Biosafety of a biopesticide and some pesticides used on cotton crop against green lacewing, *Chrysoperla carnea* (Stehens) (Neuroptera: Chrysopidae)

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ABSTRACT

Chlorpyrifos, lambda-cyhalothrin, cypermethrin, spinosad and buprofezin were tested against the second instar larvae and adults (except buprofezin) of the green lacewing, *Chrysoperla carnea*. The results showed that chlorpyrifos was more toxic to second instar larvae than lambda-cyhalothrin, cypermethrin, spinosad and buprofezin with LC_{50} values of 1.78, 8.81, 26.9, 294.36 and 997.05 ppm respectively. However, lambda-cyhalothrin was highly toxic to the adult of *C. carnea* compared to the other pesticides. The LC_{50} of lambda-cyhalothrin was 0.04 ppm. Buprofezin and Spinosad were the least toxic to second instar larvae and adults of *C. carnea* respectively. According to the percents of mortality, these pesticide toxicity was classified into harmful pesticide (chlorpyrifos), moderately harmful (lambda-cyhalothrin and cypermethrin), slightly harmful pesticide (spinosad) and harmless pesticides (buprofezin). While, with the adults treated, these pesticides classified into two groups such as moderately harmful (lambda-cyhalothrin, chlorpyrifos and cypermethrin) and less harmful (spinosad) pesticides. These results confirmed that the adult of *C. carnea* was more susceptible to the previous pesticides than second instar larvae. Buprofezin and spinosad are more suitable pesticides for integrated pest management programs and can be used upon the peak of *C. carnea* population density.

Key words: *Chrysoperla carnea*, pesticides, adult, second instar larvae, toxicity.

INTRODUCTION

Natural enemies are a key component of IPM, and they are often recommended as the first line of defense in an IPM program (Lugojja *et al*., 2001). Chrysoperla carnea, one of the most important natural enemies has a great role in reducing the use of pesticides and environmental pollution in field crops and vegetables (Dean and Sterling, 1992). It has received much attention as a potential biological control agent because of its geographical distribution and wide prey range including aphids, eggs and neonate of lepidopteran insects, scale insects whitefly and mites (New, 1975; Remoldi *et al.* 2008). The most crucial requirement for pesticides is that they must be compatible with biological control. Therefore, only those pesticides should be used that are most selective and which have no adverse effects on beneficial organisms (Hassan, 1989; Nasreen, *et al.* 2007). The use of pesticides to control pests in cotton crop in Egypt has a great effect on natural enemies especially green lacewing, C. carnea. So the use of selective pesticides is an important strategy for pest control. Conservation of natural fauna in general either through selective use of pesticides or by other means has been the main criterion for integrated plant protection (Nasreen, *et al.* 2005). The same authors found that chlorpyrifos recorded the lowest LC_{50}, s values when treated with the second instar larvae of *C. carnea*. Cypermethrin is either highly toxic (Schneider et al., 2006) or slightly harmful (Reddy and Divakar, 1998) to *C. carnea* larvae. Spinosad is slightly toxic to C. carnea (Elzen *et al*., 1998). Buprofezin, chitin synthesis inhibitors, has no effects in the viability and development of the second instar larvae of Chrysoperla rufilabris (Liu and Chen, 2000). Lambda-cyhalothrin seemed to have no effect on aphids, but it was toxic to green lacewing (Booth *et al.*, 2007).

Chlorpyrifos, cypermethrin, lambda-cyhalothrin, spinosad and buprofezin are used against many pests on cotton in Egypt. These pesticides are used upon the peak of *C. carnea* population density. In the present study, five pesticides which are mentioned above are extensively used to control insect pests in cotton field were selected under laboratory conditions to test their toxicity against the second instar larvae of *C. carnea*, and adult of the green lacewing except buprofezin (which was used only against the immature stages). So, the purpose of this study is to screen out some selected pesticides that can be used in integrated pest management (IPM) programs.

MATERIALS AND METHODS

Toxicity of chlorpyrifos, cypermethrin, lambda-cyhalothrin, spinosad and buprofezin were investigated against second instar larvae and adult of green lacewing, *C. carnea* under laboratory conditions.

TEST INSECT

The adults of *C. carnea* were collected from the cotton fields in El-Ibrahimai region, Sharkai Governorate, Egypt and then transferred to the Unit of Predator and Parasite, Plant Protection Research Institute, Agriculture Research Center, Dokki, Giza, Egypt. These adults were put in glass cages and fed on sugar solution. The eggs of these adults were collected and put in glass jar until they were hatched. The larvae and adults were taken and investigated in this experiment.

TEST PESTICIDES

Different pesticides were used from different classes of pesticides. Chlorpyrifos (Organophosphates), cypermethrin and lambda-cyhalothrin (Pyrethriods), spinosad (Biopesticides) and buprofezin (Chitin Synthesis Inhibitors). Buprofezin was used only against the second instar larvae because it is generally used only against the immature stages. Three concentrations of these pesticides were used as mentioned in Table 1. The lethal concentration for 50 % of population (LC_{50}) was estimated.

BIOASSAY

Five pesticides were used on second instar larvae of *C. carnea* to evaluate the toxic efficacy of these pesticides and lethal concentration for 50% (LC_{50}) of population on the second instar larvae (1-day–old). The larvae of *C. carnea* were put individually in glass tubes (2 x 7 cm) and exposed to *Sitotroga cerealella* eggs treated with different concentrations of pesticides used (Table 1). Each concentration was divided into three replicates. Each replicate included 10 healthy starved larvae. Other three replicates were fed on *Sitotroga cerealella* eggs treated with water as a control. All tubes were covered with a piece of sterilized cotton and incubated at 26 ± 1°C, 70 ± 5 RH and 12h L photophase. All tubes were inspected after 24 h with all pesticides, except buprofezin (chitin synthesis inhibitors) the tubes were inspected after three days (time of second instar larvae to transfer into the third instar, Balasubramani and Swamiappan, 1994). The percent of

Table 1. Concentrations of the tested pesticides against the second instar larvae and adults of the green lacewing, *C. carnea*

Preparations	Concentrations (ppm)					
	Larvae			Adults		
	C1	C2	C3	C1	C2	C3
Spinosad (Tracer 24% SC)	960	480	240	300	150	7.50
Chlorpyrifos (Dursban 48% EC)	10	5	2.5	2.5	1.25	0.6
Buprofezin (Applaud 25% SC)	2500	1250	625	----	-----	------
Cypermethrin (Cyperkill 10% EC)	150	75	37.5	100	50	25
L – cyhalothrin (Karate 2.5% EC)	50	25	12.5	1	0.5	0.25

C1: the first concentration
C2: the second concentration
C3: the third concentration

Table 2. Toxicity of the tested pesticides to the second instar larvae and adults of the green lacewing, *C. carnea*

Insecticides	Second instar larvae		Adults	
	LC_{50} and fiducial limits	Slope ± SE	LC_{50} and fiducial limits	Slope ± SE
Spinosad	294.36 (197.69 – 372.27)	1.55±0.31	145.95 (125.32 – 174.40)	2.29 ± 0.32
Chlorpyrifos	1.78 (1.28 – 2.23)	1.5 ± 0.3	0.19 (0.08 – 0.29)	1.22 ± 0.22
Buprofezin	997.05 (439.30 – 10354.67)	0.88 ± 0.22	----------	---------------
Cypermethrin	26.9 (16.6 – 34.9)	2.2 ± 0.4	89.36 (68.38 – 147.78)	1.81 ± 0.34
L-cyhalothrin	8.81 (5.9 – 10.9)	3.1 ± 0.6	0.04 (0.01 – 0.08)	1.06 ± 0.23

mortalities were estimated. The LC_{50}, s values were also calculated, by probit analysis, using the SPSS program.

The same method was carried out with the adults. Thirty healthy adults in each concentration were divided into three replicates (10 adults in each replicate) and put in glass cage. The adults in all replicates were fed on sugar solution 10% contaminated with different concentrations of all pesticides (Table 1). Other three replicates with 30 adults were fed on sugar solution only as a control. All cages were incubated at 26 ±1°C, 70 ± 5 RH and 12h photophase, and inspected after 24 h., the percentage of mortality and LC50 were calculated.

Statistical analysis

Data of the percent mortality in all treatments whether in second instar larvae or the adults were analyzed by one way ANOVA analysis (SAS Institute Inc 2003).

RESULTS AND DISCUSSION

Second instar larvae of *C. carnea*

As mentioned in Table 1, spinosad, chlorpyrifos, cypermethrin, lambda-cyhalothrin and buprofezin were evaluated against second instar larvae of *C. carnea.* Chlorpyrifos is highly toxic to second instar larvae followed by lambda-cyhalothrin, cypermethrin, spinosad and buprofezin. The mean percents of mortality were 93.3, 86.7, 80.7, 63.3 and 21.7% for chlorpyrifos, lambda-cyhalothrin, cypermethrin, spinosad and buprofezin respectively. The results showed that the lowest mortality percent occurred in buprofezin concentrations. According to the recommendation of the International Organization for Biological Control, West Palaearctic Regional Section (IOBC/ WPRS) working group, harmless pesticides caused less than 50% mortality, slightly harmful caused 50 - 79% mortality, moderately harmful caused 80–89% mortality and harmful caused more than 90%. According to this recommendation, these pesticides were classified into four classes. The first one is harmful pesticide and this includes chlorpyrifos. The second class, moderately harmful, include lambda-cyhalothrin and cypermethrin. The third slightly harmful pesticides, include spinosad. The fourth class is harmless pesticides and this includes buprofezin. The statistical analysis shows that there are no differences in efficacy among chlorpyrifos, cypermethrin, lambda-cyhalothrin and spinosad. While there are significant differences between these pesticides and buprofezin. Data in Table 2 show that the second instar larvae of *C. carnea* are suffering from conventional pesticides chlorpyrifos, lambda – cyhalothrin, and cypermethrin. While, the larvae slight suffered from spinosad and buprofezin, when the second instar larvae were treated by all pesticides, toxicity of buprofezin occurred after three days from treatment (the time of second instar larvae), while with spinosad it occurred after 24hs. Toxicity with the chlorpyrifos, lambda–cyhalothrin, and cypermethrin occurred only after three hours. This mean that chlorpyrifos, lambda–cyhalothrin, and cypermethrin have acute toxicity to the second instar larvae. The highest slope value was found with lambda-cyhalothrin and the least slope value was found with buprofezin. These results showed that the susceptibility of population with lambda-cyhalothrin was homogeneous, while with buprofezin it was heterogeneous.

These results are in agreement with Varghese and Beevi (2004). The authors found that chlorpyrifos was the most toxic to the second instar larvae of the green lacewing, *C. carnea* followed by profenfos. Spinosad was less toxic than profenfos (organophosphours compound) (Elzen *et al*., 1998). Balasubramani and Swamiappan (1997) noticed that chlorpyrifos was highly toxic to the second instar larvae of *C. carnea*. Nasreen *et al*. (2005) found that buprofezin was harmless to the larvae of *C. carnea* when it was used with the high concentrations. Pathan *et al*. (2008) reported that the LC_{50} of lambda-cyhalothrin against the larvae of *C. carnea* was 359.08 ppm. Cypermethrin produced 100% mortality on larvae of *C. externa* after 48 h of eggs hatching. Reddy and Divakar (1998) found that spinosad caused significantly higher mortality than controls but this effect was less immediate, lasted longer and was less intense than effects with conventional insecticides. The LC_{50} of cypermethrin and spinosad against *Chrysoperla externa* were 75 and 120 ppm respectively. The authors found that cypermethrin was highly toxic towards eggs and larvae with mortality rates 100%. Schneider *et al.* (2006) stated that toxicity of spinosad was intermediately causing short-term effects, but it did not cause any long-term effects. On the other hand, these results did not agree with those of some researchers. Other researchers found that cypermethrin was slightly harmful to *C. carnea* under laboratory condition Reddy and Divakar (1998). Cisneros *et al.* (2006) found that the larvae of *Chrysoperla carnea* was not affected by spinosad.

Chrysoperla carnea adults

The percent of mortality adults were 85.7, 83.3, 80 and 36 with lambda-cyhalothrin chlorpyrifos, cypermethrin, and spinosad treatments respectively. It shows that the highest percent of mortality occurred with lambda-cyhalothrin, and the lowest in spinosad treatment. According to the IOBC/ WPRS these pesticides are classified into two groups. The first group is moderately harmful pesticides. This group includes lambda-cyhalothrin, chlorpyrifos and cypermethrin. The second group is less harmful pesticides, which includes spinosad.

The statistical analysis shows that there are significant differences between the conventional pesticides (chlorpyrifos, cypermethrin and lambda-cyhalothrin) and spinosad; and no significant differences among chlorpyrifos, cypermethrin and lambda-cyhalothrin. These results agree with those of Mizell and Schiffhauer (1990). The authors found that pyrethriods were not toxic to larvae and adults of *Chrysoperla rufilabris* but organophosphates and carbamates were. Medina *et al.* (2003) found that spinosad after 72h reduced the number of *C. carnea* adult by 39.8 and 87.2 % in topical and ingestion treatment at the maximum concentration (800 mg a.i. l^{-1}). Nadel *et al.* (2007) stated that spinosad when mixed with honey caused significant mortality to adult of *C. carnea* under laboratory conditions.

Lethal concentrations

The lethal concentrations for 50% (LC_{50}) of five pesticides to the second instar larvae were estimated. The results showed that the LC_{50}, to chlorpyrifos, lambda–cyhalothrin, cypermethrin, spinosad and buprofezin were 1.78, 8.8, 26.90, 294.36 and 997.05 ppm respectively (Table 2). Many if not all researchers are concerned with eggs and immature stages of *C. carnea.* Data in Table 2, demonstrated the efficiency of some pesticides on adults of *C. carnea*. The LC_{50} for the adults were 0.04, 0.19, 89.36 and 145.95 ppm to lambda – cyhalothrin chlorpyrifos, cypermethrin and spinosad, respectively. Buprofezin was not used against the adults because this pesticide had its effect only on the immature stages not adults.

To throw some light on the effect of previous pesticides (chlorpyrifos, cypermethrin, lambda-cyhalothrin, spinosad and buprofezin) on both second instar larvae and adult of *C. carnea.* The results conclude that adults of *C. carnea* were more susceptible than second instar larvae to all pesticides. Buprofezin was less toxic to the second instar larvae. This result means that buprofezin can be used safely as an effective pesticide against whitefly in the end of cotton season with maximum peak of *C. carnea* instead of lambda-cyhalothrin or cypermethrin. The same result was found by Naveed *et al*. (2008). The authors found that the whitefly population was lower in treatment of buprofezin, while the number of predators was higher. Spinosad is harmless to both adult and second instar larvae of *C. carnea*, so it can be used safely against pink bollworm with maximum peak of *C. carnea*. Both buprofezin and spinosad are suitable for integrated pest management program (IPM). Chlorpyrifos and lambda – cyhalothrin are highly toxic to second instar larvae and adult of *C. carnea*, so these pesticides can be used when the population density of *C. carnea* is low.

Finally, the results recommended that when using conventional pesticides, it must be used with appropriate formulations in the right concentration and at the optimum time of intervention following proper application methods to avoid natural enemies damage. Although the data obtained from laboratory toxicity studies have been sufficient to decide upon the use of insecticides in IPM (in cases where mortality was low in laboratory experiments), semi-field and field studies are still needed.

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Received: May20, 2011 Revised:July08,2011 Accepted:July11, 2011