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Assessing the Effectiveness of a Range of Treatment Options for Protecting Wood Poles against Termite Attack

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Assessing the Effectiveness of a Range of Treatment Options for Protecting Wood Poles against Termite Attack

Prepared for the

Forest & Wood Products Research & Development Corporation

by

M. Horwood

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Executive Summary

This study was initiated by the Power Poles Committee of the Electricity Association NSW. Funding is provided by the member agencies of the Power Poles Committee and the Forest and Wood Products Research and Development Corporation. State Forests of NSW undertake the research in collaboration with EnergyAustralia, CountryEnergy and Integral Energy.

The study objectives were to:

1. Identify the most efficacious treatments for controlling termites in wood power poles
2. Reduce the costs borne by power supply companies associated with controlling termites
3. Identify alternatives to arsenic trioxide dust

To achieve the study objectives, 2 trials were established:

1. A Service Trial to test the efficacy of treatments for controlling termite infestations in poles in service.
2. A Field Trial to test the efficacy of soil barriers for protecting new poles from termite attack.

The study started in December 2000 and is scheduled for completion in 2007. Results obtained in the first 12 months of the Service Trial are discussed in this report. Future inspections will be held annually for 5 years. The Field Trial was established only recently and no meaningful results were available to report.

Future results from the Service and Field Trials will be published in scientific journals, Department of Primary Industries publications, or reports to the Power Poles Committee.

For the Service Trial, 10 different treatments were applied to over 450 poles in a diverse range of environments in NSW. After treatment, poles were inspected 1, 6 and 12 months after treatment to determine treatment effectiveness.

Results from each inspection were adjusted for changes in infestation rates amongst controls and expressed as percentage reductions in infestation. All treatments were effective to some extent, and a number were comparable to arsenic trioxide.

Although effective alternatives to conventional treatments were identified, single applications did not provide acceptable levels of control. The use of combinations of treatments may achieve levels of efficacy acceptable to the power supply industry.

Project Objectives

- Produce efficacy and reliability data on a range of termite treatment systems for wood poles. While the data will be developed on poles, it will be applicable to both hardwood and softwood timbers in a wide range of end uses.
- Significantly reduce the estimated annual expenditure of approximately $5,000,000 on termite protection of wood poles and replacement of wood poles due to termite attack.
- Identify effective alternatives to arsenic trioxide dust for eradicating existing termite infestations.

Introduction

The protection of wood poles from subterranean termite attack is a significant issue for wood pole asset managers in the power supply industry. A 1999 survey of NSW and interstate pole asset managers indicated that the annual Australia-wide cost of treating and replacing poles infested with termites was approximately $10-15 million. These costs were considered conservative, as they did not include the associated indirect costs that may arise from the unexpected failure of termite affected poles, which might include compensation for injury or property damage, equipment damage and loss of revenue due to the loss of supply.

The power supply industry has traditionally used arsenic trioxide dust and organochlorine termiticides to protect wood poles from termite attack. The situation has changed dramatically in the past decade. Regulatory changes have prohibited the use of organochlorines since 1995 and occupational, environmental and disposal considerations have increased concerns about the continued use of arsenic trioxide. The chemical industry has developed alternative chemicals for arsenic trioxide and the organochlorines and some of these have been approved for use on wood poles although no evidence of efficacy that is specific to wood poles has been developed. Some of these chemicals are being used for termite control by some power supply authorities.

Concerns have been expressed about the efficacy and reliability of available chemicals and the lack of knowledge about the efficacy and reliability of other termite treatment options that are, or could be, available to the power supply industry.

In 1998, the Power Poles Committee of the Electricity Association of NSW asked the Research and Development Division of State Forests of NSW to prepare a research proposal to assess current and potential termite control options. The research project that arose from this proposal became known as the Termite and Power Pole Evaluation Research (TAPPER) trial. The Electricity Association of NSW funds the work in conjunction with the Forest and Wood Products Research and Development Corporation. State Forests of NSW undertake the research in collaboration with EnergyAustralia, CountryEnergy and Integral Energy.

The TAPPER trial was constructed in 2 parts:

1. The Service Trial is evaluating the performance of termiticidal treatments including toxic dusts, chemical soil barriers and a residual timber fumigant for eradicating termite infestations from infested power poles.

2. The Field Trial is evaluating the performance of termiticidal soil barriers and a physical barrier for protecting new poles from termite attack.

Both parts of the trial focus on protecting poles from *Coptotermes acinaciformis* (Froggatt) (Isoptera: Rhinotermitidae), in economic terms Australia's most damaging termite species.

Progress

Service Trial installation began in December 2000 and was completed in October 2002. Treatments were applied to over 450 termite infested poles located throughout urban and rural NSW. Two "offshoot" evaluations were set up in conjunction with the Service Trial. These were:

1. Testing of 5 of the 10 Service trial treatments on 50 poles on the north coast of NSW (known as the NorthPower Subtrial)
2. Testing of the soil chemical permethrin on 10 poles near Dunedoo in central western NSW (known as the Permethrin Subtrial)

Both subtrials were established at the request of NorthPower, the network responsible for northeastern NSW prior to the formation of CountryEnergy.

Poles have been monitored to assess treatment performance. Because pole treatment was staggered, not all poles have been monitored for the same period. All poles have been monitored for at least 12 months.

The Field Trial was established in November 2002 in a State Forest near Narrandera. Five hundred and forty timber posts have been placed in the ground protected by an assortment of barrier systems. Posts are being inspected at intervals to determine the effectiveness of the treatments. The first annual inspection of posts was conducted in November 2003.

Materials and Methods

Service Trial

Service Trial Poles were selected from either the "inland", west of the Great Dividing Range, or from the "coast", around Sydney (Fig. 1). Two hundred poles were treated in each region, comprising 20 replicates of each treatment.

Poles were inspected before treatment to ensure termites were present. Infested poles were treated in blocks of 50. As far as possible, a complete set of treatments was applied to poles in close proximity to each other. Each block contained 5 replicates per treatment.

The 50 NorthPower sub-trial poles were located on the north coast of NSW (Fig. 1). Each treatment was applied to 10 poles.

For the Permethrin Subtrial conducted near Dunedoo in the central west of NSW, 5 poles were treated with permethrin diluted with water and another 5 were treated with permethrin diluted with diesel. No controls were included in this examination.

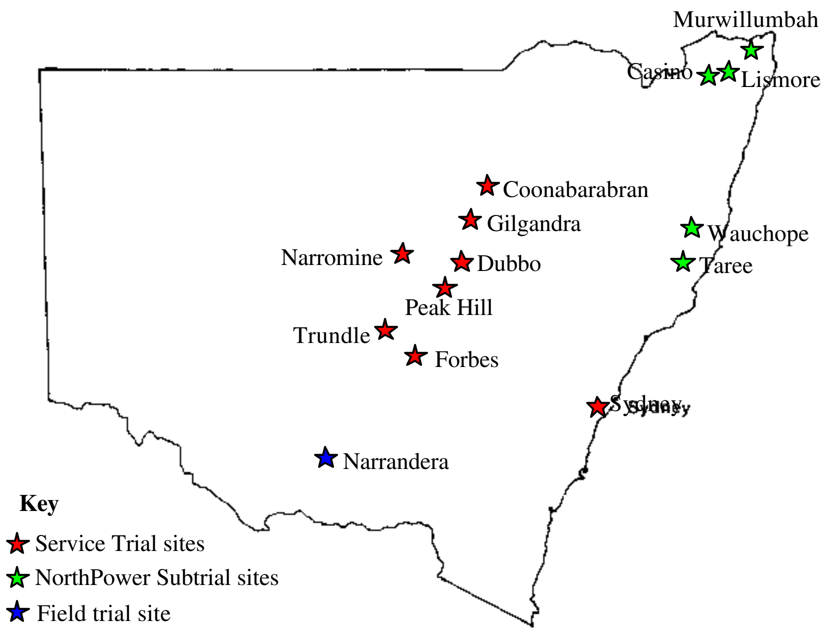

Figure 1. Approximate locations of TAPPER trial study sites.

A conspicuous identification plate was attached to each pole after treatment (Fig. 2). Written on the plate was a message warning against interference and network contact information.

Figure 2. Identification plates on a TAPPER trial study pole.

Treatments

Treatments included in the trial were a selection of registered termiticides and experimental products chosen by the trial organising committee. Treatments were selected on the basis of potential efficacy and also compatibility with pole groundline maintenance procedures.

Treatment Type	Active Constituent[a]	Brand Name	Use Rate
Chemical Soil Barrier	Bifenthrin 100 g/L EC	Biflex®	5 mL concentrate/L of water/10 L of soil
	Chlofenapyr 240 g/L SC	Phantom[b,c]	5.2 mL concentrate /L of water/10 L of soil
	Chlorpyrifos 450 g/L EC	Dursban Micro-Lo®	22 mL concentrate /L of water/10 L of soil
	Fipronil 100 g/L SC	Termidor®[b,c]	3 mL concentrate[d] /L of water/10 L of soil
	Imidacloprid 200 g/L SC	Premise®	2.5 mL concentrate /L of water/10 L of soil
	Permethrin 500 g/L EC[e]	Perigen 500®	40 mL concentrate /L of water or diesel/10 L of soil
Toxic Dust	Arsenic trioxide 375 g/kg	Garrards Termite Powder®	Approximately 1-2 g dust/pole
	Metarhizium anisopliae 3 x 10^{10} spores/g	nil[b,c]	Approximately 10 g dust /pole
	Triflumuron 800 g/kg	Intrigue®[c]	Approximately 5-10 g dust /pole
Timber Fumigant	Dazomet 990 g/kg	Basamid®[f]	According to pole diameter; on average approx. 250 g powder/pole

[a]EC=emulsifiable concentrate; SC = suspension concentrate
[b]Not registered when trial started
[c]Used in NorthPower Subtrial
[d]Use rate based on advice by Aventis Crop Science; product registered at twice this rate i.e. 6 mL/L
[e]Used in Permethrin Subtrial only
[f]Registered as a soil fumigant but not registered for controlling termites in timber

Application Methods

Chemical Soil Barriers and Controls

Soil around poles is often unsuited for chemical barrier formation because it may be clumpy or because of the presence of rocks, organic matter and other contaminants. Consequently, soil barriers were constructed by removing the original soil from around poles and replacing it with new, chemically treated soil.

Chemical was diluted according to chemical manufacturer's mixing instructions and mixed with the required volume of replacement soil in a 90 L electrically driven cement mixer (Fig. 3). For controls, water only was added to the soil.

An adjustable steel cowling was used as formwork to help ensure each soil barrier was constructed with consistent dimensions (Fig. 4). The cowling was placed in the trench around the pole and adjusted to sit 150 mm from the pole to a depth of 350 mm from the surface. Some of the original soil was used to backfill the cowling once it was adjusted and in place.

Figure 3. A cement mixer was used to thoroughly mix diluted chemical and soil.

Figure 4. An adjustable cowling was used as formwork to maintain consistent barrier dimensions around each pole.

Figure 5. Chemically treated soil was placed between the cowling and the pole.

Figure 6. After the cowling was slipped out and removed from the pole, treated soil was compacted.

Treated soil was placed between the cowling and the pole (Fig. 5). Soil was compacted and the cowling was slipped out of the soil and removed from the pole (Fig. 6). After the barrier was constructed, chemical mixture (at the same concentration used to treat the soil) or water (in the case of control poles) was injected into poles with internal voids (Fig. 7). Liquid was injected near ground level using a hand-pressurised spray unit to the point of refusal, up to a maximum of 10 L.

Figure 7. Chemical mixture was injected into poles with internal voids.

Termiticidal Dusts

When they are used for routine termite control, toxic dusts are applied to termite infestations as often as required to achieve eradication. Since the focus of the trial was to assess the comparative effectiveness of treatments, rather than achieve eradication *per se*, poles were given only a single application of dust.

Dusts were puffed into parts of poles where termites were or had been active (Fig. 8) using standard pest control industry hand held dust applicators. A 3 m ladder was used to apply dust access parts of the pole as high as 2-3 m above ground.

Figure 8. Dust is puffed into a check using a standard pest control industry hand applicator.

Fumigant

Dazomet powder was applied into 14 mm or 16 mm holes drilled at the base of the pole using a petrol-powered drill (Figs. 10 & 11). The amount of powder used was proportional to the diameter of the pole, with an average of approximately 250 g used per pole. Typically, 4-5 holes up to 500 mm long were drilled on an abaxial pattern, starting 150 mm above groundline. Following insertion of the powder, approximately 20 mL of a 1% aqueous copper sulphate solution was poured into each hole. Copper sulphate accelerates the release of methylisothiocyanate (MITC) the active ingredient of dazomet (Forsyth *et al.* 1998). Holes were sealed with CCA-treated wooden plugs after treatment.

Figure 9. Several 500 mm long holes were drilled into poles 150 mm from ground level.

Figure 10. Fumigant powder was poured into holes. A steel rod was used for clearing blockages in the holes.

Post-Treatment Assessments

In the Service Trial plan, inspections of poles for termites were scheduled for 1, 6, 12, 24, 36, 48 and 60 months after treatment (MAT). The plan called for the inspection of all trial poles up to 12 MAT. In order to limit the extent of termite damage, poles infested 12 MAT, and at later inspections, were to be dropped from the trial and returned to normal service, which entailed reapplication of termiticide. Treatments were to be considered as having failed at the time poles were dropped, and no further inspections were to be carried out on them.

At the time of writing, all trial poles (Service Trial, NorthPower Subtrial and Permethrin Subtrial) had been inspected up to 12 MAT. All NorthPower Subtrial poles had been inspected up to 24 MAT. A small number of Service Trial poles (11) and the Permethrin Subtrial poles remained to be inspected 24 MAT. Three blocks of Service Trial poles (i.e. 15 of each treatment) had been inspected 36 MAT.

Only the above ground portions of treated poles were inspected. A 3 m ladder was used if necessary to increase the examinable area of the pole. Parts of the pole surface examined included existing tunnels and workings, loose sapwood and checks, cracks containing termite workings and baits placed in drill holes (Fig. 11). Internal voids were examined using a borescope inserted through drill holes (Fig. 12). Several of these were made in test poles, typically at 150 mm above ground line and 1 m above ground line. New holes were drilled in poles as required during an inspection.

Figure 11. Baits made of radiata pine or mountain ash were used to detect termites in poles.

Figure 12. A borescope was used for inspecting internal voids for termites.

Results of Service Trial inspections conducted 1, 6 and 12 MAT (for which data for all treated poles was available) were summed and the percentage mean reduction in termite infestation was calculated for each treatment group and control. As well, the percentage mean reduction in termite infestation (corrected for any increase or decrease in infestation rates amongst controls) was calculated using Abbot's (1925) formula.

The significance of reductions caused by treatments compared to controls and of differences between treatments was determined using an analysis of variance followed by Fisher's LSD procedure. All data were judged at $\alpha = 0.05$.

Data for NorthPower Subtrial were adjusted for changes amongst controls. The Permethrin Subtrial had no controls, and data were presented as raw percentages. Data for NorthPower Subtrial and the Permethrin Subtrial were not statistically analysed.

The failure time data arising from inspections later than 12 MAT was incomplete at time of writing and will not be presented in this report.

Field Trial

In November 2002 a field study of termite barrier systems was established in a managed cypress forest in south-western NSW with a known high termite hazard. The predominant termite species at the study site are *C. acinaciformis* (Froggatt) and *C. frenchi* Hill.

Barrier efficacy is being evaluated by observing the periods of protection afforded to partially buried blackbutt heartwood posts 50 mm x 50 mm in cross section and 750 mm in length.

Twelve different treatments are being examined, consisting of 1 untreated control, 5 full chemical barriers, 5 partial chemical barriers and 1 physical barrier.

Chemical soil barriers were constructed by mixing chemical termiticides with the soil placed around posts. Between posts and the surrounding untreated soil the width of chemical soil barriers ranged between 140 mm and 150 mm (Fig. 13). Full chemical barriers extended to a depth of 700 mm (Fig. 14a). At the base of each post, the barrier was 150 mm deep. Partial chemical barriers extended to a depth of 350 mm (Fig. 14b).

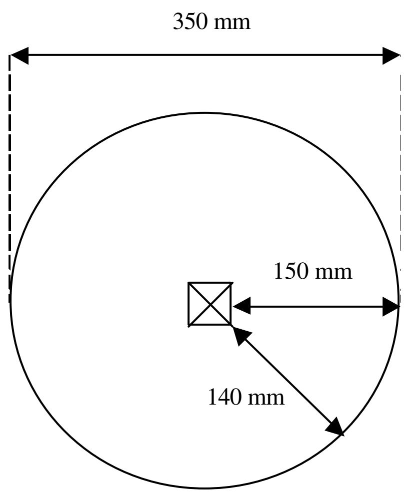

Figure 13. Chemical barrier - horizontal dimensions.

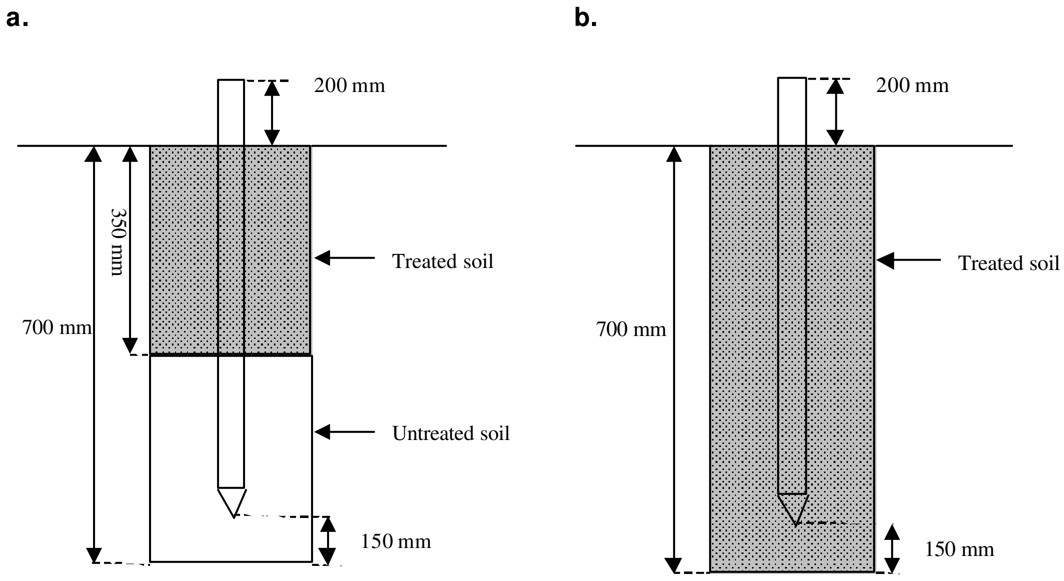

Figure 14. Chemical barrier - vertical dimensions. a. Full barrier. b. Partial barrier.

Treatments

The following termiticides were included in the Field Trial:

Active Constituent[a]	Brand Name	Use Rate
Bifenthrin 100 g/L EC	Biflex®	5 mL concentrate/L of water/10 L of soil
Chlofenapyr 240 g/L SC	Phantom[b]	5.2 mL concentrate /L of water/10 L of soil
Chlorpyrifos 450 g/L EC	Dursban Micro-Lo®	22 mL concentrate /L of water/10 L of soil
Fipronil 100 g/L SC	Termidor®[b]	6 mL concentrate /L of water/10 L of soil
Imidacloprid 200 g/L SC	Premise®	2.5 mL concentrate /L of water/10 L of soil

[a]EC=emulsifiable concentrate; SC = suspension concentrate
[b]Not registered when trial started

Fipronil was used at twice the concentration used in the Service Trial. All other termiticides were used at the same concentration in both trials.

The physical barrier under evaluation is stainless steel mesh (Termimesh®). Sheets of mesh were folded into a sock-like shape and slipped over the post (Fig. 15). The sock covered the full embedded portion of the post (550 mm) and extended 75 mm above finished ground level. Mesh was placed on posts by the manufacturer, TMA Corporation. Only a full physical barrier is being tested.

Figure 15. Post with stainless steel mesh barrier installed.

Experimental Design

Treatments are being tested in 3 separate 'Treatment Sets'. Sufficient numbers of posts were installed to allow statistically significant numbers to be destructively sampled on 6 different occasions. Five replicate posts from each treatment are examined at each inspection.

The largest set, Treatment Set 1, includes conventional chemicals (products registered for at least 2 years) and stainless steel mesh physical barrier.

Manufacturers of fipronil and chlorfenapyr claim these chemicals can cause the decline and death of termite colonies some distance from where they are applied. Effects are believed to result from the translocation of treated soil back to the nest by foraging termites. Although these claims are unproven, fipronil and chlorfenapyr were physically separated from each other and from Treatment Set 1, to avoid the possibility of overlapping effects. However, a standard reference treatment, chlorpyrifos, was included in the fipronil and chlorfenapyr Treatment Sets for comparison.

The design of each Treatment Set was based on the Latin square. Treatment Sets 2 and 3 are complete 5 x 5 Latin squares (5 treatments by 5 replicates). Treatment Set 1, because of its larger size, is a partial 8 x 5 Latin square (8 treatments x 5 replicates).

In the Field Trial layout, treatments within each Treatment Set were installed as a grid, in the order given in the appropriate Latin Square. 'Treatment Subsets' consist of 6 posts (1 for each inspection event) with the same treatment installed in a row, 1 m apart (Fig. 16). Treatment Subsets are separated by 5 m, as is each row in a Treatment Set.

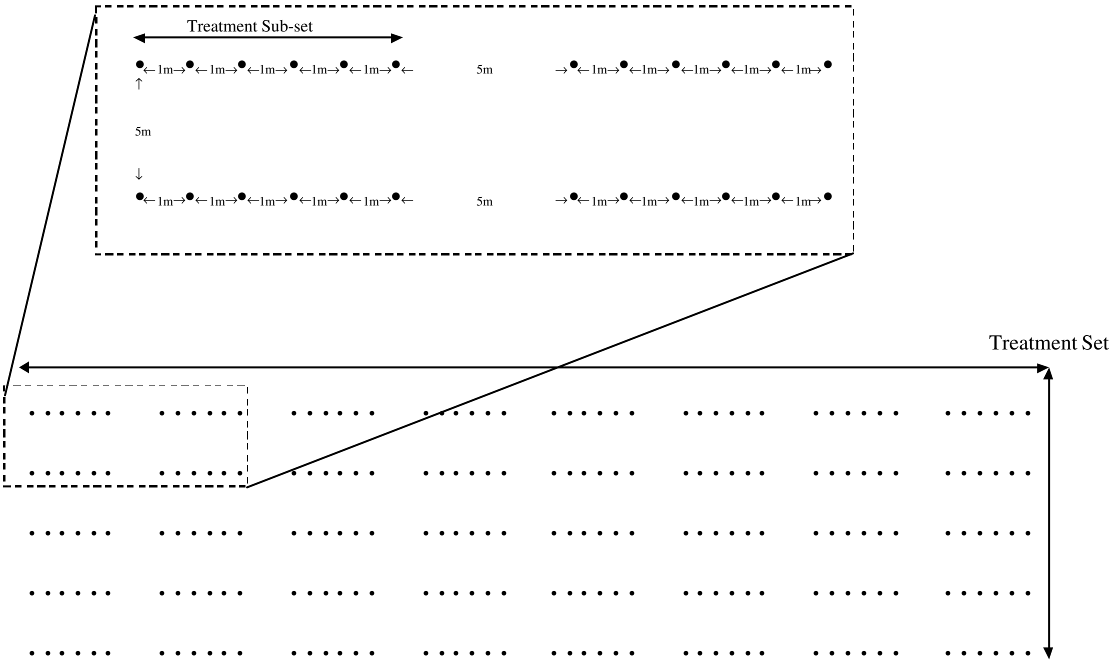

Figure 16. Layout of posts and Treatment Subsets in Treatment Set 1. Blow-up shows details of the spacing of individual posts and Treatment Subsets. Drawing not to scale.

Application Methods

Preparation of chemically treated soil

Diluted termiticides were mixed with soil using a 6 m^3 capacity cement truck at the rate of 100 L per cubic metre. Soil excavated at the test site was not used. Instead, a 50:50 sand/soil mixture obtained from a local supplier at Narrandera was used. Soil and chemical were loaded and mixed at Narrandera then transported to the test site in the cement truck.

Treated soil was placed into pre-drilled holes directly from the cement truck (Fig. 17). Posts (50 mm x 50 mm x 750 mm long) were placed in the centres of holes as they were filled (Fig. 18). Treated soil was compacted as it was poured into the holes.

Figure 17. Treated soil was placed into holes directly from the cement truck.

Figure 18. Post and barrier installed at the Field Trial site.

Monitoring

Inspection intervals

In the Field Trial plan, inspections of specimen posts were scheduled for 1, 3, 5, 7, 10 and 20 years after treatment (YAT). These times were chosen to coincide with other events in the pole life cycle. For example, the 5 year inspection coincides with the interval between regular inspections of poles for fungal degrade (3-6 years), while 20 years is comparable to the period before the first inspection is required for preservative impregnated (e.g. CCA or creosote) poles (18 years).

At each sampling time, a single post will be randomly selected from each Treatment Subset and removed for inspection (Fig. 19). Evidence of termite damage to the post will constitute failure of the particular barrier treatment.

Figure 19. Specimen post with severe termite damage being removed at the Field Trial site.

Results

Service Trial

Post treatment termite abundance was summed for all blocks and the percentage reduction in infestation was calculated. As the trial progressed, there was a general decrease in infestation rates amongst controls. As a result, percentage reduction in infestation for controls rose from 12.5% at 1 MAT to 25.6% at 6 MAT and 20.6% at 12 MAT. The decreased termite abundance in controls coincided with the arrival of drought conditions in NSW in 2001 and 2002. Termites are dependant on moisture, and presumably the dry conditions associated with drought made them either harder to find in test poles or forced them to abandon some poles completely.

Despite the confounding effects of drought, at every inspection, all treatments achieved significant reductions in termite infestation compared with controls. Comparisons of treatment effectiveness were made after correcting for changes amongst controls (Fig. 20). 1 MAT, dazomet and arsenic trioxide caused reductions significantly greater than those caused by bifenthrin, chlorfenapyr, imidacloprid and triflumuron, but not significantly greater than those caused by chlorpyrifos, fipronil and *Metarhizium.* A similar ranking was maintained 6 MAT, except for a reduction in of arsenic trioxide. 12 MAT dazomet remained the most effective treatment, while the effectiveness of arsenic trioxide dropped below fipronil and chlorpyrifos. Dazomet and fipronil caused reductions significantly greater than those caused by chlorfenapyr, *Metarhizium* and triflumuron, but were not significantly greater than those caused by arsenic trioxide, bifenthrin, chlorpyrifos and imidacloprid.

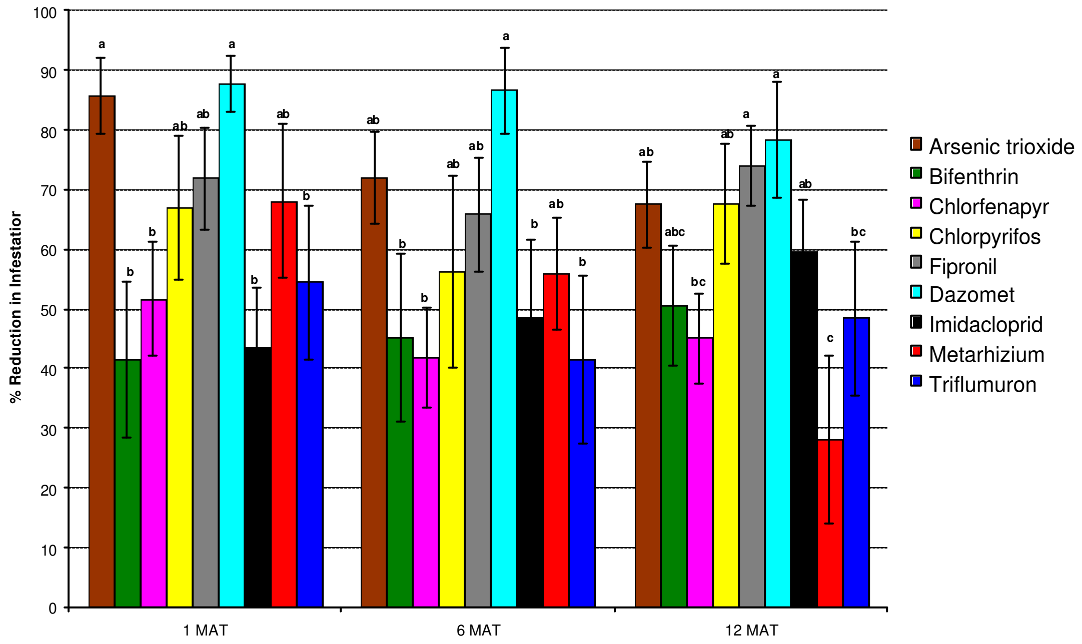

Figure 20. Mean (±SE) reductions in termite infestation (percentage) in Service Trial poles 1, 6 and 12 months after treatment (MAT). For each group, among treatments, means with the same letter are not significantly different (*P*>0.05).

NorthPower Subtrial

Data from the NorthPower subtrial were corrected for changes amongst controls (Fig. 21). 1 MAT *Metarhizium* achieved the greatest reductions in infestation. Its effectiveness dropped to 43% 6 MAT, then increased to 50 % 12 MAT. The effectiveness of fipronil increased at each inspection and reached 100 % 12 MAT. Chlorfenapyr declined from a maximum 43% effectiveness 1 MAT to 14% 6 MAT, and 0% 12 MAT. The maximum effectiveness achieved by Triflumuron was 17% 12 MAT.

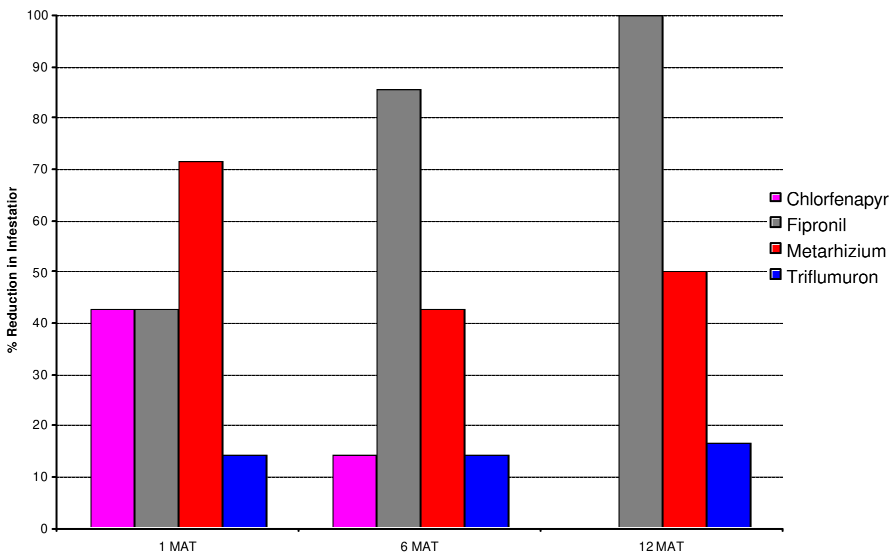

Figure 21. Mean reductions in termite infestation (percentage) in Service Trial poles 1, 6 and 12 months after treatment (MAT).

Permethrin Subtrial

Permethrin diluted with water achieved 80% effectiveness at each inspection (Fig. 22). When diesel was used as diluent, a maximum reduction of 20% was achieved 1MAT. At later inspections this treatment was completely ineffective.

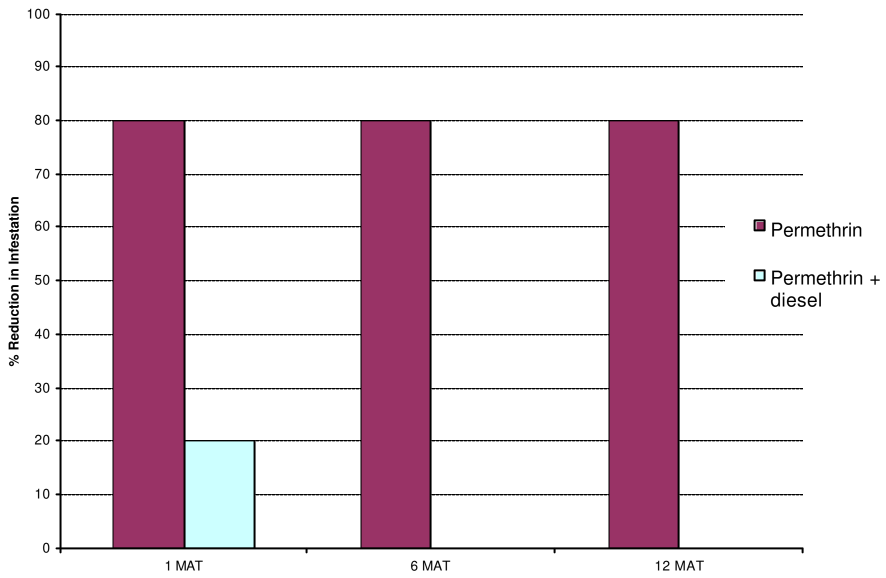

Figure 22. Mean reductions in termite infestation (percentage) in Permethrin Subtrial poles 1, 6 and 12 months after treatment (MAT).

Field Trial

At time of writing, only the 1 year after treatment inspection had been conducted. Termite attack upon all posts (treatments and controls) was at a very low level. These results will not be presented in this report.

Discussion

Data presented in this report are from the first 12 months of a trial intended to last for up to five years. As more results become available they will be published either in scientific journals or in internal Department of Primary Industries publications. The report author should be contacted for further information about the trial at a later date.

Significant headway has already been made in meeting the Project Objectives. Data pertaining to a diverse range of conventional and experimental products has been obtained. Differences in efficacy have been detected, revealing a ranking of treatment reliabilities. A number of treatments have levels of effectiveness at least comparable to that of arsenic trioxide. At least one network operator has already altered its termite treatment practices in accordance with the optimum control methods identified by this research. Before the project is completed, adoption by the industry of improved termite treatment practices should be widespread. Expectations are high that these changes will result in significant progress towards Project Objective number 2, i.e. reducing the cost of termite damage and treatment to the power supply industry.

Of all products tested, the timber fumigant dazomet achieved the highest mean percentage reductions in termite infestation. Dazomet is one of a group of fumigants that decompose into methylisothiocyanate (MITC) as the active ingredient. Studies have shown that MITC will penetrate the heartwood of softwood for considerable distances and will provide years of residual protection against decay fungi (Morrell *et al.* 1996). Limited research suggests that MITC will also control termites and other insects (Hand *et al.* 1970). Although this group of fumigants is used extensively in the USA for protecting poles against decay, they are not used for controlling termites.

While dazomet is registered in Australia (as a soil sterilant), it is not approved as a timber treatment. Additions to the approved dazomet label will therefore be necessary before it can be used on power poles. Once regulatory approval has been gained, the power supply industry should seriously consider adopting dazomet as a termite treatment. Moreover the potential for dazomet as a dual-action treatment, for decay and termites, should also be investigated.

The mode of action of dazomet may have been a function of the contamination of timber or air spaces inside poles, which created a toxic or repellent barrier to termites. It was noted that when dazomet treatment failed, the treated pole generally had a large longitudinal crack running through the treated zone. Termites were able to built runways in these cracks and traverse the treated section apparently unaffected. It is possible that cracks in poles allow MITC fumes to dissipate and not reach effective concentrations. Procedures for managing cracked poles will be needed if dazomet comes into use as a remedial treatment for termite infested poles. Options may include filling the crack with an epoxy-filling compound, installing a plastic wrap over the treated section, or the use of an alternative treatment.

Results demonstrated that the alternative dust treatments *Metarhizium* and triflumuron were not as effective as arsenic trioxide. The effectiveness of *Metarhizium* declined as the trial progressed, which presumably was a function of the mortality of infective spores. A negative aspect of *Metarhizium* was its susceptibility to high temperatures, and the care required protecting it from extremes of temperature. On the other hand, as a natural product it may prove acceptable where chemicals such as arsenic trioxide do not.

Metarhizium is not registered as a termiticide in Australia, nor is it manufactured commercially for this purpose. Consequently, the likelihood of its eventual development as a marketable commodity is not known. It is hoped that the results from this trial may provide some impetus for commercial development.

The performance of triflumuron was consistent, but mean percentage reductions in infestation never exceeded 50% in the Service Trial or the NorthPower Subtrial. Triflumuron lacks the activity of arsenic trioxide and results suggest that more than one application is needed to achieve acceptable performance.

Fipronil, the most effective soil treatment, was only released onto the Australia market approximately 12 months ago. At the start of the trial, the manufacturer recommended that fipronil should be used at an active ingredient concentration of 0.06% (3 mL concentrate /L of water). Contrary to this advice the product was eventually registered at 6 mL per L. Used at the higher rate, fipronil could be expected to be even more effective than indicated in the trial.

Permethrin effectiveness was significantly impaired by the use of diesel as a diluent. This may be a reflection of the repellency of diesel to termites, which forced them to move away from the treated soil rather than coming into contact with toxic chemical residue. As a result, termites continued probing the barrier until a way through or under it was discovered.

CONCLUSIONS

This trial has identified a number of highly effective termite treatments. Some of these are not currently used by the power supply industry. They represent effective alternatives to conventional chemicals such as arsenic trioxide and chlorpyrifos, should the continued use of these chemicals becomes undesirable.

Notwithstanding the above, the extent of reductions in infestation achieved by single treatments was not sufficient to be acceptable for protecting poles from termites between routine pole maintenance inspections (4-5 years). However, acceptable levels of control might be achievable using sequential applications of termiticide. Possible combinations might include either dazomet or an eradicant dust, followed by the installation of a chemical soil barrier.

RECOMMENDATIONS

- Continue inspection programs to determine periods of protection conferred by treatments
- Develop dazomet as pole treatment i.e.
  - Seek registration of dazomet for treating termites
  - Examine effectiveness of dazomet against decay fungi in hardwood poles
- Examine the efficacy of combinations of termiticidal treatments
- Test fipronil at the registered rate

References

Abbot, W. S. 1925. method for computing the effectiveness of an insecticide. *Journal of economic entomology*. **18**: 265-267.

Forsyth, P. G., Morrell, J. J., and Chen, H. 1998. Rates of MITC release from Basamid (R) applied with selected additives to Douglas-Fir poles. *Forest Products Journal*. **48**: 40-43.

Hand, O. F., Lindgren, P. A., and Wetsch, A. F. 1970. The control of fungal decay and insects in transmission poles by gas phase treatment. Bonneville Power Administration Branch of Laboratories.

Morrell, J. J., Love, C. S., and Freitag, C. M. 1996. Integrated remedial protection of wood in bridges. In: *National conference on wood transportation structures* (eds Ritter, M. A., Duwadi, S. R., and Lee, P. D. H.). US Department of Agriculture, Forest Service, Forest Products Laboratory.