U.S. Forest Service Termiticide Tests

by

Terence L. Wagner[1]

ABSTRACT

The U.S. Forest Service has been testing chemicals for termite control since 1939. Today its termiticide testing program is nationally recognized for providing unbiased efficacy data for product registration using standardized tests, sites, and evaluation procedures. Virtually all termiticides undergo Forest Service testing before being registered by EPA. Termiticides undergo 18-24 months of laboratory screening before going to the field. Based on the concrete slab test, termiticides are considered effective in the field at the lowest concentration(s) that prevent termites from penetrating treated soil in 10 plots at each site for at least five years. Sites are located in Arizona, Mississippi, Florida, and South Carolina. Results provide a benchmark to compare and assess new and existing products. Because termite control is no longer limited to repellent or contact chemical barriers, tests are also performed on non-repellent delayed-action termiticides, barriers, and wood products. Some of the new products have novel effects on termite biology, ecology, and behavior that require new evaluation procedures. The Forest Service presently has 26 funded agreements with industry involving laboratory screening of three termiticides and field evaluations of 20 termiticides and four impregnated barriers. We also continued to monitor plots on five termiticides and two physical barriers from past (expired) agreements. Marketed termiticides being tested by the Forest Service include bifenthrin (Biflex®), chlorpyrifos, cypermethrin, fenvalerate, permethrin (Dragnet® and Torpedo®), imidacloprid (Premise®), and fipronil (Termidor®). Candidate termiticides include chlorfenapyr, cyfluthrin (Tempo®), and deltamethrin[2].

INTRODUCTION

The mission of the U.S. Forest Service, Wood Products Insect Research Unit is to improve the protection of wood against subterranean termite damage, define the role of termites in forest ecosystems, and understand their impact on forest health. To accomplish this

---

[1]Wood Products Insect Research Unit, 201 Lincoln Green, Starkville, MS 39759. email address: twagner01@fs.fed.us

[2]Mention of company or trade names does not imply an endorsement by the U.S. Forest Service.

mission, the research is organized into three problem areas: (1) develop, refine, and assess new and alternative compounds, materials, and treatment techniques for effective protection against damage caused by termites, (2) investigate termite biology, ecology, and behavior to promote an understanding of forest ecosystems and efficacy of protection techniques in urban environments, and (3) investigate factors that allow the Formosan subterranean termite to survive standard termiticide treatments and assess their damage and risks to forested lands.

The research is formulated with an understanding that termites play dual roles as pests in urban environments and, conversely, as contributors to forest productivity and health. Their role in forest ecosystems as wood decomposers contributes to soil genesis, fertility, stability, and hydrology — aspects that are little studied and poorly understood. Their role as wood-product pests is better understood. The cost of controlling termites and repairing their damage is estimated at $2 billion annually in the United States. These losses do not include those incurred by the military or the growing impact from the Formosan termite. Termite control also carries the highest risk for the pest control industry of all categories in urban pest management, and increasing restrictions on insecticides make their control less reliable and more costly. For these reasons, the project considers applied research on termite control a high priority. Part of this effort involves the termiticide testing program.

TEST METHODS

Termiticides

The Forest Service has a long history of providing reliable termiticide efficacy data to its pest control stakeholders. We began evaluating chemicals as soil treatments for termite control in 1939 (Beal 1984). In 1943, tests were initiated in Mississippi and Panama in response to U.S. Army requests. They were interested in preventing damage to wooden ammunition boxes stored on the ground, and motor oil was among the early "products" evaluated. The "standard ground board test" originated from this work, which is still used today (Beal 1980, Beal *et al.* 1994). It consists of a 6 by 6 by 1-inch sapwood board, held in place by a brick in the center of a 17 by 17-inch treated soil plot, replicated 10 times in each of four study sites. This test was the principal method for evaluating termiticide efficacy for more than 20 years. During this time, chemicals were considered effective at concentrations that prevented termites from penetrating the treated soil in 50% or fewer of the replicated plots over a 5-year period. Wooden stake tests were also used until 1958, after which they were discontinued because results were similar to those obtained from the ground board tests.

The standard ground board test was replaced as the principal method for assessing termiticide efficacy because organophosphates, carbamates, and pyrethroids raised concerns of degradation and leaching of chemicals from the exposed treated plots. In 1967, a modified ground board method was introduced in Mississippi to simulate conditions beneath a concrete slab. The method was installed nationwide in 1971 and is now known as the "concrete slab test." It consists of a 21 by 21-inch plot of bare soil, trenched 2-inches deep and 2-inches wide around the perimeter, and treated with a termiticide within the 17 by 17-inch center. A polyethylene vapor barrier is placed over the treated soil, a 4-inch diameter by 5-inch long PVC pipe is positioned in the center, and concrete is poured over the barrier, around the pipe, extending into the perimeter trench. The vapor barrier is removed from inside the pipe to expose the treated soil, a wooden block is placed on the soil, and the pipe is capped. Plots are inspected annually for a minimum of five years, or until the barrier is penetrated by termites resulting in a failure. When 50% or more of the plots (10 replicates) at a given site have failed for a given treatment, the treatment is no longer evaluated at that site. Termiticides are considered effective based on this test at the lowest concentrations that prevent termites from penetrating the treated soil in 100% of ten replicated plots for at least five years on four sites.

Test sites are located in Arizona, Florida, Mississippi, and South Carolina. Typically, a randomized complete-block design is used to assign each treatment (e.g. test concentration), including controls (water only), to a test plot in each of 10 blocks of land at each site. Within each block, plots are spaced on 5-foot centers. The numbers of chemicals and concentrations planned for a test determines the number of plots in each block. For example, a test that includes two chemicals applied at five concentrations each (without controls) using two methods (e.g. ground boards and concrete slabs) requires at least 2 (chemicals) by 5 (concentrations) by 2 (methods) = 20 usable plots in each block, totaling 200 plots at each of the four test sites. Because trees, roots, and other obstructions render some plots unusable, blocks must contain extra plots. In the example, a plot arrangement of 6 by 6 = 36 plots in each of 10 blocks would satisfy the requirements, including one control plot for each test method — ground boards and concrete slabs.

Other plot designs have been used with newer termiticides because some of these compounds have novel effects on termite populations. Instead of combining test concentrations of the same and different termiticides within a block, the 10 plots per concentration are grouped together and separated from other treatments by at least 50 feet. The goal of isolating test concentrations is to prevent interactions among treatments and the effects they may have on termites.

Another aspect of the testing program involves screening of compounds as a condition to field evaluation. Beginning in 1970, all termiticides were tested in the laboratory to assess their ability to kill termites in timed exposures to treated soil at different concentrations. An initial evaluation is made, followed by tests on the same soil every six months over a 2-year period. Laboratory screening prevents unnecessary field work on ineffective chemicals and is useful in establishing the lowest concentration to be installed in the field. Many products fail this initial screening and never make it to the field.

Chemically-Impregnated Barriers

Impregnated barriers are typically evaluated using concrete slab and concrete block tests. The concrete slab is similar to that used with termiticides except the vapor barrier is replaced with an impregnated barrier, which remains intact (uncut) within the pipe. The second method applies a 24 by 24-inch barrier wrapped and banded securely around an open end of a 16 by 16 by 8-inch flue LW concrete block. A 4-inch diameter by 6-inch long PVC pipe is inserted through an X-type cut in the center of the barrier, a 2 by 21-inch sleeve of barrier is wrapped around the fitted sheet over the pipe and secured with plastic cable ties, the block is centered barrier-side down over a plot of 21 by 21-inch bare soil, a wooden block is placed in the pipe on the soil (the pipe is then capped), two additional blocks are placed on the barrier sheet, and the block is covered. In both methods, a 6 by 6 by 1-inch sapwood board is buried just below the soil surface in the center of the plot to insure termite pressure on the barrier. Plots are inspected annually.

RESULTS

The testing program provides unbiased and authoritative data to federal and state regulators for product registration. In 2000, the Forest Service maintained 27 funded collection agreements with industry involving laboratory screening of three termiticides and one chemically-impregnated barrier and field evaluations of 21 termiticide compounds or formulations and three impregnated barriers. In 2001, 26 agreements are active involving laboratory screening of three termiticides and field evaluations of 20 termiticides and four impregnated barriers. We also continued to monitor plots on five termiticides and two physical barriers from past (expired) agreements. Marketed termiticides tested by the Forest Service include bifenthrin (Biflex®), chlorpyrifos, cypermethrin, fenvalerate, permethrin (Dragnet® and Torpedo®), imidacloprid (Premise®), and fipronil (Termidor®). Candidate termiticides include chlorfenapyr, cyfluthrin (Tempo®), and deltamethrin (Table 1).

Termiticides

1. Chlorpyrifos

In 2000, manufacturers of chlorpyrifos signed a memorandum of agreement with the Environmental Protection Agency stating, in part, that the end-use dilution of the product for termite control cannot exceed 0.5% active ingredient (AI), and use of the labeled rates at 0.75 and 1.0% AI would be phased out. Subsequently, the Mississippi Department of Agriculture and Commerce, Bureau of Plant Industry denied the use of chlorpyrifos at 0.5% in Mississippi based on Forest Service data. These data indicate three years of 100% control at 0.5% in the state (Table 1), instead of the five years required by EPA Pesticide Registration Notice 96-7. Louisiana also decided not to allow the use of chlorpyrifos for termite control at 0.5 or below. Other states have taken or are considering similar action. According to the agreement, registrants had to discontinue the sale of their product for application at 0.75 to 1% after January 2001. Pest control suppliers must discontinue retail of the product after December 2001, and the final deadline for product use is December 2005.

In a separate but related development, EPA recently gave a manufacturer of chlorpyrifos a Section 3 registration at 0.25% AI. Based on the lack of Forest Service test data for this specific product, and the general failure of chlorpyrifos at 0.25% (Table 1), this action prompted state regulators, acting through the Association of Structural Pest Control Regulatory Officials, to request that EPA withdraw the registration for this termite control product.

2. Cyfluthrin

Bayer is holding registration of Tempo®. The product was installed in the field in 1987 and has provided 100% control in preventing termite penetration through the treated soil in concrete slab tests at all four test sites for at least six years at 0.25% AI and above.

3. Premise® (Bayer)

Premise® (imidacloprid) was registered in the United States in February 1995 at 0.05 and 0.1% AI using foreign test data. The Forest Service installed the compound in the field in 1992, and after eight years of investigation, some interesting observations on this and other new termiticides have stimulated an interesting dialog among officials in the testing, registration, and registrant communities. Imidaclorid was the first of the so-called modern non-repellent, delayed-action termiticides that affect termites differently than traditional chemistries. These new

Table 1. Number of years that termiticides remained 100% effective in concrete slab tests at 4 field sites[1].

% A.I.	Site			
	AR	FL	MS	SC
Bifentrhrin - Biflex (1986 – present)				
0.031	0	4	2	2
0.062*	15+	15+	7	10
0.125*	10	9	2	14+
0.25	15+	15+	14+	14
0.5	6	15+	14+	14+
Chlorpyrifos - Dursban (1971 – 2000)				
0.1	2	2	1	4
0.25**	2	3	4	6
0.5 **	4	7	3	7
1.0	6	9	11	12
2.0	11	19	15	21
Cyfluthrin – Tempo (1987- present)				
0.125	4	9	2	4
0.25	10	12	6	13+
0.5	11	14+	13+	13+
1.0	14+	14+	13+	13
Cypermethrin (1982 – present)				
0.125	1	1	1	2
0.25*	4	11	3	4
0.5*	4	5	7	12
1.0	8	8	6	12
Deltamethrin (1988 – present)				
0.05	1	3	3	2
0.125	5	13+	4	7
0.5	9	13+	12+	12+
1.0	13+	13+	12+	12+
Fenvalerate (1978 – present)				
0.25	8	1	2	3
0.5*	12	3	7	4
1.0*	12	6	10	6
Permethrin – Dragnet (1978 – present)				
0.25	8	2	1	0
0.5*	13	4	5	5
1.0*	15	15	5	10
Permethrin - Torpedo (1980 – present)				
0.25	9	3	2	0
0.5*	11	6	4	1
1.0*	19	19	3	6

[1] * = registered rates; ** = interim rates

termiticides may initially disorient or confuse termites instead of killing them outright. For example, tests on imidacloprid have shown that termites can reach the wooden sample block on top of the treated soil before the termiticide takes effect, and not all penetrated plots have active termites at the time of annual inspection (not necessarily an uncommon observation). These observations have caused the Forest Service to reassess its testing procedures, including the design of the concrete slab test, the layout of field plots, and even the pass/fail criteria used for product registration. The concrete slab test and associated field design was first used by the Forest Service in 1967, brought about by a new set of chemistries (e.g. organophosphates, carbamates, and pyrethroids). Unlike standardized termiticide tests in which the wooden blocks in the 10 replicated plots are discarded after first attack and future readings on those plots discontinued, the wooden blocks in Premise® plots are replaced and read each year regardless of their attack status to help evaluate termite activity in the area over time. Premise® plots are also arranged differently than standard tests — the 10 plots of a given concentration are grouped together and separated from other test concentrations by at least 50 feet to minimize influence among test rates. In Mississippi and Arizona, the 10 treated plots of each concentration are grouped with 10 water-only control plots, and the treated and control plots are spaced alternately at 5-foot intervals in a 5 column by 4 row block design. Eight concentrations (0.025 to 0.4% AI) were applied to the soil surface at standard sub-slab preconstructing volumes.

Premise® provided 100% control in preventing termite penetration through the treated soil in concrete slab tests in Arizona and Florida for at least five years at all eight test concentrations. In South Carolina, Premise® remained 100% effective during five or more years at all but the lowest rate, 0.025% AI, where it failed after the third year. The product did not perform as well in Mississippi, where termites penetrated the soil after the first year at 0.025%, after the second year at 0.05, 0.1, 0.2, and 0.25%, and the third year at 0.15%. These results changed little using damage as the pass/fail criterion; e.g., failure at damage to the wooden block greater than ASTM rating 9. Changes occurred at 0.1 and 0.15%, where penetration and damage was observed after the fourth year. Even applying the less rigorous criterion for failure (e.g. damage), the product did not satisfy the guidelines recommended in PR Notice 96-7 (e.g. 100% control for five years at all four test sites) at rates below 0.3% in Mississippi. Only at 0.3 and 0.4% did Premise® meet or exceed these guidelines. Notwithstanding, by all accounts Premise® has done well in the experimental use permit (EUP) homes and in other tests, and EPA is not expected to alter the registration at the labeled rates of 0.05 and 0.1% AI.

4. Deltamethrin EC

Aventis is holding registration of DeltaGard®. The product was installed in the field in 1988 and has provided 100% control for at least five years at 0.125% AI and above, except in Mississippi where four years of complete control was observed at 0.125%. The proposed general use rate for the product is 0.125% and 0.25% for more difficult situations.

5. Termidor® (Aventis)

Termidor® (fipronil) was installed in 1994 using 80% AI water dispersible granule formulation and in 1995 using 300g/kg AI micro-emulsion formulation. No failures have been observed at any concentration or test site, and the termiticide was registered September 1999 at 0.062 and 0.125% AI. The product became commercially available in the Spring 2000. Because treated and control plots in these tests were grouped together (a standard practice with termiticides), and termite activity decreased in the control plots during the first several years (suggesting an effect of the termiticide on foraging or colony activity in the surrounding area), additional tests were installed with a newer formulation (3.73% wettable powder) at six concentrations, three lower than the initial tests. These tests were installed in 1998, and each fipronil concentration was separated from the others to prevent overlapping effects among rates and to further evaluate changes in termite activity. A fourth test was installed in 1999 using Termidor® SC formulation.

6. Chlorfenapyr

Chlorfenapyr was installed in the field at six test concentrations in 1996 using a suspension concentrate formulation and in 1999 at three rates as a water dispersible granule and two rates as a suspension concentrate. To date, the termiticide has undergone five years of evaluation in Florida and Arizona. The remaining two sites will be read later this year. Chlorfenapyr has remained 100% effective in preventing damage to wooden blocks (greater than ASTM 9) in concrete slab tests through five years in Arizona and four years in South Carolina at all concentrations tested. In Florida, the product provided 100% control through five years at 0.25, 0.5, 1.0 and 2.0% AI, but failed after the first year at 0.125 and 0.75%. Chlorfenapyr provided 100% control in Mississippi through four years at 0.5, 0.75, and 1.0%, but failed after the first year at the lowest and highest rates (0.125 and 2.0%) and after the second year at 0.25%. BASF will submit the registration package to EPA this year under the product name Phantom®.

Chemically-Impregnated Barriers

Four impregnated barriers are presently undergoing evaluation: Kordon Blanket® (Aventis, installed 1997), Termi-Film® (Cecil, installed 1998), Impasse® (Syngenta, installed 1999), and A+Protect® (HPC Enterprises, installed 2001). No failures have been observed.

FUTURE OF THE FOREST SERVICE TESTING PROGRAM

Recent events have influenced product testing inside and out of the Forest Service. For almost 50 years, the Forest Service maintained 5-7 scientists in a stable termite project, but between 1994-97 the unit lost 5 of 6 scientists, two Project Leaders, and 6 of 8 technicians. It was also moved to Starkville, MS in 1996 because of aging and non-compliant facilities in Gulfport. By mid 1997-98, the project was down to one scientist and two technicians. These events dramatically affected the project's ability to impact its mission. In order to fulfill agreement obligations with product manufacturers (registrants), a greater proportional effort from the remaining staff was directed to testing work at the expense of other research. In fact, much of the effort during the last six years has been directed to maintaining the testing program.

Concurrent with these events, the number, type, and complexity of termite control products were changing rapidly during the 1990s. New products, compounds, and formulations were being developed, challenging the testing program. For example, testing protocols, field designs, and pass/fail criteria are presently issues of great importance largely because of the introduction of non-repellent delayed-action termiticides. Development of a new bait pesticide registration notice and testing guidelines has also challenged regulators, registrants, and researchers. These issues are ongoing and will continue to affect testing research for some time.

Fully aware of these events and their relevance to product registration and marketing, registrants recently requested that EPA abandon its policy requesting efficacy data from the Forest Service as a condition to product registration. This registration guideline is unique among insecticides. Specifically, registrants have requested permission to obtain registration data from other sources, possibly to the exclusion of the Forest Service. A decision is pending on this issue, which has potential implications on the Forest Service testing program.

Notwithstanding these events, Forest Service commitments to industry remain strong. It has been engaged in product testing for more than 60 years, and it will continue to support and enhance the program to the extent that, and for as long as, adequate funds are available. During the last two years, the Forest Service has been reviewing testing program activities, procedures, and policies. It has engaged relevant stakeholders in this process, including federal and state regulators, registrants, and representatives of the pest control industry. Two stakeholder meetings were held in 2000 to discuss the changes taking place in the project, the challenges facing manufacturers and the pest control industry, including the regulatory process, potential solutions to the challenges, and ways to promote sound research planning. This effort initiated a process aimed at building confidence and communication between the Forest Service and its stakeholders and provided a platform from which to initiate meaningful changes to Forest Service research. A primary goal was to identify and correct weaknesses in the testing program, stabilize funding and personnel, and upgrade services to customers. Although the process is continuing, much progress has been made.

Administrative changes have been made within the project and Southern Research Station to better manage and track agreements with registrants, not only from a logistical and technical standpoint but from a financial standpoint as well. The project has more and better-trained staff working on product testing today than in the recent past. Since January 1999, a Project Leader, scientist, four technicians, support service specialist, and secretary have been hired. Two additional scientists are presently being recruited. This increase in personnel has provided short-term stability to the testing program, but it will not solve the long-term problems. As important as testing research is, it represents only a portion of the total research commitment of the project. All problem areas outlined in the mission statement must be effectively addressed. To accomplish this task, an independent staff is needed to run the day-to-day activities of the testing program, freeing project scientists and technicians to engage in research on this and other important issues.

The goal of establishing a separate, yet interconnected, testing team has been difficult to achieve for several reasons. The testing program is funded on a fee-for-service basis, and in recent years the Forest Service has not passed all costs on to the registrants. A fee increase will help, but not resolve, this problem. There is no consistency in the number of products tested each year, and this fact results in erratic and unpredictable funding that undermines efforts to create an independent, dependable, and well-trained testing staff. The idea of establishing a foundation for funding has been discussed with stakeholders and opportunities for implementing this idea are being explored. The goal of creating a stable testing team will make the program more efficient and responsive to the needs of all. Ultimately, the future constitution and role of the Forest Service termiticide testing program will depend on resolution of these ongoing issues.

REFERENCES

Beal, R. 1984. Termiticide Research Update. Pest Control Technology. 12(3): 71-72, 74.

Beal, R.H. 1980. New Materials for Termite Control. Pest Control. 48(11): 46-54.

Beal, R.H., J.K. Mauldin & S.C Jones. 1994. Subterranean termites - their prevention and control in buildings. Home and Garden Bull. No. 64. USDA Forest Service, Washington, D.C.