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EVALUATION OF NEWER TERMITICIDES INCLUDING PLANT PRODUCTS FOR FOREST PLANTATION ESTABLISHMENT

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ABSTRACT

Till recently, success in termite control was mainly due to the use of highly persistent organochlorine insecticides such as aldrin. Because of environmental concerns use of organochlorines is now being phased out. The present study was undertaken in the above context to evaluate less persistent insecticides and other ecofriendly products for control of termites attacking young plantations of eucalypts.

Three small-scale and one large-scale field trials were carried out from 1993 to 1995. An organophosphate (chlorpyrifos), two synthetic pyrethroids (cypermethrin and fenvalerate), a plant product (neem cake) and a bacterial broth based on Rhizobacteria were evaluated

Chlorpyriios was found to give the best protection by prophylactic application to soil in the polythene bag container (1 2 cm x 18 cm). Neem cake and the bacterial preparation were totally ineffective. Fenvalerate and cypermethrin gave varying degrees of protection at higher doses.

Chlorpyriios, at a dosage of 0.25g a.i. (active ingredient) per plant gave effective protection. However, a dosage of 0.5g a.i. per container is recommended for large-scale field application A two ha area planted with E. tereticornis at the above dosage in Erumapetty (Wadakkancherry Range, Thrissur Forest Division) proved the efficacy of the treatment. Peak incidence of termite attack occurred during the fist six months after planting out in all the trials and 20 to 70 per cent of the plants were killed in untreated control plots.

1. INTRODUCTION

In the tropics, termite damage is a serious problem in the establishment of forest plantations of many trees. Generally, exotics are more prone to attack than indigenous trees. *Eucalyptus* is the most vulnerable. Throughout the country eucalypts in nurseries and young plantations suffer mortality due to attack by subterranean termites. The termite problem in forest plantations has been reviewed by Nair and Varma (1981), Sen Sarma (1983) and Varma (1990). During the first year of establishment, death up to 80% of the transplants have been recorded in eucalypts when control measures were not adopted (Nair and Varma, 1981).

In Kerala, about 30,000 ha has been planted under eucalypts by the State Forest Department. The intensity of termite damage can vary from locality to locality. Till recently the control measures were based on the prophylactic use of organochlorine insecticides, standardised by Nair and Varma (1981). This involved drenching the basketed eucalypt seedlings prior to planting out with an appropriate dilution of aldrin or heptachlor. The method was described fully in KFRI Information bulletin No.3 which served as a practical guide for the field staff of the Forest Department to carry out the above prophylatic treatment. However, the use of Aldrin was banned in India since 1994 due to environmental concerns. Though Heptachlor was also included initially in the banned list, it was subsequently exempted and is available for restricted use. However, search for alternatives is necessary because of the high environmental persistence of the organochlorines.

Research to develop less persistent chemicals as termiticides has been in progress since 1980's in the developed countries. Most of the research efforts have centered around newer and less persistent organophosphate insecticides, synthetic pyrethroids, controlled-release formulations and non-chemical methods (Wood *et al.,* 1987; May, 1986; Chilima, 1991; Bhanot *et al.,* 1991; Su and Scheffratin, 1989; Yoshioka *et al.,* 1991). Among these, the controlled release formulations, though effective, are not suitable for developing countries due to the high cost. No suitable non-chemical means have so far been developed for practical use, although many ecofriendly products such as botanicals and microbial pathogens are reported to have termiticidal effects.

In a recent review Logan *et al.* (1990) concluded that biological control of termites by predators or pathogens is unlikely to be successful due to the social structure and behavioral responses to the infected individuals within the termite colony. The field of research on non-chemical methods for termite control is still wide open.

The purpose of the present study was to test currently available non-organo-chlorine insecticides as well as biological products which are credited to be effective against termites attacking eucalypts, when applied to soil in the initial establishment phase.

The biological products tested included neem cake and a bacterial broth developed by the Regional Research Laboratory, Jorhat and credited to have termiticidal properties (Bezbaruah, Personal Communication).

2. MATERIALS AND METHODS

Field trials were carried out at Kottappara in the Malayattur Forest Division in the Central Forest Circle. The area was planted earlier with *E. tereticornis* for one rotation. For laying out the experiment, the land was prepared by cutting the coppice growth of *Eucalyptus* and other shrubs and the material was burnt at site. Termite proneness of the area was indicated by the presence of termite mounds.

Three field trials were laid out to evaluate different insecticides, a plant product and a bacterial preparation. Treatments which did not show promise were excluded in the subsequent trials. A large-scale field trial was laid out in a 2- ha plot at Erumapetty in Wadakkancherry Range to evaluate the effectiveness of the most promising termiticide.

2.1. THE PLANTING MATERIAL

Eucalyptus tereticornis Smith was used for all the trials. Seeds of *E. tereticornis* obtained from the Forest Genetics Division, Tamil Nadu Forest Department, Coimbatore were used for raising the nursery.

2.2. NURSERY RAISING AND PLANTING METHODS

Nursery of *E. tereticornis* was raised using standard practices (Nair, 1968).

Three-to four-months-old seedlings from primary nursery beds were transplanted into polythene bags (18 cm x 12 cm) filled with sieved soil. These container seedlings were arranged in groups of 175 each for giving various treatments. When the seedlings got established in the containers in a month or *so,* various treatments were given. Within a week after this, the seedlings were planted out in field pits, 30 cm x 30 cm x 30 cm, at an espacement of 2 m x 2 m. At the time of planting out. the polythene bags were slit open and discarded, keeping the treated soil intact. The pits were then filled with soil and packed lightly.

Generally, planting was done for all the experiments after the onset of the South-West monsoon. However, Experiment No.II was laid out in December 1993 because during Experiment No. I which was laid out in July 1993, a large number of seedlings were lost due to causes other than termite attack, mainly cattle damage. Hence another trial was laid out in the same year, after fencing the area.

2.3. EXPERIMENTAL DESIGN

All the small-scale field trials were laid out in a randomised complete block design, with 3 replicates of 50 seedlings each. The treatments and methodology adopted are described separately under each experiment.

2.4. EXPERIMENT I

2.4.1. The products tested

Twenty treatment combinations involving emulsified concentrate (EC) formulations of an organophosphate, two synthetic pyrethroids and neem cake (oiled and deoiled) were evaluated. Two formulations of the organophosphate-chlorpyrifos, viz., Lentrek 20 EC (New Chemi Industries Ltd.) and Durmet 20 EC (Cynamid India Ltd.), were tested. The two synthetic pyrethroids tested were cypermethrin [Ripcord 20 EC, NOCIL) and Fenvalerate (Sumicidin 20 EC, Rallis India Ltd.). The neem cake, both oiled and deoiled, was obtained through Keycer Agro Products Private Ltd, Salem, Tamil Nadu.

There were two controls - one with no treatment at all and another with dry cowdung mixed to the potting soil at the rate of 50 g/kg of soil. The cowdung control was included to enhance the incidence of termite attack, as cowdung is known to attract termites. For each insecticide treatment tested, the middle dosage was replicated with the addition of dry cowdung to the potting soil.

2.4.2. Dosages tested

Three dosages of each insecticide formulation were tested- chlorpyrifos, 0.125, 0.25 and 0.5g a.i./plant and synthetic pyrethroids, 0.05,0. 1 and 0.2 g a.i./plant. Neem cake, both oiled and deoiled were tested @ 50g/kg of soil.

2.4.3. Application procedure

The insecticide application procedure standardised in an earlier study (Nair and Varma 1981) was followed. Required quantity of the insecticide was diluted in appropriate volume of water and poured over groups of container seedlings using a rose can (Fig. 1).

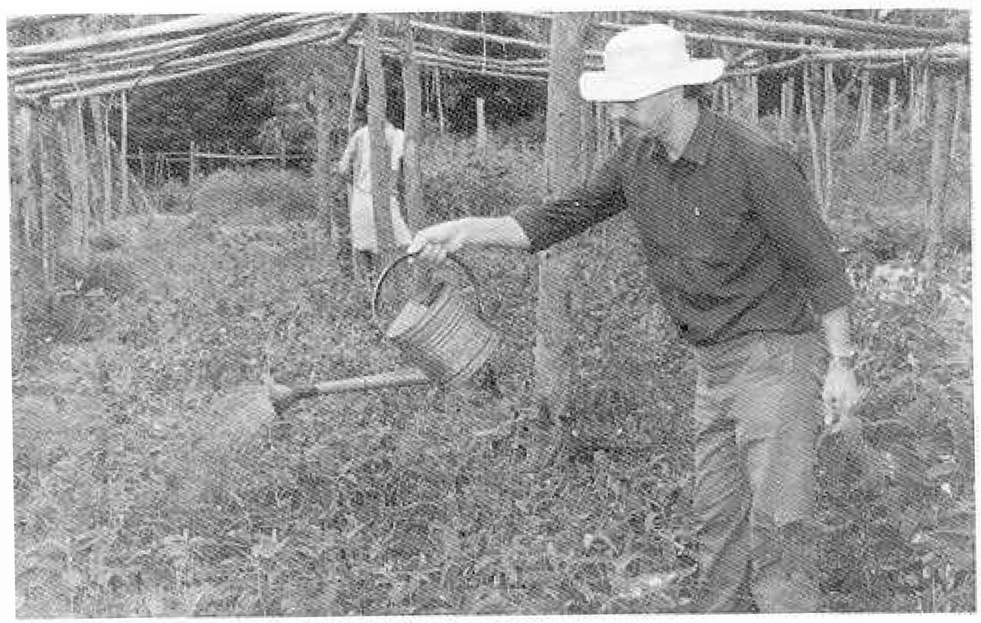


Fig. 1. Method of insecticide application in container seedlings

The neem seed cake was added to the potting soil used to fill the polythene containers @ 50g/kg of soil, and mixed well.

2.5. EXPERIMENT II

This trial was laid out in the same area where Experiment I was conducted and the planting was done during December 1993.

Some of the treatments which were not found promising in Experiment I, were excluded.

Fourteen treatment combinations were tested. Among chlorpyrifos formulations Lentrek was dropped as it showed phytotoxicity in Experiment I; instead a new formulation viz., Piramid 20 EC (Montari Industries Ltd.), was added. **A** bacterial preparation (BPPS) supplied by Dr. Bez-baruah of the Regional Research Laboratory, CSIR., Jorhat was included. Part of the BPPS stock solution supplied was added onto 10 parts of water and applied to the container soil @ 100 ml/bag. The treatment was given as in the case of other insecticides by group drenching.

Other experimental details were the same as described under Experiment I.

2.6. EXPERIMENT III

A Third field trial was laid out in August 1994 at Kottappara with 7 treatment combinations chosen on the basis of the results of the previous trials. The experimental design was the same as in previous year's trials.

2.7. RECORDING OF OBSERVATIONS

In the observation sheets, each seedling was identified by its location in the field and numbered. In general, monthly observations were made, but during the initial months after planting, observations were more frequent. For each seedling that died, the causes of mortality was recorded: death due to termites was confirmed by pulling out the seedling and examining the root portion. Wherever possible, termites feeding on the roots of eucalypts were collected and identified.

2.8. ANALYSIS OF DATA

For each treatment, the number of seedlings lost due to causes other than termite attack was deducted from the initial number to get the "effective initial number" of seedlings. Termite mortality was expressed as percentage of the effective initial number.

Since the initial number of plants were not uniform before planting and also because of large-scale non-termite mortality during the observation period in Experiment I, the data gathered were not amenable to statistical analysis. In the case of Experiments II and 111, the percentage mortality due to termite were transformed to their angular values and the significance of the differences between treatments tested using F-test.

2.9. LARGE-SCALE FIELD TRIAL

Based on the three small-scale field trials, the most effective treatment was field-tested in a 2 ha area within an *E. tereticornis* plantation at Erumapetty in Wadakkancherry Forest Range. The insecticide used was chlorpyrifos (Durmet 20 EC) and the dosage was 0.5 g a.i. per plant. Although even lower dosage was found effective in small-scale trials, this higher dosage was used taking into consideration the possible spillage of treated container soil during large-scale operations.

3. RESULTS AND DISCUSSION

3.1. EXPERIMENT I

The treatments and the results obtained in 15months of observations from July 1993 to October 1994 are summarised in Table 1.

In this experiment, the loss of seedlings due to causes other than termite attack was very high. It occurred mainly due to cattle grazing. In addition, some plants died due to the fungal disease,Cylindrocladiurn leaf blight.Thus the effective initial number of plants was very small and very unequally distributed among various treatments. The results, could not therefore be subjected to statistical analysis. However, some conclusions are evident.

In the untreated controls, without and with neem cake, mortality due to termite attack reached 73 to 75%. Almost similar termite caused mortality (70 to 75%) was recorded in neem cake treatment (oiled or deoiled).

All the middle doses of the insecticides, tested along with cowdung, except Lentrek (Treatment Nos. 15-18,Table 1)showed attack by termites, with 22 to 30% of the plants being affected. Lentrek at 0.25% prevented termite mortality even in the presence of cowdung. In the absence of cowdung, all the insecticides prevented termite attack, except at the lowest concentrations tested.

Lentrek, (a formulation of chlorpyrifos) caused typical symptoms of phytotoxicity in the treated plants.

To sum up, Experiment I demonstrated the following:

1. The experimental area was termite prone as evidenced by the damage due to termites in the control.
2. Neem seed cake was not effective as a termiticide.
3. Lentrek showed phytotoxicity.
4. The middle dosages of the insecticides tested except Lentrek were only partially effective against termites (as evidenced by the incidence of 22-30%mortality compared to 73-75% in the untreated
5. Cow-dung mixed with potting soil enhanced termite incidence.
6. Most termite-caused mortality occurred during the first six months after transplanting.

Table 1. Incidence of termite attack during the fifteen months observation in Expt. I.

Sl No.	Treatment	Formulation	Dosage (g a.i./ seedling)	Total No of plants	Effective initial* No. of plants	Mortality due to termite attack (%)
1.	Nil	--	--	150	71	73.2
2.	Nil (With Cowdung)	--	--	107	41	75.6
3.	Lentrek	20 EC	0.5%	142	12	0
4.	Lentrek	20 EC	0.25%	150	26	3.8
5.	Lentrek	20 EC	0.125%	140	15	13.3
6.	Radar	20 EC	0.5%	150	5	0
7.	Radar	20 EC	0.25%	150	25	4.0
8.	Radar	20 EC	0.125%	143	23	4.3
9.	Sumicidin	20 EC	0.2%	140	18	0
10.	Sumicidin	20 EC	0.1%	150	18	0
11.	Sumicidin	20 EC	0.05%	134	15	26.6
12.	Ripcord	20 EC	0.2%	64	2	0
13.	Ripcord	20 EC	0.1%	84	12	8.3
14.	Ripcord	20 EC	0.05%	136	23	13.0
15.	Lentrek (With Cowdung)	20 EC	0.25%	58	9	0
16.	Radar (With Cowdung)	20 EC	0.25%	101	18	22.2
17.	Sumicidin (With Cowdung)	20 EC	0.1%	100	10	30.0
18.	Ripcord (With Cowdung)	20 EC	0.1%	100	14	28.5
19.	Neemcake	deoiled	50 g/kg soil	138	48	70.8
20.	Neemcake	oiled	50 g/kg soil	73	28	75.0

* Seedlings lost due to causes other than termite attack excluded.

Data from the untreated controls and the neem cake treatments (where the highest incidence of termite attack occurred) showed that most mortality caused by termites occurred during the initial six months after transplanting the plants in the field (Fig. 2).

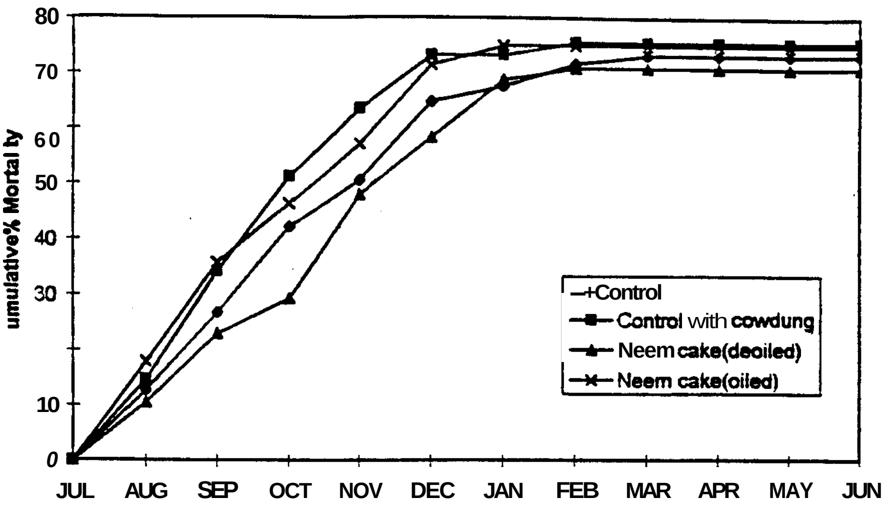


Fig. 2. Cumulative percentage of termite-caused mortality in the control and ineffective treatments, in Experiment 1.

To study the phytotoxicity of Lentrek further, a systematic pot-trial was carried out in the KFRI campus in July 1993. Ten potted eucalypt seedlings each were used. All the three concentrations of Lentrek (0.5% and 0.25%. 0.125%) included in Experiment I along with a still higher dose of 1%, were included in the study. Each plant was drenched with 100 ml each of the desired concentration of Lentrek. No symptoms of phytotoxicity were observed within 24 hours in any of the treatments. However, in course of time, in the higher concentrations (1% and 0.5%) the leaves wilted and shed off, starting from the lower pairs. Death of the seedlings did not occur. In the lower dosages (0.25% and 0.125%), the seedlings did not show symptoms of phytotoxicity even after a month. The literature on Lentrek indicate its use as a non-crop insecticide, which can probably explain the observed phytotoxic symptoms. Rajagopal (1990), in a preliminary study on screening Lentrek as a termiticide in forest plantations reported that Lentrek at 0.25% a.i. and above provided 100% protection to young eucalypt seedlings for more than six months. The observed phytotoxicity and the non-availability of Lentrek readily in the local market prompted us to exclude this from the subsequent trials.

3.2. EXPERIMENT 11

This experiment was laid out during 1993 itself in the same locality were experiment I was laid out, because of the high mortality of eucalypt seedlings due to reasons other than termite attack.

Lentrek was dropped for reasons indicated above and two formulations of chlorpyrifos which were readily available in the market, viz., Piramid (Montari Industries Ltd.) and Durmet (Cynamid Industries Ltd.) were used. The two synthetic pyrethroids, Ripcord and Sumicidin were again tested.

In this experiment, the normal planting period i.e. June-July was altered and planting was carried out during December, 1993. However, frequent showers during the planting period and subsequent occasional rains helped the establishment of seedlings. Observations were taken for 15 months (December 1993 to February 1995).The mortality of seedlings due to causes other than termite attack was low: the small mortality observed was mainly due to drought.

In the control (untreated), about 21% of the plants were killed by termites (Table 2). Plants treated with the bacterial preparation (BPPS)suffered equal damage (22%).Both were significantly different from all the other treatments (Table 2). Very little damage occurred in all other treatments. Chlorpyrifos and fenvalerate gave complete protection at all the dosages while a few plants were killed at lower dosages of cypermethrin.

As in Experiment I, most deaths occurred during the initial six months after transplanting (Fig. 3),but compared to Experiment I, the incidence of attack was lower.

To sum up, Experiment demonstrated the following.

1. The bacterial preparation, BPPS, was not effective as a termiticide, when applied to the potting soil.

2. Chlorpyrifos and fenvalerate gave complete protection at all dosages tested: cypermethrin gave full protection only at the highest concentration (0.2%).

Table 2. Incidence of termite attack during the fifteen months observation in Expt.II

Sl. No.	Treatment	Formulation	Dosage (g a.i./seedling)	Total No. of plants	Effective initial No. of plants*	Mortality due to termite attack (%)
1.	BPPS	--	--	150	138	22.5
2.	Piramid	20 EC	0.5%	150	139	0[a**]
3.	Piramid	20 EC	0.25%	150	140	0[a]
4.	Piramid	20 EC	0.125%	150	142	0[a]
5.	Durmet	20 EC	0.5%	150	138	0[a]
6.	Durmet	20 EC	0.25%	150	140	0[a]
7.	Durmet	20 EC	0.125%	150	145	0[a]
8.	Sumicidin	20 EC	0.2%	150	136	0[a]
9.	Sumicidin	20 EC	0.1%	150	142	0[a]
10.	Sumicidin	20 EC	0.05%	150	128	0[a]
11.	Sumicidin	20 EC	0.1%	150	142	0[a]
12.	Ripcord	20 EC	0.1%	150	138	1.4[a]
13.	Ripcord	20 EC	0.05%	150	140	3.6[a]
14.	Control	--	--	150	140	20.7

* Seedlings lost due to causes other than termite attack excluded.

Figures superscribed by the same letters are not significantly different at 5% level of significance.

In addition to the above main findings, this experiment also showed the following. In Kerala, the usual planting time for eucalypts is June-July, soon after the onset of monsoon and the annual swarming of the alate (reproductive) termites also occur during this period.

The commonly recorded peak incidence of termite attack during the initial six months after planting out in June-July, had led to the suspicion whether the peak incidence of termite attack is a function of the seasonal activity

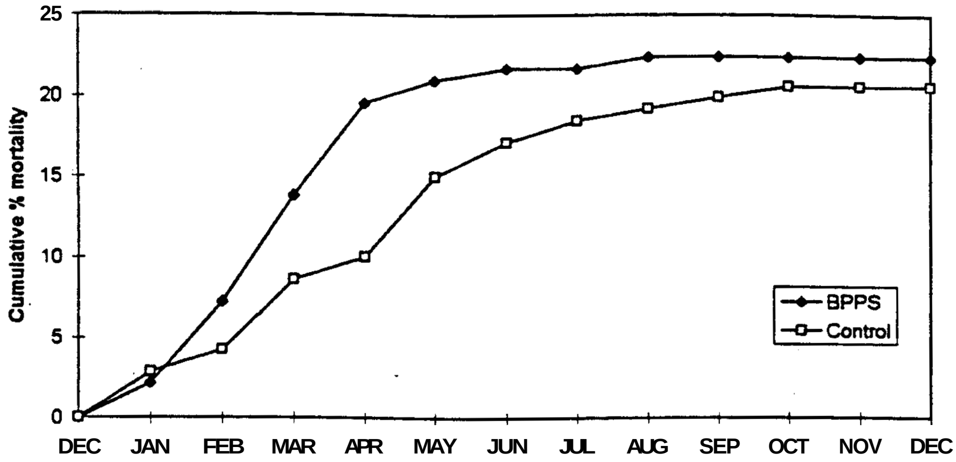


Fig. 3. Cumulative percentage of termite-caused mortality in the control andineffective treatment, in Experiment 2.

rhythm of the termites (Nair and Varma, 1981).This study shows unequivocally that it is related to the time of planting out of eucalypts, and not to the seasonal activity rhythm of termites. Therefore altering the planting time, will not help to prevent termite attack.

The bacterial preparation tested in this experiment (BPPS)is a bacterial broth derived from Rhizobacteria developed at the CSIR Regional Research Laboratory, Jorhat. Bezbaruah and Singh(1995)reported that termites on live tea plants can be controlled by spraying a 10%solution of the bacterial broth on the termite galleries. However, the present study has shown that as a prophylatic measure, this product is ineffective.

3.3. EXPERIMENT III

The third experiment was laid out in July 1994 with seven treatments. The highest dose tested in earlier experiments was excluded (Table 3). The experimental design was the same as in previous trials, with 52 plants per treatment and three replicates. Due to lack of space in the experimental area, the usual espacement of 2 m x 2 m was reduced to 1 m x 1 m.

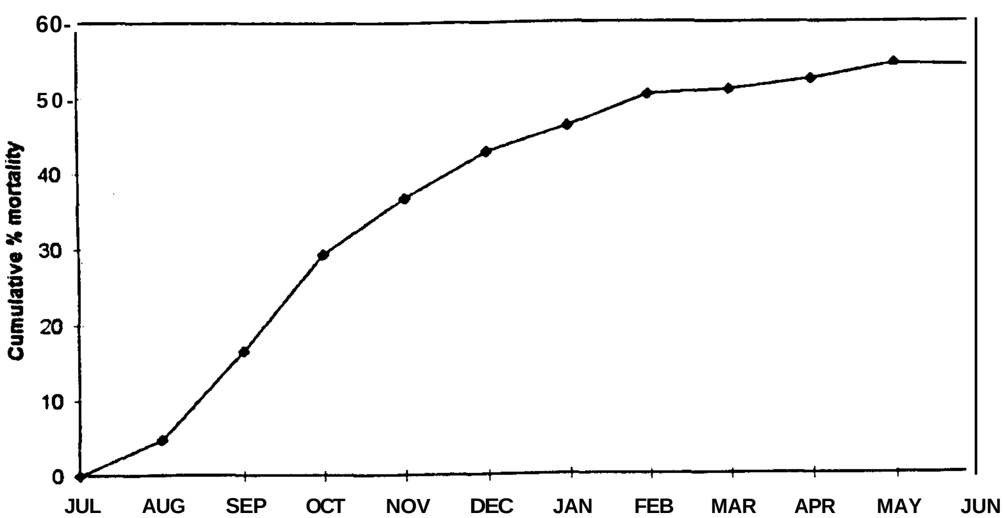
Table 3. Incidence of termite attack during the 2-year observation period in Expt.III

Sl. No.	Treatment	Formulation	Dosage (g a.i./seedling)	Total No. of plants	Effective initial No. of plants*	Mortality due to termite attack (%)
1.	Piramid	20 EC	0.25%	156	146	2.7[a]**
2.	Piramid	20 EC	0.125%	156	148	5.4
3.	Durmet	20 EC	0.25%	156	148	0[a]
4.	Durmet	20 EC	0.125%	156	150	4.0
5.	Sumicidin	20 EC	0.1%	156	147	10.9
6.	Sumicidin	20 EC	0.05%	156	140	9.3
7.	Control	--	--	156	148	55.4

* Seedlings lost due to causes other than termite attack excluded.

** Figures superscribed by the same letter are not significantly different at 5% level of significance.

In the untreated control, over 55% of the seedlings were killed by termites during the first year (Table 3: Fig.4): no further mortality occurred in the second year.



Pig. 4. Graph showing the cumulative percentage of termite mortality In the control plot in Experiment 3.

Chlorpyrifos at 0.25 g a.i. per plant (both Piramid and Durmet) gave the least mortality and was significantly different from all other treatments (Table 3). Although the mortality figures were comparatively small for the lower dose of chlorpyrifos and for both the doses of fenvalerate, they did not differ significantly from that of control. These results demonstrate that only chlorpyrifos at 0.25% gave sufficient protection, unlike in Experiment 11. The difference between the two experiments may be due to the higher pest pressure in Experiment 111 (55% versus 21% mortality in control).

Currently chlorpyrifos and pyrethroids are recommended for control of termites. There are conflicting reports on the persistence of these chemicals and most of the available data are from abroad. Wood *et al.* (1987) reported that both chlorpyrifos and pyrethroids do not have the desirable persistence of 3-5 years under tropical conditions. Teshima *et al.* (1991) reported, based on laboratory tests, that there was no residual effect of chlorpyrifos EC in soil at the end of 2 years. Menzie (1972) reported that the approximate half-life of chlorpyrifos in soil is a maximum of 100 days. Preliminary studies by Rajagopal (1990) showed chlorpyrifos to be effective for at least more than six months against termites attacking eucalypts. It must be pointed out that the persistence of insecticides in soil will depend on the structure of soil and many other factors. Any chemical which can give effective protection against termites during the first year after planting would be suitable for the purpose. The pyrethroid insecticides in general, are known to degrade fast due to both chemical and biological factors. There is not much published literature on use of pyrethroids for subterranean termite control under Indian conditions. Based on concrete slab tests in the U.S. at Panama under tropical condition, Mauldin *et al.* (1987) showed that both fenvalerate and permethrin at 1% concentration gave 1-3 years of protection against termites and the results were comparable with chlorpyrifos. Yoshimura *et al* (1990) based on studies in Japan on the termiticidal performance of pyrethroids after soil burial, found fenvalerate to be most effective. It is also reported that in addition to the toxic effects, pyrethroids when mixed with soil also show repellent action against termites (Jones, 1989). The effectiveness of pyrethroids could also be due to the added repellent action. However, all the results mentioned above were based on surface treatment of susceptible timbers and in situations with ground contact, rapid degradation of pyrethroids may occur, especially under tropical conditions, thereby rendering it less effective than chlorpyrifos at the concentration tested.

4. LARGE SCALE TRIALS

Chlorpyrifos which was the best among the insecticides tested in small-scale field trials, was tested in large-scale trial over two hectares at Erumapetty in Wadakkancherry Range of Trichur Forest Division. Though satisfactory protection was obtained at a concentration of 0.25% in small-scale trials, a higher dosage of 0.5% was used for large-scale field application to increase the safety margin.

Two sets of 2,500 seedlings each of *E. tereticornis* were kept ready for treatment (Fig.5.).Three litres of Durmet 20 EC was added to 125 litres of water and applied to each group of 2,500 seedlings in 4 instalments.

Fig. 5. Treated seedlings of *E. tereticornis* used for large- scale field trials.

Field planting was done in July 1995, in a two hectare area as part of a plantation raised by the Forest Department. Out of the treated plants, 1500 plants within marked transects were observed periodically to check on the incidence of termite attack. Observations over a period of 1 year showed that out of the 1500 plants observed, only 6 were killed by termite attack. All the mortality occurred during the first 4-months after planting out. A few casualties were also observed due to cattle grazing, but were replaced with treated seedlings. During the months of March- April, 15 plants planted close to a rocky area were found dried up, presumably due to drought and no symptoms of termite attack noticed. The percentage of plants killed by termites works out to only 0.4%, which is negligible.

The results of this study demonstrate the efficacy of chlorpyrifos in protecting eucalypt seedlings, during the one year observation period after planting out. Generally termite damage seldom occurs after the first year.

5. ECOLOGICAL OBSERVATIONS

Data gathered on some ecological aspects of the termite problem during this study are presented briefly, below.

5.1. NATURE OF DAMAGE

A detailed account on the nature of damage caused by termites to eucalypts has already been given earlier (Nair and Varma, 1985). Observations during the present study were in conformity with the earlier findings. Typical damage where the tap root is tapered out and severed by termite feeding may be seen in Fig. 6.

Fig. 6. Two to three months old *E. tereticornis* seedlings showing typical damage symptom

5.2. SPECIES OF TERMITES ATTACKING EUCALYPTS

Three species of termites belonging to the genus Odontotermes were identified as feeding on the root of eucalypts. The identifications were made by Dr. R. K. Thakur, Scientist, Forest Research Institute, Dehra Dun. The species were:

1. Odontotermes anamallensis Holmg. & Holmg.
2. **O.** bellahunisensis Holmg. & Holmg.
3. **O.** ceylonicus (Wasmann)

Of these, only **O.** ceylonicus has been reported earlier as feeding on eucalypt root (Nair and Varma, 1985). **O.** anamallensis was collected from other habitats in the earlier study but was not associated with root feeding.

These two species viz; **O.** anamallensis and **O.** bellahunisensis were reported to feed on eucalypt root earlier; in South Arcot District of Tamil Nadu (Roonwal and Rathore, 1984). **O.** bellahunisensis was first reported from Kerala in 1985

Fig.7. A mound of *Odontotermes obesus* in the study area.

(Verma, 1985) from a collection made from Kottavasal by R.V. Varma in 1976. Some of the other root feeding termites may have escaped collection, in this study.

Mounds of **O.** obesus (Rambur) were present within the plantation (Fig. 7), but this species was not found attacking the eucalypt seedlings. Earlier studies (Roonwal and Rathore 1984; Nair and Varma, 1985) have also revealed the occurrence of **O.** obesus in eucalypt plantations in other feeding habitats.

5.3. VARIATION IN DAMAGE INTENSITY

In the three small-scale trials at-Kottappara over two years, the incidence of termite attack ranged from 20 to 70 per cent (70% in Expt. I, 20% in Expt.II and 55% in Expt. III). In all the experiments the incidence was maximum during the first 6 months after planting out, irrespective of the planting time.

The soil in the experimental area was acidic with a pH of 6.1 ± 0.2 and low in organic content. (Balagopalan, KFRI - Pers. Comm.). The factors which determine the variability in the intensity of attack within the same location are not understood.

6. CONCLUSIONS AND RECOMMENDATIONS

In the past, termite control in eucalypts has relied mostly on persistent organochlorine insecticides. Because of environmental concerns, use of organochlorines, is now being phased out in preference to less persistent insecticides. The present study confirmed the earlier finding (Nair and Varma, 1981) that termite attack of eucalypts is mostly confined to the first six months after planting out. Long persistence of the insecticides is therefore not necessary. Any insecticide which gives protection during the first year will be of use. The present study shows that chlorpyrifos applied at 0.25 g a.i. per plant satisfies this requirement. To increase the safety margin in large-scale operations carried out by unskilled labour, a dosage of 0.5 g a.i. is recommended. This was also'field-tested in a large-scale trial. The procedure recommended is as follows.

Add 3 litres of chlorpyrifos to 125 litres of water in a drum and mix well with a stick to get a milky solution. Using a rose can, drench each group of 2,500 seedlings with 125 litres of the diluted insecticide emulsion. The drenching may be carried out in three or four consecutive instalments, covering the entire group of 2,500 seedlings as uniformly as possible.

The cost of treatment with chlorpyrifos works out to Rs.975 per hectare. Labour cost is negligible as the treatment can be made as part of the regular watering operation in the nursery.

A recent development in raising eucalypt seedlings is the use of root-trainers. Because of the small quantity of potting medium (150 CC) in root trainers, the insecticide treated protective layer around the plant is very small in root trainer raised planting stock. Therefore the treatment may not be as effective as when applied to seedlings raised in conventional polythene bag containers. When rooted cuttings are planted out in the field, a portion of the stem is also burried into the soil. It has been observed that in such cases, termites attack from the sides at the level of stem portion. Separate field experiments are required to standardise methods for control of termites attacking root-trainer raised planting stock. In the meantime, based on preliminary studies, it is suggested that in addition to drenching the root-trainer raised planting stock with insecticide, an additional insecticide treatment may be given after field planting. A few holes may be made around the seedling with a stick and the insecticide (0.5% Chlorpyrifos) applied as a drench.

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