

That means less pesticide is applied than if it was sprayed onto the plants. “It’s a much more environmentally friendly way to apply a chemical,” says David Fischer, director of environmental toxicology and risk assessment at Bayer CropScience in Research Triangle Park, North Carolina, a major manufacturer of neonicotinoids.

As use of neonicotinoids has grown, however, researchers have become concerned about their potential to harm birds, earthworms, aquatic insects, and especially bees. They have found traces of clothianidin and other seed-based pesticides in a large fraction of samples of dead honey bees from commercial beekeeping operations. “That’s pretty astonishing” and “suggestive that the pesticides are related to the deaths,” says Reed Johnson, an entomologist at Ohio State University’s Agricultural Research and Development Center, Wooster. Honey bees and other pollinators can pick up the chemicals by feeding on nectar and pollen, or sipping on drops of liquid, called guttation, exuded by corn and other plants. The compounds are eventually fed to young bees back at the hive.

There’s no debate that high doses of neonicotinoids kill pollinators, and studies suggest that chronic or intermittent exposure to low doses can also cause trouble. Over the past 5 years, for example, a host of findings have indicated that low doses can trigger behavioral effects in honey bees, such as memory and learning, which could affect foraging. The big question facing researchers is how to extrapolate from lab studies on individual bees to evaluate the impact on entire colonies, which are quite resilient. “You can lose a lot of bees and the colony is able to maintain itself,” says Dennis vanEngelsdorp of the University of Maryland, College Park.

To study colony impacts, researchers have fed neonicotinoids to bees in colonies. But determining realistic doses experienced by bees is a sticky problem. Scientists don’t know how much soil residue levels rise as fields are repeatedly planted with treated seeds. And homeowners can apply the pesticides at rates up to 120 times higher than farmers. “The actual exposure is likely higher than we think,” Spivak says. New data could come

soon: The United Kingdom’s Department for Environment, Food & Rural Affairs (DEFRA) has funded David Goulson of the University of Stirling to measure pesticide concentrations more widely in the landscape, including soils, crops, flowers, and hedgerows.

Smaller hives

Some scientists have started to focus on bumblebees, suspecting that they may be more vulnerable than honey bees because their colonies are much smaller. “You can have quite a dramatic effect compared to honey bee colonies,” Rosenkranz says. In a high-profile study, Goulson and colleagues fed bumblebees pollen and sugar water containing imidacloprid. After the bees foraged in the open for 6 weeks, the team found 85% fewer new queens in the colonies that had been exposed to the pesticide, they reported in *Science* (20 April 2012, p. 351). “To me, the evidence is pretty close to overwhelming” that exposure has big impacts, Goulson says.

Scientists with DEFRA, however, objected. Goulson’s doses were unrealistically high and thus “biased towards showing a deleterious

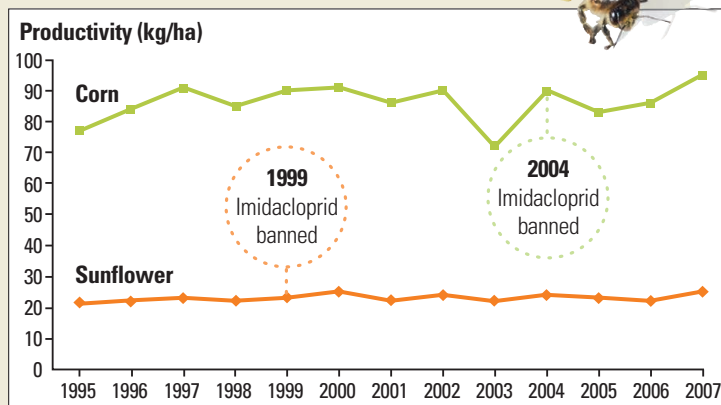
How Big a Role Should Neonicotinoids Play in Food Security?

Proponents of neonicotinoid-treated seeds claim that the chemicals offer many benefits besides killing pests, including improved plant vigor and higher yields. The business itself has certainly boomed. Almost all the corn and about one-half of the soybeans in the United States are grown from insecticide-treated seeds. “The companies are marketing them aggressively,” says Paul Mitchell, an agricultural economist who studies pest management at the University of Wisconsin, Madison.

But how important are neonicotinoid seed treatments for agriculture? Agronomist Palle Pedersen, technology manager for seed care at Syngenta, says that treated corn seed produces an extra 9 bushels an acre above a national average of about 160. “We’ve seen a dramatic yield increase,” he says. But researchers studying soybeans and other major crops have found treated seeds can come up short.

A 2-year trial of treated soybeans in South Dakota, for example, found no yield benefit. Insecticide concentration in the plants was too low by the time the major pest, aphids, arrived, according to a study published last year in the *Journal of Pest Science* by Jonathan Lundgren of the U.S. Department of Agriculture in Brookings, South Dakota. He says that his findings mirror those of other trials. A worrying postscript: The neonicotinoids also harmed predators of the aphids, such as omnivorous pirate bugs (which feed on the soybean plant itself as well as aphids). Pedersen isn’t convinced. “It’s such a small data set, we can’t draw a conclusion out of that.”

Companies say that they have copious data to prove the efficacy of treated seeds. “Admittedly, they do not increase yield all of the time, but the larger body of data says that they do provide an increase in yield a high percentage of time,” says William Hairston, director of product development for seed growth at Bayer CropScience in Research Triangle Park, North Carolina. Few of these data are peer-reviewed, however, and some scientists are skeptical, saying that the trials often combine insecti-



Steady. Farmers kept yields after France banned neonicotinoid-treated seeds.

cide with fungicides, which are known to help prevent losses from disease.

Another reason that some scientists debate the overall value of the seed treatments is that the pests they target—such as wireworms, Japanese beetles, and seed corn maggots—are rarely major problems, or are already resisted by genetically modified crops. Still, with sky-high commodity prices, farmers don’t want to risk lower yields, and want to guard against any potential pests. “The price of corn is so high, it’s peace of mind,” says entomologist Reed Johnson of Ohio State University’s Agricultural Research and Development Center, Wooster.

Entomologist Christian Krupke of Purdue University in West Lafayette, Indiana, says that neonicotinoids are good tools, but overused. “They do not need to be on virtually every annual crop seed, every year,” he says. “Our pest pressures do not justify the practice in fields that I and others have examined.”

—E. S.