ENY-350

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Natural Products for Insect Pest Management[1]

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Ideally, insecticides should reduce pest populations, be target-specific (kill the pest but not other organisms), break down quickly, and have low toxicity to humans and other mammals. Although, synthetic insecticides (e.g., chlorinated hydrocarbons, organophosphates, and pyrethroids) have been an important part of pest management for many years, the disadvantages and risks of using them have become apparent. Some synthetic insecticides leave unwanted residues in food, water, and the environment. Some are suspected carcinogens, and low doses of many insecticides are toxic to mammals. As a result, many people are looking for less hazardous alternatives to conventional synthetic insecticides.

Some alternatives include less-toxic or natural products, such as insecticidal soaps, horticultural oils, microbials (see ENY-275), mineral and botanical insecticides ("botanicals"). Most of these groups will be discussed in this publication. In particular, botanicals are insect toxins that are derived or extracted from plants or plant parts. Many botanical insecticides have been known and used for hundreds of years, but were displaced from the marketplace by synthetic insecticides in the 1950s. These old products, and some newer, plant-derived products, deserve consideration for use in pest control. Botanical insecticides have different chemical structures and modes of action. However, some general traits of botanicals and other natural products include the following:

Fast breakdown. Botanicals degrade rapidly in sunlight, air, and moisture, and by detoxification enzymes. Rapid breakdown means less persistence and reduced risks to nontarget organisms. However, precise timing and/or more frequent applications may be necessary.

Fast action. Although death may not occur for hours or days, insects may be immediately paralyzed or stop feeding.

Toxicity. Most botanicals have low to moderate mammalian toxicity, but there are exceptions (e.g., nicotine). See Table 1 for a summary of insecticide toxicity to animals. Even though botanicals are naturally derived and are relatively safe if used properly, they are nevertheless poisons and should be

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handled with the same caution as synthetic insecticides. All products must be used according to the label on the product container. They are most effective when used in an integrated pest management (IPM) program, which includes sanitation, cultural practices, mechanical controls, use of resistant plant varieties, and biological control.

Synergism. Some botanicals quickly break down or are metabolized by enzymes inside bodies of their target pests. Breakdown may occur rapidly, so that the insecticide only temporarily stuns the insect, but does not kill it. A synergist may be added to a compound to inhibit certain detoxification enzymes in insects. This enhances the insecticidal action of the product. Synergists are low in toxicity, have little or no inherent insecticidal properties, and have very short residual activity.

Pyrethrins are often mixed with a synergist such as piperonyl butoxide (PBO), MGK 264, rotenone, or ryania to increase their effectiveness. PBO and MGK 264, however, should not be mixed with lime or soap solutions because of accelerated breakdown. PBO has also been implicated as a carcinogen, and may not be used in some organic certification programs.

Selectivity. Rapid break down and fast action make botanicals more selective to certain plant-feeding pests and less harmful to beneficial insects.

Phytotoxicity. Most botanicals are not phytotoxic (toxic to plants). However, insecticidal soaps, sulfur, and nicotine sulfate may be toxic to some vegetables or ornamentals.

Cost and Availability. Botanicals tend to be more expensive than synthetics, and some are not produced in great supply or are no longer commercially available (e.g., nicotine). The potency of some botanicals may vary from one source or batch to the next.

Research. Data on effectiveness and long-term (chronic) toxicity to mammals are unavailable for some botanicals. Tolerances for residues of some botanicals on food crops have not been established.

State Registration. Several botanicals are registered by the United States Environmental Protection Agency (EPA) and are available by mail order, but are not registered for legal sale in certain states. Check the label before buying or applying these products.

Organic Production. Lists of products that are acceptable in organic plant production can be found at the Organic Materials Review Institute (http://www.omri.org) and the Florida Certified Organic Growers and Consumers, Inc. (http://www.foginfor.org) web sites.

I. Botanical Insecticides

Limonene and Linalool

Citrus oils are extracted from oranges and other citrus fruit peels and refined to make the compounds d-limonene and linalool. Both compounds are generally regarded as safe by the United States Food and Drug Administration, and are used extensively as flavorings and scents in foods, cosmetics, soaps, and perfumes.

Limonene and linalool are contact poisons (nerve toxins) and may have some fumigant activity against fleas. They have low oral and dermal toxicities. Both compounds evaporate readily from treated surfaces and have no residual. They are effective against all external pests of pets, including fleas, lice, mites, and ticks. Commercial products (usually called “d-Limonene”) are available as sprays, aerosols, shampoos, and dips for pets.

Neem

Neem or neem oil is extracted from the seeds of the neem tree, *Azadirachta indica*, a native of India. The neem tree supplies at least two compounds with insecticidal activity (azadirachtin and salannin), and other unknown compounds with fungicidal activity. Azadirachtin acts as an insect feeding deterrent and growth regulator. The treated insect usually cannot molt to its next life stage and dies. It acts as a repellent when applied to a plant and does not produce a quick knockdown and kill. It has low mammalian toxicity and does not cause skin irritation in most formulations.

Neem has some systemic activity in plants. Currently registered products for ornamental pest control claim activity against a variety of sucking and chewing insects. Neem is most effective against actively growing immature insects. Neem oil is used to control powdery mildew.

Nicotine

Nicotine, derived from tobacco, is one of the most toxic botanicals. It is a fast-acting nerve toxin and is highly toxic to mammals. It is easily absorbed through the eyes, skin, and mucous membranes. It is only slightly less hazardous if eaten. Protective clothing (e.g., long-sleeves, pants, gloves, goggles, mask) is essential if using a nicotine-based product. It breaks down quickly and has little residual.

The insecticide usually is marketed as a 40% liquid concentrate of nicotine sulfate, which is diluted in water and applied as a spray. Dusts can irritate skin and are not normally available for garden use. Nicotine is used primarily for insects with piercing-sucking mouthparts, such as aphids, whiteflies, leafhoppers, thrips, and mites. Nicotine is more effective when applied during warm weather. It was registered for use on a wide range of vegetable and fruit crops, but is no longer registered commercially.

Pyrethrum / Pyrethrins

Pyrethrins are highly concentrated active compounds which are extracted from the daisy-like flower of *Chrysanthemum cinerariaefolium*, commercially grown in Kenya. When the flower is ground into a powder, the product is called a pyrethrum. Pyrethrum is the most widely used botanical insecticide in the United States. Synthetic insecticides that mimic the action of the pyrethrins are known as pyrethroids (e.g., bifenthrin, cyfluthrin, and permethrin).

Most insects are highly susceptible to low concentrations of pyrethrins. The toxins cause immediate knockdown or paralysis on contact, but insects often metabolize them and recover. Pyrethrins break down quickly, have a short residual, and low mammalian toxicity, making them among the safest insecticides in use. However, people may have allergic skin reactions and cats are highly susceptible to poisoning (e.g., flea powder).

Pyrethrins may be used against a broad range of pests including ants, aphids, roaches, fleas, flies, and ticks. They are available in dusts, sprays, and aerosol "bombs."

Rotenone

Rotenone is extracted from the roots of two tropical legumes, *Lonchocarpus* and *Derris*. Insects quickly stop feeding and death occurs several hours to a few days after exposure. Rotenone degrades rapidly when exposed to air and sunlight. It is not phytotoxic, but is extremely toxic to fish, and moderately toxic to mammals. It is more toxic to mammals by inhalation than by ingestion, and skin irritation and inflammation of mucous membranes may result from skin contact. Protective clothing and a mask should be worn while handling rotenone. It may be mixed with pyrethrins or piperonyl butoxide to improve its effectiveness.

Rotenone is a broad-spectrum contact and stomach poison that is effective against leaf-feeding insects, such as aphids, certain beetles (asparagus beetle, bean leaf beetle, Colorado potato beetle, cucumber beetle, flea beetle, strawberry leaf beetle, and others) and caterpillars, as well as fleas and lice on animals. It is commonly sold as a 1% dust or a 5% powder for spraying.

Ryania

Ryania is extracted from the stems of a woody South American plant, *Ryania speciosa*. Although a slow-acting stomach poison, it causes insects to stop feeding soon after ingestion. It works well in hot weather. Ryania is moderate in acute or chronic oral toxicity in mammals. It is generally not harmful to most natural enemies, but may be toxic to certain predatory mites. Ryania has longer residual activity than most other botanicals.

It is used commercially in fruit and vegetable production against caterpillars (European corn borer, corn earworm, and others) and thrips. Ryania may be difficult to find in stores but is available from Gardens Alive alone or mixed with rotenone and pyrethrin.

Sabadilla

Sabadilla comes from the ripe seeds of the tropical lily *Schoenocaulon officinale*. The alkaloids in Sabadilla affect insect nerve cells, causing loss of nerve function, paralysis, and death. The dust formulation of sabadilla is the least toxic of all registered botanical insecticides. However, pure extracts are very toxic if swallowed or absorbed through the skin and mucous membranes. It breaks down rapidly in sunlight and air, leaving no harmful residues.

Sabadilla is a broad-spectrum contact poison, but has some activity as a stomach poison. It is commonly used in organic fruit and vegetable production against squash bugs, harlequin bugs, thrips, caterpillars, leaf hoppers, and stink bugs. It is highly toxic to honeybees, however, and should only be used in the evening, after bees have returned to their hives. Formulations include baits, dusts or sprays.

II. Soaps and Oils

Horticultural Oil

Considered effective and safe, horticultural oils (e.g., petroleum oils or vegetable oils) are used to control insects and diseases. Commercial products are highly refined, and formulated as dormant or summer oils. Dormant oils are heavier oils, are more likely to damage plant tissue, and are used on dormant plants to control overwintering insects (e.g., aphids, spider mites, and scales). Summer oils are a lighter version of dormant oil and can be applied to actively growing plants to control aphids, mites, thrips, scales, mealybugs, and their eggs. Oils coat the insects and suffocate them, therefore, thorough coverage is important.

If the product is not used properly, plant damage can occur. This may happen when too much oil is used, plants are water stressed, temperatures exceed 90°F or when dormancy is mistaken (i.e., spraying too early in the fall). Temperatures must be above 45°F for dormant oil application for proper viscosity and coverage on plants.

Insecticidal Soap

Insecticidal soaps are made from plant oils (cottonseed, olive, palm, or coconut) or animal fat (lard, fish oil), but are generally not considered botanicals. They are made from the salts of fatty acids, which are in the fats and oils of animals and plants.

The mode of action is still unclear, despite years of use. Soaps are thought to physically disrupt the insect cuticle (outer skin), but additional toxic action is suspected. Soaps act on contact and must be applied directly to the insect to be effective. No residues remain on plants. They are effective against soft-bodied insects like aphids, some scales, psyllids, whiteflies, mealybugs, thrips, and spider mites. Hard-bodied insects (e.g., adult beetles or wasps) are not harmed because of their tough, chitinous bodies.

Some plants may be sensitive to soaps, resulting in leaf burn. Plants that have hairy leaves may be more susceptible to soap injury than smooth-leaved plants. Consult the label to see which plants are listed. Apply the soap spray on a small area of the plant to check for phytotoxicity. Commercial soaps are less likely to be phytotoxic.

III. Mineral Insecticides

Diatomaceous Earth

Diatomaceous earth is a nontoxic insecticide mined from the fossilized silica shell remains of diatoms (single-celled or colonial algae). It absorbs the waxy layer on insect bodies, abrades the skin, and dries out the insect.

Diatomaceous earth occurs as a dust, and is sometimes combined with pyrethrin. It may control slugs, millipedes and sow bugs, as well as soft-bodied insects like aphids. It has low mammalian toxicity. Two kinds of diatomaceous earth exist, a "natural grade" and a filtering agent in swimming pools, but the "natrual grade" is the one used as an insecticide.

Sulfur

Sulfur is probably the oldest known pesticide in current use. It can be used as a dust, wettable powder, paste or liquid, primarily for disease control (e.g., powdery mildews, rusts, leaf blights, and fruit rots). However, mites, psyllids and thrips also are susceptible to sulfur. Most pesticidal sulfur is labeled for vegetables (e.g., beans, potatoes, tomatoes, and peas) and fruit crops (e.g., grapes, apples, pears, cherries, peaches, plums, and prunes). Sulfur is nontoxic to mammals, but may irritate skin or especially eyes.

Sulfur has the potential to damage plants in hot (90°F and above), dry weather. It is also incompatible with other pesticides. Do not use sulfur within 20 to 30 days on plants where spray oils have been applied; it reacts with the oils to make a more phytotoxic combination.

References

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Table 1. Summary of insecticide (botanical, mineral, synthetic) toxicity to mammals

Chemical Name (Trade Name)	Class	Oral LD_{50} [1]	Dermal LD_{50}	Mode of Action	Signal Word
Bifenthrin (Talstar®)	Pyrethroid	632	>2,000	Contact & stomach activity	Caution
Carbaryl (Sevin®)	Carbamate	590	>2,000	Contact & stomach activity	Warning/ Caution
Cyfluthrin (Tempo®)	Pyrethroid	960 - 1,150	>2,000	Contact & stomach activity	Caution
d-Limonene (VIP®)	Botanical	>5,000	-	Contact poison	Caution
Diatomaceous Earth	Mineral	-	3,160 - 8,000	Cuticle disruption	Caution
Horticultural Oil (Volck Oil®)	Oil	5,000	-	Suffocation	Caution
Imidacloprid (Merit®)	Neonicotinyl	1,858 - 2,591	>2,000	Contact & stomach activity	Caution
Insecticidal Soap (Safer®)	Soap	16,500	-	Cuticle disruption	Caution
Linalool	Botanical	2,440 - 3,180	3,578 - 8,374	Contact poison	Caution
Malathion	Organophosphate	885 - 2,800	4,100	Contact & stomach activity	Caution
MGK 264	Synergist	2,800	-	--	Caution
Neem	Botanical	13,000	-	Insect growth regulator, repellent	N/A
Nicotine (Black-Leaf 40®)	Botanical	50 - 60	50	Contact poison	Danger
Permethrin (Astro®)	Pyrethroid	430 - 4,000	>2,000	Contact & stomach activity	Caution
Piperonyl butoxide (PBO)	Synergist	>7,500	7,500	--	Caution
Pyrethrins	Botanical	1,200 - 1,500	>1,800	Contact activity	Caution
Rotenone	Botanical	60 - 1,500	940 - 3,000	Inhibits cellular respiration	Caution
Ryania	Botanical	750 - 1,200	4,000	Stomach poison	Caution
Sabadilla (Red Devil®)	Botanical	4,000	-	Contact & stomach activity	Caution
Sulfur	Mineral	5,000	-	Contact poison	Caution

[1] An LD_{50} is the median lethal dose, in milligrams (mg) of toxicant per kilogram (kg) of body weight of the test animal, that kills 50% of the population of test animals. A low LD_{50} indicates a more toxic substance. The larger the LD_{50}, the less toxic the substance.