Chemosphere 92 (2013) 490–496

Contents lists available at SciVerse ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

Toxicity and sublethal effects of seven insecticides to eggs of the flower bug *Orius insidiosus* (Say) (Hemiptera: Anthocoridae)

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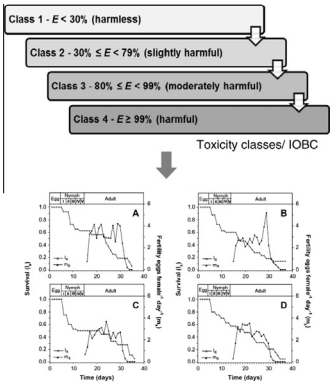
HIGHLIGHTS

- Flubendiamid and spirotetramat + imidacloprid had corrected mortality up to 80%.
- Nymphs hatched from eggs treated with abamectin showed 100% of mortality.
- Pyriproxyfen and rynaxypyr were harmless and pymetrozine were slightly harmful.
- Pyriproxyfen affected some parameters of the life table.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 29 October 2012
Received in revised form 14 January 2013
Accepted 24 January 2013
Available online 5 March 2013

Keywords:
Physiological selectivity
Biological control
Orius insidiosus
Tomato leafminer
Integrated pest management
Life table

ABSTRACT

The predatory bug *Orius insidiosus* is an important biological control agent of several insect pests, and is one of the most commonly used species in biological control programs worldwide. This study assessed the lethal and sublethal effects of insecticides on this species through life table, and classified the insecticides according to the definitions of toxicity given by the International Organization for Biological and Integrated Control of Noxious Animals and Plants (IOBC). A bioassay was carried out using a completely randomized design with eight treatments and 40 replicates. Eggs of *O. insidiosus* laid naturally in plant stems were immersed in aqueous solutions of the chemical products. Egg viability, duration of the embryonic period, survival of nymphs, and duration of the nymphal period were assessed daily. Insects that reached adulthood were paired and their reproduction assessed. The number of eggs produced and the survival of adults were assessed daily. The insecticides abamectin, cartap hydrochloride, spirotetramat + imidacloprid, and flubendiamid were classified as harmful. Pyriproxyfen and rynaxypyr were categorized as harmless and pymetrozine was classified as slightly harmful. Pyriproxyfen affected the population parameters r_m, *GT*, *DT*, and λ, whereas other insecticides did not.

1. Introduction

The predatory bug *Orius insidiosus* (Say) (Hemiptera: Anthocoridae) is an important biological control agent of several insect pests, including thrips, aphids, mites, whiteflies, and the eggs and small larvae of Lepidoptera (Silveira et al., 2004; Ragsdale et al., 2011; Weintraub et al., 2011). *O. insidiosus* is a voracious generalist predator in all its active life stages, which means it can be released at different stages of its development (Lattin, 1999; Symondson et al., 2002). *O. insidiosus* also has the ability to feed on pollen and can adapt to different habitats and ecosystems, which allows

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0045-6535/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.chemosphere.2013.01.111

it to remain within a given agricultural area and enables small populations of the insect to be used (Silveira et al., 2003; Harwood et al., 2007; Desneux and O'Neil, 2008).

Another factor that makes *O. insidiosus* a desirable agent in biological control programs is the ease of mass rearing the insect. Releases of *O. insidiosus* are usually undertaken for the control of thrips on greenhouse crops. However, releases on field crops are also being carried out successfully (Mendes et al., 2002; Silveira et al., 2003; Bueno, 2009). This predator has great potential as a biological control agent of the tomato leafminer *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), an important pest that has caused severe damage to tomato crops worldwide (Desneux et al., 2010; García-Marí and Vercher, 2010). *O. insidiosus* is more prevalent in tomatoes cultivated with low levels of insecticide use (Miranda et al., 1998), and the use of pesticides can significantly diminish its populations (Pacora, 1982).

The indiscriminate use of insecticides can result in lethal and sublethal effects on many non-target natural enemies. These effects can modify insects' biological parameters, for example, reducing longevity and reproductive capacity. One means by which to reduce these unwanted effects is to use selective insecticides – products that control the target organism but that do not affect beneficial organisms (Moura et al., 2005; Carvalho et al., 2007). Effective integration of chemical and biological control is important for the implementation of integrated pest management (IPM) programs, is only possible with the use of selective insecticides.

Many studies have evaluated the selectivity of pesticides for natural enemies, but few take into account the sublethal effects. These sublethal effects can be studied through life tables, which can be used to assess the effects of chemical products across generations improve understanding of insect population dynamics in areas with pesticide use (Stark and Banks, 2003; Stark et al., 2007).

Considering the importance of the predator *O. insidious* as a biological control agent, and the need for studies that improve understanding of pest control tactics for IPM programs, our goals were to assess the lethal and sublethal effects of insecticides on *O. insidiosus* through life tables, and to classify the toxicity of the insecticides according to definitions given by the International Organization for Biological and Integrated Control of Noxious Animals and Plants, West Palearctic Regional Section (IOBC/WPRS).

2. Materials and methods

The bioassay was carried out in the Laboratory of Selectivity Studies, Department of Entomology, Federal University of Lavras, Lavras, Minas Gerais, Brazil. Laboratory conditions were controlled at 25 ± 2 °C, relative humidity of 70 ± 10%, and photoperiod of 12:12 (light:dark).

2.1. Insects

For the bioassay, approximately 100 adults of *O. insidiosus* were collected from the host plant *Bidens pilosa* L. (Asteraceae), commonly known as Spanish needle, at the Federal University of Lavras (21°23′18″S 44°99′40″W).

The insects collected were brought to the laboratory, where 50 adults were placed per glass container (2 L). Each recipient contained strips of paper towel, which served as a place of shelter; *B. pilosa* stems as substrate for oviposition and UV sterilized *Anagasta kuehniella* (Zeller, 1879) (Lepidoptera: Pyralidae) eggs as a food source, offered every 48 h. These containers were covered with plastic lid with a central hole fixed with a fine mesh net, to allow ventilation. The *B. pilosa* stems containing eggs of the predator were changed every 48 h and kept in Petri dishes (20 cm diameter) which were covered with perforated polyvinyl chloride film (PVC film). In these Petri dishes were placed moistened cotton wicks, strips of paper towel and eggs of *A. kuehniella* until nymphs reach adulthood. The adults were collected and transferred to glass containers for continuity of rearing (Bueno, 2009).

Every 30 d new adults were collected from the field and added to laboratory rearing. The bioassay was carried out with insects from the third generation laboratory rearing.

2.2. Insecticides

Seven commercial formulations of insecticides were evaluated, representing the primary compounds in insecticides used in agricultural fields in Brazil. All compounds were tested at the label rates recommended for control of tomato leafminer, *T. absoluta*, at the Brazilian Ministry of Agriculture (MAPA, 2012). The insecticides, concentrations of active ingredient tested and mode of action (IRAC, 2012) were as follows: abamectin 1.8 mg a.i. L^{-1}, chloride channel activator (Vertimec® 18 emulsifiable concentrate; Syngenta, São Paulo, SP, Brazil); cartap hydrochloride 0.00125 mg a.i. L^{-1}, nicotinic acetylcholine receptor channel blockers (Cartap® 500 soluble powder; Ihara, Sorocaba, SP, Brazil); spirotetramat 0.120 mg a.i. L^{-1} + imidacloprid 0.360 mg a.i. L^{-1} interference of lipid biosynthesis + acetylcholine receptor agonists (Movento Plus® 480 suspendable concentrate; Bayer, São Paulo, SP, Brazil); flubendiamid 0.480 mg a.i. L^{-1}, ryanodine receptor modulator (Belt® 480 suspendable concentrate; Bayer, São Paulo, SP, Brazil); pymetrozine 0.5 mg a.i. L^{-1}, selective feeding blockers (Chess® 500 water-dispersible granules; Syngenta, São Paulo, SP, Brazil); pyriproxyfen 0.1 mg a.i. L^{-1}, juvenile hormone mimic (Tiger® 100 emulsifiable concentrate; Ihara, Sorocaba, SP, Brazil); and rynaxypyr 0.8 mg a.i. L^{-1}, ryanodine receptor modulators (Premio® suspendable concentrate; Du Pont, Barueri, SP, Brazil).

2.3. Bioassay

The bioassay was carried out using a completely randomized design with eight treatments and 40 replicates. To constitute the experimental unit, *B. pilosa* stems were offered to adults of *O. insidiosus* for 24 h period. After this time, the eggs present in stems were counted and the stems that had more of an egg, had unfeasible eggs with the help of entomological pin, leaving only one egg per stem. Therefore each experimental unit consisted of one egg of *O. insidiosus* aged up to 24 h. For treatment application, these *B. pilosa* stems (2 cm) were immersed in aqueous solutions of the chemical products for 5 s. The basal ends of the stems were wrapped in moistened cotton wicks to prevent desiccation. Water was used as the control treatment. These stems were then placed in individual Petri dishes and covered with perforated PVC film. Egg viability, duration of the embryonic period, survival of nymphs, and duration of the nymphal period were assessed daily. Soon after hatching, the nymphs were transferred to new Petri dishes (5 cm diameter), thus avoiding the contact of these nymphs with *B. pilosa* stem. Eggs in which the operculum had not opened by the end of the 10th day were considered unviable. The nymphs were fed with eggs of *A. kuehniella* every 48 h, and moistened cotton wicks were placed in the Petri dishes as a source of moisture.

To evaluate the effect of insecticides on the life table parameters of *O. insidiosus*, the insects that adulthood were paired. Only treatments that allowed the formation of five or more pairs were assessed, these treatments were considered to be harmless to *O. insidiosus*. Each couple was placed in a 5-cm-diameter Petri dish containing a *B. pilosa* stem as oviposition substrate and moistened cotton wicks. The *B. pilosa* stems were changed daily and couples were fed eggs of *A. kuehniella* every 48 h. The number of eggs laid and the survival of adults were assessed daily.