Popular Article

ENTOMOPATHOGENIC FUNGI: A POTENTIAL BIOCONTROL AGENT IN INSECT PEST MANAGEMENT

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ABSTRACT
Application of synthetic insecticides resultant insect pest control is the primary means of crop protection in conventional agriculture all over the world. Indiscriminate uses of chemical pesticides at frequent intervals leads to insecticide resistance, pest resurgence, toxic residues in the environment and depletion of natural enemy population causing environmental pollution and severe health hazards. Biopesticides are considered to be the best alternative to synthetic pesticides that are highly effective, target specific and reduce environmental risks. Biopesticides are pesticides derived from natural materials such as animals, plants, bacteria, fungi, algae, viruses, nematodes and protozoa and minerals. Global biopesticides market is estimated to reach $4 billion by 2024, growing at a CAGR of 8.8% between 2016 and 2024. However, bio-pesticides may represent about 4.2% of the overall pesticides market in India. Globally, biopesticides production is 4.5% and in USA it is 6%, whereas in India, it accounts only 3% of the total chemical pesticides production. Entomopathogenic fungi identified as a promising biocontrol agent in the regulation of insect pest population without harming the non-target insects. Over 800 species of entomopathogenic fungi and 1000 species of protozoa pathogenic have been described and identified. Most research on entomopathogenic fungi has been aimed at developing them as inundative biological control agents of insects, mites and ticks, despite the great potential for use in conservation and classical biocontrol strategies. In the present article efforts will be made to draw attention and sound knowledge on the basics of use of entomopathogenic fungi in eco-friendly insect pest management.

INTRODUCTION

Entomopathogenic fungi are considered to play an important role as biological control agent to control insect populations. A very diverse array of fungal species is found from different classes that infect insects. These insect pathogenic species are found in a wide range of adaptations and infecting capacities including obligate and facultative pathogens. Spreading of fungal diseases is common in many insect species while some species may not be affected. In 1980s,the first insect pathogenic studies were carried out and their focus was to find the methods of disease management of the silkworm. Bassi in 1835, first time formulated the germ theory by the use of white muscardine fungus on the silkworm that was then named in his honor as *Beauveria bassiana*. Gilbert and Gill (2010) described that this silkworm disease gave the idea of using insect infecting fungi for the control of insect pest management. Most of the commercially produced fungi are species of *Beauveria*, *Metarhizium*, *Lecanicillium* and *Isaria* that are relatively easy to mass produce. Attention has focused predominantly on the technical aspects of biopesticide development, such as mass production and formulation, and the selection of strains with rapid kill (Shahid *et al*., 2012). Production requirements include reasonable cost, long-term stability, and, most importantly, consistent efficacy under field conditions. The prevalent methods involve the production of diaspores (dispersal units) by induction of aerial conidiation on solid growth media, production of blastospores by yeast-like growth in liquid media or growth of hyphal biomass in liquid or solid media (Faria and Wraight, 2007). Many commercial products are available globally that are formulated by utilization of less than ten species of fungi. A group of fungi that kill an insect by attacking and infecting its insect host is called entomopathogenic fungi. The main route of entrance of the entomopathogen is through integument and it may also infect the insect by ingestion method or through the wounds or trachea. At the recent times, about 90 genera and almost above 800 species are considered as insect infecting fungi that represent about all the major classes of fungi. Entomopathogenic fungi are a major component of integrated pest management techniques as biological control agents against insect pests and other arthropods and are an integral part of myco-insecticides in horticulture, forestry and agriculture. The mass production of Hyphomycete fungi is not very expensive. Its storage is very easy and it is efficient on a wide range of humidity and temperature. Insect pathogenic fungi are being developed and produced in mass production globally to control a wide range of harmful insects of crops.

Biology

The most common portal entry of fungi is through the integument though invasion via the respiratory or alimentary tract is also reported. In a general view, the life cycle of insect pathogenic fungi, an infective spore stage, usually conidia are required generally that germinates on the host cuticle. In favourable conditions, it forms a germ tube penetrating the host cuticle and occupies the internal body of the host. The infecting fungal spores then increase in number, causing toxin production that ultimately kills the insect. The fungus comes out of the insect cadaver in suitable temperature and humidity conditions and disseminates in the environment. Several species form the resting spores that become capable of infecting at the time of favorable environmental conditions. The fungus needs a strategy for the dissemination to infect new hosts. In general, the vital factors for the survival and reproduction in fungus infection are host and suitable environmental conditions.

Host range

Fungal diseases are common in Lepidoptera (particularly larvae), Homoptera (particularly aphids, whiteflies, cicadas, scale insects), Hymenoptera (bees), Coleoptera (beetles) and Diptera (flies and mosquitoes).

Mode of action and host reaction

The mode of action of insect pathogenic fungi varies and kills the insect by different ways such as causing starvation to toxin production. These insect pathogenic fungi produce many toxins and extracellular enzymes such as proteases and chitinases which aid penetration of the host physical defenses. Cuticle is the main hurdle to infection in insects as it is the main path of fungus penetration. Hence, it needs some physical or enzymatic means to pierce the hard cuticle. The infective unit in most fungi is a spore, usually a conidium. In many cases, the conidia are adhesive to the cuticle, or secrete adhesive mucus as the conidium swells during pregermination. In favourable conditions, the conidium, germinates into a short germ tube which gives out small swellings called appressoria. The appressorium attaches itself to the cuticle and sends out an infection peg which provides a firm attachment that the fungus needs to physically force its way into the host. The hyphae then penetrate the layers of the integument by enzymatic dissolution of chitin and protein, ramify first in the cuticle and then reach the haemocoel and internal organs. The invasion by the fungal mycelium continues until the insect is virtually filled with the fungus and becomes quite firm to touch. Conidiophores are then produced which erupt through the cuticle and produce spores on the outside of the insect, infecting nearby healthy insects also. Death of the host is by obliteration (choking) of the tissues and also by the toxins produced by the fungus.

Symptoms

Loss of appetite and an attempt to climb higher up are the early symptoms of the fungal disease. They are followed by decreased irritability, general of partial paralysis, discoloured patches on integument and increased acidity in the blood. The body hardens and the insect in upright on its legs at the time of death. Death occurs within a week or even within 24 hours. The causes of death may be as follows: hyphae may force apart muscles, blood cells may stop circulating due to increased hyphae, blockage of the gut and by the toxin produced by the fungus.

Uses

- ***Beauveria bassiana*** **–** These entomopathogenic fungi enter the host insects body through food or in contact with the host cuticle and reproduce inside the insect body. It produces toxins namely beauvericin, bassianocide etc. inside the host body causes paralysis of the host insects and ultimately kills the insects within four or five days. They are used particularly to control sucking pests and caterpillars infesting crop plants. These fungi are used to control the caterpillars of yellow stem borer and leaf folder of rice, white grub of groundnut, sugarcane pyrilla, coconut rhinoceros beetle, caterpillars of pulses, tomato and cotton, diamond back moth, leaf eating caterpillars of tobacco and sunflower etc.

(Source-Hopetoun Falls Walk, Otways Ranges, 2008)

(Source- Louis Tedders, USDA Agricultural Research Service, Bugwood.org)

Fig. 1. Infected larvae by *Beauveria bassiana*

Verticillium lecanii–This beneficial fungus mainly used to control whiteflies, aphids, thrips, brown plant hopper, scale insects, mealy bugs and other sucking insect pests of crop plants.

(Source- IPM Support Ethiopia)

(Source- Brian Bushe, CTAHR)

Fig. 2. Infected aphid nymphs and adults and scale insects by *Verticillium lecanii*

Metarrhizium anisopliae **–** This pathogenic fungus is used to control mainly coconut rhinoceros beetle, groundnut cut worm, rice brown plant hopper, diamond back moth and early shoot borer, top shoot borer and internode borer of sugarcane.

(Source – Google Image)

Fig. 3. Insects infected by *Metarrhizium anisopliae*

Nomuraea rileyi–It is used to control pod borers, cut worms, cabbage borers etc.

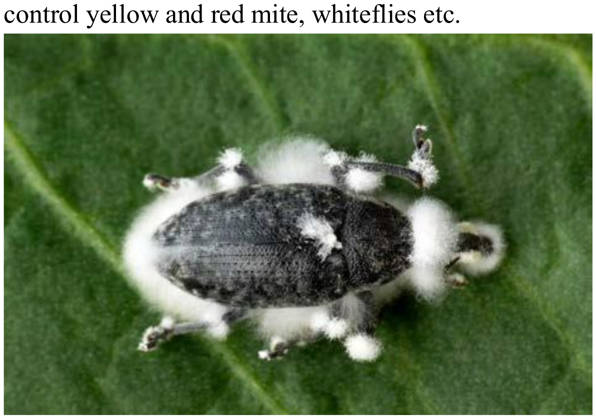
(Source- Donald C. Steinkraus, University of Arkansas, Bugwood.org)

(Source-https://www.plantmanagementnetwork.org/pub/php/brief/2003/fungus/)

Fig. 4. Larvae infected by *Nomuraea rileyi*

***Hirsutella thompsonii*–**These fungi are used to control different hoppers and bug pests, whiteflies, red mites etc.

***Paecelomyces fumosoroseus* –** This fungus is used to control yellow and red mite, whiteflies etc.



(Source- https://alchetron.com/Paecilomyces-fumosoroseus-3970609-W)

(Source- https://organicsoiltechnology.com)

Fig. 5. Insects infected with *Paecelomyces fumosoroseus*

Table 1. Name and recommended dose of some popular commercial product of entomopathogenic fungi in the market

Name of insecticide	Trade name	Recommended dose
Beauveria bassiana 1.15% WP	Biopower, Larvocel, Biorin, Bassina	Spray: 1-2 gm/lit. of water In soil: 2.5 Kg/ha + 100 Kg FYM or compost
Verticillium lecanii 1.15% WP	Biolin, Biocatch	Spray: 5 gm/lit. of water
Metarrhizium anisopliae 1.15% WP	Biomagic, Biomate, Metasin	Spray: 5 gm/lit. of water In soil: 2.5 Kg/ha + 50 Kg FYM or compost
Nomuraea rileyi 1.15% WP	Biopower	Spray: 1-2 gm/lit. of water
Hirsutella thompsonii 1.15% WP	Biopower	Spray: 2-3 gm/lit. of water
Paecelomyces fumosoroseus 1.15% WP	Priority, Mycomite	Spray: 5 gm/lit. of water In soil: 3.75 Kg/ha + 50 Kg Neem cake
Paecelomyces lilacinus 1.15% WP	Bionematon, Niyantran	Spray: 5 gm/lit. of water In soil: 3 Kg/ha + 100 Kg FYM or compost

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