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Laboratory Evaluation and Bioavailability of Termiticides in Tropical Soils to Subterranean Termites at Different Temperature †

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Abstract: Soil termiticide treatment is a fundamental method to control termite population and infestation. This method involves creating a continuous barrier surrounding the structures. However, termiticides may dissipate, depending on a half-life, degradation rate, leaching activity and storage method. In this study, the degradation rate and half-life of three commercially available termiticides, with active ingredient such as bifenthrin, fipronil and imidacloprid were determined under the field and laboratory conditions. The objective of this study was to determine the bioavailability of termiticides towards subterranean termites, *Coptotermes gestroi* under the laboratory conditions at two different temperature 30°C and 40°C using two types of soils i.e. sandy loam and loamy sand. No-choice bioassay was done to determine the mortality rate for each termiticide tested. Types of termiticides showed a significant difference toward termite mortality (F= 82.744; df= 2; P= 0.00). Bifenthrin revealed a higher termite mortality compared to fipronil and imidacloprid. Thus, the bifenthrin LT50 and LT95 values were lower compared to fipronil and imidacloprid. Termiticide concentration did affect the termite mortality (F= 9.407; df= 2; P= 0.00) where the higher the concentration, the higher the termite mortality. The laboratory study on termiticide degradation indicated that bifenthrin was more persistent in the soils compared to fipronil and imidacloprid.

Keywords: termite baiting; chlorfluazuron; subterranean termite; termite ratio; mortality

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1. Introduction

The global cost of termite infestations ranges from US$ 22 billion to US$ 40 billion [1]. The cost of damages from subterranean termites alone is estimated to be around $400 million each year [1]. Chemical-based termiticides, primarily soil termiticides, account for about 90% of subsurface control products, with bifenthrin and imidacloprid accounting for 65%. [2] . A properly applied soil-termiticide treatment should give good protection for at least 5 years [3] . Treatment efficiency of soil termiticides may differ depending on location [4], and termiticide susceptibility may differ depending on species [4]. [5]. Termiticide toxicity and mechanism of action are two critical aspects in determining the efficacy of termiticide-treated soil.

The goal of this study was to assess the bioavailability of termiticides against subterranean termites (*Coptotermes gestroi*) in the laboratory using two types of soils, sandy loam and loamy sand, at two different temperatures of 30°C and 40°C. This was done using a no-choice bioassay to determine the mortality rate for each termiticide tested

2. Materials & Methods

Laboratory degradation study

Soil sampling

For sandy loam, soil samples were taken from Durian Valley, Universiti Sains Malaysia (USM) (5°21.35'N; 100°18.16'E) and Teluk Bahang, Penang (5°26.47'N; 100°13.04'E). The soils were sampled from the top layer at a depth of about 10 cm (A-horizon). Stones, plants, and macro faunas were among the surviving detritus. At room temperature (20-25°C), the soils were air-dried. The soils were then sieved using a 2 mm sieve, stored at room temperature, and air-dried. The particle size, pH, and organic matter content of the soils were then determined. The pH of the soil was then measured using a pH metre (HANNA HI 8424, Romania). To obtain the pH value, the soils were combined with distilled water in a 1:2 ratio and left overnight (Chan, 2010).

Termiticides

There were three chemical families of termiticides used: chloronicotinyl (imidacloprid), phenyl pyrazole (fipronil), and pyrethroid (bifenthrin). Imidacloprid 200 SC (Ensystex, MALAYSIA Sdn. Bhd., Kuala Lumpur), Bifenthrin 100 SC (Ensystex, MALAYSIA Sdn. Bhd., Kuala Lumpur), and Fipronil 5.0 SC (Hextar Chemicals Sdn. Bhd., Selangor, Malaysia) were bought from a local supplier.

Bioavailability of termiticides

The data from the no-choice bioassay were analysed using log-probit analysis to determine the LT50 and LT95 with a 95% confidence limit. To detect significant differences between the independent variables evaluated with termite mortality, a factorial analysis of variance (ANOVA) was done on termiticide, concentration, temperature, and soil types as independent variables (dependent variable). The Tukey's test at P0.01 was used to evaluate significant differences between the groups using a two-way ANOVA with termite mortality as the dependent variable. The control groups that had a mortality rate of more than 10% were retested, and all data was adjusted using Abbott's formula (Abbott, 1925).

$$P = (Po-Pc)/(100-Pc)\times 100$$

Where,

P = corrected mortality (%).
Po = observed mortality (%).
Pc = control mortality (%)..

3. **Result**

Bifenthrin, fipronil, and imidacloprid lethal time values (LT50 and LT95) were determined by counting dead termites in the first, third, sixth, twelfth, and twentieth months. The results showed that the LT50 and LT95 values rose over time, meaning that termiticide efficacy declined over time. Bifenthrin showed the lowest LT50 and LT95 values compared to fipronil and imidacloprid for all months tested. While, imidacloprid indicated the highest LT50 and LT95 values for all months tested compared to fipronil and bifenthrin.

There was a significant difference in termite mortality by month, according to statistical analysis ($F= 11.794$; $df= 3$; $P= 0.00$). The LT50 and LT95 were lower in the first month compared to the 12th month (Table 1), indicating that it took the first month less time to kill 50% and 95% of the termites. There was a significant difference in termiticide types in

terms of termite mortality (F= 82.744; df= 2; P= 0.00). Termite mortality was higher with bifenthrin than with fipronil or imidacloprid. As a result, the LT50 and LT95 values of bifenthrin were lower than those of fipronil and imidacloprid. Termiticide concentration did affect the termite mortality (F= 9.407; df= 2; P= 0.00) where the higher the concentration, the higher the termite mortality (Table 1).

Table 1: Effects of soil, month, termiticide, concentration and temperature on termite mortality for laboratory degradation study

Source	df	Mean Square	F	Sig.
Soil	1	188.5	0.399	0.528
Month	3	5578.502	11.794	**0**
Termiticide	2	39137.72	82.744	**0**
Concentration	2	4449.48	9.407	**0**
Temperature	1	421.508	0.891	0.345
Soil * Month	3	386.655	0.817	0.484
Soil * Termiticide	2	831.488	1.758	0.173
Soil * Concentration	2	31.322	0.066	0.936
Soil * Temperature	1	32.812	0.069	0.792
Month * Termiticide	6	553.94	1.171	0.319
Month * Concentration	6	40.027	0.085	0.998
Month * Temperature	3	584.451	1.236	0.295
Termiticide * Concentration	4	225.931	0.478	0.752
Termiticide * Temperature	2	524.961	1.11	0.33
Concentration * Temperature	2	13.822	0.029	0.971
Soil * Month * Termiticide	6	135.174	0.286	0.944
Soil * Month * Concentration	6	38.423	0.081	0.998
Soil * Month * Temperature	3	110.334	0.233	0.873
Soil * Termiticide * Concentration	4	22.792	0.048	0.996
Soil * Termiticide * Temperature	2	76.36	0.161	0.851
Soil * Concentration * Temperature	2	9.626	0.02	0.98
Month * Termiticide * Concentration	12	48.925	0.103	1
Month * Termiticide * Temperature	6	281.345	0.595	0.735
Month * Concentration * Temperature	6	22.087	0.047	1
Termiticide * Concentration * Temperature	4	4.982	0.011	1
Soil * Month * Termiticide * Concentration	12	36.356	0.077	1
Soil * Month * Termiticide * Temperature	6	149.548	0.316	0.929
Soil * Month * Concentration * Temperature	6	14.42	0.03	1
Soil * Termiticide * Concentration * Temperature	4	16.078	0.034	0.998

Month * Termiticide * Concentration * Temperature	1 2	7.803	0.016	1
Soil * Month * Termiticide * Concentration * Temperature	1 2	12.505	0.026	1

df: degree of freedom; bold: significant value

4. Discussion

In comparison to fipronil and imidacloprid, bifenthrin produced the most termite mortality. Smith & Rust [6] found that termite mortality in soil treated with bifenthrin was high despite being exposed to low concentrations. Imidacloprid, on the other hand, caused the lowest termite mortality. This result corroborated the ideas of Manzoor & Pervez, [7], who suggested that bifenthrin provided the highest mortality among termiticides tested (bifenthrin and fipronil). The results were also supported by Saran & Kamble [8], who revealed that LT50 and LT90 for bifenthrin were shorter, followed by fipronil and imidacloprid.

Temperature has a significant impact on termiticide degradation; the greater the temperature, the faster the process [9], [10]. There was no influence of temperature on termite mortality in this investigation. The exploratory activities of C. formosanus Shiraki were found to be substantially larger in sands with a temperature of 22°C compared to sands with a temperature of 28°C in a study by Gautam & Henderson [11]. The bioavailability of imidacloprid in the laboratory was identical to the results in the field. A study by Ramakrishnan et al., [4] on termite mortality using imidacloprid at varying concentrations (25, 35, and 50 ppm) on four types of soils found that imidacloprid administered in sandy loam and loam soils had no effect on termite mortality. In comparison to sandy clay loam, Manzoor & Pervez [7] found that bifenthrin and fipronil were more effective in bioavailability experiments in sandy loam. Ramakrishnan et al., [4] found no significant difference in termite mortality in soils treated with imidacloprid in sandy loam and loamy sand, which corroborated the findings of this study. In contrast to this study, Manzoor & Pervez [7] discovered a substantial variation in termite mortality across two types of soils (sandy loam and sandy clay loam). Finally, the bioavailability laboratory investigations revealed that among the termiticides examined, bifenthrin had the lowest LT50 and LT95 values. The breakdown and bioavailability of termiticides studied in the laboratory experiment were unaffected by soil type or temperature.

5. Conclusion

The bioavailability laboratory investigations revealed that among the termiticides examined, bifenthrin had the lowest LT50 and LT95 values. The breakdown and bioavailability of termiticides studied in the laboratory experiment were unaffected by soil type or temperature.

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