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The efficacy of some ecological insecticides against the defoliating larvae of *Lepidoptera* spp. on European plum under controlled conditions

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ABSTRACT

The European plum (*Prunus domestica* L.) is the most important fruit species in Romania, and the second most cultivated in temperate regions, after apple. The plum is challenged by a number of pests and defoliating larvae from the order *Lepidoptera*, that can cause significant losses. Therefore, at Fruit Research and Development Station Bistrita (FRDS Bistrita), the efficacy of four ecological products: Oleorgan (0.3%), Laser 240 SC (0.06%), BactoSpeine DF (0.1%) and Konflic (0.3%), was tested under laboratory conditions in two consecutively years (2021 and 2022). The experiment was conducted on a sample of 50 larvae, the treatments were applied by spraying, and observations were made over a four-days period after the application of the treatments. The results obtained highlighted the potential of some ecological products in controlling defoliating larvae. Thus, Laser 240 SC achieved significant results, causing a mortality rate of up to 80%. Also, BactoSpeine DF demonstrated significant potential in controlling these pests, with a mortality rate of up to 50%. In contrast, Oleorgan and Konflic were less efficient in controlling defoliating larvae. Data collected over the two years laboratory experiments revealed the real potential of some ecological products under controlled conditions.

Keywords: eco-friendly, mortality rate, pest, phytosanitary treatments, *Prunus domestica*

INTRODUCTION

The interest in sustainable and environmentally friendly agricultural systems has grown significantly in the last 20 years according to The World of Organic Agriculture Statistics and Emerging Trends (2023). In the European Union, the support of farmers through non-reimbursable funds for the development of organic crops has encouraged sustainable agricultural methods. However, in fruit growing, major challenges include managing diseases and pests, which can cause significant economic losses. Although organic farming research is still in its early stages, the sector has the potential for rapid evolution due to the growing interest in sustainable practices and their positive impact on the environment. The success of organic farming depends on the intensification of research, the development of organic technologies and financial support for farmers who adopt these methods.

Prunus domestica L.*,* commonly known as the European plum, is a highly popular and valued fruit-bearing species worldwide being consumed fresh or processed in a diversity of products (Gil *et al.,* 2002; Botu *et al*., 2008; Ortega-Vidal *et al.,* 2022; Sottile *et al.,* 2022).

Plum continues to be the predominant fruit species in Romania (FAOSTAT, 2024), and it is desirable for at least a portion of its production to be ecological. However, managing the primary diseases and pests in orchards represents a significant challenge due to the limited information regarding the actual effectiveness of ecological phytosanitary products. Despite Romania's important position in the global plum production market, a large portion of pest and disease control remains largely reliant on chemical treatments that are now being withdrawn from the European market due to their toxicity.

Due to global warming, some *Lepidoptera* species in Romania have longer flight periods and more generations per year compared to the last century (Roşu-Mareş e*t al.,* 2020). This further complicates matters for farmers, who must keep their crops healthy with less means to control the pest populations (Sjöberg *et al.,* 2015). Defoliating moths such as *Adoxophyes reticulana* (summer fruit tortrix), *Hedya nubiferana* (marbled orchard tortrix), *Archips podana* (fruit tree tortrix), and *Spilonota ocellana* (eye-spotted bud moth) are significant pests in European orchards, including those in Romania (Roşu-Mareş, 2021). These larvae feed on plum leaves, fruits and buds. They typically exhibit one to two generations annually and have the ability to overwinter in various stages, requiring integrated control strategies that combine eco-friendly approaches with pest biology knowledge (Charmillot, 2000).

The use of pheromone traps for monitoring *Lepidopterae* populations using species-specific pheromones have been successfully used in Romania (Jakab *et al.,* 2009, (Kutinkova *et al*., 2009, Roşu-Mareş *et al.,* 2021) to monitor adult populations, allowing growers to time treatments more accurately and reduce unnecessary applications of insecticides (Gündüz & Karagüzel, 2020).

Biological control plays a central role in eco-friendly pest management. Additionally, maintaining habitats for predators like lady beetles (*Coccinellidae*) and birds contributes to natural pest control. Biological insecticides such as the small parasitoid wasp *Trichogramma* spp. (Keszthelyi and Pénzes, 2014) or *Bacillus thuringiensis* (Cross *et al*., 1999) are effective against lepidopteran larvae while being safe for non-target species, including pollinators.

By incorporating biological control agents, microbial and botanical insecticides and environmentally safe cultural practices, growers can reduce the reliance on synthetic chemicals, promoting both sustainable agriculture and long-term orchard health.

In this context, research conducted at FRDS Bistriţa has focused on controlling larvae from the *Lepidoptera* order, one of the most widespread pests affecting plum trees, which can cause significant damage. The purpose of the study was to identify the best ecological treatment options for *Lepidopterae* order larvae, among those currently existing on the Romanian insecticide market.

MATERIALS AND METHODS

The studies were conducted at the Fruit Research and Development Station Bistrita (FRDS Bistrita) in laboratory conditions, during 2021 and 2022, where the efficacy of four ecological products with insecticidal effects was evaluated for controlling defoliating larvae of the *Lepidoptera* order on plum. Performing the tests under controlled conditions was chosen to limit the interference of external factors as well as for the accuracy of determining the mortality of the larvae.

The adults captured on pheromonal traps in the experimental orchard in 2021-2022 were from the tortricid species: *Adoxophyes reticulana* (summer fruit tortrix), *Hedya nubiferana* (marbled orchard tortrix), *Archips podana* (fruit tree tortrix) and *Spilonota ocellana* (eye-spotted bud moth). *Adoxophyes reticulana* (figure1), was the most prevalent species in pheromonal traps in both years but the biological similarities between the larvae of the

above mentioned species determined us to consider the results for the whole group of tortricid moths existent in our orchard.

Figure 1. *Adoxophyes reticulana* adult and defoliating larvae

The ecological products tested were: Oleorgan, Laser 240 SC, BactoSpeine DF, and Konflic (Table 1). The ecological insecticides tested were selected based on their manufacturer-claimed insecticidal properties. The specific concentrations used in the experiments were based on the manufacturer recommended guidelines.

Table 1. List of ecological products evaluated in experiments aimed at controlling *Lepidoptera* defoliating larvae

No.	Commercial name	Concentration (%)	Active substance
1.	Oleorgan	0.30%	40% saponified oil extract from the Neem tree
2.	Laser 240 SC	0.06%	240 g/l spinosad
3.	BactoSpeine DF	0.10%	*Bacillus thuringiensis* subsp. *kurstaki,* 54%
4.	Konflic	0.30%	Potassium salt from vegetable oil extract 50% and *Quassia amara* extract 50%

In the experiment, plum shoots from the Stanley variety were collected from an untreated orchard. In the laboratory, the shoots were placed in plastic containers after being shortened to optimize space, with each treatment variant allocated its own container. The tests were conducted on a sample of 50 tortricid moths larvae, which were kept in plastic containers according to the treatment variant (Figure 2).

The results obtained for the four ecological products were compared to an untreated control variant. The data were analyzed using XLSTAT software (version 2019.3.2) from Addinsoft, operating on the MS Office Excel Professional Plus 2019 platform. All data, collected from laboratory, were organized in a completely randomized block design. XLSTAT was then employed to perform an analysis of variance (ANOVA, Fisher, 1925), followed by Duncan's Multiple Range Test (Duncan, 1955) to determine significant differences between the treatment variants at a significance level of $p < 0.0001$.

Figure 2. Preparation and application of treatments for controlling defoliating larvae of the *Lepidoptera* order

RESULTS AND DISCUSSIONS

The two-year study (2021-2022) demonstrated promising results for certain ecological products in controlling defoliating larvae. The results obtained in 2021, compared to those in 2022 indicate similar mortality rate of four organic products in controlling tortricid moths larvae, minor variations were observed particularly for Laser 240 SC, which showed a 10% difference in effectiveness (Figure 3).

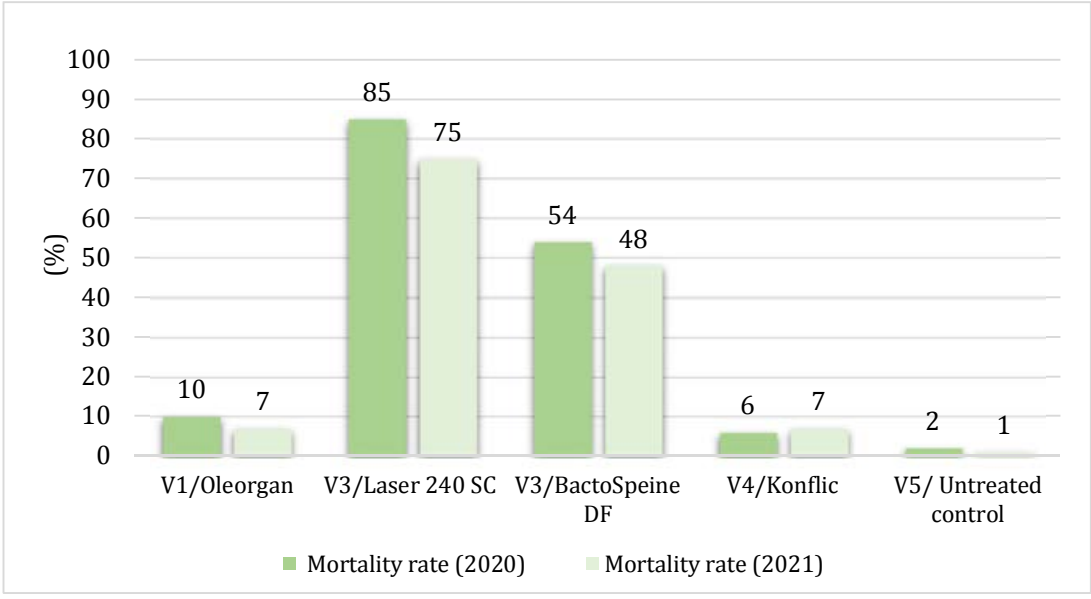

Figure 3. The efficacy of the products tested in the laboratory during the study

The results obtained in the laboratory over the two years (2020-2021), four days after applying the treatments, assessed that the organic product Laser 240 SC (0.06%, 240 g/l Spinosad) demostrated the highest effectivness, causing an average mortality rate of 80%. BactoSpeine DF (0.1%, **Bacillus thuringiensis** subsp. *kurstaki*, 54%), followed with a mortality rate of 51%. Oleorgan (0.3%) and Konflic (0.3%), exhibited significantly lower mortality rates, at 8.5% and 6.5%, respectively. The untreated control variant recorded a mortality rate of 1.5% (Table 2).

Table 2. The data obtained regarding the mortality rate of defoliating larvae during the study

No.	Product	Concentration (%)	Average mortality rate (2020-2021)
1	V1/Oleorgan	0.3%	8.5%
2	**V2/ Laser 240 SC**	**0.3%**	**80%**
3	V3/ BactoSpeine DF	0.06%	51%
4	V4/ Konflic	0.1%	6.5%
5	V5/ Untreated control	-	1.5%

***Note:** *the best results obtained in the experience are marked in bold*

Following the statistical analysis of multiple years data using the Duncan test to evaluate the effectiveness of various organic products in controlling defoliating larvae, significant differences were found among the tested products in the laboratory. The results were divided into four significance classes. The product with the best performance, Laser 240 SC, was found to be significantly better than the other tested products. Bactospeine DF was significantly more effective than the products Oleorgan and Konflic, which were in the same significance class. As expected, the untreated control variant was placed in the lowest significance category (Table 3).

Table 3. Statistical processing of multi-year data on the control of defoliating larvae

Produs	The effectiveness of ecological products tested in the laboratory
V3/Laser 40 SC	80.000 ± 2.200 [a]
V4/Bactospeine DF	51.000 ± 1.852 [b]
V1/Oleorgan	8.500 ± 0.600 [c]
V4/Konflic	6.500 ± 2.042 [c]
V5/ Untreated control	1.500 ± 0.700 [d]
Pr > F(Model)	<0,0001
Signification	Yes

Of the four organic products tested, Laser 240 SC (0.06%) achieved the best results. Similar to our findings, Laser 240 SC, based on spinosad, has been reported to have a strong insecticidal effect in controlling pests from the *Lepidoptera* order, such as *Spodoptera littoralis*, *Helicoverpa zea*, *Helicoverpa armigera*, *Tuta absoluta*, and *Helicoverpa amigera* (Brickle *et al.,* 2001; Aydin & Goulson, 2006; Abouelghar *et al.,* 2013; Singh *et al.,* 2022; Erasmus *et al.,* 2023; Jimu *et al.,* 2023). Spinosad has been demonstrated

as an effective pest control agent, particularly in managing *Lepidopteran* insect pests (Wanner *et al.,* 2000). Specialized studies have shown that the mortality of defoliating larvae is directly influenced by the concentration of spinosad applied (Jat and Ameta, 2013). Higher concentrations of Spinosad resulted in the highest mortality rates, that highest concentrations showed a 95% mortality 95% (Nawaz *et al*., 2019). Galvan *et al.* (2005) reported that spinosad reduced the survival rate of first instar larvae, prolonged their development time to adulthood, decreased weight gain, and lowered the fertility of female *Harmonia axyridis*. Spinosad, a naturally derived insecticide produced by the fermentation of *Saccharopolyspora spinosa*, acts on the insect's nervous system, causing rapid mortality in targeted pests while having minimal impact on beneficial organisms (Cross *et al.,* 1999). Most studies on the toxicity of spinosad in *Lepidoptera* pests have primarily focused on larval stages, with limited research on its sublethal effects in adult target species (Sparks *et al.,* 1998; Pineda *et al.,* 2004). However, Pineda *et al.* (2007) observed reproductive effects in *Spodoptera littoralis* when adults were exposed to spinosad through both residual contact and ingestion. Spinosad acts as a neurotoxin on insects, disrupting their nervous activity and causing paralysis and death. Beneficial effects have also been reported in the control of pests from the *Coleoptera* order, to *Sitophilus oryzae* and *Rhyzopertha dominica* species (Andrić *et al.,* 2018; Perišić *et al.,* 2022; Abdelgaleil *et al.,* 2024; Bohórquez *et al.,* 2024).

Among the eco-friendly substances tested, spinosad has proven to be the most effective in controlling *Lepidoptera* order larvae in plum orchards during our recent trials.

The product Bactospeine DF (0.3%) demonstrated high potential in controlling defoliating larvae, causing over 50% mortality in four days after treatment. The products Oleorgan (0.3%) and Konflic (0.3%) showed unsatisfying results, causing a low mortality rate. Regarding these two products, based on *Azadirachta indica* (Neem tree) and *Quassia amara* oil, the results obtained recommend them at most as an auxiliary in a program to control the larvae of defoliating lepidoptera.

Identifying efficient ecological solutions for controlling the main pests and diseases of plum remains an important topic of discussion in the context of the European Green Deal, which aims to ensure that a significant part of agriculture is practiced in eco-friendly systems. By developing sustainable and eco-friendly strategies, we can protect plum orchards and ensure a resilient agricultural future.

CONCLUSIONS

The results obtained after two years of study (2021-2022) highlight, overall, the potential of certain organic products in controlling defoliating larvae from the *Lepidoptera* order, which can cause serious issues in plum orchards. The organic substance spinosad could represent an effective solution for controlling defoliating larvae in organic plum cultivation, as well as in Integrated Pest Management (IPM). The other biologic substances tested did not performed very well in our two-year study for tortricid moth control and probably require future improvment.

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