USE OF MULTIPLE FIELD TECHNIQUES TO EVALUATE PERFORMANCE OF DELTAMETHRIN SUSPENSION CONCENTRATE TERMITICIDE IN THE USA

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Abstract - Termiticidal activity of deltamethrin as a technical and/or formulated material has been well documented around the world by governmental and university researchers in laboratory and long-term field evaluations. United States Department of Agriculture- Forest Service (USDA-FS) "Gulfport" field testing provides basic insight into soil termiticide longevity for *Reticulitermes* spp. in southeastern states and *Heterotermes* sp. in the southwestern USA by use of ground board (GB) and concrete slab (CS) tests. The GB and CS tests simulate a pre-construction scenario with a surface drench. Additional testing is required to document performance with other treatment regimes in other areas of the country with different soils, conditions and termite species, as well as to evaluate new formulations. and use rates. The extension of GB-type tests was made into regional field plots with differing soil types, environmental conditions and termite species. This plus soil sampling for residual or biological assays provides additional observations beyond natural termite attack ratings. A priority is placed on annual chemical residual assays. Testing with soil incorporation of termiticide mimics a thorough post-construction treatment. Further use of the soil samples for repellency/mortality tunneling bioassays from soil samples supplements the detailed degradation curves in diverse soil types and conditions. Such tests are routinely run in multiple representative locations within some states by university researchers. Soil incorporation treatments of simulated foundations and homes in key areas allowed residue and performance monitoring under more diverse soil pH conditions Pest control operator (PCO) treatment of homes, including soil residue analysis and bioassays in key regional areas further confirms protection of structures and commercial feasibility of the product. Re-evaluation of deltamethrin (DeltaGard® TC) as a suspension concentrate in Gulfport trials, as well as university, consultant and industry tests found superior performance at lower use rates than found with the original emulsifiable concentrate formulation.

Key words - Pyrethroid, soil residue

INTRODUCTION

Early performance data of deltamethrin activity on termites indicated the potential value in a control program (Rutherford *et al.*, 1980). Dipping wooden stakes in dilutions as low as 0.001% active were found to give 100% protection through the course of the 72 week test by *Reticulitermes santonensis* Feytaud in a laboratory soil test. Topical applications showed deltamethrin to have an LD_{50} of 0.4-0.7 ng per termite. This was ten times the permethrin activity in the same test. Oliveira (1983) found deltamethrin to provide 12 month *Cryptotermes* sp. control at deltamethrin doses as low as 0.001%. Pospischil (1986) found 10 ppm of deltamethrin in aged soil tests to be toxic to *Reticulitermes* sp.

The demise of chlordane led to greater interest in pyrethroids due to high activity and repellency. Su and Scheffrahn (1990) laboratory studies found LD_{50}s with deltamethrin to be 0.12 and 0.01 ug per gram for *Coptotermes formosanus* Shiraki and *R. flavipes* (Kollar) respectively. This was more than sixty times more active than permethrin and two thousand times more active than chlordane. They further noted that 5-10 ppm of deltamethrin prevented *Coptotermes* and *Reticulitermes* soil tunneling in their methodology. Higher levels were required for contact mortality of the termites.

The performance of deltamethrin EC was further supported by testing in Australia and South Africa in soil incorporation tests. The Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) testing (Runko, 1998) found 100% effective performance at 0.025% for 3 years, at 0.05% for 7 years and 8+ years at 0.15% on *Coptotermes acinacaiformis* (Froggatt). South African Bureau of Standards (SABS) tests at 0.05 and 0.075% gave 100% control for 5 years on *Microtermes, Microcertermes, Allodontotermes* and *Odontotermes* spp. (van der Linde, 1996).

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USDA-Forest Service laboratory testing (1988) found levels as low as 5 ppm deltamethrin to provide complete mortality of *Reticulitermes flavipes* in laboratory aged soil tests (Jones, 1988). Subsequent field evaluations of a deltamethrin emulsifiable concentrate formulation in the Gulfport concrete slab tests showed 100% termite control for 1-3 years at 0.05% and 4-9+ years at 0.125% (Kard, 1994). As the ground board test was typically more rigorous, a higher rate at 0.5% had shorter term control of 2-9+ years of 100% control, dependent on state. The 0.5% concrete slab tests have still not failed, through 1998. Attack on controls was at high levels during the first five years of this testing.

With a basic understanding of effective field rates and a new aqueous suspension concentrate formulation of deltamethrin that was thought to have improved potential, additional field testing was warranted. Advantages of the formulation were seen as longer soil residuality due to the microcrystalline nature of the formulation without the objectionable solvent odor of emulsifiable concentrates. Field evaluations were initiated to determine whether effective rates could be lowered from those for 5 year effective performance with an emulsifiable concentrate in the USA.

MATERIALS AND METHODS

A variety of test methods was conducted to optimize data obtained from each field test site. All locations were treated with dilutions of 25% (wt/vol) deltamethrin suspension concentrate.

Stake screening tests

Southern yellow pine stakes, $2 \times 4 \times 30$ cm, were driven 15 cm into the soil. For preventative treatment, they were immediately withdrawn and 200 ml of dilution poured into the hole while simultaneously re-inserting the stake. This treated the stake and approximately a 1 cm adjacent layer of soil. Remedial treatments were made in a similar manner once the stakes were infested. Replicates were installed on a 1 meter grid, with multiple assessments per year for performance.

Ground board tests

Test methods were similar to the USDA-FS methodology (Kard and Mauldin, 1994). Plots were often enlarged where supplemental annual soil sampling was likely, to be used for residual studies. Where termite pressure was lower than anticipated bioassays were also run from soil plugs. Tests were established by AgrEvo and consultants. The standard methodology was utilized by USDA-FS for the ground board (GB) and concrete slab (CS) tests with the suspension concentrate initiated in 1994, but levels were reduced from those used in the EC study.

Soil incorporation tests

Both post-hole and meter square plots were excavated and native soils treated with appropriate volumes of termiticide dilution either manually or in a concrete mixer. Pine stakes inserted into the plots and area were monitored for attack and soil samples taken annually for analysis. Tests were placed and run by AgrEvo and university researchers. Additional university research tests, with varying pH soils, treated and placed next to concrete foundations were monitored semi-annually to investigate degradation under alkaline conditions.

Structural protection

Soil treatments were made by PCOs under the supervision of university researchers or consultants in key areas at label rates. Homes were inspected annually and soils sampled for deltamethrin analysis.

RESULTS AND DISCUSSION

Stake tests

Initial levels as low as 0.00125% deltamethrin per stake applied as a preventative, were found to give 12+ months 100% protection, with 50% attack of untreated stakes. This low use rate was penetrated by

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18 months, with 30% attack, while there was 85% attack in the untreated stakes. Rates over 0.075% in this test are providing effective protection. With remedial treatment, 0.00125% deltamethrin per stake gave over 6 months of protection, with re-invasion of the previously attacked stake occurring by 12 months. Replacement of the stake at the remedial treatment had protection similar to preventative treatment. An increase in use rate was found to be required for effective remedial control when attacked wood was not replaced. This demonstrates the strong attraction of previously infested wood to the termites. Screening of field performance in areas of moderate or greater infestation was rapidly accomplished across a range of finer increments of use rate than could be accomplished with more cumbersome field methods involving soil excavation. Greater replication could be easily placed in the field.

Ground board / concrete slab

Surface drenches (pre-construction) treatments with 0.075% or greater concentrations are providing effective protection of ground boards from *Reticulitermes* spp. to date. In North Carolina (Figure 1) the surface drenches were found to have up to 50% of initial ppm levels after 4 years. Higher levels of treatment (0.125%) are required in the southwestern USA for *Heterotermes* protection due to adverse environmental and soil chemistry conditions causing more rapid degradation. *Coptotermes* protection also requires a 0.125% preventative treatment, with higher residues required to maintain repellency.

All treatments in the Gulfport USDA-FS trials for both the GB and CS methods at 0.08, 0.10 and 0.12% are providing 100% efficacy at all state sites. The 0.5% rate in the GB test provided only 2 years protection in two states with the EC formulation. However, the current test has had lower termite pressure in recent years. This testing is the primary data reviewed by the U. S. Environmental Protection Agency and the Association of Structural Pest Control Regulatory Officials (ASPCRO) to judge biological performance.

Soil incorporation

Soil-incorporation field trials, which coupled field effectiveness in high termite pressure areas (or supplementary analytical and/or bioassays in low pressure areas), also gave valuable degradation rate data for soil types and conditions in different regions from a structured soil sampling program. Studies in Virginia (Figure 2), Florida (Figure 3), and Texas (Figure 4) give examples of degradation rates to differing soil types and environmental conditions. Rate responses at these sites are obvious from the residue data. Sites were found to have as much as 50% of initial loading after 3 years, as in Virginia or Florida, or as low as 15-30% in a Texas site.

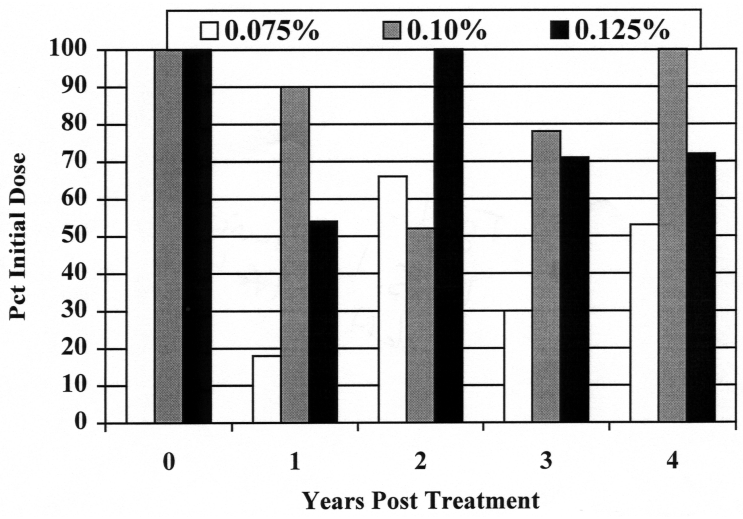

Figure 1. Percentage deltamethrin SC termiticide remaining following surface drench application to soil in North Carolina, USA.

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Structural protection

Soils treated with deltamethrin SC around structures in California, New Jersey, Texas and Nebraska had effective residual active ingredient levels across a range of rates. High levels of repellency, are found in soil penetration bioassays from these treatments, as found in the 150+ ppm levels found after 3 years in California (Figure 5), which easily repel any termite attack.

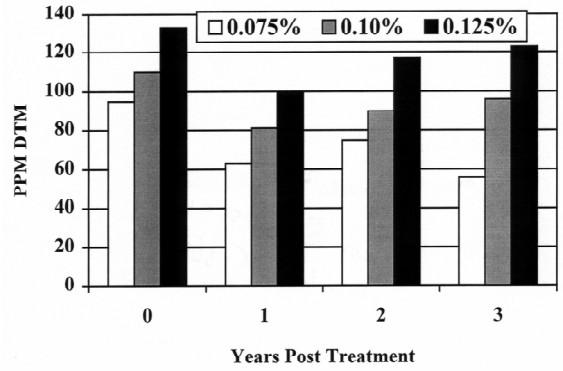

Figure 2. Deltamethrin SC termiticide residues following soil incorporation, Virginia, USA.

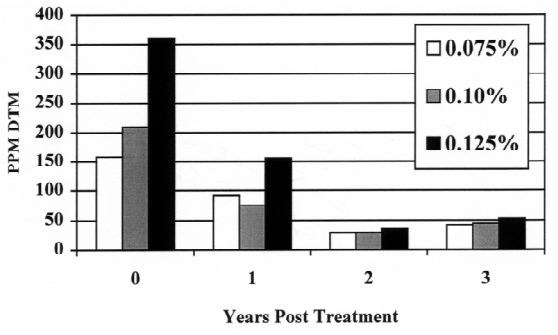

Figure 4. Deltamethrin SC residues following soil incorporation, Dr. R. Gold, Texas A&M, USA.

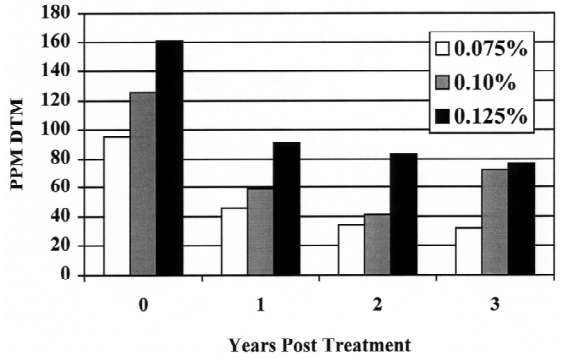

Figure 3. Deltamethrin SC termiticide residues following soil incorporation, Florida, USA.

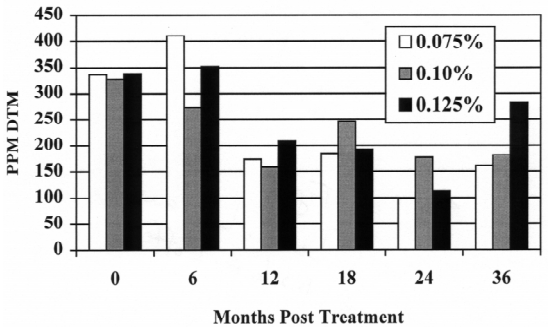

Figure 5. Deltamethrin SC termiticide levels in residential soils, Dr. M. Rust, Univ. California- Riverside, USA.

CONCLUSIONS

The concurrent testing of biological field and laboratory performance coupled with soil residue data in key regional areas provides invaluable evidence of performance under simulated as well as actual structural protection situations for preventative as well as remedial conditions. The field studies have documented both biologically and chemically that deltamethrin suspension concentrate is effective at lower levels than the previously tested emulsion concentrate.

The standard CS and GB tests used by the USDA-FS provide good insight of effective performance in areas with consistent termite pressure, but evaluations in low pressure areas requires additional confirmation through residue and bioassay studies. Low attack sites may otherwise give false impressions of performance without additional validation. Initial rate screening with field stake studies can aid in bracketing effective use rates for long-term performance. 1999 is the fifth year of USDA-FS testing on the DeltaGard SC termiticide. Reduced use rates will be submitted for registration.

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