Journal Home page : www.jeb.co.in ★ E-mail : editor@jeb.co.in

JEB
Journal of Environmental Biology

ISSN: 0254-8704
CODEN: JEBIDP

Anti-termite properties of root and leaf powder of vetiver grass

S. Jayashree[1]*, J. Rathinamala[2] and P. Lakshmanaperumalsamy[3]

[1]Department of Biotechnology, Nehru Arts and Science College, T.M.Palayam, Coimbatore-641 105, India
[2]Department of Microbiology, Nehru Arts and Science College, T.M.Palayam, Coimbatore-641 105, India
[3]Karpagam University, Coimbatore-641 021, India
*Corresponding Author E-mail: jaishri.subramanian@gmail.com

Publication Info

Paper received:
05 July 2012

Revised received:
07 January 2013

Revised received:
19 April 2013

Accepted:
03 June 2013

Abstract

A comparative study was conducted to determine the effect of roots and leaves of vetiver grass (*Chrysopogon zizanioides. L. Roberty*) when used as mulch against Indian termites. The major subterranean species, *Heterotermes indicola* were taken for the study. In this, the vetiver root and leaves (1 kg) were shade dried and powdered in a pulverizer and tested against termites. The 100% vetiver root powder proved to decrease tunnelling activity and wood consumption. This also increased mortality rate of termites than leaf powder. To reach the food source, termites had to tunnel through the treatment chamber. Three replicates were performed for each treatment. Each container was covered and placed in a dark room at room temperature for 21 days. To maintain moisture, 10 ml of distilled water was added to the soil once in three days. Appropriate control without vetiver root and leaves were maintained separately and the tunnel length of termites was determined. On 7th, 14th and 21st day, the tunnel length was determined by scanning the bottom of each container to fix the image of tunnels. Images were printed to actual size to measure the total tunnel length. The containers were dismantled to check the number of live termites in the treatments. The number of live termites was counted from the compartments of nest chamber, treatment chamber and food chamber, to determine mortality. Wood slices were cleaned, dried for 2 hrs and weighed to determine consumption. The tunnel length of termites on different days (7th, 14th and 21st day) showed a significant difference between the treatments (root and leaves) and control.

Key words

Chrysopogon zizanioides, *Heterotermes indicola*, Nest chamber, Tunnel length

Introduction

Termites are a serious menace to both plants and structures. They are the most problematic pest threatening agriculture and urban environment. They cause significant loss to annual and perennial crops and damage to wooden components in buildings, especially in the semi-arid and sub humid tropics (Monica *et al.,* 2009). In India termites are widely distributed in red, sandy loams, lateritic and red loam soils. They are known to damage field crops such as wheat, maize, sugarcane, cotton, groundnut, pulses and forest plantation trees such as *Eucalyptus*, silver oak, *Casuarina* and all kinds of timber used in buildings. Several million of rupees on agricultural crops are lost due to termite problems alone. About 10-25% loss is estimated in most field and forest crops. Out of 300 species of termites known so far from India, about 35 species have been reported as damaging agricultural crops and timber in buildings. The majority of the pest species are soil inhabiting, either as mound builders or as subterranean nest builders (Rajagopal, 2002). Chemical control has been a successful method of preventing termite attack but the effects of these chemicals are of concern as they create problems for our health and the environment. Biological methods could be suitable alternatives in this regard (Monica *et al.,* 2009).

Plants produce many natural compounds that are repellent or act to alter feeding behaviour, growth and development of insects (Duke, 1990). Vetiver (*C. zizanioides*), native to India is a fast growing, belonging to family Poaceae that also includes maize, rice, wheat, sorghum, sugarcane and lemon grass. The vetiver roots and leaves contain hundreds of terpenes, terpenoids, phenols, etc. It currently has three primary commercial applications: as aromas in perfumes, as food

flavouring additives, and as natural insecticide. In recent years, biological activities, like, antioxidant, antimicrobial, insecticidal, anticancer effects and termiticidal activities etc., of vetiver roots and oil (Zhu *et al.,* 2001b) are known. Chemical components of vetiver root are also very important because they possess fungicide, herbicidal and insecticidal properties. Vetiver oil and one of its minor constituents, nootkatone, have been shown to inhibit germination and seed expansion in a variety of economically important weed species (Mao *et al.,* 2004) and possess repellent properties useful against ants, cockroaches, bedbugs, head lice, flies and moths (Henderson *et al.,* 2005a). Vetiver oil and some of its constituents are also repellent and toxic to termites (Henderson *et al.,* 2005b; Ibrahim *et al.,* 2004; Zhu *et al.,* 2001a, 2001 b). A previous wood treatment study indicated that wood treated with vetiver oil or nootkatone was not only toxic but acted as feeding deterrents (Maistrello et al., 2001). The usual behaviour exhibited by termites in the presence of vetiver root mulch observed on 8, 12 and 16 days were described as lingering behaviour by Maistrello *et al.* (2002). The testing procedure was modified from Nix *et al.,* (2006) which showed that vetiver root mulch has been tested to control termites in the chambers of plastic containers on 4, 8, 12 and 16 days but no study has been carried out to compare the efficiency of vetiver root with leaf powder on tunnelling activity, wood consumption and termite mortality. In view of above, the present study was carried out to compare the efficiency of root and leaf powder of vetiver grass (*Chrysopogon zizanioides*) against termites.

Materials and Methods

The vetiver (*C. zizanioides*) roots and leaves of biomass production (120 days old root), were rinsed thoroughly with water to remove soil and other debris. The root was shade dried and leaves under sunlight for 4 days. Dried roots and leaves were powdered in the pulverizer.

Experimental containers of 30 cm x 10 cm x 10 cm size with three compartments were taken for the study (Fig. 1). The holes of 5mm diameter were made in the inner walls connecting the chamber. In the same way small pin holes (3 mm dia) were made on the lid of boxes for ventilation. The three chambers were labelled as nest chamber (NC), where termites were introduced, treatment chamber (TC) with vetiver root powder (25 g) and food chamber (FC) where the wood of Ravi tree (*Aesculus hippocastanus*) was placed. The experiment was conducted in triplicate.

Untreated wood of Ravi tree (*A. hippocastanus*) of 5 cm size was collected and dried under sunlight for 2 hrs. It was weighed (20 g) and placed inside the food chamber of all containers. The garden soil was sieved with 2 mm sieve. Then 100 g of sieved soil was taken and moistened with 10 ml of distilled water and put in the control chamber of the experimental containers.

One hundred termites with mixed groups (queen, workers and soldiers) collected from a colony at the garden of Department of Environmental Sciences, Bharathiar University campus, were introduced into the nest chambers. To reach the food source, termites had to tunnel through the treatment chamber. Three replicates were performed for each treatment. Each container was covered and placed in a dark room at room temperature for 21 days. To maintain moisture, 10 ml of distilled water was added to the soil once in three days. Appropriate control with garden soil in the control chamber of the experimental container without vetiver root and leave was maintained and the tunnel length of termites was determined.

On 7th, 14th and 21st day, the tunnel length was determined by scanning the bottom of each container (HP SCANJET 3370) to fix the image of the tunnels. Images were printed to actual size to measure the total tunnel length. The containers were dismantled to check the number of live termites in the treatments. The number of live termites was counted from NC, TC and FC chambers to determine mortality. Wood slices were cleaned, dried for 2 hrs and weighed to determine consumption by the following formula :

$$\text{Percent Mortality} = \frac{\text{Number of deaths from a specified cause during time period} \times 100{,}000}{\text{Total population from a specified cause during time period}} \times 100$$

$$\text{Percent Consumption} = \frac{\text{Initial weight} - \text{Final weight}}{100} \times 100$$

Field study was carried out by taking a square of 1m x 1m (3 squares of 1m x 1m size) in the garden, Square 1: Control plot (garden soil alone); Square 2 : Vetiver root powder (VR) on ground surface in the soil and Square 3 : Vetiver leaf powder (VL) on ground surface in the soil

In Square 2, VR powder (500 gm) was spread on the ground soil, similarly in Square 3, VL powder (500 gm) was spread on the ground soil, respectively.

Statistical analysis : The percent consumption of the wood samples and percent mortality were analyzed using analysis of variance (ANOVA) procedure. The mean and standard error was calculated using SPSS software.

Results and Discussion

In the control set on 7th day, the tunnel length was 22.7 cm where as on 14th day the tunnel length increased to 27.3 cm, respectively. But on the final day (21st day) the tunnel length did not show any significant difference from 14th day. A significant difference was found between the treatments and control in the present study (Table 1 and Fig. 1).

The container, containing vetiver root powder, formed tunnels on 7th day (10.5 cm). There was a minor difference in the tunnel length on 14th day (10.6 cm) from 7th day. On 21st day, the tunnel formation was found constant from that of 14th day. This may be the reason that the tunnel formation by the termites might be over or due to the mortality rate of the animals. Termites did not

tunnel all the way through the treatment chamber to get into the food chamber in VR containers. But in control set and VL the tunnel was formed through the middle chamber to reach the food chamber. The tunnel length formed on 7th day was 12.3 cm comparatively more than that of vetiver root, where as it was found less than control. On 14th day, the tunnel length in the leaf container was 19.9 cm and on 21st day it increased to 20.6 cm. Instead of displaying the normal exploratory behaviour on 7th, 14th and 21st day, termites in the nest and treatment chamber of VR chamber were very sluggish and remained clump together.

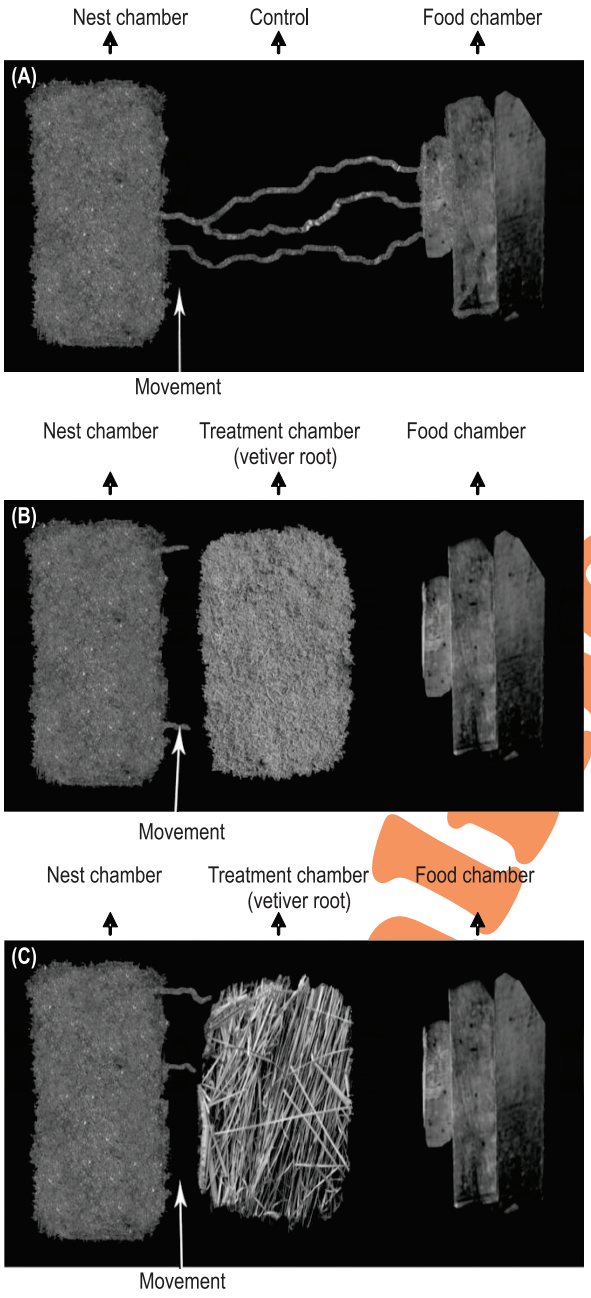

Fig. 1 : (A) Movement of termites in experimental container from nest chamber to food chamber *via* treatment chamber (Control); (B) Restricted movement of termites in experimental containers from nest chamber; (C) Restricted movement of termites in experimental containers from nest chamber

Consumption of wood was appreciably lower in VR treatment (10.9%). The highest wood consumption was observed in control (46.8%) and next moderate amount of consumption was observed in VL treatment (18.7%) which was not notably different from each other (i.e., VL and control). Termites in VR chamber exhibited high mortality rates (26.6%) than termites present in control and VL chamber (Table 1).

Results of the field study were similar to those of laboratory experiment. In Square 1, where the garden soil was used as control, the colonization was formed on 7th day. In Square 2, that contained the vetiver root powder no colonization was found till termination of the experiment (21st day). But in Square 3, where vetiver leaf powder was applied, the colonization was not formed till 14th day but established after 21st day.

Termites are ecologically important insects that aid in breakdown of cellulose material and recycling of nutrients. Currently, control of subterranean termites depend mainly on the incorporation of synthetic chemical treatments with a long persistence into the soil. There has been an increased public awareness of pesticide use in the urban landscape and an increased desire to reduce their use and implement more environmentally safe control strategies (Forschler and Jenkins, 2000). There is an increasing interest in using natural products in pest control because of their low mammalian toxicity and environmental safety (Duke, 1990).

Roots of vetiver plants have been used in many areas of the world as a repellent to a variety of insects (Chomchalow, 2003). In the present study, it was recorded that vetiver root powder prevented formation of termite colony under experimental condition. In field condition, where vetiver root powder was applied previously to the soil, mulching of vetiver leaves did not invite termites. This coincided with the findings of Long *et al.* (2001) who reported that mulches (materials spread over soil surfaces) reduces moisture evaporation, protects soil from erosion, provide insulation during periods of extreme temperatures and inhibit weed growth.

Also, because mulches protect the soil by conserving moisture, they create a conducive environment for termites. While data indicate that organic mulches do not increase the rate of termites scouting to the area (Long *et al.,* 2001), because mulches are often placed directly against a home's foundation, they can provide a hidden, direct way for termites into a home. In cases where mulches are placed at top soils previously treated with termiticides, mulches provide a bridge allowing termites to cross over treated soil (Long *et al.,* 2001). The present result

Table 1 : Mean total length of tunnels, mortality of termites and wood consumption for each treatment of vetiver root and leaf obtained after 21 days

Treatment	Tunnel length			Mean	Mean wood
	7th day	14th day	21st day	mortality (%)	consumption (%)
Control	22.7± 12.4	27.3 ± 6.3	28.9 ± 8.4	5.2 ± 1.2	46.8 ± 14.6
VR	10.5 ± 3	10.6 ± 2	10.6 ± 2	86.6 ± 12.8	0.9 ± 0.2
VL	12.3 ± 2	19.9 ± 4	20.6 ± 3	28.4 ± 4.3	18.7 ± 5.4
F-value	17349.3*	28009.3*	33583.3*	87461.85*	2336.84*

*Significant at 0.05 level, values are mean of three replicates ± SD

indicate that the tunnelling and consumption of food by the termites was more in control sets, where as the mortality rate was more in the container having vetiver root powder. In addition, wood treated with nootkatone, a compound present in vetiver oil, from vetiver roots acts as a repellent and feeding deterrent against Formosan subterranean termites, decreasing the number of protozoa in the gut of termite and also disrupting tunneling behaviour (Maistrello et al. 2000, 2001, and 2002). Earlier, it has been shown that vetiver oil and many of its constituents are effective repellents and toxicants to termites (Nix *et al.,* 2003, Ibrahim *et al.,* 2004, Henderson *et al.,* 2005a). One can speculate that since vetiver roots and oil have been shown to be an effective repellent to a variety of insects, including termites, it would be likely that vetiver roots used as mulch would act as an effective repellent against termites. The fast growing root system of this plant contain essential oils, natural compounds found in many different plants (Zhu *et al.,* 2001b).

Thus, from the present study, it can be concluded that the tunnelling and consumption of food was higher in VR and mortality rate in the VL treatment was found to be less as compared to VR.

Acknowledgment

The authors are grateful to the Head, Department of Environmental Sciences, Bharathiar University, Coimbatore, for providing the facilities to carry out this research work during the year 2008-2009.

References

Chomchalow, N.: The role of vetiver in controlling water quality and treating water quality. An overview with special reference to Thailand. *Au. J. T.,* **6**, 145-161 (2003).

Duke, S.O.: Natural pesticides from plants. Advances in new crops. (Eds.: J. Janick and J.E. Simon), Timber press, Portland, Ore., pp. 511 – 517 (1990).

Forschler, B.T. and T.M. Jenkins: Subterranean termite in the urban landscape: Understanding their social structure is the key to successfully implement population management using bait technology. *Urban Ecosyst.,* **4**, 231- 251 (2000).

Henderson, G., R.A. Laine, D.O. Henmann, F. Chen and B.C.R. Zhu: Extracts of vetiver oil as repellents and toxicants to ants, ticks and cockroaches. U.S.Patent No.6, **906**, 108 B2 (2005a).

Henderson, G., R.A. Henmann. D.O. Chen and B.C.R. Zhu: Vetiver oil extracts as termite repellent and toxicant. U.S. Patent No. 6890, 960 B1 (2005b).

Ibrahim, S.A., G. Henderson and R.A. Laine: Toxicity and behavioural effects of rootkatone.I, 10-dihydrorootkatone and tetrahydrorootkatone on the Formosan subterranean termite (Isoptera: Rhinotermitide). *J. Econ. Entomol.,* **97**, 102-111 (2004).

Long, C.E., B.L.Thome, N.L. Breisch and L.W. Douglas: Effect of organic and inorganic landscape mulches on subterranean termite (Isoptera: Rhinotermitidae) foraging activity. *Environ. Entomol.,* **30**, 832- 836 (2001).

Maistrello, L., G. Henderson and R.A. Laine: Effects of nootkatone and a borate compound on Formosan subterranean termite (Isoptera: Rhinotermitidae) and its symbiotic protozoa. *J. Entomol. Sci.,* **36**, 229 – 236 (2000).

Maistrello, L., G. Henderson and R.A. Laine: Efficacy of vetiver oil and nootkatone as soil barriers against Formosan subterranean termite (Isoptera: Rhinotermitidae). *J. Econ. Entomol.,* **94**, 1532-1537 (2001).

Maistrello, L.G. Henderson and R.A. Laine: Comparative effects of vetiver oil, nootkatone and disodium octoborate tetrahydrate on Coptotermes formosanus and its symbiotic fauna. *Pest Manag. Sci.,* **59**, 58-68 (2002).

Mao, L., G. Henderson and R.A. Laine: Germination of various weed species in response to vetiver oil and nootkatone. *Weed Technol.,* **18**, 263-267 (2004).

Monica.V., S. Sathyawati and P. Rajendra: Biological alternatives for termite control: A review. *Inter. Biodeter. Biodegr.,* **63**, 959-972 (2009).

Nix, K.E., G. Henderson and R.A. Laine. Field evaluation of nootkaone and tetrahydro nootkatone against *Coptotermes formosanus*. *Sociobiol.*, **42**, 413-424 (2003).

Nix, K.E., G. Henderson, B.C.R. Zhu and R.A. Laine: Evaluation of vetiver grass root growth and repellency against Formosan Subterranean termite. *Hort Sci.,* **41**, 167-171 (2006).

Rajagopal, D.: 33 economically important termite species in India. *Sociobiol.*, **40**, 33-46 (2002).

Zhu, B., G. Henderson, F. Chen, L. Maistrello and R.A. Laine: Nootkatone is a repellent for Formosan subterranean termites (*Coptotermes formosanus*). *J. Chem. Ecol.,* **27**, 523– 531 (2001a).

Zhu. B., G. Henderson, F. Chen, H. Fei and R.A. Laine. Evaluation of vetiver oil and seven insect-active essential oils against the Formosan subterranean termite. *J. Chem. Ecol.,* **27** , 1617-1625 (2001b).