Natural Products for Managing Landscape and Garden Pests in Florida[1]

Eileen A. Buss and Sydney G. Park Brown[2]

Ideally, insecticides and fungicides should reduce insect and disease problems; be target-specific (kill the pest, but not other organisms); break down quickly; have low mammalian toxicity; and have minimal impact on the environment. Although synthetic products (e.g., pyrethroids and neonicotinoids) have long been an important part of pest management, there are risks to using them. As a result of this, as well as the increased interest in organic gardening, many people are seeking less hazardous alternatives to conventional pesticides. Lists of products that are acceptable in organic plant production can be found at the Organic Materials Review Institute (OMRI) (http://www.omri.org/omri-lists/download).

This publication describes "natural" pesticides—alternatives that are usually less toxic to non-target organisms and the environment and that, when used correctly, can be effective substitutes for synthetic products. In this publication, natural substances used for pest management in landscapes and gardens are grouped into oils, plant extracts, insecticidal soaps, mineral insecticides, microbial insecticides, and products that control diseases.

Some general traits of natural products include the following:

Fast breakdown. Most natural products degrade rapidly in sunlight, air, and moisture, and when they are exposed to insect detoxification enzymes. Rapid breakdown means these products do not persist long in the environment, which reduces risks to nontarget organisms. However, precise timing and/or more frequent applications may be necessary.

Fast action. Insects may be quickly paralyzed or stop feeding, although death may occur hours or days later.

Low toxicity. Most of the natural products discussed here have low to moderate acute mammalian toxicity. Although these products are naturally derived and relatively safe if used properly, most are nevertheless toxins and should be handled with the same caution as synthetic insecticides. All products must be used according to the label on the product container. These products are most effective when used in an integrated pest management (IPM) program that includes sanitation, proper cultural or maintenance practices, mechanical

1. This document is ENY-350 (IN197), one of a series of the Department of Entomology and Nematology, UF/IFAS Extension. Published January 2002. Revised June 2009 and June 2014. Please visit the EDIS website at http://edis.ifas.ufl.edu.

2. Eileen A. Buss, associate professor, Department of Entomology and Nematology, UF/IFAS Extension, Gainesville, 32611; and Sydney G. Park Brown, extension associate professor, Gulf Coast REC, Plant City, FL 33563.

controls, use of resistant plant varieties, and biological control (Figures 1 and 2).

Figure 1. *Harmonia axyridis* beetle, a beneficial insect
Credits: Lyle Buss, UF/IFAS

Figure 2. The larva of a species of ladybird beetle, a beneficial insect.
Credits: Eileen Buss, UF/IFAS

However, data on effectiveness and long-term (chronic) toxicity to mammals are unavailable for some natural products. Tolerances for residues on food crops have not been established for many products.

Phytotoxicity (leaf burn). Most natural products do not damage treated plants (phytotoxicity often causes leaves to turn brown). However, insecticidal soaps, horticultural oils, and sulfur may be toxic to certain sensitive vegetables or ornamentals, especially if applied at higher rates.

Cost and availability. Natural products sometimes are more expensive than synthetics, and some are hard to find. The potency of some natural products may vary from one source or batch to the next.

State registration. Many natural products 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.

Many natural products are toxins derived or extracted from plants or plant parts. Some 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. These insecticides have different chemical structures and modes of action. They break down or are metabolized by enzymes inside the bodies of their target pests. Breakdown may occur rapidly, so that the insecticide temporarily stuns but does not kill the insect.

A *synergist*, a substance that works with a product to increase its effectiveness, may be added to a botanical compound to inhibit certain detoxification enzymes in the target pests and increase pest mortality. For example, Pyrethrins, such as Pyrenone,are often mixed with a synergist such as piperonyl butoxide (PBO) or MGK 264. PBO is not approved by OMRI for use in most certified organic programs. Neither PBO or MGK 264 should be mixed with lime or soap solutions because of accelerated breakdown Most synergists have low toxicity, little or no inherent insecticidal properties, and very short residual activity.

I. Oils (Plant- and Petroleum-derived)

In general, oils are most effective against small, soft-bodied insects and mites that are immobile or slow-moving (e.g., aphids, scales, leafhopper nymphs, whiteflies). The target pests should be thoroughly covered by the oil spray. Oils lack residual activity, so they cannot prevent insect reinvasion, and often need to be reapplied. Oils affect insects in several ways. When sprayed onto insects, plant and petroleum oils can block the insects' breathing holes (spiracles), so they suffocate. Oils prevent gas exchange through egg membranes, so eggs are often targets of control with oils. The fatty acids in plant oils may disrupt cell membranes and interfere with normal metabolism. Some oils may also have repellent or anti-feedant properties, or may clog insect mouthparts, which may reduce the chance that insects like aphids and leafhoppers will transmit viruses to plants.

Citrus Oils--Limonene and Linalool

Citrus oils, which are extracted from oranges and other citrus fruit peels (Figure 3), are used extensively as flavorings and scents in foods, cosmetics, soaps, and perfumes. The oils can also be refined to make the insecticidal compounds d-limonene and linalool. Both compounds are generally regarded as safe for mammals by the United States Food and Drug Administration.

Figure 3. Citrus oils from fruit peels are used to make the insecticidal compounds d-limonene and linalool.
Credits: RusN/iStock/Thinkstock, (c)RusN

Limonene and linalool are contact poisons (nerve toxins) that may be synergized by PBO. They have low oral and dermal (skin) toxicities. Both compounds evaporate readily from treated surfaces and have no residual activity. They have been registered for use against fleas, aphids, and mites, but they also kill fire ant workers, several types of flies, paper wasps, and house crickets. Commercial products (usually containing "d-Limonene") are available as liquids, aerosols, shampoos, and dips for pets. Skin or eye contact can be irritating to some animals, but symptoms are usually temporary. It is wise to use these products cautiously to also minimize phytotoxicity to sensitive plants.

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 that kill insects (azadirachtin and salannin), along with an unknown number of other unidentified compounds that have 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 within a few days. Azadirachtin acts primarily as a repellent when applied to a plant and may kill an insect within 24 hours. It has low mammalian toxicity and does not cause skin irritation in most formulations. Neem products can be very different in their activity. For intance, neem oil works well against caterpillars and Azatrol works well against aphids.

Neem has some systemic activity in plants. Currently registered neem products for ornamental pest control claim to be active against various sucking and chewing insects. As a plant extract, Neem can be extracted and formulated in different ways, and different insects will react in different ways to the same product. Thus, effectiveness varies among products. Neem is most effective against actively growing immature insects. Neem oil (70%) is used to manage powdery mildew but is less effective on black spot and other leaf spot diseases.

Other Plant Oils Used As Insecticides and/or Repellents

Many products containing plant oils besides citrus and neem are commercially available. These are usually combinations of different plant oils, plant oils combined with plant extracts such as pyrethrins, and plant oils combined with fish oil. These products are promoted as insecticides, insect repellents, or both. The most common oils used in these products are garlic, canola, sesame, and soybean. Some herbal extracts include thyme, rosemary, peppermint, cinnamon, and clove. Others—such as cedar, lavender, eucalyptus, pennyroyal, and citronella—are commonly used as flea and mosquito repellents on pets and humans. These are normally regarded as safe when applied as recommended to the skin. The exception is pennyroyal, which is highly toxic to humans and pets when ingested.

Horticultural Oils

Horticultural oils, derived from petroleum, can be used to manage piercing-sucking insects and mites. Current horticultural oils are highly refined, lightweight oils that may be sprayed onto plant foliage. If a plant is dormant, a higher concentration of horticultural oil may be used (e.g., 4% oil in solution), but if a plant is actively growing or blooming, a lower concentration (e.g., 2%) should be used to minimize the risk of phytotoxicity or a chemical burn on sensitive plants. Avoid horticultural oil applications when outdoor temperatures exceed 90°F.

II. Plant Extracts

Pyrethrum/Pyrethrins

Pyrethrins are highly concentrated compounds extracted from the daisy-like flower of *Chrysanthemum*

cinerariaefolium, commercially grown in Kenya (Figure 4). When the flower is ground into a powder, the product is called a pyrethrum. Synthetic insecticides that mimic the action of pyrethrins are known as pyrethroids (e.g., bifenthrin, cyfluthrin, and permethrin).

Many insects are susceptible to low concentrations of pyrethrins. The toxins cause immediate knockdown or paralysis on contact, but insects may metabolize them and recover if a synergist is not used. Pyrethrins break down quickly, have a short residual, and have low mammalian toxicity, making them among the safest insecticides in use. However, they cause allergic skin reactions in some people, and cats are highly susceptible to poisoning (e.g., flea drops and powder). Pyrethrins are toxic to fish, so use care when applying these products near water sources.

Figure 4. Pyrethrins are extracted from a Chrysanthemum species.
Credits: chatchawin jampapha/iStock/Thinkstock, © chatchawin jampapha

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," and they may be mixed with synthetic pesticides or other natural products.

Rotenone, Ryania and Sabadilla

These plant extracts used to be common botanical insecticides. However, none of them are currently registered or available for purchase for landscape and garden use in Florida. They pose significant health risks to to nontargets and mammals. Thus their use is not recommended.

Hot Pepper

Products made with hot pepper (Figure 5) contain *capsaicin*, the compound that gives certain peppers their "heat." Low doses of capsaicin are often combined with paraffin and sold as "hot pepper wax" insect and animal repellents. The flavor does not affect the taste of fruits or vegetables that have been treated.

Figure 5. Hot pepper products containing capsaicin claim to repel certain insects.
Credits: Medioimages/Photodisc/Thinkstock

III. Insecticidal Soap

Insecticidal soaps are made from plant oils (cottonseed, olive, palm, or coconut) or animal fat (lard, fish oil). They are made from the salts of fatty acids, which are in the fats and oils of animals and plants.

The mode of action of insecticidal soaps is still debatable. They may physically disrupt the insect skin or cuticle, block insect breathing holes (i.e., spiracles), or act as nerve toxins. Soaps act on contact and must be applied directly to the insect to be effective. Any soap residue that remains on plants has no insecticidal effect. Soaps are useful against soft-bodied pests like aphids, some scales, psyllids, whiteflies, mealybugs, thrips, and spider mites.

Some plants, such as those with hairy leaves, may be more sensitive to phytotoxicity from soaps than other plants (i.e., smooth-leaved plants). Check the product label to see which plants are listed. Spray the soap onto a small area of a plant first to ensure the product doesn't burn the leaves.

IV. Mineral Insecticides

Diatomaceous Earth

Diatomaceous earth is mined from the fossilized silica shell remains of diatoms (single-celled or colonial algae). It can abrade and absorb the waxy layer on an insect's body because of its angularity, which causes the insect to dry out.

Diatomaceous earth is formulated as a dust and may be combined with pyrethrins. It is labeled against slugs, snails,

millipedes, or sowbugs. It has low mammalian toxicity, but it can pose an inhalation hazard, so the use of a dust mask is suggested. Two kinds of diatomaceous earth are available, a "natural grade" and a filtering agent in swimming pools; the "natural grade" is the one used as an insecticide.

Sulfur

Sulfur is probably the oldest known pesticide in current use and dates back to the Roman era. It can be used as a dust, a wettable powder, a paste, or a liquid. Sulfur is used primarily for disease control (e.g., powdery mildews, rusts, leaf blights, and fruit rots), but mites, psyllids, and thrips are also 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 it may irritate skin or eyes.

Sulfur has the potential to damage plants in dry, hot weather (90°F and above). It is also incompatible with other pesticides. Plants sprayed with oil should not be treated with sulfur for 20–30 days; sulfur reacts with oil to form a phytotoxic combination.

Slug and Snail Baits

Iron phosphate bait is available under many trade names and is a safer alternative to metaldehyde baits, which are highly toxic to pets and wildlife. Snails and slugs immediately stop feeding after ingesting these compounds and die after several days. Irrigate infested areas before applying and sprinkle (don't pile) the baits in late afternoon or evening (slugs and snails are most active on cloudy days or at night). Avoid watering afterwards so that the bait doesn't dissolve.

V. Microbial Insecticides

Microbial insecticides contain microorganisms (viruses, bacteria, fungi, protozoa, or nematodes) or the toxins they produce. Their toxicity to humans, pets, and wildlife is extremely low. They usually target a specific category of insect pest (e.g., caterpillars) and therefore pose a reduced risk for other nontarget insects. They can be applied as sprays, dusts, liquid drenches, liquid concentrates, wettable powders, or granules. Most are available through retail garden centers or internet sites. Like many natural insecticides, their effectiveness is reduced by heat, sun, and dry conditions.

Bt *Bacillus thuringiensis*

When caterpillars ingest leaves that have been treated with the bacterium Bt var. *kurstaki*, they stop feeding and die within 1–3 days (Figure 6). Common caterpillars that Bt var. *kurstaki* effectively controls include fall webworm, cabbage looper, bagworm, orangedog, tomato/tobacco hornworm, Io, and oleander caterpillars. It does not control corn earworm on corn, squash vine borer, or cutworms very well. Bt is rapidly inactivated in the environment by sunlight, and repeated applications may be necessary for some pests. In recent years, other Bt varieties have been developed that target other types of pests such as mosquito, blackfly, and fungus gnat larvae (*Bacillus thuringiensis* var. *israelensis* [Bti]); wax moth larvae in honeybee hives (*B. thuringiensis* var. *aizawai*); and certain beetles (*B. thuringiensis* var. *san diego* and *B. thuringiensis* var. *tenebrionis*). Before selecting a Bt product, it is essential to correctly identify the type of pest insect and its life stage. For example, Bti will control mosquito larvae, but not the adults.

Spinosad

Spinosad is a microbial insecticide derived from a species of soil bacteria. It is a fermented toxin, much like *Bacillus thuringiensis*, but has a longer residual. This product works on several types of insects (caterpillars, flies, thrips, and beetles), but has low to moderate toxicity to most beneficial organisms. It is highly toxic to bees when wet, but dry residues have minimal effect. Therefore, applications should be made in early morning, late evening, or night when pollinators are not actively foraging. Spinosad attacks the nervous systems of insects that come in contact with or ingest it. Feeding stops within minutes and death occurs within 2 days.

Other Bacterial Insecticides

Chromobacterium subtsugae, sold as Grandevo, controls a broad range of insects and mites by repelling them and disrupting feeding and reproduction. It is easy on beneficial insects and is OMRI approved.

Japanese beetle grubs can be treated with "milky spore disease" products containing the bacteria *Bacillus popillae* and *Bacillus lentimorbus*. However, the efficacy of these products on other grub species is inconsistent or poor. Japanese beetle is not resident in Florida, so these products are not recommended for use here.

Fungi

Fungi thrive when high rainfall and humidity favor the germination of fungal spores. After germination, spores penetrate insect bodies. The insects die from the toxins produced by the fungi. Thus, unlike bacterial and viral pathogens, fungi do not need to be consumed by the insect.

Figure 6. Webworm caterpillars killed by Bt var. *kurstaki*.
Credits: John Capinera, UF/IFAS

Beauveria bassiana is one of the few fungal products available to homeowners and is sold under the product names of BotaniGard™ and Naturalis O™. This fungal pathogen naturally occurs in soils, and many soil-dwelling insects may be naturally tolerant to it. Commercially available products are therefore labeled for use against susceptible foliar-feeding pests such as aphids, thrips, whiteflies, beetles, and spider mites. The product must contact the pest for infection to occur. Reduction in pest populations may take some time.

Protozoa

Protozoan pathogens naturally infect a wide range of insect hosts. These pathogens are valued for the debilitating effects they have on insects, such as decreased appetite and sexual reproduction. One product, *Nosema locustae*, is targeted against grasshoppers (product names: NOLO Bait, Grasshopper Attack), but reportedly has minimal efficacy.

Parasitic Nematodes

Although not truly microbial, these multicellular roundworms are used much like microbials and are often called "biopesticides." *Steinernema* and *Heterorhabditis* species are commonly used beneficial nematodes. They infect and kill the soil-dwelling host insects by entering through body openings and releasing bacteria into the insect's blood, so that the insect becomes septic. As the insect dies, the infective juvenile nematodes exit and search for a new host. Products containing parasitic nematodes have been developed to control grubs and mole crickets in turfgrass, as well as root weevil larvae and similar soil pests that attack lawn and garden plantings. They work well in sheltered or undisturbed environments where high moisture levels are maintained.

Viruses

Although they are not well known or widely available, several insect viruses have been developed and registered for use as insecticides, especially the nuclear polyhedrosis virus (NPV) used against forest pests like the gypsy moth (product name: Gypchek). Most viruses disperse naturally in the environment.

VI. Disease Management with Natural Products

Far fewer products exist for disease control compared to the numerous materials discussed above for insect control. For these products to be effective, a few guiding principles of disease management should be emphasized:

1. Healthy and resistant plants are the best defense. Follow the "right plant/right place" rule when buying and planting, and use good cultural practices.

2. Applying products to plants that are already diseased is a waste of time and money. Early detection and removal of infected plants or plant parts should precede applications of chemicals. The products below should be used to prevent diseases because they usually cannot cure them.

The following is a limited list of natural fungicides that are readily available to homeowners:

Bacillus subtilis

When applied as a seed treatment or soil drench, this bacterium colonizes roots and outcompetes root-infecting fungi. A strain of *Bacillus subtilis* (QST 713) is a foliar application product predominantly used against powdery mildew.

Copper

Products containing copper hydroxide and copper sulfate are organic fungicides that are effective against many fungal and bacterial diseases. They act as a lethal barrier between the plant surface and the pathogen, thereby preventing infection. Copper sulfate is toxic to humans, other mammals, and aquatic environments. Plants need copper as a

nutrient, but only in very tiny amounts. Over-use of copper products will damage them.

Potassium Bicarbonate and Sodium Bicarbonate

Although they are labeled for powdery mildew and a wide variety of other diseases, fungicides containing sodium bicarbonate (baking soda) and potassium bicarbonate do not offer a high level of disease control. However, they have minimal mammalian and environmental toxicity and do provide some protection.

For treatment of plant disease, lime sulfur, a mixture of hydrated lime and sulfur, is more commonly used. This compound is effective against more diseases than sulfur alone. It has the same burn potential as sulfur and is not commonly found at garden centers.

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

Product	Type	Mode of Action	Plant Pest(s) Targeted
Btk (*Bacillus thuringiensis* var. kurstaki)	Microbial	Stomach poison	Caterpillars
Bacillus subtilis	Fungicide	Protectant	Root-infecting fungi; powdery mildew
Diatomaceous earth (Silica shells of diatoms)	Mineral	Cuticle disruption	Slugs, millipedes, sowbugs, and soft-bodied insects like aphids
Bicarbonates (Potassium and sodium)	Fungicide	Protectant	Powdery mildew and other diseases
Horticultural oil (Petroleum-based)	Oil	Suffocation	Scales, aphids, mites, whiteflies, and many others
Copper	Fungicide	Protectant	Many fungal and bacterial diseases
Hot pepper (*Capsaicin*)	Botanical	Repellent	Many insects
Insecticidal soap (Potassium fatty acid soaps)	Soap	Cuticle disruption and other modes	Soft-bodied pests (aphids, mites, whiteflies, thrips, mealybugs, etc.)
Limonene/Linalool (Citrus oils)	Botanical	Contact poison	Aphids, mites, fire ants, flies, and wasps
Neem extracts (*Azadirachtin indica*)	Oil/Botanical	Repellent, insect growth regulator	Numerous chewing and sucking insects (when immature); powdery mildew disease
Plant oils (Extracts of garlic, sesame, citronella, many others)	Oil	Repellent, contact and stomach poison	Numerous insects (depends on extract)
Pyrethrins/Pyrethrum (*Chrysanthemum* sp. extract)	Botanical	Contact activity	Many insects
Spinosad	Microbial	Contact and stomach activity	Caterpillars, flies, and thrips
Slug and snail baits (Iron phosphate)	Mineral	Stomach poison	Slugs and snails
Sulfur (By-product of natural gas and petroleum refinement)	Mineral/Fungicide	Contact poison	Mites, psyllids, thrips; powdery mildew, rust, leaf blight, and fruit rot diseases