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AROMATIC PLANT ESSENTIAL OILS AS BIOLOGICAL ALTERNATIVES FOR THE CONTROL OF FUNGAL DISEASES IN SUNFLOWER

Pintilia Sabina[1,2], Cristea Stelica[2], Anton Florin Gabriel[2], Bordei Marius[1,2],Pantazi Cristina[1,2]

[1]National Agricultural Rersearch and Developement Institute Fundulea
[2]University of Agronomic Sciens and Veterinary Medicine, USAMV Bucharest

• Introduction

- Sunflower (*Helianthus annuus* L.) is a major oilseed crop, but its productivity and seed quality are affected by fungal diseases.
- The intensive use of synthetic fungicides may lead to pathogen resistance, environmental contamination and risks for non-target organisms.
- Essential oils (EOs) from aromatic plants are considered promising natural alternatives with antifungal activity.
- *Mentha* spp. are of particular interest due to their rich in bioactive terpenes (e.g., menthol, menthone, carvone and menthofuran) with documented antifungal effects.





• Materials and Methods

The review approach was based on scientific literature concerning:

Literature search
(scientific databases: Scopus, Web of Science, PubMed, etc.)

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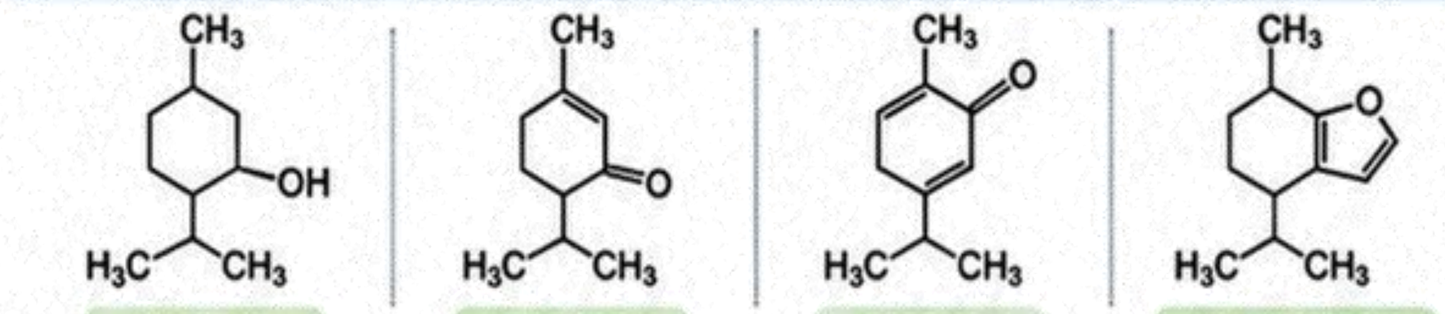
Selection of relevant studies
(EOs, *Mentha* spp., antifungal activity, sunflower phytopathogens)

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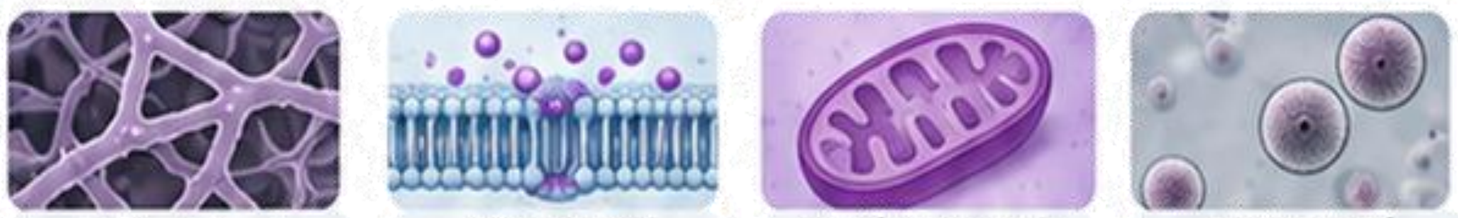
Analysis and synthesis
(chemical composition, mechanisms of action, efficacy, influencing factors, limitations and future applications)

• Results and Discussions

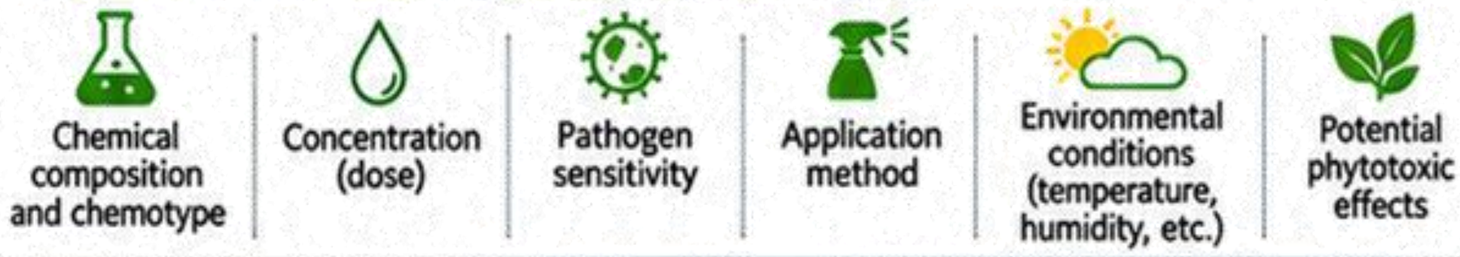
■ Main bioactive compounds in *Mentha* spp. essential oils



■ Antifungal mechanisms of action



■ Factors influencing antifungal efficacy



■ Current limitations

- High volatility
- Limited stability and persistence
- Formulation challenges
- Variable field performance
- Regulatory constraints

■ Future research perspectives

- Nanoformulations (e.g., nanoemulsions, nanocapsules)
- Controlled-release systems
- Synergistic combinations (with other EOs or biocontrol agents)
- Integration into integrated disease management (IPM) strategies



• Conclusions



- Essential oils, particularly those derived from *Mentha* spp., exhibit considerable potential as natural antifungal agents against sunflower-associated phytopathogens.
- Their antifungal activity is primarily associated with bioactive terpenes, including menthol, menthone, carvone and menthofuran, which interfere with essential fungal cellular processes.
- Their efficacy depends on several factors, including chemical composition, concentration, pathogen sensitivity, application method and environmental conditions.
- Appropriate formulation strategies and integration into integrated disease management (IPM) could contribute to the development of environmentally compatible biofungicides for sustainable sunflower protection.