

Role of Botanicals in Sustainable Pest Control

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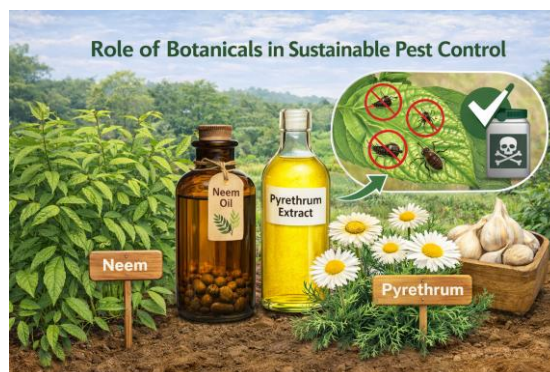
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INTRODUCTION

Agricultural pests cause significant losses in crop production worldwide. Farmers have relied on chemical pesticides as their primary method to combat insect pests and plant diseases and weed problems. The environmental and ecological problems created by synthetic pesticides stem from their excessive use which results in pesticide resistance and food product contamination through residue buildup and soil and water contamination and harmful impacts on beneficial organisms.

Sustainable pest management strategies have emerged as crucial solutions to meet these environmental challenges. One such approach is the use of botanicals, which are natural compounds extracted from plants with pesticidal properties. Many plants produce bioactive compounds that protect them from insect attacks, pathogens, and herbivores. Farmers can use natural compounds as eco-friendly pest control solutions for their agricultural operations. In response to these challenges, sustainable pest management strategies have gained importance. One such approach is the use of botanicals, which are natural compounds extracted from plants with pesticidal properties. Many plants produce bioactive compounds that protect them from insect attacks, pathogens, and herbivores. These natural compounds can be utilized as eco-friendly pest control agents in agriculture.

Botanical pesticides have been used for centuries in traditional farming systems and are now receiving renewed interest as components of sustainable agriculture and integrated pest management programs.



Botanical Pesticides in Sustainable Agriculture

2. Concept of Botanical Pesticides

Botanical pesticides are chemicals that come from plants. These plants have properties that help control pests that can harm crops. We get these chemicals from parts of plants like leaves, seeds and flowers. Many plants make their own chemicals to protect themselves from insects and other pests.

These plant chemicals can hurt pests in ways. They can stop pests from eating or growing. They can even kill pests. Botanical pesticides are good for the environment because they break down quickly and do not stay in the soil for a time. You can make pesticides in different ways. You can use solvents to extract the chemicals from plants. You can also use the oils from plants. Some people. Grind the plants to make a powder. Others make a tea by boiling the plants in water. There are also products that use botanical pesticides.

These natural products can affect pests in ways. They can stop pests from eating or growing. They can even kill pests. Because botanical pesticides are natural and break down quickly they are an alternative to synthetic pesticides.

3. Important Botanical Pesticides Used in Agriculture

There are plants that have pesticides in them. These plants have been used for a time to control pests. Now they are becoming more popular in agriculture.

3.1 Neem-Based Products

One of the most widely used botanical pesticides is derived from the neem tree, scientifically known as *Azadirachta indica*. Neem has been used for centuries in traditional agriculture for pest control due to its strong insecticidal and repellent properties.

The most important active compound in neem is azadirachtin, which is primarily extracted from neem seeds. This compound acts as an insect growth regulator and interferes with the hormonal system of insects. Neem-based

pesticides exhibit several modes of action, including:

- ✓ Insect growth regulation, preventing normal development and molting
- ✓ Antifeedant activity, discouraging insects from feeding on treated plants
- ✓ Repellent action, deterring insects from approaching crops
- ✓ Reduction in egg-laying and reproductive capacity

Neem formulations are effective against a wide range of agricultural pests such as aphids, whiteflies, thrips, leaf miners, caterpillars, and beetles. Due to their low toxicity to beneficial insects and mammals, neem products are widely used in organic farming and Integrated Pest Management (IPM) programs.

3.2 Pyrethrum

Pyrethrum is another pesticide. It comes from the flowers of the chrysanthemum plant. Pyrethrum is an insecticide. It hurts the system of insects and kills them. Pyrethrum is used to control types of pests. It is used to control mosquitoes, flies and beetles. Pyrethrum is safe for people and animals. It breaks down quickly when it is exposed to sunlight and air. Pyrethrum is commonly used to control pests such as:

- ✓ Mosquitoes
- ✓ Houseflies
- ✓ Beetles
- ✓ Caterpillars
- ✓ Aphids

3.3 Nicotine

Nicotine is a pesticide that comes from tobacco plants. It is a neurotoxin that hurts the nervous system of insects. Nicotine was used a lot in the past to control pests. It is not used as much now because it is toxic to people and animals.

3.4 Rotenone

Rotenone is a pesticide that comes from the roots of certain plants. It is an insecticide that hurts the cellular respiration of insects. Rotenone is used to control types of pests. It is not used as much now because it is toxic to people and animals. Rotenone has been used to control several insect pests, including:

- ✓ Beetles
- ✓ Caterpillars
- ✓ Leaf-eating insects

3.5 Essential Oils

Essential oils are oils that come from plants. They have pesticidal properties. Essential oils can be used to control types of pests. They can be used to repel insects or kill them. Some plants that have oils with pesticidal properties are garlic, eucalyptus, lemongrass, peppermint and clove. These oils can be used in farming to control pests. Some commonly used pesticidal essential oils are obtained from plants such as:

- ✓ Garlic (*Allium sativum*)
- ✓ Eucalyptus (*Eucalyptus spp.*)
- ✓ Lemongrass (*Cymbopogon citratus*)
- ✓ Peppermint (*Mentha piperita*)
- ✓ Clove (*Syzygium aromaticum*)

4. Modes of Action of Botanical Pesticides

Botanical pesticides control pests in ways. They can repel insects. Stop them from eating. They can also hurt the system of insects or stop them from growing.

4.1 Repellent Action

Many botanical compounds produce strong odors that repel insects and prevent them from approaching treated plants. This reduces the likelihood of pest infestation and crop damage.

4.2 Antifeedant Activity

Some botanical pesticides stop insects from eating. They make the plants taste bad to the insects.

4.3 Growth Regulation

Some botanical pesticides interfere with the hormonal system of insects, disrupting their growth and development. These compounds may prevent molting, metamorphosis, or normal development of larvae into adults.

4.4 Toxic Effects

Certain botanical compounds directly affect the nervous system, metabolic processes, or cellular respiration of insects, leading to paralysis or death. The presence of multiple active compounds in botanical pesticides often results in complex modes of action, making it more difficult for pests to develop resistance.

5. Advantages of Botanical Pesticides

Botanical pesticides offer several advantages compared to synthetic chemical pesticides.

5.1 Environmentally Friendly

Most botanical pesticides are biodegradable and break down rapidly in the environment. This reduces long-term environmental contamination and pesticide residues.

5.2 Reduced Toxicity

Plant-based pesticides generally exhibit lower toxicity to humans, livestock, and beneficial organisms such as pollinators and natural enemies of pests.

5.3 Compatibility with Integrated Pest Management

Botanical pesticides can be easily integrated with biological control agents, cultural practices, and mechanical pest management techniques within IPM programs.

5.4 Reduced Pest Resistance

Due to the presence of multiple bioactive compounds, pests are less likely to develop resistance to botanical pesticides compared to synthetic pesticides.

5.5 Suitability for Organic Farming

Botanical pesticides are widely accepted in organic agriculture systems because they are derived from natural sources and have minimal environmental impact.

6. Limitations of Botanical Pesticides

Despite their advantages, botanical pesticides also have certain limitations.

- ✓ Short residual activity, requiring frequent application
- ✓ Low stability under sunlight and environmental conditions
- ✓ Variability in effectiveness depending on plant source and extraction methods
- ✓ Limited commercial availability in some regions
- ✓ Higher cost of standardized formulations compared to locally prepared extracts

These limitations highlight the need for improved formulations and better application techniques.

7. Role of Botanicals in Integrated Pest Management (IPM)

Botanical pesticides play an important role in Integrated Pest Management (IPM) strategies

aimed at reducing reliance on synthetic chemical pesticides.

Within IPM programs, botanical pesticides can be combined with:

- ✓ Biological control agents such as parasitoids and predators
- ✓ Cultural practices including crop rotation and intercropping
- ✓ Mechanical pest control methods such as traps and barriers
- ✓ Use of pest-resistant crop varieties

This integrated approach enhances pest control effectiveness while minimizing environmental impact and pesticide residues in agricultural products.

8. Future Prospects

The demand for botanical pesticides is expected to increase due to growing concerns about pesticide residues, environmental pollution, and human health risks associated with synthetic pesticides. Future research efforts should focus on:

- ✓ Identification of new plant species with pesticidal properties
- ✓ Isolation and characterization of bioactive compounds
- ✓ Development of stable and standardized botanical formulations
- ✓ Improvement of extraction and processing technologies
- ✓ Integration of botanicals with modern pest management tools

Advances in biotechnology, phytochemistry, and nanotechnology may also contribute to the development of more effective botanical pesticide formulations.

CONCLUSION

Botanical pesticides represent an important component of sustainable pest management strategies in modern agriculture. Derived from natural plant sources, these substances provide environmentally safe alternatives to synthetic

chemical pesticides. Their diverse modes of action, biodegradability, and compatibility with Integrated Pest Management programs make them valuable tools for eco-friendly agriculture. Although certain limitations such as short persistence and variable effectiveness exist, continued research and technological advancements will help overcome these challenges. Promoting the use of botanical pesticides can significantly contribute to sustainable crop production, environmental conservation, and food safety while reducing dependence on synthetic chemical pesticides.

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