

Review Article

***Beauveria bassiana* Insect Pest Management**

Abstract

The excessive use of synthetic pesticides in farming has raised serious concerns over environmental damage and health risks. As a safer and sustainable option, *Beauveria bassiana*, a naturally occurring fungus found in soil, has gained attention for its ability to control various insect pests. This fungus infects insects by attaching to their outer body, penetrating their defences, and growing inside until the insect dies. Studies have shown its effectiveness against major pests such as *Callosobruchus maculatus*, *Tuta absoluta*, and *Macrosiphum rosae*, making it a valuable biological control agent. Its broad host range and eco-friendly nature allow it to fit well within Integrated Pest Management (IPM) systems, reducing the reliance on harmful chemicals. Additionally, advancements like combining *B. bassiana* with additives such as kaolin have improved its efficiency in real-world conditions. While enhancing its pest-killing ability through genetic modifications shows promise, it's also important to maintain its natural resilience. Overall, *B. bassiana* provides long-term pest control, supports sustainable farming practices, and offers a reliable alternative to chemical pesticides, contributing to safer agriculture and environmental conservation.

Keywords: *Beauveria bassiana*, Pest Management, Agriculture and IPM

Introduction

In contemporary agriculture, effective pest control remains essential for ensuring healthy crop production and global food security. Nevertheless, the heavy reliance on synthetic pesticides has sparked growing concerns due to their adverse effects on ecosystems and human health. These impacts include the emergence of pesticide-resistant pests, reduction in biodiversity, deterioration of soil quality, and pollution of water bodies (Isman, 2006; Aktar *et al.*, 2009). In light of these pressing issues, there is a growing interest in sustainable alternatives, particularly biological control strategies that harness the natural enemies of pests—such as predators, parasites, and microbial pathogen to reduce their populations. Among the various biological agents explored, the

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White Muscardine Fungus, *Beauveria bassiana*, stands out as a particularly effective option. This entomopathogenic fungus is known for its ability to infect and kill a wide array of insect pests. Found globally in soil environments, *B. bassiana* has demonstrated efficacy against more than 200 insect species (Faria & Wraight, 2007). Infected insects typically become covered in a characteristic white fungal coating, which gives the fungus its common name. Due to its pest specificity, minimal environmental impact, and compatibility with integrated pest management (IPM) systems, *B. bassiana* is considered a valuable and eco-friendly alternative to chemical pesticides (Meyling & Eilenberg, 2007).

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Brief History of Beauveria and White Muscardine Disease

The story of *Beauveria bassiana* begins in the early 19th century, when Italian scientist Agostino Bassi made a ground-breaking discovery (Sharma et al., 2023; Sharmila et al., 2023; Liu et al., 2025; Wakil et al., 2023). He found that a mysterious disease turning silkworms into stiff, white-covered corpses was actually caused by a microscopic fungus. Because of the white, dusty appearance of the dead insects, the condition became known as “white muscardine disease.” This was one of the first times a microorganism was recognized as the cause of an animal disease, laying the foundation for modern germ theory. In honour of Bassi’s work, the fungus was later named Beauveria. By the mid-1800s, it was already being used in the United States to combat chinch bug infestations in crops, marking one of the earliest examples of using fungi for pest control. Since then, *Beauveria bassiana* has proven to be a powerful natural insect killer, known to infect hundreds of insect and mite species. With its growing importance in integrated pest management (IPM), agriculture, and even pharmaceutical research, *B. bassiana* continues to be a central focus in the study of microbial insecticides (Mascarin & Jaronski, 2016).

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Taxonomy and Morphology of White Muscardine Fungus (N. Kobmoo et al., 2021)

- Kingdom: Fungi
- Phylum: Ascomycota
- Class: Sordariomycetes
- Order: Hypocreales
- Family: Cordycipitaceae

- Genus: *Beauveria*
- Species: *Beauveria bassiana*

Beauveria bassiana, the fungus species that causes for white muscardine disease, belongs to the phylum Ascomycota, order Hypocreales, and family Cordycipitaceae. It is a well-known entomopathogen that naturally targets a broad spectrum of insect hosts. One of its most distinctive features is the white, powdery growth that appears on the surface of infected insects, often making identification straightforward. The fungus enters the insect through its outer cuticle, grows inside its body, and eventually kills the host. The remains become stiff and dry as the infection worsens and is called as mummification. This transformation is due to the fungal mycelium replacing internal tissues and producing an external coating of spores. These spores, known as conidia, play a key role in transmission, as they are discharged into the environment to infect other vulnerable insects. The hardened body of the insect and the visible white fungal layer are reliable indicators of *B. bassiana* infection, especially in field observations where symptom-based identification is essential. (N. Kobmoo *et al.*, 2021)

Life cycle and pathogenicity

Beauveria bassiana is a naturally occurring fungus that infects a wide range of insect hosts and is known for causing white muscardine disease. Its infection process starts when fungal spores attach to the outer surface of an insect. These spores then germinate and invade the host by penetrating the cuticle, eventually reaching the internal body cavity. Inside, the fungus transforms into blastospore small, yeast-like cells that multiply quickly and spread through the insect's body. During this phase, the fungus releases several chemical compounds, one of which is oosporein, a red pigment that helps suppress the insect's immune response and limits bacterial competition after the host dies. This compound doesn't directly kill the insect but creates conditions that favour fungal growth and reproduction. Research has shown that by disrupting a regulatory gene called *Bbsmr1*, the fungus can produce more oosporein, leading to faster germination, quicker spread within the insect, and higher mortality rates. These genetically modified strains show stronger insecticidal activity than the natural form, making them promising candidates for improved biological control. However, while these changes enhance virulence, they may also affect other fungal traits like sporulation or resistance to environmental stress, which must be considered when developing practical applications (Mascarin *et al.*, 2024).

Host Range and Ecological Distribution

Beauveria bassiana, commonly known as the white muscardine fungus, is a widely distributed entomopathogenic fungus that inhabits diverse ecological niches. While traditionally viewed as a soil-associated fungus, research has revealed its presence on tree bark and foliage, with its abundance varying seasonally. Environmental factors, namely temperature, humidity, as well as ultraviolet exposure, greatly impact its distribution, especially in above-ground habitats where adverse conditions limit its survival during warmer months. The fungus disperses through multiple pathways, including rain splash, wind, and via insects that facilitate its movement between soil and vegetation. Understanding the host range of *B. Bassiana* is equally important. Its ability to infect various insect species was evaluated through bioassays involving global isolates tested on nine insect species from various taxonomic orders, including Lepidoptera, Coleoptera, Hemiptera, Homoptera, as well as Hymenoptera. Additionally, isolates were assessed against two distinct populations within specific insect species to examine intraspecific variation. Target species included *Bombyx mori*, *Spodoptera litura*, *Chilo partellus*, *Helicoverpa armigera*, *Epilachna vigintioctopunctata*, *Mylabris pustulata*, *Aphis craccivora*, *Maconellicoccus hirsutus*, and *Oecophylla smaragdina*. Results demonstrated that the differences in virus infection across species were comparable to those observed within populations of a single species. This finding confirms *B. Bassiana*’s generalist nature, lacking strict host specificity. Its broad-spectrum pathogenicity makes it an effective biological pest management practice, capable of targeting multiple insect infestation in agricultural ecosystems. As such, *B. Bassiana*-based biopesticides present a sustainable substitute for chemical insecticides, fitting well with integrated pest management strategies aimed at environmentally friendly crop protection.

Table 1: Susceptible hosts of *B. bassiana* from various insect orders

Order	Susceptible hosts
Coleoptera	<i>Lathrobium brunnipes</i> , <i>Calvia quattuordecimguttata</i> , <i>Phytodectra olivacea</i> , <i>Otiorhynchus sulcatus</i> , <i>Sitona lineatus</i> , <i>S. sulcifrons</i> , <i>S. macularius</i> , <i>S. hispidulus</i> , <i>Anthonomus pomorum</i> , <i>Hylaster ater</i>
Hymenoptera	<i>Ichneumonidae</i> , <i>Lasius fuliginosus</i> , <i>Vespula</i> spp., <i>Bombus pratorum</i>
Lepidoptera	<i>Hepialus</i> spp., <i>Hypocrita jacobaea</i> , <i>Cydia nigricans</i>
Heteroptera	<i>Picromerus bidens</i> , <i>Anthocoris nemorum</i>

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Order	Susceptible hosts
Homoptera	<i>Eulecanium</i> spp.
Diptera	<i>Leria serrata</i>

Efficacy of *Beauveria bassiana* against Coleoptera

Beauveria bassiana has been shown to be an effective biological control agent against the cowpea weevil, *Callosobruchus maculatus*. The fungus infects the insect through direct contact, penetrating the cuticle and proliferating inside the host, leading to mortality. In laboratory experiments, infected weevils exhibited nearly 100% mycosis, confirming successful fungal infection. Mortality began a few days after exposure and reached complete control within eight days under favourable conditions. Additionally, higher temperatures were found to accelerate the infection process and increase fungal efficacy. The observed outcome suggests that *B. bassiana* can serve to be a promising alternative biochemical pesticides for managing *C. maculatus* infestations in stored legumes (Ozdemir, Tuncer, Erper, & Kushiyeve, 2020).

Efficacy of *Beauveria bassiana* against lepidoptera

The entomopathogenic fungus *Beauveria bassiana* has proven effective in suppressing populations of Tomato Leaf Miner (*Tuta absoluta*), a dominant pest of tomato crops. This biocontrol agent invades the pest through its external cuticle, spreads within its body, and leads to death by exhausting vital nutrients and producing harmful toxins. Laboratory trials with commercial strains of *B. bassiana* (ATCC 74,040 and R444) demonstrated high mortality rates, with eggs showing up to 71.42% mortality and second-instar larvae exceeding 80% mortality at a concentration of 10^{10} spores/mL. The ATCC 74,040 strain was particularly potent, as indicated by lower LC50 values compared to other tested fungi. Additionally, *B. bassiana* applications significantly hindered pupation and reduced the emergence of adult moths, underlining its suitability as a biocontrol tool within integrated pest management (IPM) programs targeting *T. absoluta* infestations (Chouikhi et al., 2022).

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Efficacy of *Beauveria bassiana* against hemiptera

Beauveria bassiana (Balsamo) Vuillemin, an fungus pathogenic to insects, has demonstrated promising capability as a biocontrol agent against aphid pests, particularly the rose aphid *Macrosiphum rosae* L. (Hemiptera: Aphididae). Research evaluating four indigenous isolates of *B. Bassiana* revealed that one isolate was especially effective, achieving a notably low LC50 value of 6.46×10^4 spores/ml. Field studies further confirmed the fungus's efficacy, with both local and commercial strains significantly reducing aphid populations when applied at a dosage of 4.6×10^6 conidia/ml, resulting in up to 98% infestation reduction. Additionally, the use of *B. Bassiana* has resulted in higher rose oil yields by protecting plants from aphid damage. These results provide support to the use of *B. Bassiana* as an sustainable substitute for chemical insecticides, aligning with organic pest management strategies in rose cultivation (Sayed, Ali, & Al-Otaibi, 2019).

Mode of action

Like other fungus pathogenic to insects, *Beauveria* specieses infect its insect hosts through percutaneous entry. The infection process involves several stages: first the fungus adheres to the insect cuticle, germinates on the surface, penetrates through the cuticle, eludes the host immune defences, multiplies within the host's body, and finally, emerge from the dead insect to produce new spores. The ability of *Beauveria bassiana* to germinate and establish infection depends on factors such as host susceptibility, developmental stage, and environmental conditions like temperature and humidity. Typically, germination begins about 10 hours after spore deposition and is completed within 20 hours at 25°C. The fungus preferentially invades less hardened regions of the cuticle—such as joints, mouthparts, and intersegmental area by releasing enzymes like proteases and chitins that degrade structural barriers. Once inside, it rapidly colonizes internal tissues through vegetative development and releases deadly secondary metabolites that subsequently decimate the host (Keswani et al., 2015).

Formulation and Application Techniques

The effectiveness of the entomopathogenic fungus *Beauveria bassiana* was notably improved through the addition of kaolin, which acted as a synergistic co-formulant in formulations targeting stored grain beetles. To achieve this, dry conidia of the *B. bassiana* isolate were blended with kaolin, alongside agents such as Entostat® and silica, which facilitated better adhesion, distribution, and flow properties. The application process involved thoroughly mixing precise

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amounts of these formulations with wheat grains, using equipment like vortex mixers and bottle rollers to ensure uniform coverage. Experimental bioassays were conducted to evaluate the impact of varying fungal and kaolin concentrations. While kaolin by itself did not exhibit insecticidal activity, its combination with the fungus significantly enhanced fungal virulence. Additionally, environmental conditions, particularly temperature and humidity, were found to influence treatment outcomes, with elevated temperatures correlating with higher insect mortality. These results underscore the importance of carefully formulated products and application methods to maximize the biological control potential of *B. bassiana* in stored product pest management strategies (Storm *et al.*, 2016).

Benefits of Using *Beauveria bassiana* in Pest Control

1. Eco-Friendly Pest Management

Beauveria bassiana is a safer and more environmentally conscious option compared to chemical pesticides. Since it occurs naturally and breaks down easily in the environment, it doesn't pollute the soil or water. This makes it particularly suitable for organic farming and sustainable agriculture, where reducing chemical use is a priority (Goettel & Inglis, 1997).

2. Efficient in combating a wide range of pests

One of the standout features of *B. bassiana* is its ability to infect an extensive number of insect pests. It works effectively against beetles, aphids, caterpillars, whiteflies, and many other crop-damaging insects. This broad host range makes it an ideal solution for farmers dealing with multiple pest species across different types of crops.

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3. Low Risk of Insect Resistance

A major concern with chemical pesticides is that pests often develop resistance over time. In contrast, *B. bassiana* attacks insects through a multi-stage process—attaching to their surface, penetrating their outer shell, and growing inside their bodies—which makes it harder for pests to build resistance. This mode of action ensures it remains effective over longer periods, even with repeated use (Faria & Wraight, 2007).

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4. Works Well in Integrated Pest Management (IPM)

B. bassiana can be easily incorporated into Integrated Pest Management strategies. It doesn't interfere with other biological controls like predatory insects or beneficial nematodes, and it can sometimes be used alongside low-toxicity chemical treatments. Its ability to fit into diverse pest control programs makes it a flexible and valuable tool for growers.

5. Safe for People and Non-Target Organisms

Safety is another big advantage. *B. bassiana* poses little to no harm to humans, animals, and beneficial insects like pollinators when applied properly. Because of this, it can be used in a variety of environments, including greenhouses, homes, and food production areas where strict safety standards are in place.

6. Long-Term Presence and Plant Protection

This fungus doesn't just disappear after application. It can survive in the soil and even grow inside plant tissues without harming the plant. As an entophyte, it provides lasting protection by deterring or killing insects that try to feed on the plant. This extended activity means fewer reapplications are needed, saving time and effort (Vega *et al.*, 2008)

7. Cost-Effective Over Time

While the upfront cost might be higher than some chemical products, *B. bassiana* offers long-term savings. Its lasting effects, reduced need for frequent application, and minimal environmental cleanup costs can lead to better crop yields and reduced input expenses over time.

Conclusion

Beauveria bassiana proves to be a highly effective and sustainable solution for managing infestation of pests in agriculture. Its unique way of infecting and killing pests makes it less likely for insects to develop resistance, unlike chemical pesticides. What sets it apart is its compatibility with other biological control methods, ensuring beneficial insects and ecosystems are not harmed. Its persistence in the soil and ability to live inside plants gives crops extended protection against pests. Improved formulations, like blending it with kaolin, have further increased its effectiveness

in the field. Though boosting its potency through genetic tweaking has shown better pest control results, it's essential to ensure these enhancements don't compromise its durability in natural conditions. While initial costs for *B. bassiana* products might be higher, the long-term benefits in crop yield and reduced chemical use make it a cost-effective choice. Ultimately, *B. bassiana* plays a key role in promoting greener farming practices, helping reduce pesticide dependency, and supporting global food security. With continued research and smart application, it holds great possibilities for future crop protection strategies that are safer for both people and the environment.

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