Review Paper (T-3)

ENTOMOPATHOGENIC FUNGI AS POTENT BIOCONTROL AGENTS

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ABSTRACT

Insect pest menace is a major factor that destabilizes crop productivity in agro-ecosystems. Chemical pesticide are the “silent killers” responsible for resistance in pests, environmental persistence and toxicity. Biological control involves ‘natural enemies’ against pest invasions. Biocontrol agents are highly specific to host insects, besides being safe to environment and mankind. Microbial pesticides may be based on bacteria, viruses, fungi and nematodes. Entomopathogenic fungi (EPFs) are used for the control of insect pests by causing disease in them. Common EPFs are Beauveria bassiana and Metarhizium anisopliae. EPFs are advantageous over other pest management strategies because of significantly higher host specificity, broad host range, reduction of hazards and theoretical impossibility of the insects to develop resistance as fungi use simultaneously several mode of action, and as a ‘living pesticide’ is subjected to adaptation too. The success of EPFs in a winning strategy against the insect pests pivots upon three factors viz., the physiology of EPF-pest interaction, insect defences, and entomopathogenesis coupled with environmental conditions. The multiple development processes require the activities of fungal molecules like adhesion aiders, penetration effectors, enzymes and toxins. As a conclusion, the entomopathogenic fungi with their unique mode of pathogenesis hold high affirmations for commercial market

Key Words: Entomopathogenic fungi, Biological control agents, Insect pests, Entomopathogenesis

INTRODUCTION

The last century has been witness to both the keynote augmentation of the chemical pesticides as well as its backlashes. The intensive use of the chemicals has shown to cause numerous deleterious effects on the environment and caused its toll on human safety and non-target hosts. Saying ‘no’ to the hazardous chemical pesticides has been explicitly talked about since a long time but somehow the real momentum for the cause is not yet a thorough practicality. The virtual torrent to fight back the ‘silent-killers’ has its basis in real-time studies and proven evidences. Frantic efforts are being directed towards non-chemical and sustainable plant protection methodologies. Cultural methods, though quite effective are handicapped by their slow and low efficacy. Under this management turmoil, all hopes in the present agricultural scenario are besetted upon the bio-control of insect pests. This method
involves reduction in pest population through the activity of living organisms that occur naturally, by manipulation of environment or through the introduction of antagonists. Though the bio-management is not as rapid as the chemicals, but it is practically more feasible and sustainable than the chemical cure. Several microorganisms are currently under consideration as control agents of insects, including viruses, bacteria, fungi and protozoa. Entomopathogenic fungi (EPFs) are used for the biological control of insect pests. Eilenberg et al. recognized four cardinal strategies for insect pest management employing EPFs, viz., (a) the classical biological control which is the intentional introduction of exotic strains for long term unmanaged control, (b) inoculative biocontrol which is the intentional release of endemic strains for long term unmanaged control of endemic pests, (c) inundative biological control which uses the fungi to limit pests when control is achieved exclusively by the mass release of the bioagent and (d) conservative biological control, which involves modification of the environment to enhance fungal infection.

RESULTS AND DISCUSSION

EPFs: The organisms

*Metarhizium anisopliae* (Fig. 2) and *Beauveria bassiana* are perhaps the most heavily researched upon EPFs probably because of their high host-specificity, non-persistance and non-toxicity to environment, unique mode of action and appreciable shelf life. They belong to class Hyphomycetes and are characterized by mycelial forms that bear asexual resting spores called “conidia” (Fig. 1). The conidia serve as the infective propagule. Both of these are cosmopolitan in occurrence.

![Fig. 1: Germinating and non-germinating spores of *M. anisopliae* isolate](image)
The hosts

Both *M. anisopliae* and *B. bassiana* have a broad host range with individual isolates being more specific. *M. anisopliae* causes “green muscardine” disease while *B. bassiana* causes “white muscardine” in various insect pests belonging to orders lepidoptera, coleoptera, orthoptera etc. They are unique when compared to other microbes causing diseases in insects because they cause infection by growing through the insect cuticle and not required to be ingested, thus showing great potential for control of even sucking insect pests. These fungi cause insect death and can be transmitted to other insects.

Pathogenesis by EPFs

They have the ability to invade insects through the external cuticle. The physiology of EPF-pest interaction depends upon the following events, viz. attachment of infective unit to insect cuticle and germination thereafter. This is followed by penetration of the cuticle, either directly by germ tube or by infection pegs from appressoria. After enzymatic hydrolysis of the cuticle (Fig. 3), the EPF reaches the haemolymph of the insect where it grows as yeast like blastospores or hyphal bodies, rather than in mycelial form. Before proliferation in the haemocele, the EPFs produce toxins to suppress the insect defense response. *B. bassiana* produces various toxic compounds including beauvericin, bassianolide and oosporin, and *M. anisopliae* produces numerous cyclic depsipeptides termed destruxins, which lead to an immuno-suppression or a titanic paralysis. Destruxins produced by *M. anisopliae* have been suggested to be an important virulent factor in accelerating insect pathogenesis.
Destruxins A and E are said to be more insecticidal than others\textsuperscript{11}. Growth in the mycelial phase with invasion of virtually all host organs occurs, followed by penetration of the hyphae from the interior through the cuticle to the exterior of the host. Finally the infective units i.e. the conidia are produced to the exterior of the host\textsuperscript{12}.

**Mycoinsecticides : The advantages and constraints**

The advantages of EPFs over chemical pesticides are their significantly higher host specificity, the reduction of hazards and the inability of the insects to develop resistance as the EPFs simultaneously use several modes of actions and as a “living-pesticide” is subjected to adaptation too. The constraints include the slow efficacy in comparison to the chemicides and on-field exposure to various biotic and abiotic stresses.

**CONCLUSION**

The answer to the question as to why to pursue biological control is in simplest jargon “corporate commitment”. It is now evident that the stage is set for the fungal biological disease control agents to play a greater part in commercial agriculture. The research and development sectors, the world over, commit funds to ensure that an efficacious, cost-effective and eco-friendly product will reach the market. The commitment is not limited to just the sale of products but also includes the follow-through to ensure that the end-users will be satisfied and successful when using their products. The search for and development of commercially viable EPFs entails several steps viz., isolation of the EPFs from the environment/host insect, followed by experiments and studies to generate knowledge of the ecology, physiology and taxonomy of potential myco-insecticide. The knowledge of EPF ecology such as tolerance
to environmental stress can contribute to a better understanding of the effect of optimum factors on the survival and distribution of EPFs in field. This in turn can enable prediction and application time and/or promote habitats that encourage amplification of natural inoculum and the induction of epizootics. The study of virulence determinants like cuticle-hydrolyzing enzymes is the most imperative feature towards the success of EPFs. The high producers of the cuticle-degrading enzymes (the maximum extent of enzyme production by an isolate) are definitely the most attractive initial candidates towards isolate screening of EPFs.

Entomopathogens are cosmopolitan in nature. There are numerous isolates for each species in *M. anisopliae* and *B. bassiana*. Virulence and host specificity are the major criteria used towards the selection of a suitable isolate for commercial biological control. A particular species of an entomopathogen may have a wide host range but it might have differences in host-specificity and virulence traits among its isolates. Distinctive markers that characterize individual isolates are used to determine their host specificity, virulence efficacy, longevity and niche distribution in field. Molecular fingerprinting techniques like RAPD, RFLP and AFLP are commonly employed.

EPFs have significantly higher host specificity in comparison to the conventional biocontrol agents like bacteria, protozoa, nematodes, predatory insects and viruses. They are unique when compared to other microbes causing diseases in insects because they cause infection by growing through the insect cuticle and not required to be ingested, thus showing great potential for control of even sucking insect pests. It is theoretically impossible for the insects to develop resistance, as EPFs simultaneously use several modes of action, and as a “living pesticide” is subjected to adaptation too. This is in contrast to the single site of action of the much-hyped Bt-based biopesticides. Unlike the chemical pesticides, which are the ‘silent killers’ responsible for environmental persistence and toxicity, the EPF based biopesticides are safe to environment and mankind. The shelf life of EPF based mycopesticide is upto 8 months at room temperature but can retain viability for upto 8 years when stored at low temperatures. The use of mycopesticides is slowly but gradually gaining momentum and its utilization for commercial purposes, inevitably leads to considerations of ways of improving its on-field performance. There can be many features that might benefit from genetic improvement. Some of the limitations of bioinsecticides, such as slow rate of action, restricted host range and limited persistence in field can be addressed by various strategies involving genetic manipulation. PEG, electroporation and biolistic methods have been employed to transform *M. anisopliae* using benomyl resistance as selectable marker.

**REFERENCES**


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**Environment is God’s gift, preserve**

If U Protect NATURE

NATURE will Protect U

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