to sulfur is to enhance its effectiveness as a fungicide. Sulfur is also sold in blends with copper, and as bordeaux mix, which is copper sulfate and hydrated lime. Products containing sulfur and copper are designed for use against diseases.

Sulfur is also often sold in a mix with dormant oil to control plant diseases and insects. Oils and copper can cause sulfur to be more potent, but this also increases the chances of the sulfur burning plant tissue. Sulfur sprays or dusts therefore should not be applied within two or three weeks of an oil spray. Sulfur also should not be applied to plants when the air temperature exceeds 90° F.

For more information on Earth Kind Gardening, watch the Oklahoma Gardening television show broadcast 11:00 a.m. Saturdays and 3:30 p.m. Sundays on Oklahoma Educational Television Authority channels.

Helpful Fact Sheets for Earth-Kind Gardeners

Home & Garden Insects...

EPP-7306 Ornamental & Lawn Pest Control
EPP-7307 Beneficial Insects
EPP-7313 Home Vegetable Garden Insect Pest Control
E-918 Major Horticulture & Household Insects of Oklahoma

Greenhouses...

HLA-6713 IPM in the Greenhouse Series: Using Bio-control Agents in the Commercial Greenhouse
E-909 Commercial Greenhouse Pests

Pesticides...

EPP-7450 Safe Use of Pesticides in the Home & Garden
EPP-7457 Toxicity of Pesticides
E-838 Ornamental Pest Management Manual

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Earth-Kind Gardening Series

Botanical Pest Controls

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Oklahoma Cooperative Extension Fact Sheets are also available on our website at:
http://osufacts.okstate.edu

Botanicals are pesticides derived from plants. They degrade rapidly and therefore are considered safer to the environment than the common synthetic chemicals. However, as with any pesticide, botanicals must be used properly. This fact sheet will describe the use of botanical insect control to help gardeners understand their alternatives when an insecticide is needed.

Some Helpful Definitions

Earth-Kind Gardening—a program developed by the Oklahoma Cooperative Extension Service and the Texas Agriculture Extension Service to address environmental garden and lawn issues. Earth-Kind Gardening encourages non-chemical practices such as cultural, mechanical, botanical, and biological controls for garden pests.

Organic Gardening—a system of growing healthy plants by encouraging healthy soil, beneficial insects, and birds (also known as "natural," "ecological," or "common sense" gardening). The philosophy includes the way gardeners treat the soil, design their gardens, and choose which plants to grow. It also includes how gardeners decide which fertilizers to use and how to control weeds and pests. Organic gardeners avoid the use of synthetically produced fertilizers, pesticides, and livestock feed additives. However, the term organic gardening has different meanings among different individuals, so a synthetically manufactured fertilizer or pesticide may be objectionable to one organic gardener, but acceptable to another.

Integrated Pest Management—a combination of pest management techniques to reduce the need for pesticides. IPM programs rely on monitoring pests and pest damage. IPM techniques include maintaining healthy plants, that resist insects and diseases better; encouraging natural predators of pests to stay in your yard; using non-chemical means to remove insects when possible, such as handpicking caterpillars on cabbage; and when using pesticides, choosing the one that is least toxic, most effective, and most pest-specific, and that has the least potential impact on the environment.

Characteristics of Botanicals

Botanicals have been used for centuries and were widely used in the United States until the 1940s and 50s when synthetic pesticides were introduced. The synthetics quickly became popular because they did not break down as quickly. But insecticides that last longer can potentially leave residues in the soil and water supply, and on food.

As with any insecticide, there are advantages and disadvantages associated with botanicals.

- Botanicals degrade rapidly from sunlight, air, and proper moisture, which generally makes them less toxic to the environment, but may also require them to be applied more often, applied correctly, and with more precise timing.
- Botanicals act quickly to stop feeding of insect pests and often cause immediate paralysis or cessation of feeding, but they may not cause the insect's death for hours or days.
- Most botanicals have low to moderate toxicity to mammals, yet they are still poisons and pose a hazard to humans or to the environment.
- Most botanicals are not toxic to plants, except insecticidal soaps.
- Botanicals cost more than synthetic insecticides and may not be readily available.

Botanicals generally act in one of two ways: either as a contact poison when sprayed on the insect, or as a stomach poison when applied to the plant and eaten by the insect.

- Potency of some botanicals may differ from one source or batch to the next.
- Botanicals tend to be broad spectrum insecticides, meaning they kill whatever they come in contact with—both "good" and "bad" insects.

Botanicals are processed into various forms: dusts and powders made from ground and dried plant parts; pure chemicals isolated from plants; and plant extracts or resins. These extracts and resins are formulated as liquid concentrates or impregnated onto dusts or wettable powders.

Botanicals generally act in one of two ways: either as a contact poison when sprayed on the insect, or as a stomach poison when applied to the plant and eaten by the insect.

Contact Poisons

(1) Pyrethrins—Pyrethrum comes from a chrysanthemum species, Dendranthema grandiflora, found in Kenya and Ecuador. Pyrethrins, which are chemical components of pyrethrum, kill insects by interrupting their nerve impulses.

This insecticide is very fast-acting and causes an immediate "knockdown" paralysis in insects. However, many insects can break down pyrethrins quickly, and after a brief period they may recover rather than die.

To overcome this break-down ability, many pyrethrin insecticides contain a synergist such as piperonyl butoxide (PBO). A synergist enhances insecticidal action by inhibiting the enzymes in the insect's body that break down the toxin. PBO is a synthetically produced chemical substance that is not allowed by some organic certification programs. Before purchasing pyrethrins or other botanicals, check the label to see if PBO is listed among active ingredients.

Pyrethrins are effective against many sucking and chewing insects as well as flying insects such as gnats (see table on page 3).

(2) Rotenone—Extracted from the roots of derris plants in Asia and cube roots in South America, rotenone is both a contact and stomach poison. It is particularly effective against leaf-feeding beetles and certain caterpillar pests.

Rotenone is a powerful inhibitor of cellular respiration, the process of converting cell nutrients into energy. It acts primarily in insects' nerve and muscle cells, causing them to stop feeding quickly. Death occurs several hours to a few days later.

Rotenone is extremely poisonous to fish. Mammals detoxify ingested rotenone with enzymes found in the liver, but it can be quite toxic when inhaled. It is one of the more toxic of the botanicals.

Stomach Poisons

(3) Neem—A mixture of leaves, seed, and bark extracts from an evergreen tree native to Asia, the Azadirachta indica, neem contains a bitter chemical that is both a deterrent to feeding and a growth regulator. Its bitterness deters insects from feeding.

As a growth regulator, neem is thought to interfere with insect hormone production or reception, thereby preventing insects from maturing enough to reproduce.

It has extremely low toxicity to mammals, but the seed dust may be very irritating to some people.

Research has shown that neem has some systemic action in plants, meaning that the plants absorb it. When applied as a dust to soils, neem can be taken up by the roots of some plants and translocated to other parts of the plant. Neem may remain active in the soil up to four weeks, depending on soil conditions.

When neem is applied to plant foliage, its systemic action is limited—new foliage must be sprayed periodically for adequate protection.

Neem can also control plant diseases, such as powdery mildew, anthracnose, black spot, and many others.

Mineral-Based Chemicals

Certain natural chemicals such as sulfur are effective as pesticides. Sulfur is used by itself or in a mix with other pesticides to control plant diseases and spider mites. Once sprayed on a plant, sulfur oxidizes to become sulfur dioxide, a toxic fume that disrupts the metabolic processes of target pests, which absorb it and try to use it in place of oxygen.

Elemental sulfur is available as wettable sulfur and liquid sulfur.

Sulfur is also packaged as an important component of other pesticides, such as lime sulfur. Lime sulfur may help control spider mites, but the primary purpose of adding lime

INSECTICIDE LABELS

Whether an insecticide is botanically derived or synthetic, strict adherence to label directions is important. Insecticide labels are always the best source of information about a product. Read the label before purchasing, before applying, and again before storing. Do not mix more than the amount needed to control a particular insect problem. Remember to wear protective clothing, especially gloves, goggles, and dust masks, during mixing, application, and cleanup.

TOXICITY

Insecticides undergo rigorous testing to determine the dose necessary to produce a toxic reaction. "LD 50" is a term often used to rank insecticides by their toxicity level. The lower the LD 50, the more toxic the insecticide.

For example, nicotine, considered a natural insecticide, is extremely toxic, with an oral LD 50 of 55. The chart below shows LD 50 values for other common insecticides and two products, salt and aspirin, found in most households.

Insecticide	Oral LD 50
Sevin	246-283
Aspirin	1,200
Rotenone	1,500
Pyrethrin	1,500
Malathion	2,800
Salt	3,320
Neem	>5,000

Common Insects and What to Use on Them

	neem	lime sulfur	sulfur	pyrethrum/ pyrethrins	rotenone
ants		●		●	●
aphids	●			●	●
apple maggots				●	●
armyworms	●			●	
asparagus beetles				●	●
blister beetles					●
cabbage worms, butterflies	●				
caterpillars, leaf-feeding	●			●	●
codling moths					
Colorado potato beetles	●			●	●
corn earworms				●	
cucumber beetles	●			●	●
earwigs				●	
elm leaf beetles	●				
flea beetles					●
fungus gnats	●			●	
geranium budworms				●	
grubs				●	
leafhoppers					●
leaf miners	●				
looper caterpillars	●				
mealybugs	●				
psyllids			●		
root-knot nematodes	●				
scales		●			
spider mites	●	●	●		●
squash bugs				●	●
squash vine borers					●
stink bugs					●
thrips	●	●	●		●
whiteflies (greenhouse)	●				●
whiteflies (sweet potato)	●				

This is a generalized list of botanical treatments recommended for common garden insect pests. However, these treatments are sold under many different brand and trade names. Always read the label of a product to see if it is formulated for use against the particular insect you want to control. The chart does not list every insect pest you may find in your garden, but does include many of the most common ones.