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Assessment of some new pesticides as molluscicides against the adult and eggs of chocolate banded snail, *Eobania vermiculata*

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Abstract

Background: Land snails, especially the chocolate banded snails, *Eobania vermiculata* are destructive pests of a wide range of field and vegetable crops. New pesticides in different pesticides groups were used against the adults and eggs of chocolate banded snail, *E. vermiculata* under laboratory conditions. These pesticides include indoxacarb, abamectin, and spiromesifen. Other two pesticides were used against the eggs as ovicides. These two pesticides are imidacloprid and fipronil.

Results: The obtained results showed that indoxacarb was the most effective against the adults of *E. vermiculata* followed by abamectin and spiromesifen. The LC_{50}'s were 58.6, 83.3, and 280.9 ppm, respectively. On the other hand, the recommended field rate of both fipronil and imidacloprid sharply decreased the hatchability percentage to 22.7 and 16.2%, respectively, compared with 96.3% in control.

Conclusion: These results cleared that indoxacarb and abamectin can be used as promising molluscicides against the adults of *E. vermiculata* especially in the conventional crops such as wheat and imidacloprid and fipronil can be used as soil treatment against the eggs of *E. vermiculata*.

Keywords: Land snails, *Eobania vermiculata*, Indoxacarb, Abamectin, Spiromesifen, Imidacloprid and fipronil

Introduction

Recently, land snails are considered one of the most serious pests to many crops and vegetables (Ismail 1997). Land snails cause heavy damages by eating the plants leaves, fruits, and roots (El-Deeb et al. 1999). The chemical control is still one of the most effective methods (Radwan et al. 2008).

The chocolate banded snail, *Eobania vermiculata* usually exist in dry vegetation, in hedgerows, gardens, vineyards, and agricultural fields (Puizina et al. 2013). This species was recorded in Europe, the USA, Australia, and Egypt (Herbert 2010).

Indoxacarb is a widely used and new pesticide that belongs to the oxadiazine pesticide group, which acts on target organism as a sodium channel blocker (Shono et al. 2004). The main advantage of this pesticide is its weak toxic effect against mammalian (Narahashi 2002).

Abamectin is a biopesticide synthesized from secondary metabolites from *Streptomyces avermitilis* bacteria (Fisher and Mrozik 1989). This pesticide consists from two parts: the first one is avermectin B_{1a} (80%) and the second is avermectin B_{1b} (20%). This pesticide acts on target organism by effecting on gamma aminobutyric acid (GABA) and chloride flow in nerve cells.

Spiromesifen is a pesticide which belongs to a new pesticide group (spirocyclic phenyl-substituted tetronic acids) (Nauen et al. 2002). This pesticide acts as a lipid synthesis inhibitor in target organisms and has low toxicity against nontarget organisms such as mammalian (Planes et al. 2013).

Imidacloprid which belongs to neonicotinoids pesticide group acts on acetylcholine receptors in the target organism central nervous system (Ware 2000). It is used

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as a seed dressing against seedling pests in maize fields (Duan et al. 2011). Charmillot et al. (2007) used imidacloprid as an ovicide against oriental fruit moth.

Fipronil is a promising pesticide which belongs to a new pesticides group called phenylpyrazole that acts on the target organism by blocking GABA-gated chloride channels and glutamate-gated chloride (GluCl) channels (Raymond et al. 2005). Diaz (2005) recorded that fipronil is an effective larvicide and also ovicide.

This work aims to evaluate the abovementioned new pesticides against the adults and eggs of chocolate banded snail, *Eobania vermiculata.*

Methods

Tested animal

Adults of chocolate banded snail, *Eobania vermiculata* were collected from the Egyptian clover (*Trifilium alexandrium*), cabbage (*Barssica oleracea*), wheat (*Triticum aestivum*), maize (*Zea mays*), lettuce (*Lactuca stavia*), tomato (*Lycopersicon esculentum*), and potatoes (*Solanum tuberosum*) at Ismallia, Qalubia, Munyfia, and Sharkia Governorates during two successive years 2017–2018. The adults were reared in plastic cages with moist sandy loam soil. These adults were fed with lettuce leaves. The eggs of these adults were collected and used in the evaluation process.

Tested pesticides

Five new pesticides were used; three were used against adults and other two against eggs as ovicides (Table 1).

Bioassay

Evaluation of tested pesticides against adults of chocolate banded snail, E. vermiculata

Three pesticides were used against snail adults; indoxacarb, abamectin, and spiromesifen. Three concentrations from all tested pesticides were used; the first concentration is the recommended field rate and other less two concentrations. Each concentration has three replicates. Each replicate has ten healthy adults of *E. vermiculata* kept in plastic cages and covered with pores cover. All treated adults were fed on fresh lettuce leaves dipped in tested concentrations. Other three replicates were fed on lettuce leaves dipped in water as a control. All tested adults were kept in incubators (25 ± 1 °C and 70 ± 5 RH). After 24 h from treatment, other clean and fresh lettuce leaves were used in adults feeding. All replicated were inspected. The percentages of adult mortalities were recorded and LC_{50}'s calculated by Proban software Program.

Evaluation of imidacloprid and fipronil against the eggs of chocolate banded snail, E. vermiculata

The recommended field concentration of both imidacloprid and fipronil were used against the eggs (with different ages) of chocolate banded snail. Each concentration has three replicates. Each replicates has a random number of eggs put on filter papers. The eggs were sprayed by the tested concentrations in Petri dish. Other three replicates were sprayed by water as a control. All Petri dish were put in incubator. The percent of hatchability was observed daily for 2 weeks. The percentage of hatchability was calculated as follow:

$$\text{The percentage of hatchability} = \frac{\text{The numbers of hatched eggs}}{\text{The numbers of treated eggs}} \times 100$$

The pictures of treated eggs and untreated (control) were taken.

Statistical analysis

Data were analyzed by the analysis of variance (one-way classification ANOVA) followed by a least significant difference (LSD) at 5% (Costat Statistical Software 1990).

Results

Effect of tested pesticides on the chocolate banded snail, *Eobania vermiculata* adults

As mentioned in Table 2, three pesticides are used against the adults of chocolate banded snail, *E. vermiculata*. Each pesticide has three concentrations. The obtained results show that the first concentration of indoxacarb (recommended field rate) was the most effective compared with the first concentration in other testes pesticides (abamectin and spiromesifen). The mortalities percentages were 100, 73.3, and 60.0 with the first concentration of indoxacarb, abamectin, and spiromesifen, respectively. The statistical analysis shows significant difference among indoxacarb and other tested pesticides. No significant

Table 1 List of the five tested pesticides

Pesticide	Trade name	Producer	Target	RC[a]
Indoxacarb	Avaunt 15% EC	Du Pont De Nemours, USA	Adults	200
Abamectin	High kin 5.4%EC	Hunan, China		100
Spiromesifen	Oberon 24% SC	Bayer Crop Science, Germany		250
Imidacloprid	Commando 35% SC	Fabco Company, Gordon	Eggs	200
Fipronil	Fipris 5% SC	Anhui Huaxing Chemical industry Co. China		100

[a]Recommended concentration (ml/feddan)

Table 2 Toxicity of tested pesticides against the adults of chocolate banded snail, *E. vermiculata*

Insecticides	Percentages of mortalities %			Slope ± SE	LC50 and fudicial limits
	*Means ± SE	**Means ± SE	***Means ± SE		
Indoxacarb	100 ± 0.0a	66.7 ± 11.5a	33.3 ± 11.5a	2.9 ± 0.4	58.6 (50.9–66.1)
Abamectin	73..3 ± 11.5b	26.7 ± 11.5b	13.3 ± 11.5b	2.9 ± 0.8	63.3 (55.9–72.9)
Spiromesifen	60.0 ± 0.0b	33.3 ± 11.5b	6.7 ± 11.5b	2.8 ± 0.4	280.9 (244.5–336.3)
Control	6.7 ± 11.5c	6.7 ± 11.5b	0.0b		
****F* values	**69.3****	**14.1****	**6.2***		
LSD	**15.4**	**21.7**	**18.8**		

*First concentration, **second concentration, ***third concentration
****Means under each variety sharing the same letter in a column are not significantly different at $P < 0.05$

difference between abamectin and spiromesifen. Significant difference among all tested pesticides and control was found. With the second and third concentration (half and quarter concentration of recommended field rate), there are significant difference between indoxacarb and other treatments.

The results show also no significant difference among abamectin, spiromesifen, and control. The LC_{50}'s were 58.6, 63.3, and 280.9 ppm for indoxacarb, abamectin, and spiromesifen, respectively (Fig. 1). These results clearly show that indoxacarb was the most effective pesticide followed by abamectin and spiromesifen, respectively.

Effect of imidacloprid and fipronil on the chocolate banded snail, *Eobania vermiculata* eggs

The recommended field concentration of both imidacloprid and fipronil was used against different ages of *E. vermiculata* eggs (Table 2).

The obtained result shows that both tested pesticides reduced the percentages of eggs hatchability compared with control. The percentages of hatchability were 22.7, 16.2, and 96.3% with imidacloprid, fipronil, and control, respectively (Table 2 and Fig. 2). The treated eggs were affected by both imidacloprid and fipronil (Fig. 3). The figures show damaged eggs in both treatments compared with control (untreated).

Statistical analysis showed no significant difference between imidacloprid and fipronil but there are significant difference between both tested pesticides and control.

Discussions

Indoxacarb was very effective against the adults of chocolate banded snail, *Eobania vermiculata*. These results were consistent with Shaker et al. (2015). The authors found that the chocolate banded snail, *E. vermiculata* was affected by methomyl, oxamyl, acetamiprid, and lambda-cyhalothrin pesticides. Although all tested pesticides considered insecticides, these pesticides used as molluscicides successfully. The previous studies confirmed that abamectin was more effective against the chocolate snail (Essawy et al. 2009; Abdallah et al. 2015; Hemmaid et al. 2017). Using of imidacloprid and fipronil as ovicides was a very effective action against the hatchability of *E. vermiculata* eggs. The results cleared that both imidacloprid and fipronil are promising ovicides against the eggs of *E. vermiculata*. Musman et al. (2013)

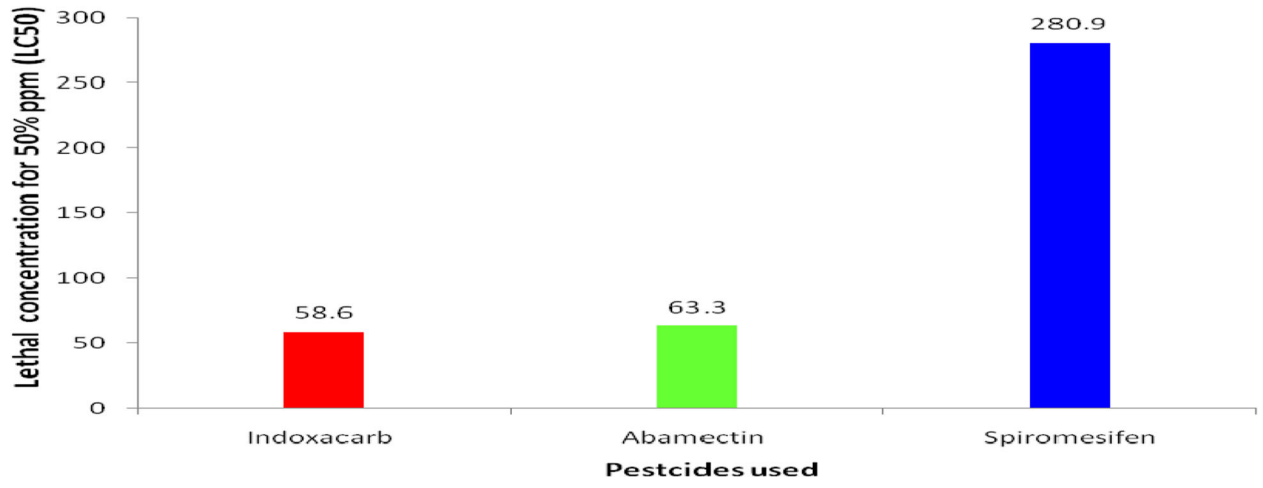

Fig. 1 Effect of the tested pesticides on the adults of chocolate banded snail, *Eobania vermiculata*

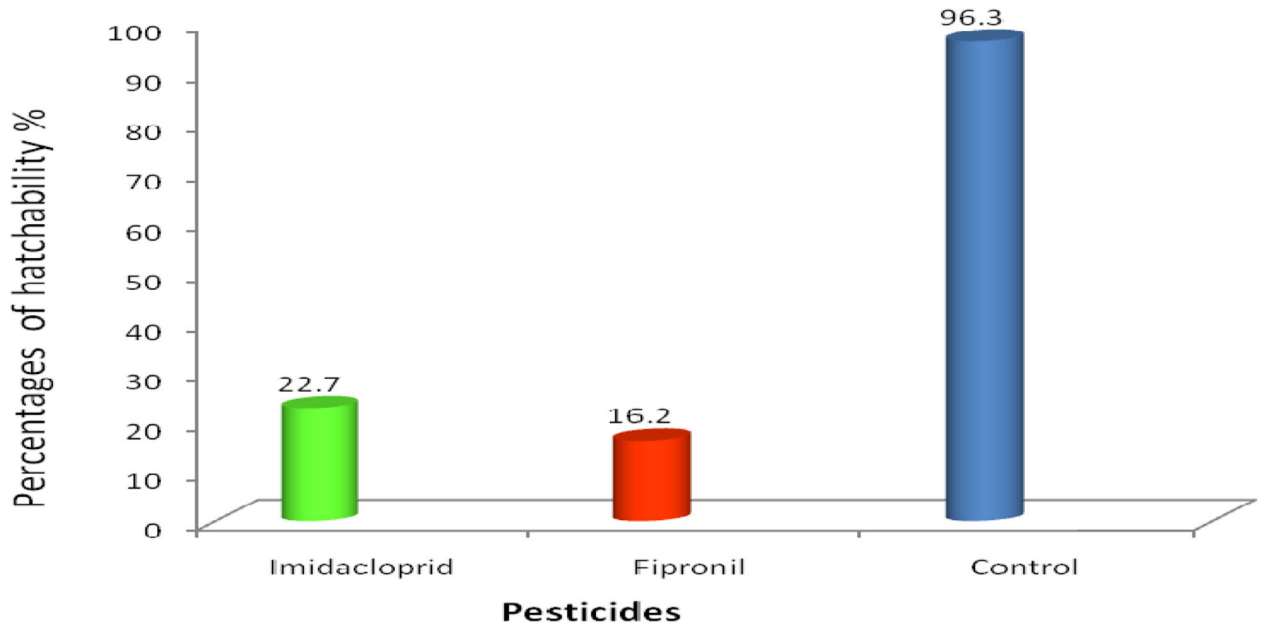

Fig. 2 Effect of the tested pesticides on the eggs hatchability of chocolate banded snail, *Eobania vermiculata*

tested the *Barringtonia racemosa* seed extract against the *Pomacea canaliculata* eggs. The obtained results showed that the plant extract significantly decreased the hatchability of *P. canaliculata* to 0% with 100 ppm concentration. El-Bolkiny et al. (2000) tested the diethyldithiocarbamate as an ovicide against the *Biomphalaria alexandhna* snail eggs. The authors found that the hatchability was decreased significantly with low concentrations of diethyldithiocarbamate. Sukumaran et al. (2004) evaluated nicotinanilide against the eggs of the freshwater snail *Lymnaea luteola*. The obtained results found that nicotinanilide was very toxic against the eggs of *L. luteola*.

Conclusion

The chocolate banded snail, *Eobania vermiculata* is consider a destructive pest for many crops and vegetables in Egypt. The conventional pesticides have limited effects on this pest after using it year by year. So, it needs to use new and rational pesticides to increase the effectiveness and overcome to pesticides resistance. Indoxacarb (new pesticides that belong to the oxadiazine pesticides group) was the most effective compound against the adults of *E. vermiculata*. The recommended field concentration gave 100% mortality after 1 week of application. The main advantage of indoxacarb is the short pre-harvest interval (PHI) (1.4–2.1 days in summer and

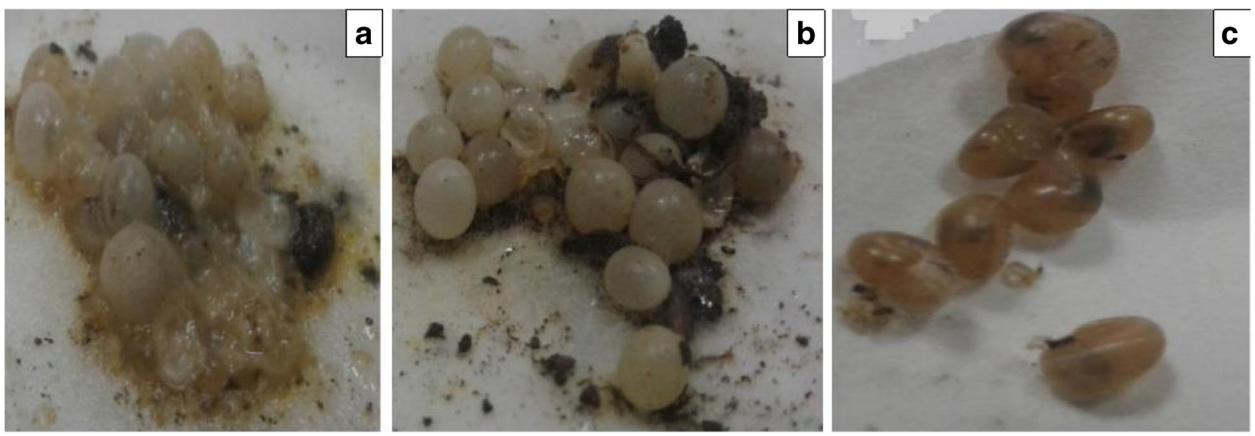

Fig. 3 Efficacy of imidacloprid (**a**) and fipronil (**b**) on hatchability of *E. vermiculata* compared with control (**c**)

2.8–4.8 days in winter (Shams EL Din et al. 2015). Imidacloprid also has short pre-harvest interval (3.8 day in summer (Sabry et al. 2016). So, it can be used safely against this pest in vegetable such as lettuce. Fipronil was very effective against the eggs. Abamectin and spiromesifen were moderately toxic against the adults of *E. vermiculata*. The moderately toxic compound can be used in integrated pest management program.

Abbreviations

LC50: Lethal concentration of 50% of total insect; LSD: Less significant difference; RC: Recommended field concentration

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

MAH reared the tested animal, collected the data, and participated in paper writing and data analysis. AHS carried out the toxicity assay, collected the data, participated in writing the paper, statistical analysis, and publishing the paper. Both authors read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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