Neonicotinoids – Your essential brief

Background

Q: What are neonicotinoids?
A: Neonicotinoids (neonics) are a class of systemic insecticides, meaning that they are absorbed throughout the plant. The first commercial neonic, Imidacloprid, was patented by Bayer in 1985 and became widely used in the 1990s[1].

Q: How are they applied?
A: Usually seeds are coated in a substance that contains the insecticide. Because the substance is absorbed into the plant and travels through it, the neonic from the coated seed protects the entire plant through the germination and early seedling stages. They can also be sprayed onto plants in the conventional manner.

Q: Are they effective?
A: Yes. They are taken up into the plant and distributed throughout its structure, rather than remaining on the surface like some conventional insecticides. They therefore protect the whole plant, and continue this protection for many weeks[2].

Q: What do they protect against?
A: They protect against many insect pests but are particularly effective against sucking insects such as aphids on cereals, and pests such as cabbage stem flea beetle larvae.

Q: Are these pests a big problem?
A: Uncontrolled, they can be. Resistance is developing to older insecticides, and outbreaks of these pests can lead to serious reductions in yield and therefore economic losses. Pests such as aphids on cereals can transmit viruses to the crop, so they require constant protection over several months. This is difficult to achieve with sprays. Cabbage stem flea beetle larvae are also difficult to control with sprays because they attack plants in the early growth stages.

Q: Are neonics widely used around the world?
A: Yes. Growth in use was very rapid after their development, so that a single compound from the group, Imidacloprid, was the most commonly used insecticide in the world in 2008. Of insecticide-coated seeds sold worldwide at this time, 80% were coated with neonics[1].

Q: Why are neonics so successful at doing their job?
A: There are several reasons[2]:

1. They are systemic, specifically targeting biting, chewing and sucking insects that damage the plant
2. They can be applied to the seed but protect the whole plant
3. They protect from pests for up to 10 weeks
4. This reduces the need for spraying
5. Resistance to alternatives is common in certain pest species

Q: If spraying is reduced, is there less of the chemical in the environment?
A: One benefit of the concept of seed dressing is that it should target only those pests that consume the plant, rather than a spray where the chemical is introduced to the wider environment. However, evidence shows that only a small amount of the treatment coated on the seed is absorbed by the plant, with the residual retained in the soil or leached through field drainage systems to water courses. The potential effects of this on soil organisms and other species requires further study.

Conventional spraying is less targeted, resulting in treatment leaching through soils and into water courses.

Q: How do they kill insects?
A: Neonics bind to certain proteins in the brain, causing paralysis and death of insects. They are one of the most effective insecticides against sucking insects such as aphids and whitefly[1].

Q: Why are they not dangerous to mammals and birds?
A: Most neonics have low toxicity to mammals and birds, as they do not bind well to the protein inside them. Some, however, like imidacloprid, are highly toxic to seed-eating birds and some mammals. The most common method of application (seed coating) means that mammals and birds are unlikely to ingest treated seeds if the seeds are buried in full compliance with manufacturers' instructions. Problems can arise when seeds remain on the soil surface through spillage or careless drilling, when they can be consumed by wildlife and cause lethal or sublethal effects[3].

Neonic effects on bees

Q: Are bee populations falling?
A: Yes. In recent decades, there have been declines in the number of wild bee species and the number of wild bee colonies, and the area in which they thrive has become smaller[4].

Q: When did these declines start?
A: In the US, there was a 59% loss in wild bee colonies between 1947 and 2005. In Europe, there was a 25% loss between 1985 and 2003[4].

Q: So some declines were seen before neonics were introduced?
A: Yes. But it is still important to determine whether neonics have contributed to these ongoing trends.

Q: Why are these changes so important?
A: Loss of biodiversity is an important issue wherever it occurs. However, in addition to the desire to protect bee species themselves, bees form an important group of pollinators that is essential for the pollination of food crops and wild plants.

Q: What is pollination?
A: Pollination is the transfer of pollen between plants by insects, other animal agents or wind, which starts the process of fruit or seed formation. Without pollination, many of our crops would not yield any produce.

Q: How many crops depend on insect pollination?
A: 87 of the leading food crops globally depend on insect pollination[5]. This accounts for over a third of the world's food production by volume[5] and has an estimated global value of £136 billion annually[6].

Q: Which insects perform pollination?
A: Many different species contribute, but bees are the main pollinators. This includes honey bees, bumblebees and other wild and solitary bees, all of which are involved in the pollination of not only crops, but also many wildflowers and hedgerow shrubs.[5,7].

Q: Which bees are most important?
A: Many bee species pollinate. Although domesticated honey bees are by far the most numerous (and also provide honey), bumblebees are thought to be almost solely responsible for the pollination of certain crops, including soft fruits[7-9].

Q: Are the changes in bee populations a result of neonic use?
A: We don't know. Neonics were not available commercially until the 1990s, and usage only became widespread towards the end of that decade, so it seems unlikely that they are exclusively responsible. But it is important to find out whether they have contributed, and if so to what extent.

Q: Aren't insecticides tested to ensure they are safe to other species?
A: Yes, but those tests look at exposure over four days, and determine the dose at which 50% of bees die in that time. Procedures for licensing do not currently look at longer-term effects of lower doses[10].

Q: So how could neonics be causing bee declines?
A: It may be that long-term, low-level (sublethal) effects are causing problems for bee health or behaviour. It is important to clarify whether this is happening, either alone or in combination with other factors.

Q: What other factors?
A: The main factor identified in most studies is habitat loss – of both breeding sites and suitable flowers for feeding. As well as this, adverse weather, disease, insecticides other than neonics, and the introduction of new parasites may all have played a role[4].

Q: Are bees exposed to neonics when crops are treated?
A: Yes. As the chemical is present throughout the plant, the pollen and nectar also contain neonics and bees ingest this[11].

Q: Do they absorb it?
A: Yes. Evidence shows low levels of neonics can sometimes be measured in bees[12,13].

Q: Are these levels high?
A: No. The levels detected are well below those that are lethal to bees, but we don't know if they cause sublethal effects.

Q: What sort of effects could they have?
A: There is evidence to show that exposed bees from various species have reduced navigational and communication abilities, reduced foraging abilities[7], a weaker immune system, and fewer queens may be produced[14]. There may also be effects on developing larvae[7].

Q: What does this mean?
A: More bees may be lost. The individuals as well as the colonies may be more susceptible to disease or stress. Individuals may forage for food less effectively, fewer new bees may be produced, and the colony may be less healthy and less likely to thrive.

Q: Where does this evidence come from?
A: Some experiments are done in laboratories, and some are 'semi-field', which are done partly outside. They provide a starting point for researchers but they may not reflect what happens in commercially treated fields.

Q: How do we know if these effects are really happening?
A: At the moment we don't know for sure, although evidence is accumulating. The only way to study this is with large-scale field studies. Some have been done recently, and more are under way, some in the UK.

Q: What do they show?
A: The picture that is gradually appearing is that honey bees seem to have a higher tolerance for neonics than other wild bees.

Q: So are honey bees not affected?
A: Several field studies published recently have not demonstrated an effect on honey bee colonies[6,15-17]. However, other evidence does detect a link between honey bee colony losses and areas of increased neonic usage[2]. The evidence is not yet conclusive.

Q: What effects have been detected in other bees?
A: Bumblebees and other wild bees seem to be particularly susceptible to neonics, with evidence of reduced foraging[7,18-20], reduced wild bee density[15], solitary bee nesting[15], and bumblebee colony growth and reproduction[15,21]. However, once again some reports suggest the opposite conclusion: that bumblebees are unaffected by neonics under field conditions[22].

Q: Are species other than bees affected?
A: There is recent evidence that the declines in a number of common butterfly species may be more severe in areas with higher neonic use, but the significance of this remains unclear. It may be that

neonics *caused* the declines, or it may be that neonic use is a marker for something else associated with increased farming intensity that is responsible.

Q: So the evidence is not clear?
A: The interpretation of the evidence is not straightforward. For example, differences in study procedures, or use of different dose levels or exposure times, can make it hard to compare results from different studies. There is some evidence that neonics can have a negative effect on some species, but it is not conclusive. There is also evidence that neonics are not as damaging as they are sometimes presented. This is a case for watchfulness and further study to determine the appropriate response.

Q: When will there be more research evidence?
A: A great number of studies have been carried out, with more under way. However, some scientists report that studies showing no effect are less likely to be published by scientific journals because a zero response is less interesting to report. If true, this may affect the overall debate.

Neonicotinoid regulations

Q: Weren't neonics banned?
A: In the EU, the use of neonics was restricted in 2013 to prevent their use on crops that are attractive to bees. This was initially a two-year ban, which was extended in December 2015 to allow more time for scientific investigation. This is ongoing.

Q: Are they banned for all crops?
A: No. They cannot be used on bee-attractive crops listed in the legislation[23] but can be used on some crops that bees do not feed or forage on. Crops such as kale, which are important components of game cover, flower in the second year after sowing, so neonic seed coatings are permitted. Neonic coating can be used on winter-sown cereals.

Q: If there is a possibility of harm to bees, shouldn't we ban them anyway?
A: It depends on the alternatives. The world needs agriculture, but agriculture needs anti-pest treatments, both chemical and cultural. Agriculture also needs bees. It is a difficult and political balance.

Q: What are the alternatives?
A: Since the restrictions on neonic use, farmers have reverted to using older insecticides such as synthetic pyrethroids for these crops. However, there have been widespread problems with resistance to these products, as well as other environmental impacts, including toxicity to non-target species, especially aquatic invertebrates[24].

Q: Why does that matter?
A: Farmers have been unable to control certain pests using these older insecticides, resulting in repeated applications, sometimes up to five times. This means increased application costs, more harmful chemicals in the environment, negative effects on other species (including those pollinators we rely on), and pests remaining uncontrolled.

Q: But are these insecticides safer for bees?
A: No. These older insecticides can also be harmful to bees. For example, although now rarely used in the UK, one of the pyrethroid group, permethrin, was the tenth most toxic in a study of 100 insecticides[25]. The warning "This product is very toxic to bees. Avoid spraying when bees are foraging", or similar, is included on the insert for permethrin products.

Q: What happens next?

A: Some farmers have been losing crops, particularly oilseed rape, or switching away from growing these crops altogether.

Q: Can't farmers manage without insecticides?

A: Commercial, large-scale agriculture needs pest control. The cost of crop production per hectare is high, and sometimes the inability to use pest or weed control would render the production of food unviable. The use of Integrated Pest Management techniques, for example beetle banks, can minimise the use of chemical pest and weed control, but insecticide use may be necessary to protect a crop when these techniques fail.

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Q: But haven't farmers always sprayed all crops?

A: No. But there are more people to feed now, and we expect to pay less for food than we used to, so farmers must be more efficient. These are the methods that allow us to produce cheap food. Organic food is available, but is more expensive.

Q: So what is the answer?

A: No one knows for sure yet. We need to wait for further scientific evidence to guide us, and be cautious but practical in the meantime. Once we understand better the pathways of exposure, it may be possible to amend the way we manage the use of these products to reduce unwanted impacts.

Q: Why don't we just ban them?

A: The fewer insecticides we are able to use, the more likely it is that resistance to the ones we can use will build up in the pest population, which can result in higher doses and more frequent spraying, all of which can have negative environmental impacts. Being able to use diverse classes of insecticides, which control pests through different metabolic pathways or at various stages in their life cycles, helps to prevent resistance building up.

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