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A POSSIBLE LINK BETWEEN RAINFALL AND HEART ROT INCIDENCE IN *ACACIA MANGIUM* ?

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LEE, S.S. & ARENTZ, F. 1997. A possible link between rainfall and heart rot incidence in *Acacia mangium* ? Over the last 20 years extensive plantations of *Acacia mangium* have been established in Sabah and Kalimantan on the island of Borneo, Peninsular Malaysia, Sumatra and Papua New Guinea. Areas under *A. mangium* plantations continue to expand annually in these regions. Although there are several reports of heart rot in *A. mangium,* figures are only available from Malaysia. In Sabah, between 10 and 50% heart rot incidence has been reported in 6- to 9-y-old trees while in Peninsular Malaysia between 49 and 98% of 2- to 8-y-old trees have been found to have heart rot. The volume of wood affected by the disease was, however, relatively low. In its natural habitat, *A. mangium* grows in areas with a strongly seasonally distributed mean annual rainfall of 1500-3000 mm. It is our hypothesis that the higher incidence of heart rot in A. *mangium* in Peninsular Malaysia compared to Sabah may be associated with the lack of a seasonal distribution of rainfall in the peninsula. The absence of a dry spell probably reduces the self-pruning ability of *A. mangium* branches in Peninsular Malaysia. These dying branches probably permit the development of entry points for the decay fungi. Such conditions of continuous high relative humidity are also conducive to fungal infection.

Key words: *Acacia mangium* - heart rot - rainfall

LEE, S.S. & ARENTZ, F. 1997. Mungkinkah terdapat hubungan di antara hujan dan kejadian reput teras pada Acocta*mangium?* Dua puluh tahun kebelakangan ini ladang *A. mangium* telah ditubuhkan dengan ekstensif di Sabah dan Kalimantan di pulau Borneo, Semenanjung Malaysia, Sumatra dan Papua New Guinea. Keluasan ladang *A. mangium* terus bertambah setiap tahun di kawasan tersebut. Walaupun terdapat beberapa laporan mengenai reput teras dalam *A. mangium,* angka-angka tersebut cuma diperoleh dari Malaysia. Di Sabah antara 10 dan 50% kejadian reput teras dilaporkan pada pokok berumur dari 6 hingga 9 tahun manakala di Semenanjung Malaysia, antara 49 dan 98% daripada pokok berumur 2 hingga 8 tahun didapati mempunyai reput teras. Walau bagaimanapun isi padu kayu yang rosak akibat reput teras adalah sedikit. Di habitat semulajadinya *A. mangium* tumbuh di kawasan yang mengalami taburan hujan bermusim dengan purata sebanyak 1500-3000 mm

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setahun. Hipotesis kami ialah lebih banyak kejadian reput teras dalam *A. mangium* di Semenanjung Malaysia berbanding Sabah mungkin berkaitan dengan kekurangan taburan hujan bermusim di semenanjung. Ketiadaan musim kering di Semenanjung Malaysia mungkin mengurangkan keupayaan dahan *A. mangium* memangkas dengan sendiri. Dahan yang mati mungkin membenarkan perkembangan tempat masuk untuk kulat reput. Keadaan seperti kelembapan relatif yang sentiasa tinggi juga menggalakkan jangkitan kulat.

Introduction

Acacia mangium Willd., which is native to northern Australia, southern New Guinea and the eastern islands of the Indonesian archipelago, has been used extensively in the last twenty-five years to reforest degraded grasslands and logged-over rain forests in the humid tropics, particularly in Indonesia, Malaysia and Papua New Guinea (Carron & Aken 1992). The choice of *A. mangium* as a plantation species has been based on its rapid growth rate (Mahmud *et al.* 1993) and its suitability for sawing, moulding, veneer, paper pulp, particleboard, firewood and charcoal.

In Sumatra, Indonesia, extensive areas of lowland rain forest have been and are being cleared and planted with *Acacia* spp. to supply several pulp and paper mills. In Peninsular Malaysia, some 50 000 ha of *A. mangium* have been planted as part of a programme to plant 188 000 ha of fast-growing tree species to meet an expected demand for timber in the domestic market. In Sabah approximately 100 000 ha of hardwood plantations have been planted, a large proportion of which consists of *A. mangium*. Plantings in Papua New Guinea have been on a smaller scale; the trees are being grown on a seven-year rotation exclusively for pulpwood.

In recent years, there have been a number of reports of the development of heart rot in *A. mangium*, particularly in Malaysia (Lee *et al.* 1988, Arentz 1993, Lee *et al.* 1993, Mahmud *et al.* 1993, Zakaria pers. comm.). It should be emphasised from the outset that studies on heart rot in *A. mangium* have largely been confined to determination of incidence of the disease only and that there are no in-depth studies on the mode of entry and etiology of the disease. Here we re-examine these reports and hypothesise on the possible causes for the high incidence of heart rot in *A. mangium* trees in Peninsular Malaysia. Verification of this hypothesis would have to be obtained from field experiments and suggestions for further research are made.

The disease and its severity

Heart rot, the decay of the heartwood of living trees caused by certain fungi, was first reported on *A. mangium* in Sabah by Gibson (1981) who noticed a white fibrous decay with a peripheral brown stain in 44-month-old thinnings. Subsequently heart rot in *A. mangium* has been reported from Peninsular Malaysia, Indonesia and Papua New Guinea.

In Peninsular Malaysia, a volume loss of between 0.7% and 17.5% of the merchantable timber of *A. mangium* has been reported as a result of heart rot (Lee *et al.* 1988, Zakaria *et al.* 1994) with up to 85% of trees showing some form of decay

(Table 1). In another study carried out in Sabah, the volume affected by decay ranged from 0.02 to 18.1% although mean volume loss was approximately 1% of merchantable volume (Mahmud *et al.* 1993). Overall, heart rot incidence in *A. mangium* trees was much lower in Sabah with the highest incidence (50%) being recorded from 9-y-old trees at Bongkol and Kinarut (Table 1).

Several rot types associated with different groups of fungi have been identified from *A. mangium* heart rot (Lee & Maziah 1993). These were honeycomb rot associated with *Phellinus noxius* (where the heartwood is bleached pale yellow to white with distinctly yellowish-brown plates of fungal hyphae forming a honeycomb pattern on the rotted wood; also known as pocket rot), spongy rot, spongy rot with zone lines (like spongy rot where the heartwood is bleached pale straw to white but with angular black zone lines), wet fibrous rot (where the heartwood is brownish and very wet, oozing water when pressed), white fibrous rot, brittle rot (where the heartwood is pale brown to white, pitted and brittle) and pink pocket rot (where small pockets of spongy, pink coloured rot occur in the heartwood). The white fibrous rot was the most common type of rot while the pink pocket rot was encountered only occasionally.

Lee *et al.* (1988) and Lee and Maziah (1993) reported that 26 species of fungi were isolated from the discoloured and decayed heartwood. One of the species has been positively identified as *Phellinus noxius* (Corner) G. Cunn. leaving another 25 unidentified hymenomycetes. Identification of these fungi is difficult due to lack of fruiting bodies and the scanty knowledge of tropical wood decay fungal taxonomy. There is also a need to carry out pathogenicity studies to test the ability of these fungi to cause heart rot. The one identified fungus, *P. noxius,* is associated with root and heart rot and tree mortality in a number of other plantation tree species including *Cordia alliodora, Acacia auriculiformis, Eucalyptus deglupta, Arauca-*hacwnnmg-/zamn(Arentz & Simpson 1988) and *Hevea brasiliensis* (Anonymous 1961, Ismail Hashim pers. comm.).

Preliminary studies showed that entry of pathogens into the heartwood of trees planted in Sabah could be traced to dead branch stubs and dead persistent branches (Ito 1991, Mahmud *et al.* 1993). Mahmud *et al.* (1993) traced 38% of heart rot infection courts to dead branch stubs and another 35% to dead persistent branches while Ito (1991) found that dead branch stubs and dead branches accounted for 50% of infection courts. Wounds sustained during thinning and pruning or from other causes such as fire could also be important entry points (Lee *et al.* 1988, Ito 1991, Arentz 1993, Mahmud *et al.* 1993). Basal and trunk wounds are known as entry points for heart rot causing organisms in trees (Jacobi *et al.* 1980, Wilkes 1985). Entry of heart rot pathogens via the roots was recorded for only a small proportion (<3%) of trees sampled (Mahmud *et al.* 1993). However, further experimental studies are neccesary to verify the point of entry of the heart rot fungi.

Studies carried out in Peninsular Malaysia have shown no relationship between the incidence of heart rot and site (Zakaria *et al.* 1994). In Sabah, on the other hand, the incidence of heart rot was found to be significantly lower at Kudat (10%) than at Keningau (49%) (Mahmud *et al.* 1993). This difference was attributed to site

Table 1. Mean percentage incidence of heart rot in *Acacia mangium* at various sites in Malaysia

Year planted	Peninsular Malaysia*				Sabah**						
	Ulu Sedili	Kemasui	Setul	Bukit Tarik	Bongkol	Kinarut	Telupid	Kolapis	Kudat	Keningau	Ulu Rakut
1980	100	-	-	-	-	-	-	-	-	-	-
1981	96	100	-	-	50	50	-	-	-	-	10
1982	-	100	-	-	-	-	-	-	10	49	-
1983	-	100	100	96	45	-	-	-	-	-	-
1984	88	100	95	100	-	-	37	25	-	-	40
1985	88	78	65	80	20	-	-	-	-	-	40
1986	09	100	63	-	10	-	-	-	-	-	-
1987	76	25	83	98	0	-	-	-	-	-	-
1988	41	51	81	77	0	-	-	-	-	-	-
1989	53	86	-	60	-	-	-	-	-	-	-
1990	-	-	-	87	-	-	-	-	-	-	-
Mean	76	82	81	85	21	50	37	25	10	49	30

Sources: * Zakaria *et al* (1984),
** Ito (1991), Mahmud *et al* (1993).

factors, including better drainage of soils at Kudat compared to Keningau, and to the impact of a 1987 fire at Keningau which caused scarring of trees (Mahmud *et al* 1993). The influence of site factors on the self pruning ability and heart rot incidence of *A. mangium* needs to be examined more thoroughly and carefully.

Ecology of *Acacia mangium*

In its natural habitat in northeast Australia, the Indonesian islands of Sula, Ceram and Aru, Irian Jaya, and the Western Province of Papua New Guinea, *A. mangium* is found in a range of vegetation types, including swamp grassland, grassland, savanna, dry evergreen forest and woodlands (Skelton 1987). Its distribution is strongly influenced by rainfall patterns and soil drainage. The species is associated chiefly with rain forest-savanna boundaries, which are regularly affected by dry-season fire, and disturbed sites on well-drained acid soils of low fertility (Pinyopusarerk *et al.* 1993). Rainfall is generally seasonal, with a distinct dry season for up to five months of the year (Table 2).

Trees, when mature, are up to 30 m tall with a clear bole length of up to half the height of the tree. However, self-pruning of trees has been reported as generally poor (Pinyopusarerk *et al.* 1993). It is not clear from the literature whether this refers to trees grown in plantations or in natural stands. Ito (1991) reported that *A. mangium* plantation trees in Sabah started producing many branches from the age of three years and that dead branches, which developed following crown closure, remained attached to the stem for many years. Similar observations have been made in Peninsular Malaysia (Arentz & Levingston pers. comm.). Quantitative data, however, need to be gathered on the self-pruning ability of *A. mangium* trees in their native habitat and in plantations in Southeast Asia, focusing particularly on the mechanisms of self-pruning.

Self-pruning in trees

The shedding or abscission of lateral twigs and well-developed branches is a common phenomenon inherent to a range of woody plants. However, not many studies into this phenomenon have been carried out (Kozlowski 1973).

Two distinct mechanisms appear to operate. The first involves physiological processes whereby separation of branches occurs along well-defined cleavage zones, preceded by tissue weakening and periderm formation. The second involves the interaction of biotic and mechanical agents whereby dead branches low on the bole of trees grown in dense stands die and are attacked by saprophytic fungi and insects, thus weakening the branches making them susceptible to breakage by such environmental elements as animals and wind (Kozlowski 1973).

Lateral branch abscission has been reported for a large number of tree species, including those of the Leguminosae. For example, in *Albizia procera,* most of the previous year's branches with diameter of 8-10 mm are shed at the beginning of the new growing season (Kozlowski 1973). There may be a number of triggering mechanisms for abscission, including changes in day length and temperature (in

Table 2. Rainfall data of meteorological stations associated with the natural distribution of *Acacia mangium*

Australia	J	F	M	A	M	J	J	A	S	O	N	D	Mean
Cairns	421	422	460	264	110	72	39	42	43	50	98	203	2224
Cardwell	457	466	417	211	92	50	33	29	36	52	107	193	2143
Lockhart	383	384	456	338	127	57	43	28	17	19	61	212	2125
Papua New Guinea	J	F	M	A	M	J	J	A	S	O	N	D	Mean
Morehead	332	262	318	157	154	86	54	52	38	80	114	224	1871
Merauke	252	237	249	186	111	42	33	20	21	38	75	182	1446

Table 3. Rainfall data of meteorological stations located near *A. mangium* plantations in Malaysia

Peninsular Malaysia	J	F	M	A	M	J	J	A	S	O	N	D	Mean
Kota Tinggi	235	133	172	169	218	180	185	218	224	240	265	306	2544
Temerloh	109	106	161	171	174	115	135	122	143	177	201	258	1922
Seremban	94	127	183	211	206	121	122	129	220	236	269	153	2071
Batang Kali	147	180	229	274	264	150	146	201	252	317	345	217	2723
Sabah	J	F	M	A	M	J	J	A	S	O	N	D	Mean
Bongkol	311	176	96	93	87	98	113	128	164	145	329	506	2246
Kudat	332	145	55	55	109	117	105	133	152	172	314	394	2083
Keningau	118	114	110	142	164	85	115	137	125	132	145	125	1502

temperate zones) and drought, the most common trigger for abscission of leaves and branches in tropical plants (Kozlowski 1973).

Site matching for establishment of *Acacia mangium* plantations

Acacia mangium is planted widely in the humid/subhumid tropics, particularly on logged-over forest sites as well as in revegetation and rehabilitation projects (Pinyopusarerk *et al.* 1993). The species is being promoted as being most suitable on wet sites with a high annual rainfall of up to 4500 mm (Pinyopusarerk *et al.* 1993). During a prolonged dry season, when monthly rainfall is below 100 mm, growth is slowed and trees are under moisture stress (Mead 1989 in Pinyopusarerk *et al.* 1993).

Acacia mangium originates in areas with strong rainfall seasonality, average rainfall being less than 100 mm per month for up to five months each year (Table 2). It is likely that the species is physiologically adapted to such periods of low rainfall and we suggest that these conditions provide a trigger for the development of a cleavage zone in branches, which may eventually lead to branch abscission. Although branches may persist on the tree for a prolonged period, the presence of periderm tissue along the cleavage zone could prevent entry of decay fungi into the heartwood of the tree.

In Malaysia, *A. mangium* is being planted in areas with no distinct seasonality of rainfall, particularly in Peninsular Malaysia where average monthly rainfall is generally more than 100 mm. Although growth would be maximised under such conditions, it is hypothesised that the absence of periods of low rainfall would not favour the development of a physiological cleavage zone in dying branches. As a consequence there would not be any physical barriers to infection of the heartwood by decay microorganisms, particularly for branches which die as a result of reduced light availability associated with canopy closure. Schmitt et *al.* (1995) found that the intensity of wound reactions in A. *mangium* was low four weeks after wounding when compared with reactions of the European hardwoods *Belula and Tilia.* The incompletely occluded vessels and fibers would permit an inflow of air and this would be followed by fungal invasion of the wound-adjacent xylem. They also state that the lumen aggregations were hardly toxic to the fungi which could be quite aggressive.

Sabah, on the other hand, has a distinct, short, dry season (Table 3) and growth of *A. mangium* is reportedly affected by seasonal conditions (Pinyopusarerk *et al.* 1993). The higher incidence and extent of decay reported in *A. mangium* in Peninsular Malaysia compared with Sabah therefore appears to support our hypothesis.

Conclusion

The increasing number of reports of heart rot and other diseases in Southeast Asian plantations of A. *mangium is* an indication that insufficient attention is being given to species-site matching. The present trend of converting logged rain forests in areas with no marked wet and dry seasons to *A. mangium* plantations could lead to more disease problems and reduced productivity in the future. However, we emphasise that verification of our hypothesis would require a thorough investigation of the impact of rainfall seasonality on tree physiological processes leading to branch abscission, the self-pruning ability of *A. mangium*, and the point of entry for heart rot pathogens via infection of branch stubs.

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