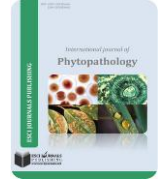




Available Online at ESci Journals
International Journal of Phytopathology

ISSN: 2305-106X (Online), 2306-1650 (Print)
<http://www.escijournals.net/phytopathology>



DISEASES OF PLANTATION FORESTRY TREES IN SOUTHERN GHANA

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ABSTRACT

Ghana is on the verge of exhausting its timber resources and has embarked on reforestation. However, the establishment of pure stands of high value indigenous tree species such as Odum (*Milicia excelsa* and *M. regia*), Mahogany (*Khaya* and *Entandrophragma* species) and Kokrodua (*Pericopsis elata*) were not successful as a result of insect pest and disease problems. These failures, together with the need to establish plantations partly account for the widespread planting of teak (*Tectona grandis*), cedrela (*Cedrela odorata*) and other introduced tree species. Disease outbreaks in *Tectona grandis*, *Cedrela odorata* and *Ceiba pentandra* have been observed with the expansion of plantation estates. A study was therefore conducted to identify key diseases occurring in tree plantations, determine their distribution and evaluate management strategies to contain them. Diseases encountered include root rot caused by *Armillaria hemii* on *T. grandis* and *Cedrela odorata*, leaf spot and dieback on *Ceiba pentandra* seedlings and saplings caused by *Colletotrichum capsici*, *Fusarium solani* and *Lasiodiplodia theobromae*, stem canker on *Eucalyptus* spp. caused by *Botryosphaeria* sp. and leaf blight caused by a *Calonectria* species. Management of these diseases will require training of foresters on tree health issues, quarantine and silvicultural practices and initiation of sound breeding and selection programmes.

Keywords: *Armillaria hemii*, *Botryosphaeria* sp., *Lasiodiplodia theobromae*, indigenous and introduced trees, pure stands.

INTRODUCTION

Ghana has one of the highest rates of deforestation in West Africa (Benhin and Barbier, 2001). Between 1990 and 2000, the average estimated annual rate of deforestation was high (2%), covering approximately 135,000 hectares (FAO, 2010a). It was estimated by Ghana's Ministry of Environment and Science (2002) that less than 1% of the forest cover was found outside forest reserves, much of it being in small scattered patches in swamps and sacred groves. This prompted the Government to initiate a National Forest Plantation Development Programme which resulted in the establishment of 120,000 hectares of forest plantations by the end of 2007, to supplement timber from the natural forest and sustain its supply for domestic and international markets (Forest Commission, 2007). These plantations are predominantly made up of non-

native species such as *Tectona grandis*, *Cedrela odorata*, *Gmelina arborea*, *Pinus caribaea* and *Eucalyptus* spp. with *T. grandis* alone constituting well over 70%. Native tree species included in the Plantation project were *Mansonia altissima*, *Terminalia superba*, *Terminalia ivorensis*, *Ceiba pentandra*, *Heritiera utilis*, *Entandrophragma angolense* and *Triplochiton scleroxylon* (Foli *et al.*, 2009).

Establishment of many of the species was on a very small scale and limited to a narrow range of habitats and conditions. This reduced the chances of pest and disease outbreaks on these trees. However, with the establishment of pure stands over increasingly large areas the threat of disease problems has increased.

Some diseases hitherto unknown in Ghana have thus been observed recent times. The establishment of *Milicia excelsa* (Odum), for example, has been hindered by the attack of *Phytolyma lata*, which predisposes the plant to dieback (Wagner *et al.*, 2008). Besides, *Lasiodiplodia theobromae* and

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Fusarium solani have been associated with dieback and decline of *M. excelsa* seedlings (Apetorgbor *et al.*, 2003b). Attempts made in raising seedlings of *Ceiba pentandra* in nurseries and establishment in plantations have been hampered by leaf spot resulting in dieback. *Colletotrichum capsici* was isolated from the leaf spot while *Fusarium solani* and *Lasiodiplodia theobromae* were found associated with dieback of stems in both the nursery and field (Apetorgbor *et al.*, 2003a). The establishment of *Khaya senegalensis* has been abandoned because of root rot by *Pseudophaeolus baudonii* which caused serious problems in mahogany plantations (Ofosu-Asiedu, 1988). *Pseudophaeolus baudonii* also caused appreciable losses to plantations of *Senna siamea*, *Eucalyptus citriodora*, *E. dagambae*, *Pinus caribaea* and *Tectona grandis* (Ofosu-Asiedu, 1988). During disease surveys of *Eucalyptus grandis*, *E. camaldulensis* and *E. dagambae* plantations in the Ashanti, Central and Eastern Regions of Ghana, stem cankers on mature *E. dagambae*, which resemble that caused by species of *Chrysosporthe* were observed in a single compartment near Kumasi (Roux and Apetorgbor, 2009).

Among the plantations established, disease problems started emerging on *Tectona grandis* (Teak) and *Cedrela odorata* (Cedrela) plantations. Plantation developers reported that disease problems in these plantations are increasing in the Anhwiaso South, Kwamisa, Opro, Tano Nimri, Mamiri and Afram Headwaters forest reserves (Apetorgbor and Bosu, 2009).

This paper presents new disease outbreaks and pathogens affecting tree plantations in Ghana. It also discusses management strategies undertaken to reduce the impact of these problems.

MATERIALS AND METHODS

Study Area: Field surveys were conducted randomly in 31 plantation situated in degraded forest reserves based on reports on disease incidents received from the National Forest Plantation Development Programme and small scale plantations. The reserves included the Afram Headwaters, Opro, Asubima, Mankrang, Yaya, Tain II, Worobong South and Volta Block I forest reserves in the Dry semi-deciduous forest zone. The others included Kwamisa, South Formangso, Asenanyo, Jimira, Anhwiaso South, Bosomkese, Esuboni, Birim and Pra Anum forest reserves in the Moist semi-deciduous forest zone and Mamiri and Tano Nimri in the Moist evergreen forest

zone. Visits were also made to the African Plantations for Sustainable Development (APSD) Ghana Limited at Kwame Danso in the Guinea Savannah woodland (Figure 1).

Field survey: The surveys were on *Tectona grandis* and *Cedrela odorata* plantations in all the forest reserves, *Eucalyptus* species in APSD and *Ceiba pentandra* plantations and nurseries in the Afram Headwaters, Jimira and Pra Anum forest reserves from 2006 to 2012 (Figure 1, Table 1). Informal discussions were held with communities around these reserves prior to the field assessments to determine the status of diseases in the plantations. Background information on establishment of the plantations including planting techniques, land clearings and site history was documented. Hundred trees each per hectare were selected for sampling and inspected individually. Trees suffering from root diseases were identified based on observation of both above and below-ground symptoms. Trees with cracks on stems and branches, canker, wilt, dieback and leaf spots were examined. To determine the extent of damage to trees within the plantations, three replicates per hectare of each plantation were sampled out for intensive assessment. Infected trees were classified using a five-point damage rating:

- (i) Healthy (No visible sign of disease)
- (ii) Minor damage (New infections with symptoms evident on bole; however, tree shows no sign of damage)
- (iii) Moderate damage (Infection on bole and spreading, most leaves are necrotic and/or drooping, sap flow)
- (iv) Severe (Over 75% of infected trees completely defoliated, heavy flow of sap/cracks at base of stem)
- (v) Death of trees.

Samples of diseased leaves, stems, twigs and roots were collected for laboratory examination.

Laboratory studies: Morphological studies of fungal pathogens were conducted macroscopically and microscopically. Ascomycetes fungi were isolated using 2.0% Malt extract agar (MEA) and Potato dextrose agar (PDA) supplemented with streptomycin sulphate (100ppm). For the isolation of Basidiomycetes, a selective medium containing benomyl and streptomycin sulphate was used.

Fungal colonies were isolated using identification keys (Brayford, 1997; Rivarden *et al.*, 1994; Arora, 1986) as well as DNA sequence data (IGS and ITS gene regions).

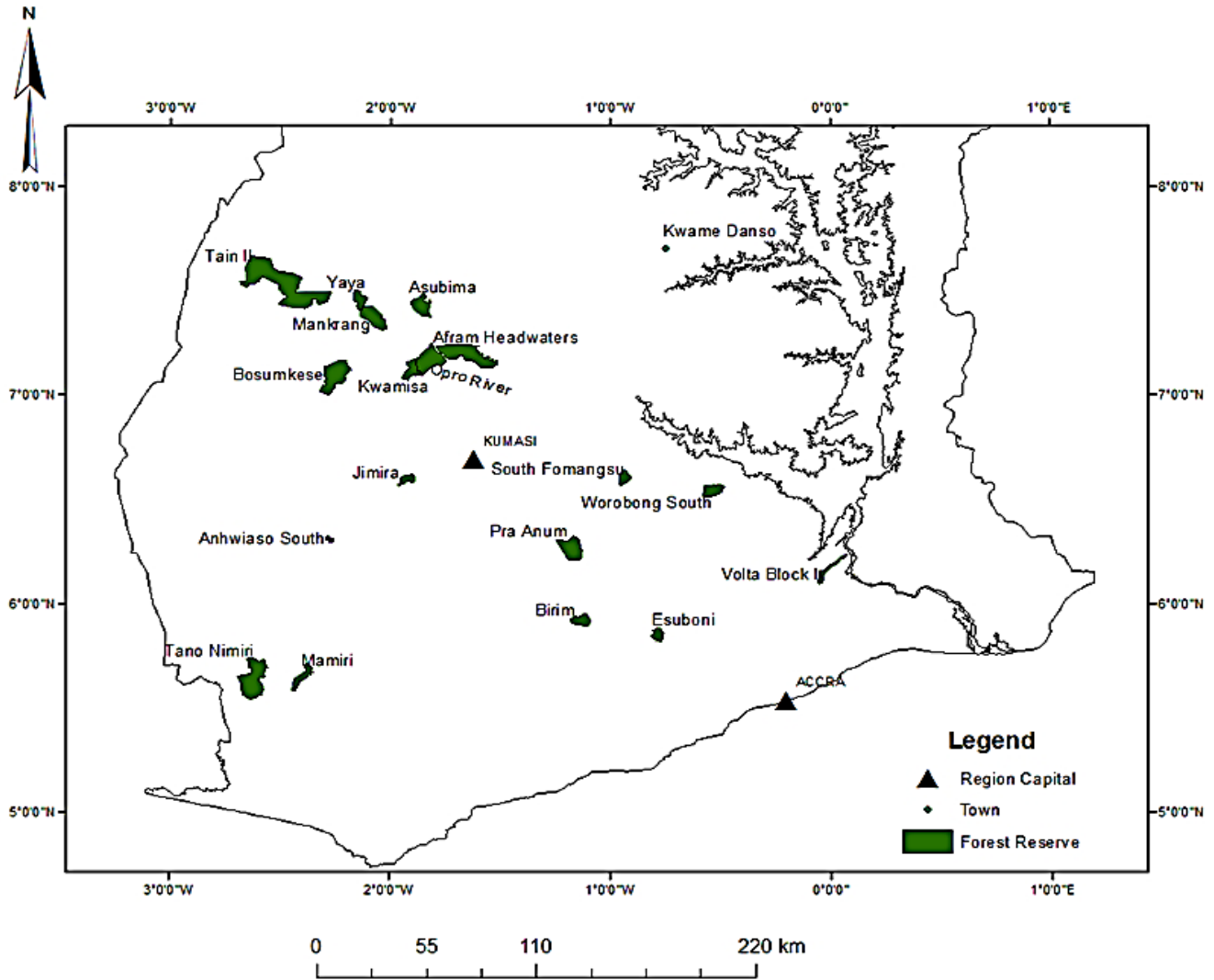


Figure 1. Distribution of plantations surveyed in forest reserves.

RESULTS

Disease incidence was variable depending on tree species, location and age.

Diseases of *Tectona grandis*: Ninety five percent of 17 teak plantations surveyed were free from diseases. However, teak mortality was observed in plantations around the Asubima, Afram Headwaters, Kwamisa, Mamiri and Opro forest reserves. Symptoms of poor tree health such as defoliation, dieback and stunted growth were recorded on trees as young as one year after planting while yellowing and dieback were observed in pole-sized trees in the Yaya and Tain II forest reserves. Dying trees had their leaves yellowing from the crown and later died back. In Asubima and Kwamisa disease incidence was minor but moderate in pole-sized trees in the Afram Headwaters and Opro forest reserves.

Root rot was found in only three out of 17 plantations surveyed (Table 1). It was recorded in the Kwamisa, Mamiri and Tano Nimri plantations with mortality being severe in plantations in the Mamiri Forest reserve.

Distribution of disease was in isolated patches in all the plantations surveyed. For plantations in Asubima, Worobong South, Afram Headwaters and Opro, poor tree health was attributed to poor site factors. In Kwamisa, Mamiri and Tano Nimri the causes were as a result of root rot pathogen.

Symptoms above-ground were wilting, yellowing of leaves, bark cracking, defoliation and dieback. Severely infected trees shed their leaves and died eventually (Figure 2a). At the bases of tree trunks were rot which were advancing up the stem with white mycelia between the bark and wood of stem.

Table 1. Major disease outbreaks in forest reserves in Ghana (2006-2012).

Host	Region	Forest Reserve	Ecological Zone*	Age (Yrs.) of plantations	Disease Status	Disease Severity	Causative Agent	Disease Distribution
<i>Tectona grandis</i>	Ashanti	Asubima	DS	1-2	Mortality	Minor	Drought	Isolated
				1-2	Defoliation/Dieback	Moderate	Drought	Isolated
		Opro	DS	2-4	Defoliation/Dieback	Moderate	Drought/Hardpan	Scattered
		Afram Headwaters	DS	2-4	Mortality	Moderate	Drought/Hardpan	Scattered
		Kwamisa	MS	2-4	Dieback/Basal rot	Moderate	<i>Armillaria</i> sp.	Isolated
				6	Mortality/Basal rot	Minor	<i>Armillaria</i> sp.	Isolated
		Jimira	MS	6-8	Nil	Nil	Nil	Nil
	Mankrang	MS	1-2	Defoliation/Dieback	Moderate	Drought/Hardpan	Scattered	
	Brong	Yaya	DS	2-4	Defoliation/Dieback	Moderate	Drought/Hardpan	Scattered
	Ahafo	Tain II	DS	2-4	Defoliation/Dieback	Moderate	Drought/Hardpan	Scattered
	Western	Mamiri	ME-WE	9	Mortality/Basal rot	Severe	<i>Armillaria hemii</i>	Isolated
		Tano Nimiri	ME-WE	6	Mortality/Basal rot	Severe	<i>Armillaria hemii</i>	Scattered
		Anwhiaso South	MS	2-3	Dieback	Moderate	<i>Armillaria hemii</i>	Isolated
	Eastern	Pra Anum	MS	6-8	Nil	Nil	Nil	Nil
Worobong South		DS	1	Stunting	Moderate	Drought/Hardpan	Isolated	
Birim		MS	6-8	Nil	Nil	Nil	Nil	
Volta Block I		DS-SM	8-10	Dieback	Minor	Drought	Drought	
<i>Cedrela Odorata</i>	Ashanti	Asubim	DS	1-2	Mortality	Minor	Drought	Isolated
	Brong	Yaya	MS	1-2	Defoliation	Moderate	Poor site	Scattered
					Stunting	Minor	Drought/Hardpan	Scattered
	Western	Mamiri	ME-WE	9	Basal rot	Severe	<i>Armillaria hemii</i>	Scattered
		Tano Nimiri	ME-WE	9	Basal rot	Severe	<i>Armillaria hemii</i>	Scattered
			8	Wind throwing	Minor	Drought/Hardpan	Isolated	
<i>Ceiba pentandra</i>	Ashanti	Mankrang	MS	Nursery	Leaf spot	Severe	<i>Colletotrichum</i> sp.	Scattered
		Asenanyo	MS	1-2	Dieback	Severe	<i>Colletotrichum</i> sp.	Scattered
		FORIG	MS	Nursery	Leaf spot	Severe	<i>Colletotrichum</i> sp.	Scattered
	Eastern	Pra Anum	MS	3	Mortality	Moderate	<i>Colletotrichum</i> sp.	Scattered
<i>Eucalyptus</i> spp.	Brong	Kwame Danso	DS		Cutting rot	Minor	<i>Calonectria</i> sp.	Isolated
	Ahafo				Leaf spot	Minor	<i>Mycosphaerella</i> sp.	Isolated
			Nursery		Leaf blight	Minor	<i>Cylindrocladium</i> sp.	Isolated
	Central	Yenku	SM	8-12	Nil	Nil	Nil	Nil

*DS: Dry Semi-deciduous; MS: Moist Semi-deciduous; ME-WE: Moist Evergreen-Wet Evergreen; SM: South Marginal



Figure 2a. Death of teak trees.



Figure 2b. Rot of stem with mycelia mat at base.



Figure 3a. White mycelia under bark of cedrela stem.



Figure 3b. Disease in *Cedrela odorata* plantations.

Table 2. Disease incidence in *Cedrela odorata* plantations.

Tree Health Status	Disease incidence (%) in <i>C. dorata</i> plantations in	
	Mamiri	Tano Nimiri
Healthy	31.7	13.0
Moderately diseased	14.5	4.1
Severely diseased	36.5	61.6
Death of trees	16.3	21.3

The incidence of disease was more severe in plantations in the Mamiri forest reserve with 1.2% of the trees infected with root rot. Macroscopic and DNA sequencing of isolates (fruit bodies) revealed *Armillaria hemii* complex as the pathogen (Figure 2b).

Diseases of *Cedrela odorata*: In plantations at the Tano Nimri and Mamiri forest reserves basal root rot was observed in 68.3% pole-sized trees. Disease was severe and scattered in the plantations. Bark of trees were cracked and decaying from the base up the stems, and leaves of newly attacked trees first turned yellowish and shed off as the infection advanced

(Figure 3a). About 68% and 87% of plantations in Tano Nimri and Mamiri forest reserves, respectively were affected and cleared resulting in huge economic losses to the developers. *Armillaria hemii* was identified on the roots and base of affected trees as in the teak plantations (Figure 3).

Defoliation and dieback were observed in one to two-year-old trees in Yaya and Asubima respectively. Drought-related stunting appeared to be a common problem in the one to two-year-old plantations in Afram Headwaters, especially in areas with dry weather.

Diseases of *Ceiba pentandra*: In the nursery at

Mankrang, leaf spot and dieback were observed on seedlings at the onset of the rainy season in April. In Pra Anum and Asenanyo, dieback and mortality occurred in saplings of between one to four-year-olds. The severity of these infections resulted in 90-100% losses in the nursery depending on the provenances and 50-70% in plantations. Leaf spot was caused by *Colletotrichum capsici*, whereas *Fusarium solani* and *Lasiodiplodia theobromae* were associated with dieback of stems in both nursery and field.

Diseases of *Eucalyptus* species: Low levels of disease (<1.0%) were observed in *Eucalyptus* plantations; however, *Cylindrocladium* leaf blight was common on *Eucalyptus* trees in plantations of APSD Ghana Limited. A *Calonectria* species was also found causing rot in the nursery.



Figure 4. *Botryosphaeria* canker on trunk of *Eucalyptus* tree.

Isolated cases of disease caused by species of *Botryosphaeria* (Figure 4), *Pestalotiopsis* and *Phomopsis* (*Diaporthe*) were observed on branches and trunks of *Eucalyptus argophloia* and *E. grandis* hybrids. Species of *Mycosphaerella* and *Teratosphaeria* were isolated from leaf spot symptoms while *Quambalaria eucalypti* was found on a single *E. grandis* tree.

DISCUSSION

Defoliation, dieback and stunted growth were found in ten out of 17 teak plantations in one to two-year-old saplings as a result of drought during the dry season. This is similar to observations made in Indonesia by Widyastuti and Widyastuti (2002). Poor tree health was considered to have significant impact on plantation production, particularly during the early phase of establishment by tree growers (Mohd Farid *et al.*, 2005).

Generally, majority of the plantations surveyed were free from root disease. Root disease was found in only two out of the twenty forest reserves surveyed. In these reserves basal root rot was present in both teak and cedrela plantations. Disease infection on teak was recorded seven years after planting in the Mamiri forest reserve. However, Mazia and Lee (1999) have reported teak trees aged two years and above were frequently infected by root disease in Malaysia.

In Ghana, signs and symptoms of pathogen attack were visible on stems and roots of cedrela and teak trees and were of high incidence and severity (68.3%) in cedrela and minor (1.5%) in teak). The first visible symptom of root disease was gradual yellowing of leaves followed by shedding of leaves and decay of most root system. Spread of disease to adjacent healthy trees was primarily through root contact. Earlier work by Tewari (1992) reported that this was the most common mode of disease spread in plantation-grown teak. Frequently, the source was infected old stumps and wood debris remaining in the soil or standing diseased trees.

Armillaria hemii was identified on the roots and root collars of affected teak and cedrela plantations in Mamiri and Tano Nimri forest reserves. Wilting and yellowing of tree crowns as well as occurrence of white mycelial fans under the bark of infected teak trees were common symptoms of *Armillaria* infections (Morrison *et al.*, 1991). *Armillaria hemii* has been reported to have infected trees (*Eucalyptus*, *Pinus*, *Acacia*, *Grevillea* and *Cupressus* species) in several countries in south, central, east and western Africa (Coetzee *et al.*, 2000; Mwenje and Ride, 1996; Gezahgne *et al.*, 2003). *Armillaria* root rot exists naturally in dense rain forest zones where annual rainfall exceeds 1,300 mm. Clearing the forest breaks this natural equilibrium and causes pre-existing infection centres to spread in the new plantations. Thus the incidence of pathogens in young plantations depends on the previous density of inoculum in the forest (Nandris *et al.*, 1987). Mohd Farid *et al.* (2005) indicated that root rot disease was found mostly in plantations with poor land preparation, where stumps and wood debris have been left on the ground to decay.

Outbreaks of leaf spot in *Ceiba pentandra* which resulted in dieback caused high mortality (70-100%) in nurseries established in Mankrang and Pra Anum. Reports have been made on leaf spot of *C. pentandra* in Assam, Madya Pradesh and Uttar Pradesh in India

where the disease was first detected in seedlings at the nursery. The disease was destructive and damaged as much as 40% of the leaf area (Mehrotra, 1989). *Colletotrichum capsici* was identified as the causal agent of leaf spot in the nursery whereas *Fusarium solani* and *Lasiodiplodia theobromae* were associated with dieback of stems in both nursery and field. However, in Nagpur, India, dieback and canker were caused by *Colletotrichum gloeosporioides* (syn. *Glomerella cingulata*) in established trees of *C. pentandra* (Chakrabarty *et al.*, 1993).

On branches of *Eucalyptus argophloia* and *E. grandis* hybrid plantations in APSD, isolated cases of diseases caused by species of *Botryosphaeria* were observed. *Botryosphaeria* species are known to be saprophytes and opportunistic pathogens (Barnard *et al.*, 1987; Shearer *et al.*, 1987; Smith *et al.*, 1994) on Eucalyptus species. However, these are viewed as latent pathogens that occur on leaf and branch tissues of healthy woody plants which later cause disease when trees are stressed (Fisher *et al.*, 1993; Smith *et al.* 1996) due to drought, frost, waterlogging and insect damage (Old *et al.*, 1990). In South Africa, wide-spread twig dieback and stem cankers caused by *Botryosphaeria dothidea* and *B. eucalyptorum* were observed on *E. grandis*, *E. nitens* and *E. smithii*, clones of *E. grandis*, hybrids of *E. grandis* with *E. camaldulensis*, as well as on *E. urophylla* (Smith *et al.*, 1994, 2001). Since the Eucalyptus plantations in Ghana are being developed on marginal soils where moisture is a limiting factor there is the need for careful matching of planting stock to site to avoid stress-induced damage.

Cylindrocladium leaf blight affected young trees in *Eucalyptus* plantations of APSD Ghana Limited. *Cylindrocladium* are common pathogens of *Eucalyptus* and *Acacia* species particularly in nurseries (Crous *et al.*, 1991) causing damping off of young seedlings as well as leaf defoliation, shoot blight and cankers on the stems of young plants. In Kenya and Uganda young seedlings of *Eucalyptus* showed signs of *Cylindrocladium* infection, including damping off and stem cankers. Since *Cylindrocladium* infection is common on *Eucalyptus* trees in nurseries, it is a potential threat to plantation establishment in the country.

A species of *Mycosphaerella* was isolated from leaf spot on an *E. grandis* tree. Several *Mycosphaerella* species have been reported from southern and east Africa and found to display differences in host range and age with

regard to infection of leaves (Crous, 1998; Hunter *et al.*, 2004). Some *Mycosphaerella* species are capable of causing more serious disease on mature foliage in Australia and South East Asia (Crous, 1998; Crous *et al.*, 1998; Wingfield *et al.*, 1996) and every effort must be made to exclude them from African countries.

CONCLUSIONS

Although several forest tree plantations have been established under the National Forest Plantation Development Programme in the different forest districts of Ghana, survey was undertaken only in a limited number of plantations. The study found new records of exotic diseases with no serious management of the pathogens by plantation developers. Suggestions have been made for stump removal and trenching in areas affected with root rot, removal of infected trees, proper farm maintenance culture, sanitation and thinning followed by insecticide and fungicide application. Establishment of new plantations should take into account the presence of pathogens causing these diseases and also match planting stock to site to avoid stress. There is also the need to establish plantation health networks to monitor, protect and prevent introduction of new pathogens with the increase in new tree plantations.

ACKNOWLEDGEMENT

Funding for the research and survey was provided by the African Development Bank (AfDB), Forestry Commission, APSD Ghana Ltd., National Research Foundation (NRF) of South Africa and the Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria.

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