Fruit Growing Research, Vol. XXXIX, 2023 DOI 10.33045/fgr.v39.2023.16
https://publications.icdp.ro/index.php

ALTERNATIVE ECOLOGICE UTILIZATE PENTRU ÎNLOCUIREA PESTICIDELOR DIN POMICULTURĂ

ECOLOGICAL ALTERNATIVES USED TO REPLACE PESTICIDES IN FRUIT CULTURE

Matache Andreea, Vanghele Nicoleta - Alexandra, Nenciu Florin, Pruteanu Augustina
National Institute of Research – Development for Machines and Installations Designed for Agriculture and Food Industry – INMA Bucharest, Romania

Abstract

The increase in dependence on synthetic pesticides applied in fruit growing has raised, in recent years, a series of economic and environmental problems. Difficulties associated with contamination of the environment, acute or chronic poisoning for wildlife exposed to chemical compounds, non-selective elimination of beneficial microorganisms present in the soil and on plants, the persistence of substances in fruits and the acquisition of pathogen resistance are just some of the concerns of farmers. Many studies link the severe damage to biodiversity to the widespread use of pesticides, along with other practices implemented in modern intensive agriculture. This paper aims to analyze the impact of the use of pesticides in modern agriculture and present ecological plant-based alternatives that could replace the chemicals frequently used in fruit growing, for a sustainable agriculture.

Cuvinte cheie: livezi, dăunători, biopesticide, agricultură durabilă
Key words: orchards, pests, biopesticides, sustainable agriculture

1. Introduction

With an ever-increasing global population, which is estimated to reach 9.1 billion by 2050, food production is expected to increase by 70% to meet market demands. Considered the main source of food, agriculture has seen an intensive development that has led to the intensive use of chemical pesticides to improve yields by controlling pests such as weeds, insects, bacteria and fungi. Even though these agricultural practices have had a good yield against pests, pesticides used uncontrolled and in an excessive way have also led to negative effects on the crops themselves and the environment. Both crop pests and climate change issues have made it difficult to achieve food security. To reduce the negative impact of chemicals, an ecological approach is needed for sustainable agriculture (Rao et al., 2016; Samada et al., 2020; Adisa et al., 2019).

In general, food safety authorities check pesticide residues in crops by setting maximum residue limits (MLRs). Determination of MRLs is done with data from field tests for each individual pesticide, according to good agricultural practices. It must be realized that pesticide residues in food pose risks to human health, therefore it is essential to analyze the potential of substitutes for chemical products (Chung, 2017). As an alternative to conventional products, biopesticides can be applied due to their proven effectiveness in controlling pests and obtaining safe, ecological products (Hernández-Suárez et al., 2021).

Derived from plants, insects and microorganisms, biopesticides have been used to manage diseases in agricultural crops (Lengai et al., 2018). The use of biopesticides by farmers and growers is continuously increasing due to the benefits brought:

- Effectiveness against the target pest;
- Protecting the ecosystem;
- Protection of human safety (Glare et al., 2016).

Globally, there is a continuous increase in the use of biopesticides that favors a sustainable approach to optimizing plant production. Research on the application of biopesticides is turning its attention to optimizing their action spectra, which should expand their use and popularity in the future (Samada et al., 2020).

Just like vegetables, fruits play an essential role in nutrition, therefore it is important that food products come from ecological agricultural crops. The growing demand for organic food requires an efficient manager of crops, which is as friendly as possible to the environment and contributes to the conservation of biodiversity (Parajuli et al., 2019).

2. Material and methods

Biopesticides are divided into three significant classes, namely: microbial pesticides (MCPs), biochemical pesticides (BCPs) and plant-incorporated protectants (PIPs), figure 1. Plant- and microorganism-based biopesticides are the most well-known biopesticides used for centuries to combat pests (Babu, 2020).

A study in Kuwait investigated pesticide residue levels in commonly used fruits and vegetables. The results indicated that most of the fruit and vegetable samples were contaminated with pesticide residues, with concentrations above the maximum residue limits (MRL). The levels of pesticide residues observed pose a potential risk to consumer health (Table 1) (Jallow et al., 2017).

An effective method of applying biopesticides to reduce C. pyricola in pears was analyzed, and the injection of substances into the trunk of the tree proved to be a viable solution. The essential oils of cinnamon (C. cassia J. Presl) and peppermint (M. spicata L.) were applied for the study. In figure 2 is a graphic presentation of a trick injection device (Werrie et al., 2021).

3. Results and discussions

Biofertilizers

Application of biofertilizers consisting of bacteria, cyanobacteria or fungi can improve and restore soil fertility and ensure sustainable agricultural production using green technology (Jitendra et al., K., 2021).

Biopesticides

An example of a biopesticide is the Neem tree, known for its insecticidal properties and can be used as a pesticide, fungicide and herbicide. Neem leaves can also be used as a biofertilizer, having the potential to increase the yield of vermicompost. In addition to these properties, the active components of neem bark, leaf, seed and oil have antimicrobial, anticancer, anti-inflammatory and hepatoprotective capabilities. Figure 3 shows the schematic representation of the neem tree (azadirachta indica) (Chaudhary et al., 2017).

In a research center in Ukraine, a study was carried out on the biological methods of protecting apple orchards against aphids and the development of apple diseases. The results showed that the use of biofungicides, bioinsecticides and their mixtures had a considerable contribution in reducing the number of aphids by 61.1-76.8% and the spread of scab on apple leaves by 66.5-72.5% and on the fruits of apple by 68.7-73.3%, compared to the control sample. Some of the biopesticides applied were the biofungicide Phytodoctor and the antibacterial and biofungicide Planriz-bio. The treatments ensured an increase in the yield of apple orchards by 1.7-1.9 t/ha (Hunchak M., 2022).

An ecological alternative to classic pesticides was analyzed for the reduction of the population of the genus Microtus de campie, these being considered mammal species that cause the most damage in fruit crops in Europe and North America. In winter, rats (slobs) feed on the bark and vascular tissues of trees. Applied as mulches, sweet straw (Galium odoratum (L.) Scop.) and creeping thyme (Thymus serpyllum L.) reduced the abundance of weeds in the orchards, repelled the rat population and lessened the negative effects on the development of young trees (Sullivana et al., T.P., 2018).

A study on the effectiveness of the entomopathogenic nematode, Heterorhabditis pakistanensis, strain NBAIR H-05 against Codling moth larvae attacking apple orchards is described in the literature. The results of the analysis show a real potential of the nematode, as shown in figure 4 (Ahmad et al., 2020).

Post-harvest application of biopesticides

Postharvest, Penicillium expansum (blue mold) and Botrytis cinerea (gray mold) are among the most common stone fruit pathogens. For their control, the effectiveness of cyclolipopeptides (CLP), in the form of fengycin and iturin A, in crude metabolite extracts from Bacillus amyloliquefaciens was analyzed as an alternative to chemicals. The resulting biofungicide applied with zein (a protein extracted from corn kernels) on apples and pears, shows that it has a real potential against infection with the two pathogens (Magwebu et al., 2023).

4. Conclusions

It is well known that the practices of conventional (integrated) agriculture, through the use of synthetic pesticides, in an immeasurable way, can have harmful consequences related to food safety, but also to the health of the ecosystem.

Population exposure to chemicals in fruits is clearly a concern and requires special attention. Biopesticides are an ecological alternative in sustainable agriculture, with real potential in pest control and limiting the application of chemical pesticides that have negative effects on the environment. Along with plant extracts, applied in the form of biopesticides, biofertilizers from different bacteria or fungi that can contribute to soil fertilization, have the potential to ensure a less polluting agriculture.

Therefore, to reduce this risk, awareness among farmers to adopt better pesticide safety practices and the need for continuous monitoring of pesticide residues is vital. For a more favorable approach in order to obtain safe products for people but also for the ecosystem, a continuous collaboration between scientists, farmers and decision-makers is needed for the future development of ecological technology.

5. Acknowledgment

This research was supported by Project PN 23 04 02 01 Contract no.: 9N/ 01.01.2023 SUSTAIN–DIGI -AGRI: Innovative biofertilizer production technology used to restore soil biodiversity and reduce the effects of drought on agricultural lands and Program 1 - Development of the national research-development system, Subprogram 1.2 - Institutional performance - Projects for financing excellence in RDI, Contract no. 1PFE/30.12.2021.

References

1. Adisa I.O., Pullagurala V.L.R., Peralta-Videa J.R., Dimkpa C.O., Elmer W. H., Gardea-Torresdey J. and White J., 2019. Recent advances in nano-enabled fertilizers and pesticides: A critical review of mechanisms of action, Environ., Sci. Nano.
2. Ahmad M.J., Mohiudin S., Askary T.H. et al., 2020. Efficacy of indigenous strain of entomopathogenic nematode against diapausing larvae of Codling moth, Cydia pomonella L. (Lepidoptera: Tortricidae), in apple-growing hilly areas of Ladakh Region. Egypt, J Biol Pest Control 30: 62.
3. Ayer K.M., Strickland D.A., Choi M. and Cox K.D., 2021. Optimizing the Integration of a Biopesticide (Bacillus subtilis QST 713) with a Single-Site Fungicide (Benzovindiflupyr) to Reduce Reliance on Synthetic Multisite Fungicides (Captan and Mancozeb) for Management of Apple Scab, Vol.105, Nr. 11, An International Journal of Applied Plant Pathology plant disease.
4. Babu S.B., 2020. Role of Biopesticides in the Management of Insect Pests of Fruit Crops, Recent Trends in Insect Pest Management, vol.4, AkiNik Publications, New Delhi.
5. Chaudhary S., Kanwar R.K., Sehgal A., Cahill D.M., Barrow C.J., Sehgal R. and Kanwar J.R., 2017. Progress on Azadirachta indica Based Biopesticides in Replacing Synthetic Toxic Pesticides, Front. Plant Sci., Sec. Plant Biotechnology, Vol. 8.
6. Chung S.W.C., 2017. How effective are common household preparations on removing pesticide residues from fruit and vegetables? A review, Journal of the Science of Food and Agriculture.
7. DuPont S.T., Cox K., Johnson K., Peter K., Smith T., Munir M. & Baro A., 2023. Evaluation of biopesticides for the control of Erwinia amylovora in apple and pear, Journal of Plant Pathology.
8. El-Sayed A., Bengtsson M., Rauscher S., Lofqvist J., Witzgall P., 1999. Multicomponent Sex Pheromone in Codling Moth (Lepidoptera: Tortricidae) Environ. Entomol., 28: 775–779.
10. Essiedua J.A., Adepojub F.O. and Ivantsova M.N., 2020. Benefits and limitations in using biopesticides: A review, AIP Conference Proceedings 2313, 080002, Ekaterinburg, Russia.
11. FAO Report, 2019. Food Outlook-Biannual Report on Global Food Markets.
12. Glare T.R., Gwynn R.L. and Moran-Diez M.E., 2016. Microbial-Based Biopesticides: Methods and Protocols, Methods in Molecular Biology, vol. 1477, Humana Press, New York.
13. Guerra F., Sepúlveda S., 2021. Saponin Production from Quillaja Genus Species. An Insight into Its Applications and Biology. Sci. Agric., 78: 305.
14. Hernández-Suárez E. M. and Beitia F., 2021. Sustainable Management Methods of Orchard Insect Pests, Insects, 12(1): 80.
15. Hunchak M., 2022. Biological method of protection of apple trees from green apple aphids and apple scab in the conditions of the Pre-Carpathian province of the Carpathian mountain zone of Ukraine, Quarantine and Plant Protection, (2): 36-40.
16. Jallow M.F.A., Awadh D.G., Albaho M.S., Devi V.Y., Ahmad N., 2017. Monitoring of Pesticide Residues in Commonly Used Fruits and Vegetables in Kuwait, International Journal of Environmental Research and Public Health, 14(8): 833.
17. Jitendra K., Ayyagari R., Dharmendra M. and Vachaspati M., 2021. An Overview of Some Biopesticides and Their Importance in Plant Protection for Commercial Acceptance, Plants (Basel), 10(6): 1185.
18. Kadoić B.M., Bažok R., Mikac K.M., Lemic D., Pajač Ž.I., 2020. Pest Management Challenges and Control Practices in Codling Moth: A Review. Insects, 11: 38.
19. Lengai G. M.W. and Muthomi J.W., 2018. Biopesticides and Their Role in Sustainable Agricultural Production, Journal of Biosciences and Medicines, Vol.6 , Nr. 6.
20. Magwebu S., Meitz-Hopkins J.C., Pott R.W.M. and Lennox C.L., 2023. Efficacy of the cyclolipopeptides fengycin and iturin A against postharvest pome fruit pathogens, Front. Hortic., Sec. Sustainable Pest and Disease Management, Vol. 2.
21. Mauchline A.L., Hervé M.R., Cook S.M., 2018. Semiochemical-based alternatives to synthetic toxicant

insecticides for pollen beetle management. Arthropod-Plant Interact, 12: 835–847.
22. Mossa A.T.H., Abdelfattah N.A.H., Mohafrash S.M.M., 2017.Nanoemulsion of camphor (*Eucalyptus globules*) essential oil, formulation, characterization and insecticidal activity against wheat weevil, Sitophilus granaries. Asian J. Crop Sci. 2017; 9: 50–62.
23. Parajuli R., Thoma G., Matlock M.D, Martin R.E., 2019. Environmental sustainability of fruit and vegetable production supply chains in the face of climate change: A Review, Science of The Total Environment, Vol. 650, Part 2: 2863-2879.
24. Radwan M.A. and Darwesh D.R., 2018. Effect of Integrated Control Program of Powdery Mildew Disease on Growth and Productivity of Apple, J. Plant Prot. and Path., Mansoura Univ., Vol.9 (12): 787 – 794.
25. Rao M.S., Umamaheswari R., Priti K., Rajinikanth R., Grace G.N., Kamalnath M., Prabu P., Kumar R. M., Chaya M.K. and Vidyashree, 2016. Role of Biopesticides in the Management of Nematodes and Associated Diseases in Horticultural Crops, Plant, Soil and Microbes, vol. 1.
26. Samada L. H. and Tambunan U. S. F., 2020. OnLine Journal of Biological Sciences, 20 (2): 66-76.
27. Samada L.H. and Tambunan U.S.F, 2020. Biopesticides as promising alternatives to chemical pesticides: A review of their current and future status, Journal of Biological Sciences, 20 (2: 66-76.
28. Sîrbu C.E., Deșliu-Avram M., Cioroianu T.M., Constantinescu-Aruxandrei D. and Oancea F., 2023. High-Temperature Influences Plant Bio-Stimulant-like Effects of the Combination Particle Film-Forming Materials-Foliar Fertilizers on Apple Trees, Agriculture, 13(1): 178.
29. Sullivana T.P., Sullivanb D.S., Granatstein D.M., 2018. Influence of living mulches on vole populations and feeding damage to apple trees, Crop Protection, Vol. 108: 78-86.
30. Werrie P.Y., Burgeon C., Le Goff G.J., Hance T. and Fauconnier M.L., 2021. Biopesticide Trunk Injection Into Apple Trees: A Proof of Concept for the Systemic Movement of Mint and Cinnamon Essential Oils, Front. Plant Sci., Sec. Plant Metabolism and Chemodiversity, Vol. 12.
31. Wheeler C.E., Vandervoort C., Wise J.C., 2020. Organic Control of Pear *Psylla* in Pear with Trunk Injection. Insects., 11(9), 650.
32. https://agrointel.ro.
33. www.fertilizeronline.com.

Tables and Figures

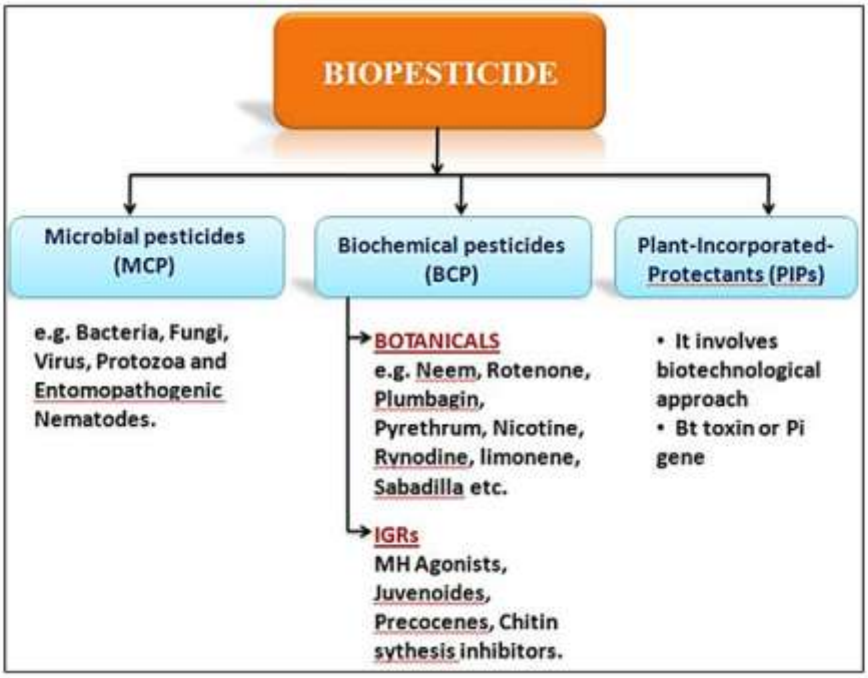

Fig. 1. Classification of biopesticides (Babu, 2020)

 DOI 10.33045/fgr.v39.2023.16

Table 1. Determinations of pesticides in fruit and vegetable samples (Jallow et al., 2017).

Pesticide	% Recovery (RSD) [a] Fortification Levels ($mg \cdot kg^{-1}$)		LOD ($mg \cdot kg^{-1}$) [b]	LOQ ($mg \cdot kg^{-1}$) [c]
	0.01	0.05		
Oxamyl	94 (4.32)	89 (8.45)	0.0020–0.0031	0.0059–0.0212
Cypermethrin	86 (5.46)	92 (6.42)	0.0013–0.0030	0.0051–0.0098
Deltamethrin	89 (3.21)	86 (4.98)	0.0019–0.0028	0.0034–0.0061
Fenpropathrin	102 (6.80)	94 (2.04)	0.0700–0.1869	0.2140–0.4521
Malathion	98 (2.67)	100 (3.98)	0.0040–0.0092	0.0162–0.0312
Profenofos	100 (5.47)	89 (4.21)	0.0018–0.0021	0.0031–0.0074
Monocrotophos	96 (5.21)	89 (6.21)	0.0012–0.0021	0.0069–0.0123
Primiphos-methyl	98 (4.89)	100 (10.18)	0.0026–0.0089	0.0163–0.0281
Diazinon	85 (1.34)	79 (4.51)	0.0018–0.0025	0.0096–0.0184
Chlorpyrifos-methyl	106 (4.82)	97 (8.23)	0.0016–0.0027	0.0057–0.0098
Imidacloprid	95 (6.21)	89 (6.18)	0.0009–0.0014	0.0036–0.0075
Acetamiprid	99 (3.21)	100 (2.98)	0.0021–0.0031	0.0098–0.0123
Thiophanate-methyl	102 (6.18)	87 (3.21)	0.0035–0.0192	0.0632–0.0971
Metalaxyl	92 (3.41)	85 (6.21)	0.0007–0.0021	0.0029–0.0036
Difenoconazole	93 (4.29)	90 (4.21)	0.0019–0.0034	0.0067–0.0132
Aldrin	89 (3.19)	85 (2.89)	0.0008–0.0012	0.0049–0.0086

[a] Numbers in parenthesis represent relative standard deviation (RSD); [b] LOD: Limit of detection; [c] LOQ: Limit of quantification.

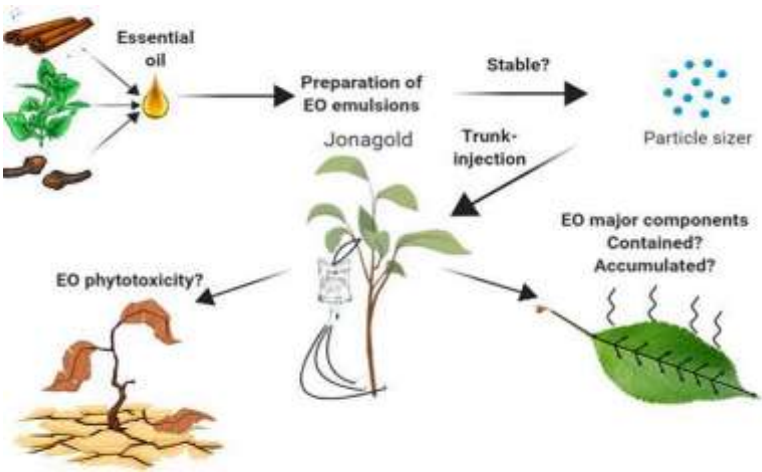

Fig. 2. Experimental design Development Of A Biopesticide Based On Essential Oils (Werrie et al., 2021)

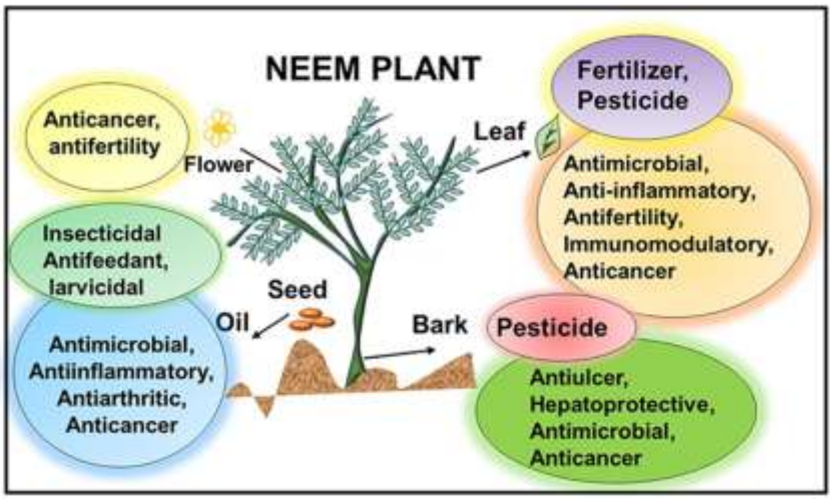

Fig. 3. Schematic representation of the agro-medicinal tree, *Azadirachta indica* indicating the potential of this tree as a biopesticide and therapeutic agent (Chaudhary et al., 2017)

 DOI 10.33045/fgr.v39.2023.16

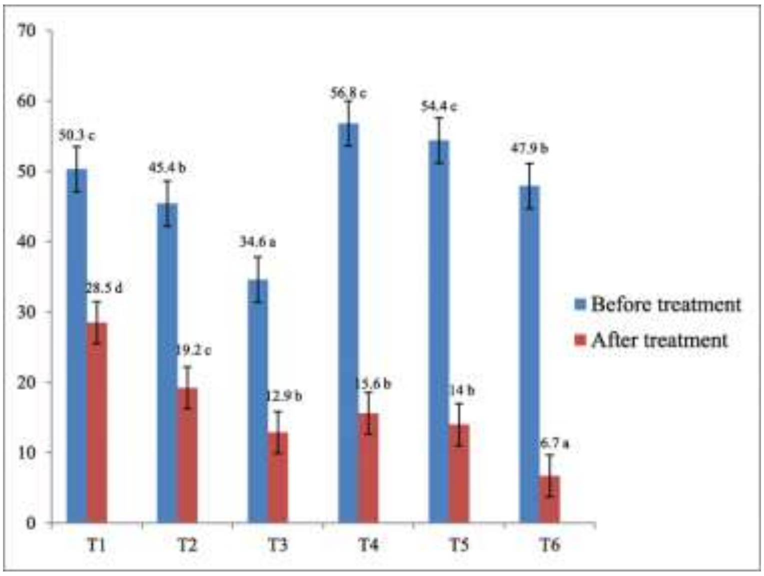

Fig. 4. Average larval density of codling moth/tree trunk before and after treatments during 2017 and 2018 (Ahmad et al., 2020)

Table 2. Other common biopesticides, their types, sources and target crops are described along with the neem tree with the authors who have published such reports

Biopesticide	Mode of action	Active elements	Injury	Target crops	References
Neem (*Azadirachta indica)*	insecticide	Azadirachtin	aphids, scale, thrips, whitefly, weevils	pears and other fruits and vegetables	Chaudhary et al., 2017; Wheelere et al., 2020
Cymbopogon (lemongrass)	attractant	Citronellol	tetranychida mites	apples, pears, stone fruits	Mauchline et al., 2018; Mossa et al., 2017
Cydia pomonella granulovirus	insecticide	*Cydia pomonella* granulovirus (CpGV)	cod moth	apples and pears	Kadoić et al., 2020; FAO, 2019
Quillaja saponaria	nematocide	quillaia	plant parasitic nematodes	orchards, vineyards	Guerra et al., 2021
Chrysanthemum	insecticide	*Pyrethrum / Pyrethrins*	ants, aphids, roaches, fleas, flies, and ticks	fruits and vegetables	Essiedua et al., 2020
Blossom Protect	fungicide	*A. pullulans*	*Erwinia amylovora*	apples and pears	DuPont et al., 2023
Bacillus subtilis Strain QST 713	fungicide	*Bacillus subtilis QST 713*	apple crust	apples	Ayer et al., 2021
Diatomaceous earth	insecticide and fertiliser	*Silicon*	aphids and a wide range of other parasites	apples and a number of other fruits and vegetables	Sîrbu et al., 2023 agrointel.ro; fertilizeronline.com
Bio Zied	fungicide	*Trichoderma album*	mildew (*Podosphaera leucotricha*)	apples	Radwan et al., 2018
Bio Arc	fungicide	*Bacillus megaterium*	mildew (*Podosphaera leucotricha*)	apples	Radwan et al., 2018
AQ10	fungicide	*Ampelomyces quisqualis*	mildew (*Podosphaera leucotricha*)	apples	Radwan et al., 2018