ABSTRACT

Ecologically sustainable potato production requires a reduced reliance on pesticides, and consumers are increasingly advocating for environmental protection and emphasizing these demands by changing their purchasing patterns, while farmers are responding with a reduced and more efficient use of pesticides through greener chemicals, superior application equipment, research, training, and increased communication.

Research on coleopteran species in potato crops in the northern part of Moldova is of significant importance from several perspectives.

These studies are essential for the correct identification of insect species that can affect these crops, especially in the climatic conditions specific to the region. For instance, the Colorado potato beetle (*Leptinotarsa decemlineata*) is one of the most well-known potato pests, but other species that can cause damage are also possible.

Furthermore, the research allows for a detailed understanding of the behavior and life cycle of coleopterans. This is crucial for determining optimal times for intervention, such as the application of phytosanitary treatments, to prevent significant damage to potato production. Studies of this type also help assess the impact of these insects on yields and tuber quality, which is essential for farmers.

The doctoral thesis " *Research on beetle species in potato crops in the Northern Area of Moldova, Romania*" addresses aspects related to studies on beetles from potato crop areas in northern Moldova that are essential not only for protecting them from pests but also for promoting ecological balance in agriculture, thus contributing to finding efficient and sustainable solutions for preventing crop losses and maintaining a healthy agricultural environment.

The doctoral thesis totals 167 pages and is structured in two parts, including four chapters, to which are added the sections with conclusions, bibliography, and annexes. These include a total of 32 tables, 17 figures, and 137 bibliographical sources.

Part I of the work, "Current State of Knowledge," is structured into two chapters in which relevant information from the specialized literature regarding the subject of the doctoral thesis is synthetically presented. This data was subsequently used to interpret and compare the results obtained in the "Own Research" section.

This part also includes a detailed description of the natural setting of the city of Rădăuți in the county, highlighting essential aspects such as geographical location, pedoclimatic conditions, and meteorological characteristics. The information presented contributes to outlining a solid scientific context necessary for understanding and analyzing the research results.

Part II, “Own Research,” consists of two chapters: Chapter III presents the purpose and objectives of the research, as well as the materials and research methods used.

The study compares three experimental variants, each representing a pest management strategy. Its main objective is to determine the most efficient and sustainable method of pest management in potato crops, taking into account efficiency in pest control, the impact on beneficial beetles, and ecological sustainability—a comparison of the effects on biodiversity and the environment between the organic and chemical variants.

This research aims to identify a pest management strategy that is both agriculturally efficient and environmentally friendly. Conserving and promoting beneficial fauna can reduce the need for pesticides, offering a natural and effective solution for pest management. The study can help identify more economically efficient solutions that reduce costs for farmers while ensuring optimal yields, without negatively impacting the environment.

The purpose of this doctoral thesis is to find a balance between protecting potato crops and maintaining environmental health. The comparative evaluation of control, ecological, and chemical variants can provide essential answers for more sustainable, efficient, and biodiversity-friendly agriculture, which is crucial for the future of agriculture in the northern area of Moldova and beyond.

To meet the proposed goal, the following objectives were established:

1. Collection and analysis of the diversity of coleopteran species using Barber-type soil traps in different experimental variants (chemical, ecological, and control).

2. Establishing the impact of the strategies on the ecological balance: analysis of the distribution of beneficial, harmful, and saprophagous species in the various variants investigated.

3. Evaluation of the effectiveness of yellow chromatic traps: study of their efficiency in attracting coleopterans and evaluation of the diversity of fauna species captured.

4. Detecting pest resistance trends: analyzing the behavior of the *Leptinotarsa decemlineata* species under various control methods and discovering potential signs of resistance to chemical treatments.

5. Analyzing and comparing biodiversity indices to assess the impact of the treatments applied on the diversity of coleoptera in potato crops.

Chapter IV, "Results and Discussions," presents the results obtained from a comparative study between chemical and ecological methods that will help identify the most effective solutions for pest control while preserving the integrity of the environment and protecting beneficial insects. In this way, recommendations can be formulated for practices that are as sustainable as possible.

The study conducted in the potato plantation in Rădăuți, Suceava County, analyzed three approaches to pest control: chemical treatment, ecological option, and control variant. The aim of the study was to identify the most efficient and sustainable strategy, taking into account both the effectiveness in pest control and the effect on biodiversity and the environment.

The use of chemical treatments in variant V1 in 2022 impacted the diversity and abundance of coleopteran species observed in the crop. During the collection periods, a variation in the number of species and specimens was noted, with a gradual decrease in the second part of the season. Additionally, the high percentage of species collected as single specimens indicates a considerable impact of the treatments on insect diversity.

The control variant (V3) from 2022, without the application of chemical or ecological treatments, had the highest diversity and richness of Coleoptera in potato crops. The large number of species and individuals throughout the entire collection period indicates a more stable ecosystem, in which natural interactions between predators and herbivores were preserved without external influences. Species such as *Pterostichus niger, Pterostichus cylindricus*, and *Harpalus calceatus* had a significant presence, suggesting increased activity of natural predators. At the same time, the significant presence of rare species indicates rich biodiversity, but also natural competition among the various trophic groups. The considerable prevalence of the pest *Leptinotarsa decemlineata* suggests that the absence of treatments contributed to its proliferation.

4. The species structure obtained for the chemically treated variant (V1) illustrates a relative balance among beneficial, harmful, and saprophagous species but highlights a considerable impact of the treatments on biodiversity. Beneficial species, which assist in the natural management of pests, constitute almost 50% (46.5%) of the total number of Coleoptera identified, suggesting a significant presence of natural predators. Pests, such as *Leptinotarsa decemlineata* and *Agriotes ustulatus*, constituted 27.9% of the total species, indicating that, even if chemical treatments reduce their numbers, they do not completely eradicate them. This may also suggest a possible resistance of certain species to the applied substances. Saprophagous species, comprising 25.6%, are essential for the degradation of organic matter and the recycling of nutrients in the soil; nonetheless, the application of chemical treatments could affect their activity in the long term.

In the ecological variant (V2), the structure of the collected Coleoptera illustrates a balanced biodiversity, with an increased number of beneficial species and a fairly uniform distribution among the functional categories. Beneficial species, which constitute 50.5% of the total, include the families Staphylinidae and Carabidae, which are frequently encountered, highlighting their relevance in the natural management of pests. Pests, although present (24.8% of the total), did not dominate the ecosystem, which may suggest the effectiveness of ecological control methods, such as the use of neem oil and *Bacillus thuringiensis*. This approach minimizes the negative effects on pollinators and natural predators, facilitating a more stable biological regulation.

Control variant (V3), the structure of the beetles collected in 2022 indicates a varied and dynamic ecosystem, with a considerable proportion of beneficial species. These species constituted 46.7% of the total number of species collected, suggesting a natural balance among the various ecological functions in the ecosystem. In conclusion, in the

control variant, the biodiversity and variety of beneficial species highlight an efficient ecosystem in which beetles play an important role in the natural management of pests, ensuring a balance among the elements of the ecosystem.

The 2023 collections for the chemically treated variant (V1) indicate moderate diversity in the coleopteran community, with notable seasonal variations. The chemical treatments used (insecticides, fungicides, herbicides, and foliar fertilizers) appear to influence the composition and number of the coleopteran community, supporting certain species while reducing the presence of others. This indicates that the agricultural ecosystem may be less diverse than the control variant (V3) or the ecologically treated variant (V2).

In the V2 (organic) variant of 2023, important species such as *Leptinotarsa decemlineata (*Colorado beetle) and *Oxytelus inustus* were observed, frequently encountered at different stages of the season. Additionally, species like *Phyllotreta vittata* and *Pterostichus* niger exhibited high activity during peak times of the season. Furthermore, the presence of less common species such as *Cicindela germanica* and *Mycetophagus quadriguttatus* indicates a medium level of ecological diversity, typical of an organically managed agricultural ecosystem. Overall, the organic methods employed in this variant helped maintain ecological balance, promoting a greater diversity of species compared to the chemically treated variant (V1) and ensuring sustainable pest management.

In 2023, in variant V3 (the control variant), where no chemical treatments were used, a variable diversity of Coleoptera was observed during the season, with notable fluctuations depending on the harvest date and climatic conditions. During the observation period, the most abundant species were *Oxypora vittata* and *Anthicus humeralis* in May, while in June and July, species such as *Leptinotarsa decemlineata*, *Sipalia circellaris*, and *Oxytelus rugosus* were represented significantly. Species with only one recorded individual were frequently observed, suggesting a high variability of the habitat, but also a less regular activity at certain times of the season.

In 2023, the V1 variant subjected to chemical treatment highlighted the structure of the collected species, depending on their role in the ecosystem, which identified three main categories: beneficial species, harmful species, and species that assist in decomposing organic matter. Beneficial species constituted 51.6% of the total number of coleoptera collected, while harmful species accounted for 27.9% of the total number of coleoptera recognized, with these species having a direct negative impact on plant health and agricultural output. Thus, the composition of the species collected in the V1 variant highlights a balanced agricultural system, where beneficial species help manage pests, and decomposing species play a significant role in nutrient recycling.

The 2023 V2 ecological variant emphasizes a well-balanced ecosystem in which beneficial species play a key role in the natural management of pests and the maintenance of soil health. Approximately 46% of beetles are useful in agriculture, helping to reduce the need for chemical interventions and control pests through predation by carnivorous species.

Variant V3 - control from 2023 presents a diverse ecosystem in which approximately 42.5% of the beetles are beneficial species, having crucial importance in the natural management of pests, helping to reduce the number of harmful insects and, therefore, promoting the health of the agricultural ecosystem. Species such as *Calosoma sycophanta* and the species structure obtained for the chemically treated variant (V1) illustrates a relative balance among beneficial, harmful, and saprophagous species but highlights a *Coccinella 7 punctata* play a crucial role in ensuring the natural balance and have a beneficial effect on agricultural crops by eliminating pests. However, 33.1% of the identified beetles are species that can become harmful, causing notable damage and highlighting the need to implement control measures to protect crops.

The study on the evolution of Coleoptera collected in the potato plantation during the research shows that the control variant (V3), which was not subjected to chemical or ecological treatments, had the highest quantity of Coleoptera, totaling 1,852 individuals. This result indicates that the lack of chemical treatments favors a larger population of organisms with a greater diversity of species. In contrast, the variant subjected to chemical treatment (V1) showed a considerably lower number of Coleoptera (845 individuals), suggesting the harmful effect of pesticides on the community of organisms.

Following the use of yellow chromatic traps for the collection of Coleoptera in 2022, variant V1 resulted in the collection of 94 specimens of various species, suggesting moderate diversity in the fauna attracted by these traps. Traps of this type proved effective at capturing a varied spectrum of Coleoptera, with common species consistently present and significantly increased activity during the summer months. Species with agricultural impact, such as

Agriotes ustulatus, Phyllotreta vittula, and *Meligetes aeneus*, were among the most common, while the occurrence of less common species suggests an intriguing diversity in the fauna collected using this type of trap.

Beetles collected using yellow chromatic traps variant V2 in 2022 show lower species diversity compared to variant V1, with a total of 80 specimens collected. These collections suggest varied but more focused activity on a few species, especially during the summer seasons. Overall, the collections from variant V2 highlighted a variety of species, particularly *Coccinella, Meligetes aeneus*, and *Cantharis cryptica*, along with the emergence of rarer species, such as *Staphylinus pedator* and *Acanthoscelides obsoletus*. These findings indicate that, although species diversity is lower compared to variant V1, yellow chromatic traps remain effective in capturing a diverse spectrum of beetles, including species relevant to agriculture and specific crop pests.

The beetles collected using the yellow chromatic traps of type V3 in 2022 exhibited considerable species diversity and consistent activity throughout the year, with maximum abundance during the summer season. In May, at the start of the season, the collections were modest, featuring only a few specimens, such as *Clivia fossor* (1 specimen) and *Pleurophorus caesus* (2 specimens), indicating low activity at the beginning of spring. In total, 211 specimens of beetles were collected in the V3 variant, highlighting their diversity and richness in the analyzed area in 2022.

After using yellow chromatic traps type V1 (with chemical treatment) to collect beetles in 2023, moderate diversity was found, resulting in a total of 64 specimens collected. The small number of individuals indicates that the chemical treatments used had a considerable effect on the beetle population, restricting their presence in the ecosystem. An interesting detail is the appearance of *Leptinotarsa decemlineata* (Colorado potato beetle), with 3 individuals collected. This suggests that despite the use of chemical treatments, this particular pest can adapt and survive, which is a sign of resilience and a constant challenge for its management in agriculture.

The beetles collected in the V2 (ecological) variant in 2023 totaled 102 specimens, indicating a higher prevalence of these insects compared to the chemical treatment variant. This result highlights that ecological methods contribute to the preservation of a greater diversity of coleoptera, without the harmful effects of chemical interventions. The presence of some harmful species, such as *Leptinotarsa decemlineata* (Colorado potato beetle) and *Aphodius granarius,* is also noted, indicating that the absence of chemical treatments facilitates the survival of certain insects with a negative impact on crops. This observation emphasizes that although the ecosystem supports biological diversity, challenges may arise in pest management.

The beetles collected in the V3 variant (control) in 2023 totaled 158 specimens, indicating high biodiversity without chemical treatments or specific ecological interventions. This information suggests that the control variant provides natural conditions conducive to the development of beetles, favoring both beneficial and potentially harmful species. Among the most common species are *Phyllotreta vittula* (11 specimens), *Phyllotreta atra* (20 specimens), *Meligethes aeneus* (20 specimens). The species structure obtained for the chemically treated variant (V1) illustrates a relative balance among beneficial, harmful, and saprophagous species but highlights a *Coccinella 7 punctata* (14 specimens), and *Coccinella undecimpunctata* (14 specimens), all of which are beneficial species in the fight against aphids. These species indicate an ecosystem where useful beetles contribute significantly to maintaining plant health.

Regarding the analysis of biodiversity indices, it is observed that variant V3 (control) has a higher biodiversity than V1 (chemically treated) and V2 (ecological). Although V3 presents a greater diversity of species, a tendency for some species to predominate is noted, which suggests a more unequal distribution of individuals. In contrast, V1 and V2 highlight a more balanced biodiversity, featuring a more uniform distribution among different species. Broadly speaking, the environmental conditions in V3 support increased variability, although there are some indications of inequality in the distribution of individuals.

Examination of the 2023 biodiversity indicators shows that the V3 (control) variant has higher species diversity and a more even distribution of species. However, a tendency towards the predominance of certain species is observed, as highlighted by the Berger-Parker index and the Gini coefficient. This suggests that, without chemical and ecological treatments, the ecosystem in V3 provides conditions conducive to considerable diversity but with little inequality in the distribution of individuals. In contrast, V2 (ecological) has lower species diversity and a fairly even distribution, while V1 (chemically treated) displays values between V2 and V3. Therefore, V3 supports biodiversity at a global level, although with a slight tendency to favor certain species, while V2 and V1 are more balanced, exhibiting lower species diversity but a more even distribution of individuals.

The 2022 study of the biological cycle of *Leptinotarsa decemlineata* highlights that this pest, with a two-generation life cycle, is effectively adapted to temperate climate conditions, having a considerable effect on potato crops and other plants of the Solanaceae family. The combined temperature and favorable climatic conditions led to the emergence of hibernating adults in April and the rapid development of larvae and adults, with a first generation active by July and a second generation completing in August. This information is fundamental for creating a treatment notification system, facilitating the determination of the ideal times for phytosanitary interventions. Effective management of this pest is based on careful monitoring of temperature changes and the biological stages of the insect, thus guaranteeing more accurate control of Colorado potato beetle populations and reducing damage to potato crops.

In 2023, *Leptinotarsa decemlineata* had a similar life cycle to that of 2022; however, a general delay in development was observed due to the cooler weather in the spring of this year. Mature beetles appeared later, between April and May, and egg and larval development occurred under favorable temperature and humidity conditions, which stimulated the rapid multiplication of the species.

Despite this delay, the biological behavior of the species remained constant, with two generations alternating throughout the year. The pests affecting potato crops had a significant impact, especially during the period when the larvae fed abundantly, and the pupation and emergence of adults in August sustained the life cycle of this pest.

Comparing the two biological sheets from 2022 and 2023, it is evident that climatic conditions impacted the evolution of the species, but its ability to adapt and reproduce rapidly remains a crucial aspect of its persistence as an important pest in potato crops.

In 2022, the use of chemical treatments in the V1 variable was crucial for protecting the potato crop from pests and diseases, creating an environment conducive to plant growth and generating a high yield. The chemicals used, such as Mospilan 20SG, Nemathorin , and Zoxis 250 SC, had a considerable influence on controlling pests like the Colorado potato beetle and aphids, but also in combating diseases caused by fungi. Additionally, biostimulants such as Physiocrop helped not only to protect the crop but also to encourage plant growth and resistance.

In contrast, the treatments used in variant V2 were more environmentally friendly, based on biological and natural products. The use of products such as *Trichoderma* spp., *Bacillus thuringiensis* and Spinosad showed a beneficial effect on the crop, being more ecological and safer for the health of beneficial insects and consumers.

In 2023, chemical treatments in the V1 variant were essential in controlling pests and diseases, as several effective chemicals were used throughout the growing season. These procedures aimed to combat pests and fungal diseases while promoting plant development. In total, nine chemical interventions were carried out, and the substances used were carefully selected to address the various challenges encountered during the sowing of the potato crop.

In the V2 experimental variant, the strategy was more balanced, integrating both organic and chemical products, which facilitated more sustainable management of the crop. The treatments used were adjusted to the different stages of plant development and included both biopreparations and chemical products for more efficient control of pests and diseases.