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EXPLORING THE DIVERSITY: AN OVERVIEW OF DIFFERENT TYPES OF BIOPESTICIDES IN MODERN PEST MANAGEMENT

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ABSTRACT

Modern agriculture faces a pivotal shift towards sustainable and environmentally conscious practices, prompting a reevaluation of conventional chemical pest control methods. Biopesticides have emerged as environmentally friendly alternatives to chemical pesticides in pest management. Derived from natural sources such as microorganisms, and botanicals, biopesticides offer targeted control, decreasing the negative effects on non-target organisms and reducing environmental impact. This article underscores the different types of biopesticides, advantages and disadvantages, and the growing importance of biopesticides in mitigating the environmental and health concerns, urging continued research and adoption for a more sustainable agricultural future.

INTRODUCTION

The biological agents or botanically-derived products known as biopesticides are applied to manage the insect pest population which pose a threat to the ecosystem. Biopesticides cause mortality and play a crucial role in prophylactic pest management. The use of microbial pathogens and the botanicals have shown potential to suppress the pest population below the economic threshold level (Rajamani and Negi, 2021).

CATEGORIES OF BIOPESTICIDES

Fungi, bacteria, viruses, nematodes and protozoa are examples of microorganisms that can be used as effective active ingredients in microbial pesticides to control various insect pests (Olson, 2015).

MICROBIAL PESTICIDES**:** Fungus, Bacteria, virus, and protozoa are examples of microorganisms that can be used effectively as active ingredients in microbial pesticides to control insect pests.

Bacterial Biopesticides

Three major categories can be used to classify bacterial biopesticides,

a) Obligate pathogens: "Milky disease" is caused by *Bacillus papillae* in white grubs.

b) Facultative pathogens: *B. thuringiensis* , a crystalliferous spore producing bacteria.

c) Potential pathogens: *Pseudomonas aeruginosa* and *Serratia marcescens*.

Table 1. List of *Bt* subspecies used against pests (Rajamani and Negi, 2021)

Bt subspecies	Category of toxin	Size of prototoxin (K Da)	Targets	Trade products
Bt subsp. kurstaki	Cry I	130–140	Caterpillar	Bioasp,
Bt subsp. kurstaki	Cry II	71	Caterpillar, Flies	BioDart
Bt subsp. tenebrionis	Cry III	66-73	Beetles	M-one
Bt subsp. israelensis	Cry IV	68	Flies	Bactimos

Viruses as Biopesticides

The application of baculoviruses (BV) as viral biopesticides is ubiquitous. Nuclear polyhedrosis viruses (NPVs), cytoplasmic polyhedrosis viruses (CPVs), and granulosis viruses (GVs) are the three subgroups of baculoviruses which are mostly used in pest management. A single larval equivalent (LE), or 6×10^9 POB is the fixed dose of viral biopesticides.

Examples: *Helicoverpa armigera*, *Spodoptera exigua* NPV (HaNPV, SeNPV) commercially available as Helivax, Spodopterin (Cory, 2000).

Fungal Biopesticides

The most widely used commercial fungal biopesticides on the market are from species such as *Verticillium lecanii*, *Beauveria bassiana*, and *Metarhizium anisopliae*. Fungal spore conidia penetrate the cuticles of insects and enter their hemocoel, causing death.

Table 2. Fungal biopesticides and their host ranges (Usta, 2013)

Fungus	Target pests	Commercial products
Beauveria Bassiana	White grubs, grasshoppers	Mycotrol, Naturalis
Metarhizium anisopliae	Black vine weevil, locusts	Bio-Blast, Bio-Path

Entomopathogenic Nematodes (EPNS)

On a commercial level two families, *Heterorhabditidae* and *Steinernematidae*, have been successfully discovered and utilized as bionematicides in insect control programs. The third stage infectious juveniles enter an insect's body through mouth, anus, or breathing holes.

Table 3. EPN and their host ranges (Koul, 2011)

EPN	Target pests	Commercial products
H. bacteriophora	Cutworms, Root weevils	BioSafe, Nemaplant,
S. carpocapsae	Borer beetles, caterpillars	NemaGard, Nemastar

Protozoans as Biopesticides

Protozoa also called as microsporidia can also be utilized as biopesticides in crop pest management. Insects such as *Nosema* sp. and *Vairimorpha* sp. are attacked by microsporidia, which can be employed as biopesticides. Insects must consume microsporidia to become infected. In the midgut area, the spores germinate, and the midgut cell is injected with sporoplasm. Compared to other organisms like bacteria, viruses, and fungus, they are not as effective and function slowly. Commercially available NOLO Bait (*Nosema locustae*) is an excellent anti-locust remedy (Rajamani and Negi, 2021).

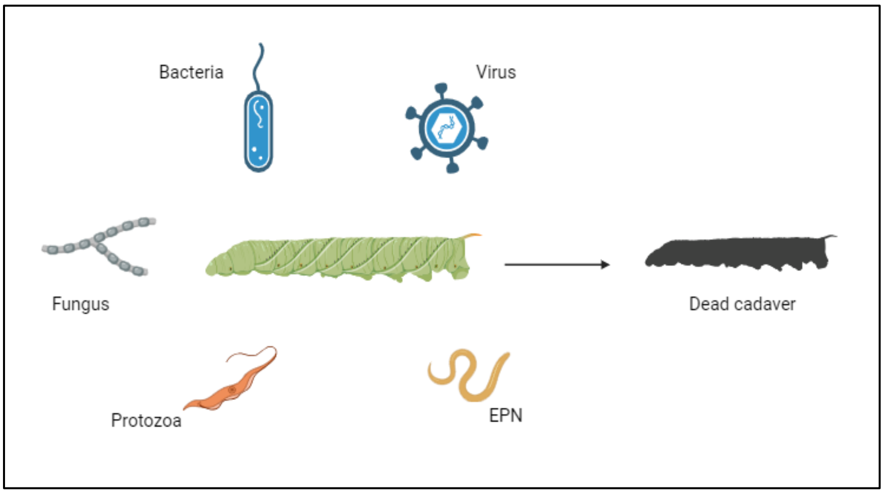

Figure 1. Biopesticides infecting host

PLANT-INCORPORATED PROTECTANTS (PIPS)

Plant-Incorporated Protectants (PIPs) refer to a category of pesticides that are produced by plants themselves through genetic modification. This technology has been developed to enhance the plant's resistance to pests, reducing the need for external chemical applications. The use of PIPs is part of the broader field of biotechnology in agriculture.

Table 4. Plant-incorporated protectants against crop pest (Rajamani and Negi, 2021)

Crops	Incorporated genes	Insect resistance	Trade names
Cotton	*Bt* Cry 1Ac toxins	Bollworm	Bollgard
Maize	*Bt* Cry 1Ab toxin	European corn borer	Yieldgard
Brinjal	*Bt* Cry1Ac toxin	Shoot and fruit borer	*Bt* Brinjal

BOTANICALS

Botanical pesticides, also known as botanicals or plant-based pesticides, refer to substances derived from plants that are used for pest control. Plant parts such as flowers, leaves, stems, and roots are used to extract these natural chemicals.

Table 5. Botanicals used against crop pest (Rajamani and Negi, 2021)

Plant source	Target pest	Compounds
***Azadirachta* spp.,**	Bollworms, , Leaf folder, Pod borer	Azadirachtin
***Nicotiana* spp.**	Aphids, Jassids, Thrips, Whitefly	Nicotine
Chrysanthemum cinerariaefolium	Crawling and flying insects	Pyrethrium

ADVANTAGES OF BIOPESTICIDES IN PEST MANAGEMENT

- Many biopesticides have a targeted mode of action, affecting only the specific pests they are designed to control.
- They are derived from natural sources, reducing the impact on ecosystems and minimizing harm to non-target organisms.
- Biopesticides often leave little or no residue on crops, addressing consumer concerns about pesticide residues in food.
- It is possible to successfully include biopesticides in Integrated Pest Management (IPM) systems.
- The diverse modes of action of biopesticides can help reduce the risk of pest populations developing resistance.

DRAWBACKS OF BIOPESTICIDES

- Their performance can be influenced by factors such as environmental conditions, pest density, and application methods.

- Biopesticides often have a shorter duration of activity compared to some chemical pesticides.
- While biopesticides are effective against certain pests, they may have a limited spectrum of control compared to broad-spectrum chemical pesticides.

CONCLUSION AND PROSPECTS

Biopesticides, which provide environmentally friendly substitutes for chemical pesticides, are essential to modern insect pest management. While biopesticides may have limitations in terms of efficacy and cost, their advantages in reducing environmental impact, preserving non-target organisms, and addressing consumer concerns make them an important component of a balanced and eco-friendly approach to pest control. Continued research and development in this field are essential for optimizing the efficacy and cost-effectiveness of biopesticides, ensuring their continued contribution to sustainable and resilient agricultural systems.

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