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# PESTS OF THE SOLANACEOUS VEGETABLES: AN OVERVIEW OF BIOLOGICAL CONTROL

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***Abstract***

*The Solanaceae family comprises species present on all continents except Antarctica. They are species with different biological cycle durations and adapted to a wide range of environments. Vegetables of the Solanaceae family are not only important for human nutrition, some species are grown for ornamental purposes but also pharmaceutical purposes. Pest species cause significant losses, and many are vectors of disease. Today, many scientists focus on developing new tools to control pest populations, with promising results of use in plant protection. Therefore, the quantitative and qualitative increase in the production of vegetables from the Solanaceae family is not only dependent on environmental factors, an important role is also played by pest prevention and control activities. This is why the objective of this paper was to identify, based on the publications available in the scientific databases of the last ten years, pests from solanaceous vegetable crops from Romania and to list the most important and effective methods of biological control that can be used by producers as more sustainable forms of pest management.*

***Key words***: *solanaceous vegetables, pest prevention and control, Romania vegetables crops, pest management.*

## INTRODUCTION

Vegetables of the *Solanaceae* family comprise about 98 genera and about 2,700 species, with a great diversity of habitats, morphology and ecology (Khafagi, El-Ghamery, Ghaly, & Ragab, 2018; Shilpa Kumari, Anokhe, & Kumar, 2017). They have a wide distribution worldwide, being present on all continents, except Antarctica. The greatest diversity of species is found in South and Central America (Dupin et al., 2017). They are good sources of protein, vitamins, minerals and carbohydrates (Shweta Kumari et al., 2019; Kunjwal & Srivastava, 2018). The *Solanaceae* family includes many horticultural species of economic importance as tomatoes (*Solanum lycopersicum*), peppers (*Capsicum annuum*), eggplants (*Solanum melongena*) and potatoes (*Solanum tuberosum*) (Y. Liu et al., 2018). But in this paper, we will focus on the first three species of major importance for Vegetable Research and Development Station Bacău. Also, many of these vegetables are grown for fruit, for ornamental and medical purposes (Gebhardt, 2016; Kunjwal & Srivastava, 2018; Kwon et al., 2020). Vegetable crops have been selected and breaded predominantly for production and, to a lesser extent, for resistance to diseases and pests (Bebber, Holmes, & Gurr, 2014). Crops destruction by pests represents one of the worst problems for vegetable growing, especially in developing countries (Chowański et al., 2016). Some species are vectors in the transmission of viral diseases or mycoplasmosis (Shweta Kumari et al., 2019; Navas-Castillo, Fiallo-Olivé, & Sánchez-Campos, 2011). In the last century, chemical pest control management occupied an important place among plant protection methods (Pavela, 2016), and made rapid progress since the development of DDT (Taiz, 2013). The persistence of pesticide residues causes them to accumulate in the food chain (Pavela, 2016) and, since this phenomenon has become known, the application of these products seemed no longer justified and has been already prohibited in many countries (Alavo, 2015). In the past 20 years, global public awareness has grown regarding the dangers of using chemical-synthesis pesticides (Pérez-Consuegra et al., 2018). The European agriculture is currently in transition from conventional crop protection, based on chemical pesticides, to integrated pest management (IPM). To make any IPM system successful, an alternative to conventional pesticides and plant protection measures that allow an effective management of crop pests is needed. Biological control has the potential to become one of the main pillars of IPM systems (Lamichhane et al., 2017). By biological control, we mean all plant protection (tools, methods, agents, measures) (Umpiérrez, Lagreca, Cabrera, Grille, & Rossini, 2012; C. Wang & Feng, 2014) that are based on the use of beneficial organisms and their natural mechanisms and interactions between biological species found in the natural environment (Lamichhane et al., 2017), used by humans as a biological means to control animals that have become pest (Alavo, 2015). In this review we identify, based on the publications available in the scientific databases of the last ten years (mainly Google Academic, ScienceDirect.com and Springer), pests from solanaceous vegetable crops from Romania and to underline the most important and effective methods of biological control that can be used by producers as more sustainable forms of pest management.

## MATERIALS AND METHODS

### Data sources and selection criteria

We have compiled data from specialized studies over the past ten years, studies that address pest management for solanaceous crops (tomatoes, peppers, and eggplant). The main pests, as well as their main pathogens, predators and parasites have been identified. We searched the databases in Google Academic, ScienceDirect, Springer using the following keywords "*Solanaceae* crop pests", "Biological pest control", "Solanaceous pests in Romania", "Pathogens for pests in solanaceous crops", "Parasites for solanaceous pests", "Predators for solanaceous pests", "Pest prevention and control" and "Integrated pest management".

We have identified a number of 623 papers that have been analyzed. The studies selected for this review had to meet the following criteria: (1) publication period, 2011-2021; (2) to present the pests of the plant species in question; (3) to present the microbial biologic control agents, parasites, and predatory species for the identified pests.

## RESULTS AND DISCUSSIONS

### Biological pest control

The number and importance of harmful species is constantly changing due to international tourism, trade and transport of crops (van Lenteren, Alomar, Ravensberg, & Urbaneja, 2020). From the outset, it should be noted that biological pest control does not solve all problems with a complex of pests in a crop. To some degree, populations of all living organisms are reduced by actions of their predators, parasites, antagonists and diseases. This is why this process has been called "natural control" because it includes the effects of natural enemies (Alston, 2011; Snyder, 2019; Ulloa-Ogaz, Muñoz-Castellanos, & Nevárez-Moorillón, 2015). Biological control or biocontrol differs from chemical, cultural, and mechanical controls because the biocontrol agent must survive. It is therefore necessary to maintain a certain level of food supply, such as the pest. Biological control itself is not a mean of eradicating the pests from the crops, it is only a measure to reduce the adverse effect of pest (Alston, 2011). Humans can exploit biological control in various ways to suppress pest populations (Hajek & Eilenberg, 2018), that’s why biological control has been used for centuries (Barratt, Moran, Bigler, & Van Lenteren, 2018), and it is mainly defined as the introduction of a natural enemy to control a pest, making it less abundant or less harmful for crops (Kenis, Hurley, Hajek, & Cock, 2017). Integrated pest control is extremely important due to the number of vegetable species grown in our country, as well as the diversity of existing pests. Farmers should know that over the past two decades, Romanian researchers have found and developed solutions that concern the controlling of pests in vegetable crops. Therefore, there are integrated control technologies and control methods that excludes or limits the use of chemicals (Scurtu, Lăcătuș, Sbîrciog, & Buzatu, 2016).

The main groups of biocontrol agents are the microorganisms and invertebrates (van

Lenteren et al., 2020). Microbial pest control refers to viruses, bacteria and fungi. In greenhouses, mainly three species of microbial control agents are used, while several species are applied to field crops. For example, *Bacillus thuringiensis* is used for over 40 years in control of young lepidopteran caterpillars, *Beauveria bassiana* is one of the oldest known entomopathogenic organisms and is applied especially in protected greenhouses crops and nucleopolyhedrovirus is used against *Helicoverpa armigera* specie. The invertebrates use to control plant pests belongs to *Acari* subclass, *Coleoptera* orders, *Diptera, Hymenoptera, Hemiptera, Nematodes, Neuropteran* and different microorganisms (van Lenteren et al., 2020).

**Biological pest control in Romania**

After Spain, France, Italy and Germany, which are the main agricultural producers in the EU, Romania is currently ranked in the top sales of pesticides (Petrescu-Mag, Banatean-Dunea, Vesa, Copacinschi, & Petrescu, 2019). According to Ene et al. (2012), who studied the levels and distribution of organochlorine pesticides (CMOs), polycyclic hydrocarbons (PAH) and DDT from S-E region of Romania soils, it claims that the level of contamination is high according to Romanian legislation on soil pollution, mainly due to agricultural activities (Ene, Bogdevich, & Sion, 2012). Changes in temperatures and seasons could also affect the proliferation and spread of pests (Andrei & Cristina, 2018), which can affect solanaceous crops. The use of biocontrol agents is an important strategy for integrated pest management in many economically important plants species (Flint & Van den Bosch, 2012). Like other countries, Romania aims to reduce the use of chemical pesticides, so Romanian researchers are developing biocontrol technologies that maintain a natural balance between pests and useful fauna (Stoleru, Munteanu, Stoleru, & Rotaru, 2012).

**Pests of solanaceous plants**

Knowledge of pests specific to solanaceous crops is very important for establishing the most effective measures to prevent attacks and reduce crop losses (Badii, Billah, Afreh-Nuamah, Obeng-Ofori, & Nyarko, 2015; Campos, Biondi, Adiga, Guedes, & Desneux, 2017; Mazzi & Dorn, 2012). In the literature of the last ten years, the authors of this paper have found a number of 15 pests for solanaceous crops (tomatoes, peppers and eggplant) listed in Table 1.

Table 1. List of the main species of pests for tomato, pepper, and eggplant crops in Romania

| Plant species | Pest | Author |
|---|---|---|
| **Tomatoes (*Solanum lycopersicum*)** | - *Meloidogyne incognita* (root-knot nematode)<br>- *Nezara viridula* (southern green stink bugs)<br>- *Tuta absoluta* (tomato leaf miner)<br>- *Halyomorpha halys* (brown marmorated stink bug)<br>- *Tetranychus urticae* (two-spotted spider mite)<br>- *Helicoverpa armigera* (cotton bollworm)<br>- *Liriomyza trifolii* (celery leaf miner)<br>- *Macrosiphum euphorbiae* (potato aphid)<br>- *Thrips tabaci* (onion thrips)<br>- *Trialeurodes vaporariorum* (glasshouse whitefly)<br>- *Tetranychus urticae* (two-spotted spider mite)<br>- *Leptinotarsa decemlineata* (Colorado potato beetle) | (Calin et al., 2020; Cean, 2011; Cean & Dobrin, 2009; Ciceoi & Gutue, 2020; Gabriela Șovărel, Marcel Costache, Emilia Cenușă, & Hogea, 2020; Grozea, Ștef, Virteiu, Cărăbeț, & Molnar, 2012; Kurzeluk, Fătu, & Mihaela Monica, 2015; Macavei et al., 2015) |
| **Peppers (*Capsicum annuum*)** | - *Meloidogyne incognita* (root-knot nematode)<br>- *Nezara viridula* (southern green stink bugs)<br>- *Halyomorpha halys* (brown marmorated stink bug)<br>- *Tetranychus urticae* (two-spotted spider mite)<br>- *Helicoverpa armigera* (cotton bollworm)<br>- *Thrips tabaci* (onion thrips)<br>- *Trialeurodes vaporariorum* (greenhouse whitefly)<br>- *Liriomyza trifolii* (celery leaf miner)<br>- *Polyphagotarsonemus latus* (broad mite)<br>- *Myzus persicae* (green peach aphid)<br>- *Frankliniella occidentalis* (Californian thrips) | (Calin et al., 2020; Cean, 2011; Gabriela Șovărel et al., 2020; Hoza et al., 2016; Kurzeluk et al., 2015; Macavei et al., 2015) |

| Plant species | Pest | Author |
|---|---|---|
| **Eggplants (*Solanum melongena*)** | - *Meloidogyne incognita* (root-knot nematode)<br>- *Halyomorpha halys* (brown marmorated stink bug)<br>- *Tetranychus urticae* (two-spotted spider mite)<br>- *Helicoverpa armigera* (cotton bollworm)<br>- *Liriomyza trifolii* (celery leaf miner)<br>- *Polyphagotarsonemus latus* (broad mite)<br>- *Macrosiphum euphorbiae* (potato aphid)<br>- *Thrips tabaci* (onion thrips)<br>- *Trialeurodes vaporariorum* (glasshouse whitefly)<br>- *Bemisia tabaci* (tabacco whitefly)<br>- *Leptinotarsa decemlineata* (Colorado potato beetle) | (Calin et al., 2020; Cean, 2011; Gabriela Șovărel et al., 2020; Macavei et al., 2015) |

**Types of biological control**

Four different types of biological control are known: natural, conservation, classical, and augmentative biological control (van Lenteren, Bolckmans, Köhl, Ravensberg, & Urbaneja, 2018):

- Natural biological control refers to the fact that harmful organisms are reduced by natural beneficial organisms without human intervention. This is found in all ecosystems and has a benefit especially for agrophyto-technical ecosystems (Rusch, Bommarco, & Ekbom, 2017; van Lenteren, 2012).
- Conservation biological control takes advantage of the pest's natural enemies and involves management strategies to conserve populations and the services it provides (Romeis, Naranjo, Meissle, & Shelton, 2019).
- Classical biological control refers to the intentional introduction of an exotic biological control agent for the permanent establishment and long-term pest control in an area that has been infested by pests (Heimpel & Cock, 2018; Kenis et al., 2017).
- Augmentative biological control refers to the release of an additional numbers of natural enemies when there are fewer in agrophytotechnical ecosystems to effect-tively control a pest (Barratt et al., 2018; De Clercq, Mason, & Babendreier, 2011).

**Microbial biological control agents (MBCA)**

MBCA contains living organisms, such as bacteria, fungi or viruses (Figure 1) (Lacey, 2017) for pest control in crops, like vegetable crops, and are regulated in the European Union (EU) at both EU and Member State(MS) levels (Frederiks & Wesseler, 2019). Compared to the chemical pesticides these agents have been considered safe for mammals (Baelum, Larsen, Doekes, & Sigsgaard, 2012). Most research are focused on the baculoviruses, important pathogens of some 34 globally important pests for which control has become difficult due to either pesticide resistance or pressure to reduce pesticide residues (Lacey et al., 2015). Usually the MBCA are isolates from local soil (Rios-Velasco et al., 2014).

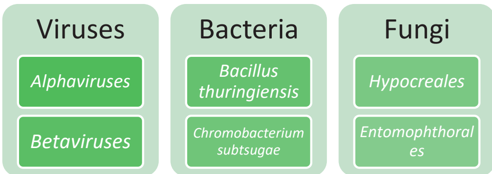


Figure 1. Entomopathogens, after Lacey, 2017

**Parasite and predatory species**

Farmers are facing serious plant protection issues and phytosanitary risks. The ability of some pests to use a wide range of plants as alternative hosts is the main limitation to the suppressive role (Ratnadass, Fernandes, Avelino, & Habib, 2012). Biological control can be achieved with both MBCA help, as well as by launching parasites and predators (Cornelius, Dieckhoff, Vinyard, & Hoelmer, 2016). This maintain a natural balance between pests and their predators and parasites (N.W. Yang et al., 2014). There are 1590 different terrestrial arthropod species identified in Europe, from which 513 are predators or parasites. The largest group is represented by insects (409 species), spiders (47 species), myriapods (34 species) and mites (23 species) (Roy, Roy, & Roques, 2011). All these organisms contribute to regulatory mechanisms that maintain the stability in agroecosystems (Peterson, Eviner, & Gaudin, 2018), and the success or failure of pest management strategy is mainly attributed to the ability of a few key natural enemies to suppress the pest density (Bouvet, Urbaneja, Pérez-Hedo, & Monzó, 2019). In the following we will present the microbial biologic control agents, parasites, and predatory species for pests of the main Solanaceous crops (Table 2.).

Table 2. Microbial biologic control agents, parasites, and predatory species for pests of the main Solanaceous crops

| Solanaceous pest | Microbial biological control agents | Parasite and Predatory species | Authors |
|---|---|---|---|
| ***Meloidogyne incognita* (root-knot nematode)** | - *Aspergillus niger*<br>- *Hypocrea rufa*<br>- *Beauveria bassiana*<br>- *Bacillus megaterium*<br>- *Trichoderma album*<br>- *Trichoderma harzianum*<br>- *Ascophyllum nodosum*<br>- *Bacillus firmus T11*<br>- *Bacillus aryabhattai A08*<br>- *Paenibacillus barcinonensis A10*<br>- *Paenibacillus alvei T30*<br>- *Bacillus cereus N10w* | - Oribatid mites (*Scheloribates species, Scheloribates praeincisus, Scheloribates fimbriatus africanus*)<br>- *Stratiolaelaps scimitus* | (Compendium, 2021h; Radwan, Farrag, Abu-Elamayem, & Ahmed, 2012; Ramakrishnan & Neravathu, 2019; Viljoen, Labuschagne, Fourie, & Sikora, 2019; S.-H. Yang, Wang, Chen, Xu, & Xie, 2020) |
| ***Tetranychus urticae* (two-spotted spider mite)** | - *Beauveria bassiana*<br>- *Bacillus thuringiensis*<br>- *Aspergillus melleus*<br>- *Aspergillus terreus*<br>- *Emericella nidulans*<br>- *Chaetomium globosum*<br>- *Lecanicillium attenuatum* 4-1<br>- *Purpureocillium lilacinum* 2R-4-6 | - *Stethorus gilvifrons*<br>- *Orius albidipennis*<br>- *Amblyseius swirskii*<br>- *Phytoseiulus persimilis* | (Compendium, 2021l; Hoza et al., 2016; Osman, Elnasr, Nawar, & Hefnawy, 2019; Shin, Bae, Kim, Yun, & Woo, 2017; Taghizadeh, Haddad Iraninejad, Iranipour, & Moghaddam Vahed, 2020) |
| ***Polyphagotarsonemus latus* (broad mite)** | - *Isaria fumosorosea*<br>- *Beauveria bassiana* | - *Amblyseius andersoni*<br>- *Neoseiulus californicus*<br>- *Neoseiulus cucumeris*<br>- *Amblyseius swirskii* | (Compendium, 2021k; LeFors, 2018; Onzo, Houedokoho, Hanna, & Liu, 2012; Satpathy, Gotyal, & Babu, 2019) |
| ***Macrosiphum euphorbiae* (potato aphid)** | - *Lecanicillium lecanii* | - *Aphidius matricariae*<br>- *Adalia bipunctata*<br>- *Aphidoletes aphidimyza*<br>- *Chrysoperla carnea*<br>- *Coccinella septempunctata*<br>- *Episyrphus balteatus*<br>- *Eupeodes corollae*<br>- *Harmonia axyridis* | (Brodeur, 2012; Compendium, 2021g; Mohammed, Kadhim, & Kamaluddin, 2018) |
| ***Myzus persicae* (green peach aphid)** | - *Beauveria bassiana*<br>- *Glomerella cingulate*<br>- *Lecanicillium lecanii* | - *Aphidius matricariae*<br>- *Ephedrus plagiator*<br>- *Adalia bipunctata*<br>- *Anthocoris sibiricus*<br>- *Aphidoletes aphidimyza*<br>- *Chrysopa formosa*<br>- *Chrysoperla carnea*<br>- *Coccinella septempunctata*<br>- *Episyrphus balteatus*<br>- *Propylea quatuordecimpunctata*<br>- *Scaeva pyrastri* | (Abbas, Khan, & Sohail, 2015; Amnuaykanjanasin et al., 2013; Compendium, 2021i; Ikeura, 2014; Li et al., 2018; Rotari, Tălmaciu, & Tălmaciu, 2011) |

| Solanaceous pest | Microbial biological control agents | Parasite and Predatory species | Authors |
|---|---|---|---|
| ***Thrips tabaci*** **(onion thrips)** | - *Beauveria bassiana*<br>- *Lecanicillium lecanii* | - *Nabis pseudoferus*<br>- *Amblyseius swirskii*<br>- *Chrysoperla carnea*<br>- *Coccinella septempunctata*<br>- *Deraeocoris serenus*<br>- *Eupeodes corollae*<br>- *Nabis pseudoferus*<br>- *Nabis rugosus* | (Annamalai, Kaushik, & Selvaraj, 2016; Compendium, 2021m; Rotari et al., 2011; Wu et al., 2013) |
| ***Frankliniella occidentalis*** **(Californian thrips)** | - *Beauveria bassiana*<br>- *Lecanicillium lecanii* | - *Amblyseius swirskii* | (Compendium, 2021b; Hoza et al., 2016; Zhang, Lei, Reitz, Wu, & Gao, 2019) |
| ***Liriomyza trifolii*** **(celery leaf miner)** | - *Bacillus thuringiensis*<br>- *Beauveria bassiana* | - *Orius dissitus* | (Compendium, 2021f) |
| ***Tuta absoluta*** **(tomato leaf miner)** | - *Bacillus thuringiensis*<br>- *Beauveria bassiana* | - *Copidosoma spp.*<br>- *Diadegma spp.*<br>- *Necremnus tutae*<br>- *Trichogramma spp.*<br>- *Nabis pseudoferus* | (Allegrucci, Velazquez, Russo, Pérez, & Scorsetti, 2017; Compendium, 2021o; Manohar, Sharma, Verma, Sharma, & Chandel, 2020) |
| ***Helicoverpa armigera*** **(cotton bollworm)** | - *Bacillus thuringiensis*<br>- *Beauveria bassiana* | - *Copidosoma spp.*<br>- *Bracon brevicornis*<br>- *Compsilura concinnata*<br>- *Exorista larvarum*<br>- *Exorista xanthaspis*<br>- *Trichogramma spp.*<br>- *Argiope brunnichii*<br>- *Chrysoperla carnea*<br>- *Chrysopa formosa*<br>- *Chrysopa pallens*<br>- *Coccinella septempunctata*<br>- *Passer domesticus* | (Compendium, 2021d; B. Liu et al., 2016; Pereira, Reigada, Diniz, & Parra, 2019; Rana, Chand, & Patyal, 2014) |
| ***Bemisia tabaci*** *(tabacco whitefly)* | - *Bacillus thuringiensis*<br>- *Lecanicillium lecanii*<br>- *Beauveria bassiana* | - *Encarsia formosa*<br>- *Amblyseius swirskii*<br>- *Chrysoperla carnea*<br>- *Coccinella septempunctata*<br>- *Eupeodes corollae* | (Compendium, 2021a; Salazar-Magallon, Hernandez-Velazquez, Alvear-Garcia, Arenas-Sosa, & Peña-Chora, 2015; Q. L. Wang & Liu, 2016) |
| ***Trialeurodes vaporariorum*** **(glasshouse whitefly)** | - *Bacillus thuringiensis*<br>- *Lecanicillium lecanii*<br>- *Beauveria bassiana* | - *Chrysopa pallens*<br>- *Chrysoperla carnea*<br>- *Coccinella septempunctata*<br>- *Deraeocoris serenus*<br>- *Propylea quatuordecimpunctata*<br>- *Encarsia formosa* | (Compendium, 2021n; Oreste, Bubici, Poliseno, & Tarasco, 2016; Rotari et al., 2011) |
| ***Halyomorpha halys*** **(brown marmorated stink bug)** | - | - *Trissolcus flavipes* | (Compendium, 2021c; Y. Yang et al., 2015) |

| Solanaceous pest | Microbial biological control agents | Parasite and Predatory species | Authors |
|---|---|---|---|
| ***Nezara viridula* (southern green stink bugs)** | - *Bacillus thuringiensis*<br>- *Beauveria bassiana* | - *Telenomus chloropus*<br>- *Trissolcus grandis* | (Compendium, 2021j; Hasnah, Susanna, & Sably, 2012) |
| ***Leptinotarsa decemlineata* (Colorado potato beetle)** | - *Bacillus thuringiensis*<br>- *Beauveria bassiana* | - *Meigenia mutabilis*<br>- *Ardea cinerea*<br>- *Chrysoperla carnea*<br>- *Nabis rugosus*<br>- *Coccinella septempunctata*<br>- *Hexamermis spp.*<br>- *Formica pratensis*<br>- *Formica rufa*<br>- *Passer domesticus*<br>- *Perdix perdix*<br>- *Perillus bioculatus*<br>- *Phasianus colchicus*<br>- *Pica pica*<br>- *Pterostichus cupreus* | (Compendium, 2021e; Rotari et al., 2011; Sorokan et al., 2020) |

The insecticidal properties of MBCA, like *Bacillus thuringiensis, Beauveria bassiana, Lecanicillium lecanii, Glomerella cingulate, Isaria fumosorosea*, are used to provides evidence that MBCA are efficient not only to decreased the number of pests but also to reduce the spread to the next host. Plant-promoting rhizobacteria (PGPR) can increase reduction of the gall numbers of *M. incognita* up to 86% (Viljoen et al., 2019). Also, fungi are a promising source of bioactive secondary metabolites against various agricultural pests (Osman et al., 2019). Both *Isaria fumosorosea* and *Beauveria bassiana* recorded significantly higher mortality of broad mite (Satpathy et al., 2019). Plants that were treated by *L. lecanii* showed a significant reduction in the number of *M. persicae* and *A. gossypii.* Although *M. euphorbiae* is less susceptible to *L. lecanii* infection in laboratory experiments, this entomopathogen is still effective against this pest (Mohammed et al., 2018).

The use of parasites and predators in biological control programs revealed spectacular economic and ecological results (Hajek & Eilenberg, 2018). The species presented in this paper contributed to the suppression of pests from *Solanaceae* crops. The use of natural predators has led to the protection of biodiversity and the protection of vegetable crops. For example, studies on the activity of natural enemies for *H. armigera* have shown that the diversity and abundance of natural enemies tends to be higher in crops that have not been sprayed with insecticides (Downes et al., 2017). Scheloribates mites in the soil are effective predators against juvenile nematodes. Following a study by Ramakirishnan (2019) , it was shown that after the introduction of mites into the soil, juveniles of *M. incognita* not only decreased numerically, but also reduced the spread to the next host (Ramakrishnan & Neravathu, 2019). Another study tested the effectiveness of *Stratiolaelaps scimitus* in feeding on *M. incognita*. It was concluded that *S. scimitus* could develop normally and can complete its life cycle by feeding only on the harmful nematode. In fact, it is found to be an effective predator and an effective enemy of nematodes (S.H. Yang et al., 2020). The results of a study by Tagizadeh et al. (2020) on the efficacy of predation rate of *T. urticae* showed that both *Stethorus gilvifrons* and *Orius albidipennis* are promising biological control agents of the pest. However, the species *Stethorus gilvifrons* proved to be a superior predator in terms of population growth parameters, predation rate and ability to convert prey biomass into predatory offspring (Taghizadeh et al., 2020). Four predatory mites (*Amblyseius andersoni, Neoseiulus californicus, Neoseiulus cucumeris and Amblyseius swirskii)* are utilized as biocontrol agents for *P. latus*. The efficacy of these predatory mites could be affected by seasonal changes in broad mite densities caused by dispersal, but the mites would make very good predators of the broad mite (LeFors, 2018; Onzo et al., 2012). The ladybird beetle *Coccinella septempunctata* is one of the most widespread aphidophagous coccinellids and has proved to be an effective biocontrol agent for selected aphid species such as *Macrosiphum euphorbiae*, *Myzus persicae nicotianae*, etc. (Norkute, Olsson, & Ninkovic, 2020).

## CONCLUSIONS

Given demand, plants of the *Solanaceae* family are the most cultivated. Whether grown in greenhouses or in open fields, pests can affect roots, leaves or fruits and therefore decrease crop yields. Thus, knowledge of harmful fauna, pathogens, parasites, and predators can enhance the results of pest management practices.

The method of biological pest control has been practiced for centuries and is a cost-effective, environmentally friendly approach to solving the problems of vegetables agroecosystems.

MBCA, predators and parasitoids are important in pest management and have proven to be an excellent alternative to chemical pesticides. The main pathogens for solanoceus pests observed in Romania are represented by *Bacillus thuringiensis*, *Beauveria bassiana* and *Lecanicillium lecanii*. Also, there are many parasites and predators described in the literature for Romania solanaceous plants, as shown in Table 2, and they need national protection programs.

This review of the major pest of *Solanaceae* family crop may serve as a base in developing recommendations for sustainable management of vegetables pests. Also, the species of pests recently entered in the Romanian fauna, such as *Nezara viridula*, suggest the importance and critical need for the permanent monitoring of pests from vegetables crops.

Future field studies may increase the list of pests but also of pathogens, parasites, and predators.

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