**An Overview of Bio Pesticides : Their mode of action against insect pests and Importance in Plant Protection for Organic Farming**

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**ABSTRACT**

Biopesticides are environmentally friendly naturally occurring substances used to manage various agricultural pests. A broad variety of microbial pesticides, biochemicals sourced from microorganisms and other natural sources, and plant-incorporated protectants—which give protection against insect damage by integrating DNA into agricultural crops—are all included in the term "biopesticide." Entomopathogenic fungi, bacteria, viruses, nematodes, and plant secondary metabolites are examples of biopesticides, which are becoming more and more important as chemical pesticide substitutes and an essential part of many pest management strategies. Certain microbial pesticides, including Bacillus thuringiensis, have a long history of being used as biological pesticides in a safe and efficient manner. This article provides an overview of the current state of knowledge regarding the potential use of biopesticides, their mechanisms for pest control on a global scale, and emphasizes the concept of biopesticides, their classifications, utilization in pest management, and their importance in organic farming. The future of biopesticides in agriculture appears promising, driven by the growing demand for organic foods.

**Keywords:** Agricultural pest, Biopesticides, Microorganisms, Organic farming

1. **INTRODUCTION**

Biopesticides play a crucial role in integrated pest management (IPM) programs. The growing utilization of biopesticides can be attributed to several advantages, including enhanced operator safety, higher specificity in targeting pests, decreased environmental persistence, and improved compatibility with biological control methods compared to many synthetic alternatives. Biopesticides are categorized into microbial biopesticides, biochemical biopesticides, and plant-incorporated protectants (PIPs). Collectively, they hold a 5% share of the global pesticide market, with microbial biopesticides being the dominant category (Pathma et al., 2021). At $3 billion USD, the biopesticide market represents 5% of the total pesticide business worldwide (Marrone, 2014). Between 2040 and 2050, the market share of biopesticides is predicted to reach parity with synthetic pesticides, exhibiting an annual growth rate of 15% (Olson, 2015; Dalmas and Koutroubas, 2018).

Biopesticides, which are created from naturally occurring living species including animals, plants, and microorganisms like bacteria, fungus, and viruses, have a nontoxic, ecologically friendly mechanism of action that makes them effective at controlling significant plant-damaging insect pests. making them increasingly important worldwide. The primary purpose of biopesticides and their byproducts is to control pests that harm plants (Mazid et al., 2011).

Customers are quite concerned about the absence of residues in biopesticides, particularly when it comes to consumable fruits and vegetables. When used as a part of insect pest control, biopesticides can be just as effective as conventional pesticides, particularly for crops such as fruits, vegetables, nuts, and flowers. Biopesticides function effectively with the tractability of minimal application limits and with improved resistance management potential by integrating the performance of synthetic pesticides with environmental safety (Kumar 2012; Senthil-Nathan 2013). According to Copping and Menn (2000), biopesticides are becoming more and more popular among those working to develop integrated crop management (ICM) that is safe and beneficial to the environment.

**2. Microbial Pesticides**

**2.1 Entomopathogenic Fungi**

 Entomopathogenic fungi (EPF) are fungal species with the capability of causing diseases in insects. This group of fungi primarily resides in the soil and infects insects by breaching their cuticles to enter their bodies, subsequently leading to the insects' demise and serving as a source of nutrition (Dara, 2017). These entomopathogenic fungi can be classified into various divisions.

, Ascomycota, Zygomycota, Deuteromycota, Oomycota and Chytridiomycota (Esparza-Mora et al., 2017). For the past 200 years or so, entomopathogenic fungi have been actively used to manage an abundance of economically significant pests of crop plants. Approximately 170 years have passed since Beauveriabassiana was first isolated and recognized (Zimmermann, 2007b).

Microbial pesticides often incorporate various entomopathogenic fungi and their derivatives. Among these, Metarhizium anisopliae, a hyphomycete entomopathogenic fungus, is extensively employed for insect pest control and is globally distributed. This species encompasses a diverse array of strains and isolates sourced from various geographical locations and hosts (Roberts and St. Leger, 2004).

The taxonomy of the genus Metarhizium was reevaluated in a research by Driver et al. (2000) using RAPD patterns and sequencing data from the ITS and 28S rDNA D3 regions. This investigation revealed the presence of ten distinct clades within the genus. Clade 9 is represented by M. anisopliae var. anisopliae. These entomopathogenic fungi have been recognized for their safety and have been considered as environmentally friendly and effective alternatives to synthetic chemical pesticides, as previously noted by Domsch et al. (1980) and Zimmermann (1993). Furthermore, these entomopathogenic fungi have been officially registered as microbial agents and are currently undergoing commercial development for the biological control of various pests, as documented by Butt et al. (2001a, b).

Entomopathogenic fungi have a direct cuticle penetration mechanism, as observed by Sevim et al. (2015). This process is characterized by both physical and enzymatic interactions, as indicated in studies by Erkılıç and Uygun (1993) and Clarkson and Chamley (1996). The action mechanisms of these fungi involve several steps: firstly, the fungal spores adhere to the insect's cuticle, then they germinate and gain entry through the cuticle by forming an appressorium. Subsequently, hyphae develop within the insect's hypodermis and continue to proliferate within the body and blood cells, ultimately leading to the demise of the insect. A key area of research in the study of entomopathogenic mechanisms revolves around the secretion of toxins by these fungi.

 For example, *Beauveria bassiana* and *Metarhiziumanisopliae* release poison in synthetic settings. Prior to spreading and forming spores in the tissue of the parasitic fungus, these chemicals have the ability to kill insects. Most of the time, rather than mycosis, the digestion of fungal propagules can be fatal due to a toxic effect (Charnley, 2003)(Fig. 1).



Fig .1 Mode of action of Entomopathogenic fungi

**2.2 Entomopathogenic Bacteria**

Entomopathogenic bacteria and their associated toxins have achieved significant commercial success as microbial insecticides. They are employed on a global scale because of their cost-effectiveness, the ability for mass production, specificity in targeting pests, long-lasting presence in the environment, and their safety profile, as documented by Glare et al. (2017). Numerous bacterial species and subspecies, with a notable emphasis on Bacillus, Pseudomonas, and similar genera, have been recognized as biopesticides and are primarily utilized for the management of insect and plant diseases.

When it comes to focusing on specific insect species, Bacillus thuringiensis (Bt) is well-known for its high specificity. These species include Lepidoptera (butterflies and moths), Coleoptera (beetles), and Diptera (flies and mosquitoes). When enough Bt is digested by insects with an alkaline gut pH, such as butterflies, moths, beetles, flies, and mosquitoes, it is clear that the treatment is effective. The Bt spores grow on the intestinal flora after intake and then burst, releasing the protein toxin (Crystalline protein), which causes damage to the intestinal lining. A number of reasons, including malnutrition, tissue damage, and gastrointestinal illnesses brought on by other diseases like bacteria and fungi, cause affected insects to stop feeding and eventually die. (Copping and Menn, 2000).

**2.3 Entomopathogenic Virus(EPV)**

 Entomopathogenic viruses, often referred to as EPV, encompass a wide array of viruses that target insects, potentially leading to the mortality of the infected individuals. These viruses are being explored as a promising means to manage economically significant insect pests. Within the viral family Baculoviridae, certain members are exclusive in their infection of insect larvae belonging to the orders Lepidoptera, Hymenoptera, and Diptera. Several of these viral members have been harnessed and developed as biopesticides for the control of insect pests.

Top of Form

Many viruses, including Granulosis viruses (GV), Nucleopolyhedrovirus (NPV), and Cytoplasmic Polyhedrosis viruses, have been used all over the world to manage insect pests. This method involves the ingestion of insect-specific viral particles by the insects, which then allow the virions to infect the gut wall cells, fat body, and hemolymph, finally leading to the insects' death. It is crucial to thoroughly investigate the traits of these entomopathogenic viruses as well as the molecular processes that underlie both their infection and insect-killing ability.

**2.4 Entomopathogenic Nematodes (EPNs)**

Entomopathogenic nematodes are unsegmented, soft-bodied roundworms found in two families (Heterorhabditidae and Steinernematidae) and have proven to be highly effective in pest management programs employing biological insecticides, as noted by Grewal et al. (2005). These nematodes seamlessly integrate into integrated pest management (IPM) strategies due to their non-toxicity to humans, their relatively specific impact on their target pest(s), and their compatibility with standard pesticide application equipment, as highlighted by Shapiro-Ilan et al. (2006).

During the juvenile stage, the nematodes gain access to the host insect through various entry points such as the spiracles, mouth, anus, or, in certain species, through the intersegmental membranes of the cuticle, ultimately infiltrating the insect's hemocoel, as described by Bedding and Molyneux (1982). Both Heterorhabditis and Steinernema nematodes have a mutual association with bacteria belonging to the genera Photorhabdus and Xenorhabdus, respectively, as documented by Ferreira and Malan (2014). The juvenile stage of these nematodes then releases cells from their symbiotic bacteria into the insect's hemocoel. These bacteria subsequently multiply within the insect's hemolymph, leading to the death of the infected host, typically occurring within 24 to 48 hours.

Nematodes feed on host tissue after the host dies, develop, procreate, and infect new victims to complete their life cycle (Kaya and Gaugler, 1993).Fig.2.

Certain EPNs e.g., *Steinernema glaseri, Steinernema kraussei,Heterorhabditis bacteriophora, Heterorhabditis indica* etc., are being used as a commercial Biopesticides to control the White grubs , banana root borers etc.,



Fig 2: Mode of Action of Entomopathogenic Nematodes

**3. Importance of Biopesticides in Organic Farming**

Biopesticides employ various mechanisms of action, including growth regulation, disruption of gut function, metabolic poisoning, neuromuscular toxin activity, and non-specific multi-site inhibition, as outlined by Sparks and Nauen (2015) and Dar et al. (2021). In the foreseeable future, biopesticides have the potential to replace synthetic pesticides without substantial impacts on productivity and yield, provided their capabilities are fully harnessed, as indicated by Mishra et al. (2020). This transition supports environmentally friendly agricultural practices by eliminating the need for harmful chemicals.

**4. Biochemical Pesticides**

The plant products e.g., neem, pyrethrum, rotenone, etc are being used as a bio pesticides against various insects ,pests such as aphids, thrips, caterpillars,leaf hoppers etc. are being used globally. Vrikshayurveda is an ancient book written by Surpala in which certain plant products were described for insect pest management.

**Conclusion**

Biopesticides are important tools in sustainable agriculture. In this context use of natural products for pest control is highly recommended. Increasing consciousness regarding health among the human beings has also created the need of biopesticides and organic farming as overuse of chemical pesticides is degrading our environment. For this reason, using natural enemies like entomopathogens to control insect infestations has gained more attention in recent years. They can be applied to improve agro-sustainability and reduce insect pests as biological control agents. Within the pesticide area, research on microbial pesticides offers a singular opportunity for prospective and predictive studies.

Organic farming is the best way for food safety. Therefore, the demands for bio-pesticides for organic farming are continuously increasing day by day. Thus the investigation of the bio-pesticide might generate organic farming methods in the field of agricultural study. Organic farming follows eco-friendly agricultural practices without making use of harmful chemicals.

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