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The Center for Agriculture, Food and the Environment

Home of UMass Extension & Mass. Ag. Experiment Station

Published on *Center for Agriculture, Food and the Environment* (https://ag.umass.edu)

Toxicity of Pesticides to Pollinators and Beneficials

"Pesticide" is a general term used for a chemical designed to kill target pests such as insects (insecticide), mites (miticide), weeds (herbicide) and organisms which cause plant diseases such as bacteria (bactericide) and fungi (fungicide). Unfortunately, many agricultural pesticides may be toxic to bees. Each year many honey bee colonies are damaged or destroyed by pesticides, primarily insecticides. Such losses have a devastating impact on the beekeeper, who may have to relocate damaged hives or perhaps even be forced out of business. Growers of most insect-pollinated crops (apples, raspberries, cucurbits, alfalfa seed and many others) experience lower yields, and ultimately the consumer must pay higher food prices.

Potential Factors for Honey Bee Damage:

Many factors involving insecticide application affect the potential for honey bee losses. The most important factors are outlined below.

1. **Plant Growth Stage**: Severe bee poisoning most often results from spraying insecticides directly on flowering plants. Insecticide applications are generally not recommended on blooming crops.
2. **Relative Toxicity of the Chemical**: Pesticides vary in their toxicity to honey bees. Most fungicides, herbicides and miticides are relatively nontoxic to honey bees and can generally be used around them without serious harm. The biological insecticide Bacillus thuringiensis exhibits very low toxicity to bees. One group of insecticides which is highly toxic to honey bees cannot be applied to blooming crops when bees are present without causing serious injury to colonies. Among the materials in this high-risk category are diazinon, Imidan, malathion and Sevin.
3. **Choice of Formulation**: Different formulations, even of the same pesticide, often vary considerably in their toxicity to bees. Dust formulations are typically more hazardous than sprays because they are picked up on bee hairs. A wettable powder such as Sevin 80S would usually remain toxic in the field for longer time than Sevin XLR Plus, an emulsifiable concentrate. However, granular insecticides are less hazardous to honey bees. Microencapsulated materials such as Penncap-M are particularly dangerous to use around bees because the capsules have a special tendency to adhere to bees due to their size and electrostatic charge, and because the contaminated pollen collected by bees in the treated fields is stored in the hive and remains toxic for an extended period.
4. **Residual Action**: Residual activity of an insecticide is an important factor in determining its safety to pollinators. An insecticide which degrades within a few hours can generally be applied with minimum risk when bees are not actively foraging.
5. **Drift**: Drift of spray applications can cause significant bee poisoning problems, particularly when drift reaches colonies or adjacent flowering weeds. In general, sprays should not be applied if wind speed exceeds 10 mph and favors drift towards colonies.
6. **Temperature**: Temperature can have a substantial effect on the bee poisoning hazard. If temperatures following treatment are unusually low, insecticide residues can remain toxic to bees many times longer than if higher temperatures prevail.
7. **Distance from Treated Fields**: The most severely damaged colonies are usually those closest to fields where insecticides are being applied. However, during periods of pollen or nectar shortage, hives within five miles of the treated area can be injured.
8. **Time of Application**: Evening application of a short residual insecticide can greatly reduce any potential for bee damage.

Steps to Reducing Damage:

Reducing pesticide injury to honey bees requires communication and cooperation between beekeepers, farmers and applicators. It is important that beekeepers understand cropping practices and pest management practices used by farmers in the vicinity of their apiaries. Likewise, insecticide applicators should be sensitive to locations of apiaries, obtain a basic understanding of honey bee behavior, and learn which materials and application practices are the most hazardous to bees. While it is unlikely that all poisonings can be avoided, a balance must be struck between the effective use of insecticides, the preservation of pollinators and the rights of all--the beekeeper, farmer and applicator. In most cases, bee poisonings can be avoided by observing the following practices.

1. Do not treat fields in bloom. Be especially careful when spraying crops such as alfalfa, soybeans, and other legumes and pollinating crops. The label of certain insecticides expressly prohibits their application to flowering crops.
2. Examine fields and field margins before spraying to determine if bees are foraging on flowering weeds such as milkweeds, smartweed or dandelions. Where feasible, eliminate weeds by mowing or tillage.
3. Choose short residual materials and low-hazard formulations if insecticides absolutely must be applied during the flowering period to save the crop. Notify local beekeepers as far in advance as possible.
4. Avoid spray drift. Give careful attention to position of bee colonies relative to wind speed and direction. Changing spray nozzles or reducing pressure can increase droplet size and reduce spray drift.
5. Apply insecticides when bees are not foraging. Some insecticides can be applied in late evening or early morning with relative safety. In the case of corn, where bees collect pollen which is shed by tassels in the early morning, short residual materials could be applied from late afternoon until midnight to reduce the bee hazard.
6. Adjust spray programs in relation to weather conditions. Reconsider the timing of insecticide application if unusually low temperatures are expected that night because residues can remain toxic to bees which enter the field the following day. Cease applications when temperatures rise and bees re-enter the field in early morning. Avoid treating during hot evenings if beehives are very close to the target field and honey bees are clustered on the outside of the hives. Be especially careful that spray does not contact hives.
7. Read the pesticide label. Carefully follow listed precautions with regard to bee safety.

Table 60. Poisoning hazard to honey bees of common small fruit pesticides†.

Active Ingredient (common product names)**	DURATION OF HAZARD TO HONEYBEES (Residual Toxicity)	Active Ingredient (common product names)**	DURATION OF HAZARD TO HONEYBEES (Residual Toxicity)
EXTREMELY to Highly TOXIC: DO NOT APPLY ON BLOOMING CROPS OR WEEDS			
***Beta-cyfluthrin** (*Baythroid, *Leverage, *Tempo)	1 day RT§ > 1 day ERT§§	**Lambda-cyhalothrin** (Warrior, Voliam)	> day ERT > day ERT for encapsulated formulation
***Bifenthrin** (*Brigade, *Sniper)	< 1 day RT > 1 day ERT	**Malathion** (Malathion, Cythion)	2-6 hrs RT 2-5 days ERT
Carbaryl (Sevin)	< 1 day RT 2-14 day ERT	***Methomyl** (*Lannate, *Nudrin)	2 hrs RT 1.5 days ERT
***Chlorpyrifos** (*Dursban, *Lorsban)	2 hrs RT 4-6 days ERT	***Naled** (*Dibrom)	2 hrs RT 1-1.5 days ERT
Clothianidin (Belay, Clutch)	? RT > 5 days ERT	**Phosmet** (Imidan)	3-5 days ERT
Copper Sulfate + Lime (Bordeaux Mixture)	?	**Pyrethrin** (Azera, Pyganic, Pyrenone)	< 2 hrs RT
***Cyfluthrin** (*Baythroid, *Tombstone, *Tempo)	? RT > 1 day ERT	**Pyridaben** (Nexter, Pyramite, Sanmite)	< 2 hours RT > 8 hrs ERT
***Diazinon** (*Diazinon)	? RT 2 days ERT	**Sabadilla** (Veratran-D)	1 day ERT
Dinotefuran (Venom, Scorpion)	? RT 39 hrs ERT	**Sulfoxaflor** (Closer)	3 hrs RT
***Esfenvalerate** (*Asana)	< 1 day RT 1 day ERT	**Thiamethoxam** (Actara, Platinum, Voliam)	7-14 days ERT
***Fenpropathrin** (*Danitol)	< 1 day RT 1 day ERT	***Zeta-cypermethrin** (*Mustang, *Hero,	> 1 day ERT

		*Mustang Max)	
Imidacloprid (Admire, Brigadier, Merit, Pasada, Provado)	8 hrs RT > 1 day ERT		
Indoxacarb (Avaunt)			
MODERATELY TOXIC[A]: APPLY ONLY DURING LATE EVENING, NIGHT, OR EARLY MORNING IF BLOOMING PLANTS ARE PRESENT.			
Acetamiprid (Assail)	2 day ERT	**Copper Hydroxide** (Badge, Champ, Kocide, Nu-Cop)	?
Azadirachtin (Neemix, Aza-Direct, Azera)	2 hr RT	**Horticultural Oil** (Superior, Dormant, Summer)	< 3 hr RT
Beauvaria bassiana (Mycotrol, Botaniguard)	?	**Novaluron** (Rimon)	?
Bifenzate (Acramite)	?	**Oxydemetonmethyl** (Metasystox-R)	< 2 hours RT
Capsacin (Hot pepper wax)	?	**Petroleum/Paraffinic Oil** (JMS Stylit Oil)	< 3 hours RT
Chlorfenapyr (Phantom, Pylon)	< 4 hr RT > 2 day ERT	**Spinetoram** (Delegate, Radiant)	3 hour RT
		Spinosad (Entrust, Success)	?
Chromobacterium subtsugae (Grandevo)	?	**Spirotetramat** (Movento)	?
SLIGHTLY TOXIC OR NONTOXIC: CAN BE APPLIED AT ANY TIME WITH REASONABLE SAFETY TO BEES.			
Acequinocyl (Kanemite)		**Lime Sulfur** (Lime Sulfur)	
Aluminum tris O-ethyl phosphonate (Alliette, Fosetyl-Al)		**Mancozeb** (Dithane, Gavel, Manzate, Penncozeb, Ridomil Gold MZ)	
Azoxystrobin (Abound, Quadris)		**Mefenoxam** (Maxim, Ridomil)	
Bacillus subtilis (Rhapsody, Serenade, Cease)	Laboratory tests suggest potential effects on bumble bees.	**Metaldehyde bait** (Deadline)	
Bacillus thuringiensis (BT, Agree, Javelin, Thurcide)		**Metconazole** (Quash)	
Boscalid (Endura, Pristine)		**Methoxyfenozide** (Intrepid)	
Calcium Polysulfide (Lime Sulfur, Sulforix)		**Metrafenone** (Vivando)	
Captan (Captan, Captec, Captevate)	Up to 7 day ERT for mason bees. Effects on honey bee brood in laboratory, but not in field tests.	**Myclobutanil** (Rally, Sonoma)	No impact on bumble bees.
Chlorantraniliprole (Altacore, Coragen, Grubex)	No impact on bumble bees.	**Neem oil** (Trilogy)	Must be ingested to be toxic.
Chlorothalonil (Bravo, Echo)	Tentatively associated with "entombed pollen". Common contaminant of beeswax.	**Oils: Cottonseed, Clove, Garlic** (Pest Out, GC-mite)	
Clofentezine (Apollo)		***Paraquat** (*Paraquat)	Although no PS on label, laboratory studies suggest effects on honey bee larvae, and paraquat has been associated with colony losses.
Cyflufenamid (Miltrex, Torino)		**Penthiopyrad** (Fontelis)	
Cymoxanil (Tanos)		**Phosphorous acid, mono and di-potassium salts** (Fosphite, Prophyt)	
Cyprodinil (Switch, Vanguard)	No impact on bumble bees.	**Polyoxin D zinc salts** (Oso, Ph-D, Tavano)	
Dicofol (Dicofol)	Mixing with insecticides increases hazard to bees.	**Potassium bicarbonate** (MilStop, Greencure, Kaligreen)	No impact on bumble bees.
Difenoconazole (Inspire, Quadrus, Revus)		**Progargite** (Omite)	Mixing with insecticides increases hazard to bees
Dodine (Syllit)		**Propiconazole** (Propicure, Quilt, Tilt)	Mason bees more sensitive than honey bees. If mixed with lambda-cyhalothrin, may increase toxicity.
Etoxazole (Zeal)	3 days ERT for bumble bees	**Pyraclostrobin** (Cabrio, Pristine)	
Famoxadone (Tanos)		**Pyrimethanil** (Luna, Scala)	
Fenarimol			

(Rubigan, Vintage)		**Pyriproxyfen** (Esteem)	<2 hours RT for alfalfa leafcutting and alkali bees. May be toxic to bumble bee larvae. Avoid direct application or spray drift to honey bee hives (per label). No PS on label, other sources suggest ERT to bees.
Fenbuconazole (Indar)		**Quinoxyfen** (Quintec)	
Fenbutatin-oxide (Vendex)		***Reynoutria sachaliensis*** (Regalia)	
Fenhexamid (Elevate)		**Spiromesifen** (Oberon)	Structure and mechanism of action similar to spirodiclofen and spirotetramat, which are potentially toxic to honey bee larvae.
Fenpyroximate (Fujimite, Akari)		***Streptomyces lydicus*** (Actinovate)	
Flonicamid (Beleaf)	Possible effects on honey bees, further research needed. Short RT for alfalfa leafcutting bees and alkali bees. Short RT for bumble bees.	**Sulfur** (various products OMRI classification varies by product)	See also lime sulfur. While most sources say sulfur poses little risk for bees, other sources suggest sulfur may cause toxicity for bees for up to a day and a half.
Flubendiamide (Belt, Tourismo, Vetica)	Possible effects on honey bee larval development, further research needed.	**Tebuconazole** (Adament, Luna, Orius)	2 days ERT for bumble bees.
Fludioxonil (Switch)	No impact on bumble bees.	**Tebufenozide** (Confirm)	
Fluopicolide (Presidio)		**Tetraconazole** (Mettle)	1 day ERT for bumble bees
Fluopyram (Luna)		**Thiacloprid** (Calypso)	Less toxic to bees than most other neonicotinoids. 1-2 days ERT for bumble bees.
Hexythiazox (Onager, Savey)	>2 hours RT for alfalfa leafcutting and alkali bees	**Thiophanate-methyl** (Topsin-M)	
Iprodione (Rovral)	Laboratory studies suggest effects on honey bee larval development, field studies needed.	**Triflumizole** (Procure)	May increase toxicity of certain neonicotinoids.
Kaolin Clay (Surround)		**Ziram** (Ziram)	Laboratory studies suggest effects on honey bee larval development, field studies needed.
Kresoxim methyl (Sovran)			

[†] Sources: 2010 New England Apple Pest Management Guide and Oregon State University Bulleting PNW591 'How to Reduce Bee Poisoning from Pesticides'.
§ Residual Toxicity - The length of time the residues of the product remain toxic to bees after application.
§§ Extended Residual Toxicity - Residues D are expected to cause at least 25 percent EC mortality for longer than 8 hours after F application.
[a] Late evening means after 6-8 PM and assumes that evening temperatures are not unusually high and that bees have stopped foraging. Late evening, night or early mornings means after 6-8 PM, and before 4-7 AM, depending on temperature. Shift time if abnormally high temperatures cause bees to start foraging earlier or continue later than ususal (5:30 AM to 8:00 PM). Few honeybees forage when springtime temperature is below 51˚F. Maximum foraging activity occurs at temperatures above 63˚F. Evening applications are generally less hazardous to bees than early morning applications.
***Where trade names are used, no discrimination is intended and no endorsement by Cooperative Extension is implied. Not a complete list.*
Restricted use pesticide; pesticide applicators license required. OMRI certified for organic production

Table 61. Toxicity of pesticides to birds, fish, bees, and beneficials.

(SOURCE: 2010 THE MID-ATLANTIC BERRY GUIDE FOR COMMERCIAL GROWERS)						
	TOXICITY TO:					
				MITE PREDATORS		APHID PREDATORS
PESTICIDE	BIRDS	FISH	BEES	N. FALLACIS	Z. MALI	
INSECTICIDES						
Actara	N[a]	N	H	N	N	H
Admire	M	M	H	M	S	S-M
Asana	N	H	H	H	M	H
Aza-Direct	--	H	N	--	--	S
Brigade/Capture	M	H	H	H	M	H
Confirm	S	H	M	N	N	N
Danitol	H	H	H	H	M	H
Diazinon	H	H	H	M	S	M
*Dibrom	--	--	M	--	--	--
Dipel (B.t.)	N	N	N	N	N	N
Entrust/Spintor	H	--	H	S	N	N
Esteem	--	--	N	S	N	N
Imidan	S	H	H	S	S	S
Lannate	H	H	H	H	M	H
*Lorsban	M	H	H	M	M	H
Malathion	M	H	H	S	--	M
M-Pede	N	N	N	S	S	--
Mustang Max	--	H	H	H	M	H
Platinum	--	M	--	--	--	--
Provado	M	M	H	S	S	M
Sevin XLR	S	N	H	M	M	M
*Thionex	H	H	S	S	N	M
MITICIDES						
Acramite	--	--	H	M	M	S

AgriMek	N	N	H	H	M	--
Kanemite	--	H[b]	--	S	S	S
Kelthane/Dicofol[c]	M	H	N	H	S	S
Oberon	--	H	--	--	--	--
Savey	--	H	N	S	S	N
Vendex	M	M	N	M	M	H
Zeal	--	--	N	M	S	M

[a] N = reasonably safe (for bees, apply anytime); S = slightly toxic (for bees, apply in evening after bees have stopped foraging until early morning before they start foraging); M = moderately toxic (for bees, apply in evening after bees have stopped foraging); H = highly toxic (for bees, do not apply to blooming plants); — = insufficient data

[b] Toxic to invertebrate aquatic organisms such as oysters.

[c] Kelthane use is being discontinued. Growers may continue to use existing stocks for strawberries. VA's 24C label for Kelthane on brambles is no longer in effect.

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