SMOKED WOOD RESISTANCE AGAINST TERMITE

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HADI YS, NURHAYATI T, JASNI, YAMAMOTO H & KAMIYA N. 2010. Smoked wood resistance against termite. Mindi wood (*Melia azedarach*) and sugi wood (*Cryptomeria japonica*) were smoked for 12 hours using mangium wood (*Acacia mangium*) to study their resistance against termite. For comparison, wood preserved with 5% borax and untreated wood were prepared. All wood specimens were tested against (1) subterranean termite (*Coptotermes curvignathus*) in the in-ground test for one year, (2) subterranean termite in the laboratory, and (3) dry wood termite (*Cryptotermes cynocephalus*) in the laboratory. Sizes of wood specimen were 2 × 0.8 cm in cross-section, and in longitudinal directions were 20 cm for in-ground test, 2.5 cm for subterranean termite test and 5 cm for dry wood termite test. Ten replications were conducted for the in-ground test while for the rest of the tests, five replications. Results showed that mindi wood was more resistant to subterranean termite and dry wood termite attacks compared with sugi wood. Based on the Indonesian National Standard 2006, wood resistance against subterranean and dry wood termite attacks increased one class higher when samples were treated with smoke although it was still lower than wood preserved with borax 5%.

Keywords: Subterranean termite, dry wood termite, termite resistance class

HADI YS, NURHAYATI T, JASNI, YAMAMOTO H & KAMIYA N. 2010. Ketahanan kayu asap terhadap serangan anai-anai. Kayu *Melia azedarach* dan kayu *Cryptomeria japonica* diasapkan selama 12 jam menggunakan kayu mangium (*Acacia mangium*) untuk mengkaji ketahanan kayu-kayu tersebut terhadap anai-anai. Sebagai perbandingan, kayu yang diawet dengan 5% boraks dan kayu yang tidak dirawat turut disediakan. Semua spesimen diuji terhadap (1) anai-anai bawah tanah (*Coptotermes curvignathus*) dalam ujian tertanam untuk setahun, (2) anai-anai bawah tanah di makmal dan (3) anai-anai kayu kering (*Cryptotermes cynocephalus*) di makmal. Spesimen kayu mempunyai keratan rentas 2 cm × 0.8 cm dan panjang 20 cm untuk ujian pancang, 2.5 cm untuk ujian anai-anai bawah tanah dan 5 cm untuk ujian anai-anai kayu kering. Sebanyak 10 replikasi dijalankan untuk ujian tertanam dan lima untuk dua ujian lagi. Keputusan menunjukkan bahawa kayu *M. azedarach* lebih rintang terhadap serangan anai-anai bawah tanah serta anai-anai kayu kering berbanding kayu *C. japonica*. Berdasarkan Standard Nasional Indonesia 2006, rintangan kayu terhadap serangan anai-anai bawah tanah serta anai-anai kayu kering meningkat satu kelas apabila sampel dirawat dengan asap. Bagaimanapun nilai ini masih lebih rendah daripada kelas kayu yang diawet dengan 5% boraks.

INTRODUCTION

Since the year 2000, logs for the Indonesian wood industries have been supplied dominantly by plantation forests. In 2006 production of logs reached 21.8 mil m^3 of which 9.0 mil m^3 were from natural forest, 0.3 mil m^3 from Perhutani or state-owned enterprise for plantation forest, 11.5 mil m^3 from industrial plantation forest and 1.0 mil m^3 from community forest, meaning plantation forests comprised 59% of total logs supply (Anonymous 2007). The reliance on plantation forest for future supply of logs will be more critical. Therefore, the Indonesian Ministry of Forestry has been working towards establishing more industrial plantation forests of fast growing species in order to ensure continuous supply of logs.

About 3.6 mil ha of fast growing species, with cutting cycles of 10–15 years, have been established. These include mangium (*Acacia mangium*), sengon (*Paraserianthes falcataria*), tusam (*Pinus merkusii*) and mindi (*Melia azedarach*) (Anonymous 2005, Nurrochmat & Hadi 2005, Anonymous 2009). Wood from plantation forest generally has a large amount of juvenile wood and is inferior in physical–mechanical properties as well as biodeterioration resistance compared with mature wood from natural forest. However, houses in Indonesia which are mostly built using mature wood are not spared from termite attacks. In 1995 the economic loss of various buildings due to termite attack was about USD200 mil (Rakhmawati 1995) and in 2000 it was USD200–300 mil (Yoshimura & Tsunoda 2005). Thus, in future, when wood from plantation forest replaces natural wood, it is expected that this loss will increase if the juvenile wood is not preserved prior to use for building materials. The service life of timber can be extended by employing various chemical treatment methods. Currently chemical treatment is very popular but it has adverse influence on the environment in terms of pollution besides being harmful to humans and other organisms; e.g. chromated copper arsenate (CCA) is very effective for wood preservation but since 2001, it was banned in most countries because of its poisonous characteristics (Hadi *et al.* 2005).

Smoking is a traditional way to preserve wood in Indonesia (Supriana 1999). Wood smoke contains a large number of polycyclic aromatic hydrocarbons (PAHs) and is composed mainly of phenols, aldehydes, ketones, organic acids, alcohols, esters, hydrocarbons and various heterocyclic compounds (Stołyhwo & Sikorski 2005). When wood is placed above a stove for a certain period of time, its moisture content is reduced and PAHs enter the wood. This will enhance resistance of the wood against biological deterioration. Smoke wood condensates have been shown to be effective against *Aeromonas hydrophila* and *Listeria monocytogenes* (Sunen *et al.* 2003).

Mangium wood is used for fire wood or charcoal. When burning wood for charcoal, pyrolisis produces smoke as by-product. This smoke is currently not utilised but has potential to be used as an environmental-friendly preservative of wood.

The purpose of this work was to determine the resistance of smoked mindi and sugi (*Cryptomeria japonica*) woods against subterranean termite attack in the field and in laboratory tests, and to dry wood termite attack in the laboratory. The wood samples were smoked with acacia wood for 12 hours and, for comparison, wood specimens without treatment as control and wood preserved with borax 5% were included in the tests.

MATERIAL AND METHODS

Materials

Samples of mindi wood from Bogor, Indonesia and sugi wood from Japan were used in the experiment. Air-dried mangium wood was pyrolised to produce charcoal and the smoke released was used for smoking wood specimens for 12 hours (Hadi *et al.* 2008). For comparison, wood preserved with 5% borax (borax and boric acid in 1:1.5 w/w) was used as reference for conventional preservation while wood without treatment, as control. For borax treatment, wood specimens were soaked in 5% borax for 24 hours using cold soaking process. All treated woods were conditioned at room temperature for one month prior to the tests. The width and thickness of mindi and sugi woods were 2 and 0.8 cm respectively while the length was according to the purpose of the test. The number of replications was 10 for in-ground test and 5 for laboratory tests.

In-ground test

In-ground test were carried out in Bogor. Ten wood specimens of size 20 × 2 × 0.8 cm (length × width × thickness respectively) were vertically buried in the ground at 15 cm depth for one year and observations were done at 3, 6, 9 and 12 months. Wood failure degree was determined according to the score described by Pablo and Gracia (1997) (Table 1).

Table 1 Wood failure degree

Sample condition	Score
No damage	0
Slight attack, 1–25% failure	40
Moderate attack, 26–50% failure	70
Heavy attack, 51–75% failure	90
Very heavy attack, 76–100% failure	100

Subterranean termite test

Five wood specimens (2.5 × 2 × 0.8 cm) were put in the oven at 100 °C until constant weight and then placed in a 450–500 ml wide-mouth round glass jar with a bottom area of 25–30 cm^2. Each glass jar was then added 200 g moist sand (7%

moisture content under water holding capacity) and 200 healthy and active worker subterranean termites (*Coptotermes curvignathus*). The jar was then kept in a dark room at 25–30 °C with more than 70% relative humidity for four weeks. Each week the bottles were weighed and if moisture content of the sand reduced 2% or more, water was added to reach the standard moisture content. At the end of the four weeks, weight loss of wood specimens and termite mortality percentages were determined (SNI 2006).

Dry wood termite test

Five wood specimens (5 × 2 × 0.8 cm) were put in the oven at 100 °C until constant weight. A glass tube (3 cm height × 1.8 cm diameter) was placed at the centre of each specimen after which 50 worker dry wood termites (*Cryptotermes cynocephalus*) were introduced into the tube. The samples were then kept in a dark room for 12 weeks. At the end of the test, weight loss of wood and termite mortality percentages were determined (SNI 2006).

Data analysis

Analysis of data was done using factorial 2 by 3 in a completely randomised design; the first factor was wood species (mindi and sugi) and the second factor was treatment of the wood (control, smoked 12 hours and preserved with borax 5%). Duncan's test was used for further analysis because the factor was significantly different.

RESULTS AND DISCUSSION

Retention of borax 5% in mindi and sugi woods reached 5.2 and 12.2 kg m^{-3} respectively. Penetration of sugi wood was greater because of its lower density (0.34 g cm^{-3}) compared with mindi wood (0.43 g cm^3) and this concurred with findings by Hadjib *et al.* (2000).

In-ground test

Results for wsood failure degree after 3, 6, 9 and 12 months of in-ground test and their analyses are shown in Tables 2, 3 and 4.

Table 2 Wood failure degree during in-ground test

Treatment	Sugi				Mindi			
	3 months	6 months	9 months	12 months	3 months	6 months	9 months	12 months
Control	100 ± 0	100 ± 0	100 ± 0	100 ± 0	65 ± 19	65 ± 19	74 ± 24	85 ± 25
Smoked	88 ± 25	88 ± 25	100 ± 0	100 ± 0	13 ± 30	13 ± 30	61 ± 27	69 ± 28
Borax 5%	97 ± 9	100 ± 0	100 ± 0	100 ± 0	8 ± 17	8 ± 17	46 ± 13	49 ± 20

Each sample was scored and these values were the averages of five replications.

Table 3 The F values from analysis of variance results

Test, treatment	Wood failure degree			
	3 months	6 months	9 months	12 months
In-ground				
Wood species (A)	174.8**	187.6**	99.8**	48.2**
Treatment (B)	17.0**	17.0**	3.2*	5.9**
Interaction (AB)	10.4**	11.8**	3.2*	5.9**
Subterranean termite	Weight loss	Mortality		
Wood species (A)	153.4**	816.3**		
Treatment (B)	146.6**	4495**		
Interaction (AB)	74.4**	816.3**		
Dry wood termite	Weight loss	Mortality		
Wood species (A)	58.9**	28.9**		
Treatment (B)	7.9**	480.0**		
Interaction (AB)	13.3**	19.2**		

** = Highly significant difference; * = significant difference

Table 4 Results of Duncan's test

Test, response	Sugi			Mindi		
	Control	Smoked	Borax	Control	Smoked	Borax
In-ground						
3 months	a	a	a	b	c	c
6 months	a	a	a	b	c	c
9 months	a	a	a	b	b	c
12 months	a	a	a	a	b	c
Subterranean termite						
Weight loss	a	b	bc	b	bc	c
Mortality	c	a	a	b	a	a
Dry wood termite						
Weight loss	a	b	b	c	d	d
Mortality	d	b	a	c	b	a

The same letter at each test indicates no significant difference.

Untreated mindi was more resistant than untreated sugi up to nine months of in-ground treatment but after that both woods had the same level of resistance. There was a significant inverse association between percentage of mass loss and specific gravity (Arango *et al.* 2006) and the higher density of mindi made it more resistant compared with sugi. There was no evidence of fungi attack and instead deterioration of both woods was due to termite attack.

Smoke treatment and borax preservative did not enhance the resistance of sugi against subterranean termite attack (Table 4). However, mindi wood showed better resistance against termite damage for up to six months. With borax preservative, mindi had more resistant even up to 12 months compared with untreated and smoked wood. This result is similar to findings by Kartal and Ayrilmis (2005). Leaching rate is greater in wood with lower density. The ineffectiveness of both treatments to sugi wood was also contributed by the high precipitation of more than 4000 mm per year at the test site.

Subterranean termite test

After four weeks exposure to subterranean termite in the laboratory, wood weight loss and termite mortality of both wood species were determined (Table 5). Untreated mindi wood had better resistance to termite attack than untreated sugi as seen from the lower weight loss of wood and higher termite mortality of the former (Tables 4 and 5). Based on the weight loss of their untreated woods, mindi was categorised as class III while sugi, class V (SNI 2006).

Smoke treatment significantly affected wood resistance to subterranean termite attack (Tables 3–5). The treatment increased the resistance of samples as indicated by their lower weight loss and higher termite mortality compared with untreated wood. The resistance class of smoked mindi increased by one class and sugi by two classes compared with the control, but both smoked woods had lower resistance class compared with borax-preserved wood.

Table 5 Weight loss of wood specimens and termite mortality in subterranean termite test

Treatment	Sugi		Mindi	
	% Wood weight loss (resistance class)*	% Termite mortality	% Wood weight loss (resistance class)	% Termite mortality
Control	45.4 ± 5.4 (V)	4 ± 2.0	10.3 ± 3.1 (III)	61 ± 4
Smoked	10.4 ± 1.9 (III)	100 ± 0	5.9 ± 0.7 (II)	100 ± 0
Borax 5%	7.2 ± 4.2 (II)	100 ± 0	2.8 ± 1.6 (I)	100 ± 0

*Resistance class refers to SNI (2006).

Dry wood termite test

At the end of the dry wood termite test, mindi wood showed better resistance than sugi wood which was indicated by its lower wood weight loss and higher termite mortality (Tables 3, 4 and 6). Based on weight loss of untreated wood, sugi was categorised as class IV or not resistant to dry wood termite attack, and mindi wood to class III or moderately resistant (SNI 2006).

With lower weight loss of wood and higher termite mortality compared with control, it is obvious that smoke treatment also increased wood resistance to dry wood termite attack. Smoked sugi and mindi woods were categorised as classes III and II respectively; both smoked woods increased one class but they were still one class below borax-preserved wood.

Prolonged smoking in traditional stove can be effective in increasing resistance of wood against termites (Supriana 1999). Thus, in future the duration of smoking can be extended to allow more PAHs to penetrate into the wood. Also, since PAHs in this study are specific to mangium wood, it is suggested that tests should be conducted using woods of other species.

CONCLUSIONS

Based on findings of this work it could be concluded that mindi wood was more resistant than sugi wood against subterranean and dry wood termite attacks because of its higher density. Smoke treatment increased the resistance classification of sugi and mindi woods by one class. However, smoking for 12 hours was insufficient to increase resistance of wood to be higher that those treated with 5% borax.

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Table 6 Weight loss of wood samples and termite mortality in the dry wood termite test

Treatment	Sugi		Mindi	
	% Wood weight loss (resistance class)*	% Termite mortality	% Wood weight loss (resistance class)	% Termite mortality
Control	16.9 ± 5.6 (IV)	22 ± 5	6.9 ± 7.5 (III)	46 ± 4
Smoked	6.1 ± 4.9 (III)	68 ± 7	2.9 ± 1.5 (II)	72 ± 7
Borax 5%	2.3 ± 1.4 (II)	100 ± 0	1.9 ± 0.9 (I)	100 ± 0

*Resistance class refers to SNI (2006).

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