TUNNELING BEHAVIOR OF HETEROTERMIS INDICOLA WASMANN (ISOPTERA: RHINOTERMITIDAE) UNDER INSETICIDE TREATED CONDITIONS

KAMRAN SOHAIL 1, IMTIAZ ALI KHAN 1, AHMAD UR RAHMAN SALJOQI 2, FARKHANDA MANZOOR 1, SANA ASHFAQ 1 and AMNA SADOZAI 1

1 Department of Entomology, The University of Agriculture, Peshawar - Pakistan
2 Department of Plant Protection, The University of Agriculture, Peshawar.
3 Entomology Division, Nuclear Institute for Food and Agriculture, Peshawar- Pakistan
4 Dept. of Plant Protection and IPM, Faculty of Agriculture Mu’tah University, Karak, Jordan

*Corresponding Author: professorimtiazkhan@yahoo/gmail.com.

ABSTRACT

Laboratory experiments were conducted at the Nuclear Institute for Food and Agriculture Peshawar, Pakistan to study the tunneling behavior of Heterotermes indicolaWasmann (Isoptera: Heterotermitidae) in soil treated with five concentrations of Chlorpyrifos (400, 200, 100, 50, 25 ppm), Cadusafos(50, 25, 12.5, 6.25, 3.125 ppm) and Agenda(100, 50, 25, 12.5, 6.25 ppm). Heterotermes indicola traveled longest the cumulative tunnel distance of 6.96 cm at 25 ppm of Chlorpyrifos, 11.20 cm at 3.125 ppm of Cadusafos and 9.56 cm at 6.25 ppm of Agenda treated sand. At lower concentrations toxicity of all insecticides increased with time. Heterotermes indicola traveled longer tunnel distance and made more number of tunnels at lower concentrations of all the insecticides. In control Heterotermes indicola traveled the longest cumulative distances and made longer and more tunnels than all the treatments. Agenda was slow acting among the three insecticides. The study recommends the use of Chlorpyrifos and Cadusafos for quick knockdown and Agenda for long-term control of termite.

Key words: Heterotermes indicola, insecticides, tunneling behavior


INTRODUCTION

Termites (Order: Isoptera) are widely distributed in the tropics and temperate regions of the world while fewer species at higher latitudes. Some termite species extend their range of occurrence to the relatively cool zones of temperate regions. There are 2500 known species of termites in the world, which are grouped into seven families namely Mastotermitidae, Hodotermitidae, Termopsidae, Kalotermitidae, Rhinotermitidae, Serritermitidae and Termitidae. The first six families are collectively known as lower termites. Members of the Termitidae are known as higher termites. Termitidae is the most diverse family, exhibiting a wide range of social specifications (Inward et al., 2007).

All the 15 species of termites infesting agricultural crops recorded in Khyber Pakhtunkhwa Province of Pakistan are subterranean and have no detectable structures on ground. Heterotermites indicola Wasmann (Isoptera: Heterotermitidae) is a widely distributed termite species of the genus Heterotermites found in different parts of Pakistan (Sheikh et al., 2008). Two species including Heterotermites indicola and Coptotermesheimi have been reported infesting buildings in Peshawar (Salihah et al., 1994).

Successful methods of control have not been developed largely due to the lack of information on organization of termite colonies, which do not build mounds or any other readily detectable structures. Subterranean termite species are serious pests to agricultural crops. They cause 90-100% damage to sugarcane crop. They also cause 45% damage to maize and 10-12% damage to wheat crop and 80-90% to fruit orchards (Zubair et al., 2007). The potential horizontal transfer of non-repellent insecticides has become an important paradigm to control termites in recent years (Neil et al., 2008).

In the past, chlorinated hydrocarbon insecticides were extensively used for termite control but many of these materials have been phased out because of health and environmental concerns (Rust and Saran, 2006).

Insecticides are categorized as repellent, toxic and non-repellent or non repellent with delayed toxicity. Repellent insecticides protect structures typically by repelling foraging termites and sub lethal exposure to pyrethroid insecticides inhibit termite tunneling. The toxic and non-repellent insecticides kill termites by contact. With slow
acting insecticides, the level of mortality and the speed of kill are dependent on pesticide concentrations (Raj and Rust, 2007).

The use of non-repellent insecticides has increased over the last many years as termites cannot detect the treated soil and continue foraging in such soil. These compounds have a delayed mode of action (Renato et al., 2007). All insecticides formulations are able to stop termite soil penetration, either by killing or repelling them. The termitekicide properties (repellent or non-repellent) may be dependent on the concentrations of the insecticides used (Yeoh and Lee, 2007).

Based on the above information, the present laboratory study aimed to study tunneling behavior of *H. indicola* in the insecticides treated and untreated sand for its effective control in agricultural crops and in buildings.

**MATERIALS AND METHODS**

**Heterotermes indicola Stock Culture**

*Heterotermes indicola* were collected from the infested orchards at the Newly Developmental Farm and buildings at the campus of the University of Agriculture, Peshawar by using NIFA-TERMAP (Saliyah et al., 1994). The experiments were conducted in the Termites Research Laboratory, Entomology Division, NIFA, Peshawar. The foraging points of termites (end of tunnels) were detected by using stake method as well as visually observing termite’s galleries (Rahman, 2008). For termite detection and collection the detection stakes (2.5 x 4.0 x 28 cm) of poplar wood were driven 25 cm deep into the soil (Saliyah et al., 2012).

**Insecticide Formulations and Testing Procedure**

The insecticides used for the experiments were Chlorpyrifos, Cudasafos and Agenda. Stock solutions of Chlorpyrifos, Cadusafos and Agenda were 400 ppm, 50 ppm and 100 ppm, respectively (Sohail et al., 2012, unpublished). Five concentrations of each of these insecticides were prepared by serial dilutions of the stock solutions and tested in sand in this experiment (as is prefers more sandy soils). The serial dilutions of each insecticide (after initial lab testing, Sohail et al., 2012, unpublished) were: Chlorpyrifos: 400, 200, 100, 50 and 25 ppm; Cadusafos: 50, 25, 12.50, 6.25 and 3.125 ppm and Agenda: 100, 50, 25, 12.50 and 6.25 ppm.

**Tunneling Behavior of *H. indicola* in Insecticides Treated Sand**

For the experiment, the apparatus consisted of a 30 cm glass tube (1.4 cm diameter) containing 26 g untreated sand (8 cm long moistened sand layer) and 6.5 g treated sand (2 cm sand layer) sandwiched between 1 g (2 cm layer) poplar sawdust (120 mesh size) and 2 cm 10% agar layer. Two cut pieces of moistened filter paper were placed into 3 cm void adjacent to agar layer serving as a temporary food source. One end of the glass tubes were sealed with transparent plastic tape. Forty five workers and five soldier (Sohail et al., 2012, unpublished) termites were introduced into each vial and allowed to make tunnel freely. The other end of the glass tubes were covered with cotton. The glass tubes were stored horizontally under dark conditions. The cumulative tunneling distance was measured daily up to 7 days post treatment. After 7 days, the setup was disassembled and the number of survived termites was counted. Five different concentrations of the insecticides mentioned above were tested along with control. In control, the sand was not treated with any insecticide. There were three replications for each pesticides concentration.

**Data Analysis**

The experiments were conducted using Randomized Complete Block Design (RCBD) and the data were analyzed using two-way ANOVA test at 5% level of significance using MSTATC package and means were separated with LSD (Steel and Torrie, 1980). Descriptive Statistics was used to calculate the means and percentages using Microsoft Excel Version 2007.

**RESULTS AND DISCUSSION**

**Heterotermes indicola tunneling in treated and untreated sand**

*Heterotermes indicola* tunneled in the Chlorpyrifos treated and untreated sand (Table 1). The cumulative distance traveled varied with the Chlorpyrifos concentrations. It was longest of 6.96 cm with 25 ppm and shortest of 0.00 cm with 400 ppm of Chlorpyrifos. In control, the cumulative distance traveled was significantly longer (13.86 cm) than all the Chlorpyrifos treatments. Among the treatments, the tunnel length was longer with the lower concentration of Chlorpyrifos treated sand and vice versa. It was 2.90 cm with 25 ppm treated sand and 0.00 cm with 400 ppm treated sand. In control, the tunnel length was significantly longer (6.00 cm) than all the Chlorpyrifos treated sand.
The number of tunnels made was nil with 400 ppm and 3.33 with 50 ppm of the Chlorpyrifos. The number of tunnels in control were significantly more (6 tunnels) than all the Chlorpyrifos treatments.

**Table 1. Heterotermes indicola tunneling in the Chlorpyrifos treated and untreated sand after 7 days exposure during 2009-2010.**

<table>
<thead>
<tr>
<th>Conc. (ppm)</th>
<th>Cumulative tunneling distance (cm)</th>
<th>Tunnel length (cm)</th>
<th>No. of tunnels</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>0.00 d</td>
<td>0.00 c</td>
<td>0.00 c</td>
</tr>
<tr>
<td>200</td>
<td>0.50 d</td>
<td>0.50 c</td>
<td>0.66 c</td>
</tr>
<tr>
<td>100</td>
<td>4.10 c</td>
<td>1.90 b</td>
<td>2.66 b</td>
</tr>
<tr>
<td>50</td>
<td>6.90 b</td>
<td>2.76 b</td>
<td>3.33 b</td>
</tr>
<tr>
<td>25</td>
<td>6.96 b</td>
<td>2.90 b</td>
<td>3.00 b</td>
</tr>
<tr>
<td>Control</td>
<td>13.86 a</td>
<td>6.00 a</td>
<td>6.00 a</td>
</tr>
</tbody>
</table>

LSD value  **1.34**  **1.13**  **1.68**

Means within columns followed by different letters are significantly different at 0.05 probability level.

Heterotermes indicola tunneled extensively in the Cadusafos treated and untreated sand (Table 2). The cumulative distance traveled was significantly different with the concentrations. Among the treatments it was the longest (11.20 cm) with 3.125 ppm and shortest (1.93 cm) with 50 ppm. In control, the cumulative distance traveled was significantly longer (12.93 cm) than all the treatments. The tunnel length was longer (4.70 cm) with 6.25 ppm and shorter (0.96 cm) with 50 ppm of the insecticide. In control, it was significantly longer (7.53 cm) than all the treatments. Among the treatments the number of tunnels made were significantly more (4.0) with lower concentration of 3.125 ppm and less (2.0) with higher concentration of 50 ppm. In control the number of tunnels made were significantly more (5.33 tunnels) than all the treatments.

**Table 2. Heterotermes indicola tunneling in the Cadusafos treated and untreated sand after 7 days exposure during 2009-2010.**

<table>
<thead>
<tr>
<th>Conc. (ppm)</th>
<th>Cumulative tunneling distance (cm)</th>
<th>Tunnel length (cm)</th>
<th>No. of tunnels</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>1.93 f</td>
<td>0.96 c</td>
<td>2.00 c</td>
</tr>
<tr>
<td>25</td>
<td>4.90 e</td>
<td>2.63 bc</td>
<td>2.66 bc</td>
</tr>
<tr>
<td>12.5</td>
<td>6.46 d</td>
<td>3.30 b</td>
<td>3.33 bc</td>
</tr>
<tr>
<td>6.25</td>
<td>8.43 c</td>
<td>4.70 b</td>
<td>2.33 c</td>
</tr>
<tr>
<td>3.125</td>
<td>11.20 b</td>
<td>4.03 b</td>
<td>4.00 ab</td>
</tr>
<tr>
<td>Control</td>
<td>12.93 a</td>
<td>7.53 a</td>
<td>5.33 a</td>
</tr>
</tbody>
</table>

LSD value  **1.03**  **2.30**  **1.61**

Means within columns followed by different letters are significantly different at 0.05 probability level.

Table 3 shows H. indicola tunneling in the Agenda treated and untreated sand. The results indicated that the cumulative distance traveled was different with the concentrations. Among the treatments it was longer (9.56 cm) with 6.25 ppm and shorter (2.63 cm) with 100 ppm. In control, the cumulative distance traveled was significantly longer (14.70 cm) than all the treatments. The tunnel length was longer (5.83 cm) with 6.25 ppm treated sand and shorter (2.36 cm) with 100 ppm treated sand. In control the tunnel length was significantly the longest (10.37 cm). Among the treatments, the numbers of tunnels made were significantly more (3.66) with 12.5 ppm and less (1.67) with 100 ppm of Agenda. The number of tunnels was significantly more in control (5.66 tunnels) than all the treatments.

**Table 3. Heterotermes indicola tunneling in the Agenda treated and untreated sand after 7 days exposure during 2009-2010.**

<table>
<thead>
<tr>
<th>Conc. (ppm)</th>
<th>Cumulative tunneling distance (cm)</th>
<th>Tunnel length (cm)</th>
<th>No. of tunnels</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>2.63 e</td>
<td>2.36 cd</td>
<td>1.67 b</td>
</tr>
<tr>
<td>50</td>
<td>3.16 e</td>
<td>2.40 d</td>
<td>2.66 b</td>
</tr>
<tr>
<td>25</td>
<td>5.86 d</td>
<td>4.23 bc</td>
<td>2.00 b</td>
</tr>
<tr>
<td>12.5</td>
<td>7.93 c</td>
<td>3.63 bcd</td>
<td>3.66 ab</td>
</tr>
<tr>
<td>6.25</td>
<td>9.56 b</td>
<td>5.83 b</td>
<td>3.00 b</td>
</tr>
<tr>
<td>Control</td>
<td>14.70 a</td>
<td>10.37 a</td>
<td>5.66 a</td>
</tr>
</tbody>
</table>

LSD value  **1.27**  **2.78**  **2.34**

Means within columns followed by different letters are significantly different at 0.05 probability level.

At higher concentration of Chlorpyrifos termite did not make any tunnel which might be due to fast acting nature of higher concentration. The fast acting lethal nature of chlorpyrifos has been documented earlier. Sheikh *et al.* (2008)
carried out research on the toxicity of Tenekil (Polychlorinated petroleum hydrocarbon), Termidor (Fipronil) and Terminus (Chlorpyrifos) against *H. indicola* in soil. Different concentrations of insecticides were used for the experiment. Low doses (25 ppm) of Termidor (Fipronil) were more effective than high doses of Tenekil (100 ppm) and Terminus (480 ppm). Ahmed *et al.* (2006) evaluated the efficacy of imidacloprid, chlorpyrifos and monomehypo against termites on sugarcane. After 15, 45, 60, 75 days of Chlorpyrifos application on setts gave control of the termites’ population and significantly reduced the termites as compared to imidacloprid and monomehypo. Similarly very low population of termites was recorded on the sugarcane setts in the plots treated with Chlorpyrifos as compared to imidacloprid and monomehypo.

At lower concentrations of Cudasafos and Agenda *H. indicola* workers tunneled to longer distances of 11.20 cm at 3.125 ppm and 9.56 cm at 6.25 ppm, respectively as compared to 6.96 cm at 25 ppm of Chlorpyrifos. It showed the slow acting effect of two insecticides. Some previous researchers have also reported slow acting nature of Agenda. Sohailet *et al.* (2010, unpublished) reported that Chlorpyrifos and Cudasafoshad fast acting lethal effect as compared to Agenda. Sattar *et al.* (2008) tested six concentrations of five insecticides (Biomax, Lorsban, Steward, Agenda and Dursban) to screen out the most palatable and slow-acting toxicant for an effective control of *H. indicola* under laboratory conditions. The results showed that slow acting toxicity and palatability in *H. indicola* was inversely proportional to their concentrations. The most desirable results of 87.30% and 100% mortality were observed after 12 and 15 days, respectively, with Agenda 0.000625% concentration.

CONCLUSION AND RECOMMENDATIONS

At lower concentrations of Cudasafos and Agenda the termites traveled longer cumulative tunnel distance as compared to Chlorpyrifos. The highest tunnel distance and more number of tunnels were recorded at lower concentrations of Cudasafos and Agenda. On the basis of study findings the following recommendations are made:

i. Chlorpyrifos, with fast lethal effect at higher concentrations, should be used for quick knock down effect.

ii. Cudasafos and Agenda, with slow acting effect, should be used for long-term control of termites in soil.

REFERENCES


