

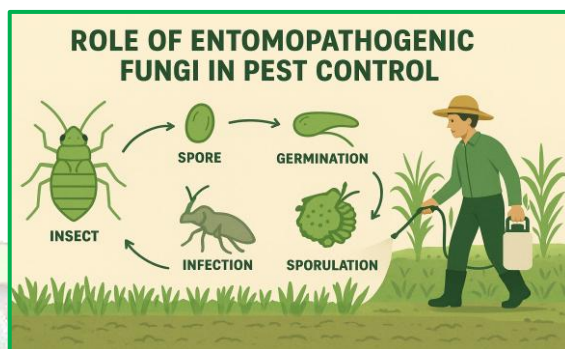
## Role of Entomopathogenic Fungi in Pest Control

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Entomopathogenic fungi (EPF) are a vital group of biological control agents that play a significant role in the eco-friendly management of insect pests in agriculture. Unlike chemical pesticides, which often cause resistance and ecological imbalance, these fungi are natural regulators of insect populations. They infect and kill insects through direct contact, offering an environmentally sustainable approach to integrated pest management (IPM). Common EPF such as *Beauveria bassiana*, *Metarhizium anisopliae*, *Lecanicillium lecanii*, and *Isaria fumosorosea* have been widely researched and applied for controlling pests like aphids, whiteflies, thrips, and beetles. This article discusses the biology, infection mechanism, advantages, applications, and limitations of entomopathogenic fungi in pest management.



### Introduction

Insects are among the most destructive pests affecting global agriculture. They attack crops at all stages—seedling, vegetative, and reproductive—leading to substantial yield and quality losses. Conventional pest management relies heavily on synthetic pesticides, which, though effective in the short term, pose serious challenges such as environmental contamination, development of pest resistance, residue accumulation, and destruction of beneficial fauna. To overcome these issues, biological control has emerged as a promising alternative. Among biological agents, entomopathogenic fungi (EPF) have gained considerable attention for their effectiveness, safety, and broad host range. EPF are naturally occurring microorganisms capable of infecting and killing insects by invading their cuticle and proliferating inside their bodies. These fungi are a key component of Bio-intensive Pest Management (BIPM) and Integrated Pest Management (IPM) programs, offering a sustainable solution to crop protection.

### Concept and Definition

The term “entomopathogenic” is derived from three Greek words:

Entomon = insect,

Pathos = disease, and

Genic = producing.

Thus, entomopathogenic fungi are fungi that cause disease in insects. They are natural pathogens that infect and eventually kill their insect hosts. Over 700 species of EPF have been identified, belonging mainly to the genera *Beauveria*, *Metarhizium*, *Lecanicillium*, *Isaria*, and *Nomuraea*.

EPF are obligate or facultative parasites that use insects as hosts to complete part of their life cycle. They are capable of controlling several major pest groups, including lepidopterans (caterpillars), hemipterans (aphids, whiteflies), coleopterans (beetles), and dipterans (flies).

### Mode of Action of Entomopathogenic Fungi

Unlike bacterial or viral pathogens that must be ingested, EPF infect insects through direct contact with the cuticle (outer body covering). The process of infection involves several key stages:

- **Spore Adhesion**

When fungal spores (conidia) come into contact with the insect's cuticle, they adhere to it through hydrophobic interactions and specific surface proteins.

- **Germination**

Under favorable conditions (humidity, temperature), the spores germinate to produce germ tubes.

- **Cuticle Penetration**

The germ tube differentiates into an appressorium (a specialized structure) that secretes cuticle-degrading enzymes such as chitinase, protease, and lipase, allowing the fungus to penetrate through the insect's cuticle.

- **Invasion and Colonization**

After entering the hemocoel (insect's body cavity), the fungus proliferates as yeast-like cells called blastospores, consuming nutrients and releasing toxins like beauvericin, destruxin, and verticillin, which cause paralysis and death.

- **Death and Sporulation**

After killing the insect, the fungus grows outward, covering the insect's cadaver with a dense mycelial layer. Under humid conditions, the cadaver sporulates, releasing new conidia that can infect other insects.

### Major Entomopathogenic Fungi and Their Target Pests

| Fungal Species                                                       | Target Pests                                | Crops                            |
|----------------------------------------------------------------------|---------------------------------------------|----------------------------------|
| <i>Beauveria bassiana</i>                                            | Whiteflies, aphids, thrips, borers, beetles | Cotton, tomato, brinjal, cabbage |
| <i>Metarhizium anisopliae</i>                                        | Grasshoppers, termites, beetles             | Vegetables, sugarcane, maize     |
| <i>Lecanicillium lecanii</i> (formerly <i>Verticillium lecanii</i> ) | Aphids, whiteflies, mealybugs               | Vegetables, coffee, citrus       |
| <i>Isaria fumosorosea</i>                                            | Thrips, aphids, whiteflies                  | Ornamental and vegetable crops   |
| <i>Nomuraea rileyi</i>                                               | Spodoptera litura (armyworm), Helicoverpa   | Pulses, soybean, cotton          |

These fungi have demonstrated broad-spectrum efficacy and compatibility with other bio-agents and botanicals, making them ideal components of IPM systems.

### Production and Formulation of EPF

The success of fungal biopesticides depends largely on their mass production and formulation for field application. EPF can be produced using solid-state or liquid fermentation methods. Formulations include wettable powders, oil-based emulsions, granules, and aqueous suspensions designed to enhance shelf life, spore viability, and field performance.

➤ **Mass Production**

EPF can be produced using:

- **Solid-state fermentation:** Using rice, sorghum, or wheat bran as substrates for conidial production.
- **Liquid fermentation:** Produces blastospores or submerged conidia, often used for formulations.

### ➤ Formulation Types

Formulations are designed to enhance shelf life, spore viability, and field performance:

- Wettable powders (WP)
- Oil-based formulations (EC)
- Granules (GR)
- Aqueous suspensions
- Dust formulations

Additives like UV protectants, surfactants, and humectants improve the stability and infectivity of spores.

### Factors Affecting Fungal Efficacy

The performance of entomopathogenic fungi is influenced by several environmental and biological factors:

1. **Temperature and Humidity:** High humidity (>70%) and moderate temperatures (25–30°C) favor fungal germination and infection.
2. **UV Radiation:** Ultraviolet rays can destroy fungal spores, reducing effectiveness.
3. **Host Susceptibility:** Younger insect stages (larvae, nymphs) are generally more vulnerable.
4. **Application Timing and Method:** Late evening or early morning applications ensure better infection due to higher humidity.
5. **Compatibility:** EPF are compatible with other bioagents and botanical pesticides but may be inhibited by chemical fungicides.

### Role of Entomopathogenic Fungi in Integrated Pest Management (IPM)

EPF play a central role in **biological and ecological pest regulation**, complementing other IPM components:

#### 1. Biological Regulation

EPF naturally control pest populations in the ecosystem. In IPM, they are released to maintain pest density below the Economic Threshold Level (ETL).

#### 2. Compatibility with Other Agents

EPF are compatible with:

- *Trichogramma* parasitoids
- *Chrysoperla carnea* predators
- Neem-based products and pheromone traps

#### 3. Environmental Sustainability

They reduce dependence on hazardous pesticides and help preserve biodiversity.

#### 4. Specific Examples

- *Beauveria bassiana* combined with neem oil effectively controls whiteflies in tomato.
- *Metarhizium anisopliae* is used for termite management in sugarcane and rice.
- *Lecanicillium lecanii* works well against aphids in chillies and brinjal.

### Advantages of Using Entomopathogenic Fungi

1. **Eco-Friendly:** No chemical residues; safe for humans, animals, and pollinators.
2. **Wide Host Range:** Effective against multiple pest species.
3. **Self-Propagating Nature:** Fungi reproduce and spread under favorable conditions.
4. **Compatibility with IPM Components:** Works well with botanicals, predators, and parasitoids.
5. **Resistance Management:** Reduces selection pressure compared to repeated chemical use.
6. **Reduced Production Cost:** Locally available substrates allow low-cost production for small farmers.
7. **Long-Term Control:** Establishes a natural balance within the ecosystem.

## Limitations and Challenges

Despite their potential, some challenges hinder widespread use of EPF:

1. **Environmental Dependence:** Require specific humidity and temperature for infection.
2. **Slow Action:** Takes 3–7 days for visible mortality, unlike chemical insecticides.
3. **Short Shelf Life:** Spores lose viability if not properly stored.
4. **UV Sensitivity:** Spores degrade under sunlight, limiting field persistence.
5. **Limited Commercialization:** Few companies produce standardized, quality EPF formulations.
6. **Farmer Awareness:** Many farmers lack knowledge about correct application and handling.

## Recent Advances and Future Prospects

### 1. Genetic Improvement

Molecular tools are being used to develop **virulent and stress-tolerant fungal strains**.

### 2. Nano-Formulations

Nanoparticle-based carriers protect spores from UV light and increase field longevity.

### 3. Combination with Botanicals and Insect Growth Regulators (IGRs)

Such combinations enhance efficacy and reduce pest resistance.

### 4. Endophytic Role

Some EPF can live inside plant tissues (endophytically), offering systemic pest protection and growth promotion.

### 5. Field Validation

Continuous field evaluation and farmer training are improving adoption rates.

## Conclusion

Entomopathogenic fungi offer a promising and sustainable alternative to chemical insecticides in modern pest management. Their natural mode of action, eco-safety, and compatibility with IPM strategies make them indispensable tools for sustainable agriculture. Although environmental constraints and awareness issues persist, advancements in formulation technology, strain improvement, and integrated application will undoubtedly enhance their role in future pest control programs. Promoting the use of EPF in vegetable and field crops not only ensures healthy crop production but also contributes to environmental conservation and food safety.

## References

1. Butt, T.M., Jackson, C., & Magan, N. (2001). *Fungi as Biocontrol Agents: Progress, Problems and Potential*. CABI Publishing.
2. Lacey, L.A., & Kaya, H.K. (2007). *Field Manual of Techniques in Invertebrate Pathology*. Springer.
3. Goettel, M.S., & Inglis, G.D. (1997). *Fungi: Hyphomycetes*. In: *Manual of Techniques in Insect Pathology*. Academic Press.
4. Shapiro-Ilan, D.I., et al. (2012). *Microbial Control of Insect Pests in Agriculture and Forestry*. In: *Annual Review of Entomology*, 57: 409–431.
5. FAO (2023). *Biological Control in Integrated Pest Management: Role of Entomopathogens*.
6. NIPHM (2022). *Bio-Intensive Pest Management Manual*. Government of India.
7. Kabaluk, J.T., & Gazdik, K. (2007). *The Use of Beauveria bassiana for the Control of Agricultural Insect Pests*. Agriculture and Agri-Food Canada.