Nicotine and neonicotinoids: powerful neurotoxins

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A recent report confirms the role of neonicotinoid insecticides in the decline of bee populations. This negative impact is caused by the high toxicity of these synthetic molecules, derived from nicotine, towards the nervous system of these insects.

NICOTINE, A POWERFUL INSECTICIDE

Although nicotine is best known as the molecule responsible for the strong dependence of smokers on cigarettes, it should also be remembered that this substance is basically a powerful insecticide made by the tobacco plant as a form of defense. Plants cannot escape their aggressors and have therefore had to develop, during their evolution, a very sophisticated biochemical arsenal, able to neutralize the predators which threaten their survival.

The mechanism involved is quite complex: when an insect (e.g. a caterpillar) begins to feed on the leaves of the tobacco plant, the plant detects the presence of specific amino acids in the insect saliva and quickly responds, in just a few minutes, by producing large amounts of nicotine in its leaves (a single leaf can then contain the nicotine equivalent of a hundred cigarettes). Nicotine is quite toxic for insects because the chemical structure of this molecule is similar to that of the neurotransmitter acetylcholine and thus induces excessive stimulation of nerve pathways which lead to paralysis and death for the insect aggressor.

THE NEONICOTINOIDS

The insecticidal properties of nicotine have long been known by Native Americans who used it, by steeping tobacco in water, to protect their crops against insect pests. Nicotine is, however, far too toxic for humans to be widely used in agriculture, which led to the creation of derivatives of this molecule that have high insecticidal activity but are less toxic to animals. Synthetic neonicotinoids are the result of these efforts, and this family of neurotoxins chemically similar to nicotine became the most widely used insecticides worldwide during the 1990s.

Neonicotinoids are often used for pest deterrence, for example by coating the seeds of plants grown on a large scale, such as corn and soybeans, thus protecting them from insects during their growth. Unfortunately, these insecticides are very stable and can thus be found in the pollen of treated plants where they are absorbed by bees living near the treated fields. In addition, neonicotinoids are water-soluble and can thus spread into the environment where they are absorbed by other plants which are also pollinated by bees.

"BEE KILLERS"

A large number of studies suggest that this contamination of pollen by neonicotinoids is very harmful to the activity and survival of bees. For example, some studies have shown that neonicotinoid insecticides lead not only to disorientation problems in foraging bees that prevents them from returning to their hives, but also limit hive growth and the development of new queens, with disastrous consequences for the survival of the colony (only the queens survive winters)[1]. This suggests that these insecticides could thus play a major role in the decrease in bee populations observed since the beginning of the millennium, a very worrying phenomenon since about 80% of the world's commercially grown plants need pollinators in order to reproduce.

An analysis of all scientific data collected on this subject, recently published by the European Food Safety Agency, confirms that the three main neonicotinoids used in agriculture, namely clothianidin, imidacloprid and thiamethoxam, are truly toxic to bees[2]. In addition, a meta-analysis has recently shown that neonicotinoids do not significantly increase crop yields[3]. In the European Union, these insecticides have been banned since 2013 for crops attractive to bees (corn, rapeseed and sunflower) and it is possible that this report may eventually lead to a complete ban. In Canada, however, these pesticides continue to be widely used for seed coating and it is likely that this situation will be re-evaluated for the upcoming food policies set to be released in 2018.

(1) Woodcock B et al. Country-specific effects of neonicotinoid pesticides on honey bees and wild bees. Science 2017; 356(6345):1393-1395.

(2) EFSA (European Food Safety Authority). Conclusion on the peer review of the pesticide risk assessment for bees for the active substance clothianidin considering the uses as seed treatments and granules. EFSA Journal 2018; 16(2): 5178 https://doi.org/10.2903/j.efsa.2018.5177ISS.

(3) Furlan L et al. An update of the Worldwide Integrated Assessment (WIA) on systemic insecticides. Part 3: alternatives to systemic insecticides. Environ. Sci. Pollut. Res. Int. (published online February 25, 2018).

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