Entomopathogenic Fungi (EPF)

Aditya Kumar Sharma[1]*, Ankit Kumar[2], Abhishek Kumar Yadav[3] and Sandeep Kumar Singh[1]

[1]Research Scholar (Ph. D.), Department of Ag. Entomology, B.R.D. PG. College Deoria- 274001, Uttar Pradesh, India
[2]Research Scholar (Ph. D), Department of Ag. Entomology, A.N.D.U.A & T, Kumarganj-224229, Ayodhya, Uttar Pradesh, India
[3]Research Scholar (Ph. D), Department of Ag. Entomology, C.S.A.U.A & T, Kanpur- 208002, Uttar Pradesh, India

Corresponding Author
Aditya Kumar Sharma
Email: adisharmajmd098@gmail.com

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ABSTRACT

Entomopathogenic fungi are a diverse group of microorganisms that infect and kill insects, playing a crucial role in natural pest regulation and sustainable agriculture. These fungi, including well-known genera such as *Beauveria, Verticillium, Metarhizium*, *Nomuraea*, *Paecilomyces* and *Hirsutella* invade their hosts through direct penetration of the insect cuticle, bypassing the need for ingestion. Once inside, they proliferate within the host body, producing toxins and consuming internal tissues, ultimately leading to the insect's death. The life cycle of entomopathogenic fungi involves spore attachment, germination, host invasion, internal colonization, and external sporulation, allowing the fungi to spread to new hosts. Environmental factors such as temperature, humidity, and host availability significantly influence their effectiveness. Due to their specificity and eco-friendly nature, these fungi are widely used as biological control agents in integrated pest management (IPM) programs, reducing dependence on chemical pesticides.

INTRODUCTION

Entomopathogenic fungi (EPF) are specialized, parasitic fungi that infect, kill, and consume insects and other arthropods, acting as natural biological control agents. Unlike bacteria or viruses that must be eaten, these fungi infect by directly penetrating the insect's exoskeleton (cuticle) using enzymes and pressure, making them powerful tools for eco-friendly, sustainable pest management. Entomopathogenic fungi (EPF) are a specialized group of fungi that act as natural parasites to insects and other arthropods (like mites and ticks). Unlike most other insect pathogens—such as bacteria or viruses—they don't usually need to be eaten to work; they infect their hosts by drilling directly through their "skin" (exoskeleton). The potential use of entomopathogenic fungi (EPF) as bio control agents against herbivores is an environmentally viable alternative insect pest management strategy. EPF are known for their capacity to infect insects and cause sickness by entering their cuticles. More than 700 species from around 90 distinct genera have been identified as insect-pathogenic fungus till date. The most well-known EPF are belonging to genera ***Beauveria, Metarhizium,Isaria Hirsutella***, and ***Lecanicillium.*** The most widely used EPF are ***Beauveria bassiana***, ***Isaria fumosorosea***, ***Metarhizium anisopliae***, and ***Lecanicillium lecanii*** (Chen *et al*., 2015). Biological plant protection with entomopathogenic fungi is an important component of a long-term pest management strategy. When compared to conventional pesticides, entomopathogens offer significant benefits as bio control agents. Low prices, great efficiency, safety for beneficial creatures, residue reduction in the environment, and improved biodiversity in human-managed ecosystems are some of the benefits of EPF. EPF is an essential component of myco-insecticides used in horticulture, forestry, and agriculture. It is a vital component of integrated pest management strategies for biological control of insect pests and other arthropods.

Some important genera of EPF (Entomopathogenic fungus)

1. Genus – ***Beauveria***
2. Genus – ***Verticillium***
3. Genus – ***Metarhizium***
4. Genus – ***Nomuraea***
5. Genus – ***Paecilomyces***
6. Genus - ***Hirsutella***

1. **Genus** – ***Beauveria*:** It is an entomopathogenic fungus used as a bio-pesticide in crop pest management. It lives in the soil saprophytically and frequently produces large epizootics that kill out insect populations on crops. The two more important species are in this group i.e., ***Beauveria bassiana*** and ***Beauveria brongniartii***. It creates poisons such as **beauvericin**, **bassianocide,** and others inside the host body, causing paralysis and eventually killing the insects within four or five days. ***Beauveria bassiana*** is a natural inhabitant of the soil, an obligate parasite of several insect species (Zimmermann 2007). They are particularly useful in controlling sucking pests and caterpillars that infest agricultural plants. These EPF are used to manage caterpillars such as the yellow stem borer and leaf folder of rice, the white grub of groundnut, the coconut rhinoceros beetle, sugarcane pyrilla, caterpillars of pulses, tomato, and cotton, diamond back moth and leaf eating caterpillars of tobacco & sunflower.

2. **Genus** – ***Verticillium*:** It is a naturally occurring entomopathogenic fungus which

can be used as a bio-pesticide. The two most important species in this genus are ***Verticillium chlamydosporium*** and ***Verticillium lecanii***. The fungus ***V. lecanii*** is widely spread and can produce massive outbreaks in tropical and subtropical climates, as well as in warm and humid conditions. ***Verticillium lecanii*** is most effective to manage the whitefly, thrips, mealy bug and several aphid species of vegetables and ornamentals etc.

3. **Genus – *Metarhizium*:** It is a fungal insecticide widely used against a wide range of insects including soil insects, caterpillars, sucking pests and locusts. ***Metarhizium anisopliae***, ***Metarhizium album*** and ***Metarhizium flavoviride*** are the three most significant species in the genus. It is known to attack over 200 species of insects covering seven orders. This pathogenic fungus is mostly used to manage the coconut rhinoceros beetle, groundnut cut worm, rice brown plant hopper, diamond back moth, sugarcane early shoot borer, top shoot borer and internode borer.

4. **Genus – *Nomuraea*:** It is also an EPF used as a bio-pesticide against ***Sopdoptera litura*** and ***Helicoverpa armigera*** of groundnut, sorghum and chickpea etc. ***Nomuraea rileyi*** is a dimorphic hyphomycete that may induce epizootic death in various insects. ***N. rileyi's*** host specificity and environmentally favourable characteristics support its application in insect pest management. This biological control is effective against a variety of insect hosts, including ***Trichoplusia sp., Heliothis zea, Bombyx mori, Plathypena scabra***, and others.

5. **Genus – *Paecilomyces*: *Paecilomyces fumosoroseus*** is a major bio-control agent against whiteflies that causes "yellow muscardine." The ability of this fungus to grow extensively over the leaf surface under humid conditions is a characteristic that certainly enhances its ability to spread rapidly through whitefly populations. ***P. fumosoroseus*** is best for controlling the nymphs of whitefly. This fungus is used to manage yellow and red mites, whiteflies, and other insects in both field and greenhouse environments.

6. **Genus – *Hirsutella*: *Hirsutella thompsonii***, ***Hirsutella gigantea***, and ***Hirsutella citriformis*** are the three most significant species in the genus ***Hirsutella***. ***Hirsutella thompsonii*** is used to control the citrus rust mite. This bio control is also effective against the Arachnida, Lepidoptera, and Hemiptera insect families.

Mode of Action Entomopathogenic Fungi

1. EPF kill insects in a variety of ways, including starving to toxin production. It produces several toxins and extracellular enzymes such as proteases and chitinases.

2. Cuticle is the principal barrier to infection in insects since it is the primary avenue of fungal penetration. As a result, it requires either physical or enzymatic techniques to breach the impenetrable cuticle.

3. The infection process begins with spore contact with the host cuticle. Most fungi have an infective unit that is a spore, commonly a conidium. Conidia are usually sticky to the cuticle or exude adhesive mucus when they enlarge during pre-germination.

4. In favourable conditions, the conidium germinates into a short germ tube that produces tiny swellings called appressoria. The appressorium adheres to the cuticle and sends out an infection peg, which gives the fungus with the solid connection it requires to physically push its way into the host.

5. The hyphae then penetrate the insect cuticle by enzymatic chitin and protein disintegration, first dissolving the cuticle and then entering the insect's haemocoel and internal organs. The infectious fungal mycelium invades the insect until it is completely filled with the fungus and becomes quite solid to the touch.

6. Following that, conidiophores are generated, which erupt through the cuticle and create spores on the exterior of the fly, infecting surrounding healthy insects as well.

Advantage of Entomopathogenic Fungi

1. High Target Specificity
2. Resistance Management.
3. Safety for Humans and the Environment.
4. Secondary Transmission (The "Epicentre" Effect).
5. Multi-Functional Roles.

1. High Target Specificity: One of the coolest things about EPF is that they are picky eaters. Many strains are host-specific, meaning they can target a specific pest (like aphids or whiteflies) while leaving **beneficial insects** like bees, ladybugs, and spiders unharmed.

2. Resistance Management: Insects are notorious for developing resistance to chemical sprays. Because fungi attack via complex biological processes using a cocktail of enzymes and mechanical pressure to breach the cuticle. it is much harder for pests to evolve a defence against them.

3. Safety for Humans and the Environment:

A. Low Toxicity: They are generally non-toxic to humans, pets, and livestock.

B. No Residue: Unlike synthetic chemicals, they don't leave harmful residues on crops, making them ideal for organic farming.

C. Zero Re-entry Interval: Farmers can often return to the field almost immediately after application.

4. Secondary Transmission (The "Epicentre" Effect): Fungi have a unique way of spreading. An infected insect can carry spores back to its colony or nest. Once the insect dies, the fungus erupts from the body (sporulation), releasing millions of new spores into the environment to infect the rest of the population.

5. Multi-Functional Roles: Recent research shows that these fungi do more than just kill bugs. Some species:

A. Promote Plant Growth: They can form symbiotic relationships with roots, helping plants take up nutrients

B. Endophytic Properties: Some can live *inside* the plant tissue, providing a built-in "shield" against future attacks.

CONCLUSION

It is evident that EPF is an essential bio control agent for insect pests. There is a wide variety of fungal species from several families that can infect insects. It infests the host insects via digestion, respiration and through integument. In infestation from integument which is one of the most common infestation methods, fungi grow hyphae to penetrate epicuticle and progresses into hypodermis to achieve the infestation. In certain circumstances, EPF have high host selectivity for arthropod pest management. As a result, they have no effect on beneficial insect populations. Microbial pesticide residues provide no danger to humans or other beneficial creatures. Farmers can use them even when a crop is nearly ready for harvest. They persist in the environment

for a long period after application, resulting in the rapid mortality of the arthropod hosts and provide long-term control.

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