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COMMUNICATION

Resistance of Some Forest Plantation Timbers Against Rotting Fungus and Their Durability in Ground Contact

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ABSTRAK

Empat spesies kayu hutan ladang, Acacia crassicarpa, Acacia auriculiformis, Gmelina arborea (yemane) *and* Azadirachta excelsa *(sentang)) telah diuji sifat ketahanan semula jadi terhadap kulat pereput putih* (Pycnoporous sanguineus) *dan juga ketahanannya selepas 3 bulan pendedahan kepada tanah.* Hevea brasiliensis *(kayu getah) dan* Neobalanocarpus heimii *(cengal) digunakan sebagai sampel kawalan. Sampel kayu ini dinilai menurut Piawaian ASTM dan disediakan dari bahagian kayu teras. Kehilangan berat sampel kayu spesies kayu-kayu ini berjulat 7.69 hingga 14.69% bagi kayu teras luar dan 13.16 hingga 24.20 bagi kayu teras dalam. Secara puratanya semua kayu hutan ladang yang diuji termasuk dalam kelas tahan daripada serangan kulat pereput putih. Dalam kelas ini* G. arborea *merekodkan tahap kehilangan berat paling tinggi (19.88%), diikuti oleh* A. crassicarpa *(19.53%),* A. excelsa *(15.44%) dan* A. auriculiformis *(10.75%).* H. brasiliensis *dan* N. heimii *masing-masing mengalami kehilangan berat 61.20% dan 2.16%. Selepas 3 bulan pendedahan kepada tanah,* A. auriculiformis *memperolehi tahap ketahanan paling tinggi terhadap kulat pereput sementara* A. excelsa *pula paling tahan terhadap serangan anai-anai.* A. crassicarpa *dan* G. arborea *pula, masing-masing tidak tahan terhadap serangan anai-anai.*

ABSTRACT

Four plantation species, Acacia crassicarpa, Acacia auriculiformis, Gmelina arborea (yemane) *and* Azadirachta excelsa (sentang)) *were tested for their natural resistance towards a white rot fungus* (Pycnoporous sanguineus) *and for their durability after three months' exposure to the ground.* Hevea brasiliensis *(rubberwood) and* Neobalanocarpus heimii *(cengal) were used as controls. Samples were prepared from the heartwood portion. The weight loss of the timbers caused by the white rot fungus and their durability in ground contact were evaluated in accordance with ASTM Standards. The weight loss values for the outer heartwood of the plantation timbers ranged from 7.69 to 14.69% while those for the inner heartwood ranged from 13.16 to 24.20%. On average, all the plantation timbers fell in the class of resistant against white rot fungus. Within the class,* G. arborea *had the highest average weight loss value (19.88%), followed by* A. crassicarpa *(19.53%),* A. excelsa *(15.44%) and* A. auriculiformis *(10.75%).* H. brasiliensis *and* N. heimii *had weight loss values of 61.20% and 2.16%, respectively. After three months of exposure in the ground,* A. auriculiformis *was the most durable against decay fungi whilst* A. excelsa *was the most durable against termite attack. The least durable against decay and termite attack were* A. crassicarpa *and* G. arborea, *respectively.*

INTRODUCTION

The scarcity of commercial timber species has led many wood processing industries towards the utilisation of exotic, secondary and plantation species. The development of commercial forest plantations in Peninsular Malaysia began in 1957 and the launching of the Compensatory Forest Plantation Programme (CFPP) in 1982 accelerated the planting of exotic species such as *Acacia* spp., *Gmelina arborea, Azadirachta excelsa* and several other species (Thai 1994).

Unlike the commercial timbers, the service life and natural durability of these plantation timbers against deteriorating agents have scarcely been documented. The *Acacia* spp. originally from Australia, have been tested for their service life in their country of origin but under climatic conditions totally different from Malaysia. Degradation of wood due to biological agents proceeds at a much faster rate in the tropical regions than in the temperate regions and decay of wood may be three or four times more rapid (Willeitner and Liese 1992). For these reasons, it is very important to know the natural durability of the potentially available species in the territory concerned, and also the hazards to which they may be exposed and the means by which they can be protected. Such information can be used as guidelines for the utilisation of these timbers.

This paper reports on the resistance of selected plantation timber species against a rotting fungus and their durability in ground contact.

MATERIALS AND METHODS

The plantation species used in this study were *Acacia mangium, Acacia auriculiformis, Acacia crassicarpa, Gmelina arborea* (yemane) and *Azadirachta excelsa* (sentang). The trees were 10 years old and were obtained from Universiti Putra Malaysia (UPM) plantations. Timbers of *Neobalanocarpus heimii* (cengal), a durable species and *Hevea brasiliensis* (rubberwood), a non-durable species, were used for comparison purposes.

Two tests were carried out to assess the durability of the timbers. The tests were standard accelerated laboratory test and field test (graveyard test). Wood blocks, (14 x 14 x 14) mm3 were cut from the heartwood of the stem of each species. Fifteen blocks were obtained from the inner part of the heartwood, i.e., from near the core to the middle portion of the heartwood, and another 15 from the outer part (15 blocks), which is from the middle of the heartwood to the periphery. For the controls, 15 blocks were randomly cut, each from rubberwood and cengal heartwood. Apart from the controls, another 16 reference blocks were prepared from the rubberwood and these blocks were used as a guide for terminating the incubation period. The blocks were tested against white rot fungus (*Pycnoporous sanguineus* Wuflex Fries) in accordance with the method specified in the American Standard of Testing Material, ASTM D 2017-71 (Anon 1972).

The resistance of the plantation species against the fungus was calculated based on the percentage weight loss $((W_a - W_b) / W_a) \times 100)$ from the conditioned weight before (W_a) and after exposure (W_b). An analysis of variance was performed on the weight loss value to detect any difference among the species studied at 95% confidence interval. The results obtained were classified into four classes of degradation resistance: 0-10% weight loss was classified into highly resistant; 11-24% weight loss, resistant; 25-44% weight loss, moderately resistant and above 45% weight loss, slightly/non resistant (Anon 1972).

For the graveyard test, timber stakes of size (25 x 25 x 300) mm^3 were used. A total of 30 stakes was prepared from the heartwood of each species. All stakes were planted in the ground at Ayer Hitam Forest Reserve, Puchong, Selangor. A Standard procedure (ASTM D 1758-74, Anon 1974) was followed. The first inspection of the stakes was done two months after installation. A dull blade was used and probed into the stakes which was pulled from the ground to determine the depth and extent of decay. The assessments of the damage on the stakes were rated separately as follows: 10 (sound), 9 (trace of decay / trace of termite attack), 7 (moderate decay / moderate termite attack), 4 (heavy decay / heavy termite attack) and 0 (Failure to decay / failure to termite attack) (Anon 1974). The results discussed in this paper are based on data obtained up to three months after installation.

RESULTS AND DISCUSSION

Resistance of Plantation Timbers Against White Rot Fungus

After exposure to the fungus, all the wood blocks exhibited a reduction in weight showing that deterioration had occurred (Table 1). A significant lower weight loss value was recorded for the blocks taken from the outer heartwood when compared to the blocks obtained from the inner heartwood blocks of the plantation timbers. The weight loss for the outer heartwood ranged from 7.69 to 14.69% whilst for the inner heartwood it was 13.16 to 24.20%. These findings corroborate with those summarised by Scheffer and Cowling (1966). They found that in many hardwood

TABLE 1
Mean percentage weight loss of wood blocks caused by the white rot fungus, *Pycnoporous sanguineus*

Species	Density[1] (gcm^{-3})	Weight loss (%) Outer heartwood	Inner heartwood	Mean wt. loss	Decay resistance class[2]
Acacia auriculiformis	0.70 (30)	7.69 ± 0.207[3] (15)	13.16 ± 0.258 (15)	11.12 ± 0.236e[4] (30)	Resistant
Acacia Crassicarpa	0.67 (30)	14.69 ± 0.542 (15)	24.20 ± 0.741 (15)	19.53 ± 0.647b (30)	Resistant
Azadirachta excelsa	0.60 (30)	12.46 ± 0.281 (15)	18.43 ± 0.228 (15)	15.44 ± 0.233d (30)	Resistant
Gmelina arborea	0.58 (30)	13.92 ± 0.477 (15)	22.33 ± 0.827 (15)	19.88 ± 0.652b (30)	Resistant
Control					
Hevea brasiliensis	0.55 (30)	-	-	61.20 ± 0.987a (30)	Non-resistant
Neobalanocarpus heimii	0.88 (30)	-		2.16 ± 0.013f (30)	Highly resistant

[1] Density (based on air dry volume), [2]decay resistance class (Anonymous 1974),[3]standard deviation and
[4] means followed by the same letter are not significantly different ($p > 0.05$) using Duncan Multiple Range Test (DMRT) and values in parentheses are number of samples.

species the inner heartwood shows lower durability than the outer heartwood.

Among the plantation species, *G. arborea* showed the highest weight loss with an average of 19.88%. This was followed by *A. crassicarpa* (19.53%) and *Azadirachta excelsa* 15.44% with least weight loss in *A. auriculiformis* (11.12%). The weight loss values for all the plantation timbers fell within the range of 11-24% and was therefore classified as resistant to the white rot fungus (Anonymous 1974). For the controls, *H. brasiliensis* is non resistant while *N. heimii* is highly resistant to the white rot fungus with average weight loss values of 61.20% and 2.16%, respectively.

Variability in the resistance of the plantation species timber against the white rot is possibly due the extractive contents in the heartwood. Extractives in heartwood are known to be toxic and important elements in determining decay resistance to fungi, a range of insects (Rudman and Gay 1963) and marine borers (Bultman 1976). Many of the extractives imparting decay resistance are the hydrolysable and condensed tannins, lignans, alkaloids, terpenoids, flavanoids and a few others (Eaton and Hale 1995). The amount of these compounds vary between species and genera. The relationship between extractives and natural durability of the plantation timbers is worth investigating.

Durability of Plantation Timbers in Ground Contact
Stakes were examined for decay and termite attack after three months' exposure in the ground. Each stake was graded separately according to type of damage even though decay and sign of termite attack might occur on the same stake. The majority of the analysed stakes had a whitish appearance and soft surface which indicates white-rot and some stakes had crack and shrink surfaces indicating the presence of brown rot. Termite activities were also noticed on the surface of the stakes in the ground. The termite was identified as *Macrototermes* sp. Table 2 summarises the results of the decay and termite damage assessment of the timbers.

Assessment of Decay - At the end of the third month, all *A. auriculiformis* stakes were still sound (Grade 10). However, the average percentage of sound stakes for the other plantation timbers ranged from 77 to 90%. *G. arborea* had the highest percentage and *A. crassicarpa* the lowest percentage of stakes that were sound. A trace of decay (Grade 9) was seen in 16% of *A. crassicarpa*, and 20% of *A. excelsa* stakes. Moderate decay (Grade 7) was only recorded in *A. crassicarpa*

TABLE 2
Decay and termite ratings of wood stakes after 3 months' exposure in soil

Species	No. of stakes	Decay Grades (No. of stakes)	Termite Grades (No. of stakes)
A. auriculiformis	30	10(30) [100%] Avg. rating 10	10(16) 9 (8) 7 (5) 4(1) [53%] [27%] [17%] [3%] Avg. rating 9.0
A. crassicarpa	30	10(23) 9(5) 7 (2) [77%] [16%] [7%] Avg. rating 9.6	10(24) 9(4) 7(2) [80%] [13%] [7%] Avg. rating 9.7
Aadirachta. excelsa	30	10(24) 9(6) [80%] [20%] Avg. rating 9.6	10(30)) [100%] Avg. rating 10
G. arborea	30	10(27) M(3) [90%] [10%] Avg. rating 9	10(12) 9(7) 7(4) 4(2) 0(3) M(2) [40%][23%][13%][13%][13%] [8%] Avg. rating 7.3
H. brasiliensis	30	10(8) 9(11) 7(5) 4(4) M(2) [27%][37%][17%][13%] [6%] Avg. rating 7.7	10(2) 9(7) 7(3) 4(11) 0(5) M(2) [6%] [23%] [10%] [37%] [17%] [6%] Avg. rating 4.9
N. hemii	30	10(30) [100%] Avg. rating 10	10(30) [100%] Avg. rating 10

10, 9, 7, 4, 0 are grade number, ( ) = number of stakes, [ ] = percent grade of stakes, M = missing stake

(7%). The average rating for the plantation timbers were between 9 to 10. For the control timbers, all stakes of *N. heimii* remained in their original states, whilst for *H. brasiliensis* only 27% of the stakes were sound (Grade 10), with 37% in Grade 9 and 17% in Grade 7. The remaining 13% were heavily decayed and 6% were missing. The average rating for this timber was 7.7. From Table 2, it can be seen that all the plantation timbers showed a remarkably low percentage of decayed stakes (0-23%) when compared to *H. brasiliensis* (83%). This implies that these timbers are more durable than rubberwood when they are used in contact with the ground.

Although the values recorded for the field test was taken in a short period of time, in most cases, there was a similar trend in the field and laboratory data (Table 1). For instance, *A. auriculiformis* which exhibited the lowest weight loss in the laboratory test, was not decayed after three months' exposure in the soil. On the other hand, 23% of the less resistant *A. crassicarpa* stakes were either slightly or moderately decayed when in ground contact. The same trend was observed in the control stakes of *H. brasiliensis.* Eaton and Hale (1995) reported that in most species, the laboratory and field data are comparable although some wood species appeared less durable in laboratory tests.

Assessment of Termite Damage - After three months' exposure, assessment of the termite damage recorded from the plantation timbers varied from sound (Grade 10) to failure due to termite attack (Grade 0). The average ratings were from 7.3 to 10. About 40-100% of all the plantation timbers remained in their original states (Grade 10) with no sign of termite attack on *A. excelsa.* The worst condition of failure due to termite attack (Grade 0) was observed on *G. arborea* (13%). The average rating for this timber was 7.3. Although *A. auriculiformis* was resistant to fungal degradation, 3% of the stakes were heavily attacked by termites (Grade 4). On the other hand, even though *A. excelsa* exhibited no sign of termite attack, 20% of its stakes were slightly decayed.

When compared to *H. brasiliensis,* all the plantation species tested were more durable against termite attack. At the end of the three months' exposure, 94% of the rubberwood stakes were attacked by termites with an average rating of 4.9. Only *A. excelsa* timber was comparable to *N. heimii.*

From the field test, it appears that there was no relationship between the degradation due to fungi and termite for the plantation timbers over the 3-month period. For example, *A. auriculiformis* and *G. arborea,* were more resistant against decay than termite attack but the reverse occurred with *A. excelsa*. Further trials should be conducted to determine the durability over a longer exposure period.

CONCLUSION

The outer heartwood of the plantation species was more resistant against the white rot fungus, *P. sanguineus* than the inner heartwood. All the plantation timbers were in the class of resistant. Within the class, *A. auriculiformis* had the lowest weight loss values followed by *A. excelsa*, *A. crassicarpa* and *G. arborea*. All the plantation timbers were more resistant against the fungus when compared to rubberwood (non-resistant).

In ground contact, *A. auriculiformis* had the highest resistance against decay fungi followed by *G. arborea*, *Azadirachta excelsa* and *A. crassicarpa*. The highest resistance of plantation timbers against termite attack was *A. excelsa*. This was followed by *A. crassicarpa*, *A auriculiformis* and the least resistant was *G. arborea*. All the plantation timbers were more durable than rubberwood in ground contact but less durable when compared to *N. heimii*. There was no relationship between the degradation due to rotting fungi and termite for the plantation timbers over the 3-month period in the ground.

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