Invertebrate Conservation Fact Sheet

Organic-Approved Pesticides

Minimizing Risks to Bees

While organic farming offers significant environmental benefits, even some organic-approved pesticides can cause harm to pollinators.

By selecting the least toxic options and applying them when pollinators are not present, harm can be minimized.

Productive cropping systems do not have to rely on chemical inputs for pest control. *Photograph by Matthew Shepherd*

Approximately four thousand species of bees are native to the United States. These wild insects provide crop pollination services, and are often specialized for foraging on particular flowers, such as tomatoes, squash, berries, orchard, or forage crops. This specialization results in efficient pollination, high yields, and larger fruit.

The non-native European honey bee (*Apis mellifera*) is in decline because of disease and other factors. This makes native bees, which contribute an estimated $3 billion worth of crop pollination annually to the U.S. economy, more important than ever. Native bees are of particular importance to organic farming because unlike honey bees, their populations can be supported without the use of antibiotics and other chemical inputs.

The reduced use of pesticides, as well as more sustainable management practices, makes organic farms an important asset in protecting our national pollinator resources. Many organic operations already have good numbers of wild bees. In some cases, these native bees can provide all necessary crop pollination services when adequate habitat is available and bee-friendly management practices are implemented.

Unfortunately, however, even pesticides approved for organic agriculture can cause significant harm to bees. This fact sheet provides a brief overview of how to select and apply pesticides for organic farm operations while minimizing pollinator mortality. Keep in mind that the same practices outlined here that help protect pollinators also may protect beneficial insects such as parasitoid wasps and flies; predacious wasps, flies and beetles; ambush and assassin bugs; lacewings; and others. The presence of these insects can further reduce pest pressure and the need for chemical treatments.

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Toxicity of Common Organic-Approved Pesticides To bees

The following table summarizes some of the known interactions between bees and pesticides. Please note that this is not an exhaustive list. Additional pesticides approved for use in organic agriculture may have adverse effects on bees depending on factors such as method of application (e.g., time of day) and persistence. Also, recent laboratory studies suggest that compounds such as fungicides and surfactants may be causing bee mortality in the field and merit further study. In a few cases, not all sources agree on a product's level of toxicity to bees. Where discrepancies occurred, results were ranked according to the highest potential toxicity. For more information on each pesticide, see Notes on Pesticides section that follows.

Pesticide	Non-Toxic	Low Toxicity	Highly Toxic
Insecticides/Repellants/Pest Barriers			
Bacillus thuringiensis (Bt)	■		
Beauveria bassiana			■
Boric Acid		■	
Cydia pomonella granulosis	■		
Diatomaceous Earth			■
Garlic	■		
Insecticidal Soap [a]			■
Kaolin Clay	■		
Limonene [a]		■	
Neem [a]		■	
Horticultural Oil [a,b]			■
Pyrethrins [c]			■
Rotenone [c]			■
Ryania/Ryanodine		■	
Sabadilla [c]			■
Spinosad			■
Herbicides/Plant Growth Regulators/Adjuvants			
Adjuvants		■	
Corn Gluten	■		
Gibberellic Acid	■		
Horticultural Vinegar		■	
Fungicides/Bactericides			
Copper		■	
Copper Sulfate			■
Lime Sulfur [a], Sulfur [c,d]		■	

[a]Low risk to bees if applied at night when bees are inactive.
[b]Some horticultural oils (such as formulations with thyme or rosemary oil) primarily sold as fungicides.
[c]Repellant >1 day. In greenhouse setting, bees should be removed prior to spray and not replaced before 1½ days after spray.
[d]Long residual toxicity (1 - 7 days).


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Effects of Pesticides on Bees

Bees are poisoned by insecticides when they absorb toxins through their exoskeleton, drink tainted nectar (or in the case of honey bees, contaminated water), or when insecticidal dusts become trapped in their pollen-collecting hairs.

These poisonings may occur directly in the field when pesticides are applied. However, mortality can occur hours after the application where toxic residues still persist. Poisonings may also disproportionably affect smaller bee species. Unfortunately, most label guidelines only reflect toxicity to honey bees, even though smaller bees are often harmed by correspondingly smaller doses of insecticides. Another point worth remembering is that while honey bee hives can be moved or covered before pesticides are applied, scattered populations of wild bees cannot be similarly protected.

In addition to directly killing adult bees, insecticides may be carried back to the nest in contaminated pollen or nectar and fed to developing brood. Similarly, leafcutter and mason bees gather leaf pieces or flower petals to construct brood cells within their nests. Where this brood food or vegetation is contaminated, larval mortality may occur.

Finally, rather than directly killing bees, some insecticides have detrimental sub-lethal effects. These can include disorientation, disruption of movement, reduced reproduction, and paralysis.

Safer Pesticide Applications

The first step in reducing harm to pollinators when applying pesticides is to choose the least toxic option available. In addition to product selection, however, application method and timing can have a significant impact.

The best application method is the one that keeps the pesticide on target. Drift, the movement of spray droplets to adjacent non-target areas, can be minimized by properly calibrating equipment, adjusting nozzles to spray as close to the crop canopy as possible, and spraying during appropriate weather conditions.

The best application times are when crops (or immediately adjacent weeds and cover crops) are not in bloom. Where insecticides must be applied near blooming plants, select the product with the lowest residual toxicity and spray during the late evening when bees are not actively foraging. Keep in mind that pesticide residues may persist longer on wet foliage, so dewy conditions should be avoided. For more information on applying pesticides safely, see *Farming for Bees: Guidelines for Providing Native Bee Habitat on Farms* (see References for details).

Spray drift can be a significant threat to bees and other pollinators foraging in habitats near crop fields. Correct nozzle calibration is one way to reduce drift and maintain accurate application of pesticide sprays. Photograph from USDA-ARS.

Notes on Pesticides

Insecticides/Repellents/Pest Barriers

***Bacillus thuringiensis* (Bt)**: Bt is a naturally occurring soil-dwelling bacterium that acts as a stomach poison against certain groups of insects (moths, butterflies, flies, and beetles). It is generally considered to be a bee-safe pesticide, with no persistence (Riedl et al. 2006).

Beauveria bassiana: This naturally occurring insect pathogenic fungus has been reported to be extremely virulent to alfalfa leafcutter bees, resulting in >87% mortality after 10 days. The fungus also has been found to harm bumble bees and likely has potential to harm all bees. It should be avoided as a pest control option where pollinators are present (Caldwell et al. 2001, Hokkanen et al. 2003).

Boric Acid: Boric acid is a mild acid and abrasive registered for use when not in contact with food or crops. It is toxic to bees on contact, but because use is targeted for structural pests like ants and cockroaches, there is usually little danger that bees will come in contact.

Cydia pomonella granulosis: Granulosis virus is intended to control codling moths (a pest of various fruit trees) and has been reported as safe for honey bees (Riedl et al. 2006). Threats are likely minimal to other bees as well.

Diatomaceous Earth (DE): DE is a naturally occurring chalk-like rock, that when crushed into a fine powder, it readily absorbs lipids from the waxy outer-layer of insect exoskeletons causing them to dehydrate and die. It is a universal insecticide with the potential to kill not only pest

Crop scouting reduces pesticide applications. Treatments are only made when threshold levels are met. Photograph by Eric Mader.

species, but also beneficial species such as bees. Care should be taken to not apply DE to flowering plants (Safe Solutions, Inc. 2007). Applications made during late evening, night, or early morning may result in less exposure to bees (Riedl et al. 2006). As a powder, DE may have the potential to become trapped in the pollen collecting hairs of bees and consequently be brought back to the nest resulting in larval and adult mortality.

Garlic: This insect repellent (sold as a pungent extract) can be applied at any time with reasonable safety to bees (Riedl et al. 2006). Anecdotal concerns exist about the potential for garlic to mask floral aromas and result in lower bee visitation.

Insecticidal Soap: Potassium fatty acid soaps only work when directly applied to pest insects. The soap disrupts cell membrane permeability, causing cell contents to leak, leading to death. Mortality may occur if directly applied to foraging bees, however no residual toxicity exists. Apply only to non-blooming crops, or apply at night, or when bees are not present. Where managed pollinators are maintained, hive entrances should be closed (Koppert Biological Systems 2012).

Kaolin Clay: This pest barrier consists of finely ground kaolin particles, mixed into a liquid slurry which is then sprayed onto fruits and vegetables. The resulting dry particulate film discourages insect feeding. It can be applied at any time with reasonable safety to bees (Riedl et al. 2006).

Limonene: Limonene is a botanical extract (monoterpene) used as a repellent and insecticide. Direct contact is toxic to bees, breaking down waxy cuticles. Spray only when bees are not active, in the late evening or at night (Ellis and Baxendale 1997).

Neem: Neem is a botanical extract from the tropical tree *Azadirachta indica*. The active ingredient, azadirachtin, disrupts the hormonal system of immature insects preventing maturation. Direct contact has resulted in no observable effect on worker honey bees at concentrations well in excess of normal field application rates, and little effect on parasitic wasps. To ensure minimal contact with adult bees (that can potentially bring neem back to the nest, thus harming larvae) only apply during late evening, night, or early morning (Riedl et al. 2006).

Horticultural Oil: Horticultural oils, consisting of lightweight petroleum or vegetable oils, are used to smother pest insects and are only harmful on contact (Applied Bio-nomics, Ltd 2006). These products should be applied only during late evening, night, early morning, or as a dormant treatment (Riedl et al. 2006).

Pyrethrins: These products are a fast-acting derivative from the pyrethrum (*Chrysanthemum cinerariifolium*) plant, and act as a broad-spectrum poison. Pyrethrin is highly toxic, with as little as 0.02 micrograms sufficient to kill a bee (Caldwell et al. 2001, Cox 2002). Pyrethrins may be harmful for up to seven days (Applied Bio-nomics, Ltd 2006).

Rotenone: This dust is derived from the roots of a tropical legume and is very broad spectrum, disrupting cellular processes by inhibiting oxygen uptake. Various sources report residual effects of rotenone persisting anywhere from two hours to 42 days after application. Rotenone is extremely harmful and not compatible with bees. Where managed pollinators are present, hives should be covered or removed prior to application, and applications should be made only during late evening, night, or early morning when pollinators are not present (Applied Bio-nomics, Ltd 2006, Koppert Biological Systems 2012, Riedl et al. 2006).

Ryania/Ryanodine: Ryania is a botanical pesticide (an anthranilic diamide) that causes paralysis to insects by disrupting muscle regulation, but has relatively low toxicity to bees and wasps (MacPhee 1956, Koppert Biological Systems 2012, Larson et al. 2012). It has been used primarily in citrus and apples and is in the re-registration process.

Sabadilla: Sabadilla is a broad-spectrum powder or spray derived from the seeds of the sabadilla lily (*Schoenocaulon officinale*), which acts as a stomach and nerve poison. It is toxic to many insects including bees and other beneficials.

Residual field toxicities lasting at least 24 hours have been reported (Klass and Eames-Sheavly 1993). Its use should be minimized wherever pollinators are present.

Spinosad: A nerve and stomach poison derived from the bacterium *Saccharopolyspora spinosa*, this product is highly toxic to bees (Caldwell et al. 2001). After spray residues have dried, it may be much less toxic (Bret et al. 1997). Avoid use where bees are present. If it must be used, apply only during late evening (Riedl et al. 2006).

HERBICIDES/PLANT GROWTH REGULATORS/ADJUVANTS

Adjuvants: Adjuvants are substances that improve pesticide performance by helping the active ingredient to spread or stick, or by stimulating feeding. In general, most spray adjuvants are not believed to be toxic to bees. Three exceptions have been reported, including: Pulse (organosilicone surfactant), Boost (organosilicone), and Ethokem (polyethanoxy alkylamine, ethoxylated tallow amine) (Mussen 2006).

Corn Gluten: When applied as a pre-emergent herbicide according to label directions, it is unlikely that corn gluten will have any adverse effects on bees (EPA 2002).

Gibberellic Acid: This plant growth regulator has been reported as relatively non-toxic to bees (EPA 1995).

Horticultural Vinegar: No information is available on the effects of horticultural vinegar on pollinators. It may be harmful if it is directly applied to foraging bees, so reasonable caution should be exercised.

FUNGICIDES/BACTERICIDES

Copper: Copper fungicides have been reported to negatively effect some bee survival and reproduction (Applied Bio-nomics, Ltd 2006). Their use should be minimized where bees are present.

Copper Sulfate: Bordeaux mixture of copper sulfate, lime, and water, as well as other water-based copper fungicides have been reported to be harmful to bees (Caldwell et al. 2001). Avoid where pollinators are present.

Lime Sulfur: Limited information is available but, recent research has indicated some toxicity to bees, particularly at higher concentrations (Efrom et al. 2012). Avoid spraying when bees are present.

Sulfur: Limited information is available but, some impact on bee survival and reproduction has been reported from sulfur use, and where managed pollinators are present, colonies or nests should be removed or covered. Toxic residuals or repellent effects may persist for one to seven days (Applied Bio-nomics 2006, Koppert Biological Systems 2012).

Dozens of species of native bees pollinate flowers on the low-bush blueberry barrens in the northeast United States and southeast Canada. Protecting these insects from pesticides is important to maintain large harvests. Photograph by Eric Mader.

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