Volume 02, Issue 11, 2024
ISSN: 2584-153X
Article ID: G-24-1131

BIOPESTICIDES IN AGRICULTURE

Urmila Parvathy, Neeru Singh Redhu*, Jyoti Taunk, Shikha Yashveer and Anil Panwar

College of Biotechnology, Chaudhary Charan Singh Haryana Agricultural University, Hisar – 125004

**Corresponding Author Mail ID: redhuneeru95@hau.ac.in*

Introduction

Agriculture is the most significant sector of the Indian economy, where almost 70% of the population depends upon agriculture for a job and/or a living. However, India loses nearly 18% of the crop yield valued at ₹ 90,000 crores due to pest attacks each year.

Pesticide use for crop protection has undoubtedly helped to reduce these production losses through the precise administration of pesticides, targeting insect populations.

Furthermore, pesticides are essential to contemporary agriculture, where insecticides, fungicides, and herbicides are frequently used to control pests and weeds.

India ranked 12th in pesticide use globally and 3rd in Asia after China and Turkey, which account for a share of only 1% of the worldwide pesticide use. According to FAO, India used over 61,000 tonnes of pesticides in 2020. The total pesticide production of India in 2022 to 2023 (258,130 tonnes) increased by two-fold from 1998 (102,240 tonnes).

Currently, out of 293 registered pesticides 104 pesticides are being manufactured in India (Soman *et al*., 2024).

Even though the recommended requirement of pesticide use per acre is minimal in India, however, due to its careless and generous application, residues from these chemicals can be found in both living and non-living areas of the ecosystem. This careless and unprofessional application of pesticides not only poses a risk to the environment and public health, but also results in several other issues like development of pest resistance and, resurgence of minor pests as major pest. In this instance, the role of bio pesticides becomes relevant as their application significantly reduce environmental contamination. Thereby, bio pesticides support the aim of achieving sustainable agriculture, by protecting environment, extending the Earth's natural resource base and improving soil fertility.

Bio pesticides are naturally occurring substances that are developed or isolated from a variety of biological sources and are utilized to control agricultural pests. Numerous types of potential bio pesticides have been identified from plants. These bio pesticides could be excellent alternatives to chemical pesticides. Currently, the Indian market offers several environment-friendly microbial and plant-based bio pesticides. Reportedly, only 8% of the Indian farmers uses these biopesticides. As the popularity of organic food and agricultural products is on the rise, the usage the biopesticides is also expected to boom. The benefits of biopesticides are shown in Fig 1. This article emphasizes the types and usefulness of different biocontrol agents developed from plants or microorganisms such as bacteria, cyanobacteria, and microalgae. It also includes prospects of RNA interference (RNAi)-based technology for developing bio pesticides (Nayak & Solanki, 2021). RNAi is a smart tool which allows scientists to selectively turn off the target genes, indirectly.

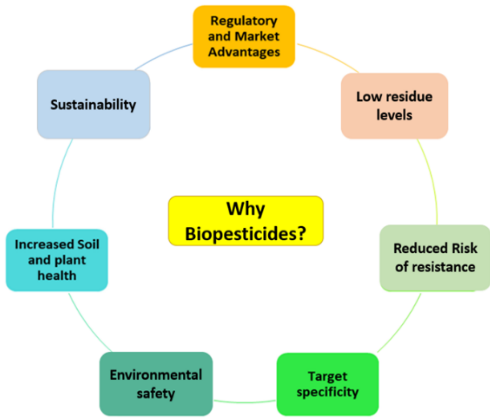

Figure 1. Benefits of Biopesticides

Types of biopesticides

The biopesticides are classified according to their sources as well as the type of molecule/compound used for their preparation. Another classification method majorly focuses on target species. Here the term 'bioinsecticides' is used specifically for biopesticides which target harmful insects. Similarly the term 'bioherbicides' is used for those biopesticides which can control weeds through the action of microorganisms, such as fungi. The Environmental Protection Agency, Washington (US) categorized Biopesticides as Microbial, Biochemical and Plant incorporated protectants.

1. Microbial Pesticides

The pesticides wherein microorganisms like bacteria, fungi, and viruses are utilised as pesticides are classified as microbial pesticides. Generally, the active compounds isolated from these organisms target specific pest species or group like entomopathogenic nematodes. In the past decade, significant research on microbial biopesticides has led to the development and commercialization of products like 'Shatpada Armour'. This microbial pesticide constituting *Bacillus thuringiensis var. kurstaki* protects maize against Fall armyworm (*Spodoptera frugiperda*) attack. Another microbial pesticide containing Baculoviruses species controls Chewing insects (Lepidopteran caterpillars) infestation in a species-specific manner. This biopesticide controls insects through the production of crystalline occlusion bodies. Commercial pesticide named 'Shatpada Aphid Kill' with, *Beauveria bassiana,* a fungal constituent has been reported to reduce aphid infestation in chilli and brinjal.

2. Biochemical Pesticides

These pesticides are natural substances like pheromones, insect growth regulators, plant extracts or oils that control pests through non-toxic mechanisms. Unlike synthetic or chemical pesticides, which directly kill pests to control their infestation, biochemical pesticides manage infestations by trapping the pest.

Insect Pheromones: Pheromones are produced by insects and have a role in insect mating and progeny production. These chemicals are utilized in integrated pest management to disrupt insect mating, and reduce progeny. As pheromones are diffused in the environment through pheromone flumes associated with insect traps, the targeted insects become confused and get trapped. Insect pheromones aren't true insecticides since they don't kill but influence the insect's olfactory system to alter their behaviour. Commonly used volatile esters such as ethyl acetate from the host not only induce the release of the pheromone but also activate the pheromone after release.

Plant-Based Extracts and Essential Oils: Plant-based extracts and essential oils are other alternatives to synthetic insecticides for managing insect pests. These contain a wide range of bioactive compounds depending on plant selection and exhibit diverse effects on insects based on their physiological traits. They can function as repellents, attractants, or antifeedants. They can inhibit respiration, disrupt insects' ability to identify host plants, prevent egg-laying, and reduce adult emergence through ovicidal and larvicidal actions. 'Astha Killer' is a biopesticide which containing neem seed kernal emulsifiable concentrate with atleast 1% Azadirachtin. It is very useful for the control of shoot and fruit borer of fruits and vegetables.

Insect Growth Regulators: Insect growth regulators (IGRs) disrupt essential processes of insects leading to their death in a highly selective manner, causing minimal toxicity to non-target organisms. These IGRs can control a variety of insects including fleas, cockroaches, and mosquitos by preventing reproduction, egg hatching, and moulting in young insects. Even though they are not fatal for adult insects, they can still be utilized to effectively target adult insects when used in combination with other insecticides. Popularly used IGRs are Tebufenozide, methoxyfenozide, halofenozide, and chromafenozide (Kumar et al., 2021).

3. Plant Incorporated Protectants

Plant Incorporated Protectants (PIPs) are biopesticidal protectants made from the genetic material of plants that have been incorporated into another plant. These are non-conventional pest control products as they are directly expressed in the tissues of crops which have been genetically modified using scientific techniques to provide defence against viruses and insects. Cry protein and double-stranded ribonucleic acid (dsRNA) are examples of PIPs. In 2001, Tenllado and colleagues were the first to report the successful foliar application of dsRNAs targeting plant viruses such as Pepper mild mottle virus (PMMoV), Alfalfa mosaic virus (AMV), and Tobacco etch virus (TEV) (Tenllado and Diaz-Ruiz, 2001).

The correct usage of these commercial biopesticides can prevent loss and results in a higher crop yield. Apart from these biopesticide categories, RNA interference (RNAi)-based biopesticides are becoming popular and are currently being researched extensively for their application in agriculture.

RNAi -based Biopesticides

RNA interference (RNAi), is a process that halts protein production via some regulatory nucleic acids called as small RNA (sRNA). These sRNAs binds with target mRNA (which codes for protein) and triggered its degradation. Incorporating RNAi process can aid in plant protection without need to integrate dsRNA in plants through techniques like transformation. The topical applications of dsRNA specific to target mRNAs of plant pests and pathogens can effectively protect plants and control pest infestation. As a result, RNAi-based biopesticides are emerging as a precise, narrow-spectrum alternative to chemical controls for targeting pests and pathogens with accuracy (Fletcher et al., 2020).

Over the last two decades, the screening and functional analysis of potential target genes, along with the development of RNAi-based strategies for crop protection and improvement, has resulted in the introduction of the first RNAi-based product named ‘SmartStax Pro’ to the global market. The US and Chinese regulators approved the product in 2017 and 2021, respectively. Bayer's ‘SmartStax Pro’ maize (Mon87411) combines the expression of *Bacillus thuringiensis* (Bt) Cry3Bt1 toxin with glyphosate resistance and a dsRNA targeting the Snf7 gene of the western corn rootworm (*Diabrotica virgifera virgifera*). The environmental application of dsRNA, particularly through spray formulations, for RNAi-based pest control holds great promise as a species-specific, sustainable, and eco-friendly approach for achieving plant protection (De Schutter et al., 2021).

Current status of Biopesticide use in India:

Over the past decade, significant progress has been made in standardizing production techniques for biocontrol agents like *Trichoderma, Gliocladium, Paecilomyces, Pseudomonas, Trichogramma*, Nuclear Polyhedrosis Virus, and *Bacillus*, which has led to their wider use against various insect pests and plant diseases. In India, several successful applications of biocontrol agents include: (i) The weed *Lantana camara* has been effectively managed using the bug *Telonemia scrupulosa*. (ii) Sugarcane pests, such as Pyrilla, have been successfully controlled in several states through the introduction of its natural predators, *Epiricania melanoleuca* and *Tetrastictus pyrillae*. (iii) *Trichogramma*, known for feeding on the eggs of sugarcane borers, has been deployed in states of Tamil Nadu, Rajasthan, Uttar Pradesh, Bihar, and

Haryana to control borer infestations. (iv) *Trichogramma, Bracon, Chelonus*, and *Chrysopa* species have been utilized to manage cotton bollworms. *Trichogramma* has also been effective against rice stem borers and leaf folders. (v) In states like Uttar Pradesh, West Bengal, Gujarat, and Karnataka, predatory coccinellid beetles have been used to combat the sugarcane scale insect. (vi) 'Bio Jodi' is one product that contains both *Pseudomonas fluorescens* and *Bacillus subtilis* bacteria. These pathogens colonize the rhizosphere and phylloplane and are marketed as soil inoculants because of their ability to outcompete or exclude infection of fungal pathogens.

Conclusion and Future Aspects

The integration of biopesticides into agricultural practices represents a promising shift towards more sustainable and environmentally friendly pest management. With the significant challenges posed by traditional chemical pesticides—including environmental contamination, pest resistance, and health risks—biopesticides offer valuable alternatives by leveraging natural mechanisms to control pests. The recent advancements in biopesticide research, including microbial, biochemical, and RNAi-based technologies provide a diverse toolkit for managing agricultural pests with precision and minimal ecological impact. Advancement in the delivery system of biopesticides, improving field performance, low cost of production, enhanced activity of biopesticide against targets, longer shelf life, easy availability, awareness among farmers and simple registration and regulation policies will help in the incorporation of biopesticide in the mainstream of agriculture.

Molecular-based technologies to reconstruct the evolution of natural microbial enemies and separate the molecular basis for their pathogenicity. Adequate training should be given to farmers on how to utilise biopesticides for maximum benefits. This includes creating an awareness about biopesticide storage, use and the policies regarding them. In India, biopesticide adoption has been slow, with limited usage so far. However, their success in controlling pests and reducing environmental and health risks shows their potential to transform pest management. Increased investment in research, supportive policies, and education are key to expanding their use and promoting sustainable agriculture that protects human health and the environment while maintaining crop productivity. Additionally, the manufacture and application of bio-pesticides need to be encouraged to promote sustainable agricultural development and safeguard the environment against the harmful effects of chemical pesticides.

References:

1. De Schutter, K., Taning, C. N. T., Van Daele, L., Van Damme, E. J., Dubruel, P., & Smagghe, G. (2022). RNAi-based biocontrol products: Market status, regulatory aspects, and risk assessment. *Frontiers in Insect Science*, *1*, 818037.

2. Fletcher, S. J., Reeves, P. T., Hoang, B. T., & Mitter, N. (2020). A perspective on RNAi-based biopesticides. *Frontiers in plant science*,*11*, 51.

3. Kumar, J., Ramlal, A., Mallick, D., & Mishra, V. (2021). An overview of some biopesticides and their importance in plant protection for commercial acceptance. *Plants*,*10*(6), 1185.

4. Nayak, P., & Solanki, H. (2021). Pesticides and Indian agriculture- a review. *International Journal of Research -GRANTHAALAYAH*, *9*(5), 250–263.

5. Tenllado, F., & Dıaz-Ruız, J. R. (2001). Double-stranded RNA-mediated interference with plant virus infection. *Journal of virology*, *75*(24), 12288-12297.

6. Soman, S., Christiansen, A., Florinski, R., Bharat, G., Steindal, E. H., Nizzetto, L., & Chakraborty, P. (2024). An updated status of currently used pesticides in India: Human dietary exposure from an Indian food basket. *Environmental Research*, *242*, 117543.