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Pesticide usage and honey bee toxicity: A review

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Abstract
Pesticide usage in today's agriculture has become unavoidable. Pesticide use has increased dramatically over the last four decades. Pesticides poses severe side effects to many non-targeted organisms and one of them is honey bee. Many researchers documented that there is strong evidence to associate pesticide use with bee population decline (Woodcock *et al*., 2016) and subsequently with potential losses to pollination services and crop yields (Stanley & Raine, 2016; Stanley, *et al*., 2015). These impacts may occur as a result of bee fauna being exposed to pesticides directly or indirectly through contact with pesticide residues. Direct exposure occurs when pesticides are used to treat bee colonies for disinfestation or when honey bees visit fields during spraying. Spray drift from neighbouring fields or bee foraging in sprayed crops are the sources of indirect exposure. Pesticide contaminated water bodies are also a source of bee poisoning.

Keywords: pesticide, honey bee, *Apis mellifera*, pesticide poisoning, honey

Introduction

Symptoms of honeybee poisoning

The fundamental symptom indicating that poisoning occurs is the high number of dead bees. The figures established by the FAO as guidelines for assessing the extent of pesticide poisoning are that 100 dead bees per day is the colony's normal death rate; 200-400 dead bees indicate a low level of pesticide poisoning; 500-1000 dead bees indicate a medium level of pesticide poisoning; over 1000 dead bees indicate a high level of pesticide poisoning. The Canadian Pest Management Regulatory Agency (PMRA) classifies bee poisoning incidents as 'minor', 'moderate', or 'major'. The classification is based not only on the number of dead bees but also on the abnormal behavioural effects exhibited by ≤10% of bees in any one colony, 10–30% of bees in any one colony (1000–3000 bees from each of five or more colonies), or at least 30% of bees in any one colony (at least 3000 bees from each of five or more colonies), respectively. Typical clinical symptoms of acute insecticide poisoning include cramping, disoriented behaviour of bees, locomotion problems and abnormal wing movements (Tomasz *et al.*, 2016) [12]. A temporary effect of strong aggressiveness during exposure of bees to pesticides is also a typical symptom.

Detrimental effect of pesticides on bees

Hassani *et al*. (2008) [3] found that thoracic application of acetamiprid @ 0.1 and 0.5 g per bee increased locomotor activity in *Apis mellifera* under controlled laboratory circumstances, implying that honeybee behaviour is particularly vulnerable to sublethal dosages of acetamiprid.

Carvalho *et al.* (2009) [1] observed that thiamethoxam at 37.5 g a.i. /100 liters of water recorded 50 per cent mortality of bees in 3.5 hours when exposed by several channels, including spraying, ingestion, and residue on the crop surface, and that it was found extremely toxic to Africanized honey bees.

Decourtye and Devillers (2010) [2] recorded that thiamethoxam affected the homing flight of the honeybee. Laurino *et al.* in the year 2011 also stated that honey bees are subjected to mortality within 6 hours at the field concentration of 100 ppm and within 72 hours at 10 ppm by indirect contact.

Insecticides may have long-term effects on honey bees causing persistent physiological changes and also accumulate in colony's honey and wax resulting in negative impact on essential colony features such as worker population size, honey output, and brood rearing (Webster and Peng, 1989) [13]. Pesticides also reduced worker longevity, homing behaviour (Thompson, 2003) [11], temporal division of labour (MacKenzie and Winston 1989) [8], poor

defence against wax moth, and inability to remove debris, impaired the ability to communicate the location of the food source to other workers.

Honey bee recovery from pesticide poisoning

If a honey bee colony has lost many foragers but still has enough brood and uncontaminated pollen and honey, it may be able to recover without intervention. If possible, relocate bees to a pesticide-free foraging location. If there isn't enough forage, offer them sugar syrup and pollen substitute and provide clean water to aid their recovery (Kishan Tej and Srinivasan, 2016) [5].

Protect the bees from severe heat and cold, and combine weak colonies if necessary. Brood and workers may continue to die until the colony is lost if the pesticide has accumulated in pollen or nectar storage. Because many pesticides easily transfer into beeswax, you may consider rebuilding the comb with new foundation from undamaged colonies, or shaking the bees into a new hive and discarding the old comb and woodenware. Replacing brood comb on a regular schedule (typically 3 to 5 years) may prevent accumulation of pesticides to deleterious levels in brood comb wax.

Minimising pesticide hazards

Selection of a pesticide-free apiary location should be a priority, but it is not always possible; thus, raising awareness within the farming community about honey bees and their loss due to pesticides should be promoted. Cooperation between beekeepers and growers is the most effective strategy to decrease bee poisoning, and its significance cannot be overstated. Rather than malicious intent, most bee poisoning occurrences are caused by a lack of knowledge or awareness. Most pest-control systems can be tweaked to reduce or eliminate bee poisoning with minimal cost or inconvenience to the grower. Both beekeepers and growers benefit from developing working relationships and familiarizing themselves with each other's management practices.

If at all possible, avoid mixing insecticides and fungicides, as certain combinations may have synergistic hazardous effects on bees and most combinations haven't been studied. Covering hives during treatment is often impractical for beekeepers. It is more reasonable to choose a product with a short residual toxicity than to ask the beekeeper to relocate the hives.

Growers can inform beekeepers to know where, when, and what type of pesticides they are using. Spraying in the evening is always desirable because it not only improves pesticide deposit and dispersion but also the activity of honeybees is low in evening times. Apply granules or sprays in preference to dusts. Consider alternatives to pesticides. Well-planned, integrated pest-management programs often are less dangerous to pollinators and other beneficial insects than last-minute efforts to suppress pest outbreaks (Hooven *et al.*, 2013) [4].

Recommendation to beekeepers and growers

If the crops in the surrounding areas are being sprayed with insecticides during bloom, it is always best to keep the bees in the hives. If it is apprehended that the spray programme will continue for a longer period, it is better to move the hives away to the safe location free from the drift in advance. If beehive disinfestation becomes required, he or she should only apply the recommended chemicals that are safe for the bees. (Kishan Tej *et al.* 2017) [6]. Following pesticide application, feeding colonies with sugar syrup to limit bee foraging may assist in minimising pesticide exposure. Beekeepers may communicate nearby growers and let the growers know where the colonies are located. Beekeepers can place their apiaries on ridge tops rather than in canyon bottoms. Insecticides drift down into the canyons and flow with morning wind currents.

Growers can Control blooming weeds, such as dandelion, in orchard cover crops before applying insecticides which have long residual hazard to bees. This is particularly significant in early spring, when bees will fly several miles to obtain pollen and nectar from even a few blooms of dandelion or mustard. Growers should go for need based application of insecticides and follow integrated management of pest and disease principles to reduce the pesticide load in the field. If there is a choice for insecticides, use should be limited to the compounds in the less hazardous groups. Growers shall consider Economic threshold level of pest incidence before going for pesticide application.

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