Choosing Less Toxic Insecticides and Fungicides for use in Landscapes and Gardens

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Pesticides are substances applied to control, prevent or repel pests, or to reduce the problems they cause. Pesticides can be an important component of integrated pest management. However, some products pose significant hazards to humans, pets, wildlife, beneficial insects, or the environment. Some products—often termed "less toxic pesticides"— are likely to cause few injuries to people and organisms other than the target pest. Where they are effective, these less toxic pesticides should be a first choice when applying pesticides in urban environments. This publication reviews common home, garden and landscape insecticides and fungicides, including less toxic materials and materials that present significant hazards to humans or the environment.

Some confusion exists between the classification of pesticides as less toxic and "organically-acceptable" pesticides, which are allowable for growing products that can be sold as certified USDA organic. Organically acceptable pesticides must be derived from natural sources and not contain prohibited synthetic materials. Although organically acceptable pesticides are often safer than conventional materials, they are not always less toxic—e.g., some pose significant hazards to fish or wildlife. And even though they are very safe, not all less toxic pesticides are organic.

Protecting natural enemies of insect pests is very important in IPM programs. Whenever possible, choose insecticides that are least harmful to beneficials. Table 1 provides a guide.

Table 1. Relative Toxicity to Natural Enemies of Certain Insecticide Groups.

INSECTICIDE	TOXICITY[1]	
	Direct contact	**Residual contact**
Bacillus thuringiensis	no	no
spinosad	yes	short[2]
botanicals	yes	short[2]
oils, soaps	yes	no
neonicotinoids	yes	yes[2]
carbamates, organophosphates	yes	yes
pyrethroids	yes	yes

1. Direct contact toxicity is killing within several hours from spraying the beneficial or its habitat. Residual contact toxicity is killing or sublethal affects (such as reduced reproduction or impaired ability to locate and kill pests) due to residues that persist.

2. Toxicity depends on the material, type of application, and the species and life stage.

What are some least toxic products for insect, mite and plant pathogen control?

The products listed in this table have extremely low toxicity to humans and other vertebrates and generally low or very short-term negative impacts on natural enemies, bees and other beneficial invertebrates.

Common Name	Active ingredient	Pests effective against	Comments
Bacillus thuringiensis (Bt)	*Bacillus thuringiensis* ssp. *kurstaki*	Caterpillar larvae of moths and butterflies, especially newly hatched individuals feeding exposed on leaves or buds	A bacterial disease of caterpillars. Must be consumed by caterpillar within 24-48 hours of application. Breaks down rapidly. Not harmful to organisms outside moth and butterfly group. Good coverage essential.
Bacillus thuringiensis (Bt)	*Bacillus thuringiensis* ssp. *israelensis*	Mosquito, black fly and fungus gnat larvae	A bacterial disease of flies. Not harmful to organisms outside fly family. Commonly used as floating dunks for mosquito control.
Insecticidal soap	Potassium salts of fatty acids	Aphids, whiteflies, immature scale insects, spider mites	Good coverage essential as insect must be completely covered. Provides partial control (70-80%) and no residual, but natural enemies will mostly survive to help control the population. Repeat application may be required. Sold in easy to use squirt bottles ideal for amateur gardeners with small plants.
Horticultural oil, insecticidal oil (many terms and brand names)	Petroleum oil, superior oil, supreme oil, narrow range oil	Aphids, whiteflies, scale insects, spider mites, mealy bugs, lacebugs, psyllids, thrips, other sucking insects, some insect eggs; also powdery mildew on many plants, black spot on roses	Good coverage essential. Insect must be smothered. Pressurized application equipment required. Trees must not be water stressed and temperatures must be below 90°F. Natural enemies may be killed by contact, but not by residue.
Jojoba oil	Jojoba oil	Powdery mildew on fruits, vegetables, and ornamentals	Good coverage essential. Don't use on drought-stressed plants or when it is hot.
Neem oil	Neem oil	Aphids, whiteflies, scale insects, spider mites, mealy bugs, lacebugs, psyllids, thrips, other sucking insects, some insect eggs. Also powdery mildew on many plants, black spot on roses	Good coverage essential. Insect must be smothered. Pressurized application equipment required. Trees must not be water stressed and temperatures must be below 90°F. Natural enemies may be killed by contact, but not by residue.
Iron phosphate snail bait	Iron phosphate	Snails and slugs	Any snail or slug management program must also employ practices that reduce moisture, shelter, and food.
Wettable sulfur (with soap surfactants)	Sulfur	Powdery mildew	Products formulated with soap (potassium salts of fatty acids) are easiest for garden users. Avoid sulfur dusts-- they can cause skin and eye irritation. Lime sulfur is especially hazardous.
Bacillus subtilis (Serenade)	Biological fungicide	Powdery mildew on fruits, vegetables and ornamentals	Nontoxic to pets and people. Not as effective as oils against powdery mildew.
Entomophagous nematodes	*Steinernema* spp*;* *Heterorhabditis* spp.	Clearwinged moths, carpenterworm, lawn cutworms, lawn grubs	Usually must be mail ordered and used right away. Some nurseries provide mail order forms. Read UC Pest Notes for directions. *Heterorhabditis* used for lawn grubs. *Steinernema* for others.

Other Lower Toxicity Insecticides

Spinosad

Spinosad is a relatively new soft insecticide that is used primarily against, caterpillars, leafminers, thrips, and katydids. Not effective against sucking insects. Predaceous thrips and syrphid flies or parasitic wasps may be killed in first 24 hours, but rapidly breaks down. Low toxicity to people. Derived through fermentation of a naturally occurring organism—thus classified as a microbial—some organically acceptable products.

Botanical Insecticides

Botanical insecticides are derived from plants and are considered organically acceptable unless formulated with synthetically produced ingredients such as PBO (piperonyl butoxide). They vary greatly in toxicity. Most break down rapidly in the environment, but those effective on pests can have some initial negative impacts on natural enemies, so are not listed above but certainly they can be good choices in some situations. Currently the primary products available to home gardeners are pyrethrins (**pyrethrum**) and materials derived from the neem tree (**azadirachtin or neem oil**). Nicotine sulfate, long a standard garden material but extremely toxic to people, is no longer available. Various plant-based materials (see below) are on the market, but there is little information about their efficacy. Many plant-derived oil products are listed in the least toxic list; many of these products can be used to manage soft-bodies insects and some fungi.

Pyrethrum or pyrethrin

A botanical, usually combined with a synergist piperonyl butoxide (PBO) which greatly increases insecticidal activity but has some environmental concerns. Sometimes formulated with insecticidal soap for control of aphids and other soft-bodied insects. Not very effective alone. Moderately effective general contact insecticide, rapidly knocks down flying insects, breaks down rapidly in the environment. Low toxicity to mammals except cats, although some people have allergic reactions to the dust. Very toxic to fish and many aquatic organisms.

Azadirachtin

Botanical derived from the neem tree. General insecticide has broad-spectrum activity against insects, may be more effective against chewing insects; however, not generally recommended as the most effective product against any garden pests. Deters insect feeding and oviposition, interferes with insect growth as well as some contact toxicity to insects. Some toxicity to beneficials. Appears to have very low toxicity to mammals, fish and many other nontargets. Don't confuse this extract with neem oil, which is also derived from neem tree, but has different properties.

Plant-based oils and other botanicals

Garlic, hot pepper, peppermint oil, rosemary oil, clove oil, and many others are all sold as contact insecticides and insect repellents. We have little reliable data indicating that these products are effective for protecting plants from pests or keeping ants or other household pests at bay; however, various botanical oils probably have some activity against pests.

Diatomaceous Earth

Diatomaceous earth is an inorganic product made up of the mined deposits of diatoms. These products kill insects primarily by absorbing waxes on their exoskeleton, producing excessive water loss. To be effective, it must be kept dry. Sold for control of crawling insects and other arthropods (e.g. millipedes, sowbugs, earwigs). Effectiveness in garden situations questionable because of high moisture in the

environments that these pests favor. Use only products labeled as insecticide. Inhalation may cause respiratory irritation.

A Note on Ant Baits: Bait stations or stakes are considered low risk, but care must be taken to keep them away from children and pets who might find them attractive and be injured by ingestion. **Boric acid or borate-based** baits are most effective against Argentine ant and have low toxicity to humans and most nontargets but must be 1% or less boric acid for optimal control. Refillable liquid bait dispensers such as the KMAntPro work well with borate baits. Other active ingredients in some bait stations include **fipronil** or **hydramethylnon.** US EPA cancelled **arsenic trioxide** ant stakes in 2011 (although existing stocks can be sold and used). In all cases, baits in bait stations are much safer and more effective than sprays for ants. Remember, baits will not effectively control ants by themselves. They must be accompanied by efforts to reduce food and moisture sources and entryways into homes.

Fungicides

The commonly used copper-based and lime sulfur fungicides applied for disease control in backyard trees can pose some health and environmental problems. Proper precautions should be taken to avoid injury or harm to the environment. Sulfur dusts should be avoided because they are associated with respiratory problems and skin rashes; wettable sulfurs or sulfur soap products are a better option. Oils are excellent, environmentally safe fungicides for many foliar diseases. The biological fungicide *Bacillus subtilis*, sold as Seranade, is another environmentally safe fungicide that can be used against powdery mildew and some other foliar diseases.

Bordeaux mixture and Fixed Copper Fungicides

Copper compounds are used against peach leaf curl and apple scab. Copper accumulates in the soil and repeated heavy use can have negative impacts on earthworms and other soil organisms. In aquatic environments it is toxic to fish and many aquatic invertebrates. Do not allow them to drain into storm drains, creeks or other water bodies, and limit applications to the amount necessary.

Lime Sulfur—NO LONGER REGISTERED FOR HOME USE

Lime sulfur, also known as calcium polysulfide, previously was used for controlling peach leaf curl and other fungi in fruit trees is very caustic and poses significant toxicity for people.

Pesticides to Avoid When Possible—*Not Less Toxic*

Organophosphates

Chlorpyrifos (Dursban)— **Removed from market in 2000**

Home and garden uses of this insecticide have been phased out by US EPA as of 2001 because of concerns about child exposure. Some people may have stocks in garage, however. A broad-spectrum insecticide that was used to control caterpillars, aphids, scales, and many other insects. Widely used in the management of lawn grubs and moths, also ants and borers. Negative impacts on natural enemies. Serious concerns about hazards to people and the environment. Residues found in storm water and rivers with negative impacts on aquatic organisms.

Diazinon – Removed from market in 2001

Home and garden uses of this insecticide have been phased out by US EPA for health and environmental reasons. Sales to retailers ceased in December 2004 but some people still have supplies in their garages. Used for a broad array of exposed sucking and chewing insects;

has no systemic activity. Moderate persistence and significant impacts on natural enemies. Quite toxic to birds, residues found in storm water with negative impacts on aquatic organisms. Encourage people to use alternatives to diazinon.

Malathion: Still available

Used against a wide range of insects including aphids and chewing insects. Often not very effective against mites because of resistance. Not systemic. Has strong unpleasant odor. Breaks down fairly rapidly. Relatively low mammalian toxicity but very toxic to natural enemies and other beneficials. Not currently being phased out, but has been found at levels toxic to aquatic invertebrates in stormwater runoff.

Disulfoton: Removed from market in 2011

A soil applied systemic insecticide picked up by plant roots and translocated to leaves and other actively growing areas. Effective against most leaf-feeding insects and mites but not borers and scales. Used frequently on roses. Not registered for food crops. Until its removal from the market in 2011, this was the most toxic (to humans) insecticide available for use to home gardeners and extreme care should be taken with its use. Some gardeners may still have it in their garage. Encourage use of alternatives.

Acephate: Still available

Acephate has systemic activity when applied to leaves so is useful for managing concealed insects such as leafminers and leaf-curling aphids. Moderate to low toxicity to people but breakdown product methamidophos is highly toxic to mammals. Not registered for use on food crops in home gardens. Home lawn registrations were phased out in 2002 because of concerns about exposure to children.

Carbamates: Another older group of insecticides that work on the nervous system

Carbaryl. Effective against most chewing insects, but poor control of sucking insects. Has some activity on snails and slugs (thus sometimes formulated with metaldehyde). Nonsystemic. Frequently causes outbreaks of mites, aphids and other secondary pests. Quite persistent, residues may remain effective for up to 28 days, so can be used for tree borers and codling moth if appropriately labeled. Particularly harmful to honeybees, earthworms, and natural enemies of insects. Encourage use of alternatives where possible.

Pyrethroids

Synthetic analogs to the botanical insecticide **pyrethrum (pyrethrins)**. Broad-spectrum against insects, although less effective against aphids. Persist much longer in the environment (often months) so much more effective than pyrethrins but have large **negative impacts on natural enemies** of insects. Can be quite useful as trunk treatments against some borers, but most materials labeled at rates effective for borers must be purchased and applied by licensed pesticide applicators. Most have low mammalian toxicity but foliar sprays often cause serious secondary outbreaks of other pests. High toxicity to bees. Encourage use of alternatives, especially for foliar treatments. High toxicity to aquatic wildlife. Have been regularly found in water at levels toxic to aquatic wildlife in urban areas. Take extreme care to keep out of water and storm drains. One common pyrethroid available for home garden use is **permethrin**. Products containing **cyfluthrin**, **cypermethrin**, **gamma-cyhalothrin**, **lambda-cyhalothrin**, and **bifenthrin** are also very common in the home-use market. The most widely used is bifenthrin.

Neonicotinoids

Neonicotinoids are a class of synthetic insecticides which are chemically similar to nicotine. Neonicotinoid products available to home gardeners include acetamiprid, clothianidin, dinotefuran, imidacloprid, thiacloprid, and thiamethoxam. The most widely used is imidacloprid (see below).

Imidacloprid

Systemic and contact insecticide with primary activity on piercing/sucking insects such as aphids, thrips, and whiteflies. Also used against some lawn grubs and elm leaf beetle. Not effective against caterpillars. May increase spider mite problems. Must be applied in advance of severe problems. May be applied as a granule or foliar treatment (turf and shrubs) or a soil drench or soil injection (trees). Most injection products are available only to licensed pesticide applicators. Plant spikes will probably be quite useful for whiteflies and soft scales on potted houseplants. Moderate oral mammalian toxicity. Foliar products can be toxic to bees and beneficial insects—avoid these products. Soil-applied products also have negative impacts on some beneficials (move to nectar to kill parasitoids and bees; also very toxic to certain lady beetles). Imidacloprid is acutely toxic to earthworms and perhaps other nontarget invertebrates. Avoid imidacloprid products combined with the pyrethroid **cyfluthrin**.

Metaldehyde

Metaldehyde baits are particularly poisonous to dogs and cats, and the pelleted form is especially attractive to dogs. Metaldehyde snail baits should not be used where children and pets cannot be kept away from them. Some metaldehyde products are formulated with carbaryl, partly to increase the spectrum of pests controlled to include soil and debris-dwelling insects, spiders and sowbugs. However, carbaryl is toxic to soil-inhabiting beneficials like ground beetles and earthworms and should be avoided if snail and slug management is all that is required. Metaldehyde baits containing 4% metaldehyde are significantly more effective than those products containing only 2% metaldehyde, however, they are also more toxic to dogs and wildlife. **Iron phosphate** products are a safer, effective alternative.

For specific pesticide suggestions for over hundreds of landscape and garden pests, see the *Home, Garden, Turf* & *Landscape Pests* section on the UC Statewide IPM Program website: **http://www.ipm.ucanr.edu**

Useful web sites related to pesticides

- National Pesticide Information Center: npic.orst.edu/
- Extoxnet: ace.orst.edu/info/extoxnet/ghindex.html
- US EPA Reregistration Fact Sheets: www.epa.gov/pesticides/reregistration/status_page_c.htm
- Pesticide Action Network Pesticide Database: www.pesticideinfo.org/
- UC IPM Pesticides & Water Quality: ipm.ucanr.edu/WATER/U/index.html
- UC IPM Pesticide Active Ingredient database: ipm.ucanr.edu/PMG/menu.pesticides.php

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