REPELLANT AND TERMICIDAL ACTIVITY OF SOME PLANT EXTRACTS IN THE LABORATORY AND ON THE FIELD

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ABSTRACT: The study evaluated the residual, repellant and termiticidal effects of extracts from four botanicals namely; *Moringa oleifera, Polyalthia longifolia, Tithonia diversifolia* and *Azadirachta indica* on termite in the laboratory and on the field at Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. A synthetic insecticide, chlorpirifos was used as positive check and distilled water as control. Residual effect, repellency and contact toxicity of the treatments by topical application was conducted in the laboratory using standard methods. Chlorpirifos caused 100% mortality at 2 h after treatment and all the extracts except *P. longifolia* caused 100% at 10 h after treatment. The least in terms of repellency was the extract of *P. longifolia* that repelled 60% of the insects; followed by the extracts of *A. indica* and *T. diversifolia* that comparably ($p>0.05$) repelled 80% of the insects at a piece. Chlorpyrifos and extract of *M. olefeira* repelled all the insects (100%). The percentage repellence of chlorpyrifos and the plant extracts were ($p>0.05$) comparable. The residual effects of chlorpyrifos and all the extracts after 24 h caused 100% mortality of the termites. On the field, chlorpirifos and all the plant extracts except *A. indica* were rated as highly effective, while extract of *A. indica* and distilled water were rated as ineffective. Extracts of *M. oleifera, P. longifolia* and *T. diversifolia* has repellant, residual and termiticidal effects on termite in the laboratory and on the field and could be used as relatively cheaper and eco-friendly termiticide for the management of termite.

KEY WORDS: Chlorpirifos, extract, botanicals, termites, mortality

Termites are among the most important structural insect pests in the world; they are cosmopolitan and exhibit the most complex social life of all known insects. Termite belong to the group of insect called *Isoptera*, a term in Latin that refers to the fact that termites have 2 wings that look similar (Crawshaw and Whitney, 2013). They live in highly organized colonies with well-differentiated castes that exhibit division of labour. In general terms, three types of termites occur worldwide: the drywood, dampwood, and subterranean termites. Drywood termites build their nests in sound, dry wood above ground. Dampwood species locate their nests in moist, decaying wood but can extend tunnels into drier parts of the wood, while subterranean termites typically dwell in the soil and work through it to reach wood above ground.

Termites are social insects that live in highly organized colonies with specific structure and division of labour that makes the colony work. The colony composed of "castes" of individuals that have different physical features or behavioral roles, or both. The castes consists of reproductive forms, sterile workers, soldiers, and immature individuals; the reproductives are of two types, primary and supplementary. The primary reproductive; the king and queen, are pigmented and fully developed winged adults. Their role is egg production and distribution by colonizing flights. The queen lays about 3000 eggs a day through its enlarged abdomen, The Queen, king, soldier, worker and larval termites live in nests or mounds that are either located in the soil or wood. (Thompson, 2000).

Although termites play beneficial roles in ecology; they are also destructive and are major threat to crops and household properties (Edward & Mill, 1986). Crops such as yam and cassava (Atu, 1993), sorghum (Logan et al., 1990) and maize (Wood et al., 1980) have been reported infested and damaged by termites. They also feed on wood and wood products and cause structural damage while foraging for food. The insect also penetrate and damage non-cellulose materials like plastering, plastic, rubber, polystyrene, soft metal covering, electric and telegraph cables and structures such as buildings, bridges, dams, roads and rangelands (Harris, 1971; Logan et al., 1990; Pearce, 1997; Gurusubramanian et al., 1999). There are about 2,600 species of termites, represented by 7 families and 281 genera. However, the most economically important termite genera in agricultural and forest areas are *Macrotermes, Allodontermes, Amitermes, Pseudacanthotermes, Odontotermes, Ancistrotermes, Trinervitermes, Hodotermes and Microtermes* (Mitchell, 2002; Kumar & Pardeshi, 2011). Termites are known for their symbiotic relationship with a variety of other organisms, which help them to digest the plant materials they consume. They also have intestinal bacteria and protozoa in their intestines that help in digesting cellulose (Upadhyay, 2011).

Termites are toxic to synthetic chemicals such as Bifenthrin, a synthetic pyrethroid pesticide, Chlorpyrifos, an organophosphorus insecticide, Imidacloprid and Fipronil. The pesticides however, are toxic to human and beneficial organisms. There is also the drawbacks of high cost, resistance and environmental concern among others. These drawbacks has heighten the search for plant-derived insecticides that are relatively cheaper, effective and environmentally friendly. Botanical insecticides are one of the best alternatives for the hazardous synthetic agro-chemicals. They are plant-derived insecticides, either naturally occurring plant materials or products simply derived from such plants (Gupta et al., 2005). A number of plant species like *Azadirachta indica*, *Melia azedarach, Nicotiana tabacum, Cannabis sativa* Linn.*, Nerium indicum* Mill.*, Eucalyptus* sp.*, Ricinus communis* Linn., *Solanum nigrum* Linn. etc. are known to possess insecticidal properties, although only a few of these have been exploited commercially (Mordue, 2004; Ukeh et al., 2008; Prakash & Rao, 1997). This study therefore evaluated the residual, repellant and termiticidal potential of aqueous extracts of four plants namely *Moringa oleifera, Polyalthia longifolia, Tithonia diversifolia* and *Azadirachta indica* in the laboratory and on the field.

MATERIALS AND METHOD

Source of materials

The synthetic insecticide, chlorpirifos (Act force gold) used as positive check was sourced from Agbeloba agro-chemical store, Abeokuta, Ogun State, Nigeria. The plants, *Moringa oleifera, Polyalthia longifolia, Tithonia diversifolia* and *Azadirachta indica* were sourced from the field of Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria where they grew naturally. Worker termites used for the laboratory study were sourced from termite mounds in the premises of zoological garden, FUNAAB. They were collected in 250 cm^3 Kilner jars about 30 minutes prior to use and placed in the deep freeze for one minute to make the insects passive for easy handling (Osipitan et al., 2010).

Preparation of treatments

The leaves of plants collected on the field were detached and placed on work tables in the laboratory of Department of Crop Protection, FUNAAB until they were crispy dry. They were thereafter ground into fine powder with a grinding machine. One hundred g of the powder was soaked in 10 L of water (1 % w/v) for 24 h to aqueously extract the active moieties in the plants. The synthetic termiticide, chlorpirifos was mixed in water to 1% according to manufacturer recommendation.

Determination of contact toxicity of treatments to termite by topical application

The study was carried out in the laboratory of Crop Protection Department, Federal University of Agriculture, Abeokuta using the standard method described by McDonald et al. (1970). Ten termites of undetermined age and sex were placed in a Petri dish lined with moist filter paper. Dorsal surface of the thorax of each insect were individually treated with ten ml each of the extract of *Azadirachta indica, Moringa olefeira, Polyathia longifolia* and *Tithonia diversifolia* and the synthetic insecticide (0.1% Chlorpyrifos) using a micro-applicator (Obeng-Ofori & Reichmuth 1997; Ebenezer, 2000) to determine contact toxicity of the plant extracts to termite by topical application. The control were insects in petri dishes treated with distilled water. Mortality of the plant extract-treated insects and the untreated ones were observed at 2-hour intervals after application for 10 hours and insect mortality was noted. Insects that did not move or respond to three probings with a blunt probe were considered dead (Obeng-Ofori & Reichmuth, 1997). All the treatments and the control petri dishes were arranged on a work table in the laboratory using Complete Randomised Design (CRD). The number of dead termites in each of the petri dishes was noted and percentage insect mortality was calculated according to Baba-Tierto (1994):

$$\% \text{ Mortality} = \frac{\text{No. of dead insect}}{\text{Total number insects}} \times 100\%$$

Repellency study of the extracts

The ability of the extract to repel termites was assessed using treated filter paper method based on an area of preference test described by Landani et al. (1955) and McDonald et al. (1970). The test area was 11 cm Whatman number 1 filter paper cut into equal halves that have no contact with each other to prevent exchange of content. One half was dipped into each of the treatments with forceps and allowed to drain before placement into the plastic Petri dish. The other half was placed into distilled water (control) and placed sideway with the first half after it has drained. Ten termites were separately placed into the center of each filter paper in perforated Petri dishes covered with nylon mesh and tightly held in place with rubber bands. The treatments and control were replicated four times and arranged on work tables in the laboratory using complete randomised design. The Number of Termites Present on Control (NC) and Treatment (NT) halves were recorded after one hour exposure. The Percent Repellency (PR) values were computed using the method of Hossanah et al. (1990) as follows:

$$\% \text{ Repellency} = \frac{NC-NT}{NC+NT} \times 100\%$$

All negative values were treated as zero.

Residual effects of treatments

The lasting effect of the treatments after application on a treated surface was evaluated. Filter paper was dipped into five milliliters of the extract and synthetic insecticide and placed in Petri dishes. The Petri dishes were tightly covered for 24 hours. Thereafter, five termites were separately introduced into the Petri dishes and left for 24 hours. The number of dead insects was noted and the percentage mortality was calculated.

Field study

The plant extracts were evaluated outside the Zoological Garden, Federal University of Agriculture, Abeokuta, Ogun State. Six average-sized termitaria of between 1.5 and 1.6 metre height were located and used for the study. Each of the termitaria was demolished and dug to a depth of 40–50 cm below ground level to expose the termites to application of the treatments. The king and queen were not injured or killed during the digging to evaluate the effect of the treatments on all the castes of the termites. Thereafter, 5 liters each of the extracts was evenly applied to the dug termitaria with aid of a Cooper Peegler (CP15) knapsack sprayer. One of the demolished termitaria was sprayed with 5 liters of 0.1% chlorpyrifos (synthetic insecticide) to serve as positive check and another with 5 liters of distilled water and these served as control. The termitaria were observed for re-built and/or termite resurgence from the second day after application of the extracts.

Statistical analysis

Statistical analysis of data was based on SASs general linear models procedure (SAS Institute, 2003). Data were subjected to Analysis of Variance (ANOVA) and means separation was done at $p < 0.05$ with Student Newman-Keuls Test (SNK).

RESULTS

Effect of plant extracts on mortality of termites using topical application

The mortality of termites topical applied with the extracts of the plants was 15%, 15%, 20% and 35% for *Polyalthia longifolia, Azadirachta indica, Tithonia diversifolia* and *Moringa olefeira* respectively at two hours after application of the treatments. The mortalities were however, not significantly ($p > 0.05$) different from each other. The synthetic insecticide (0.1% chlorpyrifos) induced 100% mortality at this period and it was significantly ($p < 0.05$) higher than mortalities caused by extracts of the botanicals. At 6 hours after application of treatments, the mortality was comparable at 100% at a piece for *Moringa olefeira* and Chlorpyrifos. The percentage mortality for other extracts was 50%, 85% and 90% for *Polyathia longifolia, Azadirachta indica* and *Tithonia diversifolia* respectively. The mortality (75%) caused by extract of *Polyathia longifolia* was least at 10 hours after application of treatments. It was however, comparable with 100% mortality each caused by the synthetic insecticide (Chlorpyrifos) and extracts of *Azadirachta indica, Tithonia diversifolia* and *Moringa olefeira* (Table 1).

Repellency and residual effect of plant extracts on termite

The results on Table 2 shows that the synthetic insecticide and extracts from all the plants repel the insects. The least in terms of repellency was the extract of *Polyathia longifolia* that repel 60% of the insects. This was followed by the extracts of *Azadirachta indica* and *Tithonia diversifolia* that comparably ($p > 0.05$) repel 80% of the insects at a piece. The synthetic insecticide (Chlorpyrifos) and extract of *Moringa olefeira* repel all the insects (100%). The percentage repellence of the insects by chlorpyrifos and all the other plant extracts were ($p > 0.05$) comparable. The synthetic insecticide (chlorpyrifos) and the extracts from all the plants caused 100% mortality of all insects placed on a treated surface 24 hours after treatment (Table 3).

Termiticidal rating of the treatments on the field

The termiticidal effect of the treatments at controlling termites on treated termitaria was modified based on the ratings according to Osipitan et al. (2010) on Table 4. The synthetic insecticide, chlopirifos and the plants extracts *Moringa olefeira, Polyathia longifolia* and *Tithonia diversifolia* were rated as highly effective, while extracts of *Azadirachta indica* was not effective. Demolished termitaria treated with distilled water was rebuilt 2 days after treatment (Table 5).

DISCUSSION

The results indicated effectiveness of the extracts from *Polyalthia longifolia, Tithonia diversifolia* and *Moringa oleifera* at controlling termite in the laboratory and on the field. This is agrees with the report of Mordue (2004) that compounds from plants performs a number of useful activities such as regulating insect growth, toxicity, repellence, feeding and oviposition deterrence. In the laboratory, all the extracts from the plants repelled between 60% and 100% of the termites suggesting that they could act as repellant and the extracts killed between 75% and 100% of the test termites suggesting that they could be used as termiticide. Prakash & Rao (1997) reported that botanical extracts kill and repel pests, affect their growth and development, exhibit antifeedant and arrestant effects, have antifungal, antiviral and antibacterial properties against pathogens. Dutta et al. (1993), Adoyo et al. (1997) and Tongma et al. (1997) reported that extracts from *Tithonia* plant parts protect crops from termites and contain chemically active compounds that inhibit plant growth and control other insects. Kuo & Chen (1998), Tona et al. (2000), Jama et al. (2000) and Uduak & Nodeley (2013) reported saponins, alkaloids, tannins, flavonoids, phenol compounds and sesquiterpenes as some of the bioactive compounds isolated from the leaves of *T. diversifolia*. Khater (2012) reported that the bioactive compounds can be grouped into five major chemical categories namely nitrogen compounds (primarily alkaloids), terpenoids, phenolics, proteinase inhibitors and growth regulators.

Two of the major detriments of synthetic insecticide are their effects on beneficial organisms and their pollution of underground water. Synthetic termiticide needs to be applied to the soil for their effect on subterranean termicide; this however, is detrimental to natural enemies of insect pests and other beneficial organisms such as earth worm, millipede and centipedes that lives in the soil. The effectiveness of extracts of *Polyalthia longifolia, Tithonia diversifolia* and *Moringa oleifera* at controlling termites on the field is a good development. Parugrug and Roxas (2008) reported that use of botanical pesticides to protect plants from pests is very promising because of several distinct advantages. Ukeh et al. (2008) reported that plant powders are cheap, easily biodegradable and readily available and will not contaminate food products in acting as protectants in small-scale storage systems. In this study, leaf extract of neem was not effective at controlling termite on the field. This result was in consonance with the results of Osipitan et al. 2010 which reported that leaf extracts of *A. indica* was not effective at managing the population of termites on the field. However, Osipitan et al. (2010) reported that the seed extract of *A. indica* effectively controlled termites on the field. Similarly, Umeh and Ivbijaro (1999) reported the efficacy aqueous extracts of ripe seeds of neem for the control of termites on maize-cassava-'egusi' melon intercrops with significantly ($P < 0.05$) higher maize yield and lower population of the termites *Microtermes* spp., *M. bellicosus* Smeathman = *Nigeriensis sjostedt* and *M. subhyalinus* Rambur (Isoptera: Termitidae) on the treated plots than the control plots. The ineffectiveness of leaf extract of *A. indica* is likely to be due to the part used. Jilani and Malik (1973) reported that neem seeds exhibited maximum repellency when compared with leaves and flowers.

The plant extracts evaluated in this study were still effective after 24 hours of application and killed all the termites introduced to treated surface. This indicated that the extracts have residual effect and suggests their ability to kill termites entering the colony from foraging. In this study, the species of the termites in each of the termitaria used could not be determined due to logistics challenges. However, the effectiveness of the extracts of three termitaria on the field suggest that the extracts are likely to have wide spectrum activity on different species of termites. However, suppression of rebuilding of termitaria by the plant extracts indicated wide spectrum activity of the extracts on all the caste of the termite in each of the termite colony. The results of the study therefore conclude that the extracts of *Polyalthia longifolia, Tithonia diversifolia* and *Moringa oleifera* are effective for the control of termite in the laboratory and on the field. The extracts from these plants are therefore recommended for control of termites in termitaria on the field.

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Table 1. Mortality of termites topically treated with plant extracts.

	% Mortality± SE (Hours After Application of Treatments)				
Treatments	2	4	6	8	10
Polyalthia longifolia	15.00±0.e	25.00±1.2de	50.00±2.2c	55.00±0.5c	75.00± 2.2b
Azadirachta indica	15.00±1.1e	45.00±2.3c	85.00±0.6ba	100.00±0.0a	100.00±0.0a
Tithonia diversifolia	20.00±1.2de	45.00±1.1c	90.00±1.0ba	100.00±0.0a	100.00±0.0a
Moringa oleifera	35.00±0.4dc	55.00±2.2c	100.00±0.0a	100.00±0.0a	100.00±0.0a
0.1% Chlorpyrifos	100.00±0.0a	100.00±0.0a	100.00±0.0a	100.00±0.0a	100.00±0.0a

Means followed by the same letter along and across the column are not significantly different from each other at p< 0.05 with Student'sNewman-Keuls Test (SNK).

Table 2. Repellency effect of treatments on termite.

Treatments	Parts Used	% Repellency ± SE
Polyalthia longifolia	Leaf	60.0 ± 1.24[a]
Azadirachta indica	Leaf	80.0 ± 2.10[a]
Tithonia diversifolia	Leaf	80.0 ± 1.15[a]
Moringa oleifera	Leaf	100.0 ± 2.22[a]
0.1% Chlorpyrifos	-	100.0 ± 0.22[a]

Means followed by the same letter are not significantly different from each other at P < 0.05 using Student's Newman-Keuls Test (SNK)

Table 3. Residual effect of treatments on a treated surface

	Residual effect of treatments after 24 hours
Treatments	% Mortality
Polyalthia longifolia	100.0 ± 0.0[a]
Azadirachta indica	100.0 ± 0.0[a]
Tithonia diversifolia	100.0 ± 0.0[a]
Moringa oleifera	100.0 ± 0.0[a]
0.1% Chlorpyrifos	100.0 ± 0.0[a]

Means followed by the same letter are not significantly different from each other at $P < 0.05$ using Student'sNewman-Keuls Test (SNK).

Table 4. Scale of measuring treatment effectiveness at managing termite on the field

Upsurge/rebuilt of termitaria (Days after application of the treatments)	Rating
1–30	Not effective
31–60	Slightly effective
61–90	Effective
91 days and above	Highly effective

Source: Modification of Osipitan et al. 2010

Table 5. Rating of treatment effectiveness at managing termite on the field

Treatments	Rating
Azadirachta indica	Not effective
Polyalthia longifolia	Highly effective
Tithonia diversifolia	Highly effective
Moringa oleifera	Highly effective
0.1% Chlorpyrifos	Highly effective