CAES

The Connecticut Agricultural Experiment Station

Putting Science to Work for Society since 1875

Dr. Kimberly A. Stoner
Department of Entomology
The Connecticut Agricultural Experiment Station
123 Huntington Street
New Haven, CT 06511

Phone: (203) 974-8480
Fax: (203) 974-8502
Email: Kimberly.Stoner@ct.gov
Website: https://portal.ct.gov/caes

Protecting Pollinators from Pesticides

What is pollination?

Pollination involves the transfer of pollen from the male part of a plant (in flowers, the anthers) to the female part of a plant (the stigma) of a plant in the same species. For most plants, pollination is required for the plant to produce seed or fruit.

Different kinds of pollination:

- **Self-Pollination**: In some plant species, transfer of pollen from anthers to stigma in the same flower is sufficient for fertilization and seed set. But even some self-pollinated plants (like tomatoes) set more seed when flowers are visited by pollinators who buzz or shake the flowers and move pollen around.
- **Wind or Water Pollination:** Many species of grasses (including corn), sedges, and coniferous trees use wind to move pollen between plants. A small number of plant species use water for pollination.
- **Animal Pollinators:** The vast majority of plants (about 75%) need the help of animals to move pollen between plants. Most of these pollinators are insects: bees, flies, moths, butterflies, ants, wasps, beetles, and many other insects. Some birds, bats, small mammals, and other vertebrates are also pollinators. A worldwide review of insect pollination in 105 crops found that bees visited the widest range of crops, followed by flies, particularly hoverflies and blowflies.

Examples of crops in Connecticut that have higher yield when visited by bees:

Apples, blueberries, cherries, cranberries, cucumbers, eggplant, melons, peaches, pears, peppers, pumpkins, raspberries and blackberries, squash, strawberries, sunflowers, tomatoes.

Diversity of bees in Connecticut that visit crop plants:

Connecticut has 378 species of bees. All of them visit flowers, at least for nectar, and most of them collect pollen as well. Beyond the familiar honey bees and bumble bees, important bee groups with species that pollinate crop flowers include mining bees, leaf-cutter bees, mason bees, longhorn bees, sweat bees, and squash bees. It is important to protect all these wild bee pollinators in addition to protecting honey bees. The nesting sites of wild bees are not as easily identified as honey bee hives. Most bee species nest in soil, digging tunnels in the ground. Other bees nest in cavities or tunnels in wood or hollow stems.

Why are we concerned about pollinator health and particularly about bees?

Honey bees have been under severe stress across the country since the late 1980s, when the *Varroa* mite, a parasitic mite that attacks honey bees directly and also transmits viruses among bees, arrived and spread across the U.S. A disease named Colony Collapse Disorder observed in 2006-2007 was a warning sign that honey bee colonies were not sustainable under current practices. Colony Collapse Disorder is still not entirely understood, but it was likely caused by some combination of parasites and pathogens (including *Varroa* mites and viruses), combined with multiple stressors including transport of hives for pollination services, declining availability of floral sources of nectar and pollen throughout the season, and pesticide exposure.

Some **bumble bee** species that were formerly common and important pollinators across the U.S. and in Connecticut declined rapidly in the early 2000s, and, while some species continue to flourish, others have disappeared entirely from our region.

We know much less about the status of other wild bees, but there is evidence that some native species of **mason bees** may be in decline across the Northeast.

We know even less about many of the other insect pollinators, except for some species of butterflies and moths, which have declined over a period of decades according to long-time records from collectors and observers.

Risk to Pollinators from Pesticides

The U.S. Environmental Protection Agency (EPA) considers risk to be "the chance of harmful effects to human health or to ecological systems resulting from exposure to an environmental stressor."
With respect to the risk of pesticides to pollinators, these are three important factors:

1. How toxic is the pesticide to the pollinator?
2. Where and how would the pollinator be exposed to the pesticide? (For example, feeding on nectar or pollen, or contact in the air or in nesting materials.)
3. How much pesticide would the pollinator be exposed to? (The amount consumed in food or in contact with the pollinator.)

This is often summed up as:

Risk = Toxicity × Exposure

Toxicity of Pesticides to Bees

Bees and most other pollinators are insects, so they are generally susceptible to poisoning from broad spectrum insecticides. Fungicides and herbicides are generally much less toxic to bees, but fungicides can have sublethal effects, or they can increase the toxicity of insecticides when bees are exposed to combinations of pesticides.

EPA puts pesticides in three categories according to their acute toxicity to honey bees. **Acute toxicity** measures the amount of pesticide that results in death of worker honey bees within a few hours, either by spraying the pesticide directly on the bees (contact toxicity) or feeding the pesticide to the bees in sugar water (oral toxicity). Acute toxicity is expressed as the LD_{50} – the concentration at which 50% of the bees die. Based on these laboratory tests for acute toxicity, the EPA categorizes pesticides as "highly toxic to bees," "moderately toxic to bees," or "practically non-toxic to bees."

Pesticides may affect bee health in other ways besides acute toxicity. They can have **chronic toxicity** with effects on bee larvae or adults, particularly if the bees are exposed over a long period in food (pollen or nectar), wax, or other nesting materials. They can have **sublethal effects** on the ability of bees to reproduce, or their resistance to disease, or the complex foraging behaviors they use to find sources of nectar and pollen in the environment.

Pesticides are tested one at a time for bee toxicity, but bees may simultaneously be exposed to multiple pesticides when presented in tank mixes, or over a longer period when residues of various pesticides applied sequentially overlap. Because bees may combine pollen or nectar from various sources and over time, some exposure to mixtures of pesticides may occur in their stored food resources.

The relatively low toxicity of some insecticides to honey bees and bumble bees is due to the bees' ability to enzymatically convert the active ingredient into a non-toxic product. When exposed to a chemical (called a **synergist**) that blocks this detoxification enzyme, these insecticides become highly toxic. The increased toxicity to bees over the toxicity of each active ingredient alone, known as **synergism,** should be expected when bees are jointly exposed to any one of several insecticides with demethylation inhibitor fungicides, such as propiconazole, myclobutanil, tebuconazole or triflumizole.

Nearly all pesticides used outdoors are tested for acute toxicity to honey bees. Fewer are tested for toxicity to bumble bees or other wild bees. Many are also tested for other beneficial insects such as ladybird beetles or parasitic wasps, but not for other important pollinators such as hover flies.

How Long are Pesticides Toxic to Bees?

Residual toxicity is a measure of how long a pesticide remains toxic, and it is expressed as RT_{25} – the time that the pesticide retains enough toxicity in the field to kill 25% of worker honey bees. Pesticides vary widely in how quickly they break down in the environment, from a matter of hours to days, weeks, or much longer, and the residual toxicity is important in determining the label instructions about when you can apply a pesticide.

Reading the Label of Pesticides for Precautions Protecting Bees

To find instructions about protecting pollinators, carefully read the **Environmental Hazards** statement on the pesticide label. Some pesticides will say on the label "This product is highly toxic to bees" while others may say "moderately toxic" to bees, simply "toxic to bees," or have no statement of bee toxicity at all. Each of these phrases represents a level of acute toxicity of the active ingredient in the pesticide, with specific thresholds specified by the EPA for each phrase. Pesticides with no statement of bee toxicity are less acutely toxic. By choosing less-toxic pesticides, you can help to protect bees.

If the formulated pesticide has a high residual toxicity (continues to kill bees for more than 8 hours), the label should say "Do not apply while bees are foraging (or visiting) the treatment area." This means that you cannot apply the pesticide at all during the period of bloom.

If it has a lower residual toxicity (continues to kill bees for less than 8 hours), the label should say "Do not apply while bees are actively foraging (or visiting) the treatment area." This means that it is legal to apply the pesticide at dusk, for example, because the pesticide would be expected to break down to a lower level of toxicity overnight, before bees return the next day.

Certain insecticides (the neonicotinoids imidacloprid, dinotefuran, clothianidin and thiamethoxam) are required to have additional information about hazards to bees, highlighted by the bee hazard icon:

These insecticides have special precautions because, in addition to being highly toxic to bees, they are also **systemic** and persist over a long period in plants and in soil when applied as seed treatments, soil applications, tree injections, or foliar applications. They travel into the nectar and pollen that pollinators use as food. Thus, there are special precautions on the label to limit the drift of these insecticides onto non-target pollinator habitat, and limits to how much of these insecticides can be applied to a site or crop per year.

Pesticide Seed Treatments

The neonicotinoids imidacloprid, clothianidin, and thiamethoxam are also applied as seed treatments, often in combination with fungicides, to crops like corn, soybeans, wheat, and pumpkins. Planting seeds treated with pesticides should be considered a pesticide application.

Consider whether the soil and early season insect pests in your field require insecticides for treatment before ordering neonicotinoid-treated seed, and make sure you know what pesticides have been applied to your seed. Handle treated seed with appropriate precautions to prevent damaging the seed and releasing pesticide dust and dispose of the seed properly by burying or planting it according to the label to prevent poisoning of birds and other wildlife.

Precautions Limiting Exposure of Pollinators to Pesticides

Because Risk = Toxicity × Exposure, you can reduce the risk to pollinators from pesticides by **choosing pesticides less toxic to bees** and by **limiting exposure** with the following precautions:

1. Read and follow the precautions listed in the **Environmental Hazards** statement and the **Use Recommendations** and **Use Limitations** for each specific crop or site.
2. Learn if and when your crops are attractive to pollinators and plan your pest control operations with pollinator hazards in mind.
3. Work with beekeepers to keep honey bee hives protected from exposure.
4. Control or mow blooming weeds or ground covers before applying pesticides.
5. Avoid drift in the direction of bee hives, flowering weeds, adjacent habitat, or nontarget crops. Verify wind direction and speed. Choose sprayer and nozzle technologies designed to reduce drift. Modify seed

planting equipment to minimize the discharge of pesticide-laden dust.

6. Err on the side of caution – avoid spraying any pesticide near bee colonies and on flowering plants as much as possible, whether or not it has a bee caution on the label.
7. Use Integrated Pest Management to identify alternatives to pesticides and limit pesticide use to when the benefits will outweigh the costs (including costs in lost pollination and harm to beekeepers).
8. Mechanized planting of treated seeds can release dust toxic to pollinators resulting from abraded seed coatings. When there is a risk of dust escaping from planting equipment, the same considerations for protecting bees from pesticide sprays should be applied to reduce drift and contamination of surrounding flowering plants.

Most Bee Poisonings Occur When:

- Insecticides are applied when bees are foraging
- Insecticides are applied to bee-pollinated crops during bloom
- Insecticides are applied to when weeds or ground cover in-between crop rows are blooming
- Insecticides drift onto blooming crops or weeds near the target crop
- Bees collect insecticide-contaminated pollen, nectar, or other materials from treated crops that do not require bee pollination (such as corn or potatoes)
- Bees collect insecticide-contaminated nectar from plants treated with systemic pesticides
- Bees collect insecticide-contaminated nesting materials, such as leaf pieces collected by alfalfa leafcutting bees
- Bees collect insecticide-contaminated water (from drip tape or chemigation, for example)
- Beekeepers and growers do not adequately communicate.

(adapted from Hooven et al., 2013. How to Reduce Bee Poisoning from Pesticides)

Pesticide Incident Reporting & Enforcement Inquiries:

Federal Reporting
National Pesticide Information Center at: www.npic.orst.edu or
directly to EPA at: beekill@epa.gov

State Reporting
Bee Kills: State Apiary Inspector Mark Creighton at CAES: (203) 974-8467
CT Dept. of Energy and Environmental Protection: (860) 424-3369

References Used:

Bucy, M. T. and A. Melanthopoulos. (2020). Labels of insecticides to which Oregon honey bee (*Apis mellifera* L.) hives could be exposed do not align with federal recommendations in their communication of acute and residual toxicity to honey bees. *Pest Management Science*, *76*, 1664-1672.

EPA. (2021). About Risk Assessment. https://www.epa.gov/risk/about-risk-assessment Accessed Feb. 17, 2022.

EPA. (2013). The New EPA bee advisory box.
https://www.epa.gov/sites/default/files/2013

-11/documents/bee-label-info-graphic.pdf
Accessed Feb. 28, 2022.

Hooven et al. (2013). How to reduce bee poisoning from pesticides. Pacific Northwest Extension Publication. PNW 591. https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw591.pdf

Michigan State. Protecting Pollinators for Pesticide Applicators. Online Distance Learning Course. www.D2L.msu.edu

Rader et al. (2020). Non-bee insects as visitors and pollinators of crops: Biology, ecology, and management. *Annu. Rev. Entomol.*, *65*, 391-407.

Wagner, D. L. (2012). Moth decline in the northeastern United States. *News of the Lepidopterists' Society*, *54*, 52-56.