EFFECTS OF ACARICIDES USED IN COFFEE CROPS ON THE EGGS AND SUBSEQUENT STAGES OF GREEN LACEWING

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ABSTRACT: One of the most common predatory species in coffee agrosystems is *Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae). Its maintenance, however, depends on the application of non-toxic pesticides. Thus, bioassays were carried out in laboratory conditions to evaluate the selectivity of the acaricides spirodiclofen (Envidor – 0.12 g a.i.L^{-1}), fenpropathrin (Meothrin 300 – 0.15 and 0.30 g a.i.L^{-1}), sulphur (Thiovit Sandoz – 4.0 and 8.0 g a.i.L^{-1} and, abamectin (Vertimec 18 CE – 0.0067 and 0.0225 g a.i.L^{-1}) on this predator's eggs. The *C. externa eggs* were directly sprayed using a Potter's tower. The eggs were then placed in glass tubes and kept in a climatic chamber at 25±2ºC, RH of 70±10% and 12h of photophase. The pesticides were classified according to the recommendations of the IOBC. Fenpropathrin (0.30 g a.i.L^{-1}) was harmful and fenpropathrin (0.15 g a.i.L^{-1}) was moderately harmful to the green lacewing. The products spirodiclophen, sulphur and abamectin were moderately harmful to the predator. New assays in greenhouse and field conditions should be carried out to verify the toxicity of these compounds.

Key words: *Coffea arabica*, integrated pest management, *Chrysoperla externa*, selectivity, agrochemicals.

AÇÃO DE ACARICIDAS UTILIZADOS EM CAFEEIRO SOBRE OVOS E FASES SUBSEQUENTES DO DESENVOLVIMENTO DE CRISOPÍDEOS

RESUMO: *Uma das espécies de predadores mais encontradas no agroecossistema cafeeiro é a Chrysoperla externa (Hagen, 1861) (Neuroptera: Chrysopidae); entretanto, a sua manutenção depende da utilização de produtos fitossanitários seletivos. Dessa forma, foram realizados bioensaios em laboratório para avaliar a seletividade dos acaricidas espirodiclofeno (Envidor – 0,12 g i.a.L^{-1}), fenpropatrina (Meothrin 300 – 0,15 e 0,30 g i.a.L^{-1}), enxofre (Thiovit Sandoz – 4,0 e 8,0 g i.a.L^{-1}) e abamectina (Vertimec 18 EC – 0,0067 e 0,0225 g i.a.L^{-1}) para ovos desse predador. Após a pulverização dos produtos em torre de Potter, os ovos foram colocados em tubos de vidro e mantidos em câmara climática a 25±2 ºC, UR de 70±10% e fotofase de 12 horas. Os compostos foram enquadrados em classes de toxicidade de acordo com o seu efeito total (E), seguindo recomendações da IOBC. Fenpropatrina (0,3 g i.a.L^{-1}) foi nocivo e fenpropatrina (0,15 g i.a.L^{-1}) foi moderadamente nocivo ao crisopídeo. Os produtos espirodiclofeno, enxofre e abamectina foram moderadamente nocivos ao predador. Novos testes em condições de casa de vegetação e campo devem ser realizados para comprovação ou não da toxicidade desses compostos.*

Palavras-chave: Coffea arabica, manejo integrado de pragas, Chrysoperla externa, seletividade, agroquímicos.

1 INTRODUCTION

Among the various pest mites that infect coffee agroecosystems (*Coffea* sp.), the red spider mite *Oligonychus ilicis* (McGregor, 1917) (Acari:Tetranychidae) and the coffee ringspot mite *Brevipalpus phoenicis* (Geijskes, 1939) (Acari:Tenuipalpidae) may cause serious economic losses (REIS et al., 2002).

In order to feed, the red spider mite perforates and absorbes the cell contents of the upper leaf surface. The leaves then lose their natural shine and become bronzed. The attack frequently occurs in spots and may, in favorable conditions and if control is not done at the onset of the infestation, affect an entire crop (REIS & TEODORO, 2000).

The damage caused by *B. phoenicis* in coffee production is due to the transmission of the ringspot virus, responsible for leaf fall and a low quality beverage. The species has been inflicting great financial losses on the coffee producers in the Triângulo Mineiro and Alto Paranaíba regions, in Minas Gerais state, Brazil (PAPA, 1999; REIS & SOUZA, 2000; REIS & CHAGAS, 2001).

In spite of the action of natural predators in coffee agroecosystems, control of these mites is still

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dependant on acaricides, whose action is faster and more effective. However, extensive applications of broad range compounds may reduce the populations of natural enemies and contaminate the environment (FRAGOSO et al., 2002; REIS et al., 2002). Non-selective products used to control pest mites in coffee crops lead to the resurgence of pests, including phytofagous mites, and a decrease or elimination of their natural predators.

Insects of the Chrysopidae family have played an important role in balancing the populational density of many pests (mites, mealybug, whitefly etc.) in coffee crops. Among the chrysopids, *Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae) occurs naturally in cash crops in the Neotropical Region (CARVALHO & SOUZA, 2000; FONSECA et al., 2001).

In an integrated pest management program (MIP) in coffee systems, one of the concerns should be the preservation of chrysopids and other natural predators, which depends on compatibility with the other control methods adopted, especially the chemical. Therefore, studies on the impact of pesticides on beneficial agents should be prompted (CARVALHO et al., 2003).

To subsidize an MIP program in coffee systems, and considering the potential and importance of *C. externa* as a regulator of pest mite populations, the aim of this work was to study the effects of spirodiclofen, fenpropathrin, sulphur and abamectin, used to control *O. ilicis* and *B. phoenicis*, on this predator's eggs and subsequent development phases.

2 MATERIAL AND METHODS

Third generation *C. externa* eggs developed in the laboratory (maximum 24 hours old) were selected and placed on a 15 cm diameter Petri dish in groups of 40 for application of the treatments. The acaricides tested were sprayed directly over the eggs with a Potter's tower, at 15 $lb.pol^{-2}$ pressure and a volume of application of 1,5 ± 0,5 $\mu L.cm^{-2}$. The acaricides were sprayed in the maximum dose recommended by the manufacturer for control of the red spider mite and ringspot mite in coffee (Table 1). The control treatment consisted only of water.

The experimental design was entirely random, consisting of 8 treatments with 8 replications and plots composed of 5 eggs. Egg viability, duration of the embryonic period, duration and survival of the first, second and third-instar larvae and pupa were assessed. The data were subjected to variation analysis and the treatment means were compared by the Scott-Knott test at 5% significance (SCOTT & KNOTT, 1974).

To assess the effects of the compounds on the adults originated from the treated eggs, the survivors were paired up and each pair was placed in PVC cage (10 cm diameter x 10 cm height), internally lined with filter paper, sealed at the bottom with laminated film and at the top with "voil" cloth. The adults were fed with beer yeast and honey (1:1 $v.v^{-1}$) based diet, according to Barbosa et al. (2002).

During four consecutive weeks the eggs deposited were counted at three day intervals. In each treatment 96 eggs were collected and placed separately in ELISA test ("Enzime Linked Immunosorbent Assay") microtitulation plate compartments, sealed with laminated PVC and stored in a climatic chamber. A random experimental design with plots consisting of one pair each was used. The number of treatments varied according to the mortality levels of the eggs treated with the compounds. A minimum of seven replications, each represented by one pair, was done. Adult mortality rate, daily and total oviposition capacity/female and egg viability were assessed.

The total effect of each product (E) was determined through the Vogt formula (1992): E = 100% - (100% - M%) x R1 x R2, where: E = total effect (%); M = treatment mortality corrected by the Abbott formula (1925); R1 = ratio between mean daily number of eggs deposited by treated and untreated females and R2 = ratio between mean viability of the eggs deposited by treated and untreated females. After the total effect was determined, each compound was categorized into one of the four toxicity classes proposed by IOBC members (BOLLER et al., 2005): class 1 = harmless or slightly harmful (E<30%), class 2 = moderately harmful ($30 \leq E \leq 79\%$), class 3 = harmful ($80 \leq E \leq 99\%$) and class 4 = harmful (E>99%).

3 RESULTS AND DISCUSSION

Contact with the acaricides did not impair the duration of the embryonic period in *C. externa* eggs, with mean results varying between 4.9 and 5.0 days (Table 2). Similar results were found by Carvalho et al. (2002), who treated *C. externa* eggs with Danimen 300 CE (0.09 g $a.i.L^{-1}$ fenpropathrin), and by

Silva (2004) for treatment with Kumulus 800 PM (4.0 g a.i.L^{-1}sulphur) and Turbo 50 CE (0.013 g a.i.L^{-1} betacyflutrin). The acaricides fenpropathrin (0.3 g a.i.L^{-1}) and abamectin reduced egg viability in both doses tested, with means of 70.0%, 65.0% and 57.5%, respectively (Table 2). Carvalho et al. (2002), applying fenpropathrin (0.09 g a.i.L^{-1}) to *C. externa* eggs also obtained similar results, with 73.3% of viability.

The duration of the larva phase was not affected by the compounds assessed, with means that varied between 8.7 to 10.9 days (Table 2). Similar results were found by Maia et al. (2000), Fonseca et al. (2001) and Silva et al. (2002), who registered means of 11.0, 10.9 and 11.7 days, respectively, for larvae fed on various prey. Fenpropathrin (0.3 g a.i.L^{-1}), sulphur (8.0 g a.i.L^{-1}) and abamectin (0.0225 g a.i.L^{-1}) reduced survival rates in the larva phase, with accumulated values of 60.3, 85.7 and 89.6%, respectively (Table 2). In the treatment with 0.3 g a.i.L^{-1} of fenpropathrin, survival of first-instar larvae decreased (Table 3). Godoy et al. (2004) also found that pyrethroid products, such as deltamethrin (0.0125 g a.i.L^{-1}), reduce survival rates of first-instar larvae (38.3% mean survival rate).

In the second and third-instar larvae and in the *C. externa* pre-pupa and pupa phases, the acaricides did not affect survival rates (Tables 3 and 4).

Table 1 - Commercial and technical names, doses, chemical groups and toxicological classes of the products assessed in this work.

Name		Dose	Group	Class
Technical	Commercial	g a.i.L^{-1}	Chemical	Toxicological
Spirodiclofen	Envidor	0.12	Cetoenol	III
Fenpropathrin	Meothrin 300	0.15	Pyrethroid	I
Fenpropathrin	Meothrin 300	0.3	Pyrethroid	I
Sulphur	Thiovit Sandoz	4.0	Inorganic	IV
Sulphur	Thiovit Sandoz	8.0	Inorganic	IV
Abamectin	Vertimec 18 EC	0.0067	Avermectins	III
Abamectin	Vertimec 18 EC	0.0225	Avermectins	III

Table 2 - Duration (days) and survival (%) (±EP) of *Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae) eggs and larvae, originated from eggs treated with the acaricides. Temperature of 25 ± 2°C, RH 70 ± 10% and 12h of photophase.

Treatment	Egg phase		Larva phase	
	Duration	Viability	Duration	Survival
Control	5.0 ± 0.00 ns	95.0 ± 1.16 b	8.7 ± 0.10 ns	95.0 ± 0.32 a
Spirodiclofen 0.12 g a.i.L^{-1}	5.0 ± 0.00 ns	85.0 ± 2.59 b	9.6 ± 0.17 ns	91.2 ± 0.31 a
Fenpropathrin 0.15 g a.i.L^{-1}	5.0 ± 0.00 ns	85.0 ± 2.59 b	10.9 ± 0.54 ns	94.4 ± 0.86 a
Fenpropathrin 0.3 g a.i.L^{-1}	4.9 ± 0.02 ns	70.0 ± 2.67 a	9.5 ± 0.10 ns	60.3 ± 0.21 c
Sulphur 4.0 g a.i.L^{-1}	4.9 ± 0.03 ns	90.0 ± 1.89 b	9.0 ± 0.09 ns	95.0 ± 0.63 a
Sulphur 8.0 g a.i.L^{-1}	4.9 ± 0.02 ns	87.5 ± 1.86 b	9.3 ± 0.14 ns	85.7 ± 0.54 b
Abamectin 0.0067 g a.i.L^{-1}	5.0 ± 0.00 ns	65.0 ± 2.59 a	9.5 ± 0.11 ns	92.7 ± 0.86 a
Abamectin 0.0225 g a.i.L^{-1}	5.0 ± 0.01 ns	57.5 ± 2.48 a	9.1 ± 0.08 ns	89.6 ± 0.83 b
CV (%)	-	23.0	-	6.8

Means followed by the same letter in the column did not differ significantly in the Scott-Knott test (P<0.05).

Table 3 - Duration (days) and survival (%) (±EP) of *Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae) larvae, originated from eggs treated with the acaricides assessed. Temperature of 25 ± 2ºC, RH 70 ± 10% and 12h of photophase.

Treatment	First-instar		Second-instar		Third-instar	
	Duration	Survival	Duration	Survival	Duration	Survival
Control	3.5 ± 0.04 ns	95.0 ± 1.16 b	2.7 ± 0.02 a	100.0 ± 0.00 ns	2.4 ± 0.04 ns	100.0 ± 0.00 ns
Spirodiclofen 0.12 g i.a.L^{-1}	4.3 ± 0.09 ns	95.0 ± 1.77 b	2.9 ± 0.02 a	97.5 ± 0.88 ns	2.5 ± 0.06 ns	100.0 ± 0.00 ns
Fenpropathrin 0.15 g i.a.L^{-1}	5.3 ± 0.42 ns	94.4 ± 1.31 b	3.0 ± 0.07 a	100.0 ± 0.00 ns	2.6 ± 0.05 ns	100.0 ± 0,00 ns
Fenpropathrin 0.3 g i.a.L^{-1}	4.0 ± 0.01 ns	60.3 ± 3.14 a	3.2 ± 0.03 b	100.0 ± 0.00 ns	2.4 ± 0.06 ns	100.0 ± 0.00 ns
Sulphur 4.0 g i.a.L^{-1}	4.0 ± 0.01 ns	95.0 ± 1.77 b	2.9 ± 0.02 a	100.0 ± 0.00 ns	2.1 ± 0.06 ns	100.0 ± 0.00 ns
Sulphur 8.0 g i.a.L^{-1}	3.9 ± 0.04 ns	90.8 ± 1.66 b	3.4 ± 0.03 b	97.5 ± 0.88 ns	2.1 ± 0.07 ns	96.9 ± 1.10 ns
Abamectin 0.0067 g i.a.L^{-1}	4.1 ± 0.02 ns	92.7 ± 1.71 b	3.0 ± 0.02 a	100.0 ± 0.00 ns	2.4 ± 0.06 ns	100.0 ± 0.00 ns
Abamectin 0.0225 g i.a.L^{-1}	4.0 ± 0.00 ns	89.6 ± 1.83 b	3.0 ± 0.01 a	100.0 ± 0.00 ns	2.2 ± 0.07 ns	100.0 ± 0.00 ns
CV (%)	-	16.8	7.8	-	-	-

Means followed by the same letter in the column did not differ significantly in the Scott-Knott test (P<0.05).

Table 4 - Duration (days) and survival (%) (±EP) of *Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae) pre-pupa and pupa, originated from eggs treated with the acaricides assessed. Temperature of 25 ± 2ºC, RH 70 ± 10% and 12h of photophase.

Treatment	Pre-pupa phase		Pupa phase	
	Duration	Survival	Duration	Survival
Control	3.6 ± 0.05 a	100.0 ± 0.00 ns	8.1 ± 0.07 b	93.7 ± 1.45 ns
Spirodiclofen 0.12 g a.i.L^{-1}	3.5 ± 0.04 a	100.0 ± 0.00 ns	5.8 ± 0.09 a	88.7 ± 2.26 ns
Fenpropathrin 0.15 g a.i.L^{-1}	3.7 ± 0.03 a	100.0 ± 0.00 ns	7.8 ± 0.05 b	85.7 ± 4.37 ns
Fenpropathrin 0.3 g a.i.L^{-1}	4.3 ± 0.06 b	100.0 ± 0.00 ns	5.9 ± 0.11 a	88.7 ± 2.26 ns
Sulphur 4.0 g a.i.L^{-1}	2.7 ± 0.03 a	100.0 ± 0.00 ns	8.1 ± 0.03 b	100.0 ± 0.00 ns
Sulphur 8.0 g a.i.L^{-1}	3.6 ± 0.02 a	100.0 ± 0.00 ns	8.0 ± 0.04 b	100.0 ± 0.00 a
Abamectin 0.0067 g a.i.L^{-1}	3.7 ± 0.04 a	100.0 ± 0.00 ns	8.2 ± 0.05 b	100.0 ± 0.00 ns
Abamectin 0.0225 g a.i.L^{-1}	3.6 ± 0.06 a	100.0 ± 0.00 ns	7.8 ± 0.04 b	100.0 ± 0.00 ns
CV (%)	9.3	-	6.8	-

Means followed by the same letter in the column did not differ significantly in the Scott-Knott test (P<0.05).

Similar means were obtained by Gody et al. (2004), who found that the compounds abamectin (0.0054 g a.i.L^{-1}) and deltamethrin (0.0125 g a.i.L^{-1}) did not affect survival in the second and third-instar larvae (95% and 100% mean survival rate) or of *C. externa* pupa (100% mean survival rate).

The sex ratio of *C. externa* adults originated from the eggs treated was not affected by the products (Figure 1) and varied from 0.33 to 0.56, results corroborated by Silva (2004), who registered a sex ratio between 0.39 and 0.52.

In light of the total effect (E) of the acaricides on females originated from treated eggs, all the products were categorized in class 2 (moderately harmful) (Table 5), except for the fenpropathrin (0.3 g a.i.L^{-1}) treatment, considered harmful (class 3). Godoy (2002) also found the pyrethroid deltamethrin (0.0125 g a.i.L^{-1}) moderately harmful.

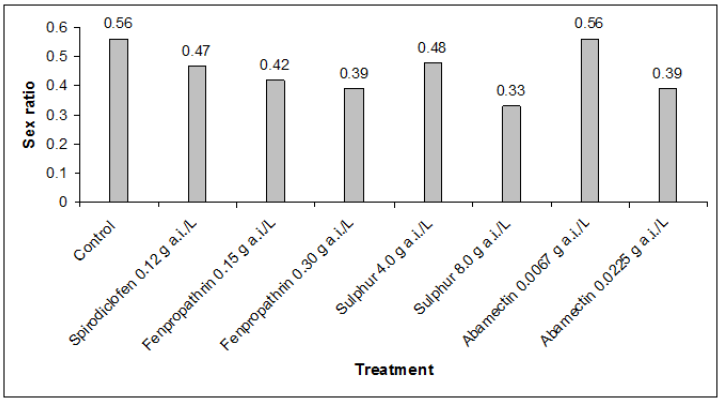

Figure 1 - Sex ratio of *Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae) adults originated from eggs treated with the pesticides (F Test; P>0.99).

Table 5 - *Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae) mortality rate (%), mean number of eggs/day/female, egg viability (%) and total effect followed by the toxicity classification of the compounds applied to the predator's eggs. Temperature of 25 ± 2ºC, RH 70 ± 10% and 12h of photophase.

Treatment	NIO*	M%[1]	Mc%[2]	R'[3]	R"%[4]	E%[5]	Class[6]
Control	40	15.0	-	1	1	-	-
Spirodiclofen 0.12 g a.i.L^{-1}	40	52.5	44.1	0.6	0.9	66.4	2
Fenpropathrin 0.15 g a.i.L^{-1}	40	50.0	41.1	0.6	0.9	69.7	2
Fenpropathrin 0.3 g a.i.L^{-1}	40	70.0	64.7	0.4	0.8	87.1	3
Sulphur 4.0 g a.i.L^{-1}	40	25.0	11.8	0.7	0.9	41.6	2
Sulphur 8.0 g a.i.L^{-1}	40	32.5	20.6	0.7	0.8	58.7	2
Abamectin 0.0067 g a.i.L^{-1}	40	60.0	52.9	0.8	1.0	62.3	2
Abamectin 0.0225 g a.i.L^{-1}	40	55.0	47.1	0.6	1.0	66.5	2

* Initial number of eggs.
[1] Accumulated insect mortality (%) until the adult phase, taking into account the number of dead farate insects.
[2] Accumulated insect mortality (%) until the adult phase, corrected by the Abbott formula (1925).
[3] Mean number of eggs/day/female in four consecutive weeks, from the start of oviposition.
[4] Viability (%) of the eggs collected during the four consecutive weeks.
[5] Total effect of the compounds.
[6] IOBC toxicity class (BOLLER et al., 2005) where: class 2 = moderately harmful (30 ≤ E ≤ 79%), class 3 = harmful (80 ≤ E ≤ 99%).

4 CONCLUSIONS

Among the products assessed, only spirodiclofen, sulphur and abamectin may be sprayed in the highest dose recommended by the manufacturer to control pest mites in coffee without significantly affecting the population of the predator *C. externa*.

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