Journal of Tropical Forest Science 1 (2): 170 - 177

DISCOLOURATION AND HEART ROT OF *ACACIA MANGIUM* WILLD. - SOME PRELIMINARY RESULTS

S. S. Lee

Faculty of Forestry, Agriculture University of Malaysia, 43400 Serdang, Selangor, Malaysia.

S.Y. Teng

Bio-Organo Fertilizer Sendirian Berhad, Kelang, Selangor, Malaysia.

M.T. Lim & Razali Abd. Kader

Faculty of Forestry, Agriculture University of Malaysia, 43400 Serdang, Selangor, Malaysia.

Received November 1988, accepted December 1988.

LEE, S. S., TENG, S.Y., LIM, M.T. & RAZALI ABD. KADER. 1988. Discolouration and heart rot of *Acacia mangium* Willd. - some preliminary results. The association of discolouration and heart rot in stems of *Acacia mangium* Willd. trees with external cull indicators, the amount of wood affected and the associated fungi were determined in this study. It was found that cankers associated with decayed branch stubs and poorly healed basal pruning wounds were good indicators of discolouration and heart rot. The volume of discoloured wood ranged from between 18 to 48% (n = 8) while the volume of heart rot ranged from between 2.7 to 17.5% (n = 8). The length of the bole of the sample trees affected by heart rot ranged from between 34 to 100%. Seventeen species of fungi were isolated from the discoloured and decayed wood. Species of *Phialophora, Trichoderma, Rhinocladiella, Thelaviopsis* and *Paecilomyces* were most frequently isolated. However, no single species could be identified as the main discolouration or decay causing organism.

Key words: *Acacia mangium* - discolouration - heart rot - cull indicators - fungi.

Introduction

Acacia mangium Willd., one of the fast-growing tropical hardwoods has been planted widely in Peninsular Malaysia since the early 1980's. Older plantations exist in Sabah and in 1981 it was reported that some 44-month old thinnings from a seed stand were affected by heart rot caused by an unknown basidiomycete (FAO 1981). A similar observation was made in four-year old thinnings from Kemasul plantation in Peninsular Malaysia (Lee 1985). However, little is known of the cause, or seriousness and extent of the problem. Other species of *Acacia* grown elsewhere are known to be affected by heart rot caused by various fungi. In India, heart rot in *A. catechu* is caused by *Fomes badius* (Bakshi 1951) and in Australia and New Zealand, heart rot in *A. dealbata* is caused by *Ganoderma applanatum* (Bakshi 1976).

Wounds, dying branches and roots are known as infection courts for microorganisms causing discolouration and heart rot in living trees. *A. mangium* trees are self-pruning but often many poorly pruned branch stubs remain attached to the bole. Moreover, poorly healed pruning wounds and cankers are often found at the basal region of trees which had been artificially pruned earlier to obtain good form. Discolouration and heart rot in *A. mangium* trees were thus suspected to be caused by microorganisms entering the wood through these wounds. In this preliminary report, the results of a study undertaken to determine the association of discolouration and heart rot in *A. mangium* trees with external cull factors, the amount of wood affected and the associated fungi are presented.

Materials and methods

A. mangium trees in four, five and six year-old stands in Kemasul plantation possessing external indicators of possible decay, such as dead or broken branches, decayed branch stubs or cankers were located and marked. Four such trees were selected from the four-year-old stand and two trees were selected from each of the five- and six-year-old stands. One tree free from external decay indicators (control) was also selected from each stand.

The selected trees were felled and bucked with a chain saw into logs approximately 1.0 *m* in length and up to a diameter of 10.0 *cm*, and the cut ends painted with a layer of creosote before being taken back to the laboratory for evaluation of discolouration and decay. The logs were bucked into shorter bolts, approximately 0.3 *m* in length and the position of each bolt in the tree was then numbered. The volume of discoloured and decayed wood in each bolt was determined from the freshly cut green wood at the upper end (Figure 1 & formulae):

Formulae

Gross volume	$GV = 3.142\ (d_4/2)^2\ h$
Cull volume for heart rot	$RV = 3.142\ (d_1/2)^2\ h$
Volume of sound wood in between discoloured and heart rotted portion	$SV = 3.142\ h\ [(d_2/2)^2 - (d_1/2)^2]$
Cull volume for discolouration	$DV = 3.142\ h\ [d_3/2)^2 - d_2/2)^2]$
Percent cull volume for heart rot	$\%RV = RV/GV \times 100$
Percent cull volume for discolouration	$\%DV = DV/GV \times 100$

The vertical extent of heart rot in each tree was determined by splitting the bolts into halves through the infection court and measuring the length of each bolt affected by the rot and then summing up the total length affected in each tree. The position of cull indicators in relation to their distance from ground level was also measured.

Chips of wood approximately 2 x 4 x 5 *mm* were cut from surface sterilised discoloured and rotted portions of the bolts and incubated on 0.5% malt extract

agar (MEA) containing 300 *ppm* streptomycin sulphate at 28 + 2° C. Fungi growing out from the chips were transferred onto fresh MEA plates to obtain pure cultures for identification.

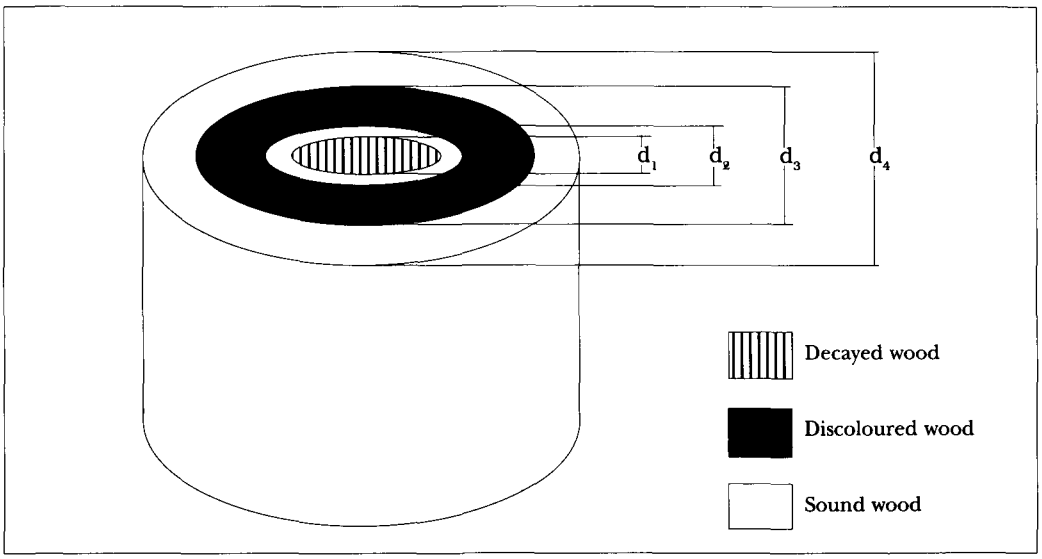

Figure 1. Diagramatic representation of volume determination

Results and discussion

Cankers were the most common cull indicators observed in the three stands. These cankers were mainly associated with decayed branch stubs of basal pruning wounds (Table 1). Fungal fruiting structures which are useful cull indicators were not found on any of the trees. In control trees, sound sapwood was light coloured while sound heartwood was medium brown in colour. In comparison, in the eight sample trees discoloured sapwood was light to dark greenish yellow, greenish or brown, and discoloured heartwood was purple to black in colour. The discoloured wood occurred in continuous columns of uniform colour or in discontinuous columns of irregular colour. This discolouration was probably due to the increased oxidation of phenols in the wood by the polyphenol oxidases produced by some of the wound invading microorganisms. Decayed heartwood had a light yellow to bleached straw colour and was fibrous as is typical of white rotted wood. Some trees had hollow centres where the decayed heartwood had completely rotted away. All eight sample trees had discoloured wood and heart rot regardless of their age (Table 2).

It was evident that discolouration was initiated at the decayed branch stubs and poorly healed pruning wounds, progressing subsequently into the heartwood and sapwood of the trees. The most common point of entry appeared to be branch stubs.

Table 1. Symptoms and signs indicative of discolouration and heart rot and the points and position of invading microorganisms in *Acacia mangium* trees of 4-6 years age

Tree age (Years)	Tree number	Symptoms & signs	Main point of invasion	Position of invasion point from ground level (*cm*)
4	1	Canker	Branch stub	198
	2	Canker	Branch stub	76
	3	Canker	Basal pruning wound	10
	4	Canker & black ooze	Basal pruning wound	18
5	5	Canker	Branch stub	149
	6	Canker & broken branch	Basal pruning wound & broken branch	15 1083
6	7	Canker & broken branch	Branch stub basal pruning wound	252 top
	8	Canker	Basal pruning wound & branch stub	20 502

Table 2. Extent of heart rot and volumes of wood affected by discolouration and decay in *Acacia mangium* trees

Tree age (Years)	Tree number	Tree height* (*cm*)	% length heart rot	Volume affected (%)		
				Discolouration	Heart rot	Total
4	1	706.0	50.0	31.4	2.7	34.1
	2	610.0	34.0	18.0	8.0	26.0
	3	479.5	45.0	42.0	5.0	47.0
	4	454.5	100.0	48.4	5.7	54.1
5	5	826.0	74.0	35.0	7.0	42.0
	6	1107.0	100.0	46.3	17.5	63.8
6	7	947.0	100.0	47.0	4.3	51.3
	8	1179.5	50.0	34.0	4.0	38.0

* Up to a diameter of 10.0 *cm*

Discolouration was also observed to originate from branch stubs that had been callused over. These stubs were not associated with external cankers and thus were only discovered when the bolts of wood were split. The main points of entry listed in Table 1 are the larger wounds associated with external indicators and from which development of discolouration and decay were very obvious. In two trees (tree no. 3 & 4), decay resulting from invasion of basal pruning wounds appeared to have developed subsequently into heart rot and in three trees (tree no. 6, 7 & 8), heart rot was continuous between the various major points of decay initiation making it difficult to distinguish the first entry point 1 (Tables 1 & 2).

Heart rot fungi usually do not penetrate sound trees, and require an opening into the heartwood or exposure of dead sapwood adjacent to heartwood through which to initiate infection (Scharps 1978). Heart rots in many hardwoods are known to originate as infections of wounded external stem tissue which subsequently become slowly enclosed, discoloured, and decayed (Shigo & Hillis 1973, Shigo 1984a, 1984b). Such openings are found in *A. mangium* trees in the form of slow or poor healing wounds left by dying or dead branches resulting from natural pruning. Discolouration and decay also develop in callused-over stubs by the breakdown of compartmentalization by reactivated microorganisms resident in the wood. Entry through the basal portion of the trees appeared to be due to invasion of the large wounds left after pruning of the multiple leader shoots at an earlier age. In the delay or absence of formation of a protective barrier across the exposed heartwood, microorganisms can enter the centre of the trees (Peace 1962) causing discolouration of the tissue (Shigo & Hillis 1979), and subsequent invasion by other fungi can lead to the development of heart rot.

The percentage length of the bole affected by heart rot ranged from 34 to 100% (Table 2). Generally, where there were more than one entry point, the length of heartwood affected by heart rot was more extensive. In clear cut cases of entry through branch stubs or broken branches only, the development of heart rot above the entry point was always more extensive than below. Columns of heart rot in *A. mangium* were found to advance along the pith while columns of discolouration generally advanced along the sapwood-heartwood boundary. In species of *Quercus*, columns of discolouration and decay have been found to advance rapidly above and below the wound along the sapwood-heartwood boundary present at the time of wounding (Shigo *et al.* 1971).

In calculations of the volume of heart rot, hollows were considered as volumes of heart rot as were the punky, loose fibred pith. The amount of discoloured wood in the trees ranged from 18 to 48% while the amount of heart rot ranged from 2.7 to 17.5% of the total volume (Table 2). On average it appeared that about 45% of the volume of wood in the *A. mangium* trees studied were affected by discolouration and heart rot irrespective of age or point of entry. Older trees did not necessarily have larger volumes of heart rot or discolouration and large volumes of discolouration were not necessarily associated with large volumes of heart rot. This result has been obtained in studies elsewhere (Hepting & Shigo 1972, Shigo & Sharon 1968). An extensive vertical spread of heart rot in a tree was also not always associated with

a large volume of heart rot (Table 2).

The volume and extent of discolouration and heart rot in a tree may be affected by the size and severity of the wound and the vigour and age of the host (Manion 1981). Wounds that break the bark and only slightly injure the cambium and xylem of the host usually heal over rapidly (Shigo & Hillis 1973). However, if more severe wounds are inflicted and conditions for infection are favourable, invasion by microorganisms occurs. It is therefore highly desirable that artificial pruning of *A. mangium* be conducted at an early stage while the shoots are still of small diameter so that the resulting wound is small and can heal over rapidly. Sealing of wounds with bitumen mixtures or fungus resistant paints should also be properly and carefully conducted so that no heartwood is left exposed. Selection of trees which produce fewer branches or those that self-prune efficiently is also important in reducing the occurrence of discolouration and heart rot in *A. mangium.*

Sixteen non-hymenomycetous fungi and one hymenomycete (brown sterile) were isolated from the discoloured and decayed wood. Almost half of the fungi isolated were common to both the discoloured wood and the decayed wood (Table 3). Most of the fungi were pioneer wound invading fungi and common moulds. *Rhinocladiella* sp., *Paecilomyces* sp., *Thielaviopsis* sp. and *Trichoderma* sp. which were frequently isolated from discoloured and decayed *A. mangium* wood, have also been commonly isolated from red oak and white oak after wounding (Shigo 1972) and from decayed sweetgum and yellow poplar (Shortle & Cowling 1978a). These cosmopolitan fungi are among the early invaders of wounds regardless of tree species.

Table 3. Fungi isolated from discoloured and heart rotted *Acacia mangium* wood

Fungus	Number of isolates obtained from	
	Discoloured wood	Heart rotted wood
Phialophora sp.	9	7
Trichoderma sp.	7	6
Rhinocladiella sp.	6	5
Thielaviopsis sp.	-	6
Paecilomyces sp.	-	6
Rhizopus sp.	5	4
Brown sterile hymenomycete	3	8
Fusarium sp.	4	-
Penicillium sp.	2	2
Asperqillus sp.	2	1
Chrysosporium sp.	1	-
Chaetomium sp.	-	1
Phialomycetes sp.	1	-
Curvularia sp.	1	-
Verticillium sp.	-	1
Pestalotiopsis sp.	1	-
Gliocladium sp.	1	-

Phialophora sp. and the brown sterile hymenomycete were most frequently isolated from discoloured and decayed wood, respectively. *Phialophora* is often associated with discolouration and heart rot in living trees (Shortle & Cowling 1978a) and it has been reported to be associated with decay in teak trees in India (Singh 1970). This fungus is known to be able to use some of the cell wall substances for food and to maintain strong mycelial growth in wood much longer than the pioneer wound invading fungi (Shortle & Cowling 1978b). Unlike the decay fungi, *Phialaphora* can flourish on substrates with a high content of polyphenols which strongly inhibit the growth of the former. Hence, *Phialaphora* is favoured by the accumulation of phenolic compounds in the wood in response to injury (Shortle & Cowling 1978b). *Phialophora* and other phenol-tolerant fungi are known to be able to alter the wood so that it becomes more susceptible to attack by decay fungi (Singh 1970).

The frequent isolation of the sterile brown hymenomycete from the decayed wood suggests this fungus may be an important causal fungus of heart rot in *A. mangium*. This fungus could not be conclusively identified due to absence of fruiting structures.

Conclusion

Broken branches, decayed branch stubs and cankers resulting from poorly healed wounds were good indicators of discolouration and decay in *A. mangium* trees of various ages. The amount of discoloured wood in the eight sample trees ranged from between 18 to 48% and the amount of heart rot from between 2.7 to 17.5%. Although 17 species of fungi were isolated from the discoloured and decayed wood, no single fungus species could be identified as the main discolouration or decay causing organism.

It appears that discolouration and heart rot in *A. mangium* are caused by fungal invasion of poorly healed wounds, especially those left by branch stubs. Thus, wounding of *A. mangium* trees should be avoided and wounds treated or protected.

Acknowledgements

We would like to thank the Director General, Forest Department Peninsular Malaysia and the Manager of Compensatory Plantation Forests, Kemasul for permission to collect samples, and Agriculture University of Malaysia for facilities provided.

References

BAKSHI, B.K. 1957. Fungal diseases of Khair (*Acacia catechu* Willd.) and their prevention. *Indian Forester* 85: 41-46.

BAKSHI, B.K. 1976. *Forest pathology - Principles and practices in forestry*. The Controller of Publications. Delhi. 400 p.

FAO. 1981. Seed source establishment and tree improvement - Sabah, Malaysia. Forest Mycology. *Consultant's report* No. 3. FAO/UNDP-MAL/7B/009. Rome. 45 p.

HEPTING, G.H. & SHIGO, A.L. 1972. Difference in decay ratefollowing fire between oaks in North Carolina and Maine. *Plant Disease Reporter* 56: 406 - 407.

LEE, S.S. 1985. Tree diseases and wood deterioration problems in Peninsular Malaysia. *Occasional Paper* No. 5. Faculty of Forestry, Agriculture University of Malaysia, 15 p.

MANION, P.D. 1981. *Tree disease concepts.* Prentice-Hall Inc., Englewood Cliffs, New Jersey. 388 p.

PEACE, T.R. 1962. *Pathology of trees and shrubs.* Clarendon Press, Oxford. 753 p.

SCHARPF, R.F. 1978. Diseases of Pacific Coast Conifers. *Agriculture Handbook* No. 521. Forest Service, United States Department of Agriculture. 206 p.

SHIGO, A.L. 1972. Successions of microorganisms and patterns of discolouration and decay after wounding in red oak and white oak. *Phytopathology* 62: 256 - 259.

SHIGO, A.L. 1984a. Trees and discoloured wood. *International Association of Wood Anatomist Bulletin* 5(2): 99 - 101.

SHIGO, A.L. 1984b. Compartmentalization : A conceptual framework for understanding how trees grow and defend themselves. *Annual Review of Phytopathology* 22: 124 -189.

SHIGO, A.L. & WILLIS, W.E. 1973. Heartwood, discoloured wood and microorganisms in living trees. *Annual Review of Phytopathology* 11: 197 - 222.

SHIGO, A.L. & SHARON, E.M. 1968. Discolouration and decay in hardwoods following inoculations with hymenomycetes. *Phytopathology* 58: 1493 - 1498.

SHIGO, A.L., STANKEWICH, J. & CONSENZA, B.J. 1971. *Clostridium* sp. associated with discolored tissues in living oaks. *Phytopathology* 61: 122 - 123.

SHORTLE, W.C. & COWLING, E.B. 1978a. Development of discolouration, decay and microorganisms following wounding of sweetgum and yellow poplar trees. *Phytopathology* 68: 609 - 616.

SHORTIE, W.C. & COWIING, E.B. 1978b. Interaction of live sapwood and fungi commonly found in discolored wood and decayed wood. *Phytopathology* 68: 617 - 623.

SINGH, S. 1970. Role of precursor fungus in decay in standing teak. *Indian Forester* 96: 874 - 875.