J. Crop Prot. 2016, 5 (1): 89-98
doi: 10.18869/modares.jcp.5.1.89

Research Article

Effects of pyriproxyfen and imidacloprid on mortality and reproduction of *Menochilus sexmaculatus* (Coleoptera: Coccinellidae), predator of *Agonoscena pistaciae*

Mahsa Nazari, Shahnaz Shahidi-Noghabi* and Kamran Mahdian

Department of Plant Protection, Faculty of Agriculture, Vali-e-Asr University of Rafsanjan, Rafsanjan, Iran.

Abstract: The effect of two insecticides, imidacloprid and pyriproxyfen, were investigated on some biological parameters of ladybird beetle *Menochilus sexmaculatus* (F.) (Coleoptera: Coccinellidae) under laboratory condition. The ladybird beetle were exposed to insecticides by ingestion of the common pistachio psylla, *Agonoscena pistaciae* Burckhardt and Lauterer (Hemiptera: Psyllidae) (prey). For imidacloprid, maximum field recommended concentration (MFRC) (1/1 MFRC = 140 ppm), 1/2 and 1/4 MFRC were tested. For pyriproxyfen dilutions of 1/1 MFRC (50 ppm), 2/1 and 1/2 MFRC were used after 24 h. The 100% mortality was observed with imidacloprid in all tested concentrations, whereas no mortality was observed by pyriproxyfen even at the highest concentration (2/1 MFRC). Because of the high mortality observed with imidacloprid, lower concentrations of 1/10, 1/20 and 1/40 MFRC were tested and all predators were killed 3, 7 and 10 days after treatment, respectively. At 1/100 MFRC, no eggs were laid but prey consumption was continued for two weeks. At 1/1 and 2/1 MFRC of pyriproxyfen, ingestion of prey was reduced by 18% and 23%, respectively. At 1/1 and 1/2 MFRC of pyriproxyfen, fecundity and fertility of the coccinellid predator was decreased to 43% and 24.5%, respectively. Imidacloprid at 1/100 MFRC caused significant reduction on fecundity but had no detrimental effect on fertility of the produced eggs. Therefore, unlike the pyriproxyfen that had not acute toxicity, the imidacloprid was extremely toxic to coccinellid at MFRC. However, pyriproxyfen was able to affect on feeding ratio and reproduction of *M. sexmaculatus*.

Keywords: The common pistachio psylla, Insecticide, *Menochilus sexmaculatus*, Predator, Sublethal effects

Introduction

The pistachio tree *Pistacia vera* is a subtropical plant that adapted to adverse environmental conditions such as water and soil salinity, drought tolerance and dehydration and might be considered as the best horticultural products in many arid countries. Some of the important factors that reduce the production of pistachio nuts are activities of various pest insects with much greater role than other biotic factors (Mehrnejad, 2001). Among the insects that are damaging pistachio, the common pistachio psylla, *Agonoscena pistaciae* Burckhardt and

Handling Editor: Khalil Talebi Jahromi

* **Corresponding author**, e-mail: shahidi@vru.ac.ir
Received: 22 June 2015, Accepted: 29 September 2015
Published online: 14 December 2015

[DOR: 20.1001.1.22519041.2016.5.1.9.8]

Lauterer (Hemiptera: Psyllidae) is one of the most important pests in Iran. Intense use of pesticides and high ability of psylla to develop resistance to pesticides make failure in chemical control program. Therefore, use of other control methods, particularly natural enemies can reduce the environmental pollution and also enhance the effect of chemical pesticides. Ladybeetles are the most beneficial insects in agricultural ecosystems and play a main role in natural balance and control of aphids, mealybugs, psyllids, whiteflies, leaf hoppers and ticks (Obrycki and Kring, 1998, Planes *et al*., 2012). *Menochilus sexmaculatus* (F.) (Coleoptera: Coccinellidae) is one of the most important biological control agents in various parts of East Asia. Activity of this beetle as a predator of aphids and psyllids has been reported. Also, it has been considered as a common biocontrol agent in the pistachio orchards of Rafsanjan against pistachio psylla (Mehrnejad *et al*., 2011). Normally, during the outburst of pests the natural enemies alone are notable to control the pests. Therefore use of pesticides with low risk at the right time is necessary. In addition to the direct effects of pesticides, that is mortality rate, sublethal concentrations of pesticides can also influence the physiology and behavior of natural enemies (Johnson and Tabashnik, 1999). Sublethal concentrations of insecticides are able to reduce the life cycle parameters such as growth (Vinson, 1974), fertility (Stark *et al*., 1992 ; Grosch and Hoffman, 1973), fecundity (Rezaei *et* a*l*., 2007; Stark *et al.*, 1992; Graepel, 1982) and lead to change in sex ratio (Vinson, 1974), consumption ratio (Desneux *et al*., 2006).. Also, the sterility and repellency have been reported in laboratory studies (Croft, 1990). Imidacloprid is a neonicotinoid insecticide and acts on the insect nervous system by attaching to the acetylcholine binding sites (Elbert *et al*., 1991). Pyriproxyfen, a juvenile hormone analog, is an insect growth regulator (IGR) considered as effective insecticide for control of pests (Liu and Stansly, 2004). The effects of high concentration of malathion on reduction of reproduction, survival and fertility of eggs of *M. sexmaculatus* have been reported by Parker *et al*. (1976). Use of chemical insecticides, fungicides, acaricides and plant growth regulators had adverse effect on fertility and feeding behavior of *Cryptolaemus montrozieri* (Mulsant) (Coleoptera: Coccinellidae) (Simmonds *et al*., 2000). Study of the effects of spinosad and indoxacarb on the growth and reproduction of *Harmonia axiridis* (Coleoptera: Cocinellidae) showed that the insecticides reduced the population of this predator through reduction of growth and reproduction (Galvan *etal.*, 2005). In this research, the compatibility of a biorational insecticide (pyriproxyfen) and a conventional insecticide (imidacloprid) has been investigated on the adults of *M. sexmaculatus* following ingestion of treated prey, *A. pistacia* with different concentrations of each insecticide. Studies have focused to describe the effects of insecticides on survival, prey consumption and reproduction of *M. sexmaculatus*.

Materials and Methods

Insect culture

Menochilus sexmaculatus was collected from pistachio orchards of Rafsanjan, Iran. Beetles were held in plastic boxes and fed on the common pistachio psylla nymphs, A*gonoscena pistaciae*, which were also collected from pistachio orchards. Beetles were reared in the growth chamber. All tests were performed in the growth chamber at 25 ± 5 ^{o}C, 60 ± 5% RH and 16:8 (L: D) h. For all experiments the beetles were checked every 12 hours and beetles of same age were chosen. Eggs (> 12 h) were chosen and were monitored until they were adults.

Insecticides and bioassays

Commercial formulations of two insecticides, imidacloprid (Confidor, 35% suspension concentration, Kavosh Kimia) and pyriproxyfen (Admiral, 10% suspension concentration, Arista Life Science) were used. The following

[DOR: 20.1001.1.22519041.2016.5.1.9.8]

concentrations of the pyriproxyfen were used: Field recommended concentration (1/1 MFRC) on pistachio orchards against A. *pistaciae* (50 ppm), 2 MFRC (100 ppm, to pretend multiple treatments) and 1/2 MFRC (25 ppm, to evaluate sublethal effects). Because of the high mortality observed in all three concentrations of imidacloprid, including of MFRC (140 ppm), 1/2 MFRC (70 ppm) and 1/4 MFRC (35 ppm) and also based on the results of pre-tests with other concentrations (1/10, 1/20, 1/40 MFRC), the concentration of 1.4 ppm (1/100 MFRC) was used to test the sublethal effects on *M. sexmaculatus*. Distilled water was used as control.

Effects of pesticides on ingestion of treated prey by *M. sexmaculatus*

Effects of imidacloprid and pyriproxyfen were investigated on feeding rate of *M. sexmaculatus* adults 5th instar psylla nymphs, which were treated with different concentrations of each insecticide. Also, distilled water was used as control. For this purpose, 10 *M. sexmaculatus* females were selected as soon as the first mating was observed and were placed in Petri dishes (9 cm in diameter) individually. To determine the effects of infested psylla nymphs on feeding rate of *M. sexmaculatus*, the pistachio leaves, containing psylla, were dipped in insecticides dilutions for five seconds, and left to stay for half an hour. Afterwards, 150 insecticide-treated prey (5th instar nymphs) were randomly separated from the treated leaves and were placed on the clean leaf disk in each Petri dish containing one female predator. During the test, remaining nymphs were discarded daily and predators were fed with new treated prey. In these experiments, the number of preys eaten by adults of *M. sexmaculatus* and their mortality were recorded for two weeks.

Effects of insecticides on *M. sexmaculatus* reproduction

In this study, *M. sexmaculatus* adults were exposed to insecticides through ingestion of treated *A. pistaciae*. Ten pairs of adults were collected and each couple was placed in one Petri dish. Later, ladybeetles were exposed to the certain concentrations of insecticides by feeding of infested prey for two weeks. To investigate the pre-oviposition period, the insects were fed by treated prey from adult emergence and pre-oviposition period was 1recorded from emergence to production of the first egg for each couple (Wermelinger and Sefert, 1999). Distilled water was used as control. In this test, pre-oviposition period, oviposition, fertility of eggs and mortality percentage of adults were evaluated for two weeks.

Effects of insecticides on mortality of *A. pistaciae*

The pistachio leaves, infested by psylla, were dipped in different concentrations of insecticides for five seconds and left to stay for half an hour. Afterwards, forty 5th instar treated nymphs were randomly separated from the treated leaves and were placed on the clean leaf disk. After 24 h, the mortality of nymphs was recorded. Distilled water was used as control. Three replications were prepared for this experiment.

Data analysis

The experiments were conducted in a completely randomized design with 5 treatments (control, three concentrations of pyriproxyfen and one concentration of imidacloprid). Data were analyzed with SPSS 22 and average of parameters was compared by Tukey's multiple range test at $P < 0.05$.

Results

Lethal effects of the insecticides

Mortality of *M. sexmaculatus* adults was %100, 24 h after ingestion of *A. pistaciae* which were treated with imidacloprid at 140 ppm (1/1 MFRC), 70 ppm (1/2 MFRC) and 35 ppm (1/4 MFRC). Also, 100% mortality was observed in coccinellid adults fed on prey treated with imidacloprid at 14 ppm

[DOR: 20.1001.1.22519041.2016.5.1.9.8]

(1/10 MFRC) after three days, 7 ppm (1/20 MFRC) after seven days and 3.5 ppm (1/40 MFRC) after ten days. Furthermore, no eggs were laid by *M. sexmaculatus* in any of these treatments. Therefore, 1.4 ppm (1/100 MFRC) was used as sublethal concentration to determine the effects of imidacloprid. After two weeks, no mortality was observed in control, 1.4 ppm imidacloprid and 25 ppm pyriproxyfen treatments but pyriproxyfen caused mortality of 10% and 40% at higher concentrations of 50 and 100 ppm, respectively (Table 1).

Ingestion of treated prey by *M. sexmaculatus*

After two weeks, no significant effect was observed in feeding rate of *M. sexmaculatus* at 1.4 ppm of imidacloprid (75.55 ingested preys) and pyriproxyfen at 25 ppm (79.80 ingested preys) as compared to control (82.65 ingested preys). Whereas, at the higher concentrations of pyriproxyfen, 50 ppm (1/1 MFRC) and 100 ppm (2 MFRC), the number of prey nymphs were 68.12 and 64.84, respectively, which were significantly lower than control ($F = 9.02$; $df = 4,65$; $P < 0.05$). Also, the more time predator was exposed to the toxin the less was feeding rate ($F = 4.51$; $df = 13,56$; $P < 0.05$) (Table 2).

Effects of insecticides on fecundity of *M. sexmaculatus*

Results from this experiment revealed that reproduction of *M. sexmaculatus* was significantly reduced when exposed to the treated prey with all concentrations of pyriproxyfen and imidacloprid compared to control ($F = 9$; $df = 4,36$; $P < 0.05$). In all treatments the egg production started at day two (Fig. 1). The lowest daily number of eggs (2 eggs/female) was laid at 100 ppm pyriproxyfen, which was significantly lower than the two other concentrations (6 and 8 eggs/female for 50 and 25 ppm respectively) and control with 8 eggs/female. Besides, egg laying did not continue past 7 days, whereas in control eggs were laid through the whole two weeks. Also, 5 eggs / female were laid daily when the ladybeetles were treated with 1.4 ppm imidacloprid, which was significantly lower than control. When predator was exposed to pyriproxyfen at 25 and 50 ppm, no eggs were laid past 11 days. Likewise, no egg was observed at 100 ppm of pyriproxyfen and 1.4 ppm of imidacloprid after 7 and 8 days, respectively.

Based on the results obtained from counting of the eggs hatched in two weeks, imidacloprid despite having adverse effect on egg production, did not cause significant effect on *M. sexmaculatus* fertility at the concentration of 1.4 ppm compared to control ($t = 7.8$; $df = 13,18$; $P > 0.05$) and 83.83% of the eggs hatched, but fertility was significantly reduced when predator fed on prey treated with any concentration of pyriproxyfen used in this experiment ($F = 302$; $df = 3,36$; $P < 0.05$) (Fig. 2).

After 3 days 88.77% of the eggs were hatched in the control, whereas at 100 ppm of pyriproxyfen no egg hatch was observed. Furthermore, at 25 and 50 ppm of pyriproxyfen only 22.45% and 4.13% of the eggs hatched.

Findings showed that neither insecticide affected the pre-oviposition period of predator compared to control. Pre-oviposition period was four days in all treatments.

Insecticidal activity of imidacloprid and pyriproxyfen on A. *pistaciae*

Lethal effect of both insecticides was investigated on the 5th instar nymphs of *A. pistaciae*. After 24 h, 88% and 38% mortalities were observed when psylla were exposed to 1/1 MFRC of imidacloprid and pyriproxyfen, respectively. Pyriproxyfen caused 16% and 61% mortality at concentrations of 2/1 MFRC and 1/2 MFRC, respectively. Imidacloprid caused 66% and 44% mortality after 24 h at 1/2 and 1/1 MFRC. Imidaclopride was more toxic (1.4 times) than pyriproxyfen against psylla at the field rate (Table 3).

[DOR: 20.1001.1.22519041.2016.5.1.9.8]

Table 1 Mortality of *Menochilus sexmaculatus* fed on insecticide-treated 5th instar nymphs of A*gonoscena pistaciae* over two weeks.

Insecticides	Mortality (%)					
	Days after treatment					
	1	2	3	7	10	14
Pyriproxyfen						
1/1 MFRC[1]	0	0	0	0	0	10
1/2 MFRC	0	0	0	0	0	0
2/1 MFRC	0	0	0	0	40	40
Imidacloprid						
1/1 MFRC[2]	100					
1/2 MFRC	100					
1/4 MFRC	100					
1/10 MFRC	0	0	100			
1/20 MFRC	0	0	0	100		
1/40 MFRC	0	0	0	0	100	
1/100 MFRC	0	0	0	0	0	0
Control (distilled water)	0	0	0	0	0	0

[1] MFRC for imidacloride = 140 ppm.
[2] MFRC for pyriproxyfen = 50 ppm.

Table 2 Mean daily feeding of *Menochilus sexmaculatus* females on insecticide-treated A*gonoscena pistaciae* nymphs for two weeks.

Time (day)	Control	Pyriproxyfen			Imidacloprid
		25 ppm	50 ppm	100 ppm	1.4 ppm
1	90.6 ± 1.25[a]	89.2 ± 0.70[a]	82.4 ± 2.38[b]	81.1 ± 3.59[b]	89.5 ± 0.76[a]
2	89.9 ± 1.28[a]	91.0 ± 1.19[a]	90.3 ± 1.42[a]	79.7 ± 4.32[b]	86.8 ± 1.20[a]
3	86.2 ± 1.65[a]	89.2 ± 0.96[a]	74.3 ± 2.3[b]	66.6 ± 3.22[c]	82.5 ± 1.20[a]
4	90.9 ± 1.34[a]	87.2 ± 0.90[a]	82.4 ± 2.31[b]	69.2 ± 3.62[c]	74.5 ± 1.25[b]
5	90.6 ± 1.27[a]	85.5 ± 1.36[a]	71.8 ± 3.17[b]	70.5 ± 2.70[b]	73.5 ± 2.20[b]
6	80.2 ± 2.69[a]	84.5 ± 1.19[a]	79.2 ± 2.81[a]	65.2 ± 2.80[b]	81.0 ± 2.20[a]
7	81.9 ± 1.74[a]	82.7 ± 1.35[a]	70.4 ± 3.41[b]	58.9 ± 3.93[c]	79.5 ± 1.60[a]
8	86.7 ± 2.47[a]	79.3 ± 1.49[a]	69.5 ± 4.65[c]	69.4 ± 4.34[c]	76.0 ± 2.30[b]
9	87.9 ± 1.94[a]	73.9 ± 2.58[b]	63.5 ± 2.60[c]	58.5 ± 3.62[c]	74.5 ± 1.30[b]
10	83.5 ± 2.38[a]	74.2 ± 2.20[a]	59.5 ± 3.87[b]	58.5 ± 3.06[b]	75.0 ± 1.96[a]
11	72.8 ± 1.49[a]	75.1 ± 2.48[a]	56.0 ± 4.14[b]	61.3 ± 4.11[b]	71.0 ± 1.56[a]
12	63.8 ± 2.39[a]	67.5 ± 2.52[a]	48.1 ± 2.3[b]	53.3 ± 4.18[b]	68.5 ± 1.22[a]
13	79.1 ± 1.84[a]	70.6 ± 2.82[a]	50.3 ± 2.10[c]	51.0 ± 2.80[c]	66.5 ± 1.53[b]
14	73.0 ± 2.13[a]	67.3 ± 2.32[a]	56.0 ± 2.82[b]	54.8 ± 4.10[b]	67.0 ± 2.20[a]
Mean	82.7 ± 1.80[a]	79.8 ± 1.50[a]	68.1 ± 2.80[b]	64.8 ± 3.10[b]	75.6 ± 1.80[a]

Means with the same letters in each row are not significantly different (Tukey's test, $P < 0.05$).

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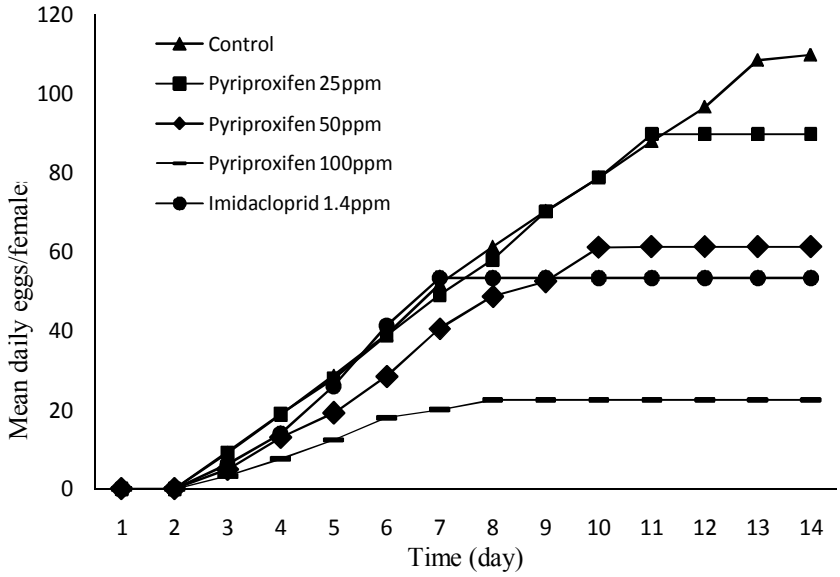

Figure 1 Daily reproduction of *Menochilus sexmaculatus* female (eggs / female / day), fed on insecticide-treated A*gonoscena pistaciae* nymphs or control (distilled water) in two weeks. Data are presented as means of three replicates of 10 pairs of adults.

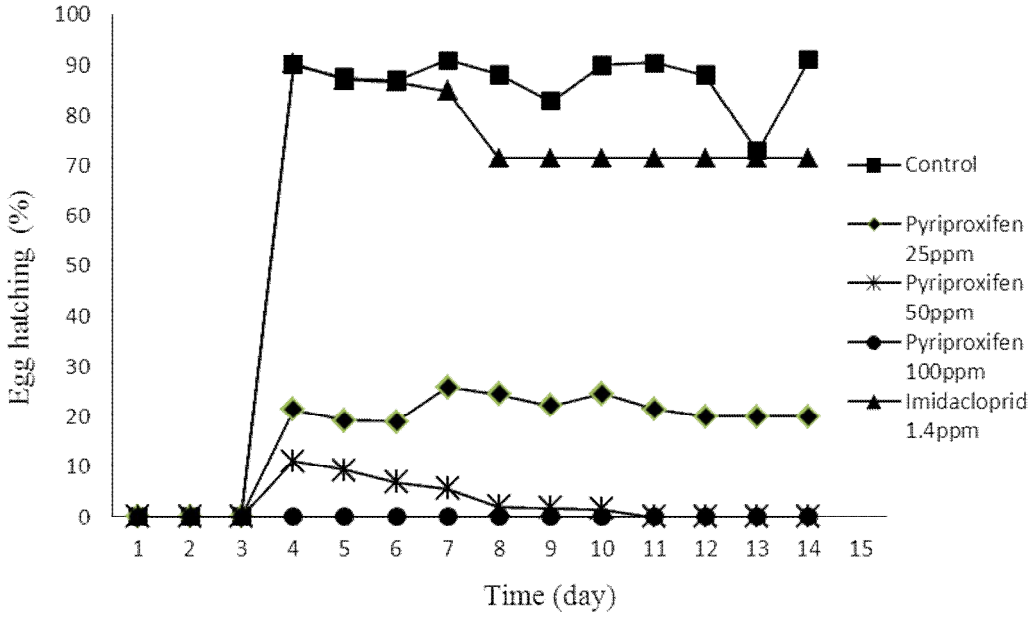

Figure 2 Fertility of *Menochilus sexmaculatus* female fed on insecticide-treated A*gonoscena pistaciae* nymphs or control (distilled water) in two weeks. Data are presented as means of three replicates of 10 pairs of adults.

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Table 3 Mortality of 5th instar nymphs of A*gonoscena pistaciae* 24 h after treatment with insecticides or distilled water (control).

Treatments	Concentration	Mortality (%)[1]
Pyriproxyfen	2/1 MFRC,100 ppm	61
	1/1 MFRC, 50 ppm	38
	1/2 MFRC, 25 ppm	16
Imidacloprid	1/1 MFRC, 140 ppm	88
	1/2 MFRC, 70 ppm	66
	1/4 MFRC, 35 ppm	44
Control	-	0

[1] Percent mortality was derived from forty 5th instar nymphs for each treatment.

Discussion

The purpose of this study was to evaluate the lethal and side effects of two different groups of insecticides, imidacloprid (neonicotinoid) and pyriproxyfen (IGRs) against *M. sexmaculatus*. In this research, only ingestion of insecticide-treated prey has been tested to evaluate the effects of insecticides on adult ladybeetles. Feeding on 5th instar nymphs of psylla treated with imidacloprid increased the mortality and decreased consumption rate and reproduction at 1/1 MFRC and even at lower concentrations (e.g. 1/40 MFRC). Although, the reproduction of the predator was not influenced by pyriproxyfen at the field rate (50 ppm) but the hatching rate or fertility of adults were decreased significantly.

Our findings showed little compatibility between *M. sexmaculatus* and use of imidacloprid or pyriproxyfen. We found that within 24 h, imidacloprid was more toxic than pyriproxyfen to adult *M. sexmaculatus*. Imidacloprid at 1/1, 1/2, 1/4 and 1/10 MFRC caused 100% mortality but, at 1/1, 1/2 MFRC of pyriproxyfen no mortality was observed. No harmful effect was observed after topical application of pyriproxyfen on *Chrysoperla externa* (Hagen) (Zotti *et al*., 2013) and *Chrysoperla carnea* (Stephens) (Medina *et al*., 2003), in which the lack of toxicity of pyriproxyfen was attributed to its quick defecation time (24 h) (Medina *et al*., 2003). Moreover, chronic toxicity was observed in adult of *M. sexmaculatus* when fed on *A. pistaciae*, which were treated with the lower concentrations than 1/1 MFRC of imidacloprid i.e.,1/10, 1/20 and 1/40 MFRC, as 100% mortality was observed after 3, 7 and 10 days, respectively. Also, from this study, it could be concluded that pyriproxyfen and imidacloprid affected the feeding rate of *M. sexmaculatus*, but imidacloprid had more effect compared with pyriproxyfen and less of Psyllid nymphs treated with imidacloprid were consumed by *M. sexmaculatus*. Imidacloprid at 18 times less concentration (1.4 ppm) than pyriproxyfen (25 ppm) had almost the same effect on reduction of *M. sexmaculatus* feeding rate

It is worth mentioning that imidacloprid at concentration of 1.4 ppm (1/100 MFRC) reduced the fecundity, but had no effect on fertility of *M. sexmaculatus* female eggs. In the continuation of these experiments we found, that pyriproxyfen at all three concentrations used was effective and reduced the fecundity of *M. sexmaculatus*. Furthermore, reverse relation was observed between concentration of pyriproxyfen and *M. sexmaculatus* fecundity and fertility, in which by increasing of the concentration, fecundity and fertility were decreased, hence effects of pyriproxyfen on immature stages of predator (e.g. egg) was more than imidacloprid. Also no significant differences were observed in pre-oviposition period of different treatments, as it was four days in all treatments. Results of our study revealed that none of the eggs were hatched in high concentration of pyriproxyfen (100 ppm) and only 4.13% and 22.45% of eggs were hatched at concentrations of 50 and 25 ppm, respectively. The same result was observed on the effect of pyriproxyfen on the predator *Delphastus catalinae* (Horn), as only 0.3% of *D. catalinae* eggs were hatched when fed on whitefly's egg treated with high concentration of pyriproxyfen (0.2 gr/lit) (Liu and Stansly, 2004). Also, the effects of pyriproxyfen were determined on the predators *Cryptolaemus montrouzieri* Mulsant and *Chilocorus circumdatus* Gyllenhal via treated host.

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Pyriproxyfen was more effective on the *C. circumdatus*, and at the high concentration (100 ppm) prolonged hatching time (Smith *et al*, 1999). As reported by Planes *et al*. (2012), pyriproxyfen was categorized as detrimental for larvae of *C. montrouzieri*, because of the acute pupal mortality. Furthermore, adults of *C. montrouzieri* fed with prey treated with pyriproxyfen showed improved fecundity, but eggs were not fertile and could not hatch. Moreover, the larvae fed on pyriproxyfen-treated prey did not develop to the adult stage.

In another study, the sensitivity of predator *Podisus maculiventris* (Say) to two pesticides, imidacloprid and diafenthiuron was evaluated and showed that percentage of adult mortality was high in both pesticides (De Cock *et al*., 1996). In our research, based on both lethal and sublethal effects on adult of *M. sexmaculatus*, none of the insecticides were compatible with augmentative releases of this coccinellid predator.

Concerning the adverse effects of imidacloprid on survival of *M. sexmaculatus* adult at MFRC and lower concentrations, it is advisable to limit its use as much as possible to decrease chances of predators being affected by the compound It is concluded that pyriproxyfen compared to imidacloprid had lower toxicity at the field rate, but caused sublethal effects on *M. sexmaculatus* including effects on reproduction and prey consumption ratio and most probably it has detrimental influence on its population growth. Finally, it is very important to evaluate the side effects of sublethal concentrations of pesticides in order to devise appropriate trials for the application of both conventional and biorational insecticides in the IPM programs.

References

Croft, B. A. 1990. Arthropod Biological Control Agents and Pesticides. John Wiley and Sons Inc. New York. 723 pp.

De Cock, A., De Clercq, P., Tirry, L. and Degheele, D. 1996. Toxicity of diafenthiuron and imidacloprid to the predatory bug *Podisus maculiventris* (Heteroptera: Pentatomidae). Environmental Entomology. 25: 476-480.

Desneux, N., Denoyelle, R. and Kaiser, L. 2006.A multi-step bioassay toassess the effect of the deltamethrin on the parasitic waspa*phidius ervi*. Chemosphere, 65: 1697-1706.

Elbert, A., Becker, B., Hartwig, J. and Erdelen, C. 1991. Imidacloprid-a new systemic insecticide. Nachrichten Bayer. 44 (2).

Galvan, T. L., Koch, R. L. and Hutchison, W. D. 2005. Effects of spinosad and indoxacarb on survival, development, and reproduction of the multicoloredasian lady beetle (Coleoptera: Coccinellidae). Biological Control, 34: 108-114.

Graepel, H. 1982. Investigations on the influence of some insecticides on natural enemies ofaphids. Journal of Plant Disease and Protection, 89: 241-252.

Grosch, D. S. and Hoffman, A. C. 1973. The vulnerability of specific cells in the oogenetic sequence of *Bracon hebetor* Say to some degradation products of carbamate pesticides. Environmental Entomology, 2: 1029-1032.

Johnson, M. W. and Tabashnik, B. E. 1999. Enhanced biological control through pesticide selectivity. In: Fisher, T. D. and T. S. Bellows (Eds.), Handbook of Biological Control. academic Press, New York, pp. 297-317.

Liu, T. and Stansly,a. P. 2004. Lethal and sublethal effects of two insect growth regulators onadult Delphastus catalinae (Coleoptera: Coccinellidae), a predator of whiteflies (Homoptera: Aleyrodidae). Biological Control, 30: 298-305.

Mehrnejad, M. R. 2001. The current status of pistachio pests in iran. In: Ak, B. E. (Ed.). XI GREMPA Seminar on pistachios and Almonds. Zaragaza : CIHEAM. pp. 315-322.

Mehrnejad, M. R., Jalali, M.a. and Mirzaei, R. 2011. Abundance and biological parameters of *psyllophagous coccinellids* in pistachio orchards. Journal of Applied Entomology, 9: 673-683.

Medina, P., Smagghe, G., Budia, F., Tirry, L. and Vinuela, E. 2003. Toxicity and absorption of azadirachtin, difluben-zuron, pyriproxyfen,

[DOR: 20.1001.1.22519041.2016.5.1.9.8]

and tebufenozide after topicalapplication in predatory larvae of *Chrysoperla carnea* (Neuroptera: Chrysopidae). Environmental Entomology, 32: 196-203.

Obrycki, J. J. and Kring, T. J.. 1998. Predaceous Coccinellidae in biological control. Annual Review of Entomology, 43: 295-321.

Parker, B. L., Ming, S., Peng, T. S. and Singh, G. 1976. The effect of malation on fecundity, longevity and geotropism of *Menochilus sexmaculatus* Fabricius (Coleoptera: Coccinellidae). Environmental Entomology, 5: 575-584.

Planes L., Catalan, J., Tena, A. J., Porcuna, L., Jacas, J. A., Izquierdo, J. and Urbaneja, A. 2012. Lethal and sublethal effects of spirotetramat on the mealybug destroyer, *Cryptolaemus montrouzieri*. Journal of Pest Science, 86: 321-327.

Rezaei, M., Talebi, K., Hoseyni Naveh, V. and Kavousi, A. 2007. Impacts of the pesticides imidacloprid, propargite, and pymetrozine on *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae): IOBC and life table assays. BioControl, 52: 385-398.

Simmonds, M. S. J., Manlove, J. D., Blaney, W. M. and Khambay, B. P. S. 2000. Effect of botanical insecticides on the foraging and feeding behavior of the coccinalid predator *Cryptolaemus montrouzieri*. Phytoparasitica, 28: 99-107.

Smith, K. M., Smith, D. and Lisle A. T. 1999. Effect of field-weathered residues of pyriproxyfen on the predatory coccinellids *Chilocorus circumdatus* Gyllenhal and *Cryptolaemus montrouzieri* Mulsant. Animal Production Science, 39: 995-1000.

Stark, J. D., Tim Wong, T. Y., Vargas, R. I. and Thalman, R. K. 1992. Survival, longevity and reproduction of tephritid fruit fly parasitoids (Hymenoptera: Braconidae) reared from fruit flies exposed toazadirachtin. Journal of Economic Entomology, 85: 1125-1129.

Vinson, S. B. 1974. Effect ofan insect growth regulator on two parasitoide developing from treated tobacco budworm larvae. Journal of Economic Entomology, 67: 335-336.

Wermelinger, B. and Seifert, M. 1999. Temperature-dependent reproduction of the spruce bark beetle *Ips typographus*, and analysis of the potential population growth. Ecological Entomology 24: 103-110.

Zotti, M. J., Grutzmacher,a. D., Lopes, I. H. and Smagghe, G. 2013. Comparative effects of insecticides with different mechanisms ofaction on *Chrysoperla externa* (Neuroptera: Chrysopidae): Lethal, sublethal and dose–response effects. Insect Science, 20: 743-752.

[DOR: 20.1001.1.22519041.2016.5.1.9.8]

اثرات پایری‌پروکسی فن و ایمیداکلوپراید روی مرگ‌ومیر و تولیدمثل *Menochilus sexmaculatus*، شکارگر *Agonoscena pistaciae*

مهسا نظری، شهناز شهیدی نوقابی، کامران مهدیان

گروه گیاهپزشکی، دانشکده کشاورزی، دانشگاه ولیعصر رفسنجان، رفسنجان، ایران.
* پست الکترونیکی نویسنده مسئول مکاتبه: shahidi@vru.ac.ir
دریافت: ۱ تیر ۱۳۹۴؛ پذیرش: ۷ مهر ۱۳۹۴

چکیده: در تحقیق حاضر، تأثیر حشره‌کش‌های ایمیداکلوپراید و پایری‌پروکسی‌فن روی پارامترهای زیستی حشرات کامل کفشدوزک *Menochilus sexmaculatus* در شرایط آزمایشگاه مورد بررسی قرار گرفت. کفشدوزک به‌روش تغذیه‌ای و با خوردن پسیل پسته *Agonoscena pistaciae* به‌عنوان طعمه آلوده با غلظت‌های مختلف هر یک از حشره‌کش‌ها تیمار شد. برای ایمیداکلوپراید غلظت‌های حداکثر توصیه شده در مزرعه (MFRC) (۱/۱ MFRC = ppm۱۴۰)، ۱/۲ و ۱/۴ MFRC مورد آزمایش قرار گرفت. برای پایری‌پروکسی‌فن غلظت‌های ۱/۱ MFRC (۵۰ ppm)، ۱/۲ و ۲/۱ MFRC استفاده شد. پس از ۲۴ ساعت، ایمیداکلوپراید در بالاترین غلظت توصیه شده در مزرعه باعث ۱۰۰ درصد مرگ ومیر در این شکارگر شد، درحالی‌که پایری‌پروکسی‌فن تأثیری در مرگ‌ومیر آنها نداشت. بعد از ۲۴ ساعت، حتی در غلظت‌های پایین‌تر ایمیداکلوپراید (۱/۲ و ۱/۴ MFRC) نیز تمام حشرات از بین رفتند. به‌علاوه، ایمیداکلوپراید در غلظت‌های ۱/۱۰، ۱/۲۰ و ۱/۴۰ MFRC به‌ترتیب پس از ۳، ۷ و ۱۰ روز باعث ۱۰۰ درصد مرگ‌ومیر در کفشدوزک شد و به‌علاوه تخم‌ریزی در آنها مشاهده نشد. هم‌چنین، پس از دو هفته، در غلظت‌های زیرکشنده ایمیداکلوپراید (۱/۱۰۰ MFRC = ۱/۴ ppm) تأثیری در نرخ مصرف طعمه مشاهده نشد. غلظت‌های ۱/۱ و ۲/۱ MFRC پایری‌پروکسی‌فن به‌ترتیب باعث ۱۸ و ۲۳ درصد کاهش در مصرف طعمه شدند. علاوه بر این، با بالا رفتن غلظت پایری‌پروکسی‌فن، باروری و زادآوری شکارگر بالغ کاهش یافت، به‌طوری‌که، به‌ترتیب ۴۳ و ۲۴/۵ درصد کاهش در باروری و زادآوری در غلظت‌های ۱/۱ و ۱/۲ MFRC مشاهده شد. ایمیداکلوپراید در غلظت زیرکشنده ۱/۱۰۰ MFRC باعث کاهش معنی‌داری در تخم‌ریزی *M. sexmaculatus* گردید، اما، تأثیری در زادآوری مشاهده نشد. از نتایج به‌دست آمده می‌توان نتیجه‌گیری نمود که ایمیداکلوپراید برای این شکارگر بسیار سمی می‌باشد و پایری‌پروکسی‌فن در غلظت توصیه شده در مزرعه در مقایسه با آن سمیت حاد ندارد، اما پایری‌پروکسی‌فن زمانی که از راه تغذیه از میزبان آلوده وارد سیستم گوارش حشره می‌شود دارای اثرات زیرکشنده مانند تأثیر روی تولیدمثل و میزان تغذیه از طعمه یا شکار می‌باشد که نهایتاً منجر به ایجاد اثرات منفی روی رشد جمعیت این شکارگر می‌گردد.

واژگان کلیدی: پسیل معمولی پسته، حشره‌کش، *Menochilus sexmaculatus*، اثرات زیرکشندگی

[DOR: 20.1001.1.22519041.2016.5.1.9.8]