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(Original Article)

Toxicity Assessment of Emamectin Benzoate Pesticide to The Bird Cherry-Oat Aphid, *Rhopalosiphum padi* (Linnaeus) (Hemiptera: Aphidiae) Under Laboratory Conditions

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Abstract

The bird cherry-oat aphid, *Rhopalosiphum padi* (Linnaeus), is considered one of the most dangerous and destructive pests of the cereal family. It directly affects nutrition and indirectly transmits viral diseases, leading to a reduction in quantity and quality. Therefore, the use of appropriate and effective control methods is vital. In this study, the effectiveness of emamectin benzoate on the nymph stage of *R. padi* on wheat was evaluated using the leaf-dip method. Mortality was recorded after exposure to different concentrations of the pesticide after 24, 48, and 72 hours under laboratory conditions. The results revealed the clear effectiveness of emamectin benzoate, especially after exposure at 48 and 72 hours, with LC_{50} values of 0.017 and 0.004 µg/ml, respectively. Additionally, the toxicity of emamectin benzoate increased from 10.59-fold after 48 hours to 45-fold after 72 hours based on the time dependent increase in toxicity. Therefore, emamectin benzoate is an effective pesticide for controlling *R. padi* on wheat and a promising tool in integrated pest management programs.

Keywords: *Emamectin benzoate, Integrated pest management, Rhopalosiphum padi**,** Toxicity index, Wheat*

Introduction

The bird cherry-oat aphid, *Rhopalosiphum padi* (Linnaeus), is a significant pest affecting cereal crops such as oats, barley, and wheat (Zhang *et al.,* 2019; Peng *et al.,* 2020). This aphid species not only causes direct damage by feeding plant sap but also serves as a vector for plant viruses, leading to substantial yield losses (Li *et al.,* 2018; Ahmed *et al.,* 2022). Effective management of *R. padi* is crucial for maintaining crop productivity (Ahmed *et al.,* 2022).

However, chemical control is considered an effective tool in controlling *R. padi* (Dorai *et al.,* 2024). In the interim, pesticides are used in large amounts in agriculture, thus it's important to assess any negative consequences on public and environmental health (Ahmed *et al.,* 2022). Insecticides are one type of pesticide that acts to kill or repel insects and are used for domestic, agricultural, and public health reasons (Ahmed *et al.,* 2022).

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Furthermore, emamectin benzoate is a semi-synthetic pesticide derived from *Streptomyces avermitilis* metabolism (Liu *et al.,* 2025). However, emamectin benzoate is a potent neurotoxic toxin belonging to the avermectin family, primarily developed to control lepidopteran insects (Chen *et al.,* 2025). By increasing the permeability of membrane chloride ions, emamectin benzoate interferes with the neurotransmitter gamma amino butyric acid (GABA), leading to permanent paralysis and loss of cell function in invertebrates (Kamel *et al.*, 2024; Lalmalsawmi *et al.,* 2024).

Therefore, in this study, we investigate the toxicological effects of emamectin benzoate on *R. padi* after 24, 48, and 72hours of exposure under laboratory conditions.

Materials and Methods

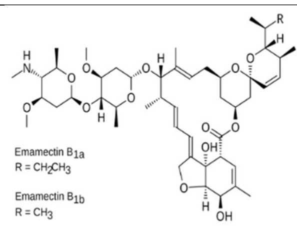
Insect

R. padi individuals used in this study were roughly of the same size for all toxicity tests. Samples of wheat plants infested with the aphid were collected by cutting plants and then transferred to the laboratory in plastic bags immediately before the assays, where the mean temperature reached about 26± 2°C. The field population of the aphid was collected from infested wheat field batches under Assiut conditions during the 2024/2025 season.

Pesticide

The selected pesticide that was used in this study was emacit 5% SG (Emamectin benzoate 5%). The pesticide obtained from Central Agricultural Pesticide Laboratory (CAPL) in Dokki, Giza, Egypt. (Table 1).

Table 1. The pesticide that is used in this study

Commercial name	Common name	Group	IUPAC name	Molecular formula	Chemical structure
Emacit 5% SG	Emamectin benzoate	Avermactin	4″-Deoxy-4″-epi-methylamino-avermectin B1; Epi-methylamino-4″-deoxy-avermectin	$C_{49}H_{75}NO_{13}$	

Acute toxicity test

With minor changes, we used the leaf-dip method to evaluate the acute toxicity assessment of a few pesticides against nymph stage of *R. padi* (Li *et al.,* 2018). The pesticide stock solutions of 9 concentrations (0.001, 0.01, 0.1, 1, 3, 7, 10, 100, and 1000 µg/ml) were prepared in distilled water. After cutting the leaves and dipping them in pesticide solutions for ten seconds, we placed them in a shaded area to dry air for five minutes. The leaves were then positioned in a Petri dish (9.0 cm in diameter) with their abaxial surface facing downward. Typically, three replicates of twenty nymph of *R. padi* were used in each treatment. As a control, we immersed leaves in distilled water.

Statistical analysis

Abbott's formula (Abbott, 1925) was used to compute the corrected mortality rates. Using IBM SPSS Statistics Desktop for Windows, version 25 (SPSS Inc., Chicago, IL), we combined the acute toxicity parameters (LC_{50}, LC_{90}, 95% confidence limit (CL) values, slope, and standard error values) for the analysis. The non-overlap between the 95% CLs of two LC_{50} and LC_{90} values, interpreted in µg/ml, was the basis for a significant level of mean separation ($P<0.05$). Thus, to determine the relative effectiveness of the pesticide investigated, LC_{50} and LC_{90} values were used to calculate the toxicity index and relative potency based on time-dependent changes (Sun, 1950).

Results and Discussions

Data presented in Table 2 and Fig.1 demonstrate the toxicity of emamectin benzoate to *R. padi* after 24, 48, and 72-h of exposure under laboratory conditions. The toxicity of emamectin benzoate was least potent after 24-h of exposure, with LC_{50} value of 0.18 µg/ml. However, after 48-h of treatment, the toxicity was 0.017 µg/ml. Furthermore, the highest toxic effect was observed after 72-h of exposure, with LC_{50} value of 0.004 µg/ml.

Furthermore, the toxicity of emamectin benzoate to *R. padi* increased after 48 and 72-h of exposure (Fig. 2). For instance, the toxicity of emamectin benzoate increased from 10.59-fold after 48-h to 45-fold after 72-h compared to the toxicity after 24-h.

Moreover, toxicity index values of emamectin benzoate were presented in Fig. 3. From these values, the treatment after 72-h was more time dependent in terms of toxicity. However, the toxicity index after treatments of 48 and 24-h was 23.53 and 2.22, respectively,

Table 2. Toxicity of emamectin benzoate to *R. padi* after 24, 48, and 72-h of exposure under laboratory conditions

Time of exposure	LC_{50} (µg/ml)	95% Confidence limits of LC_{50} *	LC_{90} (µg/ml)	95% Confidence limits of LC_{90}*	Slope ± SE
24-h	0.18	(0.062-0.44) a	717.84	(163.25-6616.65) a	0.36± 0.027
48-h	0.017	(0.002-0.065) a	54.45	(11.07-804.51) b	0.37± 0.029
72-h	0.004	(0.00024-0.023) b	7.35	(1.53-113.43) c	0.40± 0.033

*LC_{50} and LC_{90} values having different letters are significantly different (95% Confidence limits did not overlap).

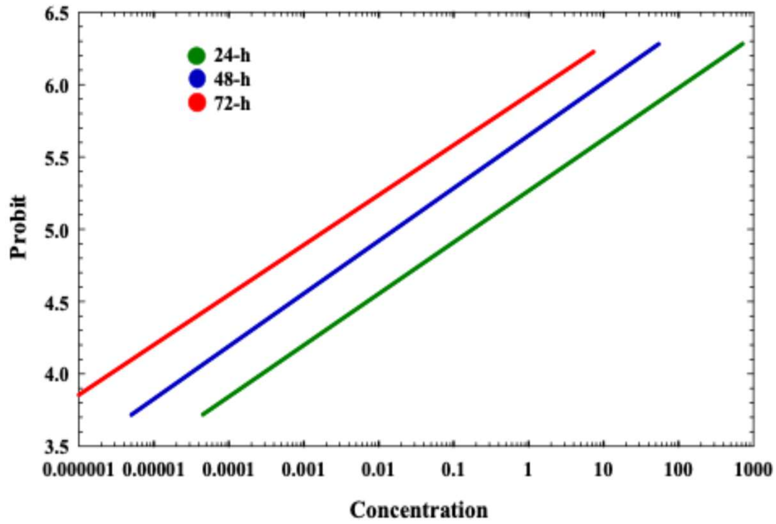


Fig. 1. LCP lines of the toxicity of emamectin benzoate to *R. padi* after 24, 48, and 72-h of exposure.

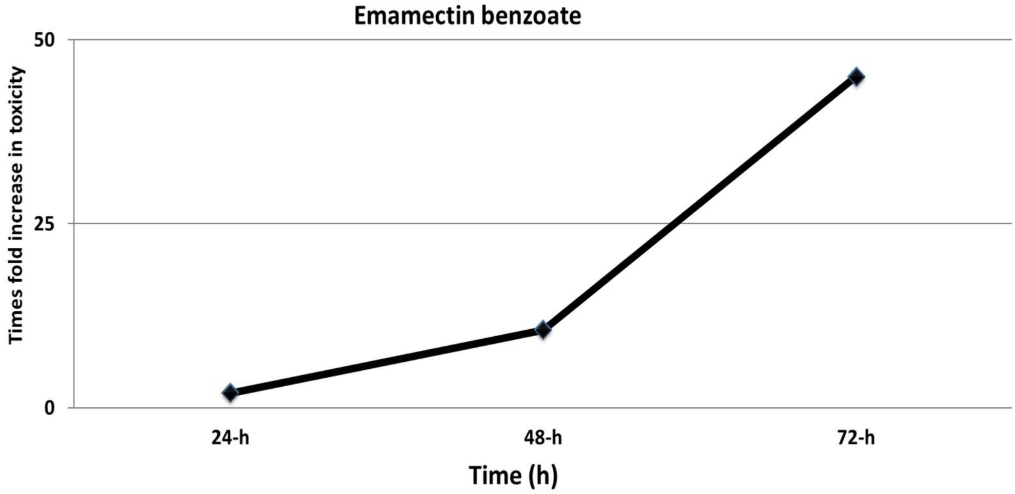


Fig. 2. Times fold increase in toxicity of emamectin benzoate to *R. padi* after 24, 48, and 72-h of exposure.

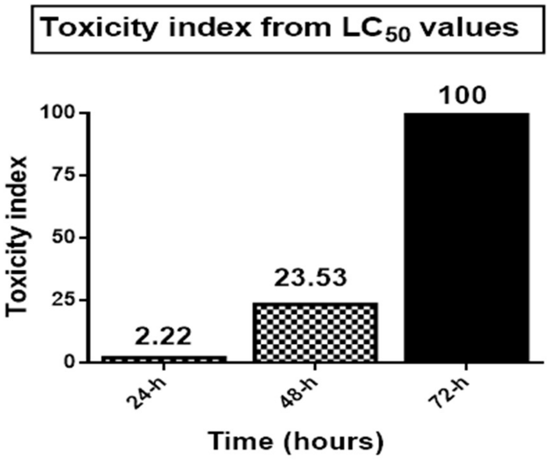


Fig. 3. Toxicity index of emamectin benzoate to R. padi after 24, 48, and 72-h of exposure. Toxicity index = [(LC_{50} of the most toxic time dependent / LC_{50} of each time dependent) ×100].

In general, emamectin benzoate displayed a potent effect on the nymph stage of *R. padi* after 24, 48, and 72-h of exposure under laboratory conditions. In harmony with our findings, Gong *et al.* (2021) showed that the susceptibilities of 29 strains of *R. padi* in China to macrolides (Avermectin) were assessed in this study between 2018 and 2019. *R. padi's* sensitivity to emamectin benzoate was demonstrated by LC_{50} values. According to monitoring data, populations either demonstrated little resistance to macrolides or were susceptible to them. Additionally, numerous studies have focused on the effectiveness of emamectin benzoate pesticide on different aphids species. For instance, Rajabi *et al.* (2023) stated that a combination product including emamectin benzoate (4.8%) and acetamiprid (6.4%) was evaluated against adult *Aphis gossypii*. The LC_{50} value was 2.67 µl/l. However, Dakhli *et al.* (2022) demonstrated that emamectin's effectiveness against adult *Brevicoryne brassicae* aphids was LC_{50}= 5.01 ppm in a leaf-dip test after 24-hour. On the other hand, in a thin film test, the LC_{50} value was 176.6 ppm. Furthermore, Cruces *et al.* (2021) claimed that emamectin was tested in the field against complexes of quinoa aphids, such as *Macrosiphum* spp. emamectin's long-term efficacy against aphids was hampered by its lack of systemic activity. Furthermore, El-Sherbeni *et al.* (2018) demonstrated the results of a study, conducted throughout the 2016 and 2017 seasons, where field and lab research were carried out at the Sakha Agriculture Research Station in Egypt. In cotton fields, the effectiveness of seven pesticides, including emamectin-benzoate, against *A. gossypii* was evaluated. The weak effects of emamectin benzoate against *A. gossypii* resulted in a mean reduction of 21.00% in 2016 and 16.35% in 2017.

Furthermore, Mukherjee *et al.* (2014) conducted a field experiment to determine the effectiveness of emamectin benzoate 5% SG as indofil at 5, 7.5, and 10 g a.i./ha and as proclaim at 7.5 g a.i./ha of Proclaim (commercial product) against cabbage aphid (*Brevicoryne brassicae L.*) during rabi 2010-2011 and 2011-2012. Aphid observations were made on days 1, 7, and 15 after three treatments, which were administered at 30, 45, and 60 days following transplantation (DAT). Both indofil and proclaim products with 7.5 g a.i./ha of emamectin benzoate 5% SG demonstrated a much lower aphid population. Moreover, Awatshi *et al.* (2013) observed that emamectin benzoate's toxicity value against cotton aphids, *A. gossypii*, based on the LC_{50} value was 1.57 ppm.

Conclusion

To sum up, the study's findings indicated that, under laboratory conditions, emamectin benzoate pesticide significantly affected the nymph stage of *R. padi*. Emamectin benzoate is distinguished by its broad spectrum of control over several pests, low toxicity, high efficacy, and relatively low environmental residues. However, further valuable experiments need to be conducted, including assessments on other stages of *R. padi*, evaluating its efficacy in field settings, testing on resistant strains, elucidating the reasons behind resistance, and investigating sophisticated application mechanisms for a sustainable future.

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تقييم سمية مبيد الإيمامكتين بنزوات على حشرة منّ الشوفان *Rhopalosiphum padi* (Linnaeus) تحت الظروف المعملية

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الملخص

يُعتبر منّ الشـــوفان *Rhopalosiphum padi* (Linnaeus) من أخطر الآفات وأكثرها ضـــررا لنباتات العائلة النجيلية، ســـواءً من حيث تأثيره المباشـــر على التغذية أو من خلال نقله غير المباشـــر للأمراض الفيروسية، مما يؤدي في النهاية إلى انخفاض في كمية المحصول وجودته. لذلك، يُعد استخدام أسـاليب مكافحة مناسـبة وفعالة متطلبًا حيويًا. في هذه الدراسـة، تم تقييم فعالية مبيد الايماميكتين بنزوات على طور الحورية لمن الشـوفان على القمح باسـتخدام طريقة غمس الأوراق، وسُجلت نسـب الموت بعد التعرض لتركيزات مختلفة من المبيد بعد 24 و48 و72 ســاعة تحت الظروف المعملية. أظهرت النتائج فعالية واضحة لمبيد الايماميكتين بنزوات، وخاصة بعد التعرض لفترات 48 و72 ساعة، حيث بلغت قيم التركيز السـام النصـفي 0.017 و0.004 ميكروجرام/مل، على التوالي. بالإضـافة إلى ذلك، زادت سـمية مبيد الايماميكتين بنزوات من 10.59 ضعفا بعد 48 ساعة إلى 45 ضـعفا بعد 72 ساعة، بناءً على زيادة السـمية بمرور الوقت. لذلك، يُعد إيماميكتين بنزوات مبيدًا فعالًا لمكافحة حشـرة من الشـوفان على القمح، وأداة واعدة في برامج المكافحة المتكاملة للآفات.

الكلمات المفتاحية: *الإدارة المتكاملة للآفات، القمح، حشـــرة من الشـــوفان، مبيد الايماميكتين بنزوات، معدل السمية.*