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Toxicity and repellency of scent leave (*Ocimum gratissimum*), kerosene and naphthalene in single and mixed forms on termites (*Macrotermes bellicosus*)

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ABSTRACT

Termites (*Macrotermes*) are destructive pests in nature and their activities cause economic loss to field crops, wooden and building structures. Plant protectants have been widely used but information on the use of *Ocimum gratissimum*, kerosene and naphthalene in their single and mixed forms at various concentrations in the control of *Macrotermes* is lacking. Hence this study determined the toxicity and repellency of *O. gratissimum*, kerosene and naphthalene in their single and mixed forms on *Macrotermes*. Termites were sourced using axe and shovel, and exposed to 0.5, 1.0 and 1.5g of *O. gratissimum*, naphthalene and kerosene in single forms respectively. Mixed forms were in 50%:50% of 0.5-1.5g of *O. gratissimum* and naphthalene, 0.5 -1.5g/mL of kerosene and *O. gratissimum*, and naphthalene and kerosene respectively. The set up was in triplicate and exposed for 24 hours. Results revealed that all concentrations of *O. gratissimum*, naphthalene, kerosene in single and mixed forms showed anti-termite activities. The differences were not significant ($p > 0.05$). Complete mortality was recorded in all treatment concentrations except 0.5 and 1.0g of *O. gratissimum*, 0.5g of naphthalene and *O. gratissimum*. All concentrations of kerosene, 0.5 and 1.5g/mL of naphthalene and kerosene, 1.0g/mL of kerosene and *O. gratissimum* caused complete mortality after 6 hours of treatment. The difference between the time mortality was significant $p < 0.05$. Repellency and their distances being remarkably high across all concentrations and the differences were significant ($p<0.05$). Lethal concentrations at 50% and 95% of all treatment were 0.347 and 0.471, respectively except for *O. gratissimum* which was 0.086 and 0.071g respectively. The results of this research indicated that higher concentrations of *O. gratissimum* and the other two treatments in their single forms as well as the mixed forms could limit the destructive activities and economic losses caused by termites.

Keywords: Toxicity, Repellency, Scent leaves, Kerosene, Naphthalene, *Macrotermes bellicosus*
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INTRODUCTION

Termites are ground-dwelling and destructive pest species of economic importance found globally except in the Antarctica (Eggleton, 2010). In Africa, they are the largest species of organisms in terms of relative abundance (Arhin *et al.*, 2015). They occupy greater percentage of the lands in the tropics and an estimated between 70 to 110 kg ha^{-1} has been reported in the African region thus making them the most abundant soil-dwelling fauna (Moe *et al.*, 2009). Termites are mound-loving species constructing networks of mounds above and below the soil. According to Makonde *et al.* (2013), their excavating activities serve in soil engineering, influencing the composition, abundance and distribution of associating organisms. Termite mounds may differ accordingly with regards to factors related to environment, species and availability of feed. Termite mound can be cathedral or lenticular in nature but the damage they cause is independent of their mounds. Jouquet *et al.* (2017) observed that the depths for termite mounds may range between 60 and 100cm. Termites in the Subfamily Termitinae, build their mound with detritus and inorganic material, while fungus growing termites build mounds using soil and clay cemented by their salivary excretions.

In classifying the Genus *Macrotermes,* Osipitan and Oseyemi (2012) grouped this termite species under the Family Termitidae and subfamily Macrotermitinae. They have been known for the economic losses they cause in field and stored crops, tree and non-tree plants and household products (Owusu *et al.*, 2008; Samb *et al.*, 2011). Furthermore, rangelands, wood materials, books, utility poles in several parts of Africa are negatively impacted (Cox, 2004). Complete loss in economic value of agricultural and domestic products has been reported (Nyeko *et al.*, 2010). In most parts of Africa, yield losses of between 30 and 60% has been reported (UNFAO, 2000). Nyeko *et al.* (2010) reported that tree and crop losses as a result of termite attacks range from fifty percent to complete loss. In Ethiopia, economic damage as a result of termite activities ranged from 25-percent to complete loss in different crops and tree (OADB, 2001).

Effective pesticide applications have been the only remedy to the damages caused by insect pests and equally been an important part of Integrated Pest Managements (IPM). However, following several reports of developed resistance, cost effectiveness, non-target toxicity, and environmental issues, some chemical insecticide such as aldrin, dieldrin and several others have been withdrawn for use (Soomro *et al.*, 2008; Sileshi *et al.*, 2009). Considering these negative impacts, the search for persistent eco-friendly alternatives for termite control is ongoing. Studies have reported the use of different plant materials in the management of termites (Suganthy, 2013; Ojianwuna *et al.*, 2016; Ilondu and Enwemiwe, 2019; Ojianwuna and Enwemiwe, 2020b). The efficiency of *O. gratissimum* and *Vernonia amygdalina* have equally been demonstrated on beans weevils *Callosobruchus* sp. (Nta *et al.*, 2017), even that of ginger rhizome, seeds of alligator pepper and pepper fruit (Ojianwuna and Enwemiwe, 2020a), on house flies (Ojianwuna and Surveyor, 2017), ginger rhizomes, garlic, pepper and pepper fruits in single and mixed forms were also used against termites (Ojianwuna *et al.*, 2016) and *Tarchonanthus camphoratus* on maize weevils (Nanyonga *et al.*, 2015). Naphthalene has been used in the topical treatment of tungiasis lesions and were found to be effective in several concentrations and mixtures with other compounds (Enwemiwe *et al.*, 2020). Their application in the control of other pest including termites could reduce their destructive activities and produce good results, if adopted. *Macrotermes* sp. is one of the major termite species causing great economic damages to agricultural and domestic products. Thus, there is a need to control the pest using affordable and locally available indigenous plant materials (Dubey *et al.*, 2008; Khan, 2009). Some natural plants are toxic to insects including termite (Sakasegawa *et al.*, 2003).

Scent leaf (*Ocimum gratissimum*) is a popular Nigerian herb known for their medical and culinary applications. The leaf has numerous potentials but information on their toxicity in controlling termites are lacking. Similarly, kerosene, naphthalene, scent leaf in single and mixed forms have not been tried in any study relating to termites. Therefore, the present investigation was set up to determine the potentials of using scent leaf, kerosene and naphthalene in single and combined forms in the control of *Macrotermes bellicosus.*

MATERIALS AND METHODS

Study Area

This experiment was carried out in the Entomology laboratory of the Department of Animal and Environmental Biology, Delta State University, Abraka, Nigeria at temperature of 28±2ºC and humidity of 78±3%.

Plant materials Collection and Preparation

Leaves of *O. gratissimum* were collected, air-dried in an open space for 14 days, milled in an electric miller and the powder was sieved through a 0.5 mm mesh net to obtain fine homogeneous powder. The powder was stored in an ambient condition for 48 hours before use.

Source of Test Insect

Termites for this study were sourced from a termitarium in Delta State University, Abraka. Camel hair brush was used to sort the termites as described by Addisu *et al.* (2014). Termites were fed with dry wood obtained from the termitarium.

Toxicity Assay

Scent leaf powder, Kerosene, Naphthalene in their single and mixed forms were tried in 0.5, 1.0 and 1.5 concentrations with water served as control for the comparison. The concentrations include 0.5-1.5g of scent leaf, 0.5-1.5 mL of kerosene, 0.5-1.5g of naphthalene in single forms while 0.5-1.5g of scent leaf & naphthalene, 0.5-1.5g/mL of scent leaf & kerosene, and 0.5-1.5g/mL of naphthalene & kerosene at the ratio of 50:50% in mixed forms. Twenty termites were introduced into each concentration of the treatment which was in triplicate. Water served as control. The experiment was observed for 0-96 hrs. Mortality, time of mortality and repellence alongside the distance of repellence were computed. Termites in the various exposures were prickled with entomology forceps. Dead species of termite in treated groups was recorded and removed till the end of the experiment. The distance of repellence was measured with a ruler in centimetres. Repellence was calculated using the equation adopted from Yoon *et al.* (2015):

$$\text{Repellency (\%)} = \frac{UT-TT}{UT} X\ 100$$

Where:

UT = No. of termites collected from the control group

TT = No. of termites collected from the treated group

Statistical Analysis

The data for the different response variables were entered in MS Excel Spreadsheet and analyzed statistically using XL Stat for analysis of variance (ANOVA) and descriptive statistics. Probit analysis was used in the determination of lethal concentration (LC_{50} and LC_{95}). Means were compared using Tukey's test and were found to be significant at *p*<0.05.

RESULTS

Mortality Records of Termites

The results received with the single and mixed forms of different treatments are presented in Table 1 and 2. The mortality recorded with Scent leaf, Naphthalene in single forms and mixed form ranged between 18.5 and 20.00 and were found on par with each other at 5% significance.

The results obtained with Kerosene and naphthalene in single form and Kerosene & Naphthalene as well as kerosene and scent leaf in mixed forms indicated the highest mortality and there is no significant difference between the treatments.

Table 1. Mean mortality of termites exposed to scent leaf and naphthalene in their single and mixed forms. Means of similar superscript letter do not differ significantly between treatments (p<0.05).

Treatment	Conc. (grams)	Log dose	Mean mortality ±SE	Lower bound 95% CI	Upper bound 95% CI
Water	0.0	0.00	0.0 ±0.28[a]	-0.6	0.6
Scent leaf	0.5	-0.30	18.5±0.28[b]	17.9	19.1
	1.0	0.00	19.0 ±0.28[b]	18.4	19.6
	1.5	0.18	20.0 ±0.28[b]	19.4	20.6
Naphthalene	0.5	-0.30	20.0 ±0.28[b]	19.4	20.6
	1.0	0.00	20.0 ±0.28[b]	19.4	20.6
	1.5	0.18	20.0 ±0.28[b]	19.4	20.6
Naphthalene + Scent leaf	0.5	-0.30	19.5 ±0.28[b]	18.9	20.1
	1.0	0.00	20.0 ±0.28[b]	19.4	20.6
	1.5	0.18	20.0 ±0.28[b]	19.4	20.6

Table 2. Mean mortality of termites exposed to Kerosene, kerosene + naphthalene and kerosene + scent leaf.

Treatment	Conc.	Log dose	Mean mortality ±SE	Lower bound 95% CI	Upper bound 95% CI
Water	0.0	0.00	0.0 ±0.28[a]	-0.6	0.6
Kerosene	0.5	-0.30	20.0±0.28[b]	19.4	20.6
	1.0	0.00	20.0±0.28[b]	19.4	20.6
	1.5	0.18	20.0 ±0.28[b]	19.4	20.6
Kerosene + Naphthalene	0.5	-0.30	20.0 ±0.28[b]	19.4	20.6
	1.0	0.00	20.0 ±0.28[b]	19.4	20.6
	1.5	0.18	20.0 ±0.28[b]	19.4	20.6
Kerosene + Scent leaf	0.5	-0.30	20.0 ±0.28[b]	19.4	20.6
	1.0	0.00	20.0 ±0.28[b]	19.4	20.6
	1.5	0.18	20.0 ±0.28[b]	19.4	20.6

Note: Kerosene was measured in mL, kerosene + naphthalene and Kerosene + scent leaf were measured in g/mL. Means of similar superscript letter were not significant between treatments (p<0.05).

Termite mortality with time

The results recorded with time mortality of termites exposed to scent leaf, naphthalene and kerosene in single and mixed forms at different concentrations is presented in Table 3. After 6 hours of exposure, 1.0 and 1.5mLof kerosene, 0.5 and 1.5 g/mL of kerosene + naphthalene and

1.0g/mL of kerosene + scent leaf recorded the highest mortality while 0.5g of scent leaf recorded the lowest mortality (2.00). After 24 hours of exposure, all the termites in the treatment concentrations were dead except in 0.5 and 1.0g of scent leaf. There was no significant difference between the time mortality recorded in 1.0g of scent leaf, 1.0g of naphthalene, 1.0 and 1.5mL of kerosene, 0.5 to 1.5g/mL of kerosene + naphthalene and 1.0g/mL of scent leaf and kerosene. The difference between the time mortality recorded in 0.5g and 1.5g of scent leaf was equally not significant. Furthermore, the differences between 0.5g of naphthalene, 0.5 and 1.0g of naphthalene and scent leaf, 0.5mLof kerosene, and 1.5g/mL of kerosene and scent leaf was not significant *p*> 0.05.

Table 3. Time mortality records of termites exposed to scent leaf, naphthalene and kerosene in single and mixed forms at different diagnostic concentrations

Treatment	Conc.	Log Dose	0-6hrs	6-24hrs
Water	0.0	0.00	0.0 ±0.99a	0.0 ±0.99a
Scent leaf	0.5	-0.30	2.0 ±0.99a	18.5 ±0.99[cde]
	1.0	0.00	14.5 ±0.99[bcde]	19.0 ±0.99[de]
	1.5	0.18	2.5 ±0.99a	20.0±0.99[bcde]
Naphthalene	0.5	-0.30	16.0 ±0.99[cde]	20.0 ±0.99[bcde]
	1.0	0.00	15.5 ±0.99[bcde]	20.0 ±0.99[bcde]
	1.5	0.18	13.0 ±0.99[bc]	20.0 ±0.99[bcde]
Naphthalene & Scent leaf	0.5	-0.30	17.0 ±0.99[cde]	20.0 ±0.99[bcde]
	1.0	0.00	18.0 ±0.99[cde]	20.0 ±0.99[bcde]
	1.5	0.18	13.5 ±0.99[bcd]	20.0 ±0.99[bcde]
Kerosene	0.5	-0.30	18.0 ±0.99[cde]	20.0 ±0.99[bcde]
	1.0	0.00	20.0 ±0.99[bcde]	20.0 ±0.99[bcde]
	1.5	0.18	20.0 ±0.99[bcde]	20.0 ±0.99[bcde]
Kerosene & Naphthalene	0.5	-0.30	20.0 ±0.99[bcde]	20.0 ±0.99[bcde]
	1.0	0.00	14.5 ±0.99[bcde]	20.0 ±0.99[bcde]
	1.5	0.18	20.0 ±0.99[bcde]	20.0 ±0.99[bcde]
Kerosene & Scent leaf	0.5	-0.30	10.0 ±0.99[b]	20.0 ±0.99[bcde]
	1.0	0.00	20.0 ±0.99[bcde]	20.0 ±0.99[bcde]
	1.5	0.18	18.5 ±0.99[cde]	20.0 ±0.99[bcde]

Note: Scent leaf and naphthalene was measured in grams, kerosene was measured in mL, kerosene & naphthalene and Kerosene & scent leaf was measured in g/mL. Means of similar superscript letter were not significant between treatments (p<0.05).

Repellency records

The mean repellency of termites exposed to scent leaf and naphthalene in their single and mixed forms is presented in Table 4. Repellency was highest in 0.5 g naphthalene and all other concentrations of scent leaf and naphthalene. The difference was not significant at *p*> 0.05.

Table 4. Mean repellency of termites exposed to scent leaf and naphthalene in their single and mixed forms.

Treatment	Conc. (grams)	Log dose	Mean mortality ±SE	Lower bound 95% CI	Upper bound 95% CI
Water	0.0	0.00	1.00±0.04[c]	0.9	1.1
Scent leaf	0.5	-0.30	0.13±0.04[ab]	0.1	0.2
	1.0	0.00	0.3 ±0.04[b]	0.2	0.3
	1.5	0.18	0.1 ±0.04[ab]	0.01	0.15
Naphthalene	0.5	-0.30	0.0 ±0.04[a]	-0.1	0.1
	1.0	0.00	0.1 ±0.04[ab]	-0.02	0.13
	1.5	0.18	0.1 ±0.04[ab]	-0.02	0.13
Naphthalene & Scent leaf	0.5	-0.30	0.0 ±0.04[a]	-0.1	0.1
	1.0	0.00	0.0 ±0.04[a]	-0.1	0.1
	1.5	0.18	0.0 ±0.04[a]	-0.1	0.1
Kerosene	0.5	-0.30	0.0 ±0.04[a]	-0.1	0.1
	1.0	0.00	0.0 ±0.04[a]	-0.1	0.1
	1.5	0.18	0.0±0.04[a]	-0.1	0.1
Kerosene & Naphthalene	0.5	-0.30	0.0 ±0.04[a]	-0.1	0.1
	1.0	0.00	0.0 ±0.04[a]	-0.1	0.1
	1.5	0.18	0.0 ±0.04[a]	-0.1	0.1
Kerosene& Scent leaf	0.5	-0.30	0.0 ±0.04[a]	-0.1	0.1
	1.0	0.00	0.0 ±0.04[a]	-0.1	0.1
	1.5	0.18	0.0 ±0.04[a]	-0.1	0.1

Note: Kerosene was measured in ml, kerosene & naphthalene and Kerosene & scent leaf was measured in g/mL. Means of the same superscript letter do not differ significantly between treatments (*p*<0.05).

Repellency was not observed in the control. The mean repellency of termites exposed to kerosene, kerosene & naphthalene and kerosene & scent leaf is shown in Table 5. All the concentrations of the treatment recorded highest repellency. There was no significant difference in the termites exposed to the various concentrations at *p*>0.05. The mean distance of repellency of termites exposed to scent leaf, kerosene and naphthalene in their single and mixed forms is presented in Table 5.

Toxicity Bioassay

The susceptibility status of termites to scent leaf, kerosene and naphthalene in their single and combined forms showed that LC_{50} and LC_{95} values ranged from 0.086 to 0.347 and 0.071 to 0.471 respectively. This study found that all the termites exposed to the various treatments were susceptible and a higher susceptibility in all groups except the scent leaf group. There was no significant difference between the treatments with regard to repellency recorded at $p > 0.05$. Considering the distance of repellency, 1.5g of kerosene and scent leaf recorded the maximum distance and was followed by 0.5g of naphthalene. The mean distance recorded in 1.5g of scent leaf, 1.5g of kerosene, and 0.5 g/mL of kerosene & naphthalene found on par.

Table 5. Mean distance of repellency of termites exposed to scent leaf and naphthalene in their single and mixed forms.

Treatment	Conc. (grams)	Log dose	Mean distance ±SE	Lower bound 95% CI	Upper bound 95% CI
Water	0.0	0.00	0.0 ±0.94[a]	-2.0	2.0
Scent leaf	0.5	-0.30	5.5 ±0.94[b]	3.5	7.5
	1.0	0.00	6.8 ±0.94[b]	4.8	8.7
	1.5	0.18	7.3 ±0.94[b]	5.3	9.2
Naphthalene	0.5	-0.30	7.8 ±0.94[b]	5.8	9.7
	1.0	0.00	6.3 ±0.94[b]	4.3	8.2
	1.5	0.18	3.8 ±0.94[ab]	1.8	5.7
Naphthalene + Scent leaf	0.5	-0.30	6.9 ±0.94[b]	4.2	8.2
	1.0	0.00	6.7 ±0.94[b]	4.9	8.8
	1.5	0.18	5.8 ±0.94[b]	3.8	7.8
Kerosene	0.5	-0.30	5.8 ±0.94[b]	3.8	7.7
	1.0	0.00	5.5 ±0.94[b]	3.5	7.5
	1.5	0.18	7.3 ±0.94[b]	5.3	9.2
Kerosene + Naphthalene	0.5	-0.30	7.3 ±0.94[b]	5.3	9.2
	1.0	0.00	4.5 ±0.94[ab]	2.5	6.5
	1.5	0.18	5.3 ±0.94[ab]	3.3	7.2
Kerosene + Scent leaf	0.5	-0.30	6.2 ±0.94[b]	4.2	8.2
	1.0	0.00	6.2 ±0.94[b]	4.2	8.2
	1.5	0.18	7.9 ±0.94[b]	5.9	9.8

Note: Kerosene was measured in ml, kerosene + naphthalene and Kerosene + scent leaf was measured in g/ml. Means of similar superscript letter were not significant between treatments ($p<0.05$).

It was equally observed that mortality records in kerosene alone, kerosene and naphthalene mixture, kerosene and scent leaf mixture, naphthalene alone, and scent leaf & naphthalene followed similar pattern of regression model curve and reporting similar goodness of fit (Table 6).

DISCUSSION

The effect of *O. gratissimum*, kerosene and naphthalene in their single and mixed forms at various concentrations in the management of *Macrotermes* was conducted. The present study showed that all treatments were toxic and deterred the activities of termites compared to the control groups.

Table 6. Susceptibility of termites to scent leaf, kerosene and naphthalene in their single and combined forms.

Treatments	N	Regression line	Pearson χ^2 goodness of fit	LC_{50} (95% CI)	LC_{95} (95% CI)
O. gratissimum	60	Y= 1.80X + 1.92	2.43	0.086 (0.081-0.098)	0.071 (0.061-0.080)
Naphthalene	60	Y= 12.36X + 5.68	0.0001	0.347 (0.258-0.429)	0.471 (0.342-0.572)
Kerosene	60	Y= 12.36X + 5.68	0.0001	0.347 (0.258-0.429)	0.471 (0.342-0.572)
Kerosene + Naphthalene	60	Y= 12.36X + 5.68	0.0001	0.347 (0.258-0.429)	0.471 (0.342-0.572)
Kerosene + Scent leaf	60	Y= 12.36X + 5.68	0.0001	0.347 (0.258-0.429)	0.471 (0.342-0.572)
Scent leaf + Naphthalene	60	Y= 12.36X + 5.68	0.0001	0.347 (0.258-0.429)	0.471 (0.342-0.572)

N: Total number of mosquitoes assayed; 50% and 95% lethal concentration, LC_{50} and LC_{95}, are in mL; 95% confidence interval; p> 0.05 suggests a well

High mortality was recorded in all concentrations of the treatment except in 0.5 and 1.0g of *O. gratissimum* and 0.5g of naphthalene and *O. gratissimum* mixture. Adebowale and Adedire (2006) reported that essential oils, leaf powders, resins, dust of roots and woods inhibit the growth, survival and feeding potential of insect pests. The use of other botanicals such as *Azadirachta indica*, *Nicotiana tabacum* and *J. curcas* reported in the study of Ajayi *et al.* (2020) caused complete mortality in worker termites after 4hrs while complete mortality was recorded in soldier termites after 6 hrs with these plant materials in their mixed forms. In this study various degrees of mortality was recorded with powders of *O. gratissimum* used. Time mortality was highly recorded within 0 to 6 hrs in 1.0g of *O. gratissimum* compared to other concentrations. The distance of repellency ranging from 5.50 to 7.25cm. The findings of this study corroborates the above reports.

Termites exposed to naphthalene, and kerosene + naphthalene mixture showed complete mortality, high repellency and distance of repellency. According to observation made by Chen *et al.* (2013) naphthalene have been widely adopted as supplements in cosmetic, food, valuable ingredient in local insecticides, as well as topically for medical applications. Juteau *et al.* (2002) confirmed that naphthalene is the major component of synthetic camphor constituting of 37% of the compounds, cineole (30%), and 5% of α-terpineol and safrole respectively. Naphthalene alone in this study alongside its mixture with kerosene caused 100% mortality. Mortality in the all concentrations of naphthalene occurred 6 to 24 hrs after exposure. However, in their mixture with kerosene 0.5 and 1.5 g/mL caused 100% mortality below 6 hrs of exposure. It is probable that all concentrations of this mixture caused complete mortality but the repellency recorded might have caused the delayed mortality in 1.0g/mL of naphthalene and kerosene mixture. This study is new as current reports on the efficiency of scent leave, kerosene and naphthalene on termite are lacking. More so, all concentrations of naphthalene and kerosene mixture caused high repellency whereas in the naphthalene applied singly, the lowest concentration caused the highest repellency. Henderson *et al.* (2005) has reported that several active ingredients of naphthalene makes them effective toxicants and repellents of termites, thus the resulting significant decline in termite activities. They also confirmed that concentration as low as 8 mg/kg dust would reduce termites tunneling and feeding activity. Other characteristics such as inability to molt in some dead termites have been observed. The observation in the study of Henderson *et al.* (2005) corroborates the findings of this study for termites exposed to naphthalene, and kerosene and naphthalene mixture. The distance of repellency ranged from 3.75 to 7.75cm in the naphthalene group and 4.50 to 7.25cm in the kerosene and naphthalene group. Obeng-Ofori *et al*. (1998) noted that topical application of naphthalene caused high mortality and acted as deterrent to the storage pests. The toxicity of pests was dependent on the highest concentrations which exerted mortalities over 90% in a day. Contact toxicity was more effective than noncontact. The present findings are in accordance with the above reports.

O. gratissimum recorded complete mortality at higher concentrations. At 1.0 and 1.5g of naphthalene + *O. gratissimum* mixture equally caused complete mortality in termites. In the same vein at all concentrations of kerosene + *O. gratissimum* caused complete mortality. This predicts that 1.5g of *O. gratissimum* is sufficient to cause mortality without 50% mixture with other treatments. The toxicity recorded in the best concentration of *O. gratissimum* is in agreement with the study of Ekhuemelo *et al.* (2017) who earlier reported termicidal effect. However Ajayi *et al.* (2020) reported that mortality rates in termites is hinged on the active ingredients in plant material, time of treatment as well as nature of mound. The mortality recorded in this present study also agrees with the study of Shiberu *et al.* (2013) which recorded complete mortality in termites with the three insecticidal plants after 24 hours. Similarly, the study of Ssemaganda *et al.* (2011) showed that engine oil induced mortality and reduce susceptibility of wood to termite attack. Although, this present study adopted kerosene and their mixtures with leaf powder of *O. gratissimum*. The use of kerosene as treatment against termite activities has not been reported but this study has shown it to be effective causing high toxicity in termites. This may be due to the hydrocarbons present in the kerosene that suffocates the termite causing difficulty in breathing. It could also be explained that carbon content in kerosene oxidize to form carbon dioxide a respiratory waste in termite species. In this study only 1.0g/mL of kerosene and naphthalene exerted 100% mortality in less than 6 hrs. The other concentration of the mixture and naphthalene and *O. gratissimum* mixture caused mortalities within 6 to 24 hrs. The repellency recorded in this study was higher than those reported in the study of Ajayi *et al*. (2020) where termites exposed to the mixture of two botanicals within 4 hrs had the most repellency.

All concentration of kerosene caused complete mortality. This mortality occurring within 0 to 6 hours after exposure for 1.0 and 1.5 mL of kerosene treatment. This observation is in accordance with the reports of Ekedo *et al.*

(2019) where *Anopheles* mosquitoes were highly susceptible to petroleum products after minutes of exposure in in potential breeding habitats. Similarly, Ojianwuna *et al.* (2021) observed high mortality in *Aedes* larvae and pupae exposed to petroleum products. Kerosene in this present study was effective with 100% mortality with lethal concentration (LC_{50}) of kerosene high at 0.347mL and LC_{95} at 0.471mL. This trend of LC_{50} and LC $_{95}$ was equally observed for naphthalene, kerosene and naphthalene, kerosene and *O. gratissimum*, and naphthalene and *O. gratissimum* respectively. The study of Fu *et al.* (2015) confirmed the lethal dose (LC_{50}) of the naphthalene contained essential oil capable of causing high mortality in termites within a day with knockdown time (*kdt*) for 50% recorded below 15 minutes. Their treatments observed reduced termite attacks, feeding as well as working activities. The results of the present findings are in accordance with that of Fu *et al.* (2015).

This study has demonstrated that all concentrations of *O. gratissimum,* naphthalene, kerosene in single and mixed forms showed anti-termite activities. All treatment concentrations caused complete mortality except 0.5 and 1.0g of *O. gratissimum,* 0.5g of naphthalene + *O. gratissimum*. All concentrations of kerosene, 0.5 and 1.5g/ml of naphthalene and kerosene, 1.0g/mL of kerosene and *O. gratissimum* caused complete mortality within 6 hours of post treatment. Repellency and their distances being remarkably high in all concentrations. Lethal concentrations of all treatment being similar except for *O. gratissimum.* Thus, adopting the best concentrations of *O. gratissimum,* the other treatments in their single forms as well as the mixed forms would limit the destructive activities and economic losses caused by termites.

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