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Toxic effects of some pesticides on *Deraeocoris lutescens* in the laboratory

Najmeh AZIMIZADEH[1], Kamal AHMADI[2], Sohrab IMANI[1], Hajimohammad TAKALLOOZADEH[2], Alimorad SARAFRAZI[3]

[1]*Department of Entomology, Science and Research Branch, Islamic Azad University, Tehran, Iran*
[2]*Department of Plant Protection, Faculty of Agriculture, Shahid Bahonar University of Kerman, Kerman, Iran*
[3]*Department of Insect Taxonomy Research, Iranian Research Institute of Plant Protection, Tehran, Iran*

Abstract

The susceptibility of the predatory bug, *Deraeocoris lutescens* Schilling (Rhynchota Miridae), to some common pesticides was investigated in the laboratory. Seven pesticides (abamectin, fenpropathrin, imidacloprid, pirimicarb, spirodiclofen, thiacloprid and penconazole) were assayed for their effects on the predator. These pesticides were tested at a single rate of application corresponding to their maximum recommended label rate. The toxicity of these compounds to eggs, N_1 and N_5 nymphs and adults of *D. lutescens* by residual contact was investigated and mortality of the biotests was recorded 24, 48, 72 and 96 hours after treatment. The corrected mortalities of N_1 and N_5 nymphs and adults were evaluated by the IOBC toxicity rating scale for pesticides. Penconazole and spirodiclofen caused the least mortality on different life stages of the predatory bug. The highest mortality was occurred by fenpropathrin, imidacloprid and thiacloprid. The eggs mortality was highest after exposure to fenpropathrin. Spirodiclofen and penconazole caused the least mortality with 10.4% and 19.1%, respectively. The residue of fenpropathrin, imidacloprid and thiacloprid were harmful to N_1 and N_5 instars of the predator. In contrast, penconazole and spirodiclofen residues were harmless. Abamectin was slightly harmful to N_1 and N_5 instars. The residue of pirimicarb was moderately harmful to the N_1 instar and it was harmless to the N_5 instar and adults of the predator. Fenpropathrin was harmful to adult males and females. In contrast, abamectin, pirimicarb, spirodiclofen and penconazole were harmless to the adults.

Key words: predatory bug, *Deraeocoris lutescens*, toxic effects, mortality, pesticides.

Introduction

Unexpected side effects of pesticide applications, such as pest resistance, pest resurgence and outbreaks of secondary pests may occur when overuse of insecticides is employed in crops over prolonged periods. These harmful side effects show the need for alternative methods of control that do not rely on insecticides alone. The conservation of insect predators can be an important component of alternative strategies (Badawy and El Arnaouty, 1999). Insects in the family Miridae are often particularly effective against small, soft-bodied arthropods such as aphids, psyllids, thrips, and mites (Westigard, 1973; Herard, 1986; Hodgson and Aveling, 1988; Lattin, 1999). *Deraeocoris lutescens* Schilling (Rhynchota Miridae) is a predatory bug found commonly on a wide variety of plants across Middle East and Europe that feeds on a wide range of arthropod pests such as aphids, small caterpillars, mites and insect eggs. Natural enemies such as predatory bugs play an important role in suppressing populations of many insect pests and are an essential component of integrated pest management (IPM) and integrated production of crops Thus, compatibility of new insecticides with the natural enemy populations in the field is critical for pest control (Rajakulendran and Plapp, 1982).

In recent years insecticides are being used with other methods to combat the control of insect pests. One of the challenges of insect control with pesticides is achieving a selection and kill of target pests whilst minimizing mortality to beneficial insects. Biological control agents such as insect and mite predators and hymenopterous parasitoids are usually more sensitive to pesticides than the target pests. This has been explained by the food limitation hypothesis and by differential abilities of herbivores and entomophages to detoxify pesticides (Huffaker, 1971). Pesticides can be used selectively to favor beneficial arthropods in the field through selection of active ingredient, choice of concentration, careful timing and location of application (Grafton-Cardwell and Hoy, 1986).

Understanding the impact of pesticides usually requires a variety of investigations to determine both the selectivity of pesticides against natural enemies and their other possible effects on the feeding and biological characteristics of the natural enemies in addition to mortality. Therefore, study of side effects of pesticides on predators as natural enemies is necessary. Several recent studies have illustrated the side effects of some pesticides on predatory bugs. The impact of pirimicarb on *Podisus maculiventris* (Say) (De Cock *et al*., 1996), *Orius laevigatus* (Fieber) (Delbeke *et al*., 1997) and *Orius insidiosus* (Say) (Studebaker and Kring, 2003) has been investigated. Van De Veire *et al*. (2002) studied the effect of abamectin on the 2nd and 5th nymphal instars and the adult stage of *O. laevigatus* and Kim *et al*. (2006) investigated the toxicity of abamectin on eggs and nymphal instars of the predaceous plant bug, *Deraeocoris brevis* (Uhler).

There are several ways to test the acute effects of a pesticide or other compound on predatory insects. Harmful compounds, however, need further examination. A number of tests can be used for this purpose, according to the requirements of the IOBC (Hassan,

1994). An extended laboratory test is an additional test which helps to estimate the hazard before deciding whether further trials under semi-field or field conditions are required. According to the IOBC, once an insecticide is tested in the laboratory and shows no toxicity to natural enemies, no further semi-field or field studies are needed (Hassan, 1998). In addition to killing natural enemies directly, insecticides may also have sublethal effects on insect behaviour, reproductive capabilities, egg hatch, rate of development, feeding rate, and life span. Therefore, sublethal effects experiment is necessary for both harmless and harmful chemicals.

The aim of the present investigation was to study the acute effects of the most commonly used pesticides in greenhouses in Iran, such as penconazole, abamectin, fenpropathrin, imidacloprid, pirimicarb, thiacloprid and spirodiclofen on the predatory bug *D. lutescens*, according to IOBC toxicity criteria under laboratory conditions. The toxicity of these seven compounds to eggs, nymphal instars (N_1 and N_5) and adults of *D. lutescens* by residual contact was investigated.

Materials and methods

Rearing of the predatory bug, *D. lutescens*

The predatory bug, *D. lutescens* was originally obtained from the experimental teaching garden of Shahid Bahonar University of Kerman, Iran. This species was identified by Department of Insect Taxonomy Research, Iranian Research Institute of Plant Protection, Tehran, Iran. They were reared in a climatically controlled chamber at 25 ± 1 °C temperature, relative humidity of 60 ± 10% and a photoperiod of 16:8 (L:D). Broad bean leaves were used as oviposition substrate in round plastic Petri dishes (6 cm diameter) filled with 2 cm thick-layer of 0.7% agar gel. The bugs were offered daily 40 of one or two day-old individuals of *Myzus persicae* (Sulzer) as prey.

Procedures of the experiments

During these studies, commercial formulations of seven pesticides, being one fungicide (penconazole) and six insecticides (abamectin, fenpropathrin, imidacloprid, pirimicarb, spirodiclofen and thiacloprid) were assayed for their effects on *D. lutescens* (table 1). These pesticides were tested at a single rate of application, corresponding to their maximum recommended label rate, which is generally used by farmers in greenhouses.

For each experiment, all products were diluted in distilled water at concentrations corresponding to the highest recommended label rates. The residual contact toxicity of pesticides was determined using a leaf dip bioassay. The excised broad bean leaf discs (5 cm diameter) were submerged in the pesticides solutions for 5 seconds and left to dry at room temperature for circa two hours. In the control treatments, the leaves were immersed only in distilled water. The leaf discs were placed into the round plastic Petri dishes (6 cm diameter) as described above. The round plastic Petri dishes were held in climate chambers (mentioned above).

Acute toxicity to eggs

In order to assess the percentage mortality of *D. lutescens* eggs after exposure to the pesticides, the mated females of the predatory bug (5 days after starting oviposition) were confined individually on leaves in the Petri dishes for egg laying. After 24 hours, the egg-infested leaves were treated with different pesticides as described above. The eggs were incubated and checked daily until eggs hatched and the nymphs came out from the leaves. At least ten egg-infested leaves were used for each treatment (The hatched eggs were considered as alive and others were as dead).

Acute toxicity to nymphal instars

In this experiment, five newly hatched N_1 instars of *D. lutescens* (10 replicates; n = 50) were placed together into a Petri dish on a broad bean leaf treated with different pesticides, and eggs of *Sitotroga cerealella* (Olivier) were offered as food. Mortality of nymphs was recorded 24, 48, 72 and 96 hours after treatment. Ones that did not move in response to probing with a camelhair brush were considered as dead. In another set of experiments, five newly moulted 5^{th} nymphal instars (10 replicates; n = 50) were used in each Petri dish and the experiment was conducted in a similar way.

Acute toxicity to adults

Prior to recording mortality of adult females and males of *D. lutescens* after contact with the pesticides, the newly emerged females and males were transferred

Table 1. List of common name, trade name, chemical class and concentration of selected pesticides tested on *D. lutescens*.

Pesticide group	Common name (active ingredient)	Trade name	Chemical class	Concentration tested* (mg a.i. per litre)
Insecticides and Acaricides	Abamectin	Vertimec	Macrocyclic lactone (Biopesticide)	9
	Fenpropathrin	Danitol	Pyrethroid	100
	Imidacloprid	Confidor	Neonicotinoid	150
	Pirimicarb	Primor	Carbamate	250
	Spirodiclofen	Envidor	Tetronic acid	148
	Thiacloprid	Calypso	Neonicotinoid	150
Fungicide	Penconazole	Topas	Triazole	4

*The maximum recommended label rate.

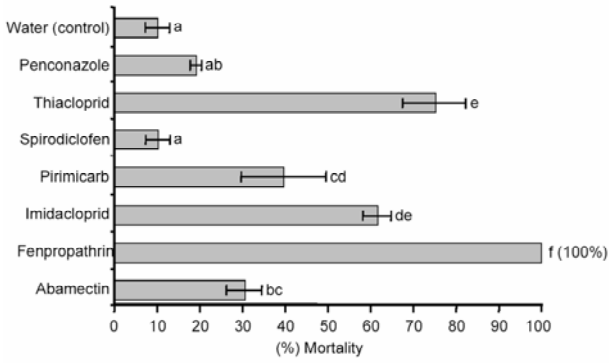

Figure 1. Percentage mortality of *D. lutescens* eggs after exposure to maximum recommended label rates of selected pesticides.

into Petri dishes for two days for mating. They were offered eggs of *S. cerealella* as food. Five mated females/males were then transferred to a new Petri dish on the treated broad bean leaf. The experiments continued in a similar procedure to the experiments for the nymphal instars and replicated 10 times for each sex and pesticide (n = 50).

Statistical analysis

For the 24, 48, 72 and 96 hours assessments, the mortality data were adjusted for mortality in the water control using Abbott's correction (Abbott, 1925). The actual pesticide induced mortality as:

M_a (%) = [(M_t − M_c) / (100 − M_c)] × 100; where M_a is corrected mortality (%), M_t is mortality in treatment (%), and M_c is mortality in the control (%). The corrected mortalities of nymphal instars and adults were evaluated by the IOBC toxicity rating scale for pesticides under laboratory conditions: 1, harmless (< 30% mortality); 2, slightly harmful (30 - 79% mortality); 3, moderately harmful (80 - 99% mortality) and 4, harmful (> 99% mortality) (Hassan, 1994).

For statistical comparison of the mortality of eggs, nymphal instars and adults of *D. lutescens*, the laboratory data were subjected to a one-way analysis of variance (ANOVA) followed by a Tukey Test (StatPlus version 4.9, 2007).

Results

Acute toxicity to eggs

The mortality of *D. lutescens* eggs caused by different pesticides and water control showed significant differences among the treatments (figure 1). The egg mortaliy of the predatory bug was highest with fenpropathrin (100%) compared to the other pesticides tested. Spirodiclofen and penconazole caused the least mortality with 10.4% and 19.1%, respectively.

Acute toxicity to nymphal instars

Fenpropathrin and imidacloprid caused 100% mortality of N_1 instars 24 hours after exposure to the pesticides (table 2). The mortality of N_1 instars in the penconazole treatment was 2.9% 24 hours. Moreover, pirimicarb was moderately harmful to N_1 instars of the predator in the 96 hours after treatment according to IOBC ratings for laboratory assays, while the fungicide penconazole and spirodiclofen residues were harmless.

The mortality of N_5 instars of *D. lutescens* was 100% in the fenpropathrin treatment 24 hours after exposure, while pirimicarb was harmless after 96 hours (table 3). The pesticides impact speed was variable, and fenpropathrin was faster than other treatments. The residue of fenpropathrin, imidacloprid and thiacloprid were harmful to N_5 instars of the predator after 96 hours. Abamectin was slightly harmful to N_5 instars, while penconazole, pirimicarb and spirodiclofen residues were harmless.

Acute toxicity to adults

The mortality of *D. lutescens* females was 96.0% in the fenpropathrin treatment 24 hours after exposure (table 4). The residues of imidacloprid and thiacloprid were moderately harmful to predatory females 96 hours after treatment.

The residue of fenpropathrin and imidacloprid were harmful to the males after 96 hours (table 5). Moreover, thiacloprid was moderately harmful, while other pesticides were harmless to males and females of the predator during the mentioned period.

Table 2. Percentage mortality of N_1 instars of *D. lutescens* after 24, 48, 72 and 96 h of exposure to maximum recommended label rates of pesticides and toxicity rating.

Pesticide group	Treatment	Corrected mortality (%) of N_1 instars after (hours) (mean ± SE)				IOBC* rating
		24	48	72	96	
Insecticides & Acaricides	Abamectin	17.1 ± 6.2	36.4 ± 6.7	61.4 ± 8.3	70.0 ± 7.9 b	2
	Fenpropathrin	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0 c	4
	Imidacloprid	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0 c	4
	Pirimicarb	61.4 ± 10.5	76.4 ± 7.5	85.0 ± 6.4	89.3 ± 4.8 c	3
	Spirodiclofen	2.9 ± 1.9	5.7 ± 2.3	5.7 ± 2.3	6.1 ± 1.0 a	1
	Thiacloprid	52.8 ± 5.3	91.4 ± 3.4	100.0 ± 0.0	100.0 ± 0.0 c	4
Fungicide	Penconazole	2.9 ± 1.9	2.9 ± 1.9	2.9 ± 1.9	2.9 ± 1.9 a	1

* IOBC toxicity rating scale for pesticides evaluated under laboratory conditions: 1, harmless (< 30% mortality); 2, slightly harmful (30-79% mortality); 3, moderately harmful (80-99% mortality) and 4, harmful (> 99% mortality) (Hassan, 1994).

Table 3. Percentage mortality of N_5 instars of *D. lutescens* after 24, 48, 72 and 96 h of exposure to maximum recommended label rates of selected pesticides and toxicity rating.

Pesticide group	Treatment	Corrected mortality (%) of N_5 instars after (hours) (mean ± SE)				IOBC* rating
		24	48	72	96	
Insecticides & Acaricides	Abamectin	4.0 ± 2.7	14.0 ± 5.2	19.3 ± 3.8	30.0 ± 5.1 b	2
	Fenpropathrin	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0 d	4
	Imidacloprid	92.0 ± 4.4	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0 d	4
	Pirimicarb	4.0 ± 2.7	4.0 ± 2.7	6.0 ± 3.0	9.3 ± 3.7 a	1
	Spirodiclofen	0.0 ± 0.0	0.0 ± 0.0	2.9 ± 1.9	2.9 ± 1.9 a	1
	Thiacloprid	16.0 ± 5.8	46.0 ± 5.2	64.0 ± 5.8	82.0 ± 7.0 c	4
Fungicide	Penconazole	3.6 ± 3.6	3.6 ± 3.6	3.6 ± 3.6	3.6 ± 3.6 a	1

* IOBC toxicity rating scale (see table 2).

Table 4. Percentage mortality of *D. lutescens* females after 24, 48, 72 and 96 h of exposure to maximum recommended label rates of selected pesticides and toxicity rating.

Pesticide group	Treatment	Corrected mortality (%) of females after (hours) (mean ± SE)				IOBC* rating
		24	48	72	96	
Insecticides & Acaricides	Abamectin	0.0 ± 0.0	2.9 ± 1.9	12.9 ± 4.4	17.1 ± 6.2 b	1
	Fenpropathrin	96.0 ± 2.7	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0 d	4
	Imidacloprid	46.0 ± 9.0	70.0 ± 7.9	87.1 ± 4.7	95.7 ± 2.8 cd	3
	Pirimicarb	0.0 ± 0.0	2.9 ± 1.9	4.3 ± 2.2	4.3 ± 2.2 a	1
	Spirodiclofen	0.0 ± 0.0	1.4 ± 1.4	4.3 ± 2.2	7.1 ± 2.4 ab	1
	Thiacloprid	30.7 ± 9.6	46.4 ± 8.6	65.7 ± 7.3	85.0 ± 5.6 c	3
Fungicide	Penconazole	0.0 ± 0.0	0.0 ± 0.0	1.4 ± 1.4	1.4 ± 1.4 a	1

* IOBC toxicity rating scale (see table 2).

Table 5. Percentage mortality of *D. lutescens* males after 24, 48, 72 and 96 h of exposure to maximum recommended label rates of selected pesticides and toxicity rating.

Pesticide group	Treatment	Corrected mortality (%) of males after (hours) (mean ± SE)				IOBC* rating
		24	48	72	96	
Insecticides & Acaricides	Abamectin	2.0 ± 2.0	10.0 ± 4.5	11.4 ± 5.5	20.0 ± 5.6 b	1
	Fenpropathrin	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0 c	4
	Imidacloprid	62.0 ± 7.0	90.0 ± 5.4	100.0 ± 0.0	100.0 ± 0.0 c	4
	Pirimicarb	0.0 ± 0.0	6.0 ± 3.0	6.0 ± 3.0	6.0 ± 3.0 a	1
	Spirodiclofen	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0 a	1
	Thiacloprid	24.0 ± 7.8	56.0 ± 10.2	87.1 ± 6.5	95.7 ± 2.8 c	3
Fungicide	Penconazole	0.0 ± 0.0	6.2 ± 4.1	6.2 ± 4.1	6.2 ± 4.1 a	1

* IOBC toxicity rating scale (see table 2).

Discussion

The purpose of this test was to screen out products which can be considered as completely and definitely harmless by acute toxicity to eggs, nymphal instars (N_1 and N_5) and the adult stage of *D. lutescens*. This was the case for the fungicide penconazole as well as the insecticide spirodiclofen. A similar study was conducted by Studebaker and Kring (2003) where the mortalities of N_3 instars and adult females and males of *O. insidiosus* due to tebufenozide were 15, 21.3 and 20% respectively. As a residual contact treatment, spirodiclofen and penconazole were ranked as harmless to eggs James (2004) also reported spirodiclofen was harmless to the predatory bug, *Orius tristicolor* (White) (Rhynchota Anthocoridae), ladybeetle, *Stethorus punctum* (LeConte) (Coleoptera Coccinellidae) as well as predatory mites (*Galendromus occidentalis* (Nesbitt), *Neoseiulus fallacis* (Garman), *Amblyseius andersoni* (Chant): Phytoseiidae).

In this study, the residue of abamectin was slightly harmful to nymphal instars of the predator in the 4 days after treatment and it was harmless to the adult stage of the predator. Kim *et al*. (2006) showed abamectin at the full field rate did not affect egg hatch of *D. brevis*, but the residue had moderate to high toxicity to hatched nymphs. Also, topically applied acetamiprid and abamectin had moderate to high acute toxicity to

nymphs and adults at the full field rate, but moderate toxicity at the 10% rate. This pesticide also has been innocuous to *Acanthinus* sp., *Discodon* sp. and *Lasiochilus* sp. (Bacci *et al*., 2007). In contrast, abamectin has shown harmful effects on hymenopterous parasitoids such as *Trichogramma cacoeciae* Marchal (Hassan *et al*., 1998) and *Encarsia* sp. (Bacci *et al*., 2007). Abamectin was also toxic to the predator *Cycloneda sanguinea* (L.) (Michaud, 2002).

Concerning the effect on predatory bugs, imidacloprid was more toxic against *Podisus maculiventris* (Say) (De Cock *et al*., 1996) and *O. laevigatus* (Delbeke *et al*., 1997) than diflubenzuron, pyriproxyfen and diafenthiuron. In the present study, fenpropathrin followed by imidacloprid caused the highest mortality in nymphs and adults of *D. lutescens*. This agrees with the results of Studebaker and Kring (2003), where imidacloprid was harmful to N_3 instars, adult females and males of *O. insidiosus* according to IOBC ratings for laboratory assays. In contrast, Mizell and Sconyers (1992) showed that imidacloprid was harmless to the predatory insect *Chrysoperla rufilabris* (Burmeister) and predatory mites *Neoseiulus couegae* (De Leon), *Phytoseiulus macropilis* (Banks) and *Proprioseiopsis mexacanus* (Garman). Kunkel *et al.* (1999) found that imidacloprid did not affect a population of predatory arthropods in soil. Pfluger and Schmuck (1991) showed that this compound was not harmful to predatory mites.

The residue of pirimicarb was moderately harmful to N_1 instars and it was harmless to N_5 instars, females and males of the predator. Castane *et al*. (1996) showed among the conventional insecticides tested, pirimicarb was harmless to *Dicyphus tamaninii* Wagner (Rhynchota Miridae) nymphs. Moreover, pirimicarb, applied in IPM plantations are proved not to have negative effects on populations of parasitoids of leaf miners and predatory mites (Fitzgerald *et al*., 2003). Therefore, pirimicarb could be considered as a selective insecticide for chewing and sucking insects (Badawy and El Arnaouty, 1999; Bartlett, 1964; Lingren and Ridgway, 1967; Bigler and Waldburger, 1994).

Spirodiclofen and penconazole residues were harmless to nymphal instars and adults of the predatory bug. Spirodiclofen is a broad spectrum acaricide acting via lipid biosynthesis inhibition (LBI) with no cross resistance to currently available acaricides and with additional insecticidal properties. According to new investigations (De Maeyer and Geerinck, 2009), spirodiclofen constitutes an important tool in plant sucker control in a tandem strategy with abamectin.

In conclusion, experimental results presented here suggest that using some of the tested pesticides that have a low toxicity for the predatory bug, *D. lutescens*, alone or integrated with this predator in an IPM program has potential to provide a great level of pest suppression.

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Authors' addresses: Najmeh AZIMIZADEH (corresponding author, e-mail: n.azimizadeh@yahoo.com), Sohrab IMANI (Imanisohrab@yahoo.com), Department of Entomology, Science and Research Branch, Islamic Azad University, Tehran, Iran; Kamal AHMADI (kahmadi@mail.uk.ac.ir), Hajimohammad Takalloozadeh (Takalloo_Mohammad@mail.uk.ac.ir), Department of Plant Protection, Faculty of Agriculture, Shahid Bahonar University of Kerman, Kerman, Iran; Alimorad SARAFRAZI (sarafrazi@iripp.ir), Department of Insect Taxonomy Research, Iranian Research Institute of Plant Protection, Tehran, Iran..

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