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Sustainable Approaches for Nematode Management in Modern Agriculture: A Focused Review

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Plant-parasitic nematodes pose a significant threat to global agricultural productivity, causing substantial yield losses across a wide range of crops. Reliance on chemical nematicides has raised serious concerns regarding environmental safety, human health, and sustainability. Consequently, there is increasing emphasis on eco-friendly and sustainable nematode management strategies. This review highlights major sustainable approaches for nematode management in modern agriculture, including crop rotation and diversification, use of organic amendments, biological control agents, host plant resistance, and integrated nematode management practices. These strategies contribute to improved soil health, reduced nematode populations, and long-term agricultural sustainability. Adoption of integrated and sustainable practices offers a viable alternative to chemical-based nematode control and supports environmentally responsible crop production.

Keywords: Plant-parasitic nematodes; Sustainable agriculture; Biological control; Organic amendments; Integrated nematode management

Introduction

Plant-parasitic nematodes (PPNs) are microscopic roundworms that attack plant roots and significantly reduce crop productivity worldwide. These pests interfere with nutrient and water uptake, leading to symptoms such as stunting, root galling, chlorosis, and yield losses. Annual global crop losses due to nematodes are estimated to exceed USD 150 billion, making them a serious constraint in modern agriculture (Devi et al., 2024). Conventional nematicides have been widely used to manage nematode problems; however, their excessive use has resulted in environmental contamination, non-target effects, and health risks. Therefore, sustainable and eco-friendly nematode management approaches are increasingly emphasized.

Crop Rotation and Diversification

Crop rotation is one of the oldest and most effective cultural practices for managing nematodes. Rotating susceptible crops with non-host or poor-host crops reduces nematode population densities by disrupting their life cycle. Crops such as cereals, marigold (Tagetes spp.), and sunhemp are commonly used in nematode-suppressive rotations. Crop diversification and intercropping further enhance soil biodiversity, which promotes natural suppression of nematode populations (Prisa & Jamal, 2025).

Organic Amendments and Soil Health

The application of organic amendments such as farmyard manure, compost, vermicompost, oil cakes, and green manures has shown promising results in nematode management. These materials improve soil organic matter, enhance microbial activity, and release toxic compounds during decomposition that suppress nematodes. Organic amendments also

improve soil structure and nutrient availability, thereby enhancing plant tolerance to nematode attack (Devi et al., 2024).

Biological Control of Nematodes

Biological control involves the use of living organisms to suppress nematode populations. Several fungi and bacteria have been reported to be effective against plant-parasitic nematodes. Nematode-trapping fungi, egg-parasitic fungi, and plant growth-promoting rhizobacteria reduce nematode populations by parasitism, antibiosis, or induced systemic resistance. Biological control agents are environmentally safe and compatible with other sustainable practices (Westerdahl, 2021).

Resistant Varieties and Host Plant Resistance

The use of nematode-resistant crop varieties is a cost-effective and environmentally friendly strategy. Resistant plants either prevent nematode penetration or restrict their development and reproduction. However, continuous use of resistant varieties may lead to the development of virulent nematode populations. Therefore, resistance should be combined with crop rotation and biological control for long-term sustainability.

Integrated Nematode Management

Integrated Nematode Management (INM) combines multiple sustainable practices such as crop rotation, organic amendments, biological control, and resistant varieties. INM minimizes reliance on chemical nematicides while maintaining effective nematode suppression. This approach aligns well with the principles of sustainable agriculture and integrated pest management (Devi et al., 2024).

Conclusion

Sustainable nematode management strategies play a crucial role in modern agriculture. By integrating cultural, biological, and organic approaches, nematode populations can be effectively managed while preserving environmental health. Future research should focus on refining integrated strategies and improving farmer awareness to ensure widespread adoption.

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