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Production, Formulation and Application of *Beauveria bassiana* as an Entomopathogenic Fungus for Sustainable Pest Management

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Beauveria bassiana is an important entomopathogenic fungus widely used as a biological control agent against several economically important insect pests. The production, formulation, and application of *B. bassiana* for sustainable pest management. Efficient mass production of the fungus on suitable substrates is essential for obtaining adequate quantities of viable and infective conidia. Different formulation approaches can improve the stability, shelf life, and field performance of fungal spores. The formulated product can be applied to crops through suitable spraying and other application methods for effective pest suppression. *B. bassiana* infects insects mainly through the cuticle, thereby providing an alternative to conventional chemical insecticides. Its use helps reduce pesticide residues, environmental pollution, and risks to beneficial organisms when appropriately applied. The integration of *B. bassiana* with other biological and cultural practices can enhance the effectiveness of integrated pest management. Thus, production and formulation of *B. bassiana* have considerable potential for developing eco-friendly, cost-effective, and sustainable pest management strategies.

Keywords: *Beauveria bassiana*; Entomopathogenic fungus; Biological control; Pest management; Mass production; Formulation; Conidia; Sustainable agriculture; Integrated pest management (IPM); Biopesticide.

Introduction

Beauveria bassiana is a naturally occurring entomopathogenic fungus found in soils throughout the world. It acts as a parasite on a wide range of arthropod species and causes a disease known as white muscardine disease. Therefore, *B. bassiana* belongs to the group of entomopathogenic fungi and is widely recognized for its potential as a biological control agent against insect pests. *Beauveria bassiana* is used as a biological insecticide for the management of several economically important pests, including termites, thrips, whiteflies, aphids, beetles, caterpillars and other insect pests. Its potential for controlling bed bugs and malaria-transmitting mosquitoes has also been investigated. As a microbial insecticide, the fungal spores can be applied to crops as an emulsified suspension or wettable powder. They can also be applied to mosquito nets as a biological control agent. As a species, *B. bassiana* can parasitize a very wide range of arthropod hosts. However, different strains may vary considerably in their host range and virulence. Some strains have a relatively narrow host range. For example, strain Bba 5653 is highly virulent to larvae of the diamondback moth but kills only a few other types of caterpillars. In contrast, some strains have a broad host range and should therefore be considered non-selective biological insecticides. Such strains should be used carefully and should not be applied indiscriminately to flowers visited by pollinating insects. Known target insects of *B. bassiana* include aphids, whiteflies, mealybugs, thrips, termites, fire ants, flies, grasshoppers, psyllids, caterpillars and beetles.

Taxonomic Classification of *Beauveria bassiana*

Taxonomic Category	Classification
Domain	Eukaryota
Kingdom	Fungi
Division	Ascomycota
Class	Sordariomycetes
Order	Hypocreales
Family	Cordycipitaceae
Genus	*Beauveria*
Species	*Beauveria bassiana*

Morphology

The morphological characteristics of entomopathogenic fungi are important for determining the form, size and organization of spores, as well as colony characteristics. On common culture media, colonies of *B. bassiana* generally appear white to cream in colour, with a fluffy to powdery surface. The fungal hyphae are tubular, slender and delicate filaments that are generally white but may become yellowish with age. The width of the hyphae generally ranges from approximately 1.7 to 2.8 µm. The conidiogenous cells of *B. bassiana* are short and ovoid and terminate in a rachis-like apical projection. The conidia are single-celled, haploid and hydrophobic. These morphological characteristics are useful for the preliminary identification and characterization of *B. bassiana* in culture.

Isolation of *Beauveria bassiana*

For isolation of *B. bassiana*, infected insect cadavers are surface sterilized by washing them in 5% sodium hypochlorite solution for 60 seconds, followed by rinsing with sterile distilled water for 60 seconds. The sterilized cadavers are then incubated in moistened Petri dishes at approximately 25°C until fungal growth develops on the cadavers. The conidia developing on the insect cadavers are transferred onto Sabouraud Dextrose Agar (SDA) supplemented with ampicillin and chloramphenicol at 40 µg/ml. The inoculated plates are incubated for approximately two weeks at 28°C under relative humidity above 60% and continuous darkness. The developing fungal colonies are subcultured several times on SDA plates to obtain pure cultures. Pure cultures can subsequently be maintained in 20% glycerol at −80°C for long-term preservation.

Materials Required for Mass Production

The major materials required for the production and formulation of *B. bassiana* include:

- Glass bottles
- Plastic boxes
- Steel utensils
- Pressure cooker
- Polypropylene (PP) bags
- Disposable syringes
- Talcum powder
- Rubber bands
- Strainer

Composition of Sabouraud Dextrose Agar (SDA)

S. No.	Ingredient	Quantity (g/L)
1	Dextrose	40.00
2	Peptone	10.00
3	Agar	15.00

S. No.	Ingredient	Quantity (g/L)
4	Distilled water	1000 ml
5	pH	5.6

Mass Production of *Beauveria bassiana*

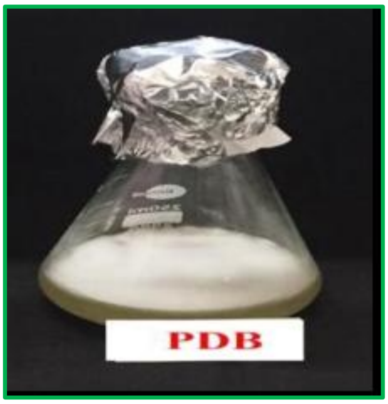
Mass production of *B. bassiana*, as well as other fungal entomopathogens, is essential for their use as microbial insecticides. The inundative use strategy requires cost-effective production, stabilization and delivery of a large number of viable and infective fungal propagules. The production process involves several important stages, beginning with the maintenance of a pure fungal culture and ending with the harvesting, drying and processing of fungal spores.

Steps Involved in Mass Production of *Beauveria bassiana*

1. Growing the pure culture of the fungus
2. Preparation of fungal mycelia
3. Preparation of solid substrate
4. Inoculation of the solid substrate
5. Fermentation of the inoculated substrate
6. Harvesting of spores
7. Collection of spores
8. Drying of spores
9. Grinding of spores

Culture of *Beauveria bassiana*

The selection of a suitable substrate and maintenance of appropriate environmental conditions are important for obtaining high yields of viable and infective conidia.



Formulation of *Beauveria bassiana*

Formulation is an important step in the development of *B. bassiana* as a microbial insecticide because it improves the stability, handling, storage and field application of the fungal propagules.

Liquid Formulation

For the liquid formulation, sodium carboxymethyl cellulose (CMC) and glycerol are incorporated into freshly fermented *B. bassiana* culture. A formulation may contain approximately 10 ml of sodium CMC and 10 ml of anhydrous glycerol per litre of freshly fermented fungal culture.

Wettable Powder Formulation

For preparation of a wettable powder formulation, approximately 10 ml of freshly fermented *B. bassiana* culture and 10 ml of glycerol are mixed with 1 kg of talcum powder. The resulting formulation can be used for convenient storage and application.

Application Methods of *Beauveria bassiana*

Foliar Application

For the management of borers and cutworms, the fungal product can be applied at approximately 3 litres or 4 kg per hectare in 500 litres of water. This corresponds to approximately 6 ml or 8 g of product per litre of water, respectively.

Soil Application

For the management of soil-dwelling pests such as root grubs, the fungal product can be applied at approximately 3 litres or 4 kg per hectare in 500 litres of water. The fungal formulation can be applied around the root zone and incorporated into the soil either mechanically or through adequate irrigation. Alternatively, the formulation can be mixed with organic fertilizer or field soil and applied uniformly to the target area.

Advantages of Using *Beauveria bassiana*

The major advantages of using the entomopathogenic fungus *B. bassiana* as a biological control agent include:

- It is relatively harmless to many non-target forms of life when appropriately selected and applied.
- Some strains have a high degree of host specificity.
- It can be compatible with several chemical insecticides when properly integrated into pest-management programmes.
- Development of resistance in insect populations may be slower than with conventional insecticides when microbial control agents are used appropriately.
- It can be self-sustaining under favourable environmental conditions and may therefore be economical.
- It is relatively easy to apply.
- It is environmentally acceptable as part of an integrated pest-management programme.

Information provided to the farmer about *Beauveria bassiana*

Conclusion

Beauveria bassiana has considerable potential for sustainable agriculture because of its ability to infect and suppress a wide range of economically important insect pests. Its use as an entomopathogenic fungus can contribute to reducing dependence on conventional chemical pesticides and thereby support environmentally friendly pest-management practices. The successful adoption of *B. bassiana* requires proper selection of effective fungal strains, appropriate mass-production techniques, suitable formulation, and correct application methods. Educating farmers about the benefits and proper use of *B. bassiana* and demonstrating its effectiveness under field conditions can encourage wider adoption of microbial pest-management practices. Integrating *B. bassiana* into integrated pest management programmes can help promote sustainable crop production while reducing potential environmental impacts associated with excessive use of chemical pesticides.