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Colin McCown, *Editor*

Efficacy of a Non-pressure Wood Protection System in an Above Ground Protected Field Test

Mark E. Mankowski
USDA, Forest Service, Forest Products Laboratory
Starkville, Mississippi

Lukas Dant
Syngenta Corporation
Greensboro, North Carolina

ABSTRACT

The efficacy of a spray-on combination formula containing the insecticides thiamethoxam and chlorantraniliprole was tested against subterranean termites using a covered ground proximity test. The test consisted of six treatments, five were chemical treatments and one was water control. Southern pine wood samples were treated with varying rates or treatment methods of the aforementioned insecticide combination, chlorantraniliprole alone, borate alone, or no chemical (water) treatment. Treated samples were installed at the Harrison Experimental Forest in Saucier, Mississippi using a modified protocol based on that described in the AWPA E26-21 – Standard Field Test for Evaluation of Wood Preservatives to be Used for Interior Applications (UC1 and UC2), Ground Proximity Termite Test. Using this method, test samples were placed in three arrays and monitored for termite attack at six months and annually thereafter. Four-year ratings for termite attack averaged 9.5 and above for all treatments tested except the water treated control which was rated at 4.2. Wood decay ratings averaged higher than 9.5 for all treatments except the water control (rating = 6.27). The amount of termite damage was evaluated using two rating systems, the AWPA E26-21 and ASTM D1758-06.

INTRODUCTION

Subterranean termites are one of the most economically important pests of wood structures in service in North America. Worldwide damages estimates are upwards of 40-50 billion dollars annually (Rust and Su, 2012). New application methods and new products or product combinations are often examined for efficacy against termites compared to existing products. There has been sustained interest in using existing chemical products for non-pressure wood treatment. Such treatments are meant to be applied by pest management professionals to existing structures or as potential remedial treatments in structures. To achieve the proper labeling, chemical companies must gather data to supply regulatory entities to expand or augment an existing label for inclusion of new uses or application rates.

Recent studies have shown the benefits of using American Wood Protection Association (AWPA) standardized field tests to evaluate wood preservation systems (Hassan et al., 2021; Mankowski et al., 2018; Mankowski et al., 2020). These studies have stressed the usefulness of the AWPA E26-21 - Standard field test for evaluation of wood preservatives to be used for interior applications (UC1 and UC2); Ground proximity termite test, (AWPA, 2023a). This test simulates wood in service in a man-made structure and exposes it according to various use category designations associated with particular wood protection chemical systems. In this case, the E26 standard evaluates wood in a structure that is not in direct ground contact but near the soil surface and covered to simulate wood in a structure near the foundation or sill plate. Such locations within a structure are often associated with high moisture and high biodeterioration conditions.

In this study, we examined the effectiveness of a currently registered soil termiticide (chlorantraniliprole) in combination with another insecticide as a spray-on system applied to wood to control subterranean termites, *Reticulitermes spp*. The objectives of this study were to examine insecticidal combinations and insecticides for termite control using an AWPA E26-21 (UC1 UC2) ground proximity field test. Using two rating systems, we wanted to see if the treated wood samples could pass AWPA E26-21 (AWPA, 2023a) or ASTM 1758-06 (ASTM, 2007) termite rating scales with a score of 10 for 5 years.

MATERIALS AND METHODS

The following chemical systems were evaluated:

A16130J Chlorantraniliprole alone

Consisted of the registered insecticide chlorantraniliprole. Chlorantraniliprole was registered as a termiticide in 2010 (Buczkowski et al., 2012). The compound is considered a reduced risk insecticide because it is specific to insect muscle systems only and has low mammalian toxicity. Chlorantraniliprole has been shown to be an effective soil termiticide around structures (Buczkowski et al., 2012; Jones et al., 2017).

A15452C Thiamethoxam + Chlorantraniliprole

Consisted of a combination of the insecticides thiamethoxam + chlorantraniliprole. Thiamethoxam is a neonicotinoid that acts by overstimulating the insect nervous system, causing death (Buczkowski et al., 2012). Chlorantraniliprole is a relatively new compound, registered for use as a soil termiticide. It is an anthranilic diamide that disrupts insect calcium stores causing over excitation in insect muscle tissue and eventual death (Buczkowski et al., 2012). Combinations of these two chemicals were shown to be effective on termite tunneling in a lab study (Kard et al., 2019), but no field studies examining the application wood have been performed.

Disodium Octaborate Tetrahydrate

Also referred to as DOT, Disodium Octaborate Tetrahydrate is a known diffusible insecticide and fungicide and an established non-pressure wood treatment system referenced in the AWPA Book of Standards (AWPA, 2023a). DOT is commonly used as a spray on treatment to wood in service that is considered above ground and protected from liquid water.

Test Formulations and Rates

We tested the efficacy of formulations of thiamethoxam + chlorantraniliprole (A15452C) at a low rate = 32 fl oz product/100 gallons of water, this same low-rate x two applications, and a high rate = 64 fl oz product/100 gallons. These application rates were compared to: chlorantraniliprole alone (A16130J), disodium octaborate tetrahydrate, and a water (untreated) control. Formulations of thiamethoxam + chlorantraniliprole (A15452C) were mixed and applied to wood at a low rate (32 fl oz product/100 gallons). Another treatment consisted of this low rate applied two times and another treatment employed a high rate (64 fl oz product/100 gallons) applied one time. Chlorantraniliprole alone (A16130J) was applied at a rate of 32 fl oz/100 gallons and disodium octaborate tetrahydrate was applied at its labeled rate of 12,800 fl oz/100 gallons. Water was applied as a non-chemical control treatment. Concentrations and application rates are summarized in Table 1.

The AWPA E26-21 was followed with minor modification. Southern pine wood was cut into 2.0 x 5.0 x 0.5-inch samples for testing. All six sides of the test samples were treated separately by stacking or book ending the sample stacks surrounded by extra non-test boards to prevent residual spray from getting onto already treated faces. After the sprayed edge sides were dried (30-60 minutes) the samples were laid flat, and the faces were sprayed. These were allowed to dry, and the samples were flipped over, and the opposite face was treated. A Solo 456, 2.5-gallon pump sprayer equipped with a 21psi flow valve to control flow and pressure was used to apply the treatments. A TeeJet® spray tip was used to get a uniform even band of coverage across approximately 2 ft^2. Exposed sides were sprayed at 1 gallon/400 ft^2. For the low-rate x two application treatment, we allowed the first coat to dry for two hours before applying the second spray application.

Field Testing

The AWPA E26-21 ground proximity termite test standard was followed with slight modifications. No plywood was used as an earlier study indicated that it is not needed and hinders attack by *Reticulitermes* spp. (Hassan et al., 2021). A plastic grid to support samples that is described in the standard was not used, and samples were placed in direct contact with a layer of bricks as described in the standard. The bricks used were three-hole masonry bricks that allowed for feeder stakes to be placed in brick holes and pounded into the ground. Three separate test arrays were placed in the field consisting of 60 samples each. Each array contained 10 replicates for each of the 6 treatments, with a total sample size of 30 replicates per treatment. Pine feeder stakes were placed in brick holes under the samples and also between columns of samples in the arrays (Figure 1). These long feeder strips were replaced if hit when the samples were rated. The test arrays were placed at least 100 ft from each other and covered (Figure 1). Samples were evaluated annually using the E26-21/E21-18 termite/decay scales (AWPA, 2023a; AWPA, 2023b) and the ASTM D1758-06 termite/decay scale (ASTM, 2007).

Table 1: Formula concentrations and application rates.

Treatment name	Formulation Concentration	Rate	Rate	Mix rate	Spray solution concentration
	g ai/L	*g ai/100 L*	*fl oz product/100 gal*	*ml product/L water*	*g ai/L*
Untreated (water)	--	--	--	--	--
A16130J (chlorantraniliprole)	**200**	**50**	**32**	**2.5**	**0.50**
A15452C (thiamethoxam + chlorantraniliprole) Low	**300**	**75**	**32**	**2.5**	**0.75**
A15452C (thiamethoxam + chlorantraniliprole) ***Low two applications***[a]	**300**	**75**	**32**	**2.5**	**0.75**
A15452C (thiamethoxam + chlorantraniliprole) High	**300**	**150**	**64**	**5**	**1.50**
Disodium octaborate tetrahydrate (DOT)	**552**	**100**[b]	**12800**	**1000**	**N/A**

[a]This treatment received two applications at the prescribed rate; allowing the first coat to dry before applying the second.
[b]Percent weight/volume (%w/v).

Figure 1. AWPA E26-21 Ground proximity termite test showing uncovered sample array (left) and covered array (right).

The Test Site – Harrison Experimental Forest.

Samples were installed at the Harrison Experimental Forest (HEF) near Saucier, Mississippi. The HEF has an average annual precipitation of 1600 mm. Mean annual minimum and maximum temperatures (Jackson, Mississippi data) are 12°C and 24°C, with no mean monthly temperature below 10°C. The topography is relatively flat with a slope of 5 to 12 percent. The soil is Poarch fine sandy loam with a pH of 4.9. The site has a Scheffer Index value of 70 (Morris and Wang, 2008). Ground cover is predominately yaupon holly, wiregrass, broom sage with loblolly and long leaf pine. The HEF has a well-documented occurrence of *Reticulitermes* spp., dominated by eastern subterranean termites, *Reticulitermes flavipes* (Kollar), *R. virginicus* (Banks) and *R. hageni* (Banks) (Shelton et al., 2014; Shelton et al., 2021).

Two different rating systems were used to evaluate samples because AWPA systems use a rating of 9.5 for samples with slight termite attack. The ASTM D1758-06 however, includes slight attack with its highest rating 10. This system identifies slight attack as minor traces of surface grazing or nibbles on the wood by termites. This was done because regulatory entities increasingly want to see scores of at least 10 for 5 years to approve a product for wood protection. The AWPA system uses 9.5

as a gauge to highlight that although the sample is not perfectly sound there is very slight attack, and it should be noted. An issue arises with this as regulatory entities are not really aware that a rating average of 9.5 or greater after five years is very good for any product. The rating systems used in this test are described below and in Tables 2 and 3. The E26-21 scale is used for termite attack only (AWPA, 2023a). Decay ratings for this test are optional and generally one can use the AWPA E21-18 for a decay rating scale (AWPA, 2023b). The ASTM D1758-06 Standard Test Method of Evaluating Wood Preservatives by Field Tests with Stakes allows a score of 10 to have superficial attack such as nibbles/grazing, and superficial etching (ASTM, 2007).

Table 2. AWPA E26-21 and E21-18 visual termite and wood decay damage rating scheme.

10	Sound, no decay or insect damage
9.5	Trace, surface nibbles permitted
9	Slight attack, up to 3% of cross-sectional area affected
8	Moderate attack, 3–10% of cross-sectional area affected
7	Moderate/severe attack, penetration, 10–30% of cross-sectional area affected
6	Severe attack, 30–50% of cross-sectional area affected
4	Very severe attack, 50–75% of cross-sectional area affected
0	Failure

Table 3. ASTM D1758-06 visual termite and wood decay damage rating scheme.

10	Sound, no decay or insect damage; Trace, surface nibbles permitted
9	Slight attack, up to 3% of cross-sectional area affected
8	Moderate attack, 3–10% of cross-sectional area affected
7	Moderate/severe attack, penetration, 10–30% of cross-sectional area affected
6	Severe attack, 30–50% of cross-sectional area affected
4	Very severe attack, 50–75% of cross-sectional area affected
0	Failure

RESULTS AND DISCUSSION

Termite ratings using the AWPA E26 or ASTM D1758-06 rating scales are shown in Tables 4 and 5, respectively. After four years, untreated control samples had incurred high levels of attack by termites (average rating = 4.2). All the chemical treatments tested were performing well after 4 years at ratings averaging 9.5 or above according to the AWPA E26-21 scale and ratings of 10 (sound wood) using the ASTM D1758-06 scale. There appeared to be little difference between the thiamethoxam and chlorantraniliprole combinations compared to chlorantraniliprole alone and DOT. Using the AWPA scale the thiamethoxam and chlorantraniliprole high rate performed similarly to chlorantraniliprole alone (ratings = 9.8). Using the AWPA E26-21 scale gave lower ratings than the ASTM D1758-06 scale because all the termite attack at the four-year point was superficial grazing and very minor etchings on the samples that the ASTM standard accounts for in the 10 rating. Using the AWPA scale lowered the ratings because as time progressed more samples incurred superficial etchings and ratings of 9.5. There was also some array variability that will be analyzed after future ratings. Array 1 incurred attack first whereas arrays 2 and 3 did not show termite attack until year three.

Table 6 shows decay ratings using both the AWPA E21-18 and ASTM D1758-06 scales. Untreated pine samples incurred the highest level of decay at an average rating of 6.7 after four years. Chemically treated samples, aside from the DOT treated samples, did incur higher levels of decay compared to termite attack but it must be remembered that the test systems aside from

the DOT did not have a known fungicide in them. The samples treated with DOT performed as would be expected with this wood protection system since it functions very well on wood in above ground protected situations. Interestingly samples treated with the thiamethoxam + chlorantraniliprole or chlorantraniliprole alone performed well against wood decay. This may be an inadvertent effect of the solvent system or in-can preservative used for the insecticides.

Table 4. Termite attack ratings using the AWPA E26-21 scale for samples sprayed with various insecticides and placed in an AWPA E26-21 ground proximity termite test after four years.

Termite AWPA E26-21/E21-18				
Treatment	Six Month	1 Year	3 Years	4 Years
Untreated (water)	9.77	8.87	5.43	4.20
A16130J Chlorantraniliprole	10.00	10.00	9.98	9.98
A15452C Thiamethoxam + Chlorantraniliprole Low	10.00	10.00	9.95	9.92
A15452C Thiamethoxam + Chlorantraniliprole Low x 2 Applications	10.00	9.98	9.98	9.95
A15452C Thiamethoxam + Chlorantraniliprole High	10.00	10.00	9.98	9.98
Disodium octaborate tetrahydrate (DOT)	10.00	9.98	9.97	9.88

Table 5. Termite attack ratings using the ASTM D1758-06 rating scale for samples sprayed with various insecticides and placed in an AWPA E26-21 ground proximity termite test after four years.

Termite Rating ASTM D1758-06				
Treatment	Six Month	1 Year	3 Years	4 Years
Untreated (water)	9.77	8.87	5.43	4.20
A16130J Chlorantraniliprole	10.00	10.00	10.00	10.00
A15452C Thiamethoxam + Chlorantraniliprole Low	10.00	10.00	10.00	10.00
A15452C Thiamethoxam + Chlorantraniliprole Low x 2 Applications	10.00	10.00	10.00	10.00
A15452C Thiamethoxam + Chlorantraniliprole High	10.00	10.00	10.00	10.00
Disodium octaborate tetrahydrate (DOT)	10.00	10.00	10.00	10.00

Table 6. Wood decay ratings using the AWPA E21-18 or ASTM D1758-06 scale for samples sprayed with various insecticides and placed in an AWPA E26-21 ground proximity termite test after four years.

Wood Decay Rating AWPA E21-18/ASTM D1758-06				
Treatment	Six Month	1 Year	3 Years	4 Years
Untreated (water)	10.00	9.87	7.20	6.27
A16130J Chlorantraniliprole	10.00	9.97	9.82	9.75
A15452C Thiamethoxam + Chlorantraniliprole Low	10.00	9.97	9.82	9.73
A15452C Thiamethoxam + Chlorantraniliprole Low x 2 Applications	10.00	10.00	9.80	9.72
A15452C Thiamethoxam + Chlorantraniliprole High	10.00	10.00	9.80	9.78
Disodium octaborate tetrahydrate (DOT)	10.00	10.00	9.98	9.98

CONCLUSIONS

All treatments except the water control were found to be performing well against termites and wood decay after four years. Termite attack consisted of minor trace nibbles and surface etchings that often made rating difficult, especially when the AWPA E26 termite rating scale was employed. Since the ASTM termite scale allowed for more flexibility regarding trace attack, samples retained high ratings (perfect condition/sound) at the four-year point. This difference in the rating scales is highly important from a product testing and chemical labeling standpoint as regulatory agencies have become very strict on how a wood preservative system is approved. The systems tested here would be considered failures at 4 years according to the AWPA scale, but not according to the ASTM scale. The use of the 9.5 rating in the AWPA scale must be used with caution in the future. The systems tested in this study were holding up very well and next year's five-year rating will elucidate on this even more. Decay ratings after four years were better than expected for the non-borate (DOT) chemical systems tested. This may have been an effect of the solvent system used or possibly an in-can preservative effect. The outcome from this study overall was very encouraging for the future of different spray-on wood protection systems, however, regulatory entities may not consider this type of filed test valid as it does not represent a full-scale human dwelling. Regulatory agencies are leaning towards a preference on actual structures for chemical testing in some cases particularly termite insecticides for wood in service (Jones et al., 2017).

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