CONFERENCE ON FORESTRY AND FOREST PRODUCTS RESEARCH 1997

Proceedings of the Fourth Conference

Editors

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2000

Conference on Forestry and Forest Products Research 1997: 386–391

TERMITE RESISTANCE OF POTENTIAL FOREST PLANTATION WOODS IN MALAYSIA

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The resistance of selected Malaysian grown woods to attack by aggressive subterranean termites was evaluated in four-week, no-choice laboratory tests with *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae), and in an accelerated four-week, in-ground field test at the Forest Research Institute Malaysia (FRIM). This is part of an on-going effort between FRIM and the University of Hawaii to document the termite resistance of timber species of potential value in plantation forestry in Malaysia. Several of these tree genera also occur in Hawaii, or could potentially be of value as well in forestry efforts in the Hawaiian island. Woods included in the first stage of the project reported here are the heartwood of acacia (*Acacia mangium*), batai (*Albizia falcataria*), casuarina pine (*Casuarina equisetifolia*), sentang (*Azadirachta excelsa*), Malaysian-grown teak (*Tectona grandis*), and sapwood of the susceptible species of rubberwood (*Hevea brasiliensis*). Of these, casuarina pine proved most resistant to termite attack. Malaysian teak and sentang demonstrated somewhat less, but still significant termite resistance in the laboratory evaluations and a high degree of resistance in the field test. Sentang is a relatively pest-free tree of interest for plantation forestry, and was also quite toxic to termites. Acacia, batai and rubberwood were very susceptible to termite attack, and would require protection in the field and treatment of the resulting wood products.

Introduction

A number of tree species are of increasing interest in Malaysia as candidates for increased use and cultivation as plantation species. This subject is also of interest in Hawaii, where declining cultivation of sugar cane and pineapple has opened large blocks of land for alternative crops and forestry. Throughout the tropical

Pacific region, the potential for damage by termites is an important consideration in both the selection and growth of plantation species and the manufacture and use of the resulting wood products.

Malaysia has a rich termite fauna, including several species of *Coptotermes* Wasmann (Tho 1992). Hawaii, on the other hand, is known to have only six termite species at present. However, one of these species is the notorious Formosan subterranean termite, *Coptotermes formosanus* Shiraki, which accounts for over US$ 100 million in cost of damages and control in Hawaii each year (Tamashiro 1990), and is considered to be one of the single most destructive structural pests in the world (Su & Tamashiro 1987).

This report represents part of an on-going collaborative effort between the Forest Research Institute Malaysia (FRIM) and the University of Hawaii to document the in-ground termite resistance of potentially useful Malaysian grown timbers. Several of these represent genera which are also found in Hawaii (Little & Skolmann 1989), and these genera and certain Malaysian species are also of interest to the Hawaiian forestry industry, as are other termite-resistant woods (Grace *et al.* 1996, Grace & Tome 1996). For example, acacia (*Acacia mangium*) and casuarina pine (*Casuarina equisetifolia*) are grown in both locations. Teak (*Tectona grandis*) is of interest throughout Southeast Asia and the Pacific, and Laotian teak has been reported to be quite resistant to *C. formosanus* (Grace & Yamamoto 1994). Sentang (*Azadirachta excelsa*) has attracted interest in Malaysia as a promising plantation species (Ahmad Zuhaidi & Mohd Noor 1996, Ahmad Norani 1997), while the bark of the closely related neem tree (*Azarirachta indica*) has been shown to have some termite-deterrent properties (Delate & Grace 1995).

In the present research project, we are performing laboratory evaluations of the selected wood species (primarily heartwood, since sapwood rarely resists termites or decay) against the aggressive Formosan subterranean termite at the University of Hawaii, using standard laboratory methodology (AWPA 1997, Grace 1998). Field evaluations of these same woods, using an accelerated in-ground procedure, are being performed at FRIM. The important structural pest *Coptotermes curvignathus* Holmgren is prevalent at the FRIM field site, and several other subterranean species are also present.

Materials and methods

For both laboratory and field evaluation, 2x2x2 cm blocks were cut from the heartwood of the selected timber species (with the exception of sapwood from rubberwood). Species included in this report are: acacia (*Acacia mangium*), batai (*Albizi falcataria*), casuarina pine (*Casuarina equisetifolia*), sentang (*Azadirachta excelsa*), teak (*Tectona grandis*) and rubberwood (*Hevea brasiliensis*).

Laboratory evaluations

In the laboratory tests, these wood samples were subjected to a four-week, no-choice laboratory bioassay (AWPA 1997, Grace 1998). This bioassay includes (a) visual ratings of the test blocks using the scale of 10 (sound, surface nibbles permitted), 9 (light attack), 7 (moderate attack), 4 (heavy attack), or 0 (failure); (b) evaluation of the oven-dry wood mass; and (c) evaluation of termite mortality.

Formosan subterranean termites, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae), were collected from an active field colony on the Manoa campus of the University of Hawaii immediately before their use in laboratory assays, using a trapping technique (Tamashiro *et al.* 1973). Test containers were 80 mm diameter by 100 mm high screw-top jars, each containing 150 g washed and oven-dried silica sand and 30 ml distilled water. The test blocks were oven-dried (90 °C for 24 hours), weighed, and allowed to equilibrate to laboratory conditions for several hours before test initiation. One test block was then placed on the surface of the damp sand and 400 termites (360 workers and 40 soldiers, to approximate natural caste proportions) were added to each jar. Each wood species was replicated five times, and three samples of each species were also included as exposure controls, subjected to the same test conditions but with no termites present. Jars were placed in an unlighted controlled-temperature cabinet at 28 ± 0.5 °C for four weeks (28 days). At the conclusion of the test, percentage termite mortality was recorded, the blocks were visually rated according to the 0–10 scale, and the oven-dry mass change was measured for each block (adjusted by the average mass change, if any, of the control samples).

Field evaluations

Similarly-cut wood blocks were oven-dried and weighed as in the laboratory evaluations. The field test site on the grounds of FRIM is a shaded and humid forest location inhabited by the severe structural pest *Coptotermes curvignathus* and several other subterranean termite species. The wood test blocks (five replications) were buried at *ca.* 15-20 cm below the soil surface, and layered with lignocellulosic residues (to encourage termite activity) and top soil. After a four-week (28 day) field exposure, the blocks were recovered and dried and the oven-dry mass change recorded. The test samples were also rated visually according to the 0–5 field rating scale, where 0 represents a sound sample, and 5 represents complete failure due to termite consumption.

Results and discussion

Visual ratings of the test samples, mass losses, and termite mortality in the laboratory evaluation are represented in Table 1. Results of the in-ground accelerated field test are given in Table 2. Malaysian teak proved extremely durable in the field test, but demonstrated a significant but lesser degree of termite resistance in the laboratory evaluation. This difference is likely due to the different test methodologies, since termites under natural field conditions have a variety of woods available to choose amongst, while termites in the laboratory test have no option but to feed on the single wood species presented to them. Differences among the termite species in the two tests with respect to foraging behaviour and feeding activity are also possible, since *C. formosanus* is an extremely aggressive species. The moderate, but significant, durability of the Malaysian teak samples in the laboratory test contrasts somewhat with the high durability of Laotian teak previously demonstrated against *C. formosanus* (Grace & Yamamoto 1994). This may be attributable to the greater age and tree diameter of the Laotian teak stands, although attempts to correlate documented site-specific differences in teak extractive content with tree diameter have not been overly successful to date (Simatupang *et al.* 1995).

Table 1. Results of a four-week, no-choice laboratory test at the University of Hawaii of heartwood of potential tropical trees and sapwood of the susceptible rubberwood exposed to 400 *Coptotermes formosanus* termites

Tree	Name species	Mean visual rating[1]	Mean mg mass loss (±SD)	Mean % mass loss (± SD)	Mean termite mortality (±SD)
Tectona grandis (Malaysia)	Teak	5.80	279.67 (140.10)	5.75 (3.04)	61.20 (14.91)
Casuarina equisetifolia	Casuarina pine	9.00	224.25 (65.01)	2.94 (0.98)	53.45 (4.27)
Azadirachta excelsa	Sentang	5.80	202.77 (94.22)	4.45 (2.16)	82.35 (18.60)
Hevea brasiliensis	Rubberwood	1.60	843.67 (149.07)	19.98 (3.72)	16.55 (4.98)
Acacia mangium	Acacia	0.80	887.12 (185.25)	24.94 (7.11)	21.13 (8.33)
Albizia falcataria	Batai	0.00	505.62 (42.77)	27.23 (3.51)	36.50 (6.54)

[1]Visual rating according to AWPA scale of 10 (sound, surface nibbles permitted), 9 (light attack), 7 (moderate attack), 4 (heavy attack), or 0 (failure)

Table 2. Results of a four-week field test at FRIM of heartwood of potential tropical plantation trees and rubberwood sapwood exposed to naturally high levels of termite foraging activity

Tree species	Name	Mean visual rating[1]	Mean mg mass loss	Mean % mass loss
Tectona grandis (Malaysian)	Teak	0	47	0.8
Casuarina equisetifolia	Casuarina pine	0.2	0	0
Azadirachta excelsa	Sentang	0.8	0	0
Hevea brasiliensis	Rubberwood	5.0	4369	100
Acacia mangium	Acacia	4.8	745	23.0
Albizia falcataria	Batai	3.2	960	11.2

[1]Visual ratings according to scale of 0 to 5, where 0 is sound and 5 is complete failure due to termite consumption.

Casuarina equisetifolia (casuarina pine) proved to be extremely durable in both the laboratory and field tests. As with teak, *Azadirachta excelsa* (sentang) was extremely durable in the field test, but was attacked to a slightly greater extent in the laboratory evaluation, although it also proved very toxic to *C. formosanus* (mean 82% mortality). Sentang is a relatively pest-free tree, and has characteristics that are quite promising for plantation growth (Ahmad Zuhaidi & Mohd Noor 1996, Ahmad Norani 1997). The principal obstacles to increased planting of *A. excelsa* are variation in seed germination rates (Lim & Shaji 1996) and heterogenous growth patterns, resulting in distinct variation in tree sizes within even-aged stands (Ahmad Zuhaidi & Mohd Noor 1996). However, the fairly high degree of termite resistance demonstrated in the present study certainly contributes to its potential.

Rubberwood, acacia, and batai (*Albizia falcataria*, also known as Moluccan albizia) were all very susceptible to termite feeding, and would thus likely require protection as seedlings and treatment of the resulting wood products. Other studies (Grace *et al.* 1996, Grace & Tome 1996) have also demonstrated the susceptibility of *A. falcataria* in Hawaii to attack by *C. formosanus*.

It is hoped that these results and those of our continuing collaborative laboratory and field evaluations of termite resistance will aid both plantation forestry in Malaysia and efforts to promote forestry as a viable and diverse industry in the Hawaiian islands.

Acknowledgements

We are grateful for the support of the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, and the Forest Research Institute Malaysia. L. G. Kirton (FRIM) provided valuable assistance with identification of

Malaysian termite species, and R. J. Oshiro (University of Hawaii) assisted in the laboratory studies. Funding for laboratory evaluations was partially provided by the McIntire-Stennis funds for forestry research.

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