

Termiticidal Efficacy of Three Tropical Plant Oils on Epigeal Mound Builder Termite, *Macrotermes bellicosus* (Blattodea: Termitidae)



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Abstract

The use of botanical pesticides in pest management is considered to be environmentally safe compared to synthetic pesticides. The utilization of these botanical pesticides and their modes of application for effectiveness are of great importance to researchers and farmers. The focus of this study was to determine the anti-termite efficacy of Neem seed oil, *Jatropha* seed oil and Palm kernel oil using two methods of application. Five aqueous concentrations, 0, 2.5, 5.0, 7.5 and 10.0 percent of the oil were applied to soil and a food source in plastic cages. Thereafter, thirty adult worker castes of *Macrotermes bellicosus* were introduced. The treatments were replicated five times and arranged in a Completely Randomized Design in a dark cupboard. Termite mortality was assessed at 2, 6, 12, 24, 48 and 72 hours after treatment. Data were analysed using ANOVA, LSD at $p \leq 0.05$ and Probit analysis was carried out to determine the LC_{50} and LT_{50} of the different oil. The results showed that termite mortality in both soil and feeding experiments increased with increase in oil concentration and period of exposure to oil. The estimated values of LC_{50} and LT_{50} were lower in soil bioassay than in feeding bioassay. Application of the three plant oils as soil treatment gave a higher and faster termite mortality than when applied directly to food. Hence, soil application of neem seed oil, *Jatropha* seed oil or /and palm kernel oil could be included in Integrated Pest Management (IPM) component of termites.

Keywords: *Macrotermes bellicosus*, Modes of application, Termite mortality, Plant oil and IPM.

INTRODUCTION

Termites are considered as serious pests to crops, rangeland and forestry in tropical Africa. Some of the deleterious species belong to the family Termitidae, which comprises four subfamilies namely, Macrotermitinae, Nasutitermitinae, Termitinae, and Apictotermitinae (Murgerwa *et al.*, 2014). Over 90% of the termite damage in agriculture, forestry and urban settings in Africa has been attributed to members of the subfamily Macrotermitinae (Sileshi *et al.*, 2009; Abdurahman *et al.*, 2010). Members of this family which include species from the genera *Macrotermes*, *Odontotermes*, *Ancistrotermes* and *Microtermes* have been reported to be associated with *Eucalyptus* plantations in Nigeria (Alamu, 2017). Other reports have also shown that members of the genus *Macrotermes* cause complete damage to agricultural crops and domestic products (Umeh *et al.*, 1999; Joshi *et al.*, 2005; Nyeko *et al.*, 2010).

Different methods have been used by local farmers in Africa in the control of termites. These include destruction of termite mound (Murgerwa *et al.*, 2011a), application of wood ash (Nyeko and

Olubayo, 2005; Mugerwa *et al.*, 2011b) and animal excreta (Mugerwa *et al.*, 2008). Synthetic pesticides remain the primary method use to prevent termite attack to wooden structures, agricultural crops and forest trees. They are applied directly to termite mound (Mugerwa *et al.*, 2011b), plant or wood materials and also directly to soil. However, the persistent use of synthetic termiticides is of environmental concern and has resulted in the need to search for plant-derived compounds as an alternative for termite control.

Many plants have been recognized to have anti-termite activities (Sakasegawa *et al.*, 2003; Supriadi and Ismanto, 2010) or repellent to the termites (Zhu *et al.*, 2001). The crude seed oil of *Piper guineense* at a 10% concentration significantly lowered damage by termites (Umeh and Ivbijaro, 1999). Neem seed oil has been reported to inhibit growth of termite surface-tunnels (Yashroy and Gupta, 2000). Soil treated with 2% solution of *Calotropis procera* L. and *Azadirachta indica* prevented damage by *Odontotermes obesus* (Rambur) to sugarcane setts (Deka and Singh, 2001). Extracts from leaves of

Tephrosia vogelii have been reported to protect tree seedlings from termites' infestation in Malawi and Zambia (Nkunika 1998; Sileshi *et al.* 2008). Extract from *Lagenaria breviflora* fruit pulp has also been used as a wood protectant against termites (Emerhi *et al.*, 2015).

The indiscriminate use of pesticides for the management of termites has generated a number of biological and environmental hazards in air, water, soil and in food chains (Abdullah *et al.*, 2014). Insecticides from plant materials are very common, environmentally friendly and reservoir of chemical compounds with anti-termite properties. There is the need however, in addition to the identification of these plants to determine the effective rate and methods of applications. The objective of this study therefore was to assess the anti-termite efficacy of different concentrations and two methods of application of neem seed oil, Jatropha seed oil and palm kernel oil on adult worker caste of *Macrotermes bellicosus*.

MATERIALS AND METHODS

Sources of oils

Neem and *Jatropha* oil extracts were obtained from National Research Institute for Chemical Technology (NARICT), Zaria, Kaduna State and Palm kernel oil was obtained from local producers in Ekiti State, Nigeria.

Collection of termites for laboratory studies

Worker caste of *Macrotermes bellicosus* were collected from *Macrotermes* mounds in the experimental fields of Institute of Agricultural Research, Ahmadu Bello University, Zaria, Savanna Forestry Research Station office premises and Kurumi Bomo village, Zaria in Zaria North Local Government Area of Kaduna State, Nigeria. The termites were maintained in the laboratory on Sugar cane strips for 72 hours prior to use. The moribund termites were removed and only active ones were used for the experiments.

Mortality rate of termite on food source treated with different botanical oil extracts

Feeding deterrence bioassay was conducted to determine the effects of different concentrations such as (0%, 2.5%, 5%, 7.5%, and 10%) of Neem seed oil (NSO), Jatropha seed oil (JSO) and Palm kernel oil (PKO) on termite mortality rate. The experiment was carried out in plastic containers (15 cm in diameter and 10 cm high) using sugar cane strip as a source of food on sand substrate. River sand was collected and oven-dried at 100°C

for 6 hours. After cooling, 30 g of sand was weighed into each plastic container and moistened with 6 ml of sterile distilled water using hypodermic syringe. The sand was stirred with a rod for uniform distribution of water in the soil. Sugar cane strips were cut to 6 x 2 x 1 cm in size and individually soaked in different concentrations of the oils for five minutes and placed in the plastic cages. Thirty adults worker caste of *M. bellicosus* were introduced into each plastic container and covered with a perforated lid. Each treatment was replicated five times and arranged in a dark cupboard in a Completely Randomized Design. Termite mortality was assessed at 12, 24, 48 and 72 hours. All dead termites were removed at each time of counting.

Mortality of termites on soil treated with different concentrations of plant oils

Thirty grammes (30 g) of oven-dried river sand was weighed into plastic cages and treated with 3 mls of different concentrations (0%, 2.5%, 5%, 7.5% and 10%) of Neem seed oil (NSO), Jatropha seed oil (JSO) and Palm kernel oil (PKO) using hypodermic syringe. The soil was stirred with a stirring rod for uniform distribution of oil in the sand medium. Thirty (30) worker caste of *M. bellicosus* were introduced into each plastic cage and sugar cane strip was added as food. Each treatment was replicated five times and arranged in a Completely Randomized Design in a dark cupboard. The number of dead termites was counted at 12, 24, 48 and 72 hours. Data on percentage termite mortality for the two experiments were corrected using Abbott's (1925) formula thus:

$$P_T = \frac{P_o - P_c \times 100}{100 - P_c}$$

Where P_T = Corrected mortality (%); P_o = Observed mortality (%); P_c = Control mortality (%)

Data on termite mortality was analyzed using ANOVA and means were separated using LSD at $p \leq 0.05$. Probit analysis of termite mortality was carried out to determine the LC_{50} and LT_{50} . Significant differences in LC_{50} and LT_{50} were determined by the overlapping and non-overlapping of the 95% confidence intervals (CI) (Appel *et al.*, 2001).

RESULTS

Mortality of Termite on Food Treated with Different Concentrations of Plant Oils

The highest mortality of termite (79.85% - 100.00%) recorded in 10% Neem seed oil at 24 and 48 hours after application was significantly higher than average mortality of termites in 0% - 5.0% Neem seed oil (Table 1). However, the mean mortalities of termites between 7.5% and 10.0% Neem seed oil were not significantly different at 24 and 48 hours after application. In addition, at 72 hours after termite exposure to Neem seed oil, termite mortalities at concentrations of 5% to 10.0% were not significant but significantly higher than mortalities at 0% and 2.5%. Sugarcane strips treated with 7.5% and 10.0% Jatropha seed oil caused more than 50% termite mortality at 24, 48 and 72 hours after application. Termite mortalities in 7.5% and 10.0% Jatropha seed oil were significantly higher ($p \leq 0.05$) than average mortalities in 0%, 2.5%, and 5% Jatropha seed oil. Similarly, Palm kernel oil concentrations of 5.0, 7.5 and 10% gave significantly higher ($p \leq 0.05$) termite mortalities than Palm kernel oil concentration of 2.5%. In all cases, higher termite mortality was recorded with increase in the period of termite exposure to treated food.

Mortality of Termite on Soil Treated with Different Concentrations of Neem, *Jatropha* and Palm Kernel Oils

Termite mortality recorded on sand treated with Neem seed oil at concentrations of 7.5% and 10% between 24 and 72 hours were not significant but significantly ($p \leq 0.05$) higher than termite mortality at 2.5% Neem seed oil concentration (Table 2). Across the three periods of termite exposure to sand treated with Jatropha seed oil, the mean mortality of termite at the concentration of 2.5% were significantly lower than mortality recorded at the concentrations of 5.0, 7.5 and 10.0%. Termite mortality on sand treated with different concentrations of Jatropha seed oil at 24 hours after application were significantly different. However, at 48 and 72 hours after application, the mean mortality of termite observed at the concentrations of 5.0 to 10.0% Jatropha seed oil was not significant. Termite mortality at 24, 48 and 72 hours in all the concentrations of Palm kernel oil were significantly different except at 48 hours where mean termite mortality of 71.51% and 71.53% recorded at Palm kernel oil concentrations of

5.0% and 7.5%, respectively were not significantly different.

DISCUSSION

The application of botanical pesticides in the management of termites and other insects in agriculture and forestry holds a promise for reducing threats posed to the environment by synthetic pesticides and also has prospects for increasing crop yield. From this study, application of Neem seed oil, Jatropha seed oil and Palm kernel oil to a food source and soil showed that mortality response of termite is dose and time dependent.

Mortality of termite increased with increase in oil concentration and with increase in the period of exposure to oil. The mortality response of *Odontotermes obesus* to leaf extract of *Cordia dichotoma* has been reported to be dose and time dependent (Pal *et al.*, 2013). The formation of thin oil layer on termite cuticle when in contact with oil may also be a contributory factor to termite mortality. The covering of respiratory opening on termite body with oil could prevent passage of oxygen into the insect respiratory organs and also prevent exit of carbon dioxide from the body. The accumulation of carbon dioxide in insect tissues and low supply of oxygen to internal tissues reduce insect metabolism and also lead to suffocation which could lead to eventual death. Insect mortality has been reported to be increased with lower oxygen concentrations (Hoback and Stanley, 2001).

Probit analysis of termite mortality in Neem seed oil, Jatropha seed oil and Palm kernel oil showed that the three oil sources were effective against termite as indicated by the low values of LC_{50} both in soil and feeding bioassays. However, the LC_{50} in Neem seed oil and Jatropha seed oil were lower than LC_{50} in Palm kernel oil indicating that Neem seed oil and Jatropha seed oil were more toxic than Palm kernel oil. The lower LT_{50} values observed in Neem seed oil indicates that the application of Neem seed oil caused termite mortality faster than Jatropha seed oil and Palm kernel oil in soil and feeding bioassays. The lower values of LC_{50} and LT_{50} in soil bioassay compared to feeding bioassay is an indication that the three oils are more potent when applied as soil termiticides than when applied directly to plant materials.

Table 1. Mortality of worker caste of *Macrotermes bellicosus* on food treated with different concentrations of Neem, *Jatropha* and Palm kernel oils

Oil concentration	Neem seed oil			<i>Jatropha</i> seed oil			Palm kernel oil		
	Period of exposure (hour)								
	24	48	72	24	48	72	24	48	72
0%	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
2.5%	16.81±3.00	40.43±3.05	52.94±3.75	13.47±5.18	32.11±2.73	48.87±2.55	13.80±4.50	36.12±2.93	50.00±2.53
5.0%	54.85±13.75	80.14±11.30	86.03±10.49	39.58±9.73	63.50±2.00	72.93±3.23	27.59±5.67	60.56±3.41	71.66±3.02
7.5%	61.81±8.14	92.91±3.17	99.26±0.74	53.47±6.64	71.53±2.92	89.47±1.41	53.11±4.31	66.20±3.95	86.59±1.50
10.0%	79.85±5.95	100.00±0.00	100.00±0.00	60.42±4.34	73.72±2.13	96.99±2.19	64.14±4.83	75.36±1.11	93.31±2.73
LSD(0.05)	23.08	16.00	14.73	17.92	6.53	6.43	12.80	8.03	6.62

Table 2. Mortality of worker caste of *Macrotermes bellicosus* on sand treated with different concentrations of Neem, *Jatropha* and Palm kernel oils

Oil concentration	Neem seed oil			<i>Jatropha</i> seed oil			Palm kernel oil		
	Period of exposure (hour)								
	24	48	72	24	48	72	24	48	72
0%	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
2.5%	57.72±4.32	84.50±2.86	92.54±3.92	42.86±3.94	56.71±8.05	74.73±7.56	17.01±3.33	44.45±3.64	65.40±6.58
5.0%	79.20±4.16	97.89±2.11	100.00±0.00	62.58±1.52	93.28±2.94	100.00±0.00	38.77±2.40	71.51±2.31	83.06±2.59
7.5%	95.31±2.28	100.00±0.00	100.00±0.00	82.99±1.08	100.00±0.00	100.00±0.00	48.94±3.40	71.53±1.30	95.14±2.05
10.0%	97.32±0.67	100.00±0.00	100.00±0.00	90.48±2.72	100.00±0.00	100.00±0.00	60.54±2.31	82.64±3.80	100.00±0.00
LSD (0.05)	8.51	4.69	5.18	6.78	11.33	9.97	7.67	7.78	9.72

Table 3. Median lethal concentrations (LC₅₀) of three plant oils on adult worker caste of *M. bellicosus* in feeding and soil assays after 24 hours of exposure

Plant oil	Feeding bioassay		Soil bioassay	
	LC ₅₀ (%)	95% Confidence Interval	LC ₅₀ (%)	95% Confidence Interval
Neem seed oil	5.19a	4.09 – 6.36	2.22a	1.10 – 3.00
<i>Jatropha</i> seed oil	7.12a	5.59 – 10.21	3.17a	1.93 – 4.09
Palm kernel oil	7.38a	5.93 – 10.23	7.39b	5.64 – 10.85

Table 4. Median lethal time (LT₅₀) of three plant oils on adult worker caste of *M. bellicosus* in feeding and soil bioassays at 10% concentration

Plant oil	Feeding bioassay		Soil bioassay	
	LT ₅₀ (hour)	95% Confidence Interval	LT ₅₀ (hour)	95% Confidence Interval
Neem seed oil	18.37a	13.38 – 27.67	4.26a	2.97 – 5.55
<i>Jatropha</i> seed oil	26.19a	22.23 – 30.98	4.29a	2.94 – 5.65
Palm kernel oil	25.27a	21.33 – 30.10	18.68b	12.04 – 35.06

The presence of oil in the soil and the contacts made with termite body could have caused termite mortality and could also deter termites from constructing tunnels in the soil. It has been suggested that inhibition of tunneling may be exploited in agricultural ecosystem to prevent termites from access to seed and plant parts (Ahmed *et al.*, 2007). Similarly, the result of feeding bioassay suggested that NSO, JSO and PKO could serve as deterrent to feeding by termites on plant materials. The inability of termites to feed might lead to starvation and eventual death. The three oils tested were effective for the control of termite, but NSO was the most effective followed by JSO. It should however be noted that though, all the oils were toxic to termite; the degree of toxicity depends on the concentration applied and the period of exposure. Extracts of neem and *Jatropha* seeds have been reported to be effective as termiticides at concentrations of 10 - 35% (Adissu *et al.*, 2014).

The insecticidal activity of seed oil of *J. curcas* has been attributed to the presence of sterols and terpene alcohols in the seed (Adebawale and Adedire, 2006; Nisar *et al.*, 2012) and has been reported as contact and stomach poison insecticides (Jembere *et al.*, 2005). The main active ingredient of

Azadirachta indica, azadirachtin has been reported as contact poison (Adissu *et al.*, 2014). Isman (2006) reported that azadirachtin has broad mode of activity and demonstrated feeding deterrence, insect growth regulator, repellent, sterilant and may also inhibit oviposition of insect pest. Other locally sourced plant materials such as African locust bean, *Parkia biglobosa* (Olugbemi, 2011), *Moringa oleifera* (Janfa *et al.*, 2015), *Curcuma longa* (Turmeric), *Nerium indicum* (Oleander) and *Melia azedarach* (Derek) (Manzoor *et al.*, 2011) have been reported to possess anti-termite properties in Nigeria. The application of Neem seed oil, *Jatropha* seed oil and palm kernel oil as soil termiticides could be utilized by poor resource farmers in the management of termites in agriculture and forestry in sub-Saharan Africa.

CONCLUSION AND RECOMMENDATIONS

The results of this study showed that Neem seed oil, *Jatropha* seed oil and Palm kernel oil caused termite mortalities at the concentration of 2.5% - 10% when applied to food substrate or as soil treatment. However, the oils were more potent as soil termiticides due to the observed low LC₅₀ and LT₅₀. It is therefore recommended that these three plant oils can be

used by farmers in Sub-Saharan Africa as alternatives to synthetic termiticides.

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