

Nanoformulated essential oil-based insecticides: an ongoing scenario for greenhouse pest control

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Among insecticides derived from plants, essential oils (EOs) sound promising for the sustainable control of agricultural pests because their potential to reduce environmental harms associated to synthetic chemicals.

However, EO's challenges such as phytotoxicity, stability and degradation hinder their practical application. Advanced nanotechnology holds promise in overcoming these limitations. On the other hand, the side effects of nanoformulated EOs on plants and non-target beneficial insects remain poorly understood. In the laboratory the efficacy of different nanoformulated EOs from four plant families (Apiaceae, Asteraceae, Liliaceae, and Lamiaceae) was assessed for controlling key tomato pests with diverse feeding strategies: *Tuta absoluta* (chewing), *Phenacoccus solenopsis* and *Aphis gossypii* (sap-sucking). Additionally, the non-target effects of EOs were investigated on plants and beneficial insects commonly used in biological pest control programs. The majority of tested EOs showed significant insecticidal activity against target pests, with varying lethal concentrations. Fennel and anise EOs were particularly effective against *T. absoluta*, while garlic EO showed high efficacy against *P. solenopsis*. Most EOs showed minimal toxicity towards tomato plants but garlic and peppermint EOs activated plant defense signaling pathways triggering multiple behavioral responses on insect upper trophic networks. By contrast, EOs had different lethal and sublethal effects on the bioassayed natural enemies. These findings provide a foundation for integrating EOs into Integrated Pest Management strategies. Nevertheless, further research is necessary to extend the use of EOs at a large scale.