FIPRONIL **TERMITE**

EFFECTIVENESS OF FIPRONIL 2.5 E.C. FOR TERMITE MANAGEMENT IN BUILDINGS

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ABSTRACT

In an attempt to find out bio-efficacy of Fipronil 2.5 E.C., as termiticide for buildings, a long-term study was carried out. Three experiments were conducted viz. Modified Ground Board test, Residual toxicity test and Anti-termite treatment in termite infested buildings using four test doses i.e. 0.5%, 0.25%, 0.1% and 0.05% (a/i) of Fipronil 2.5 E.C. Modified Ground Board test and Residual toxicity test were carried out in three different climatic and soil conditions of India. Anti-termite treatment in termite infested buildings was done as per Indian Code of Practice for Anti-termite Measures in Buildings, IS: 6313 (2001). Experimental findings indicates that 0.25% and above concentrations (a/i) of Fipronil 2.5 E.C. is 100% effective for termite management in buildings up to five years. It is relatively immobile in soil and has low potential to leach into groundwater.

***KEY WORDS:* Termite management, Buildings, Fipronil 2.5 E.C., Pest control, *Microcerotermes beesoni*, Snyder.**

Introduction

Termite is a serious and well known pest of agriculture, horticulture, forestry and buildings of India. Main food of termite is wood (cellulose). It has variety of usage such as building, furniture, railway sleepers, transmission poles, paper, pulp, plywood, veneers, composite board, matches, fuel and fuel wood etc. (Akanbi and Ashiru 2002).Wood is highly prone to damage by termites, thus posing lot of social and economic problems, since it requires additional labour and expenses to replace the damaged wood. Degradation of wood by termites is a chronic problem in many tropical regions. Bamboo which is poor man's timber for buildings, their huts are also seriously attacked and destroyed in India (Sen-Sarma 1986). Common termite species reported to attack buildings in India are - *Cryptotermes domesticus, Coptotermes heimi, Macrotermes spps., Microcerotermes spps., Odontotermes feae and Heterotermes indicola. Odontotermes spp.* (Tho and Kirton 1990, Rajagopal 1995). Subterranean termites annually causes damage to buildings worth several million of dollars (Hizroglu 2009, Lloyd 2011). Currently, termite management relies on the use of persistent pesticides. Previously, millions of dwellings were treated successfully around the world with chlorinated hydrocarbon based pesticides. However, lately these compounds were found highly toxic and hazardous. Surveys from around the world had demonstrated the presence of Cyclodiene residue in human adipose tissue and in breast milk. This accumulation property of Cyclodiene was due to lipopilic property. These pesticides were then legally banned around the world including India. But the current awareness of environmental and health hazards associated with pesticide usage has spurred intensive research in the search of alternative strategies. (Kutz et al. 1991, EPA 1997, Tsunoda 2003).

Fipronil, 5-amino-1-(2,6-dichloro-α,α,α-trifluorop-tolyl)-4-trifluoromethylsulfinyl pyrazole-3-carbonitrile belongs to the chemical class of compounds containing phenyl pyrazole moiety (*Fig.1*). It is a broad spectrum pesticide and highly effective to control wide range of pest of crops, pûblic hygiene, veterinary and household pests e.g. ants, beetles, cockroaches, fleas, ticks, mites,

Table 1

Observations of modified ground board test of all the sites

Dose Rates % (a/i)	Test Sites	Months 06	12	18	24	30	36	42	48	54	60
0.1%	R	—	—	—	—	—	—	—	—	—	XX
	D	—	—	—	XX	XX	XX	XX	XXX	XXX	***
	M	—	—	—	—	—	—	—	—	—	ONR
0.05%	R	—	—	—	X	X	X	XX	XX	***	***
	D	—	—	—	XXX	XXX	***	***	***	***	***
	M	—	—	—	X	X	X	X	XX	***	ONR
Control	R	X	XX	XXX	***	***	***	***	***	***	***
	D	X	XX	XX	XXX	XXX	***	***	***	***	***
	M	X	XX	XXX	XXX	XXX	XXX	XXX	***	***	ONR

*Abbreviations: — = No damage, X = Slight Damage, XX=Damage, XXX = Highly Damaged, *** = Eaten away or failure of test block, R = Roorkee site, D = Dehradun site and M = Mumbai site, ONR = Observation not recorded.*

mole crickets, thrips, rootworms, weevils, and other insects (Colliot *et al.* 1992). It is considered highly toxic to honey bees *(Apis mellifera)* (Vidau *et al.* 2011). Fipronil, an *N*-phenylpyrazole with a trifluoromethylsulfinyl substituent, initiated the second generation of insecticides acting at the gamma-aminobutyric acid (GABA) receptor to block the chloride channel. The first generation includes polychlorocycloalkanes alpha - endosulfan and lindane (Dominik 1998). It has different modes of action than any other common insecticides (Ware 2000). It is extremely active molecule as it disrupts the nerves in the brain and spinal cord by interfering with the ability of these nerve cells to transmit nerve impulses. The result is uncontrolled activity leading to death of insect (Tingle *et al.* 2003).

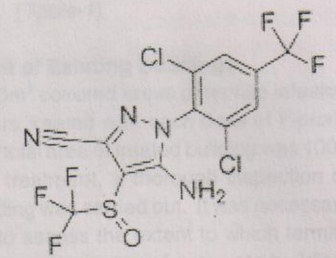

Fig.1: Chemical structure of Fipronil

The present study was undertaken to investigate the effectiveness of Fipronil 2.5 E.C. for termite management in buildings. Three experiments were carried out as follows:

Material and Methods

(i) Modified Ground Board (MGB) test:

This test simulates building conditions in the field with cement -concrete slabs on the prepared ground. It consist 43 x 43 cms. plot of treated soil covered by a slab. The soil under the slab was treated with chemical solution of known concentration at the rate of 3 litre/m^2 . Solution of Fipronil 2.5.E.C. was prepared in water following label instructions. After the chemical solution has been soaked into the soil, it was covered with polyethylene vapour barrier. The soil and vapor barrier surrounding the inspection port were covered with cement –concrete slab (size 45 x 45 cms and thickness 4cms.). A PVC pipe of 10 cms diameter extends through the centre of the concrete slab to serve as an inspection port. It was covered with 15x15cms transparent perspex sheet and weighed down with a brick. The vapour barrier was removed from inside the pipe. Inspection port of PVC pipe contains a 5x5cms square test block of perishable mango wood (*Mangifera indica*) placed on treated soil. The test block was examined regularly after every interval of six months till the end of experimental period. Replicates were set out in a randomized complete block design. The test was conducted at three distant locations of India viz. Roorkee, Dehradun and Mumbai. Four concentrations of Fipronil 2.5 E.C. were used for this test, these were 0.5%, 0.25%, 0.1% and 0.05% (a/i). At each site there were three replicas of each concentration. The results obtained were compared with untreated

Table 2

Mortality of termites on soil previously treated with various concentrations (a/i) of Fipronil 2.5 E.C.

Dose rate % (a/i)	Test Sites	100% Termite Mortality (in hrs) Depth (in cms) 0-15 cms	15-30 cms	30-45 cms	45-60 cms	60-75 cms	75-90 cms
0.50%	R	50	30	32	48	56	72
	D	32	30	30	48	54	72
0.25%	R	48	48	48	54	72	72
	D	50	48	32	54	56	72
0.10%	R	54	50	50	54	72	72
	D	54	52	50	54	72	72
0.05%	R	56	54	56	72	72	72
	D	56	56	56	72	72	72
Control	R	72	72	72	72	72	72
	D	72	72	72	72	72	72
Chlor.1.0%	R	56	48	48	50	50	72
	D	56	32	48	56	56	56

Abbreviations: R = Roorkee, D = Dehradun, M = Mumbai, Chlor. = Chlorpyrifos 20 E.C.

control (treated with water only) and 1.0 % concentration (a/i) of Chlorpyrifos 20 E.C. under similar conditions. Ground board (GB) and concrete slab (CS) test methods are currently used by the EPA and thus Forest Service (USDA) to evaluate soil-applied termiticides. (Beal 1986, Kard et al. 1989, Mulrooney et al. 2007). Termite attack was defined as the presence of termites and damage to test blocks at the time of inspection. Termite damage was rated according to the U.S. Forest Service "Gulfport" scale, where 0 or — = is no damage, 1 or X = is nibbles to surface etching or slight damage, 2 or XX = is damage with penetration, 3 or XXX = is moderate or highly damage, 4 or *** = is Eaten away or test block failure. (*Table-1*)

(ii) Treatment of Existing Buildings:

About 250m² covered areas of termite infested buildings were treated with each dose of Fipronil 2.5 E.C. The total area of treated building was 1000 m². Prior to treatment, a thorough inspection of infested building was carried out. It was necessary with a view to assess the extent to which termite was spread and the routes of entry into building. Termite hiding places such as ceiling, behind wooden paneling, electrical wires, battens, conduits, switchboards and similar locations were thoroughly searched. The aim of treatment was to create a continuous chemical barrier between nest of termite present in the soil and its food present in the building. Externally, the soil in contact with foundation was treated with chemical solution at the rate of 7.5 ltr/m² of the vertical surface to a depth of 30cms. To facilitate this treatment a shallow channel was directed towards the wall at 1.75 ltr/running metre of the solution.

Roding with 12 mm diameter mild steel rods at 15 cms apart was done in the channel, if felt necessary for uniform dispersal of the solution to 30 cms depth from the ground level. The balance solution of 0.5 ltr/running metre was used to treat the backfill earth as it was returned to the channel directing the spray towards the wall surface. In case of concrete or masonry apron, holes of approximately 19 mm diameter were drilled as close as possible to the plinth wall at intervals of 30 cms and chemical solution pumped into these holes to soak the soil below at the rate of 2.25 ltr/linear metre. The holes were drilled at a downward angle at about 45° at approximately 30 cms intervals. The solution was squirted through these holes using a hand operated pressure pump. Holes were also drilled at critical points such as wall corners and the point where door and window frames were erected. The methodology of treatment was in accordance with Indian Code of Practice IS: 6313- 2001, (Shripat et al. 2005, AS 3660- 2000).

(iii) Residual Toxicity Test:

In order to determine residual toxicity of Fipronil 2.5 E.C., the experimental procedure of MGB test was slightly changed. The test consist 43 x 43 cms. plot of treated soil covered by a cement-concrete slab. The soil under the slab was treated with chemical solution of known concentration at the rate of 3 litre/m^2. The treated soil was then covered with cement –concrete slab (size 45 x 45 cms and thickness 4cms.) without inspection port and the test block. 75 gms of soil treated with each concentration was collected from all the three replicas and from different depths of soil. It was mixed thoroughly, ground and sieved. Distilled water was mixed in the soil so that the moisture content should be around 20%. It was then put in equal amount and in three different Borocil glass Petri dishes (90 mm dia) in the form of 4mm thin bed at 28^{0}C±5^{0}C and 90%±5% Rh. Active termite workers (10 Nos.) of *Microcerotermes beesoni*, Snyder were released over these beds and their rate of mortality was determined after every two hours interval. It was compared with the rate of mortality of active workers of termite on untreated soil and soil treated with 1.0 % concentration (a/i) of Chlorpyrifos 20 E.C. under similar laboratory conditions (Sen-Sarma and Mishra 1969, Owusu *et al.* 2008, Sohail and Muhammad 2006, El-Sherif *et al.* 2010).

Results and Discussion

In MGB test, termite attack was started within first six months on all the test blocks, which were kept on untreated soil. The intensity of attack was increased further and all the test blocks were observed 100% damaged in all the sites at the end of 48 months. Further, no sign of termite infestation were noticed on any of the test blocks (up to 18 months), which were kept on the soil treated with 0.05% and 0.1% concentrations (a/i) in all the three sites and all the replicas. At 0.05% concentration (in Dehradun site), termite attack on all the test blocks were observed after 24 months, these test blocks were completely eaten away by termites till the end of fourth year. While, in Roorkee and Mumbai site, the termite attack was rather slow, the test blocks were sustained up to fourth year. Termite infestation was noticed on fourth observation (24 months) at 0.1% concentration (in Dehradun site), it was increased slowly up to 54 months. Whereas, no termite attack was observed on any of the test block kept in Dehradun and Mumbai sites in the same concentration (0.1%). Termite infestation has not been observed in any of the test blocks, which were kept on soil treated with 0.25% and 0.50% (a/i) concentrations of Fipronil 2.5 E.C. and 1.0% concentration (a/i) of Chlorpyrifos 20 E.C. till the end of experimental period of five years.

After five years of experimental period, all the treated buildings were examined carefully. Generally, reappearance of termite starts from the damp, moist, dark and less ventilated areas of building. Therefore, care was taken to examine these areas. It was observed that termite was reappeared in building, which was treated with 0.05% concentration (a/i) of Fipronil 2.5 E.C. Termite galleries were noticed in kitchen, cupboard, below sink, toilet, wash basin and electric fixture of store room etc. However, all the other buildings were found in good condition, which were treated with 0.1%, 0.25% and 0.5% concentration (a/i) of Fipronil 2.5 E.C. It is clear from *Table-2*, that the residue of pesticide percolated maximum up to 75 cms underground in the soil, when the soil was treated with maximum dose of 0.50% (a/i). It shows binding property of pesticide with soil particles. The soil samples collected from 0-75cms were observed evenly toxic because 100% mortality of termites was achieved between 30 to 48 hrs. In case of untreated control, 100% mortality of termites was achieved within 72 hrs. under similar laboratory conditions. However, residue of Chlorpyrifos 20 E.C. percolated maximum up to 90cms underground in the soil (Ying and Kookana 2006).

The persistence of Fipronil 2.5 E.C. was also studied by Sharma et al. 2008, they concluded that Fipronil degrades into two metabolites viz. desulfinyl and sulfide. At lower dosage, however no metabolite was detected. At 0.25% and 0.5% application rate, 1.87 and 2.75 ìg g"1 desulfinyl and 1.56 and 3.18 ìg g"1 sulfide, respectively were detected. The degradation products are sulfide formed through reduction in soil, desulfinyl formed by photolysis in water or on soil. In soil, as well as vegetation also three major metabolites i e. desulfinyl, sulfide and sulfone are formed, however in different relative concentration (Fenet *et al.*

2001). Desulfinyl and sulfide metabolites are more toxic than the parent compound. Texture and structure of soil particles control permeability of pesticides in soil. Soils having coarse or sandy textures are generally more permeable than loamy or clayey soils. Soils with good structure generally have larger pores and greater permeability than soils with poor structure. As soil permeability increases, the potential for pesticides to reach the ground water by downward leaching increases. The organic matter present in the soil, adsorb many pesticides and serves to reduce the rate of downward movement in the soil. Therefore, pesticide mobility and potential contamination of groundwater are greater in soils having low organic matter content than soils having high organic matter content (Grace et al. 1993, Dominik et al. 1998, Mulrooney et al. 2006, Baker and Bellamy 2006, Ying and Kookana 2006, Mukherjee and Kalpana 2006, Fenet et al. 2001).

Conclusion

On the basis of experimental findings, it can be concluded that 0.25% and above concentrations (a/i) of Fipronil 2.5 E.C (Termidor 2.5 E.C.) is 100% effective for termite management in buildings up to five years.

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Bibliography

AS 3660 (2000): Termite Management. Standards Australia.

Ahmed, S., Farhan, M. (2006): Laboratory evaluation of Chlorpyrifos, Bifenthrin, Imidacloprid, Thiamethoxam and Flufenoxuron against *Microtermes obesi* (Isoptera: Termitidae). *Pakistan Entomologist* 28: 45-49.

Akanbi, M.O. and Ashiru, M.O.(2002): A hand book of forests and wood insects of Nigeria. *Agbo Areo Publishers*, Ibadan, pp.66.

Baker, P.B. and Bellamy, D.E. (2006): Field and laboratory evaluation of persistence and bioavailability of soil termiticides to desert Subterranean termite *Heterotermes aureus* (Isoptera: Rhinotermitidae). *J. Econ. Entomol.*, 99(4): 1345-1353.

Beal, R. H. (1986): Field testing of soil insecticides as termiticides. *In* Proceedings of the 17th Annual Meeting International Research Group on Wood Preservation, Working Group 1b, 26-30 May 1986, Avignon, France. *IGR Secretariate, Stockholm, Sweden.* Document IRG/WP/1294.

Bobe, A., Coste, C. M., and Cooper, J-F. (1997): Factors influencing the adsorption of Fipronil in soils. *Journal of Agricultural and Food Chemistry*, 45: 4861-4865.

Colliot, F., Kukowski, K. A., Hawkins, P. W., and Rober, D. A. (1992): Fipronil: a new soil and foliar broad-spectrum insecticide. *Brighton Crop Protection Conference – Pests and Diseases*, 1, 29-34.

Dominik, H., Loretta, M. C., and John, E. C.(1998): Mechanisms for selective toxicity of Fipronil insecticide and its sulfone metabolite and desulfinyl photoproduct. *Chem. Res. Toxicol.*, 11: 1529-1535.

El-Sherif, S.I., Belal, M.H., Rashad, H.M. and El-Latif, N.A.A. (2010): Movement of three termiticides in a sandy loam soil and their biological activity on the workers of the subterranean termites *Anacanthotermes ochraceus*, Burmeister (Isoptera: Hodotermitidae). *Research Journal of Agricultural Sciences* 1(3): 177-183.

EPA. (1997): Toxicological Review of Chlordane (Technical). (CAS No. 12789-03-6).

Fenet, H., Beltran, E., Gadji, B., Cooper, J. F., and Coste, C. M. (2001): Fate of a phenyl-pyrazole in vegetation and soil under tropical field condition. *Journal of Agriculture and Food Chemistry*, 49: 1293-1297.

Grace, K.J., Yates, J.R., Tamashiro, M., and Yamamoto, R.T.(1993): Persistence of organochlorine insecticides for Formosan subterranean termite (Isoptera: Rhinotermitidae) control in Hawaii. *J. Econ.Entomol.* 86(3): 761-766.

Hiziroglu, S.(2009): Basics of pressure treatment of wood. *Division of Agriculture Sciences and Natural Resources. Okahoman State University. http://pods.dasnr.okstate.edu.*

IS: 6313 (2001): Code of practice for anti-termite measures in buildings. Part-III: Treatment for existing buildings, (Second revision), *Bureau of Indian Standards, India.*

Kard, B. M., Mauldin, J.K. and Jones, S.C. (1989): Evaluation of soil termiticides for control of subterranean termites (Isoptera). *Sociobiology*, 15: 285-297.

Kutz, F.W., Wood, P.H. and Bottimore, D.P. (1991): Organochlorine pesticides and polychlorinated biphenyls in human adipose tissue. *Reviews of Environmental Contamination and Toxicology*, 120: 1-82.

Lloyd, J., and Meiracker, K.V.D.(2011): Termite Control - with Experience from the U.S.A. *Proceedings of the 8th Conference of the Pacific Rim Termite Research Group*. (February 28 & March 1, 2011, Bangkok, Thailand).

Mukherjee, I., and Kalpana, (2006): Sorption of Fipronil in Indian soils. *Bulletin of Environmental Contamination and Toxicology*, 76(2): 334-340.

Mulrooney, J.E., Wagner, T.L., Shelton, T.G., Peterson, C.J. and Gerard, P.D. (2007): Historical review of termite activity at forest service termiticide test sites from 1971 to 2004. *J. Econ. Entomol.* 100(2): 488-494.

Mulrooney, J.E., Davis, M.K., Wagner, T.L. and Ingram, R.L.(2006): Persistence and efficacy of termiticides used in preconstruction treatments to soil in Mississippi. *J. Econ. Ent.*, 99(2): 469-475.

Owusu, E.O., Akutse, K.S., Afreh-Nuamah, K, (2008): Effect of some traditional plant components on the control of termites, *Macrotermes* spp. (Isoptera: Termitidae). *African Journal of Science and Technology* (AJST) *Science and Engineering Series*, 9(2), pp. 82-89.

Rajagopal, D. (1995): Ecology of termites. *Proceeding of national workshop on termite management in buildings*, CSIR-CBRI, Roorkee, India Feb. 20-21, 1995, 129-137.

Sen-Sarma, P.K. (1986): *Proc. Indian Natl. Sci. Acad.*, (B) 52: 134-147.

Sen-Sarma, P.K. and Mishra, S.C.(1969): Seasonal variations of the nest population in *Microcerotermes beesoni* Snyder. *Proc. Natn. Inst. Sci. India* (B) 35: 361-367.

Sharma, K.K., Kalpana, Vandana, S., Gupta, P., Jaya, M., Kumar, A. and Singh, B. (2008): Persistence and vertical distribution of termiticide Fipronil in modified ground board test. *Environ. Monit. Assess.*, 137: 179-184.

Shripat,T.K. and Robert, W.D.(2005): Innovation in perimeter treatment against subterranean termites. (Isoptera: Rhinotermitidae). *Proceedings of the Fifth International Conference on Urban Pests*, Printed by Perniagaan Ph'ng @ P&Y Design Network, Malaysia. pp.198-203.

Tho,Y.P. and Kirton,L.G.(1990):The economic significance of *Coptotermes* termites in Malaysian forestry. *Proc. Int. Conf. Plant. Prot. Trop.*, 4: 193-199.

Tingle, C.C.D. et al. (2003): Fipronil: Environmental fate, ecotoxicology, and human health concerns. *Rev. Environ. Contam. Toxicol.* 176: 2-3.

Tsunoda, K. (2003): Economic importance of Formosan termite and control practices in Japan. *Sociobiology*, 41(1), 27-36.

Vidau, C., Diogon, M., Aufauvre, J., Fontbonne, R., and Viguès, B., *et al.* (2011): Exposure to sublethal doses of Fipronil and Thiacloprid highly increases mortality of honeybees previously infected by *Nosema ceranae*. PLoS ONE, 6(6): e 21550.

Ware, G.W. (2000): *The pesticide book. Fresno, CA: Thomson Publications*. p. 69.

Ying, G. G., and Kookana, R. S. (2006): Persistence and movement of Fipronil termiticide with under slab and trenching treatments. *Environmental Toxicology and Chemistry*, 25: 2045-2050.

Brazil to build first algae-based biofuel plant

The world's first industrial plant producing biofuels from seaweed will be built in the northeastern Brazilian state of Pernambuco in late 2013, the official in charge of the projects said recently.

The factory to be set up by Austrian firm SAT on a sugar cane plantation that yields ethanol, will produce 1.2 million litres of algae-based biofuels annually, Mr. Rafael Bianchini, head of SAT's Brazilian subsidiary, told newsmen.

The $9.8-million facility will make use of the carbon dioxide (CO_2) emitted in the ethanol production to speed up the photosynthesis process in the seaweeds and thus reduce emissions of polluting gases into the environment. Mr. Bianchini said the goal was to 'convert the CO_2 from a passive to an active' state, "making use of the strong CO_2 emissions lost in the sugar cane ethanol production."

Initially, the algae-based biofuel facility will use five percent of the emissions from the sugar cane ethanol process but later the proportion will be increased, Mr. Bianchini said.

Brazil is the world's second largest producer of biofuels after the United States.