

CONVENTIONAL AND BIOLOGICAL CONTROL OF PESTS IN PEPPERS AND EGGPLANTS CROPS IN THE GREENHOUSE. A REVIEW

Simona HOGEA, Gabriela ȘOVĂREL

Romania Research and Development Institute for Vegetable and Flower Growing Vidra,
22 Calea București, Vidra, Ilfov, Romania

Corresponding author email: gabriela_sovarel@yahoo.com

Abstract

*The paper presents the main pests that affect peppers and eggplants crops and chemical and biological methods to control. In the 2010-2021 period, in Romania, the average area of eggplants was 9233,75 hectares and in peppers case was 18745.5 hectares. The most common pests in peppers and eggplants crops are trips, whiteflies, aphids, mites and caterpillars. Even though the use of pesticides can reduce the percentage of damage caused by pests, they are less and less used worldwide due to several disadvantages. To reduce the amount of pesticides used, more and more studies are being conducted on the application of biological products based on plant extracts (such as citrus, cinnamon, mimosa tenuiflora and seaweed extract) or microorganisms (*Bacillus thuringiensis*) and on the release of parasites and predators (*Macrolophus pygmaeus*, *Amblyseius swirskii*, *Chrysoperla carnea* etc.) to reduce risks to human health and the environment.*

Key words: control, eggplant, pepper, pest.

INTRODUCTION

In recent years, agriculture has been subjected to excessive use of chemicals, which has caused significant damage to the soil, climate, water and global ecosystem of our planet. (Barcanu et al., 2023). Pesticides are often used to help increase pepper crop production by reducing damage caused by pests. This could improve farmers profitability in pepper production (Oerke et al., 2004; Shim et al., 2023). However, it is important to note that the use of pesticides can also have negative effects, including risks to human health and the environment (Radwan et al., 2005; Shim et al., 2023). The World Health Organization (WHO) reported that approximately three million cases of pesticide poisoning occur annually worldwide, of which 220,000 cases are fatal (Shim et al., 2023).

In response to these challenges, there is now a concerted effort to develop and adopt organic farming practices to remedy the damage and prevent further damage. Organic farming has become a vital objective of the European Commission, aiming for at least 25% of agricultural land to be dedicated to organic crops by 2030 (Barcanu et al., 2023). Practicing organic farming systems can be solutions to

these problems, and their role will contribute to improving food security through survival (Sterie et al., 2023).

The global harvested area of eggplant was estimated at 1.85 million hectares in 2019, with a production of nearly 33 million tons, where China, India, Indonesia, Egypt, Turkey, the Philippines and Iran are major producers with 90% of the total global area (FAO, 2019; Nayak et al., 2021). The total vegetable area in Romania recorded 262.7 thousand acres in 2010, reaching 197.7 thousand hectares in 2021, showing a decrease of 24%. The average area under eggplants in Romania in the period 2010-2021 was 9233.75 hectares, varying between 8576 hectares (2020) and 10315 hectares (2010), presenting a negative growth rate (-1.13%). In the case of areas under peppers, they varied between 17188 hectares (2020) and 21005 hectares (2010), with a period average of 18745.5 hectares (Sterie et al., 2023). The harvested area of eggplants in 2022 was estimated at 4140 ha, with a production of 15594.2 kg/ha, and in 2021 it was 4940 ha and a production of 19404.9 kg/ha (FAOSTAT).

There are many advantages to growing plants in high tunnels, but there are also disadvantages such as reduced ventilation which can lead to an

increase in temperature and relative humidity, leading to a favorable environment for the emergence and development of pests (Weintraub, 2006).

Both eggplant and pepper crops are attacked by pests from the seedling stage to the mature plant stages (El Arnaouty et al., 2020). Pests that can reduce production through qualitative and quantitative depreciation are thrips, whiteflies, aphids, mites and caterpillars. Also, some of the insects listed can transmit viruses and bacteria (Shim et al., 2023).

PESTS IN PEPPERS AND EGGPLANTS CROPS

Thrips

Thrips is one of the main pests of crops in protected areas, causing damage and production losses in many vegetable crops. They can cause direct damage due to feeding and oviposition, as well as indirect damage by transmitting plant viruses such as Tospoviruses (Rosenheim et al., 1990; Visschers et al., 2023). It is a polyphagous insect that has the ability to quickly develop resistance to insecticides. The most harmful species are *Frankliniella occidentalis*, *Trips tabaci*, *Thrips palmi* and western flower thrips (WFT) (Lewis, 1997; Weintraub, 2006).

Larvae and adults of thrips can be identified on the leaves, the vegetative tops, flowers and fruit and suck the sap out of tissue. As a result of the attack, discoloring spots appear, which in time become silver or even brown (Hoza et al., 2016). Thrips like many other pests are becoming resistant to many insecticides, but attempts to control the virus they vector are unsuccessful because thrips can transmit the pathogen faster than they acquire a lethal dose of insecticide (Todd et al., 1996; Weintraub, 2006).

Whiteflies

Among the whiteflies the two species, the sweetpotato whitefly, *Bemisia tabaci* and the greenhouse whitefly, *Trialeurodes vaporariorum* cause most of the damage (Nauen et al., 2014; Perring et al., 2018). These whiteflies, using mouthparts modified for sucking, damage plants by removing sap, excreting honeydew, vectoring plant-limiting viruses (Perring et al., 2018) and can be found both in greenhouses and open field. Severe

infestation of whitefly adults and progeny can cause seedling death or a reduction in the vigor and yield of plants (Kumar et al., 2019; Horowitz et al., 2020; Zayed et al., 2022).

These pests can be found in crops like pepper, eggplant, cucumber, tomato, bean etc. (Șovărel et al., 2022).

Mites

The principal spider mites in horticulture crops is *Tetranychus urticae* known as the two-spotted spider mite. This mite has needle-like chelicerae which pierce plant cells, often feeding on chloroplasts on the undersurface of the leaf (Zhang, 2003; Weintraub, 2006). In Romania, the pest attacks crops of eggplant, peppers, cucumbers, beans, tomatoes etc. (Călin et al., 2017). As a result of the attack, upper leaf surfaces develop whitish or yellowish stippling and produce silk webbing which covers the leaves (Weintraub, 2006).

The broad mite, *Polyphagotarsonemus latus*, is an important pest in tropical and subtropical regions which attacks young, growing plant parts (Weintraub et al., 2003). This mite is 0.1-0.3 mm long, also known as the white mite, and is found in the apical portion of plants, especially in shoot structures (Venzon et al., 2008). Being very small and difficult to detect, usually feeds on the lower leaf surface and causes leaf edges to become rigid and roll under, and causes distortion and discoloration of flowers and blistering of fruits (Weintraub, 2006). Usually the damage begins in small clumps, but infestations can spread rapidly (Venzon et al., 2008).

Aphids

Among the aphids, the green peach aphid, *Myzus persicae* is widely distributed in temperate regions, being a polyphagous insect pest of protected vegetables (Wang et al., 2021), with more than 800 host plant species (Raeyat et al., 2021). Another problematic aphids are *Macrosiphum euphorbiae*, *Aphis gossypii* and *Aulacorthum solani* (Sanchez et al., 2011).

The aphids form crowded colonies on the underside and upper side of the leaves, later dispersed on the flowers (Costache et al., 2023). The main problems caused by aphids are that they are vectors of viruses and produce a large

amount of honeydew that they leave on the plants (Sanchez et al., 2011).

Aphid control is very important and can be achieved through preventive and curative methods: IPM, barrier crops integrating companion cropping and nitrogen application, agronomic, biological and botanical practices (Călin et al., 2020).

Caterpillars

The main insect species that cause damage on plants foliage and fruits are *Helicoverpa armigera* and *Spodoptera exigua*.

H. armigera damages 68 plant families, more than 350 species of plants (Kuznetsov, 1999; Cunningham & Zalucki, 2014; Terlemezyan et al., 2024). The larvae cause the main problems, because its feeding with vegetative parts of the plants and with buds, inflorescences, fruits and pods (Suzana-Milan et al., 2022; Terlemezyan et al., 2024).

S. exigua attacks the leaves and fruits, causing damages to over 185 species of plants belonging to 50 families (Terlemezyan et al., 2024). The caterpillars are usually found on the back of the leaves, where they feed, destroying the leaf tissues, leaving only the veins that maintain the leaf's shape (Terlemezyan et al., 2024).

AGROPHYTOTECHNICAL METHODS

The efficiency of control actions and the reduction of production losses caused by harmful insects in vegetable crops are conditioned by the application of a complex of agrophytotechnical measures (Costache et al., 2023). The main agrophytotechnical measures are crop rotation, cultivation of resistant/tolerant hybrids and varieties, planting on soil mulched with foil (inhibits weed growth, maintains soil temperature and moisture, protects the soil from erosion caused by wind or water, leaching of fertilizers, especially on sandy soils, as well as protecting against infection and the development of soil-borne diseases) (Moursy et al., 2015), plant nutrition: seaweed-based biostimulators can be used successfully in the eggplant fertilization program (Constantin et al., 2023) and peppers need a significant amount of nitrogen, which helps the plant grow (Constantin et al., 2024), crops irrigation, mechanized and manual plows, phytosanitary

hygiene measures (periodic removal of affected organs and plants from the crop) etc.

CHEMICAL CONTROL

Pesticides are the main method for disease and pest management and the productivity of crops depends on their effective control (Jeyanthi & Kombairaju, 2005). Most chemical insecticides are very effective in controlling pests, however, few pesticides are safe for use and storage (Iosob et al., 2021).

Over time, pests have developed resistance to pesticides due to their excessive use (some example of conventional insecticides: organophosphates, carbamates and synthetic pyrethroids; Kodandaram et al., 2010).

Pesticides with active substance thiamethoxam and acetamaprid were used to control whitefly (Kalaf & Dawood, 2020) in the past, this substances are banned now. The product Avaunt (indoxacarb) was used against whitefly nymphs, which reduced the pest population density from 7.51 to 1.01 after 14 days of treatment (Patel et al., 2014).

The active substance abamectine was used to control thrips, mites and leafminer flies and imidacloprid to control whitefly, thrips and aphids. Jodeh et al. (2016) noticed that the amount of imidacloprid and abamectine residues were very high even after the first day of treatment. Was demonstrate that photodegradation caused a decrease of the pesticide residues in the plant parts (Jodeh et al., 2016). The products with these substances are also banned.

In Romania, in this moment, the following substances are approved for pest control in pepper crops: hexythiazox, deltamethrin, acetamiprid, flonicamid, emamectin benzoate, and for eggplant crops: hexythiazox, chlorantraniliprole.

Hexythiazox is an acaricide used for the control of many phytophagous mites. Glăvan et al. (1993) claim that the product based on hexythiazox in a concentration of 0.1% caused a mortality, in the mobile stages of the pest *T. urticae*, of 100% (12 days after treatments) in the Ișalnița area and of 93.44-97.07% in the Vidra area (Romania). They also found that the product's effectiveness on eggs is lower (67.70% - 12 days after treatment).

BIOLOGICAL CONTROL

Excessive use of pesticides increases the cost of production, causes human health problems and environmental pollution (Jeyanthi and Kombairaju, 2005). Controlling pests in crops under high plastic tunnels by chemical pesticides has conducted to several problems such as development of resistance and raising environmental and health concerns (El Arnaouty et al., 2020).

In order to reduce the amount of pesticides used, more and more studies are being carried out on the application of biological products based on plant extracts (such as citrus, cinnamon, mimosa tenuiflora and seaweed extract) or microorganisms (*Bacillus thuringiensis*) and on the release of parasitoids (*Aphidius colemani*) and predators (*Macrolophus pygmaeus*, *Amblyseius swirskii*, *Chrysoperla carnea*, *Coccinella septempunctata* etc.) to minimize risks to human health and the environment.

Biological products will not completely eliminate pest problems, but they can reduce pest populations and damage to a reasonable level (below the economic threshold). Applying biological control generally requires more time than chemical control to bring a pest population to an acceptable level of control (El Arnaouty et al., 2020). Despite their beneficial effect on environmental quality, biopesticides generally have several limiting characteristics (rapid degradation in sunlight, air and humidity) that make them less accepted by large farming communities, being recognized and used mainly in organic agriculture in developed countries (Cenușă et al., 2016).

Classes of insecticides have been marketed that are not persistent or bioaccumulative and have few effect on mammals, but can be very toxic to aquatic invertebrates. These are based on citrus, neem azadirachtin, garlic, chili pepper derivatives, and limonene from citrus peel (Sarwar & Salman, 2015).

Neem oil is extracted from the neem seeds of *Azadirachta indica*, a tree native to India that grows in poor, degraded soils and semi-arid climates. The oil extracted from these seeds has repellent, antifendant and insecticidal properties (Siegwart et al., 2015). Neem extracts work against chewing and sucking insects such as lepidopterous caterpillars and beetle larvae (Xu

et al., 2008). The active ingredient accumulates in the growing tips of the treated plants, usually reaching functional levels within 24 hours of foliar spraying (Xu et al., 2008).

Bacillus thuringiensis is an aerobic bacterium, Gram-positive, of the bacilli family and is widely present in soil, water, air and plants in its vegetative form, being the most common and described bioinsecticide in the world (Raymond et al., 2010; Siegwart et al., 2015).

Aphidius colemani is a parasitic wasp of aphids which laid eggs directly in the aphid body, hatch and consume the aphid. After that the body of aphids bloats and develops a hard shell. When the wasp reaches maturity cuts a circular hole and escapes (Weintraub, 2006). The advantage of parasitoids is that they can develop in large numbers before aphid pests are observed and a continuous supply of parasitoids is ensured over a period of several weeks (Weintraub, 2006).

Macrolophus pygmaeus is native to the Mediterranean region and often occurs in greenhouses or tunnels, where pesticides have not been applied for a long time (Ramzi et al., 2022). It feeds on with plant tissue and attacks pests like whiteflies, thrips, aphids, spider mites, leaf miners and *Lepidoptera* species including *Tuta absoluta* (Urbaneja et al., 2009; Zhang et al., 2022).

Amblyseius swirskii is a mite used to control thrips in pepper, eggplant and cucumber crops grown in greenhouse. Some research showed that predator provided better control on the foliage of pepper plants, compared with the flowers (Călin et al., 2020). Another research made in Turkey showed that releasing 50 adults/sqm of *A. swirskii* can control the thrips attack, even on the long term in pepper crops in heated and not heated tunnels (Kutuk et al., 2011; Hoza et al., 2016).

Chrysoperla carnea is a generalist predator that spontaneously appears in crops (Weintraub, 2006). Have been recorded as an effective predator of aphids (Liu & Chen, 2001), coccids, mites and mealy bugs (Zaki & Gesraha, 2001; Sattar et al., 2011).

Coccinellid predators are usually utilized for aphid control, since many species can reduce aphid populations in greenhouses (Skouras et al., 2023). *Coccinella septempunctata* known as the seven-spotted lady beetle, is an important biological control agent which can be found in

a wide range of agricultural and/or natural habitats or crops all over the world (Singh et al. 2004) and can prey more than 20 aphid species, as well as species of *Psylloidea* and *Tetranychidae* (Skouras et al., 2023). Bratu (1998) states that the *T. urticae* attack superimposed on that of the *M. persicae* species, negatively influences the efficiency of the *C. septempunctata* predator, reducing it by up to 14.9 - 52.0%.

Another method to control is baculoviruses as insecticides, being ideal tools in IPM programs. About 60 baculovirus-based pesticides have been utilized to control diverse insect pest all over the world (Beas-Catena et al., 2014). Insect viruses are unable to infect mammals and humans, being very safe to handle. Because the most insect viruses are relatively specific the risk of non-target effects on beneficial insects is very low (Gupta & Dikshit, 2010) with no or negligible effects on non-target organisms (beneficial insects, vertebrates and plants) (Yaqoob et al., 2016; Gelaye & Negash, 2023). Most baculoviruses infect caterpillars, which are the immature form of moths and butterflies (Rodriguez et al., 2012; Gelaye & Negash, 2023).

CONCLUSIONS

To minimize pesticide residues, which directly and indirectly affect the human population, fauna and the environment, farmers globally are adopting biological control, less harmful. Biological control of insect pests can be achieved by applying biological pesticides and releasing parasites and predators (*Macrolophus pygmaeus*, *Amblyseius swirskii*, *Chrysoperla carnea*, *Coccinella septempunctata* etc.) into crops.

It is also important to apply a complex of agrophytotechnical measures to increase the efficiency of control measures and means (chemical or biological).

ACKNOWLEDGEMENTS

This research work was carried out with the support of Ministry of Agriculture and Rural Development, financed from Project ADER 6.3.15/2023 – Integrated management for the control of pest agent in the main vegetable

species grown in greenhouses in conventional and organic system.

REFERENCES

- Barcanu, E., Agapie, O., Gherase, I., Tanase, B., & Dobre, G. (2023). Evaluating cultivars for organic farming: tomatoes, peppers and aubergine in south Romania. *Agriculture & Food*, Vol. 11, ISSN 1314-8591.
- Beas-Catena, A., Sanchez-Miron, A., Garcia-Camacho, F., Contreras-Gomez, A., & Molina-Grima, E. (2014). Baculovirus pesticides: an overview. *The Journal of Animal & Plant Sciences*, 24(2), page 362-373, ISSN: 1018-7081.
- Bratu, E. (1998). Efficiency of the predator *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) released in egg stage to reduce populations of the pest *Myzus persicae* Sulz. in pepper crops. *Anale I.C.D.L.F.*, Vol. XV, pp.215-227, ISSN 0250-2917.
- Călin, M., Cristea, T.I., Ambăruș, S., Brezeanu, C., Brezeanu, P. M., Muscalu, S. P., Costache, M., Șovărel, G., & Bratu E. (2017). Biological control of two-spotted spider mite in pepper and melon crops cultivated in tunnels. *Scientific papers. Seria B Horticulture*, Volume LVI, pag. 347–352.
- Călin, M., Cristea, T.I., Ambăruș, S., Brezeanu, C., Brezeanu, P. M., Iosob, G.A., Muscalu, P.S., Calara, M., Bute, A., & Prisecaru, M. (2020). Behavior of vegetable plant seeds at aphids attack and control of these pests. *Biologie*, 29/2, pp 70-74, Universitatea "Vasile Alecsandri" din Bacău.
- Călin, M., Cristea, T.O., Brezeanu, P.M., Ambarus, S., Brezeanu, C., Muscalu, S.P., Sova, F., Antal, C.A., Prisecaru, M., Costache, M., Sovarel, G., Bratu, L., Burnichi, F., & Sbirciog, G. (2020). Biological control of pepper pests in organic agriculture. *Acta Hort.* 1269. ISHS, DOI 10.17660/ActaHortic.2020.1269.22.
- Cenușă, A.E., Șovărel, G., Costache, M., & Bratu, E. (2016). Effect of some "bio-insecticides" used against two spotted spider mites (*Tetranychus urticae* KOCH.) in the cucumbers crop under plastic tunnels conditions. *Scientific Papers. Series B, Horticulture*. Vol. LX, Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653.
- Constantin, D. C., Gheorghe, M.C., Buzatu, M.A., & Scurtu, I. (2023). The role of biostimulants in the fertilization program in eggplant. *Romanian Journal of Horticulture*, Vol. IV, pp 59-64, 10.51258/RJH.2023.06.
- Constantin, D. C., Paraschiv, M., & Sbirciog, G. (2024). The impact of foliar treatments on yield and quality of round pepper (*Capsicum annuum* L.) at Asteroid 204 cv. *Romanian Journal of Horticulture*, Vol. V, pp 35-42, 10.51258/RJH.2024.04.
- Costache, M., Sovarel, G., Hoge, S., & Cenușă, E. (2023). *Bolile și dăunătorii culturilor de legume din spații protejate și câmp. Recunoaștere și combatere*. Editura PIM Iasi, pp 131, ISBN 978-606-13-8010-7.
- Cunningham, J.P., & Zalucki, M.P. (2014). Understanding heliothine (Lepidoptera: Heliothinae)

- pests: what is a host plant? *J. Economic Entomology*, 107: 881-965. doi: 10.1603/EC14036.
- El Arnaouty, S. A., El-Heneidy, A. H., Afifi, A., Heikal, I. H., & Kortam, M. N. (2020). Comparative study between biological and chemical control programs of certain sweet pepper pest in greenhouses. *Egyptian Journal of Biological Pest Control* 30:28, <https://doi.org/10.1186/s41938-020-00226-z>
- Gelaye, Y., & Negash, B. (2023). The role of baculoviruses in controlling insect pests: A review. *Cogent Food & Agriculture*, 9: 2254139. <https://doi.org/10.1080/23311932.2023.2254139>.
- Glăvan, L., Negru, G., Popescu, A., Szabo, Al., Bratu, E., & Tudose, M. (1993). Effectiveness of some new biological products in the control of certain pests in the vegetable crops. *Anale I.C.D.L.F., vol. XII*, pp. 163–172, ISSN 0250-2917.
- Gupta, S., & Dikshit, A. (2010). Biopesticides: An ecofriendly approach for pest control. *Journal of Biopesticides*, 3(1), 186–188.
- Horowitz, A.R., Ghanim, M., Roditakis, E., & Nauen, R.; Ishaaya, I. (2020). Insecticide resistance and its management in *Bemisia tabaci* species. *J. Pest Sci.*, 93, 893–910.
- Hoza, G., Dobrin, I., Dinu, M., Becherescu, A., Ilie, V., & Catuneanu Bezdadea, I. (2016). Research regarding the use of natural predators for the control of pests for pepper in protected culture. *Agriculture and Agricultural Science Procedia* 10, 192–197.
- Iosob, G.A., Cristea, T.O., Bute, A., & Avasiloaiei, D-I. (2021). Biological control of pests in cucurbitaceous vegetables: an overview. *Biologie*, 30/2, pp. 68-76, Universitatea "Vasile Alecsandri" din Bacău.
- J.A. Sanchez , M. La-Spina , J.M. Michelena , A. Lacasa & A. Hermoso de Mendoza (2011). Ecology of the aphid pests of protected pepper crops and their parasitoids. *Biocontrol Science and Technology*, 21:2, 171-188.
- Jeyanthi, H., & Kombairaju, S. (2005). Pesticide use in vegetable crops: frequency, intensity and determinant factors. *Agricultural Economics Research Review*, vol. 18, pp 209-221.
- Jodeh, S., Al Masri, S., Haddad, M., Hamed, O., Jodeh, D., Salghi, R., Radi, S., Amarah, J., El-Hajjaji, F., & Warad, I. (2016). Evaluation of potential Residue of Imidacloprid and Abamectin in cucumber and pepper plants after spraying using high performance liquid chromatography (HPLC). *J. Mater. Environ. Sci.* 7(3), pp. 1037 – 1047, ISSN: 2028-2508.
- Kalaf J., M., & Dawood, S., H. (2020). Test of the chemical pesticides effect and some Biological agents in the control of white fly nymphs, *Bemisia tabaci* (Genn) on Eggplant. *International Journal of Agricultural and Statistical Sciences.*, Vol. 16, Supplement 1, pp. 1289-1294. DocID: <https://connectjournals.com/03899.2020.16.1289>.
- Kodandaram, M.H., Rai, A.B., & Halder, J. (2010). Novel insecticides for management of insect pests in vegetable crops: A review. *Veg. Sci.* 37(2): 109-123.
- Kumar, P., Naqvi, A.R., Meena, R.S., & Mahendra, M. (2019). Seasonal incidence of whitefly, *Bemisia tabaci* (Gennadius) in tomato (*Solanum lycopersicum* Mill). *Int. J. Chem. Stud.*, 7, 185–188.
- Kutuk, H., Yigit, A., Canhilal, R., & Karacaoglu, M. (2011). Control of western flower thrips (*Frankliniella occidentalis*) with *Amblyseius swirskii* on greenhouse pepper in heated and unheated plastic tunnels in the Mediterranean region of Turkey. *African Journal of Agriculture Research* vol. 6(24), pg. 5428-5433.
- Kuznetsov, V.I. (1999). *Insects and mites are pests of agricultural crops. Volume III. Lepidoptera. Part 2*. St. Petersburg: Publishing house "Nauka". 410 p.
- Lewis T (1997). *Thrips as Crop Pests*. CAB International, Wallingford.
- Liu, T-X., & Chen, T-Y. (2001). Effects of three aphid species (Homoptera: Aphididae) on development, survival and predation of *Chrysoperla carnea* (Neuroptera: Chrysopidae). *Appl. Entomol. Zool.* 36(3): 361-366.
- Moursy, F. S., Mostafa, F. A., & Solieman, N. Y. (2015). Polyethylene and rice straw as soil mulching: reflection of soil mulch type on soil temperature, soilborne diseases, plant growth and yield od tomato. *Global Journal of Advanced Research*, vol. 2, Issue 10, pp. 1497-1519, ISSN: 2394-5788.
- Nauen, R., Ghanim, M., & Ishaaya, I. (2014). Whitefly special issue organized in two parts. *Pest Management Science*, 70, 1438–1439.
- Nayak, S.B., Rao, K.S., & Mekala, S. (2021). *Management of important insect-pest o eggplant (Solanum melongena L). Solanum melongena: Production. Cultivation and Nutrition*, ISBN: 978-1-68507-311-4.
- Oerke, E.C., & Dehne, H.W. (2004). Safeguarding production - Losses in major crops and the role of crop protection. *Crop Prot.*, 23,275–285.
- Patel, R., T.M. Bharpoda, N.B. Patel, & P.K. Borad (2014). Bio-efficacy of cyantraniliprole 10% od-ananthranilic diamide insecticide against sucking pests of cotton. *International Quarterly Journal of life sciences Bioscan*, 9(1), 89-92.
- Perring, T.M., Stanly, P.A., Liu, T.X., Smith, H.A., & Andreason, S.A. (2018). Whiteflies: Biology, Ecology, and Management. In: Wakil, W., Brust, G.E., Perring, T.M. (Eds.), *Sustainable Management of Arthropod Pests of Tomato. Academic Press, Elsevier*, pp. 73–110. ISBN: 9780128024416.
- Radwan, M.A., Abu-Elamayem, M.M., Shiboob, M.H., & Abdel-Aal, A. (2005). Residual behavior of profenofos on some field-grown vegetables and its removal using various washing solutions and household processing. *Food Chem. Toxicol.*, 43, 553–557.
- Raeyat, Z., Razmjou, J., Naseri, B., Ebadollahi, A., & Krutmuang, P. (2021). Evaluation of the Susceptibility of Some Eggplant Cultivars to Green Peach Aphid, *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). *Agriculture*, 11, 31. <https://doi.org/10.3390/agriculture11010031>.
- Ramzi, S., Madahi, K., Lotfollahi, P. & Azimi, S. (2022) Can host plants affect egg predation of two-spotted spider mite by *Macrolophus pygmaeus* (Hemiptera: Miridae)?, *Persian Journal of Acarology*, 11(2): 309–322.
- Raymond, B., Johnston, P., Nielsen-Leroux, C., Lereclus, D., & Crickmore, N. (2010). *Bacillus thuringiensis*: an

- impotent pathogen? *Trends Microbiol.* 18, 189–194. doi: 10.1016/j.tim.2010.02.006.
- Rodriguez, V. A., Belaich, M. N., & Ghiringhelli, P. D. (2012). Baculoviruses: Members of Integrated Pest Management Strategies. In *Integrated Pest Management and Pest Control-Current and Future Tactics*, pp. 463–480. <https://doi.org/10.5772/32779>.
- Rosenheim, J.A., Welter, S.C., Johnson, M.W., Mau, R.F.L., & Gusukuma-Minuto, L.R. (1990). Direct Feeding Damage on Cucumber by Mixed-Species Infestations of *Thrips palmi* and *Frankliniella occidentalis* (Thysanoptera: Thripidae). *J. Econ. Entomol.*, 83, 1519–1525.
- Sarwar, M., & Salman, M. (2015). Success stories of eco-friendly organically acceptable insecticides as natural products discovery. *International Journal of Materials Chemistry and Physics Vol. 1*, No. 3, pp. 388–394 <http://www.aiscience.org/journal/ijmcp>.
- Sattar, M., Abro, G.H., & Syed, T.S. (2011). Effect of different hosts on biology of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) in Laboratory Conditions. *Pakistan J. Zool.*, vol. 43 (6), pp. 1049–1054.
- Shim, J.-H., Eun, J.-B., Zaky, A.A., Hussein, A.S., Hacimüftüoğlu, A., & Abd El-Aty, A.M. (2023). A Comprehensive Review of Pesticide Residues in Peppers. *Foods*, 12, 970. <https://doi.org/10.3390/foods12050970>.
- Siegiwart, M., Graillot, B., Blachere Lopez, C., Besse, S., Bardin, M., Nicot, P.C. & Lopez-Ferber, M. (2015). Resistance to bio-insecticides or how to enhance their sustainability: a review. *Front. Plant Sci.* 6:381. doi: 10.3389/fpls.2015.00381.
- Singh, S.R., Walters, K.F.A., Port, G.R., & Northing, P. (2004). Consumption rates and predatory activity of adult and fourth instar larvae of the seven spot ladybird, *Coccinella septempunctata* (L.), following contact with dimethoate residue and contam-inated prey in laboratory arenas. *Biol. Control*, 30, 127–133.
- Skouras, P.J., Karanastasi, E., Lycoskoufis, I., Demopoulos, V., Darras, A.I., Tsafouros, A., Tsalgatiidou, P.C., Margaritopoulos, J.T., & Stathas, G.J. (2023). Toxicity and Lethal Effect of Greenhouse Insecticides on *Coccinella septempunctata* (Coleoptera: Coccinellidae) as Biological Control Agent of *Myzus persicae* (Hemiptera: Aphididae). *Toxics*, 11, 584. <https://doi.org/10.3390/toxics11070584>
- Șovărel, G., Costache, M., & Hoge, S. (2022). *Managementul integrat pentru controlul agenților de dăunare la culturile de legume din familia Solanaceae*, Editura Pim, Iași, p. 47, ISBN 978-606-13-7222-5.
- Sterie, M.C., Stoica, G.D., Giucă, A.D., & Bogos, I.B. (2023). An overview of the vegetable sector in Romania. Conference: Competitiveness of Agro-Food and Environmental Economy DOI: 10.24818/CAFEE/2022/11/01
- Suzana-Milan, C.S., Bruschi, L., Schaeffer, A.H., Fiorentin, F.J.R., & Salvadori, J.R. (2022). Feeding preference of *Helicoverpa armigera* larvae (Lepidoptera: Noctuidae) on vegetative and reproductive organs of soybean plants. *Research, Society and Development.* 11(4): e5311426 789. doi: 10.33448/rsd-v11i4.26789.
- Terlemezyan, H.L., Manvelyan, A.A., Harutyunyan, H.R., Mkrtchyan, H.N., & Ghazaryan, M.H. (2024). Pests of *Helicoverpa armigera* (Hübner) and *Spodoptera exigua* (Hübner) in Pepper Fields in Armenia. *Indian Journal of Agricultural Research.* 1-6. doi: 10.18805/IJAR.AF-898.
- Todd, J.W., Culbreath, A.C., & Brown, S.L. (1996). Dynamics of vector populations and progress of tomato spotted wilt disease relative to insecticide use in peanuts. *Acta Hort.*, 431:491–198.
- Urbaneja, A., Montón, H., & Mollá, O. (2009). Suitability of the tomato borer *Tuta absoluta* as prey for *Macrolophus pygmaeus* and *Nesidiocoris tenuis*. *J Appl Entomol*, 133: 292–296. <https://doi.org/10.1111/j.1439-0418.2008.01319.x>
- Venzon, M., Rosado, M.C., Molina-Rugama, Duarte, V.S., Dias, R., & Pallini, A. (2008). Acaricidal efficacy of neem against *Polyphagotarsonemus latus* (Banks) (Acari: Tarsonemidae). *Crop Protection*, 27, 869–872. doi:10.1016/j.cropro.2007.10.001.
- Vischers, I.G.S., Macel, M., Peters, J.L., Sergeeva, L., Bruin, J., & van Dam, N.M. (2023). Exploring Thrips Preference and Resistance in Flowers, Leaves, and Whole Plants of Ten Capsicum Accessions. *Plants*, 12, 825. <https://doi.org/10.3390/plants12040825>.
- Wang, J., Li, S., Fang, Y., Zhang, F., Jin, Z.Y., Desneux, N., & Wang, S. (2021). Enhanced and sustainable control of *Myzus persicae* by repellent plants in organic pepper and eggplant greenhouses. *Pest Manag Sci*, DOI 10.1002/ps.6681.
- Weintraub, P.G. (2006). Review. Integrated control of pests in tropical and subtropical sweet pepper production. *Pest Management Science*, DOI: 10.1002/ps
- Weintraub, P.G., Kleitman, S., Mori, R., Shapira, N., & Palevsky, E. (2003). Control of the broad mite (*Polyphagotarsonemus latus* Banks) on organic greenhouse sweet peppers (*Capsicum annum* L.) with the predatory mite, *Neoseiulus cucumeris* (Oudemans). *Biological Control*, 27, 300–309. doi:10.1016/S1049-9644(03)00069-0.
- Xu, H.-L., Xu, R., Qin, F., Ma, G., Yu, Y., & Kumar Shah, S. (2008). Biological pest and disease control in greenhouse vegetable production. *Acta Hort.*, 767, ISHS.
- Yaqoob, A., Shahid, A. A., Samiullah, T. R., Rao, A. Q., Khan, M. A. U., Tahir, S., Mirza, S. A., & Husnain, T. (2016). Risk assessment of Bt crops on the non-target plant-associated insects and soil organisms. *Journal of the Science of Food and Agriculture*, 96(8), 2613–2619. <https://doi.org/10.1002/jsfa.7661>.
- Zaki, F.N., & Gesraha, M.A. (2001). Production of the green lacewing, *Chrysoperla carnea* (Steph.) (Neuroptera: Chrysopidae) reared on semi-artificial diet based on algae, *Chlorella vulgaris*. *J. appl. Ent.*, 125: 97–98.
- Zayed, M.S., Taha, E.-K.A., Hassan, M.M., & Elnabawy, E.-S.M. (2022). Enhance Systemic Resistance Significantly Reduces the Silverleaf Whitefly Population and Increases the Yield of Sweet Pepper,

- Capsicum annuum* L. var. *annuum*. *Sustainability*, 14, 6583. <https://doi.org/10.3390/su14116583>.
- Zhang, N. X., Andringa, J., Brouwer, J., Alba, J. M., Kortbeek, R. W. J., Messelink, G. J., & Janssen, A. (2022). The omnivorous predator *Macrolophus pygmaeus* induces production of plant volatiles that attract a specialist predator. *Journal of Pest Science*, 95(3), 1343-1355. <https://doi.org/10.1007/s10340-021-01463-3>.
- Zhang, Z-Q. (2003). Mites of Greenhouses, Identification, Biology and Control. *CAB International*, Wallingford, UK.
- WHO. Pesticide Poisoning and Public Health. 2017. Available online: https://www.who.int/whr/1997/media_centre/executive_summary1/en (<https://www.who.int/home>) <https://www.fao.org/faostat/en/#data/QCL>