

Role of bio-pesticides in organic farming: A scientific perspective for India

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Bio-pesticides play a pivotal role in organic farming by providing environmental friendly alternatives to synthetic pesticides. They are derived from natural sources like plants, microorganisms, and minerals, and target specific pests without harming beneficial organisms or the environment. In India, organic farming is being gradually adopted with bio-pesticides such as neem oil, Bacillus thuringiensis, and Beauveria bassiana being widely used to control pest populations and promote sustainable agriculture. These bio-pesticides offer several advantages, including reduced chemical residue, improved soil health, and better pest resistance management. Their growing adoption in India supports the country's shift toward sustainable, eco-friendly agricultural practices.

Keywords: *Bacillus thuringiensis*, Eco-friendly, Neem oil, Sustainable agriculture

ORGANIC farming has emerged as one of the most sustainable and environmental friendly agricultural practices worldwide. The rise in demand for organic products due to concerns about the adverse effects of synthetic pesticides on human health and the environment has led to a significant shift in farming practices. In India, a country with a rich agricultural heritage and a large farming community, the transition towards organic farming has been gaining momentum. A key component in this transition is the use of bio-pesticides which play a crucial role in maintaining crop health while adhering to the principles of organic farming. This article highlights the advantages and significance of bio-pesticides in organic farming in India.

Understanding bio-pesticides

Bio-pesticides are natural or biologically derived agents used to control pests. Unlike synthetic chemical pesticides, which are often toxic and environmentally harmful, bio-pesticides offer a safer, more

sustainable alternative as they do not leave harmful residues in the soil, water, or food. They are typically derived from microorganisms or natural substances found in plants, animals, or minerals. The three main types of bio-pesticides are:

Microbial pesticides: These are made from microorganisms such as bacteria, fungi, and viruses that target specific pests. For example, *Bacillus thuringiensis* (Bt) is a bacterium commonly used to control insect larvae.

Biochemical pesticides: These include natural substances that control pests by disrupting their behaviour or physiology. Examples include plant-derived compounds such as neem oil or garlic extract.

Plant-incorporated protectants (PIPs): PIPs are biopesticides like Bt proteins or dsRNA engineered directly into a crop's DNA. They are applied broadly in agriculture to protect corn, cotton, and specialty crops from targeted destructive insects and plant viruses. However, genetically engineered crops (like Bt crops) are not permitted in organic farming.

Need for organic farming in India

India is one of the largest agricultural producers in the world, with agriculture occupying a significant portion of the country's economy and providing employment to millions of people. However, the over-reliance on chemical pesticides in conventional farming has led to numerous challenges, including soil degradation, water contamination, biodiversity loss, and adverse health effects on farmers and consumers.

In recent years, there has been an increasing awareness of the harmful effects of chemical pesticides, and this has fuelled the growth of the organic farming sector in India. Organic farming emphasises the use of natural methods to enhance soil fertility, control pests, and maintain ecological balance. India's organic certified area has grown from 2.8 million hectares (mha) to 5.97 mha. While Sikkim and Uttarakhand remain organic pioneers, Madhya Pradesh and Maharashtra now lead in total land volume. However, organic farming faces challenges, particularly in pest control. Traditional organic practices



Neem

Neem (*Azadirachta indica*) is one of the most well-known plants used in bio-pesticides. It contains compounds like *azadirachtin*, which disrupt the feeding and reproductive systems of many pests. Its formulations are widely used in India for controlling pests like aphids, whiteflies, and caterpillars.

Pseudomonas fluorescens

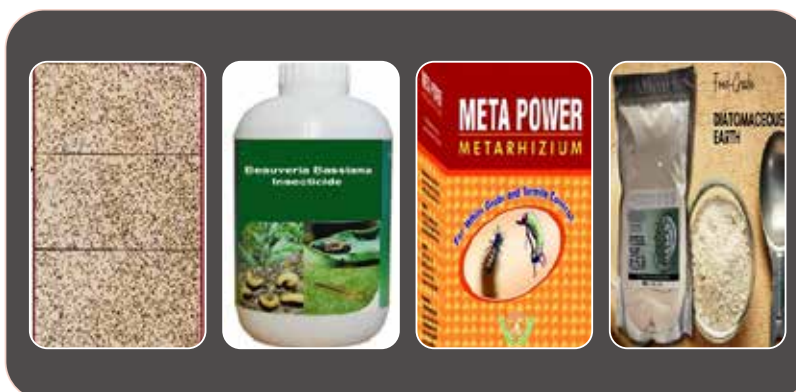
A bio-pesticide to control a range of plant pathogens, including fungi and bacteria that cause diseases like wilt and blight. It is especially effective in controlling soil-borne pathogens and improving plant health.

Bacillus thuringiensis

It produces proteins toxic to certain insect larvae. It is widely used in organic farming to control pests such as caterpillars and root worms. Its formulations are commonly sprayed on crops or incorporated into the soil.

Trichoderma spp.

Beneficial fungi that help control soil-borne diseases caused by pathogenic fungi. They are particularly useful in managing root rot and damping-off diseases in vegetables and other crops.



Trichogramma spp.

Parasitic wasps that control lepidopteran pests by parasitising their eggs, preventing larvae hatching. Widely used in organic farming to manage pests like corn borers, cotton bollworms, and cabbage worms.

Beauveria bassiana

A soil-borne fungus that acts as a biological insecticide by producing spores that attach to insects' exoskeletons, germinates, and kills the pest. It controls aphids, whiteflies, thrips, and beetles, and is safe for humans, animals, and beneficial insects.

Metarhizium anisopliae

An entomopathogenic fungus that targets pests like termites, ants, and root weevils. It infects insects' exoskeletons and is particularly effective against soil-dwelling pests that damage crop roots.

Diatomaceous Earth

Made from the fossilised remains of diatoms, this natural product works by dehydrating the pests, making it a non-toxic solution for pest control. It is effective against pests like ants, termites, and cockroaches.

Popular bio-pesticides in India

often involve manual labour, crop rotation, and the use of non-chemical repellents. While these methods are effective to an extent, they may not be sufficient in controlling pest outbreaks that can damage crops and reduce yields. This is where bio-pesticides come into play.

Advantages of bio-pesticides in organic farming

Eco-friendly and sustainable:

Bio-pesticides are naturally occurring substances, which means they are biodegradable and do not persist in the environment like synthetic chemicals. They break down into non-toxic compounds and do not contaminate soil, water, or air. This aligns with the core principles of organic farming, which emphasises sustainability and environmental stewardship. For instance, *Bacillus thuringiensis* is a bacterial pesticide that specifically targets certain insect larvae without harming other beneficial insects like bees or ladybugs.

Reduced health risks: The use of bio-pesticides reduces the exposure of farmers and consumers to toxic chemicals. In India, where farmers often apply chemical pesticides without protective gear, the health risks associated with chemical pesticide exposure are substantial. The long-term use of such chemicals has been linked to various health issues, including cancer, neurological disorders, and reproductive problems. By using bio-pesticides, farmers can minimise these risks and ensure safer food production.

Targeted action: Unlike broad-spectrum synthetic pesticides, which can affect a wide range of organisms, bio-pesticides are often pest-specific. For example, *Trichoderma* species, a type of fungus, can be used to control fungal diseases in crops without harming other beneficial microorganisms in the soil. This specificity helps maintain biodiversity and ecological balance in the farming ecosystem.

Resistance management: A major challenge with synthetic pesticides is the development of pest resistance, which reduces

their effectiveness over time. Bio-pesticides, particularly those derived from microorganisms, offer a valuable alternative for managing this issue. For example, the targeted application of *Bt* microbial sprays provides distinct modes of action that can be integrated into pest management practices to delay or manage resistance development.

Improved soil health: Organic farming aims to maintain soil health and fertility through practices that enhance the natural biological activity of the soil. Bio-pesticides, especially those derived from beneficial microorganisms, can improve soil health by promoting the growth of beneficial soil microbes, which in turn enhances nutrient cycling and soil structure. This reduces the need for external inputs like synthetic fertilisers, which can degrade soil quality over time.

Challenges and future prospects

While bio-pesticides have immense potential, there are several challenges to their widespread adoption in India. These include

the high cost of production, lack of awareness among farmers, and regulatory hurdles in the approval process. Additionally, the availability of quality bio-pesticides in rural areas remains limited, and farmers may lack the technical knowledge to apply them effectively.

However, the Indian government has been actively promoting organic farming and the use of bio-pesticides through various initiatives. The National Programme for Organic Production (NPOP) and the Paramparagat Krishi Vikas Yojana (PKVY) are two such programmes that encourage organic farming and provide financial assistance to farmers. Moreover, research institutions and universities are working to improve bio-pesticide formulations and make them more accessible to farmers.

The future of bio-pesticides in organic farming in India looks promising. With growing awareness about the benefits of organic farming, combined with advancements in biotechnology, bio-pesticides are likely to play an even greater role

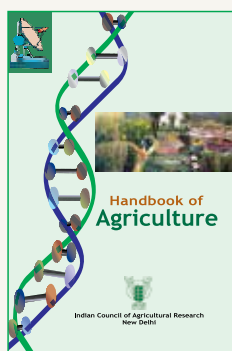
in ensuring sustainable agricultural practices. If supported by appropriate policies, education, and infrastructure, bio-pesticides could become an essential component of India's organic farming landscape.

SUMMARY

Bio-pesticides are a critical tool for the success and growth of organic farming in India. They offer a sustainable, eco-friendly, and effective alternative to chemical pesticides, helping to protect both the environment and human health. With the increasing adoption of organic farming practices, the role of bio-pesticides will only grow stronger, contributing to a more resilient and sustainable agricultural system in India. By continuing to invest in research, policy support, and farmer education, India can build a future where organic farming and bio-pesticides work hand-in-hand to create a healthier planet and a thriving agricultural sector.

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