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Original Article

Neonicotenoids: A threat to bee pollinators

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ABSTRACT

Neonicotinoid insecticides, widely adopted in modern agriculture for pest control, have become a growing concern due to their unintended effects on pollinators, especially bees. These chemicals, absorbed systemically by plants, are present in pollen, nectar, and water sources, exposing pollinators to harmful doses. This article compiled data from numerous studies to investigate the effect of neonicotinoids on the pollinator behavior, health, and population dynamics. Documented effects include impaired foraging, reduced reproductive success, weakened immune responses, and increased susceptibility to pathogens. The synergistic effect of these stressors is associated with broad-scale declines in pollinator populations and is believed to contribute to colony collapse disorder. The article emphasizes the need for strict regulations and alternative pest management strategies to better understand and mitigate these risks.

Key words: Bees, Neonicotinoid, Pollinators, Population dynamics

INTRODUCTION

Pollinators play a vital role in maintaining global food production and biodiversity. In the presence of these pollinators, there is an increase in the yield of agricultural crops (Klein et al., 2007). Pollinators including honeybees, bumble bees and solitary bees, are well known and ecologically most important group of pollinators worldwide. But with time, the increased reliance of farmers on pesticides for the control of pests in field leads to a serious threat to non target organisms especially pollinators. Due to the ill effect of use pesticides there is a decline in pollinator population which ultimately leads to decline in the production of agricultural produce (Blacquiere et al., 2012). Among several pesticides, neonicotinoids are most widely used in the global market along with organophosphates, carbamates, pyrethroids, and phenyl pyrazoles (Casida & Durkin, 2013). Neonicotenoid have been found to cause serious problems to non-target organism including pollinators. They are even considered as contraceptive for honeybees (Elston, 2013). The effects of neonicotenoids along with route of exposure to safety measures are discussed below:

Mode of action of neonicotenoids

Neonicotinoids belong to class 4(a) of IRAC (Insecticide Resistance Action Committee) mode of action classification and act by binding to nicotinic acetylcholine receptor (nAChR) in the central nervous system of insects inhibit nicotinic acetylcholine and disrupting neural transmission, which leads to receptor blockage, paralysis, and ultimately death (IRAC, 2025).

Routes of exposure for pollinators

Pollinators were exposed to these pesticides via ingested contaminated pollen, nectar, guttation water, or exuded water droplets (Pohorecka et al., 2012). Multiple pesticide residues, including neonicotinoids, have detected in hive components such as bee-collected pollen, stored pollen (bee bread), and wax (Girolami et al., 2012). These residues originate from annual crops grown near hives, which are often treated with neonicotinoid-coated seeds.

Behavioral Impacts on Pollinators

Mortality and Colony Health

Direct exposure of higher doses of pesticides such as neonicoenoids causes acute toxicity in pollinators causing mortality. Multiple studies indicated that the neonicotinoids trigger biological disruption in bees, which is one of the important contributing factors to Colony Collapse Disorder (CCD). Scholer and Krischik (2014) conducted an experiment to test the effect of imidacloprid and clothianidin by feeding contaminated sugar solutions to honey bees, mortality was observed at higher doses. At medium dose all worker bees died and the reduced movement of worker and wax production affected the survival of queen, which leads to a decline in colony weight. This concluded that the low doses may not immediately harm colonies, but higher doses pose a serious threat to bee health and survival. Similarly, Sharma et al. (2018) reported significant increase in mortality of bees in semi-field conditions after application of thiamethoxam and imidacloprid on mustard.

Impaired foraging and homing behavior

Foraging, the process of seeking out food, is essential for any organism to survive and reproduce. Meanwhile, learning and memory refer to changes in behavior shaped by previous experiences. Neonicotenoids have found to impact foraging and homing behaviour by disrupting memory, learning and movements of bees (Lambin et al., 2001). The disruption in learning leads to difficulty in navigation hence reduced homing flight in bees (Henry, 2012).

Delayed Return and Reduced Pollen Collection:

Neonicotenoids have been found to increase the return time and pollen collection ability of bees. It was reported that when bees are fed with sucrose solution contaminated with imidacloprid there is delay in return or homing flight (Yang et al., 2008) and reduces nectar/pollen collection even at low doses (Tan et al., 2014).

Neurological Impacts:

Neonicotenoids have been found to affect physiology of bees as exposure causes metabolic and neurotransmitter changes (e.g., reduced serotonin), affecting brain functions like homing and learning (Shi et al., 2018).

Effects on Pollination Efficiency

Pollination is a key ecological process involving interaction with pollinators, most commonly bees and specialized flower structures. Some flowers have specialised anther that only require high frequency vibrations to release pollen. This process is called buzz pollination (De Luca & Vallejo-Marın, 2013). Various studies examined the widely used neonicotinoids effect on field-realistic and chronic exposure on the development of buzz characteristics over time, as well as the collection of pollen from pollinated flowers.

Immune Suppression and Disease Susceptibility

The immune system is a host defense system comprised of many biological processes and structures within an organism that protects against diseases. In pollinators, a strong immune defense is essential for maintaining health and colony survival. This defense can be weakened by environmental factors that make pollinators more susceptible to parasites and pathogens. The sublethal effect of neonicotinoids on individual immunity was found to be one of the stress factors that may lead to colony failure (Osterman et al., 2019). With long term exposure to sublethal doses of neonicotenoids, there is reduction in immune response of pollinators render them vulnerable to diseases.

Management Strategies and Recommendations

- First and foremost management strategy includes reduced reliance on pesticides for crop protection. Instead, follow integrated pest management (IPM) which offers a sustainable solution by combining biological control, habitat manipulation, and targeted pesticide use only when absolutely necessary. This approach minimizes chemical use while keeping crops healthy.
- Manufacturers should be legally obliged to provide data on safety of non target organism especially bees with data on short/long term exposure and risk assessment.
- Farmers should be made aware towards the safety of bees from pesticides. They should be advised to remove bee hives from treated and to be treated areas to reduce pesticide exposure.
- Proper application of chemicals should be done so as to avoid contamination of nearby water resources.
- Avoid use of neonicotenoids in area close to an apiary and use other relatively safer chemicals when necessary.

SUMMARY

Neonicotinoids are a widely used class of pesticides worldwide, which causes negative impact on pollinator health. These pollinators seem to be highly vulnerable to neonicotinoids indicating that chronic, sublethal effects are more common compared to acute toxicity. This new insecticide class is one of the causes of colony collapse disorder of honey bees. Therefore, effective measures should be applied to minimize different impacts on pollinators. In addition, the effects of exposure to complex mixtures of various neonicotinoids, neonicotinoid metabolites, other agricultural chemicals and adjuvants, and other environmental contaminants should be comprehensively understood to minimize harm to advantageous organisms. Therefore, systematic

use of integrated pest management needs to be judiciously undertaken against the many insect pests of a crop, which will in turn check the decrease in population of non-target species of pollinators.

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