnsii* in South Africa. These included *P. boehmeriae* Sawada and *P. meadii.* McRae. In pathogenicity trials, both species were shown to be capable of causing lesions similar in size to those caused by *P. nicotianae* (Roux & Wingfield 1997).

It has been suggested that black butt is a complex of diseases not caused by a single organism (Zeijlemaker 1968). This hypothesis was supported by results of a survey conducted by Roux and Wingfield (1997). Several other pathogens were isolated from disease symptoms. It is currently thought that *Phytophthora* spp. are the primary pathogens resulting in cracks and other wounds that become infected by secondary and opportunistic pathogens. Reports also state that *P. nicotianae* can only be isolated from the basal part of infected trees (Wingfield & Roux 2000a, Roux 2002).

i 16522448
b 15944463

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

This has, however, been shown to be inaccurate, with *Phytophthora* spp. being isolated from areas at breast height and also from the xylem of wilting trees (Roux, personal communication).

In South Africa, three ***Ganoderma*** spp. are reported to be associated with root and collar rot of *A. mearnsii* (Gibson 1964, Lückhoff 1964). *Ganoderma lucidum* (Leyss.:Fr.) Karst causes white spongy rot (Bakshi 1976, Gorter 1977), *G. applanatum* (Pers. Wallr.) Pat. causes heart rot and *G. rugosum* Blume and Nees has been given as the cause of collar rot (Gibson 1964, Lückhoff 1964, Sherry 1971).

It has been reported that ***Lasiodiplodia theobromae*** (Synonym= *Botryodiplodia theobromae* Pat., *Diplodia natalensis* Pole Evans) caused collar rot of *A. mearnsii* in South Africa (Sherry 1971, Gibson 1975, Roux, Wingfield & Morris 1997). The disease is reported to affect the whole root system and infection spreads up the stems to form black cankers. In South Africa, several other root pathogens have also been recorded on *A. mearnsii*. These include *Macrophomina phaseolina* (Gibson 1975, Bakshi 1976), *Armillaria mellea* sensu lato and *Rhizoctonia* sp. (Kotze 1935, Laughton 1937). In Kenya, Armillaria root rot is found in association with *Acacia mearnsii, A. melanoxylon* R. Br. and *A. saligna* (Labill.) HL Wendl. (Mwangi *et al.* 1989, Onsando *et al.* 1997). Armillaria root rot, which is broadly ascribed to *A. mellea*, and collar rot caused by *Corticium* spp. have also been recorded on *A. mearnsii* in Malawi (Lee 1970).

Stem diseases/canker

In recent years, severe mortality of *A. mearnsii* has been reported from South Africa, caused by ***Botryosphaeria dothidea*** (Roux *et al.* 1995, Roux *et al.* 1997, Roux 2002). Infection causes stem cankers, tip die-back, wilt and death of infected trees. The internal symptoms of *Botryosphaeria* canker and wilt include discoloration and death of the cambium and xylem, which is manifested as a visible dark brown ring in cross sections of infected trees (Roux 2002). The disease is also associated with frost and drought stress.

Fusarium spp. are known to be pathogens on a wide range of hosts. Roux & Wingfield (1997) reported several *Fusarium* spp. from die-back and canker symptoms on *A. mearnsii*. Included were *F. graminearium* Schwabe, which was isolated from stem and branch cankers (Roux *et al.* 2001b). *Fusarium* spp. have also been isolated from basal cankers associated with black butt disease (Zeijlemaker 1971), blister and mottle lesions associated with Ceratocystis wilt and mechanical wounds on stems and branches (Zeijlemaker 1971, Roux *et al.* 2001b). *Fusarium graminearum* was shown to be pathogenic to *A. mearnsii* in inoculation experiments (Roux *et al.* 2001b).

Pink disease caused by ***Erythricium salmonicolor*** affects several different *Acacia* spp. In Africa its occurrence was reported on *A. mearnsii, A. auriculiformis* and other *Acacia* spp. from Mauritius and South Africa (Sherry 1971, Gibson 1975, Bakshi 1976). Infection by *E. salmonicolor* resulted in death of branches and leaf cast due to the girdling of the branches. As the infected bark dies, patches of pink mycelium appear on the surface of the dying bark (Gibson 1975, Wingfield & Roux 2000a, Roux 2002).

In South Africa ***Physalospora abdita*** (Berk & curt) N. E. Stevens (Bakshi 1976) and *Sphaeropsis* sp. (Roux & Wingfield 1997) have also been isolated from *A. mearnsii*. *P. abdita* caused stem and twig cankers on *A. mearnsii* and *A. decurrens* Wendl. (Browne 1968) while a *Sphaeropsis* sp. has been isolated from stem cankers (Roux & Wingfield 1997). In inoculation trials, the *Sphaeropsis* sp. showed high levels of pathogenicity (Roux & Wingfield 1997).

Schizophyllum commune Fries is an opportunistic wound parasite that leads to the eventual death of trees. Pruning wounds are thought to be sites of infection for this pathogen (Ledeboer 1946). In Kenya, *Phoma herbarum* Westend. was reported to cause die-back on *A. mearnsii* and *A. deccurrens* (Olembo 1972). Infection by *P. herbarum* is also initiated through wounds (Olembo 1972, Gibson 1975).

Leaf diseases

Few foliage diseases have been reported on exotic Australian *Acacia* spp. They include leaf spot caused by *Camptomeris albiziae* (Petch) Mason (Sherry 1971, Wingfield & Roux 2000a) and *C. verruculosa* Syd. on *A. mearnsii* in South Africa (Bakshi 1976). The disease is associated with early leaf drop in autumn (Wingfield & Roux 2000a). A rust caused by *Uromycladium alpinum* McAlp. has also been reported from *A. mearnsii* in South Africa (Morris, Wingfield & Walker 1988). Apart from these two diseases on *A. mearnsii*, the only recorded leaf disease of Australian *Acacia* spp. grown in plantations in Africa is leaf spot of *A. longifolia* caused by *Cylindrocladium scoparium* Morgan (Hagemann & Rose 1988).

Wilt disease

One of the most devastating diseases of *A. mearnsii* is that caused by the wilt pathogen, ***Ceratocystis albofundus*** De Beer, Wingfield & Morris. This disease was first described from South Africa in 1988 (Morris, Wingfield & De Beer 1994). The most common symptom associated with *C. albofundus* infection is the rapid wilt and death of susceptible trees, the formation of swollen gum pockets in the stems, stem cankers, extensive oozing of gum and discoloration of the xylem (Morris *et al.* 1994, Roux *et al.* 1997, 2000a).

Ceratocystis wilt, caused by *C. albofundus,* has been reported only from South Africa (Morris *et al.* 1994) and Uganda (Roux *et al.* 2001a). Roux *et al.* (2001d) suggested that *C. albofundus* is native to South Africa. The only alternative hosts known for *C. albofundus* are South African *Protea* spp. (Gorter 1977) and *A. decurrens* (Roux *et al.* 2001d). *Ceratocystis* spp. require wounds to initiate infection. Thus, *C. albofundus* is especially damaging where trees are affected by hail, insect or silvicultural practices (Roux 2002) that cause wounding of trees.

EXOTIC PLANTATION FORESTRY IN ETHIOPIA

In Ethiopia, wood plays a major role in meeting more than 85% of the energy requirements of the country. Mostly, this wood comes from the natural forests. For this reason, natural forest resources are diminishing rapidly. Estimates indicate that the natural forest cover has declined from 40% to 2.4% in the 1990's (Davidson 1988, Anonymous 1994). At present, the annual rate of forest exploitation is much higher than the annual replacement, both in terms of area and yield. If this trend continues, the remaining natural forests will not remain for long and it may not be possible to meet the demand for wood products. To overcome this problem, exotic tree planting was commenced and has been practiced for many years in different parts of Ethiopia. Generally speaking it is said that the planting of exotic tree species started with the introduction of *E. globulus* in the late 1890's.

Currently, in Ethiopia, fast growing exotic species such as *E. globulus, E. camaldulensis, E. saligna, E. grandis,* and *E. citriodora* are widely planted in different parts of the country (Persson 1995, Negash 1997). *C. lusitanica, P. patula, Grevillea robusta* Cunn., *A. mearnsii* and *A. decurrens* are among other genera planted, both in plantations and around homesteads. Plantations of these exotic species cover a total area of about 200 000 ha (Anonymous 1994, Vercoe 1995).

This figure indicates only the areas of the plantations in National Forest Priority Areas, Peri-urban plantations and community woodlots. It does not include those trees planted around homesteads, farmlands or those planted for rehabilitation of degraded land.

Many exotic plantation species die at the seedling stage or at maturity for various reasons. However, no study has been conducted to investigate the cause of this death and it has been usually arbitrarily associated with poor species site matching and inadequate tending practices. The role of biotic factors in tree death is underestimated, poorly understood and has not received much attention in Ethiopia.

Generally, little information is available on the damage pathogens cause to plantation trees in Ethiopia. A few records of tree diseases in Ethiopia can be found. Several of these deal with *Armillaria* spp. One such report mentions the infection of *Armillaria* spp. of pine trees (Mengistu 1992) and another indicates the occurrence of *A. mellea* in *Coffea arabica* L. plantations (Eshetu, Teame & Girma 2000). According to these reports *Armillaria* spp. were found on recently cleared and planted sites and where shade trees had been removed. Recently Ota, Intini & Hattori (2000) reported that the *Armillaria* sp. found on a hard wood species at Kerita and Jimma is *A. mellea sensu stricto*.

Some records of tree pathogens from Ethiopia can be found in herbarium and survey reports. For example, Gibson (1972) mentioned that T. Middleton had found *Dothistroma* needle blight on *P. radiata* trees around Addis Ababa. Simillarly, based on unpublished records, Crous *et al.* (1989c) mentioned that *Pseudocerospora eucalyptorum*, the cause of *Eucalyptus* leaf spot, has been recorded from Worota, North Ethiopia. Walker, Sutton & Pascoe (1992) also mentioned that they obtained a specimen of *Phaeoseptoria epicocoides* from Ethiopia that was collected from *E. saligna* and *E. globulus* at Gora and Gumuro. However, the importance of these fungi in causing leaf spot on *Eucalyptus* in Ethiopia is not clear.

There are some reports that deal with diseases of native tree species in Ethiopia. The results of one of these studies reported the occurrence of *Antrodia juniperina* (Murrill) Niemela & Ryvarden on *Juniperus exelsa* Hochest. Ex. Endl. (Niemela & Ryvarden 1975). *A. juniperina* is reported to be parasitic and saprophytic on stems of *J. exelsa* and to cause heart rot and necrosis of the butt. Infection causes intensive brown cubical rot of the wood (Niemela & Ryvarden 1975). In another report Niemela, Revenvall & Hjortstam (1998) recorded several decay fungi in natural stands of

Hagenia abyssinica (Bruce) J. F Gmel. in East Africa, including Ethiopia. This report only mentioned fungi involved in decaying *H. abyssinica.* They included *Hymenochaete ochromarginata* Talbot. collected from living trunks and stumps. This fungus is considered to be the main decayer of living *Hagenia* trees. Other wood rot fungi included *Phellinus ferruginosus* (Schrad. Fr:) Bourdot and Galizn and *Trametes socotrana* Cooke, collected from fallen branches and stems. Their role in disease of *Hagenia* can, however, be questioned as they are not generally considered to be primary pathogens. A number of *Corticioid* fungi have also recorded from *H. abyssinica* branches and stems. They include *Asterostroma medium* Bres., *Cystidiodontia isabellina* (Berk. & Broome) Hjortstam and *Dichostereum kenyense* Boidin & Lanq (Niemela *et al.* 1998).

Recently, tree deaths of unknown causes have been experienced in many plantations in Ethiopia. Many different disease symptoms are associated with the dying trees. This situation necessitates a study of the pathological problems in plantations in order to develop strategies to reduce losses to this important enerprise.

CONCLUSIONS

In this review I have attempted to include information on as many of the diseases of exotic plantation trees in Africa as possible in the limited space available. However, the information available on forest diseases from African countries is scanty and often recorded in unpublished government reports. This limitation has meant that information has been gained form work done in only a few countries and often published only in the form of brief notes. Nevertheless, the information included in this review should help to provide insight into the impact of diseases in exotic plantations in Africa. Hopefully, it will also provide valuable foundation for future forest pathology studies in Africa.

The rapidly growing demand for forest products will necessitate the expansion of exotic plantations in Africa. The introduction of exotic tree species into Ethiopia commenced a century ago. Up to now, not less than 160 exotic trees and shrubs have been introduced to the country, for different purposes. In a situation where exotic plantations substitute the native forests, an outbreak of disease could severely damage plantations.

Diseases have had a serious impact on exotic plantations in various parts of Africa. Various of these have been discussed in this review. It must be expected that other diseases will negatively impact of exotic plantation forestry in the future. Thus, every effort must be made to reduce this situation.

It is clear from this review that the problems already experienced with tree diseases in Africa highlight the urgency of studying tree diseases in Ethiopia. In Ethiopia the significance of pathogens in tree health has had little attention in the past. Hence, to minimise the risk associated with diseases of exotic plantations it is essential to obtain adequate information on the prevalence of disease causing organisms in plantations. It is also equally important to understand the risks of diseases to various tree species suited to planting in the country. This knowledge will provide a firm base on which to develop appropriate disease management strategies.

REFERENCES

Abomo-Ndongo, S. & Guillaumin, J.-J. (1997) Somatic incompatibility among African *Armillaria* isolates. *European Journal of Forest Pathology* **27**: 201-206.

Allen, E. A. & Humble, L. M. (2002) Non-indigenous introductions: A threat to Canada's forests and forest economy. *Canadian Journal of Plant Pathology* **24**: 103-110.

Anagnostakis, S. L. (1987) Chestnut blight: the classical problem of an introduced pathogen. *Mycologia* **79**: 23-37.

Anagnostakis, S. L. (1988) *Cryphonectria parasitica*, cause of chestnut blight. *Advances in Plant Pathology* **6**: 123-136.

Anderson, R. L., Belcher, E. & Miller, T. (1984) Occurrence of seed fungi inside slash Pine seed produced in seed orchards in the United States. *Seed Science and Technology* **12**: 795-799.

Anonymous (1978) Biological control of Australian *Acacias*. *News No. 62*. Pietermaritzburg. South Africa.

Anonymous (1994) *Ethiopian Forestry Action Plan. Final report.*, Vol. I. pp 14 and Vol. II, pp 34. Addis Ababa, Ethiopia.

Anonymous (1998). *Forestry facts for the year 1996/97*. Forestry Owners Association. Rivonia, South Africa.

Bakshi, B. K. (1976) Wattles-*Acacia* spp. In *Forest pathology: Principles and practice in forestry:* pp191-194. F. K. I. Press. Forest Research Institute and Colleges, Dehra Dun, India.

Barnard, E. L., Geary, T., English, J. T. & Gilly, S. P. (1987) Basal cankers and coppice failure of *Eucalyptus grandis* in Florida. *Plant Disease* **71**: 358-361.

Barnes, I., Roux, J., Wingfield, M. J., Coetzee, M. P. A. & Wingfield, B. D. (2001) Characterization of *Seiridium* spp. associated with cypress canker, based on β-Tubulin and Histone sequence. *Plant Disease* **85**: 317-321.

Baxter, A. P., Van der Westhuizen, G. C. A. & Eicker, A. (1983) Morphology and taxonomy of South African isolates of *Colletotrichum*. *South African Journal of Botany* **2**: 259-289.

Bettucci, L. & Saravay, M. (1993) Endophytic fungi of *Eucalyptus globulus*: a preliminary study. *Mycological Research* **97**: 679-682.

Bloomberg, W. J. (1981) Disease caused by *Fusarium* in forest nurseries. In *Fusarium*: *Disease, biology and taxonomy* (P. E. Nelson, T. A. Toussoun, & R. J. Cook eds): pp. 178-187. Pennsylvania State University Press: University Park, USA.

Boerboom, J. H. & Maas, P. W. T. (1970) Canker of *Eucalyptus grandis* and *E. saligna* in Surinam caused by *Endothia havanensis*. *Turrialba* **20**: 94-99.

Boesewinkel, H. J. (1983) New records of the three fungi causing cypress canker in New Zealand, *Seiridium cupressi* (Guba) comb. nov and *S. cardinale* on *Cupressocyparis* and *S. unicorne* on *Cryptomeria* and *Cupressus*. *Transactions of the British Mycological Society* **80**: 544-547.

Bottomley, A. M. (1937) Some of the more important diseases affecting timber planting in the Transvaal. *South African Journal of Science* **33**: 373-376.

Brasier, C. M. (1990) China and the origins of Dutch elm disease: an appraisal. *Plant Pathology* **39**: 5-16.

Bright, C. (1998) *Life out of bounds. Bio-invasion in a borderless world*. New York: W. W. Norton.

Browne, F. G. (1968) *Pest and diseases of forest plantation trees*. Clarendon Press: Oxford, UK.

Carnegie, A. J. (1991) *The susceptibility of certain Eucalyptus species and provenances to infection by Mycosphaerella spp. and other leaf parasites*. B. Sc. Honours Thesis. La Trobe University, Australia.

Carnegie, A. J. (2000) *A study of the species of Mycosphaerella on Eucalyptus in Australia and the impact of the Mycosphaerella leaf disease on Eucalyptus globules Labill*. Ph. D Thesis. The University of Melbourne, Australia.

Carnegie, A. J. & Keane, P. J. (1994) Variation in susceptibility of *Eucalyptus globulus* provenances to *Mycosphaerella* leaf disease. *Mycological Research* **98**: 413-418.

Chipompha, N. W. S. (1987) *Phaeoseptoria eucalypti*: A new pathogen of *Eucalyptus* in Malawi. *South African Journal of Forestry* **142**: 10-12.

Chou, C. K. S. (1981) Monoculture, species diversifications, and disease hazards in forestry. *New Zealand Journal of Forestry* **26**: 20-36.

Christensen, P. S. & Gibson, I. A. S. (1964) Further observations in Kenya on a foliage disease of Pines caused by *Dothistroma pini* Hulbary, effect of disease on height and diameter increment in three and four year old *Pinus radiata*. *Commonwealth Forestry Review* **43**:326-331.

Ciesla, W. M., Diekmann, M. & Putter, C. A. J. (1996) *FAO/IPGRI Technical guidelines for the safe movement of germpalasm*, No. 17. *Eucalyptus* spp. FAO/IPGRI: Rome, Italy.

Ciesla, W. M., Mbugua, D. K. & Ward, J. D. (1995) Ensuring forest health and productivity; A perspective from Kenya. *Journal of Forestry* **93**: 36-39.

Coetzee, M. P. A. (1997) *Characterisation of Armillaria in South Africa*. M. Sc. Thesis, Faculty of Science, Department of Microbiology and Biochemistry, University of Orange Free State, South Africa.

Coetzee, M. P. A., Wingfield, B. D., Coutinho, T. A. & Wingfield, M. J. (2000) Identification of the causal agent of *Armillaria* root rot of *Pinus* species in South Africa. *Mycologia* **92**: 777-785.

Conradie, E., Swart, W. J. & Wingfield, M. J. (1990) *Cryphonectria* canker of *Eucalyptus*, an important disease in plantation forestry in South Africa. *South African Forestry Journal* **152**: 43-49.

Coutinho, T. A., Wingfield, M. J., Alfenas, A. C. & Crous, P. W. (1998) *Eucalyptus* rust: a disease with the potential for serious international implications. *Plant Disease* **82**: 819-825.

Coutinho, T. A., Roux, J., Riedel, K. H., Terblanche, J. & Wingfield, M. J. (2000) First report of bacterial wilt caused by *Ralstonia solanacearum* on *Eucalyptus* in South Africa. *Forest Pathology* **30**:1-8.

Coutinho, T. A., Preisig, O., Mergaert, J., Cnockaert, M. C., Riedel, K-H., Swings, J. & Wingfield, M. J. (2001) Bacterial blight and die-back of *Eucalyptus* species hybrids and clones in South Africa. *Plant Disease* **86**: 20-25.

Crous, P. W., Knox-Davies, P. S. & Wingfield, M. J. (1988) *Phaeoseptoria eucalypti* and *Coniothyrium ovatum* on *Eucalyptus* spp. in South Africa. *Phytophylactica* **20**: 337-340.

Crous, P. W., Knox-Davies, P. S. & Wingfield, M. J. (1989a) A list of *Eucalyptus* leaf fungi and their potential importance to South African forestry. *South African Forestry Journal* **149:**16-29.

Crous, P. W., Knox-Davies, P. S. & Wingfield, M. J. (1989b) A summary of fungal leaf pathogens of *Eucalyptus* and the diseases they cause in South Africa. *South African Forestry Journal* **149**: 9-16.

Crous, P. W., Wingfield, M. J., Marasas, W. F. O. & Sutton, B. C. (1989c) *Pseudocercospora eucalyptorum* sp. nov. on *Eucalyptus* leaves. *Mycological Research* **93**: 394-398.

Crous, P. W., Knox-Davies, P. S., & Wingfield, M. J. (1989d) Newly recorded foliage fungi of *Eucalyptus* spp. in South Africa. *Phytophylactica* **21**: 85-88.

Crous, P. W., Knox-Davies, P. S. & Wingfield, M. J. (1989e) Infection studies with *Phaeoseptoria eucalypti* and *Coniothyrium ovatum* on *Eucalyptus* spp. *South African Forestry Journal* **149**: 31-35.

Crous, P. W., Phillips, A. J. L. & Wingfield, M. J. (1991) The genera *Cylindrocladium* and *Cylindrocladiella* in South Africa, with special reference to forest nurseries. *South African Forestry Journal* **41**: 11-14.

Crous, P. W., Phillips, A. J. L. & Wingfield, M. J. (1993) New records of *Cylindrocladium* and *Cylindrocladiella* spp. in South Africa. *Plant Pathology* **42**: 302-305.

Crous, P. W. & Wingfield, M. J. (1996) Species of *Mycosphaerella* and their anamorphs associated with leaf blotch disease of *Eucalyptus* in South Africa. *Mycologia* **88**: 441-458.

Crous, P. W., Ferreira, F. A. & Sutton, B. C. (1997) A comparison of the fungal genera *Phaeophleospora* and *Kirramyces* (Coelomycetes). *South African Journal of Botany* **63**: 111-115.

Crous, P. W. (1998) *Mycosphaerella* spp. and their anamorphs associated with leaf spot diseases of *Eucalyptus*. *Mycologia Memior* **21**: 1-170.

Currie, D. & Toes, E. (1978) Stem volume loss due to severe *Diplodia* infection in a young *Pinus radiata* stand. *New Zealand Journal of Forestry* **23**:143-148.

Da Costa, E. B. (1955) Effects of blue stain on the strength of *Pinus radiata*. *CSIRO Forest Products Newsletter* **209**, Australia.

Darvas, J. M., Scott, D. B. & Kotze, D. B. (1978) Fungi associated with damping-off in coniferous seedlings in South African nurseries. *South African Forestry Journal* **104**:15-19.

Davidson, J. (1988) Preparatory assistance of research for afforestation and conservation, in Ethiopia. Research management of the Forestry Research Centre. FAO/UNDP. Addis Ababa, Ethiopia.

Davison, E. M. & Tay, C. S. (1983) Twig, branch and upper trunk cankers of *Eucalyptus marginata*. *Plant Disease* **67**: 1285-1287.

Denison, N. P. & Kietzka, J. E. (1993) The use and importance of hybrid intensive forestry in South Africa. *South African Forestry Journal* **165**: 55-60.

Doidge, E. M. (1950) The South African fungi and lichens to the end of 1945. *Bothalia* **5**: 1-1094.

Doidge, E. M., Bottomley, A. M., Van Der Plank, J. E. & Pauer, G. D. C. (1953) A revised list of plant diseases in South Africa. South African Department of Agriculture. *Science Bulletin* **346**.

Dungey, H. S., Carnegie, A. J., Ades, P. K. & Potts, B. M. (1995) Genetic variation in *Eucalyptus nitens, E. globulus* and their F_1 hybrid to damage by *Mycosphaerella* leaf disease. In *Proceedings of CRCTHF-IUFRO Conference on Eucalyptus Plantations: Improving Fibre Yield and Quality*: pp 235-236. CRCTHF-IUFRO, Hobart, Australia.

Dwinell, L. D., Barrows-Broaddus, J. B. & Kuhlman, E. G. (1985) Pitch canker: A disease complex of Southern pines. *Plant Disease* **69**: 270-276.

Eldridge, K. G. (1961) Significance of *Diplodia pinea* in plantations. *Review of Applied Mycology* **41**: 339

Eldridge, K., Davison, J., Harwood, C. & Van Wyk, G. (1997) *Eucalyptus* domestication and breeding. Oxford Science Publications.

Erwin, D. L. & Ribeiro, O. K. (1996) *Phytophthora, diseases world wide*. APS Press, St. Paul, Minnesota.

Eshetu Derso, Teame Gebrezgi & Girma Adugna (2000) Significance of minor diseases of *Coffea arabica* L. in Ethiopia. A review. In *Proceedings of the workshop on control of Coffee berry Disease (CBD) in Ethiopia*. p. 58-65. Ethiopian Agricultural Research Organisation: Addis Ababa, Ethiopia.

Evans, J. (1984) *Plantation forestry in the tropics*. Clarendon Press: Oxford, UK.

Fisher, P. J., Petrini, O., Petrini, L. E. & Sutton, B. C. (1993) A comparative study of fungal endophytes in leaves, xylem and bark of *Eucalyptus nitens* in Australia and England. *Sydowia* **45**: 338-345.

Florence, E. J. M., Sharma, J. K. & Mohanan, C. (1986) A Stem canker disease of *Eucalyptus* caused by *Cryphonectria cubensis* in Kerala, Kerala Forest Research Institute. *Scientific Paper* **66**: 384-387.

Germishuizen, P. J. (1979) *The re-establishment of Pinus patula Schlecht et Cham. on a pulp wood rotation in Swaziland*. MSc. Thesis. University of Stellenbosch. South Africa.

Germishuizen, P. J. (1984) *Rhizina undulata* –A Pine seedling pathogen in South Africa. In *IUFRO symposium on site and productivity of fast growing plantations* (D. C. Grey, A. P. G. Schonau, C. J. Shuutz, A. Van Laar eds): pp 968. South African Forestry Research Institute. Pretoria, South Africa.

Gibbs, J. N. (1978) Intercontinental epidemiology of Dutch Elm Disease. *Annual Review of Phytopathology* **16**: 287-307.

Gibson, I. A. S. (1964) The impact of disease on forest product in Africa. In *FAO/ IUFRO symposium on internationally dangerous forest diseases and insect*: pp 1-13. Oxford, UK.

Gibson, I. A. S., Christensen, P. S. & Munga, F. N. (1964) First observations in Kenya on a foliage disease of pines, caused by *Dothistroma pini* Hulbary. *Commonwealth Forestry Review* **43**: 31-48.

Gibson, I. A. S. & Hudson, J. C. (1969) Pelleting of pine seeds with Rhizoctol and other fungicides for control of damping-off in Kenya highland nurseries. *East African Agriculture and Forestry Journal* **35**: 99-103.

Gibson, I. A. S. & Munga, F. M. (1969) A note on terminal crook disease of pines in Kenya. *East African Agriculture and Forestry Journal* **35**: 135-140.

Gibson, I. A. S. (1970) Diseases of *Pinus patula*- A review. *Commonwealth Forestry Review* **49**: 267-274.

Gibson, I. A. S. (1972) Dothistroma blight of *Pinus radiata*. *Annual Review of Phytopathology* **10**: 51-72.

Gibson, I. A. S. (1975) *Diseases of forest trees widely planted as exotics in the tropics and Southern Hemisphere. Part I. Important members of the Myrtaceae, Leguminosae, and Meliace*: pp. 21-34. Commonwealth Forestry Institute. University of Oxford, UK.

Gibson, I. A. S. (1979) *Diseases of forest trees widely planted as exotics in the tropics and southern hemisphere. Part II, The genus pinus*: Commonwealth Forestry Institute. University of Oxford, Oxford, UK.

Gibson, I. A. S. (1981) A canker diseas of *Eucalyptus* new to Africa. *Forest Genetics Resource Information* **10**: 23-24.

Gorter, G. J. A. (1977) Index of plant pathogens and the diseases they cause in cultivated plants in South Africa. Deparment of Agricultural Technical Srvices, South Africa. *Science Bulletin* **392.**

Graniti, A. (1986) *Seiridium cardinale* and other cypress cankers. Bulletin OEPP/EPPO. *Bulletin* **16**: 479-486.

Graniti, A. (1998) Cypress canker: a pandemic in progress. *Annual Review of Pahtology* **36**: 91-114.

Hagemann, G. D. & Rose, P. D. (1988) Leaf spot and blight on *Acacia longifolia* caused by *Cylindrocladium scoparium*: A new host record. *Phytophylactica* **20**: 311-316.

Haigh, H. (1993) *Growing black wattle*. Forestry Development, Department of Water Affairs and Forestry, Pretoria, *Extension Leaflet* **1/93** (15).

Hayward, A. C. (1964) Characteristics of *Pseudomonas solanacearum*. *Journal of Applied Bacteriology* **27**: 265-277.

Heather, W. A., Pratt, B. H. & Chin, T. Y. (1977) Pre- and post-emergence damping-off on seedlings of *Pinus* species by *Phytophthora cinnamomi* and *Ph. drechsleri*. *Australian Journal of Botany* **25**: 358-359.

Hepting, G. H. (1974) Death of the American Chestnut. *Journal of Forest History* **18**: 60-67.

Heybroek, H. M. (1980) Monoculture versus mixture: Interactions between susceptible and resistant trees in mixed stands. In *Proceedings of The Third International Workshop on the Genetics of Host-Parasite Interactions in Forestry* (H. M. Heyboek, B. R. Stephan and K. Von Weissenberg eds): pp 326-341. Centre for Agricultural Publishing and Documentation, Wageningen, Netherlands.

Hocking, D. (1968) Fungi associated with damped-off and healthy pine seedlings and with the seed in East African pine nurseries. *Transactions of the British Mycological Society* **51**: 227-232.

Hodges, C. S. (1979) The implications of diseases and insects in managing tropical forests. In *Simposio Internacional Sobre Las Ciencias Forestales y su contribucion al desarrollo de la America tropical*. Editado por Manuel Chavarria: pp 75-80. San Jose, Costa Rica.

Hodges, C. S., Geary, T. F. & Cordell, C. E. (1979) The occurrence of *Diaporthe cubensis* on *Eucalyptus* in Florida, Hawaii and Puerto Rico. *Plant Disease Reporter* **63**: 216-220.

Hodges, C. S., Alfenas, A. C. & Ferreria, F. A. (1986) The conspecificity of *Cryphonetria cubensis* and *Endothia eugeniae*. *Mycologia* **78**: 343-350.

Hunter, G. C., Crous, P. W., Roux, J., Coutinho, T. A., Wingfield, B. D. & Wingfield, M. J. (2002) Identification of *Mycosphaerella* spp. associated with leaf disease of *Eucalyptus nitens* in South Africa. *Australian Journal of Pathology* (Submitted).

Ivory, M. H. (1968) Reaction of pines in Kenya to atacks by *Dothistroma pini* var. *Keniensis*. *East African Agricultural and Forestry Journal* **33**: 236-244.

Ivory, M. H. & Wingfield, M. J. (1986) First report of *Mycosphaerella gibsonii* in South Africa. *Phytophylactica* **18**: 51-53.

Ivory, M. H. (1987) *Diseases and disorders of Pines in the tropics*. Overseas Research publication. No 31. Oxford Forestry Institute: Oxford, UK.

Ivory, M. H. (1994) Records of foliage pathogens of *Pinus* species in tropical countries. *Plant Pathology* **43**: 511-518.

Khasa, P. D., Jallee, G. & Bousquet, J. (1994) Biological studies in the utilization of *Racosperma auriculiformis* and *Racosperma mangium* in tropical countries. *Journal of Tropical Forest Science* **6**: 442-443.

Kihiyo, V. B. & Kowero, G. S. (1986) Some economic aspects of the wattle industry in Tanzania. *Journal of World Forest Resouce Management* **2**: 57-62.

Kile, G. A. (1993) Plant disease caused by species of *Ceratocystis sensu stricto* and *Chalara*. In *Ceratocystis and Ophiostoma: Taxonomy, Ecology, and Pathogenicity*. (M. J. Wingfield, K. A. Seifert, J. A. Webber, M. N. eds): pp 173-183. APS Press. St Paul, Minnesota.

Kotze, J. J. (1935) Forest fungi: The position in South Africa. *In the British Empire Forestry Conference*. Government printer: Pretoria.

Laughton, E. M. (1937) The incidence of fungal disease on timber trees in South Africa. *South African Journal of Science* **33**: 377-382.

Leakey, R. R. B. (1987) Clonal forestry in the tropics-A review of development strategies and opportunities. *Commonwealth Forestry Review* **66**: 61-75.

Ledeboer, M. S. J. (1946) Development in pathological research on Wattle. *South African Forestry Journal* **4**: 30-45.

Lee, R. F. (1970) *A first checklist of tree diseases in Malawi*. Malawi Research Institute. Research records No 43.

Libby, W. J. (1982) What is a safe number of clones per plantation? In: resistance to disease and pests in forest trees. In *Proceeding of the 3rd international workshop on the genetics of host parasite interactions in forestry*: pp 342-360. Wageningen, The Netherlands.

Linde, C., Kemp, G. H. J. & Wingfield, M. J. (1994a) Disease of *Pines* and *Eucalyptus* in South Africa associated with *Pythium* and *Phytophthora* species. *South African Forestry Journal* **169**: 25-32.

Linde, C., Kemp, G. H. J. & Wingfield, M. J. (1994b) *Pythium irregulare* associated with *Pinus* seedling death on previously cultivated lands. *Plant Disease* **78**: 1002-1005.

Linde, C., Kemp, G. H. J. & Wingfield, M. J. (1994c) *Pythium* and *Phytophthora* spp. associated with *Eucalyptus* and pines in South Africa. *European Journal of Forest Pathology* **24**: 345-356.

Linde, C., Wingfield, M. J. & Kemp, G. H. J. (1994d) Root and root collar disease of *Eucalyptus grandis* caused by *Pythium splendens*. *Plant Disease* **78**:1006-1009.

Linde, C., Kemp, G. H. J. & Wingfield, M. J. (1998) First report of *Sphaeropsis sapinea* canker on cypress in South Africa. *European Journal of Forest Pathology* **27**: 173-177.

Lückhoff, H. A. (1955) Two hitherto unrecorded fungal diseases attacking pine and *Eucalyptus* in South Africa. *Journal of the South African Forest Association* **26**: 147-161.

Lückhoff, H. A. (1964) Diseases of exotic plantation trees in the Republic of South Africa. In IV *FAO/IUFR Symposium on international dangerous forest diseases and insects*: pp 1-11, Oxford, UK

Lundquist, J. E. (1984a) The occurrence and distribution of Rhizina root rot in South Africa and Swaziland. *South African Forestry Journal* **78**: 22-24.

Lundquist, J. E. (1984b) First report of terminal crook disease caused by *Colletotrichum acutatum* on *Pinus radiata* seeldings in South Africa. *Plant Disease* **68:** 732 (abstract).

Lundquist, J. E. & Roux, C. (1984) Dothistroma needle blight of *Pinus patula, P. radiata* and *P. canariensis* in South Africa. *Plant Disease* **68**: 918 (abstract).

Lundquist, J. E. (1985) Reduced growth rates of *Eucalyptus nitens* caused by *Mycosphaerella molleriana*. *Phytophylactica* **17**: 55 (Abstract).

Lundquist, J. E. & Baxter, A. P. (1985) Fungi associated with *Eucalyptus* in South Africa. *South African Forestry Journal* **138**: 9-19.

Lundquist, J. E. (1986) Fungi associated with *Pinus* in South Africa. Part I. The Transvaal. *South African Forestry Journal* **130**:1-13.

Lundquist, J. E. & Foreman, T. C. (1986) A leaf blight of *Eucalyptus* seedlings in South African nurseries caused by *Hainesia lythri* . *South African Forestry Journal* **136**: 22-25.

Lundquist, J. E. (1987) Fungi associated with *Pinus* in South Africa. Part II. The Cape. *South African Forestry Journal* **140**: 5-15.

Lundquist, J. E. & Purnell, R. C. (1987) Effects of Mycosphaerella leaf spot on growth of *Eucalyptus nitens*. *Plant Disease* **71**: 1025-1029.

Maiteki, G. A., Hakiza, G. J., Kiwuso, P. & Opiro, K. (1999) Pests and diseases of tree seedlings. A survey report. Report submitted to the strengthening of Forestry Department Project (SFD), Uganda Forestry Department, Kampala, Uganda.

Manion, P. D. (1981) *Tree disease concepts*. Prentice Hall, New Jersey.

Marks, G. C. & Kassaby, F. Y. (1974) The Pathogenicity of *Pythium* spp. and *Phytophthora drechsleri* to *Eucalyptus* spp. *Australian Journal of Botany* **22**: 661-668.

Marks, G. C. & Minko, G. (1969) The pathogenicity of *Diplodia pinea* to *Pinus radiata* D. Don. *Australian Journal of Botany* **17**: 1-12.

Maseko, B., Burgess, T., Coutinho, T. A. & Wingfield, M. J. (2001) First report of *Phythophthora nicotianae* associated with *Eucalyptus* die-back in South Africa. *Plant Pathology* **50**: 413.

Masuka, A. (1989) The incidence of Armillaria root and butt diseases in *Pinus* spp. plantations in Zimbabwe. *Commonwealth Forestry Review* **68**:121-125.

Masuka, A. J. (1990) A new canker of *Eucalyptus grandis* Hill ex Maid in Zimbabwe. *Commonwealth Forestry Review* **69**: 195-200.

Masuka, A. J. & Nyoka, B. I. (1995) Susceptibility of *Eucalyptus grandis* provenances to a root rot associated with *Ganoderma sculptrutum* in Zimbabwe. *European Journal of Forest Pathology* **25**: 65-72.

Mengistu Huluka (1992) Some aspects of forest tree disease in Ethiopia. In *National workshop on setting Forestry Research Priorities*: pp 98-120. Forestry Research Centre. Addis Ababa, Ethiopia.

Mohammed, C. (1994) The detection and species identification of African *Armillaria.* In *Modern assays for plant pathogenic fungi*: *Identification, detection and quantification* (A. Schots, F. M. Dewey, & R. P. Oliver eds): pp 141-147. CAB International. Oxford, UK.

Morgan, P. D. & Driver, C. H. (1972) Rhizina root rot of Douglas-fir seedlings planted on burned sites in Washington. *Plant Disease Reporter* **56**: 407-409.

Morris, M. J., Wingfield, M. J. & Walker, J. (1988) First record of a rust on *Acacia mearnsii* in South Africa. *Transactions of the British Mycological Society* **90**: 324-327.

Morris, M. J., Wingfield, M. J. & De Beer, C. (1994) Gummosis and wilt of *Acacia mearnsii* in South Africa caused by *Ceratocystis fimbriata*. *Plant Pathology* **42**: 814-817.

Mwangi, L. M., Lin, D. & Hubbes, M. (1989) Identification of Kenyan *Armillaria* isolates by cultural morphology, intersterility tests and analysis of isozyme profiles. *European Journal of Forest Pathology* **19**: 399-406.

Mwangi, L., Mwenje, E., Makambila, C., Chanakira-Nyahwa, F., Guillaumin, J-J. & Mohammed, C. (1994) Ecology and pathogenecity of *Armillaria* in Kenya, Zimbabwe and the Congo. In *Proceedings of the 8th IUFRO Conference on Root and Butt Rots* (Johanson and J. Stenlid eds): pp 34-44. Upsala, Sweden.

Mwenje, E. & Ride, J. P. (1996) Morphological and biochemical characterization of *Armillaria* isolates from Zimbabwe. *Plant Pathology* **45**: 1036-1051.

Nattrass, R. M., Booth, C. & Sutton, B. C. (1963) *Rhynchosphaeria cupressi* sp. nov. the causal organsim of Cupressus canker in Kenya. *Transactions of the British Mycological Society* **46**: 102-106.

Negash Mammo (1997) *Performance of Pinus patula and Pinus patula ssp. tecunumanii provenances at Bonga*. M.Sc. Thesis. Swedish University of Agricultural Sciences, Faculty of Forestry. Sweden.

Newhook, F. J. & Podger, F. D. (1972) The role of *Phytophthora cinnamomi* in Australian and New Zealand forests. *Annual Review of Phytopathology* **10**: 299-326.

Ngulube, M. R. (1988) Survival and growth of seedlings of 14 Australian dry-zone *Acacias* under nursery conditions in Zoma, Malawi. *Forest Ecology and Management* **25**: 291-297.

Nichol, N. S., Wingfield, M. J. & Swart, W. J. (1992) Differences in susceptibility of *Eucalyptus* species to *Phaeoseptoria eucalypti*. *European Journal of Forest Pathology* **22**: 418-423.

Niemela, T., & Ryvarden, L. (1975) Studies in the *Aphyllophorales* of Africa IV: *Antrodia juniperina*, new for East Africa. *Transactions of the British Mycological Society* **65**: 427-432.

Niemela, T., Renvall, P. & Hjortstam, K. (1998) *Hagenia abyssinica* and its fungal decayers in natural stands. *Journal of Botany* **55**: 473-484.

Nsolomo, V. R., Madoffe, S. S. & Maliondo, S. M. S. (2000) Prospects for control of disease and insect pests of exotic trees in East Africa. Department of Forest Biology, Sokoine University of Agriculture, Morogoro, Tanzania. Unpublished.

Ofosu-Asiedu, A. (1975) A new disease of *Eucalyptus* in Ghana. *Transactions of the British Mycological Society* **65**: 285-289.

Old, K. M., Yuan, Z. Q., and Kobayashi, T. (1991) A *Valsa* teleomorph for *Cytospora eucalypticola*. *Mycological Research* **95**: 1253-1256.

Olembo, T. W. (1972) *Phoma herbarum* Westend.: A pathogen of *Acacia mearnsii* De Wild. in Kenya. *East African Agricultural and Forestry Journal* **October 1972**: 201-206.

Onsando, J. M., Wargo, P. M. & Waudo, S. W. (1997) Distribution, severity and spread of *Armillaria* root disease in Kenya tea plantations. *Plant Disease* **81**: 133-137.

Ota, Y., Intini, M. & Hattori, T. (2000) Genetic characterization of heterothallic and non-heterothallic *Armillaria mellea* sensu stricto. *Mycological Research* **104**: 1046-1054.

Palm, M. E. (1999) Mycology and world trade: a review from the front line. *Mycologia* **91**: 1-12.

Palmer, M. A. & Nicholls, T. H. (1985) Shoot blight and collar rot of *Pinus resinosa* caused by *Sphaeropsis sapinea* in forest nurseries. *Plant Disease* **69**: 739-740.

Palmer, M. A., McRoberts, R. E. & Nicholls, T. H. (1988) Source of inoculum of *Sphaeropsis sapinea* in forest tree nurseries. *Phytopathology* **78**: 831-835.

Park, R. F. & Keane, P. J. (1982) Leaf diseases of *Eucalyptus* associated with *Mycosphaerella* species. *Transactions of the British Mycological Society* **79**: 101-115.

Pegler, D. N. (1977) A preliminary agaric flora of East Africa. *Kew Bulletin, Additional Series* **6**: 91-95.

Persson, A. (1995) Exotic-prospects and risks from European and African viewpoint. *Buvisindi Agricultural Science* **9**: 47-62.

Peterson, G. W. (1977) Infection, epidemiology and control of Diplodia blight of Austrian Ponderosa and Scots pines. *Phytopathology* **67**: 511-514.

Punithalingam, E. & Waterston, J. M. (1970) *Diplodia pinea*. C.M.I. Descriptions of pathogenic fungi and bacteria. No 273. Mycological Institute: Kew, Surrey, England.

Raabe, R. D. (1962) Host list of the root rot fungus, *Armillaria mellea*. *Hilgardia* **33**: 25-88.

Ramos, L. J., Lara, S. P., MacMillan, R. T. & Narayanana, K. R. (1991) Tip dieback of Mango (*Mangifera indica*) caused by *Botryosphaeria ribis*. *Plant Disease* **75**: 315-318.

Rattan, P. S. & Pawsey, R. G. (1981) Death of tea in Malawi caused by *Pseudophaeolus baudonii*. *Tropical Pest Managment* **27**: 225-229.

Roberds, J. H., Namkoong, G. & Skrøppa, T. (1990) Genetic analysis of risk in clonal populations of forest trees. *Theoretical and Applied Genetics* **79**: 841-848.

Roux, J., Kemp, G. H. J & Wingfield, M. J. (1995) Diseases of black wattle in South Africa. A review. *South African Forestry Journal* **174**: 35-40.

Roux, J. & Wingfield, M. J. (1997) Survey and virulence of fungi occurring on diseased *Acacia mearnsii* in South Africa. *Forest Ecology and Management* **99**: 327-336.

Roux, J., Wingfield, M. J. & Morris, M. J. (1997) *Botryosphaeria dothidea*, a pathogen of *Acacia mearnsii* in South Africa. *South African Journal of Science* **93**: XII.

Roux, J., Wingfield, M. J., Bouillett, J-P., Wingfield, B. D. & Alfenas, A. C. (2000a) A serious new wilt disease of *Eucalyptus* caused by *Ceratocystis fimbriata* in Central Africa. *European Journal of Forest Pathology* **30**: 175-184.

Roux, J., Coutinho, T. A., Wingfield, M. J., Bouillett, J. P. & Leigh, P. (2000b) Diseases of plantation *Eucalyptus* in the Republic of the Congo. *South African Journal of Science* **96**: 454-456.

Roux, J., Coutinho, T. A., Mujuni Byabashaija & Wingfield, M. J. (2001a) Diseases of plantation *Eucalyptus* in Uganda. *South African Journal of Science* **97**: 16-18.

Roux, J., Steenkamp, E. T., Marasas, W. F. O., Wingfield, M. J. & Wingfield, B. D. (2001b) Characterization of *Fusarium graminearum* from *Acacia* and *Eucalyptus* using β-tubilin and histone gene sequences. *Mycologia* **11**: 704-711.

Roux, J., Harrington, T. C., Steimel, J. P. & Wingfield, M. J. (2001c) Genetic variation in the Wattle wilt pathogen *Ceratocystis albofundus*. *Mycoscience* **42**: 327-332.

Roux, J., Heath, R. N., Van der Hoef, A. & Wingfield, M. J. (2001d) First report of pink disease on *Eucalyptus* and *Podocarpus* in South Africa. *Phytopathology* **S78**. (Abstract).

Roux, J. (2002) Diseases of *Acacia mearnsii* in South Africa. In *Black wattle the South African research experience* (R. W. Dunlop and L. A Maclennan eds): pp 121-126. Institute of Commercial Forestry Research. Pietermaritzburg, South Africa.

Rudd Jones, D. (1953) Studies of canker disease of Cypresses in East Africa, caused by *Monochaetia unicornis* (Cook & Ellis) Sacc. I. Observations on pathology and possible origin of the disease. *Annals of Applied Biology* **40**: 323-343.

Rudd Jones, D. (1954a) Studies on canker disease of Cypresses in East Africa, caused by *Monochaetia unicornis* (Cooke & Ellis) Sacc. II Variation in the morphology and physiology of the pathogen. *Transactions of the British Mycological Society* **37**: 286-305.

Rudd Jones, D. (1954b) Studies on a canker disease of Cypresses in East Africa caused by *Monochaetia unicornis* (Cooke & Ellis) Sacc. III Resistance and susceptibility of species of *Cupressus* and allied genera. *Annals of Applied Biology* **41**: 325-335.

Schoch, C. L., Crous, P. W., Wingfield, B. D. & Wingfield, M. J. (1999) The *Cylindrocladium candelabrum* species complex includes four distinct mating populations. *Mycologia* **91**: 286-298.

Schoeneweiss, D. F. (1979) Protection against stress predisposition to *Botryosphaeria* cankers in containerised *Cornus stolonifera* by soil injection with Benomyl. *Plant Disease Reporter* **63:** 896-900.

Shakacite, O. (1991) *A review on the pathology of Eucalyptus in Zambia*. Research note No. 51. Divison of Forest Research. Kitwe, Zambia.

Sharma, J. K., Mohanan, C. & Florence, E. J. M. (1984) Nursery diseases of *Eucalyptus* in Kerala. *European Journal of Forest Pathology* **14**: 77-89.

Sharma, J. K., Mohanan, C. & Florence, E. J. M. (1985) Occurrence of *Cryphonectria* canker disease of *Eucalyptus* in Kerala, India. *Annals of Applied Biology* **106**: 265-276.

Sharma, J. K., Florence, E. J. M., Sankaran, K. V. & Mohanan, C. (1988) Differential Phytotoxic response of cut shoots of *Eucalyptus* to culture filtrates of the pink disease fungus. *Corticium salmonicolor*. *Forest Ecology and Management* **24**: 97-111.

Shaw, C. G. and Kile, G. A. (1991) *Armillaria root disease.* Agriculture Handbook, No. 691. U.S.D.A. Forest Service, United States of Agriculture, Washington D.C.

Shearer, B. L., Tippett, J. T. & Bartle, J. R. (1987) *Botryosphaeria ribis* infection associated with death of *Eucalyptus radiata* in species selection trials. *Plant Disease* **71**: 140-145.

Sherry, S. P. (1971) *The Black Wattle (Acacia mearnsii* de Wild.). University of Natal Press: Pietermaritzburg, South Africa.

Smith, H., Kemp, G. H. J. & Wingfield, M. J. (1994) Canker and die-back of *Eucalyptus* in South Africa caused by *Botryosphaeria dothidea. Plant Pathology* **43**: 1031-1034.

Smith, H. (1995) *Botryosphaeria dothidea* as a pathogen and endophyte of *Eucalyptus* in South Africa. M.Sc thesis, University of Orange Free State, Bloemfontein, South Africa.

Smith, H., Wingfield, M. J., Crous, P. W. & Coutinho, T. A. (1996a) *Sphaeropsis sapinea* and *Botryosphaeria dothidea* endophytic in *Pinus* spp. and *Eucalyptus* spp. in South Africa. *South African Journal of Botany* **62**: 86-88.

Smith, H., Wingfield, M. J. & Petrini, O. (1996b) *Botryosphaeria dothidea* endophytic in *Eucalyptus grandis* and *Eucalyptus nitens* in South Africa. *Forest Ecology and Management* **89**: 189-95.

Smith, H., Crous, P. W., Wingfield, M. J., Coutinho, T. A. & Wingfield, B. D. (2001) *Botryosphaeria eucalyptorum* sp. nov. a new species in the *B. dothidea*-complex on *Eucalyptus* in South Africa. *Mycologia* **93**: 277-285.

Strouts, R. G. & Winter, T. G. (1994) *Diagnosis of ill-health in trees, Research for amenity trees* no. 2. Forestry Commission, UK.

Swart, W. J., Knox-Davies, P. S. & Wingfield, M. J. (1985) *Sphaeropsis sapinea* with special reference to its occurrence in *Pinus* spp. in South Africa. *South African Forestry Journal* **35**: 1-8.

Swart, W. J., Wingfield, M. J. & Knox-Davies, P. S. (1987) Factors associated with *Sphaeropsis sapinea* infection of pine trees in South Africa. *Phytophylactica* **19**: 505-510.

Tidball, C. J. & Linderman, R. G. (1990) *Phytophthora* root and stem rot of apple rootstocks from stool beds. *Plant Disease* **74**: 141-146.

Turnbull, J. W. (1991) Future use of *Eucalyptus*: Opportunities and problems. In *Proceedings of IUFRO symposium on Intensive Forestry: The role of Eucalyptus* (A. P. G. Schonau eds): pp 2-27. South African Institute of Forestry. Pretoria, South Africa.

Van der Westhuizen, G. C. A. (1973) *Polyporus baudonii* Pat. on *Eucalyptus* spp. in South Africa. *Bothalia* **11**: 143-151.

Van der Westhuizen, I. P., Wingfield, M. J., Kemp. G. H. J. & Swart, W. J. (1993) First report of the canker pathogen *Endothia gyrosa* on *Eucalyptus* in South Africa. *Plant Pathology* **42**: 661-663.

Venter, M., Myburg, H., Wingfield, B. D., Coutinho, T. A. & Wingfield, M. J. (2001) A new species of *Cryphonectria* from South Africa and Australia pathogenic to *Eucalyptus*. *Sydowia* **54**: 98-117.

Vercoe, T. K. (1995) International, social and economic importance of Australian *Eucalyptus*. In: *Eucalyptus pests and diseases* (M. Diekmann and J. B. Ball eds): pp. 14-20. International Plant Genetic Resource Institute (IPGRI). Bangkok, Thailand.

Viljoen, A., Wingfield, M. J. & Crous, P. W. (1992) Fungal pathogens in *Pinus* and *Eucalyptus* seedling nurseries in South Africa: A review. *South African Forestry Journal* **161**: 45-51.

Viljoen, A., Wingfield, M. J. & Marasas, W. F. O. (1994) First report of *Fusarium subglutinans f.* sp. *pini* on pine seedlings in South Africa. *Plant Disease* **78**: 309-312.

Viljoen, A., Wingfield, M. J., Kemp, G. H. J. & Marasas, W. F. O. (1995) Suceptibility of pines in South Africa to the pitch canker fungus *Fusarium subglutinans* f. sp. *pini*. *Plant Pathology* **44**: 877-882.

Viljoen, A., Marasas, W. F. O., Wingfield, M. J. & Viljoen, C. D. (1997a) Characterization of *Fusarium subglutinans f.* sp. *pini* causing root disease of *Pinus patula* seedlings in South Africa. *Mycological Research* **101**: 437-445.

Viljoen, A., Wingfield, M. J., Marasas, W. F. O. & Coutinho, T. A. (1997b) Pitch canker of pines- A contemporary review. *South African Journal of Science* **93**: 411- 417

Von Broembsen, S. L. (1984) Occurence of *Phytophthora cinnamomi* on indigenous and exotic hosts in South Africa, with special reference to the South Western Cape Province. *Phytophylactica* **16**: 221-225.

Von Broembsen, S. L. & Donald, D. G. M. (1981) Control of *Phytophthora* root rot and other soil borne disease of forest nurseries. *South African Forestry Journal* **117**: 37-40.

Walker, J., Sutton, B. C. & Pascoe, I. G. (1992) *Phaeoseptoria eucalypti* and similar fungi on *Eucalyptus*, with description of *Kirramyces* gen. nov. (Coelomycetes). *Mycological Research* **96**: 911-924.

Wargo, P. M. & Shaw, C. G. (1985) *Armillaria* root rot: The puzzle is being solved. *Plant Disease* **69**: 826-832.

Wingfield, M. J. & Knox-Davies, P. S. (1980a) Association of *Diplodia pinea* with a root disease of pines in South Africa. *Plant Disease* **64**: 221-223.

Wingfield, M. J. & Knox-Davies, P. S. (1980b) Observations on diseases in *Pine* and *Eucalyptus* plantations in South Africa. *Phytophylatica* **12**: 57-60.

Wingfield, M. J. & du Toit, I. (1986) Cypress canker caused by two *Seiridium* species in South Africa. *Phytophylactica* **18**: 43 (Abstract).

Wingfield, M. J. (1987a) Foliar pathogens of *Eucalyptus* in South Africa. *Phytophylactica* **19**: 123.

Wingfield, M. J. (1987b) Diseases in South African forest plantations. In *Forestry Hand Book* (2). (K. Von Gadow, D. W. Van der Zel, A. Van Laar, A. P. G. Schonau, H. W. Kassier, P. W. Warkotch, H. F. Vermaas, D. L. Own & J. V. Jordan eds): pp 153-164. The South African Association of Forestry. Pretoria, South Africa.

Wingfield, M. J., Swart, W. J. & Von Broembsen, S. L. (1988) Root diseases of pines and *Eucalyptus* in South Africa. In *Proceedings of the* Seventh *IUFRO Conference on Root and Butt rots* (D. J. Morrison ed): pp 563-5569. Canada Pacific Forestry Centre: Canada.

Wingfield, M. J., Swart, W. J. & Abear, B. J. (1989) First record of *Cryphonectria* canker of *Eucalyptus* in South Africa. *Phytophylactica* **21**: 311-313.

Wingfield, M. J. (1990) Current status and future prospects of forest pathology in South Africa. *South African Journal of Science* **86**: 60-62.

Wingfield, M. J., Swart, W. J. & Kemp, G. H. J. (1991) Pathology considerations in clonal propagation of *Eucalyptus* with special reference to the South African situation. In *Proceedings of the IUFRO symposium on Intensive Forestry: The Role of Eucalyptus* (A. P. G. Schonau ed): pp 811-820. South African Institute of Forestry. Pretoria, South Africa.

Wingfield, M. J., Crous, P. W. & Swart, W. J. (1993) *Sporothrix eucalypti* (sp. nov.), a shoot and leaf pathogen of *Eucalyptus* in South Africa. *Mycopathologia* **123**: 159-164.

Wingfield, M. J., Crous, P. W. & Coutinho, T. A. (1996) A serious canker disease of *Eucalyptus* in South Africa caused by a new species of *Coniothyrium*. *Mycopathologia* **136**: 139-145.

Wingfield, M. J. & Roux, J. (2000a) Forest pathogens, forests and society. *In Proceedings of XXI IUFRO World Congress on Forest and society. The Role of Research* (Vol. I): pp 174-180. Kuala Lumpur, Malaysia.

Wingfield, M. J. & Roux, J. (2000b) Plant diseases of South African forest plantations. In *South African Forestry Handbook* (D. L. Owen ed): pp 241-252. The South African Forestry Institute. Pretoria, South Africa.

Wingfield, M. J., Slippers, B., Roux, J. & Wingfield, B. D. (2001) World-wide movement of exotic forest fungi, especially in the tropics and the Southern Hemisphere. *Bioscience* **51**: 134-140.

Wright, J. P. & Marks, G. C. (1970) Loss of merchantable wood in radiata pine associated with infection by *Diplodia pinea*. *Australian Forestry* **34**: 107-119.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Zeijlemaker, F. C. J. (1968) *The gummosis of black wattle: a complex of diseases.* Report for 1967-1968: pp 40-43. Wattle Research Institute, University of Natal: South Africa.

Zeijlemaker, F. C. J. (1971) Black butt disease of black wattle caused by *Phytophthora nicotianae* var *parasitica*. *Phytopathology* **61**: 144-145.

Zentmyer, G. A. (1980) *Phytophthora cinnamomi and the disease it causes. Monograph 10*. pp 96. American Phytopathological Society, St. Paul, Minnesota.

Ziller, W. G. (1974) The tree rusts of Western Canada. Canadian Forestry Service publication No. 1329. Department of Environment, Victoria, British Colombia.

Zwolinski, J. B., Swart, W. J. & Wingfield, M. J. (1990a) Intensity of dieback induced by *Sphaeropsis sapinea* in relation to site conditions. *European Journal of Forest Pathology* **20**: 167-174

Zwolinski, J. B., Swart, W. J., & Wingfield, M. J. (1990b) Economic impact of post hail outbreak of dieback induced by *Sphaeropsis sapinea. European Journal of Forestry Pathology* **20**: 405-411.

Table 1. Diseases reported in plantation forestry nurseries in African countries

Pathogen	Host	Symptoms	Distribution	References
Botrytis cinerea (Pers.) (Anam=*Sclerotinia fuckeliana* de Bary)	*E. globulus, P. patula*	Grey mould, Seed damage, Seedling die-back	S. Africa, Kenya, Zimbabwe, Tanzania	Viljoen, Wingfield & Crous 1992, Gibson 1964, Browne 1968
Colletotrichum acutatum Simmonds	*P. radiata*	Necrosis (Shoot tip, terminal bud, & needles), stunting & stem malformation	S. Africa, Kenya	Gibson & Munga 1969, Lundquist 1984b
C. gloeosporioides (Penz.) Penz. & Sacc.	*E. dives, E. grandis, E. globulus, E. saligna*	Leaf spot, stem canker	S. Africa	Viljoen *et al.* 1992, Baxter, Van Westhuizen & Eicker 1983
Coniella castaneicola (Ell. Ev.) Sutton	*E. camaldulensis, E. globulus*	Leaf spot	S. Africa	Viljoen *et al.* 1992
Cylindrocladiella spp.	*Eucalyptus* spp., *Acacia* spp., *Pinus* spp.	Damping-off, seedling blight	S. Africa	Crous *et al.* 1993
C. camelliae Venkataramani & Venkata Ram	*Eucalyptus* spp., *A. mearnsii* *P. radiata, Eucalyptus* spp.	Root rot, leaf spot	S. Africa	Crous *et al.* 1993
C. parva Anderson		Root infection, seedling death	S. Africa, Malawi	Crous *et al.* 1991

Pathogen	Host	Symptoms	Distribution	References
Cylindrocarpon destructans (Zins) Scholten	*P. radiata, P. roxburghii*	Root rot, Damping-off	South Africa	Darvas *et al.* 1978
Cylindrocladium pauciramosum C.L. Schoch et Crous	*Eucalyptus* spp., *Acacia* spp., Conifers	Root rot, damping-off, leaf blight, stem canker	S. Africa, Kenya	Lundquist & Baxter 1985, Crous *et al.* 1991, Crous *et al.* 1993, Schoch *et al.* 1999, Roux 2001*
C. colhouni Peeraly	*E. grandis*	Leaf spot, root rot, wilt	S. Africa	Crous *et al.* 1993
C. clavatum Hodges & May	*Eucalyptus* spp., *P. radiata*	Damping-off, seedling blight	S. Africa	Crous *et al.* 1993
Fusarium spp.	*Pinus* spp., *Eucalyptus* spp., *Acacia* spp.	Damping-off	S. Africa, E. Africa, Uganda	Browne 1968, Hocking 1968, Maiteki *et al.* 1999
F. oxysporum (Schlecht. Ex Fr.	*P. palustris, P. roxburghii, P. taeda, P. caribaea, P. khasya A. mearnsii*	Damping-off	S. Africa, E. Africa, Uganda	Darvas *et al.* 1978, Viljoen, Wingfield & Crous 1992, 1994
F. solani (Mart.) Sacc.	*P. patula, P. caribaea, P. khasya A. mearnsii*	Damping-off	S. Africa, E. Africa, Uganda	Bakshi 1976, Viljoen *et al.* 1995, Roux *et al.* 2001b
F. moniliformis Sheld.	*P. radiata, P. roxburghii, P. caribaea, P. khasya*	Damping-off	S. Africa, E. Africa	Zeijlemaker 1968
F. equiseti (Corda) Sacc.	*P. caribaea, P. khasya, P. radiata, P. roxburghii*	Damping-off	E. Africa, S. Africa	Hocking 1968, Darvas *et al.* 1978

Roux et al 2001* personal communication

Pathogen	Host	Symptoms	Distribution	References
F. semitectum Berk. & Rav	*P. caribaea, P. khasya*	Damping-off	E. Africa, S. Africa	Hocking 1968, Darvas *et al.* 1978
F. subglutinans	*P. patula*	Root rot, damping-off	S. Africa	Viljoen *et al.* 1997a, 1997b
Hainesia lythri (Desm.) Hohn	*E. globulus, E. robusta, E. saligna, E. grandis*	Leaf spotting, stunting, multiple stems	S. Africa, Zambia	Baxter *et al.* 1983, Lundquist 1986, Lundquist & Foreman 1986, Crous *et al.* 1993
Harknessia hawaiiensis (Stevens & Young)	*E. grandis, E. nitens*	Leaf spot	S. Africa	Crous *et al.* 1989b
Helicobasidium compactum (Boedijn)	*P. patula*	Root infection	Tanzania	Browne 1968
Oidium spp.	*A. mearnsii*	Leaf deformation, leaf drop, stunting	S. Africa, Uganda	Roux *et al.* 2001a, Roux 2002
Macrophomina phaseolina (Tassi.) G.	*A. mearnsii, A. decurrens, Eucalyptus* spp. & *Pinus* spp.	Stunting, chlorosis, foliage death, necrotic lesions on roots	Malawi, Zimbabwe, Tanzania, S. Africa	Gibson 1975, Bakshi 1976 Darvas *et al.* 1978
Pantoea ananatis Corrig. (syn= *Erwinia ananas, E. uredovora*	*E. grandis, E. saligna, E. dunii, E. nitens, E. smithii*	Leaf blight, shoot die-back	S. Africa	Coutinho *et al.* 2001

Pathogen	Host	Symptoms	Distribution	References
Phaeoseptoria eucalypti Hansf. (*Kirramyces epicoccoides*)	*E. bicostata, E. camaldulensis, E. cladocalyx, E. dunnii, E. globulus* spp., *E. saligna*	Leaf spot, defoliation	S. Africa, Malawi, Uganda	Crous *et al.* 1989e, Chipompha, 1987, Roux *et al.* 2001a, Viljoen *et al.* 1992
Phytophthora spp.	*Eucalyptus* spp., *Pinus* spp.	Damping-off, root rot	S. Africa, Uganda	Darvas *et al.* 1978, Maiteki *et al.* 1999
P. cinnamomi Rand	*E. citriodora, P. elliottii, P. halepensis, P. patula, P. pinaster, P.radiata*	Damping-off, root rot	S. Africa	Darvas *et al.* 1978
Pythium spp.	*P. patula* & *Pinus* spp.	Damping-off, root rot	S. Africa, E. Africa, Uganda	Doidge 1950, Hocking 1968, Maiteki *et al.* 1999
P. ultimum Trow	*E. grandis*	Root rot	S. Africa, E. Africa,	Gibson 1970, Darvas *et al.* 1978
P. irregularae Buisman	*Pinus* spp., *Eucalyptus* spp.	Damping-off	S. Africa	Hocking 1968, Viljoen *et al.* 1992
P. pyrilobum Vaartaja	*Pinus* spp., *E. grandis*	Damping-off	S. Africa	Linde *et al.* 1994a
P. splendens H.Braun	*E. grandis*	Damping-off	S. Africa	Linde *et al.* 1994b
Pseudocercospora pinidensiflorae (Horri & Nambu) Deighton	*P. halepensis, P. patula, P. radiata*	Needle blight	S. Africa	Viljoen *et al.* 1992

Pathogen	Host	Symptoms	Distribution	References
Rhizoctonia solani Kuhn [anam.=*Thanetophorus cucumeries* (Frank) Don =*Corticium solani* (Prill & Delacr.) Bourd. & Galz.]	*Pinus* spp., *E. grandis*	Damping-off, root rot, collar rot, seedling blight	S. Africa, E. Africa, Uganda	Darvas *et al.* 1978, Viljoen *et al.* 1992, Maiteki *et al.* 1999, Hocking 1968, Gibson & Hudson 1969, Gibson 1970
Rosellinia necatrix (Hartig) Prill. [anam= *Dematophora necatrix* Hartig]	*Pinus* spp.	Root infection	Kenya, Tanzania	Gibson 1964, Browne 1968
Sphaerotheca pannosa (Wallr.: Fr.) Lev. *(syn= Aephitomorpha pannosa, Erysiphe pannosa, Oidium leucocnium, Oidium eucalypti*)	*E. camaldulensis, E. globulus, E. maidenii*	Leaf spot, malformation of leaves & shoots	S. Africa, Uganda, Kenya	Crous *et al.* 1989e, 1989c, Chipompha 1987, Roux *et al.* 2001a, Roux 2001*
Sphaeropsis sapinea	*P. patula*	Needle & shoot blight	S. Africa	Darvas *et al.* 1978
Sporothrix eucalypti Wingfield, Crous & Swart sp. nov.	*E. grandis*	Leaf spot, defoliation, shoot die-back	S. Africa	Wingfield, Crous & Swart 1993

* Personal communication.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Chapter Two

Diseases of Exotic Plantation *Eucalyptus* and *Pinus* Species in Ethiopia

Published as: Alemu Gezahgne, J. Roux & M. J. Wingfield (2003) Diseases of exotic plantation *Eucalyptus* and *Pinus* species in Ethiopia. *South African Journal of Science* **99**:29-33

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

ABSTRACT

A survey of diseases in exotic plantations was undertaken in Southern and South Western Ethiopia during 2000 and 2001. The aim was to consider the occurrence and distribution of diseases of major plantation species in this country and to provide a foundation for further research. Samples were collected from plantations and trees planted around farms and homesteads in and around Wondo Genet, Munessa Shashemene, Jima, Bedele, Mizan and Menagesha and included those from roots, stems and leaves. Armillaria root rot was the most common disease, mainly associated with *Pinus patula* but was also found on *Acacia abyssinica*, *Cordia alliodora* and *Cedrela odorata* trees. Stem cankers associated with *Botryosphaeria* spp. were common on *Eucalyptus globulus, E. saligna* and *E. citriodora*. Stem canker disease associated with a *Coniothyrium* sp. was frequently observed on *E. camaldulensis*. Leaf blotch associated with *Mycosphaerella* spp. was common on *E. globulus* in most areas where this species is planted. In addition, *Sphaeropsis sapinea* on *Pinus* spp., cankers associated with *Cytospora* spp. and pink disease caused by *Erythricium salmonicolor* on *Eucalyptus* were also recorded in some plantations. This is the first general evaluation of plantation diseases in Ethiopia and it will provide a foundation for developing planting and disease management strategies, to ensure optimum production in plantations.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

INTRODUCTION

Establishment of exotic plantation forestry has been successful and profitable in many tropical and subtropical countries (Gibson 1979, Evans 1984). The timber derived from these plantations is commonly used to produce pulp and paper, viscose and rayon. It also provides a resource for construction and in developing countries, is an important source of fuelwood (Evans 1984, Turnbull 1991).

In Ethiopia, wood provides 85% of the country's energy requirements and is used for construction purposes. However, the natural forest resource is diminishing rapidly (Anonymous 1994). This is while the demand for forest products is rapidly increasing, necessitating the establishment of plantations of rapidly growing trees. In Ethiopia, the introduction of fast growing exotic tree species took place a century ago, with the introduction of *Eucalyptus globulus* Labill. in the late 1890's (Persson 1995). Since then, several other *Eucalyptus* spp., as well as *Cupressus, Pinus, Grevillea* and *Acacia* species have been widely planted in plantations and around farms and homesteads (Evans 1984, Persson 1995). Plantations of these exotic species now occupy approximately 200 000 ha (Anonymous 1994).

Plantations of exotic species have been highly successful in many countries (Wingfield 1990, Persson 1995). This is partially attributed to the separation of the trees from their natural enemies. However, these trees are established as monocultures in new environments and they are exposed to unique suites of pests and diseases. Thus, serious disease problems have emerged in most countries where they have been planted (Wingfield 1990).

Diseases have had serious impacts on exotic plantation forestry and in some cases, have resulted in the abandonment, or restriction of species to specific localities. For example, the fast-growing *Pinus radiata* D. Don. has been abandoned in several Eastern, Central and Southern African countries due to Dothistroma needle blight caused by *Dothistroma septospora* (Dorog.) Morelet (Gibson 1972, Ciesla, Mbugua & Ward 1995). In these countries, *P. radiata* has been substituted by slower growing *P. patula* Schl. & Cham. but, in South Africa, severe losses to *P. patula* have subsequently occurred due to an interaction between hail damage and *Sphaeropsis sapinea* (Fr.:Fr.) Dyko & Sutton (Swart, Wingfield & Knox-Davies 1987). Similarly, planting *Cupressus macrocarpa* Hartw., which showed remarkable growth in Kenya and other East African countries, has been abandoned due to cypress stem canker caused by *Seiridium cupressi* (Guba) Boesew (Rudd Jones 1953, Gibson 1964). As a result, the slow growing *C. lusitanica* Mill. has been introduced as an alternative species (Rudd Jones 1953, Gibson 1964).

Diseases have negatively affected the planting of *Eucalyptus* spp. for example, Mycosphaerella leaf blotch on *E. globulus, E. nitens* (Deane et Maid.) Maid. and *E. maidenii* F. Muell. has resulted in reduction of planting these species (Lundquist & Purnell 1987). Likewise, *E. fastigata* Deane et Maid. and *E. fraxinoides* Deane et Maid., which initially performed well in frost prone areas of South Africa, have been abandoned due to root disease caused by *Phytophthora cinnamomi* Rands (Linde, Kemp & Wingfield 1994).

Several diseases new to *Eucalyptus*, for example stem canker caused by *Cryphonectria cubensis* (Bruner) Hodges (Conradie, Swart & Wingfield 1990), *Coniothyrium zuluense* Wingfield, Crous & Coutinho (Wingfield, Crous & Coutinho 1996), and wilt caused by *Ceratocystis fimbriata* Ellis & Halst. (Roux *et al.* 2000), have appeared in recent years. These pathogens not only damage the trees in their exotic habitat, but now also threaten *Eucalyptus* in their areas of origin (Wingfield 1990, 1999).

Knowledge of plantation diseases in Ethiopia is limited. This is despite the fact that tree death is common in the country. These deaths are typically attributed to poor site-species matching, poor management and adverse climatic conditions. The role of biotic factors in tree death is underestimated, poorly understood and has received little attention. Thus, a survey of plantation tree species was conducted in some parts of South and South Western Ethiopia in 2000 and 2001. The objective was specifically to determine the occurrence of diseases of exotic plantation species, to provide a basis for further study and to establish a foundation for disease avoidance. This study provides the first detailed overview of plantation tree pathogens in Ethiopia.

MATERIALS AND METHODS

Survey areas and sample collection

Surveys were conducted in April 2000 and in June-September 2001 in Southern and South Western Ethiopia. Collections were made in plantations and small-holdings around Munessa Shashemene, Wondo Genet, Jima, Mizan Teferi, Bedele, Menagesha and Addis Ababa (Figure 1, Table 1). Samples were primarily collected from *Eucalyptus* and *Pinus* plantations and included samples from roots, bark, stems, twigs and leaves.

Isolation techniques

Samples were collected from all trees showing symptoms of disease. Diseased plant tissue was collected and kept in paper bags for transport to the laboratory. Growth media used to isolate the fungi included 2% malt extract agar (MEA, Biolab) and MEA amended with 100 ppm streptomycin (MEAS) for the isolation of Ascomycetes and Coelomycetes. A selective medium containing benomyl was used for the isolation of Basidiomycetes (Harrington, Worall & Baker 1992).

In the laboratory, several different techniques were used to isolate disease-causing organisms. These included the transfer of pieces of mycelium or fruiting bodies from diseased plant tissue directly onto the growth medium; incubating symptomatic plant material in moist chambers; as well as inoculating segments of plant parts with disease symptoms onto growth media. All plates were incubated at 25 °C to induce fungal growth. For the isolation of *Mycosphaerella* spp., discs of leaves with disease symptoms were attached beneath the cover of petri dishes with the pseudothecia facing downward, so that spores were released onto MEAS (Crous, Phillips & Wingfield 1991). After 24 hr, ascospore germination was checked under the microscope and single germinating ascospores were transferred to MEA. Microscope slides were prepared of each isolate to determine the germination pattern of ascospores.

Fungi isolated in this study were identified and representative isolates of the pathogens are maintained in the culture collection of the Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, South Africa. Specimens have also been deposited in the herbarium of the South African National Fungus Collection, Pretoria (PREM).

RESULTS

The results of this survey clearly demonstrate the prevalence of some important tree diseases in the exotic plantations examined. Diseases recorded during this survey included root diseases, stem cankers and leaf diseases.

Root diseases

Armillaria Root Rot

Armillaria root rot was commonly found associated with the death of *P. patula* in Wondo Genet, Belete and Bedele. The causal fungus (PREM 57377 and 57378) was also isolated from dying *Acacia abyssinica* Hochst. trees growing in *Pinus* plantations. In addition, Armillaria root rot was found in association with dead and dying *Cordia alliodora* (Ruiz & Pav.) Oken. and *Cedrella odorata* L. trees in a research plot near Aman. Symptoms were typical of those known for the disease and included death of trees in groups, wilting and yellowing of the crowns (Figure 2a), the occurrence of white mycelial fans between the bark and the wood of symptomatic trees (Figure 2b) as well as the occurrence of rhizomorphs on the bark of infected trees. Armillaria root rot was the major cause for the death of *P. patula* at Wondo Genet. The damage caused at other plantation sites appeared to be mild at the time of this survey.

Stem cankers

Stem cankers were observed on several *Eucalyptus* spp. Disease symptoms included bark cracking, production of copious amounts of kino, stem discoloration and malformation, as well as the production of kino pockets in the xylem (Figures 3, 4).

Stem Canker associated with Botryosphaeria

The most common disease observed on *Eucalyptus* spp. in Ethiopia was canker, from which a *Botryosphaeria* sp. (PREM 57379, 57380 and 57381) was isolated. At Wondo Genet these cankers were found on *E. saligna* Sm., *E. grandis* Hill ex Maid., *E. citriodora* Hook and *E. globulus*. At Munessa Shashemene, they were observed on *E. globulus*, both on coppice and first generation stands, as well as on mature *E. saligna*. At these two sites, stem cracking and kino exudation was observed over the entire length of stems of affected trees. When the bark was removed from these trees, well developed kino pockets were visible in the cambium and xylem (Figure 3a).

In the Jima area, similar disease symptoms were observed on *E. citriodora* and *E. saligna*. Here the damage was most severe on *E. citriodora* and not less than 50% of the trees in the plantation near Jima were symptomatic, but no death of trees were observed at the time of the survey. On this species, large basal cankers were observed. The disease was characterised by black discoloration and cracking of stems, starting at ground level up to approximately one metre height (Figure 3b). When the bark was removed, the cambium was completely discoloured and soaked with kino. Two or three layers of black lines were observed in the wood indicating different seasons of infection (Figure 3c). At Menagesha symptoms of stem canker were commonly found on coppice stems of *E. globulus*. At this site, several coppice stems were dead and wilting. A *Botryosphaeria* sp. was frequently isolated from symptomatic plant material collected from all sites.

***Coniothyrium* Stem Canker**

Stems of *E. camaldulensis* Dehnh. trees in Jiren plantation at Jima and on trees in wood lots between Jima and Woliso, as well as between Wolkite and Sodo, were seriously affected by a stem canker disease. The disease resulted in extensive stem malformation. Initial symptoms of the disease include small discrete lesions on young green bark. Patches of large necrotic lesions developed from these on the stems, branches and twigs (Figure 4a). A *Coniothyrium* sp. (PREM 57382) was consistently found sporulating on the surface of the lesions. Stems often showed a reddish colour due to the exudation of kino from the cracks. The wood of the affected stems showed the formation of pitted kino pockets (Figure 4b). Several of the infected trees produced epicormic shoots. It was estimated that at least 50% of the trees in a stand were affected by this pathogen.

Pink disease

Stem samples of diseased *E. camaldulensis* obtained from Pawe in the Benshangul Gumuz region, yielded structures typical of the pink disease pathogen, *Erythricium salmonicolor* (Berk. & Broome) Burds. (Syn. *Corticium salmonicolor* Berk. & Br.). Branch die-back, stem cankers, branch and stem girdling, production of epicormic shoots on the stems, death of trees as well as the production of pink mycelial growth on symptomatic plant parts are characteristic symptoms of pink disease. The fungus produced typical flat/resupinate fruiting structures on the surface of affected stems.

Leaf disease

***Mycosphaerella* leaf blotch**

Leaf spot and blight was commonly observed on *E. globulus,* wherever this species is grown. The symptoms observed on *E. globulus* are characteristic of those caused by *Mycosphaerella* spp. and in many cases, resulted in defoliation of young trees (Figure 5a, 5b). Isolations from leaves with leaf blotch symptoms consistently yielded

Mycosphaerella spp. (PREM 57386). From the examination of the germination patterns of ascospores, it is clear that more than one *Mycosphaerella* sp. is involved in causing leaf blotch on *E. globulus* leaves in Ethiopia.

Other fungi

Several other fungi, known to be associated with tree disease elsewhere in the world, were found in *Pinus* and *Eucalyptus* plantations, although they appeared to be relatively unimportant. For example, *Sphaeropsis sapinea* was isolated from pine cones collected from Wondo Genet and Munessa Shashemene. Species of *Cytospora, Fusarium graminearum* Schwabe and *Cylindrocladium* Morgan were also isolated from *Eucalyptus* branches collected from Wondo Genet, Wolkite and Menagesha. *Phaeophleospora eucalypti* (Cooke & Massee) Crous, F. A. Ferreira & B. Sutton was common on *E. camaldulensis* and *E. grandis* leaves, in all areas examined.

DISCUSSION

Planting exotic species in plantations has been practised for more than a century in Ethiopia. The impact of diseases on plantation development has, however, received minimal attention. In recent years, tree deaths have been frequent but usually attributed to extreme climatic and poor site conditions. The results of this study have shown that several well-known fungal pathogens are involved in causing considerable damage in exotic plantations. This study thus provides the first comprehensive documentation of plantation diseases in Ethiopia and provides a firm foundation for future study.

Root rot caused by an *Armillaria* sp. was frequently found in *P. patula* plantations. *Armillaria* spp. are known to cause root rot on a wide range of tree species including both exotic as well as native trees and are known world-wide (Shaw & Kile 1991). The identification of Armillaria root rot from native *A. abyssinica* as well as from *C. odorata* and *C. alliodora* suggest that this disease could be important not only in *P. patula,* but also on other trees, including native species. Further study is essential to determine its

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

role in causing root rot in other localities not included in this survey. Previous studies have attributed Armillaria root rot in Ethiopia to *A. mellea* (Mengistu 1992, Eshetu, Teame & Girma 2000, Otta, Intini & Hattori 2000). Fruiting bodies recovered from this survey, however, do not match the macro-morphological characteristics of *A. mellea*. We are currently conducting further studies to identify the species isolated during the present surveys.

Botryosphaeria spp. have a cosmopolitan distribution and are found on many different hosts including *Eucalyptus* spp. (Barnard *et al.* 1987, Smith, Kemp & Wingfield 1994) and it was not surprising to find them in this study. They are considered to be opportunistic wound and stress related pathogens (Pusey 1989, Smith *et al.* 1994). Environmental stress such as drought (Pusey 1989) and frost (Wene & Schoenesweiss 1980) especially, provide conducive conditions for disease development. *Botryosphaeria* spp. are also known as endophytes and are found in healthy plant tissues (Smith, Wingfield & Petrini 1999). In some areas the presence of this pathogen seems to have resulted in poor growth of the coppice sprouts of *E. globulus* and it most likely contributed to the failure of coppice development. Regenerating *Eucalyptus* spp. by coppicing is widely practised in Ethiopia, and further investigation is needed to determine the association of the stem canker with poor growth and coppice failure. Currently studies are underway to determine which *Botryosphaeria* spp. are involved in causing stem canker on *Eucalyptus* spp. in Ethiopia and thus to evaluate their relative importance.

Stem canker associated with a fungus that closely resembles *C. zuluense* was the most common stem canker found affecting *E. camaldulensis*. This is the most widely planted *Eucalyptus* sp. in Ethiopia and given the importance of the disease on *Eucalyptus* spp., clones and hybrids in South Africa, Thailand and Mexico (Wingfield *et al.*1996, Van Zyl *et al.* 2002, Roux, Wingfield & Cibrán 2002), this disease is of considerable concern. Coniothyrium canker is considered to be one of the most important threats to *Eucalyptus* plantation forestry in the world. This disease not only complicates debarking but it also affects the quality of sawn timber, growth and in severe cases may also result in death of trees (Wingfield *et al.* 1996, Roux *et al.* 2002, Van Zyl *et al.* 2002). At present little is known regarding its occurrence in other *E. camaldulensis* growing areas of Ethiopia or whether it infects other *Eucalyptus* spp. It will, therefore, be important to conduct further surveys for this disease. A study is currently also in progress to confirm the identity of the *Coniothyrium* sp. found in Ethiopia and to determine whether it is the same fungus found in South Africa and elsewhere in the world.

Pink disease caused by *E. salmonicolor* is common in the tropics, affecting a wide range of hosts including *Eucalyptus* spp., coffee, rubber, cacao, tea, *Acacia* and *Podocarpus* spp. (Gibson 1975, Roux *et al.* 2001a) and its discovery on *Eucalyptus* in Ethiopia is considered important. In South Africa, pink disease has been reported on *E. macarthurii* Deane et Maid. and *E. cloeziana* F. Mueller in temperate areas of the country (Roux *et al.* 2001a). The damage caused by this disease is of concern for the development of *E. camaldulensis* in Ethiopia and studies including those relating to distribution and host range are required in Ethiopia.

Leaf blotch caused by *Mycosphaerella* spp. is widely distributed and important on *Eucalyptus* spp. world-wide. It is especially well-known for the defoliation it causes on *E. globulus* and *E. nitens* (Park & Keane 1982, Lundquist & Purnell 1987), and its occurrence on *E. globulus* in Ethiopia is significant. Elsewhere in Africa, MLB has been reported from South Africa (Crous & Wingfield 1996), Uganda (Roux *et al.* 2001b), Malawi (Lee 1970), Zimbabwe and Kenya (Gibson 1964). Thirty *Mycosphaerella* spp. have been described in association with leaf blotch of *Eucalyptus*, of which 11 have been recorded on the African continent (Hunter *et al.* 2003). Nothing is known regarding the diversity, distribution or importance of *Mycosphaerella* spp. in Ethiopia and these questions deserve investigation.

Results of this study include many new records of diseases of *Pinus* and *Eucalyptus* spp. in Ethiopia. They also provide a foundation on which to base future studies and to develop management strategies. In the past, tree deaths have been ascribed to factors such as adverse climatic conditions, poor species selection and inadequate post-planting management. This study has shown that the situation is more complicated and that diseases play an important role. These findings suggest that management strategies to reduce the impact of diseases, and facilities to diagnose and monitor these problems should be instituted. In addition, most of the pathogens require more detailed taxonomic study and pathogenicity tests should be conducted to better understand their role in tree death.

REFERENCES

Anonymous (1994) *Ethiopian Forestry Action Plan* (EFAP). Final report, vol. I , pp 14 and vol. II, pp 34. Addis Ababa, Ethiopia.

Barnard, E. L., Geary, T., English, J. T. & Gilly, S. P. (1987) Basal cankers and coppice failure of *Eucalyptus grandis* in Florida. *Plant Disease* **71**: 358-361.

Ciesla, W. M., Mbugua, D. K. & Ward, J. D. (1995) Ensuring forest health and productivity; A perspective from Kenya. *Journal of Forestry* **93**: 36-39.

Conradie, E., Swart, W. J. & Wingfield, M. J. (1990) Cryphonectria canker of *Eucalyptus*, an important disease in plantation forestry in South Africa. *South African Forestry Journal* **152**: 43-49.

Crous, P. W., Phillips, A. J. L. & Wingfield, M. J. (1991) The genera *Cylindrocladium* and *Cylindrocladiella* in South Africa, with special reference to forest nurseries. *South African Forestry Journal* **157**: 69-85.

Crous, P. W. & Wingfield, M. J. (1996) Species of *Mycosphaerella* and their anamorphs associated with leaf blotch disease of *Eucalyptus* in South Africa. *Mycologia* **88**: 441-458.

Crous, P. W. (1998) *Mycosphaerella* spp. and their anamorphs associated with leaf spot diseases of *Eucalyptus*. *Mycologia Memoir* **21**: 1-170.

Eshetu Derso, Teame G. Ezgi & Girma, A. (2000) Significance of minor diseases of *Coffea arabica* L. in Ethiopia. A review. In *Proceedings of the workshop on control of Coffee berry Disease (CBD) in Ethiopia*. Ethiopian Agricultural Research Organization. pp 58-65. Addis Ababa, Ethiopia.

Evans, J. (1984) *Plantation forestry in the tropics*. Clarendon Press, Oxford. UK.

Gibson, I. A. S. (1964) The impact of disease on forest product in Africa. FAO/ Forpest. 64. In *Proceedings of the FAO/ IUFRO symposium on internationally dangerous forest diseases and insects.* pp 1-13. Oxford.

Gibson, I. A. S. (1972) Dothistroma blight of *Pinus radiata*. *Annual Review of Phytopathology* **10**: 51-72.

Gibson, I. A. S. (1975) *Diseases of forest trees widely planted as exotics in the tropics and Southern Hemisphere, Part I. Important members of the Myrtaceae, Leguminosae and Meliace.* Commonwealth Forestry Institute: University of Oxford, UK.

Gibson, I. A. S. (1979) *Diseases of forest trees widely planted as exotics in the tropics and southern hemisphere, part II. The genus Pinus*. Commonwealth Forestry Institute, University of Oxford.

Hunter, G. C., Crous, P. W., Roux, J., Coutinho, T. A., Wingfield, B. D. & Wingfield. M. J. (2003) Identification of *Mycosphaerella* spp. Associated with leaf diseases of Eucalyptus nitens in South Africa. *Australian Plant Pathology* (Submitted).

Harrington, T. C., Worrall, J. J. & Baker, F. A. (1992) Armillaria. In *Methods for research on soilborne phytopathogenic fungi* (L. L. Singleton, J. D. Mihail and C. M. Rush eds.): pp 81-85. The American Phytopathological Society, St. Paul, Minnesota.

Hunter, G. C., Crous, P. W., Roux, J., Coutinho, T. A., Wingfield, B. D. & Wingfield, M. J. (2003) Identification of Mycosphaerella spp. Associated with leaf disease of Eucalyptus nitens in South Africa. *Australian Journal of Pathology*, (submitted).

Lee, R. F. (1970) *A first check list of tree diseases in Malawi*. Malawi Research Institute. Research Record No. 43.

Linde, C., Kemp, G. H. J. & Wingfield, M. J. (1994) Diseases of Pines and *Eucalypts* in South Africa associated with *Pythium* and *Phytophthora* species. *South African Forestry Journal* **169**: 25-32.

Lundquist, J. E. & Purnell, R. C. (1987) Effects of Mycosphaerella leaf spot on growth of *Eucalyptus nitens*. *Plant Disease* **71**: 1025-1029.

Mengistu Huluka (1992) Some aspects of forest tree disease in Ethiopia. In *National workshop on setting Forestry Research Priorities*. Forestry Research Centre. Addis Ababa, Ethiopia.

Ota, Y., Intini M. & Hattori, T. (2000) Genetic characterisation of heterothallic and non-heterothallic *Armillaria mellea sensu sticto*. *Mycological Research* **104**: 1046-1054.

Park, R. F. & Keane, P. J. (1982) Leaf diseases of *Eucalyptus* associated with *Mycosphaerella* species. *Transactions of the British Mycological Society* **79**: 101-115.

Persson, A. (1995) Exotics-prospects and risks from European and African viewpoints. *Buvisindi Agricultural Science* **9**: 47-62.

Pusey, P. L. (1989) Influence of water stress on susceptibility of nonwounded peach bark to *Botryosphaeria dothidea*. *Plant Disease* **73**: 1000-1003.

Roux, J., Wingfield, M. J., Bouillet J-P., Wingfield, B. D. & Alfenas, A. C. (2000) A serious new wilt disease of *Eucalyptus* caused by *Ceratocystis fimbriata* in Central Africa. *European Journal of Forest Pathology* **30**: 175-184.

Roux, J., Heath, R. N., van der Hoef, A. & Wingfield, M. J. (2001a) First report of pink disease on *Eucalyptus* and *Podocarpus* in South Africa. *Phytopathology* **91**: S78.

Roux, J., Coutinho, T. A., Mujuni Byabashaija, D. & Wingfield, M. J. (2001b) Diseases of plantation *Eucalyptus* in Uganda. *South African Journal of Science* **97**: 16-18.

Roux, J., Wingfield, M. J. & Cibrián, D. (2002) First report of Coniothyrium canker of *Eucalyptus* in Mexico. *Plant Pathology* **51**: 382.

Rudd Jones, D. (1953) Studies on a canker disease of Cypresses in East Africa, caused by *Monochaetia unicornis* (Cook and Ellis) Sacc. I. Observations on pathology, spread and possible origins of the disease. *Annals of Applied Biology* **40**: 323-343.

Shaw, C. G. & Kile, G. A. (1991) Armillaria root disease. Agriculture Hand book No. 691. Forest Service, United States Department of Agriculture. Washington D.C.

Smith, H., Kemp, G. H. J. & Wingfield, M. J. (1994) Canker and die-back of *Eucalyptus* in South Africa caused by *Botryosphaeria dothidea*. *Plant Pathology* **43**:1031-1034.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Smith, H., Wingfield, M. J. & Petrini, O. (1999) *Botryosphaeria dothidea* endophytic in *Eucalyptus grandis* and *Eucalyptus nitens* in South Africa. *Forest Ecology and Management* **89**: 189-195.

Swart, W. J., Wingfield, M. J. & Knox-Davies, P. S. (1987) Factors associated with *Sphaeropsis sapinea* infection of pine trees in South Africa. *Phytophylactica* **19**: 505-510.

Turnbull, J. W. (1991) Future use of *Eucalyptus*. Opportunities and problems. In *Proceedings of the IUFRO Symposium on Intensive Forestry: The role of Eucalyptus* (A.P. G. Schonau ed): pp. 2-27. South African Institute of Forestry, Pretoria, South Africa.

Van Zyl, L. M., Coutinho, T. A., Wingfield, M. J., Pongpanich, K. & Wingfield, B. D. (2002) Morphological and molecular relatedness of geographically diverse isolates of *Coniothyrium zuluense* from South Africa and Thailand. *Mycological Research* **106**: 51-59.

Wene, E. G. & Schoeneweiss, D. F. (1980) Localised freezing predisposition to Botryosphaeria canker in differentially frozen wood stems. *Canadian Journal of Botany* **58**: 1455-1458.

Wingfield, M. J. (1990) Current status and future prospects of forest pathology in South Africa. *South African Journal of Science* **86**: 60-62.

Wingfield, M. J. (1999) Pathogens in exotic plantation forestry. *International Forestry Review* **1**: 163-168.

Wingfield, M. J., Crous, P. W. & Coutinho, T. A. (1996) A serious canker disease of *Eucalyptus* in South Africa caused by a new species of *Coniothyrium*. *Mycopathologia* **136**: 139-145.

Table 1. Climatic conditions and altitude of survey areas

Locality	Mean Annual Temperature ^{0}C	Mean Annual Rainfall (mm)	Altitude (masl)
Bedele	19	1 800	2 010
Hossana	16	1 300	2 320
Jima	20	1 500	1 750
Menagesha	14	1 017	2 400
Mizan/Aman	24	2 200	1 350
Munessa Shashemene	19	1 200	2 140-2 600
Woliso	17	1 100	2 150
Wondo Genet	19	1 200	1 800-2 200

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Figure 1. Map of Ethiopia showing the plantation areas where samples were conducted.

Figure 2. Symptoms of Armillaria root rot on *Pinus* spp. (A) Group death and crown die-back of *P. patula*, (B) White mycelial fan expanding up the stem of an infected tree.

Figure 3. Disease symptoms associated with *Botryosphaeria* on *Eucalyptus* spp. (A) Wood discoloration on *E. saligna* associated with stem canker, (B) Basal canker resulting in the cracking of the stem of *E. citriodora*, (C) Internal resin zones associated with external cankers on *E. citriodora*

Figure 4. Coniothyrium canker of *Eucalyptus camaldulensis*. (A) Infected twig, (B) Kino Pocket.

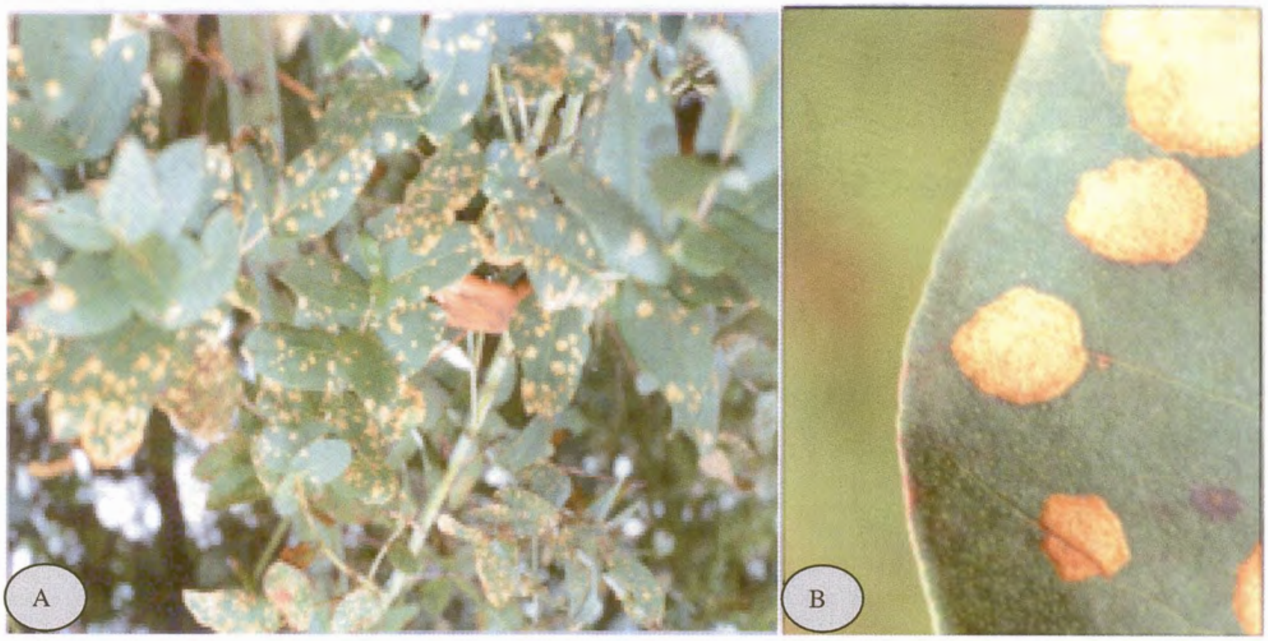

Figure 5. Leaf spots on *E. globulus* associated with *Mycosphaerella* spp. (A) multiple leaf infections, (B) single spots with black pseudothecia.