

## Use of Biopesticides in Spice Crops

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Spices occupy an integral place in Indian and global agriculture due to their wide use in culinary, medicinal, and industrial applications. India, being the “Land of Spices,” is the largest producer, consumer, and exporter of spices such as black pepper, cardamom, turmeric, ginger, coriander, cumin, chili, clove, nutmeg, and fennel. However, spice crops are highly vulnerable to insect pests, diseases, and nematodes that significantly reduce yield and quality. Conventional chemical pesticides, though effective, have resulted in pesticide residues, pest resistance, and environmental degradation. In this context, biopesticides have emerged as sustainable alternatives. Derived from natural organisms such as bacteria, fungi, viruses, nematodes, and plants, biopesticides offer eco-friendly and safe pest management solutions. Their use is gaining importance in spices, where export markets demand residue-free produce. Understanding their types, applications, advantages, and limitations is crucial for promoting sustainable spice cultivation.

### Types of Biopesticides and Their Relevance in Spice Crops

Biopesticides are broadly categorized into several groups:

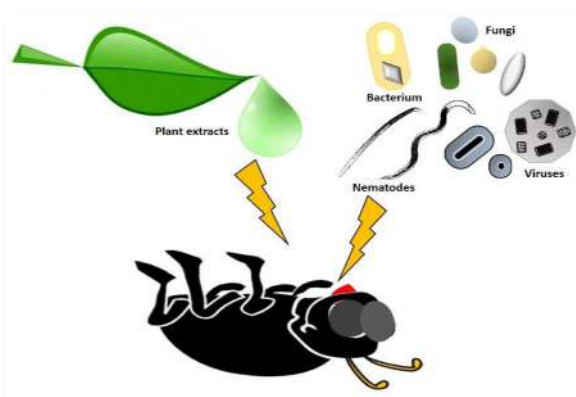
#### 1. Microbial Biopesticides

**Bacteria:** *Bacillus thuringiensis* (Bt) produces endotoxins effective against caterpillars like shoot borers in cardamom and fruit borers in chili. *Pseudomonas fluorescens* is widely used in turmeric and ginger to control rhizome rot and leaf spot diseases.

**Fungi:** *Trichoderma harzianum* and *T. viride* act as antagonists against soil-borne pathogens such as *Fusarium*, *Rhizoctonia*, and *Pythium* affecting black pepper and turmeric. *Beauveria bassiana* and *Metarhizium anisopliae* infect insects like thrips and whiteflies.

**Viruses:** Nuclear polyhedrosis viruses (NPVs) control lepidopteran larvae such as *Helicoverpa* in chili and cardamom.

**Nematophagous Fungi:** *Paecilomyces lilacinus* helps manage root-knot nematodes in coriander and black pepper.



## 2. Botanical Pesticides

Plant-derived products such as neem (Azadirachtin), pongamia oil, garlic extract, and chili extracts are effective against sucking pests, mites, and fungal pathogens. For example, neem oil sprays are extensively used in chili, turmeric, and coriander for aphid and thrips control.

## 3. Biochemical Pesticides

These include naturally occurring substances such as pheromones and plant growth regulators. Pheromone traps are used in black pepper and cardamom plantations to monitor and mass trap shoot and capsule borers.

## 4. Entomopathogenic Nematodes (EPNs)

Species like *Steinernema* and *Heterorhabditis* are effective against soil-inhabiting insect pests in ginger and turmeric.

### Relevance

Each type of biopesticide plays a critical role in spice crops: microbials suppress soil-borne diseases, botanicals control foliar pests, pheromones help in monitoring and reducing pest populations, while EPNs protect roots and rhizomes from soil pests. This integrated use makes them highly relevant for residue-free and export-oriented spice production.

## Major Spice Crops and Biopesticide Applications

### 1. Black Pepper (*Piper nigrum*)

Major Pests: pollu beetle (*Longitarsus nigripennis*), top shoot borer (*Cydia hemidoxa*), nematodes.

Biopesticides: *Trichoderma harzianum* for root rot, neem cake for nematodes, pheromone traps for shoot borers, *Pseudomonas fluorescens* for foot rot suppression.

### 2. Cardamom (*Elettaria cardamomum*)

Pests: thrips, capsule borer, root grubs.

Biopesticides: Neem oil sprays for thrips, NPVs for capsule borer, *Metarhizium anisopliae* for root grubs.

### 3. Chili (*Capsicum annuum*)

Pests: thrips, mites, fruit borers, aphids.

Biopesticides: Neem seed kernel extract (NSKE 5%) for sucking pests, *Bacillus thuringiensis* for fruit borers, *Verticillium lecanii* for aphids and whiteflies.

### 4. Turmeric (*Curcuma longa*) & Ginger (*Zingiber officinale*)

Pests: rhizome rot pathogens (*Pythium*, *Fusarium*), shoot borer (*Conogethes punctiferalis*).

Biopesticides: *Trichoderma viride* and *Pseudomonas fluorescens* for rhizome protection, neem cake for nematode management, *Beauveria bassiana* for shoot borer.

### 5. Coriander, Cumin, and Fennel

Pests: aphids, powdery mildew, and root-knot nematodes.

Biopesticides: Neem oil and *Verticillium lecanii* for aphids, *Paecilomyces lilacinus* for nematodes, *Trichoderma spp.* for soil-borne fungi.

### 6. Clove and Nutmeg

Pests: leaf spot, stem borer, and fruit borers.

Biopesticides: Neem oil sprays, *Trichoderma* for collar rot, and *Beauveria bassiana* for borers.

## Advantages of Biopesticides in Spice Crops

**1. Eco-friendly and Sustainable:** They decompose rapidly, leaving no harmful residues on spices, ensuring compliance with export quality standards.

2. **Target-specific:** Most biopesticides affect only target pests without harming beneficial insects like pollinators and natural enemies.
3. **Resistance Management:** Multiple modes of action help in delaying pest resistance compared to synthetic pesticides.
4. **Improved Soil Health:** Products like *Trichoderma* and neem cake enhance soil microbial diversity and plant vigor.
5. **Market Advantage:** Residue-free spice produce fetches premium prices in international markets.
6. **Safe for Farmers and Consumers:** Low toxicity ensures reduced occupational hazards.
7. **Compatibility with IPM and Organic Farming:** Easily integrated into existing pest management practices.

### Limitations of Biopesticides

1. **Slow Action:** Unlike chemical pesticides, biopesticides act gradually, making them less suitable for emergency pest outbreaks.
2. **Short Shelf Life:** Many microbial formulations require proper storage and have limited shelf stability.
3. **Environmental Dependence:** Efficacy is influenced by temperature, humidity, and soil conditions, which may vary across spice-growing regions.
4. **High Cost and Limited Availability:** Quality formulations are sometimes costly and not easily available in rural spice belts.
5. **Lack of Awareness:** Farmers often prefer chemical pesticides due to immediate visible effects and limited knowledge about biopesticides.

6. **Field Efficacy Variability:** Performance may differ between laboratory trials and field applications.

### Future Prospects

The future of pest management in spice crops lies in expanding the use of biopesticides through:

- Development of next-generation formulations with longer shelf life and higher field efficacy.
- Greater investment in research and extension to educate farmers.
- Policy support for subsidies and promotion of biopesticides under Integrated Pest Management (IPM) and organic farming programs.
- Development of consortia products (mixtures of microbes like *Trichoderma* + *Pseudomonas*) for broad-spectrum disease suppression.
- Wider use of nanotechnology-based biopesticides for better delivery and stability.

### Conclusion

Spice crops face diverse pest and disease challenges that threaten both yield and export potential. Biopesticides, with their eco-friendly and sustainable attributes, have proven effective in managing pests of black pepper, cardamom, chili, turmeric, ginger, coriander, and other spices. Despite limitations such as slow action and dependency on environmental factors, their advantages far outweigh the drawbacks when integrated with cultural and mechanical control measures. By promoting biopesticide use, the spice industry can meet global standards while ensuring sustainability and profitability for farmers.

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