

SUMMARY

Corn (*Zea mays* L.) plays an important role in human nutrition and animal feed and is used as a raw material in various industries (Mogârzan, 2012; Trotuş, 2021). Due to its phytotechnical and biological characteristics, corn ranks third in terms of cultural importance (Trotuş, 2021).

The species *Diabrotica virgifera virgifera* Le Conte (western corn rootworm) was first reported in Romania in 1996, and since then, it has rapidly spread to all corn-growing regions, forming significant populations and becoming a common pest of this crop (Trotuş, 2021).

The study of the species *Diabrotica virgifera virgifera* Le Conte is essential for understanding its impact on agricultural crops, especially corn.

Knowing the current status of this pest is necessary for implementing effective prevention and control measures against attacks. Understanding how this species interacts with the environment and host plants is essential for reducing the negative impact on agricultural production and for protecting agricultural ecosystems.

The doctoral thesis titled "**Research on the biology, ecology, mode of damage, and prevention and control methods of the species *Diabrotica virgifera virgifera* Le Conte under the pedoclimatic conditions of Central Moldova, Romania**" follows the biological cycle of the species, the ecological development conditions, as well as the mode of attack and prevention and control methods, contributing to the scientific foundation of integrated pest management strategies in corn cultivation and the development of solutions adapted to the agroecological specifics of the studied region.

The thesis aims to obtain relevant and detailed results regarding the biology, mode of attack, and the efficiency of prevention and control methods for the species *Diabrotica virgifera virgifera* Le Conte in corn crops in the Central Moldova region. These results will contribute to the development of integrated pest management strategies, as well as to increasing the efficiency and sustainability of corn production in the Central Moldova region.

The paper contains a number of 151 pages and is structured into two parts consisting of five chapters, to which the bibliography and appendices are added. The thesis includes a number of 30 tables, 71 figures, and 123 bibliographic titles.

The first part of the thesis, titled "Current Status of Research," includes a chapter dedicated to presenting the current level of research on the species *Diabrotica virgifera virgifera* Le Conte, both nationally and internationally. In this chapter, the results obtained in previous studies conducted by Romanian and foreign researchers are synthesized and analyzed, highlighting the relevant contributions to the understanding of the species' biology, ecology, and control methods.

Part II of the thesis, titled "Original Contributions," consists of Chapters II, III, IV, and V, followed by the bibliography and annexes.

Chapter II presents the natural, organizational, and institutional context in which the research was conducted, providing detailed information about the pedoclimatic conditions, the experimental structure, and the institution where the study was carried out. The research was conducted at the Agricultural Research and Development Station Secuieni – Neamţ.

Chapter III describes the purpose and objectives set for conducting the research, as well as the materials and methods used to establish the bioecology, mode of attack, and prevention and control methods for the species *Diabrotica virgifera virgifera* Le Conte.

The objectives that were set in order to achieve the goal were:

1. The study of the bioecology of the species under the conditions of Central Moldova - a complete understanding of the life cycle of the species *Diabrotica virgifera virgifera* Le Conte, including the developmental stages (egg, larva, pupa, adult) and the factors that influence their durability in the soil of the Central Moldova region.

2. Monitoring attacks and feeding behavior - investigating how *Diabrotica virgifera virgifera* larvae affect corn roots and the damage caused by adult beetles to leaves, silk, pollen, and kernels at the tip of the ears.

3. Monitoring the appearance, development, and end of flight of the species *Diabrotica virgifera virgifera*, as well as determining the peak flight period.

4. Testing prevention and control methods - developing and testing effective infestation prevention techniques, such as the use of chemical treatments in the soil and on vegetation, crop rotation, and the use of traps.

To determine the biology of the species *Diabrotica virgifera virgifera* Le Conte, assessments were carried out in the corn crop throughout its entire growing season. To determine the appearance of the egg, larva, and pupa stages, soil surveys were conducted by removing 10 corn plants in three repetitions, and the roots as well as the soil were analyzed, establishing the developmental stage of the species at the time of determination. The appearance of the adult stage was monitored using yellow sticky traps, determining the start, duration, and end of the flight, as well as the peak flight period.

For the evaluation of larval attack on roots, 25 plants per repetition were analyzed in each experimental variant. Plants with the "neck of a swan" symptom were identified, based on which the attack frequency was calculated. The attack of the adults was also evaluated on 25 plants, in three repetitions, for each variant, by analyzing the leaves and corn silk. The attack frequency was calculated, and through visual observations, the average number of adults per plant was also determined.

In order to prevent and control the attack caused by the species *Diabrotica virgifera virgifera* Le Conte, various insecticidal products were tested, applied to the soil, seed, and vegetation.

Thus, in 2022, to initiate the monitoring process of the species *Diabrotica virgifera virgifera* Le Conte and to understand the level of presence and attack in the Central Moldova area, observations and determinations were made within the framework of a laboratory experiment, without establishing an experiment specifically dedicated to monitoring the species.

For monitoring the attack caused by larvae, the experimental variants with soil and seed treatment were:

- V₁ - Control
- V₂ - *Beauveria bassiana* 150 kg/ha
- V₃ - *Beauveria bassiana* 300 kg/ha
- V₄ - Biosem 10 l/t
- V₅ - Langis (cypermethrin 300 g/l) 2.0 l/t
- V₆ - Nuprid 8.0 l/t
- V₇ - Lumiposa (cyantraniliprol 625g/l)

For monitoring the attack caused by adults, the experimental options with vegetation treatments were:

- V₁ - Control
- V₂ - Decis (deltamethrin 100 g/l) – 0.075 l/ha
- V₃ - Inazuma (acetamiprid 100 g/kg + lambda-cyhalothrin 30 g/kg) – 0.2 kg/ha
- V₄ - Fastac active (alpha-cypermethrin 50 g/l) – 0.6 l/ha

In the years 2023 and 2024, for the monitoring, establishment, and control of the attack caused by the species *Diabrotica virgifera virgifera* Le Conte, three experiments were set up as follows:

The first experience consisted of the ground application of granular insecticides for larval control, with the following variants:

- V₁ - Control
- V₂ - Force 1.5 G (teflutrin 15 g/kg) – 15 kg/ha
- V₃ - Picador 1.6 MG (cypermethrin 1.6%) – 12 kg/ha
- V₄ - Trika Expert (lambda cyhalothrin 4 g/kg) – 15 kg/ha

The second experiment consisted of applying chemical insecticides on vegetation for adult control, with the following variants:

- V₁ – Control
- V₂ – Decis (deltamethrin 100 g/l) - 0.075 l/ha
- V₃ – Inazuma (acetamiprid 100 g/kg + lambda cyhalothrin 30 g/kg) - 0.2 kg/ha
- V₄ – Faster 10 CE (cypermethrin 100 g/l) - 0.15 l/ha
- V₅ – Fastac Active (cypermethrin 50 g/l) – 0.6 l/ha

The third experiment consisted of applying granular products to the soil for larval control and chemical insecticides to the vegetation for adult control, with the following variants:

- V₁ – Control
- V₂ – Force 1.5 G (tefluthrin 15 g/kg) – 15 kg/ha + Fastac Active (cypermethrin 50 g/l) – 0.6 l/ha
- V₃ – Picador 1.6 MG (cypermethrin 1.6%) – 12 kg/ha + Inazuma (acetamiprid 100 g/kg + lambda cyhalothrin 30 g/kg) – 0.2 kg/ha
- V₄ – Trika Expert (lambda cyhalothrin 4 g/kg) – 15 kg/ha + Faster 10 CE (cypermethrin 100 g/l) - 0.15 l/ha

In Chapter IV, the results obtained over the three years of study are presented.

The agricultural year 2021/2022 was characterized by an atypical thermal regime, with temperatures consistently above the multiannual average. The most significant thermal deviations were recorded in the winter months, with +4.8°C in February, while the summer was marked by intense heat, especially in August (+3.2°C above normal). Precipitation was extremely deficient, with an annual total of only 260.8 mm, which is a deficit of 283.5 mm compared to the multiannual average. The drought affected the germination of corn and vegetative development, compromising the density and homogeneity of the crop.

The species *Diabrotica virgifera virgifera* Le Conte had intense biological activity, with larval hatching on June 1 and adult emergence on July 1. A total of 610 adults were collected, with the peak flight recorded in the first decade of August (182 individuals).

In combating larvae, the most effective treatments were applied to the seed: Langis (cypermethrin 300 g/l) - 2.0 l/t and Nuprid 8.0 l/t (3 larvae/plant). The "swan neck" symptom was reduced to 1.3% in these variants, compared to 14.7% in the untreated control.

The attack by adults on silk (93.4%) and leaves (92%) was severe.

Regarding adult control, the best results were observed with the insecticide Fastac Active (cypermethrin 50 g/l), which recorded an efficacy of 93.8%, while the efficacy of the insecticide Inazuma (acetamiprid 100 g/kg + lambda-cyhalothrin 30 g/kg) was 91.6%.

From a climatic perspective, **the 2022/2023** agricultural year was dominated by instability in the spring and excessive heat during the summer. April was unexpectedly cold (–1.4°C compared to the multiannual average), with even snowfall recorded, which delayed corn planting. The summer was hot, with July and August having positive deviations of up to +3.5°C. The rainfall regime was also deficient: the total precipitation was 403.9 mm, with a deficit of 128 mm compared to normal. The months of May and June were extremely dry, with only 21 mm and 29.8 mm of precipitation, respectively.

In 2023, the larvae hatched on June 1, and the adults appeared on June 30. A total of 956 adults were captured, a high level, with the peak flight recorded in the third decade of August (296 individuals).

In the experience with soil-applied chemical treatment using granular products, the insecticide Force G (tefluthrin) applied at a dose of 15 kg/ha was the most effective, with only 1 larva/plant and a "swan neck" symptom frequency of 0%. The insecticide Trika Expert (lambda cyhalothrin) recorded average efficacy (3 larvae/plant and 0% attack), while the insecticide Picador (cypermethrin) showed no significant differences compared to the control.

In the experiment where products with insecticidal action were tested only on vegetation, without soil treatment, the frequency of the "swan neck" symptom ranged between 0% and 2% at the first

assessment, but after the onset of strong winds, the frequency recorded values between 45% and 63%. This fact demonstrates that in the absence of a treatment applied to the soil or seed, the roots are attacked by the larvae of the species *Diabrotica virgifera virgifera* Le Conte, causing the plants to become more fragile and lose their stability.

The attack on the silk was complete, recording a frequency of 100%, while the one on the leaves reached a percentage of 52.4%.

The average number of adults per plant ranged between 8.6 and 11 before the application of the chemical treatment on the vegetation. In the observations made three days after the application of the chemical treatment on the vegetation, it was observed that the insecticides used significantly reduced the average number of adults per plant, ranging from 0.6 to 3.1 adults per plant in the treated variants, compared to the control variant, where the average number of adults per plant was 9.2.

The effectiveness of the insecticides ranged between 66.3% and 93.7%, with the best result recorded in the variant where the insecticide Inazuma (acetamiprid + lambda-cyhalothrin) was applied to the vegetation. All the insecticides used reduced the average number of adults per plant, ensuring good protection for corn plants against adults of *Diabrotica virgifera virgifera* Le Conte.

Regarding the application of chemical treatment both in the soil and on vegetation, these have played an important role in controlling the larvae and adults of *Diabrotica virgifera virgifera* Le Conte.

Among the products applied to the soil, the most effective proved to be the granular insecticide Force G (tefluthrin), which recorded an average of 1 larva per plant and an attack rate of 0%. The products Picador (cypermethrin) and Trika Expert (lambda-cyhalothrin) also reduced the number of larvae per plant and the damage caused by them, compared to the control variant.

Regarding the attack caused by adults, it recorded a frequency of 47.5% on the leaf and 100% on the silk, with adults partially or completely consuming the corn silk.

Before the application of the chemical treatment on the vegetation, the average number of adults per plant ranged between 8.5 and 9.4. After the treatment, the average number of adults per plant decreased, ranging from 1.1 to 2.2 adults per plant in the treated variants and 9.9 adults per plant in the control variant. The most effective variant in controlling the species *Diabrotica virgifera virgifera* Le Conte was shown to be the one where the insecticide Picador (cypermethrin) was used at the soil and the insecticide Inazuma (acetamiprid + lambda cyhalothrin) on the vegetation (V₃). Here, a significant reduction in the adult population was noted, with an average of only 1.1 adults per plant, the effectiveness being 87.2%.

The agricultural year 2023/2024 was the hottest of all years, with exceptional temperature deviations, such as +7.7°C in February and +4.3°C in August. The summer was extremely hot, and during the period from April to September, a high thermal regime was recorded, increasing stress on the crops. The total precipitation was 451.8 mm, which represents a deficit of 80.1 mm. In May, which is essential for the emergence of the crop, a deficit of -28.3 mm was recorded. Although September was rainy, it was already too late to positively influence production.

The corn crop was affected, with undeveloped ears, a lack of grains, and a high percentage of sterile plants being observed.

In 2024, the first larvae were recorded on June 7, showing accelerated development, with the appearance of adults by the end of June (June 27). During the corn vegetation period, a total of 1150 adult specimens of the species *Diabrotica virgifera virgifera* Le Conte were recorded. The peak flight was reached in the first decade of August, with 226 specimens.

In the experience with soil-applied treatment, the granular products reduced the number of larvae per plant, as well as the damage caused by them. The best results were obtained in the variant where the granular insecticide Force G (tefluthrin) was applied to the soil at a dose of 15 kg/ha, with an average of 1.3 larvae/plant and a 0% frequency of the "swan neck" symptom, compared to the untreated control which recorded an attack frequency of 50%. The attack by adults on leaves recorded a frequency of 86%, while on silk it was 91%.

In the experience with chemical treatment only on vegetation, the frequency of the "swan neck" symptom was on average 50.8%, a high incidence caused by the lack of chemical treatment on the soil or seed.

The observations and determinations made on the attack caused by the adults of the species *Diabrotica virgifera virgifera* Le Conte on the leaf highlighted an attack frequency of 56.2%, while the attack on the silk recorded a frequency of 90.2%.

Before the application of the chemical treatment on the vegetation, the average number of adults per plant varied between 3.8 and 8.1. Following the application of phytosanitary treatments, the determinations carried out highlighted a considerable reduction in the adult population density. Thus, the average number of adults per plant decreased to values between 0.2 adults/plant in the V₂ – Decis (deltamethrin), V₃ – Inazuma (acetamiprid + lambda cyhalothrin), and V₅ – Fastac (alpha cypermethrin) variants, and 0.4 adults/plant in the V₄ – Faster (cypermethrin) variant, while the control variant recorded an average of 4 adults/plant.

The treatments applied were generally effective. The lowest efficacy was recorded in the variant where the product Faster (cypermethrin) was applied at a dose of 0.15 l/ha, achieving a 95.1% reduction in the adult population. In contrast, the highest efficacy was observed in the variant treated with the insecticide Fastac Active (alpha-cypermethrin) at a dose of 0.6 l/ha, where a control percentage of 97.2% was recorded. Among the products that provided exceptionally good results in reducing the number of adults, Fastac Active (97.2%) and Inazuma (97.1%) stood out, thus confirming the high efficiency of the active substances in their composition in controlling the pest.

In the context of the experiment aimed at evaluating the efficiency of chemical treatments applied both to the soil and on vegetation against the species *Diabrotica virgifera virgifera* Le Conte, the monitoring carried out revealed that the insecticides used protected the corn plants from the attack.

Among the options with soil treatment, the variant with the lowest larval density was variant V₂, where soil treatment was performed with the granular insecticide Force G (tefluthrin), with 1.3 larvae/plant, and the absence of attack was also noted here. The frequency of adult attacks on leaves was 68.1%, while on silk it was higher, at 91.5%.

Before the application of chemical treatment on the vegetation against adults, the average number of adults per plant varied between 6.3 and 7.6. After applying the tested insecticide treatments, the average number of adults per plant was significantly reduced, ranging from 0.1 (V₂ - Force G + Fastac and V₃ – Picador + Inazuma) to 0.3 adults/plant (V₄ – Trika Expert + Faster) in the treated variants, and 7.8 adults per plant in the control variant, without treatment.

The effectiveness of the insecticides applied in the experiment was significant, ranging between 95.7% - Trika Expert (lambda cyhalothrin) + Faster (cypermethrin) and 98.5% - Force G (tefluthrin) + Fastac (alpha cypermethrin) and Picador (cypermethrin) + Inazuma (acetamiprid + lambda cyhalothrin).

Correlating the years 2022, 2023, and 2024 based on the number of adults captured per decade using the Pearson coefficient (r), it is observed that between 2022 and 2024, there is a moderate correlation (~0.60), indicating a certain consistency in the evolution of captures during these years. In comparison, the correlation between 2022 and 2023 is significantly lower (~0.38), suggesting only a partial similarity and a notable deviation in 2023. This trend is accentuated in the comparison between 2023 and 2024, where the coefficient drops to ~0.15, indicating a very weak correlation and confirming the atypical nature of the year 2023 in the analyzed context.

Analyzing the Spearman coefficient (rs), being a rank correlation, it is observed that the strongest association is between the years 2022 and the year 2024, suggesting a relatively constant and predictable seasonal pattern, especially in July and August, which have remained peak periods of pest activity.

Between 2022 and 2023, a moderate correlation is noted, indicating the maintenance of seasonal peaks, although with notable deviations, such as the unusually high values in the third decade of August 2023. In contrast, the almost nonexistent correlation between 2023 and 2024 signals a major change in population dynamics, influenced by climatic conditions as well as crop rotation.

Thus, although a clear seasonal trend is emerging in 2022 and 2024, the year 2023 stands out as atypical, with an abnormal distribution that necessitates a detailed investigation of the climatic and agricultural context. For effective monitoring, the analysis of multi-year trends is essential, avoiding the interpretation of isolated short-term values.

In Chapter V, the conclusions are presented, listing the main ideas that emerged from the research conducted for this doctoral thesis, as well as the recommendations for the prevention and control of the attack caused by the species *Diabrotica virgifera virgifera* Le Conte.

Finally, the bibliographic titles consulted for the documentation and elaboration of the doctoral thesis are presented in alphabetical order.