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# Bio-Pesticides: Essential for Controlling Insect Pests

**Dr. Manoj Kumar**

Assistant professor, Department of Zoology, F.S. University Shikohabad Firozabad, Uttar Pradesh, INDIA.

Corresponding Author: manoj9412896264@gmail.com

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**ABSTRACT**

**In the context of India's agricultural landscape, where synthetic chemical pesticides have played a significant role, this exploration underscores the pressing need for sustainable alternatives. Biopesticides, sourced from natural materials, emerge as pivotal tools in eco-friendly pest management. The diverse types of biopesticides, their current utilization in India, and the potential for expanded adoption are discussed. Despite constituting a mere 3% of total pesticides, the intrinsic qualities of biopesticides, exemplified by Neem-based products, present a promising avenue for sustainable pest control. The significance of India's biodiversity and traditional knowledge is highlighted, suggesting their potential in shaping innovative biopesticides. With a growing emphasis on organic farming, there is a foreseeable shift towards increased acceptance and integration of biopesticides in Indian agriculture.**

***Keywords***- Biopesticides, Pesticides, Pest management, Crop protection.

## I. INTRODUCTION

Agriculture stands as the cornerstone of the Indian economy, contributing 18% to the GDP. Securing food for over 1.26 billion Indians amidst shrinking cultivable land poses a formidable challenge. In the battle for crop protection against agricultural insect-pests, pesticides have emerged as potent tools. The advent of green revolution technology witnessed an extensive application of high-yielding varieties, chemical fertilizers, pesticides, and irrigation water. While this led to remarkable agricultural production post the green revolution, the indiscriminate use of chemical fertilizers and pesticides has given rise to numerous adverse effects on the environment, raising concerns about the overall sustainability of farming systems.

Nevertheless, the widespread application of synthetic chemical pesticides in the past four decades has had detrimental impacts on human health, non-target organisms, and the environment. It has also led to the development of pesticide resistance among pest species. The adverse effects manifest as pesticide residues in various elements like soil, air, water, and food, while the consequences include phytotoxicity, physiological deformities, diseases, mortality, population shifts, genetic disorders, gene erosion, and more in plants, mammals, birds, insects, and other organisms. The infiltration of chemical pesticides into the food chain and their subsequent bioaccumulation give rise to numerous unforeseen repercussions. In contrast, traditional agriculture relied on natural and sustainable practices like cultural, mechanical, and physical control strategies to manage weeds, pests, insects, and diseases. Balancing environmental safety with agricultural sustainability becomes imperative for the continued existence on Earth.

Hence, it is imperative to urgently explore alternatives to chemical pesticides that can protect plants without compromising agricultural productivity and profitability. Given the adverse effects associated with chemical pesticides, there is a pressing need for sustainable crop production through eco-friendly management practices. Biopesticides emerge as a crucial component in this context, offering a means to protect the environment and promote sustainability in agricultural production. As a response to these challenges, farmers are increasingly embracing biopesticides, known for their environmental friendliness, leading to a reduced reliance on synthetic insecticides for pest control. In the

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contemporary scenario, numerous biopesticides have been developed utilizing microorganisms (such as bacteria, fungi, viruses), plant and animal-derived products (pheromones, hormones, insect-specific toxins), and genetically modified organisms, gaining widespread use in insect pest management globally.

## II. WHAT IS BIOPESTICIDE?

As per the definition provided by the US Environmental Protection Agency (USEPA), biopesticides refer to pesticides sourced from natural materials, including animals, plants, bacteria, and minerals. This category also encompasses living organisms employed for the purpose of eliminating agricultural pests. Biochemical pesticides, on the other hand, are compounds either extracted from natural sources or artificially synthesized to replicate the structure and function of naturally occurring chemicals. What sets biochemical pesticides apart from conventional pesticides is both their origin (structure source) and their method of action (the mechanism through which they kill or control pests). In a broader sense, biopesticides represent a specific class of pesticides derived from natural sources like animals, plants, bacteria, and certain minerals. Notably, substances like canola oil and baking soda, with pesticidal applications, fall under the category of biopesticides.

## III. TYPES OF BIOPESTICIDES

Biopesticides play a vital role in Integrated Pest Management (IPM) strategies by preserving natural diversity without relying on artificial or synthetic residues. These biopesticides can originate from microbial sources, such as bacteria, fungi, or viruses, herbal sources like plant extracts, or genetically modified plants (GM). Microbial biopesticides include Beauveria spp., Trichoderma spp., and Bacillus spp., while herbal biopesticides often utilize products derived from garlic and neem. The Environmental Protection Agency (EPA) categorizes biopesticides into three primary classes based on the active ingredient type: biochemical, plant-incorporated protectants, and microbial pesticides.

***Microbial Pesticides***

Microbial pesticides are derived from microorganisms such as bacteria, fungi, or certain protozoan groups. These organisms are typically specific to particular targets and are designed to eliminate one or a group of pests, utilizing agents like bacteria, fungi, viruses, or protozoa.

***Biochemical Pesticides***

These natural substances originate from plants or organisms, offering a non-toxic and biodegradable solution. They aid plants in defending themselves against pests by either launching a counter-attack or producing chemicals that act as a deterrent, with examples including fatty acids and pheromones.

***Plant Incorporated Protectants***

Scientists create genetically modified materials by modifying a protein and inserting it into the plant, enabling the plant to produce its own pesticide. For instance, the gene for the Bt pesticidal protein is introduced into the plant's genetic material, allowing the plant to manufacture the substance that eradicates pests, replacing the need for the Bt bacterium. In India, the insecticides sector dominates the crop protection market, constituting nearly 60% of the domestic market. Main applications are observed in rice and cotton crops, while fungicides and herbicides are emerging segments, accounting for 18% and 16% of the total crop protection chemicals market, respectively. Herbicides experience seasonal demand due to weed growth in damp and warm weather, with rice and wheat crops being major application areas. Herbicides see increased demand due to rising labor costs and shortages, while fungicides are applied in fruits, vegetables, and rice.

Major factors propelling the growth of fungicides involve a transition in agriculture from cash crops to fruits and vegetables, coupled with government backing for the exportation of fruits and vegetables. Bio-pesticides encompass all biological substances utilized for pest control. Presently, bio-pesticides make up a mere 3% of the Indian crop protection market. Nonetheless, substantial growth prospects exist for this product category due to escalating apprehensions regarding the safety and toxicity of pesticides, rigorous regulations, and government initiatives.

***Pesticide used in India***

In India, over 240 pesticides are currently registered under section 9(3) of the Insecticide Act, 1968, with domestically manufactured technical grade pesticides. While biopesticides constitute approximately 4.2% of the overall pesticides market in India, this share is anticipated to witness significant growth in the coming years. Globally, biopesticides make up 4.5% of production, with the USA at 6%, whereas in India, they constitute only 3% of the total chemical pesticides production. Presently, India has registrations for only 12 types of biopesticide formulations. Neem-based pesticides, Bacillus thuringiensis, NPV, and Trichoderma are among the major biopesticides registered under the Insecticide Act, 1968 in India. In contrast, over 230 synthetic pesticides are registered for use as chemical pesticides.

**Table 1: Biopesticides registered as insecticide**

| Serial No. | Biopesticides |
|---|---|
| 1 | *Bacillus thuringiensis* var. israelensis |

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|---|---|
| 2 | *Bacillus sphaericus* |
| 3 | *Bacillus thuringiensis* var. galleriae |
| 4 | *Bacillus thuringiensis* var. kurstaki |
| 5 | *Beauveria bassiana* |
| 6 | Cymbopogan |
| 7 | Neem based pesticides |
| 8 | NPV of *Helicoverpa armigera* |
| 9 | NPV of *Spodoptera litura* |
| 10 | *Pseudomonas fluoresens* |
| 11 | *Trichoderma harzianum* |
| 12 | *Trichoderma viride* |

In India, there is a crucial need to enhance the production of biopesticides for effective pest management and sustainable agriculture. Recent studies on phytochemicals and natural products have uncovered a vast array of compounds exhibiting diverse chemical structures and bioactivities. Botanical pesticides, also referred to as 'phytochemical insecticides' or 'green chemical insecticides,' serve as environmentally safe and non-harmful alternatives. Researchers in the field of botanical insecticides primarily focus on exploring and screening plant materials for managing insect pests. This trend is followed by emerging scientists in the same field.

To meet the demand for botanical pesticides production, there is a call for an alternative research approach to support organic farming and integrated pest management (IPM) in developing countries. India, as the 12th largest global producer of chemical pesticides, witnesses a significant portion of synthetic pesticides, with around 50% being utilized on cotton crops and 17% on rice. Figure 2 illustrates the treated area under synthetic chemicals and biopesticides in India from 2011 to 2016 as part of the overall pesticide production.

At present, the average pesticide consumption per hectare in India stands at approximately 280 g/ha, with an annual growth rate in consumption ranging from 2 to 5%. It's worth noting that the current usage of chemical pesticides in India is comparatively low, measuring 381 grams per hectare, as opposed to the global average of 500 grams per hectare. India utilizes over 40,000 metric tons of pesticides annually.

Regarding the consumption and distribution of biopesticides in India, there exists significant regional disparity among states. Maharashtra, West Bengal, Kerala, Karnataka, and Haryana collectively contribute to 60% of the total biopesticides consumption in the country. Maharashtra leads in consumption with 1454 M.T. (Technical Grade), followed by West Bengal (838 M.T. Technical Grade) and Kerala (62 M.T. Technical Grade). Conversely, states like Rajasthan, Sikkim, Goa, Meghalaya, Nagaland, Manipur, and Uttar Pradesh exhibit lower consumption levels of biopesticides. Other states, including Karnataka, Haryana, Madhya Pradesh, Chhattisgarh, Bihar, Tamil Nadu, Gujarat, and Odisha, fall into the category of medium users.

***Plant products***

The utilization of botanicals is increasingly recognized as a significant approach in safeguarding crop yield and the environment against the challenges of pesticide pollution, a widespread global issue.

**Table 2: Plant products registered as biopesticides.**

| Plant Product | Source | Target Pests | Specific Efficacy |
|---|---|---|---|
| Limonene and Linalool | Plant-derived | Fleas, aphids, mites, fire ants, flies, paper wasps, house crickets | Broad spectrum against various pests |
| Neem | Neem tree | Sucking and chewing insects | Natural solution for pest management |
| Pyrethrum / Pyrethrins | Chrysanthemum flowers | Ants, aphids, roaches, fleas, flies, ticks | Effective against a range of pests |
| Rotenone | Various plant sources | Leaf-feeding insects (aphids, certain beetles, caterpillars), fleas, lice on animals | Targets specific pests and animal parasites |
| Ryania | Ryania plant | Caterpillars (European corn borer, corn earworm), thrips | Particularly effective against specific caterpillars and thrips |
| Sabadilla | Seeds of Schoenocaulon officinale | Squash bugs, harlequin bugs, thrips, caterpillars, leaf hoppers, stink bugs | Versatile effectiveness against multiple pests |

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Neem is acknowledged as a highly efficient and environmentally friendly solution. Neem-based products exhibit effectiveness against over 350 arthropod species, 12 nematode species, 15 fungi species, three viruses, two snail species, and one crustacean species. Its abundant production in India makes Neem a readily accessible and potent resource for various applications.

## IV. LIMITATIONS

Farmers are accustomed to readily available packaged pesticides on store shelves. While farmers acknowledge the significance of opting for plant-based alternatives over chemical pesticides, the widespread adoption of these plant products will require some time to gain popularity. One effective approach to promote their usage is by processing and making them accessible to farmers in a convenient and ready-to-use form.

## V. CONCLUSION

India's abundant biodiversity serves as a significant advantage, offering a diverse array of biopesticides that can be effectively employed on a large scale in agriculture. Additionally, the growing health consciousness among Indian citizens has led to an increased demand for organic food, signaling substantial potential for the expansion of the biopesticide sector. The extensive traditional knowledge possessed by the diverse indigenous communities in India holds promise for the development of innovative and efficient biopesticides. The emphasis on organic farming and the desire for residue-free produce are likely to drive greater acceptance and utilization of biopesticides among farmers.

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