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Managing
Insect and Mite Pests
in Vegetable Gardens

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For a fresh, satisfying and tasty way to help lower your grocery bill and provide personal satisfaction, nothing is better than vegetable gardening.

But growing vegetables is not always easy, especially when it comes to controlling insects and other pests.

Understanding insects

About 30,000 species of insects are found in Texas; fewer than 100 routinely cause problems in vegetable gardens. Most garden insects are either incidental or beneficial when they help with pollination, recycle organic matter or keep pests under control. A garden with many insects may be quite healthy and productive.

However, insect pests can reduce the vegetable crop's quantity and/or quality or transmit diseases from one plant to another. When that happens, control measures may be necessary.

When dealing with insects in the garden, first identify the species to de-

termine whether they are beneficial or pests. Learn to recognize the common insects in the area, especially common pests, and the signs of pest damage. Inspect the garden for pests at least once a week.

Whether they arrive by walking or flying, insect pests can take up permanent residence in the garden. Flying insects are highly mobile and can migrate in large numbers. In addition, pests such as aphids and mites can have a complete life cycle in about a week under good conditions, so their populations can increase rapidly. When many pests seem to appear overnight, they have either flown in or are reproducing rapidly.

As insects grow, they change size, shape and color in a process called metamorphosis. In some insect species, both the immature and adult stages damage plants. Because their forms change, insects can be difficult to identify; the damage they cause to plants also can change with their forms. Size matters too—small caterpillars may barely scrape the surface of a leaf, while larger caterpillars may eat great chunks.

• Professor and Extension Entomologist, The Texas A&M System

Damage to plants depends on the insect's mouthparts. Insects with sucking mouthparts feed by piercing leaves or fruit, leaving pock marks or mottled leaves. Insects with chewing mouthparts chew holes in plant tissues. Recognizing how an insect feeds can help a gardener select the proper insecticides; choose stomach poisons for chewing insects or contact poisons for sucking insects.

Plan ahead

When planning a vegetable garden, consider possible pests and how to manage them before they cause problems. Implement the management plan in plenty of time to deal with pest problems.

Integrated pest management

Integrated pest management, often called IPM, uses a combination of pest control techniques that balance economic production and environmental stewardship. IPM is the overriding strategy for most of production agriculture today and is being adopted in urban environments as well.

Monitoring crops for the presence and absence of pests is an important part of IPM. In situations where a pest is present and could cause significant damage, management is justified.

Although many practices can be implemented as part of an IPM program, the use of insecticides is a control option. When non-chemical control practices are used, the IPM approach is much like organic gardening.

The following sections list many control practices available for home vegetable gardeners.

Cultural control

Gardening practices that reduce pest numbers or impact are called cultural control. These practices include variety selection, crop rotation, cultivation, weed management, water management and fertilizer use. For some pests, the best choice is to interrupt their life cycle by leaving the land fallow and weed-free for a period or by rotating crops. Plant debris can harbor pests; always remove it from a garden area. Weeds can attract insect pests and also must be controlled.

Host plant resistance

Through a natural process called host plant resistance (HPR), vegetable varieties can continue to produce in spite of the presence of insects and other pests. These plants show tolerance, nonpreference or antibiosis. Tolerance is the plant's ability to grow and produce even with pest damage. Nonpreference is exhibited when a plant has structures, such as plant hairs, repellent odors or colors that cause insects to choose other plants. Some plants produce chemicals that kill or slow development of a pest—this is called antibiosis.

Extensive trials are needed to understand the host plant resistance of vegetables. Most variety selection emphasizes appearance, taste and production volume without regard to pests. The host plant resistance status of many varieties has not yet been tested.

Recently researchers have altered the genetic material of some vegetables including tomatoes, potatoes and corn—these are called transgenic plants. Dramatic results can be achieved when genes for insect resistance are incorporated in the new varieties. Most of the insect-resistant transgenic vegetable varieties incorporate genes of the bacterium, *Bacillus thuringiensis,* making them resistant to some caterpillar pests. This resistance inhibits the growth of caterpillars feeding on these plants. Resistant transgenic vegetable varieties are expected to become increasingly available to homeowners.

Biological control

Biological control uses one organism to control another. Three successful approaches to biological control are importation, conservation and augmentation.

Importation requires bringing a parasite or predator from a foreign country to control an introduced exotic pest species. Because it is highly regulated by state and federal agencies, importation is not available to home vegetable gardeners, although they do benefit from successful importation research programs.

Conservation encourages natural enemies already in the area. Conservation methods include:
- Planting nectar-producing flowers that provide food for parasites.

- Avoiding unnecessary pesticide applications.
- Selecting pesticides that are toxic to a pest but relatively nontoxic to beneficial insects.

Augmentation is the release of additional predators and parasites, such as lady beetles, praying mantids and parasitic wasps, into the natural populations. However, the benefit of additional releases may be marginal because many of these predators and parasites already exist in the environment.

Biological control is not an instant solution to pest problems. A sound biological control program must be supported by careful study, starting with proper identification in order to match pests and beneficial organisms. Increased monitoring is necessary. Many biological control agents are specific to certain pest species. Usually, biological controls are not available for a specific pest.

Mechanical control

Mechanical control—including barriers, covers, high pressure water sprays and hand-picking pests—uses physical means to reduce insect numbers or damage.

Barriers, which prevent the movement of pests onto plants, include cardboard or plastic cylinders around the base of transplants or cloth or plastic screening to protect a newly planted garden. Screening may increase the temperature of a planting bed, often an additional benefit. Screening is most useful for susceptible young plants and seedlings and may provide some protection from frost as well.

High pressure water spraying, one of the few options available when vegetables are near harvest, is most effective against small, soft-bodied pests such as aphids. High pressure water sprays may help remove webbing, dissolve droppings and reduce the number of pests in a short time. However, water sprays may not kill all of the pests and may distribute pests to other hosts.

Hand-picking and destroying some pests may be feasible in small gardens, and can be successful for tomato hornworms and even squash bugs if persistently done. Obviously, hand picking is more feasible for larger insects than for small insects.

Chemical control

Pesticides in any form are regulated for safety by the Environmental Protection Agency (EPA); the sale and use of these products is regulated by the Texas Department of Agriculture. These agencies do not consider effectiveness in the registration process. Labeled insecticides may or may not be effective in killing pests that are mentioned on the product label. The number of products available for use in home vegetable gardens and the rapid turnover in the market makes the effectiveness of products difficult to determine. Their effectiveness can change as pests become more tolerant or as environmental factors interact with a chemical. Furthermore, a pesticide may fail if it is not applied according to the label directions.

The user is always responsible for the proper use of any pesticide. Using a product in a manner or situation not defined on a pesticide label is illegal.

Product labels list restrictions that must be considered, including limits on product rate, number of applications per season, specific crops the product may be applied to, method of application and number of days required from last application to harvest.

Some generic insecticides have several trade names; special restrictions may be noted on a specific label. Read the label for additional restrictions and follow directions carefully.

The EPA approves pesticides for use on a particular crop after evaluating safety data only, in most cases. *If a crop is not listed on a product label, the pesticide can not be considered safe for use on that crop.* The EPA considers greenhouses to be separate from crop lands; therefore products must specifically state for greenhouse use on the product label. These products may not be safe to use on some crops because of other factors such as phytotoxicity. Table 1 lists a summary of the chemicals registered for use in home gardens. This list was prepared from product labels; not all products have been examined by the Texas AgriLife Extension Service.

Product labels also list suggested target pests. Table 2 lists product labels reviewed for this guide, and includes most of the common active ingredients available for use in home gardens.

Pesticide registration status changes rapidly. In most cases, products are phased out with dates to stop both wholesale and retail sales. Usually provisions allow homeowners to use already purchased products beyond those dates.

Pesticides vary widely in their hazardous effects on humans and the environment. The key words on the label—**CAUTION** (least toxic), **WARNING** (more toxic), and **DANGER** (most toxic)—indicate toxicity of the product. Use this label information as a guideline on product use and potential hazard. Most of the products mentioned here include *caution* on the label. Mixing the product for use is one of the most hazardous steps in pesticide use—take special care during that step.

Insecticide classes provide a key to understanding how the product works and thus which pests are most likely controlled. When insect control is unsatisfactory, change to a product from another insecticide class. (See Table 3.)

Less toxic approaches

Instead of applying conventional chemicals, many gardeners prefer to use less toxic approaches to insect management, which can range from "soft" insecticides to natural control. Home gardeners have more of these products to choose from than ever before. Some of the less-toxic products registered and sold as pesticides are included in this guide.

Less toxic chemicals are available under different legal registrations. Chemicals listed in the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) EPA Title 40, Chapter 1, Subchapter E, Part 152.25 are considered "minimum risk pesticides" and are exempt from FIFRA registrations. This list includes cedar oil, citric acid, citronella, cloves, garlic, lemongrass oil, mint, peppermint, rosemary, thyme and white pepper. For more information visit the Web at http://www.epa.gov/lawsregs/laws/fifra.html.

Inert ingredients often are included in pesticide formulations to dilute the active ingredients and/or facilitate the application. Inert ingredients are also covered under the same FIFRA registrations in list 4A and are considered minimal risk.

Putting it all into practice

Plant a garden of manageable size

Garden size directly affects the feasibility of control measures. Removing pests by hand and swabbing pests with alcohol may not be feasible in larger gardens. The larger the garden, the lower the likelihood that non-pesticidal controls will be practical.

Leave the garden fallow for a time before planting

Insect pests such as white grubs, wireworms and cutworms overwinter in the soil and feed on abandoned plants or weeds. Removing these food sources during the off season reduces pest numbers before spring planting.

Practice good sanitation

Remove dead leaf piles, boards, railroad ties and other objects where pests such as cutworms, slugs, snails, pillbugs and sowbugs can congregate. Mulches help maintain moisture and provide shelter for spiders and predatory insects; however, mulch also provides shelter for pests.

Select pest-free transplants

Inspect plants before purchasing to be sure they have no pests. Most common insect and mite pests can be found on the undersides of leaves. Purchase only healthy pest-free transplants.

Select pest-resistant vegetable varieties

Some vegetable varieties are unattractive or resistant to certain pests. Planting resistant varieties adapted to your area can dramatically reduce the need for insecticides. For example, the sweet corn variety "Seneca Sentry" is resistant to corn earworms and is adapted to Central Texas. The leaves that wrap around the corn ear tip are much tighter around the silk than in more susceptible varieties. Unfortunately, the pest resistance status of only a few vegetable varieties is known.

Practice good horticultural methods

Properly prepare the soil before planting. Thoroughly till the soil to kill many insects and provide good growing conditions for seedlings and transplants. Healthy plants will be less sus-

ceptible to pest damage. The composition of the soil and spring growing conditions also affect pest populations. Soils with high organic matter are more likely to support white grubs, root maggots, pillbugs and sowbugs, even though these soils may promote better plant growth.

Keep a weed-free garden. Weeds supply food for insect pests and compete with vegetable plants for soil nutrients and water, which can decrease vegetable yield considerably. A weed-free garden and grass mowed short around the garden will discourage insects such as grasshoppers and armyworms.

Fertilize properly. Plants need adequate nutrients to grow well. However, using too much fertilizer can produce lush, green plants that attract aphids and other insect pests. A soil test will determine which nutrients may be lacking and which are at adequate levels.

Water properly. Either too much or too little water can be unhealthy for plant growth. Drought-stressed plants are more likely to attract spider mites.

Inspect plants and properly identify pests

Learn to identify the various insects and other creatures in the garden. Many of them are beneficial. Extension agents can help identify plant pest problems. Don't treat undiagnosed problems.

Pests can attack garden plants from seed to maturity. Inspect the plants weekly or more often for pests, monitor natural enemies and evaluate the effects of control tactics. Check the undersides of leaves for aphids, whiteflies, spider mites and egg clusters of armyworms, Colorado potato beetles and squash bugs.

To detect low populations of spider mites and thrips, beat the plants on a piece of off-white paper; the pests will fall off the plant onto the paper, where they can be identified. Although yellow sticky cards are occasionally promoted as insect control devices, they are best used to monitor pest activity. These cards attract the winged adult stages of aphids, leafminers, thrips, whiteflies and many flies. Cards should be inspected and replaced regularly so pests can be detected early and their numbers monitored. Sex-attractant chemicals called pheromones are available commercially to monitor many insect pests, especially moths.

Consider all pest suppression methods

When a pest outbreak occurs, consider prevention methods and the best method of reducing pest numbers. Some mechanical suppression methods are:

- Reflective mulches such as foil paper, which can slow infestation by some pests such as aphids.
- Barriers to protect young plants or transplants from cutworms, sowbugs or pillbugs. Place a barrier made from cardboard, plastic or metal cans with the tops and bottoms removed around the base of each plant.
- Screens over the garden. Fine-mesh screens or fabrics can provide a barrier that even tiny insects such as thrips cannot cross. Several products are available. When barriers are properly maintained, insects can be excluded; however, plants should still be monitored regularly, which requires removing the barrier. The temperature inside barriers often exceeds that outside, so remove them before the plants experience heat stress. This method works best in early spring or fall when the temperatures under the screen are moderate.
- Cages and trellises. Plants growing on the ground are susceptible to soil pests. Vine plants such as cucumbers and tomatoes are easier to manage when grown on trellises or in cages. Monitoring for pests and spraying plants thoroughly is easier when they are held up off of the ground.
- High pressure water sprays. Small pests such as aphids and spider mites can be dislodged from plants with high-pressure water sprays directed to the undersides of leaves. Commercial spray devices (Water Wand® and Jet-All Water Wand®) are available, but similar devices also can be made at home. Be careful not to harm the plant or to distribute pests around the garden. Repeated treatments may be necessary.

Conserve natural enemies and protect bees

The first line of defense against insect pests is their natural enemies. Spiders, praying mantids, lady beetles, ground beetles, green lacewings, ambush bugs, assassin bugs, minute pirate bugs and some wasp species prey on other insects. However, the most effective natural enemies

are tiny parasitic wasps and flies, together with bacteria, fungi and viruses.

Use pesticides only as a last resort; allow natural enemies to suppress the pest infestation. If a pesticide is required, select the least toxic, most target-specific varieties that decompose quickly.

Whether naturally occurring or deliberately released into the garden, these organisms should be encouraged. Natural enemies can be released in the garden to control pests. Lady beetles and green lacewing larvae eat aphids and whiteflies; predaceous mites eat two-spotted spider mites; and certain wasps parasitize specific insect pests. (*Trichogramma* species develop inside caterpillar eggs; and *Encarsia* species develop inside immature whiteflies.)

Companies that sell these natural enemies do not guarantee the results; factors such as the number of pests present, the environment, release times, prior pesticide use and the presence of ants can affect releases. Parasitic nematodes (Biosafe 100® and other products containing *Steinernema carpocapsae*) are available to control a variety of vegetable garden soil pests.

Bees are necessary for pollinating vegetables such as cucumbers, pumpkins, squash and melons, and should be protected. Do not apply pesticides during the hours when bees are active. Instead, treat plants when bees are not active—very early in the morning or late in the afternoon. Avoid using products or formulations toxic to bees. If a bee hive is located nearby, cover it during the pesticide application or protect the hive from pesticide drift.

Apply pesticides only when justified

If other measures have failed to control a pest population, a pesticide may be required. Because they are toxic and must be used carefully, pesticides are regulated by law and must be applied strictly according to label directions.

To control leaf-feeding insects, the pesticide must cover the undersides of leaves, which can be difficult to accomplish with dust-formulated products. When using liquids such as emulsifiable concentrates or wettable powders, mix the directed amount with water and spray immediately. Alkaline water may decompose the active ingredients if the solution is allowed to stand. Shake the mixture while treating. If spray

droplets bead up and roll off the treated foliage, an additive called a spreader-sticker such as Hi-Yield® Sticker-Spreader may be necessary. Spreader-sticker products are sold in most pesticide outlets. After treatment, clean the sprayer thoroughly, store the pesticides properly and wash the protective clothing separately from other laundry.

Policy statement

All pesticides are potentially hazardous to human health and the environment. Pesticide users are legally required to read and carefully follow all directions and safety precautions on the container label. Label instructions are subject to change, so read the label carefully before buying, using and disposing of any pesticide. Regardless of the information provided in an Extension publication, always follow the product's label. When in doubt about any instructions, contact the pesticide seller, or the manufacturer listed on the label, for clarification. Store all pesticides in their original labeled containers and keep them of the reach of children and pets. Never pour leftover pesticides down a drain.

Table 1 shows registered pesticides for use on home garden vegetables and common insect pests.

Product labels found in trade channels were the primary source of information in this table. This includes many, but not all, of the products available to the home vegetable grower.

A list of the products reviewed during preparation of the guide is provided in Table 2. Only a few products with a mixture of two or more active ingredients where reviewed for this guide. Because multiple active ingredients complicate the summary, these were not included in this table.

The column titled "Pesticides Registered" lists the common names of the chemicals with that particular vegetable listed on the label. "Pesticides Registered by Pest" are similarly the pesticides that have that pest on the label. *The pesticide label may not specifically state the combination of commodity and pest on a particular label. The user is responsible for reading and following directions on the label.*

Pests sometimes have several common names; additional common names are given in parentheses. Some labels have a general common name for a pest group listed under the pest name; specific examples are listed after the colon. In a few cases, the adult and immature forms have different common names and control measures. The control measures for each stage are indicated in the table, or both names are listed separately with different control measures. For example, immature cucumber beetles are called rootworms. This example includes several species that can be damaging in Texas, with adults that feed on flowers and foliage and larvae that feed on roots.

General use products

Some products have broad pest and site combinations on the product label. For example, the product label might just say "pests" on "vegetables." Some of these products are Green Light® Tomato & Vegetable Spray Read-to-Use (neem oil), Green Light® Neem Concentrate (neem oil), Green Light® Neem II Ready-to-Use (neem oil and pyrethrins), Green Light® Bioganic® series, Bonide® Bio-Neem, and some insecticidal soaps. Monterey® Worm-Ender® is a *Bacillus thuringiensis* product that is simply labeled for caterpillars (often referred to as worms) on vegetables. These products are not included in the table but can be considered legal uses for vegetables as listed on the product label.

Products for specific pests

Ants: Several ant species—fire ants and Texas leafcutting ants being the most severe—can be found in vegetable gardens. Control ants outside the garden if possible. Baits or mound treatments are preferred. Never apply a pesticide for an ant treatment inside the vegetable garden if vegetables are not listed on the product label. A mound drench of boiling water can be used inside the garden to control fire ants; be careful to avoid burning the applicator or the plants. For more information on fire ant management see http://fireants.tamu.edu.

Snails and slugs: Products containing metaldehyde are the primary control measures for snails and slugs. These products are granular baits, meal or pastes. Use metaldehyde products with caution around pets. Some snail and slug baits contain carbaryl and include other pests on the label. Iron phosphate and orthoboric acid also are active ingredients in some snail and slug baits. Most snail and slug baits may not be used on vegetables or in the garden; however, Green Light® Snail & Slug Bait states on the label that it can be used in the garden.

Grasshoppers and crickets: Grasshoppers and crickets may move into gardens rapidly, especially when winged. Protecting foliage with an insecticide may not be very successful if these insects invade in large numbers. Insecticides including carbaryl, esfenvalerate, malathion and azadirachtin are labeled for use on grasshoppers; bait formulations with carbaryl and some with a combination of carbaryl and metaldahyde also are available. Treating the grounds outside of the garden may help. Use barriers to protect the most valuable plants.

Sowbugs, pillbugs, millipedes, centipedes, mole crickets, cutworms, root maggots, mole crickets, wireworms, springtails and earwigs are soil pests that can be avoided by using winter or summer fallow periods. These pests may also be controlled with preplant treatments of insecticides in the soil. Some formulations of synergized pyrethrins and carbaryl are labeled for these pests. Some bait products may have these pests on the label. No home vegetable pesticide products were found with white grubs or wireworms on the label.

Additional publications on management of these pests can be found at http://insects.tamu.edu/extension/publications/index.cfm. The Vegetable IPM Web site has images of pests, their biology and a database of control measures. See http://vegipm.tamu.edu.

Additional pesticide precautions

Oil products may damage plants, especially in hot weather.

Bacillus thuringiensis products for caterpillars work best when the caterpillars are small.

Table 1: Registered pesticides for use on home garden vegetables and common insect pests.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
asparagus	azadirachtin (NA) carbaryl (1) insecticidal soap (0) malathion (1) permethrin (1-3) petroleum oil (0) pyrethrins (0) rotenone (1)	aphids	malathion permethrin
		asparagus beetle	carbaryl malathion permethrin petroleum oil pyrethrins rotenone
		cutworms	carbaryl permethrin
		thrips	carbaryl malathion

beans
 	
Comments: Pesticide restrictions are often different between succulent beans and dried beans. Read the label to check the restrictions.
	azadirachtin (NA)
	Bacillus thuringiensis (0)
	bifenthrin (3)
	carbaryl (3)
	   (14-21 dry beans)
	esfenvalerate (3)
	   (21 dry beans)
	insecticidal soap (0)
	malathion (1)
	permethrin (3)
	petroleum oil (NA)
	pyrethrins (NA)
	rotenone (1)
	spinosad (3)
		aphids: pea aphid	azadirachtin
			bifenthrin
			carbaryl
			esfenvalerate
			insecticidal soap
			malathion
			petroleum oil
			pyrethrins
			rotenone

		beetles: yellow-margined leaf beetle	carbaryl esfenvalerate petroleum oil pyrethrins rotenone
		blister beetles	pyrethrins
		cabbage looper	azadirachtin *Bacillus thuringiensis* bifenthrin esfenvalerate insecticidal soap pyrethrins rotenone
		corn earworm (tomato fruitworm, bollworm, soybean podworm)	bifenthrin carbaryl esfenvalerate permethrin pyrethrins spinosad
		cucumber beetles	bifenthrin carbaryl esfenvalerate malathion permethrin pyrethrins rotenone
		cutworms: black cutworm	azadirachtin bifenthrin carbaryl esfenvalerate pyrethrins spinosad

NA = no specific preharvest interval information was found on the label.
P = application is a preplant soil application. Such applications are for pests in the soil.
PHI = preharvest interval or the time from last application to harvest in days.

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
beans (cont.)		European corn borer	bifenthrin carbaryl esfenvalerate rotenone
		flea beetle	azadirachtin bifenthrin carbaryl esfenvalerate permethrin pyrethrins rotenone spinosad
		leafhoppers	azadirachtin bifenthrin carbaryl esfenvalerate insecticidal soap malathion permethrin petroleum oil pyrethrins rotenone
		leafminers: serpentine leafminer	azadirachtin esfenvalerate insecticidal soap petroleum oil spinosad
		Mexican bean beetle	azadirachtin bifenthrin carbaryl esfenvalerate malathion permethrin pyrethrins rotenone
		mites: spider mites	insecticidal soap malathion petroleum oil pyrethrins rotenone
		plant bugs: lygus	bifenthrin carbaryl esfenvalerate insecticidal soap permethrin pyrethrins rotenone
		saltmarsh caterpillar	bifenthrin esfenvalerate

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PHI = preharvest interval or the time from last application to harvest in days.

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
beans (cont.)		stink bugs	bifenthrin carbaryl esfenvalerate permethrin pyrethrins rotenone
		thrips: western flower thrips	azadirachtin carbaryl insecticidal soap petroleum oil pyrethrins rotenone spinosad
		velvetbean caterpillar	bifenthrin carbaryl esfenvalerate
		western bean cutworm	bifenthrin carbaryl esfenvalerate
		whiteflies	azadirachtin bifenthrin esfenvalerate insecticidal soap petroleum oil pyrethrins rotenone
		wireworms	no products labeled
beets (roots and tops) Comments: There are often differences in restrictions between table beets and beet greens.	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (3-7) (7 tops) insecticidal soap (0) malathion (7) petroleum oil (NA) pyrethrins (NA) rotenone (1)	aphids	azadirachtin insecticidal soap malathion petroleum oil pyrethrins rotenone
		armyworms: beet armyworm	azadirachtin carbaryl pyrethrins
		corn earworm	carbaryl
		flea beetles	azadirachtin carbaryl pyrethrins rotenone
		leafhoppers	carbaryl malathion
		mites	petroleum oil
		stink bugs	carbaryl pyrethrins rotenone
		webworms: beet webworm, garden webworm	carbaryl pyrethrins rotenone

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
bok choy (see lettuce)			
broccoli (see cole crops)			
Brussels sprouts (see cole crops)			
cabbage (see cole grops)			
cantaloupe (see melons)			
carrots	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (7-14) cyfluthrin (0) esfenvalerate (7) insecticidal soap (0) malathion (7) pyrethrins (NA) rotenone (1)	aphids	esfenvalerate malathion rotenone
		cutworm: black cutworm	azadirachtin carbaryl esfenvalerate
		flea beetles	azadirachtin carbaryl cyfluthrin esfenvalerate pyrethrins rotenone
		leafhoppers	azadirachtin carbaryl esfenvalerate insecticidal soap malathion pyrethrins rotenone
		mites: spider mites	insecticidal soap rotenone
		thrips	carbaryl cyfluthrin rotenone
		wireworms	no products labeled
		weevils: carrot weevil	esfenvalerate rotenone
cauliflower (see cole crops)			
celery	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (7-14) insecticidal soap (0) malathion (7) permethrin (1-3) pyrethrins (NA) rotenone (1) spinosad (1)	aphids	azadirachtin insecticidal soap malathion permethrin petroleum oil pyrethrins rotenone
		armyworms: beet armyworm, fall armyworm, southern armyworm	azadirachtin *Bacillus thuringiensis* carbaryl permethrin pyrethrins
		corn earworm	azadirachtin *Bacillus thuringiensis* carbaryl permethrin pyrethrins

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
celery (cont.)		cutworm: black cutworm	azadirachtin carbaryl *Bacillus thuringiensis* permethrin
		leafhoppers	azadirachtin carbaryl insecticidal soap permethrin petroleum oil pyrethrins rotenone
		leafminers: serpentine leafminer	azadirachtin insecticidal soap permethrin petroleum oil spinosad
		mites: spider mites	insecticidal soap malathion petroleum oil rotenone
		weevils: carrot weevil	rotenone
chives	azadirachtin (NA) *Bacillus thuringiensis* (0) insecticidal soap (0)		
cole crops: broccoli, Brussel sprouts, cabbage, cauliflower, kohlrabi Comments: Product labels vary greatly in regard to which crops are on the label and PHI.	azadirachtin (0) *Bacillus thuringiensis* (0) bifenthrin (7) carbaryl (3-14) esfenvalerate (3) insecticidal soap (0) lambda-cyhalothrin (1) malathion (3-7) permethrin (1-2) pyrethrins (0) rotenone (1) spinosad (1)	aphids: cabbage aphid, poplar-petiole gall aphid	azadirachtin bifenthrin esfenvalerate insecticidal soap lambda-cyhalothrin malathion permethrin petroleum oil pyrethrins rotenone
		armyworms: beet armyworm	azadirachtin bifenthrin carbaryl esfenvalerate lambda-cyhalothrin permethrin pyrethrins
		cabbage looper	azadirachtin *Bacillus thuringiensis* bifenthrin carbaryl esfenvalerate lambda-cyhalothrin permethrin pyrethrins rotenone spinosad

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PHI = preharvest interval or the time from last application to harvest in days.

Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
cole crops: broccoli, Brussel sprouts, cabbage, cauliflower, kohlrabi (cont.)		corn earworm (tomato fruitworm, bollworm, soybean podworm)	azadirachtin bifenthrin carbaryl esfenvalerate lambda-cyhalothrin permethrin pyrethrins
		cutworm: black cutworm	azadirachtin bifenthrin carbaryl esfenvalerate lambda-cyhalothrin permethrin
		diamondback moth	azadirachtin *Bacillus thuringiensis* bifenthrin carbaryl esfenvalerate lambda-cyhalothrin malathion permethrin pyrethrins rotenone spinosad
		flea beetle	azadirachtin bifenthrin carbaryl esfenvalerate lambda-cyhalothrin malathion permethrin pyrethrins rotenone
		imported cabbageworm	azadirachtin *Bacillus thuringiensis* bifenthrin carbaryl esfenvalerate lambda-cyhalothrin malathion permethrin pyrethrins rotenone spinosad
		harlequin bug	carbaryl malathion pyrethrins rotenone
		leafminers	permethrin spinosad
		mites: spider mites	lambda-cyhalothrin
		root maggots: cabbage maggot	azadirachtin

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
cole crops: broccoli, Brussel sprouts, cabbage, cauliflower, kohlrabi (cont.)		stink bugs	bifenthrin carbaryl esfenvalerate lambda-cyhalothrin permethrin rotenone
		thrips: western flower thrips	azadirachtin carbaryl insecticidal soap lambda-cyhalothrin permethrin petroleum oil pyrethrins rotenone
		weevils: vegetable weevil	bifenthrin esfenvalerate rotenone
		whiteflies: sweetpotato whitefly	azadirachtin bifenthrin esfenvalerate insecticidal soap lambda-cyhalothrin petroleum oil pyrethrins rotenone
collards (see greens)			

corn (sweet)	azadirachtin (NA)
	Bacillus thuringiensis (NA)
	bifenthrin (1)
	carbaryl (2)
	  (14 for forage or silage)
	  (48 for dry grain and fodder)
	cyfluthrin (0)
	esfenvalerate (1)
	insecticidal soap (0)
	malathion (5)
	permethrin (1-7)
	petroleum oil (0)
	pyrethrins (1)
	rotenone (1)
	spinosad (1)
		aphids: corn leaf aphid, English grain aphid	azadirachtin
			bifenthrin
			esfenvalerate
			insecticidal soap
			lambda-cyhalothrin
			malathion
			permethrin
			petroleum oil
			pyrethrins
			rotenone

		armyworms: fall armyworm, southern armyworm	azadirachtin bifenthrin carbaryl cyfluthrin esfenvalerate lambda-cyhalothrin permethrin pyrethrins
		chinch bugs	bifenthrin carbaryl cyfluthrin esfenvalerate lambda-cyhalothrin

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
corn (sweet) (cont.)		corn earworm (tomato fruitworm, bollworm, soybean podworm)	azadirachtin bifenthrin carbaryl cyfluthrin esfenvalerate lambda-cyhalothrin permethrin pyrethrins spinosad
		cucumber beetles	bifenthrin carbaryl esfenvalerate lambda-cyhalothrin malathion permethrin pyrethrins rotenone
		European corn borer	bifenthrin carbaryl esfenvalerate lambda-cyhalothrin permethrin rotenone
		flea beetles	azadirachtin bifenthrin carbaryl cyfluthrin esfenvalerate permethrin pyrethrins rotenone
		leafhoppers	bifenthrin carbaryl esfenvalerate insecticidal soap permethrin
		mites: spider mites	insecticidal soap lambda-cyhalothrin petroleum oil
		rootworms: southern, western, northern and Mexican corn rootworm; spotted corn rootworm; twelve spotted cucumber beetle	bifenthrin carbaryl esfenvalerate lambda-cyhalothrin malathion permethrin pyrethrins
		root maggots: seedcorn maggots	no label found
		sap beetles	carbaryl esfenvalerate lambda-cyhalothrin malathion permethrin

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
corn (sweet) (cont.)		stalk borers: lesser cornstalk borer, southwestern corn borer	azadirachtin bifenthrin carbaryl esfenvalerate lambda-cyhalothrin permethrin
		stink bugs	bifenthrin carbaryl cyfluthrin esfenvalerate lambda-cyhalothrin permethrin pyrethrins
		thrips	carbaryl cyfluthrin insecticidal soap lambda-cyhalothrin malathion
		wireworms	no label found
cow peas (see peas, southern)			
cucumbers	azadirachtin (NA) *Bacillus thuringiensis* (0) bifenthrin (3) carbaryl (3) esfenvalerate (3) insecticidal soap (0) malathion (1) permethrin (0-3) petroleum oil (NA) pyrethrins (1) rotenone (1) spinosad (1)	aphids: melon aphid or cotton aphid	azadirachtin bifenthrin esfenvalerate insecticidal soap malathion permethrin pyrethrins rotenone
		cabbage looper	azadirachtin *Bacillus thuringiensis* bifenthrin esfenvalerate permethrin pyrethrins rotenone
		cucumber beetles: southern corn rootworm	bifenthrin carbaryl esfenvalerate malathion permethrin pyrethrins rotenone
		cutworm: black cutworm	azadirachtin *Bacillus thuringiensis* bifenthrin carbaryl esfenvalerate permethrin
		flea beetles	bifenthrin carbaryl esfenvalerate permethrin rotenone

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
cucumbers (cont.)		leafhoppers	azadirachtin bifenthrin carbaryl esfenvalerate insecticidal soap permethrin petroleum oil pyrethrins
		leafminers: serpentine leafminer	azadirachtin esfenvalerate insecticidal soap malathion permethrin
		melonworm	azadirachtin *Bacillus thuringiensis* carbaryl permethrin rotenone
		mites: spider mites, two-spotted mites	insecticidal soap malathion petroleum oil pyrethrins rotenone
		pickleworm	azadirachtin bifenthrin carbaryl esfenvalerate permethrin rotenone
		plant bugs	bifenthrin esfenvalerate insecticidal soap permethrin pyrethrins
		squash bug	azadirachtin bifenthrin carbaryl esfenvalerate permethrin rotenone
		squash vine borer	azadirachtin bifenthrin esfenvalerate permethrin rotenone
		stink bugs	carbaryl bifenthrin esfenvalerate permethrin pyrethrins rotenone

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
cucumbers (cont.)		thrips: western flower thrips	carbaryl insecticidal soap petroleum oil pyrethrins rotenone spinosad
		whiteflies: sweetpotato whitefly	azadirachtin bifenthrin esfenvalerate insecticidal soap petroleum oil pyrethrins rotenone
eggplant	azadirachtin (NA) *Bacillus thuringiensis* (0) *Bacillus thuringiensis* var. *tenebrionis* (NA) bifenthrin (7) carbaryl (3-7) esfenvalerate (7) insecticidal soap (0) malathion (3) permethrin (3) petroleum oil (NA) pyrethrins (NA) rotenone (1) spinosad (1)	aphids	azadirachtin bifenthrin esfenvalerate insecticidal soap malathion permethrin petroleum oil pyrethrins rotenone

		Colorado potato beetle
		
		Comments: *Bacillus thuringiensis*
		  var. *tenebrionis* formulations
		  are specific for beetles.
			azadirachtin
			Bacillus thuringiensis var. *tenebrionis*
			bifenthrin
			carbaryl
			esfenvalerate
			permethrin
			pyrethrins
			rotenone
			spinosad

		cucumber beetles	bifenthrin carbaryl esfenvalerate permethrin pyrethrins rotenone
		flea beetles	azadirachtin bifenthrin carbaryl esfenvalerate insecticidal soap permethrin pyrethrins rotenone
		lace bugs: eggplant lace bug	carbaryl bifenthrin malathion
		leafhoppers	azadirachtin bifenthrin carbaryl esfenvalerate petroleum oil

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
eggplant (cont.)		leafminer: serpentine leafminer	azadirachtin esfenvalerate insecticidal soap permethrin petroleum oil spinosad
		mites: broad mite, spider mites	insecticidal soap malathion petroleum oil rotenone
		whiteflies: sweetpotato whitefly	azadirachtin bifenthrin esfenvalerate insecticidal soap petroleum oil pyrethrins rotenone
greens: Chinese cabbage, collards, kale, mustard greens, turnip greens Comments: Registration for specific crops varies between product labels. Check the label for specifics.	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (14) esfenvalerate (7) insecticidal soap (0) lambda-cyhalothrin (1) malathion (7) permethrin (1) pyrethrins (NA) rotenone (1) spinosad (1)	aphids	azadirachtin esfenvalerate insecticidal soap lambda-cyhalothrin malathion permethrin pyrethrins
		armyworms: beet armyworm	azadirachtin carbaryl esfenvalerate lambda-cyhalothrin permethrin pyrethrins
		beetles: yellow-margined leaf beetle	esfenvalerate pyrethrins
		cabbage looper	azadirachtin *Bacillus thuringiensis* esfenvalerate lambda-cyhalothrin permethrin pyrethrins
		diamondback moth	azadirachtin *Bacillus thuringiensis* carbaryl esfenvalerate lambda-cyhalothrin malathion permethrin pyrethrins
		flea beetles	azadirachtin carbaryl esfenvalerate lambda-cyhalothrin malathion permethrin pyrethrins

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
greens: Chinese cabbage, collards, kale, mustard greens, turnip greens (cont.)		harlequin bug	carbaryl malathion
		imported cabbageworm	azadirachtin *Bacillus thuringiensis* carbaryl esfenvalerate lambda-cyhalothrin malathion permethrin pyrethrins
		leafhoppers	azadirachtin carbaryl esfenvalerate permethrin pyrethrins rotenone
		mites: spider mites	insecticidal soap lambda-cyhalothrin
herbs	azadirachtin (NA) *Bacillus thuringiensis* (0) insecticidal soap (0)		
horseradish	azadirachtin (NA) carbaryl (7-14) permethrin (22) pyrethrins (NA)	imported crucifer weevils	permethrin
kale (see greens)			
kohlrabi (see cole crops)			
lettuce Comments: Registration status may vary for head lettuce or leaf lettuce. Check the label for specifics.	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (7-14) insecticidal soap (0) lambda-cyhalothrin (1) malathion (7) permethrin (1) petroleum oil (NA) pyrethrins (NA) rotenone (1) spinosad (1)	aphids: red lettuce aphid, green peach aphid	azadirachtin insecticidal soap lambda-cyhalothrin malathion permethrin petroleum oil pyrethrins rotenone
		armyworms: beet armyworm, southern armyworm	azadirachtin carbaryl lambda-cyhalothrin permethrin pyrethrins
		beetles: yellow-margined leaf beetle	pyrethrins
		cabbage looper	azadirachtin *Bacillus thuringiensis* insecticidal soap lambda-cyhalothrin malathion permethrin pyrethrins rotenone

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
lettuce (cont.)		corn earworm (bollworm, tomato fruitworm, soybean podworm)	azadirachtin carbaryl lambda-cyhalothrin permethrin pyrethrins
		cutworm: black cutworm	azadirachtin carbaryl lambda-cyhalothrin permethrin
		diamondback moth	azadirachtin *Bacillus thuringiensis* lambda-cyhalothrin permethrin pyrethrins
		flea beetles	azadirachtin carbaryl lambda-cyhalothrin pyrethrins rotenone
		imported cabbageworm	azadirachtin *Bacillus thuringiensis* carbaryl lambda-cyhalothrin permethrin pyrethrins rotenone
		leafhoppers	azadirachtin carbaryl insecticidal soap malathion permethrin petroleum oil pyrethrins rotenone
		leafminers: serpentine leafminer, vegetable leafminer	azadirachtin insecticidal soap permethrin petroleum oil spinosad
		thrips: western flower thrips	azadirachtin carbaryl insecticidal soap lambda-cyhalothrin petroleum oil pyrethrins rotenone spinosad
		whiteflies	azadirachtin insecticidal soap lambda-cyhalothrin pyrethrins

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
melons Comments: Specific melon types may be listed on some of the labels. Check product labels for specific restrictions.	azadirachtin (NA) *Bacillus thuringiensis* (0) bifenthrin (3) carbaryl (3) esfenvalerate (3) insecticidal soap (0) malathion (1) permethrin (0) pyrethrins (0) rotenone (1) spinosad (3)	aphids: melon aphid or cotton aphid	azadirachtin bifenthrin esfenvalerate insecticidal soap malathion permethrin petroleum oil pyrethrins rotenone
		cabbage looper	azadirachtin *Bacillus thuringiensis* bifenthrin esfenvalerate permethrin pyrethrins rotenone
		cucumber beetles: southern corn rootworm	bifenthrin carbaryl esfenvalerate malathion permethrin pyrethrins rotenone
		cutworm: black cutworm	azadirachtin bifenthrin carbaryl esfenvalerate permethrin
		leafminer: serpentine leafminer	azadirachtin esfenvalerate insecticidal soap permethrin petroleum oil spinosad
		melonworm	azadirachtin *Bacillus thuringiensis* carbaryl permethrin rotenone
		mites: spider mites	insecticidal soap malathion petroleum oil rotenone
		pickleworm	azadirachtin bifenthrin carbaryl esfenvalerate malathion permethrin rotenone

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
melons (cont.)		squash bug	azadirachtin bifenthrin carbaryl esfenvalerate permethrin rotenone
		squash vine borer	azadirachtin bifenthrin esfenvalerate permethrin rotenone
		stink bugs	bifenthrin carbaryl esfenvalerate permethrin pyrethrins rotenone
		thrips: western flower thrips	carbaryl insecticidal soap petroleum oil pyrethrins rotenone spinosad
		whiteflies: sweetpotato whitefly	azadirachtin bifenthrin esfenvalerate insecticidal soap petroleum oil pyrethrins rotenone
muskmelon (see melons)			
mustard greens (see greens)			
okra	carbaryl (3) permethrin (1) pyrethrins (0) spinosad (1)	aphids	permethrin pyrethrins
		corn earworm (bollworm, tomato fruitworm, soybean podworm)	carbaryl permethrin pyrethrins spinosad
		lacebugs	carbaryl
		leafminers	spinosad
		stink bugs	carbaryl pyrethrins
onions Comments: Dry onions may be on the label as a separate site. Some labels also include garlic.	azadirachtin (NA) *Bacillus thuringiensis* (0) insecticidal soap (0) lambda-cyhalothrin (14) malathion (3) permethrin (1) pyrethrins (1) rotenone (1)	armyworms: beet armyworm	azadirachtin lambda-cyhalothrin permethrin

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
onions (cont.)		cutworm: black cutworm	azadirachtin lambda-cyhalothrin permethrin
		root maggots: onion maggot	azadirachtin malathion lambda-cyhalothrin permethrin
		thrips: onion thrips, western flower thrips	insecticidal soap malathion lambda-cyhalothrin petroleum oil permethrin rotenone
		wireworms	no products labeled
parsley	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (7-14) insecticidal soap (0) malathion (21) permethrin (1) pyrethrins (0) spinosad (1)	aphids	azadirachtin insecticidal soap malathion permethrin pyrethrins
		armyworms	azadirachtin carbaryl permethrin pyrethrins
		flea beetles	azadirachtin carbaryl malathion permethrin pyrethrins
		weevils: carrot weevil	no product labeled
peas (English, green, succulent) Comments: Dry peas have different restrictions. Read the label for information.	azadirachtin (NA) bifenthrin (3) carbaryl (0-3) (21 dry) esfenvalerate (3) (21 dry) insecticidal soap (0) malathion (3) pyrethrins (0-1) rotenone (1) spinosad (3)	aphids: pea aphid	azadirachtin bifenthrin esfenvalerate insecticidal soap malathion pyrethrins rotenone
		armyworms	azadirachtin bifenthrin esfenvalerate pyrethrins spinosad
		cutworm: black cutworm	azadirachtin bifenthrin esfenvalerate
		leafhoppers	azadirachtin bifenthrin esfenvalerate insecticidal soap pyrethrins rotenone

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P = application is a preplant soil application. Such applications are for pests in the soil.
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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
peas (English, green, succulent) (cont.)		leafminers	azadirachtin esfenvalerate insecticidal soap spinosad
		loopers: alfalfa looper	azadirachtin bifenthrin esfenvalerate insecticidal soap pyrethrins
		stink bugs	esfenvalerate bifenthrin pyrethrins rotenone
		wireworms	no products labeled
peas (southern, blackeyed, crowder, cowpeas) Comments: Succulent use has different restrictions than dry pea use. Read the label for specifics.	bifenthrin (3) carbaryl (3) (21 dry) malathion (1) pyrethrins (NA) spinosad (3)	aphids: cowpea aphid	bifenthrin insecticidal soap malathion pyrethrins
		caterpillars	spinosad
		cowpea curculio	bifenthrin carbaryl
		leafminers	spinosad
		thrips	insecticidal soap spinosad
peppers	azadirachtin (NA) bifenthrin (7) carbaryl (3-7) cyfluthrin (7) esfenvalerate (7) insecticidal soap (0) malathion (3) permethrin (3) petroleum oil (NA) pyrethrins (NA) rotenone (1) spinsodad (1)	aphids: green peach aphid, melon aphid or cotton aphid	azadirachtin bifenthrin esfenvalerate insecticidal soap malathion permethrin petroleum oil pyrethrins rotenone
		armyworms: beet armyworm	azadirachtin *Bacillus thuringiensis* bifenthrin carbaryl esfenvalerate permethrin pyrethrins
		cabbage looper	*Bacillus thuringiensis* bifenthrin cyfluthrin esfenvalerate permethrin spinosad
		cutworms: black cutworm	azadirachtin bifenthrin carbaryl esfenvalerate permethrin

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
peppers (cont.)		corn earworm (tomato fruitworm, bollworm, soybean podworm)	azadirachtin bifenthrin carbaryl cyfluthrin esfenvalerate permethrin pyrethrins
		European corn borer	bifenthrin carbaryl cyfluthrin esfenvalerate permethrin
		flea beetles	azadirachtin bifenthrin carbaryl esfenvalerate permethrin pyrethrins rotenone
		leafminers: serpentine leafminer	azadirachtin cyfluthrin esfenvalerate insecticidal soap permethrin petroleum oil spinosad
		mites: broad mites, spider mites	insecticidal soap petroleum oil rotenone
		psyllids: potato psyllid	bifenthrin esfenvalerate permethrin pyrethrins
		thrips: western flower thrips	carbaryl cyfluthrin insecticidal soap petroleum oil pyrethrins rotenone spinosad
		weevils: pepper weevil, vegetable weevil	bifenthrin cyfluthrin esfenvalerate permethrin rotenone
		whiteflies	bifenthrin esfenvalerate petroleum oil

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest

potatoes (Irish, white)	azadirachtin (NA)
	Bacillus thuringiensis (0)
	Bacillus thuringiensis var.
	  tenebrionis (NA)
	carbaryl (0-14)
	esfenvalerate (7)
	insecticidal soap (0)
	malathion (0)
	permethrin (7-14)
	petroleum oil (NA)
	pyrethrins (0)
	rotenone (1)
	spinosad (7)
		aphids: green peach aphid,
		  melon aphid or cotton aphid
			azadirachtin
			esfenvalerate
			insecticidal soap
			malathion
			permethrin
			petroleum oil
			pyrethrins
			rotenone

		cabbage looper	*Bacillus thuringiensis* esfenvalerate permethrin
		Colorado potato beetle	azadirachtin *Bacillus thuringiensis* var. *tenebrionis* carbaryl esfenvalerate permethrin pyrethrins rotenone spinosad
		cutworms: black cutworm, variegated cutworm	azadirachtin *Bacillus thuringiensis* esfenvalerate permethrin
		cucumber beetles	carbaryl esfenvalerate permethrin pyrethrins
		European corn borer	azadirachtin carbaryl esfenvalerate permethrin
		flea beetles	azadirachtin carbaryl esfenvalerate permethrin pyrethrins rotenone
		leaffooted bug	no products labeled
		leafhoppers	azadirachtin carbaryl esfenvalerate insecticidal soap malathion permethrin petroleum oil pyrethrins rotenone
		leafminers	permethrin petroleum oil spinosad

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
potatoes (Irish, white) (cont.)		plant bugs: tarnished plant bug, lygus bug	carbaryl esfenvalerate insecticidal soap permethrin petroleum oil pyrethrins rotenone
		psyllids: potato psyllid	azadirachtin esfenvalerate insecticidal soap permethrin pyrethrins
		stink bugs	carbaryl esfenvalerate permethrin rotenone
		wireworms	no products labeled
pumpkin (see squash)			
radishes	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (3-14) cyfluthrin (0) esfenvalerate (7) insecticidal soap (0) malathion (0-7) petroleum oil (NA) pyrethrins (0) rotenone (1)	aphids	azadirachtin esfenvalerate insecticidal soap malathion petroleum oil pyrethrins
		beetles: yellow-margined leaf beetle	esfenvalerate petroleum oil pyrethrins
		cabbage looper	azadirachtin *Bacillus thuringiensis* cyfluthrin esfenvalerate pyrethrins
		flea beetle	azadirachtin cyfluthrin carbaryl esfenvalerate pyrethrins
rhubarb	azadirachtin (NA) permethrin (1) pyrethrins (0) spinosad (1)		
rutabagas	azadirachtin (NA) carbaryl (3-14) *Bacillus thuringiensis* (0) insecticidal soap (0) malathion (3) pyrethrins (0) rotenone (1)	aphids	azadirachtin malathion pyrethrins
		cabbage looper	azadiractin *Bacillus thuringiensis* pyrethrins

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
spinach	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (7-14) insecticidal soap (0) malathion (7) permethrin (1-7) pyrethrins (0) rotenone (1) spinosad (1)	aphids	azadirachtin insecticidal soap malathion permethrin pyrethrins
		armyworms: beet armyworm	azadirachtin *Bacillus thuringiensis* carbaryl permethrin pyrethrins spinosad
		cabbage looper	azadirachtin *Bacillus thuringiensis* permethrin pyrethrins spinosad
		corn earworm	carbaryl permethrin
		cutworm: black cutworm	azadirachtin carbaryl permethrin spinosad
		European corn borer	carbaryl permethrin
		flea beetles	azadirachtin carbaryl permethrin pyrethrins
		leafhoppers	carbaryl permethrin spinosad
		webworms: garden webworm	azadirachtin *Bacillus thuringiensis* pyrethrins spinosad
squash Comments: Product labels differ in the statements regarding winter squash, summer squash, pumpkin, etc. Read the product labels for specifics.	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (3) bifenthrin (3) esfenvalerate (3) insecticidal soap (0) malathion (1-7) permethrin (0) petroleum oil (NA) pyrethrins (0) rotenone (1) spinosad (3)	aphids: melon aphid or cotton aphid	azadirachtin bifenthrin esfenvalerate insecticidal soap malathion permethrin petroleum oil pyrethrins rotenone
		cabbage looper	azadirachtin *Bacillus thuringiensis* bifenthrin esfenvalerate permethrin pyrethrins rotenone

NA = no specific preharvest interval information was found on the label.
P = application is a preplant soil application. Such applications are for pests in the soil.
PHI = preharvest interval or the time from last application to harvest in days.

Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
squash (cont.)		cucumber beetles: southern corn rootworm	bifenthrin carbaryl esfenvalerate malathion permethrin pyrethrins rotenone
		cutworm: black cutworm	azadirachtin bifenthrin carbaryl esfenvalerate permethrin
		leafhoppers	carbaryl esfenvalerate insecticidal soap permethrin
		leafminer: serpentine leafminer, vegetable leafminer	azadirachtin esfenvalerate insecticidal soap permethrin petroleum oil spinosad
		melonworm	azadirachtin carbaryl permethrin rotenone
		mites: spider mites, two-spotted mites	insecticidal soap malathion petroleum oil rotenone
		pickleworm	azadirachtin bifenthrin carbaryl esfenvalerate malathion permethrin rotenone
		squash bug	azadirachtin bifenthrin carbaryl esfenvalerate malathion permethrin rotenone
		squash vine borer	azadirachtin bifenthrin esfenvalerate malathion permethrin rotenone

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PHI = preharvest interval or the time from last application to harvest in days.

Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
squash (cont.)		stink bugs	carbaryl bifenthrin esfenvalerate permethrin pyrethrins rotenone
		thrips: western flower thrips	carbaryl petroleum oil pyrethrins rotenone spinosad
		whiteflies: sweetpotato whitefly	azadirachtin bifenthrin esfenvalerate petroleum oil pyrethrins rotenone
strawberries	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (7) insecticidal soap (0) permethrin (14) petroleum oil (NA) pyrethrins (NA) rotenone (1) spinosad (1)		
sweet corn (see corn)			
sweet potatoes	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (7) insecticidal soap (0) malathion (3) pyrethrins (NA) spinosad (7)	beetles: tortoise beetles	carbaryl pyrethrins
		cutworm: black cutworm	azadirachtin carbaryl
		flea beetles	azadirachtin carbaryl pyrethrins
		leafhoppers	carbaryl malathion
		sweetpotato weevil	carbaryl
		wireworms	no products labeled
Swiss chard	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (7-14) insecticidal soap (0) malathion (7) permethrin (1) pyrethrins (0) rotenone (1) spinosad (1)	aphids	azadirachtin insecticidal soap malathion permethrin pyrethrins rotenone
		armyworms: beet armyworm	azadirachtin carbaryl permethrin pyrethrins spinosad

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P = application is a preplant soil application. Such applications are for pests in the soil.
PHI = preharvest interval or the time from last application to harvest in days.

Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
Swiss chard (cont.)		flea beetles	azadirachtin carbaryl permethrin pyrethrins
		stink bugs	carbaryl permethrin pyrethrins
		webworms: beet webworm, garden webworm	azadirachtin pyrethrins spinosad
tomatoes	azadirachtin (NA) *Bacillus thuringiensis* (0) *Bacillus thuringiensis* var. *tenebrionis* (NA) bifenthrin (1) carbaryl (3) cyfluthrin (0) esfenvalerate (1) insecticidal soap (0) lambda-cyhalothrin (5) malathion (1-7) permethrin (0) petroleum oil (NA) pyrethrins (0) rotenone (1) spinosad (1)	aphids	azadirachtin bifenthrin esfenvalerate insecticidal soap lambda-cyhalothrin malathion permethrin petroleum oil pyrethrins rotenone
		armyworms: beet armyworm, fall armyworm, southern armyworm	azadirachtin *Bacillus thuringiensis* bifenthrin carbaryl cyfluthrin esfenvalerate lambda-cyhalothrin permethrin pyrethrins spinosad
		cabbage looper	azadirachtin *Bacillus thuringiensis* bifenthrin cyfluthrin esfenvalerate lambda-cyhalothrin permethrin pyrethrins rotenone spinosad
		cutworms: black cutworm	azadirachtin *Bacillus thuringiensis* bifenthrin carbaryl cyfluthrin esfenvalerate lambda-cyhalothrin permethrin

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Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
tomatoes (cont.)		flea beetles	azadirachtin bifenthrin carbaryl cyfluthrin esfenvalerate lambda-cyhalothrin permethrin pyrethrins rotenone
		leaffooted bug	no products labeled
		leafminers: serpentine leafminer	azadirachtin cyfluthrin esfenvalerate insecticidal soap lambda-cyhalothrin permethrin petroleum oil spinosad
		mites: spider mites	insecticidal soap malathion petroleum oil rotenone
		stink bugs	carbaryl bifenthrin cyfluthrin esfenvalerate lambda-cyhalothrin permethrin pyrethrins rotenone
		thrips: western flower thrips	carbaryl cyfluthrin insecticidal soap lambda-cyhalothrin petroleum oil pyrethrins rotenone spinosad
		tomato pinworm	azadirachtin bifenthrin carbaryl cyfluthrin esfenvalerate lambda-cyhalothrin permethrin rotenone

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P = application is a preplant soil application. Such applications are for pests in the soil.
PHI = preharvest interval or the time from last application to harvest in days.

Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
tomatoes (cont.)		tomato hornworm (tobacco hornworm is a close relative)	*Bacillus thuringiensis* bifenthrin carbaryl cyfluthrin esfenvalerate lambda-cyhalothrin permethrin rotenone
		tomato fruitworm (corn earworm, bollworm, soybean podworm)	azadirachtin *Bacillus thuringiensis* bifenthrin carbaryl esfenvalerate lambda-cyhalothrin permethrin pyrethrins
		whiteflies: sweetpotato whitefly	azadirachtin bifenthrin esfenvalerate insecticidal soap lambda-cyhalothrin petroleum oil pyrethrins rotenone
turnips Comments: The site generally refers to roots. Also see greens for turnip tops.	azadirachtin (NA) *Bacillus thuringiensis* (0) carbaryl (3-14) (7-14 tops) insecticidal soap (0) malathion (3) pyrethrins (NA) rotenone (1)	aphids	azadirachtin insecticidal soap malathion pyrethrins
		blister beetle	pyrethrins
		flea beetles	carbaryl
		stink bugs: harlequin bug	carbaryl
		weevils: vegetable weevil	no products labeled
watermelon Comments: Also see melons.	azadirachtin (NA) *Bacillus thuringiensis* (0) bifenthrin (3) carbaryl (3) malathion (1) permethrin (0) pyrethrins (0) rotenone (1) spinosad (1-3)	aphids: melon aphid or cotton aphid	azadirachtin bifenthrin malathion permethrin pyrethrins
		armyworms: beet armyworm	azadirachtin bifenthrin carbaryl permethrin pyrethrins
		cabbage looper	azadirachtin bifenthrin permethrin pyrethrins
		cucumber beetle	bifenthrin carbaryl malathion permethrin pyrethrins

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PHI = preharvest interval or the time from last application to harvest in days.

Table 1 continued.

Vegetable	Registered Pesticides (PHI)	Common Insect Pests	Pesticides Registered by Pest
watermelon (cont.)		cutworm: black cutworm	azadirachtin bifenthrin carbaryl permethrin
		leafminers: serpentine leafminer	azadirachtin permethrin spinosad
		mites: spider mites	malathion
		melonworm	carbaryl permethrin spinosad
		pickleworm	bifenthrin permethrin spinosad
		squash bug	azadirachtin bifenthrin carbaryl permethrin
		thrips: western flower thrips	carbaryl pyrethrins spinosad
		webworms: garden webworm	azadirachtin carbaryl pyrethrins
		whiteflies: sweetpotato whitefly	azadirachtin bifenthrin insecticidal soap pyrethrins

Table 2. Insecticides and example product names.

Insecticide (generic name of active ingredients)	Example Product Names
azadirachtin	Gordon's® Garden Guard Liquid insecticide Neemix® 4.5, Certis
B.t., *Bacillus thuringiensis* var. *kurstaki* (and other caterpillar products)	Bonide® Dipel® 150 Dust Bonide® Thuricide® Bacillus Thuringiensis (BT) Green Light® Bt WormKiller Home & Garden Dipel® Dust, Southern Agriculture Insecticides, Inc. Monterey® Worm-Ender Thuricide® HPC, Southern Agriculture Insecticides, Inc.
B.t., *Bacillus thuringiensis* var. *tenebrionis* (and others for beetles)	Bonide® Colorado Potato Beetle Beater Concentrate (spinosad is also formulated under this name)
bifenthrin	OrthoMax Lawn & Garden Insect Killer
carbaryl	Bayer® Advanced™ Complete Insect Killer for Gardens Bonide® Bug Beater® Yard & Garden Granules Bonide® Eight™ Insect Control, Yard & Garden Granules Cutworm & Cricket Bait, Southern® Agricultural Insecticides, Inc. Garden Tech Sevin-5 Gordon's Dura-Dust® 5% Carbaryl Insecticide Mole Cricket Bait, Southern® Agricultural Insecticides, Inc.
cyfluthrin	Bayer® Advanced™ Power Force Multi-Insect Killer Concentrate Bayer® Advanced™ Power Force Multi-Insect Killer Ready-to-Spray Bayer® Advanced™ Power Force Multi-Insect Killer Ready-to-Use
esfenvalerate	Bonide® Bug Beater, Home and Garden Insect Control, Ready to Use Evercide® EC 2668, MGK® Evercide® EC 28051, MGK® Monterey® Bug Buster
insecticidal soap	Bonide® Bon-Neem Insecticidal Soap Ready to Use Bonide® Insecticidal Soap, Multi-Purpose Insect Control Concentrate
iron phosphate	Bayer® Advanced™ Snail & Slug Killer Bait Sluggo® Monterey
lambda-cyhalothrin	Martin's Cyonara® Lawn & Garden Insect Control
malathion	Bonide® Malathion® Insect Control Concentrate Gordon's® Malathion 50% Spray for Flies and Garden Insects Spectracide® Malathion® Insect Spray Concentrate
metaldehyde	Deadline® Bullets Deadline® T&O™ mini pellets, AMVAC Monterey® 7½% Snail-Slug Granules Monterey® Slug-it! Monterey® Snail-Slug Concentrate Monterey® Snail-Slug Slayer Bonide® No Escape™ Slug & Snail Killer Bonide® Slug Magic Snail & Slug Bait, Southern Agricultural Insecticides, Inc.
orthoboric acid	Green Light® Snail & Bug Bait
neem oil extracts (some also contain pyrethrins)	Bonide® Tomato & Vegetable, 3 in 1 70% Neem™ Oil, Certis™ Bon-Neem™ Insecticidal Soap

(continued on next page)

Table 2 continued.

Insecticide (generic name of active ingredients)	Example Product Names
permethrin	Bayer® Advanced™ Complete Insect Dust for Gardens Bonide® Borer Miner Killer Concentrate Bonide® Bug Beater® Garden & Pet Insect Control, Dust Bonide® Bug Beater® Yard & Garden Insect Control Bonide® Eight™ Insect Control, Garden Dust Bonide® Eight™ Insect Control, Garden & Home Bonide® Eight™ Insect Control, Vegetable, Fruit & Flower Bonide® Eight™ Insect Control, Yard & Garden Bonide® Home Garden & Pet Dust Evercide® Permethrin Dust, MGK® Garden Insect Dust with Permethrin, Southern Agricultural Insecticides, Inc. Gordon's® Bug-No-More® Yard & Garden Insect Spray Green Light® Borer Killer Monterey Hose'em® Fruit & Vegetable Insect Spray
petroleum oil (paraffinic oil)	Bonide® All Seasons® Horticultural & Dormant Spray Bonide® All Seasons® Horticultural and Dormant Spray Oil Monterey® Saf-T-Side®
pyrethrins (some also have canola oil or piperonyl butoxide)	Bonide® Eight Insect Control, Flower & Garden Spray Gordon's® Garden Guard® Gordon's® Liquid Garden Guard Monterey® Bug Buster® - O Monterey® Take Down Spray Ready to Use Monterey® Take Down Garden Spray Natural Pyrethrins Concentrate, Southern Agricultural Insecticides, Inc. Pyrocide® Indoor/Outdoor Insect Killer, MGK Pyrocide® Home and Garden Spray, MGK Spectricide® Garden Insect Killer
rotenone (usually with cube extracts; some have copper)	Bonide® Garden Dust for Fruit, Vegetables and Flowers Bonide® Rotenone 1.00% Dust
rotenone + pyrethrins	Bonide® Liquid Rotenone-Pyrethrins Spray
spinosad	Conserve® Naturalyte® Insect Control, Southern Agricultural Insecticides, Inc. Conserve SC, Turf and Ornamental, Dow Agroscience Fertilome® Borer, Bagworm, Leafminer & Tent Caterpillar Spray Monterey Garden Insect Spray
oils (thyme oil, clove oil, rosemary oil and sesame oil, etc.)	Bonide® Mite X, Ready to Use Monterey Phyta-Guard EC

Table 3. Chemical classes and mode of action.

Insecticide Class	Examples	Mode of Action
botanical	azadirachtin	• Insect growth regulator which inhibits molting
	pyrethrins	• Derived from a dried pyrethrum daisy flower head • Provides quick "knockdown" by destabilizing nerve cell membranes
	rotenone	• Derived from several tropical legume roots such as derris and cube root • Inhibits cellular respiration primarily in nerve and muscle cells causing death in hours or days after exposure
synthetic pyrethroid	bifenthrin cyfluthrin esfenvalerate permethrin	• Synthetic compounds related to natural pyrethrins • Destabilizes nerve cell membranes
carbamate	carbaryl metaldehyde	• Inhibits cholinesterase, preventing the termination of nervous impulses
inorganic	iron phosphate	• Causes pathological changes on a cellular basis in slug and snail crop and hepatopancreas
	orthoboric acid	• Acts when ingested and destroys the foregut epithelium, slow acting
	sulfur	• Elemental sulfur, when ingested causes dehydration and electrolyte depletion
microbial	*Bacillus thuringiensis*	• Bacteria-produced spores and delta endotoxin, which cause disruption of the stomach lining of certain leaf feeding caterpillars, beetles and fly larvae
spinosyns	spinosad	• Extract of *Actinomycetes* fungus Activates nerve receptors with a unique mechanism
organophosphate	malathion	• Inhibits cholinesterase, preventing the termination of nervous impulses
insecticidal soaps and oils	insecticidal soap neem oil paraffinic oil	• Derived from animal byproducts (fat) or plant oils, or petroleum-based • Causes physical disruption of the insect cuticle, resulting in water imbalance