



## Impact of Pesticides on Beneficial Insects and Mitigation Strategies

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The study analyzed how pesticide usage affects beneficial insect populations while conducting research on effective methods to control this environmental problem. The agricultural system uses pesticides as its primary method to control insect pests and crop diseases and weed problems which leads to higher crop yields and improved food security. The practice of using pesticides without control has created severe negative consequences that affect all types of beneficial insects which include pollinators and predators and parasitoids. The third word in the sentence describes how these beneficial organisms help maintain ecological balance and support crop pollination activities and control pest populations through their biological processes. The agricultural system needs to protect its sustainable development and ecological integrity from the adverse effects of pesticide exposure because it threatens the viability of these essential insect species. The pesticides which enter the environment through their active ingredients lead to three main ways which insects experience harmful effects: direct toxicity and sub-lethal effects and long-term environmental contamination. The study investigates how pesticides impact beneficial insect populations while presenting practical methods to safeguard crops against pests.

### Introduction

Farmers use pesticides as their primary solution to protect their crops from pests while reducing their crop losses. The use of these chemical substances has resulted in larger crop yields which produce more food for consumption. The majority of pesticides operate as non-selective agents because they lack the ability to distinguish between dangerous pests and helpful insects.

Pollination and biological pest control and nutrient cycling represent essential ecosystem services which beneficial insects deliver to their environment. The widespread and indiscriminate use of pesticides has negatively impacted these organisms, leading to ecological imbalance.

The main effects of excessive pesticide application lead to decreased pollinator numbers and destruction of natural pest control methods and creation of pollution in soil and water and development of pest resistance. The existing problems demonstrate the necessity for pest control methods which sustain beneficial insect populations while delivering effective solutions for agricultural production.

### Beneficial Insects in Agriculture

Beneficial insects provide ecological and economic advantages because they assist with crop production while protecting ecosystem health.

#### Pollinators

Bees butterflies and moths together with certain beetle species function as essential pollinators which enable flowering plants to reproduce. They enable pollen transfer between male flower parts with female flower parts to create seeds and fruit.

Insect pollination serves as essential for agricultural production of various crops which includes fruits vegetables and oilseeds. Healthy pollinator populations determine the crop yield together with its quality and genetic diversity.

#### **Predators**

Predatory insects operate as natural enemies which consume insect pests that cause damage to crops. Ladybird beetle's lacewings and spiders serve as common species for this category. Predators consume large numbers of insects such as aphids and mites and caterpillars. The approach serves as essential because it allows pest control without chemical pesticide use.

#### **Parasitoids**

Parasitoids operate as specialized insects which deposit their eggs either on or within host insects. Host insect larvae develop and feed on the host until they reach maturity, which results in host death. Trichogramma and Bracon species serve as important biological control agents through their widespread application in biological control programs. Sus-based parasitoids function as effective control agents because they focus on particular pest species, making them essential for pest management.

### **Impact of Pesticides on Beneficial Insects**

#### **Direct Toxicity**

Direct toxicity occurs when beneficial insects come into contact with pesticides through spraying, residues on plant surfaces, or contaminated water sources. The exposed organisms will experience instant death from the pesticide contact. The broad-spectrum insecticides bring extreme danger because they eliminate all insect species present in an area, which includes beneficial insects.

#### **Sub-lethal Effects**

The pesticides produce sub-lethal effects on beneficial insects because they interfere with the insects' regular activities which lead to death. The effects create a range of impacts which include decreased reproduction rates and lower fertility levels and diminished foraging capacity and insect disorientation. The impacts create a long-term decrease in both productivity and survival rates for beneficial insect populations.

#### **Residual Toxicity**

Numerous pesticides maintain their presence in nature as they create residual traces which contaminate soil water and plant tissues. The beneficial insects will experience direct contact with these residues for a long time. The chronic exposure results in long-lasting toxicity which decreases insect numbers while damaging the health of entire ecosystems.

#### **Disruption of Ecological Balance**

The use of pesticides eliminates natural enemies which creates an imbalance in ecological systems that operate within agricultural ecosystems. The elimination of both predators and parasitoids permits pest populations to multiply which results in pest outbreaks. The absence of natural control agents leads to secondary pests, which were previously minor threats, developing into major infestations.

#### **Bioaccumulation and Biomagnification**

Certain pesticides accumulate in the tissues of organisms and move through the food chain, a process known as bioaccumulation and biomagnification. The higher trophic levels, which include birds and mammals, will experience effects from this process which will also indirectly affect beneficial insect populations.

### **Impact on Pollination and Crop Production**

Pollinator population declines caused by pesticide exposure create major problems for agricultural output. The pollination decrease results in poor fruit development which reduces overall crop yield capacity and produces lower quality agricultural products. This situation creates income problems for farmers while it ends with food shortages and nutritional deficiencies. Insect-pollinated crops experience higher risk levels because of these negative effects.

## Factors Influencing Toxicity

Various factors determine how pesticide chemicals affect beneficial insects. Pesticide type and pesticide formulation determine toxicity because different chemical compounds have different levels of toxicity. The dose and frequency of application also influence the level of exposure. The process becomes more dangerous when people use higher amounts of substances combined with multiple treatment sessions. The timing of the pesticide application needs to be controlled because spraying should not happen during peak insect activity periods which occur during flowering time because that will lead to more severe crop damage. Pesticide persistence and distribution in the environment depends on temperature and humidity and wind speed, which together determine the level of toxicity.

## Mitigation Strategies

### Adoption of Integrated Pest Management (IPM)

Integrated Pest Management (IPM) functions as a comprehensive system which uses biological methods together with cultural techniques and mechanical systems and chemical treatments to control pest populations. The system aims to minimize chemical pesticide dependence while promoting environmentally safe substitute solutions.

### Use of Selective and Safer Pesticides

Pesticide selection requires choosing products which pose lower health risks to essential insect populations. Biopesticides and botanical insecticides are preferred because these substances create minimal effects on organism groups that are not their intended targets.

### Proper Timing of Application

Pesticide application timing serves as a vital element which protects beneficial insect populations from danger. Spraying should be avoided during flowering periods when pollinators are most active. Pesticide application during evening or nighttime periods reduces bee contact with pesticides.

### Dose Optimization

Pesticide application at recommended levels produces effective pest control results while reducing unnecessary pesticide contact. Environmental contamination and hazardous substance release increase when excessive pesticide application takes place.

### Habitat Management

Maintaining proper habitats for beneficial insects promotes their population growth and helps them carry out their natural functions. Planting flowering strips and hedgerows and cover crops will create food sources and safe spaces which will support pollinators and natural enemies.

### Buffer Zones

Untreated buffer zones which surround fields create protected spaces that benefit insect populations. The areas function as protected environments which allow insects to live and reproduce without coming into contact with pesticides.

### Awareness and Farmer Training

Farmers need education about the vital role of beneficial insects and the correct methods for using pesticides. Sustainable pest control methods require training programs which will help farmers learn about these practices through extension services.

### Regulatory Measures

Government policies and regulations work together to effectively reduce pesticide-related dangers. Banning or restricting highly dangerous pesticides while offering safer pesticide solutions will safeguard populations of beneficial insects.

## Role of Biopesticides

Biopesticides provide a safer alternative to conventional pesticides because they come from natural sources which have lower negative effects on beneficial insects. The product works together with biological control agents in integrated pest management systems because it can be used as a complementary solution. Their use supports environmental sustainability because it decreases environmental pollution while maintaining biodiversity conservation.

## Future Perspectives

Future efforts should focus on developing eco-friendly pesticide formulations that are highly selective and less harmful to non-target organisms. Precision agriculture technologies will enable more efficient pesticide applications while decreasing material losses. Agricultural productivity will depend on enhanced research efforts which focus on protecting and understanding pollinator health. Sustainable farming practices will become more widely adopted when governments provide policy support and financial incentives for safer pest management methods.

## Conclusion

While pesticides remain an important tool for crop protection, their adverse effects on beneficial insects must be carefully managed. Protecting these organisms is essential for maintaining ecological balance and ensuring sustainable agricultural production. A balanced approach that combines reduced pesticide use, adoption of IPM practices, and promotion of safer alternatives is necessary. Increasing awareness among farmers and implementing supportive policies will play a crucial role in safeguarding beneficial insect populations and achieving long-term sustainability in agriculture.

## References

1. Khan, B. A., Nadeem, M. A., Nawaz, H., Amin, M. M., Abbasi, G. H., Nadeem, M., ... & Ayub, M. A. (2023). Pesticides: impacts on agriculture productivity, environment, and management strategies. In *Emerging contaminants and plants: Interactions, adaptations and remediation technologies* (pp. 109-134). Cham: Springer International Publishing.
2. Ndakidemi, B., Mtei, K., & Ndakidemi, P. A. (2016). Impacts of synthetic and botanical pesticides on beneficial insects.
3. Reddy, K. N., Nagarjuna, T., Tippimath, S., Shwetha, G. S., Sugeetha, G., & Nagaraju, M. C. (2025). Safeguarding beneficial insects: strategies and innovations for conservation amidst growing threats. *International Journal of Bio-Resource & Stress Management*, 16(3).
4. Roubos, C. R., Rodriguez-Saona, C., & Isaacs, R. (2014). Mitigating the effects of insecticides on arthropod biological control at field and landscape scales. *Biological control*, 75, 28-38.
5. Samanta, S., Maji, A., Sutradhar, B., Banerjee, S., Shelar, V. B., Khaire, P. B., ... & Bansode, G. D. (2023). Impact of pesticides on beneficial insects in various agroecosystem: a review. *International Journal of Environment and Climate Change*, 13(8), 1928-1936.
6. Siviter, H., & Muth, F. (2020). Do novel insecticides pose a threat to beneficial insects?. *Proceedings of the Royal Society B: Biological Sciences*, 287(1935).