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RESEARCH ARTICLE - TERMITES

Performance of Soil Termiticides in Open Field and Under Roof Overhang

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Abstract

The study investigated the performance of cypermethrin and chlorpyrifos based soil termiticides using concrete slab test installed in open field and under roof overhang in the Philippines over a 5 year study period. Plots treated with cypermethrin and chlorpyrifos in open field showed higher proportion of termite attacks compared to that installed under roof overhang. The high proportion of plots attacked by termites in open field could be attributed to environmental factors such as presence of a wider diversity of termite species, moisture, temperature, soil properties, microbial communities common in tropical climates, etc. The results of these two methods of installation could affect protocol used for field trial and the granting of registration or performance warranty to candidate termiticides in Philippines and other tropical countries.

Introduction

The distribution and sale of soil termiticides in the Philippines for structural protection against subterranean termites requires registration with the Food and Drug Administration (FDA) of the Philippines. Registration of termiticides with the FDA involves field efficacy trial against endemic species of subterranean termites in at least three sites. The trial is conducted by government agencies or an accredited researcher. After successful performance in field trial for 2 and 5 years, conditional and full registration can be granted, respectively. The protocol currently used is the concrete slab test as described by Beal (1986) and Kard et al. (1989). The test involves application of the termiticide at the recommended rate to a plot of soil under concrete slabs with a capped PVC pipe placed at the center. A block of non-durable wood is placed on the treated soil at the bottom of the pipe and the degree of termite damage is evaluated on a yearly basis. For registration purposes, a candidate termiticide should prevent termites from penetrating treated soil in all test plots for at least five years. The concrete slab test is normally installed in open field on tests conducted by the US Department of Agriculture Forest Service (USDA/FS) in the Unites States (Wagner, 2003; Shelton et al., 2016). However, there are debates in the Philippines between registrants, regulators and the pest control industry on whether concrete slabs test for candidate termiticides should be installed in open field or in soil under cover from the weather. The debate stemmed from the premise that structures in the Philippines and other tropical countries are built with wide roof overhang or eaves (Fig 1).

Overhang on all four sides of the structure are common to protect exterior doors, windows, and siding from the weather. Consequently, the soil under roof overhang is relatively dry and free of vegetation. Considering that soil termiticides used for chemical barrier treatments are generally applied along the perimeter of structures under wide roof overhang, many would argue that concrete slab test should be installed in soil under cover from weather to simulate actual service condition. However, no data is available in the literature to make comparison between termiticide efficacy in open and covered concrete slab test. Efficacy of termiticides is reported to be affected by various environmental factors such as moisture, temperature, soil properties (e.g. type, organic matter and pH), microbial communities, etc. (Gold et al.,

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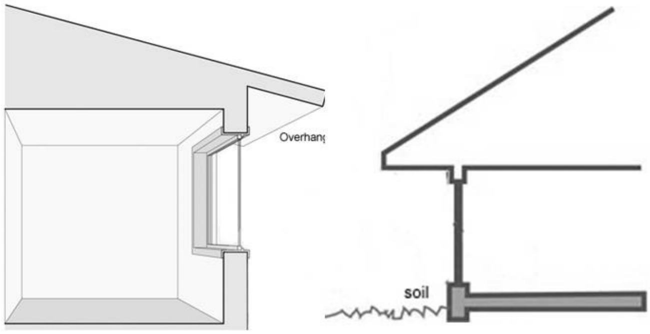

Fig 1. Schematic of roof overhang commonly used for built structures in the Philippines.

1996; Baskaran et al., 1999; Saran & Kamble, 2008; Spomer et al., 2009; Wiltz, 2010). Considering that environmental factors are more severe in tropical countries, many candidate termiticides experience high percentage of failure and consequently fail the 5 year efficacy requirement. The present paper reports on the performance of soil termiticide chlorfyripos and α-cypermethrin in concrete slab tests placed in open field and under roof overhang to compare efficacy and how they affected results of field trial.

Materials and Methods

Termiticides

Commercial soil termiticides with active ingredient consisting of chorpyrifos (Dursban® TC, DowAgrosciences) and α-cypermethrin (Probuild® TC, Syngenta Philippines Inc.) were used in this study. Solution strength of 2.0% for Dursban® TC and 0.5% for Probuild® TC were prepared in water following label instructions.

Field Sites

The experiment was conducted in six selected buildings with wide roof overhang (1.2-1.4 m) and adjacent to an open field within University of the Philippines Los Banos (UPLB) campus (14.1655° N latitude, 121.2396° E longitude). The trial sites were atleast 1 km away from each other and have not been treated with soil termiticides. Four of the buildings have been treated along the perimeter with pyrethroid based termiticides (rodding 1 m apart) in 2002 and two buildings received no prior treatment. It is assumed that the pyrethroid used to treat said buildings have already been depleted before the start of this study. The experimental sites have loamy soil with pH of about 7.2-7.6. An average temperature of 23-31°C with annual rainfall of about 1,942 mm prevailed in UPLB during the study period (2011-2015). In general, the soil is dry to moist during the summer months and very wet during the rainy season under roof overhang and open field sites, respectively. Each trial site was treated with only one type of termiticide. Heavy and sometimes multiple infestations of *Coptotermes gestroi* Wasmann, *Macrotermes gilvus* Hagen, *Microcerotermes* spp., and *Nasutitermes* spp. are present in all sites.

Concrete Slab Test

Two groups of concrete slab tests were conducted simultaneously in two conditions viz., under roof overhang of a built structure and in open field. One set of concrete slabs were installed along the side of buildings (30 cm from the wall, 2 m apart) under roof overhang and an identical number in open field opposite (3 m apart) to that placed under cover (Fig 2). The concrete slab test was conducted similar to that described by Beal (1986) and Kard et al. (1989) with some modifications. Briefly, termiticide solutions were applied at a preconstruction rate of 4.07 liters m^{-2} to a plot of soil (100 x 432 x 432 mm) cleared of debris and vegetation. After the chemical has soaked into the soil, the plot was covered by a polyethylene sheet vapor barrier. A precast concrete slab (100 x 432 x 432 mm) with a 100 mm PVC cleanout adapter and plug at the center was placed on top of the treated plot to serve as inspection port. The vapor barrier was cut from inside and a block of wood (*Paraserianthes falcataria* L, 50 x 64 x 64 mm) was placed on the soil inside the pipe. Ten (10) replicates for each termiticide were installed in concrete slabs under roof overhang and 10 replicates in the adjacent open field as described above for each of the field sites. Water only control slabs (10 replicates) were randomly installed between termiticide in both open field and under overhang. Boards were inspected annually and replaced if attacked by termites. Termite attack was defined as presence of termites or damage to wood at the end of each year of inspection. Termite damage was rated according to the U.S. Forest Service "Gulfport" scale, where 0 is no damage, 1 is nibbles to surface etching, 2 is light damage with penetration, 3 is moderate damage, 4 is heavy damage, and 5 is destroyed. Data from the three field sites were pooled and the ratio of the number plots attacked by termites (i.e. wood blocks receiving ratings of 2 to 5) to the total number of slabs installed was used to determine the proportion of plots attacked for each year and termiticide used. Goodness of fit using chi-squared (χ^2) test was performed to compare differences in plots attacked by termites in open field and under roof overhang. An analysis of means (ANOM) plot was also used to determine which time period are significantly different from the grand mean for each termiticide used (Statgraphics, 2010).

Results and Discussion

The percentage of plots attacked by termites in soil treated with cypermethrin and chlorpyrifos located in open field and under roof overhang over the 5-year study period is shown in Figs 3 and 4. The number of plots penetrated by termites in soil treated with cypermethrin under roof overhang showed significant difference compared to that installed in open field (χ^2 = 17.70, p-value <0.001). Plots in open field experienced higher termite penetration (10-50%) compared to that under roof overhang (Fig 3). Similar results were observed with plots treated with chlorpyrifos (χ^2 = 16.04,

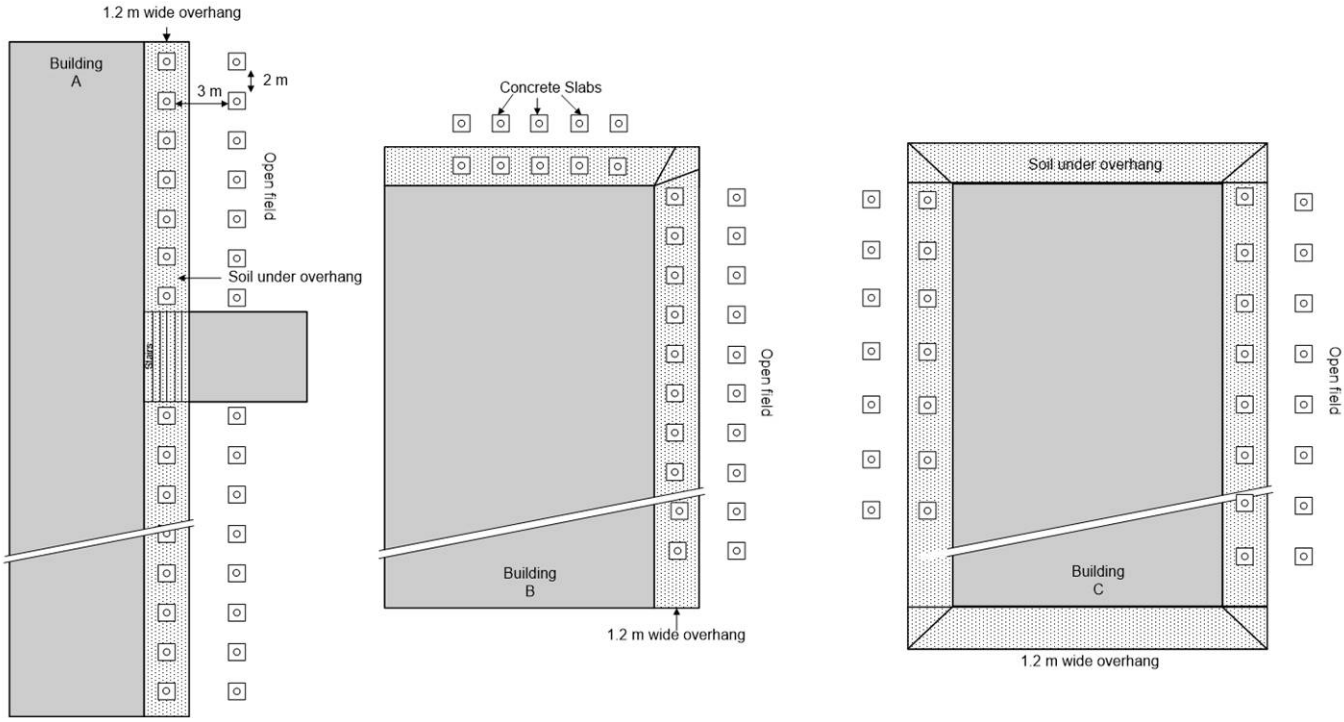

Fig 2. Schematic position of concrete slabs in three field sites used for cypermethrin in open field and under roof overhang.

p-value <0.003) with 13-40% higher penetration in slabs installed in open field. In comparison, control plots of both termiticides were readily penetrated and wood blocks heavily attacked by termites (97-100%) indicating the high termite pressure in the selected test sites. Apparently, the results confirmed the claim that performance of repellent or contact poison termiticides vary under cover by roof overhang and in open field. Studies have shown that efficacy of termiticides is affected by various environmental factors such as moisture, temperature, soil properties (e.g. type, organic matter and pH), microbial communities, etc. (Gold et al., 1996; Baskaran et al., 1999, Saran & Kamble, 2008; Spomer et al., 2009; Wiltz, 2010). In open field condition, these factors are present in elevated levels contributing to the early degradation of termiticides and consequently breach of chemical barrier. Termite species in the tropics are also more diverse (e.g., Termitidae) and active throughout the year (Tho, 1992; Acda, 2004a). Furthermore, diffuse root system of trees and woody shrubs often penetrate treated soil and serve as conduit for the entry of termites into concrete slabs in open field. Apparently, these factors may have contributed to the relatively higher percentage of plots penetrated by termites in open field compared to those under roof overhang.

The results further showed that termite penetrated 1 to 4 treated plots during the first year of trial in concrete slabs treated with cypermethrin and chlorpyrifos in both open field and under overhang. The percentage of termite attacks increased rapidly for both termiticides every year thereafter (Figs 3 and 4). Analysis of means (ANOM) showed significant increase in the mean proportion of plots penetrated by termites during each year compared to that of the grand mean for both cypermethrin ($\chi^2 = 14.54$, *p*-value <0.001) and chlorpyrifos ($\chi^2 = 16.03$, *p*-value <0.004). *M. gilvus* was the predominant termite species observed attacking wood blocks inside concrete slabs. *M. gilvus* is a very large, aggressive species that dominate the soil and open field in the Philippines (Acda, 2004a; Rojo & Acda, 2016). Termite species observed attacking wood blocks under roof overhang were mostly *Nasutitermes* and *Microcerotermes* spp., although *M. gilvus* and *C. gestroi* were also common. This is consistent with foraging behavior observed with destructive Philippine subterranean termites (Acda, 2004b; 2007). In comparison, concrete slab tests of cypermethrin and chlorpyrifos conducted in the U.S. showed lower percentage of termite penetration over longer period of time (Mulrooney et al., 2007).

For registration purposes in the Philippines, the current practice of using the 100% passing rate of concrete slabs in open field would present a stringent criterion for new termiticide registration if this requirement would be the only

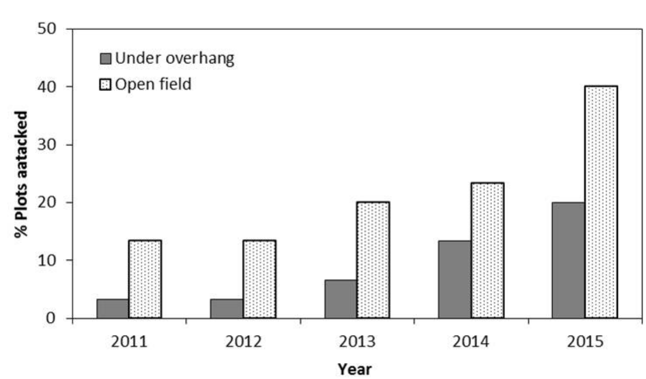

Fig 3. Percentage proportion of concrete slab plots treated with cypermethrin attacked by termites over 5 years.

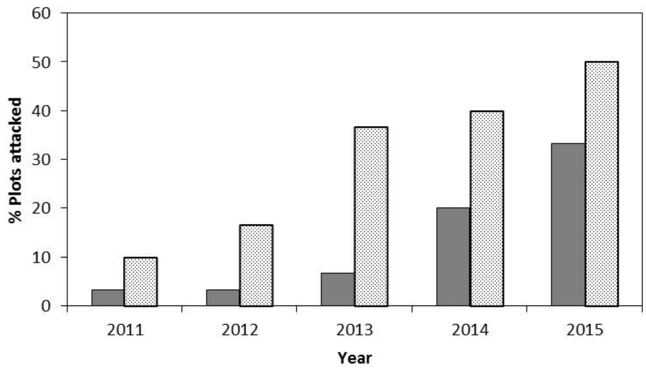

Fig 4. Percentage proportion of concrete slab plots treated with chorpyrifos attacked by termites over 5 years.

basis of evaluation. However, other factors such as product chemistry, toxicology, environmental data, toxicity to non-target organisms, etc. are commonly used for evaluation purposes. More often, regulating agencies do not prescribe assessment criteria and efficacy data is reduced to a lower status in the evaluation process or used as basis in providing period of service warranty. Similar problems and issues were reported in Australia, Brazil, European Union and other countries for evaluation and registration of new termiticides (Krygsman, 2005).

Conclusions

Generally, the study showed that there was a significant difference in the performance of termiticide using concrete slab test placed under roof overhang and those installed in open field. Plots treated with cypermethrin and chlorpyrifos in open field showed higher proportion of termite penetration and attack compared to those under roof overhang during each year of evaluation. In both conditions termites were able to penetrate treated plots during the first year of trial albeit at lower percentage then increased rapidly for both termiticides every year thereafter. The high percentage of plots attacked by termites in open field compared to that under overhang could be attributed to severe environmental factors such as moisture, temperature, soil properties, microbial communities, etc. common in tropical climates. The presence of wide diversity of termite species in the Philippines could also be a factor. The results in both sites could affect trial protocol to determine performance of termiticide or performance warranty to candidate termiticides in the Philippines.

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