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## Study on effect of A entomopathogenic fungus (*Beauveria bassiana*) & utilization of A botanical insecticide in the control and management of gram pod borer (*Helicoverpa armigera*)

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### Abstract

To determine whether or if entomopathogenic fungi, namely *Beauveria bassiana* isolates Bb111, Bb112, Bb 113, and Bb 114, are capable of killing the spotted pod borer, *Maruca vitrata*, researchers conducted experiments (Geyer). Bioassays were performed on larvae of the spotted pod borer in their third, fourth, and fifth instars in five different pulse hosts. These hosts were lablab, cowpea, green gramme, and black gramme. No matter whatever pulses were investigated, the efficiency of Bb 112 was shown to be much higher. It was discovered that the median lethal concentrations of Bb 112 for third, fourth, and fifth instar larvae on various pulses, such as lablab, cowpea, black gramme, and green gramme, were found to be in the range of  $0.10 \times 10^8$  to  $2.04 \times 10^8$  spores ml<sup>-1</sup>,  $0.14 \times 10^8$  to  $2.67 \times 10^8$  spores ml<sup>-1</sup>, and  $0.20 \times 10^8$  to  $4.80 \times 10^8$  spores ml<sup>-1</sup>. Since they were first developed, synthetic pesticides have quickly risen to the forefront of competition among various strategies for the control of insect pests. This continued for several decades until Rachel Carson released her book "Silent Spring" in 1962, which brought to light the dangers presented by man-made chemicals and served as a wake-up call to the globe. Since then, this problem has been mostly disregarded by everyone. Since that time, it has become an important goal to discover alternative solutions for pest management that are not only efficient but also risk-free. Research on chickpea was conducted at the Agricultural Research station in Gulbarga, Karnataka, using a variety of biorationals during the academic year 2012–2013 with the goal of achieving environmentally friendly control of the gram pod borer, *Helicoverpa armigera*. This research was carried out with the intention of achieving environmentally friendly control of the gram pod borer (Hubner). The plot that had been sprayed with azadirachtin 3 percent WSP at 400 g/ha had the lowest larval population of any of the other biorationals that were used. At seven days after the first, second, and third sprays, respectively, there were 0.33, 0.50, and 0.00 larvae per ten plants in this plot. Additionally, it had the least amount of pod damage at 9.55 percent and the maximum grain output at 1596 kg per hectare. After this, the azadirachtin 6 percent WSP at 200 g/ha experiment recorded larvae. According to the findings, the Agniasthras 5 percent treatment was the second-best available option.

**Keywords:** *Beauveria bassiana*, synthetic pesticides, *Helicoverpa armigera*

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### Introduction

The chickpea pod borer is a type of insect pest that can have a detrimental effect on the quality of chickpea plants (*Cicer arietinum*) as well as the production of these plants (*Helicoverpa armigera* H.). This pest presents a significant challenge. 1 Prior to maturing into an adult, a single *H. armigera* larva has the ability to consume as many as 30 pods. 2 Along with a great variety of other strategies, the widespread use of synthetic pesticides is one of the numerous approaches that have been developed to battle *H. armigera*. Other strategies include: The extensive use of synthetic pesticides has resulted in populations of *H. armigera* developing resistance to the chemicals; in addition, the usage of these insecticides has a severe influence on the natural predators that the pests would normally have. 3 As a consequence of this, an efficient integrated pest management (IPM) programme is necessary in order to reduce the number of pesticides that need to be used in the control of *H. armigera*.

Entomopathogenic fungi are naturally occurring insect infections that have the potential to operate as microbial insecticides. Entomopathogenic fungi may be found in a variety of habitats. Because of how powerful they are, these fungi are routinely included as components of integrated pest management programmes (IPM).

4 The vast majority of entomopathogenic fungi are classified under the recently established division Hyphomycetes, which is part of the Deuteromycota phylum. This division is home to a number of important genera and species, including *Balsamo* and *Beauveria bassiana* (Balsamo), among others (Ascomycota: Hypomycetes). 5–8 *B. bassiana* is a well-known biological control agent that may be found in its natural environment and does not represent a risk to the ecosystem that is nearby. 9 After the fungal spores have come into touch with an insect larva or pupa, they are able to break through the chitinous integument of the body and spread to the other visceral organs. 5,10 Once the insect has been pierced by the fungal spores, hyphal bodies

will be created. These hyphal bodies will begin to decompose the fat and gut tissue of the insect, which will eventually result in the death of the malpighian tubules.

Insecticides are preferred due to their easy availability and application; however, the excessive and indiscriminate use of insecticides has led to the development of insecticidal resistance in the majority of pests as well as environmental degradation. Insecticides are preferred because of their simple availability and application. The increased knowledge about the hazards presented by pesticides has inspired interest in alternative techniques of pest control that are less detrimental to the environment. This interest can be seen all around the world. This insect pest might potentially be managed with the assistance of natural enemies, entomopathogenic fungi, biologically generated pesticides, or microbial insecticides. All of these methods are possible. There is widespread consensus that each of these tactics is less harmful to the natural world.

Under field circumstances, entomopathogens have been found to be the most major regulatory factor of *M. vitrata*. [Citation needed] [Further citation is required] There have been studies suggesting that *Bacillus thuringiensis* is useful and effective in the fight against *M. vitrata*. [Citation needed] The effectiveness of spinosad and emamectin benzoate (an insecticide based on a microbial derivative) against *M. vitrata* infesting pulses was explored, as well as the formulation of a *B. thuringiensis*-based biopesticide as a potential component for the integrated management. Extensive research has been conducted on a fungal infection that kills insects called *Beauveria bassiana*. This fungus has the potential to be used as a biological agent for pest management. It has the power to stop a wide variety of economically important insects from breeding and spreading disease. What a successful *B. bassiana* is in reducing the number of *M. vitrata* populations in the wild on urdbean. In this particular experiment, the efficiency of *B. bassiana* isolates grown in the lab was tested against different stages of the life cycle of *M. vitrata*.

*Helicoverpa armigera* (Hubner) is a pest that causes losses to the grame crop, particularly during the fruiting stage, and can be seen year after year. The harm that it does to the green pods is far more severe than the damage that it causes to the plant's leaves and other parts. *H. armigera* has built up a resistance to a wide variety of insecticides as a direct result of the rising prevalence of the usage of pesticides. It is recommended to practice environmentally friendly pest management. This type of management places an emphasis on the maximum utilization of natural resources by integrating a variety of non-chemical or biorational pest control strategies. This is done in order to prevent the negative effects that can result from the excessive use of chemicals. Because of the growing need for methods of crop protection that are not only harmless to the environment but also do not have a detrimental influence on it, the use of botanical pesticides is becoming an increasingly common practice. Botanicals may be referred to as "environmentally non-persistent," and as a consequence, it is unlikely that the utilization of botanicals would result in the contamination of the environment. An indigenous agricultural system is a sort of farming that refers to a system that has developed over a period of time with cropping patterns and the status of pests. This style of farming is also known as "indigenous agriculture." This kind of farming is founded on the historical wisdom and practical experience of indigenous people, who are responsible for the creation of botanical combinations. On the basis of these concepts, a study was carried out to investigate the efficacy of a variety of biorational techniques to the control of pod borer in chickpea ecosystems.

In greenhouse and outdoor crops, *B. bassiana* is employed as a tool for the management of a wide variety of agricultural arthropod pests, including whiteflies, aphids, thrips, psyllids, weevils, and mealybugs. *B. bassiana* is also utilized as a food source for some species of psyllids. Some individuals also consume *B. bassiana* as their primary source of nutrition. Although *B. bassiana* is just one of many different types of entomopathogenic fungus, it has the potential to be the most useful in preventing the spread of whiteflies. Neem is the name of one of the botanical pesticides that can be used in organic agriculture for a range of different reasons and applications (Meliaceae). It is possible for it to have many different effects on susceptible insects, such as repellency, disruption of moulting, growth reduction, interference with development and oviposition, and high mortality, particularly in immature insects. However, it is unlikely that it will have any effect on non-vulnerable insects. This is the case for a diverse collection of plant-eating insects, one of which being the sweet potato whitefly, according to the research. Today, it is utilized all over the world either as a therapy in and of itself or in conjunction with the application of synthetic pesticides or entomopathogens. Both of these applications are used to treat insect infestations.

Within the context of IPM, biological control through the application of entomopathogens is one example of a factor that may play a potentially major role in the decrease of the population density of pests. When opposed to chemical pesticides, entomopathogenic fungi have a reduced risk of harm during application and have a more focused mode of action than pesticides. As a result, they are well-suited for use in Integrated Pest Management (IPM) programmes. IPM programs rely on the dynamic interaction that microbial organisms like *B. bassiana* have with insects in order to maintain the continuing vitality of the organisms. This connection is essential for IPM. IPM, which stands for integrated pest management, is the fundamental practice that underpins modern crop protection. This system incorporates all of the current treatments into one another in a manner that is compatible and makes compatible use of a range of agrochemicals. Additionally, this system integrates all of the treatments into one another. As a consequence of this, the function of this fungus is of the utmost significance, not only for the successful establishment of *B. bassiana* but also for the reduction of the quantity of insecticidal burden associated with IPM programmes. In light of this, the current study was carried out to investigate the combined efficacy of *B. bassiana* and neem against *B. abaci* on eggplant by the combination of two different treatment methods (soil and foliar).

In sustainable integrated pest management (IPM), pesticidal plant extracts play a crucial role. These plant extracts also have the potential to be an effective alternative to synthetic pesticides for the management of pests, particularly for smallholders, and this potential exists regardless of whether or not the extracts are actually used. Because pesticidal plants frequently have a lesser impact on higher trophic levels, including the natural opponents of pests, they are more suitable to sustainable agriculture. This is because pesticides are toxic to insects. In addition, pesticide-producing plants are readily available in the area and may be purchased at prices that are more affordable than commercially produced poisons. Products manufactured from pyrethrum and neem are among the most effective botanical pesticides that are now available for purchase on the market. Pyrethrum is a natural insecticide that is extracted from the flowers of *Chrysanthemum cineraria folium* and *Chrysanthemum cinerifolium*. [Citation needed] [Citation needed] It has been utilized in the eradication of parasites in both animals and people, in addition to pests that have been found in farms, residences, and storage facilities. In comparison, the demand for synthetic pesticides has climbed at a pace of just 3 percent per annually over the previous decade, while the demand for biopesticides has increased at an estimated rate of 15 percent per year. This expansion may be ascribed to a number of causes, such as an improved knowledge of the negative effects of synthetic pesticides and an increased level of pressure from regulatory bodies on chemicals that are authorized to be used.

There is a total of six entomotoxic compounds that may be discovered in natural pyrethrum. These substances include cinerin I and II, pyrethrin I and II, jasmolin I and II. Pyrethrin's may enter the body of an insect by ingestion or direct contact, and once they are inside, they can pierce the epidermis before being conveyed throughout the haemolymph to all sections of the body. Insects can be killed by pyrethrins in a variety of different methods. Because of the disruption caused to the insect's peripheral and central nervous systems by the pesticide, the insect will eventually become paralyzed as a result of the nerve discharges that occur repeatedly. Pyrethrins have a rapid "knockdown" effect that precedes the death of insects, and most insects die within a few minutes to a few hours after being exposed to a lethal dose of the chemical. Pyrethrins also have a "knockdown" effect on spiders.

The pyrethroids, which are comprised of synthetic insecticides such as cypermethrin, permethrin, deltamethrin, fenvalerate, and bifenthrin, are among the most widely utilized artificial pesticides. Pyrethrins had a significant role in the development of these insecticides. The need to increase the stability of these chemicals in the environment and ensure that they continue to be effective for a long length of time prompted the invention of new synthetic pyrethroids. These new pyrethroids were a response to this demand. This tactic has shown to be successful due to the widespread use of pyrethroid pesticides in agricultural contexts, as well as the high acceptance rates that have been demonstrated around the world.

## Background

Entomopathogenic fungi, sometimes known as EPF for short, are one of the most significant entomopathogens that attack insect pests. Because of the virulence it possesses against a broad variety of insect pests, *Beauveria bassiana* is one of the most extensively used EPF. It is a naturally occurring fungus that may be found in soils. It is a parasite that causes white muscadine illness in a variety of arthropod species. In addition to being an important EPF, the fungus species known as *Metarhizium anisopliae* is also responsible for the green muscardine sickness that affects insects. It is utilized extensively for the purpose of biological control of a wide variety of insect pest species.

There is evidence that certain plant compounds can kill insects. They do far less damage to the natural environment, and the use of them prevents the evolution of insect resistance to pesticides. They can be used as a direct spray, worked into the soil as additives for plant parts, intercropped with the primary crop, employed as grain protectants, and also serve as synergists. Because there are numerous items that are not only risk-free but also cost-effective, botanicals are regarded to be very beneficial. Because they are less likely to cause harm to people, natural insecticides made from plants can be an appealing alternative to synthetic chemical insecticides when it comes to pest control. Neem, also known as *Azadirachta indica*, is a well-known plant species that is utilized for the insecticidal action it has. It generates limonoid extracts that have a variety of insecticidal actions that are effective against over 250 different types of crop pests. In addition to this, it has been demonstrated to have a synergistic effect when combined with certain chemical or biological pesticides. The leaves of the eucalyptus tree contain a variety of terpenoid chemicals, including terpineol, globulol, 1,8-cineole (CIN), terpinene, and pinene. It has been hypothesized that these compounds possess antibacterial, antiviral, insecticidal, and antifungal actions. Furthermore, it has been demonstrated that these compounds possess contact and fumigant insecticidal activity against some stored grains and other insect pests.

It's possible that EPFs and insecticides that are compatible with one another will make it easier to choose the right products for IPM programmes. These combined treatments can increase the efficacy of pest management by lowering the quantity of product that is administered, hence limiting the risks of environmental contamination and the development of pest resistance. Because of this, it is essential to identify any naturally occurring antagonists that may be used in conjunction with EPFs, as the majority of synthetic insecticides do not get along with them.

## Objectives

1. Study on Effect of a Entomopathogenic Fungus (*Beauveria bassiana*).
2. Study on Utilization of a Botanical Insecticide in the Control and Management of Gram Pod Borer (*Helicoverpa armigera*).

## Research Methodology

Captive-bred *Helicoverpa armigera* are currently being developed. In the year 2018, *H. armigera* larvae were recovered from chickpea crops in the Patna City area of the state of Bihar in India. In order to prevent the larvae from eating one other, they are kept in separate containers made of sterile plastic. Repeat the processes from before, but this time make a few very little adjustments. This will allow you to feed the larvae. The artificial diet consists of chickpea flour that weighs 171 grammes, active yeast that weighs 5.7 grammes, agar that weighs 7.1 grammes, methyl-para-hydroxybenzoate that weighs 2.9 grammes, sorbic acid that weighs 0.86 grammes, ascorbic acid that weighs 2 grammes, a vitamin mixture designed for insects that weighs 1.42 grammes, streptomycin sulphate that weighs 40 milligrammes, and two milliliters' of water. The larvae were maintained in a clean "plastic container on a layer of tissue paper and given a prepared diet. The" container was placed on a clean surface. After that, the container was transferred to a clean and germ-free area.

After the adults had emerged, they were placed in a rearing cage and given cotton swabs that had been soaked in honey at a concentration of 10% for oviposition. The raising room was cleaned every day, and fresh food was supplied to reduce the risk of death that may have been caused by unclean circumstances. The rearing process took place in a climate-controlled room with temperatures of 25 2 degrees Celsius, relative humidity of 70 5 percent, and a photoperiod of 16 hours of light to 8 hours of darkness. Experiments were conducted using larvae in their third instar.

## "Isolation and Selection of Entomopathogenic fungi"

In the laboratory, the species *Beauveria bassiana* and *Metarhizium anisopliae* were effectively differentiated by making use of a method known as the "Galleria bait strategy." The infected larvae of the Greater wax moth, *Galleria mellonella*, were chosen (by trapping them with EPPF), and then *B. bassiana* and *M. anisopliae* that were commercially available were cultivated "on Sabouraud dextrose agar plate with yeast extract (dextrose 40g, peptone 10g, agar 15g, and yeast extract 10g for every 1000ml of media)". It was determined that a concentration of 125 mg/liter of chloramphenicol was necessary in order to successfully suppress the growth of bacteria. During the course of the experiment, [Goettel and Inglis] kept the plates at a temperature of 25.2 degrees Celsius and a relative humidity of 65.5 percent in a dark incubator. The experiment lasted between 15 and 20 days.

Carrying out the viability test, as well as the preparation of the conidial suspension an inoculation loop needle was used to scrape the surface of the medium in order to collect the entomopathogenic fungi's conidia. After that, the conidia were moved into a test tube that included one milliliters of Tween 80 that was diluted to a concentration of 0.1 percent. To obtain a consistent blend of the conidia, a Vortex mixer should be utilized. We determined the conidia's concentration by counting them with a Neubauer hemocytometer. This allowed us to gain an idea of how many there were. Utilizing distilled water that included Tween 80 at a concentration of 0.1 percent volume/volume and employing the serial dilution method allowed for the production of 104–109 conidia/ml. This was achieved by using the medium. Following the plating of 200 liters of conidial suspension (containing  $1 \times 10^6$  conidia ml<sup>-1</sup>) on SDAY medium, the conidia were allowed to develop in the dark for 24 hours at a temperature of 25.2 degrees Celsius and a relative humidity of 65.5 percent. This was done in order to establish whether or not the conidia have viable potential. In order to confirm the germination, we stained the seeds with lactophenol cotton blue and saw them under a microscope. Both of these methods were successful (Nikon, x450).

## Bioassay Methodology

The bioassay method was utilized for the goal of assessing the virulence of entomopathogenic fungi. Throughout the duration of the experiment, a total of four isolates of *B. bassiana* and a total of four isolates of *M. anisopliae* were used. According to what was mentioned, the larvae of *Helicoverpa armigera* in their third instar were immersed for ten seconds at each of the six different spore concentrations (range from 104 to 109 spore ml<sup>-1</sup>). The larvae were immersed in a Tween 80 solution containing 0.1 percent so that the experiment could include a control group. During the process of air-drying, after allowing the larvae to freely crawl in laminar airflow for five to ten minutes, the larvae were "transferred to sterile plastic vials that held freshly prepared meals. The plastic vials were kept in an incubator with a biological oxygen demand (BOD) at a temperature of 25.2 degrees Celsius and a relative humidity of 65.5% degrees Celsius. During the course of one week and a half, daily evaluations of the amount of larval mortality and conidial sporulation were carried out. After the larvae had passed away, they were transferred to a fresh petri dish that had some wet cotton in order to stimulate sporulation. This was done in order to prevent the fungus from going dormant. Twenty larvae were used in each of the treatments, and the experiments were repeated three times".

### Statistical Analysis

“The correct mortality percentage was determined by utilizing Abbott's approach. After that, the mortality percentage was converted, and LC50 and LC90 values were obtained by utilizing the Probit analysis feature in the Microsoft Excel 2016 software. This was done before the analysis”.

### Result

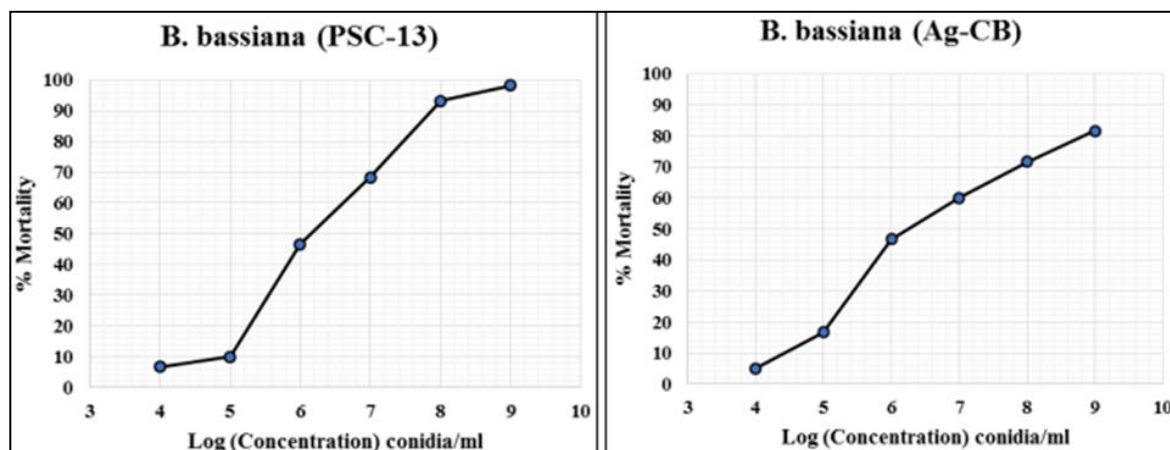
The virulence of *B. bassiana* was found to be greater than that of *M. anisopliae* when it was tested against larvae of *H. armigera* in their third instar at a range of concentrations. After 15 days, however, a high degree of mortality is indicated by all strains of *B. bassiana* and *M. anisopliae* when the spore concentration is  $1 \times 10^9$  per millilitre. This was the case when the spores were grown at an appropriate temperature. Following treatment for 15 days, a considerable “98.3 percent virulence was found in *B. bassiana* (PSC-13) with an LC50 value of ( $1.8 \times 10^6$  spores ml<sup>-1</sup>), which was followed by *M. anisopliae* PSC-11 (85.00 percent) with an LC50 value of ( $5.07 \times 10^6$  spores ml<sup>-1</sup>) (Table 1)”

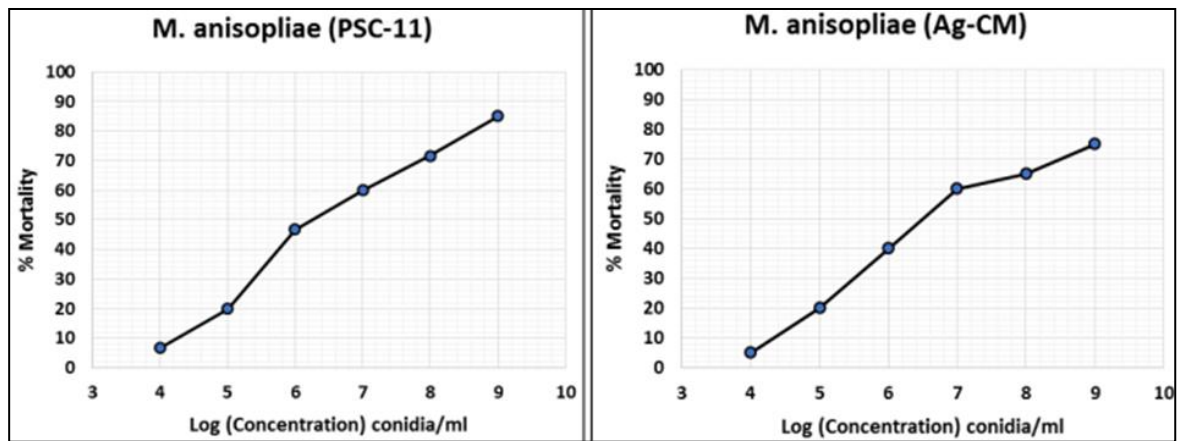
According to the findings of the trials, a certain minimal “threshold conidial concentration was required for the increased mortality; however, this threshold varied from species to species and even between different isolates of the same species. The species *B. bassiana* (PSC-13) had the lowest LC50 and LC90 values reported, followed by the species *M. anisopliae*, which had the highest values (PSC-11)”.

On the basis of the results of the LC50 and LC90, one may draw the conclusion that the fungal strain “*B. bassiana* (PSC-13) was the most virulent of the bunch, followed by *M. anisopliae* (PSC-11). Although *M. anisopliae* (Ag-CM) had the least amount of virulence possible out of the four strains of both species that were used in the bioassay” *B. bassiana* (Ag-CB) had an intermediate level of virulence. The bioassay was conducted on wheat plants that had been inoculated with *M. anisopliae* and *B. bassiana*.

**Table 1:** In a bioassay, the “LC50 and LC90 values of four different fungal isolates were measured against third-instar *H. armigera* larvae”

Isolate	LC50	LC90
<i>B. bassiana</i> (PSC-13)	$1.8 \times 10^6$	$8.4 \times 10^7$
<i>B. bassiana</i> (Ag-CB)	$7.5 \times 10^6$	$2.72 \times 10^9$
<i>M. anisopliae</i> (PSC-11)	$5.07 \times 10^6$	$1.9 \times 10^9$
<i>M. anisopliae</i> (Ag-CM)	$1.09 \times 10^7$	$7.5 \times 10^9$

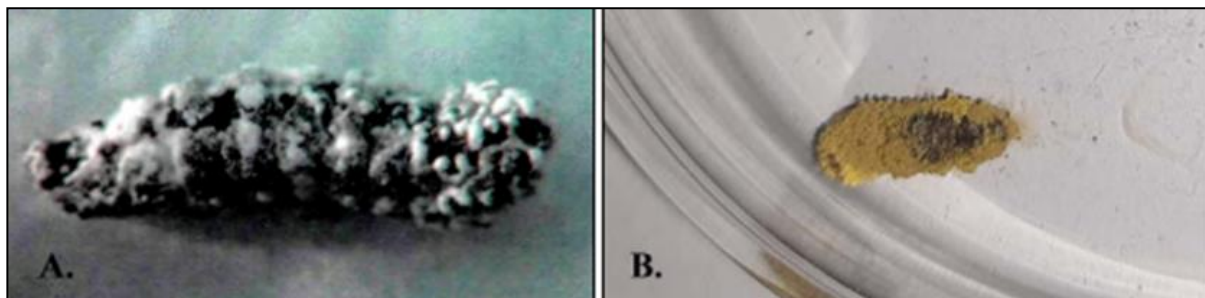




**Fig 1:** “As a function of the conidial concentration, the percentage of *H. armigera* larvae that perished 15 days after being exposed to a conidial solution containing *Bacillus bassiana* (PSC-13), *Bacillus bassiana* (Ag-CB), *Mycoplasma anisopliae* (PSC-11), or *Mycoplasma anisopliae* (Ag-CM) is given below. The numbers given for the percentage of deaths represent an average of the findings from three distinct studies”

### Microscopic View of dead larvae

Pictures of larvae exhibiting mycosis, which indicates the presence of abundantly growing mycelia of the different fungi used in the bioassay, were captured on camera (Figure 2). After being exposed to *B. bassiana*, *H. armigera* larvae acquired the typical white mycelia that cover the surface of the larvae. On the other hand, green mycelia started to form on the surface of the larvae after they were treated with *M. anisopliae*. When compared to *M. anisopliae*, the mycosis rate in *B. bassiana* is much higher (up to 82 percent), indicating that it is more susceptible to the disease (up to 62 percent).



**Fig 2:** Mycosis was seen in the third instar larvae of the *H. armigera* species after treatment with either (a.) “*B. bassiana* (PSC-13) or (b.) *M. anisopliae* (PSC-11)”

### Features of Entomopathogenic fungi recovered from infected larvae

The pure culture of all of the insect-killing fungi that were used in the bioassay was acquired from the dead larvae that were grown on SDAY medium. This was done so in order to ensure that the results of the bioassay were accurate. “The mycelial and conidial characteristics of the entomopathogenic fungi that were utilized in the bioassay were present in the isolated isolates that were tested. During the process of cultivating entomopathogenic fungi, there was only a very tiny number of contaminations, which were of little relevance”.

### Discussion

There have been several reports of local strains of *B. bassiana* that are “pathogenic to *H. armigera*. [Citation needed] (Sandh *et al.* 2001). The current investigation reveals that local isolates of *B. bassiana* (PSC-13) and *M. anisopliae* (PSC-11) were more virulent than commercial strains of *B. bassiana* (Ag-CB) and *M. anisopliae* (PSC-11)” when conducted in a controlled environment such as a laboratory (Ag-CB). This might be the consequence of several subculturings or the use of preservatives to provide a long shelf life for the product. The autumn armyworm, also known as “*Spodoptera flugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is very susceptible to *B. bassiana* isolates” which can cause larval mortality of one hundred percent at a concentration of 108 conidia/ml, as stated in the paper. The autumn armyworm is classified as a member of the family Lepidoptera: Noctuidae.

The fungal isolate PSC-13 from *B. bassiana* had the highest level of virulence when put up against the third instar larvae of *H. armigera*. This was due to the fact that it had a lower LC50 and LC90 value. This was because it had the lowest LC50 value of all of the candidates. These data suggest that the lowest LC50 value is linked to the highest (one hundred percent) larval mortality of *H. armigera* that was induced by *B. bassiana* (strain-4). Both *B. bassiana* and *M. anisopliae* have been shown to have an insecticidal effect against *Rhynchophorus ferrugineus*, according to research compiled from a number of different sources.

According to the findings of the study, the efficacy of the entomopathogenic fungus did not become obvious until 48 hours after the inoculation. At this time, the hyphae had already pierced the integument, the trachea, and the epithelial cell. The production of disease-causing spores by insect-killing fungi on the surfaces of dead creatures is a significant factor in both the spread of disease within pest populations and their ability to reproduce.

After being subjected to 109 spores/ml of *B. bassiana* (PSC-13) in the laboratory for a period of 15 days, the third-instar *H. armigera* larvae were able to achieve a high mortality percentage (98.3 percent). This was the result of this investigation. The procedure was completed successfully. In order for there to be an effect on the larvae, there has to be a sufficient amount of the pathogens present in the environment. Additionally, it reveals that an increase in the dosage of entomopathogenic fungus is related with an accompanying rise in death rates. This is demonstrated by the fact that in leguminous plants like chickpea, the use of chemical insecticides is not the only option for controlling *H. armigera* larvae. Biological pesticides, also known as biopesticides, may prove to be more efficient biological control agents for *H. armigera* larvae than chemical insecticides. In order to screen novel isolates, some of which may be more virulent, more research and development of more efficient biopesticides for the control of *H. armigera* in chickpeas is required. This is because of the necessity to control *H. armigera*.

### Conclusion

In this work, the entomopathogenic fungus *M. anisopliae* (Met 31) and *B. bassiana* (Bb 11) as well as neem oil were tested against *H. armigera* and other bollworms to determine their level of effectiveness. In spite of the fact that they are not systemic, biopesticides and neem oil are capable of providing efficient pest management for cotton if they are administered at the right time and in sufficient volume to provide optimal coverage. According to the findings of this study, it may be possible to use other methods such as *Metarhizium anisopliae* and *Beauveria bassiana*. When compared to the control group, all of the treatments showed much less damage to the pods. The lowest frequency of pod damage was seen in the plots that had been treated with *Beauveria bassiana*. Combinations of biopesticides with distinct modes of action have the potential to increase the efficacy of the individual components and minimize the development of resistance in the target pests. The cumulative effect also suggests that there is the potential for applications of pyrethrum at lower doses, which would result in less effects at higher trophic levels. Alternatively, less refined products might be utilized in order to achieve control while reducing manufacturing costs. The findings of behavioral studies shed insight on the relevance that application technique and timing have in affecting the efficacy of this unique combination pesticide technology.

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