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ENHANCING *LEUCAENA LEUCOCEPHALA* WOOD PRESERVATION BY STEEPING IT IN BORON COMPOUNDS AND ACETIC ACID TO PROTECT AGAINST TERMITES

THITI WANISHDILOKRATN, SIRILUK SUKJAREON, ITSAREE HOWPINJAI,
LAMTHAI ASANOK
MAEJO UNIVERSITY PHRAE CAMPUS
THAILAND

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ABSTRACT

This study compared steeping *Leucaena leucocephala* wood with boron compounds and acetic acid to protect it from termites (*Coptotermes gestroi*). The experiment had a completely randomized design with 10 treatments involving three wood preservatives (acetic acid, boron compounds, and mixtures of both), three treatment lengths (1, 12, and 24 h), and untreated wood, with five replicates of each for a total of 50 conditions. The moisture content of the wood and the wood destroyed by termites were assessed. The *L. leucocephala* wood treated with boron compounds for 1 h resulted increase in moisture content and no termite damage.

KEYWORDS: Wood preservation, invasive plant species, moisture content, percentage, *Coptotermes gestroi*.

INTRODUCTION

Wood is a valuable natural resource that is currently in high demand worldwide (Lauri et al. 2019) including in Thailand (Sasaki et al. 2009). The demand for wood leads to many problems, such as forest invasion, deforestation, illegal logging, and forest fires (Rahman et al. 2010, Delang 2002, Wanthongchai et al. 2008). Most people use only hard woods, such as *Tectona grandis*, *Dalbergia cochinchinensis*, and *Xylia xylocarpa* (Koirala et al. 2021, Liu et al. 2016, Saelim and Zwiazek 2000) which is major source in Thailand (Kenzo et al. 2020) because superior strength properties and higher density values compared to most of the soft wood (Musah et al. 2021). However, soft wood is another option. The forests of Thailand are being threatened, which affects biodiversity and forest ecosystems (Ghazoul 2002). Invasive plant species, such as *Leucaena leucocephala*, reproduce and spread rapidly, competing for water and food, with serious consequences on local ecosystems (Marod et al. 2012). Typically, soft woods such as *L. leucocephala* are not use for lumber but rather for other purposes such as for firewood, charcoal, and fences (Chebil et al. 2000) because softwoods were low ability to resist termites damage (Arango et al. 2006). However, increasing the durability of wood using preservatives can lead to alternative forms of wood utilization (Brischke 2020).

Wood preservation protects wood from insects, particularly termites (Eller et al. 2018). Non-pressure wood treatment is a simple preservation process that does not require a wood impregnation machine. Methods of protective vanishes include dipping, steeping, and spraying (Saavedra et al. 2021). Steeping is an easy technique that penetrates wood better than other non-pressure wood treatments, depending on time, concentration and the type of wood preservative (Hossain et al. 2013, Koyano et al. 2019) for increasing moisture content in the permeable portion of wood (Oliveira et al. 2018).

Boron compounds are bio-pesticides, while acetic acid is an environmentally friendly synthetic preservative (González-Laredo et al. 2015). These easily penetrate wood depending on the steeping time. Therefore, this study compared the effects of steeping *L. leucocephala* in boron compounds and acetic acid as protection against termites (*C. gestroi*) from using the applied AWPA E7–15 (2015) and EN 252 (1990) standards.

MATERIAL AND METHODS

Study site

The study investigated *L. leucocephala* at Maejo University Phrae Campus, Phrae Province, Thailand. The study site is approximately 155 m above sea level, with temperatures of 9.2 - 43.0°C and annual rainfall of 1010 - 1550 mm.

Preparation of wood test samples

L. leucocephala trees with a diameter at breast height of 20 cm were cut into 50 samples measuring 25 × 25 × 10 mm. The samples were dried in an oven at 103 ± 2°C for 24 h, until the moisture content was around 12%.

Experimental design

The experiment was a completely randomized design with 10 treatments involving three wood preservatives (acetic acid, boron compounds, and mixtures of these), three preservation times (1, 12, and 24 h), and untreated wood: treated with acetic acid for 1 (A1), 12 (A2), or 24 (A3) h; treated with boron compounds for 1 (B1), 12 (B2), or 24 (B3) h; treated with a mixture of acetic acid and boron compounds for 1 (AB1), 12 (AB2), or 24 (AB3) h; and untreated wood (control). With five replicates per treatment, there were 50 conditions in total.

Data collection

The change in moisture content was determined as the difference in the wood moisture content between before and after treatment, calculated by weight using:

$$\text{Moisture content (\%)} = (W_1 – W_2)/W_2 \times 100 \quad (1)$$

where: W_1 and W_2 are the weights before and after treatment, (g).

The treated wood samples were buried in a 3:1 mixture of uncontaminated sand and clean water with roughly 400 termites (*C. gestroi*) in a plastic box measuring 8 × 5 × 11 cm for 60 days and the difference in weight between before and after burial was compared using the applied AWPA E7–15 (2015) and EN 252 (1990) standards. The amount to wood destroyed was quantified as:

$$\text{Destruction of wood sample (\%)} = (W_A – W_B)/W_B \times 100 \quad (2)$$

where: W_A and W_B are the weights before and after burial, respectively, (g).

Data analysis

Statistical differences in the moisture content and amount of wood destroyed between treatments were analyzed using one-way analysis of variance (ANOVA) and Duncan's new multiple range test. The linear relationship between the increasing moisture content and destroyed *L. leucocephala* wood was determined. SPSS for Windows (version 20.0) was used for the analyses.

RESULTS AND DISCUSSION

Moisture content of *Leucaena leucocephala* wood

The moisture content of *L. leucocephala* wood increased under various preservations conditions. The highest content was with treatment A3 (27.11%), followed by AB3 (23.87%), B3 (17.80%), B2 (4.94%), A2 (4.61%), and AB2 (4.47%); these changes were all significant ($p < 0.05$). By contrast, the moisture contents of A1 (1.95%), B1 (1.71%), and AB1 (1.42%) did not change significantly (Tab. 1). These results are similar to those of Gefert et al. (2019). Acetic acid is a dissociative carboxylic acid that penetrates deep into wood. Boron compounds (boric acid and borax salts) penetrate wood more slowly than acidic substances (Gecer et al. 2015). Because, acetic acid increased irregularity of the pore structure (Chi et al. 2017). Affecting, steeping wood for long time promoted higher moisture contents and increased chemical movement (Humar and Lesar 2009, Cabrera and Morrell 2009). Gibson and Watt (2010) reported that the concentrations of wood preservative were affected to increased humidity. On the other hand, the borate-based formulations of wood preservative can diffuse for short distances at levels that confer wood protection but their ability to move deeper into wood is somewhat limited (Morrell and Freitag 1995).

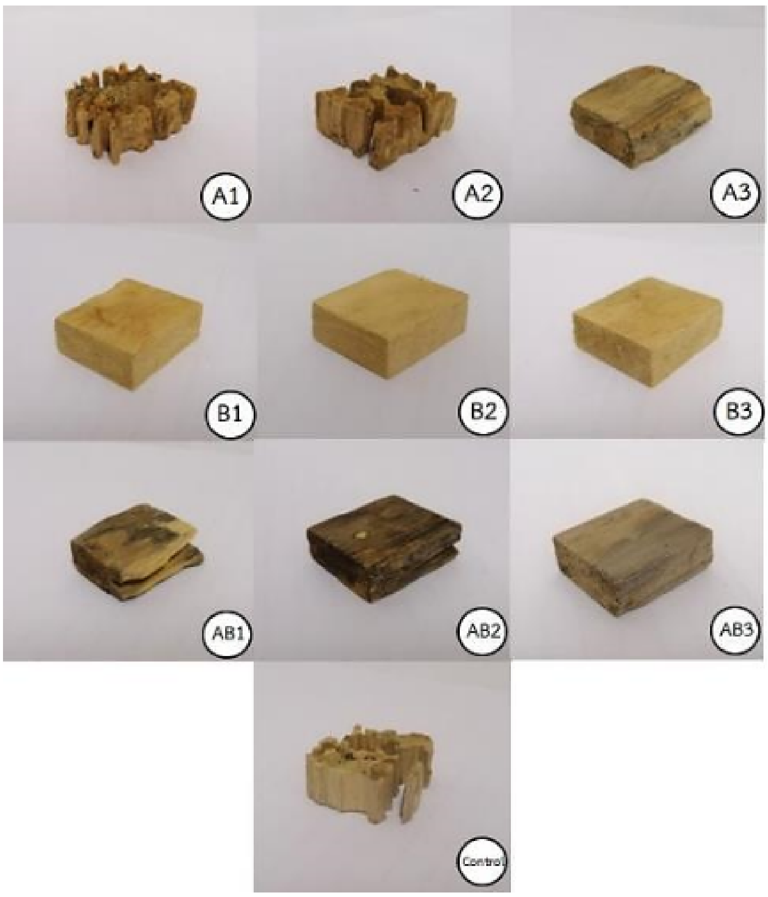
Tab. 1: Average percentage increase in moisture content of treated Leucaena leucocephala.

Treatment	Average (%)	Range (%)
A1	1.95 ± 0.27^{e}	1.79 – 2.42
A2	4.61 ± 0.20^{d}	4.33 – 4.89
A3	27.11 ± 0.24^{a}	26.83 – 27.37
B1	1.71 ± 0.28^{e}	1.33 – 2.05
B2	4.94 ± 0.26^{d}	4.74 – 5.38
B3	17.80 ± 1.38^{c}	16.17 – 19.55
AB1	1.42 ± 0.63^{e}	0.84 – 2.29
AB2	4.47 ± 0.54^{d}	3.85 – 5.16
AB3	23.87 ± 0.36^{b}	23.38 – 24.30
Average	9.76 ± 0.46	8.33 – 9.34
p-value	0.001	

Note: Different letters (a, b, c, d, e) indicate significant differences between moisture content; ANOVA, $p < 0.05$, followed by Duncan's new multiple range test.

Effects of termites on *Leucaena leucocephala*

The amount of *L. leucocephala* wood destroyed by termites depended on the wood preservative and steeping time. The wood treated with boron compounds (B1, B2, and B3) was not damaged, whereas the control was the greatest damaged, followed by the wood treated with acetic acid (A1, A2, and A3) and the wood treated with mixtures of acetic acid and boron compounds (AB1, AB2, and AB3), respectively (Fig. 1).



Note: Treatment codes indicated at experimental design.

Fig. 1: Photographs of L. leucocephala wood destroyed by termites after different treatments.

The wood treated with boron compounds (B1, B2, and B3) was not damaged, while 2–19% of the wood treated with acetic acid (A1, A2, and A3) was damaged versus 1–4% of the wood treated with mixtures of acetic acid and boron compounds (AB1, AB2, and AB3) and 20% in the control (Tab. 2).

Tab. 2: Average percentage of L. leucocephala wood destroyed by termites.

Treatment	**Average (%)**	**Range (%)**
A1	18.30 ± 3.45	14.73 – 22.89
A2	13.37 ± 1.28	12.05 – 14.89
A3	2.35 ± 0.07	2.29 – 2.44
B1	Sound	–
B2	Sound	–
B3	Sound	–
AB1	2.04 ± 0.57	1.59 – 2.98
AB2	3.54 ± 0.53	2.96 – 4.04
AB3	1.47 ± 1.05	0.26 – 1.03
Control	20.72 ± 2.43	17.84 – 23.84

These results are similar to a previous study that reported that acids such as citric acid confer less protection than boron compounds in *Melaleuca cajuputi* wood against *C. Gestroi* (Tarasin and Rattanapun 2019). Jorge et al. (2004) reported that wood preservation with boron compounds (40% boric acid and 60% borax salts) is particularly efficient against termites. Zulfiqar et al. (2020) reported that different dipping treatment times (36 and 72 hours) at 10, 20 and 30% concentrations of extractives on *Populus deltoides* wooden stakes were used and exposed to termites in submerged manner. Because, boron-treated lumber effects of reducing attack by subterranean termites because termites can excrete or metabolize slowly ingested boron over time (Gentz and Grace 2008). Moreover, the wood samples of the strong odor from the high acid content may have repelled or disturbed the termites (Indrayani et al. 2015). Thus, the wood samples were impregnated with bio preservative such as boron compounds prepared that protected from against termites (Salami et al. 2019).

CONCLUSIONS

The optimal conditions for protecting *Leucaena leucocephala* wood from termites was treatment with boron compounds for 1 h, which saves costs and time since the increasing time for wood preservation with boron compounds was low penetrated rate and not damaged by termite. These results suggest that soft wood can be treated with preservatives to enable wood utilization.

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THITI WANISHDILOKRATN, SIRILUK SUKJAREON, ITSAREE HOWPINJAI
DEPARTMENT OF FOREST INDUSTRY TECHNOLOGY
MAEJO UNIVERSITY PHRAE CAMPUS
54140 PHRAE
THAILAND

LAMTHAI ASANOK*
DEPARTMENT OF AGROFORESTRY
MAEJO UNIVERSITY PHRAE CAMPUS
54140 PHRAE
THAILAND
*Corresponding author: lamthainii@gmail.com