Beauveria bassiana: A Potential Entomopathogenic Fungi for Sustainable Insect Pests Management

Khrieketou Kuotsu*, Sandip Patra and Rumki H. Ch. Sangma
ICAR Research Complex for NEH Region Umiam, Meghalaya
*Corresponding Author: khrieketoukuotsu@gmail.com

An important environmental issue nowadays is the indiscriminate use of chemical pesticides on crops. Chemical pesticide usages have been steadily rising worldwide along with rising crop productivity and human population. This has led to a negative impact on the ecosystem and raised human health risks. The indiscriminate use of chemical pesticides against insect pest in agriculture has resulted in problems such as pest resurgence, resistance and threat to the environment as well as health of humans. The development of alternate methods of insect-pest management has been greatly accelerated by the growing urge to reduce chemical inputs in agriculture and the rise in pesticide resistance. Emphasis is now being placed on alternative pest management methods. Under such scenario the Entomopathogenic fungi (EPF) are an alternative to manage insect pests. Fungi that infect, invade, and ultimately kill insects are known as entomopathogenic fungi. The ability of the enzymatic activity, which includes the presence of lipases, proteases, and chitinases, allows entomopathogenic fungi to exhibit a wide spectrum of pathogenic activity. These enzymes disintegrate the integument of the insect, with lipases being the first enzyme produced by entomopathogenic fungus (Maravi *et al*., 2018). Entomopathogenic fungi are highly effective in managing various insect pests and play a crucial role in pest management. These fungi have been successfully used in crop production systems as microbial agents against pests. In order to regulate insect pest populations without putting non-target insects in danger, entomopathogenic fungi are recognised as a viable biocontrol strategy. They are essential in pest management due to their effectiveness in managing a wide range of insect pests. They can be used in combination with other biocontrol tactics in integrated pest management programs, providing environmentally safe alternatives to chemical insecticides.

More than 1000 species of pathogenic protozoa and over 800 species of entomopathogenic fungi have been characterised and identified. The ecofriendly control of various insect pests involves the use of entomopathogenic fungi based on *Beauveria bassiana*, *Metarhizium anisopliae, Verticillium lecanii* and *Paecilomyces fumosoroseus* (Mahankuda and Bhatt, 2019). Among these, the entomopathogen *B. bassiana* has shown great potential in managing insect pests. *B. bassiana* belongs to the kingdom- fungi, phylum-ascomycota, class -sordariomycetes, order-hypocreales and family -clavicipitaceae. It was discovered by Bassi Agostino of Lodi, Italy, in 1835.

Currently, six species namely *B. bassiana*, *B. clade*, *B. brongniartii*, *B. caledonica*, *B. vermiconia,* and *B. amorpha* has been recognized worldwide (Goettel *et al*., 2015; Rehner and Buckley, 2015). Out of all the species, *B. bassiana* has been the most thoroughly researched, widely used and commercially available as a biopesticide worldwide for the management of insect pests (Meyling and Eilenberg, 2007). The toxins produced by *B. bassiana*, such as beauvericin, bassianin, bassianolide, beauverolides, tenellin, oosporein, and oxalic acid, play a crucial role in the parasitization and killing of insect hosts (Wang *et al*., 2021). The high genetic diversity of *B. bassiana* also contributes to its importance. Recent research has demonstrated that specific genes and molecules in *B. bassiana* can change its virulence depending on the host and infection stage (Wang *et al*., 2021). This genetic diversity provides opportunities for the development of strategies to enhance the efficacy of *B. bassiana*. Identifying and targeting these genes and molecules can lead to the development of more effective and sustainable pest management strategies. The demand for chemical-free residue on foods, a reduction in the use of chemical pesticides, the growth of organic agriculture, and the expansion and consolidation of integrated pest management (IPM) programmes are all driving a significant global upswing in the use of microbial biopesticides. Further research and understanding of the ecology of these fungi will enhance their utilization in pest management strategies.

Mode of action

The mode of action of *B. bassiana* involves several mechanisms that contribute to its insecticidal activity. One of the key factors is the production of various toxins. These secondary metabolites play a crucial role in the parasitization and killing of insect hosts. The toxins can disrupt the physiological processes of the insects, leading to their death (Wang *et al*., 2021). Another important aspect is its ability to penetrate the insect cuticle. The fungus produces enzymes, such as chitinases and proteases, which degrade the insect's cuticle and facilitate the entry of *B. bassiana* into the host's body. Once inside, the fungus proliferates and colonizes the insect, leading to its eventual death. Furthermore, it can also produce extracellular enzymes, such as lipases and esterases, which are involved in nutrient acquisition from the insect host. These enzymes help *B. bassiana* to utilize the insect's tissues as a nutrient source, supporting its growth and development within the host. These mechanisms collectively contribute to the insecticidal activity of *B. bassiana* and its effectiveness as a biological control agent.

Symptoms

The symptoms of *B. bassiana* infection in insects can vary depending on the specific host and the stage of infection. Here are some general symptoms observed in infected insects:

1. Infected insects may exhibit reduced mobility or become sluggish. This is often one of the early signs of infection.
2. Infected insects may show discoloration, such as a change in the color of their exoskeleton. This can range from a slight darkening to more noticeable discoloration.
3. Visible growth of the fungus on the insect's body. Infected insects may develop a white or grayish powdery coating, which is the fungal mycelium.
4. *B. bassiana* can cause dehydration in infected insects. This can lead to desiccation and shrinkage of the insect's body.
5. Infected insects may exhibit reduced feeding or loss of appetite. The fungal infection can disrupt the insect's feeding behavior and nutrient uptake.
6. In severe cases, the infection can lead to the death of the insect. The fungus proliferates within the insect's body, causing damage to internal organs and eventually leading to the death of the host.

Host range

B. bassiana is a versatile entomopathogenic fungus with a broad host range, infecting and managing numerous insect pests. The host range extends to various insect orders, including Lepidoptera, Hemiptera, and Diptera (Meyling *et al*., 2009). Its ability to infect and parasitize a wide range of insect species makes it a valuable biocontrol agent in agriculture and pest management. Some examples of susceptible hosts belonging to different orders are Coleoptera- *Holotricha spp*., Lepidoptera- *Spodoptera litura, Helicoverpa armigera*, Hemiptera- *Aphis craccivora*, *A. gossypii*, *Bemisia tabaci,* Diptera- *Leria serrata* and Orthoptera- *Schistocera gregaria*, *Locusta migratoria* (Keswani *et al*., 2013).

Advantages

B. bassiana offers several advantages as a biological control agent for insect pests.

1. Broad-spectrum: It has a broad spectrum insecticidal activity, which allows it to target a wide range of agricultural pests. This makes it a versatile and effective tool for pest management in various settings.
2. Adaptability: It has the ability to persist and establish populations in both agricultural and semi natural habitats. This adaptability allows it to effectively target pests in different environments, including agricultural fields, greenhouses, and natural ecosystems.
3. Mode of action: It has a unique mode of action compared to chemical insecticides. It infects insects through contact and ingestion, leading to the colonization and eventual death of the pests. This mode of action reduces the risk of resistance

development in target pests, as it targets multiple physiological pathways and mechanisms.

4. Compatibility: It has the potential for integration with other pest management strategies. This integrated approach can provide a more comprehensive and sustainable solution to pest management.

Limitations

While *B. bassiana* has many advantages, there are limitations and factors to consider:

1. Specificity: *B. bassiana* is primarily effective against insect pests and may have limited efficacy against other types of pests, such as mites or nematodes.
2. Environmental conditions: *B. bassiana* requires specific environmental conditions for optimal growth and activity. Factors such as temperature, humidity, and UV radiation can affect its efficacy and persistence in the field.
3. Limited shelf life: Formulations typically have a limited shelf life, and the viability and effectiveness of the fungus can decrease over time.
4. Slow action: Slower mode of action compared to chemical insecticides.

Conclusion

B. bassiana plays a crucial role in sustainable pest management by offering an environmentally friendly alternative to chemical pesticides. Its ability to infect and manage a wide range of insect pests makes it a versatile and valuable tool in integrated pest management programs. Further research and development in understanding the mechanisms of action and improving the virulence of *B. bassiana* will enhance its effectiveness as a biocontrol agent, contributing to the development of sustainable and eco-friendly pest management practices.

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