

# Advances in Crop Protection in Organic Farming System

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The Green Deal assumes a significant reduction in chemicals in agriculture production. Reducing the use of chemical plant protection products, increasing the area of organic crops in the EU and actions to protect biodiversity are currently the biggest challenge for agriculture, but also for Member States of the EU, which must take a number of economic and strategic actions [1,2]. Currently, the search and implementation on an industrial scale of new, innovative methods and products alternative to the chemical method is quite strong and visible. The basic principles of organic farming fit very well into the trend of caring for agriculture, nature and our environment, in general. Therefore, expanding the range of methods and measures with innovative, non-chemical protection measures is a very interesting and developing field of science for practice.

The Special Issue of Advances in Crop Protection in Organic Farming System (ACPOF) includes a wide range of practices, technics, and methods and covers many topics. The published articles can be grouped into thematic blocks. The first one contains studies on the use of green mulches and the selection of the botanical composition of established flower strips in an agricultural environment in order to enhance the biodiversity and natural resilience of the environment. The influence of green covers in organic olives on the efficacy of predator insects was presented by González-Ruiz et al. [3]. Their studies have allowed them to verify the effect of implementing a mixed plant cover in olive groves, consisting of adding the fine residues from olive tree pruning to the adventitious vegetation cover. Compared to an organically managed olive grove provided with a simple plant cover, this practice stimulated the community's productivity of adventitious herbaceous cover. A clearly stimulating effect on the diversity and abundance of beneficial insects, whose activity is essentially natural pest control, was noted. The mentioned study selected the olive moth as a pest target. The practice with mixed plant cover allows for a notable increase in the effectiveness of the main natural enemies, confirming predation rates of approximately 90%, which in terms of crop loss result in averages of 12% per tree. Comparatively, in organic crops provided with simple plant cover, the average crop losses due to this pest were 19%, while in traditional crops free of any type of plant cover, the crop losses were 23% of the harvest [3].

In order to increase biodiversity in agriculture fields, the implementation of flower strips are one proposal. In order to achieve satisfactory results, the appropriate selection of plants is crucial. In a flower strip, the number and diversification of overwintering plant species are important. The observations of authors suggest that the species diversity observed in the second year of the strip's presence in western Poland, composed of mostly annual 14 plant species, did not overlap in the next year. A large variety of spontaneously emerging species (considered weeds) can also successfully colonize existing gaps in the flower strips, providing an increase in biodiversity. From the beginning of June to the end of July, the share of flowering plants from the seed bank ranged from 42.59% to 88.19%, while among the originally intended plant species, it was only 11.81–57.41%. In May and at the beginning of June, two intended species that were intensively flowering,



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*Trifolium incarnatum* L. (over 70.5%) and *Phacelia tanacetifolia* Benth. (26.47%), were definitely dominant. In later observations, it was noted that, unfortunately, the sown plants had a low level of flowering compared to the wild plants found in the flower strip. Therefore, it is very important that the flower strip consists of species that also bloom in July and August, and wild plants can emphasize the attractiveness of the flower strip for beneficial insects. The selection of the appropriate species composition of mixtures intended for flower strips should take into account not only the preferences of beneficial insects, but also environmental conditions, which, to a large extent, determine the success of their cultivation. The possibility of their overwintering is important [4].

Flower strips are increasingly implemented as part of agri-environmental programs in Poland. They can be used as a multifunctional agronomic tool because they can prevent the decline of species diversity in the agroecosystem and increase functional biodiversity, which is a prerequisite for the provision of ecosystem services, such as pollination and natural pest control. Reviews of many studies highlight the great potential and multifunctionality of flower strips [5]. Introducing flower strips to the landscape, due to their rich food base and creation of habitats, has a positive effect on the development, reproduction and wintering of beneficial organisms, and this in turn contributes to reducing the density of pests of crops. Ecological focus areas, including strips, are an important environmental refuge. They are clearly a challenge for farmers, as they require additional work and costs and require care and knowledge about the selection of mixtures and techniques for laying the belt. The literature contains many proposed species compositions for flowering plants, taking into account the selection of plants that produce significant amounts of nectar and pollen (e.g., *Fagopyrum esculentum*, *Hypericum perforatum*, species from the Apiaceae family), plants that vary in terms of their lifespan (annual, biennial, perennial species) and species with different flowering periods and flowering lengths. It is also possible to plan one's own flower mix, depending on the preferences of the insects visiting it. An example of this is given in paper [5].

The second block of paper contains the papers concerning the use of microorganisms and natural substances in the protection of plants and yields. The authors present the broad range of possibilities of yeasts and chitosan. Biocontrol yeasts are an alternative to chemical pesticides [6]. The microorganisms antagonistic against plant pathogens must produce substances harmful to the targeted pathogens. They also efficiently colonize plant surfaces such as leaves and fruit, effectively competing for available nutrients and space and surviving in shifting environments [7]. It is also crucial that they do not produce any harmful metabolites for animals and people, or that they negatively affect the final product and, therefore, cause any biosafety concerns. Among the microorganisms that are potentially antagonistic, many yeast species meet these criteria [8]. They occur in every environment. They do not produce toxic substances and quickly adapt to the environment [9]. Positive traits of yeasts as biological agents of plant and yield protection are described by Kowalska et al. [10]. Additionally, the mechanisms of yeasts as plant-protection agents are presented. This includes the production of volatile organic compounds, production of killer toxins, competition for space and nutrient compounds, production of lytic enzymes, induction of plant immunity and mycoparasitism. The mechanisms of yeast interaction with plant hosts are also described, and examples of yeasts used for pre- and postharvest biocontrol are provided. Commercially available yeast-based products are listed and challenges for yeast-based products are described.

Generally, in organic farming, disease control methods using beneficial microorganisms are needed. In [11], the use of commercially available yeast strains to prevent early blight in organically grown potatoes was presented. Six commercial yeast strains used in the food industry, mainly in baking, brewing and winemaking, were evaluated against *Alternaria alternata* and *A. solani*. An in vitro test was conducted to assess yeast antagonistic properties. The production of lytic exoenzymes by yeast strains was determined. In the greenhouse experiments, the abilities of yeast strains to colonize potato leaf surfaces and to minimize *Alternaria* symptoms on plants were assessed. The *Saccharomyces cerevisiae*

Coobra strain inhibited in vitro *Alternaria* mycelium growth and most effectively reduced *Alternaria* symptoms on inoculated plants after seven days. This strain produced the most enzymes, i.e., amylase, pectinase and protease. After eighteen days, only the *S. cerevisiae* Coobra population was isolated from the leaves. In conclusion, the authors stated that the Coobra strain shows antagonistic properties against *Alternaria* spp. and is promising for further field tests [11].

Microorganisms and natural biopesticides are also discussed in relation to use them against *Tetranychus urticae*. This insect pest is one of the most important pests of many species of economically important crops, cultivated both under cover and in open ground. Nowadays, in connection with the popularization of organic farming, non-chemical methods are sought. The aim of the study [8] is to present the current state of knowledge on methods of reducing the undesirable effects of *T. urticae* feeding. The paper discusses the main directions of searching for biopesticides against *T. urticae* and provides a list of natural components on which commercially available products are based. The aspect of using the natural properties of plants and micro- and macro-organisms is presented. The paper also deals with the issue of the spread of spider mites in connection with the observed climate changes. This review of Jakubowska et al. [12] presents examples of currently used methods to control mites, including chemical and other measures such as natural substances and biological strategies relying on bacterial and fungal microorganisms as well as macro-organisms such as predatory mites and insects [12].

Basic substances are allowed for organic farming and they are very interesting solution to use in practice as support of protective treatments [13]. Among them is chitosan, which is a biopolymer with various favorable properties (biotic/abiotic stress mitigation, qualitative improvement, bio-fertilizer, bio-stimulant and postharvest management) to meet multiple agricultural objectives. The paper by Singh et al. [14] included the use of chitosan in grapevine cultivation. In viticulture, chitosan application made significant developments towards higher contents of beneficial metabolites in grape berries as well as stress and postharvest management during recent decades. Investigations by [14] demonstrated chitosan as a potential elicitor molecule at a molecular level and opened the possibility to use chitosan for trunk disease management; moreover, there are not yet any methods to combat trunk diseases in grapevine. The paper aimed to summarize the different aspects of chitosan application in grapevines in facilitating the development of inclusive and more integrated sanitary viticulture practices in a sustainable manner. In conclusion, the authors stated that chitosan may be an excellent biomaterial for future crop protection method developments for winegrowers worldwide. Chitosan shows promise as a unique measure to answer multiple problems in grapevines, especially for the management of grapevine trunk diseases [14].

The paper describing spider mites also mentioned the impact of climate change on the spread and increase in crop losses, as a result of, among others, an increase in the number of generations of the pest during the growing season [12]. The issue of ongoing climate change is currently a hotly debated topic, and it is influenced by many factors, one of which is intensive agricultural production. Agricultural production has the potential to play an important role in mitigating climate change. It is necessary to optimize all of the agricultural practices that have high levels of greenhouse gas (GHG) emissions. There are many possibilities for reducing GHG emissions from the application of fertilizers. Further benefits in reducing the carbon footprint (CF) can be obtained through combining tillage treatments, reduced and no-till technologies, and the cultivation of catch crops and leguminous plants. Organic farming has the potential for reducing GHG emissions and improving organic carbon sequestration because this system eliminates synthetic nitrogen fertilizers and thus could lower global agricultural GHG emissions. Organic farming could result in a higher soil organic carbon content compared to non-organic systems. When used together with other environmentally friendly farming practices, significant reductions of GHG emissions can be achieved [15]. Additionally, the carbon dioxide (CO<sub>2</sub>) retention potential in soils can be increased using catch crops, the abandonment of crop residues

in the field, and the cultivation of grasses and legumes on arable land and limiting the mineral fertilizers. However, the recognition of the performance of organic farming on GHG using the life cycle assessment (LCA) is still insufficient and requires further comprehensive studies. Thus, improvements in the LCA methodology in the areas of organic farming are essential [15].

Reducing mineral fertilizers in plant production is discussed both in the context of carbon footprint and greenhouse gas emissions, but also in the context of the biodiversity protection and “farm to fork” strategies announced in the EU [1,2]. Plant nutrition treatments using stimulants have been proposed for several years as an alternative to mineral fertilizers. Sometimes they are just a treatment that supplements plant nutrition. The paper of Ratajczak et al. [16] concerns on phytostimulators. The benefit of applying such products based on microorganisms or natural substances (e.g., algae extract) is that plants can uptake them faster than soil fertilizers, targeting plant growth by regulating their phytohormones, as well as improving plant tolerance to unfavorable environmental conditions (e.g., cold stress). The aim of the study conducted in Poland was to determine the possibility of regeneration of maize plant after cold stress and phytostimulator application. Authors hypothesized that maize plants may respond differently to the selected preparations abiotic stress. The purpose of this study was to test and evaluate the effects of three commercial phytostimulators, called biostimulants (a seaweed-based extract—Kelpak<sup>®</sup>, mineral nanoparticles—Nano Active<sup>®</sup>, zinc nanoparticles—Dynamic Cresco<sup>®</sup>) on yield, chlorophyll content, and the level of CO<sub>2</sub> assimilation under cold stress. At the final measurement in maize growth stage BBCH 65, all the tested phytostimulators showed significant effects in increased values of effective quantum yield of photosystem II, maximum photosynthetic efficiency of PSII and electron transport rate. Thus, these phytostimulators can be used to enhance the yield and physiological status of plants after abiotic stress (such as cold) to improve crop productivity [16].

Plant protection in organic farming is extremely important from the point of view of maintaining the quality and quantity of crops. However, maintaining quality also involves the absence of pesticide residues in crops. Unfortunately, the problem of crop contamination due to the presence of pesticide residues in crops may be related to, among others, inappropriate techniques and conditions for performing chemical protection treatments by non-organic producers whose fields border on organic fields. The problem of droplet retention in fruit tree canopies for air assisted spraying was described by Juan Li et al. [17]. The use of chemical pesticides is essential for the healthy and stable production of high-quality and high-yielding fruit in large-scale orchards. Air-assisted spraying technology is currently a common approach for atomizing droplets into smaller droplets by using high-speed airflow before being delivering to the canopy of fruit trees. This technology can improve the effective utilization rate of pesticides with characteristics of good droplet penetration and high operating efficiency. The main conclusions can be summarized. Droplets with a large Weber number are conducive to spreading on the leaf surface, but the amount of deposition on the leaf would be reduced; hence, it is necessary to select an appropriate concentration of pesticide. According to the orthogonal test results of the four parameters of leaf inclination angle, flow velocity, roughness factor, and liquid surface tension, the significance order was obtained as follows: liquid surface tension > airflow > roughness factor > leaf inclination angle. With an increasing wind velocity, the canopy penetration rate of droplets gradually increased [17].

The Special Issue of Advances in Crop Protection in Organic Farming System contains a total of ten papers with five research papers, four review articles and one perspective paper. The papers were submitted from six countries: Poland, China, Portugal, Mexico and India.

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## References

1. European Commission. A Farm to Fork Strategy for a Fair, Healthy and Environmentally-Friendly Food System, COM/2020/381 Final, 20.05.2020. In *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*; European Commission: Brussels, Belgium, 2020.
2. European Commission. EU Biodiversity Strategy for 2030 Bringing Nature back into Our Lives, COM(2020) 380 Final, 20.05.2020. In *Communication from the Commission to the European Parliament, the European Council, the European Economic and Social Committee and the Committee of the Regions*; European Commission: Brussels, Belgium, 2020.
3. González-Ruiz, R.; Gómez-Guzmán, J.A.; Martínez-Rojas, M.; García-Fuentes, A.; Cordovilla, M.d.P.; Sainz-Pérez, M.; Sánchez-Solana, A.M.; Carlos-Hervás, J.; Rodríguez-Lizana, A. The Influence of Mixed Green Covers, a New Trend in Organic Olive Growing, on the Efficiency of Predatory Insects. *Agriculture* **2023**, *13*, 785. [\[CrossRef\]](#)
4. Kowalska, J.; Antkowiak, M.; Tymoszek, A. Effect of Plant Seed Mixture on Overwintering and Floristic Attractiveness of the Flower Strip in Western Poland. *Agriculture* **2023**, *13*, 467. [\[CrossRef\]](#)
5. Kowalska, J.; Antkowiak, M.; Sienkiewicz, P. Flower Strips and Their Ecological Multifunctionality in Agricultural Fields. *Agriculture* **2022**, *12*, 1470. [\[CrossRef\]](#)
6. Contarino, R.; Brighina, S.; Fallico, B.; Cirvilleri, G.; Parafati, L.; Restuccia, C. Volatile organic compounds (VOCs) produced by biocontrol yeasts. *Food Microbiol.* **2019**, *82*, 70–74. [\[CrossRef\]](#) [\[PubMed\]](#)
7. Freimoser, F.M.; Rueda-Mejia, M.P.; Tilocca, B.; Migheli, Q. Biocontrol yeasts: Mechanisms and applications. *World J. Microbiol. Biotechnol.* **2019**, *35*, 154. [\[CrossRef\]](#) [\[PubMed\]](#)
8. El-Banna, A.A.; El-Sahn, M.A.; Shehata, M.G. Yeasts producing killer toxins: An overview. *Alex. J. Food Sci. Tech.* **2011**, *8*, 41–53.
9. Muccilli, S.; Restuccia, C. Bioprotective role of yeasts. *Microorganisms* **2015**, *3*, 588–611. [\[CrossRef\]](#) [\[PubMed\]](#)
10. Kowalska, J.; Krzysińska, J.; Tyburski, J. Yeasts as a Potential Biological Agent in Plant Disease Protection and Yield Improvement—A Short Review. *Agriculture* **2022**, *12*, 1404. [\[CrossRef\]](#)
11. Kowalska, J.; Krzysińska, J.; Matysiak, K.; Jakubowska, M. Screening for Antagonistic Yeasts to Manage *Alternaria* spp. in Organic Farming. *Agriculture* **2022**, *12*, 1693. [\[CrossRef\]](#)
12. Jakubowska, M.; Dobosz, R.; Zawada, D.; Kowalska, J. A Review of Crop Protection Methods against the Twospotted Spider Mite—*Tetranychus urticae* Koch (Acari: Tetranychidae)—With Special Reference to Alternative Methods. *Agriculture* **2022**, *12*, 898. [\[CrossRef\]](#)
13. Toffolatti, S.L.; Davillerd, Y.; D’Isita, I.; Facchinelli, C.; Germinara, G.S.; Ippolito, A.; Khamis, Y.; Kowalska, J.; Maddalena, G.; Marchand, P.; et al. Are Basic Substances a Key to Sustainable Pest and Disease Management in Agriculture? An Open Field Perspective. *Plants* **2023**, *12*, 3152. [\[CrossRef\]](#) [\[PubMed\]](#)
14. Singh, R.K.; Ruiz-May, E.; Rajput, V.D.; Minkina, T.; Gómez-Peraza, R.L.; Verma, K.K.; Shekhawat, M.S.; Pinto, C.; Falco, V.; Quiroz-Figueroa, F.R. Viewpoint of Chitosan Application in Grapevine for Abiotic Stress/Disease Management towards More Resilient Viticulture Practices. *Agriculture* **2022**, *12*, 1369. [\[CrossRef\]](#)
15. Holka, M.; Kowalska, J.; Jakubowska, M. Reducing Carbon Footprint of Agriculture—Can Organic Farming Help to Mitigate Climate Change? *Agriculture* **2022**, *12*, 1383. [\[CrossRef\]](#)
16. Ratajczak, K.; Sulewska, H.; Panasiewicz, K.; Faligowska, A.; Szymańska, G. Phytostimulator Application after Cold Stress for Better Maize (*Zea mays* L.) Plant Recovery. *Agriculture* **2023**, *13*, 569. [\[CrossRef\]](#)
17. Li, J.; He, M.; Cui, H.; Lin, P.; Chen, Y.; Ling, G.; Huang, G.; Fu, H. Characterizing Droplet Retention in Fruit Tree Canopies for Air-Assisted Spraying. *Agriculture* **2022**, *12*, 1093. [\[CrossRef\]](#)

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