SUSTAINABLE USE OF PESTICIDES FOR DISEASE AND PEST MANAGEMENT IN SUNFLOWER (HELIANTHUS ANNUUS L.) IN BULGARIA

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Abstract

The sunflower (Helianthus annuus L.) is an important agricultural crop grown in many regions around the world. In Bulgaria, it is the most important oilseed crop. The protection of sunflowers from various pests is a pivotal task in achieving maximum yields and ensuring the production of the highest possible quality.

Research in the field of genetics, breeding and biotechnology is directed towards the identification of solutions to problems associated with crop protection and environmental pollution caused by pesticides. A significant concern is the emergence of pest resistance to widely used pesticides. The management of acquired resistance to plant protection products involves practices such as the use of biologically active substances, the use of pest-resistant varieties and the sustainable use of pesticides. The sustainable use of pesticides has been demonstrated to address environmental and social concerns, whilst concurrently offering innovative crop technologies and economic opportunities for farmers.

Key words**: **Helianthus annuis, pests, control

INTRODUCTION

Sunflower (Helianthus annuus L.) is an agricultural crop that is cultivated in various regions of the world. In Bulgaria, it is the primary oilseed crop and was introduced into the agricultural landscape in 1917.

Protecting sunflowers from various pests is essential for achieving optimal yields and quality. The correct application of plant protection products and adherence to the recommended treatment doses is mandatory for crop development and protection against economically important diseases and pests. Good plant protection practices (GPPP) for sunflowers include reasonable restrictions on the number of treatments, the use of healthy seed material, adherence to a strategy for managing acquired resistance to plant protection products, the use of biologically active agents and the use of pest-resistant varieties, as well as meeting local quality requirements.

The sustainable use of pesticides in sunflower cultivation is a global trend that aims to reduce the use of plant protection products and to reserve the use of pesticides for only those instances where treatment is necessary. Research in the field of genetics, breeding and biotechnology is directed towards identifying solutions to challenges posed by plant protection and environmental pollution resulting from the use of pesticides.

The scientific literature pertaining to research conducted in Bulgaria on sunflower-related issues encompasses a plethora of subjects. The review identified over 90 literary sources, including scientific articles and dissertations. The number of studies related to sunflower physiology,

biochemistry, genetics and breeding significantly exceeds the number of studies related to plant protection. The following topics are mainly addressed in the existing literature: the history and origin of the sunflower, its classification, genetic and breeding studies, resistance to pests, resistance to bluebottle, resistance to diseases, resistance pest, climate change and pests, resistance to abiotic stress factors, resistance to herbicides, and the use of pesticides in sunflower (Drumeva Petrova et al., 2007; Stamatov and Velcheva, 2020; Petrova et al., 2023; Georgiev, 2025).

Sunflower, an allogamous plant, is dependent on insect pollinators for seed production, with bees being especially crucial (Saeed et al., 2021; Shpak et al., 2023).

The extant literature indicates that it is imperative for farmers to be cognizant of the repercussions that pesticides, notably nitroguanidine neonicotinoid systemic insecticides (NNIs or neonics), have on pollinators. In order to reduce the risk to pollinators, it is recommended that sprays be replaced with alternative formulations of the active substances, and that their lowest effective application rates be used. In addition, systemic insecticides with reduced toxicity to bees should be used when treating honey plants. These approaches to risk reduction should be accorded a high priority by scientific research, with a view to establishing safe practices in both ornamental horticulture and the cultivation of sunflowers as an agricultural crop (Georgieva et al., 2021; Ward et al., 2023).

The objective of this study is to monitor current trends in sunflower cultivation by identifying and analysing the principles for sustainable pesticide use.

MATERIALS AND METHODS

The research material comprised a variety of literary sources and information resources pertaining to the cultivated sunflower (*H. annuus* L.). A variety of materials from national libraries, regional libraries and digital libraries were utilised in the research process. The literary data collected were then systematically summarised and analysed.

RESULTS AND DISCUSSIONS

Sunflower resistance to economically important diseases

Sunflower crops are susceptible to a range of diseases, which can result in a reduction in yield and deterioration in the quality of the produce. This necessitates the implementation of measures to control these diseases. The following sunflower diseases are considered to be of economic significance: downy mildew (*Plasmopara halstedii* (Farlow) Berlese & de Toni), white mold (*Sclerotinia sclerotiorum* (Lib.) de Bary), black stem (*Phoma macdonaldii* Boerema), stalk rot of sunflower (*Diaporthe helianthi* M. Muntañola-Cvetkovic et al), blight of sunflower (*Alternariaster helianthi* (Hansford) E.G. Simmons), leaf spot of sunflower (*Septoria helianthi* Ellis & Kellermann), various types of stem rot, and others. In the context of managing powdery mildew (*P: halstedii)* in sunflower, the predominant approach adopted by the majority of breeders involves the utilisation of approximately 8 to 10 single, dominant, resistance genes. This endogenous resistance, in conjunction with the application of fungicides, ensures an acceptable level of crop safety. However, instances of chemical resistance in the pathogen have been documented. In addition, breeders employ phenotypic and molecular classification (Dimitrijevic and Horn, 2018; Meena and Sujatha, 2022).

In the Bulgarian context, the pathogen is of significant importance for the production of sunflowers. A rapid dissemination of more virulent strains of sunflower powdery mildew has been observed, which has overcome the resistance exhibited by the varieties and hybrids that were extensively utilised in practice (Nenov, 2002).

As demonstrated in the research conducted by Petrova (2025), an increasing number of scientists are reporting the emergence of new, more

virulent races of the pathogen. The findings of the 4-year study, conducted between 2018 and 2021, revealed the isolation of ten races of *P. halstedii*. The analysis revealed a close correlation between the distribution and virulence of the pathogen, on the one hand, and both the climatic conditions of the year and the resistance of the varieties and hybrids employed in agricultural practice, on the other. The results of this study demonstrated that the pathogen formed new and more virulent races, which breeding efforts were unable to overcome.

A high degree of resistance has been achieved against downy mildew and sunflower broomrape (*Orobanche cumana* Wallroth). It is imperative to acknowledge that these are the two diseases for which resistance constitutes a prerequisite for the identification of 10 hybrids in Bulgaria. As demonstrated by Tonev et al. (2008), a degree of partial resistance has been observed in relation to stalk rot and white mold. Various biotechnological methods combined with interspecific hybridisation and conventional selection approaches are successfully applied to overcome all new virulent pathogen races and accelerate the selection process (Nenova et al., 2009).

Resistance of sunflower to insect pests

Sunflower pests are one of the factors that reduce the yield and quality of the product. The changes that have occurred in the agricultural techniques of the crop and in the climatic conditions of the country are the reason, on the one hand, for the multiplication and expansion of the distribution area of the enemies, and on the other hand, for the appearance of new ones. The economically important enemies of sunflower include: the sunflower moth (Homoeosoma nebulella (Denis et Schiffermüller)), the sunflower weevil Agapanthia dahli (Richter 1821), aphids and others.

An important characteristic of modern cultivars and hybrid cultivars is the presence of the so-called armor layer, which is located between the cork tissue and the sclerenchyma layer. It is this layer that protects the seeds from attack by the sunflower moth (*Homoeosoma nebulella* (Denis et Schiffermüller)). The armor layer is made up of sclerenchyma cells, which in the process of ripening lose their cellular structure and accumulate significant amounts of carbon, which gives them great hardness (Petrov et al., 2005). In "armored" sunflower varieties, the larve cannot pierce the shell of normally developed seeds and feed mainly on the anthocarp or on the seeds that are in the middle, which are covered with an armor layer at the latest (Andreev, 2013).

Sunflower pests are one of the factors that reduce the yield and quality of the product. Kralev et al. (2024) conducted studies on the influence of antioxidant content (phenols and flavonoids) in sunflower hybrids on their resistance to pests. The experiments investigated the relationship between antioxidant content in interspecific and intergeneric hybrids, as well as in an oilseed sunflower variety, and their resistance to pests, with a view to including plant materials in breeding programmes. A correlation was found between the level of natural antioxidants present and the level of attack by pests (R=0.39). This suggests that the observed differences are probably also due to the different levels of antioxidants present in the plants. The results obtained provide evidence that the sunflower variety HA 1114, resulting from distant interspecific hybridisation, exhibits satisfactory genetic resistance to pests. The oilseed sunflower variety 'NA 1114' was included in Bulgaria's official variety

list in 2017 as it meets the distinctness, homogeneity and stability (DHS) standards. This medium-tall variety (179 cm) has very strong lodging resistance (rated 9/9), a 1000-seed weight of 59.16 g and high resistance to blue knot, Sclerotinia, Phoma and Phomopsis. The oil content is 46.96%.

Conducting research to establish the resistance of interspecific hybrids to biotic stress factors, as well as the reasons behind the specific reactions of the studied genotypes, involves accumulating information on the potential use of wild species as donors of valuable economic traits. This research also provides direction for complex studies in theoretical and applied entomology, genetics, and selection.

Using pesticides on sunflowers

Treatments can be reduced if sunflower-growing technologies include resistant varieties and hybrids, selective plant protection products that are gentle on bees and bioagents. These are some of the measures that can be used in sustainable agriculture. Another major problem in the use of plant protection products (PPP) is the development of resistance. Pests can develop resistance to a single product or group of products. Those types of pests that can develop normally and reproduce in an environment with a certain concentration of PPP are considered resistant to a particular group of plant protection products.

For example, the fungus *P. halstedii* has overcome the mode of action of fungicides belonging to FRAC code 4 and is likely to evolve to overcome other fungicides in the future. Very few seed treatments have been shown to be effective against sunflower downy mildew, and the pathogen's insensitivity to FRAC code 4 chemicals poses a challenge for sunflower production (Harveson et al., 2017).

Based on the literature and experience gained from protecting sunflowers against pests, a chemical plant protection scheme has been developed to reduce the risk of pests developing resistance to the pesticides used (table 1).

Table 1. Plant protection programm for the sunflower variety HA 1114

Economically important diseases and pests	**Pesticide* use for disease and pest control**			
downy mildew	oxatiapiproline F, OSBPI fungicides, **49**; acibenzolar-S-Methyl **/P 01**/			
black stem, white mold stalk rot of sunflower	*Coniothyrium minitans* (strain CON/M/91-08 (DSM 9660), microbial (strains of living microbes or extract, metabolites, **BM 02**	azoxystrobin C, QoI-fungicides **11**+ difenoconazole G, DMI-fungicides (DeMethylation Inhibitors), **3**		
leaf spot of sunflower			pyraclostrobin C,QoI-fungicides **11**+ Mepiquat	

			chloride, piperidines + prohexadione-calcium, growth regulator	
aphids	growth stages	lambda-cihalothrin, **3A**, Sodium channel modulators, pyrethroids		tau-fluvalinate **3A**, Sodium channel modulators, pyrethroids
фенофази	Germination BBCH 00- 09	Leaf development BBCH 10-19	Stem elongation BBCH 30-39	Inflorescence emergence BBCH 51-59

* Mode of action classification of fungicides and insecticides (https://www.frac.info/, https://IRAC-online.org

The application of plant protection products is an essential part of contemporary sunflower cultivation technologies. To limit the use of chemical methods in plant protection, these products must be used only when necessary. To make the right
decision, it is essential to establish definitive economic thresholds for the main pests and diseases that affect agricultural crops.

If sunflower-growing technologies include resistant varieties and hybrids, selective plant protection products that are gentle on bees and bioagents as part of sustainable agricultural practices, treatments can be reduced.

CONCLUSIONS

From the review and analysis of literature sources, it is evident that genetic, breeding and biotechnological studies aim to find solutions to problems of plant protection and environmental pollution caused by pesticides.

A major problem with the use of plant protection products is the development of resistance to commonly used pesticides by pests. Correct use of pesticides involves alternating products with different modes of action, observing specified doses and economic thresholds, and taking the bioecological characteristics of the pests into account.

One of the most valuable qualities is plant resistance to diseases and pests. Growing resistant varieties and hybrids greatly reduces damage and eliminates or reduces the need for pest control. Full resistance has so far been achieved against downy mildew and sunflower broomrape, and partial resistance to the sunflower moth.

The sustainable use of pesticides involves overcoming environmental and social problems, and can also offer farmers innovative growing technologies and economic opportunities.

REFERENCES

Andreev, R. (2013). Agricultural entomology for everyone. Computer Reference Book (CD ZE-2013-RA-030). AU-Plovdiv, 1500 pp. (Bg)

Dimitrijevic, A., & Horn, R. (2018). Sunflower hybrid breeding: from markers to genomic selection. *Frontiers in Plant Science*, *8*, 2238.

Drumeva, M., Berville, A., Ivanov, P., Nenova, N., & Encheva, J. (2005). Study on a doubled haploid line of Helianthus annuus L., produced by gamma-induced parthenogenesis.

Georgiev, G. (2025). Technological solutions in hybrid seed production of sunflower. *Bulgarian Journal of Crop Science*, *62*(4), 42-53. (Bg)

Georgieva, M., Bonchev, G., Zehirov, G., Vasileva, V., & Vassileva, V. (2021). Neonicotinoid insecticides exert diverse cytotoxic and genotoxic effects on cultivated sunflower. *Environmental*

Science and Pollution Research, *28*(38), 53193-53207.

Harveson, R. M., Seiler, G. J., Scott, A., Antonova, T. S., Masirevic S., Markell S. G., Humann R. M., Gilley M., Gulya T. J, H. J. Kandel и R. Zollinger, (2017), За слънчогледа от Пионер, София

Kralev, N., Koleva, L., & Vasilevska-Ivanova, R. (2024). Influence of the content of antioxidants (phenols and flavonoids) in sunflower hybrids and the degree of attack by pests. *Bulgarian Journal of Agricultural Science*, *30*.1-6.

Meena, H. P., & Sujatha, M. (2022). Sunflower breeding. In *Fundamentals of field crop breeding* (pp. 971-1008). Singapore: Springer Nature Singapore.

Nenov, Neno Donchev, (2002), Study on some basic signs of fertility restorer lines in sunflower (*Helianthus annuus* L.), dissertation, Dobrich. (Bg)

Nenova N., Drumeva M., Encheva V., Shindrova P., Hristov M., (2009), Combined application of different methods for creating resistant to economically important diseases and parasitic lines, fertility restorers in sunflower, Field Crop Research 2009, Vol V-1, 137- 138. (Bg)

Petrov P., Stancheva, Tasev G., Milev N., (2005), Modern Technologies for Growing Sunflower Crops, 5-10. (Bg)

Petrova, M. (2025). Distribution and race composition of downy mildew on sunflower (*Plasmopara halstedii*) in Bulgaria during 2018-2021. Field Crops Studies XV(1), 5-12.

Petrova, Z., Nenova, N., Georgiev, G., & Valkova, D. (2023). Influence of a set of herbicides on yield structure in sunflower hybrids. *Journal of Mountain Agriculture on the Balkans (JMAB)*, *26*(4). (Bg)

Saeed, S., Ahmad, A., Yasir Ishfaq, M., & Mahtab Anjum, M. (2021). Pollinator community of sunflower (Helianthus annus L.) and its role in crop reproductive success. *Asian Journal of Agriculture and Biology*, *2*.

Shpak, Y. V., Leheta, U. V., & Sosnovskyi, K. S. (2023). Importance of pollinator diversity for sunflower seed production. *Agrology*, *6*(4), 79-85.

Stamatov, S., & Velcheva, N. (2020). Influence of foliar fertilizers and biostimulants on productivity in wheat and sunflower. *New Knowledge Journal of Science/Novo Znanie*, *9*(1). (Bg)

Tonev T, Bozukov H., Encheva-Vasileva V., Shindrova P., Zarkov B., Dikova B, Atanasov A., Vitanova M., Dimitrova M., Dimitrov Y., Tanova K., Dimitrova A., Stamatov A., Deshev M., Grigorova P. (2008). Guide to Integrated Pest Management in Industrial Crops, 10-11. (Bg)

Ward, L. T., Hladik, M. L., Guzman, A., Bautista, A., & Mills, N. J. (2023). Neonicotinoid sunflower seed treatment, while not detected in pollen and nectar, still impacts wild bees and crop yield. *Agrochemicals*, *2*(2), 279-295.