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THE EFFECTIVENESS OF SOME BIOLOGICAL PRODUCTS USED TO CONTROL *CYDIA POMONELLA* L. POPULATIONS AND THEIR POTENTIAL FOR INTEGRATED PEST MANAGEMENT IN APPLE ORCHARDS

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Abstract

The codling moth Cydia pomonella L. is a major pest of apple and other Rosaceae worldwide. Because in practice chemical control is intensively used to limit the damage of the codling moth, there is an urgent need for the development of sustainable control practices, involving non-chemical means. The aim of the study was to evaluate the efficacy of Bactospeine Df (T2), Laser 240 SC (T3) and Madex Top (T4) applied for C. pomonella control compared with chemical reference Coragen (T5) and untreated check (T1). The research was performed in the period 2023-2024, in an intensive apple orchard at R.S.F.G. Voinesti, with disease-resistant varieties Florina. In 2023 and 2024, the treatments efficacy at harvest ranged from 91.5% in treatment 4 to 95% in treatment 2 and 5 while the apple attack in untreated check was 24.25% and 33%. As a main conclusion, all the biological control products tested during the study have good potential for C. pomonella control and further inclusion in the integrated pest management in apple orchards from Dâmbovița fruit growing basin.

Key words*: Cydia pomonella, codling moth, biological control, apple orchards, integrated pest management.*

INTRODUCTION

A wide range of fruits, berries, and nuts are produced in Europe, where apple orchards represent the second most common single species and cover 0.5 million hectares.

From the estimated 35.4 million tons of fruits that were harvested in 2023, 12.0 million tons were apples. In 2023, in term of the surface of apple tree orchards, Romania, with 542900 hectares, comes on the 2nd position in the EU-28, after Poland, but was ranked only on 5th position on harvested production (EUROSTAT, 2024).

In recent years, the production of apple is often declined due to abiotic stresses associated with climate change, directly or indirectly, through the changes in the distributions and impacts of plant pests. Among the pest, over 50 species of Lepidoptera are known to attack the apple orchards (Rădulea et al., 2022). Those pest species that directly attack fruits are the biggest concern in apple production.

The codling moth, *Cydia pomonella*, is the most harmful insect species of the Tortricidae family that causes economic damage to apple production worldwide (Balasko et al., 2020). *C. pomonella* is a polyphagous species, and a major pest of apple and other pome fruits, and is found in almost all areas worldwide where apple trees are grown (Maggy & Chreil, 2023). The larvae bore into the fruit where they create tunnels, filled with frass, causing the fruit to rot or fall prematurely. The attacked fruits no longer develop normally, lose their commercial value and cannot be stored. If not properly managed, the fruits damage reaches up to 70% or more in unkempt orchards (Bolbose, 2022). Besides economic losses coming from direct yield reduction and post-harvest quality issues, producers are forced to invest more in crop protection. Codling moth control is the reason

for approximately 90% of insecticides' use in apple orchards in Provence, one of the main regions of apple production in France (Bosshardt et al., 2024).

In Romania, over an entire growing season, out of the 10-15 treatments applied in apple orchards, 6 to 8 are used for the codling moth control (Cârdei et al., 2007). The intense application of chemical insecticides is the usual option in great majority of apple orchards, where some populations of codling moth have developed resistance.

The alarming increase of the intensity of the codling moth attack in most plantations from Dâmbovița Fruit Growing Basin, has required reconsidering the annual phytosanitary treatment program and approaching an appropriate strategy that would reduce the number of pests in order to limit damage but also minimize the chemical impact on the environment and human health. The use of biological control agents (entomopathogens, predators and parasitoids) play key roles in IPM strategies (Lacey & Unruh, 2005), are intensively studied and several biological insecticides are available for codling moth control (Bolbose, 2022).

In this context, the aim of the study was to evaluate the efficacy of three biological control products as option for *C. pomonella* control and further inclusion in the integrated pest management program in apple orchards from Dâmbovița Fruit Growing Basin.

MATERIALS AND METHODS

Study was conducted over two years, 2023-2024, at farm no 1 of the Research Station for Fruit Growing Voinești (RSFG Voinești), in an intensive apple orchard, with disease-resistant variety Florina (45.086204, 25.235506), with the trees grafted onto the MM106 rootstock, loose palmette crown shape, and planting distances 4 x 2 m.

A randomized complete block design with four blocks and four replicate plot per treatment was used both years. Plot size was of 5 trees.

Four commercially available insecticides, three biologically and a chemical check, were used both years. The details about treatments are presented in Table 1.

All the other plant protection products (fungicides and herbicides) used, were applied uniformly to all plots, and comply with good standard practice.

Table 1. Treatment details

Treatment number/code	Specification	Active ingredient	Dose
T1	Untreated check	-	-
T2	Bactospeine DF	*Bacillus thuringiensis* subsp. *kurstaki* strain ABTS-351	1 kg/ha
T3	Laser 240 SC	Spinosad	0.6 l/ha
T4	Madex Top	*Cydia pomonella* granulovirus (CpGV)	0.1 l/ha
T5	Coragen	Rynaxypyr®	0.15 l/ha

The calendar of application, presented in Table 2, was decided based on the flight periods of the codling moth adults, monitored with traps baited with AtraPOM pheromone lure (Figure 1), produced by "Raluca Ripan" Chemistry Institute in Cluj, Romania.

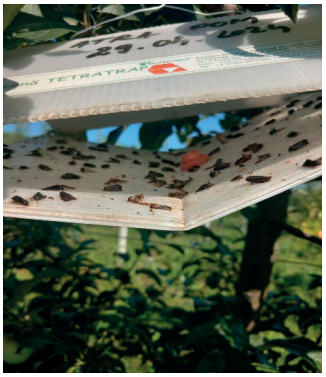

Figure 1. Pheromone trap used to monitor *Cydia pomonella* adult flight

There are usually two generations of codling moths per year. The first application to each generation was made at warning, respectively when 5 *Cydia pomonella* adults were recorded per week. Thereafter, according to label specifications of every plant protection product, there were made 0 to 2 applications, per each generation at an interval of 7-8 days.

Table 2. Callendar of applications in 2023 and 2024

	1st generation			2nd generation			
Year	Warning	A1	A2	Warning	A1	A2	A3
2023	16.05.	17.5	23.5	18.7	19.7	28.7	-
2024	13.05	14.5	22.5	14.07	15.7	23.7	2.8

Note A1- Application 1

Assessment of attacked fruits were made at three moments each year: (i) before treatment application, (ii) at the end of the first codling moth generation (28th June 2023 and 30th June 2024) and at harvest (17th September 2023 and 27th September 2024). At each assessment, three hundred fruits per plot, present on trees or on the ground, were visually examined, the number of fruits attacked by *C. pomonella* larvae were counted. Statistical data processing was carried out by Student (t) test for the confidence interval of 95% and Abott formula for treatment efficacy.

RESULTS AND DISCUSSIONS

The experimental conditions were favourable to pest dynamic, the first generation of codling moth was recorded from the first decade of May (10.05.2023 and 7.05.2024) and lasted until mid-June (18.06.2023, 12.06.2024). The first catches of second generation were recorded at 11.07.2023 and 7.07.2024 and lasted till 21.08.2023 and 3.09.2024.

The fruit damage gradually increased in untreated control plots from 0% at the beginning of observations to 24.25 % at harvest in 2023 respectively 33% in 2024.

The results obtained from testing the biological products, compared to the standard chemical product and the untreated reference are presented in the Tables 3 and 4.

In 2023, at the end of the first generation of the pest, the average frequency of attack was between 5.5% in case of treatment 5 (chemical reference Coragen), followed by treatment 2 (Bactospeine DF) with 6%, both were found statistically at pair and significant superior comparing to T3 (Laser 240 SC, 8.5%) and T4 (Madex Top, 9.5%) and very significant superior to the T1 untreated plots where the average frequency was of 16.5%. The situation was similar at harvest, the minimum average frequency of attack was similar in case of T5 and T2 (5.25%), followed by T3 (7.25%) and T4 (9.25%).

The percent of control (saved fruit on tree per treatment) was between 91.5 in treatment 4 and 94.75 in case of T2 and T5.

In 2024, at the end of the first generation of the pest, the average frequency of attack was between 5% in case of treatment 5 (chemical reference Coragen), followed by treatment 2 (Bactospeine DF) with 6.5%, both were found statistically at pair and significant superior comparing to T4 (Madex Top, 7.5%), followed by T3 (Laser 240 SC, 8%) and and very significant superior to the T1 untreated plots where the average frequency was of 24.5%. At harvest, the best efficacy results were in T5 and T2 (95%), followed by T3 (94%), and T4 (93.5%). All of them were significantly superior comparing to untreated check.

Table 3. Efficacy of various treatment applied for *C. pomonella* control in 2023

Treatment number/ code	Specification	Active ingredient	Dose	No of applications	% of attacked fruit			Pest control %
					Before A1	At the end of 1st generation	At harvest	At harvest
T1	Untreated check	-	-	-	0.00	16.5 a	24.25 a	-
T2	Bactospeine DF	*Bacillus thuringiensis* subsp. *kurstaki* strain ABTS-351	1 kg/ha	4	0.00	6.00 d	5.25 d	94.75
T3	Laser 240 SC	Spinosad	0.6 l/ha	4	0.00	8.5 c	7.25 c	92.75
T4	Madex Top	*Cydia pomonella* granulovirus (CpGV)	0.1 l/ha	3	0.00	9.5 b	9.25 b	91.5
T5	Coragen	Rynaxypyr®	0.15 l/ha	2	0.00	5.5 d	5.25 d	94.75

Table 4. Efficacy of various treatment applied for *C. pomonella* control in 2024

Treatment number/code	Specification	Active ingredient	Dose	No of applications	% of attacked fruit			Pest control %
					Before A1	At the end of 1st generation	At harvest	At harvest
T1	Untreated check	-	-	-	0.00	24.75 a	33.0 a	-
T2	Bactospeine DF	*Bacillus thuringiensis* subsp. *kurstaki* strain ABTS-351	1 kg/ha	5	0.00	6.50 c	6.25 c	95.0
T3	Laser 240 SC	Spinosad	0.6 l/ha	4	0.00	8.0 b	7.25 bc	94.0
T4	Madex Top	*Cydia pomonella* granulovirus (CpGV)	0.1 l/ha	3	0.00	7.5 b	7.75 b	93. 5
T5	Coragen	Rynaxypyr®	0.15 l/ha	2	0.00	5.0 d	6.25 c	95.0

The results are in line with previous data from the same area (Bolbose, 2022) that showed good control of *C. pomonella* in case of treatment conducted with Madex Top (94.34-95.00% fruit free from attack), and Laser 240 SC (92.67-94.00%).

CONCLUSIONS

Under the conditions of Voinești fruit growing area, during the years 2023-2024, the development of 2 generations of codling moth was recorded, starting from the first decade of May (1st generation) and second decade of July (2nd generation). In 2024, the flight period of the second generation of codling moth was longer, with the last catches recorded in September and fruit damage increased compared with previous year.

All the three biological products significantly controlled codling moth infestation compared with untreated control.

Overall, the product Bactospeine DF showed a verry good efficacy, very closed to those of the chemical reference Coragen.

Results of this experiment will be helpful in further development of Integrated control program of codling moth for Dâmbovița fruit growing basin and will also be very helpful to local apple growers for selection of effective insecticide for the management of *Cydia pomonella* populations.

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