H2 hazard class field test of planted Malaysian hardwoods engkabang, kelempayan and rubberwood dip-treated with different concentrations of cypermethrin and permethrin against *Coptotermes curvignathus*

by

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Abstract

Some prescribed use rates of agro-insecticide products are meant to control specific insect pests, including termites, in crop or wood protection. The objective of this study was to determine the efficacy of agro-insecticidal dip-treated fast-grown Malaysian hardwoods against the subterranean termite *Coptotermes curvignathus* in an aboveground H2 hazard class field test. Proprietary agro-insecticides containing cypermethrin or permethrin were used to dip-treat wood of engkabang (*Shorea macrophylla*), kelempayan (*Neolamarckia cadamba*) and rubberwood (*Hevea brasiliensis*) for 60 seconds at their prescribed rates (cypermethrin: 0.0055%g/g; permethrin: 0.0053%g/g) and reduced concentrations. Field tests were conducted under low humidity in an H2 hazard class (shielded from light and rainwater/inundation wetting) situation for 6 months. Results showed that untreated rubberwood was completely destroyed (mean mass loss 100%; mean AWPA visual termite rating 0) while relatively severe attacks occurred in engkabang (mean mass loss 57.0%, mean rating 3.7) and kelempayan (mean mass loss 31.1%, mean rating 7.5). Based on termite rating scale wood protection using cypermethrin did not occur at the prescribed spray-on concentrations, yielding mean termite ratings of 7.0 for rubberwood at 0.00275%, a rating 7.3 for kelempayan at 0.00275% and 0.0055%, and a rating 9.2 for engkabang at 0.001375% and 0.0055%. Mean termite ratings within each wood species were significantly different ($P<0.05$) among cypermethrin concentrations. Permethrin concentrations up to 0.0053%, failed to protect rubberwood (mean mass loss ≥ 85%, mean visual rating ≤ 1.3) and showed reduced protection of both kelempayan and engkabang where the best control occurred at less than prescribed concentrations (mean visual rating of 6.8 for kelempayan at 0.00265%; a rating 8.3 for engkabang at 0.00265%). In conclusion, pyrethroid treated rubberwood was not resistant while both treated engkabang and kelempayan were moderately resistant to *C. curvignathus* even at less than prescribed concentrations of the insecticides. Further tests at higher concentrations for these insecticide products would be required to detect effective concentrations for complete H2 hazard class wood protection.

Keywords: engkabang, kelempayan, rubberwood, cypermethrin, permethrin, dip-treatment, H2 hazard class

Introduction

Southeast Asian countries like Malaysia have a wealth of low termite-resistant wood species that provide a number of wood products used under H2 biological Hazard Class conditions specified in the Malaysian wood protection Standards (Wong 2004, 2005) while untreated and treated Malaysian woods typically used outdoors aboveground and inground are predisposed to high decay and termite hazards (Kirton & Wong 2001). Particularly as termites are economically important structural pests in tropical countries, their destructive significance to wood products, by public perception, seem more serious than that of tropical fungal decay (Kirton & Wong 2001), with costs incurred in 2003 to control termites in Malaysia amounting to approximately USD10-12 million (Lee 2004). Consequently, there is a need for low-moderate durability woods to be protected with wood protecting chemicals or by other means. For low hazard class applications in wood usage, it may be sufficient to surface-treat the wood [e.g. spraying, brushing, dipping, steeping-immersion or soaking (Richardson 1993)] with water-borne synthetic pyrethroids (eg. cypermethrin and permethrin) recognized as contact nerve poisons. The advantages of using dipping are: simple technique, low treatment cost, and achieving deep penetration and loading depending to duration of immersion (Richardson 1993, Ma *et al* 2013), which may encourage production of biocidal surface-treated wood products for H2 hazard class exposures.

In Australia (south of the Tropic of Capricorn) and New Zealand, the wood products industry features termite-resistant bifenthrin surface-treated (envelope-treated) softwood framing timbers (Standards Australia 2005) and that further work on such treated wood has verified their high termite-resistance (Sukartana *et al* 2009). Limited laboratory termite tests on rubberwood surface-treatments using cypermethrin, permethrin, bifenthrin and chlorpyrifos at higher than recommended concentrations for dip or brush-treatments have also conferred complete wood protection (Sornnuwat *et al* 1994). Since many water-borne organic agro-insecticidal products are available from agro-pesticide retail outlets, with instructions for spray-on dosages for protection against specific insect pests and/or for termite control of plantation trees and vegetables, these products could be considered for wood protection against termites if minimum effective dosages are determined. The objective of this study was to determine termite resistance of two commercial agro-insecticides by dip-treating engkabang, kelempayan and rubberwood as measured by an aboveground field test simulating H2 hazard class conditions.

Materials and methods

Engkabang (*Shorea macrophylla*), kelempayan (*Neolamarckia cadamba*) and rubberwood (*Hevea brasiliensis*) wood were cut into 20 x 20 x 20 mm blocks. Two commercial agro-insecticides were obtained from a local agro-pesticides retail outlet. Trade names, formulations and mode of applications of the agro-insecticides are shown in **Table 1**. Concentrations of insecticides are shown in **Table 2**.

Engkabang, kelempayan and rubberwood blocks were oven-dried for 48 hours at 105˚C. Then wood blocks were dipped, one block at a time, into agro-insecticide solutions at various concentrations up to the prescribed product concentrations for exactly 60 seconds. After conditioning for 14 days at room temperature, wood blocks were arranged randomly on a perforated aluminium tray mixed with termite baits of corrugated board and softwood blocks, and then exposed to an aboveground H2 hazard class termite test assembly providing shade and cover in a, non-wetting internal environment except humidity (Wong 2005), positioned above a stack of keruing sawn timbers infested by *Coptotermes curvignathus* for 6 months at the Timber Research and Technical Training Centre, Sarawak Forestry Corporation. Thereafter the blocks were retrieved, cleaned of soil debris, and oven-dried for 48 hours at 105˚C, before percentage mass loss and termite visual rating were evaluated. The visual rating was based on AWPA E7-07 scale (**Table 3**). Data were analysed using One-way ANOVA from the MINITAB14 statistical software.

Table 1: Properties of the agro-insecticides

Trade Name	Composition	Mode of Application	Dosages (ml) in 10 litres
GARRISON™ 5.5 EC	Cypermethrin (5.5% w/w) Inert ingredient: (94.5% w/w)	Spray	*Aphis sp.* (10ml) *Leucinodes orbonalis* (10ml) (= 0.0055%g/g cypermethrin)
KENBUSH™ 26.3 EC	Permethrin (26.3% w/w) Inert ingredient: (73.7% w/w)	Spray	*Leucinodes orbonalis* (2ml) *Plutella xylostella* (2ml) *Aphis sp.*(2ml) *Earias phabia* (2ml) (=0.0053% permethrin)

Table 2: Concentrations of the agro-insecticides used

Agro-insecticides	Concentration of active (%g/g)			
Cypermethrin	0.00	0.001375	0.00275	0.0055
Permethrin	0.00	0.001325	0.00265	0.0053

Table 3: AWPA E7-07 termite rating scheme (AWPA 2008)

Rating	Description
10	Sound
9.5	Trace, surface nibbles permitted
9	Slight attack, ≤3% of cross sectional area affected
8	Moderate attack, 3-10% cross sectional area affected
7	Moderately severe attack and penetration, 10-30% of cross sectional area affected
6	Severe attack, 30-50% of cross sectional area affected
4	Very severe attack, 50-75% of cross sectional area affected
0	Failure (destroyed)

Results and Discussion

Results (**Table 4 & 5**) showed that untreated rubberwood was completely destroyed (mean mass loss 100%, mean AWPA termite rating 0) while untreated engkabang and kelempayan sustained rather severe attacks with mean mass losses of 57.0% (mean termite rating 3.7) and 31.1% (mean termite rating 7.5) respectively. There was a significant difference ($P<0.05$) in percentage mass loss and visual rating of both engkabang or kelempayan between concentrations of cypermethrin or permethrin, while for rubberwood significant differences occurred between concentrations of cypermethrin but not permethrin (**Table 4** *cf* **Table 5**). Comparisons between cypermethrin and permethrin would not be valid due to the different formulations. Based on termite ratings of cypermethrin-treated wood (**Table 4**), the best termite control did not always occur at the prescribed dosages, with no consistent trends among the concentrations (ie. best mean termite rating for rubberwood was 7.0 at 0.00275%, engkabang rated 9.2 at 0.001375% & 0.0055%, and kelempayan rated 7.3 at 0.00275% & 0.0055%). Cypermethrin-treated engkabang sustained the best, though not completely, termite control among the 3 wood species (**Table 4**).

Table 4: Mean percentage mass loss (%) and mean visual rating of engkabang, kelempayan and rubberwood dip-treated with cypermethrin

Species	Concentrations (%g/g)	Wood Mass Loss (%)			Mean Visual Rating	Min	Max
		Mean	Min	Max			
Engkabang	Controls	57.0 (20.2) *b*	27.5	79.1	3.7 (3.2) *a*	0	8
	0.001375	20.2 (8.7) *a*	8.3	29.8	9.2 (0.7) *b*	8	10
	0.00275	25.4 (11.7) *a*	6.7	42.2	8.8 (0.7) *b*	8	9.5
	0.0055	20.5 (5.0) *a*	13.8	29.2	9.2 (0.6) *b*	8	9.5
Kelempayan	Controls	31.1 (8.3) *a*	21.8	45.1	7.5 (1.2) *b*	6	9
	0.001375	74.8 (9.6) *c*	64.5	84.7	5.0 (1.1) *a*	4	6
	0.00275	57.8 (5.9) *b*	49.5	66.5	7.3 (0.8) *b*	7	9
	0.0055	58.9 (4.8) *b*	53.8	66.9	7.3 (0.5) *b*	7	8
Rubberwood	Controls	100 (0) *c*	100	100	0 (0) *a*	0	0
	0.001375	76.2 (20.3) *b*	43.4	100	2.2 (3.4) *a*	0	7
	0.00275	42.2 (12.7) *a*	20.8	59.1	7.0 (1.1) *b*	6	9
	0.0055	85.8 (12.6) *bc*	63.6	100	2.3 (2.7) *a*	0	6

(…) = Standard deviation, n= 6.
Within-column values per wood species sharing same italicized letters denote no significant difference by LSD.
LSD values (% mass loss) for engkabang = 15.3, kelempayan = 8.9, rubberwood = 16.2
LSD values (termite rating) for engkabang = 2.0, kelempayan = 1.1, rubberwood = 2.7

Table 5: Mean percentage mass loss (%) and mean visual rating of engkabang, kelempayan, and rubberwood dip-treated with permethrin

Species	Concentrations (%g/g)	Mean Percentage Mass Loss (%)	Min	Max	Mean Visual Rating	Min	Max
Engkabang	Controls	57.0 (20.2) *b*	27.5	79.1	3.7 (3.2) *a*	0	8
	0.001325	16.0 (11.1) *a*	4.7	30.4	7.9 (0.9) *b*	7	9.5
	0.00265	20.7 (16.2) *a*	3.6	48.1	8.3 (0.9) *b*	7	9.5
	0.0053	32.8 (11.9) *a*	19.8	52.3	7.5 (1.0) *b*	6	9
Kelempayan	Controls	31.1 (8.3) *a*	21.8	45.1	7.5 (1.2) *c*	6	9
	0.001325	71.5 (11.5) *c*	56.4	86.1	5.7 (1.4) *ab*	4	7
	0.00265	57.5 (8.7) *b*	45.4	65.4	6.8 (0.8) *bc*	6	8
	0.0053	73.3 (7.4) *c*	62.8	81.8	4.7 (1.0) *a*	4	6
Rubberwood	Controls	100.0 (0.0) ns	100	100	0 (0) ns	0	0
	0.001325	100.0 (0.0) ns	100	100	0 (0) ns	0	0
	0.00265	87.2 (19.8) ns	60.9	100	1.3 (2.1) ns	0	4
	0.0053	86.3 (21.3) ns	58.6	100	1.3 (2.1) ns	0	4

(…) = Standard deviation, n= 6. ns= not significant ($P<0.05$)
Within-column values per wood species sharing same italicized letters denote no significant difference by LSD.
LSD values (% mass loss) for engkabang = 18.4, kelempayan = 10.9
LSD values (termite rating); engkabang = 2.2, kelempayan = 1.3

From **Table 5**, permethrin at the concentrations tested failed to protect rubberwood (mean termite rating ≤ 1.3, mean mass loss >85%). Based on the termite ratings, the best termite control for permethrin-treated engkabang and kelempayan was recorded at less than the prescribed concentration (engkabang and kelempayan at 0.00265%), with best mean termite ratings for engkabang and kelempayan of 8.3 and 6.8, respectively. Mean mass loss and visual ratings in **Table 5** revealed that permethrin treated engkabang was the least attacked among the 3 wood types tested.

High termite susceptibility of untreated rubberwood (**Table 4 & 5**) is typical of this wood species which was previously observed in other aboveground, inground or laboratory termite tests (Wong 2000, Grace *et al* 1998, Wong *et al* 1998). Rubberwood is indeed a suitable candidate substrate for termite baits or as a wood substrate for preservative testings as well as studies with bait toxicants. That these pyrethroids at those spray-on concentrations failed to protect engkabang, kelempayan and rubberwood is of concern, and should be re-tested at higher dosages. Read and Berry (1984) revealed that a 0.1% concentration of cypermethrin emulsion using surface application was sufficient against *Reticulitermes* termites and this contrasts with the extremely low dosages adopted in the present study, suggesting that prescribed product concentration of cypermethrin (0.0055%) was clearly inadequate for termite control. Zaidon *et al* (2008) found that exposure of rubberwood particleboard, Empty Fruit Bunch (EFB) particleboard and Rubberwood-EFB particleboard sprayed with 0.2% permethrin to *Coptotermes curvignathus* yielded low mean mass loss (range: 7.2 – 12.1%) unlike their untreated counterparts (range: 17.8 – 31.1%). Excellent protection was reported from a laboratory evaluation of 5-min dip-treated rubberwood blocks exposed to *Coptotermes gestroi* at 0.015, 0.25 and 0.5% cypermethrin and at 0.5, 1 and 2% permethrin (Sornnuwat *et al* 1994). In the present study, 60 sec. dipping time was adopted which reflects typical short duration dip-treatments of wood, yet it is useful to note that improved termite (and fungal) resistance of dip-treated wood do occur when dipping (or steeping) durations (and perceivable insecticide retentions in wood) increase appreciably [>1 min, a few or several hours (Sornnuwat *et al* 1994, Kamdem *et al* 1996, Ma *et al* 2013)]. Surface treatments rely on capillary action allowing a preservative solution to penetrate into the wood, with higher uptakes/absorptions and penetrations due to increased dipping times (Humar & Lesar 2009, Ma *et al* 2013). Since preservative performance against wood-degrading organisms depends mainly on wood species, target preservative retention (derived from concentrations and treatment methods used) and penetration of the preservative into the wood (Zabel & Morrell 1992), dip-treatments in water-borne insecticides can also enhance termite durability performance of wood under non-leaching (H2 hazard class) conditions when adequate dipping times and insecticidal concentrations are applied.

Conclusion

Both treated and untreated rubberwood were nonresistant while engkabang and kelempayan were respectively, non- and moderately termite resistant. Results shows that cypermethrin and permethrin also provide good protection to engkabang and moderate protection to kelempayan. This study revealed that agro-insecticides used at their prescribed spray-on concentrations meant for crop protection might not be adequate for wood preservation against termites. Further, similar wood dip-treatments at higher insecticidal concentrations would therefore be desirable to seek adequate concentrations (and practical dipping times) to prevent termite attacks.

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