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RESEARCH PAPER

Toxicity of insecticides and biopesticides on mortality and emergence of adult *Trichogramma chilonis* Ishii. (Hymenoptera: Trichogrammatidae) in greenhouse condition

KARTIK S. NIDAGUNDI, D. N. KAMBREKAR AND C. P. MALLAPUR

Department of Agricultural Entomology, College of Agriculture, Dharwad
University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India
E-mail: kartiknidagundi98@gmail.com

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Abstract: *Trichogramma chilonis* Ishii. is a common parasitoid on many lepidopteran insect eggs in agricultural ecosystem, but its efficacy can be severely curtailed by pesticide applications. Eight insecticides and two biopesticides were evaluated to check their compatibility with the *Trichogramma* parasitoid. Persistent toxicity studies revealed that chlorantraniliprole, *Metarhizium rileyi* and *Beauveria bassiana* are short lived by causing less than 30 per cent mortality at five days old residues. Whereas, chlorantraniliprole + lambda-cyhalothrin, emamectin benzoate, spinetoram and imidacloprid were labelled as slightly persistent. Further, thiamethoxam + lambda-cyhalothrin, thiamethoxam and spinosad caused more than 30.00 per cent mortality of parasitoids even to the 15 days old insecticide residues and they were classified as moderately persistent as per the IOBC classification. Tricho cards tied to the tomato plants sprayed with thiamethoxam + lambda-cyhalothrin, spinetoram and spinosad severely affected the adult emergence of *T. chilonis*. So, they have to be used cautiously in the Integrated Pest Management (IPM) programme.

Key words: Biopesticides, Compatibility, Efficacy, Persistent toxicity

Introduction

Mass breeding and release of natural enemies for control of various insect pests is now commercial practice in many countries. Trichogrammatid (Hymenoptera) egg parasitoids are distributed worldwide and represent around 80 genera from the Trichogrammatidae family with over 800 species (Sumer *et al*., 2009). Trichogrammatids are considered to be the most useful biological control agents for inundative release which parasitizes the eggs of over 400 species belonging to at least seven insect orders (Bao and Chen, 1989). *T. chilonis*. is an important egg parasitoid used in cotton, sugarcane and rice ecosystems which showed an appreciable success in suppressing the insect pest density. The natural enemies do not eliminate the insect pest population completely, instead they establish equilibrium with insect pest population and maintain the population below damage thresholds. When the insect pest densities exceed these thresholds, an occasional insecticide treatment is needed. Natural enemies have strong tendency of susceptibility to insecticides as compared to their herbivore host/prey. The differential susceptibility of natural enemies to insecticides creates serious compatibility problems for integration of pesticides and natural enemies in IPM programmes. Therefore, there is an urgent need of efforts to understand the risks and side effects (Lethal and sublethal effects) of commonly used pesticides on *T. chilonis*. This will assist in avoiding use of pesticide having detrimental effects on natural enemies and also to identify the timing of application of pesticide that controls the pests without adversely affecting the natural enemies. Due to limited availability of information regarding the safety of newer insecticides to *T. chilonis* the present study is proposed to investigate the persistent toxicity of insecticides and biopesticides to *T. chilonis* in greenhouse condition.

Material and methods

Persistent toxicity of insecticides on *T. chilonis* adults

Field recommended concentrations of the selected insecticides prepared in water were sprayed on potted tomato plants at flowering stage with a hand sprayer till run off point. Plants were maintained in the pots under greenhouse of Department of Agricultural Entomology, University of Agricultural Sciences, Dharwad during 2021. Four to five treated leaves were sampled from the insecticide sprayed tomato plants at different time intervals *i.e*., 0, 5, 15 and 25 days after insecticide application and they were brought to the laboratory and placed in 9×4cm vented plastic Petri dishes. Moistened filter papers were placed beneath the leaves to keep them fresh for longer period of time. Twenty freshly emerged (5 hours old) adult parasitoids were transferred into each plastic Petri dish using a small aspirator. In order to enhance the chance of insect contact with treated surface, fresh *Corcyra* eggs were placed in the middle of the leaves. The experiment was repeated three times with three replication and 20 *T. chilonis* adults per Petri dish containing treated leaves. Water was sprayed to the plant as untreated check. After 24 hours of exposure of wasps to the insecticide residues on leaves, live and dead parasitoids were counted. The per cent adult mortality was calculated with the following formula:

$$M = \frac{d}{n} \times 100$$

Where,

M=Per cent adult mortality

d=Number of wasps died after 24 hours

n=Total number of released adults

Mortality in treatments was corrected by following formula (Abbott 1925).

$$Mc = \frac{(M - C)}{100 - C} \times 100$$

Where,

Mc= Corrected mortality

M= Per cent mortality

C= Observed per cent mortality in control treatment

The insecticide persistence was computed by a method developed by members of the International Organization for Biological Control/West Palaearctic Regional Section (WPRS) Working Group for the evaluation of harmful activity duration (persistence) of insecticides against parasitoid under laboratory conditions (Sterk *et al.,* 1999). Accordingly, insecticides were classified into categories based on the interval of time in which insecticide residues caused 30% mortality (the minimum level of toxicity as described for laboratory tests by IOBC) to *T. chilonis*. The insecticides were categorised based on persistence as:

A - Short lived (<5 days)

B - Slightly persistent (5-15 days)

C - Moderately persistent (16-30 days)

D - Persistent (>30 days)

Effects on the adult emergence of *T. chilonis* from the insecticide sprayed tricho cards

The experiment was conducted in green house condition wherein tomato plants were raised in pots in the green house. Three tricho cards (2.0×1.0 cm) with 100 six days old parasitized eggs of *T. chilonis* as three replications were stapled to the lower leaves of potted tomato plants. Field recommended doses of selected insecticides prepared in water were sprayed up to runoff on the stapled tricho cards. For the untreated control normal water was sprayed. These tricho cards were removed after spraying and brought to the laboratory and shade dried for 10 min. and transferred to the glass vials (7.6×1.0 cm) and covered the mouth of the glass vial with muslin cloth to prevent the escape of emerged adults from the glass vial. After complete emergence of adults, the number of parasitoids emerged were counted using hand lens and per cent adult emergence was calculated using following formula:

$$\text{Adult emergence (\%)} = \frac{\text{Number of adults emerged}}{\text{Total number of parasitized eggs}} \times 100$$

From the data on the number of adult parasitoids emerged from insecticide treated and untreated check in different experiments, the reduction in adult emergence was computed (Manzoni *et al*., 2007).

$$RA (\%) = (1 - AEt/AEc) \times 100$$

RA (%) – Per cent reduction in adult emergence

AEt – Adult emergence in treatment

AEc – Adult emergence in control

The insecticides were classified based on the per cent reduction in adult emergence (RA%) as harmless with less than 30 per cent RA (%), slightly harmful with 30 to 79 RA (%), moderately harmful with 80 to 99 RA (%), harmful with more than 99 RA (%) (Sterk *et al.,* 1999). The experiments were conducted in a Completely Randomized Design (CRD) and the percentage values were converted to arcsine values. The mean values of treatments were then subjected to Duncan's Multiple Range Test (DMRT) (Gomez and Gomez., 1984).

Results and discussion

Persistent toxicity of insecticides against *T. chilonis*

Based on the results of persistent toxicity of insecticides and biopesticides on the *T. chilonis,* they were classified as short lived (less than 5 days), slightly persistent (5- 15 days), moderately persistent (16-30 days) and persistent (more than 30 days). The toxicity of chlorantraniliprole, *M. rileyi* and *B. bassiana* eroded quickly and were therefore, ranked as short lived (A). Residues of chlorantraniliprole + lambda-cyhalothrin, spinetoram and imidacloprid were persisted for more than five days and hence were rated as slightly persistent. Whereas thiamethoxam + lambda-cyhalothrin, spinosad and thiamethoxam were moderately persistent at their field recommended concentration (Table 1).

It is evident from the results regarding insecticide persistency that thiamethoxam followed by spinosad had high initial toxicity against the wasp and it was supported by Sattar *et al*. (2011) who verified the moderate persistency of spinosad on *T. chilonis*. He also reported that emamectin benzoate as moderately persistent which is contradictory to the present findings. This contradiction may be due to variation in the dosage, formulation and also change in the methodology of the conduct of research. The lack of effect of *M. anisopliae* has been reported in the parasitoids *T. pretiosum* (Potrich *et al*. 2009; Pazini *et al*. 2016) and *T. atopovirilia* (Polanczyk *et al*. 2010). Kumar *et al*. (2019) recorded imidacloprid as slightly persistent and chlorantraniliprole as a non-persistent insecticide to adults of *T. chilonis*. Ko *et al*., (2015) found thiamethoxam as slightly persistent to *T. chilonis*. Shankarganesh *et al*. (2013) demonstrated the slightly to moderate toxicity of thiamethoxam and dangerous toxicity of lambda-cyhalothrin to *T. chilonis* when exposed to fresh residue of these insecticides.

Adult emergence of *T. chilonis*

Among all the insecticides tested spinetoram, spinosad and thiamethoxam + lambda-cyhalothrin were moderately harmful to the *T. chilonis* with more than 80.00 per cent reduction in the emergence of parasitoids from the treated eggs. Whereas chlorantraniliprole + lambda-cyhalothrin found slightly harmful and all other insecticides including imidacloprid, thiamethoxam, chlorantraniliprole, emamectin benzoate, *M. rileyi* and *B. bassiana* were harmless (Table 2).

The present findings were in corroboration with Sharma and Agarwal (2018) who reported that Myco- Jaal 10% SC (4.00 ml/l) (*B. bassiana*) did not affect the adult emergence

Table 1. Mortality of *T. chilonis* exposed to insecticide treated tomato leaves plucked at 0, 5, 15 and 25 days after treatment

Sl. No.	Treatments	Dosage (g or ml/l)	Percentage mortality at different days after treatment (DAT) 0	5	15	25	IOBC Category
T_1	Imidacloprid 17.8 SL	0.2	92.86 (77.43)[a]	38.10 (38.03)[f]	14.29 (18.39)[e]	8.33 (16.55)[d]	B
T_2	Spinetoram 12SC	1.0	95.24 (79.67)[a]	52.38(46.37)[d]	21.43 (27.37)[d]	12.50 (20.28)[c]	B
T_3	Thiamethoxam 25 WG	0.2	100.00(90.00)[a]	71.43(57.80)[a]	40.48(39.50)[a]	31.25 (33.99)[a]	C
T_4	Chlorantraniliprole 18.5 SC	0.2	88.10 (73.40)[b]	19.05 (25.79)[g]	11.90 (16.59)[e]	4.17 (9.65)[e]	A
T_5	Emamectin benzoate 5S G	0.2	90.48 (72.26)[b]	42.86 (40.86)[e]	28.57 (32.20)[c]	14.58(22.36)[c]	B
T_6	Spinosad 45 SC	0.2	97.62 (84.83)[a]	57.14 (49.14)[c]	40.48 (39.37)[a]	16.67 (24.01)[b]	C
T_7	Chlorantraniliprole (10%) + Lambda-cyhalothrin (5%) 150 ZC	0.5	100.00 (90.00)[a]	66.67(54.94)[b]	28.57(32.20)[c]	10.42(18.63)[d]	B
T_8	Thiamethoxam (12.6 %) + Lambda-cyhalothrin (9.5%) 247 ZC	0.5	100.00 (90.00)[a]	69.05(56.23)[a]	35.71(36.63)[b]	18.75(25.66)[b]	C
T_9	*B. bassiana*	8.0	4.76 (10.33)[c]	2.38 (5.17)[i]	2.38(5.17)[f]	0.00 (0.00)	A
T_{10}	*M. rileyi*	1.0	7.14 (15.50)[c]	7.14 (15.50)[h]	2.38(5.17)[f]	2.08 (4.83)[e]	A
	S.Em.±		2.48	1.56	1.07	1.00	-
	C.D. @ 5%		7.32	4.61	3.14	2.94	-
	CV (%)		6.29	6.94	7.30	9.81	-

*Figures in the parentheses are subjected to arc sine transformation.

*A - Short lived (<5 days), B - Slightly persistent (5-15 days), C - Moderately persistent (16-30 days), D - Persistent (>30 days)

IOBC: International Organization for Biological Control

Table 2. Effect of insecticides and biopesticides on adult emergence of *T. chilonis*

SI No.	Treatments	Dosage(g or ml/l)	Adult emergence (%)	Reduction in adult emergence (%)	IOBC Category
T_1	Imidacloprid 17.8 SL	0.2	91.40 (72.94)[b]	7.96	HL
T_2	Spinetoram 12SC	1.0	2.58 (9.19)[e]	97.40	MH
T_3	Thiamethoxam 25 WG	0.2	88.34 (70.03)[b]	11.04	HL
T_4	Chlorantraniliprole 18.5 SC	0.2	96.49 (79.23)[a]	2.83	HL
T_5	Emamectin benzoate 5S G	0.2	95.08 (77.30)[a]	4.25	HL
T_6	Spinosad 45 SC	0.2	3.20 (10.21)[e]	96.77	MH
T_7	Chlorantraniliprole (10%) + Lambda-cyhalothrin (5%) 150 ZC	0.5	28.21 (32.08)[c]	71.59	SH
T_8	Thiamethoxam (12.6 %) + Lambda-cyhalothrin (9.5%) 247 ZC	0.5	11.39 (19.67)[d]	88.53	MH
T_9	*B. bassiana*	8.0	97.53 (81.00)[a]	1.78	HL
T_{10}	*M. rileyi*	1.0	97.49 (82.56)[a]	1.82	HL
T_{11}	Untreated control- UTC		99.30 (86.08)[a]	-	
	S.Em.±		1.45		
	C.D. @5%		4.26		
	C.V. (%)		4.46		

* Figures in the parentheses are arc sine transformed values.

* Reduction in adult emergence (%): HL: Harmless <30% Per cent reduction in adult emergence, SH: Slightly harmful= 30 to 79%
MH: Moderately harmful= 80 to 99%, HF: Harmful >99%

IOBC: International Organization for Biological Control

of *T. chilonis*. Potrich *et al*. (2009) and Pazini *et al*. (2016) noticed, no adverse effect of *M. anisopliae* on *T. pretiosum*. Thiamethoxam was slightly harmful (Ko *et al*., 2015) and chlorantraniliprole was harmless (Mahankuda *et al*., 2020) to *T. chilonis* when the host eggs were treated at sixth day after parasitisation. Visnupriya and Muthukrishnan (2016) reported spinetoram 12 SC as safe to the *T. chilonis* when treated at pupal stage which is contradictory to the present findings. In contrast, Hossain and Poehling (2006) found that spinetoram 12 SC negatively affected two endolarval leaf miner parasitoid immature stages. Consoli *et al*. (2008) stated that spinosad is noxious to all the immature stages of *T. galloi*. Lambda-cyhalothrin negatively affected the emergence of *T. chilonis* (Duraimurugan and Lakshminarayana, 2018). The highest impact of thiamethoxam + lambda-cyhalothrin and chlorantraniliprole + lambda-cyhalothrin on the parasitoid emergence from the parasitized eggs might be associated to the capacity to penetrate through the host chorion, affecting the parasitoid growth and development (Consoli *et al*., 2008). High octanol/ water partition coefficient (log Kow) values confer higher lipophilicity and enable penetration of a greater amount of the insecticide through the chorion and its translocation to the site of action. As lambda-cyhalothrin with log Kow of 7 makes it to penetrate the host eggs (Hoffmann *et al*., 2008). Whereas reduction in the parasitoid emergence from the spinosad treatments might be due to feeding of emerging parasitoid on the egg shell with spinosad residues (Costa *et al*., 2014).

Conclusion

Persistent toxicity studies indicated that augmentative release of *T. chilonis* should be cautiously done in the field sprayed with spinosad, thiamethoxam and thiamethoxam + lambda- cyhalothrin as their residues will persist for 15 days and these should be substituted with more selective insecticides wherever possible.

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