Journal of Agriculture and Ecology Research International
8(2): 1-10, 2016; Article no.JAERI.26185
ISSN: 2394-1073

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Biocidal Properties of *Chrysopogon zizanioides* Extracts in the Control of Termites *(Microcerotermes beesoni)*

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Authors' contributions

This work was carried out in collaboration between all authors. Author OFO designed the study, wrote the protocol and wrote the first draft of the manuscript. Author TJO provided the materials. Authors OFO and COA managed the literature searches. Authors COA and ASA handled the chemical analyses of the study. Authors OFO and COA discussed the conclusion. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAERI/2016/26185
Editor(s):
(1) Daniele De Wrachien, Department of Agricultural and Environmental Sciences of the State University of Milan, Italy.
Reviewers:
(1) Khalid Shawky Hamadah, Al-Azhar University, Egypt.
(2) P. Dhasarathan, Prathyusha Engineering College, Anna University, Chennai, India.
Complete Peer review History: http://sciencedomain.org/review-history/14798

Original Research Article

Received 4th March 2016
Accepted 10th May 2016
Published 27th May 2016

ABSTRACT

Laboratory experiments were conducted on the insecticidal properties of n-Hexane and ethanolic extracts of the leaves and roots of *Chrysopogon zizanioides* in the control of a caste of *Microcerotermes beesoni*, termites. Dried and fresh parts of the plant were used for the experiment. The mature fresh leaves and roots used were chopped into matchstick sizes, pulverized and excavated differently in n-hexane and ethanol while studies on the dried parts involved sun-drying before extraction in the solvents. Similarly, different castes of termites obtained from a termitarium were cultured in a jar in the laboratory. The extracts from *C. zizanioides* were applied differently on the castes of *M. beesoni* and efficacy was determined through insect mortality rate. Observation showed that all the extracts

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were highly effective with the highest vigour experiential in the dried root n-hexane extract within 5 seconds.

Keywords: Plant extract; pesticide; termite; efficacy; Akungba-Akoko.

1. INTRODUCTION

Chrysopogon zizanioides (L) Nash belongs to the family Graminales; Poaceae, a native of India and possesses extensive root system beneficial in the soil for water conservation where erosion is problematic according to [1,2]. In Western and Northern India it is popularly known as “Khus”. The common name for *C. zizanioides* is “Vetiver” grass, and the local name “Apakan”. Vetiver grass can grow up to 1.5 m to 2 m high and form clumps as wide. The stem are tall and the leaves are long, thin and rigid; the flowers are brownish-purple, the roots grow downward to about 2-4 m depth. It is related to sorghum and share many morphological characteristics with other fragrant grasses like *Cymbopogon citrates* (Lemon grass), *C. martini* (Palmarosa), and *C. nardus* (Citronella). *C. zizanioides* is widely cultivated as ornamental plant and grows as hedges in the house. It is also planted to control erosion alongside the slopes. *C. zizanioides* prefers arid environment. [3] report gave an account that the root system of Vetiver contained essential oils and that its main chemical components were Benzoic acid, vetiverol, furfurol, valencene, calerene, khusimene, khusimone, “a” and “b” vetivone, vetinene, vetinyl, vetinate and epizizanol. Vetiver had been confirmed to be important in medicine where various tribes use different parts of the plant for many of their ailments such as mouth ulcer, fever, boil, epilepsy, burn, snake bite, scorpion sting and decoction of the roots as tonic for weakness; and also the leaves are used in basketry, mat weaving, roof thatching. Consequently, the chemical components of the root of the plant have been reported to be very important because they possess fungicidal, herbicidal and insecticidal properties as [4] reported the inhibitory properties of its oil against germination of seed expansion in a variety of economically important weed species while [5-7] also reported its repellant properties against ants, cockroaches, bedbugs, head lice, flies, moths and (termites) *Microcerotermes beesoni*.

This research is focused on the termicidal properties of vetiver and its adoptive use in the developing country. [8,9] gave similar reports that, as a highly devastating pest, termites have caused tremendous damages and losses to finished and unfinished wooden structures in the buildings, loss in agricultural crops and forestry products. Similarly, [10,11] confirmed termites to be subterranean in nature thereby making it difficult to locate them while [12] report that termites cause up to 36% and 62% reduction in yields of both agricultural crop and forestry products respectively. The common method of termite control which had been cultural involved the removal of the queen, mould destruction, flooding with water and hot pepper. Also, the use of hot ash was either partially effectively or not at all. [11,13] also share similar opinion that the control methods adopted in termite control heavily depends on the synthetic chemicals especially organo-chorides, BHC, Dichlorophenyltrichloroethane which are currently banned from the world market due to their persistence toxicity. On the use of botanicals in termite control, [14] report that many plants species like Neem (*Azadiracta indica*) and *Ipomea fistulosa* have been used and also seen to possess insecticide and repellant properties to termites. According to [15], incorporating the derivatives of plant materials into annual cropping system may provide an ecological sound method in termites’ control.

Based on extensive review of adoptive use of botanicals in termite control, this paper therefore reports a comprehensive laboratory and field work experiment conducted on the control of termites in a locality in Nigeria through the extracts of the floral parts of vetiver.

2. MATERIALS AND METHODS

2.1 Study Area

This research was conducted at the laboratories of the Department of Plant Science and Biotechnology and the Department of Chemistry and Industrial Chemistry, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria.

2.2 Plant Collection

Mature grasses of *Chrysopogon zizanioides*, Vetiver plant were collected from a village near Akungba-Akoko, Ondo State, Nigeria. The plant was authenticated at the Department of Botany, University of Ibadan and further confirmed at International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State.

2.3 Collection and Culturing of Termites

M. beesoni castes were collected from their natural habitat (Termitarium) using the trapping method described by [16]. The colonies which consisted of 160 workers and 80 soldiers used for the experiment were cultured in McCartney bottles containing part of their termitarium in the laboratory at 28℃.

2.4 Preparation of Dried Samples of Vetiver Plant Parts

The leaves and roots of the plants were rinsed with water and air dried at room temperature of 25℃ for a month to ensure sufficient air flow so as to avoid damping. After a month of air-drying, the dried samples were pulverized into powdery form by using Marlex blender at different minutes, where the leaves were grinded for 45 minutes and the root for 35 minutes.

The samples were then weighed on a sensitive weighing balance. 359 g of the dried leaves and 250 g of the dried roots were used for the experiment. Consequently, Ethanol and n-hexane were the solvents used by cold extraction technique where 179.5 g each of the dried leaves was soaked in n-hexane (700 ml) and ethanol (700 ml); similarly, 125 g each of the dried roots was also soaked in n-hexane and ethanol in Winchester bottles with the caps wrapped with paper tape. The samples were left to ferment for seven (7) days. These were mixed by using electric shaker for about 2 minutes and repeated 3 times daily.

2.5 Production of Extract from Dried Leaves of Vetiver Plant

At the end of the 7^{th} day, the extract was then filter using vacuum filtration through the Buchner funnel. The filtrate was immediately poured into the rotatory evaporator and the temperature set at the boiling point of each of the solvents under reduced pressure to obtain a concentrated extract of the dried leaves. The extracts were preserved in a covered conical flask and refrigerated in the laboratory throughout the experiment.

2.6 Preparation of Fresh Samples of Vetiver Plant Parts

Fresh roots and leaves of *C. zizanioides* were obtained. The leaves and roots were chopped into matchstick sizes, and the samples were weighed with a sensitive weighing balance. Weighed 400 g of fresh leaves and 800 g of fresh roots were soaked differently in 700 ml ethanol and 700 ml n-hexane in a 3 litre-bucket with closed lid. The samples were left to ferment for 7 days. These samples were mixed using electric shaker for 2 minutes and repeated 3 times daily.

It was then filtered through the Buchner funnel using vacuum filtration. The filtrate from the Winchester was immediately poured to the rotatory evaporator and the temperature set at the boiling point of each of the solvents under reduced pressure to obtain the extracts from the fresh leaves. The extracts were preserved in a covered conical flask and refrigerated in the laboratory throughout the experiment.

2.7 *In vitro* Test

This consisted of four replicates each for the dried and fresh extracts from the leaves and roots as well as 20 workers and 10 soldiers. 10 drops of 5%, 4%, 3%, 2% and 1% of all the extracts were applied with syringe on the termites for contact treatment. Mortality rate was monitored and recorded. Similarly, the same number of termite colony was maintained for an *in vitro* test using 100% n-hexane and ethanol.

3. RESULTS AND DISCUSSION

3.1 *In vitro* Tests

In the *in vitro* tests, all the extracts at the different concentrations had termicidal properties. Complete termite mortality ranged between 5 and 46 seconds. The most effective concentration was observed in the 5% dry root n-hexane extract showing complete termite mortality within 5 seconds. The least effective was 1% of fresh leave ethanolic extract which showed complete termite mortality in 46 seconds.

On the affirmation of lethal properties with treatment applications of 100% n-hexane and ethanol, observations showed that the solvents had a very weak effect on the termites and gave zero mortality.

The result showed that the mortality rate of *M. beesoni* at different concentrations of dry *C zizanioides* roots n-hexane extract was within 60 seconds, Fig. 1. The mortality rate was highest at 5% of n-hexane observed within 0 and 15 seconds.

The results showed the mortality rate of *M. beesoni* at different concentrations within 60 seconds, Fig. 2. The mortality rate was highest at 5% with no significant difference with 4% n-hexane *of C. zizanioides.*

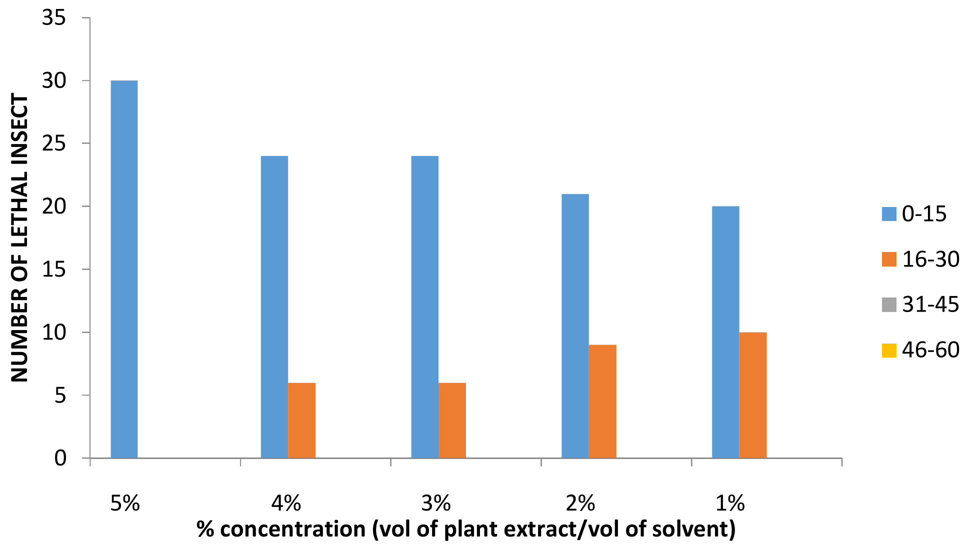

Fig. 1. Mortality rate of *M. beesoni* using n-hexane extract of dry root of *C. zizanioides* at different concentrations of 1-5% vol of plant extract/vol of n-hexane extract monitored at 0-15, 16-30, 31-45 and 46-50 seconds

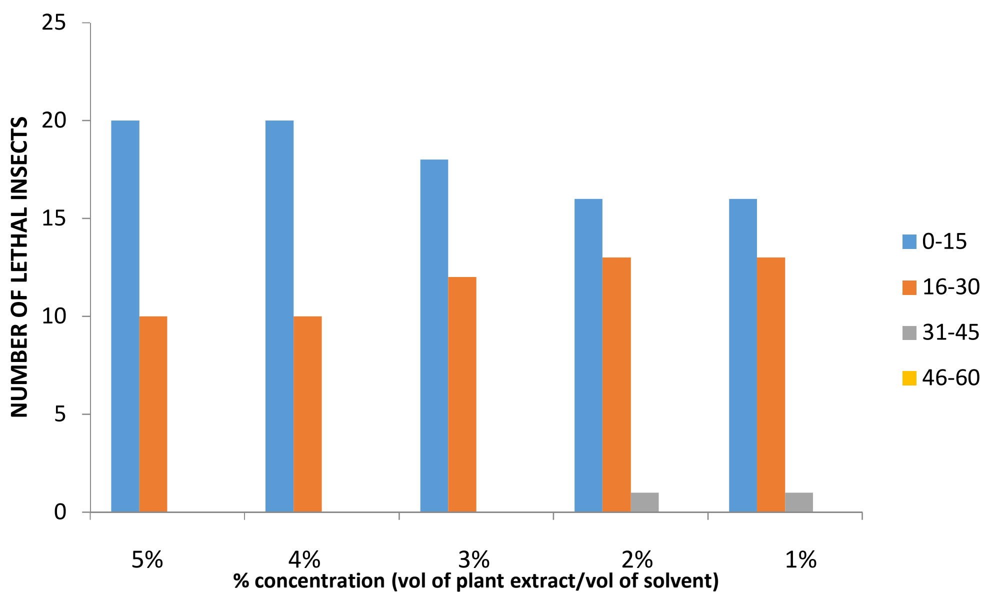

Fig. 2. Mortality rate of *M. beesoni* using n-hexane extract of fresh root of *C. zizanioides* extract at different concentrations of 1-5% vol of plant extract/vol of n-hexane extract monitored at 0-15, 16-30, 31-45 and 46-50 seconds

The results showed the mortality rate of *M. beesoni* at different concentrations within 60 seconds, Fig. 3. There was no significant difference between mortality rate observed at 5% and 4% n-hexane of *C. zizanioides* but there were significant differences between the highest concentrations and others.

The results showed the mortality rate of *M. beesoni* at different concentrations within 60seconds, Fig. 4. The mortality rate was also highest at 5% and 4% n-hexane of *C. zizanioides* but were significantly different from other concentrations.

The results showed the mortality rate of *M. beesoni* at different concentrations within 60 seconds, Fig. 5. The mortality rate was highest at 5% and 4% ethanolic extract of *C. zizanioides.* This mortality rate was significantly different from other extract concentrations.

The results showed the mortality rate of *Microcerotermes beesoni* at different concentrations within 60seconds, Fig. 6. The mortality rate was highest at 5% and 4% ethanolic extract of C. *zizanioides.* This mortality rate was significantly different from other extract concentrations.

The results showed the mortality rate of *M. beesoni* at different concentrations within 60 seconds, Fig. 7. The mortality rate was highest at 5% and 4% ethanolic extract of *C. zizanioides.* This mortality rate was significantly different from other extract concentrations.

The results showed the mortality rate of *M. beesoni* at different concentrations within 60 seconds, Fig. 8. There were not much significant differences at the different levels of treatment application since considerable number of termites were eliminated due to longer time frame.

In a general term, the use of plant extracts in this experiment was never at variance to the previous documented researches on the use of botanicals in pest control. Consequently, the efficacy of vetiver corroborates its documentation by [6,5,7] reported on the repellant properties of vetiver against ants, cockroaches, bedbugs, head lice, flies, moths and (termites) *M. beesoni*.

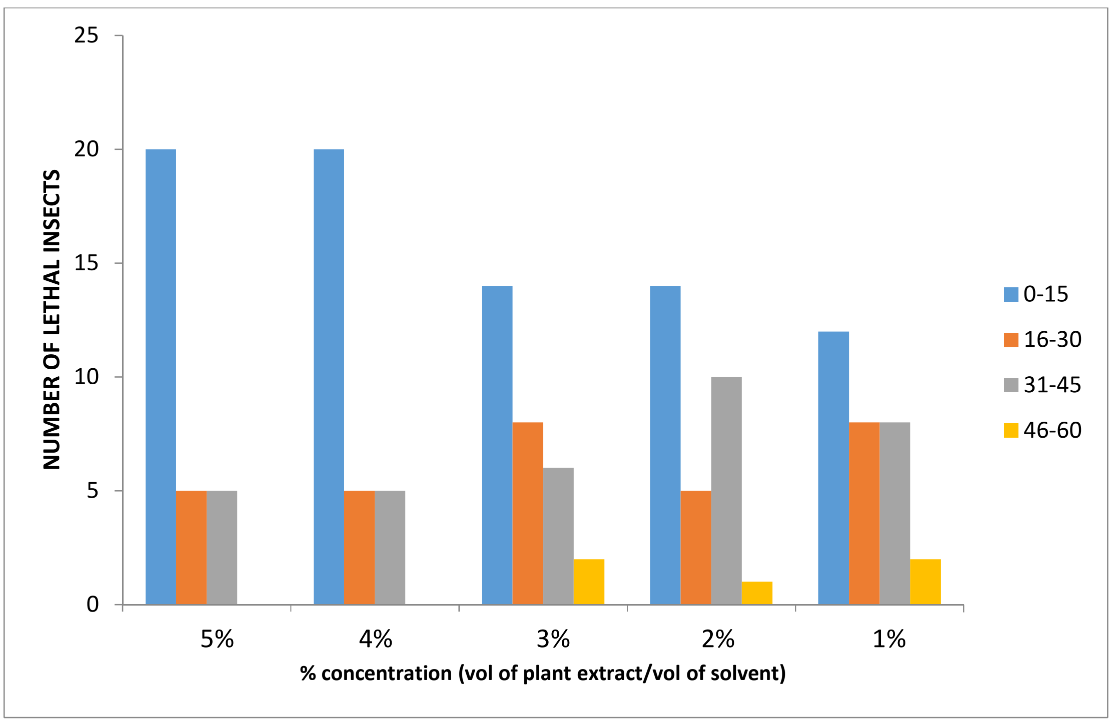

Fig. 3. Mortality rate of *M. beesoni* using n-hexane extract of dry leaves of *C. zizanioides* extract at different concentrations of 1-5% vol of plant extract/vol of n-hexane extract monitored at 0-15, 16-30, 31-45 and 46-50 seconds

The work ascertains the rate and efficacy of action of *C. zizanioides.* Consequently, the *in vitro* treatment applications of n-hexane and ethanol on mortality and their subsequent efficacy in termite control further establishes the fact that the tendencies for termite mortality could also have been attributable to the properties of *C. zizanioides.* The mortality vigour of *M. beesoni* with the use root extract against termites further corroborates the view of [17] that the highest toxicity compound of vetiver was found in the dried roots n-hexane extract. Therefore, the toxicity of these solvents depends upon the plants extracts as reported by [18]. Similarly, [19] had also attributed the insecticidal activity of the dried root oil of *C. zizanioides* to the presence of several active components. For efficiency, the concentration of vetiver in the active solvent used remains very significant. In this research, the use of 5%/vol. of extract is highly significant and rational in terms of efficacy and cost effectiveness. This also corroborates the report of [20] that the maximum wood protection against *M. beesoni* (termites) by *C. zizanioides* oil and its toxic component were obtained at the highest concentration. Although with differences in the rate of mortality, all parts of vetiver used in the research could be supposed to have termicidal properties. This consequently supports the earlier opinion of [21] that all parts of vetiver are significant in pest control.

The habitat and availability of vetiver is also of utmost importance. Being a plant that can grow in the form of tufts as wide and could be widely cultivated as ornamental plant as well as common hedges in the house, the cultivation of the plant for adoptive use in plant control will pose no stress. This gives an indication that individuals could conveniently cultivate and nurture vetiver at homes contrary to the use of synthetic insecticides which may not be readily available and are also expensive.

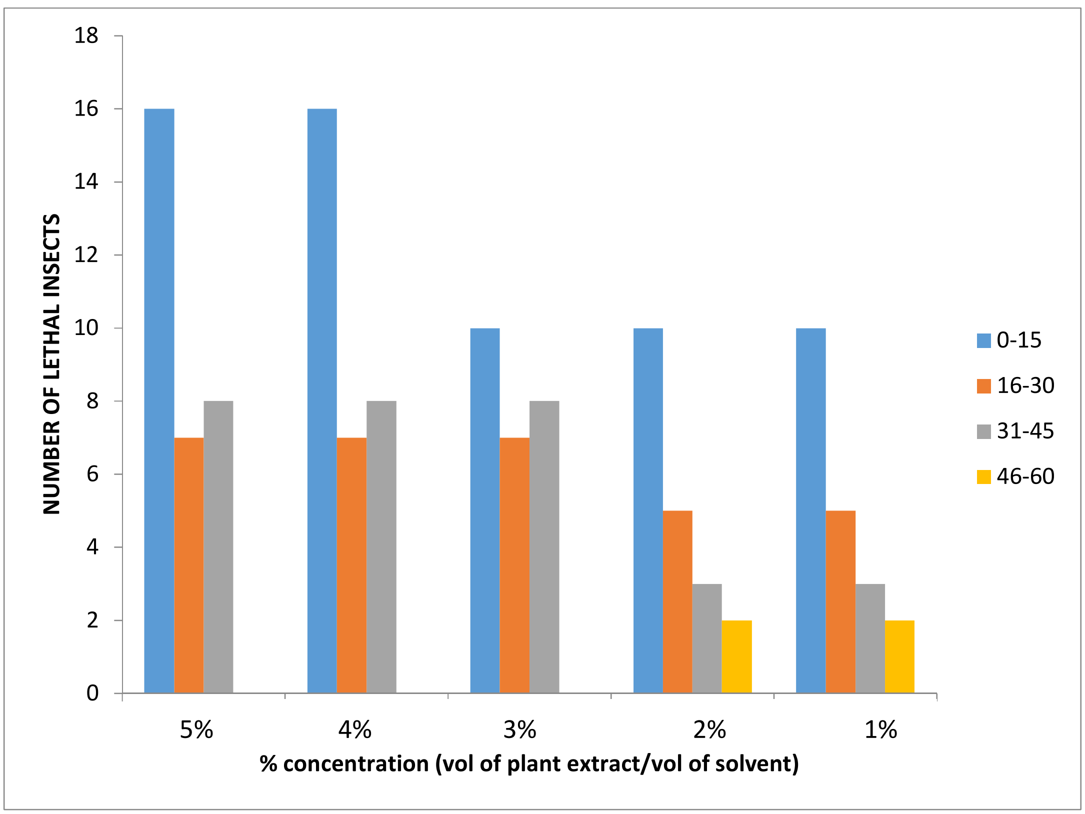

Fig. 4. Mortality rate of *M. beesoni* using n-hexane extract of fresh leaves of *C. zizanioides* extract at different concentrations of 1-5% vol of plant extract/vol of n-hexane extract monitored at 0-15, 16-30, 31-45 and 46-50 seconds

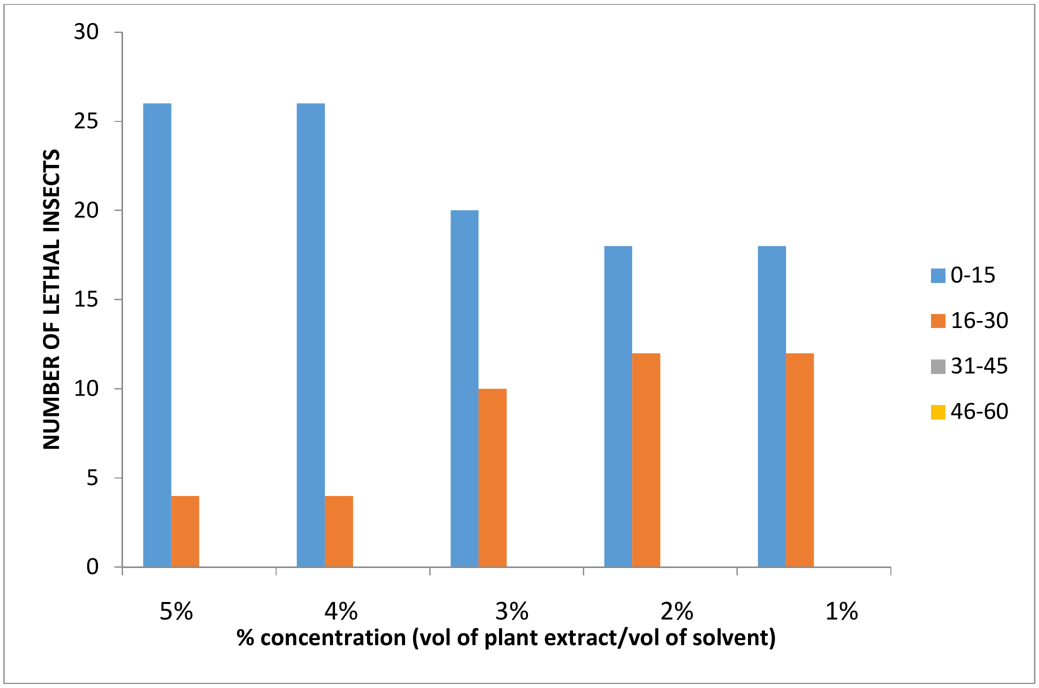

Fig. 5. Mortality rate of *M. beesoni* using ethanolic extract of dry root of *C. zizanioides* extract at different concentrations of 1-5% vol of plant extract/vol of n-hexane extract monitored at 0-15, 16-30, 31-45 and 46-50 seconds

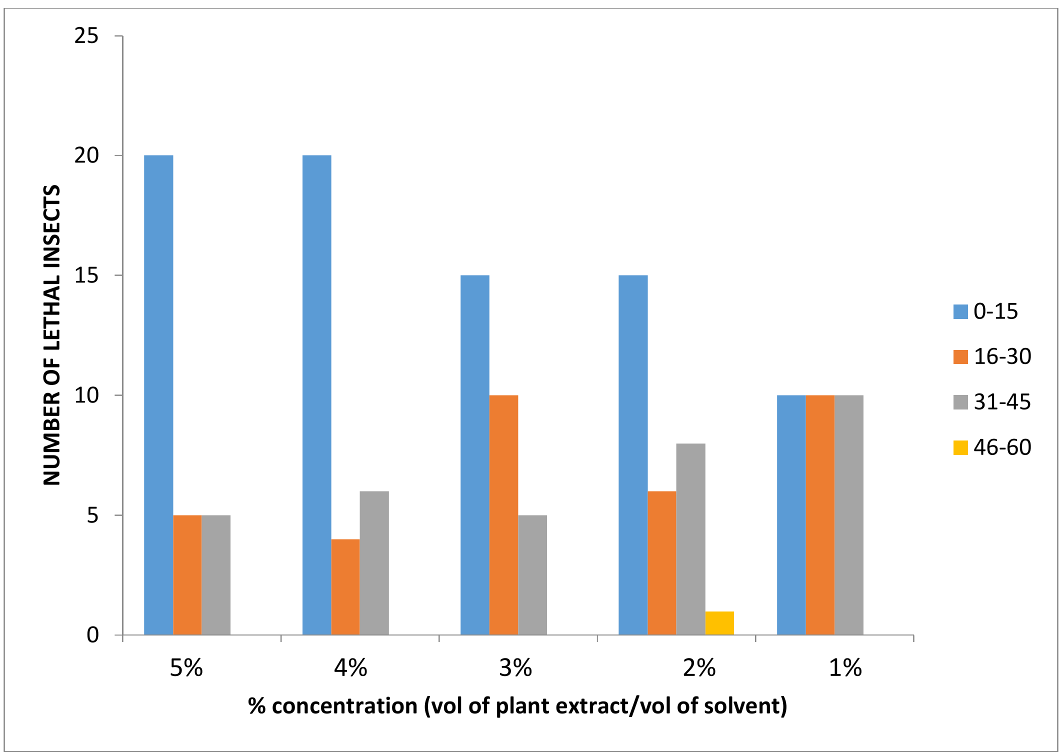

Fig. 6. Mortality rate of *Microcerotermes beesoni* using ethanolic extract of fresh root of *Chrysopogon zizanioides* extract at different concentrations of 1-5% vol of plant extract/vol of n-hexane extract monitored at 0-15, 16-30, 31-45 and 46-50 seconds

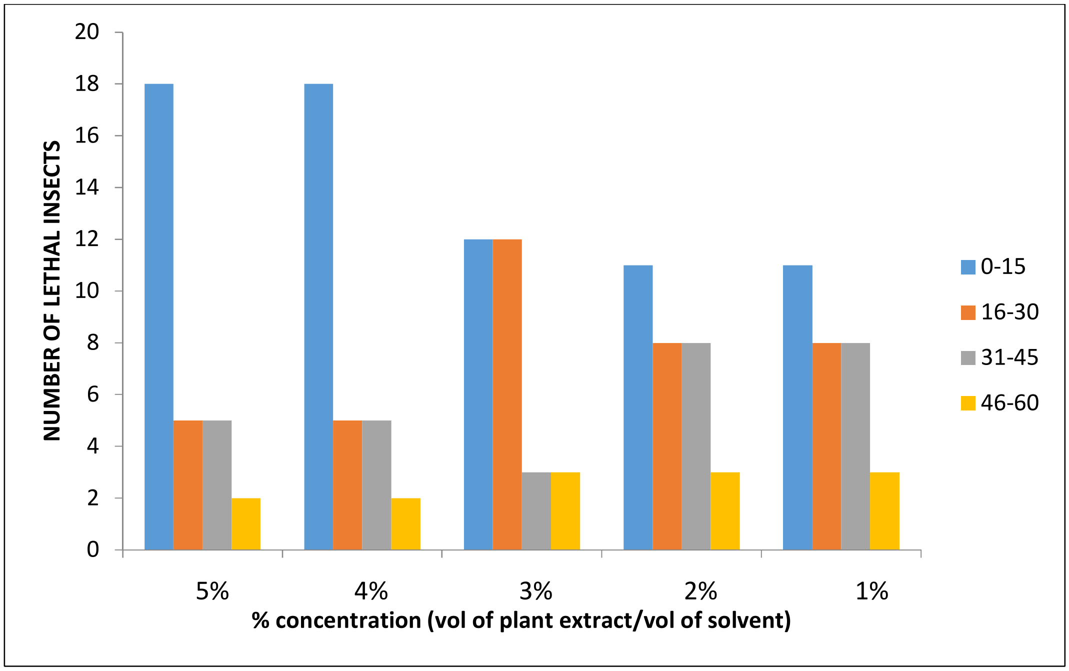

Fig. 7. Mortality rate of *M. beesoni* using ethanolic extract of dry leaves of *C. zizanioides* extract at different concentrations of 1-5% vol of plant extract/vol of n-hexane extract monitored at 0-15, 16-30, 31-45 and 46-50 seconds

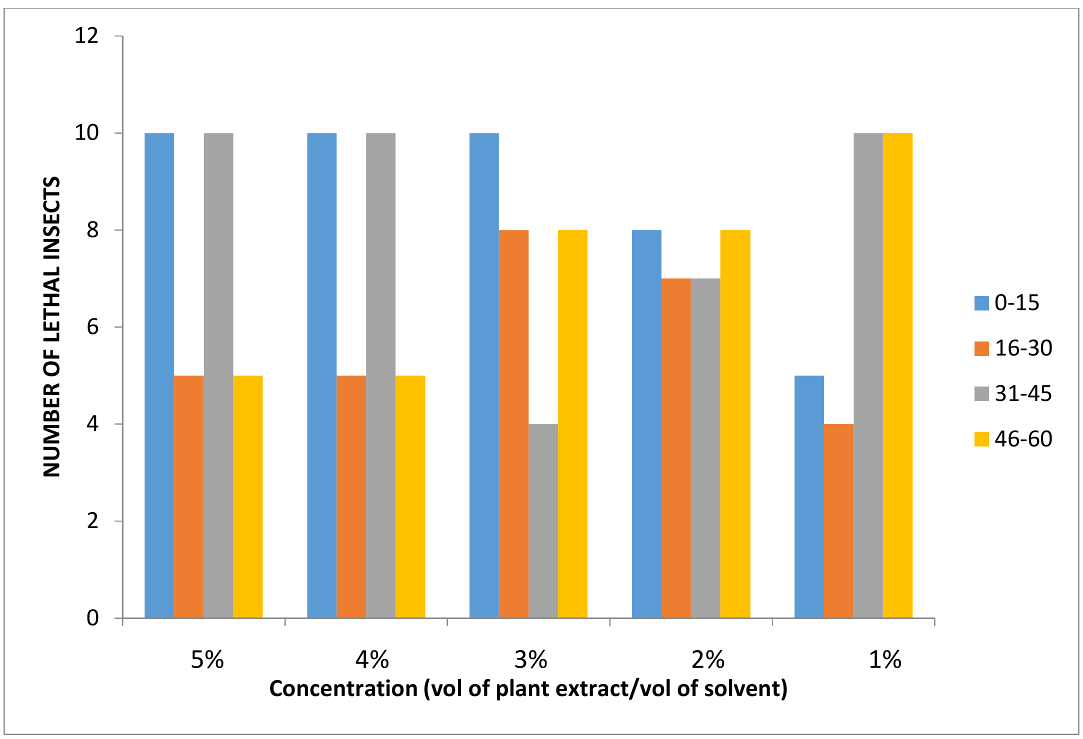

Fig. 8. Mortality rate of *M. beesoni* using ethanolic extract of fresh leaves of *C. zizanioides* extract at different concentrations of 1-5% vol of plant extract/vol of n-hexane extract monitored at 0-15, 16-30, 31-45 and 46-50 seconds

This study therefore gives an insight to the effective use of vetiver plant in insect control and also forms a basis for other research works on the use of vetiver.

4. CONCLUSION

From the results obtained in this research, it was confirmed that extracts from all parts of *C. zizanioides* exhibited a high degree of insecticidal property in the control of termites.

5. RECOMMENDATION

It is hereby recommended that based on the efficacy of *C. zizanioides* in the control of termites, it shall be desirable if further works could be done on the storage and packaging of the extract. Similarly, the shelf-life of the extracts from the various parts of the plants could be determined in further research works. In the same vein, the extracts could be made available to those found with the challenges of controlling termites and the extracts could also be made available as raw materials to paint industries, perfumery industries and wood finisher oil producers as preservatives.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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