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Toxicity Assessment of Selected Neonicotinoid Pesticides against the Sand Termite, *Psammotermes hypostoma* Desneux Workers (Isoptera: Rhinotermitidae) Under Laboratory Conditions

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ABSTRACT

Background: Sand termites, *Psammotermes hypostoma* Desneux, in New Valley, Egypt cause millions of Egyptian pounds worth of damage annually, including the cost of controlling them and repairing the damage to structures. **Objective:** We evaluate selected neonicotinoid pesticides, Imidacloprid (20% SL), Acetamiprid (20% SP), and Thaimethoxam (40% WG and 18.6% SC), comparing to one organophosphate pesticide, Chlorpyrifos (48% EC), on sand termite, *Psammotermes hypostoma* Desneux workers, using two methods, cardboard-dip bioassay and termite workers-dip bioassay. However, the mortality percentage was recorded after 3, 6, 12, 24 h. **Results:** The toxicity from termite workers-dip bioassay method was greater than from cardboard-dip bioassay. Moreover, the LC_{50} values decreased after 24 h compared with the 3 h data. Furthermore, Chlorpyrifos (48% EC) considered the most potent pesticides among all pesticides tested whereas Imidacloprid (20% SL) considered the most potent among the neonicotinoid pesticides tested. **Conclusion:** These results indicate that selected neonicotinoid pesticides are promising tools in the potential of controlling the sand termites.

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INTRODUCTION

The subterranean termites are considered the most serious pests all over the world, causing losses of millions of dollars (Su and Scheffrahn 1990). However, the annual control costs are estimated by almost $1,200 million dollars (Su 1994; Su and Scheffrahn 1998).

In Egypt, there are eight species of subterranean termites. The sand termite, *Psammotermes hypostoma* Desneux is the most important danger pest, causing damage to any materials containing cellulose (Rizk *et al*. 1982; Abdel Galil 1986; Bohibeh 2010) especially in Upper Egypt and the New Valley. While in USA, the subterranean termites are serious pests causing damage to homeowners annually (Su 1994). Three subterranean termite species (viz., *Reticulitermes flavipes* (Kollar); *Reticulitermes virginicus* (Banks) and *Coptotermes formosanus* (Shiraky) are among the most widely distributed and destructive subterranean termites in USA (Su and Scheffrahn 1988; Wang *et al*. 2002).

In general, the extensive usage of pesticides in termites control may lead to the emergence of pesticides resistance. Thus, it is very significant to use new effective countermeasure strategy in order to avoid the development of resistance particularly among major insect pests of great health concern. However, neonicotinoids are relatively new class of pesticides which belong to the fastest-growing class of pesticides in modern pest protection followed after the conventional pesticide group (Ahmed and Matsumura 2012). Furthermore, their mammalian toxicities are generally low and also show low acute toxicities to birds, and fish, but displayed significant toxicity to bees (Ahmed 2011). Thus, the use of neonicotinoid pesticides is recommended to be increased in future to control the termite pests.

In the present study, the authors investigated the toxicity of five pesticides on termite workers with two different bioassay methods comparing with one organophosphate pesticide.

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MATERIALS AND METHODS

Strain:

The healthy termite workers (same size and shape) were collected from termite nests Om Elnaseem village (New Valley Governorate). Then, transferred to the laboratory of Plant Protection Department, Faculty of Agriculture, Assiut University, New Valley branch.

Pesticides:

The formulations of Imidacloprid (20% SL), Acetamiprid (20% SP), Thaimethoxam (40% WG, and 18.6 % SC), and Chlorpyrifos (48% EC) were used in the bioassay. These materials were obtained from Central Agricultural Pesticides Laboratory (CAPL) in Dokki, Giza, Egypt as gifts.

A pilot test was conducted in order to choose the range of concentrations of each pesticide used for the bioassay. The following concentrations were used for each pesticide (0.1, 1, 10, 100, 1000 ppm).

Termite workers-dip bioassay:

The termite workers-dip bioassay is similar to the cardboard-dip bioassay with some minor modifications. Briefly, for each concentration of pesticide used, 50 healthy termite workers were dipped for 10 seconds in each concentration, then transferred to plastic cans and kept under laboratory conditions. Cardboards were put in plastic cans covered with sieved lid and repeated three times. The termite individuals were dipped in distilled water only and used as control. This technique was carried out for all pesticides used. The percentages of mortality in termite workers were recorded at 3, 6, 12, and 24 h. The corrected mortality was calculated according to Abott's formula (Abott 1925).

Cardboard-dip bioassay:

For each concentration of pesticides used, cardboards (5 cm x 5 cm) were dipped for 10 seconds of the concentration and left to dry under laboratory conditions for one hour, and then placed in plastic cans covered with sieved lid. Fifty healthy termite workers (same size and shape) with 3 replicates of the same termite colony were transferred to these plastic cans. Control cardboards were treated with distilled water. This technique was carried out for all pesticides used in the present study. The experiment was completely random design; each treatment rate was replicated three times. The mortality were recorded after 3, 6, 12, 24 h of treatment, and corrected according to Abott's formula (Abott 1925).

The bioassay mortality data were pooled and analyzed (the LC_{50} and their 95% confidence limits values) using Proban probit analysis program version 1.1 (Fenney 1971).

RESULTS AND DISCUSSION

Toxicity of selected neonicotinoid pesticides compared with organophosphate pesticide against sand termite after 3, 6, 12, 24 h using termite workers-dip bioassay is shown in Table 1. The LC_{50} value of Chlorpyrifos after 3 hours was 15.07 ppm and decreased to 0.21 ppm at 24 h. The same trend was observed in the selected neonicotinoid pesticides. For example, the LC_{50} value of Imidacloprid after 3 h was 34.67 ppm and decreased to 0.66 ppm after 24 h. In general, Imidacloprid was the most potent neonicotinoid pesticide among the selected neonicotinoid pesticides and Chlorpyrifos is the most toxic pesticide among all tested pesticides when using termite workers-dip bioassay.

The results of cardboard-dip bioassay are presented in Table 2. The LC_{50} value of Chlorpyrifos was 28.29 ppm and 0.36 ppm at 3 and 24 h respectively. Imidacloprid is the most toxic neonicotinoid pesticide. The LC_{50} value after 3 h was 50.95 ppm and decreased to 0.82 ppm after 24 h of treatment, herein, the toxicity increased by 62.13-fold. Generally, the LC_{50} values decreased significantly after 24 h as compared with the 3 h in both bioassay methods.

Also, the formulation of Thiamethoxam (18.6% SC) was more effective than the other formulation of the same pesticide (40% WG). Furthermore, Chlorpyrifos (48% EC) is the most potent pesticides among the pesticides used, whereas Imidacloprid (20% SL) is the most potent among the neonicotinoid pesticides based on both bioassay methods.

Table 1: Toxicity of selected neonicotinoid pesticides in comparison with Chlorpyrifos against sand termite, *Psammotermes hypostoma* Desneux, using termite workers-dip bioassay after 3, 6, 12, 24 h exposure.

Pesticides	After 3 h		After 6 h		After 12 h		After 24 h	
	LC_{50} (95% CL) [a]	Slope (SE)	LC_{50} (95% CL) [a]	Slope (SE)	LC_{50} (95% CL) [a]	Slope (SE)	LC_{50} (95% CL) [a]	Slope (SE)
Chlorpyrifos 48% EC	15.07(4.52-56.01)	0.31 (0.05)	3.39 (1.21-8.19)	0.43 (0.06)	1.24 (0.56-2.42)	0.63 (0.07)	0.21 (0.05-0.55)	0.52 (0.07)
Imidacloprid 20% SL	34.67 (12.23-126.38)	0.31 (0.06)	10.00 (3.51-28.43)	0.37 (0.06)	2.55 (0.77-6.68)	0.39 (0.06)	0.66 (0.14-1.89)	0.39 (0.06)
Acetamiprid 20% SP	48.42 (17.52-180.21)	0.37 (0.06)	15.07 (4.52-56.01)	0.31 (0.05)	3.82 (1.06-11.13)	0.35 (0.06)	0.81 (0.41-2.56)	0.34 (0.06)
Thiamethoxam 18.6% SC	76.75 (24.42-399.25)	0.33 (0.06)	16.67 (5.89-51.99)	0.36 (0.06)	5.95 (1.33-22.28)	0.28 (0.05)	1.11 (0.12-4.41)	0.27 (0.05)
Thiamethoxam 40% WG	NA[b]	NA[b]	21.82 (7.04-81.72)	0.33 (0.06)	11.84 (3.29-44.79)	0.30 (0.05)	5.75 (1.50-18.95)	0.31 (0.05)

[a] Concentrations are expressed in ppm
[b] NA= not applicant (the mortality percentage was significantly below 50% at the highest concentration)

Table 2: Toxicity of selected neonicotinoid pesticides in comparison with Chlorpyrifos against sand termite, *Psammotermes hypostoma* Desneux, using Cardbaord-dip bioassay after 3, 6, 12, 24 h exposure.

Pesticides	After 3 h		After 6 h		After 12 h		After 24 h	
	LC_{50} (95% CL) [a]	Slope (SE)	LC_{50} (95% CL) [a]	Slope (SE)	LC_{50} (95% CL) [a]	Slope (SE)	LC_{50} (95% CL) [a]	Slope (SE)
Chlorpyrifos 48% EC	28.29 (8.87-118.42)	0.32 (0.06)	7.20 (2.64-18.72)	0.40 (0.06)	2.10 (0.67-5.26)	0.44 (0.06)	0.36 (0.10-0.88)	0.51 (0.07)
Imidacloprid 20% SL	50.95 (15.44-266.60)	0.31 (0.06)	15.19 (5.42-46.04)	0.37 (0.06)	4.08 (1.32-10.80)	0.39 (0.06)	0.82 (0.17-2.37)	0.38 (0.06)
Acetamiprid 20% SP	52.18 (19.84-180.42)	0.39 (0.06)	15.91 (5.11-55.19)	0.33 (0.06)	4.57 (1.41-12.66)	0.36 (0.06)	1.02 (0.25-2.81)	0.39 (0.06)
Thiamethoxam 18.6% SC	83.36 (27.60-404.37)	0.35 (0.06)	21.55 (7.06-78.66)	0.33 (0.06)	7.77 (1.90-29.27)	0.29 (0.05)	1.33 (0.15-5.24)	0.27 (0.06)
Thiamethoxam 40% WG	NA[b]	NA[b]	27.50 (8.98-107.34)	0.33 (0.06)	14.80 (4.64-52.16)	0.33 (0.06)	6.21 (1.65-20.60)	0.31 (0.05)

[a] Concentrations are expressed in ppm
[b] NA= not applicant (the mortality percentage was significantly below 50% at the highest concentration)

However, certain studies conducted on the control of subterranean termite shown promising results in agreement with the present study. Ahmed and Farhan (2006) conducted a laboratory evaluation of Chlorpyrifos 40% EC, Bifenthrin 10% EC, Imidacloprid 50% SC, Thiamethoxam 70% WS and Flufenoxuron 10% DC on mortality of *Microtermes obesi* in soils from Faisalabad, Pakistan. Termites collected from sugarcane fields were exposed to the soil treated with various concentrations of the insecticides and the mortality of termites was observed until all the exposed individuals were dead. There was no difference in mortalities expressed as LT_{50} in min and hrs in three types of soil. Mortality decreased with less in concentrations of the insecticides. Topical application showed the similar trend as that observed using insecticide treated soil. In another study, Fei and Henderson (2005) found that the formosan subterranean termite exposed to Imidacloprid had greater rates of mortality than those exposed to Acetamiprid. In conclusion, the selected neonicotinoid pesticides showed effectiveness against subterranean termites. However, the most interesting findings from the present study were that, Imidacloprid, Acetamiprid, and Thiamethoxam (the newer types of neonicotinoids) are more persistent and show slower acting effects as compared with the older counterparts of neonicotinoid pesticides such as Dinotefuran, a neonicotinoid pesticide commercialized by Mitsui Chemicals (Tokyo, Japan). Thus, the efforts to understand the molecular basis of their mechanism actions should be studied in the future.

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