Mysore J. Agric. Sci., 52 (2) : 152-157, 2018

Bio-efficacy of Different Insecticides Against *Odontotermes obesus* (Rambur) and *Odontotermes horni* (Wasmann) (Isoptera : Termitidae)

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ABSTRACT

Bio-efficacy of insecticides belonging to six chemical groups was under taken in laboratory condition using potter spray tower method against termites *Odontotermes obesus* (Rambur) and *Odontotermes horni* (Wasmann) to determine the LC_{50} and relative toxicity (RT). Bifenthrin 2.5 per cent EC was found more toxic with the LC_{50} of 4.35 and 4.93 ppm against *O. obesus* and *O. horni*, respectively. The relative toxicity of latter insecticide at LC_{50} was 13.18 and 12.61 times more toxic than imidacloprid 17.5 per cent SL. The least toxic insecticide against both the species of termite was imidacloprid with LC_{50} of 57.34 and 62.19 ppm followed by indoxacarb 14.5 per cent SC with LC_{50} of 31.55 and 42.63 ppm. The order of toxicity of insecticide was bifenthrin 2.5 per cent EC > thiamethoxam 25 per cent WG > chlorpyriphos 20 per cent EC, TC (termite control) > chlorpyriphos 20 per cent EC > fipronil 5 per cent SC > clothianidin 50 per cent WDG >chlorantraniliprole 18.5 per cent SC > clothianidin 7.5 per cent CS > indoxacarb 14.5 per cent SC > imidacloprid 17.8 per cent SL against *O. obesus*. For *O. horni* it was bifenthrin 2.5 per cent EC > thiamethoxam 25 per cent WG > chlorpyriphos 20 per cent EC, TC > chlorpyriphos 20 per cent EC > clothianidin 50 per cent WDG > chlorantraniliprole 18.5% SC > fipronil 5% SC > clothianidin 7.5% CS > indoxacarb 14.5% SC > imidacloprid 17.8 per cent SL. The investigation indicated that bifenthrin 2.5 per cent EC was more toxic to both termite species (*O. obesus* and *O. horni*) at least concentration as compare to other tested insecticides.

Keywords: Potter spray tower, Toxicity, $LC_{50,}$ Relative toxicity (RT)

SEVERAL species of termites are destructive to agricultural crops, forest trees, wooden articles, (outdoors as well as indoors) etc. Out of the 3,106 (world termite fauna) living and fossils species, only 371 (12.4%) have been reported as destructive (Krishna *et al.*, 2013). Majority of the termite species are soil inhabiting, either as mound builders or as subterranean nest builders. The major mound building species are *Odontotermes obesus* (Rambur), *O. redemanni* (Wasmann) and *O. wallonensis* (Wasmann) while, major subterranean species are *Heterotermes indicola* (Wasmann), *Coptotermes ceylonicus* (Holmgren), *C. heimi* (Wasmann), *O. horni* (Wasmann), *Microtermes obese* (Holmgren), *Trinervitermes biformis* (Wasmann) and *Microcerotermes beesoni* (Snyder).

Termites are of economic importance as they damage a great variety of wood in buildings, crops, plantation and forests. The effectiveness of using the organochlorin insecticides as soil drenching to protect the structure and seed treatment for protecting the crops is widely known. However, much of this work comes from field trials carried out before the ban on organochlorines. Most of the works carried out so far with organochlorin termiticides have been outside the shores of this continent. Reports on toxicity are usually on a single or, at most a few termiticides (Spomer *et al.*, 2009). Comparing studies across, it becomes difficult to interpret as they all were conducted in slightly different conditions (*e.g.*, differences in substrates and observation time) in addition to using different experimental subjects (termite species and colonies). The present investigation was carried out with the aim of comparing the efficacy of different chemical group of insecticides directly under uniform condition that help in management of termite in field as well as household conditions.

MATERIAL AND METHODS

Collection of test insects

The foraging workers and soldiers (third instar or older) of *O. obesus* and *O. horni* were collected from termitarium and open field respectively where insecticide was not treated before. Collection was made during morning hours (6.00 to 8.00 am) of the day and were transferred to a plastic container (dia. 20 cm and ht. 10 cm) separately, having an inner lining of moist filter paper. The top of the container was covered with slightly moist muslin cloth. These containers with collected termites were kept in controlled chamber having 25 ^{0}C temperature and 80 per cent RH. Active and healthy termites were used for the experiment and were tested within hour of collection. The body weights of 25 test workers of both the species were also weighed before insecticide treatment.

Insecticides

Insecticides used in the bioassay studies are listed in the Table I. All the insecticides were procured from the market and used in bioassay studies, except clothianidin 7.5 per cent CS which was obtained from Sumitomo Chemicals India Pvt. Ltd. as it was not available in the market.

Bioassay method

In the present investigation, potter spray tower method (Potter, 1952) was used for determination of median lethal concentrations (LC_{50}). Bracketing was done for each insecticide by serial dilution to fix appropriate range of doses or concentration for different levels of mortality ranging from 10 to 90 per cent. For each insecticide, bioassay was carried out with minimum five concentrations. Soil and Whatman filter paper No. 1 were used as a medium for application of insecticide. The soil used for the laboratory experiment was sandy loam and free from insecticidal residue (collected from uncultivated area). The soil was sieved through a mesh screen (2 mm) and was oven dried at 80 ^{0}C for 24 hours. Ten grams of untreated soil was evenly spread at the bottom of each petridish (9 cm dia.). Filter paper No 1 was cut into small pieces (0.5 × 0.5 cm) and was mixed along with soil to serve as food material. Petriplate containing soil and filter paper was topically sprayed with each concentrations of test insecticide (3 ml/ petriplate) evenly by potter tower and for control equal quantity of distilled water was used. After topical application, it was shade dried for an hour. Each concentration was replicated thrice with 15 workers and 2 soldiers per replication. Termites were

TABLE I

Details of insecticides used in the experiment

Common name	Trade name	Formulation		Chemical group	Company
Bifenthrin	Biflex TC	2.5%	EC	Pyrethroid	FMC India private Limited
Chlorantraniliprole	Coragen	18.5%	SC	AnthranilicDiamide	Dupont
Chlorpyriphos	Hyban	20%	EC	Organophosphate	Hyderabad chemicals private limited
Chlorpyriphos	Lethal TC	20%	EC(TC)	Organophosphate	Insecticides (India) Ltd.
Clothianidin	Not revealed (tech. comp.)	7.5%	CS	Neo-nicotinoid	Sumitomo chemicals India Pvt. Ltd.
Clothianidin	Dantotsu	50%	WDG	Neo-nicotinoid	Sumitomo chemicals India Pvt. Ltd.
Fipronil	Regent	5%	SC	Phenylpyrazole	Bayer crop science Ltd.
Imidacloprid	Imidacel	17.8%	SL	Neo-nicotinoid	Excel crop care Ltd.
Indoxacarb	King Doxa	14.5%	SC	Oxadiazine	Gharda chemicals Ltd.
Thiamethoxam	Actara	25%	WG	Neo-nicotinoid	Biostadt India Ltd.

introduced by a soft fine camel hair brush. The observation was recorded on mortality at 2, 4, 8, 16 and 24 hours after release. Workers were considered dead when they showed no movement upon probing with a fine brush.

Statistical analysis

Data was subjected to Abbott's formula for the determination of corrected mortality (Abbott, 1925), while Lethal concentration (LC) values were determined by using probit analysis (Finney, 1971).

$$\text{Abbott's corrected mortality (\%)} = \left(1 - \frac{n\ in\ T\ after\ treatment}{n\ in\ C\ after\ treatment}\right) \times 100 \ldots \quad (1)$$

Where n=Insect population

T= Per cent mortality in treatment

C= Per cent mortality in control

The relative toxicity (RT) of insecticides was calculated based on LC_{50}value by using the following formula (Ramangouda and Srivastava, 2009)

$$\text{Relative toxicity (RT)} = \frac{\text{LC 50 value of least toxic insecticide}}{\text{LC 50 value of candidate insecticide}} \ldots\ldots(2)$$

Results and Discussion

Among the insecticides evaluated, bifenthrin was found more toxic against termite workers of *O. obesus* and *O. horni* by recording the lowest LC_{50} of 4.35 (Fig. 1) and 4.93 ppm with the fiducial limit ranges

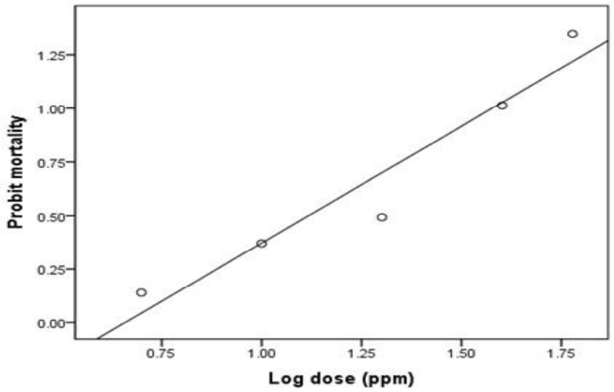

Fig. 1: Regression line showing dosage mortality response of *O. obesus* to bifenthrin

of 1.29-7.41 and 2.12-7.61 ppm respectively (Table II and III). However, it was followed by thiamethoxam, chlorpyriphos 20 per cent EC (TC) and chlorpyriphos EC. The highest and lowest toxicity of evaluated insecticides against *O. obesus* was

Table II

Dosage mortality response of different insecticides and their relative toxicity (RT) against worker termites of O. obesus

Insecticide	LC_{50} (ppm)	Relative Toxicity (RT)at LC_{50}	Fiducial limit (ppm)	Regression equation	x^2 value (df)
Bifenthrin 2.5% EC	4.35	13.18	1.29 - 7.41	$\hat{Y}$ = -0.72 + 1.09X	1.58 (3)
Thiamethoxam 25% WG	5.41	10.59	1.00 - 10.26	$\hat{Y}$ = -0.95 + 1.22X	3.11 (3)
Chlorpyriphos 20% EC, TC	5.44	10.54	2.80 - 7.97	$\hat{Y}$ = -1.22 + 1.58X	2.83 (3)
Chlorpyriphos 20% EC	8.56	6.69	4.91 - 12.21	$\hat{Y}$ = -1.15 + 1.23X	0.23 (3)
Fipronil 5% SC	12.95	4.42	5.79 - 20.06	$\hat{Y}$ = -1.37 + 1.21X	1.73 (3)
Clothianidin 50% WDG	13.95	4.11	4.14 - 23.93	$\hat{Y}$ = -0.99 + 0.86X	0.72 (3)
Chlorantraniliprole 18.5% SC	17.68	3.24	4.88 - 30.43	$\hat{Y}$ = -1.01 + 0.81X	2.36 (3)
Clothianidin 7.5% CS	25.66	2.23	14.75 - 36.81	$\hat{Y}$ = -1.68 + 1.19X	2.24 (4)
Indoxacarb 14.5% SC	31.55	1.81	12.90 - 60.63	$\hat{Y}$ = -1.0 + 0.67X	0.78 (3)
Imidacloprid 17.8% SL	57.34	1.00	19.98 - 95.14	$\hat{Y}$ = -1.35 + 0.77X	0.06 (3)

LC-lethal concentration

TABLE III

Dosage mortality response of different insecticides and their relative toxicity (RT) against worker termites of O. horni

Insecticide	LC_{50} (ppm)	Relative Toxicity (RT) at LC_{50}	Fiducial limit (ppm)	Regression equation	x^2 value (df)
Bifenthrin 2.5% EC	4.93	12.61	2.12 - 7.61	$\hat{Y}$ = -1.0 + 1.38X	2.81 (3)
Thiamethoxam 25% WG	6.35	9.79	0.42 - 13.71	$\hat{Y}$ = -0.67 + 0.8X	2.45 (3)
Chlorpyriphos 20% EC, TC	7.08	8.78	3.50 - 10.60	$\hat{Y}$ = -0.98 + 1.15X	0.72 (3)
Chlorpyriphos 20% EC	8.59	7.23	4.63 - 12.54	$\hat{Y}$ = -1.06 + 1.13X	0.06 (3)
Clothianidin 50% WDG	16.29	3.81	6.93 - 27.62	$\hat{Y}$ = -0.82 + 0.67X	1.68 (4)
Chlorantraniliprole 18.5% SC	17.86	3.48	8.5 - 27.14	$\hat{Y}$ = -1.51 + 1.2X	3.93 (4)
Fipronil 5% SC	19.29	3.22	9.94 - 31.36	$\hat{Y}$ = -0.95 + 0.74X	2.55 (4)
Clothianidin 7.5% CS	28.54	2.17	7.78 - 52.16	$\hat{Y}$ = -0.95 + 0.65X	2.95 (3)
Indoxacarb 14.5% SC	42.63	1.45	24.74 - 80.72	$\hat{Y}$ = -1.27 + 0.78X	0.34 (3)
Imidacloprid 17.8% SL	62.19	1.00	31.30 - 96.03	$\hat{Y}$ = -1.64 +0.92 X	1.26 (4)

LC - lethal concentration

bifenthrin (4.35 ppm) and imidacloprid (57.34 ppm), respectively and it was 4.93 & 62.19 ppm with the same insecticides against *O. horni*. Thiamethoxam was the next best toxic compound to both the species as indicated by its LC_{50} values of 5.41 with fiducial limit 1.00-10.26 and 6.35 (fiducial limit 0.42-13.71) ppm and the relative toxicity of 10.59 and 9.79, respectively.

Chlorpyriphos EC,TC (termite control) and chlorpyriphos EC were recorded the LC_{50} values of 5.44 (RT 10.54) and 8.56 (RT 6.69) against *O. obesus*, respectively. For *O. horni* LC_{50} value of 7.08 ppm (fiducial limit 3.50-10.60 ppm) and 8.59 ppm (fiducial limit 4.63-12.54 ppm) were recorded with chlorpyriphos EC with TC (termite control) and chlorpyriphos EC formulations, respectively (Table III).

Fipronil (Phenyl phyrozole group) was recorded LC_{50} value of 12.95 ppm (RT 4.42) and 19.29 ppm (RT3.22) against *O. obesus* and *O. horni*, respectively (Table II &III). The least toxic insecticide against both the test species of termite was imidacloprid as it was indicated by highest LC_{50} of 57.34 (fiducial limit 19.98-95.14) (Fig. 2) and 62.19 (fiducial limit 31.30-96.03) ppm for *O. obesus* and *O. horni*, respectively.

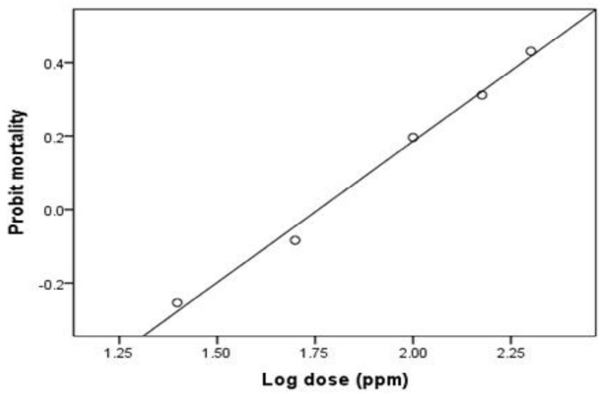

Fig. 2: Regression line showing dose mortality response of *O. obesus* to imidacloprid

Results from the study conducted by Aihetasham *et al.* (2018) indicated that LC_{50} values for fipronil and imidacloprid were 39.81 ppm and 177.32 ppm, respectively. The study conducted by Manzoor *et al.* (2012) showed that LC_{50} values for imidacloprid and fipronil was 346.75 and 14.45 ppm after 8 hrs of exposure which are different from the present findings with LC_{50} values. However similar order of toxicity was observed among the two insecticides.

Indoxacarb was found second least toxic with the LC_{50} 31.55 (fiducial limit 12.90-60.63) and 42.63

(fiducial limit 24.74-80.72) ppm and relative toxicity of 1.81 and 1.45 for *O. obesus* and *O. horni* respectively (Table II & III). The LC_{50}value of chlorantraniliprole for *O. obesus* was 17.68 (RT 3.24) and it was 17.86 (3.48) ppm for *O. horni* (Fig. 3).

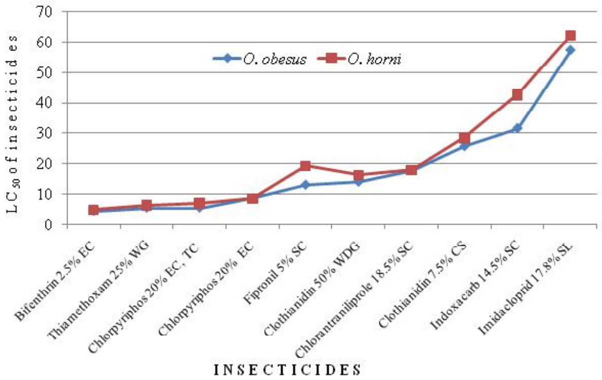

Fig. 3: Comparative efficacy of different insecticides against *O. obesus* and *O. horni*

The order of toxicity of insecticide was bifenthrin 2.5 per cent EC > thiamethoxam 25 per cent WG > chlorpyriphos 20 per cent EC TC > chlorpyriphos 20 per cent EC>fipronil 5 per cent SC >clothianidin 50 per cent WDG >chlorantraniliprole 18.5 per cent SC > clothianidin 7.5 per cent CS >indoxacarb14.5 per cent SC > imidacloprid 17.8 per cent SL against *O. obesus* (Table II). For *O. horni* it was bifenthrin 2.5 per cent EC >thiamethoxam 25 per cent WG >chlorpyriphos 20 per cent EC TC >chlorpyriphos 20 per cent EC >clothianidin 50 per cent WDG >chlorantraniliprole 18.5 per cent SC>fipronil 5 per cent SC >clothianidin 7.5 per cent CS >indoxacarb 14.5 per cent SC >imidacloprid 17.8 per cent SL (Table III). The toxicity order of thiamethaxam, fipronil, indoxacarb and imidacloprid for both the tested species are in accordance with the findings of Iqbal and Saeed (2013) where the order of average toxicity of evaluated insecticides against *Microtermes mycophagus* was chlorfenapyr > spinosad > thiamethoxam > fipronil > indoxacarb > imidacloprid.

Variation in the toxicity of different formulations of clothianidin (capsule suspension and WDG) was observed in which clothianidin with WDG formulation was found more toxic against both the tested species of termites. Similar trend was observed in chlorpyriphos EC with TC and chlorpyriphos EC formulation, where the EC with TC formulation of chlorpyriphos was specific to termite control recorded higher toxicity against both tested species of termite compared to chlorpyriphos EC formulation (Table II & III).

For all the tested insecticides, slightly higher LC_{50} and relative toxicity was recorded with *O. horni* as compared to the *O. obesus* (Fig. 3 & Fig. 4) and this variation in toxicity might be due to their variation in the foraging pattern and higher body weight. The average weight of 25 foraging worker termites of *O. horni* was 0.1340 g whereas, it was 0.0853 g for *O. obesus*.

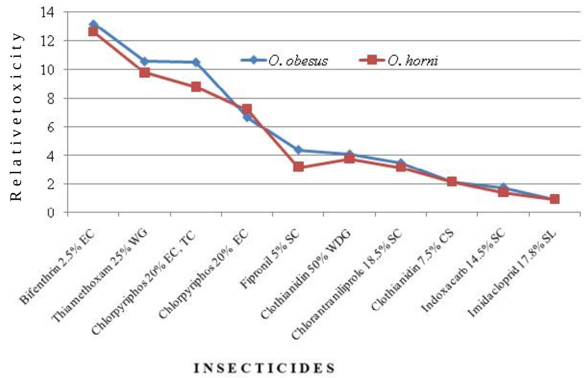

Fig. 4 : Relative toxicity of different insecticides against *O. obesus* and *O. horni*

In the present investigation among neo-nicotinoid group insecticides, imidacloprid was found least toxic as indicated by higher LC_{50} (57.34 and 62.19 ppm for *O. obesus* and *O. horni*, respectively). Rest of the neo-nicotinoid group of insecticides recorded the LC_{50} value in the range of 5.41 (thiamethoxam 25% WG) to 25.66 (Clothianidin 7.5 % CS) ppm for *O. obesus* and 6.35 (Thiamethoxam 25% WG) to 28.54 (Clothianidin 7.5% CS) ppm against *O. horni* (Table II and III). The observed variation might be due to the higher persistence in soil and their mode of action. Mortl *et al.* (2016) recorded highest retention of clothianidin and thiamethoxam in clay and loam soil. However, previous studies have shown that the imidacloprid was least toxic than other neo-nicotinoid insecticides (Rust and Saran, 2008).

Manzoor *et al.* (2012) also recorded the highest LC_{50} value (463 ppm) when it was tested against *H. indicola*. The relative toxicity of test insecticides against *O. obesus* ranged from 13.18 to 1.81 with bifenthrin and indoxacarb (Table II), respectively. Higher toxicity of bifenthrin could be due to quicker knock down action. Similar trend of relative toxicity was also recorded with *O. horni* where the relative toxicity ranged from 12.61-1.45 with bifenthrin and indoxacarb respectively compared to imidacloprid (Table III).

Determination of LC_{50} values of insecticides against termite workers indicated a higher efficacy of bifenthirn against both the tested termite species.

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(*Received :* May, 2018 *Accepted :* June, 2018)