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Full Length Research Paper

The termicidal effects of Chlorpyrifos 48 EC, Endosulfan 35 EC, Dichlorvos 1000 EC and Diazinon 600 EC against termites in South-West Nigeria

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Studies were carried out at the Cocoa Research Institute of Nigeria, Ibadan to determine the efficacy of four insecticides (Chlorpyrifos 48 EC, Endosulfan 35 EC, Dichlorvos 1000 EC and Diazinon 600 EC) on termites (workers and soldier castes). The results showed that for both topical and residual action tests, worker caste mortality rates ranging from 70 to 100% were recorded for Chlorpyrifos, Endosulfan, Dichlorvos and Diazinon at 0.063, 0.125, 0.25 and 0.5% treatment levels within 120 min after exposure (MAE). For the soldier caste, the mortality rate was between 10 and 70% at the same treatment levels within the same time interval. However, the insecticide concentrations had very low fumigant action against the termites (workers and soldiers) when exposed to different concentrations of their fumes. There was no mortality recorded in any of the control petridishes. A higher mortality of the soldier caste was recorded for the topical application (10 to 70%) than the residual application, which gave a better kill of the workers caste (90 to 100%) 120 MAE. The high death rate of the workers might be due to the fact that they were generally more active during foraging and thus more susceptible to the effects of the insecticide either by contact or systemic actions. The fact that the workers have a lower surface area and body weight than the soldiers might have also contributed to their higher vulnerability to the insecticides. The application of these insecticides at 0.25% active ingredient is adjudged the best due to the high mortality rate achieved. Also the application at 0.25% will help to maintain cost effectiveness of these insecticides and minimize environmental pollution, toxicity and phytotoxicity problems associated with pesticides.

Key words: Worker caste, soldier caste, mortality, topical, residual and fumigant.

INTRODUCTION

Termites belong to the order Isoptera. There are six families of termites, five of which are referred to as the lower or primitive termites. These five groups all possess intestinal protozoa, which help in the digestion of wood. The sixth family, the Termitidae, includes three-quarters of all living termites species. The Termitidae do not have symbiotic protozoans in their intestine but have other methods of dealing with digestion of wood (Malaka, 1973).

Termites (*Macrotermes bellicossus*, *Amitermes evuncifer*, *Nasutitermes* sp., *Microtermes* sp. etc.) attack on economic crops is common in Nigerian plantations. With particles of soils, they construct foraging galleries from tree trunk base to the branches. These galleries are extensions of their subterranean nests. They move underneath, gnawing bark and stem tissues and their infestation is particularly severe during the dry season (October-March). Termites can cause damage to crops, buildings, pasture and forestry as well as to non-cellulose materials such as dam linings and electrical cables. Surface soil mounds can also interfere with ploughing and grazing. In Nigeria, farmers have long recognized termite damage to crops and other materials, and have realized that termite damage is greater in the dry season or when crops are just planted (Malaka, 1972, 1983).

In the past much emphasis was placed on Chlordane, Aldrin and Dieldrin for the control of termites because of their persistent effects in the soil (Harris, 1971). The effec-

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tiveness of using the organochloride insecticides (Aldrin, DDT, Aldrex T) as a seed treatment, on seedlings, mature plants and for tree protection, is widely known. However much of this work comes from field trials carried out before the ban on organochlorines (Pearce, 1997). The following insecticides are reported to be currently in use against termites in modern commercial agriculture: Oftanol, Chlorpyrifos, Carbofuran and Permethrin (Pearce, 1997). Most of the achievements recorded so far with these termicides have been outside the shores of this continent; hence the main objective of this study is to investigate the activities of other chemical classes of insecticides outside the organochlorines for their suitability for termite control in our local environment.

MATERIALS AND METHODS

This research work was carried out in the Entomology laboratory of the Cocoa Research Institute of Nigeria, Ibadan at a temperature of 28 ± 3°C and relative humidity 75 ± 5%.

Collection of materials

Termite samples consisting of workers and soldiers of *M. bellicosus* and *A. evuncifer* were collected with a spatula into a tray from mound and trunks of dead woods at coffee experimental plots at CRIN Headquarters, Ibadan. The termites were conveyed to the laboratory for immediate bioassay test with the insecticides. The insecticides (Chlorpyrifos 48EC, Endosulfan 35EC, Dichlorvos 1000EC and Diazinon 600EC) were procured from the Agrochemical market at Ogunpa, Ibadan.

Bioassay test

The following tests were carried out on the termite caste (workers and soldiers) collected using different concentrations (0.0625, 0.125, 0.25 and 0.05%) of the insecticides and an untreated control).

Topical application test

Ten termites were picked from the collection tray into a Petri dish for each treatment. There were four treatments (0.063, 0.125, 0.25, 0.05%) per insecticide and a no treatment (0%) control. 10 µl of each termiticide concentration was applied directly onto the dorsal surface of the termites in each Petri dishes with the aid of a microsyringe (1 µl/insect). Each treatment was replicated four times. The Petri dishes were perforated on the top to provide aeration and prevent suffocation of the test insects. Mortality counts were taken and recorded after every 20 min for 2 h (which was the maximum time period taken to achieve 100% mortality in over 90% of the Petri dishes. A termite was regarded as dead if it showed no signs of movement when touched lightly with a soft camel hairbrush or when it is lying flat on its back.

Residual contact action

This test was carried out with Petri dishes fitted with filter papers. The filter paper was drenched with 60 µl of the termiticide and allowed to air-dry for 5 min. 10 termites were placed in each of the Petri dishes to be in contact with the residue of the termiticides. Each of the 4 treatments with a no treatment control was replicated 4 times. The petridishes were perforated on the top to provide aeration and prevent suffocation of the test insects. Mortality counts were taken every 20 min for 2 h using the same attributes of identifying a dead insect as earlier described.

Fumigant action test

The test was carried out using 500 ml plastic containers (10 x 10 x 15 cm) with cover and small muslin cloth bags measuring 7 x 10 cm. 10 termites were placed in each bag and the mouth tied with an extended rope with which it was lowered half way into the plastic container containing 2 ml of the termiticide. The cups were covered immediately to allow the termites get in contact with the fumes of the various termiticide concentrations. Each of the 4 treatments and a no treatment control was replicated four times. Mortality count and recording were taken every 2 h after treatment using the same attributes of identifying a dead insect as earlier described.

Statistical analysis of the tests

The data obtained in all the bioassays were subjected to the analysis of variance. Means were separated using Duncan's Multiple Range Test in order to test the levels of significance.

RESULTS

Table 1 shows the mean mortality rate of Chlorpyrifos on termite castes following topical, residual and fumigant action tests. There was no significant difference ($P > 0.05$) among the topical and residual action treatment means for the worker caste, but all their treatment means significantly differed ($P < 0.05$) from their control at 120 min after exposure (MAE). The mortality trend was not the same for the soldier caste, where most of the treatments gave low mortality rates, which differed significantly ($P < 0.05$) from each other and their control. A mortality rate of over 50, 70 and 90% was achieved within 20 MAE following topical application on the worker caste at 0.125, 0.25 and 0.5% treatment levels. The residual action test gave an overall high mortality of the worker caste than the topical application with 60, 80 and 100% mortality rates within 20 MAE at 0.125, 0.25 and 0.5% treatment levels, respectively. The reverse was the case for the soldier caste, where the topical application came down with 40, 60 and 70% mortality, respectively as against 30% recorded for the residual action test 120 MAE at the same treatment levels. The insecticide had very low fumigant action on the termites. A maximum of 10% mortality was achieved following exposure of the termite caste to the highest concentration (0.5%) of the insecticide. No mortalities were recorded in control Petri dishes throughout the exposure period.

The result of the mean mortality rate of Dichlorvos on termite castes following topical, residual and fumigant action tests are shown in Table 2. The trend was the same for Chlorpyrifos with both topical and residual action test achieving 50% mortality rate on the worker caste at 0.25% treatment level 20 MAE. There was no significant difference among the various treatments

Table 1. Mean mortality rate (%) of Chlorpyrifos on termites (worker and soldier castes) following topical, residual and fumigant action tests (n = 10/replicate).

% Conc.	Exposure periods (min)											
	Worker caste						Soldier caste					
	20	40	60	80	100	120**	20	40	60	80	100	120**
Topical application												
0%	0*	0	0	0	0	0 ^{b}	0	0	0	0	0	0 ^{d}
0.063%	30	60	70	100	100	100 ^{a}	0	0	10	10	20	30 ^{bc}
0.125%	50	80	90	100	100	100 ^{a}	0	0	10	10	20	40 ^{b}
0.25%	70	90	100	100	100	100 ^{a}	0	10	30	50	60	60 ^{a}
0.5%	90	100	100	100	100	100 ^{a}	10	30	50	70	70	70 ^{a}
Residual application												
0%	0	0	0	0	0	0 ^{b}	0	0	0	0	0	0 ^{d}
0.063%	30	70	90	100	100	100 ^{a}	0	0	0	10	10	20 ^{c}
0.125%	60	90	100	100	100	100 ^{a}	0	0	10	20	20	30 ^{bc}
0.25%	80	100	100	100	100	100 ^{a}	0	0	20	20	30	30 ^{bc}
0.5%	100	100	100	100	100	100 ^{a}	0	10	20	20	30	30 ^{bc}
Fumigant test* **												
0%	-	-	-	-	-	0 ^{b}	-	-	-	-	-	0 ^{d}
0.063%	-	-	-	-	-	0 ^{b}	-	-	-	-	-	0 ^{d}
0.125%	-	-	-	-	-	0 ^{b}	-	-	-	-	-	0 ^{d}
0.25%	-	-	-	-	-	10 ^{b}	-	-	-	-	-	0 ^{d}
0.5%	-	-	-	-	-	10 ^{b}	-	-	-	-	-	10 ^{d}

*Each mean mortality rate (%) value represents mean of four replicates.
**Means followed by the same superscript within each method of application are not significantly different (P > 0.05) according to Duncan's Multiple Range Test (DMRT).
***Mortality rate taken once 2 h after treatment.

Table 2. Mean mortality rate (%) of Dichlorvos on termites (worker and soldier castes) following topical, residual and fumigant action tests (n = 10/replicate).

% Conc.	Exposure periods (min)											
	Worker caste						Soldier caste					
	20	40	60	80	100	120**	20	40	60	80	100	120**
Topical application												
0%	0*	0	0	0	0	0 ^{c}	0	0	0	0	0	0 ^{e}
0.063%	20	40	50	70	80	80 ^{a}	0	0	0	10	10	10 ^{cd}
0.125%	30	50	70	90	100	100 ^{a}	0	0	10	10	20	30 ^{bc}
0.25%	50	70	90	100	100	100 ^{a}	0	0	10	20	30	50 ^{a}
0.5%	70	90	100	100	100	100 ^{a}	10	30	50	50	60	60 ^{a}
Residual application												
0%	0	0	0	0	0	0 ^{c}	0	0	0	0	0	0 ^{e}
0 .063%	20	50	70	80	90	90 ^{ab}	0	0	0	0	10	10 ^{d}
0.125%	40	60	80	100	100	100 ^{a}	0	0	0	0	10	20 ^{cd}
0.25%	50	80	100	100	100	100 ^{a}	0	0	0	10	20	30 ^{bc}
0.5%	80	100	100	100	100	100 ^{a}	0	0	10	20	20	30 ^{bc}
Fumigant test* **												
0%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.063%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.125%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.25%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.5%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}

*Each mean mortality rate (%) value represents mean of four replicates.
**Means followed by the same superscript within each method of application are not significantly different (P > 0.05) according to Duncan's Multiple Range Test (DMRT).
***Mortality rate taken once 2 h after treatment.

Table 3. Mean mortality rate (%) of Diazinon on termites (worker and soldier castes) following topical, residual and fumigant action tests (n = 10/replicate).

% Conc.	Exposure periods (min)											
	Worker caste						Soldier caste					
	20	40	60	80	100	120**	20	40	60	80	100	120**
Topical application												
0%	0*	0	0	0	0	0 ^{c}	0	0	0	0	0	0 ^{e}
0.063%	10	30	50	60	70	70 ^{b}	0	0	0	0	10	10 ^{de}
0.125%	20	40	60	70	90	100 ^{a}	0	0	10	10	20	20 ^{cd}
0.25%	50	60	80	100	100	100 ^{a}	0	0	10	20	30	40 ^{ab}
0.5%	50	80	90	100	100	100 ^{a}	0	20	40	50	50	50 ^{a}
Residual application												
0%	0	0	0	0	0	0 ^{c}	0	0	0	0	0	0 ^{e}
0.063%	20	30	70	80	90	90 ^{a}	0	0	0	0	10	10 ^{de}
0.125%	20	70	70	100	100	100 ^{a}	0	0	0	10	10	10 ^{de}
0.25%	50	70	80	100	100	100 ^{a}	0	0	0	10	20	30 ^{bc}
0.5%	70	90	100	100	100	100 ^{a}	0	10	10	20	30	30 ^{bc}
Fumigant test* **												
0%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.063%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.125%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.25%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.5%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}

*Each mean mortality rate (%) value represents mean of four replicates.
**Means followed by the same superscript within each method of application are not significantly different (P > 0.05) according to Duncan's Multiple Range Test (DMRT).
***Mortality rate taken once 2 h after treatment.

means of 0.125, 0.25 and 0.5% concentrations at 120 MAE; though they all differed significantly (P < 0.05) from their control treatments. The residual applications achieved an overall higher mortality on the worker caste, than for the soldier caste. However, the soldier caste was seen to be more tolerant to the insecticide than the worker caste. No mortalities were recorded in control Petri dishes throughout the exposure period.

The mean mortality rates of Diazinon on termite castes following topical, residual and fumigant action tests are shown in Table 3. Both the topical and residual action tests achieved 50% mortality on the worker caste at 0.25% treatment levels within 20 MAE. The mortality rates of the various treatment levels (0.125, 0.25 and 0.5%) showed no significant differences among themselves, but differed significantly (P < 0.05) from their control treatments at 120 MAE. Residual application gave a better kill of the worker caste, while higher mortality of the soldiers was recorded for the topical application than for the workers. The insecticide had no fumigant action on both termite castes 120 MAE. No mortalities were recorded in control Petri dishes throughout the exposure period.

Table 4 shows the mean mortality rate of Endosulfan on termite castes following topical, residual and fumigant action tests. The topical and residual action tests at 0.25% treatment levels gave a 40% mortality of the worker caste 20 MAE. At 120 MAE the mortality rates at 0.125, 0.25 and 0.5% treatment levels showed no significant difference, but differed significantly (P < 0.05) from their control. A higher mortality of the soldiers' caste was recorded for the topical application, while residual application gave a better kill of the workers caste 120 MAE. The workers were more vulnerable to the insecticide than the soldiers. The insecticide had no fumigant action on the termite castes. No mortalities were recorded in control petridishes throughout the exposure period.

DISCUSSION

The relatively high mean mortality recorded for these termicides especially on the worker caste was in line with earlier report by Akhtar and Shahid (1991), which stated that Chlorpyrifos when applied around the stem of cotton plants at 1,600 g of active ingredient per acre can be as effective as Aldrin at 400 g a. i. per acre. Also Chlorpyrifos according to Cowie et al. (1989) has been the major treatment in forestry and other crops in the past few years for the prevention of termite attack.

The worker and soldier castes were used for these tests because of their important roles of foraging and

Table 4. Mean mortality rate of Endosulfan on termites (worker & soldier castes) following topical, residual and fumigant action tests (n = 10/replicate).

% Conc.	Exposure periods (min)											
	Worker caste						Soldier caste					
	20	40	60	80	100	120**	20	40	60	80	100	120**
Topical application												
0%	0*	0	0	0	0	0 ^{c}	0	0	0	0	0	0 ^{e}
0.063%	10	30	50	70	70	80 ^{b}	0	0	0	10	10	20 ^{cd}
0.125%	20	40	50	80	100	100 ^{a}	0	0	10	10	20	30 ^{bc}
0.25%	40	60	90	100	100	100 ^{a}	0	20	30	50	50	50 ^{a}
0.5%	60	80	100	100	100	100 ^{a}	0	30	30	50	50	60 ^{a}
Residual application												
0%	0	0	0	0	0	0 ^{c}	0	0	0	0	0	0 ^{e}
0.063%	20	40	60	90	100	100 ^{a}	0	0	0	10	10	10 ^{de}
0.125%	40	70	90	100	100	100 ^{a}	0	0	10	20	20	20 ^{cd}
0.25%	40	80	100	100	100	100 ^{a}	0	0	20	20	20	20 ^{cd}
0.5%	60	90	100	100	100	100 ^{a}	0	10	20	20	30	30 ^{bc}
Fumigant test* **												
0%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.063%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.125%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.25%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}
0.5%	-	-	-	-	-	0 ^{c}	-	-	-	-	-	0 ^{e}

*Each mean mortality rate (%) value represents mean of four replicates.
**Means followed by the same superscript within each method of application are not significantly different (P > 0.05) according to Duncan's Multiple Range Test (DMRT).
***Mortality rate taken once 2 h after treatment.

protection of the colony. There is a clear division of labour in termite colonies. The soldiers mainly defend the colonies from invading enemies while the workers build nests, forage galleries and take care of young termite stages (Amund et al., 1986). The soldier caste was noted to have shown lower mortality than the worker caste. The high death rate of the workers might be due to the fact that they were generally more active during foraging and thus more susceptible to the effects of the insecticide either by contact or systemic actions. The fact that the workers have a lower surface area and body weight than the soldiers might have also contributed to their higher vulnerability to the insecticides.

It is worthy of note that even though Chlorpyrifos gave an overall better kill of the termites than the other termiticides, there was no significant difference among the various treatments of the four insecticides tested.

However, each of the insecticides could be utilized effectively for termite control depending on affordability and availability. The application of these insecticides at 0.25% active ingredient is adjudged the best due to high mortality rate it achieved. Also the application at 0.25% will help to maintain cost-effectiveness of these insecticides and minimize environmental pollution, toxicity and phytotoxicity problems associated with pesticides. Finally, field trials with the insecticides should be carried out to confirm the high mean mortality achieved in these laboratory trials.

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