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Efficacy of new generation insecticides for the management of shoot borer (*Conogethes punctiferalis* Guen.) (Lepidoptera: Crambidae) of turmeric (*Curcuma longa* L.)

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Abstract

The efficacy of nine insecticides and a natural product was evaluated in the field at Peruvannamuzhi (Kerala) for the management of shoot borer (*Conogethes punctiferalis*), a major insect pest on turmeric (*Curcuma longa*). Pooled analysis of data for two years showed that chlorantraniliprole 0.01% treatment had the lowest mean pseudostem damage (0.3%) that was on par with lambda-cyhalothrin 0.01% (1.0%) and flubendiamide 0.02% (1.8%), when these insecticides were sprayed at fortnightly intervals from the second fortnight of July to the first fortnight of November. Fresh rhizome yield was highest in plots treated with lambda-cyhalothrin 0.01% (9.7 kg bed^{-1}) that was on par with flubendiamide 0.02% (9.5 kg bed^{-1}), chlorantraniliprole 0.01% (9.0 kg bed^{-1}) and spinosad (9.0 kg bed^{-1}). The trials indicated that reduced-risk/low-toxic insecticides such as chlorantraniliprole and flubendiamide can be utilized for the management of the pest with less hazard to the environment.

Keywords: diamides, low risk pesticides, pest management, pseudostem borer, spices

The shoot borer (*Conogethes punctiferalis* Guen.) (Lepidoptera: Crambidae), is a major insect pest of turmeric (*Curcuma longa* L.), extensively used all over the world as a spice and health supplement. The pest is widely distributed infesting over 65 plant species belonging to different families in tropical and sub-tropical regions (Devasahayam & Koya 2007). The damage is caused by the larvae boring into pseudostems and feeding on the growing shoot that results in yellowing and drying of infested pseudostems. Sometimes the larvae also enter the pseudostem by boring into the leaf petiole. The pest has the potential to cause 72–79 g yield loss per clump when 25–75% of pseudostems are infested (Devasahayam *et al.* 2010). None of the natural enemies recorded on the shoot borer (Devasahayam 1996; Senthil Kumar *et al.* 2018) have been commercially exploited so far and the present control measures depend only on insecticides. The insecticides generally effective for the management of shoot borer on ginger are also generally recommended against the pest on turmeric. Despite being a serious pest, very few new generation insecticides have been evaluated for the management of the pest under field conditions. In view of the environmental concerns over pesticide misuse, we evaluated nine insecticides including newly developed reduced-risk/low-toxic insecticides and a natural product for the management of shoot borer on turmeric and the results are reported here.

The field trials were carried out at Peruvannamuzhi (11°.342 N, 75°.482 E and 60 m above MSL), Kozhikode District, Kerala at the Experimental Farm of ICAR-Indian Institute of Spices Research during the crop seasons of 2015-16 and 2016-17 under rain-fed conditions. The total annual rainfall was 4243 mm and 5478 mm respectively, during the study period. Turmeric variety IISR-Prathibha was grown on 3 M × 1 M size beds with a spacing of 25 cm × 25 cm between clumps, accommodating 40 clumps per bed. The planting was undertaken during June each year and all agronomic practices except plant protection measures recommended by ICAR-IISR (2015) were adopted to raise a healthy crop. The treatments included nine insecticides and spinosad, a natural product in a randomized block design; a control with water spray was also included as one of the treatments (Table 1). A single bed constituted a treatment that was replicated thrice. A knapsack sprayer was used to spray various chemicals to the point of run off. The treatments were undertaken at fortnightly intervals starting from the second fortnight of July when the first symptom of pest attack was observed on the inner most tender leaf and continued up to the first fortnight of November. Observations on the number of healthy and damaged pseudostems as characterized by the presence of bore-holes was recorded in each clump during the last week of November at crop maturity. The crop was harvested during the first fortnight of February in the subsequent year and the yield of fresh rhizomes in each bed was recorded. The data on per cent pseudostem damage for individual clumps were pooled bed-wise, transformed and subjected to ANOVA. The analysis was carried for individual years and also for the pooled data for two years. The data on yield for individual clumps were similarly pooled bed-wise and subjected to ANOVA. The means were separated by LSD (= 0.05) to determine the differences between the treatments.

The mean pseudostem damage during 2015-16 was lowest in plots treated with chlorantraniliprole (0.4%) that was on par with lambda-cyhalothrin (1.0%) and flubendiamide (1.7%) (Table 1). All other treatments except imidacloprid and thiamethoxam were superior to control. Plots treated with chlorantraniliprole had least pseudostem damage (0.3%) during 2016-17 that was on par with lambda-cyhalothrin (1.0%), flubendiamide (1.8%) and spinosad (2.1%). All other treatments except imidacloprid were superior to control. Pooled analysis of data for two years indicated that chlorantraniliprole 0.01% had the lowest mean pseudostem damage (0.3%) that was on par with lambda-cyhalothrin 0.01% (1.0%) and flubendiamide 0.02% (1.8%). All other treatments except imidacloprid were superior to control.

In trials conducted on ginger recently against shoot borer, chlorantraniliprole 0.01% was the most effective treatment that was on par with flubendiamide 0.02% (Senthil Kumar *et al.* 2017). Chlorantraniliprole, lambda-cyhalothrin and flubendiamide were also effective against many other lepidopteran borer pests of horticultural crops. Chlorantraniliprole was reported to be effective against *C. punctiferalis* in castor (Patel & Borad 2016), *Helicoverpa armigera* (Hub.) in tomato (Ambule *et al.* 2015) and *Leucinodes orbonalis* Guen. in eggplant (Kameshwaran & Kumar 2015). Cyantranilprole, spinosad and flubendiamide have been reported to be effective against *L. orbonalis* in eggplant (Sajjan & Rafee 2015). Flubendiamide was reported to be effective against *H. armigera* in tomato (Ameta & Bunker 2007) and chilli (Tatagar *et al.* 2009), *Earias vittella* (Fab.) in okra (Bansode *et al.* 2015) and *L. orbonalis* on eggplant (Saha *et al.* 2014). Earlier, lambda-cyhalothrin 0.0125% was reported to be effective in controlling shoot borer in turmeric (Devasahayam *et al.* 2010). Lambda-cyhalothrin was also reported to be effective against *H. armigera* in tomato (Naitam *et al.* 1999) and *E. vitella* in okra (Shinde *et al.* 2011).

The yield of fresh rhizomes was highest in plots treated with lambda-cyhalothrin 0.01% (9.7 kg bed^{-1}) that was on par with flubendiamide 0.02% (9.5 kg bed^{-1}), chlorantraniliprole 0.01% (9.0 kg bed^{-1}) and spinosad (9.0 kg bed^{-1}). The lowest yield was obtained in the control plot (4.5 kg bed^{-1}). In spinosad treated beds, even though the pest damage was slightly higher, the yield was comparable with chlorantraniliprole, lambda-cyhalothrin and flubendiamide treatments. Likewise, the differences in the mean shoot damages in cyantranilprole (5%) and in spinosad (4.5%) treated beds were not significant, but the yield was higher in spinosad treatment (9.0 kg

Table 1. Evaluation of insecticides for the management of shoot borer on turmeric

Treatment	Concentration (%)	Mean pseudostem damage (%)			Mean yield (kg bed^{-1})
		2015–16*	2016–17**	Pooled (2015–16 & 2016–17)*	Pooled (2015–16 & 2016–17)
Malathion 50% EC (2 ml L^{-1})	0.1	18.6(25.4)ef	15.9(4.0)fg	17.3(24.5)de	6.5cd
Lambda-cyhalothrin 5% EC (2 ml L^{-1})	0.01	1.0(5.2)ab	1.0(1.2)ab	1.0(5.7)ab	9.7a
Quinalphos 25% EC (2 ml L^{-1})	0.05	10.5(18.6)de	8.4(3.0)de	9.4(17.9)cd	7.5bcd
Fipronil 5% SC (0.5 mL L^{-1})	0.0025	8.9(16.4)cde	3.1(1.9)bc	6.0(13.8)bc	7.8bc
Imidacloprid 17.8% SL (0.5 ml L^{-1})	0.009	46.5(42.9)g	21.1(4.6)gh	33.8(35.2)fg	6.0de
Thiamethoxam 25% WG (0.5 ml L^{-1})	0.0125	28.9(32.3)fg	14.2(3.8)ef	21.5(27.3)ef	7.6bc
Spinosad 45% SC (0.5 ml L^{-1})	0.0225	6.9(14.8)bcde	2.1(1.6)ab	4.5(11.8)bc	9.0ab
Flubendiamide 39.35% SC (0.5 ml L^{-1})	0.02	1.7(7.4)abc	1.8(1.4)ab	1.8(7.6)ab	9.5a
Chlorantraniliprole 18.5% SC (0.5 ml L^{-1})	0.01	0.4(3.1)a	0.3(0.8)a	0.3(3.2)a	9.0ab
Cyantraniliprole 10.26% OD (0.5 ml L^{-1})	0.005	4.6(11.0)abcd	5.48(2.4)cd	5.0(12.9)bc	7.5bcd
Control (water spray)	-	42.5(40.3)g	27.5(5.3)h	35.0(36.2)g	4.5e
CD (P<0.05)		10.7	0.8	8.5	1.6

*Data in parenthesis are arcsine transformed values $[(x + 0.5)/100]^{1/2}$
**Data in parenthesis are square root transformed values
Means followed by different letters are significantly different by LSD ($\alpha = 0.05$).

bed^{-1}) compared to cyantranilprole (7.5 kg bed^{-1}). One possible reason for these differences may be that spinosad is a naturally derived product from the actinomycete bacterium, *Saccharopolyspora spinosa* and actinomycetes are known to have many plant growth promoting traits other than antimicrobial properties (Bhatti *et al*. 2017). However, further investigations are necessary to elucidate the role of spinosad for higher yields in turmeric plants.

In India, chlorantraniliprole and flubendiamide are categorized as green label pesticides which are considered as low risk pesticides (KAU 2011). The U.S. Environmental Protection Agency has classified chlorantraniliprole as a reduced-risk pesticide (USEPA 2019). Many of the research findings state that these diamides are less toxic and relatively safe to arthropod natural enemies, compared to many of the insecticides that are presently used against pest insects (Singh *et al.* 2016). Diamide insecticides have a favourable ecotoxicological profile and are relatively safe to insect natural enemies and these chemicals are classified as slightly harmful to harmless as per IOBC (International Organization for Biological Control) categorization against non-target natural enemies Singh *et al.,* 2016; Brugger *et al.* 2010). Among the natural enemies recorded on *C. punctiferalis* infesting turmeric in the field, mermithid nematode and hymenopterous parasitoids play a significant role in the suppression of the pest (Devasahayam 1996; Senthil Kumar *et al*. 2018). Hence use of insecticides such as chlorantraniliprole and flubendiamide that are classified as reduced-risk/low-toxic pesticides would be ideal for conservation of natural enemies and for developing integrated pest management strategies against *C. punctiferalis* in turmeric.

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