DISEASES OF TROPICAL ACACIAS

Proceedings of an International Workshop held at Subanjeriji (South Sumatra)

28 April - 3 May 1996

Edited by K.M. Old, Lee Su See and J.K. Sharma

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Published by

Center for International Forestry Research (CIFOR)
PO Box 6596, JKPWB
Jakarta 10065
Indonesia

ISBN 979-8764 13-7

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Foreword

Tropical acacias are of considerable social and industrial importance for tropical reforestation and it is expected that about 2 million hectares will be established in South East Asia by the year 2000. In Australia, the forestry industry has recently announced a visionary plan to triple the area of plantations in the country to 3 million ha over the next thirty years.Although the hardwood plantation estate is currently developing in temperate regions of Australia it is likely that more plantations will be established in the tropics and that acacias will be among the species of choice.

Recent reports from Malaysia, Indonesia Thailand and northern Australia suggest that the future productivity of some Important species may be affccted by fungal pathogens including leaf spots, shoot blights, stem cankers, heart rot, root rots and gall rusts. During 1995-96 a series of disease surveys was undertaken in native stands, trials, and operational and social forestry plantings of tropical acacias in Australia, India, Indonesia, Malaysia, and Thailand to assess the potential of fungal pathogens as limiting factors to tree growth and productivity and to assess the relative importance of individual fungal pathogens.

Lead scientists from these countries, and colleagues who had participated in the project met with research managers of five major Indonesian plantation pulp and paper companiesand goverment business enterprises April28 - May 3 1996 at the base camp of PT Musi Hutan Persada, Subanjeriji in Sumatra to present the results of their surveys. This publication is a status report on the diseases of acacia In the several countries based on information presented at the workshop It provides a benchmark of the current knowledge of the pathology of the four most important acacia species currently being grown in plantations in tropical areas of south east Asia, the Indian subcontinent and northern Australia.

The tree species chosen for study were *Acacia mangium* Willd., *A. auriculiformis* Cunn. ex Benth., *A. crassicarpa* Cunn. ex Benth. and *A. aulacocarpa* Cunn. ex Benth.

Collaborating institutions, lead scientists and roles

CSIRO Forestry and Forest Products - Dr Ken Old
Project coordination, including visits to participating countries.
Lead scientist for Australian component of the project.
Planning and facilitation of the workshop.
Co-author with Mr. Ian Hood and Mr Yuan Zi Qing of chapter on acacia diseases in northern Australia.
Co-editor of the workshop proceedings.
Overall project management.

Institute for Horticultural Development, Knoxfield, Victoria - Mr Ian Pascoe
Provision of tasonomical support and curation of herbarium collections.
Co-author with Dr Paul Cannon of the International Mycology Institute (UK) of a mycological report on collections lodged with the herbarium.

Queensland Forest Research Institute (QFRI) - Mr Ian Hood
Organiser of field trips to northern Queensland in April 1995 and 1996.
Co-author of chapter on acacia diseases in northern Australia.
Provision of taxonomic expertise on basidiomycete decay fungi.

Forest Research Institute of Malaysia (FRIM) - Dr Lee Su See
Lead scientist, for Malaysian component of the project.
Visitor to Australia for research discussions on hardwood pathology including the Queensland Forest Research Institute, Indooroopilly, CSIRO Forestry and Forest Products in Canberra, Hobart and Perth.
Author of chapter on acacia diseases in Malaysia.
Planning of the project and workshop.
Co-editor of the workshop proceedings.

Royal Forestry Department (RFD) Thailand - MS Krisna Pongpanich
Lead scientist for Thailand
Author of chapter on acacia diseases in Thailand
Visitor to Australia for 8 weeks in March-April 1995 for collaborative research.

Fakultas Kehutanan, Institut Pertanian Bogor (IPB) - Dr Soetrisno Hadi
Lead scientist for Indonesia.
Co-author with Mr Simon Taka Nuhumara of chapter on acacia diseases in Kalimantan, Indonesia.

Kerala Forest Research Institute (KFRI) - Dr Jyoti Sharma
Lead scientist for India.
Co-author with Dr Maria Florence of chapter on acacia diseases in India.
Planning of the project and workshop.
Co-editor of the workshop proceedings.

International Mycological Institute (IMI) - Dr PauI Cannon
Provision of taxonomical support and co-author of a mycological report on collections lodged at the Institute for Horticultural Development herbarium.

CIFOR - Mr Christian CossaIter
Planning of the project and workshop.
Management of the project on behalf of CIFOR.
Participant in the workshop.

PT Musi Hutan Persada - Dr Ken Gales
Planning of the project and workshop.
Organisation of the workshop at Subanjeriji, Sumatra.
Coauthor with Ms Anna Zulfiyah of chapter on disease incidence at Subanjeriji.

ENS0 Forest Development/ Balai Teknologi Reboisasi. Banjarbaru-Mr Anti Otsamo
Planning and supervision with Mrs. Lilis Kurtani of the survey at Riam Kiwa, South Kalimantan.
Mrs Kurtani participated in the workshop.

ENS0 Forest Development-Mrs Anu Honkanen
Planning and supervision of the survey at Sanggau, West Kalimantan, and participation in the workshop.

The workshop was very successful with a high level of information exchange between scientists and R&D managers. There was a strong recommendation by the participants, especially the representatives of the plantation companies that the information presented at the meeting should form the basis for an illustrated manual of diseases of tropical acacias. It was further agreed that the network of forest pathologists established through the region should be further strengthened through future collaboration, exchange visits and attachments.

Acknowledgments

The scientists participating in the project and the workshop gratefully acknowledge the support provided by the Australian Center for Agricultural Research (ACIAR), the Centre for International Forestry Research (CIFOR), and their respective Organisations and Institutes. We particularly thank the Production and Technical Director of PT Musi Hutan Persada, Dr Joedarso Djojosoebroto for extending a warm welcome to participants, for making the facilities at Subanjeriji available for the workshop and the subsequent field trip, and providing accommodation and all transport and logistics needed to hold the meeting in such a remote location. We thank Mrs Anne Griffin and Mr Vladimir Mosmondor of CSIRO Forestry and Forest Products for word processing assistance and graphic design.

K.M. Old

Diseases of Tropical Acacias in Northern Queensland

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Abstract

Acacia aulacocarpa, A. auriculiformis, A. mangium and *A. crassicarpa* are species indigenous to northern Australia that have emerged as major plantation species in south east Asia. In order to meet the demand for seed of known provenance, seed production areas of all four species have been established in parts of northern Australia. The proximity of these plantations to native acacia stands made possible a study to compare the fungi present on natural and planted hosts and in this way to identify potential pathogens on plantation crops in Australia and in other regions.

Of the fungi found in planted and natural populations of these species, four are identified as offering significant pathogenic potential. These are a *Cercospora* species which caused a severe epidemic and many tree deaths in *A. mangium* seed production areas planted in 1990 in northern Queensland; an undescribed species with affinities to *Pseudocercospora* found primarily in native stands of *A. crassicarpa* in northern Queensland and in plantations of the same species on Melville Island, Northern Territory; *Atelocauda digitata*, a rust causing phyllode distortion, which although not found in plantations was common in natural stands of all four species; and a *Phoma* species which induces a very conspicuous foliage spot on *A. flavescens* but which was not found on any of the acacia species targeted by this project. Other pathogens of uncertain status found in plantations and natural stands in northern Australia included *Colletotrichum* sp., *Ganoderma* sp.aff. *G. lucidum*, *Guignardia acaciae, Phaeotrichoconis crotalariae,* and *Uromycladium tepperianum.* The latter species was collected only once in this survey on *A. flavescens* but is widespread on both tropical and temperate acacias in Australia.

Introduction

Four tropical acacias, *Acacia aulacocarpa* Cunn. ex Benth., *A. auriculiformis* Cunn. ex Benth., *A. crassicarpa* Cunn. ex Benth. and *A. mangium* Willd., have become important as major plantation species in south east Asia. Although these species are all indigenous to northern Australia, it is only recently that significant planting of acacias has been undertaken in tropical parts of this country. Stands have now been established as seed production areas (SPAs) in Queensland and the Northern Territory under a collaborative arrangement between CSIRO Forestry and Forest Products, Queensland Department of Primary Industries Forestry and the Conservation Commission of the Northern Territory. The latter is a joint venture agreement with the indigenous Tiwi people of Melville Island (Harwood *et al.*, 1994).

There is a buoyant demand for seed of these species for plantation development in many countries in south east Asia. Although all four species fruit prolifically, a high price is paid for seed of particular provenances, especially from regions such as Papua New Guinea. By establishing SPAs the need for expensive seed collecting expeditions to relatively inaccessible parts of northern Australia, Papua New Guinea and Indonesia will be much reduced. In addition, the design of the seed production stands which incorporates the selection of superior seed trees within each of the provenances will significantly improve the genetic quality of seed (Harwood *et al*.**,** 1994).

In northern Queensland, SPAS of *A. mangium* and *A. aulacocarpa* are situated at Lannercost, near Ingham, and at Cardwell and Kuranda. Others, which were planted near Yapilika on Melville Island (Northern Territory), include *A. crassicarpa, A mangium*, and *A. auriculiformis.* The total area of plantations established as SPAs in Queensland and the Northern Territory is currently 26 ha, and there are also small scale plantations in northern Queensland. No substantial plantation areas of any of the four species exist in Australia, although currently there are plans to increase the planting of native hardwoods in northern Queensland, which will include acacias.

As the area and value of the tropical acacia plantation resource increases in south east Asia there is a greater need to identify potentially damaging fungi that could become introduced to these forests. Two previously unrecorded pathogens have already appeared in the stands of acacias recently planted in northern Australia (Old *et al*.**,** 1996). A species of *Cercospora* caused severe damage in the SPAS of *A. mangium* at Lannercost and Kuranda in 1990 (Dr Bruce Brown, unpublished report). *Phaeotrichoconis crotalariae* (Salam & Rao) Subram., although well known on a wide range of tropical species and which was known in Australia on *Xanthium pungens* Wallr. has now been found for the first time on acacias planted in this country. The outbreak of Cercospora phyllode blight in northern Queensland was particularly serious. All diseased plants originated from a single nursery and deaths were observed in out-planted trees in June, 1990. However, Brown's inspection of plantations at Lannercost and Kuranda showed that by April, 1991, the incidence of disease had declined and the fungus was not found during subsequent visits by the authors. The source of this outbreak of Cercospora phyllode blight has never been established despite an intensive search for this pathogen in seed lots of *A. mangium* stored at the CSIRO Australian Tree Seed Centre, Canberra (Solomon, 1993). The disease has not been reported outside Australia.

The SPAs and trials established in northern Australia are situated near to natural stands of the same and other acacia species present in the region. There was therefore a unique opportunity to study the susceptibility of the different *Acacia* species when exposed to a range of potential indigenous pathogens present in the adjacent natural vegetation.

The scope of the survey

The objective of this study was to survey the fungi and other microorganisms present on stems and phyllodes of trees in the SPAs and in a number of species and provenance trials in order to assess the occurrence of putatively pathogenic species, the types of symptoms induced, and the extent of damage under plantation conditions. Native stands of all four target species in northern Queensland were surveyed in order to determine the range of fungi present. Several other acacia species present in these trials and in mixed natural stands were also examined as part of the survey. Seedlings at Ingham and Walkamin nurseries and saplings in a small species trial at Mareeba were incorporated into the study, and for completeness data were included from records made by Yuan (1996) during a visit to the SPAs and nearby natural vegetation at Yapilika on Melville Island in 1994.

The distributions in Queensland of the native populations of the four tropical acacias studied are shown in Figures la-d (maps kindly supplied by the Queensland Herbarium, Department of Environment and Heritage). All four species also occur naturally in New Guinea and *A. auriculiformis* occurs in the Northern Territory of Australia. *A. aulacocarpa* occurs in Northern Territory, Western Australia and northern New South Wales (NT) (Gunn and Midgley, 1991). The study covered a major segment of the natural distribution ranges within Australia of *A. mangium* and *A. crassicarpa*, but only the southernmost natural distribution of *A. auriculiformis* stands and a limited portion of the widely distributed *A. aulacocarpa* were visited. Fungi already recorded on these species in Queensland are

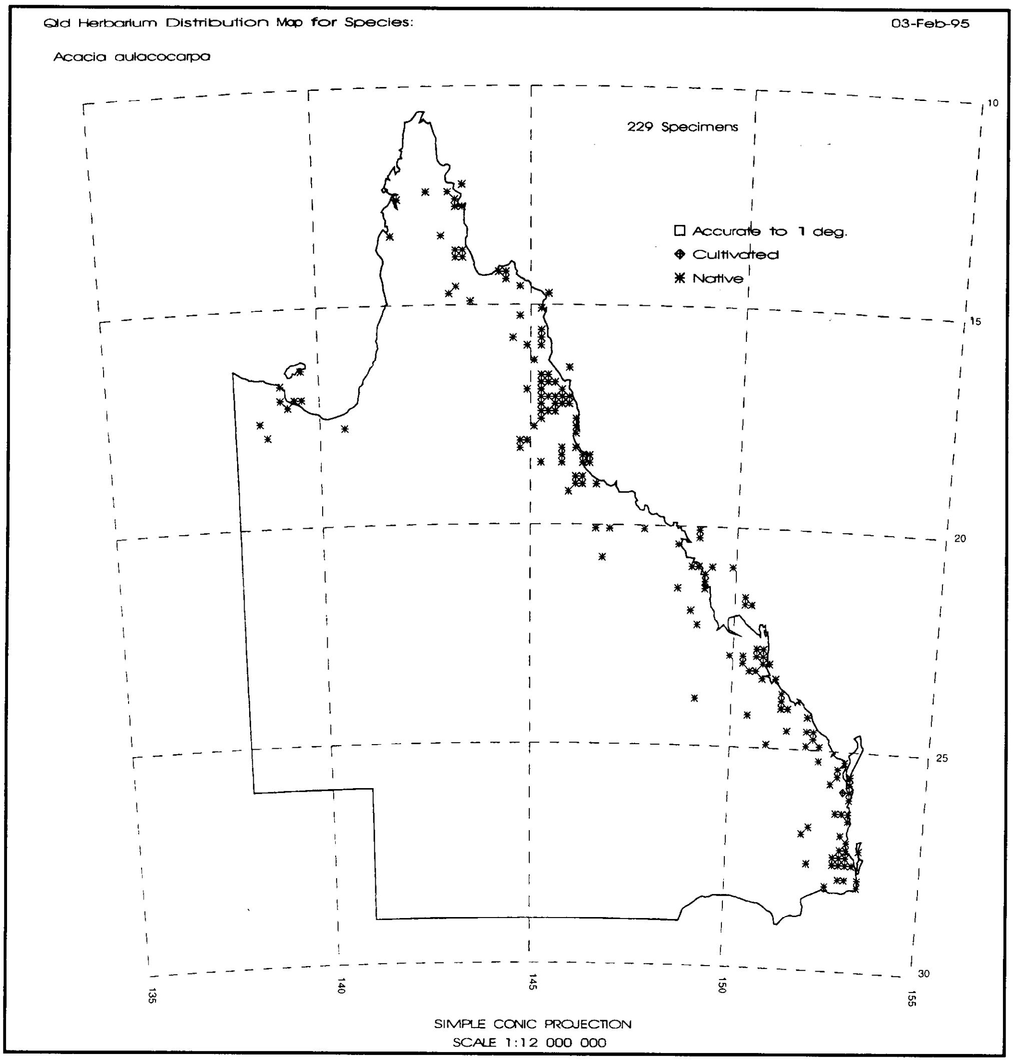

Figure 1a. Distribution in Queensland of *Acacia aulacocarpa* Cunn ex Benth.

(Reproduced with the permission of Queensland Herbarium, Department of Environment and Heritage)

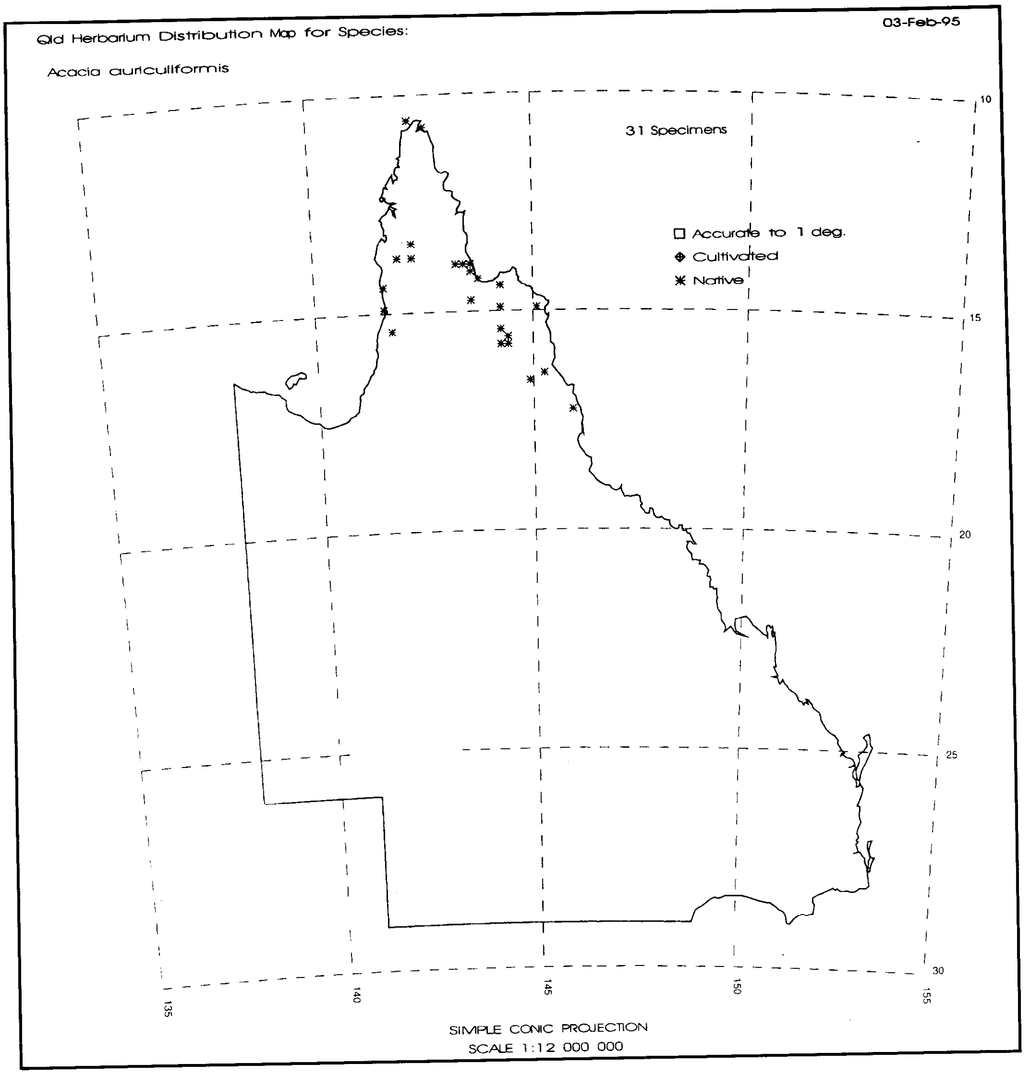

Figure 1b. Distribution in Queensland of *Acacia auriculiformis* Cunn. ex Benth.

(Reproduced with the permission of Queensland Herbarium, Department of Environment and Heritage)

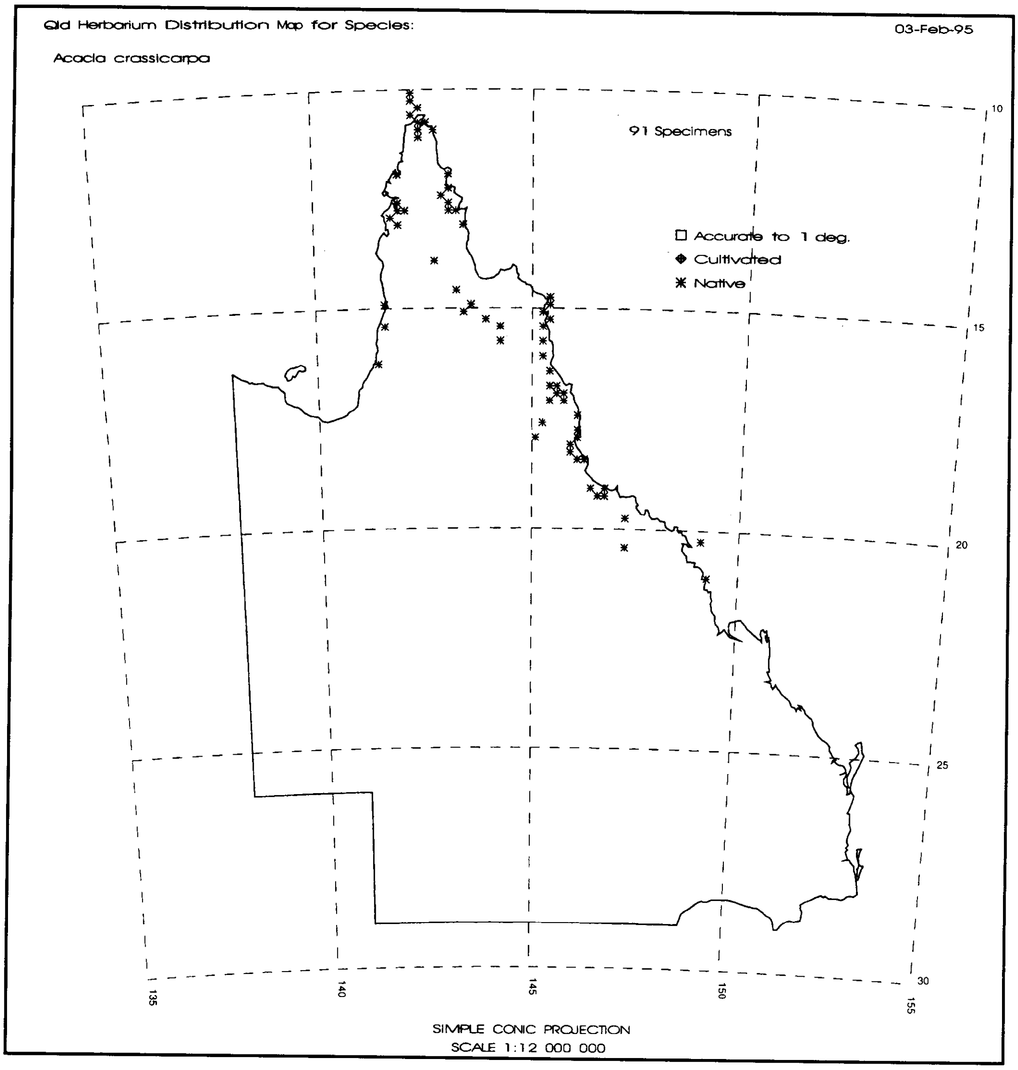

Figure 1c. Distribution in Queensland of *Acacia crassicarpa* Cunn. ex Benth.

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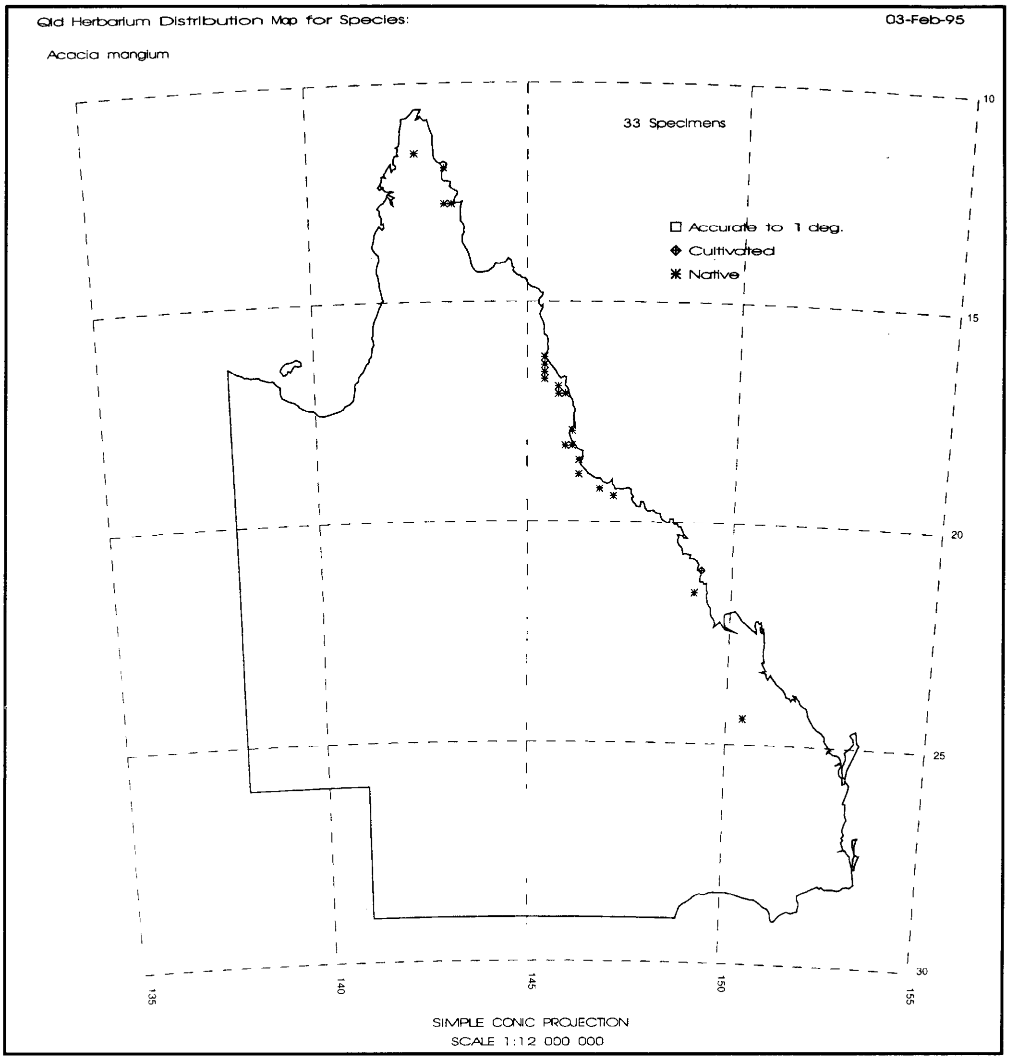

Figure 1d. Distribution in Queensland of *Acacia mangium* Willd.

(Reproduced with the permission of Queensland Herbarium, Department of Environment and Heritage)

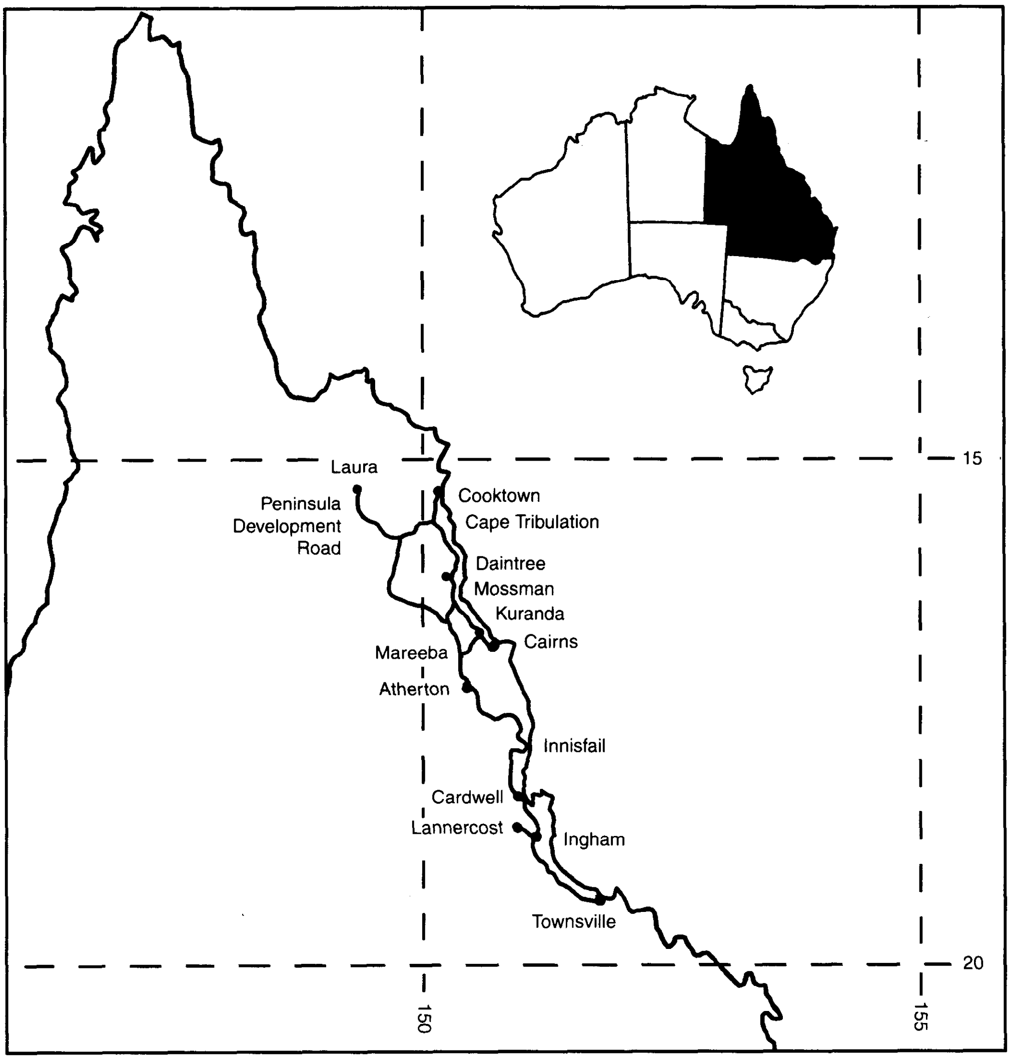

Figure 2. Localities in Northern Queensland visited during survey of diseases of tropical acacias.

listed in Table 1, which is based on an unpublished catalogue of collections held at Herbarium BRIP provided by Dr John Alcorn supplemented by several published records (Simmonds, 1966; Shivas and Alcorn 1996). Due perhaps to the remoteness of the native stands of *A. auriculiformis* there were no collections listed on this species although two Australian records were published by Boa and Lenné (1994).

Table 1. Records of fungi on four tropical Acacia species in Australia[1]

FUNGUS	HOST			
	A. aulacocarpa	***A. crassicarpa***	***A. auriculiformis***	***A. mangium***
Aecidium sp.	+*			
Alternaria alternata (Fr.: Fr.) Keisl.				+
Atelocauda digitata (G. Wint.) Cummins & Y. Hiratsuka (including *Uromyces digitatus*)[2]	+			+
Cercospora sp.				+
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. in Penz.				+
Colletogloeum sp.	+			
Corynespora queenslandica Sutton & Pascoe[3]	+*			
Coriolopsis aspera (Jungh.) Teng. (as *Trametes strigata*)[2,4]	+			
Trichaptum biformis (Fr.) Ryv.(as *Coriolus paragamenus*)[2,4]	+			
Curvularia geniculata (Tracey & Earle) Boedijn				+
Ganoderma applanatum (Pers.) Pat.[4]			+*	
Ganoderma chalceum (Cooke) Steyaert[4,5]	+			+
Ganoderma sp. (*as Fomes nigro - laccatus*)[2,4]	+			
Glomerella cingulata (Stoneman) Spauld. & H. Schrenk				+
Inonotus rheades (Pers.) Bond. & Sing.[2,4]	+			
Laricifomes concavus (Cooke) Cunn. (as *Fomitopsis concava*)[2,4]	+			
Meliola sp.	+			
Nigrospora sphaerica (Sacc.) E. Mason				+
Oidium sp.	+*	+	+*	+*
Pestalotiopsis sp.				+
Phellinus setulosus (Lloyd) Imazeki (as *Fomes setulosus*)[2,4]				
Phomopsis sp.	+*			+
Pseudocercospora sp.	+			
Spilodochium acaciae Alcorn[6]	+	+		
Trametes scabrosa (Pers.) Cunn. (as *Coriolus corrugatus*) [2,4]	+			

[1] From a list of collections from Queensland held at Herbarium BRIP, Brisbane supplied by Dr John Alcorn; asterisks (*) indicate supplementary records by Boa and Lenné (1994).

[2] Published in Simmonds (1966), who also included on *A. aulacocarpa*: *Amauroderma rude* (Berk.) Cunn. (as *Polyporus rudis*),[4] *Phellinus gilvus* (Schw.) Pat.[4]

[3] Published by Sutton and Pascoe (1988)

4 Wood decay fungus
5 Browne (1968) listed *G. lucidum* on *A. auriculiformis* in India.
6 Published by Alcorn (1974,1978)

Materials and Methods

Field inspections of stands were made in April 1995 at the localities indicated in Tables 2-5 and samples of shoots and foliage were collected. Collections were made in the SPAs of *A. mangium* and *A. aulacocarpa* at Lannercost, Cardwell and Kuranda, in an extensive species and provenance trial established in 1985 at Lannercost which included all four acacia species and in a small trial at Southedge near Mareeba. Details of the provenances represented in the SPAs are given in Table 2, and site characteristics in Table 3. Natural stands of all four species were sampled along an overland route made through the coastal stands of *A. mangium* and *A. crassicarpa* between Ingham and Innisfail and inland to the Atherton Tablelands (Fig 2). The southernmost occurrence of *A auriculiformis* was included in a detour from Rifle Creek near Mt Molloy up the Peninsular Development Road to Laura River, north-west of Cooktown. Further collections were made at localities between Cooktown and Cairns including inspection points near Cape Tribulation, Daintree, Mossman and Rex Range (Fig. 2). Collections made south from Cooktown also sampled several other native acacia species (eg. *A. flavescens* Cunn. ex Benth., *A. holosericea* Cunn. ex G. Don, *A. polystachys* Cunn. ex Benth., and *A. polystachys* x *A. mangium* hybrid). Assistance during field collecting was given by Mr Peter Pomroy, Mr Steve Kitchner and other personnel of Queensland Department of Primary Industries Forestry (QDPI), and by Krisna Pongpanich, Royal Forestry Department, Thailand (RFD).

Table 2. Seed production areas established in northern Australia and their genetic bases (Harwood *et al.*, 1994).

Species and Planting Year	Stand Location	Provenance regions	Area (ha)	No. of families
Northern QLD				
A. mangium 1990	Lannercost	PNG-N	0.8	36
	Lannercost	FNQ	1.9	80
	Kuranda	PNG-SE* & PNG-SW*	1.5	60
	Kuranda	FNQ	1.9	96
A. mangium 1991	Lannercost	QCR	1.4	98
	Lannercost	FNQ	0.7	60
	Cardwell	PNG-SW	2.7	104
	Kuranda	PNG-N	1.1	70
	Kuranda	FNQ	1.1	60
	Kuranda	PNG-SE	0.8	50
A. aulacocarpa 1991	Cardwell	PNG-SE	1.6	89
	Lannercost	PNG-SW	1.0	66
	Kuranda	PNG-SE	1.0	72
	Kuranda	PNG-SW	1.1	77
Melville Island, Northern Territory				
A. auriculiformis 1989	Maxwell River	PNG-SE QLD & NT	2.7	200
	Yapilika	PNG-SE QLD & NT	1.9	144
	Yapilika	PNG-SE Bensbach River	0.5	33
	Yapilika	PNG-SE Bensbach River **	0.6	40
	Yapilika	PNG-SE Morehead River	0.6	42
	Yapilika	PNG-SE Morehead River	0.6	40
A. auriculiformis 1990	Yapilika	PNG-SE QCR	0.8	56
A. crassicarpa 1990	Yapilika	PNG-SE PNG-SW & QLD	2.1	170

* Severely damaged by Cercospora phyllode blight.
** Failed due to attack by stem-boring insect larvae.
Key. FNQ Far north Queensland (includes Claudie River and Iron Range)

QCR	Queensland, Cairns region
NT	Northern Part of the Northern Territory of Australia
PNG-N	Western province, PNG North of Fly River
PNG-SE	Western Province, PNG South of Fly River
PNG-SW	Western Province, PNG West of Fly River

Table 3. **Site characteristics of Seed Production Areas** (Harwood *et al.*, 1994)

	Location			
	Kuranda	**Cardwell**	**Lannercost**	**Yapilika**
Altitude (m)	380	20	90	20
Latitude (°S)	16°45′	18°24′	18°38′	11°34′
Longitude (°E)	145°30′	146°06′	145°52′	130°34′
Mean annual temperature (°C)	23	24	24	25
Mean maximum temperature during hottest month (°C)	33	32	33	33
Mean minimum temperature during coldest month (°C)	12	14	13	20
Mean annual precipitation (mm)	1740	2110	1690	1750
Length of dry season (consecutive months with <40 mm rainfall)	4	4	4	4

For reasons of accessibility many of the collections from natural acacias were made from smaller regrowth trees which were often present in dense even-aged stands of mixed species that had regenerated following disturbance along roadsides or service easements. Collections from native wildlings of *A. crassicarpa* were taken within the species and provenance trial at Lannercost.

Collections were examined in the laboratory and fungi were identified from fructifications present on the sampled material. Initial identifications were undertaken by the authors and selected collections were forwarded to Mr Ian Pascoe for further examination assisted by Dr Paul Cannon of the International Mycological Institute (IMI). Diagnostic assistance was also provided by Dr John Alcorn (Queensland Department of Primary Industries). Collections are held at CSIRO Forestry and Forest Products (DFR) in Canberra and representative specimens are lodged in the Australian National Fungal Collection herbarium at the Institute of Horticultural Development, Knoxfield, Victoria (Herb VPRI), in Herbarium BRIP (Queensland Department of Primary Industries Agricultural Production, Indooroopilly, Brisbane), and in the disease collection of Queensland Forest Research Institute, Queensland Department of Primary Industries Forestry, Indooroopilly (QFRI).

Results and Discussion

Damage in plantations

With the exception of stem cankering of *A. auriculiformis* and *A. leptocarpa* associated with insect boring in a small species trial at Southedge, Mareeba, no fungal diseases were found on plantation acacias at levels that merited assessment. The only other condition giving cause for concern in the SPAs was a high incidence of borer damage on *A. aulacocarpa* from Papua New Guinea in the Cardwell SPA. More than 25% of this stand was affected even after thinning had been carried out, and the incidence of damage would have been greater before thinning. Some insect borer damage was also recorded on the same species in the Lannercost SPA.

A list of the organisms found associated with disease symptoms in planted stands is catalogued in Table 4 which also briefly describes the type of symptom observed and gives a statement on the degree of associated damage. No disease symptoms were recorded on the PNG and FNQ sources of *A. mangium* in the Lannercost SPAs, nor on the *A. auriculiformis* provenance from Balamuk, PNG, in the species and provenance trial at Lannercost.

Table 4. Diseases recognised in Acacia plantations in Northern Australia

Location/type of trial	Species/ provenance	Organism	Associated symptoms	Extent and impact
Lannercost species and provenance trial	*A. mangium* Innisfail Qld	*Pestalotiopsis* sp.	Phyllode spot	Scattered lesions; no impact
		Meliola sp.	Black mildew	Scattered; no impact
	A. mangium Oriomo PNG	*Ganoderma* sp. aff. *G. lucidum*	Butt rot	Group of dead trees (Fig.4b)
	A. auriculiformis Morehead River PNG	*Ganoderma* sp. aff. *G. lucidum* (Curtis: Fr.) P. Karst.	Root rot	One unhealthy tree
	A. aulacocarpa Julatten Qld	*Pestalotiopsis* sp. aff. *P. acaciae* (Thüm.) Yokoyama & Kaneko	Phyllode spot	Scattered lesions; no impact
	A. melanoxylon Atherton Qld	*Meliola* sp.	Black mildew	Lower crown incidence; no impact
Lannercost SPAs	*A. aulacocarpa*	*Pestalotiopsis* sp.	Phyllode spot	Minor lesions[1]
Cardwell SPAs	*A. aulacocarpa* PNG	*Pestalotiopsis* sp. aff. *P. neglecta* (Thüm.) Stey.	Phyllode spot	Minor lesions[1]
	A. mangium PNG	*Cephaleuros* sp.,	Phyllode spot	No impact
Mareeba Southedge species trial	*A. auriculiformis*	Pathogen association not established	Cankering	Severe damage associated with insect boring[1]
	A. leptocarpa		Cankering	Severe damage associated with insect boring[1]
Kuranda SPAs	*A. aulacocarpa*	*Pestalotiopsis* sp.	Phyllode spot	Scattered spots; no impact
	A. mangium	*Meliola* sp.	Black mildew	Extensive on lower crown; no impact
Yapilika SPAs	*A. crassicarpa*	Undescribed sp. aff. *Pseudocercospora* sp.	Phyllode blight	50-75% of stand affected[2]; moderate impact
	A. crassicarpa	*Pestalotiopsis* sp.	Phyllode spot	50-70% of stand affected[2], but negligible impact

[1]Insect borer stem damage also present; 25% of stems affected in *A. aulacocarpa* (PNG source, Cardwell SPA).

[2]Broad estimate, only.

Fungi and algae collected in plantations and natural vegetation

A complete catalogue of the fungi collected during the survey is presented in Table 5. Records are grouped by host, stand type (natural or planted) and location. The data include collections from the four target species as well as from a number of other acacia hosts encountered during the study.

Table 5. Fungi and algae collected on Acacias in northern Australia

Host collections Stand type	Organism	Location	Herbarium Accession Number DFR	VPRI	BRIP/QFRI
A. crassicarpa					
Natural Stands					
	Annellophorella sp.	Lannercost, QLD	DFR329c		
	Ascomycete 2	Cardwell, QLD	DFR253		
	Atelocauda digitata	Cardwell, QLD	DFR329b		
		Lannercost, QLD	DFR262b	VPRI20943	
		Woobadoa Road, QLD	DFR348a	VPRI20930	
	Cephaleuros sp.	Lannercost, QLD	DFR326		BRIP 23285, 23286, 23287
	Curvularia sp. 1	Bloomfield, QLD	DFR351b		
	Leptosphaeria sp.	Lannercost, QLD			
	Meliola brisbanensis Hansford	Lannercost, QLD			
	Meliola sp.	Lannercost, QLD			BRIP 23285
	Pestalotiopsis sp. 1	Lannercost, QLD	DFR270, 329, 262	VPRI20971	
		Bloomfield, QLD	DFR351a		
		Cardwell, QLD	DFR328	VPRI 20956	
		Lannercost, QLD	DFR326		
		Woobadoa Road, QLD	DFR348b		
	Phaeolus albertinii (Lloyd) D.A. Reid	Cardwell, QLD			QFRI 8735
	Phellinus sp.	Cardwell, QLD			QFRI 8739
	Unidentified sp. aff. *Pseudocercospora* sp.	Cardwell, QLD	DFR305	VPRI20906	BRIP23260
		Bloomfield, QLD	DFR257, 252	VPRI20904, 20902	BRIP23291
		Lannercost, QLD	DFR25, 263	VPRI20905	BRIP23286, 23300
Seed Production Areas, Trials and Nurseries					
	Ellisiopsis sp.	SPA, Yapilika, NT	DFR303b		
	Pestalotiopsis acaciae	SPA, Yapilika, NT	DFR157	VPRI20958	
	Pestalotiopsis neglecta	SPA, Yapilika, NT	DFR158	VPRI20957	
	Pestalotiopsis sp. 1	SPA, Yapilika, NT	DFR270, 329, 262		
	Phaeotrichoconis crotalariae	SPA, Yapilika, NT	DFR119	VPRI20966	
	Unidentified sp. aff. *Pseudocercospora* sp.	SPA, Yapilika, NT	DFR162, 138	VPRI20901, 20903	

Host collections Stand type	Organism	Location	Herbarium Accession Number DFR	VPRI	BRIP/QFRI
A. aulacocarpa					
Natural Stands					
Atelocauda digitata		Mission Beach, QLD	DFR258, 269	VPRI20950	BRIP23284
		Daintree River, QLD	DFR256		
		Henrietta Creek, QLD			
		Tam O' Shanter, QLD			
		Woobadoa Road, QLD			
Coelomycete 8		Rex Range, QLD			
Diarimella sp.		Henrietta Creek, QLD	DFR304a		
		Rossville, QLD	DFR350b		
Pestalotiopsis sp. 1		Henrietta Creek, QLD	DFR304b		
		Woobadoa Road, QLD	DFR348b		
Pestalotiopsis sp. 4		Station Creek, QLD			
		Tam O' Shanter, QLD	DFR350a		
Septoria sp.		Rossville, QLD			
Truncatella sp.		Station Creek, QLD			BRIP23280
Seed Production Areas, Trials and Nurseries					
Cephaleuros sp.		SPA, Lannercost, QLD			BRIP23276
Colletotrichum sp.		SPA, Lannercost, QLD	DFR341	VPRI20919	
Guignardia acaciae Hansford (*Phyllosticta* anamorph)		Walkamin Nursery, QLD	DFR310a, 336a	VPRI20936, 20937	
Leptosphaeria sp.		SPA, Cardwell, QLD	DFR340b		
		Ingham Nursery, QLD			
Meliola brisbanensis		SPA, Kuranda, QLD	DFR115	VPRI20932	
Meliola sp.		SPA, Kuranda, QLD	DFR332a, 334c		BRIP23275
Pestalotiopsis sp. aff. *P. neglecta*		Walkamin Nursery, QLD	DFR307	VPRI20954	
		Ingham Nursery, QLD	DFR331a	VPRI20923	
		SPA, Cardwell, QLD	DFR340a		
Pestalotiopsis sp. aff. *P. acaciae*		Species trial, Lannercost, QLD	DFR299a	VPRI20955	
		SPA, Kuranda, QLD	DFR332b, 334a		
Phoma sp.		SPA, Lannercost, QLD	DFR324	VPRI20969	
Sphaerellopsis filum (Biv.-Bern. ex Fr.) Sutton		SPA, Cardwell, QLD			
Sporidesmium sp.		SPA, Cardwell, QLD	DFR340c		
Tetraploa sp.		SPA, Cardwell, QLD	DFR340d		
A. mangium					
Natural Stands					
Atelocauda digitata		Mission Beach, QLD	DFR260	VPRI20945	BRIP23266, 23268
Cephaleuros sp.		Mission Beach, QLD			
Eriospora leucostoma Berk. & Br.		Tam O' Shanter, QLD	DFR237		
Meliola brisbanensis		Mission Beach, QLD			
Pestalotiopsis sp.		Bloomfield, QLD			
Phomopsis sp.		Bloomfield, QLD			BRIP23254
Sphaerellopsis sp.		Cardwell, QLD			BRIP23252

Host collections Stand type	Organism	Location	Herbarium Accession Number DFR	VPRI	BRIP/QFRI
Seed Production Areas, Trials and Nurseries					
Aschersonia sp. (on scale insects)		SPA, Yapilika, NT	DFR177	VPRI20967	
Ascomycete 4		SPA, Lannercost, QLD			
Cephaleuros sp.		SPA, Cardwell, QLD	DFR302		
Coelomycete 2		SPA, Cardwell, QLD			
Curvularia sp. 2		Ingham nursery, QLD	DFR353c		
Ganoderma sp. aff. *G. lucidum*		Species trial, Lannercost, QLD			
Leptosphaeria sp.		Ingham nursery, QLD	DFR353d		
Meliola brisbanensis		SPA, Kuranda, QLD	DFR236	VPRI20964	
Meliola sp.		Species trial, Lannercost, QLD	DFR261		BRIP23270, 23273
		SPA, Cardwell, QLD	DFR309b		
		SPA, Kuranda, QLD	DFR343	VPRI20962	
Oidium sp.		Ingham Nursery, QLD	DFR342	VPRI20907	
Pestalotiopsis sp. 1		SPA, Cardwell, QLD	DFR309c, 352	VPRI20920	
		Species trial, Lannercost, QLD			BRIP23272
		Ingham nursery, QLD			
Sphaerulina sp.		SPA, Kuranda, QLD	DFR153		
A. mangium x polystacha					
Natural Stand					
Atelocauda digitata		Rex Range, QLD	DFR349		
A. auriculiformis					
Natural Stands					
Atelocauda digitata		Mount Molloy, QLD			BRIP23263
Colletotrichum sp.		Laura River, QLD			
Phyllosticta sp.		Normanby River, QLD			
Seed Production Areas and Trials					
Atelocauda digitata		Species trial, Lannercost, QLD			
Cephaleuros sp.		Species trial,Lannercost, QLD			BRIP23264
Coelomycete 3		Species trial, Lannercost, QLD	DFR354		
Ganoderma sp. aff. *G. lucidum*		Species trial, Lannercost QLD			QFRI 8677
Rhytidhysteron rufulum (Spreng.: Fr.) Spregazzini		SPA, Yapilika, NT	DFR179		BRIP22699
Valsaria insitiva (Tode: Fr.) Ces. & de Not.		SPA, Yapilika, NT	DFR183		BRIP22702

Host collections Stand type	Organism	Location	Herbarium Accession Number DFR	VPRI	BRIP/QFRI
A. flavescens Cunn. ex Benth.					
Natural Stands					
	Colletogloeum sp.	Rossville, QLD	DFR322	VPRI20968	
	Colletotrichum sp.	Cardwell, QLD			
	Meliola sp.	Cardwell, QLD			BRIP23257, 23261
	Pestalotiopsis sp. 1	Cardwell, QLD	DFR369	VPRI20941	
	Phoma sp.	Rossville, QLD	DFR265		
		Woobadoa Road, QLD	DFR267	VPRI20922	
		Lannercost, QLD	DFR355	VPRI20920	
	Unidentified sp aff. *Pseudocercospora* sp.	Cardwell, QLD			BRIP23260
	Uromycladium tepperianum (Sacc.) McAlp.	Rossville, QLD	DFR321		BRIP23259
A. fulva Tind.					
Natural Stands					
	Pestalotiopsis sp. 1	Cardwell, QLD			BRIP23296
	Meliola sp.	Edmund Kennedy, QLD			
		Cardwell, QLD			BRIP23296
A. holosericea Cunn. ex G. Don					
Natural Stand					
	Dichomera sp.	Whites Creek, QLD	DFR 0356	VPRI20931	
A. melanoxylon R. Brown					
Species Trial					
	Meliola sp.	Lannercost, QLD	DFR264b	VPRI20933	
A. leptocarpa Benth.					
Natural Stand					
	Cephaleuros sp.	Rex Range, QLD			
	Coelomycete 6	Rex Range, QLD			
	Colletotrichum sp.	Rex Range, QLD			
A. polystacha Cunn. ex Benth.					
Natural Stands					
	Atelocauda digitata	Rex Range, QLD	DFR330a	VPRI20946	
	Leptodothiorella sp.	Rex Range, QLD	DFR330b	VPRI20935	
	Pestalotiopsis sp. 1	Bloomfield, QLD			BRIP23295
Acacia sp. 1					
Species Trial					
	Coelomycete 10	Mareeba, QLD			

Host collections Stand type	Organism	Location	Herbarium Accession Number DFR	VPRI	BRIP/QFRI
***Acacia* sp. 2**					
Species Trial					
	Unidentifed sp. aff *Pseudocercospora* sp.	Mareeba, QLD			BRIP23301
***Acacia* sp. 3**					
Species trial					
	Pestalotiopsis sp. 2	Mareeba, QLD	DFR325	VPRI20953	
***Acacia latescens* Benth.**					
Natural Stand					
	Stomiopeltis acaciae Z.Q. Yuan & M.E. Barr	Yapilika, NT	DFR173	VPRI20925	BRIP22701

QLD = Queensland; NT = Northern Territory.

DFR = CSIRO Forestry and Forest Products, VPRI = Institute of Horticultural Development, Knoxfield, Victoria.
BRIP = Queensland Department of Primary Industries Agricultural Production, Indooroopilly, Brisbane.
QFRI = Queensland Forest Research Institute, Queensland Department of Primary Industries Forestry, Indooroopilly.

Significant results from the surveys in northern Australia were as follows:

- *A. mangium* in the SPAs and species trials was free of significant diseases. Algal spot and black mildew were often present but did not affect tree health. No Cercospora phyllode blight was found on *A. mangium* at either Lannercost or Kuranda (the sites of major epidemics in 1990). The phyllode blight caused by an unidentified species with affinities to *Pseudocercospora* was also not collected from *A. mangium* at Lannercost even though infection was common on *A. crassicarpa* wildlings in close proximity (Fig. 3a, b).

- Several foliar diseases were seen in natural stands of *A. mangium* but generally the stands were relatively healthy. *Atelocauda digitata* (G. Wint.) Cummins & Y. Hiratsuka (both uredinial and telial stages) was common on vigorous pole size natural regeneration on Mission Beach Road (Fig. 4a). Black mildew, caused by *Meliola brisbanensis* Hansford (Fig. 3a), and algal spot were also common in natural stands of this species, but colonies were superficial and of little consequence.

- Infections observed in dense mixed roadside regeneration indicated that there was more potential for disease on *A. crassicarpa* than on *A. mangium*. Diseases present included phyllode rust, several species of *Pestalotiopsis* associated with phyllode spots of varying severity, and phyllode blight caused by the unidentified '*Pseudocercospora* sp.'. This unidentified pathogen was also found at Lannercost, on natural *A. crassicarpa* wildlings within a species provenance trial, and at several locations on the road between Cooktown and Cape Tribulation. It was also found on *A. flavescens* near Cardwell and on an unidentified acacia sp. at Mareeba. The symptoms produced by this fungus resembled those of the *Cercospora* sp. that caused severe infection several years ago to *A. mangium* at Lannercost, but this disease was less damaging.

- The unidentified aff. *Pseudocercospora* sp. was also collected from the *A crassicarpa* SPA on Melville Island, Northern Territory, and it seems likely that the species is indigenous to northern Australia on this host which appears to be the species most susceptible to infection. Unlike species of *Pestalotiopsis* which tended to be more prevalent on older foliage and probably cause little damage, the aff. *Pseudocercospora* sp. infected the upper part of the crown of young trees causing deformation, necrosis of phyllodes, and shoot blight (Fig.3b). This ability to invade shoots gives the fungus a propensity to cause crown damage and some loss of shoot form was observed on saplings in native stands and in the *A. crassicarpa* SPA on Melville Island.

- The most common fungi collected on *A. aulacocarpa* were the rust *Atelocauda digitata,* and species of *Pestalotiopsis*. Again native stands showed more infection than the SPAs, and *A. digitata* was found only in natural stands. The main cause for concern with *A. aulacocarpa* is its apparent susceptibility to insect borer attack. Damage from this cause was common at all three SPAs in northern Queensland and many stems of damaged trees were broken by wind.

- No significant canker diseases were found on the acacia species growing near the coast. However, deforming stem and shoot cankers were present under drier conditions further inland along the southern end of the Peninsular Development Road on *A. aulacocarpa* (at Station Creek), *A. auriculiformis* and *A. holosericea. A. auriculiformis* and *A. leptocarpa* were also severely damaged by fungal cankers and insect borers in the small species trial at Southedge, Mareeba. Individual trees were multistemmed and had major diffuse cankers present. The associated fungi have not yet been identified.

- *Ganoderma* sp. aff. *G. lucidum* was observed infecting the roots of an unhealthy tree of *A. auriculiformis* in the Lannercost species/provenance trial and was probable cause of death of a group of trees in a nearby plot of *A. mangium* (Fig. 4b) several of which bore fruitbodies of the same fungus. Although this *Ganoderma* species is known to be pathogenic (Hood *et al.,* 1996) it is unlikely to be transported with seed. However, related fungi present in regions where acacias are being established have potential for causing losses in young plantations (Browne, 1968; Lee, 1997). Stem decays were not investigated in the planted acacia stands, but fruitbodies of the heart rot fungi *Phaeolus albertinii* (Lloyd) D.A. Reid and a species of *Phellinus* were collected from a naturally growing mature tree of *A. crassicarpa.*

- *Acacia flavescens* was infected by a species of *Phoma* associated with a distinctive phyllode spot (Fig. 4c) where this host grew naturally with *A. aulacocarpa* and *A. mangium* on the Bruce Highway near Cardwell. The fungus was also found at Lannercost, on wildings of *A. flavescens* at the Cardwell SPAs and along the Cooktown-Daintree road at Rossville. Neither of the other two acacia species was affected. The same fungus was found on *A. flavescens* by Old and Yuan in a species trial at Sakaerat, Thailand (unpublished data), raising speculation that along with several other species of *Phoma* this fungus may be seed-borne.

- Pink disease caused by *Phanerochaete salmonicolor* (Berk. and Br.) Jullich (synonym *Corticium salmonicolor* Berk. and Br.) is known to cause damage in exotic acacia plantations in parts of south east Asia (Hadi and Nuhumara,1997). Although this fungus is present in Queensland (Browne, 1968) it has not been recorded on acacias in Australia and was not identified during the study. However, powdery mildew (*Oidium* sp.), which is also known in acacia stands planted outside their natural range is not infrequently reported by forestry staff in Queensland and was collected on *A. mangium* at Ingham Nursery during this survey (Table 5).

Conclusions

From observations made in the planted and native stands of acacias in northern Australia it appears that the number of species of pathogenic fungi, and their frequency of occurrence is at present greater in the natural vegetation than in the plantations. It remains to be seen whether or not this is merely a temporary condition due to a comparatively slow spread of indigenous pathogens into the small plantation areas.

The only previous record of severe disease in acacia plantations in northern Queensland has been the outbreak of Cercospora phyllode and shoot blight at the Lannercost and Kuranda SPAs in 1990. This disease was also present at Ingham Nursery where all the planting stock for the SPAs was raised, and it is possible that many seedlings left this nursery already infected prior to planting. There was some evidence that the Papua New Guinea provenances were more susceptible to the disease, but the design of the trials did not allow for rigorous comparisons since different provenances were planted in separate stands. Despite careful searching in both these SPAs no Cercospora blight was found on any natural or planted *A. mangium* during this study and the origin of the epidemic remains unknown.

The unidentified species with affinities to *Pseudocercospora* found on *A. crassicarpa* and *A. flavescens* is of potential importance due to its capacity to infect terminal shoots and affect the form of the crown. Its occurrence from Lannercost to the Cooktown region and Melville Island suggests that it may be indigenous across the humid tropical north of Australia. There is a need for further study of this fungus, including definitive taxonomic studies, and an investigation of its pathogenicity to a range of species by means of inoculation tests.

Acacia aulacocarpa is a species which offers great promise as a plantation tree. Although it is usually slower-growing than *A. mangium,* its form can be quite outstanding, and sawn timber of cabinet grade can be produced within about 20 years of planting. Trees in the SPA at Kuranda have been selected for good silvicultural features and a clonal seed orchard of this species has now been established. The incidence of insect borer damage at all three SPA locations is cause for concern, especially as severe borer damage of this species has also been found at Sakaerat in Thailand. On the other hand, *A. aulacocarpa* has the most extensive latitudinal natural distribution range of all four tropical acacias under consideration and a large range of provenances will be available for selection (Thomson 1994).

The widespread natural occurrence of autoecious rusts on all four native species is likely to be important for acacia plantations in the tropical north of Australia, as well as for stands established outside the natural host range. Two species are of concern, *Atelocauda digitata* which induces phyllode distortion (McAlpine 1906; Hodges and Gardener 1984) and *Uromycladium tepperianum* (Sacc.) McAlp. which causes stem galling (Morris, 1987). *A. digitata* was collected frequently during the survey. Damage in natural stands caused by this fungus varied considerably and no estimate of growth impact is available. *U. tepperianum* is also widespread in Queensland although only one collection was made during the study. [*U. notabile* (Ludw.) McAlp., a species closely related to *U. tepperianum*, was responsible for the failure of a prospective tannin industry based on stands of *A. decurrens* (Wendland) Willd. established in New Zealand in the 1920s (Gilmour, 1966; Gibson, 1975)]. *Sphaerellopsis filum* (Biv.-Bern. ex Fr.) Sutton was found infecting *Atelocauda digitata* on *A. mangium* growing naturally several kilometres north of Cardwell (and on *A. aulacocarpa* in the Cardwell SPA). This widely distributed mycoparasite occurs naturally on *A. digitata* in Queensland (McAlpine, 1906) and has potential for reducing the impact of phyllode rust if it becomes introduced into exotic plantations.

This survey has accumulated a significant amount of information on the pathogenic fungi present on tropical acacias in northern Australia. It is anticipated that the numbers of pathogenic fungi present within the native distribution ranges of the host species will be greater than in other regions where they are purely exotic plantation crops. An enhanced knowledge of these fungi and their effect on stand health is a necessary basis for the ensured continuation of their tree hosts as significant plantation species.

Acknowledgements

The authors thank staff of QDPI (Forestry) especially Mr Peter Pomeroy and Mr Steve Kitchener for assistance with field surveys. Thanks are also due to Ms Kristna Pongpanich, Mr Mark Dudzinski and Ms Ruth Gibbs for mycological assistance and to Dr Chris Harwood for information and guidance on species and provenance trials.

References

Alcorn J.L. (1974). *Spilodochium acaciae* sp. nov. on *Acacia aulacocarpa. Transactions of the British mycological Society 63: 598-600.*

Alcorn, J.L.(1978). Microfungi from Hinchinbrook Island. *Queensland Naturalist* **22**: 58-61.

Boa, E., and Lenné, J. (1994)**.** *Diseases of Nitrogen Fixing Trees in Developing Countries; an Annotated List***.** Natural Resources Institute. Overseas Development Administration, Chatham, U.K.

Browne, F.G. (1968). *Pests and Diseases of Forest Plantation Trees.* An annotated list of the principal species occurring in the British Commonwealth. Clarendon Press. Oxford (-pp).

Gibson, I.A.S. (1975). Diseases of forest trees widely planted as exotics in the tropics and southern hemisphere. Part 1. Important members of the Myrtaceae, Leguminosae, Verbenaceae and Meliaceae. Commonwealth Mycological Institute, Kew, Surrey. Commonwealth Forestry Institute, University of Oxford, United Kingdom. 51 pp.

Gilmour, J.W. (1966). The pathology of forest trees in New Zealand. The fungal, bacterial and algal pathogens. New Zealand Forest Research Institute *Technical Paper* No. **48**. New Zealand Forest Service.

Gunn, B.V., and Midgley, S.J. (1991). Exploring and accessing the genetic resources of four selected tropical acacias. In *Advances in tropical acacia research***;** proceedings of a workshop held in Bangkok, Thailand, 1I- 15 February 1991 .ACIAR Proceedings No.35, 234p.

Hadi, S., and Nuhumara,S.T. (1997). Diseases of species and provenances of acacias in West and South Kalimantan, Indonesia. In *Diseases of tropical acacias:* proceedings of a workshop held in Subanjeriji, Sumatra, Indonesia, April 30-May 3 1996. CIFOR special publication, 117p.

Harwood, C.E., Applegate, G.B., and Robson, K. (1994). Establishment and management of seed production areas of tropical tree species in Northern Australia. Proc. Int. Symp. on genetic conservation and production of tropical forest tree seed. Chiang Mai, Thailand ASEAN-Canada Forest Tree Seed Centre Project. Muak Lek, Sqraburi, Thailand

Hodges, C.S. Jr., and Gardner, D.E. (1984). Hawaiian forest fungi. IV. Rusts on endemic *Acacia* species, *Mycologia* **76**: 332-349.

Hood, I.A., Ramsden, M., and Allen, P. (1996). Taxonomic delimitation and pathogenicity to seedlings of *Delonix regia* and *Albizia lebbeck* of a species related to *Ganoderma lucidum* on broadleaf trees in Queensland. *Australasian Plant Pathology* **25**: 86-98.

Lee,Su See (1997). Diseases of some tropical plantation acacias in Peninsular Malaysia. In *Diseases of tropical acacias*: proceedings of a workshop held in Subanjeriji, Sumatra, Indonesia, April 30-May 3 1996. CIFOR special publication, 117p.

McAlpine, D. (1906). *The rusts of Australia***.** Government Printer, Melbourne, Australia. 349p.

Morris, M.J. (1987). Biology of the Acacia gall rust *Uromycladium tepperianum. Plant Pathology* **36**:

Old, K.M., Harwood, C.H., Robson, K.J., Haines, M.W., and Solomon, D.J. (1996). Foliar pathogens of tropical acacias in Australia. In *Impact of Diseases and Insect Pests in Tropical Forests.* (Eds K.S.S. Nair and J.K. Sharma) Proceedings of IUFRO Symposium, 23-28 November 1993, Kerala Forest Research Institute, Peechi, India (In Press).

Shivas, R.G., and Alcorn, J.L. (1996). A checklist of plant pathogenic and other microfungi in the rainforests of the wet tropics of northern Queensland. *Australasian Plant Pathology* **25**: 158- 173.

Simmonds, J.H. (1966). *Host Index of Plant Diseases in Queensland.* Queensland Department of Primary Industries, Brisbane.

Solomon, D. (1993). *Cercospora*- Have we got a problem? Internal Report, Australian Tree Seed Centre, CSIRO Division of Forestry and Forest Products, Canberra. 33 pp.

Sutton, B.C., and Pascoe, I.G. (1988). Some dematiaceous hyphomycetes from branches and phyllodes on *Acacia* in Australia. *Australian Systematic Botany* 1: 127-138.

Thomson, L.A.J. (1994). *Acacia aulacocarpa A. cincinnata, A. crassicarpa* and *A. wetanonsis*: an annotated bibliography. Australian Tree Seed Centre, CSIRO Division of Forestry, Canberra. 131 pp.

Yuan, Z.Q. (1996). Fungi and associated tree diseases in Melville Island, Northern Territory, Australia. *Australian Systematic Botany 9: 337-360.*

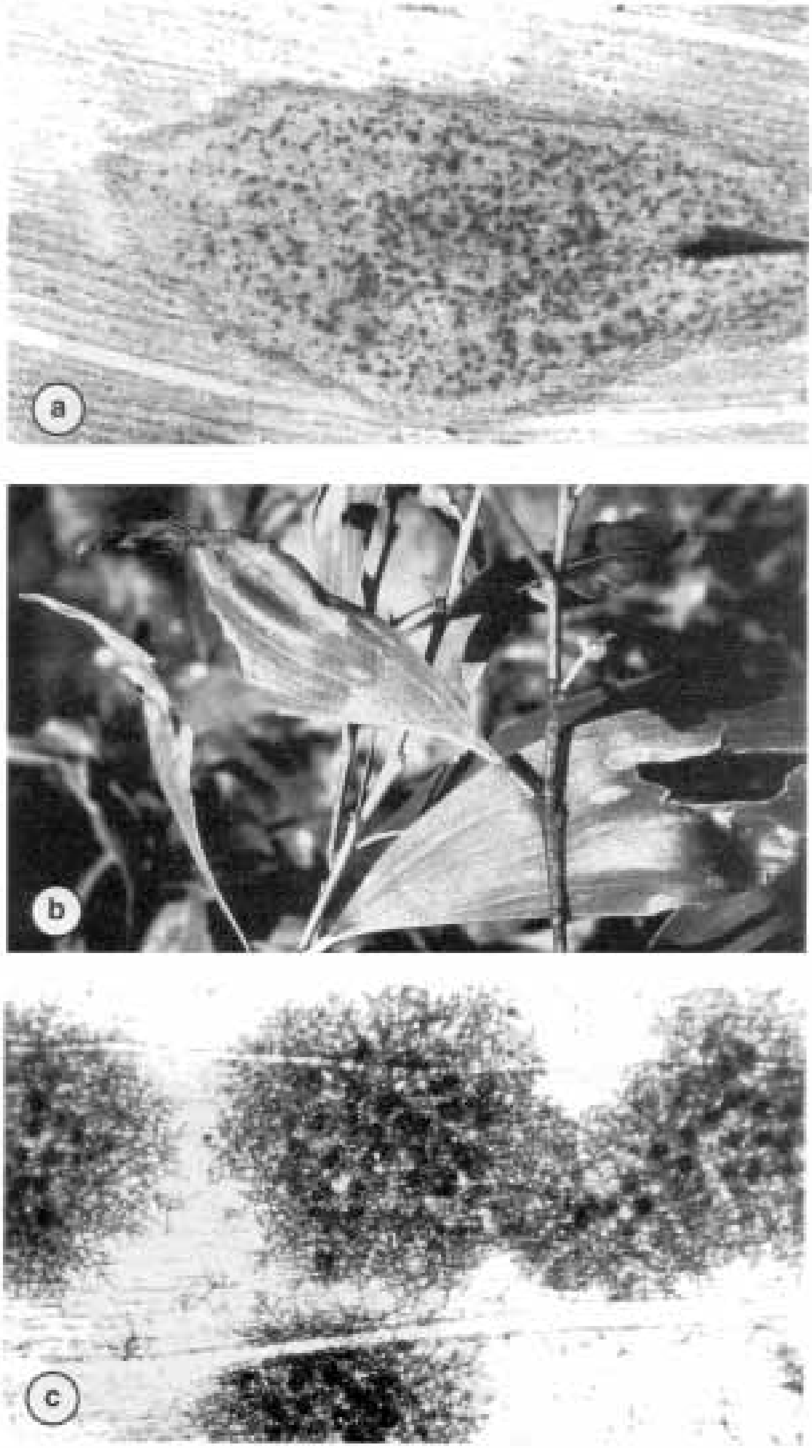

Figure 3. Diseases present on *Acacia* spp. In northern Queensland.

a) Unidentified fungus with affinities to *Pseudocercospora* fruiting on a phyllode of *A. crassicarpa.*

b) Characteristic spotting and phyllode distortion caused by the fungus shown in 3a.

c) Mycelium and perithecia of the black mildew *Meliola brisbanensis* on a phyllode of *A. mangium.*

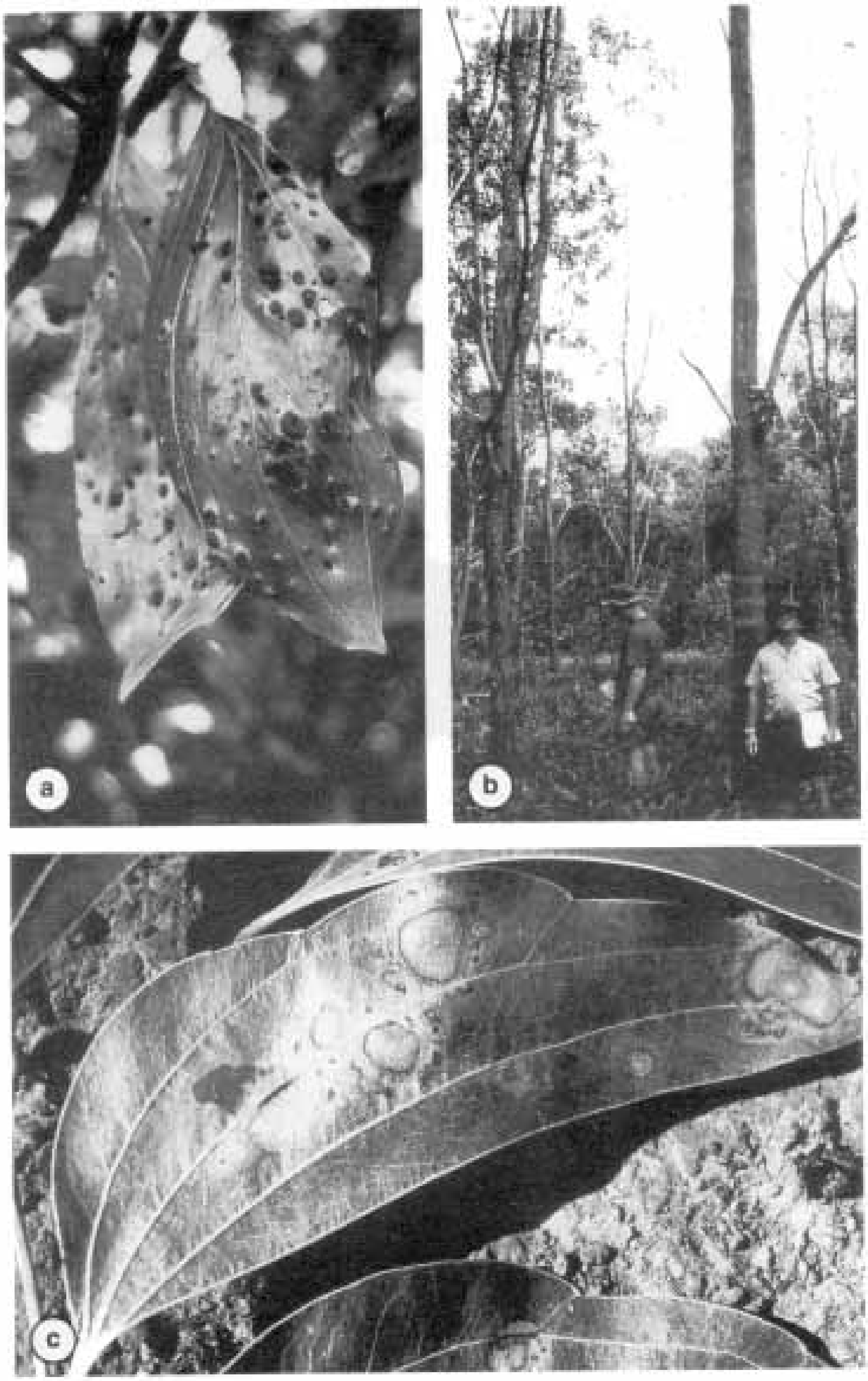

Figure 4. Diseases present on *Acacia* spp. In northern Queensland.

a) Phyllode rust caused by *Atelocauda digitata* on *A. mangium.*

b) A patch of dead *A. mangium* associated with infection by *Ganoderma* sp. aff. *G. lucidum.*

c) Phyllode spot of *A. flavescens* caused by an unidentified *Phoma* sp.

Diseases of Species and Provenances of Acacias in West and South Kalimantan, Indonesia

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Abstract

Disease surveys were conducted in *Acacia* species and provenance trials in Sanggau, West Kalimantan and in Riam Kiwa, South Kalimantan. Yellowing of leaves and necrosis of tissues on the leaf margins and leaf tips were observed on *A. crassicarpa* both in West and in South Kalimantan. Pink disease was most common on A. *mangium,* less frequent on *A. crassicarpa,* and absent from *A. aulacocarpa* and *A. auriculiformis.* Several contrasting canker symptoms were observed on *A. mangium,* including diffuse cankers bearing black stromata from which a *Phomopsis* sp. was isolated. Other symptoms included severe stem cracking with no obvious stromata present and necrotic regions of the stem at the base of branch whorls. These cankers were commonly associated with gummosis which was variable between tree species and provenances. *Lasiodiplodia theobromae* (syn. *Botryodiplodea theobromae)* was isolated from cankers occurring on *A mangium, A. auriculiformis,* and *A. aulacocarpa.* The several cankers found in Sanggau and Riam Kiwa have not been reported previously in Indonesia. Pathogenicity tests have not been carried out, so the causal agent(s) has not been determined. Cankers developing at the base of branches or at the forks of multiple stemmed trees commonly resulted in branch or stem breakage of *A. mangium* and *A. aulacocarpa*. *A. aulacocarpa* provenance SRW Bade was free from cankers. Two provenances of *A. auriculiformis* from Queensland and one from Papua New Guinea i.e., provenances 15697, 16145 and 16103 were virtually free from cankers, whereas 12 provenances from Northern Territory were severely damaged. Dieback was occasionally encountered on two and a half year-old trees of all the four species. In nine year-old *A. mangium* at Riam Kiwa dieback occurred on almost all provenances. The only unaffected provenance was a land race collection of *A. mangium* from Sanga-sanga, East Kalimantan. The latter was also free from cankers and gummosis.

It was not possible to make detailed comparisons in performance of provenances of these species between sites due to differences in age classes. Trees at Sanggau in West Kalimantan were one and a half to two and a half years of age whereas plantations at Riam Kiwa in South Kalimantan were between three and a half to nine years old. The occurrence of stem cankers on *A. mangium* at Sanggau is a cause for concern as this area receives 3,500 mm annual rainfall and predisposition of trees to disease by drought is unlikely. Several of the disease conditions described here have the potential to cause serious losses. Studies are needed to determine causal agents of canker diseases, yellowing of *A. crassicarpa* leaves and the dieback of nine year-old *A. mangium* seen at Riam Kiwa. For all the diseases recorded here, there appears to be significant variation in incidence and severity between provenances and species. Through improved knowledge of the etiology of disease, selection of resistant planting stock and appropriate silvicultural treatment, effective disease management should be possible.

Introduction

In order to have a sustainable supply of wood for sawn timber and wood-based industries and to alleviate pressure on tropical forests, the Government of Indonesia initiated a program to establish large-scale plantations in several parts of Indonesia in 1984.

Although a number of indigenous tree species may be suitable for such a program, most of the forest concessionaires preferred to plant exotic species, some of which grow well and produce high quality timber.

Up to now *Acacia* spp. and *Eucalyptus* spp. are the species most commonly planted outside Java. Among species of *Acacia, A. mangium* and *A. auriculiformis* have been preferred for the establishment of plantations in the central and western part of Indonesia where they are exotics. Their natural distribution includes the eastern part of Indonesia, Papua New Guinea and northern Australia.

In some cases the forest concessionaires established provenance trials to find those species and/or provenances most suitable to the local conditions before establishing large-scale plantations. However, in most cases no such trials exist.

So far, serious disease problems associated with large-scale acacia plantations have not been reported. However, it is possible that diseases attacking different acacia species and provenance(s) will become more prevalent as plantations have been established on sites with widely different. soil and climatic conditions.

Disease surveys were conducted in Sanggau, West Kalimantan and in Riam Kiwa, South Kalimantan where provenance trials of *A. mangium, A. crassicarpa, A. aulacocarpa* and *A. auriculiformis* have been established. The objective of the survey was to determine the prevalence of different diseases on the provenances of these species in both locations. This paper reports results of disease surveys conducted in late 1995.

Diseases Previously Reported on Acacias in Indonesia

Previous reports of diseases attacking *Acacia* spp. in Indonesia are scanty. The following summarises the available information.

Leaf Diseases

Gall rust

Santosa and Suharti (1984) found galls on phyllodes, buds and twigs of *A. auriculiformis* in nurseries in many parts of Java. The disease, suspected to be caused by *Uromyces* sp., was characterised by gall formation on phyllodes and buds as well as on young stems. Although the disease did not cause serious mortality of infected seedlings, infection on buds or stems disrupted the growth of the leader shoots resulting in chlorosis and stunted growth. The disease was also recorded in the field after outplanting.

Pycnia, aecia, uredia and telia were reported on phyllodes bearing galls. Artificial inoculation of *A. auriculiformis* seedlings and some weed species growing in the *A. auriculiformis* stand with infected plant parts failed to reproduce the disease. The life cycle of the inciting pathogen in Indonesia is thus so far still unknown, although recently several rust collections have been identified as *Atelocauda digitata,* a macrocyclic autoecious rust well known in Australia and Hawaii (Hodges and Gardner 1984; McAlpine 1906).

Powdery Mildew

In nurseries, powdery mildew has been reported to attack seedlings (Soeyamto and Mardji 1986). *Oidium* sp., the inciting pathogen, attacked the young leaves and shoots of *A. mangium* causing stunting of growth and defoliation. Seedlings older than four months were relatively resistant.

Sooty Mold and Black Mildew

Sooty mold and black mildew are known to develop on leaves and twigs of *A. mangium* and *A. auriculiformis. Capnodium* sp., the sooty mold, grows saprophytically on honeydew and other insect excretions, whereas *Meliola* sp., the black mildew, derives its food parasitically from invading epidermal leaf tissue.

Stem Diseases

Stem canker suspected to be caused by *Nectria* sp. was reported by Nuhamara (1986) to attack *A. auriculiformis* in Kediri area, East Java. The early stage of canker development could be detected as a depression of the infected part of the stem or branch. Cracking of the bark was followed by callus formation around the infected part. Stem damage was minor and the shoot and foliage above the cankered region usually remained healthy.

At Benakat, South Sumatra, A. *mangium* was reported by JICA (Japan International Cooperation Agency) to be attacked by *Cytospora* sp., whereas at Nanga Pinoh, West Kalimantan another canker incited by *Hypoxylon mammatum* was encountered (Nuhamara 1991).

Soeyamto and Mardji (1986) reported the occurrence of pink disease, a typical canker, on the pole stage of A. *mangium* in East Kalimantan. The disease, incited by *Corticium salmonicolor*, was also known to occur in Subanjeriji, South Sumatera (Darma *et al.* 1986). Unlike Nectria canker, *C. salmonicolor* girdled the stem or the branch, ultimately resulting in the death of the shoot.

Damping-off and Root Diseases

Fusarium sp. was found to be the most common damping-off pathogen attacking *A. mangium* (Soeyamto and Mardji, 1986). In plantations, *Ramaria camelicolor* was suspected to be associated with root rot of *A. mangium* (Nuhamara, 1991). Root rot was also reported from *A. mangium* plantations at Gowa, Maros, South Sulawesi (Supamo, 1991). Nurbaya (1994) reported that *Fusarium oxysporum* and *Botryodiplodia* sp. were associated with the root rot.

Shoot decline

Twig decline was reported by Nuhamara (1993) to occur in *A. mangium* plantations at Parung Panjang, Bogor, West Java, He found that the older the stand the more trees were diseased. In valleys more trees were dying compared to those on nearby hills.

The initial stage of the disease development was characterised by twig death associated with insect borer attack and cankers. Bore holes and cankers were found on young, green shoots as well as on older twigs having a diameter of 0.5-2.5 cm. Further development of the disease resulted in the wilting of shoot tips, and ultimately in the death of the twig.

Xyleborus fornicatus, X. volvulus, Thanatephorus cucumeris and heart rot fungi were associated with the disease. *X. fornicatus* was found on relatively healthy twigs, whereas *X. volvulus* occurred on dying or dead stems. Hyphae resembling *Rhizoctonia* sp. an anamorph of *T. cucumeris* was always found associated with the canker. Nuhamara (1993) suspected that the acid soil and the topography of the land could be predisposing factors of the syndrome, but the disease was not reproduced by artificial inoculation of healthy trees.

Materials and Methods

Species and provenance trials of *Acacia* spp. located in Sanggau, West Kalimantan and in Riam Kiwa, South Kalimantan were selected for this disease survey (Fig. 5). At Sanggau the trial plots were established by Enso Forest Development Ltd. and are presently managed by PT. Finnantara Intiga, whereas at Riam Kiwa, the species and provenance trials were laid out by Enso Forest Development Ltd. in cooperation with Balai Teknologi Reboisasi Banjarbaru. The primary objective of the trials at both locations was to compare the performance of different species and provenances of tropical acacias and several other forest tree species. The two locations differ markedly in their annual rainfall, 3,500 mm annually at Sanggau and 2500 mm at Riam Kiwa. The trials were considered to be suitable for this disease survey although direct comparisons between the performance of species and provenances at the two sites was not possible due to marked differences in age class which could affect symptom expression.

Experimental areas

Acacia Species and Provenance Trials in Sape and Lanong, Sanggau

The provenance trials at Kabupaten Sanggau were laid out at two locations, i.e., Sape area, Kecamatan Jangkang with a longitude of 110º50'17"E and a latitude of 0º20'25"S, and Lanong area, Kecamatan Bonti with a longitude of 110º32'30"E and a latitude of 0º21'53"S (Fig. 5).

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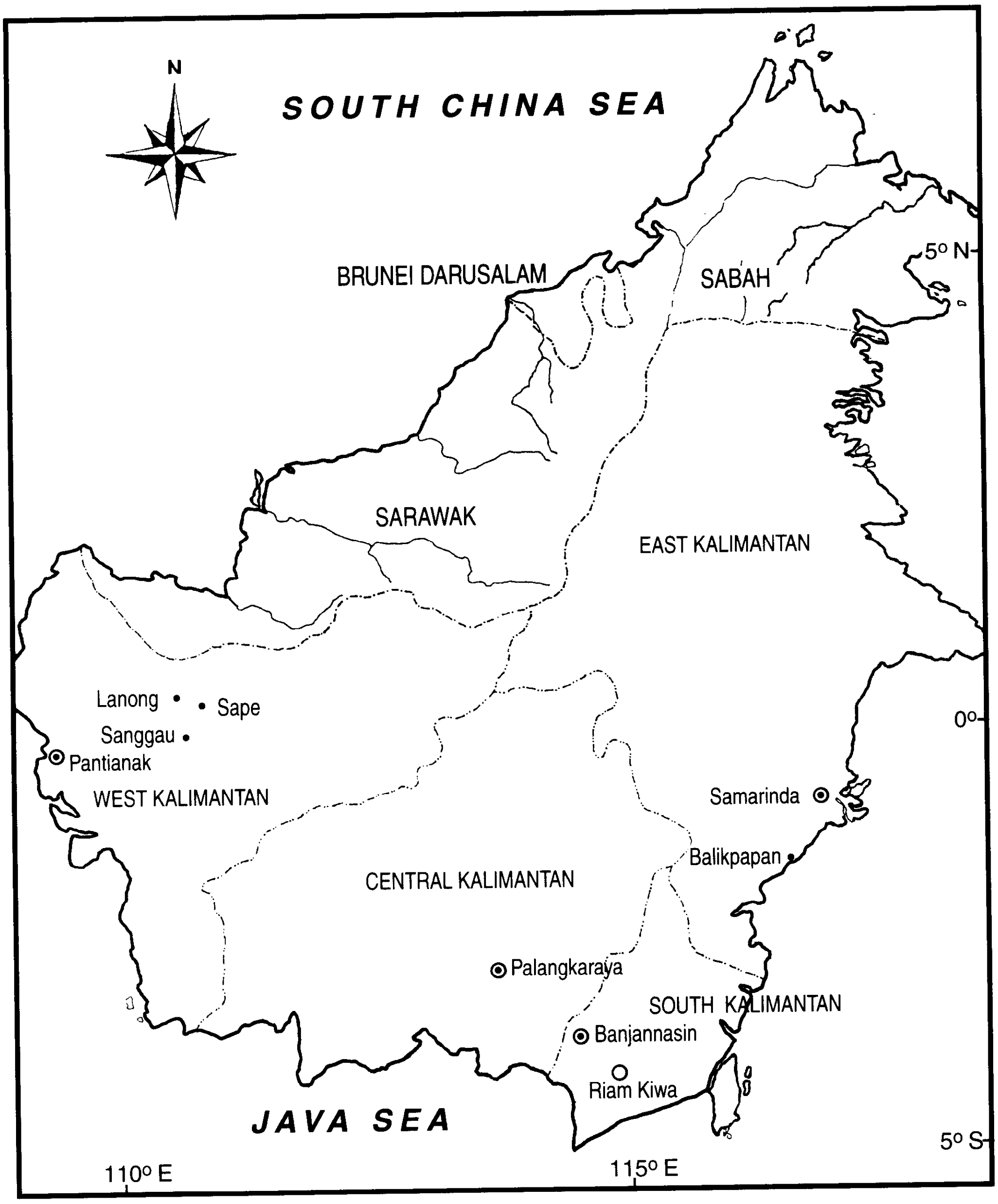

Figure 5. Location of *Acacia* species and provenance trials in West and South Kalimantan surveyed for diseases

The mean annual rainfall recorded at the Sanggau Meteorological Station (1982-I 993) is 3,5 18 mm, and maximum and minimum temperatures are 32º C and 22º C. The soil type at both Sape and Lanong is a red-yellow podsolic soil with a sandy loam or silt loam texture.

All the trials were arranged in a randomised complete block design and replicated four times.
The locations and origins of the provenances and seed lots planted in the trials which were surveyed for disease are listed in Tables A1 -A8 of the Appendix to this report.

Acacia mangium provenance trial at Sape

A trial of fiften provenances of *A. mangium* was established in March 1993 with the main objective of comparing the performance of different seedlots from different locations in Australia with that of a seedlot from Subanjeriji (Appendix Table A 1).

Each trial unit consisted of 7 x 7 trees planted at 3 m x 3 m spacing. *Paraserianthes falcataria* trees were planted as border rows between adjacent plots.

Acacia species trial at Sape

Four different acacia species consisting of 10 provenances were established in March 1993 at Sape. Kecamatan Jangkang, Kabupaten Sanggau (Appendix Table A2). Each plot consisted of 7 x 7 trees planted at 3mx3m spacing.

Acacia species trial at Lanong

Four acacia species consisting of eight provenances were established in February 1993 at Lanong (Appendix Table A3). Each plot consisted of 11 x 6 trees planted at 3m x 3m spacing.

Acacia species and provenance trials at Riam Kiwa

In South Kalimantan, provenance trials were established at Riam Kiwa located at 115º0'E and 3º30'S. The average annual temperature is 28ºC whereas the maximum and minimum temperatures are 23°C and 32ºC. The average monthly rainfall in 1994 was 2,128 mm. The soil is a red-yellow podsolic type with some loam content and a pH of 4.5-5.0.

Three year-old Acacia mangium provenance trial

Each plot consisted of 7 x 7 trees at 3 m x 3 m spacing and the trial was replicated four times. Twenty provenances were included (Appendix Table A4) and trees were planted during January-February 1992.

Nine year-old Acacia mangium provenance trial

Each plot consisted of 5 x 5 trees at 3 m x 3 m spacing with 4 replications. Thirty different provenances of *Acacia mangium* were tested (Appendix Table A5). Trees were planted during November 1986 - January 1987.

Three year-old Acacia crassicarpa provenance trial

Plots of 7 x 7 trees were laid out at 3 m x 3 m spacing and replicated four times. Seed lots and provenances are listed in Appendix Table A6. Trees were planted during January-March 1992 and plots were separated by rows of *A. mangium* trees .

Three year-old Acacia aulacocarpa provenance trial

Each plot consisted of 7 x 7 trees at 3 m x 3 m spacing with four replicates. Provenance S 16995 was planted as buffer rows. Six provenances (Appendix Table A7) were included in the trial planted in March 1992.

Acacia auriculiformis provenance trial

In each plot 4 x 4 trees were planted at 3 m x 3 m spacing. Twenty five provenances were examined (Appendix Table A8). The trial was laid out in November 30, 1989 with six replications. The main objective was to compare the survival, growth and other characteristics of a wide range of *A. auriculiformis* provenances. This is a multi-locational trial conducted by Enso Forest Development Ltd. in cooperation with Winrock International and FFred Project Coordination Unit, Faculty of Forestry, Kasetsart University, Bangkok, Thailand. The trials of *A. auriculiformis* described in the paper by Pongpanich in these proceedings are part of the same international trial, with many of the same provenances represented.

Identification of fungi from cankered stems

Samples of diseased plant parts were taken for examination in the laboratory. When no fructification were observed, isolation of fungi from cankered tissues was made. Cultures were prepared and sent to CSIRO Forestry and Forest Products in Australia for examination. Although preliminary identifications were made, pathogenicity tests on healthy stems were not conducted and the cause of disease was not determined.

Assessment of disease severity

The severity of disease symptoms was determined assigning a rating of 0, 1, 2 or 3 depending on the symptom observed. The criteria of disease severity used in assessing disease symptoms on foliage, stems and roots of trees in each plot are presented in Table 1.

Table 1. Scoring system used to assess severity of foliage infection, stem canker and dieback disease of trees.

Disease Severity	Symptoms Foliage Infection	Stem Canker	Dieback	Score
Nil	Nil	Nil	Nil	0
Low	Up to 25% of the foliage infected	One canker, no apparent harm to the tree	Dieback of branches (<25%) in the crown	1
Medium	25-50% of the foliage infected	1-2 cankers, epicormic shoots present	Dieback of branches (25-50%) in the crown	2
Severe	50-75% of the foliage infected	2 or more cankers, apical shoot dead due to girdling	Foliage pale yellow accompanied by premature defoliation, extensive dieback, death of tree	3

Based on the number of trees in a plot, the disease index for a given disease in each plot was determined as follows:

$$\text{Disease Index} = \frac{na \times 0 + nb \times 1 + nc \times 2 + nd \times 3}{N \times 3} \times 100$$

Where:
- na = number of trees in the plot with score 0
- nb = number of trees in the plot with score 1
- nc = number of trees in the plot with score 2
- nd = number of trees in the plot with score 3
- N = total number of trees in the plot

Results

Diseases observed in Sanggau and Riam Kiwa

Diseases occurring on the four species of *Acacia* in Sanggau and in Riam Kiwa are listed in Table 2.

Table 2. Diseases occurring on four *Acacia* species of at Sanggau and at Riam Kiwa.

Disease	Associated pathogen	*A. mangium*	*A crassi-carpa*	*A. aulaco-carpa*	*A. auri-culiformis*	Location
Leaf yellowing	unknown	+	+	+	+	Sanggau Riam Kiwa
Sooty mold	*Capnodium* sp.	+	+	+	+	Sanggau Riam Kiwa
Leaf gall	*Uromyces* sp.	-	-	+	+	Sanggau Riam Kiwa
Pink disease	*Corticium salmonicolor*	+	+	+	-	Sanggau Riam Kiwa
Dry/wet stem canker	*Lasiodiplodia theobromae**	-	-	-	+	Riam Kiwa
Canker at the base of a branch	*L. theobromae**	-	-	+	-	Sanggau Riam Kiwa
Stem canker with stroma	*Phomopsis* sp.*	+	+	+	+	Sanggau
Stem canker without stroma	*L. theobromae**	+	+	+	+	Sanggau
Canker at the stem base	*L. theobromae**	+	+	+	+	Sanggau
Dieback	unknown	+	+	-	+	Riam Kiwa
Gummosis	unknown	+	+	-	+	Riam Kiwa

1) + = disease present
 - = disease absent
* Causal role not confirmed

Leaf chlorosis

Yellowing of leaves was observed in almost all parts of the canopy of *A. crassicarpa* both at Sanggau, and at Riam Kiwa. The symptom was restricted to *A. crassicarpa.* Border rows *of A. mangium* were more vigorous and foliage was healthy. Yellowing was confined to the interveinal tissues and was accompanied by necrosis of leaf margins and tips suggesting that mineral deficiency might be the inciting agent. No pathogenic fungi were observed sporulating on infected tissue and the cause of this condition remains obscure. This symptom has also been observed on *A. crassicarpa* in Thailand (K.M. Old, personal communication).

Sooty mold

Black mycelium often covered the leaves and twigs of *A. mangium* and *A. auriculiformis* especially in the lower parts of the canopy. The fungus proved to be a sooty mold rather than black mildew as the mycelium was superficial and easily peeled from the leaf surface.

Rust galls

Galls on phyllodes and shoots of *A. auriculiformis* and *A. mangium* incited by the rust fungus *Atelocauda digitata* were occasionally encountered (Fig. 6a).

Pink Disease

Pink disease usually occurred on stems at the base of branches originating at a branch fork. The disease is well known on plantation species and is characterised by the formation of a white felt-like mycelium known as the "cobweb" stage of the pathogen. A pink to yellowish crust develops later bearing the perfect stage of *Corticium salmonicolor.*

Corticium salmonicolor is known to attack various species such as cemara *(Casuarina junghuniana),* rubber *(Hevea brasiliensis),* nangka *(Artocarpus integra),* guava *(Psidium guajava),* etc. The disease in stands of *A. mangium* could be readily detected from the development of the "cobweb" and the perfect stages of the pathogen (Fig. 6b).

In Sanggau and Riam Kiwa pink disease was observed primarily on *A. mangium* and less on *A. crassicarpa.* It was absent from *A. aulacocarpa* and *A. auriculiformis.*

Stem and branch cankers

Cankers were commonly observed on the main stems of six year-old *A. auriculiformis* trial plots in Riam Kiwa. Necrosis and vertical cracking of the bark and sapwood (Fig. 6d) was sometimes associated with g-ummosis (scored as "wet cankers") (Table *6). Lasiodiplodia theobromae* was isolated from cankered tissue. This fungus is a widely distributed opportunist canker pathogen of many species in the tropics (Punithalingam, 1969). Associated with the cankers were minute black stromata borne on the surface of bark of the cankered stem. Although a fungus resembling *Curvularia* sp. was isolated from these stromata, the relationship between these superficial structures and the disease was not established.

Cankers were observed on *A. aulacocarpa commonly* associated with the forked branches of multistemmed trees or at the base of branches. Sometimes a number of cankers, which were usually fissured, developed on the main stem and were a common cause of stem breakage. The cause of the cankers was not determined although *L. theobromae* was isolated from cankered tissue.

Stem cankers with long fissures which sometimes exposed areas of xylem, were also observed in *A. mangium* trial plots at Sape, Sanggau (Fig. 7a). In some instances the cankers extended to the base of the tree causing partial girdling of the stem. Again, *L. theobromae* was isolated. On some of the cankers a well developed black stromatic region (Fig. 7b) was observed. *Phomopsis* sp. was isolated from cankers of this type. Although *L. theobromae* and *Phomopsis* sp. are putative pathogens, pathogenic&y tests were not carried out and while disease symptoms were defined closely enough to allow the trials to be scored, the causal agents have not yet been determined.

Crown dieback

In Sanggau, West Kalimantan, dieback of two and a half year-old *A. mangium, A. crassicarpa, A. aulacocarpa* and *A. auriculiformis* occurred. At Riam Kiwa, dieback was particularly severe in nine year-old *A. mangium* stands. The cause of dieback was not determined but trees had clearly suffered from environmental stress predisposing them to bark beetle (Scolytidae) attack.

Severity of Diseases Attacking Different Species and Provenances of Acacia

Severity of disease symptoms on 15 provenances of two and a half year-old *A. mangium* at Sape, Sanggau

Table 3. Occurrence and severity of diseases on 15 provenances of two and a half year-old *Acacia mangium* at Sape, Sanggau, West Kalimantan.

No.	Seedlot	Disease Index[1)] 1	2	3	4	5	6	7[2)]
1.	A 529 QLD	3.4ab	10.4bcd	12.8bc	8.8ab	0 b	1.0b	0 a[3)]
2.	A 538 QLD	0.2d	5.6cde	19.5ab	2.2b	0 b	0.3b	0.2a
3.	FF 1977 QLD	2.6abcd	3.4abc	9.9bcd	5.1b	0 b	0.3b	0 a
4.	FF 1982 PNG	3.9a	15.5ab	4.3cd	3.7b	0.2b	1.0b	0.2a
5.	FF 1995 PNG	1.7abcd	6.1cde	1.9d	3.2b	0.3b	1.0b	0 a
6.	FF 1998 Irian Jaya	3.1abc	7.3bcde	3.7cd	3.1b	0 b	0.5b	0.3a
7.	FF 2011 PNG	0.5cd	7.5bcde	3.6cd	4.1b	0 b	0.8b	0.2a
8.	FF 2013 PNG	2.0abcd	8.2bcde	2.0cd	3.1b	0 b	0 b	0 a
9	S 15238 PNG	0.7cd	6.6cde	2.2cd	5.1b	0 b	1.4b	0 a
10.	S 16997 PNG	2.0abcd	6.1cde	1.4cd	3.7b	0 b	0.2b	0 a
11	S 17550 PNG	0.2d	3.7de	1.2d	4.1b	0 b	6.6a	0 a
12.	S 17701 QLD	4.1a	19.2a	25.2a	16.1a	0.3b	1.0b	0.5a
13.	S 17866 PNG	0 d	1.0e	0 d	0 b	0.9a	0.5b	0 a
14.	S 17872 PNG	1.2bcd	9.0bcde	8.2cd	3.6b	0 b	3.2b	0.5a
15.	Subanjeriji Sumatra	0 d	3.4de	4.6cd	5.3b	0 b	0.9b	0.2a

1) Based on 4 replicates of 49 trees each

2)
1 = Stem canker with black stroma
2 = Stem canker without stroma
3 = Canker on the base of the stem
4 = Dieback
5 = Sooty mold
6 = Yellowing of leaves
7 = Pink disease

3) Values in each column followed by the same letters are not significantly different at p = 0.05 according to Duncan's Multiple Range Test.

The occurrence of a range of disease symptoms on 15 provenances of two and a half year-old *A. mangium* is presented in Table 3 using the disease index rating system described above. Data can be summarised as follows:

- No pink disease was observed.
- Sooty mold was virtually absent from the stands.
- Cankers, with or without stromata were commonly present on branches and main stems, including stem bases.
- Provenance S 17866 was almost free of disease and showed the best growth.
- The common occurrence of cankers on several provenances gives cause for concern as this disease syndrome does not appear to have been previously reported in Indonesia.

Severity of disease symptoms on two and a half year-old *Acacia* species and provenances at Sape, Sanggau.

Table 4. Occurrence and severity of diseases on 10 two and a half year-old provenances of *Acacia* species at Sape, Sanggau, West Kalimantan.

No	Species/ Seedlot	Disease Index[1)]						
		1	2	3	4	5	6	7[2)]
1.	*A. aulacocarpa* FF 1987 PNG	0.3b	0 c	2.2b	0.3b	0.2b	2.7c	0 a[3)]
2.	*A. aulacocarpa* S 16996 PNG	0 b	0 c	1.4b	0.5b	0.2b	1.9c	0 a
3.	*A. auriculiformis* S 16106 PNG	1.5ab	3.1bc	7.1a	2.9b	0 b	11.6b	0 a
4.	*A. auriculiformis* S 16145 QLD	2.7a	8.7a	16.7a	10.4a	1.9a	14.5b	0 a
5.	*A. auriculiformis* S 18018 PNG	1.4ab	5.3ab	18.2a	2.9b	0.7b	25.7a	0 a
6.	*A. crassicarpa* S 16598 PNG	0.3b	3.4bc	5.4b	3.2b	0 b	27.6a	0 a
7.	*A. crassicarpa* S 17552 PNG	0 b	1.0bc	1.7b	0 b	0 b	14.5b	0 a
8.	*A. crassicarpa* S 17869 PNG	0.7ab	0.5c	4.9b	2.4b	0 b	22.1a	0.3a
9.	*A. mangium* A 538 QLD	0.2b	1.4bc	7.1b	2.7b	0 b	0 c	0.2a
10.	*A. mangium* S 17872 PNG	1.4ab	2.9bc	4.9b	3.9b	0.2b	1.4c	0 a

1) Based on 4 replicates of 49 trees each

2) 1 = Stem canker with black stroma
2 = Stem canker without stroma
3 = Canker on the base of the stem
4 = Dieback
5 = Sooty mold
6 = Yellowing of leaves
7 = Pink disease

3) Values in each column followed by the same letters are not significantly different at p = 0.05 according to Duncan's Multiple Range Test.

The occurrence of a range of disease symptoms on 10 provenances including four acacia species is presented in Table 4 using the disease index rating system. Data can be summarised as follows:

- Pink disease was not present in this trial.
- Yellowing of leaves was most prevalent on *A. crassicarpa* and least on *A. mangium.*
- The two provenances of *A. aulacocarpa* were little affected by the diseases present at Sape.
- Both *A. mangium* and *A. crassicarpa* were affected by cankers and crown dieback.
- *A. auriculiformis* was more affected by cankers than were the other three species. For example the disease indices of basal cankers for the three *A. auriculiformis* provenances were significantly higher ($p<0.05$) than for all other provenances and species.

Severity of disease symptoms on one and a half year-old *Acacia* species and provenances at Lanong, Sanggau.

Table 5. Occurrence and severity of diseases on 8 one and a half year-old provenances of four *Acacia* spp. at Lanong, Sanggau, West Kalimantan.

No	Species/ Provenance	Disease Index[1]						
		1	2	3	4	5	6	7[2]
1.	*A. mangium* 17946, QLD	2.7a	1.4a	2.7a	5.5ab	1.5a	3.7b	0 a[3]
2.	*A. mangium* 18201, PNG	0 a	0 a	0.2a	1.0bc	1.5a	1.9b	0 a
3.	*A crassicarpa* 17849	0 a	0 a	0.7a	0.7bc	0 a	16.3a	0 a
4.	*A. crassicarpa* 17603,PNG	0 a	1.5a	2.7a	6.1a	0.2a	21.8a	0 a
5.	*A. crasscarpa* 17651,PNG	0 a	1.5a	1.5a	3.4abc	6.0a	13.6a	0 a
6.	*A .aulacocarpa* 16950,PNG	0 a	0.2a	0.3a	0 c	1.2a	4.1b	0.5a
7.	*A. aulacocarpa* 17628,PNG	0 a	0.3a	1.9a	0.7bc	1.7a	6.3b	0 a
8.	*A. auriculiformis* 16729,QLD	0 a	0.5a	1.2a	2.6abc	4.9a	6.3b	0 a

[1] Based on 4 replicates of 49 trees each

[2] 1 = Stem canker with black stroma
2 = Stem canker without stroma
3 = Canker on the base of the stem
4 = Dieback
5 = Sooty mold
6 = Yellowing of leaves
7 = Pink disease

[3] Values in each column followed by the same letters are not significantly different at $p = 0.05$ according to Duncan's Multiple Range Test.

The occurrence of a range of disease symptoms on eight provenances including four acacia species is presented in Table 5 using the disease index rating system. Data can be summarised as follows:

- Pink disease was not present in this trial.
- Although the level of disease was low throughout the trial, only those provenances with some level of canker disease also showed crown dieback symptoms.
- *A. aulacocarpa* provenances were healthy, in common with *A. mangium* 18201 and *A. crassicarpa* 17849.
- Yellowing of leaves was prevalent on the three provenances of *A. crassicarpa* with the other species unaffected.

- Observations suggest that *A. mangium* Prov. 18201, which grew best at Lanong is also relatively resistant to disease. However, it must be recognised that in this young stand the overall level of disease was low and causal agents have not been determined. Further surveys are needed in future.

Severity of disease symptoms on 25 provenances of six year-old *A. auriculiformis* at Riam Kiwa.

Table 6. Occurrence and severity of canker diseases on 25 provenances of six year-old *Acacia auriculiformis* at Riam Kiwa, South Kalimantan.

No.	Provenance/CSIRO Seedlot No.	Disease Index [1]	
		Dry Canker	Wet Canker
1.	15483, QLD	2.4efg	0 b
2.	15697, QLD	0 g	0.7b
3.	15985, QLD	6.9efg	0 b
4.	16142, QLD	45.8abc	0.7b
5.	16145, QLD	0.7fg	0 b
6.	16484, QLD	5.9efg	2.8a
7.	16485, QLD	15.5defg	1.0b
8.	16147, NT	27.8de	0.3b
9.	16148, NT	68.0a	0.4b
10.	16149, NT	54.4abc	0 b
11.	16151, NT	61.6a	0 b
12.	16152, NT	24.0defg	0.4b
13.	16153, NT	26.0def	0 b
14.	16154, NT	35.8abc	0.7b
15.	16155, NT	33.7cd	1.0ab
16.	16156, NT	57.9abc	1.7a
17.	16160, NT	68.3a	0.7b
18.	16163, NT	62.4a	0.3b
19.	16187, NT	69.9	1.0ab
20.	16101, PNG	3.3fg	0 b
21.	16103, PNG	0 g	0 b
22.	16105, PNG	27.9de	1.4ab
23.	16106, PNG	6.252efg	0 b
24.	16107, PNG	1.4fg	0.7b
25.	16108, PNG	39.5bcd	1.4ab

[1] Based on 6 replicates of 16 trees each

[2] Values in each column followed by the same letters are not significantly different at $p = 0.05$ according to Duncan's Multiple Range Test.

The occurrence of stem cankers on *A. auriculiformis* is presented in Table 6 using the disease index rating system. Data can be summarised as follows:

- Canker incidence was very high compared to that observed on the younger trees examined at Sanggau.
- Some provenances from each of the three regions were susceptible to disease, e.g. QLD 16142, PNG 16108. There is however, a strong indication that Northern Territory provenances were most severely affected.

- Several provenances e.g. QLD 15697,16145 and PNG 16103, 16107 were virtually free from cankers.
- The "wet canker" symptom seems likely to be part of the same disease as "dry canker" but detailed study of the etiology of this disease is needed.

Severity of pink disease attacking 20 provenances of three year-old *A. mangium* at Riam Kiwa

Table 7. Occurrence and severity of Pink disease on 20 provenances of three year-old *Acacia mangium* at Riam Kiwa, South Kalimantan.

No.	Provenance/ Seedlot No.	Origin	Disease Index[2]
1.	S 17866	PNG	0 b[2]
2.	FF 1996	PNG	0 b
3.	S 16971	PNG	0 b
4.	S 17872	PNG	0 b
5.	FF 2011	PNG	0.3b
6.	F 16938	PNG	0.2b
7.	FF 2013	PNG	1.0b
8.	S 16997	PNG	1.0b
9.	FF 1981	PNG	0.3b
10.	S 16990	PNG	0 b
11.	FF 1998	PNG	0 b
12.	Erambo, Merauke		3.1b
13.	S 17701	QLD	0.2b
14.	S 17946	QLD	0.3b
15.	A 538	QLD	5.4b
16.	D 590	QLD	3.4b
17.	S 15367	QLD	2.9b
18.	S 15238	QLD	16.3a
19.	Inhutani	Subanjeriji	0.2b
20.	SRW Pulup	Irian Jaya	0 b

[1] Based on 4 replicates of 49 trees each

[2] Values in each column followed by the same letter are not significantly different at $p = 0.05$ according to Duncan's Multiple Range Test.

Pink disease was common at Riam Kiwa, and a trial of 20 provenances was scored for this disease. The occurrence of pink disease on *A. mangium* is presented in Table 7 using the disease index rating system. Data can be summarised as follows:

- Although the level of disease in the trial was low (only one provenance had a disease rating higher than .10), it appears that PNG provenances may suffer less from pink disease than Australian provenances. Only two out of 10 PNG provenances had a disease rating of <1 and six were free from the disease, as was a provenance from Irian Jaya.
- Only one provenance (QLD S15238) had significantly more pink disease than the others p>0.005).

Severity of disease symptoms on 13 provenances of three and a half year-old *A. crassicarpa* at Riam Kiwa

Table 8. Occurrence and severity of diseases on 13 provenances of three and a half year-old *Acacia crassicarpa* at Riam Kiwa, South Kalimantan.

No.	Provenance (CSIRO Seedlot no.)	Disease Index [1] Stem borer	Pink disease	Uprooted	Broken branch/stem	Gummosis
1.	FF2000,PNG	12.83abc	0 ab	2.5a	0 a	0 a[2]
2.	S16598,PNG	17.9a	0.9ab	2.6a	0.8a	0 a
3.	S16602,PNG	15.4ab	0 ab	2.1a	1.1a	0.7a
4.	S13680,PNG	9.7abcd	1.5ab	2.0a	1.4a	0.7a
5.	S16993,PNG	10.1abcd	0.7ab	0.7a	0.9a	0.9a
6.	S17552,PNG	8.1bcde	0.8ab	1.8a	0.8a	0 a
7.	S17561,PNG	7.6bcde	0.7ab	0.9a	1.9a	0 a
8.	S17869,PNG	11.3abcd	0 ab	2.4a	0.8a	0 a
9.	S16977,PNG	7.5cde	0.9ab	0.9a	2.9a	0.8a
10.	S16128,QLD	3.6de	0 ab	1.1a	0 a	0 a
11.	S17948,QLD S17943,QLD S17944,QLD	6.4cde	2.5a	1.6a	1.9a	0.8a[3]
12.	S16755,QLD S15950,QLD	6.7cde	0 ab	0 a	1.1a	0 a
13.	S16598,PNG	12.5abcd	0.8ab	2.7a	2.5a	0 a

1) Based on 4 replicates of 49 trees each

2) Values in each column followed by the same letter are not significantly different at $p = 0.05$ according to Duncan's Multiple Range Test.

3) These seedlots were pooled in order to get reasonable numbers of seed parents and seedlings for the sample.

In Table 8 severity of disease symptoms on 13 provenances of *A. crassicarpa* is presented using the disease index rating system. Data can be summarised as follows:

- Stem borer infestation and uprooting were common in *A. crassicarpa* stands. It appeared that the stem borer infestation made the trees prone to stem and branch breakage.
- Pink disease occurred on *A. crassicarpa* but the symptoms were not severe.

Severity of various disease symptoms on 30 provenances of nine year-old *A. mangium* at Riam Kiwa

Table 9. Occurrence and severity of diseases on 30 provenances of nine year-old *Acacia mangium* at Riam Kiwa, South Kalimantan.

No.	Provenance Seedlot No	Origin	Disease Index [1] Dieback	Other Canker	Stem attack by insects	Gummosis
1.	CSIRO/13229	QLD	1.8bcde	0 b	6.4a	2.9a [2]
2.	CSIRO/13621	Ceram	1.4cde	0 b	0 a	0 a
3.	CSIRO/13622	Irian J.	1.0de	0 b	0 a	4.5a
4.	CSIRO/15036	QLD	11.7a	0 b	23.8a	0 a
5.	CSIRO/15237	QLD	12.8a	0 b	4.6a	3.9a
6.	CSIRO/15238	QLD	10.1ab	0 b	2.6a	2.6a
7.	CSIRO/15266	QLD	7.9abcde	0 b	3.7a	0 a
8.	Dendros/0446	QLD	10.0abc	0 b	0 a	0 a
9.	Dendros/0447	QLD	9.4abd	0 b	0 a	0 a
10.	Dendros/0448	QLD	9.2abd	0 b	0 a	2.8a
11.	Dendros/0407	QLD	10.7a	0 b	3.4a	2.8a
12.	Mr Budi		6.4abcde	1.7b	2.3a	3.6a
13.	PT.ITCI,	East Kal.	11.9a	0 b	1.8a	1.8a
14.	Inhutani/13	S. Sum.	7.6abcde	0 b	5.5a	0 a
15.	For.Dept./25II	QLD	6.4abcde	0 b	1.7a	0 a
16.	For.Dept/27II	QLD	7.7abcde	2.4ab	2.9a	0 a
17.	For.Dept./28II	QLD	6.4abcde	0 b	0 a	1.8a
18.	For.Dept./29II	QLD	7.6abcde	1.8b	0 a	0 a
19.	For.Dept./30II	QLD	5.3abcde	0 b	5.1a	0 a
20.	For.Res.Ctr/2	Sabah	8.9abcd	0 b	0 a	0 a
21.	For.Res.Ctr.2332	Sabah	10.0abc	0 b	0 a	1.7a
22.	For.Res.Ctr.2333	Sabah	9.6abd	0 b	2.1a	0 a
23.	For.Res.Ctr.2343	Sabah	6.3abcde	0 b	0 a	0 a
24.	Fak-fak,	Irian J.	1.8bcde	0 b	0 a	0 a
25.	-	Taliabu	0.9de	0 b	0 a	0 a
26.	Sidei	Irian J.	1.8bcde	0 b	0 a	0 a
27.	Barabai	South Kal.	6.5abcde	0 b	2.4a	0 a
28.	Sanga-sanga	East Kal.	0 e	0 b	0 a	0 a
29.	Subanjeriji	S.Sum.	5.2abcde	1.7b	1.8a	0 a
30.	Subanjeriji	S. Sum.	6.0abcde	2.9a	0 a	0 a

[1] Based on 4 replicates of 25 trees each

[2] Values in each column followed by the same letter are not significantly different at $p = 0.05$ according to Duncan's Multiple Range Test.

In Table 9 severity of disease symptoms on 30 provenances of *A. mangium* is presented ,ing the disease index rating system. Data can be summarised as follows:

- All provenances of *A. mangium*, except provenance Sanga-sanga showed crown dieback symptoms.
- The trial suffered from significant insect attack.

Severity of disease symptoms on six provenances of three and a half year-old *A. aulacocarpa* at Riam Kiwa

Table 10. Occurrence and severity of diseases on six provenances of three and a half year-old *Acacia aulacocarpa* in Riam Kiwa, South Kalimantan.

No.	Provenance Seedlot No.	Disease Index[1]		
		Stem Canker	Broken Branch	Gummosis
1.	SRW, Bade	0 a	1.4a	0 a[2]
2.	FF1987, PNG	0.17a	0.5a	0 a
3.	S17628, PNG	0.34a	1.0a	0.2a
4.	S16996, PNG	0.17a	0.7a	0 a
5.	FF1986, PNG	0.85a	0.8a	0 a
6.	FF1983, PNG	0.17a	1.7a	0.2a

[1] Based on 4 replicates of 49 trees each

[2] Values in each column followed by the same letter are not significantly different at $p = 0.05$ according to Duncan's Multiple Range Test.

In Table 10 severity of disease symptoms is recorded using the disease index rating system.

- The only symptom of note was a low level of stem cankers. Only one provenance, SRW Bade (Irian Jaya) was free from symptoms but there were no significant differences in canker incidence between provenances.

Discussion

Yellowing of leaves and necrosis of tissues on the leaf margins and leaf tips of *A. crassicarpa* were encountered both in West and in South Kalimantan. The symptom has been also observed in Thailand on vigorously growing young *A. crassicarpa*. The nature of this condition is not known and the apparent lack of known leaf pathogens associated with the symptom suggests that it has a physiological rather than pathological basis.

Pink disease is commonly encountered on various tree species in different parts of Indonesia. In this survey the disease was found primarily on *A. mangium*, less on *A. crassicarpa*, and was absent from *A. aulacocarpa* and *A. auriçuliformis*. Pink disease on *A. mangium* commonly developed at the base of a branch or the forked part of the stem. Consequently, breakage of branches or stems occurred occasionally (Fig. 6c). Pink disease is also known to occur on *A. mangium* in East Kalimantan and at Subanjeriji, South Sumatra.

Several types of stem canker symptoms, sometimes accompanied by gummosis, were found on *A. mangium* in Sanggau, *A. auriculiformis* in Riam Kiwa, and on *A. aulacocarpa* also in Riam Kiwa. This appears to be the first report of significant canker syndromes, other than pink disease, on tropical acacias in Indonesia. Isolations of fungi from cankers on *A. mangium* included *Phomopsis* sp. and *L. theobromae*. The latter fungus was also associated with cankers on *A. aulacocarpa* and *A. auriculiformis*. No inoculation studies have been carried out on seedlings or trees in plantations so the cause of these cankers has not yet been determined.

Pongpanich in this proceedings reports on cankers on *A. auriculiformis* in Thailand, associated with borer damage and infection by *Dothiorella,* the anamorph of *Botryosphaeria* spp. and top dieback of *A. aulacocarpa* associated with cankers and borer damage. Other reports are of a low level of upper crown cankers in *A. mangium* in Malaysia by Lee Su See (also reported in this proceedings).

Although Pongpanich observed no discernible differences in susceptibility to stem cankers in two replicates of the international *A. auriculiforrnis* provenance trial at two locations in Thailand, the trial at Riam Kiwa, which included many of the same provenances, indicated clear provenance differences. At Riam Kiwa, provenances from the Northern Territory were uniformly susceptible, whereas only three provenances from northern Queensland and Papua New Guinea were similarly susceptible. This probably reflects major differences in climate between the Thailand sites and Kalimantan, the level of environmental stress the trees have been exposed to and differences in species of pathogenic fungi and stem boring insects at the three locations.

The appearance of rust caused by *Atelocauda digitata,* although currently present at a low level, in major acacia plantation areas in both regions of Kalimantan gives cause for concern, as expressed in the discussion session at this workshop.

Crown dieback, not obviously associated with stem and branch cankers, was occasionally encountered on two and a half year-old acacias. In nine year-old stands dieback occurred on almost all provenances of *A. mangium.* Some provenance variation was seen with respect to this crown condition but the cause is unclear and further investigation is needed, especially with respect to root rot pathogens. The incidence of dieback in older plantations may reflect the combined impacts of site, soil and climatic conditions, insects, and a range of pathogenic fungi. Expected rotation length is six to nine years depending on growth rates. It is important that stands remain healthy and vigorous to full rotation length if productivity of these plantations is to be sustainable.

As tropical acacias are planted in new areas, and the extent of monocultures increases, plantations will be exposed to an increasing range of disease problems. Some of these pathogens will originate from the indigenous tree species, especially those which infect roots and stumps of cut-over native forest trees. Other diseases will occur when species or provenances are poorly adapted to site conditions, and a range of opportunist pests and pathogens. for example, canker fungi and boring insects will further damage unthrifty stands. Finally non-indigenous, specialised pathogens, for example, acacia rusts will, extend their range over time to the newly established plantations.

As provenances and clones are selected and improved for plantation enterprises in Indonesia. it is essential that selection for resistance to diseases is included in tree improvement programs. Some provenances, for example, *A. mangium* 17866 are growing well in the new plantation areas and have been relatively unaffected by disease impacts. There is a need however to keep the genetic base of the plantations as broad as possible, consistent with selection of silviculturally suitable trees, thereby minimising unforeseen disease problems. There is also a need for a greater level of knowledge of those diseases which may be the cause of such future problems

Acknowledgments

The authors are indebted to Mr. Antti Otsamo and Mrs. Anu Honkanen, both of Enso Forest Development Ltd., for their kind cooperation in this acacia disease survey and for their efforts to coordinate the staff of Balai Teknologi Reboisasi Banjarbaru and those of PT. Finnantara Intiga, respectively, in carrying out the field survey. Thanks are also due to Miss Lilis Kurniati, Mr. Tjoek Sasmito Hadi, Mr. Mukhlisin and Mr. Tasar of Balai Teknologi Reboisasi Banjarbaru as well as to Mr. Ali Hayat and Mr. Yayan Subardiana of PT Finnantara Intiga for their tireless field disease survey.

The statistical analysis of the data by Mrs. Pamuji Lestari of BIOTROP is also gratefully appreciated. Identification of fungal cultures at CSIRO Forestry and Forest Products was carried out by Mr Mark Dudzinski whose assistance is gratefully acknowledged.

References

Darma, I.G.K.T., Oemijati, R., Abidin, and J. Surya. (1986). Different forest pests and diseases in *Acacia mangium* plantation at Subanjeriji, South Sumatera (In Indonesian). In 'Threat on Industrial Forest Plantations' (Eds Wirakusumah, *et al.*) Faculty of Mathematics and Natural Sciences, University of Indonesia. Jakarta. 108- 113.

Hodges, C.S. Jr., and Gardner, D.E. (1984). Hawaiian forest fungi. IV. Rusts on endemic *Acacia* species, *Mycologia* **76**: 332-349.

McAlpine, D. (1906). *The rusts of Australia*. Government Printer, Melbourne, Australia. 349p.

Nuhamara, S.T. (1986). Forest Diseases: One of the Problems in the Establishment of Industrial Forest Plantations (In Indonesian). In 'Threat on Industrial Forest Plantations' (Eds Wirakusumah, *et al.*) Faculty of Mathematics and Natural Sciences, University of Indonesia. Jakarta. 87-99.

Nuhamara, S.T. (1991). Various diseases in industrial forest plantations in Indonesia (In Indonesian). In 'Improvement of Productivity Through Integrated Pest and Disease Management'(Eds Hadi, S. *et al.*) Faculty of Forestry, Bogor Agricultural University. Bogor. 29 - 56.

Nuhamara, S.T. (1993). Factors associated with twig decline on *Acacia mangium* plantation at Parung Panjang Forest Sub-District (In Indonesian). M.S. Thesis. Graduate Program. Bogor Agricultural University. Bogor. 73 p.

Nurbayah (1994). Damage and loss due to *Fusarium oxysporum* and *Botryodiplodia* sp. the inciting agents of root rot on *Acacia mangium* in PT. INHUTANI Industrial Forest Plantation at Gowa, Maros, South Sulawesi (In Indonesian). Sarjana Script. Faculty of Forestry, Bogor Agricultural University. Bogor. 50 p.

Punithalingam, E. (1969) *Botryodiplodia theobromae.* CMI Descriptions of Pathogenic Fungi and Bacteria No. 5 19. International Mycological Institute, Ferry Lane, Kew, Surrey England.

Santosa, E., and Mieke Suharti. (1984). Study on the morphology and anatomy of rust attacking *Acacia uuriculiformis* A.Cun. (In Indonesian). *Centre for Forest Research and Development. Bogor.* Report No. **441.** 15 p.

Soeyamto, Ch., and Mardji, D. (1986). Pests and diseases in nurseries and industrial forest plantations (In Indonesian). In 'Threat on Industrial Forest Plantations' (Eds Wirakusumah, *et al*.) Faculty of Mathematics and Natural Sciences, University of Indonesia. Jakarta. 100 - 07.

Suparno. (1991). Control of pests and diseases in industrial forest plantations of PT. Inhutani I (Indonesian). In 'Improvement of Productivity Through Integrated Pest and Disease Management'(Eds Hadi, S. *et al.)* Faculty of Forestry, Bogor Agricultural University. Bogor. 141- 148.

APPENDIX

Origin of seedlots used in experimental trials in Kalimantan

Table A1. Origins of 10 provenances of two and a half year-old *Acacia mangium* at Sape, Sanggau, West Kalimantan

No	Provenance/ Seedlot No	Origin		
		Locality	Longitude	Latitude
1.	A 529	QLD	145°24'E	16°31'S
2.	A 538	QLD	145°20'E	16°53'S
3.	FF 1977	QLD	143°15'E	12°45'S
4.	FF 1982	PNG	142°58'E	08°05'S
5.	FF 1995	Wasua, PNG	141°52'E	08°17'S
6.	FF 1998	Merauke, Irian	141°113'E	08°31'S
7.	FF 2011	Balimo, PNG	142°58'E	08°01'S
8.	FF 2013	Balimo, PNG	143°02'E	08°19'S
9.	S 15238	N. of Cardwell, PNG	145°50'E	08°00'S
10.	S 16997	Boite, PNG	141°58'E	08°37'S
11.	S 17550	Bensbach, PNG	141°17'E	08°53'S
12.	S 17701	Claudie River, Qld	143°17'E	12°45'S
13.	S 17866	Lake Murray, Qld	141°29'E	08°51'S
14.	S 17872	PNG	142°54'E	08°49'S
15.	Subanjeriji	Subanjeriji, Sumatra	-	-

Table A2. Origin of 10 provenances of two and a half year-old acacia species at Sape, Sanggau, West Kalimantan.

No	Provenance/Seedlot No	Origin		
		Locality	Longitude	Latitude
1.	*A. aulacocarpa* FF 1987	PNG	141°13'E	08.31'S
2.	*A. aulacocarpa* S 16996	PNG	142°03'E	08°38'S
3.	*A. auriculiformis* S 16106	PNG	141°30'E	08°49'S
4.	*A. auriculiformis* S 16145	QLD	142°56'E	13°06'S
5.	*A. auriculiformis* S 18018	PNG	141°16'E	08°54'S
6.	*A. crassicarpa* S 16598	PNG	141°55'E	08°37'S
7.	*A. aulacocarpa* S 17552	PNG	141°17'E	08°53'S
8.	*A. crassicarpa* S 17869	PNG	141°37'E	08°45'S
9.	*A. mangium* A 538	QLD	145°20'E	15°53'S
10.	*A. mangium* S 17872	PNG	142°54'E	08°49'S

Table A3. Origin of 10 provenances of two and a half year-old *Acacia mangium* at Lanong, Sanggau, West Kalimantan

No	Provenance/ Seedlot No	Origin		
		Locality	Longitude	Latitude
1.	*A. mangium* 17946	Claudie River, QLD	143°18´E	12°88´S
2.	*A. mangium* 18201	Demisi Village, PNG	142°12´E	08°21´S
3.	*A. crassicarpa* 17849	Irian Jaya	141° 0´E	08°20´S
4.	*A crassocarpa* 17603	Morehead, PNG	141°30´E	08°40´S
5.	*A.crassicarpas* 17651	Limal-Malam, PNG	142°43´E	08°40´S
6.	*A. aulacocarpa* 16950	Wasya Pedoya, PNG	142°15´E	08°17´S
7.	*A. aulacocarpa* 17628	Keru Village, PNG	141°45´E	08°33´S
8.	*A. auriculiformis* 16729	Coen, QLD	143°03´E	13°53´S

Table A4. Origin of 20 provenances of three year-old *Acacia mangium* at Riam Kiwa, South Kalimantan.

No	Provenance/ Seedlot No	Origin		
		Locality	Longitude	Latitude
1.	S 17866	PNG	141°29´E	06°29´S
2.	FF 1996	PNG	142°41´E	08°41´S
3.	S 16971	PNG	142°52´E	08°52´S
4.	S 17872	PNG	142°54´E	08°54´S
5.	FF 2011	PNG	142°58´E	08°58´S
6.	F 16938	PNG	142°58´E	08°58´S
7.	FF 2013	PNG	143°02´E	08°02´S
8.	S 16997	PNG	141°58´E	08°58´S
9.	FF 1981	PNG	142°00´E	08°00´S
10.	S 16990	PNG	141°52´E	08°52´S
11.	FF 1998	PNG	141°13´E	08°13´S
12.	-	Erambo, Merauke	-	-
13.	S 17701	QLD	143°17´E	12°17´S
14.	S 17946	QLD	143°18´E	12°18´S
15.	A 538	QLD	145°20´E	15°20´S
16.	D 590	QLD	145°21´E	16°21´S
17.	S 15367	QLD	145°24´E	16°24´S
18.	S 15238	QLD	145°50´E	18°50´S
19.	Inhutani	Subanjeriji	-	-
20.	SRW	Pulup, Irian Jaya	-	-

Table A5. **Origin of 30 provenances of nine year-old *Acacia mangium* at Riam Kiwa, South Kalimantan.**

No	Provenance/ Seedlot No		Origin		
			Locality	Longitude	Latitude
1.	CSIRO/13229	QLD	Claudie River	143°13'E	12°44'S
2.	CSIRO/13621	Ceram	Piru, INA	128°12'E	03°04'S
3.	CSIRO/13622	Irian J.	Sidei, INA	133°34'E	00°46'S
4.	CSIRO/15036	QLD	7 km SSE	145°24'E	16°31'S
5.	CSIRO/15237	QLD	20 km S of Cardwell	146°59'E	18°26'S
6.	CSIRO/15238	QLD	30 km N of Cardwell	145°50'E	18°30'S
7.	CSIRO/15266	QLD	Innisfail Region	146°00'E	17°30'S
8.	Dendros 58/0446	QLD	SE of Daintree	145°24'E	16°18'S
9.	Dendros 30/0447	QLD	Bloomfield	145°21'E	15°58'S
10.	Dendros/0448	QLD	20 km SE of Cardwell	146°02'E	18°16'S
11.	Dendros/0407	QLD	Innisfail Region	146°00'E	01°30'S
12.	Mr Budi	-	-	-	-
13.	PT. ITCI,	East Kal	-	-	-
14.	Inhutani/13	S. Sum.	-	-	-
15.	For. Dept/2511	QLD	Goldsborough Valley	145°46'E	17°15'S
16.	For. Dept/2711	QLD	Kuranda	145°32'E	16°44'S
17.	For. Dept/2811	QLD	Hawkins Creek	146°05'E	18°35'S
18.	For. Dept/2911	QLD	Lannercost	145°53'E	18°38'S
19.	For. Dept/3011	QLD	Ingham	146°14'E	18°48'S
20.	For.Res.Ctr/2	Sabah	Jalan Madu	116°34'E	06°29'S
21.	For.Res.Ct 21 2332 21	Sabah	Lungmanis	116°21'E	05°49'S
22.	For.Res.Ct 56 2333	Sabah	Sook	116°21'E	05°09'S
23.	For.Res.Ctr. 2343	Sabah	Gum Gum	117°56'E	05°51'S
24.	Fak-fak	Irian J.	INA	-	-
25.	-	Taliabu	INA	-	-
26.	Sidei	Irian J.	INA	-	-
27.	Barabai	South Kal.	INA	-	-
28.	Sanga-sanga	East Kal.	INA	117°05'E	00°05'S
29.	Subanjeriji	S. Sum.	INA	-	-
30.	Subanjeriji	Inhutani, S. Sum.	INA	-	-

Table A6. Origin of 20 provenances of three year-old *Acacia crassicarpa* at Riam Kiwa, South Kalimantan.

No	Provenance (CSIRO Seedlot No)		Origin	
			Longitude	Latitude
1.	FF2000	PNG	141°13'E	08°31'S
2.	S16598	PNG	141°55'E	08°37'S
3.	S16602	PNG	141°13'E	08°31'S
4.	S13680	PNG	141°26'E	08°51'S
5.	S16993	PNG	141°50'E	08°40'S
6.	S17552	PNG	141°17'E	08°53'S
7.	S17561	PNG	142°43'E	08°40'S
8.	S17869	PNG	141°37'E	08°45'S
9.	S16977	PNG	142°48'E	08°49'S
10.	S16128	QLD	142°22'E	11°02'S
11.	S17948	QLD)[1]	143°23'E	12°38'S
	S17943	QLD)	142°50'E	12°19'S
	S17944	QLD)	143°18'E	12°48'S
12.	S16755	QLD)[1]	145°19'E	15°36'S
	S15950	QLD)	145°20'E	15°36'S
13.	S16598	PNG	141°55'E	08°37'S

[1] Seeds were pooled

Table A7. Origin of 25 provenances of three year-old *Acacia aulacocarpa* at Riam Kiwa, South Kalimantan.

No	Provenance Seedlot No	Origin	
		Longitude	Latitude
1.	SRW, Bade	139°39'E	07°15'S
2.	FF1987, PNG	141°13E	08°31'S
3.	S17628, PNG	141°45'E	08°33'S
4.	S16996, PNG	142°03'E	08°38'S
5.	FF1986, PNG	142°41'E	08°01'S
6.	FF1983, PNG	142°58'E	08°05'S

Table A8. Origin of 25 provenances of six year-old *Acacia auriculiformis* at Riam Kiwa, South Kalimantan

No	Provenance/ Seedlot No	Origin		
		Locality	Longitude	Latitude
1.	15483, QLD	Archer River	142°47´E	12°26´S
2.	15697, QLD	S. Coen, Cape York	143°16´E	14°07´S
3.	15985, QLD	Mt. Nolloy, Rifle Creek	143°17´E	16°41´S
4.	16142, QLD	Coen River	143°03´E	13°53´S
5.	16145, QLD	Wenlock River	142°56´E	13°06´S
6.	16484, QLD	Morehead River	143°40´E	15°03´S
7.	16485, QLD	Kings Plain	145°06´E	15°42´S
8.	16147, NT	Noogoo Swamp King Ck	131°00´E	12°23´S
9.	16148, NT	Manton River	131°07´E	12°50´S
10.	16149, NT	Douglas River	131°07´E	13°51´S
11.	16151, NT	Mary River	132°08´E	13°36´S
12.	16152, NT	E. Alligator River	132°55´E	12°17´S
13.	16153, NT	Cooper Creek	133°11´E	12°06´S
14.	16154, NT	Coomadeer River	133°41´E	12°08´S
15.	16155, NT	Mann River	134°08´E	12°22´S
16.	16156, NT	Yarunga Creek	134°48´E	12°18´S
17.	16160, NT	S. Alligator River	132°19´E	13°16´S
18.	16163, NT	Elizabeth River	131°04´E	12°36´S
19.	16187, NT	Melville River	130°50´E	11°55´S
20.	16101, PNG	N. Bensbach to Weam	142°15´E	08°50´S
21.	16103, PNG	1 hr S. Balamuk	141°15´E	09°00´S
22.	16105, PNG	Balamuk on Bensbach	141°17´E	08°55´S
23.	16106, PNG	3 km N. Mibini	141°38´E	08°49´S
24.	16107, PNG	Old Tonda Village	141°33´E	08°55´S
25.	16108, PNG	Mari Village WP	141°42´E	09°11´S

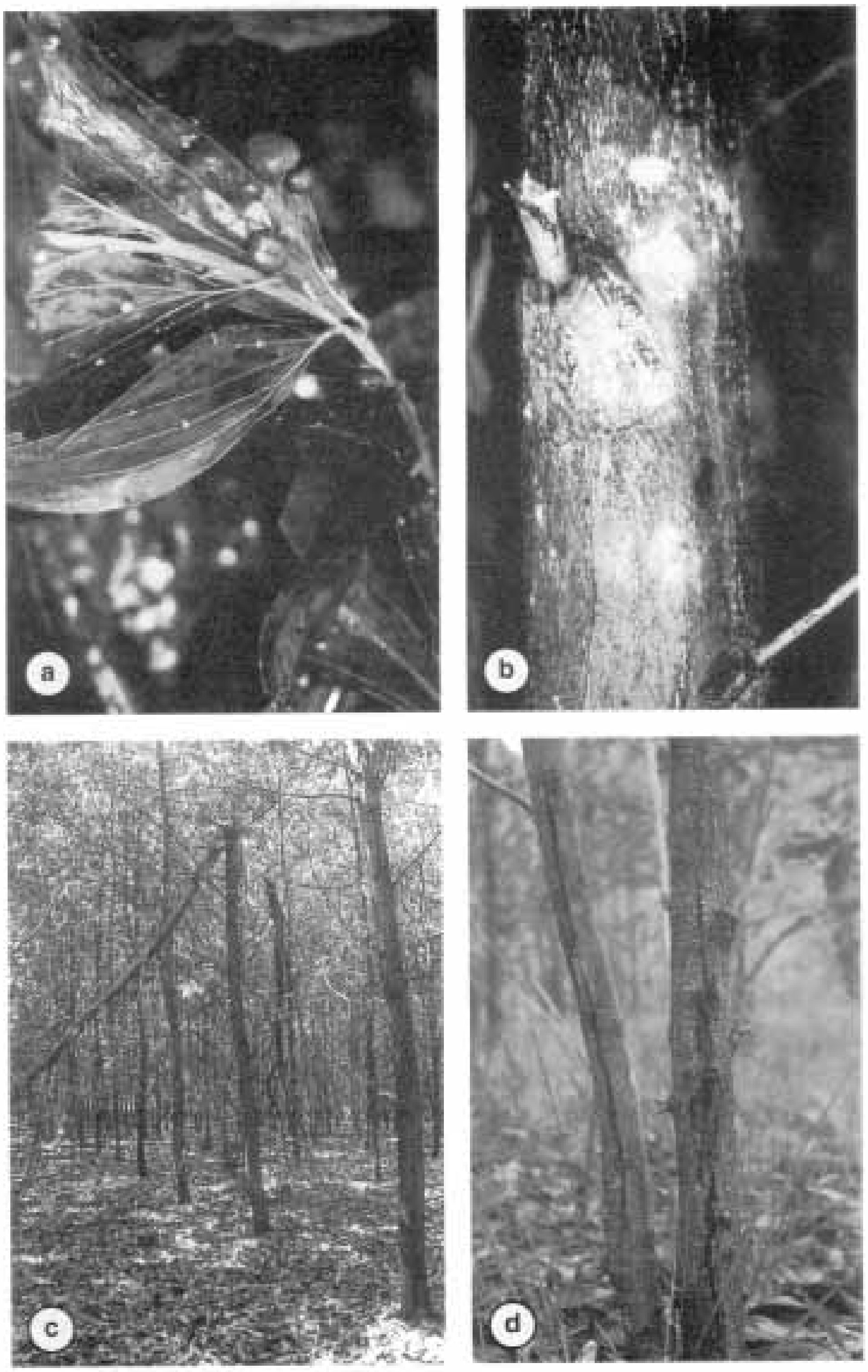

Figure 6. Diseases present on *Acacia* spp. in Indonesia.

a) Galls caused by the rust fungus *Atelocauda digitata* on *A. mangium*.

b) Cobweb stage of pink disease caused by *Corticium salmonicolor* on *A. mangium*.

c) Broken stems of *A. auriculiformis* resulting from pink disease.

d) Severely cankered stem of *A. auriculiformis*.

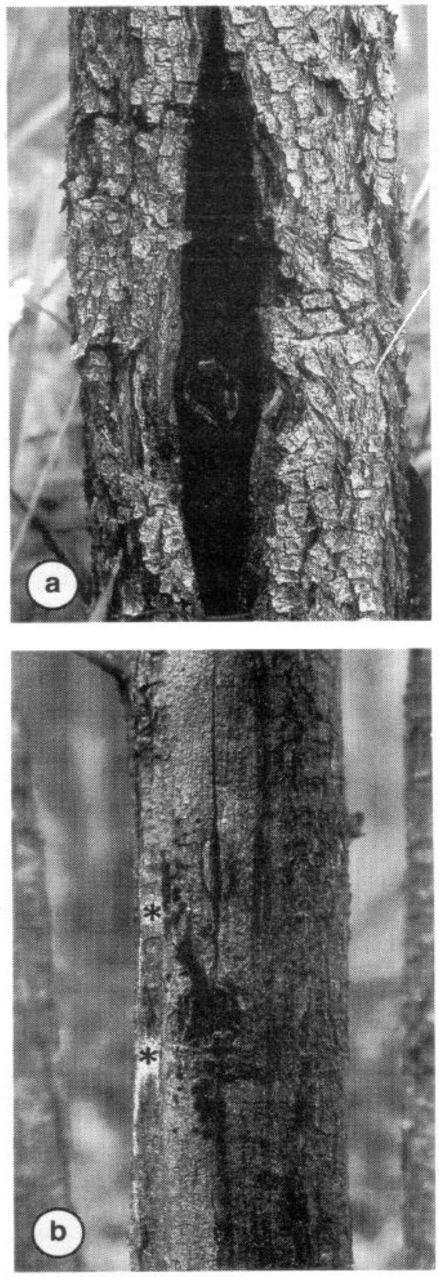

Figure 7. Diseases present on *Acacia* spp. in Indonesia.

a) Severe canker, possibly associated with a branch stub infection of *A. mangium.*

b) Vertical cracking of bark and black stomatic fungal colonies (*) on stem of *A. mangium.*

Diseases of Tropical Acacias in South Sumatra

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Abstract

Large areas in south Sumatra are being planted with acacia species, predominantly *Acacia mangium.* For example the plantations of Musi Hutan Persada near Subanjeriji cover an area of 170,000 ha. Small trial plantings of *A. crassicarpa* and *A. auriculiformis* have also been established. A disease survey, carried out during 1995 in tree improvement and silvicultural trials in the Subanjeriji area, indicated that the overall the level of disease was low. The most frequently observed disease was pink disease.Data collected in a silvicultural trial with several spacing treatments indicated that disease was favoured by high stem densities.

Introduction

The survey was done as part of a wider survey of fungal diseases in four species of *Acacia* in India, Thailand, Malaysia, Australia, and Indonesia. In Indonesia surveys were carried out in South Sumatra, Riau and Kalimantan.

The purpose of the survey was to compare four species of *Acacia*, and their provenances, with regard to occurrence of fungal diseases that attack the foliage and stems. The four species were: *Acacia mangium, A. auriculiformis, A. crassicarpa,* and *A. aulacocarpa.* In South Sumatra the plantations of Musi Hutan Persada (MHP), near Subanjeriji and Benakat were surveyed. The main species was *A. mangium*, with only small plantations of *A. auriculiformis, A. crassicarpa* and *A. aulacocarpa* available.

The Plantations

The four species of *Acacia* are not indigenous to Sumatra, being native to northern Queensland, Papua New Guinea, and eastern Indonesia.

.4cacia mangium is now the most widely planted species. The plantations of MHP cover an area of 170,000 ha and the species is planted by other companies in several areas of South Sumatra. The oldest *.4. mangium* in South Sumatra is 15 year-old, and was planted by the Forestry Department of the Ministry of Agriculture, as part of a reforestation program. The 15 year-old stands are in Subanjeriji, and are managed by PT Inhutani V. They are surrounded by the plantations of MHP.

The seed for the original Subanjeriji plantings came from four provenances in the Cairns region of Queensland: Julatten, Mossman, Daintree, and Cassowary Creek. Much of the seed for the MHP plantations was collected from seed stands in Subanjeriji, and is therefore derived from the four provenances from the Cairns region. Provenances from the Cairns region are not so productive as those from far north Queensland, and Papua New Guinea, so as part of our tree improvement program we have introduced seed from other provenances. The other provenances have been planted in provenance seed stands, provenance trials, and progeny trials.

Acacia auriculiformis was also planted in South Sumatra as part of the reforestation program. Its natural distribution is in northern Queensland, the northern part of the Northern Territories, and the southern part of Papua New Guinea. It has also been planted by MHP as part of the tree improvement program, to create a base population, and to produce hybrids of *A. mangium x A. auriculiformis.*

Acacia crassicarpa was planted as part of a species trial, 12 years ago. It has also been planted more recently, in progeny trials, as part of the tree improvement program.

Results

Most of the survey was done in the tree improvement trials with some additional surveys in silviculture trials (Table 1).

Acacia mangium

Five year-old trees of the following six provenances in tree improvement trials were surveyed:

Deri-deri, PNG
Wando, PNG
Wipim, PNG
Gubam, PNG
Claudie River, far north Queensland
Subanjeriji land race

The original planting distance of the trials was 2m x 4m, but at the time of the survey they had been thinned from about 1250 trees per hectare to about 600.

There were no serious attacks of any fungal disease.

Pink disease

The most frequently occurring disease in the Subanjeriji region is pink disease, caused by *Corticium salmonicolor.* Averaged over the whole survey, pink disease affects about 1.8% of the trees. There is no evidence that it affects one provenance more than another.

A survey carried out in a planting trial (five year-old) with several spacings showed that pink disease is more frequent in stands with closer planting distances (Table 2).

Our recommendation to the company is that trees affected by pink disease should be felled and burned, to eradicate the source of inoculum. We suspect that the original source of inoculum is rubber in nearby smallholdings.

We expect that in future pink disease will become less serious. Our early stands of *A. mangium* were planted at close distances (2m x 3m), and the trees were usually multi-stemmed, so the final stem density is rather high (more than 2000 stems per hectare). Our present policy is to plant at 2m x 4m and to single the trees, so the final stem density is 1250 stems per hectare or less.

Other diseases noted in the surveys

Sooty mould was common, but it is not regarded as a serious disease. It grows on sugary exudates on phyllode surfaces, and does not actually attack the tissue.

There were very low levels of stem canker (0.4%) and dieback (0.1%) but the causes are not known.

We also noted that 0.7% of trees had yellowish leaves, but the cause is not known.

Some trees were recorded as abnormal (stunted). The average number of trees affected was 1.9%, but this increased to 13.3% for the Subanjeriji landrace.

Gall rusts were not found during the surveys but it has since been found on wildlings of *A. mangium* growing near infected *A. auriculiformis.*

Eighteen month-old trees of the following nine provenances (sixteen trees per provenance) in tree improvement trials were also surveyed:

Deri-deri, PNG
Gubam, PNG
Arufi, PNG
Boite, PNG
Bimadebun, PNG
Dimisisi, PNG
Pascoe River, far north Queensland
Claudie River, far north Queensland
Cassowary, Cairns region Queensland

No diseases were found in any of these provenances.

The scope of the survey did not include heart rot, or root disease. To detect heart rot we would have to fell the trees and cut them open, and to detect root disease we would have to dig up the roots.

Nevertheless, we know that heart rot is present, especially where the stem has been wounded by late singling, which causes a large wound. We have also seen trees dying, sometimes in patches. We suspect that the cause of death is root disease but the causative agent has not yet been identified. The symptoms resemble white root disease in rubber, caused by *Rigidoporus lignosus.*

Acacia auriculiformis

Two 14 month-old provenances, Mibimi and Wenlock River, were surveyed. The trees had been planted at a distance of 3m x 4m. The most frequently occurring disease symptoms were dieback (18%) and rust (15.7%). The cause of dieback is not yet known. The rust is caused by *Atelocauda digitata*.

Thirteen percent of the trees were recorded as abnormal 7.3%, as having yellowish leaves, and 0.9% as having stem cankers. We are not aware of any pink disease or root rot, but the trees are probably too young to show the symptoms.

Acacia crassicarpa

The survey included only Gubam provenance, and the trees were only ten months old.
No symptoms of fungal disease were observed. About two percent were recorded as having yellowish leaves.

Discussion

The trees show few symptoms of Fungal disease at present, but the situation must be continuously monitored.

The causative agents of the cankers, diebacks, rusts, and leaf yellowing should be identified, even though their incidence is low.

More detailed surveys should be done for root rot and heart rot.

The stands may be relatively healthy now because most of the land was previously alang-alang grassland with little source of inoculum of acacia pathogens. There is a high possibility of increasing incidence of disease with time, especially of root and butt rots. We should also look for any relationship between existing incidence of disease and previous land use.

Table 1 **Results of survey for fungal diseases in Acacia species in Subanjerii/Benakat (South Sumatra)**

Species Provenance	Trial	Unit/Block	Planting Distance (m)	Age Yr	Total trees	Abnormal (No.)	Abnormal (%)	Canker (No.)	Canker (%)	Dieback (No.)	Dieback (%)	Pink Disease (No.)	Pink Disease (%)	Root rot (No.)	Root rot (%)	Yellow leaf (No.)	Yellow leaf (%)	Sooty mould (No.)	Sooty mould (%)	Rust (No.)	Rust (%)
Acacia mangium																					
Deri-deri	T.9121	III Toman	2x4	5	649	14	2.2	-	-	1	0.2	27	4.2	-	-	-	-	#	#	-	-
Deri-deri	T.9130	V Niru	2x4	5	87	-	-	-	-	-	-	-	-	-	-	-	-	#	#	-	-
Wando	T.9122	III Toman	2x4	5	310	-	-	-	-	-	-	-	-	-	-	-	-	#	#	-	-
Wando	T.9133	V Niru	2x4	5	334	29	8.7	6	1.8	1	0.3	2	0.6	-	-	-	-	#	#	-	-
Wando	T.9134	V Niru	2x4	5	78	1	1.3	7	9	-	-	-	-	-	-	-	-	#	#	-	-
Wipim	T.9124	III Toman	2x4	5	390	-	-	-	-	-	-	8	2.1	-	-	17	4.4	#	#	-	-
Claudie R	T.9132	III Toman	2x4	5	429	-	-	-	-	-	-	20	4.7	-	-	7	1.6	#	#	-	-
Claudie R	T.9132	V Niru	2x4	5	171	-	-	-	-	-	-	-	-	-	-	-	-	#	#	-	-
Gubam	T.9126	III Toman	2x4	5	405	-	-	-	-	1	0.2	5	1.2	-	-	5	1.2	#	#	-	-
Gubam	T.9131	V Niru	2x4	5	353	-	-	-	-	-	-	-	-	-	-	-	-	#	#	-	-
Inhutani	T.9123	III Toman	2x4	5	495	-	-	-	-	-	-	10	2	-	-	-	-	#	#	-	-
Inhutani	T.9135	V Niru	2x4	5	226	30	13.3	2	0.9	-	-	-	-	-	-	-	-	#	#	-	-
					3927	74	1.9	15	0.4	3	0.1	72	1.8			29	0.7				
Acacia auriculiformis																					
Mibimi	T.9405	III Banding Anyar	3x4	1.2	208	81	38 9	8	3.8	18	8.7	-	-	-	-	23	11.1	#	#	34	16.3
Wenlock R	T.9409	V Niru	3x4	1.2	1060	86	8.1	4	0.4	210	19.8	-	-	-	-	70	6.7	#	#	165	15.6
					1268	167	13.2	12	0.9	228	18					93	7.3			199	15.7
Acacia crassicarpa																					
Gubam	T.95024	VI Setuntung 79		0.8	50	-	-	-	-	-	-	-	-	-	-	1	2.0	-	-	-	-

Sooty mould occurred in all trials

Table 2 **Occurrence of Pink disease in *A. mangium* in relation to planting distance .**

Planting distance	Trees per ha	Trees per repl plot	Number of trees attacked												Percentage attack		
			Light attack				Medium attack				Severe attack						
			Repl 1	Repl 2	Repl 3	Total	Repl 1	Repl 2	Repl 3	Total	Repl 1	Repl 2	Repl 3	Total	Light	Medium	Severe
2x2	2500	40	2	1	0	3	1	5	2	8	23	6	0	29	2.5	6.7	24.2
2x3	1667	40	3	1	2	6	12	0	1	13	6	15	3	24	5.0	10.8	20.0
3x3	1111	40	2	0	0	2	0	3	3	6	7	4	0	11	1.7	5.0	9.2
4x4	625	40	0	3	0	3	1	1	4	6	2	1	2	5	2.5	5.0	4.2

Disease severity: Light - At the cobweb stage

Medium - At the greyish white stage, or just beginning to show pink

Severe - At the uniformly pink stage, and the bark is cracking

The survey was carried out in Unit II, Merbau, compartments 1, 4, and 40 in July 1995

Diseases Of Some Tropical Plantation Acacias In Peninsular Malaysia*

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Abstract

Of the several species of acacias introduced into Peninsular Malaysia since the early 1930s only *Acacia mangium* has been planted on a large-scale. There are presently about 100,000 ha of *A. mangium* plantations in Malaysia. As part of a regional CIFOR/ACIAR project on diseases of tropical plantation acacias, a survey of foliar, stem and root diseases of *A. auriculiformis, A. aulacocarpa, A. crassicarpa* and *A. mangium* planted in peninsular Malaysia was conducted in 1995. The survey focused on *A. mangium* trees planted in provenance trials in three main forest plantation areas of the peninsula. Excluding heart rot which was not assessed in this survey, the most frequently occurring disease of *A. mangium* was root rot. The associated pathogen is most probably a species of *Ganoderma.* Overall lowest incidence of root disease was found in the Papua New Guinean provenances of West of Morehead and Oriomo River and the Queensland provenance of Broken Pole Creek. Highest root disease incidence was found in the Australian provenances of Claudie River, Rex Range and Ellerbeck. The disease was most severe in the Ulu Sedili plantation in Johor, killing about 25% of the trees after 10 years. Root rot incidence was lowest at the Setol plantation (5.0%) in Negeri Sembilan, with no differences between provenances. Foliar diseases did not cause any significant damage in all three plantations. There were some stem cankers and dieback but incidence was generally low. Stem borers, however, accounted for the death of about 10% of the trees surveyed in Ulu Sedili. In Rantau Panjang, Selangor, and Setol, 4% to 6% of the trees surveyed were affected respectively. Disease incidence on the other species of acacias which have only been planted in small areas was generally insignificant. It is recommended that more intensive research into root diseases be carried out.

Introduction

Acacia auriculiformis and *A. mangium* are common trees in the landscape of present day peninsular Malaysia but these and other species of acacias are not indigenous to Malaysia. *A. auriculiformis* was first introduced in 1932 while *A. mangium* was introduced in 1966 (Yap, 1986). Other species of introduced acacias include *A. aulacocarpa, A. cincinnata, A. crassicarpa, A. holosericea* and *A. richii* (Anuar 1986, Yap, 1986). Only *A. mangium,* however, has been planted on a relatively large-scale in plantations. Presently there are about 100,000 ha of *A. mangium* plantations in Malaysia with about 50,000 ha each in the peninsula and Sabah respectively, and relatively small areas in Sarawak.

In their indigenous habitats, tropical acacias have not been reported to suffer from any serious diseases (Turnbull, 1986). However, as areas planted with such acacia species expand outside their native range, several diseases which may be potential threats to these plantations have been discovered (Lee 1993a, 1993b). It was therefore timely that this project was initiated by CIFOR and ACIAR to survey and identify diseases of tropical plantation acacias planted in several countries in south east Asia.

Materials and methods

The disease survey was only conducted in the peninsula due to the short duration of the project period, logistics and limitation of funds and manpower. *A. mangium* was the focus of the survey as it is the only species of tropical acacia planted on a relatively large-scale in Malaysia. The survey was conducted on trees planted mainly in provenance trials in three states in the peninsula as it was not possible to survey the entire plantation area. These trials were established by the Federal Forestry Department and located at

Rantau Panjang Forest Reserve, Selangor (3°18'N 101°30'E), Setol Forest Reserve, Negeri Sembilan (2°47'N 101°56'E) and Ulu Sedili Forest Reserve, Johor (1°14'N 103°12'E) (Fig. 8). The plantations were established on logged over lowland rainforest areas which had been mechanically cleared and burned before planting. At planting 120 g of Christmas Island rock phosphate and 30 g of Heptachlor were added to the planting hole.

The Forestry Department originally intended to plant 21 provenances with five replicates at each site but due to insufficient seedling supply, some provenances were not planted at some sites, and some provenances could not be replicated five times (Johari and Chew, 1987). Twelve provenances common to all three sites were chosen for the survey (Table 1). At each site three replicate plots of each provenance were assessed for incidence and severity of leaf, stem and root diseases as listed in the disease survey form (Appendix 2, Sheet 2). For each plot, 36 trees i.e., 6x6 per block, were sampled out of the 64 that had been planted (8x8) at a spacing of 3m x 3m. Further details of these trials are given in Johari and Chew, (1987). The trees were planted between 1984 and 1985 and were about 10 years old at the time of the survey.

Table 1. Provenances of *Acacia mangium* surveyed for disease occurrence in Peninsular Malaysia

Provenance	Origin	Rantau Panjang	Setol	Ulu Sedili	UPM
Jullaten	Queensland	+	+	+	-
Rex Range	Mossman, Queensland	+	+	+	-
Walsh's Pyramid	Queensland	+	+	+	-
Ellerbeck Road	Cardwell, Queensland	+	+	+	-
Broken Pole Creek	Queensland	+	+	+	-
Abergowrie	Queensland	+	+	+	-
Claudie River	Queensland	+	+	+	-
Daintree	Queensland	+	+	+	-
*Iron Range	Queensland	-	-	-	+
West of Morehead	Papua New Guinea	+	+	+	-
Oriomo River	Papua New Guinea	+	+	+	-
*Biote	Papua New Guinea	-	-	-	+
Piru	Ceram, Indonesia	+	+	+	-
Sidei	Indonesia	+	+	+	-

* planted only on tin tailings at UPM

Two provenances of eight year-old *A. mangium* planted on slime tin tailings on the campus of Universiti Pertanian Malaysia (UPM), Serdang, Selangor (3°2'N 101°42'E) (Fig. 8), were also surveyed (Table 1). Tin mining at this site stopped in 1972. The site is poorly drained with the water table at 160 cm below the surface. The soil is an entisol (udic moisture regime) with a high sand content of more than 60% in the top 108 cm while the lower layer is made up of a high proportion of clay and silt. Trees were planted at a spacing of 2m x 1m with no fertilizer application at planting. Plants were inoculated with rhizobia supplied by the Rubber Research Institute of Malaysia at the time of planting. Trees were pruned up to 50% of the total stem height at 18 months or pollarded at 2 meters when 24 months old or untreated (control).

Other species of tropical acacias which were included in this survey were *A. aulacocarpa*, *A. auriculiformis* and *A. crassicarpa*. Two provenances of eight year-old *A. auriculiformis* planted at the same tin tailing site in UPM as the *A. mangium* and subjected to the same treatments were assessed. The provenances were Bensbach, Papua New Guinea and Morehead River, Queensland. A provenance trial of *A. crassicarpa* planted on the campus of UPM was also assessed (Table 2). The site was formerly a field of *Imperata cylindrica* and the soil is fine loamy, mixed, Typic Hapludults, isohyperthermic and udic with pH 4.4. The trees were three years old at the time of the survey (Kamis Awang, pers. comm.). Stands of five year-old *A. aulacocarpa* and three year-old *A. crassicarpa* trees of unknown provenances planted in Ulu Sedili Forest Reserve, Johor, were also assessed for disease incidence.

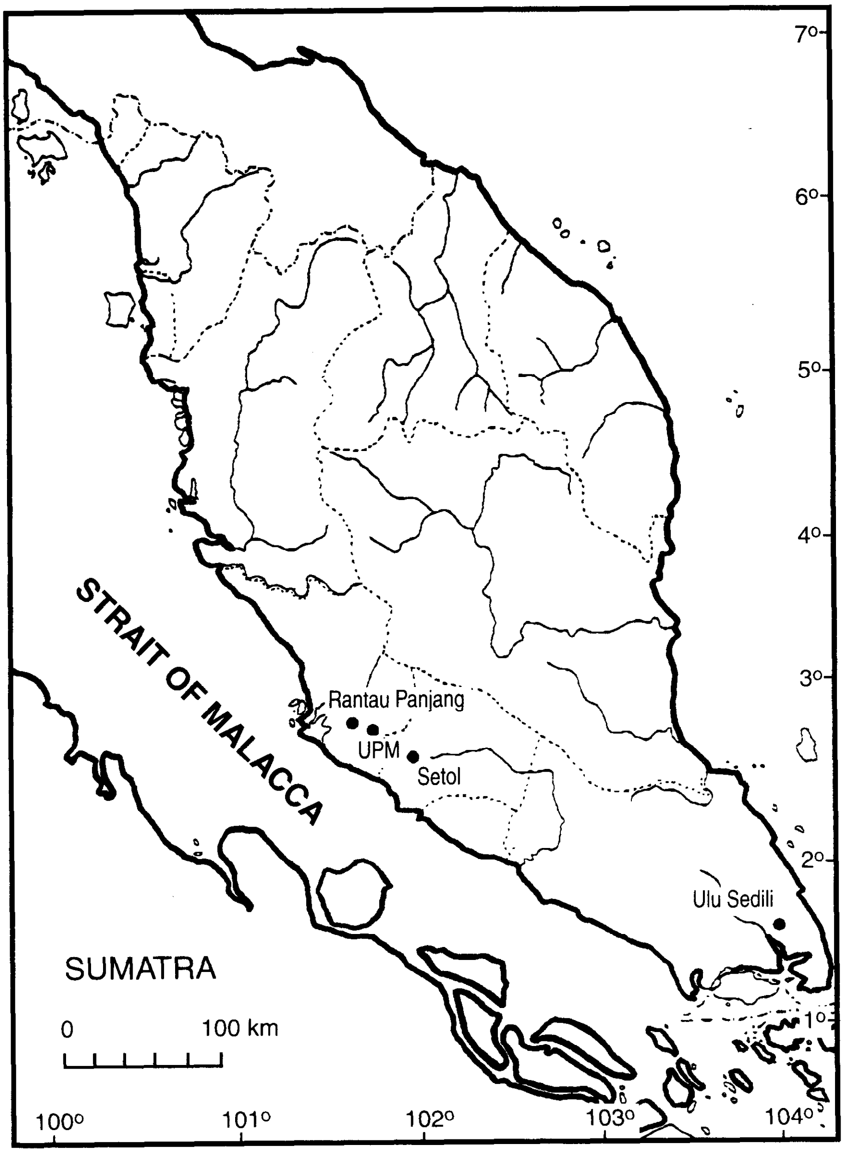

Figure 8. Location of *Acacia* plantations in Peninsular Malaysia surveyed for diseases

Table 2. Provenances of *Acacia crassicarpa* surveyed for disease incidence at UPM, Selangor

Provenance	Origin
Jardin River-Bamaga	Queensland
Olive River	Queensland
Claudie River	Queensland
Bimadebun Village	Western Province, Papua New Guinea
Oriomo Old Zim	Western Province, Papua New Guinea
Bensbach	Western Province, Papua New Guinea
Limal-Malam	Papua New Guinea
Samlleberr	Irian Java. Indonesia

Results and Discussion

Acacia mangium: Provenance trials

Excluding heart rot which was not assessed in this survey, root rot was the most frequently occurring disease on *A. mangium.* Butt rot was occasionally observed but did not affect many trees. Occasional leaf spots were observed on old and senescing phyllodes but not on younger foliage. Foliar diseases did not cause significant damage and diseases such as powdery mildew, rust and blight were not observed at all. Pink disease was not observed during the course of the survey but other stem cankers and dieback symptoms were present. Gummosis was observed on a few trees but this was never serious and did not appear to have a significant effect on the general health of the tree.

Heart rot

Data from earlier surveys of heart rot in Malaysia (Lee *et al.,* 1993; Mahmud *et al.,* 1993; Zakaria *et al.,* 1994; Ivory, 1995) show that while the incidence of heart rot in *A. mangium* was high (between 48.5% and 97.9%), the volume of wood affected was generally restricted to small pockets, with less than 10% of wood volume lost. Overall heart rot incidence increased with age of trees (Fig. 9a). Highest heart rot incidence was found in eight year-old trees, these being the oldest trees in plantations in the peninsula at that time (Lee *et al.,* 1993). A range of basidiomycete fungi including *Phellinus noxius* have been isolated from heart rotted wood but identification was hampered by the lack of fruiting bodies (Lee and Maziah, 1993). Zakaria *et al.,* (1994) found no significant differences in heart rot incidence in trees originating from different seed sources.

Studies conducted in Sabah and Peninsular Malaysia have shown that heart rot mainly occurred in pockets and that most of these pockets were associated with branch stubs, large wounds caused by fire damage and singling of large basal branches, the removal of large branches anywhere along the stem, and forking (Lee *et al.,* 1988; Ito 1991; Mahmud *et al.,* 1993; Ivory, 1995). While the small volume of wood affected by heart rot is believed to have little impact on utilization of *A. mangium* wood for pulp and paper manufacture and for MDF, it would have a significant effect on the general utility of such timber for purposes such as construction. While research needs to be conducted on reducing the incidence of heart rot and/or increasing tree resistance to heart rot, research should also be conducted on the yield and quality of heart rotted *A. mangium* wood for pulp and paper manufacture.

Root diseases

The most frequently occurring disease in the provenance trials at all three sites was root rot. Symptoms of the disease were seen as thinning of the crown, reduced size and curling of the phyllode edges, and subsequent death of trees. The disease often occurred in patches, with a concentric pattern of spread. Diseased roots were covered by a reddish-brown rhizomorphic skin and encrusted with soil in contrast to the clear pale yellow of healthy roots. Mycelia was often observed on the inside bark of diseased roots. Rotted roots were fibrous and bleached to a pale yellow colour. The associated pathogen is most probably a *Ganoderma* sp. but confirmation is dependent on finding fruiting bodies. Identical disease symptoms have been observed on patches of dead and dying *A. mangium* and *A. crassicarpa* in northern

Sumatra with fruiting of a *Ganoderma* sp., (Fig. 9b, c). Signs of other root rot fungi such as white rhizomorphs were also observed but the associated fungus has not been identified.

Of the three sites surveyed, the occurrence of root disease was highest at Ulu Sedili (Table 3). This was probably an indication of the presence of more root rot inocula and more rapid spread of the disease at Ulu Sedili than at the other two sites. Results from another study (unpublished data) show that the disease spreads by root contact from existing sources of inoculum buried in the soil or from infected trees. All three sites were former lowland rainforest sites but while the plantations at Ulu Sedili are located on low lying, flat terrain, those at Rantau Panjang and Setol are located on low, undulating terrain and hilly terrain, respectively.

Table 3. Mean disease and pest incidence on *Acacia mangium* in the provenance trials.

Location	Root rot	Stem cankers and dieback	Stem Borers
Ulu Sedili, Johore	24.7% a	3.3% a	9.7% a
Rantau Panjang, Selangor	9.9% b	3.2% a	3.6% b
Setul, Negeri Sembilan	5.0% c	2.9% a	6.7% b

Letters in the same column indicate no significant difference at p=0.05

Overall, root rot incidence was lowest in the Papua New Guinean provenances of West of Morehead and Oriomo River and the Queensland provenance of Broken Pole Creek. Highest root rot incidence was found in the Australian provenances of Ellerbeck Road, Rex Range, and Claudie River. Root disease incidence was not significantly different in the three replicate plots at Rantau Panjang and at Setol. However, at Ulu Sedili, one plot had significantly higher root disease incidence than the other two sites; 34% in Plot 3 compared to 22% and 18% in Plots 2 and 1, respectively. This indicates the variability of the presence of root rot inoculum at each site and was probably dependent on the amount of woody debris left after land clearing.

There were significant differences in the incidence of root disease in the different provenances at Ulu Sedili and Rantau Panjang but not at Setol. The provenances could be grouped into three groups of low, intermediate and high root disease incidence. At Ulu Sedili, low root disease incidence was observed in West of Morehead, Broken Pole Creek, Piru, and Oriomo River while highest incidence was observed in the provenances of Claudie River, Rex Range and Ellerbeck Road. At Rantau Panjang lowest incidence was found in Walsh's Pyramid, Oriomo River, West of Morehead, Daintree and Broken Pole Creek and highest incidence in Ellerbeck, Claudie River, Rex Range and Abergowrie. While the same general pattern of root disease susceptibility of the provenances was found at both Ulu Sedili and Rantau Panjang, levels of disease incidence were lower in all provenances in Rantau Panjang. This again probably indicates the higher levels of root disease inoculum present at Ulu Sedili. Where root disease inoculum density was very low or absent as in Setol, there was no difference in the susceptibility of the provenances.

Butt rot was observed at Rantau Panjang and Ulu Sedili but not at Setol. At both sites very few trees were affected, 0.3% at Rantau Panjang and 0.75% at Ulu Sedili. Trees affected by butt rot displayed similar above ground symptoms as trees suffering from root rot. However, at the basal portion of the tree, mycelia and rot distinctive of *Phellinus* sp. was well established underneath the bark.

Stem cankers and Dieback

Pink disease caused by *Corticium salmonicolor* was not detected in any of the areas sampled. It was also not observed in any of the plantations. This confirms earlier observations (Lee, 1993a) that pink disease is not a serious disease of *A. mangium* trees in Peninsular Malaysia. Other stem cankers and dieback were observed, usually in the upper portions of the tree crown. However, only a low proportion of the trees were affected (Table 3). As it was difficult and often not possible to obtain diseased samples, the associated pathogens were not determined. There is a possibility that the cankers and dieback were associated with secondary pathogens as the trees were already of an advanced age and growing under less than optimum conditions. No silvicultural treatments had been applied to the stands and many of the trees had broken branches due to the close spacing and damage by wind. There was also evidence of animal damage on the upper branches and bark of some of the trees.

Stem borers

Damage caused by stem borers was noticeable and especially severe at Ulu Sedili (Table 3). The bark of affected trees was easily separated from the wood, exposing tunnels made by the borers. Trees attacked by stem borers displayed symptoms of yellowing foliage and wilting, and severely attacked trees were killed. The pest is probably the Capricorn beetle, *Xystrocera globosa*. The intensity of borer infestation varied between the different provenances at each site and there were no clear patterns. The pattern of infestation could be due to the location of the trees and provenances within the plantation.

Acacia auriculiformis and *A. mangium* on tin tailings

Trees of both species growing on tin tailings at UPM were generally stunted and had poor growth, probably because of the poor fertility of the site. Root rot incidence was very low in both species and there were no significant differences due to provenances or treatments (Table 4). This was probably a reflection of the low root disease inoculum density in the tin tailing site which had been devoid of trees and other woody vegetation for an extended period of time.

Table 4. Mean disease (and pest) incidence on *Acacia auriculiformis* (Aa) and *Acacia mangium* (Am) trees planted on tin tailings at UPM and subjected to different silvicultural treatments.

	Stem canker		Dieback		Root rot		Stem borer	
	Aa	Am	Aa	Am	Aa	Am	Aa	Am
Pollarding	2.8% a	3.3% a	3.4% a	1.5% a	0.9% a	2.9% a	9.3% a	7.7% a
Pruning	4.2% a	3.0% a	2.1% a	1.0% a	1.6% a	0.7% a	6.0% a	7.9% a
Control	4.2% a	15.3% b	3.5% a	1.3% a	0.4% a	3.3% a	19.9% b	11.2% a

Letters in the same column indicate no significant difference at p=0.05

The incidence of stem cankers and dieback on *A. auriculiformis* trees was not affected by provenance or the treatment given. However, the number of trees damaged by stem borers was significantly reduced by pruning and pollarding (Table 4). The incidence of stem dieback was higher in the Australian provenance of Morehead River (5.0%) than in the Papua New Guinean provenance of Bensbach (1.0%). Treatment, however, did not have a significant effect.

Fewer pollarded and pruned *A. mangium* trees were infested by stem borers and this was not significantly different from the control. The different treatments and provenances also did not significantly affect the number of trees with dieback (Table 4). Treatment did, however, have a significant effect on the incidence of stem cankers. Untreated control trees had five times higher incidence of stem cankers than pruned and pollarded trees (Table 4). This suggests that untreated *A. mangium* trees which bore many dead/dying branches were more likely to have stem cankers than trees which had been pruned at 18 months or pollarded at 24 months. It would be interesting to see what effect such treatments would have on heart rot incidence and severity. Identification of potential pathogens was not attempted in all cases as it was not possible to obtain samples for isolation. Moreover levels of infection were low.

Acacia crassicarpa and *Acacia aulacocarpa*

A. crassicarpa trees at UPM were generally very healthy and free from disease. Of the 508 trees surveyed, none displayed any symptoms of root disease or dieback and only one tree had a stem canker. Stem borers were found on 5% of the trees surveyed with infestation being concentrated in one area. Generally, stem borer infestation was of varying intensity in other areas and absent in one area. The stem borer was not identified but it was probably not the same as the one on *A. mangium* as the exit holes were much smaller at about 1-2 mm diameter. There were no differences due to provenances.

A three year-old stand of *A. crassicarpa* of unknown provenance was also surveyed in Ulu Sedili. Of the 200 trees planted in 1992, 36 had been felled and another 22 were missing; there were no signs of the stumps. Of the 142 remaining trees, two (1.4%) had symptoms of dieback, nine (6.3%) had stem cankers and three (2.1%) were dead, probably due to root disease. There were no signs of stem borers.

A neighbouring stand of *five* year-old *A. aulacocarpa* of unknown provenance was also surveyed. Of the 216 trees remaining out of the 300 planted initially, 6 (2.8%) had symptoms of dieback, 12 (5.5%) had stem cankers, 13 (6.0%) were dead, probably due to root disease, and 82 (38.0%) were attacked by stem borers. It appeared that *A. aulacocarpa* was much more susceptible to stem borers than *A. crassicarpa* planted in the same area in Ulu Sedili. The exit holes made by the stem borer were different from those observed on *A. mangium* and larger than those found on *A. crassicarpa* at UPM. These holes resembled clean nail holes of about 2-3 mm in diameter. The associated insect(s) was not identified in the absence of specimens.

Conclusion

Root disease and heart rot are the major diseases of *A. mangium* planted in logged over forest areas in Peninsular Malaysia. The incidence and severity of root disease also appears to be much higher in plantations established on low lying former lowland rainforest areas. While the threat posed by these diseases is recognised, little research has been conducted on the means of effectively reducing or controlling them. It has been hypothesised that the high incidence of heart rot in *A. mangium* in Peninsular Malaysia may be an indication of insufficient attention being given to species-site matching (Lee and Arentz, 1995). There is a possibility that heart rot incidence may be reduced through tree breeding and selection, proper pruning techniques applied at the appropriate time and the use of specially formulated wound dressings. Selection and breeding for disease resistant trees may be a suitable option but it is a time consuming process. The development of suitable and effective wound dressings may also take a considerable length of time. Root diseases on the other hand, pose a different problem. Mortality of very young (six months old) *A. mangium* trees due to root disease has been observed, especially in “no burn” areas in Sumatra, Indonesia. This is probably due to the large amount of woody debris left in the field which could become reservoirs and ready sources of inoculum for the facultative parasites causing root disease. This is in contrast to the low incidence of root disease in *A. mangium* trees grown on tin tailings and the absence of root disease in *A. crassicarpa* in former grassland sites where sources of root disease inoculum are absent or in low density. Research needs to be conducted urgently to find means of minimising root disease losses in second rotation plantations and plantations established on logged over lowland forest sites where large amounts of woody debris remain.

In the small areas of *A. auriculiformis, A. aulocacarpa* and *A. crassicarpa* surveyed, the trees appeared to be relatively free of disease. Stem borers may, however, pose a problem for some of these species. Until more extensive surveys are conducted over larger areas under actual plantation conditions, it would be unsafe to conclude that these species are relatively disease free.

Acknowledgments

This study was funded by CIFOR and ACIAR and I thank Dr. Ken Old of CSIRO and Mr. Christian Cossalter of CIFOR for their leadership and assistance. I also thank FRIM for permission to conduct this study and the Forestry Department of Peninsular Malaysia and Dr. Kamis Awang of Universiti Pertanian Malaysia for allowing the survey to be conducted in their plantations. I am also grateful to Ramli Setapa, Noraini Sikin Yahya and Asnah Hashim for technical assistance in carrying out the survey.

References

Anuar Mohamad (1986). Growth of Acacias on a logged-over forest in Sabah. In: *Australian Acacias in Developing Countries* (Ed. J. Turnbull) pp. 167-169. Proceedings of an International workshop held at the Forestry Training Centre, Gympie, Qld, Australia, 4-7 August 1986. ACIAR Proceedings No. **16**.

Ito, S. (1991). A survey of heart rot in *Acacia mangium.* Report to SAFODA.

Ivory, M.H. (1995). Status of forest plantations and potential wood availability. In: Proceedings of the Seminar on the Potential of *Acacia* and Other Plantation Species, pp.21-30. 15 December 1993, Kuala Lumpur. MTIB.

Johari Baharudin, and Chew, T.K. (1987). Preliminary performance of *Acacia mangium* international provenance trial in Peninsular Malaysia. *Malaysian Forester* **50**: 9-28.

Lee, S.S. (1993a). Diseases. In: *Acacia mangium Growing and Utilization:* (Eds. Kamis Awang and D.A. Taylor) pp 203-223 *MPTS Monograph Series* No. **3**. Bangkok, Thailand: Winrock International and FAO.

Lee, S.S. (1993b). Diseases of Acacias:an overview. In: *Acacias for Rural, Industrial and Environmental Development* (Eds. Kamis Awang and D.A. Taylor) pp. 225-239. Proceedings of the second meeting of the Consultative Group for Research and Development of Acacias (COGREDA), Udorn Thani, Thailand, February 15-18, 1993. Bangkok, Thailand: Winrock International and FAO.

Lee, S.S., and Arentz, F. (1995). A possible link between rainfall and heart rot incidence in *Acacia mangium* Willd. Paper presented at IUFRO XX World Congress, 6-12 August 1995, Tampere, Finland.

Lee, S.S., and Maziah Zakaria. (1993). Fungi associated with heart rot of *Acacia mangium* Willd. in Peninsular Malaysia. *Journal of Tropical Forest Science* **5**: 479-484.

Lee, S.S., Zakaria Ibrahim, Hashim Mohd. Nor, and Wan Razali Wan Mohd (1996). Impact of heart rot in *Acacia mangium* Willd. plantations of Peninsular Malaysia. In *Impact of Diseases and Insect Pests in Tropical Forests.* (Eds K.S.S. Nair and J.K. Sharma) Proceedings of IUFRO Symposium, 23-28 November 1993, Kerala Forest Research Institute, Peechi, India (In Press).

Lee, S.S., Teng, S.Y., Lim, M.T., and Razali Abd. Kader. (1988). Discoloration and heart rot of *Acacia mangium* Willd. - Some preliminary results. *Journal of Tropical Forest Science* **6**: 37-47.

Mahmud Sudin, Lee, S.S., and Ahmad Hj. Harun. (1993). A survey of heart rot in some plantations of *Acacia mangium* Willd. in Sabah. *Journal of Tropical Forest Science* **6**: 37-47.

Turnbull, J. (Ed) (1986). *Australian Acacias in Developing Countries:* Proceedings of an international workshop held at the Forestry Training Centre, Gympie, Queensland, Australia, 4-7 August 1986. ACIAR Proceedings No. **16**: 316 pp.

Yap, S.K. (1986). Introduction of Acacia species to Peninsular Malaysia. In: *Australian Acacias in Developing Countries* (Ed. J. Turnbull) pp. 151-I53. Proceedings of an International workshop held at the Forestry Training Centre, Gympie, Queensland, Australia, 4-7 August 1986. ACIAR Proceedings No. **16**.

Zakaria Ibrahim, Wan Razali Wan Mohd., Hashim Mohd. Noor, and Lee, S.S. (1994). The incidence of heart rot in *Acacia mangium* plantations in Peninsular Malaysia. *FRIM Research Pamphlet* No. **114.** pp. 1-15.

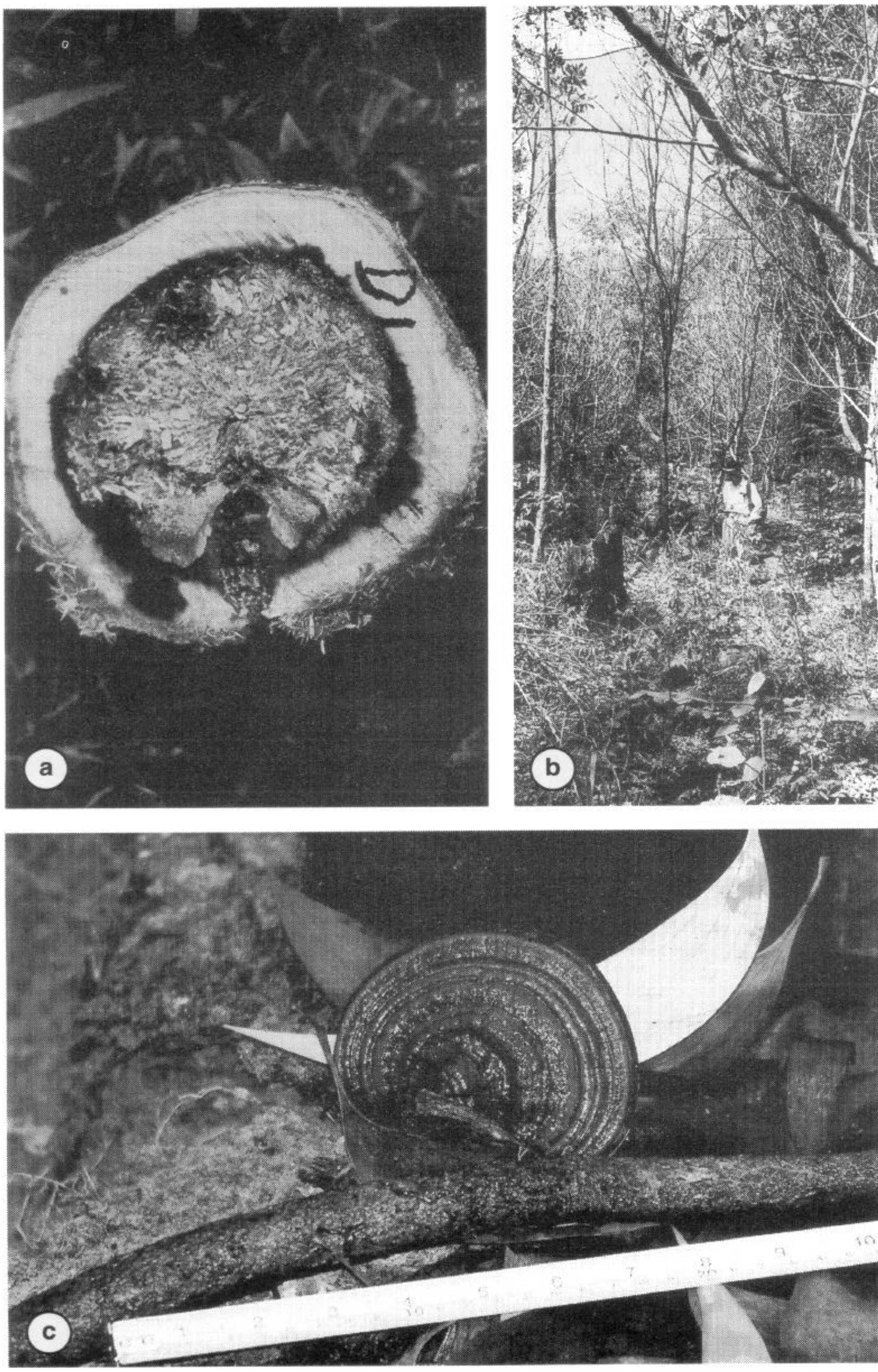

Figure 9a Extensive heart rot of *A. mangium* from Peninsular Malaysia

Figure 9b Root rot disease associated with *Ganoderma* infection in two year-old second rotation *A. crassicarpa* in northern Sumatra.

Figure 9c Characteristic diseased root covered by dark red fungal crust and a sporophore of *Ganoderma* sp. taken from dying and dead trees shown in Fig. 9b.

Diseases of *Acacia* species in Thailand

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Abstract

The disease survey was carried out in plantations and field trials of four species of *Acacia* namely, *Acacia auriculiformis,A. mangium, A. aulacocarpa* and *A. crassicarpa.* Most observations were made on *A. auriculiformis* because of the availability of two major provenance trials of this species. Stem and branch cankers of *A. auriculiformis* in the international provenance trial at Lampao-lamsai became severe after the trees were stressed by low soil fertility and severe drought. The incidence of this disease was also investigated at Sakaerat where trees have not been stressed and comparisons were made of the performance of provenances at both sites. Cooper Creek provenance appeared to be less affected by disease than other seedlots on the stressful site. Stem diseases of *A. mangium* and *A. aulacocarpa* were reported but not studied in detail. Foliar diseases of *Acacia* spp. caused by fungi included powdery mildew, black mildew, brown and black spots and phyllode blight. The main foliar pathogens were *Colletotrichum* sp., *Pestalotiopsis* sp. and *Cephaleuros virescens,* (which caused an algal spot). *Colletotrichum* sp. can also infect pods of *A. auriculiformis* and become a seed-borne pathogen.

Introduction

Twelve *Acacia* species (not including *A. mangium)* were introduced in 1985 for field trials in Thailand. *A. auriculijormis, A. aulacocarpa* and *A. crassicarpa* exhibited good growth performance and showed the best survival percentage at almost every trial site (six sites throughout Thailand) (Chittachumnonk and Sirilak, 1991). *A. auriculiformis* was the first species introduced to Thailand in 1935 followed by *A. mangium.* The latter is widely planted but few field trials have been established so far. *A. aulacocarpa* and *A. crassicarpa* were first planted in 1985. Disease problems of *A. auriculiformis* in Thailand were reported earlier in Thai by Pongpanich (1991). The list included diseases of seed, seedlings and established trees. Some diseases such as powdery mildew caused by *Oidium* sp. and leaf spot caused by *Colletotrichum* sp. have also been reported in India (Mohanan and Sharma 1988).

Materials and Methods

The general disease survey was carried out in plantations and field trials of *Acacia* spp. Disease symptoms, causal pathogens, impact on the stands and distribution of disease were recorded. Disease samples were collected for detection of causal pathogens by;

- direct examination of infected plant tissues using stereo- and compound-microscopes
- incubation of leaf and shoot samples in moist chambers at room temperature (25-28°C) for 2-5 days before examination
- isolation from diseased tissue on potato dextrose agar (PDA) by:
  1. immersion in 10% chlorox for l-3 minutes
  2. washing in sterile distilled water twice
  3. blotting on sterile filter paper
  4. transfer to sterile PDA under aseptic conditions
  5. incubation at 26°C for 3-5 days, subculturing and further incubation to allow sporulation
- identification of fungi associated with the diseases.

Seed diseases

A blotter method was used for detection of the fungi associated with the six samples of *A. auriculiformis* seed from four locations, Ngaao, Lampang; Sakaerat, Nakhon-ratchasima; Surat-thani and Sai-thong, Prachuap-khiri-khan.

Seedling diseases

Surveys of diseases of *A.auriculiformis* and *A. mangium* seedlings (the most commonly grown species) were made in nurseries in many parts of Thailand.

Diseases in plantations and field trials

Diseases in plantations and field trials of *Acacia* spp. were observed. Two existing international provenance trials of *A. auriculiformis* offered an opportunity to study disease incidence in widely variable provenances of this species. The trials were established in May-July 1989 at three locations:

1. Sakaerat Gene Conservation Station, Nakhon-ratchasima Province
2. Lampao-lamsai Experimental Station, Kanchanaburi Province
3. Sai-thong Experimental Station, Prachuap-khiri-khan Province

The locations and conditions of these sites are shown in Table 1 (Luangviriyasaeng *et.al.*, 1991).

Table 1. Site characteristics of *A. auriculiformis* provenance and species trials.

Location	lat. (N)	long. (E)	mean annual temp. (°C)	mean annual rainfall (mm)	soil type	soil pH	alt. (msl)
Sai-thong	11° 25′	99° 27′	22 - 31 (27.2)	1,500	loamy sand to sandy clay loam	4.9	50
Lampao-lamsai	13° 58′	99° 18′	29.9	900 - 1,000	sandy and silty loam	6 - 7	45
Sakaerat	14° 13′	101° 55′	19 - 31 (25.9)	1,300	red yellow podzolic	5 - 6	420

Both trials had a common design, namely, six replicates of all seedlots with each plot consisting of 16 trees (4m x 4m spacing). In addition, two extra seed lots were included in the design, 15483 and 16103 at Lampao-lamsai and 16158 and 16162 at Sakaerat (Table 2).

Four trees in each plot of three selected replicates were checked for disease and scored for canker incidence at the Lampao-lamsai and Sakaerat sites. The disease severity index was as follows :

0 = no infection
1 = 1 - 20 % infection
2 = 21 - 40 % infection
3 = 41 - 60 % infection
4 = 61 - 80 % infection and
5 = 81 - 100 % infection.

At Sai-thong only general observations of disease incidence were made.

Table 2. Details of seed sources of *Acacia auriculiformis* in the provenance trial.

Seedlot No.	Location	Country	Latitude (S)	Longitude (E)	Altitude (m)	No. of parents
15483	Archer River, QLD.	Australia	12°26′	142°57′	100	5
15697	South Coen, QLD.	Australia	14°07′	143°16′	160	10
15985	Mt Molloy, Rifle Creek, QLD.	Australia	16°41′	145°17′	380	10
16101	North Bensbach to Weam	PNG	8°50′	141°15′	10	16
16103	South Balamuk	PNG	9°00′	141°15′	10	7
16105	Balamuk on Bensbach River	PNG	8°55′	141°17′	20	12
16106	North Mibini	PNG	8°49′	141°38′	40	35
16107	Old Tonda Vill.	PNG	8°55′	141°33′	40	19
16108	Mari Village	PNG	9°11′	141°42′	5	8
16142	Coen River, QLD.	Australia	13°53′	143°03′	170	7
16145	Wenlock, QLD.	Australia	13°06′	142°56′	130	20
16147	Noogoo Swamp, NT.	Australia	12°23′	131°00′	28	5
16148	Manton River, NT.	Australia	12°50′	131°07′	100	10
16149	Douglas River, NT.	Australia	13°51′	131°09′	70	10
16151	Mary River, NT.	Australia	13°36′	132°08′	120	8
16152	East Alligator River, NT.	Australia	12°17′	132°55′	10	10
16153	Cooper Creek, NT.	Australia	12°06′	133°11′	40	5
16154	Goomadeer River, NT.	Australia	12°08′	133°41′	50	9
16155	Mann River, NT.	Australia	12°22′	134°08′	60	4
16156	Yarunga Creek, NT.	Australia	12°18′	134°48′	50	6
16158	Gerowie Creek, NT.	Australia	13°19′	132°15′	100	12
16160	South Alligator River, NT.	Australia	13°16′	132°19′	100	10
16162	Reynolds River, NT.	Australia	13°32′	130°52′	150	10
16163	Elizabeth River, NT.	Australia	12°36′	131°04′	40	9
16187	Melville Islands, NT.	Australia	11°55′	130°50′	1	7
16484	Morehead River, QLD.	Australia	15°03′	143°40′	50	6
16485	Kings Plain, QLD.	Australia	15°42′S	145°06′	150	7

Results and Discussion

A list of diseases of *Acacia* spp. And their associated fungi in Thailand is given in Table 3.

Seed diseases

Twenty-four species of fungi were found associated with six samples of *A. auriculiformis*. Most of them were saprophytic fungi, such as *Alternaria alternata, Aspergillus* spp., *Cladosporium* sp., *Curvularia* spp., *Drechslera* sp., *Fusarium* spp., and *Penicillium* spp. Several pathogenic seed-borne fungi such as *Colletotrichum* sp., *Cylindrocladium* sp., *Fusarium* sp., *Lasiodiplodia* sp. and *Phomopsis* sp. were also detected.

Table 3. Fungi and algae associated with diseases of *Acacia* spp. in Thailand.

Acacia spp.	disease	Associated fungi
A. auriculiformis	seed rot	*Cylindrocladium* sp., *Lasiodiplodia* sp., *Fusarium* spp., *Phomopsis* sp., *Drechslera* sp., *Hansfordia* sp.
	powdery mildew	*Oidium* sp.
	brown spot	*Colletogloeum sp.*
	black spot	*Colletotrichum gloeosporioides*
	black mildew	*Meliola* sp.
	canker	*Dothiorella* sp. and its likely teleomorph *Botryosphaeria* sp.
	shoot dieback	unknown
	pod disease	*Cercospora* sp., *Colletotrichum gloeosporioides* *Cylindrocladium* sp., *Phaeotrichoconis* sp., *Fusarium* sp., *Phomopsis* sp.
	algal spot	*Cephaleuros virescens*
A. mangium	powdery mildew	*Oidium* sp.
	foliar spot	*Leptosphaeria* sp.
	heart rot	unknown
A. aulacocarpa	leaf blight	*Colletotrichum gloeosporioides ;* unknown (Ascomycetes) , *Pestalotiopsis* sp.; *Phomopsis* sp.
	foliar spot	*Cephaleuros virescens*
	die-back	unknown
A. crassicarpa	collar rot	*Fusarium* sp.
	foliar blight	*Colletotrichum gloeosporioides ;* *Pestalotiopsis* sp., *Hansfordia* sp.
	foliar spot	*Pestalotiopsis* sp.
	algal spot	*Cephaleuros virescens*

Seedling diseases

Powdery mildew of *A. auriculiformis* and *A. mangium* caused by *Oidium* sp. is widespread throughout the country. *A. mangium* was occasionally infected by *Leptosphaeria* sp. which caused necrotic lesions on foliage and retarded growth but did not kill the seedlings.

Diseases in plantations and field trials

Diseases in provenance trials of *A. auriculiformis* at Lampao-lamsai and Sakaerat are shown in Table 4. The trial at Lampao-lamsai suffered from a severe drought in 1989 (total rainfall was less than 600 mm). The site is also relatively infertile so that the trees are of very poor form and show high mortality. Serious canker disease occured only in this trial site (Figs. 10, 11). In comparison trees in the Sakaerat and Sai-thong trials were generally healthy. Foliar diseases, including black spot caused by *C. gloeosporioides*, brown spot *(Colletogloeum* sp.) and algal spot were found at low to medium occurrence.

A. auriculiformis in the provenance trial at Sai-thong showed some canker symptoms and shoot dieback but at low frequency; survival was high and the trees were of good growth and form. In the plantation at Sai-thong, pods and seeds of *A. auriculiformis* were damaged by many kinds of fungi, especially *Cercospora* sp. and *C. gloeosporioides*.

Table 4. **Disease survey and scoring of canker in the international provenance trials of *Acacia auriculiformis* at Lampao-lamsai and Sakaerat**

Seedlot No.	Lampao-lamsai, Kanchanaburi				Sakaerat, Nakhon-ratchasima		
	% dead tree	canker level#	shoot dieback	foliar disease	canker level#	shoot dieback#	foliar disease
15483	*	*	*	*	0.25	0.17	a, bl, br
15697	62.50	2.17	++	bl	0.25	0.00	a, br
15985	62.50	1.50	-	bl	0.50	0.00	a, br
16101	59.38	1.00	-	bl	0.17	0.25	a, bl
16103	*	*	*	*	0.08	0.17	a, bl, br
16105	56.25	2.25	++	bl	0.17	0.08	a, bl, br
16106	50.00	1.67	-	bl	0.33	0.17	*
16107	58.33	2.18	+	bl	0.08	0.17	a, bl
16108	65.62	1.08	+	bl, br	0.25	1.00	a, bl, br
16142	81.25	2.29	++	bl	0.67	0.00	a, bl
16145	64.58	2.25	+	bl	0.42	0.75	a, bl
16147	46.88	1.33	-	bl	0.58	0.50	a, bl, br
16148	81.25	2.71	++	bl	0.08	0.83	a, bl, br
16149	43.75	1.54	++	bl	0.08	0.75	*
16151	47.92	1.88	+	bl	0.17	0.58	br
16152	68.75	1.50	+	bl	0.00	0.25	bl, br
16153	34.38	1.08	+	bl	0.00	0.50	br
16154	75.00	1.64	++	bl	0.17	0.08	br
16155	50.00	1.67	+	bl	0.00	0.00	a, bl
16156	60.42	2.20	+	bl	0.08	0.00	br
16158	58.33	1.42	++	bl	*	*	*
16160	59.38	1.92	++	bl	0.08	0.25	bl, br
16162	65.62	1.17	+	bl	*	*	*
16163	56.25	1.50	+	bl	0.08	0.75	br
16187	50.00	0.92	-	bl	0.00	0.58	bl, br
16484	54.17	1.25	+	bl	0.08	0.00	a, bl, br
16485	37.50	1.50	+	bl	0.08	0.08	a, bl, br

a = algal spot caused by *Cephaleuros virescens*; bl = black spot caused by *Colletotrichum gloeosporioides*; br = brown spot caused by *Colletogloeum* sp.; * = no data;
- = no infection; + = infection level mean of 0-1 branch affected; ++ = infection level- mean of 1-3 branches affected; # = severity index (calculated mean of 12 trees)

Some foliar diseases, such as algal spot (*C. virescens)*, black spot caused by *C. gloeospoioides* and phyllode spot associated with infection by *Pestalotiopsis* sp. were occasionally present on *A. aulacocarpa* and *A. crassicarpa*. Severe top dieback of *A. aulacocarpa* associated with stem cankers and borer damage occurred on about 40 % of a Papua New Guinean provenance in a demonstration plantation at Sakaerat. The causal agent is still unknown. Heart rot of *A. mangium* has been reported widely but there is no information regarding the severity or etiology of this disease in Thailand.

Conclusion

Diseases of *Acacia* spp. in Thailand will become more important with increasing reforestation through plantation establishment. The most severe disease encountered so far in this survey was canker of *A. auriculiformis*. The disease appeared to be strongly associated with host stress as shown by the markedly different level of disease when the same seedlots were established at two trial sites with contrasting environmental and edaphic conditions. Systematic disease surveys and detailed studies of the more severe diseases of acacias will need to be continued over the next few years as these species are more widely planted in Thailand.

Acknowledgments

The author wishes to acknowledge the Royal Forest Department, Thailand and the financial support from F/FRED project and ACIAR for the field trials establishment, and the kind cooperation of all experimental stations' officers. Many thanks are also due to Mr. Vitoon Luangviriyasaeng for his help with information on field trials and statistical advice. Special mention to Dr. Ken Old, Assistant Chief of CSIRO Forestry and Forest Products, Australia, who has been the source of inspiration in 'Fungal pathogens as a potential threat to tropical acacias' project; his kindly support is highly appreciated.

References

Chittachumnonk, P., and S. Sirilak. (1991). Performance of Acacia Species in Thailand. *Advances in Tropical Acacia Research.* (Ed. J.W.Turnbull) pp. 153-158. Proceedings of an international workshop held in Bangkok, Thailand, 1 l- 15 February 199 1. ACIAR Proceedings No.**35**.

Luangviriyasaeng, V., Pinyopusarerk, K., and Williams, E.R. (1991). Results at 12 months of *Acacia auriculiformis* trials in Thailand. *Advances in Tropical Acacia Research.* (Ed. J.W.Turnbull) pp. 77-81. Proceedings of an international workshop held in Bangkok, Thailand, 1l- 15 February 1991. ACIAR Proceedings No.35.

Mohanan, C., and Sharma, J.K. (1988). Diseases of exotic acacias in India. *Journal of Tropical Forestry,* **4:** 357-361.

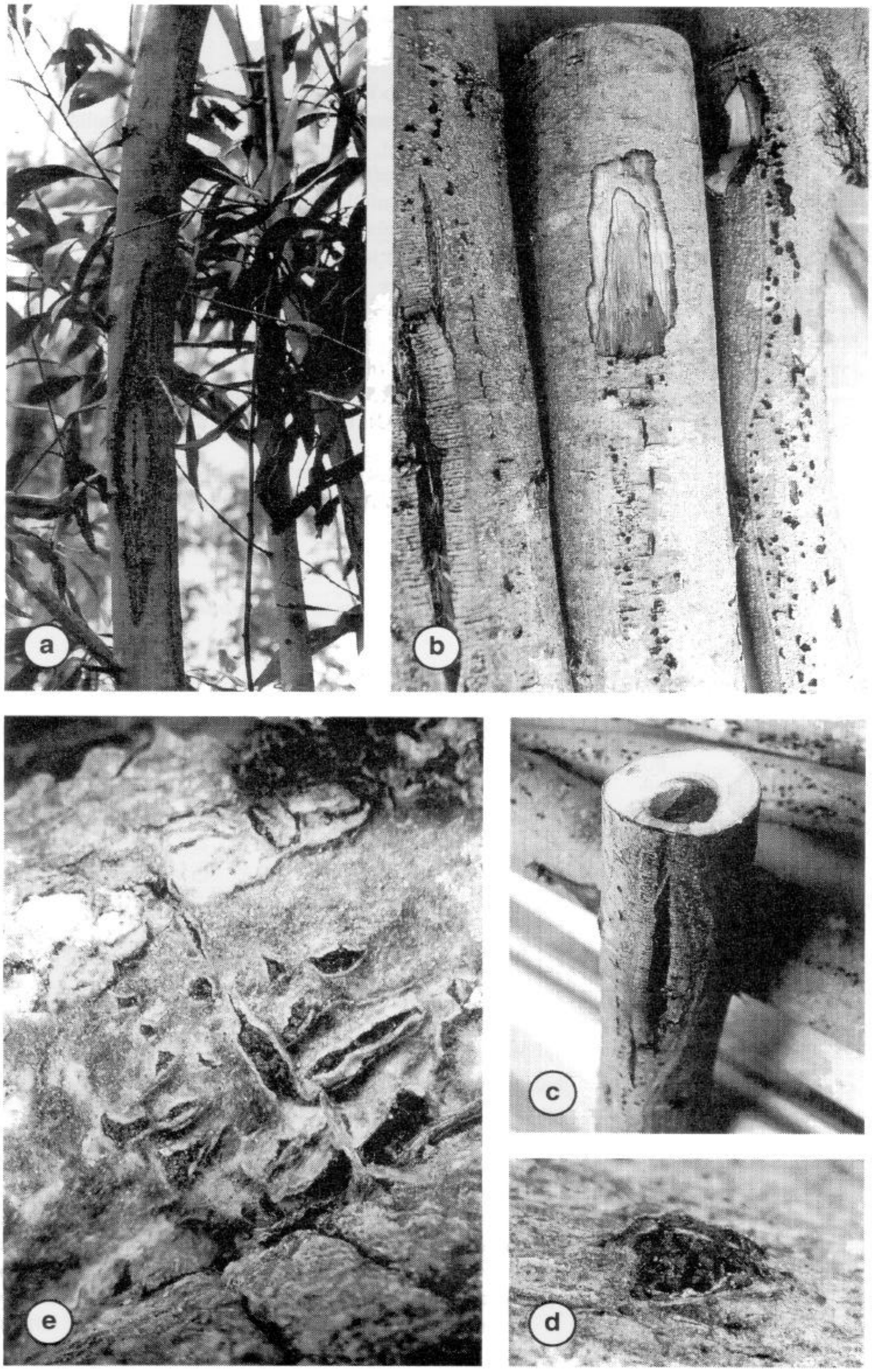

Figure 10. Canker disease of *Acacia auriculiformis* in the international provenance trial at Lampao-lamsai, Kanchanaburi :

a, b, and c — Symptoms on the stem and branches

d and e — Fruiting bodies of *Botryosphaeria* sp. and *Dothiorella* sp. on the bark lesion (erumpent)

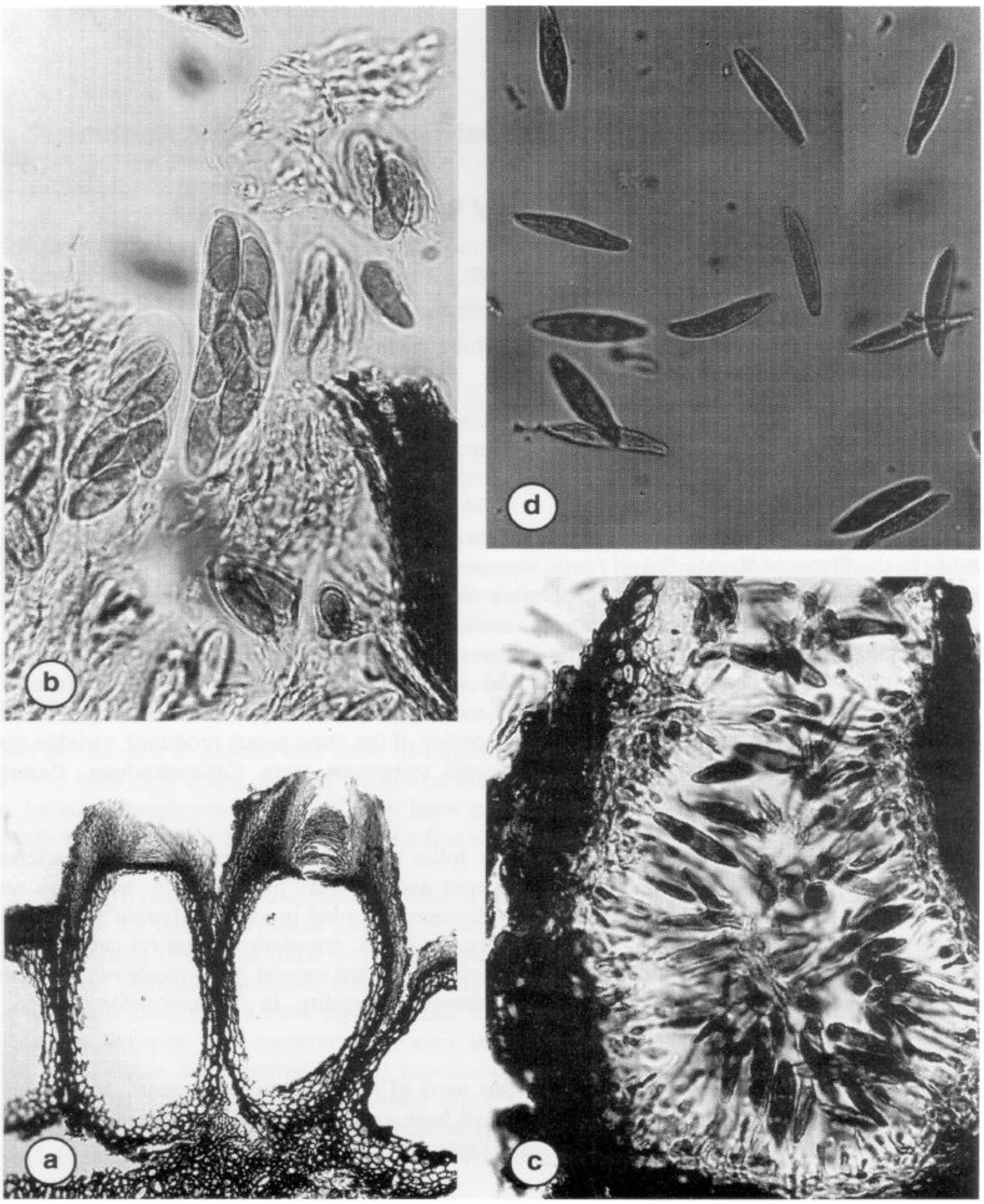

Figure 11. Fungal structures from canker lesions.

- a) Asocarp of *Botryosphaeria* sp.
- b) Ascus with 8 ascospores of *Botryosphaeria* sp.
- c) Pycnidium with conidia and conidiophores of *Dothiorella* sp.
- d) Conidia of *Dothiorella* sp.

Fungal Pathogens as a Potential Threat to Tropical Acacias

Case Study of India

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Abstract

A disease survey conducted in *Acacia aulacocarpa, A. crassicarpa, A. mangium and A. auriculiformis* trial plots and plantations in the States of Kerala, Tamil Nadu, Karnataka and West Bengal revealed a large number of new and serious diseases. All the four acacias suffered more from foliar diseases than diseases of other parts. The maximum number of diseases was recorded on *A. auriculiformis* (28), followed by *A. mangium* (23) *A. crassicarpa* (17), and *A. aulacocarpa* (13). All the diseases recorded *on A. aulacocarpa* and *A. crassicarpa are* new records for India. In the case of *A. mangium* and *A. auriculiformis*, except for a few diseases already recorded, the rest are new disease records. Although the number of diseases appeared to be high, the number of fungal genera causing diseases was not high as different species of the same genus produced variable symptoms. The genera most commonly associated with the diseases symptoms were *Colletotrichum, Pestalotiopsis, Alternaria, Curvularia and Phomopsis.*

Although some of the foliar diseases such as Phomopsis foliar spot of *A. aulacocarpa,* Colletotrichum foliar spot, Cercosporidium foliar spot, an unidentified foliar spot and powdery mildew of *A. mangium* were quite severe resulting in premature defoliation, stem and root diseases recorded in various *Acacia* species were most damaging as they caused mortality of trees. In *A. aulacocarpa* and *A. crassicarpa,* root rot caused by unknown basidiomycetes was responsible for mortality. In *A. mangium,* root rot caused by *Ganoderma* and dieback by *Hendersonula* were the most serious diseases causing extensive mortality. In A. *auriculiformis* also, dieback caused by *Hendersonula* was the most damaging disease.

Considering the spectrum of diseases recorded in various parts of India the study suggests that further surveys covering other States where species/provenance trials have been established and acacias are grown on a large scale, are required to gain a better picture of the disease situation in India.

Introduction

Due to a critical shortage of fuelwood in rural communities and the need for multipurpose trees in agricultural systems, during the 1980s a reappraisal was required of the shrub and tree species available for planting in India. Australian acacias were the first choice as afforestation species as they possess many attributes, especially their fast growth which recommend them as successful exotic trees. They are adapted to a wide range of tropical environments including acidic infertile soils, saline and arid sites, in addition to their ability to fix biological nitrogen.

The genus *Acacia* includes about 1200 species of trees and shrubs with their natural distribution in Australia, Asia, Africa and the Americas; over 800 of these species are endemic to Australia. In India although there are about 23 indigenous species of *Acacia,* most of them are slow growing thorny trees or shrubs occurring in arid regions of dry and deciduous thorny forests.

Acaciamelanoxylon R. Br. And a few other acacias were among the first introductions from Australia to the Nilgiris and Palani Hills in Tamil Nadu State in 1840. However, large-scale introduction of Australian exotic acacias, especially that of *A. auriculiformis* A. Cunn. ex. Benth. was only in the mid-1980' s under World Bank aided afforestation programmes in different States of India. At the same time species/provenance trials of Australian acacias were also initiated in different States to find out the best species/provenances suited to a particular geographical area. Provenances of the most common species tried were: *A. auriculiformis, A. aulacocarpa, A. crassicarpa, A. dunnii, A podalyrifolia, A. baileyana, A. prominens, A. pycnantha, A. torulosa, A. tumida, A. citrinovirides, A. ampliceps, A. trachycarpa, A. eriopoda, A. cincinata, A. mangium, A. leptocarpa, A. platycarpa* and *A. holosericea.*

Because of their adaptability to various adverse climatic and soil conditions and their suitability for the pulp industry the area under acacias has been increasing steadily in the past decade; so far *ca*. 45,000 ha have been planted, mostly with *A. auriculiformis.* In view of their excellent performance in south east Asia, acacias are being widely planted in most of the States and trial plantations as well as commercial plantations are being established.

With the emergence of significant disease problems in large-scale commercial plantations of exotic acacias, especially those of *A. mangium* in Malaysia and Indonesia, it became necessary to assess the disease situation in several neighbouring countries so that appropriate control strategies could be developed against some of the more serious diseases. Hence under CIFOR and ACIAR sponsorship, a disease survey was conducted in species/provenance trials, commercial plantations and native populations of four major species, viz. *A. aulacocarpa, A. auriculiformis, A. crassicarpa* and *A. mangium* in India, Indonesia, Thailand, Malaysia and Australia to provide an indication of the potential of fungal pathogens as limiting factors to growth and productivity. This report presents the results of the Indian case study.

Review of literature

Information on diseases in acacias and other multipurpose woody legumes is largely restricted to host records and there have been only a few detailed studies on their pathology, etiology and management (Boa and Lenné 1994). In India, although exotic acacias have been grown for quite some time there has been no systematic detailed study of their disease problems, except a few which were of limited nature.

In India, a total of 16 pathogens have been reported to cause diseases of *A. auriculiformis* of which the majority are root pathogens. Of these, only three diseases namely, Cylindrocladium foliar spot and Phomopsis foliar spot (Mohanan and Sharma 1988) and foliar web blight (Mehrotra, 1990) affected the foliage of seedlings (Table 1). Among the eleven plantation diseases, Exoserohilum foliar spot and Colletotrichum foliar spot are the only foliar diseases; pink disease is a stem disease while the rest affected the roots. Since there is no information available on the severity and occurrence of root diseases it was not possible to judge their impact on productivity. Mohanan and Sharma (1988) reported that during the monsoon season, severe infection by Colletotrichum foliar spot and Cylindrocladium foliar spot would result in premature defoliation and twig dieback. Florence and Balasundaran (1991) recorded 10 percent mortality of trees in a roadside strip plantation of *A. auriculiformis* due to pink disease caused by *Corticium salmonicolor* in Kerala.

Very few diseases have been recorded on *A. mangium* in India. This probably does not indicate the resistant nature of this species but merely its recent introduction to plantation forestry and consequently the lack of attention paid to disease problems of this species. Of the four diseases reported, three affected the foliage. Of these, severe Colletotrichum foliar infection caused premature defoliation and shoot dieback during the monsoon (Mohanan and Sharma 1988). No details are available on the incidence and damage caused by *Botryodiplodia theobromae* (syn. *Lasiodiplodia theobromae)* causing root disease and canker. So far, no diseases have been recorded on *A. aulococarpa* and *A. crassicarpa* in India.

Table 1. Diseases recorded on exotic Acacias in India.

Disease(s)	Pathogen	Reference(s)
A. auriculiformis		
Foliar spot	*Alternaria alternata*	Browne (1968)
Foliar spot	*Colletotrichum* state of *Glomerella cingulata*	Mohanan & Sharma (1988)
Foliar spot (seedlings)	*Cylindrocladium quinqueseptatum*	Mohanan and Sharma 1988)
Foliar spot	*Exoserohilum rostratum*	Mohanan and Sharma 1988)
Foliar spot (seedlings)	*Phomopsis* sp.	Mohanan and Sharma 1988)
Foliar web blight (seedlings)	*Rhizoctonia solani*	Mehrotra (1990)
Pink disease	*Corticium salmonicolor*	Florence and Balasundaran 1991)
Dieback, gummosis, root death	*Armillaria mellea*	Browne (1968)
Dieback, gummosis, root death	*Macrophomina phaseolina*	Bakshi, (1957)
Wilt	*Fusarium oxysporum*	Bagchee (1945,1958)
Wilt	*F. moniliforme*	Bagchee (1945,1958)
Wilt	*F. solani*	Bagchee (1945,1958)
Root disease	*Botryodiplodia theobromae*	Gibson (1975)
Root rot	*Phellinus* sp.	Browne (1968)
Root rot	*Ganoderma* sp.	Bagchee (1945, 1947)
Root rot	*Ganoderma lucidum*	Bakshi *et al.* (1968)
A. mangium		
Root disease and canker	*Botryodiplodia theobromae*	Boa and Lenné (1994)
Foliar spot	*Cylindrocladium quinqueseptatum*	Mohanan and Sharma (1988)
Foliar spot	*Colletotrichum* state of *Glomerella cingulata*	Mohanan and Sharma (1988)
Sooty mould	*Meliola* sp.	Mohanan and Sharma (1988)
A. crassicarpa		
No disease record		
A.aulococarpa		
No disease record		

Materials and methods

Selection of representative species trials/plantations

Details of the species/provenance trials of exotic acacias, especially those of *A. crassicarpa* and *A. mangium* were sought from the Forest Departments of various States in a proforma. The response was very poor and, therefore, only species trials and plantations for which information was received or gathered through other sources were selected. If there was any knowledge on the occurrence of a disease(s) on *Acacia* spp. in a particular area such locations were also included for disease survey. Lists of localities by species where the four acacias were surveyed in the States of Kerala, Tamil Nadu, Karnataka and West Bengal are given in Tables 2, 3, 4 and 5. Major locations are also shown on a map (Fig.12).

Acacia nurseries were surveyed only if they were closely located to a species trial/plantation selected for the disease survey.

Table 2. Details of *Acacia aulacocarpa* species trials surveyed for the occurrence of diseases.

Locality	District /State	Year of planting	Espacement (m)	Area (ha)	Average height (m)	Average GBH (cm)	Remarks/ seed source CSIRO Seed lot No.
Sadivayal	Coimbatore TN	1990	2.0 x 2.0	14	4-5	15.5	45 trees died over the years
Neyveli	S.Arcott, TN	1990	2.5 x 2.5	25	7.0	24.6	CSIRO
Brahmadev-ragadde*	Shimoga, KA	1985	2.5 x 2.5	50	8.6	6.8**	Garich Qld 13866
Dejuri	Bankura, WB	1994	2.5 x 2.5	25	2.5-3.6	--	CSIRO 15715
Dharampur	"	1995	2.5 X 2.5	--	0.6-0.7 1.0-1.7	--	16976 PNG
Dhengakend	"	1995	2.5 x 2.5	--	0.3-0.4 0.4-1.0	--	"

*1993 measurements; TN, Tamil Nadu; KA, Karnataka; WB, West Bengal

Observations recorded

Observations on disease severity (low, medium, severe) were recorded based on a numerical scale (1-3) of a disease rating index. In the case of serious diseases either all the trees were assessed in species/provenance trials or a small plot of 100 trees was selected at random for the assessment of disease incidence and severity. The average severity of the disease was calculated following a formula provided by Sharma *et al.* (1985). The incidence of the disease in a plot was rated on the basis of percentage of trees affected as follows:

% Diseased trees	*Rating*
75 and above	Widespread
50 - <75	Very common
25 - <50	Common
10 - <25	Occasional
<10	Rare

Table 3. **Details of *Acacia auriculiformis* provenance trials, plantations and seed stands surveyed for the occurrence of diseases.**

Locality	Dist/State	Year of planting	Espacement (m)	Area (ha)	Average height (m)	Average GBH (cm)	Remarks/ seed source CSIRO seed lot No.
Sadivayal	Coimbatore, TN	1990	2.0 x 2.0	420	10.5	21.2	60-70% hybrid CSIRO Australia
Mettupalayam	"	1986-87	2.0 x 2.0	25	8.8	--	Survival poor
Neyveli Lig. Corp	South Arcot, TN	--	---	----		--	20%,60% in two provenances
Neyveli Res. Plot	"	1990	2.0 x 2.0	25	4.5	--	Roadside planting
"	"	1990	2.0 x 2.0	1306	--	--	Espacement trial
Auroville	Pondicherry	1991	2.5 x 2.5	---	--	--	Community planting
Nallal A block (Hosekote)	--	1989	2.0 x 2.0	--	--	--	ST, PT
Jarakbande	Bangalore, KA	1989	2.0 x 2.0	--	6.5	2.1	ST, 16152
Tyarndur	Shimaga, KA	1995	2.0 x 3.0	1800	--	--	ST Springvale
Beede	"	1993 1993	1.5 x 2.5 "	---	22.5 18.35	7.5 5.7	Springvale prov. Balamuk, PNG half sib
Dejuri	Bankura, WB	1994	2.5 x 2.5	25	3.0	6.8	ST, CSIRO
Dharampur	"	1995	"	100	1.4-2.3	--	ST "
Dhengakend	"	1995	"	100	0.5-1.5	--	ST "
Arabari	Midnapur, WB	1987	"	--	--	--	Mixed softwood plantation
Ramavarma-puram	Trichur, KL	1986	2.0 x 2.0	5.0	--	--	--
Kalathode	"	1986	"	--	--	--	Roadside block plantation
Kottappara	"	1991	"	--	--	--	"

(TN, Tamil Nadu; KA, Karnataka; KL, Kerala; WB, West Bengal)
ST, Species trial; PT, Provenance trial)

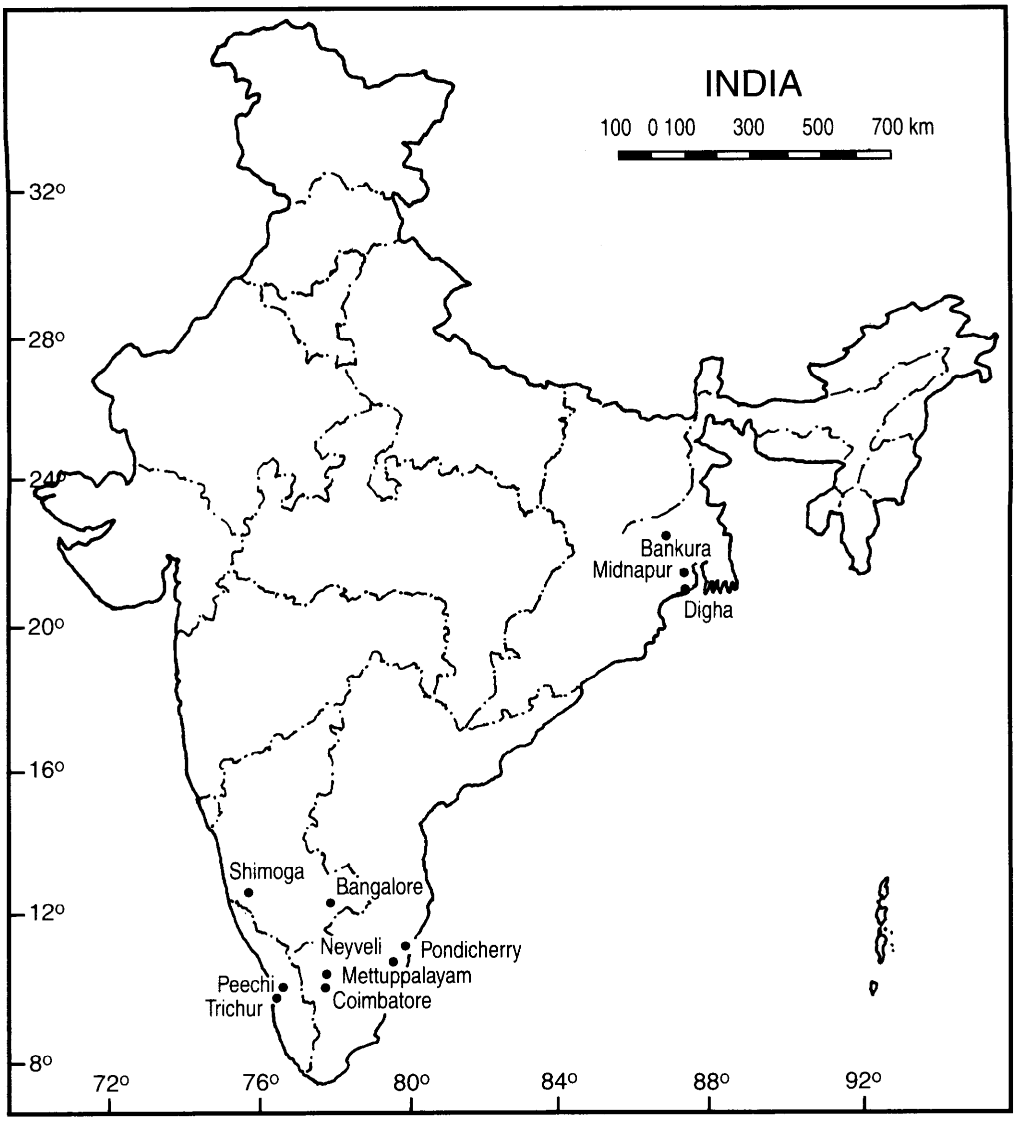

Figure 12. Major locations in the States of Kerala, Tamil Nadu, Karnataka and West Bengal visited during survey of diseases of exotic acacias.

Table 4. Details of provenance trial plots of *Acacia crassicarpa* surveyed for the occurrence of diseases.

Locality	Dist/State	Year of planting	Espacement (m)	Area (ha)	Average height (m)	Average GBH (cm)	Remarks/ seed source CSIRO seed lot No.
Mettupalayam	Coimbatore, TN	1988, 1989	2.5 x 2.5	25+25+25	3-5,6-7,3	--	Three CSIRO provenances including 15950, 16128
Neyveli	S. Arcot, TN	1990	2.0 x 2.0	8	8.5	36	Out of 30 trees only 8 surviving
Nallal A Block (Hosekote)	Bangalore, KA	1989	2.5 x 2.5	60	8.3	33.2	ST
Beede	Shimoga, KA	1993	1.5 x 2.5	0.1	6.08	20.7	Half sib progeny trial
Beede	Shimoga, KA	1985	2.5 x 2.5	50	11.48*	10.58**	Brahmade-varegadde
Dharampur	Bankura, WB	1995	2.5 x 2.5	100	1.95-2.25	--	ST
Dhengakend	Bankura, WB	1995	2.5 x 2.5	100	0.50-1.50	--	ST

*Recorded in 1993; ** Diameter;
(TN, Tamil Nadu; KA, Karnataka; KL, Kerala; WB, West Bengal; ST, species trial)

Symptoms of diseases were recorded in the field as well as from herbarium specimens. Diseased specimens were collected in clean polythene bags or paper bags for isolation and the herbarium. Fungi associated with the disease were isolated in pure culture on potato dextrose agar (PDA) medium and cultures maintained on PDA slants for identification. Non-sporulating cultures were also inoculated on malt extract medium to induce sporulation. Appropriate photographs of the diseased phyllodes/trees were taken to illustrate symptoms, plant part affected and damage. Wherever available climatic data and soil characteristics were also gathered for the surveyed plantation/trial.

Table 5. Details of *Acacia mangium* provenance trials and plantations surveyed.

Locality	Dist./State	Year of Planting	Espacement (m)	Area ha or No. of trees *	Average height (m)	Average GBH (cm)	Remarks/ seed source/ CSIRO Seed lot No.
Mettupalayam	Coimbatore TN	1986-87	2.0x2.0	25	--	--	ST; all trees died
Sadivayal	Coimbatore, TN	Jan, 1990	2.0 x2.0	420*	7.5	33.6	ST; all trees died
IFGTB	Coimbatore, Tn	1995	--	--	--	--	ST; all trees died
Nallal B Block (Hosekote)	Bangalore KA	1989	2.0 x2.0	380*	7.2	28.7	ST, CSIRO 15677
Nallal B Block (Hosekote)	Bangalore KA	1992	2.0 x 2.0	0.5	4.5	--	Drip irrigation trial
Jarakbande	Bangalore KA	1990	3.0 x 3.0	100*	7.0	--	ST
Beede	Shimaga, KA	1993	2.0 x 2.0	1+2	6.7	23.7	Fertilizer trial
Brahmadeva-regadde	Shimaga, KA	1985	2.5 x 2.5		1.8	79.0	ST
Dejuri	Bankura, WB	1994	2.5 x 2.5	25	3.7	8.2	CSIRO Local
Dharampur	Bankura, WB	1995	2.0 x2.0	900*	1.6	--	ST, CSIRO 13139
Dhengakend	Bankura, WB	1995	2.0 x 2.0	25	0.8	--	--
Ghuchisola	Midnapur, WB	1987	---	1.0	11.0	55.0	Seed stand 1993
Sapadiha	Midnapur, WB	1985	--	0.2	17.5	75.0	Seed stand 1993
Kusumadhari	Midnapur, WB	1985,86	--	1.5	10.2	75.5	--
Manjhigarh	Midnapur, WB	1993	--	1.5	8.4	13.0	--
Khadalgabra	Digha, WB	1987	--	200*	--	---	--
Gangadharpur	Digha, WB	1991,92	1.0 x1.0	1	--	--	--
Velakkarithadam/ Vilangannor	Trichur, KL	1995	--	--	--	--	Container seedlings
Kutanellur	Trichur, KL	1995	2.5 x2.5	48	--	--	--

(TN, Tamil Nadu; KA, Karnataka; KL, Kerala; WB, West Bengal)
ST, Species trial.

Results

During the survey a total of 165 diseased specimens from different plant parts of all the four species were collected for isolation and identification of the pathogen (Table 6).

Table 6. Details of diseased specimens collected during disease survey.

Acacia species	Total specimens	Phyllodes	Stem	Roots
A. aulacocarpa	22	20	-	2
A. crassicarpa	24	18	4	2
A. mangium	42	27	11	4
A. auriculiformis	77	66	10	1
Total	165	131	25	9

Most of the cultures were identified to the generic level with the help of standard taxonomic books, monographs, etc. However, several cultures which could not be identified for want of sporulation.

Diseases of *Acacia aulacocarpa*

Four types of basic symptoms were identified with which 12 fungal species were associated. Foliar diseases were more common than diseases of other plant parts (Table 7).

Table 7. Checklist of diseases recorded on *Acacia aulacocarpa* in India

Disease	Causal organism	Locality	Disease status	
			Incidence*	Severity**
Foliar tip necrosis	*Alternaria* sp.	Neyveli	VC	L
	Pestalotiopsis sp.	Neyveli	WS	L
	Colletotrichum sp.	Dharampur	C	M
	Unidentified	Dharampur	R	L
	Unidentified	Neyveli	C	M
Foliar spots	*Sporodesmium* sp.	Dharampur	0	L
	Alternaria sp.	Dharampur	VC	M
	Phomopsis sp.	Sadivayal	WS	S
	Pestalotiopsis sp.	Sadivayal	0	M
	Unidentified	Dharampur	R	L
	Unidentified	Dharampur	WS	L
	Unidentified	Tyaranadur	C	L
Branch canker	*Botryodiplodia theobromae* *Cytospora* sp.	Sadivayal	C	S
Root decay	Basidiomycetes	Neyveli	C	M

* WS, Widespread; VC, Very common; C, Common; O, Occasional; R, Rare.
** S, Severe; M, Medium; L, Low.

Foliar tip necrosis

There were five distinct types of tip necrosis diseases. Since tip necrosis was caused by various fungi producing varied symptoms each disease is described separately.

Alternaria tip necrosis

Occurrence: Although the disease was very common during January-February affecting phyllodes of most of the trees, the severity was low.

Symptoms: The disease was characterised by drying up of the phyllode tips. Tip necrosis, dark brown in colour, proceeded slowly downwards towards the centre of the phyllode as seen from dark brown zonation lines in the necrotic region.

Associated organism: *Alternaria* sp. Colony on PDA greyish black, effuse, reverse black; mycelium dark brown, septate; conidiophores dark, simple; conidia dark brown with transverse (2-5) and longitudinal septa (1-2), obclavate, with short beak, occasionally with long beak, 25-72 μ x 10-18 μ; perithecia spherical, pale brown, 28-36 μ.

Pestalotiopsis tip necrosis

Occurrence: The disease was widespread in a species trial plot at Neyveli Tamil Nadu. Almost all the phyllodes on the lower branches of most of the trees were affected., As the disease was localised at the tip it did not cause any defoliation.

Symptoms: The tips of the affected phyllodes were greyish brown on which the fungus sporulated as minute black dots.

Associated organism: *Pestalotiopsis* sp. Colony on PDA white, matted, appressed; reverse pale turning greyish; numerous dark discoid acervuli covered with mycelium present; conidia dark, fusoid, 5-celled with hyaline, pointed end cells, 14-21 µ x 3.6-5.4 µ apical appendages two, hyaline, 7-l8 µ long; basal appendage, small, 3.6-7.2 µ

Colletotrichum tip necrosis

Occurrence: The disease was common in a 1995 species trial plot atDharampur,WestBengal, during February. The infection was rated as medium.

Symptoms: The disease was characterised initially by the appearance of a dark brown spot with pale margin near the tip of the phyllode. Symptoms gradually spread towards the tip as well as centre of the phyllode. The disease mostly affected the mature phyllodes.

Associated organism: *Colletotrichum sp.* Colony on PDA grey, floccose, reverse dark, mycelium pale brown; acervuli absent, conidia directly produced on simple conidiospores on the mycelium; conidia hyaline, l-celled ovoid to oblong, guttulate, 5-l 1.5 µ x 2.3-4.6 µ sclerotia spherical, dark brown in short chains, up to 27.6 µ long.

Unidentified tip necrosis

Occurrence: The disease was observed on mature phyllodes at Dejuri, West Bengal. Although only a few plants were affected with this disease it appeared to be a serious one.

Symptoms: The reddish brown necrotic area initially developed at the tip, gradually spreading downwards, covering almost half of the phyllode.

Associated organism: Unidentified; non-sporulating.

Unidentified tip necrosis

Occurrence: The disease, common in a species trial plot at Neyveli, Tamil Nadu, mostly affected the phyllodes in the lower branches of trees. The disease appeared to be of a serious nature as the affected phyllodes abscissed prematurely.

Symptoms: The primary symptom of the disease was the development of water soaked linear lesions along the veins near the tip which soon turned greyish. These lesions coalesced to form greyish to light brown large necrotic areas. As more and more spots developed, they coalesced to enlarge the necrotic area, characterised by a dark greyish advancing margin or zonation line. The affected phyllode became pale and abscissed prematurely.

Associated organism: Unidentified; non-sporulating.

Foliar spots

Seven different types of foliar spot diseases with which different fungal organisms were associated were recorded from various localities.

Colletotrichum foliar spot

Occurrence: The disease occurred at low frequency in a species trial plot (1995) at Dharampur, West Bengal.

Symptoms: The typical symptoms of the disease were spherical to oval black spots, l-2 mm diam., scattered on the lamina irrespective of vein arrangements. The tissue around the spots became necrotic and such small necrotic lesions coalesced to form large necrotic areas, which spread from phyllode tips downwards.

Associated organism: *Colletotrichum* sp. Colony on PDA dull brownish, effuse, slightly appressed, reverse dark brownish; acervuli absent, conidia borne directly on simple conidiophores arising from mycelium, conidia hyaline, 1-celled, guttulate, ovoid, 9-16 µ x 2.8-4.6 µ

Sporidesmium foliar spot

Occurrence: The disease was recorded at low frequency, mostly on mature phyllodes in a species trial plot (1995) at Dharampur, West Bengal.

Symptoms: The disease was characterised by elongated dark brown lesions, 0.5 to 1 mm wide, running parallel to the veins. These lesions enlarged and coalesced to produce large dark reddish brown spots, which were usually initiated from the tip of the phyllode. Severely affected phyllodes turned pale and abscissed prematurely.

Associated organism: *Sporidesmium australiense* Ellis. Colony on PDA grey to dark grey, floccose, reverse dark; mycelium pale to light brown; conidiophores straight, septate, smooth dark brown; conidia straight or rarely curved, fusiform to obclavate, conidia truncate at the base with cells at each end hyaline to pale 27-7 1 µ x 1 1 - 16 µ in certain conidia the apical cells tapered into a small beak.

Alternaria foliar spot

Occurrence: The disease, very common in a species trial plot (1995) at Dharampur, West Bengal, affected young as well as mature phyllodes. The disease was of moderate severity resulting in premature defoliation.

Symptoms: Initially, dark brown spots appeared more towards the margins of the phyllode. Around the spots the tissue became light brown and coalesced giving rise to large and necrotic light brown areas along the margins. Severely affected phyllodes turned pale and abscissed prematurely.

Associated organism: *Alternaria* sp. Colony on PDA dark grey floccose, reverse dark; mycelium dark brown, septate, conidiophore simple pale to mid-olivaceous brown; conidia in short chains, obclavate, oval to ellipsoidal with or without cylindrical beak, pale, upto 13 septa; conidia with long beak with 2-4 transverse septa 25-142 µ x 6.9-9.2 µ small conidia without beak with transverse and longitudinal septa 18-23 µ x 9.2- 11.5 µ

Phomopsis foliar spot

Occurrence: Severe infection by this disease was recorded in a species trial at Sadivayal - Shiruvani, Tamil Nadu, where almost all the plants had more than 75 per cent of the foliage infected.

Symptoms: Initially, light discoloured areas developed on any part of the phyllode. At the centre of these areas irregular, small greyish spots with dark brown margin appeared (Fig. 16a). The greyish spots enlarged in size and covered; up to half the lamina. Severely infected phyllodes abscissed prematurely.

Associated organism: *Phomopsis* sp. Colony on PDA white turning off-white to light brown, reverse pale brown; mycelium appressed branched, septate, hyaline; conidiomata pycnidial, eustromatic, dark brown. separate or aggregated, thin-walled textura angularis: conidia of two basic types: a-conidia small hyaline, fusiform, straight, biguttulate, aseptate, 4.6-6.9 µ x 1.3 µ I3-conidia hyaline, filiform, curved or hamate, eguttulate, aseptate, 12.8-23 µ.

Pestalotiopsis foliar spot

Occurrence: The disease occurred on a few trees in a species trial (1995) at Sadivayal - Shiruvani, Tamil Nadu.

Symptoms: The disease was characterised by irregular, elongated brown coloured spots which spread rapidly to coalesce and form large necrotic areas. Severely affected phyllodes defoliated prematurely.

Associated organism: *Pestalotiopsis* sp. Colony on PDA white, effuse, mycelium scanty, appressed and immersed; conidiomata acervuli, dark aggregate; conidia fusiform straight, 4-euseptate 16-18 µ x 4.6-5.7 µ; basal cellx hyaline, truncate, with a simple appendage, 4.6-l 1.5 µ long; apical cell conic, hyaline with two simple appendages, filiform 9.2-27.6 µ medium cells brown.

Unidentified foliar spot

Occurrence: The disease was recorded only on a few plants in a species trial plot (1995) at Dharampur, West Bengal.

Symptoms: Characteristic brownish red irregular spots of varying size developed near the margins of mature phyllodes which enlarged to form large necrotic lesions.

Associated organism: Non-sporulating Hyphomycete.

Unidentified foliar spot

Occurrence: The disease was widespread during October/November in a species trial at Nallal, Hosekote, Karnataka and Neyveli, Tamil Nadu.

Symptoms: The disease was characterised by elongated dark coloured streaks parallel to the veins, more towards the outer margin of the phyllodes. These streaks enlarged and coalesced to give to rise greyish black lesions which resulted in premature defoliation.

Associated organism: Non-sporulating Hyphomycetes.

Unidentified foliar spot

Occurrence: Though the spot disease was common on young as well as mature phyllodes in a species trial plot at Neyveli, Tamil Nadu, it apparently did not cause much damage.

Symptoms: The symptoms resembled nutrient deficiency. The affected phyllodes had typical elongated faint yellowish streaks parallel to the veins throughout the lamina. The spots were clearly visible when the phyllode was observed against light.

Associated organism: Non-sporulating Hyphomycetes.

Branch canker

Occurrence: A branch canker disease was recorded in a species trial at Sadivayal - Shiruvani, Tamil Nadu. The incidence of the disease was very high and it caused extensive mortality of branches ultimately killing the trees. Of the 59 trees initially planted in the plot only 14 survived due to severe infection.

Symptoms: The canker developed as a depressed area initially only on one side of the branch (Fig. 16b). Tissue in the depressed area died and developed black streaks where the fructifications formed. The canker gradually girdled the tissues thus killing the whole branch.

Associated organism: *Cytospora* sp. Colony on PDA dark greyish black, effuse; reverse black; mycelium appressed, immersed, dark brown, septate; conidiomata pycnidial eustromatic, spherical dark brown, convoluted, unilocular; conidiophore, simple, hyaline, 11-23 long; conidia, hyaline, allantoid, non-guttulate, 2.3-4.6 µ x 1.2 p.

Roof decay

Occurrence: Root decay was recorded in two plots of CSIRO seed lot No. 16168 in a species/provenance trial plot (1990) at Neyveli, Tamil Nadu. The affected trees occurred in patches. Out of 60 trees in two plots seven trees were already dead and three showed initial symptoms of the disease.

Symptoms: The affected trees showed yellowing of phyllodes and premature defoliation resulting in thinning of crown. On excavation of the root system it was found that some of the roots of such trees were either already dead or in the process of dying; dead roots showed zonation lines. No fructifications were observed on the affected roots.

Associated organism: Basidiomycetes. Culture on PDA white; reverse pale, mycelium appressed with clamp connections.

Diseases of Acacia crassicarpa

Four distinct types of disease symptoms were identified with which 15 fungal and one algal species were associated. Foliar diseases were more common than others (Table 8).

Table 8. Checklist of diseases recorded on *Acacia crassicarpa* in India.

Disease	Causal organism	Locality	Disease status	
			Incidence*	Severity**
Foliar tip necrosis	*Curvularia* sp.	Dharampur	R	L
	Alternaria sp.	Mettupalayam	0	L
	Alternaria sp.	"	R	M
	Phomopsis sp.	Jarakbande	WS	M
	Unidentified	"	C	L
	Unidentified	Dharampur	0	L
Foliar spots	*Glomerella* sp.	Beede	0	L
	Colletotrichum sp.	Mettupalaym	0	L
	Alternaria sp.	"	R	L
	Pestalotiopsis sp.	Beede	C	
	Unidentified	Dharampur	WS	M
	Unidentified	Mettupalayam	0	L
	Unidentified	Nallal	C	L
	Unidentified	Dharampur	C	L
	Sooty mould	Dharampur	WS	L
Basal stem canker and root decay	*Botryodiplodia theobromae*	Mettupalaym Nallal	WS	S
Green algal spot	Unidentified	Beede	WS	M

* WS, Widespread; VC, Very common; C, Common; O, Occasional; R, Rare
** S, Severe; M, Medium; L, Low.

Foliar tip necrosis

There were six different types of symptoms and associated causal organisms recorded on *A. crassicarpa.*

Curvularia tip necrosis

Occurrence: The disease was recorded on phyllodes of only a few plants in a species trial (1995) plot at Dharampur, West Bengal, during February. The infection was mostly localised on lower phyllodes.

Symptoms: The infection started as greyish light brown spots at the tip, gradually spreading downwards. The rapidly spreading infection caused premature defoliation.

Associated organism: *Curvularia* sp. Colony on PDA greyish, floccose, fluffy; reverse dark greyish brown; mycelium dark brown septate; conidiophores brown, simple bearing conidia apically or geniculate, sympodial, growing points on sides; conidia light brown, 3-septate, middle cell larger and dark brown, end cells lighter, slightly fusiform, curved 13.8-2.7 µ x 6.9-l 1.5 µ

Alternaria tip necrosis

Occurrence: The disease was recorded in a species trial plot (1986-89) at Mettupalayam, Tamil Nadu. The incidence of the disease was very low.

Symptoms: Initially, small dark tan lesions developed near the tip which gradually extended towards the central portion of the phyllode. These lesions coalesced to form large necrotic dark tan coloured areas extending from the tip downwards, more towards the inner margin. The affected phyllodes abscissed prematurely.

Associated organism: *Alternaria* sp. Colony on PDA olivaceous grey, floccose, spreading, reverse dark; mycelium pale brown to brown; conidiophores simple; conidia pale to dark brown, verrucose with two types of conidia; with beak obclavate 23 -73 µ x 9.2- 13.8 µ with 3 -6 transverse and to 2 longitudinal septa, septa in beak O-4; conidia without beak, small oval ellipsoidal 23-32 µ x 9.2-13.8 µ with 3-4 transverse and 0-3 longitudinal septa.

Alternaria tip necrosis

Occurrence: This disease, recorded in a species trial (1986-87) at Mettupalayam, Tamil Nadu appeared to be similar to the above but the symptoms and the causal organisms differed. The disease was quite severe in one tree affecting more than 50 per cent of phyllodes.

Symptoms: Dark brown coloured necrosis started from the tip and extended downwards. Characteristic dark grey streaks running parallel to veins, developed in the necrotic area where dark minute fructifications were produced.

Associated organism: *Alternaria* sp. Colony greyish white, floccose; reverse dark; conidiophores simple dark brown; conidia dark brown with three types of conidia, with long beak, short beak and without beak; short beak conidia with 3-4 transverse and l-2 longitudinal septa; septa in beak O-2.

Phomopsis tip necrosis

Occurrence: The disease was widespread in a species trial plot (1993) at Beede, Karnataka. The severity of the disease was rated as medium.

Symptoms: Light greyish necrosis was initiated at the tip which spread gradually down the lamina with irregular raised and well defined dark brown margin. Occasionally, the fructifications of the causal organism were also produced over the necrotic area.

Associated organism: *Phornopsis* sp. Colony white turning dull brown; mycelium scanty, appressed, immersed; conidiomata pycnidial, dark, aggregate, conidiophores straight, septate, branched, only h-conidia present, hyaline, filiform, eguttulate, non-septate, 13.8-20.7 µ x 11.523 p.

Unidentified tip necrosis

Occurrence: Although the disease was commonly encountered in a species trial plot (1993) at Beede, Karnataka, its severity was rated as low.

Symptoms: Dull greyish brown necrosis started from the tip and spread down the phyllode in an oblique fashion, covering more than one-fourth of the lamina. Numerous greyish black streaks developed in the necrotic area running parallel to the veins on which black fi-uctifications of the causal organism developed.

Associated organism: Non-sporulating fungus.

Unidentified tip necrosis

Occurrence: This disease was observed occasionally on mature phyllodes in a species trial (1995) at Dharmpur, West Bengal; its severity was low.

Symptoms: Almost 75% of the phyllode length was covered with a large necrotic area which was characteristically light brown at the tip and dark tan towards the base. Within the necrotic area elongated light greyish spots with diffused margins were also seen.

Associated organism: Non-sporulating fungus.

Foliar spots

A total of nine distinct foliar spots were recorded on the phyllodes of *A. crassicarpa* growing in different localities.

Glomerella foliar spot

Occurrence: The disease was recorded on mature phyllodes in a species trial plot (1993) at Beede, Karnataka. The incidence and severity of the disease were low.

Symptoms: The disease was characterised by irregular greyish brown spots with dark brown margins. Smaller spots coalesced to form large necrotic areas (Fig. 15a). Occasionally, dark coloured fungal fiuctifications of the causal organism were observed in some of the spots.

Associated organism: *Glomerella cingulafa.* Colony on PDA initially white turning light greyish, effuse; mycelium sparse, appressed; reverse light greyish, conidiomata acervular formed on the outer periphery; conidial mass orange; setae present, dark brown septate 27-87 µ, conidia, hyaline guttulate, straight, oblong, with rounded ends, 9-l3 µ x 2.3-4.6 µ perithecia present, light to dark brown, thin walled, immersed formed singly or in groups, scattered.

Colletotrichum foliar spot

Occurrence: The disease recorded only in a few trees in a species trial (1986-87) at Mettupalayam, Tamil Nadu, had very low incidence.

Symptoms: The disease was characterised by chocolate brown large necrotic spots, mostly elongated with darker margins. The spots were found only on mature phyllodes.

Associated organism: *Colletotrichum* sp. Colony on PDA white turning light grey from the centre, effuse to cottony; reverse pale greyish; acervuli not seen; conidia borne directly on short conidiophores; conidia hyaline, guttulate, straight, oblong to oval, lo-23 µ x 2.3-4.6 µ.

Alternaria foliar spot

Occurrence: The disease was recorded at low incidence only at Mettupalayam, Tamil Nadu.

Symptoms: Usually, the necrotic spots started from the outer margin near the tip of the phyllodes and extended downwards towards the base developing into large greyish brown spots; (Fig. 15b) with dark brown margins. Numerous black coloured fructifications developed on both the sides of the spots.

Associated organism: *Alternaria* sp. Colony on PDA greyish brown, floccose, reverse dark; mycelium olivaceous brown, septate; conidiophores, long brown to dark brown; conidia dark brown, obclavate, verrucose, two types; short beak 39-69 µ x 11.5-16 u, with 3-7 transverse and 0-3 longitudinal septa; septa in beak 0-2; conidia with long beaks 85-l17 µ x 8.0-9.2 u, with 3-5 transverse and 0-2 longitudinal septa.

Pestalotiopsis foliar spot

Occurrence: The disease was commonly observed at Brahamadevagadde and Beede, Karnataka and Neyveli, Tamil Nadu. Although the disease equally affected young and mature phyllodes it was found only on the lower branches.

Symptoms: The phyllodes had numerous spots, pale brown in colour with, dark brown centres. There were more spots near the tip and middle of the phyllodes than at the base. When seen against the light the spots appeared as pale translucent areas with a dark centre.

Associated organism: *Pestalotiopsis* sp. Colony on PDA white cottony, reverse light orange coloured; conidiomata acervular, separate or confluent, near the margin immersed, dark black; conidia fusiform, straight, 4-euseptate, dark brown, except the end cells; basal cell truncate with a short appendage 5.7-9.2 µ long; apical cell conic with 3 appendages of equal size, simple spathulate, 9-23 µ long.

Unidentified foliar spot

Occurrence: The disease was widespread on mature phyllodes of one-year-old plants in a species trial (1995) at Dharmpur, West Bengal. The foliar spots spread from basal phyllodes to upper phyllodes.

Symptoms: Initially reddish brown shining irregular spots appeared on the mature phyllodes. As smaller spots developed they coalesced to form larger spots. The affected phyllodes turned pale and defoliated prematurely.

Associated organism: Unidentified; Sphaeropsidales. Colony on PDA white turning dull, reverse light pale; mycelium hyaline septate, scanty; conidiomata pycnidial, dark brown non-ostiolate, 80-172 u, covered with pointed dark brown appendages, non-septate, pointed, straight or curved. 119-l 6 1 µ young conidia hyaline, mature conidia light brown, 1-celled, thin walled, oval with slightly pointed ends, 9.2- 11.5 µ x 5.8-8.5 µ

Unidentified foliar spot

Occurrence: The disease was recorded in a species trial plot (1986-87) at Mettupalayam, Tamil Nadu. The incidence and severity of the disease were very low.

Symptoms: The affected phyllodes had minute dark coloured spots which expanded and developed light grey areas in the centre resulting in the light brown to light grey, more or less elliptical spots with dark brown margins.

Associated organism: Unidentified; non-sporulating Hyphomycete.

Unidentified foliar spot

Occurrence: Although the disease was common in a species trial plot (1990) at Neyveli its severity was low.

Symptoms: The disease was characterised by elongated greyish brown long spots along the outer margin of the phyllodes. The necrotic spot had dark greyish long lesions where the fructifications of the causal organism developed.

Associated organism: Unidentified; non-sporulating Hyphomycete.

Unidentified foliar spot

Occurrence: This foliar spot was common in a species trial (1995) at Dharmpur, West Bengal but its severity was low.

Symptoms: The affected phyllodes had light yellowish orange spots with diffuse margins throughout the laminae. When observed against the light, these spots appeared bright yellowish orange. The disease affected the mature phyllodes but it progressed upwards also affecting the younger ones. The affected phyllodes abscissed prematurely.

Sooty mould

Occurrence: The disease was very widespread in a mixed species trial (1993) of *A. mangium* and A. *crassicarpa* at Beede, Karnataka. Occasionally the incidence of sooty mould was so high that it covered almost >75 percent of the phyllode.

Symptoms: The affected phyllodes had dark black to greyish black superficial growth on the surface of phyllodes. In severe cases the phyllodes defoliated prematurely.

Associated organism: Unidentified; *Meliola* sp.

Basal stem canker and root decay

Occurrence: Stem decay was recorded in a species trial plot (1989) at Nallal, Hosekote, Karnataka and 1986-87 trial plot at Mettupalayam, Tamil Nadu. At Nallal, of the 60 trees 12 were removed after they died and eight standing trees had basal cankers. At Mettupalayam, out of 50 trees, 43 of them had already died and of the seven remaining trees one was affected with basal canker.

Symptoms: The affected trees had a basal canker characterised by appressed bark with cracks. Under the bark the sapwood was discoloured and dead with black zonation lines. The roots on the side of the canker were dead and decayed with black zonation lines. In some trees, the dead bark and the underlying dead sapwood were attacked by termites.

Etiology: After excavating the root systems of some of the recently affected trees, it was apparent that the infection was initiated in the roots. From the roots the infection spreaded upwards in the stem. Possibly, complete girdling of the stem by the infection killed the trees.

Associated organism: *Botryodiplodia theobromae* Pat. Colony on PDA dark greyish black, floccose, reverse dark; mycelium dark brown, septate; conidiomata synnematous, pycnidial unilocular, ostiolate, thick walled; immature conidia hyaline, mature conidia 1-euseptate, dark brown, with longitudinal striations, 9.2 µ x 4.6 µ.

Green algal spot

Occurrence: Algal spot was recorded in a mixed species trial (1993) of *A. crassicarpa* and *A. mangium.* The incidence of the algal spot was very high and appeared to be severe as it occurred in combination with sooty mould.

Symptoms: Epiphytic growth of a light green alga covered a larger part of the phyllodes, at times covering the entire lamina. Such phyllodes turned yellow and abscissed prematurely.

Organism: Unidentified; Chlorophyceae.

Diseases of *Acacia mangium*

Eight different types of disease symptoms were recorded on *A. mangium* with which 22 fungal organisms were associated (Table 9). Foliar diseases were predominant in most of the younger plantations whereas root/stem diseases were significant in older plantation trials.

Table 9. Checklist of diseases of *Acacia mangium* recorded in India.

Disease	Causal organism	Locality	Disease status	
			Incidence*	Severity**
Foliar tip necrosis	*Colletotrichum* sp.	Gangadharpur	L	L
	Unidentified	Gangadharpur	R	L
Foliar spot	*Curvularia* sp.	Dharampur	L	L
	Colletotrichum sp.	Vilangannur	W	S
	Pestalotiopsis sp.	Vellakkarithadam	0	S
	Pestalotiopsis sp.	Vellakkarithadam	0	L
	Pestalotiopsis sp. & *Colletotrichum* sp.	Vellakkarithadam	C	L
	Glomerella sp.	Sadivayal	C	L
	Colletotrichum sp.	Hosekote	R	L
	Cercosporidium sp.	Dharampur	WS	S
	Alternaria sp.	Dharampur	R	L
	Unidentified	IFGTB, Coimbatore	C	S
	Unidentified	Hosekote	WS	S
	Unidentified	Dharampur	0	L
Powdery mildew	*Oidium* sp.	Peechi	WS	S
Dieback	*Hendersonula* sp.	Hosekote	VC	M
Stem decay	*Gliocladium*	Saadivayal	WS	S
	Basidiomycete	Khadalgobra	C	S
	Basidiomycete	Gangadharpur	WS	S
Root decay	Basidiomycete	Khadalgobra	C	S
Root rot	*Ganoderma lucidum* complex	Sapodiha Kusumadhari, Angamaly	WS	S
Heart rot	Basidiomycete	Kusumadhari	R	L

* WS, Widespread; VC, Very common; C, Common; O, Occasional; R, Rare
** S, Severe; M, Medium; L, Low.

Foliar tip necrosis

Only two foliar tip necrosis diseases were recorded in young (<2-year-old) species trial plots in West Bengal.

Colletotrichum tip necrosis

Occurrence: The disease was commonly found in species trial plot (1995) at Dharampur, West Bengal; disease severity was rated as low.

Symptoms: Necrosis, dull greyish in colour, was initiated at the tip and progressed downwards, sometimes covering up to one-fourth of phyllodes. The necrotic area became brittle and started to crack and break into smaller pieces. Occasionally, fructifications of the causal organism were also found over the necrotic tissues.

Associated organism: *Colletotrichum* sp. Colony on PDA light to dark greyish, effuse, reverse dark grey, sclerotia absent, acervuli absent; conidia born directly on small conidiophores; conidia few in numbers, small, hyaline cylindric, straight, guttulate, 7-l 1.5 μ x 2.3 μ.

Unidentified tip necrosis

Occurrence: The disease was observed in a trial plot (1995) at Dharampur, West Bengal only on a few plants in low incidence; the severity was also low.

Symptoms: Light brown necrotic lesions developed near the tip, which coalesced to form large necrotic spots. The spot advanced further affecting the lamina. The advancing margin of the spot was defined and lighter in colour. Numerous minute brown fructifications developed in the necrotic area.

Associated organism: Unidentified; non-sporulating Hyphomycete.

Foliar spots

A total of fourteen different types of foliar spot diseases were recorded based on symptom expression. Most of the diseases occurred at low incidence and were not of any serious consequence.

Curvularia foliar spot

Occurrence: The disease occurred occasionally on young phyllodes in a species trial (1995) at Dharampur, West Bengal; the disease severity was low.

Symptoms: The disease produced irregular shaped reddish brown spots scattered on the phyllode. The smaller spots coalesced to give rise to large irregular spots with diffuse margins. The infection was also observed at the phyllode tips and margins.

Associated organism: *Curvularia* sp. Colony on PDA dark blackish, spreading, effuse, reverse dark; mycelium pale brown, septate, branched; conidiosphores long, brown geniculate;conidia dark brown, kidney shaped, curved, 2-3 septate, middle cells larger and darker brown than the end cells, 16-34 μ x 9.2-13.8 μ.

Colletotrichum foliar spot

Occurrence: The disease was recorded in container plants (4-month-old) in a nursery at Vellakkarithadam near Peechi, Kerala. The infection was widespread and severe on mature phyllodes. The plants were closely spaced providing conducive microclimatic conditions for disease occurrence and spread.

Symptoms: The disease was characterised by initial circular to oval -reddish brown spots of variable sizes with raised defined margins. There were more spots in the centre and basal part of the phyllodes. Smaller spots coalesced to produce larger irregular spots. Severe infection caused premature defoliation.

Associated organism: *Colletotrichum* sp. Colony on PDA white with greyish centre, cottony; reverse pale; mycelitim hyaline, septate, branched with brown sclerotia, terminal or intercalary; conidiomata acervular, black; conidia numerous, hyaline, aseptate, guttulate, straight, oval, 9-20 μ x 3.0-4.6 μ.

Pestalotiopsis foliar spot

Occurrence: The disease was observed in a 6 month-old container nursery at Vellakkarithadam, near Peechi, Kerala. Although of low incidence, the infection was severe as it caused considerable damage to phyllodes.

Symptoms: Initially small dark brown spots coalesced to produce elongated dark brown to tan spots with irregular margins between the veins, occasionally spreading phyllode tips or margins. Severe infection caused yellowing and premature defoliation. The disease mostly occurred on younger phyllodes.

Associated organism: *Pestalotiopsis* sp. Colony on PDA white cottony, reverse pale; mycelium hyaline, septate, profusely branched; conidiomata acervular, black, aggregate, mostly towards the centre of the colony; conidia dark brown, numerous, 4-euseptate, straight fusiform, spindle shaped with two hyaline end cells, middle cells dark, 18-23 µ x 5.8-7.0 µ, apical cell conic with 2 appendages, filiform to spathulate, 11.5-23 µ basal cell truncate with a smaller appendage.

Pestalotiopsis foliar spot

Occurrence: The disease was recorded in a 6 month-old container nursery at Vellakkarithadam, near Peechi, Kerala. The incidence and severity of the disease were low.

Symptoms: The disease produced typical interveinal dark brown, large elongated spots with rounded/obtuse ends and dark margin only at the apical end. The spots enlarged more lengthwise than across; adjacent spots coalesced together to form larger spots. Numerous black coloured fructifications were produced in the necrotic area.

Associated organism: *Pestalotiopsis* sp. Colony on PDA white floccose, reverse pale; conidiomata acervular large, black, scattered in the mycelium; conidia dark brown, euseptate, straight, fusiform, spindle shaped, 18-23 µ x 4.6-5.8 µ, end cells hyaline; apical cell conic with two terminal appendages rarely three; spathulate 7- 16 µ. basal cell truncate with one small appendage, 2.3-4.6 µ.

Pestalotiopsis/Colletotrichum foliar spot

Occurrence: The foliar spot, recorded in 6-month-old container nursery at Vellakkarithadam, near Peechi, Kerala was quite common on mature phyllodes but the severity was rated as low.

Symptoms: The spots appeared as elongated necrotic areas, dark brown in colour on the laminae. The spots also grew over the veins unlike in the previous disease where they were restricted by veins. The margin of the spots was defined, slightly raised and dark brown in colour. Black fructifications of the causal organism developed over the spots.

Associated organisms: Both *Pestalotiopsis* sp. and *Colletotrichum* sp. were isolated consistently from the same spot.
Pestalotiopsis sp. Colony on PDA white, floccose with restricted growth; conidiomata acervular dark, restricted in the centre; conidia dark brown, 4-euseptate with 3 medium dark cells and 2 ends cells hyaline, straight fusiform, spindle shaped 20-23 µ x 7 µ apical cells conic with two appendages, spathulate, euguttulate, aseptate, 9.2-16.1 µ basal cell truncate with one appendage, 2.3-4.6 µ.
Colletotrichum sp. Colony on PDA grey, effuse, reverse palish grey; mycelium hyaline to pale to light brown, septate, acervuli absent conidia borne directly on small conidiophores; conidia hyaline, straight, cylindric, oblong, aseptate, guttulate, proximal end slightly pointed, distal end obtuse, 8.0-19.5 µ x 2.3-4.6 µ.

Glomerella foliar spot

Occurrence: The disease, recorded in a species trial (1990) at Sadivayal-Shiruvani, Tamil Nadu, was common on the mature phyllodes of lower branches. The severity was rated as low.

Symptoms: The disease appeared as circular to oval dark brown spots up to 3 mm in diam. The spots were surrounded by a light pale brown halo. Occasionally, the spots were marked by veins.

Associated organism: *Glomerella* sp. Colony on PDA light brown with immersed and scanty mycelium, reverse light greyish brown; sclerotia present, dark brown, terminal, 9.2-l 1.5 µ x 6.3 µ, ascocarp dark brown, spherical, 108-133 µ, acervuli absent, conidia borne on simple conidiophores; conidia, elongate, oblong straight, hyaline, aseptate, guttulate, 9.2-13.8 µ x 2.3 µ.

Colletotrichum foliar spot

Occurrence: The disease was recorded in a 0.5 ha plot (1992) with drip irrigation at Nallal, Hosekote, Karnataka. It was not of common occurrence and the severity was low.

Symptoms: Initially, the spots appeared as light pale brown interveinal areas which turned dark brown to dark tan, spots oval to elongated measuring upto 3-4 mm. The smaller spots coalesced to produce elongated necrotic areas. Spots also occurred at the margins and tips of phyllodes. The disease was observed only on mature phyllodes.

Associated organism: *Colletotrichum* sp. Colony on PDA dark greyish, floccose, reverse dark; conidiomata acervular, setae absent; conidia straight cylindric, oblong, aseptate, hyaline guttulate, 7-14 μ x 3.4-4.6 μ.

Cercosporidium foliar spot

Occurrence: This disease was recorded in a species trial plot (1995) at Dharampur, West Bengal. The disease was widespread and of serious consequences as it caused premature defoliation.

Symptoms: Initially, the spots appeared on the lower phyllodes and the infection progressed upwards, causing defoliation of the bottom phyllodes due to extensive spotting. Numerous spots appeared as dark reddish brown necrotic areas, circular to oval, l-2 mm in diam. (Fig. 15c). These spots increased in size to 3-4 mm across. When the expanding spots coalesced, large size necrotic spots were formed. Rarely, the spots also affected the veins.

Associated organism: *Cercosporidium acaciae* sp. nov. Colony on PDA dark brown, effuse, reverse dark; mycelium pale brown, septate, branched, conidiophores simple macronematous, unbranched, brown, septate, geniculate; conidiogenous cells sympodial, conidial old scarcae flat situated on the shoulders; conidia solitary, dry cylindrical, oval with conspicuous hilum, 1-septate, 11.5-16 μ x 7-l 1.5 μ.

Alternaria foliar spot

Occurrence: The disease was recorded on the same phyllode affected with Cercosporidium foliar spot at Dharampur, West Bengal. The incidence and severity of the disease were low.

Symptoms: The spots were light greyish circular to elliptical areas with rough outline measuring 2-3 mm. The spots mostly occurred near the base of the phyllode.

Associated organism: *Alternaria* sp. Colony on PDA greyish, floccose with concentric rings, alternating dark and lighter rings, reverse dark; mycelium dark brown, septate, highly branched; conidiophores dark brown, simple, septate, long, bearing conidia terminally; conidia dark brown, obclavate, oval, obovate generally with no beak, transverse septa 3, longitudinal septa 0-2, 18-23 μ x 7-12.6 μ conidia with beak very few septa, transverse up to l-3, longitudinal 0-1, dimensions 41.4-7 1.3 μ x 7.0-9.2 μ.

Unidentified foliar spot

Occurrence: The disease was observed in 2-month-old seedlings in the nursery of the Institute of Forest Genetics and Tree Breeding, Coimbatore, Tamil Nadu. The disease was very severe on mature phyllodes resulting in premature defoliation.

Symptoms: The disease appeared as minute dark reddish brown to maroon coloured spots, less than l mm in diam., spread throughout the lamina. These spots expanded to l-2 mm diam. and developed pale to light brown colour in the centre; coalesced spots formed larger irregular reddish brown coloured spots. Severely affected phyllodes abscised prematurely.

Associated organism: Unidentified; non-sporulating Hyphomycete.

Unidentified foliar spot

Occurrence: The disease, recorded in a 0.5 ha irrigation trial plot (1993) was widespread and severe on mature phyllodes. A similar disease was also recorded in a 1 ha trial plantation (1993) at Beede, Shimoga. Karnataka; the severity and incidence of the disease, found only on mature phyllodes, were very low.

Symptoms: Initially, the elliptical spots, about 1 cm long, appeared as light orange blotches with diffuse margins; these blotches when seen against the light appeared as yellowish, water-soaked areas. In these blotches small necrotic spots developed in concentric rings which coalesced to form large reddish brown to dark brown necrotic spots with light brown haloes around them; severely affected phyllodes abscissed prematurely.

Associated organism: Unidentified; non-sporulating Hyphomycete.

Unidentified foliar spot

Occurrence: This disease was recorded in a species trial plot (1995) at Dharampur, West Bengal. The incidence and severity of the disease were very low.

Symptoms: Numerous circular dark brown spots, 102 mm diam., appeared in the upper half of the lamina. The spots expanded and coalesced to form large necrotic areas extending from one margin to the other.

Associated organism: Unidentified; non-sporulating Hyphomycete.

Powdery mildew

Occurrence: Powdery mildew was found to affect 2- to 3-month-old seedlings in KFRI nursery during January-February. The disease was widespread and very severe resulting in premature defoliation.

Symptoms: All the phyllodes were covered with whitish powdery mass on the upper surface. Gradually, the lower surface also became infected. In severe cases even the petioles and stems were covered with the whitish powdery mass.

Causal organism: *Oidium* sp.

Dieback

Occurrence: Extensive dieback of *A. mangium* (ex CSIRO seed lot no. 15677) was recorded in a species trial plot (1989) at Nallal, Hosekote, Karnataka. Considering the damage and disease severity, a plot of 100 trees (10 x 10) was selected at random out of 380 trees and assessed for the incidence and severity of the disease. Of the 100 trees only 46 trees were found to be healthy, the rest were in various stages of disease development, including dead ones and those dead removed (Fig. 13). The figure shows a patchy distribution of the diseased trees. The disease was also recorded in two-year-old trees near Angamaly, Kerala.

Symptoms: The initial symptoms of dieback were yellowing of phyllodes and subsequent thinning of the upper crown, including the top. This was followed by complete defoliation and dieback of branches and death of the main stem in the upper crown. It resulted in the development of epicormic shoots giving affected trees a bushy appearance with dead tops (Figs 15 d,e,f). The infection progressed downwards killing all the primary and epicormic shoots. The process of killing of the main stem, development and subsequent death of epicormic shoots was repeated until the infection had killed the entire tree. No infection of roots was observed.

Etiology: A close examination of freshly affected trees showed that the infection was initiated in the top 25% of the crown. Initially, the younger branches were infected and showed dieback symptoms. From these branches the infection spread to the main stem often completely girdling and killing the upper part of the tree.

Associated organism: *Hendersonula* sp. was consistently isolated in pure culture from the diseased branches and main stem. Colony on PDA greyish black, effuse, appressed, reverse dark; conidiomata pycnidial, carbonaceous, black, eustromatic, synematous, I-to several per stroma, locules occurring at different levels in stroma; conidia extruded in cirri, at first l-celled, hyaline later 3-4 celled pale brown, 16.8 x 5.6 µ.

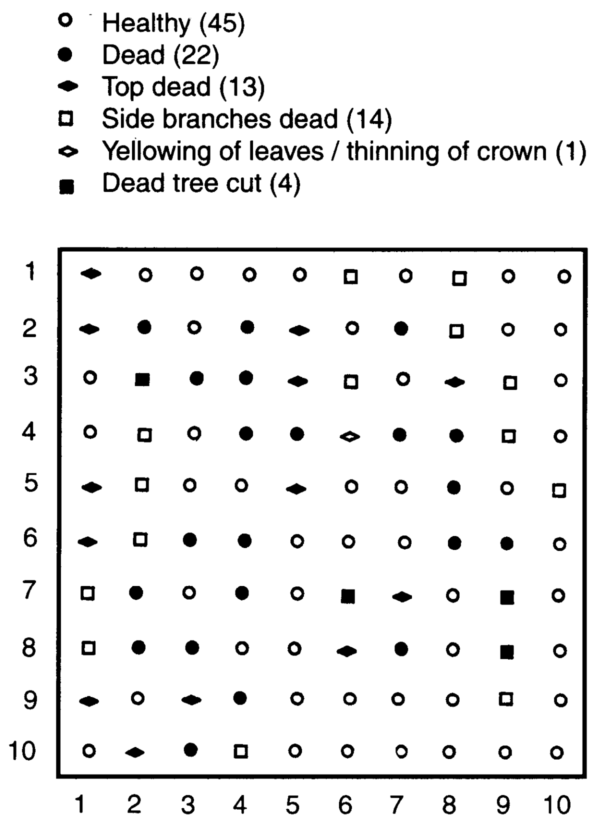

Figure 13. Incidence and severity of dieback of *Acacia mangium* at Hosekote, Bangalore. Figure in brackets indicates the number of trees.

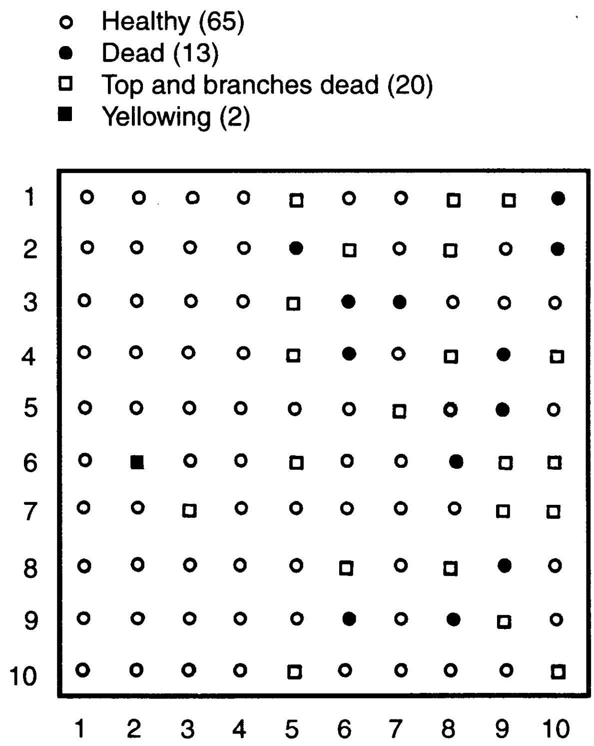

Figure 14. Incidence and severity of dieback of *Acacia auriculiformis* at Jarakbande, Bangalore. Figure in brackets indicates the number of trees.

Stem decay

Three different types of stem decay were recorded in *A. mangium*

Gliocladium stem decay

Occurrence: This disease was observed in a species trial plot (1990) at Sadivaayal, Shiruvani, Tamil Nadu. Of the 420 trees planted about 20 percent of them had already died due to the disease.

Symptoms: The affected trees had basal cankers, characterised by appressed bark on one side. When the bark was removed and a cut was made, the stem showed typical browning due to decay. When the decay advanced and girdled the stem completely the trees showed yellowing of phyllodes, defoliation and thinning of crown and ultimately death. Partially affected trees were infested by *Xyleborus.*

Etiology: It was not clear as to how the infection was initiated. The presence of the basal canker suggested that the infection took place near the ground level. Decay was also observed around the holes drilled by *Xyleborus,* indicating that possibly the infection started from the insect tunnels. Since roots could not be excavated the possibility of root infection could not be ruled out.

Associated organism: *Gliocladium* sp. was isolated from the decayed stem and decay around the insect holes. Colony on PDA dull orange, spreading, appressed reverse pale brown; mycelium hyaline to pale immersed, scanty; sporulation in concentric rings; spore masses produced in orangish yellow drops; conidiophores straight septate, branched; phialides penicilloid, primary and secondary, apex catenulate, producing chains of conidia, conidia hyaline, oval, small, 3.45-4.6 μ x 2.3 μ.

Above ground stem decay through branch stubs

Occurrence: Widespread stem decay through branch stubs was observed in a 1 ha plantation at Gangadharpur, West Bengal.

Symptoms: No external symptoms were visible. When the stubs were exposed, they showed browning extending by several centimetres in the sap and heartwood, both up and down the stem axis.

Etiology: The branches were lopped indiscriminately by the villagers for fire wood resulting in open injury through which the infection had taken place.

Associated organism: A basidiomycete was consistently isolated from all the decayed specimens.

Basal stem decay

Occurrence: Basal stem decay of *A. mangium* in a mixed planting with *A. auriculiformis* was observed at Khadalgobra; the latter species remained unaffected.

Symptoms: The affected tree had a prominent decayed area near the ground level without any bark; roots remained unaffected. On exposure, it was found that the sapwood had become very soft and spongy with black and white mycelial growth. The crown showed dieback of shoots and thinning of crown.

Associated organism: Basidiomycete; spongy rot/white rot.

Root decay and root rot

Root decay

Occurrence: Root decay was observed at Khadalgobra mixed planting (1987) where out of 1200 trees only 200 remained. The area was subjected to water logging during July-December, hence the plants had been raised on mounds.

Symptoms: The affected trees had extensive dieback of shoots, especially in the upper crown, bushy growth of epicormic shoots appeared due to death of the main leading shoot. The shoots also died as drying up of the main stem gradually advanced downwards. Roots of such trees were dying and showed typical decay symptoms. Feeder roots were decayed and turned greyish black and even some of the primary and secondary roots had greyish-black decay leading to the base of the stem.

Etiology: Possibly, water logging predisposed the decay initially in the feeder roots which later spread to other roots and stem.

Associated organism: Basidiomycete.

Root rot

Occurrence: Root rot was the most serious disease of *A. mangium* recorded in older plantations which had been converted into seed stands after removing inferior trees during 1993. These areas were Guchisola (1987), Sapodiha (1985) Kusumadhari (1985, 1986) and Manjhigarh (1989) in West Bengal. The mortality due to root rot was minimum at Guchisola (<l0 percent) and maximum at Kusumadhari (1985) where out of 238 trees counted during 1994 ca. 75 percent of them were already dead and removed at the time of survey. At Kusumadhari (1986) there were 16 freshly dying or dead and standing trees. At Sapodiha, of the 77 standing trees 15 trees were apparently affected with root rot while at Manjhigarh the mortality was also high as most of the trees in a 1.5 ha seed stand showed symptoms of root rot. The disease was also recorded in a two-year-old tree at Angamaly, Kerala.

Symptoms: Typical symptoms of root rot were yellowing of phyllodes, premature defoliation and death of branches initially only in the upper crown and later throughout followed by epicormic shoots on the dying main stem of trees in patches. The affected trees showing different stages of symptoms were felled and studied for disease etiology. The stem remained unaffected and only the roots were affected with extensive browning. Fructifications of the causal organism growing at the base of dead roots of living trees were also observed.

Associated organism: *Ganoderma lucidum* complex. From the affected roots pure cultures of a basidiomycetous fungus were obtained; the cultures resembled *Ganoderma* cultures.

Heart rot

Occurrence: Heart rot was detected at Kusumadhari (1986) West Bengal. Incidence of the disease could not be ascertained as it was not possible to cut trees in a seed stand. Considering the fact that the stubs of branches near the ground cut during singling in 1993 to convert the plantation to seed stand, were all decayed, the incidence of heart rot is likely to be very high.

Symptoms: In felled trees, rot was observed in the heart wood. The heart rot area was pale with dark zonation lines.

Etiology: The dead stubs decayed and colonised by wood rotting fungi possibly provided the entry points for decay fungus.

Associated organism: Basidiomycete. Isolations from the infected heartwood consistently yielded a basidiomycete with mycelium having clamp connections.

Diseases of *Acacia auriculiformis*

There were eight distinct disease symptoms recorded on *A. auriculiformis* with which 35 fungal organisms and one phytoplasma was found associated (Table 10). Based on symptoms there were numerous foliar diseases identifiable caused by similar or different pathogens.

Table 10. Diseases of *A. auriculiformis* recorded in India.

Disease	Causal organism	Locality	Disease status	
			Incidence*	Severity**
Foliar tip necrosis	*Colletotrichum* sp.	Neyveli	C	L
	Alternaria sp.	Dejuri	C	L
		Auroville		
Foliar spots	Unidentified	RV Puram	R	L
	Unidentified	Neyveli	0	L
	Unidentified	Neyveli	R	L
	Alternaria sp.	Neyveli	0	L
	Colletotrichum sp.	Hosekote, Mettupalayam Jarkbande	C	M
	Glomerella sp.	Auroville	C	M
	Unidentified	RV Puram	0	L
	Phomopsis sp.	Mettupalayam	0	L
	Pestalotiopsis sp.	RV Puram	0	L
	Phoma sp.	RV Puram	0	L
	Macrophomina sp.	Auroville	0	L
	Unidentified	Auroville	R	L
	Unidentified	Neyveli	0	L
	Glomerella sp.		C	M
	Alternaria sp.	Dejuri	0	L
	Phomopsis sp.	Jarakbande	C	M
	Unidentified	Auroville	C	M
	Colletotrichum sp.	Mettupalayam, Auroville RV Puram	C	M
	Cylindrocladium scoparium	RV Puram	VC	M
	Sooty mould Unidentified	Beede, Hosekote	VC	M
Powdery mildew	*Oidium* sp.	Thyaranadur, Beede	VC	S
Shoot blight	Unidentified	Ramavarmapuram	VC	S
Pod rot	*Fusicoccum* sp.	Neyveli	VC	M
Dieback	*Hendersonula* sp.	Jarakbande	C	S
Pink disease	*Corticium salmonicolor*	Trichur	C	M
Root rot	*Ganoderma*	RV Puram, Trichur	0	L
Witches broom	Phytoplasma	Calicut, Dejuri, Beede	O	L

* *VC, Very common; C, Common; O, Occasional; R, Rare*
** *S, Severe; M, Medium; L, Low.*

Foliar tip necrosis

Tip necrosis of phyllodes was caused by two different pathogens.

Colletotrichum tip necrosis

Occurrence: Although the disease was quite common in a roadside block plantation in Neyveli township, its severity was low.

Symptoms: Initially, the necrosis at the tip was brownish in colour later changing to greyish. The infection, localised at the tip of mature phyllodes, appeared as dull greyish necrotic areas with dark brown margins. The necrosis advanced further down leaving behind the previous dark brown margin.

Associated organism: *Colletotrichum* sp. Colony on PDA greyish brown, appressed reverse dark greyish-black; sclerotia spherical to variable shapes, numerous, dark brown terminal to intercalary, 7.0-l1.5 µ x 4.6-7.0 p; conidiomata non-acervular, conidia produced on simple conidiophores; conidia straight, cylindric, oblong, hyaline, aseptate, guttulate, 5.7-12.6 µ x 2.3 µ.

Alternaria tip necrosis

Occurrence: The disease was common in species trials (1995) at Dejuri and Dharampur, West Bengal and Auroville, Pondicherry. It did not cause much damage to the phyllodes except at the tip.

Symptoms: The disease affected the younger phyllodes near the growing shoot. The infection at the tip caused dark tan necrosis which advanced slowly downwards. The growing margin of the necrosis appeared dark brown.

Associated organism: *Alternaria* sp. Colony on PDA light olive green to greyish, effuse to floccose round restricted in growth; conidiophores light brown, straight, brown septate, 30-l 16 µ x 4.0-l1.5 µ conidia, produced in chains, olivaceous brown, obovate to oval with or without beak, varying sizes of beak; short beak conidia, transverse septa 1-8, longitudinal septa l-2, 30-58 µ x 4.6-l 1.5 µ; long beak conidia with 3-4 transverse and l-2 longitudinal septa, 80-152 µ x 3.2-l1.5 µ.

Foliar spots

Based on the morphology of the spots and associated organisms a total of thirty foliar spot diseases were recorded in *A. auriculiformis.* Diseases are arranged according to the size of spots and the damage they caused to phyllodes rather than by the taxonomic affinities of the associated fungi, few of which have been identified to species.

Unidentified foliar spot

Occurrence: The disease was recorded during September/October in a one-year-old experimental plantation at Ramavarmapuram, Trichur, Kerala. The incidence and severity of the infection were low.

Symptoms: The spots, light greyish with black margins and spherical to irregular in shape, were very minute (< l mm) and found only on the upper surface.

Associated organism: Unidentified; non-sporulating.

Unidentified foliar spot

Occurrence: The disease was recorded on young as well as mature phyllodes in a spacing trial at Neyveli, Tamil Nadu. The incidence and severity were very low.

Symptoms: Dark greyish black, minute spots (< l mm) were present on both surfaces of the phyllodes. As the spots were not deep seated they were not visible on the under surface.

Associated organism: Unidentified, Sphaeropidales/Ascomycete. Colony on PDA dark greyish, velvety, restricted growth, reverse dark; mycelium, dark brown septate; immersed; conidiomata pycnidial ostiolate, ostiole lined with thin walled large cells, hyaline, spherical, dark brown, long, finger-like lobed, branched, convoluted; conidia hyaline, straight to slightly curved, oblong to reniform, eguttulate non-septate, rarely 2-3 celled (unequal cells), 16-23 µ x 4.6-6.3 µ, conidia rarely with appendage like structure, possibly persistent conidiophores, hyaline, 9-54 µ long; same culture occasionally had ascocarps with asci: hyaline elongated thick walled at the tip inoperculate, 80-l15 µ x 6.9-9.2 µ ascospores spherical to oval, hyaline, thick walled, possibly 8 per ascus.

Unidentified foliar spot

Occurrence: This disease, found in Neyveli, Tamil Nadu was recorded on young phyllodes of only a few trees.

Symptoms: Numerous dark coloured spots, less than l mm across, were localised at the tip of the phyllodes. Initially, the spot appeared only on the upper surface and only later the lower surface developed the spots.

Associated organism: Unidentified; non-sporulating Hyphomycete. Colony on PDA dark greyish black, floccose; mycelium dark brown.

Alternaria foliar spot

Occurrence: The disease was recorded in an afforestation trial in a degraded rocky area at Auroville, Pondichery. The incidence and severity of this foliar spot were low.

Symptoms: The disease was characterised by small angular dark purplish spots (l-2 mm across), more on the upper surface of phyllodes. Only when some of the spots coalesced could the spots could be seen on the lower surface.

Associated organism: *Alternaria* sp. Colony on PDA dark, floccose, reverse dark; mycelium dark brown, septate, highly branched; conidiomata spherical, ostiolate, beaked, sterile perithecia like structures observed, 179-280 µ; conidia light brown produced in chains on simple dark brown conidiophore with short beak and 3-4 transverse and l-2 longitudinal septa, 18-36 µ x 7-l1 µ.

Colletotrichum foliar spot

Occurrence: The disease was common on lower branches in a species trial (1989) at Nallal, Hosekote, Karnataka. Young and mature phyllodes were equally affected. The incidence and severity of the disease were rated as medium.

Symptoms: Initially, the spots, dark brown in colour, were 1 mm across. These spots developed an elongated light greyish white area and appeared elliptical or spindle shaped. There were more spots in the upper surface than the lower. Most of the spots were of uniform size.

Associated organism: *Colletotrichum* sp. Colony on PDA light brown, effuse, reverse brownish; acervuli absent; conidia borne on short conidiophores directly on the mycelium; sclerotia present, dark brown 12.5 x 7.0 µ conidia hyaline, elongate, cylindric, oblong to narrowly oval, aseptate, guttulate, 9-14 µ x 2.3-3.4 µ.

Glomerella foliar spot

Occurrence: The disease was recorded in an afforestation trial plot in a rocky degraded site in Auroville, Pondicherry. Although the disease was common, severe infection occurred only in a few trees; young and mature phyllodes were equally susceptible (Fig. 16d).

Symptoms: The disease was characterised by amphigenous, dark brownish black, oval to spindle shaped spots with silvery grey to light brownish grey centres. The adjacent spots coalesced to form larger spots.

Associated organism: *Glomerella* sp. Colony on PDA initially dark brown turning greyish brown, lighter in the centre; reverse hyaline turning greyish black due to development of perithecia and sclerotia; sclerotia abundant, terminal to intercalary; perithecia spherical dark brown, wall textura angularis; conidiomata non-acervular, conidia borne directly on simple, short conidiophores.

Unidentified foliar spot

Occurrence: The disease, recorded in a plantation at Ramavarmapuram, Trichur, Kerala, was observed only on mature phyllodes. The incidence and severity of the disease were low.

Symptoms: Initially, the spots appeared as black blotches, 2-3 mm across on either the upper or lower surface of phyllodes. The centre of these spots became silvery white with characteristic thread-like growth radiating from the margin. Underneath the spots the tissue showed light greying in the centre with surrounding light brown tissue.

Associated organism: Unidentified non-sporulating Colony on PDA white, floccose with greyish brown sectoring, reverse white to pale; no conidiomata were observed.

Phomopsis foliar spot

Occurrence: This foliar spot disease was observed in a species trial plot (1986-87) at Mettupalayam, Tamil Nadu. The incidence and severity of the disease were very low as it occurred only in a few trees (Fig. 16c).

Symptoms: The amphigenous spots appeared spherical to elliptical dark brown to tan with a pale halo. Smaller spots (2-3 mm across) coalesced to form irregular larger spots, measuring 3-4 mm across.

Associated organism: *Phomopsis* sp. Colony on PDA white, mycelium sparse, corded, reverse pale brown; conidiomata pycnidial, black, carbonaceous, convulated; conidia of two types: cc-conidia, elliptical to spindle shaped, hyaline aseptate, guttulate, 6.9-10.4 µ x 2.3 µ; ß-conidia filiform, hyaline, eguttulate 25-39 µ x 1 µ.

Pestalotiopsis foliar spot

Occurrence: The disease was recorded in a plantation at Ramavarmapuram, Trichur, Kerala. The incidence and severity of the disease were low.

Symptoms: The disease, mostly occuring on the upper surface of mature phyllodes, was characterised by reddish brown spots, similar to pock marks with depressed centres, On the lower surface the spots appeared as dark brown slightly raised tissue. These spots coalesced to give rise to larger necrotic spots, especially near the tip region.

Associated organism: *Pestalotiopsis* sp. Colony on PDA white, cottony, spreading, reverse pale; conidiomata acervular, dark; sporulation scanty; conidia dark brown, elliptical, spindle shaped, 4-euseptate, middle 3 cells brown, centre cell darker than others, end cells hyaline, 20-23 µ x 7.0 µ apical cell conic with two filiform, spathulate occasionally branched, 14-25 µ long; appendage basal cell truncate with a basal appendage 4.6-7.0 µ.

Phoma foliar spot

Occurrence: This disease was recorded in a one-year-old experimental plantation at Ramavarmapuram, Trichur, Kerala. Since the disease was observed only on a few trees, it had low incidence and severity.

Symptoms: The disease observed on the upper surface of young as well as moderately mature phyllodes in the middle crown of the tree, was characterised by elongated streak-like white lesions up to 5-8 mm in length. Some of the lesions coalesced to give rise to irregular shaped lesions. In severe cases the lesions also developed on the lower surface. Black dot-like pycnidia were observed in the lesions.

Associated organism: *Phoma* sp. Colony on PDA light brown, mycelium immersed, scanty; conidiomata pycnidial, thin walled, spherical ostiolate; conidia, small, circular to oval, minute, pale in colour.

Macrophomina foliar spot

Occurrence: The disease was recorded in a roadside block planting at Auroville, Pondicherry. The incidence and severity of the disease were low.

Symptoms: Dark brown to purplish brown amphigeneous spots were produced on young as well as mature phyllodes. The spots, oval to elliptical to spindle shaped, 2-3 mm in length, were localised mostly at the margin; only a few spots developed on the lamina. When the spots joined, long irregular shaped lesions were produced.

Associated organism: *Macrophomina* sp. Colony on PDA, effuse, dark greyish black; reverse dark, slow growing; mycelium branched, septate, dark brown, conidiomata pycnidial, eustromatic, separate or clustered, with thick dark brown wall, textura angularis, pseudo sclerenchymatous, superficial in culture, scattered; conidia hyaline, aseptate, oval, guttulate with rounded ends, 11.5-13.8 μ x 4.0-4.6 μ.

Unidentified foliar spot

Occurrence: Low incidence of this disease was recorded in a few branches of two trees at Auroville, Pondicherry.

Symptoms: Dark brown spots, usually over the veins and distinct brown colour on the underside of the phyllodes were the typical symptoms of the disease.

Associated organism: Unidentified; non-sporulating Hyphomycete.

Unidentified foliar spot

Occurrence: This disease was recorded in a spacing trial at Neyveli, Tamil Nadu and roadside block plantation at Auroville, Pondicherry. The incidence and severity of the disease were very low.

Symptoms: The phyllodes had reddish brown elongated amphigeneous lesions, up to 1 cm long and 2-3 cm wide having irregular dark brown margins. Each phyllode had only a few spots (3-8). Occasionally, these spots coalesced, especially near the tip or margins to form larger spots; sometimes fructifications were also observed over the lesions.

Associated organism: Unidentified.

Glomerella foliar spot

Occurrence: The spot disease, observed in a species trial plot at Jarakbande, Bangalore, Karnataka, was common and of medium severity.

Symptoms: The typical symptoms of the disease were dark brown, irregular, large amphigenous spots with light greyish brown centre (Fig. 16d). The tissues around each spot were light yellowish. Such spots occurred mostly on mature phyllodes on the lower branches. Severely infected phyllodes abscissed prematurely.

Associated organism: *Glomerella* sp. Colony on PDA white turning greyish, floccose, reverse light to dark grey; sclerotia abundant, light to dark brown thick walled, mostly terminal, occasionally intercalary, oval, spherical to clavate to irregular shaped 11.5-16 μ x 4.6-11.5 μ, perithecia abundant, light to dark brown, spherical, 86-162 μ in diam.; conidiomata non-acervular, conidia borne on simple, short conidiophores; conidia, oblong, hyaline aseptate, guttulate, upper end obtuse, lower slightly pointed, 9.0-16.0 μ x 2.3-4.6 μ.

Alternaria foliar spot

Occurrence: This disease was recorded only at Dejuri, West Bengal in a species trial (1995). The incidence and severity of the disease were low.

symptoms: The spots were elongated interveinal brown coloured blotches with diffused margins. These coalesced to develop into large necrotic areas which resulted in premature defoliation.

Associated organism: *Alternaria* sp. Colony on PDA dark grey to olivaceous grey, floccose, reverse dark; conidia, borne terminally in chains, at times on geniculations at the side of conidiosphores, septate simple or branched, 115-159 μ x 4.6 μ, conidia pale brown to dark brown, highly variable in shape, oval obclavate; shorter Conidia, either in chains or singly, thick walled, smooth, vertical septa 0-3, oblique 0-l, constricted at the septum 9-22 μ x 7.0-l 1.5 μ, longer conidia with long beak, transverse septa 1-18, 69-124 μ x 4.6-9.2 μ.

Phomopsis foliar spot

Occurrence: The disease was recorded on lower branches only at Jarakbande, Bangalore, Karnataka on roadside trees of the research station. The incidence and severity were medium.

Symptoms: Initially dull light brown to light greyish brown amphigeneous spots, oval, ovate, up to 1 cm long with dark brown margin developed near the tip of phyllodes (Fig. 16c). The necrotic spots enlarged and covered the tip causing necrosis of the tip, covering up to half of the phyllodes. Fructifications were found on the necrotic spots. Severely infected phyllodes abscissed prematurely.

Associated organism: *Phomopsis* sp. Colony on PDA white turning dull light brown, appressed, reverse brownish; conidiomata pycnidial, scattered, dark multilocular, convoluted; only a-conidia present, hyaline, spindle shaped with pointed ends, guttulate, 4.6-l1.5 µ x 1.7-2.3 µ.

Unidentified foliar spot

Occurrence: This foliar spot was recorded from the roadside block amenity planting at Auroville, Pondicherry. The disease was common with medium severity.

Symptoms: The disease mostly affected younger phyllodes which had initially 2-3 cm long, dark reddish brown necrotic lesions running lengthwise, mostly over the veins, These lesions enlarged lengthwise and coalesced to form long lesions running from the tip to the bottom of the phyllodes. Such lesions were found either at the margins or on the lamina. Fructifications of the causal organism were observed in the necrotic lesions.

Associated organism: Unidentified; non-sporulating Hyphomycete.

Colletotrichum foliar spot

Occurrence: This disease was recorded in a species trial (1986-87) at Mettupalayam, Tamil Nadu, in an afforestation trial at Auroville, Pondicherry and in a plantation at Ramavarmapuram, Kerala. At Ramavarmapuram, it was widespread on young regenerated seedlings as well as on lower branches.

Symptoms: Lesions were mostly localised along the margins. Initially longish dark brown amphigenous lesions, l-3 mm long, developed along the margins. These lesions enlarged, more lengthwise and coalesced to form one long lesion running throughout the length of the phyllode. The lesions were greyish on the upper surface and dark brown on the lower surface. Fructifications of the causal organism were observed over the lesions. Severely infected phyllodes abscissed prematurely.

Associated organism: *Colletotrichum* sp.

Cylindrocladium foliar spot

Occurrence: This foliar spot was recorded during October, just after the rains, in a plantation at Ramavarmapuram, Kerala. It was common on naturally regenerated seedlings and lower branches of trees. Severity was high in seedlings.

Symptoms: The disease was characterised by large reddish brown necrotic areas, usually along the margins and tip. The affected phyllodes abscissed prematurely.

Associated organism: *Cylindrocladium scoparium* Morgan. Colony on PDA reddish brown in the centre and light dull yellowish towards the periphery, cottony, fluffy; reverse dark brown; conidia produced in abundance, hyaline, cylindric, I-septate, rarely 3-septate, 32.2-41.4 µ x 2.3-4.6 µ; sterile hyphae 80.5-179.4 µ long bearing globose vesicle 9.2-l1.5 µ.

Black mildew

Occurrence: Black mildew was quite common in plantations and species trials at Hosekote and Beede, Karnataka, Kottappara and Ramavarmapuram, Kerala. Infection of medium severity was observed at Beede.

Symptoms: The disease appeared in the form of superficial black irregular to round patches initially on the upper surface. Under warm and humid conditions these patches enlarged and coalesced to give rise to large patches. In severe cases the infection also extended to the lower surface. Severely infected phyllodes abscissed prematurely.

Causal organism: *Meliola* sp.

Powdery mildew

Occurrence: In plantations, powdery mildew was recorded at Tyarandur and Beede, Karnataka where l-year-old plants of Springvale provenance were found to be very susceptible. In an assessment at Beede, the incidence of powdery mildew was 88 percent. The phyllodes of all the affected trees were covered with white powdery masses and of these more than 10 percent of the trees were severely affected.

Symptoms: Phyllodes of various stages of maturity were affected with powdery mildew. This was characterised by the presence of white powdery masses on the upper surface. In severe cases, the infection also extended to the lower surface. Severely infected phyllodes showed curling, puckering and browning and abscissed prematurely.

Causal organism: *Oidium* sp.

Shoot blight

Occurrence: Shoot blight was recorded in a l-year-old experimental plantation at Ramavarmapuram, Kerala and Dharampur, West Bengal. At Dharampur the incidence was about 30 percent while at Ramavarmapuram, it was less than 1 percent.

Symptoms: The apical bud and 2-3 young phyllodes appeared blighted as they turned blackish brown. The tip of other phyllodes just below the blighted ones showed tip necrosis.

Associated organism: *Phomopsis* sp. Colony on PDA white turning dull with dark brown sectoring, appressed, reverse pale greyish; conidiomata pycnidial.

Pod rot

Occurrence: Pod rot was observed in a roadside block plantation at Neyveli, Tamil Nadu. The incidence of pod rot was quite high as a large number of immature pods were drying up and being shed.

Symptoms: Dull purplish brown spots were seen on green pods, especially in the lower and middle parts of the crown. These spots coalesced to form large necrotic areas. The affected pods dried up and shed prematurely. Seeds inside the pods were found to be shrivelled and brown in colour.

Associated organism: *Fusicoccum* sp.

Colony on PDA slow growing, effuse to floccose, reverse dark; mycelium dark, branched, septate; conidiomata pycnidial, eustromatic, synnematous, mostly produced in clusters on tufts of mycelium; pycnidia dark, thick walled, textura angularis; conidia hyaline, thin walled, aseptate, rounded ends and bulged in the middle, straight, eguttulate, cylindrical with truncate base, 23-27.6 µ x 4.6 µ.

Dieback

Occurrence: Dieback of *A. auriculiformis* was recorded in a species trial plantation at Jarakbande, Bangalore, Karnataka. The disease occurred in patches and ultimately killed the trees. The average incidence was estimated to be about 20-25 percent (Fig. 14).

Symptoms: Dieback of *A. auriculiformis* appeared to be similar to that of *A. mangium* at Nallal, Hosekote, Karnataka. The infection occurred in the upper portion of the crown. Initially, young shoots were affected and killed and the infection spread to the main stem. As a result of this the main stem produced numerous epicormic shoots. As the infection moved downwards the epicormic shoots produced above died and fresh shoots were produced on the healthy part of the stem (Figs. 16 e,f). This process continued until the infection had killed the main stem as well as all the side branches, eventually killing the whole tree; the roots remained unaffected. The main difference from the dieback of *A. mangium* was the greyish black colouration of the bark and sapwood, seen clearly after exposing it with a sharp knife.

Causal organism: *Hendersonula* sp. Cultural characters were similar to that of the isolate from *A. mangium.*

Pink disease

Occurrence: Pink disease of *A. auriculiformis,* mostly causing branch death, occurred commonly in Kerala due to prevailing conducive micro- and macro-climatic conditions as well as presence of a large number of alternate hosts. The incidence of the disease was recorded in a plantation at Ramavarmapuram, Kerala and roadside strip plantations stretching for about 3 km along the Trichur-Palghat highway. At Ramavarmapuram, the disease was more common (40-50 percent) in trees at the periphery; average incidence was low (less than 10 percent). In roadside plantations, the incidence was as high as 80 percent, killing more than 2-3 top/side branches in the upper crown. Infection of the main stem, though observed occasionally was not common.

Symptoms: The typical symptoms were yellowing and wilting of phyllodes of shoots followed by defoliation. On the affected branches the fungus produced only the cobweb and pustule stages and no perfect or Necator stages were observed.

Causal organism: *Corticium salmonicolor* Berk & Br.

Root rot

Occurrence: Root rot of *A. auriculiformis* was recorded at Ramavarmapuram, Kerala plantation (1989), Calicut University Campus, Kerala and mixed plantation (1987) Arabari, Midnapur, West Bengal in a block plantation. Except at Calicut where the incidence of dead trees was high, only a few trees were found to be affected in the other localities.

Symptoms: The affected trees showed yellowing of phyllodes, thinning of crown due to premature defoliation followed by death of trees. The fructifications of the fungus were produced at the base of dead stems just after the first showers in June. On dead stems numerous fructifications developed during June-September.

Associated organism: *Ganoderma lucidum* complex.

Witches broom

Occurrence: A single tree affected by witches broom was recorded in 1993 at an experimental plantation at Beede, Karnataka.

Symptoms: The affected tree was considerably stunted in growth compared to nearby healthy trees. The size of phyllodes and internodes was reduced greatly. The shape of phyllodes near the shoot apex was transformed into needle like structures. The axillary buds also sprouted producing abnormally stunted shoots. This gave rise to the appearance of witches broom.

Causal organism: Possibly a phytoplasma.

Discussion

Forest disease surveys are usually aimed at periodical or continuous surveillance of forests or plantations with the objective of detecting or even predicting outbreaks of disease and damage, and diagnosis of the cause with a view to suggesting appropriate strategies to reduce disease damage. The outcome of such surveys form the basis for assigning priorities for intensive research on specific disease problems. In this context the present disease survey, although not as exhaustive as the earlier one by Sharma *et al.* (1985) in Kerala State, India, provides very important information on the spectrum of diseases in four major *Acacia* species i.e., *A. aulacocarpa, A. crassicarpa, A. mangium* and *A. auriculiformis* and identifies serious disease problems affecting them. Due to shortage of time it was not possible to visit all the southern states in India where exotic acacias have been introduced, nevertheless the disease survey fulfilled the objectives. Since the effort was to record all the diseases encountered, whether of minor or major importance, a large number of diseases have been recorded.

The maximum number of diseases were recorded on *A. auriculiformis* followed by *A. mangium, A. crassicarpa and A. aulacocarpa* (Table 11). The occurrence of a large number of diseases on *A. auriculiformis* is possibly due to its suceptibility to disease, in addition to its early introduction and large-scale cultivation compared to other species. Figures 15 and 16 show some of the more serious diseases observed during the survey.

The survey recorded a number of new and interesting diseases. All the diseases recorded on *A. aulacocarpa* and *A. crassicarpa* are new records for India. In *A. mangium* except for Glomerella foliar spot and sooty mould all the diseases are first records whereas on *A. auriculiformis* except for five diseases (Alternaria foliar spot, Phomopsis foliar spot, Colletotrichum foliar spot, pink disease and Ganoderma root rot) the rest are new host records. Exserohilum foliar spot, earlier reported by Mohanan and Sharma (1984) from Madurai, Tamil Nadu was not encountered during this survey, possibly due to seasonal differences in the time of survey.

It is quite interesting to note that all the *Acacia* species suffer more from foliar diseases than diseases of other plant parts. However, the number of fungal genera involved is not large as different species of the same genus produced variable symptoms. The common genera associated with most of the foliar diseases were *Colletotrichum, Pestalotiopsis, Alternaria, Curvularia* and *Phomopsis.* In addition, there are several fungal isolates yet to be identified being non-sporulating in culture. However, if we consider the most damaging of the diseases then it is apparent that they are diseases of the stem and root as they result in mortality of trees.

Table 11. Number of diseases and the most serious diseases recorded during this survey on *A. aulacocarpa, A. crassicarpa, A. mangium and A. auriculiformis* in India.

Plant parts affected	Total number of diseases and most damaging diseases			
	A. aulacocarpa	*A. crassicarpa*	*A. mangium*	*A. auriculiformis*
Foliage	11; Phomopsis foliar spot	16; nil	17; Colletotrichum foliar spot, Pestalotiopsis foliar spot, Cercosporidium foliar spot	25; Powdery mildew Shoot blight
Stem	1; Branch canker	1; Basal stem canker and root decay	4; Dieback	2; Dieback
Root	1; Root decay		2; Root rot	1; Root rot
Total	13	17	23	28

In most of the species trials surveyed the mortality of *A. aulacocarpa* and *A. crassicarpa* was high due to root rot caused by unknown basidiomycetes. During the survey it was not possible to collect the fruit bodies of the causal organism as the dead trees, on which the fruit bodies may develop, were not retained in the plots to maintain hygiene. However, in most cases the fructifications of macrofungi appear just after the initiation of rains during June/July and survive for a few months only as they are commonly attacked by insects. Further surveys are needed to establish the identity of the causal organisms so that appropriate management strategies may be developed.

In *A. mangium* the most damaging diseases recorded were root rot caused by *Ganoderma lucidum* complex in the State of West Bengal and dieback caused by *Hendersonula* in Karnataka. Ganoderma root rot of *A. mangium* is considered to be a serious problem also in Papua New Guinea (Arentz, 1993). Considering the high mortality of trees in some of the seed stands, Ganoderma root rot in West Bengal appears to be both damaging and wide-spread. Further studies are urgently needed to understand the pathogen behaviour and etiology of the disease so that appropriate steps including search for disease resistance in different provenances may be taken.

Equally important and serious is the dieback of *A. mangium* associated with infection by *Hendersonula* sp. discovered in Nalla, Hosekote, Karnataka, which deserves immediate attention. While *A. mangium* at Hosekote suffered heavily from dieback the adjacent plot of a provenance of *A. auriculiformis* from Australia was unaffected. However, at Jarakbande some 40 km away, only *A. auriculiformis* had dieback and the adjacent *A. mangium* plot was unaffected. Considering the fact that the dieback of both species was caused by the same pathogen, this outcome could be due to host variation (provenances) or pathogen variation as the climatic conditions and soil are almost identical in these two locations. Although Ganoderma root rot of *A. auriculiformis* has been recorded earlier from India as causing mortality, the extent of damage was not as high as in the case of *A. mangium*. Further surveys are required in other States such as Maharashtra, Orissa and Bihar where the species is grown on a large-scale.

Conclusion

The present disease survey has revealed that the four Australian *Acacia* species suffer from potentially serious diseases, especially Ganoderma root rot of *A. mangium* in West Bengal, and Hendersonula dieback of *A. mangium* and *A. auriculiformis* in Karnataka. Equally serious are root decay of *A. aulacocarpa* and basal stem canker and root decay of *A. crassicarpa*. Furthermore, the survey shows the importance of species/provenance trials established in different parts of the country in assessing or evaluating the susceptibility to disease of different species/provenance growing under identical conditions, in addition to evaluation of their growth performance. It is suggested that further surveys be conducted in other States where species/provenance trials have been established to obtain a more comprehensive picture of the disease situation of Australian acacias in India.

Acknowledgements

The authors are grateful to Dr S. Chand Basha, former Director and Dr K.S.S. Nair, Director, KFRI for allowing us to undertake this project and their support in various ways. We wish to thank CIFOR and ACIAR for funding the regional project on Diseases of Acacias and providing an opportunity to conduct the disease survey in India, and Dr Ken Old, CSIRO, Australia and Dr Christian Cossalter, CIFOR, Indonesia for their initiative, dynamic leadership and successful implementation of this project. Our thanks are also due to the following with whose support this disease survey was made possible; Mr Meera Sai Baba, DCF, Madras, Mr S. Rajput, DCF, Coimbatore, and Forester, Neyveli, Trial Plot of Research Wing, Tamil Nadu Forest Department; Prof. R. Jambulingam, Dept. of Forestry, Tamil Nadu Agricultural University, Mettupalayam; Mr Ravi Ralf, CF, Bangalore and Mr P.P. Banerjee, ACF, Kolar of Silvicultural Research Wing, Karnataka Forest Department; Mr G.K. Shenav, CCF and Director (Forests), Mr G.S. Kariyappa, DCF and Chief Forestry Officer (Research), Mr B.K. Mohammed Amanulla, Dy. Manager (Forests of Mysore Paper Mills, Shimoga, Karnataka, Dr Kalyan Chakrabarti, CF, Calcutta and Mr S. Barari, DFP, Midnapore of Research Wing of West Bengal Forest Department. We are also thankful to Mr Subash Kuriakose for preparing illustrations and Mrs Sumangala Amma for word processing the report.

References

Arentz, F. (1993). Root rot in plantations of *Acacia auriculiformis* and *A. mangium***.** In *Impact of Diseases and Insect Pests in Tropical Forests.* (Eds K.S.S. Nair and J.K. Sharma) Proceedings of IUFRO Symposium, 23-28 November 1993, Kerala Forest Research Institute, Peechi, India. (in press).

Bagchee, K. (1945). Pathological notes. No.2. Wilt and die back on shisham (*Dalbergia sissoo*), babul (*Acacia nilotica*) and Kair (*A. catechu*) in the artificial generation under agriculture-cum-forestry management. *Indian Forester* **71***:* 20-24.

Bagchee, K. (1958). Diseases of forest trees in India - causes, effects and methods of prevention. *Indian Forester* **84**: 407-417.

Bakshi, B.K. (1957). Fungal diseases of khair (*Acacia catechu* Willd.) and their prevention. *Indian Forester* **83**: 41-46.

Boa, E., and Lenné J. (1994). *Diseases of Nitrogen Fixing Trees in Developing Countries: An Annotated List.* Natural Resources Institute, ODA, Chatham, U.K., 82 p.

Browne, F.G. (1957). *Pests and Diseases of Forest Plantation Trees*: An Annotated List of the Principal Species occurring in the British Commonwealth. Clarendon Press, Oxford.

Florence, E.J.M., and Balasundaran, M. (1991). Occurrence of pink disease of *Acacia auriculiformis* in Kerala. *Indian Forester* **117**: 494-496.

Gibson, I.A.S. (1975). *Diseases of forest trees widely planted as exotics in the tropics and the Southern Hemisphere.* Part I. Important Members of the Myrtaceae, Leguminosae, Verbenaceae and Melioceae. Commonwealth Mycological Institute, Kew, Surrey, England.

Mehrotra, M.D. (1990). *Rhizoctonia solani,* a potentially dangerous pathogen of Khasi pine and hardwoods in forest nurseries. *European Journal of Forest Pathology.* **20**: 329-338.

Mohanan, C., and Sharma, J.K. (1988). Diseases of exotic acacias in India. *Journal of Tropical Forestry.* **4**: 357-36 1.

Sharma, J.K., Mohanan, C., and Florence, E.J.M. (1985). *Disease survey in nurseries and plantations of forest tree species grown in Kerala.*KFRI Res. Rep. No.36, Kerala Forest Research Institute, Peechi, Kerala, India, 268 p.

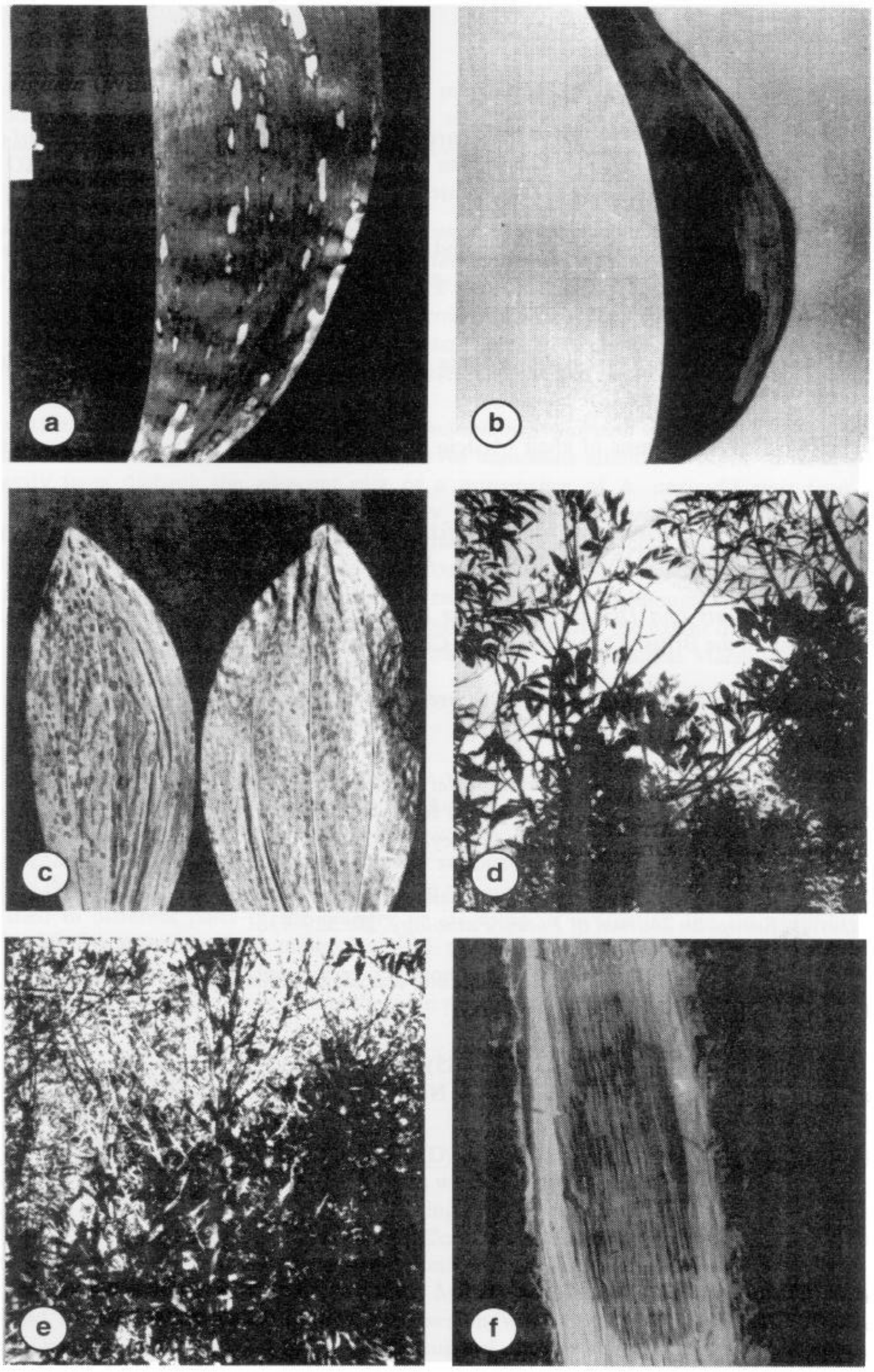

Figure 15 Diseases of *Acacia* spp.:

a-b) *A. crassicarpa.*

a) Glomerella foliar spot.

b) Alternaria foliar spot.

c-d) *A. mangium.*

c) Cercosporidium foliar spot.

d-f) Dieback of *A. mangium* caused by *Hendersonula* sp.

d) Dieback of shoots in the upper crown accompanied by yellowing of phyllodes.

e) Extensive dieback in upper crown and production of epicormic shoots.

f) Infected branch split to show the spread of infection from younger branches.

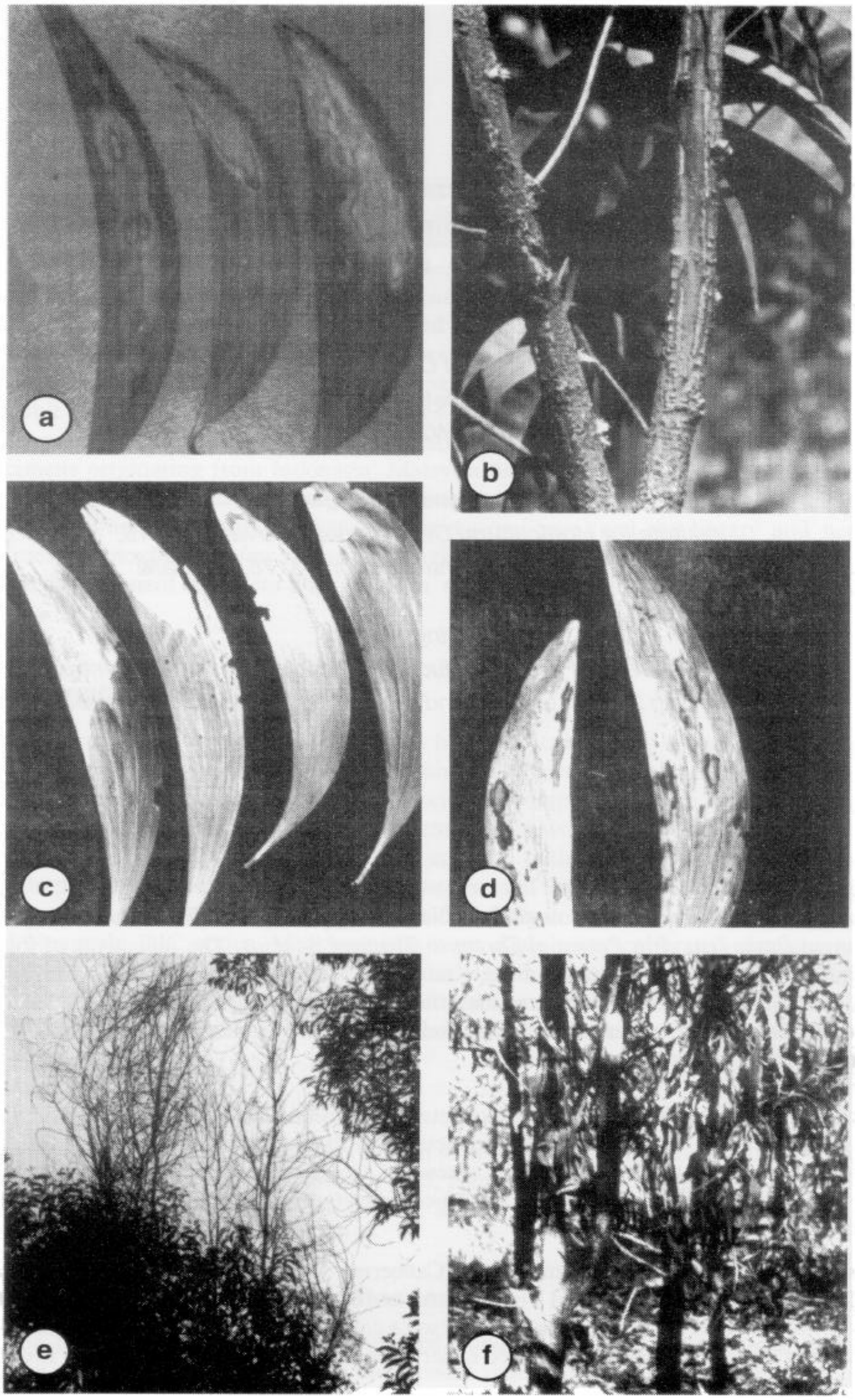

Figure 16. Diseases of *Acacia* spp.:

a-b) *A. aulacocarpa.*

a) Phomopsis foliar spot.

b) Branch canker caused by *Cytospora* sp.

c-d) *A. auriculiformis.*

c) Phomopsis foliar spot.

d) Glomerella foliar spot.

e-f) Dieback of *A. auriculiformis* caused by *Hendersonula* sp.

e) Extensive dieback in the upper crown.

f) Repeated dieback of epicormic shoots.

Report on Fungi from Diseased Acacia Samples Examined at Institute of Horticultural Development, Knoxfield Victoria

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Abstract

This report summarises outcomes of mycological studies in support of the CIFOR/ACIAR sponsored research programme *Fungal Pathogens as a Potential Threat to Tropical Acacias.* The objectives of the project carried out at the Institute for Horticultural Development, Knoxfield, Victoria, Australia (IHD) during a period of two weeks were; i) to sort and categorise, with some identification, of research material (fungal pathogens) collected by the project's collaborators in Australia, India, Indonesia, Malaysia and Thailand, and ii) to assist with identification of the more unusual taxa.

Work was carried out during a period of two weeks between 19 February and 4 March at IHD. During this time, dried specimens of putative fungal pathogens associated with phyllodes or bark samples were examined, identified, and their pathological significance assessed. Concentrating on fungi which appeared to be pathologically active and on those which could not be completely identified, species were described to facilitate future reference.

A total of 67 specimens were received from CSIRO (Canberra). Of these, 51 originated from Australia, and the remaining 16 from Indonesia, Malaysia and Thailand. All were collected by the Australian collaborators. A total of 35 fungal species was detected, of which only three were considered serious risks to *Acacia* plantations. Many specimens contained fungi which were considered either to be saprobic, or minor secondary invaders.

Text selected from a more complete mycological report submitted to CIFOR by Dr Paul Cannon (K.M. Old)

Introduction

The objective of this research was to provide identifications of representative specimens of *Acacia* diseases collected by forest pathologists from the contributing countries (Australia, India, Indonesia, Malaysia, and Thailand), concentrating on fungi likely to pose significant disease threat, and on critical groups in terms of the expertise needed for identification. Four species of *Acacia* were highlighted as of particular significance for the research programme, *Acacia aulacocarpa, A. auriculiformis, A. crassicarpa* and *A. mangium.* Collections of potential disease-causing fungi were to be screened by the forest pathologists prior to their arrival in Knoxfield, in order to reduce the time necessary for characterization of the fungal species involved. A period of two weeks in late February 1996 was spent in the Institute for Horticultural Development researching the identity and possible pathological significance of a series of dried specimens of diseased *Acacia* phyllodes and stems collected in northern and eastern Australia (primarily Queensland but also from the Northern Territory), with a few specimens originating from Indonesia, Malaysia and Thailand. No living material (cultures) was received. The specimens were examined using procedures detailed below, and the various fungi present were identified using a combination of the collaborator's own experience, and the library and herbarium (dried collection) facilities at Knoxfield. A few species of fungi were noted as being of potential significance in the establishment and development of *Acacia* plantations in northern Australia and South East Asia.

Materials and methods

A total of 67 collections of *Acacia* phyllodes and twigs from tropical regions of Australia (5 1 specimens) and Indonesia (9), Malaysia (2) and Thailand (5) were examined for disease symptoms, and the fungi present were identified. No cultural work was carried out. The specimens comprised one to several phyllodes, or small sections of twig or branch. They were dried to prevent overgrowth by saprobes, and the extra-Australian collections were subjected to gamma ray irradiation to conform with quarantine regulations. Specimens were examined with a high power binocular dissecting microscope, and fungal colonies removed using a scalpel tip. Squash mounts were made in water, lactic acid, and acid fuchsin in lactoglycerol. These were observed using bright field and Nomarski DIC optics. Measurements were made using calibrated eyepiece micrometers, of material mounted in lactofuchsin unless stated otherwise. Hand sections of fruit bodies and hyphal growth within phyllodes were made using fragments of double-edged razor blades mounted in a holder. The specimens and permanent slides made from them will be kept for further reference in the VPRI herbarium.

Results

Table 1 lists various fungi identified from the herbarium material, which were identified by reference to texts listed below. Corlett, (1991); Ellis, 1971); Gibson, (1975; Hansford, (1953) Laessoe *et al.*, (1989); McAlpine, (1906); Miller, (1961); Nag Raj, (1993); Petrak, (1953); Steyaert, (1953); Sutton, (1975); Sutton, (1980); Yuan, (1996).

Species of potential pathological significance

A large proportion of the specimens received contained fungi which were judged to be either saprobic, or secondary invaders after insect pest damage or mechanical injury (Table 1). A further range of species was considered as biotrophic (deriving nutrition from living host tissue without killing it), but of marginal pathological relevance. The species which were identified as of potentially significant impact for forest health are detailed below.

Fungus gen. indet., aff *Pseudocercospora*

This apparently undescribed fungus causes serious phyllode blight and curling on *Acacia crassicarpa,* and has been reported from several sites in northern Queensland and Melville Island (Northern Territory), Australia. The classification and pathology of this species certainly needs further study, as the fungus might prove to be a serious limiting factor in the development of *Acacia crassicarpa* plantations in South East Asia. In particular, the method of transmission is not known. Similar fungi are not seed-borne, but as its affinities are not known with certainty, it would be unwise to assume that this is the case.

***Atelocauda digitata* (Wint.) Cummins & Hiratsuka**

This phyllode rust is widespread throughout northern, eastern and south-eastern Australia, and may cause serious disruption to living plant tissue. Many texts (e.g. Boa & Lenné, 1994) refer to it either as *Uromyces digitatus* or *U. phyllodiorum.* The species as currently circumscribed is very variable, and in some circumstances prominent galls develop. A research programme to investigate its morphological and pathological variation may be appropriate, and also to chart its distribution. The species has already been identified from two localities in Indonesia (Turnbull, 1986; Boa & Lené, 1994) and is reported in this workshop proceedings as occurring in Java and Kalimantan. The fungus also occurs in Hawaii (Hodges and Gardner, 1984) and was collected from *Acacia* phyllodes in Hong Kong by Dr Cannon in the course of his return to the UK from Australia. Quarantine protection therefore becomes complex.It is not seed-borne, but at least in some locations in South East Asia further plantations would be susceptible to the disease due to air-borne transmission from surrounding trees.

Cercospora sp.

A species of *Cercospora* was reported to cause serious disease of *Acacia* trees in Queensland in the initial grant application, but material of the fungus was not included in the specimens sent to Melbourne. We cannot therefore comment further on the possible threat to production, but other species of this genus are serious pathogens.

***Colletotrichum gloeosporioides* (Pew) Sacc.**

This species was identified from one specimen submitted, and appears to be the primary cause of the phyllode spot (customarily referred to as anthracnose). *C. gloeosporioides* is a complex of species which range from wide-spectrum saprobes and weak parasites and secondary colonizers, to narrowly host-specific and serious primary pathogens. Some strains develop ascomata; they are then referred to as *Glomerella cingulata.* The species may represent a threat to the establishment of further *Acacia* plantations in South East Asia, but without a considerable amount of further research, including cultural studies, molecular analysis and probably host susceptibility trials, it is difficult to evaluate the importance of this collection in pathological terms. Further sampling and culturing of the pathogen might provide some initial indications of its significance.

***Guignardia* sp.**

Two collections were received, one primarily of the teleomorph (sexual stage) and the other largely containing the *Phyllosticta* asexual morph. The specimens were insufficient to determine whether the same species was involved in each collection. *Guignardia* species are not infrequently serious pathogens, although they have not previously been reported as causing problems in *Acacia* plantations. There are other collections of *Guignardia* species from *Acacia* in Australian herbaria, and it might be possible to get an idea at least of the morphological variation of the specie(s) and its (their) distribution within Australia by studying these. Further collections and isolation into culture of the fungi found during this project would also help in characterizing the pathogen and assessing its disease potential.

***Phoma* sp.**

The species referred to below as *Phoma* sp. 1 may well be a primary pathogen, causing severe lesions on phyllodes of *Acacia flavescens* and an unidentified species (referred to as *Acacia* sp.). The fungus on the unidentified host apparently causes rather different lesions, suggesting either variation in host response or a different fungus. *Phoma* species are particularly difficult to identify, and vary from being strong pathogens to completely saprobic. If *Acacia flavescens* is to be considered as a plantation tree in South East Asia, then this fungus might prove a significant limiting factor. *Phoma* species are frequently seed-borne, adding to the risk of transmission.

***Uromycladium tepperianum* (Sacc.) McAlp.**

This rust causes major stem galls of several *Acacia* species in Australia, and one collection of this species from Queensland was submitted for confirmation. Although it has not been reported from the four *Acacia* species highlighted in this study and is not seed-borne, an outbreak in South East Asia would pose a significant threat to forest health.

Summary table of fungi identified from herbarium collections received.

Fungus species	*Acacia* species	VPRI*	Country	Disease Potential
Fungus gen. indet aff. *Pseudocercospora*	*A. crassicarpa*	20901-20906	Australia	High
Aschersonia sp.	*A. mangium*	20967	Australia	None
Atelocauda digitata	*A. aulacocarpa*	20949	Australia, Indonesia	High
	A. auriculiformis	20948	Indonesia	
	A. crassicarpa	20942	Australia	
	A. mangium	20945	Australia	
	A. polystachya	20946	Australia	
Colletogloeum sp.	*A. flavescens*	20968	Australia	Medium
Colletotrichum gloeosporioides	*A. mangium*		Thailand	Medium
Colletotrichum sp.	*A. aulacocarpa*	20919	Australia	Low
Dichomera eucalypti	*A. holoserica*	20931	Australia	Low
Didymella sp.	*A. mangium*	20940	Thailand	Low
Didymosphaeria sp.	*A. mangium*	20926	Malaysia	Low
Fusarium aff. *coccophilum*	*A. oraria*	20921	Australia	None
Guignardia sp.	*A. aulacocarpa*	20936	Australia, Indonesia	Medium
	A. mangium	20937	Australia	
Hypoxylon sp.	*A. auriculiformis*	20938	Thailand	Low
Irenopsis berggrenii	*A. mangium*	20964	Australia	None
Leptodothiorella sp.	*A. aulacocarpa*	20969	Australia	Medium
	A. polystachya	20935	Australia	
Leptosphaeria sp.	*A. aulacocarpa*	20918	Australia	Low
Macrovalsaria megalospora	*A. aulacocarpa*	20927	Thailand	None
Meliola brisbanensis	*A. aulacocarpa*	20932	Australia, Indonesia,	None
	A. auriculiformis	20934	Malaysia	
	A. flavescens		Australia	
	A. mangium	20933	Australia	
Mycosphaerella sp. 1	*A. mangium*	20917	Thailand	None
Mycosphaerella sp. 2	*A. polystachya*	20935	Australia	None
Oidium sp.	*A. auriculiformis*	20909	Indonesia	High
	A. mangium	20908	Indonesia	
	A. mangium	20907	Australia	
Periconia sp.	*A. aulacocarpa*	20936	Australia	None
Pestalotiopsis acaciae	*A. aulacocarpa*	-	Australia	Low
	A. auriculiformis	20959	Australia	
	A. crassicarpa	20958	Australia	
	A. flavescens	20941	Australia	
	A. melanoxylon	-	Australia	
Pestalotiopsis besseyi	*Acacia* sp.	20953	Australia	Low
Pestalotiopsis torrendii	*A. binervata*	20952	Australia	Low
Pestalotiopsis sp.	*A. aulacocarpa*	20955	Australia, Thailand	Low
	A. auriculiformis	20972	Australia	
	A. crassicarpa	20971	Australia	
	A. mangium	20970	Australia	
	A. polystachya	20935	Australia	

Fungus species	Acacia species	VPRI*	Country	Disease Potential
Phaeographina sp.	*A. auriculiformis*	20973	Thailand	None
Phoma sp. 1	*A. flavescens*	20922	Australia	High
Phoma sp. 2	*A. latescens*	20925	Australia	Low
Phoma sp. 3	*A. aulacocarpa*	20969	Australia	Low
Pithomyces sp.	*A. holosericea*	20931	Australia	None
Pseudocercospora sp.	*A. flavescens*		Australia	High
Sarcostroma acaciae	*A. binervata*	20952	Australia	Low
	Acacia sp.			
Stomiopeltis acaciae	*A. aulacocarpa*	20951	Australia, Indonesia	None
	A. latescens	20925	Australia	
	A. mangium	20960	Australia	
Thelephora sp.	*A. auriculiformis*	20938	Thailand	None
Uromycladium tepperianum	*A. flavescens*	20928	Australia	High

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References

Boa, E., and Lenné, J. (1994). *Diseases of Nitrogen Fixing Trees in Developing Countries. An Annotated List.* Chatham, UK: Natural Resources Institute.

Corlett, M. (1991). An annotated list of the published names in *Mycosphaerella* and *Sphaerella. Mycologia Memoir* no. **18**: 328 pp.

Ellis, M.B. (1971). *Dematiaceous Hyphomycetes.* 608 pp. Kew, UK: Commonwealth Mycological Institute [now IMI].

Gibson, I.A.S. (1975). *Diseases of forest trees widely planted as exotics in the tropics and the Southern Hemisphere.* Part 1. Important members of the Myrtaceae, Leguminosae, Verbenaceae and Meliaceae. Kew, UK: Commonwealth Mycological Institute

Hansford, C.G. (1953). Australian fungi. New species and revisions. I. The Meliolaceae of Australia. *Proceedings of the Linnean Society of New South Wales* **78**: 51-82.

Hodges, C.S., and Gardner, D.E. (1984). Hawaiian forest fungi. IV. Rusts on endemic acacia species. *Mycologia* **76**: 332-349.

Laessoe, T., Rogers, J.D., and Whalley, A.J.S. (1989). *Camillea, Jongiella* and light-spored species of *Hypoxylon. Mycological Research* **93**: 121-155.

McAlpine, D. (1906). *The Rusts of Australia.* 349 pp. Melbourne: Victoria Department of Agriculture.

Miller, J.H. (1961). *A Monograph of the World Species of Hypoxylon.* 158 pp. Athens, Georgia: University of Georgia.

Nag Raj, T.R. (1993). Coelomycetous Anamorphs with Appendage-Bearing Conidia. 1101 pp. Waterloo, Canada: Mycologue.

Petrak, F. (1953). Beitrage zur Pilzflora von Hawaii. *Sydowia* **7**: 381-409.

Steyaert, R.L. (1953). New and old species of *Pestalotiopsis. Transactions of the British mycological Society* **36**: 81-89.

Sutton, B.C. (1975). Coelomycetes. V. Coryneum. *Mycological Papers* **138**: 224 pp.

Sutton, B.C. (1980). *The Coelomycetes. Fungi Imperfecti with Pycnidia, Acervuli and Stromata***.** 696 pp. Kew, UK: Commonwealth Mycological Institute.

Turnbull, J.W. (1986). *Australian Trees and Shrubs. Lesser Known Species for Fuelwood and Agroforestry.* Canberra, Australia: ACIAR Monograph No. 1. 316 pp.

Yuan, Z.Q. (in press). Fungi and associated tree diseases collected from Melville Island, Northern Territory, Australia. Australian Systematic Botany.

Discussion and Conclusions Session

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On the final day of the workshop, participants were asked to identify, on the basis of their experience and information presented at the workshop, those diseases which are seen as offering threats to the future productivity of industrial plantations based on tropical acacias. They also shared their ideas on the options available for managing these diseases, and this information is summarised below.

Table 1 indicates which diseases are viewed with most concern, which countries have reported problems with these diseases and lists management options.

Table 1. Summary of information on the five most significant diseases of tropical acacia plantations

Disease	Causal agents	Occurrence	Management Options	Notes	Gaps in knowledge
Root Rot	*Ganoderma* complex, especially *G.* aff. *lucidum*	All countries in survey	Surveillance. Removal of stumps and woody debris, in infection foci. Trenching 0.5-0.8 m deep around infection foci. Possible use of fungicide drench (triazole compounds).	Some evidence in Sumatra that the disease is more widespread in second rotation stands.	Identity of causal fungi. Role of woody debris after harvest as source of inoculum. Effectiveness of fire in reducing inoculum. Species, provenance, clonal differences in susceptibility.
Stem canker	Range of pathogens including *Lasiodiplodia theobromae*. *Botryosphaeria* spp. *Hendersonula* sp. (India)	All countries in survey	Remove/burn affected trees. Site, species and provenance matching to avoid stress (drought or defoliation).	Most reports for *A. auriculiformis*. Cankers often associated with borer damage.	Etiology of canker diseases. Species, provenance, clonal differences in susceptibility.
Pink disease	*Corticium salmonicolor*	India Indonesia (Sumatra and Kalimantan)	Remove, burn affected trees. Silviculture, disease favoured by close spacing. Selection of species and provenances.	Broad host range on woody hosts. Most prevalent in high rainfall areas.	Incidence in different age classes. Pathogenic variation in strains of the fungus.

Heart Rot	Range of wood decay fungi	All countries in survey	Silviculture especially early singling of multistemmed trees. Avoidance of wounds Provenance selection for slender branches, single stems. Short rotation	Problem most acute in *A. mangium.* Suggestion that plantations in regions with a seasonal drought will incur less heart rot. *A mangium /A. auriculiformis* hybrid may be less susceptible. Stands with better form due to variation in provenance or in site quality may incur fewer singling/pruning wounds and less heart rot.	Level of heart rot in different age classes. Relative susceptibility of different provenances, families, clones and hybrids. Impact of environmental and edaphic factors on heart rot incidence. Effect of pathogen, host , environmental factors on rate and extent of stem decay. Effect of fungal invasion on pulpwood quality.
Phyllode rust	*Atelocauda digitata*	Australia Indonesia (Java, Sumatra and Kalimantan)	Destroy affected plants in nursery. Spray nursery stock to prevent further infection. Select resistant provenances, families and clones.	This disease is widely distributed in Sumatra. Reported on *A. auriculiformis, A. mangium* and the hybrids between these species. The potential of the pathogen to cause serious losses is unclear. Future selection of planting stock especially of clones must include determination of susceptibility to this fungus.	Etiology of the disease and role of different spore stages. Spray schedules for control in the nursery. Screening methods for selection of resistant plants. Pathogenic variability of the rust. Geographical distribution of the fungus

Detailed information and references on the above diseases are to be found in individual papers presented at the workshop and published in this proceedings. Some additional points related to the five diseases listed in Table 1 are as follows.

Although much of the information on root rot disease provided at the workshop concerned pathogens of the *Ganoderma* complex of species, with *G.* aff. *lucidum* most commonly cited, there are several species of root and butt rot pathogens which occur in tropical forests which could cause significant disease in plantations of tropical acacias. Most of these fungi have a wide host range, and are likely to be of particular importance where native forests are cut over and replanted with plantation species (*Phellinus* spp., *Rigidoporus* spp.). Fortunately, experience in cultivation of rubber in the humid tropics has provided plantation managers with a knowledge of the main pathogens and examples of control strategies. The main pathogens of rubber in Malaysia are *Rigidoporus lignosus, Phellinus noxius and Ganoderma pseudoferreum.* Current control practices include root drenching with fungicides (Lee Su See, personal communication). There are however fewer options for disease management with a lower value crop such as short rotation plantations grown for pulp. Root rot of *A.mangium* is emerging as a serious problem in some locations in Sumatra and requires a major effort to find viable management solutions.

Stem cankers are only recently being recognised as having the potential to cause major damage in a range of species. Many fungi of a range of pathogenicities can be found associated with cankers on acacias and other tree species and a knowledge of the etiology of disease especially with regard to the occurrence of stress factors is essential before any prediction of likely impacts on the plantation resource can be made. Of the diseases discussed here the canker recorded by Sharma and Florence associated with *Hendersonula* infection appears to be the result of invasion by a primary pathogen. Pongpanich has produced strong evidence that the widespread deaths of *A. auriculiformis* in one site in western Thailand is due to invasion of drought affected trees by *Botryosphaeria* sp. together with borer attack. The causal agents, symptomology and etiology of the cankers on all four species of *Acacia* in Kalimantan reported by Hadi and Nuhumara remain unclear and require further investigation. In particular, inoculation of trees under plantation conditions with a range of putative pathogens is needed.

Pink disease was reported as a significant problem in southern Sumatra and at both locations in Kalimantan. At Subanjeriji this is currently regarded as the most significant disease. The disease tends to occur in discontinuous patches, especially in stands which are closely planted. Improvements in silviculture (especially wider spacing) are expected to reduce incidence in the future at this location. This disease is well known in rubber and responds to good silviculture and reductions in inoculum availability through cutting and removal of affected trees.

Heart rot is dealt with in some detail by Lee Su See in this report, and is the only disease syndrome (albeit complicated) of tropical acacia plantations that has received sustained research over the last decade There are still many gaps in knowledge as indicated in Table 1. The importance of the problem for short rotation (less than 10 years) pulp crops is likely to be limited. If however, acacias are to play a role in meeting the demands for sawn timber in the tropics as the available native forest resource diminishes, heart rot will need continued focus.

One of the significant outcomes of the workshop is the realisation that rust diseases, especially gall rust of shoots and phyllodes caused by *Atelocauda digitata,* are likely to be emerging problems for acacia plantations in South East Asia. Phyllode rust is now established in Java, south and central Sumatra and Kalimantan. So far reports indicate that damage in plantations is limited as tree to tree variation in susceptibility is large. The disease requires a major research effort for several reasons. Firstly, although well known in native stands, the disease appears to be spreading into new areas with the establishment of large plantations of acacias in Indonesia. The pathogen may be establishing in new areas where the environment is especially conducive to disease, so reliance on previous experience of impacts may be misleading. Secondly genetic improvement of these species is rapidly moving towards clonal forestry. Inevitably this will result in a contraction of the genetic base of the crop in favour of silviculturally superior clones. Such selection without consideration of rust susceptibility could have severe consequences for the future epidemic potential of the disease.

As a result of this workshop, the foregoing surveys and collaboration, the industry awareness of diseases of important plantation species has been heightened. With the help of CIFOR and ACIAR, a network of forest pathologists has been established across the region which can respond to the needs of industrial and social forestry in the event of epidemic disease.

APPENDIX 2

Sheet 1 - A sample data sheet to illustrate the categories of diseases surveyed and method of recording observations

Pathogen Data Form	**Foliage and Stem Diseases of Eucalypts**

Office use only		Date of observation:	____
Pathogen record ID	____	Project ID	____
Isolate/Herbarium number	____	*Locality*:	____
		Tree Species:	____

Type of trial: ____

Trial Age (months): ____ Eucalyptus species: ____

Month/year planted: ____ Seedlot number (if known): ____ Disease: Yes ☐ No ☐

Casual agent: Fungal / Insect / Other (see comments) Pathogen (if known) ____

Plant parts affected and name of disease				Extent of damage:	
	Leaves	☐	____	0-25% of stand	☐
	Growing shoots	☐	____	25-50% of stand	☐
	Branches	☐	____	50-75% of stand	☐
	Main stems	☐	____	75-100% of stand	☐
	Flowers	☐	____		
	Fruits/seeds	☐	____	**Impact of growth on host:** Negligible impact	☐
	Bark	☐	____	Moderate impact	☐
	Roots	☐	____	Severe impact	☐
	Other (see comments)	☐	____		

Comments *(including symptoms)*

Sheet 2 Disease index to assess the severity of foliage infection, stem canker and root diseases (wlt, root rot) in plantations)

Disease severity	SYMPTOMS				Disease severity index (1-3)
	Foliage infection	Cankers		Root disease	
		Main stem canker	Branch canker/gall		
Nil	Nil	Nil	Nil	Nil	0
Low (L)	Up to 25% of the foliage infected	1 canker, no apparent harm to tree	Up to 25% of the shoots of trees affected	Dieback of branches (>25%) in the crown	1 (0 -1)
Medium (M)	25-50% of the foliage infected >10% defoliated prematurely	1-2 cankers, epicormic shoots present	>25-50% of the shoots of trees affected	Dieback of branches (>50%) thinning of crown	2 (1.1-2)
Severe (S)	50-75% of the foliage infected: >25% defoliated prematurely	1-2 or more cankers, epicormic shoots present, apical shoot dead due to girdling	>50-75% of the shoots of trees affected	Foliage pale yellow accompanied by premature defoliation, extensive dieback, death of tree	3 (2.1-3)

Disease severity	Fruit/seed infection
Nil	Nil
Low (L)	Up to 25% of fruit flower infected
Medium (M)	25-50% of flower/fruit infected: >10% shed prematurely
Severe (S)	50-70% of flower/fruit infected: >25% shed prematurely

Sheet 3

Host species .... Date of Planting .... Date of observation ....
Locality .... Plot No .... Row No ....
Type of Trial .... Seed lot/Family No .... Replicate No ....

Severity of disease and name of the pathogen																	
	LEAF				STEM												
Tree Number	Leaf Spot		Blight		Die back		Pink disease		Canker other than Pink diease		Heart Rot		Gummosis		Disease intensity: L=Low; M=Medium; S=Severe Remarks (Defoliation injury, mortality etc)
	Pathogen	Intensity	Pathogen	Intensity	Pathogen	Intensity	Pathogen	Intensity	Pathogen	Intensity	Intensity	Indicators	Parasite	Intensity	
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															

Pathogen
1) .... 6) ....
2) .... 7) ....
3) .... 8) ....
4) .... 9) ....
5) .... 10) ....

APPENDIX 3

List of Participants

Australia	-	Rob Floyd CSIRO Forestry and Forest Products	Australian
	-	Ken Old CSIRO Forestry and Forest Products	Australian
	-	Yuan Zi Qing CSIRO Forestry and Forest Products	Chinese
India	-	Jyoti Sharma Kerala Forest Research Institute	Indian
	-	E J M Florence Kerala Forest Research Institute	British
Indonesia	-	Christian Cossalter CIFOR	French
	-	Ken Gales PT Musi Hutan Persada	British
	-	Soetrisno Hadi Institut Pertanian Bogor	Indonesian
	-	Anu Honkanen ENS0 Forest Development	Finnish
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	-	Wong Ching Yong PT Indah Kiat Pulp and Paper Corp.	Malaysian
	-	Shy Yikeng PT Wirya Karya Sakti	Indonesian
	-	Anna Zulfiyah PT Musi Hutan Persada	Indonesian
Malaysia	-	Lee Su See Forest Research Institute of Malaysia	Malaysian
Thailand	-	Krisna Pongpanich Royal Forest Department of Thailand	Thai

Acacias are of considerable social and industrial importance for tropical reforestation and it is expected that about 2 million hectares will be established in south east Asia by the year 2000. The acacia species currently of most interest for plantation forestry in the tropics are indigenous to northern Australia, Papua New Guinea and Irian Jaya.

Recent reports from Malaysia, Indonesia, Thailand and northern Australia suggest that the future productivity of acacia plantations may be affected by fungal pathogens including leaf spots, shoot blights, stem cankers, heart rot, root rots and gall rusts. During 1995-96 a series of disease surveys was undertaken by forest pathologists in native stands, trials, and operational and social forestry plantings of tropical acacias in Australia, India, Indonesia, Malaysia, and Thailand to assess the potential of fungal pathogens as limiting factors to tree growth and productivity and to assess the relative importance of individual fungal pathogens. Tree species included in the surveys were *Acacia mangium* and *A. auriculiformis*,on the basis of their current importance as plantation species. *A. crassicarpa* and *A. aulacocarpa* were also surveyed as, although they have been planted on a limited scale so far, they are included in provenance and species trials in many locations throughout the region. Scientists who had participated in the project met with research managers of five major Indonesian plantation pulp and paper companies and government business enterprises April 28 - May 3 1996 at the base camp of Pt Musi Hutan Persada, Subanjeriji in southern Sumatra to present the results of their surveys. This publication is a status report on the diseases of acacias in the several countries based on information presented at the workshop. It provides a benchmark of the current knowledge of the pathology of the four most important *Acacia* spp currently being grown in plantations in tropical areas of south east Asia, the Indian subcontinent and northern Australia.

The surveys and workshop were made possible through funding from the Australian Centre for Agricultural Research (ACIAR), the Centre for International Forestry Research (CIFOR) and the support of the organisations of the participating scientists.