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Codling moth (*Cydia Pomonella*) control using sex pheromones and environmentally friendly insecticides

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Abstract. The research relevance on *Codling moth* peculiarities is predefined by it being a main threat to apple culture. The sensitivity of apple cultivars that have been planted so far and continue to be planted to this pest diverges in different cultivars. The research aims to determine the main elements of *Cydia Pomonella* control using sex pheromones and environmentally friendly insecticides. To achieve the goal, an experiment was conducted in the village of Dvoran in the Korcha region on three apple cultivars: Golden Delicious, Star King, and Granny Smith. On the trees of these varieties, traps with sex pheromones were used and environmentally friendly insecticides were utilised. The study found that using sex pheromone traps to monitor *Cydia Pomonella* is simple and less expensive for apple growers. The Spinosad medicine is the most effective



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in terms of protection against the pest, the second being Indoxacarb. Golden Delicious and Granny Smith cultivars had the lowest level of pest infestation, while the Star King cultivar was the most affected by *Cydia Pomonella*. It has also been established that apple fruits do not contain toxic residues, and the ecosystem remains clean. Additionally, the use of sex pheromones can be part of an integrated pest management approach that combines different control methods to sustainably manage pest populations in gardens. The practical significance of the obtained results is that they provide apple growers with a safe and effective method of controlling *Cydia pomonella* populations in their orchards. In addition, the scientific basis for the use of sex pheromones as a method of pest control can contribute to the implementation of sustainable control methods in apple production

Keywords: codling moth; chemical preparations; bioinsecticides; pheromone; environment

INTRODUCTION

The Codling moth (*Cydia pomonella*) is a pest that causes significant damage to fruit crops. It can destroy fruits, affect their size, deteriorate crop quality, and cause various diseases (Kadoić *et al.*, 2020). Therefore, studying and developing methods of protection against *Cydia pomonella* defines the research relevance.

Codling moth in times was and remains the most troublesome pest that damages apple production worldwide (Pajač *et al.*, 2011). Scientific sources claim that it originates from the Palearctic regions but has spread along with the cultivation of apples in warm regions, namely New Zealand, Europe, China, Australia, and America (Bradley *et al.*, 1979). Albania has very favourable conditions for the development of its entire life cycle, giving two to three generations per season. Affected fruits can be distinguished from healthy ones, as they are smaller and more intensely coloured. These fruits usually fall on the ground prematurely.

One of the most effective methods for controlling *Cydia pomonella* is the use of sex pheromones. These are special substances that are produced by female *Cydia pomonella* individuals and attract males. Sex pheromones can be used to set traps, which allows for the capture of males and reduces their population (Nottingham *et al.*, 2022).

Following A.L. Knight *et al.* (2019), the use of sex pheromones can be an effective means of controlling *Cydia pomonella* populations. This is a safe and environmentally friendly method that can be used as a standalone control method or in combination with other methods, such as biological control. It is worth noting that pheromone control is safe for the environment and does not harm beneficial insects. In addition, this method is effective in the cultivation of organic crops, as it does not involve the use of chemical pesticides (DuPont & Strohm, 2019).

R.T. Carde *et al.* (2018) and Brunner *et al.* (2018) showed that the use of a combination of sex pheromones and natural insecticides reduced the *Cydia pomonella* population by 75% compared to the control group, which used only chemical insecticides. In addition, this application reduced insecticide use by 90%, which helped reduce the negative impact on the environment and human health.

M. Murray highlighted that a combination of mating disruption and the use of environmentally friendly insecticides can be an effective strategy for managing *Cydia pomonella* populations. Thus, the use of such methods resulted in a significantly lower level of pest damage for apple orchards in the state of Washington (USA) compared to the use of conventional insecticides (Murray *et al.*, 2022). In France, a study was conducted in which the use of sex pheromones reduced the number of summer caterpillars (second-generation *Cydia pomonella*) by 92% compared to the area without the use of pheromones (Paul *et al.*, 2020).

Similar data were obtained in a study on the use of environmentally friendly insecticides and in the studies by V.S.V Santos. Both insecticides were found to effectively reduce *Cydia pomonella* populations without harming beneficial insects or the environment using *Bacillus thuringiensis* and Spinosad (Santos *et al.*, 2020). In the case of sex-based destruction, L. Xing *et al.* (2021) also note positive results. Thus, the authors found that the use of synthetic sex pheromones reduced the number of laid eggs of *Cydia pomonella* by 95%, which led to a decrease in the total population of the pest from 62% to 96%.

A similar study on apple trees was conducted by B.M. Kadoić *et al.* (2020) according to which the use of pheromone traps helped reduce the *Cydia pomonella* population by 60-80% compared to the control group, which did not use pheromone traps. Jaffe & Landolt (2019) and M. Preti *et al.* (2021) in their research using the bacterial insecticide *Bacillus thuringiensis*, noted that the drug is effective in controlling *Cydia pomonella* and can reduce the pest population by 55-65%. However, the conditions and methods of application should be considered. Given the harmfulness of the Codling moth (*Cydia pomonella*) and the damage it can cause to farming, studying the possibilities of regulating its population, especially by ecological means, is particularly relevant today.

The research aims to determine the main elements of the control of the codling moth (*Cydia Pomonella*) with the help of sex pheromones and the use of environmentally friendly insecticides.

MATERIALS AND METHODS

Research structure. The experiment was conducted in the village of Dvoran, Korça region, using the three main apple cultivars: Golden Delicious, Star King and Granny Smith, for three years of study: 2019, 2020 and 2021. The age of the trees in production was 14 years. The total number of trees was 60 (including 15 trees on which environmentally friendly insecticides were applied and 5 trees of each cultivar as control variants on which no insecticides were applied).

Factor A with three levels: a1, a2, and a3 represented by the three cultivars Golden Delicious, Star King and Granny Smith. The three blocks represented the three replications. Ten apple trees of each variant were used to represent a single cultivar. Trees of each variant were labelled. Factor B with three levels: b1, b2 and b3 represents three types of drugs: 1. (Madex) a.i. Granulosevirus CpGv, 2. (Avaunt), a.i. Indoxacarb and 3. Spinosad. Spraying was carried out with a backpack pump.

The first-generation treatment was carried out at the end of May, while the second-generation, was conducted in the third week of July. The treatments were carried out 4-6 days after the maximum capture of the moth in the sexual pheromones. The plot which served as a control block was left untreated with preparations. The main pheromones that are widely used are of three main types: sexual attraction pheromones, alarm behaviour pheromones, and recruitment pheromones (Regnier and Law, 1968).

The description of the FAD gene, which acts in the biosynthesis of codlemone, was carried out, and 27 FAD genes correspond to different functional classes that were identified in insects and Lepidoptera (Lassance, 2021). Sexual pheromones are emitted by the female pest to attract the male pest. "Delta Traps" produced by the Andermatt Biocontrol company were used for the experiment.

The placement and monitoring of sexual pheromone traps for the first generation were conducted in the middle of May, where two traps with the Phero Norm® pheromone were placed in a total of nine traps in the three years of the study, in the three apple cultivars taken for analysis: Star King, Golden Delicious and Grand Smith. The traps were placed inside the crown of apples at a height of 160-170 cm from the ground. Their control was carried out every day, at 10.00. The placement and monitoring of traps with sexual pheromones for the second generation was carried out after July 10th and for their monitoring, the same procedure was followed as for the first generation. The pheromone capsule was changed once for each generation, a total of 6 pheromone capsules were used for each study year.

Average temperatures and air humidity were recorded for a period of 4 months, a period which coincides with the development of the life cycle for the generations of codling moths: May, June, July, and August, for the three years: 2019, 2020, and 2021.

Research limitations. The drugs used are included in the integrated pest and disease plant protection recommendations (Biological Control Program, 2022).

Madex is used in many developed countries as a biocontrol agent for controlling codling moths as a very serious pest, especially in apple production in both organic and integrated programmes. This Bioinsecticide is environment friendly. The challenge to the successful application of this drug against the codling moth is the development of resistance against some commercial products of CpGV (Wennmann *et al.*, 2021). Granuloviruses are enclosed within a protein capsule, which protects the virus from UV radiation. The size of a viral particle is about 400 nm. Within 2-4 days, the virus infects the pest's organs, the larvae stop feeding and die. 100 ml/ha is used.

Avaunt (a.i. Indoxacarb) is a dual-action drug, administered through contact and food. It was used with 0.035%, dissolved in 600 litres of water. The drug is effective during contact with the pest and when swallowed. It has a neurotoxic action by blocking sodium channels. The active substance causes the bioactivation of metabolites and gives neurotoxic effects. After the bioactivation of the active substance, the pest stops eating and then dies.

Avaunt is widely used in Integrated Pest Management programmes that include biological, agrotechnical, cultural and genetic practices which aim to prevent and reduce the economic damage that the pest may cause. Integrated Pest Management programmes include a series of practices such as finding pests in the field, identifying and monitoring pest populations, rotating insecticides and applying them when the critical action threshold determined at the local level is reached.

To avoid the development of resistance by codling moths, it is recommended to apply AVAUNT insecticide only once per generation of the codling moth. It is recommended that for the control of other generations of the pest, effective drugs with different active ingredients than the AVAUNT preparation should be used.

A natural bioactive product with very high values, this product is characterised by a complex chemical structure in its construction, which includes spinosins A and D, as well as molecules synthesised by the actinomycete *Saccharopolyspora spinosa*. The larval control activity of spinosad is a solution developed to control pests of several agricultural plants including the key apple pest codling moth as well as the control of species that transmit various diseases, including *Aedes aegypti* (Santos & Pereira, 2020). This drug is also widely used in agriculture to control a variety of pests, including codling moths. This Bioinsecticide is very friendly to the environment.

Spinosad is an insecticide with contact and eating action, causing insect paralysis. It belongs to the group of bioinsecticides. Spinosad is a natural substance

produced by soil bacteria, but it also has a toxic effect on insects. It consists of a mixture of two chemical substances called spinosyn A and spinosyn D. It has been used by dosing 25 grammes per 100 litres of water.

Statistical analysis. At the beginning of July, for the first generation and at the end of August for the second generation, 10 fruits per 10 labelled apple trees for each cultivar were analysed, for a total of 100 fruits. The percentage of infection indicates the number of affected fruits in 100 analysed fruits. The percentage of infection was calculated using the formula (1):

$$P = \frac{n \times 100}{N} \quad (1)$$

where P – infection percentage; n – is the number of fruits affected by the codling moth; N = the total number of fruits analysed for each variant.

The effectiveness of the tested preparations in reducing the number of pests was calculated using the equation (2):

$$E = \frac{(A-B) \times 100}{A} \quad (2)$$

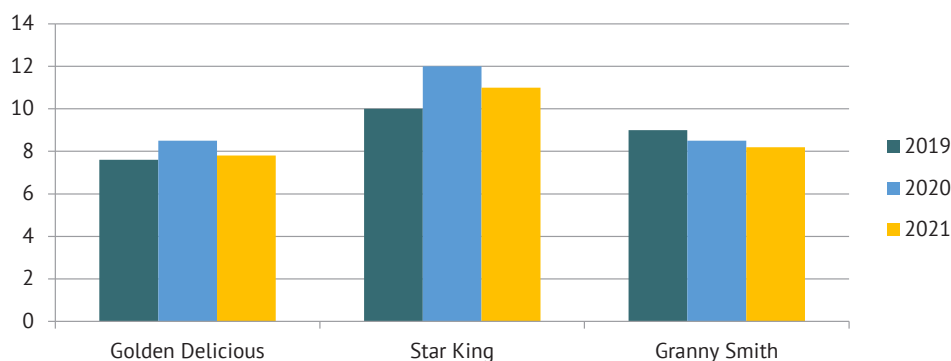


Figure 1. Percentage of *Cydia pomonella* infection of apple cultivars (2020-2021)

The emergence of *Cydia pomonella* larvae in apple varieties is associated with the choice of the female pest for egg-laying. Therefore, the characteristics of the host plant are important. Since the Star King apple variety has a high number of fruits, *Cydia pomonella* females prefer it for egg-laying. In addition, according to research, α -farnesene in fruit also affects the olfactory system of females and provokes egg-laying (Apple varieties, 2023).

where E_{∂} – reduction of pest density after treatment, %
 A – density of insects before treatment, units/m²; B – density of insects after treatment, units/m²

The statistical processing of the data is based on the analysis of variance ANOVA. Regression analysis predicts the outcome depending on the indicators: Cultivars (Golden Delicious, Star King and Granny Smith), the three years of the experiment 2019, 2020 and 2021 and the preparations tested Granulovirus CpGv, Indoxacarb and Spinosad.

RESULTS

During the research, 60 trees were examined, 20 trees for each cultivar. *Cydia pomonella* larvae were found in the fruits. In addition, the study established different densities of apple tree cultivars by *Cydia pomonella* larvae (Fig. 1). Thus, the lowest percentage of infection with larvae was observed in the Golden Delicious and Granny Smith cultivars and averaged 7.8% and 8.5%, respectively, over the years of research.

The study also suggests that *Cydia pomonella* larvae may prefer the Star King variety because its fruits have a lower concentration of polyphenols compared to other varieties. Moreover, the choice of larvae could be influenced by apple fruit phytoncides and primary metabolites amino acids, sugars, etc. The data recorded from sexual pheromone traps and treatments with preparations were shown in separate tables (Table 1).

Table 1. Pheromone trap data for 2019, 2020 and 2021

Year	Development Stages	Cultivars					
		Star King		Golden Delicious		Granny Smith	
		First Generation	Second Generation	First Generation	Second Generation	First Generation	Second Generation
2019	Beginning of flights	21 May	14 July	20 May	15 July	21 May	15 July
	Max. flights	27 "	19 "	25 "	20 "	26 "	20 "
	Spraying	30 "	25 "	30 "	25 "	30 "	25 "
2020	Beginning of flights	18 "	14 "	19 "	16 "	22 "	14 "
	Max. flights	25 "	21 "	26 "	21 "	26 "	19 "
	Spraying	30 "	25 "	30 "	25 "	30 "	25 "

Table 1, Continued

Year	Development Stages	Cultivars					
		Star King		Golden Delicious		Granny Smith	
		First Generation	Second Generation	First Generation	Second Generation	First Generation	Second Generation
2021	Beginning of flights	19 "	15 "	19 "	16 "	20 "	15 "
	Max. flights	24 "	19 "	25 "	20 "	25 "	19 "
	Spraying	29 "	24 "	29 "	24 "	29 "	24 "

Source: compiled by the authors

The results show that the first flights, for both generations in the three apple cultivars, were caught almost at the same time. This coincides with May 20, for the first generation and the middle of August month for the second generation, for all three years studied. The maximum catch of male butterflies coincides with May 24 for the first generation and after August 20 for the second generation. Chemical treatments were carried out at the end of May for the first generation and after August 24 for the second generation. The sprayings gave results as they were carried out qualitatively better, with

a centrifugal pump, using 1500 litres of solution per ha and the sprayer type 0.8 mm. Taking advantage of days with average daily temperatures of 16°C -19°C, no wind and no rain, the sprays gave maximum effect (Table 2).

Notably, the temperature is important for the development of *Cydia pomonella*. For example, the warmest year with the lowest humidity for the Korcha region over all the years of research was 2021, so the pest infestation was higher. In addition, the lowest temperatures and highest humidity were recorded in 2019, when the infestation was low.

Table 2. Damage analyse data on the three cultivars studied for the three study years 2019, 2020 and 2021

Year	Generation	Drug	Factor	Golden Delicious a1					Star King a2					Granny Smith a3				
				P1	P2	P3	Σ	Avar	P1	P2	P3	Σ	Avar	P1	P2	P3	Σ	Avar
2019	1	Granulosevirus	b1	1	0	1	2	1.3	2	1	3	6	2	1	1	1	3	1
		Indoxacarb	b2	0	0	0	0	0	0	1	1	2	0.6	0	1	0	1	0.3
		Spinosad	b3	0	0	0	0	0	0	3	0	3	1	0	1	0	1	0.3
		Control		7	8	7	22	7.3	6	9	8	23	7.6	4	6	6	16	5.3
	2	Granulosevirus	b1	2	3	1	6	2	0	4	3	7	2.3	2	2	3	7	2.3
		Indoxacarb	b2	0	0	0	0	0	1	1	1	3	1	0	0	0	0	0
		Spinosad	b3	0	1	0	1	0.3	1	1	0	2	0.6	0	0	0	0	0
		Control		8	11	6	25	8.3	10	9	8	27	9	7	6	6	19	16.3
2020	1	Granulosevirus	b1	1	1	3	5	1.6	2	2	2	6	2	1	1	1	3	1
		Indoxacarb	b2	0	0	0	0	0	2	1	3	6	2	0	0	0	0	0
		Spinosad	b3	1	0	0	1	0.3	1	1	2	4	1.3	0	0	1	1	0.3
		Control		3	7	11	21	7	7	10	8	25	8.3	10	8	12	30	10
	2	Granulosevirus	b1	2	2	0	4	1.3	0	2	2	4	1.3	1	2	1	4	1.3
		Indoxacarb	b2	0	0	0	0	0	3	2	3	8	2.6	0	0	0	0	0
		Spinosad	b3	0	1	0	1	0.3	1	1	1	3	1	0	0	0	0	0
		Control		9	5	7	21	7	6	8	7	21	7	5	10	7	22	7.3
2021	1	Granuloseviru	b1	1	2	1	4	1.3	3	3	3	9	3	1	3	1	5	1.6
		Indoxacarb	b2	0	1	0	1	0.3	2	2	0	4	1.3	1	2	0	3	1
		Spinosad	b3	0	1	0	1	0.3	2	3	1	6	2	1	1	1	3	1
		Control		7	11	8	26	8.6	16	13	10	39	13	10	6	11	27	9
	2	Granulosevirus	b1	1	3	2	6	2	2	2	2	6	2	6	2	1	9	3
		Indoxacarb	b2	0	1	1	2	0.6	3	1	4	8	2.6	0	1	2	3	1
		Spinosad	b3	1	0	0	1	0.3	1	1	1	3	1	1	0	0	1	0.3
		Control		5	4	9	18	6	12	11	10	33	11	11	11	13	35	11.6

Source: compiled by the authors

Even though the lowest percentage of apple codling moth larvae infestation was found in Golden Delicious and Granny Smith, the experimental trees of all varieties were exposed to the pest. That is why biological insecticides were applied to all apple trees in the

experiment, except for the control. Insecticide spraying was repeated three times, and no massive moth flight was observed at this time. Spraying had an impact on the number of pests, which determined the effectiveness of insecticide application (Table 3).

Table 3. The efficiency of application of environmentally friendly insecticides, %

Year	Drug	Golden Delicious	Star King	Granny Smith
2019	Granulosevirus	97.3	94.5	94.1
	Indoxacarb	97.7	96.4	97.6
	Spinosad	99.2	98.5	99.4
2020	Granulosevirus	96.1	95.4	93.3
	Indoxacarb	97.4	96.8	96.9
	Spinosad	99.1	98.1	99.4
2021	Granulosevirus	95.4	95.6	95.0
	Indoxacarb	98.4	98.2	97.2
	Spinosad	99.8	99.4	99.8

Source: compiled by the authors

Thus, the highest level of pest protection efficiency was demonstrated by Spinosad, which on average over the years of research showed 99.3% efficiency for Golden Delicious, 98.6% for Star King, and 99.5% for Granny Smith. The second most effective product was Indoxacarb. Thus, the combination of pheromones and environmentally friendly insecticides is an effective method of controlling *Cydia pomonella* in the apple tree protection system.

DISCUSSION

A study by F. Wan *et al.* (2019) evaluated the effectiveness of mating disruption based on pheromones in commercial apple orchards. The authors found that the use of pheromone dispensers reduced the number of *Cydia pomonella* caught in traps and the number of larvae found in fruits, resulting in improved fruit quality and increased yield.

L. Xing *et al.* (2021), who investigated the behavioural response of male codling moths to different pheromone blends, showed that males can distinguish different pheromone blends and that the ratio of pheromone components affects their response. Researchers also found that the effect of pheromone blends significantly reduces the success of mating and the number of eggs laid by females.

A. Gümüşsoy *et al.* (2020) conducted a study in which they studied the effect of pheromone dose on the behaviour of male Codling moth (*Cydia pomonella*). The authors found that higher doses of the pheromone mixture led to the stronger attraction of *Cydia pomonella* males, but also to faster habituation and reduced population over time. It is important to note that integrated pest management is an approach that combines several

methods of pest control, including the use of sex pheromones and environmentally friendly insecticides, and it also involves monitoring and maintaining the garden's ecosystem. This approach can reduce reliance on synthetic insecticides and promote sustainable pest management practices.

Research by I. Pajač *et al.* (2011), V.S.V. Santos and Pereira (2020) focused on combining pheromone-based management strategies with environmentally friendly insecticides to develop integrated Codling moth (*Cydia pomonella*) control programmes. The authors note the reduction of pest populations while minimising the use of chemical pesticides, which leads to improved pest control and reduced environmental impact, which is also reflected in the research conducted (Santos & Pereira, 2020).

According to the results of M.K. Balasko *et al.* (2020), sex pheromones can be used to disrupt the mating behaviour of *Cydia pomonella* by confusing males and preventing them from finding females to mate with. This approach is effective because it does not kill the pests, but instead prevents them from reproducing, reducing the number of offspring produced. S. Yadav *et al.* (2019) note that environmentally friendly insecticides such as spinosad and *Bacillus thuringiensis* can also be used to control *Cydia pomonella* populations. These insecticides are derived from natural substances and do not harm people or the environment. They work by targeting specific insect pests while leaving beneficial insects unharmed, as confirmed by a study also performed.

Similar results were obtained by C.G. Adams *et al.* (2017) according to which spinosad acts by affecting the nervous system of pests, causing paralysis and, ultimately, death. Spinosad is effective against various

insect pests, including *Cydia pomonella*, and is relatively safe for non-target organisms and the environment. The results of the performed research are also echoed in the scientific works of P.M. Lösel *et al.* (2000) argue that the use of sex pheromones and environmentally friendly insecticides provides an effective, sustainable, and environmentally friendly approach to managing *Cydia pomonella* populations in fruit crops.

However, R.T. Carde *et al.* (2018) note that although environmentally friendly insecticides are effective in controlling *Cydia pomonella* populations, they should be used in conjunction with other pest management strategies, such as cultural practices and biological control, to ensure the most effective and sustainable pest control.

CONCLUSIONS

Studies on the regulation of *Cydia pomonella* by sex pheromones have shown that this method can be effective in reducing the damage caused by this pest.

The method of using sexual pheromone traps to control the codling moth is simpler and less expensive to use by apple growers. The start of the first flights for the first generation of the pest coincides with the dates after May 15 for the first generation and after July 15 for the second generation. Maximum flights occur on the third day of May for the first generation and the beginning of July (the first week) for the second generation. Interventions with preparations against codling moths are carried out at the end of May for the first generation and after July 20 for the second generation.

The higher level of effectiveness for protection from the pest results from the preparation Spinosad, statistically proven at the level of 99%, and the second preparation is Indoxacarb. The lowest rate of infection by the pest results in the cultivar Golden Delicious and Granny Smith, while the cultivar Starking is considered

the most favoured by codling moth infection. The warmest year and the lowest humidity for the Korce region for all three years of study were in 2021, therefore the codling moth infection was higher. While the lowest temperatures and the highest humidity were in 2019, where the infection was also at a low level. The percentage of infection is slightly higher during the second generation. Apple fruits don't have toxic residues and the ecosystem remains clean.

In addition, the use of sex pheromones can be used as part of an integrated pest management approach that combines different control methods to sustainably manage pest populations. Combining the use of sex pheromones with other control measures, such as cultural practices, biological control, and insecticides, enables effective control of *Cydia pomonella* populations while minimising negative environmental impacts.

The practical significance of the research results is that they provide apple growers with a safe and effective way to control *Cydia pomonella* populations in their orchards. By providing a scientific basis for the use of sex pheromones as a method of pest control, this study may contribute to the introduction of sustainable control methods in apple production.

Further research should determine the optimal timing and placement of pheromone dispensers in orchards to maximise disruption of mating behaviour and minimise the risk of resistance developing in *Cydia pomonella* populations. This can help increase the effectiveness of the pest control method and reduce the cost of pheromone application.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Боротьба з яблуною плодожеркою (*Cydia Pomonella*) за допомогою статевих феромонів та використання екологічно чистих інсектицидів

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Анотація. Плодожерка є ключовим шкідником у культурі яблуні, тому актуальним є дослідження її особливостей. Чутливість сортів яблуні, які висаджувалися і продовжують висаджуватися до цього шкідника, відрізняється у різних сортів. Метою дослідження було визначення основних елементів контролю *Cydia Pomonella* за допомогою статевих феромонів та застосування екологічно безпечних інсектицидів. Для досягнення мети було проведено експеримент у с. Дворан Корчинського району на трьох сортах яблуні: Голден Делішес, Стар Кінг та Гренні Сміт. На деревах цих сортів використовували пастки із статевими феромонами та проводили обприскування екологічно чистими інсектицидами. Дослідження показало, що використання пасток із статевими феромонами для моніторингу *Cydia Pomonella* є простим і менш витратним для виробників яблук. Препарат Спіносад має найвищий рівень ефективності захисту від шкідника, а другий препарат – Індоксакарб. Сорти Голден Делішес і Гренні Сміт мали найнижчий рівень зараження шкідником, тоді як сорт Стар Кінг був найбільш уражений *Cydia Pomonella*. Також було встановлено, що плоди яблук не містять токсичних залишків, а екосистема залишається чистою. Крім того, використання статевих феромонів може бути частиною інтегрованого підходу до управління шкідниками, який поєднує різні методи контролю для сталого управління популяціями шкідників у садах. Практичне значення отриманих результатів полягає в тому, що вони надають виробникам яблук безпечний та ефективний метод контролю популяцій *Cydia pomonella* в їхніх садах. Крім того, наукове обґрунтування використання статевих феромонів як методу боротьби зі шкідником може сприяти впровадженню сталих методів контролю у виробництві яблук

Ключові слова: яблуна плодожерка; хімічні препарати; біоінсектициди; феромон; навколишнє середовище