The Neonicotinoids

There is growing evidence that the Neonicotinoids, a relatively new type of insecticide, used in the last 20 years to control a variety of pests, especially sap-feeding insects, such as aphids on cereals, and root-feeding grubs, are harmful to bees.

Neonics are systemic pesticides. Unlike contact pesticides, which remain on the surface of the treated foliage, systemics are taken up by the plant and transported to all the tissues (leaves, flowers, roots and stems, as well as pollen and nectar). Products containing neonics can be applied at the root (as seed coating or soil drench) or sprayed onto crop foliage. The insecticide toxin remains active in the plant for many weeks, protecting the crop season-long.

In the UK, 5 neonicotinoid insecticides are authorised for use in agriculture: acetamiprid; clothianidin; imidacloprid; thiacloprid; and thiamethoxam. They are widely used as:

- seed treatments for cereals, sugar beet and oil seed rape (around 90% of the area treated with neonics)
- soil treatment for pot plants in the ornamental sector
- treatment for turf in the amenity sector
- foliar sprays on apples, pears and a range of glasshouse crops

Several neonics are available to the public as treatments for lawns, houseplants and pot plants and greenhouse crops.

Neonicotinoids, especially seed treatments of imidacloprid and clothianidin on arable crops, have become of increasing concern to beekeepers and bee researchers in recent years with many of them suspecting that they may be connected to current bee declines. These concerns have led to a 3 year moratorium on their use in Europe. The UK government voted against this ban.

Mode of Action

The neonicotinoids are a class of insecticides with a common mode of action that affects the central nervous system of insects. They bind to receptors of the enzyme nicotinic acetylcholine, causing excitation of the nerves, leading to eventual paralysis and death. This specific neural pathway is more abundant in insects than warm-blooded animals, so these insecticides are selectively more toxic to insects than mammals.

Bees have a particular genetic vulnerability to neonics because they have more of these receptors than other insects, as well as more learning and memory genes for their highly evolved system of social communication and organisation, Unlike many insect pest species which are able to detoxify harmful chemicals, bees possess fewer genes for detoxification.

While the older organophosphate and carbamate insecticides tend to degrade quite rapidly in the environment, neonics are more persistent. Imidacloprid can last for months or years in soil and may leach into groundwater under some conditions.

Because they are biologically active at very low concentrations, neonics can be applied at much lower volumes in the field than the older groups of insecticides - in doses of a few grams, rather than kilos, per hectare of the active ingredient.

Neonics were originally welcomed as much safer for humans, livestock and birds than other insecticides. Seed treatments were seen as a more effective method of targeting pests than spraying crop foliage, and more environmentally-friendly because they can reduce the number of spray applications needed in-field. However, over time, it has become clear that they pose different and poorly understood risks to bees and other non-target invertebrates precisely because of the properties that have made them so useful to farmers: their systemic action; their persistence in crops and soil; and their potency at low concentrations. Added to this, their widespread use in many cropping systems and their unplanned presence in pollen and nectar build up a worrying picture of low level but continued exposure for pollinators. These risks are not considered by our current regulatory regimes.

How they affect Bees

Acutely toxic by direct contact: Like many other broad-spectrum insecticides, neonicotinoids are acutely toxic to bees and other pollinator species by direct contact or by mouth. To prevent accidental contact exposure, products containing neonics carry warnings on the label and instructions to avoid spraying on crops in flower or at times when bees are foraging in fields or close by. Making sure that all farmers comply with these instructions remains a challenge.

Sublethal effects in contaminated pollen & nectar: Neonics can be harmful to pollinators because the insecticides may be present in pollen and nectar at levels sufficient to impair pollinator health, including disruption to foraging behaviour, homing ability, communication and larval development. While it is rare for levels of neonics present in pollen to cause acute harm, the likelihood of levels that can cause chronic harm to the bee brood is significant. Several studies show that exposure to insecticides at low doses can negatively affect the immune system of bees, making them more susceptible to the impact of parasite and disease infections. For example, a clear increase in growth of Nosema fungal disease was reported in bees reared in colonies exposed to very low doses of imidacloprid, at below levels considered harmful to bees.

Toxic breakdown: Neonic breakdown products can be much more toxic than the original pesticides, posing a risk to bee larvae which may be exposed to the longer lasting breakdown products inside the hive.

Exposure via other routes: Neonics can also remain active in the soil for months, either being taken up unintentionally by crops in the following season or being transported in soil dust to contaminate flowering weeds or contact insects directly. Research also shows that very high concentrations of insecticides can be excreted by treated seedlings in 'guttation' droplets on young leaves, posing a risk to bees and other insects which sometimes collect these droplets as drinking water for the hive.

Mechanical problems with treated seeds: Beyond the issues of sublethal effects from low concentrations in pollen or nectar, there have been numerous serious acute bee poisoning incidents due to mechanical problems with the seed treatment process and field sowing of neonicotinoids. In southwest Germany in 2008, millions of bees died following sowing of maize seed treated with clothianidin. The seed companies involved had failed to apply the sticking agent properly during seed treatment, causing clothianidin-laden dust to be released from the drilling machines. In 2010 in parts of the US Mid-West significant bee kills were reported during spring sowing of maize. Clothianidin and thiamethoxam were found responsible, via the talc used to allow treated seed to flow smoothly through the air-assisted planter equipment. Bees were killed through exposure to the contaminated talc exhaust behind the tractor. Latest research from Italy testing modifications to the planting equipment has not found an answer to this serious problem.

Neonicotinoids are a rapidly growing sector of the pesticide market globally, used on more than 140 crop varieties. They are applied in a wide variety of settings against pests in soil, seed, turf, timber as well as foliar treatments for cereals, cotton, legumes, potatoes, orchard fruits, rice, turf and vegetables. They are also common in veterinary applications such as tick control and flea collars for pets.

The first compound, imidacloprid, was launched by Bayer Cropscience in 1991. Since then a further six compounds have been put on the global market. By 2008 neonicotinoids had taken a 24% share of the total insecticide market of €6.330 billion.

In the UK, the area of land treated with imidacloprid increased from 346, 813 hectares in 2000 to 770, 053 ha in 2006. The amount of imidacloprid applied increased more than three-fold, to 82, 254 kg over the same period.