Home Vegetables

Introduction for Home Vegetable Insect Section 2-1
Organic Controls for Insects 2-2
Table 2.1 - Organic Products and Predators 2-2
Vegetable Insects 2-5
Table 2.2 - Insecticides 2-5
Vegetable Diseases 2-18
Overview 2-18
General Cultural Controls 2-18
General Biological Controls 2-19
General Mechanical Controls 2-19
General Chemical Controls 2-19
Precautions 2-19
Factsheets 2-20
Virginia Tech Diagnostic and Identification Laboratories 2-20
Table 2.3 – Fungicide brands available for Home Vegetable Gardens 2-21
Table 2.4 - Disease Management Tools for Specific Crops and Diseases 2-22
Table 2.5 - Nematode Disease Control in Home Vegetables 2-24
Weed Management in Home Vegetable Gardens 2-25
Overview 2-25
General Cultural Controls 2-25
General Biological Controls 2-25
General Chemical Controls 2-26
Index 2-27

Introduction for Home Vegetable Insect Section

Eric R. Day, Extension Entomologist, Virginia Tech

Insect pests are rarely a problem on vigorous plants that are adapted for the climate zone where you have your home vegetable garden. Consult the Virginia Cooperative Extension publication, *Vegetables Recommended for Virginia* #426-480 for vegetables recommended for Virginia.

The following tips adapted from Integrated Pest Management for Vegetable Gardens, Publication 426-708 will help in reducing insect and mite problems:

- Plant crops and varieties that are well suited to the soil and climate, and recommended by Virginia Cooperative Extension and the Virginia Tech Department of Horticulture.

- If possible, select for insect -resistance in vegetable varieties.

- Inspect transplants when purchasing so that they are insect pest free. Insects in young seedlings may start in greenhouses or plant beds and cause heavy losses in the garden.

- Develop a calendar, but writing down the time of year you find a particular pest and if control was needed. Refer to in next year to check for earlier signs of infestations. A daily walk in the garden will do a world of good.

- Space plants properly and thin young vegetables to a proper stand. Overcrowding causes weak growth and reduces air movement, resulting in increased insect problems.

- Keep down weeds and grass. They often harbor insect and mite pests.

- Rotate your garden plot, if you can. Do not grow the same kind of produce in the same place each year. Use related crops in one site only once every three or four years. Avoid mixing soils in areas by forming permanent raised beds with distinct borders.

- Gardens growing in areas that were turf or grass the year before will often have white grub and wireworm problems the first year or two. Consider using a planting time soil insecticide.

- Time plantings in such a way that the majority of your crop will avoid the peak of insect infestations. For example, plant cucurbits as in mid June to avoid squash bug and cucumber beetles. Plant beans in early May so that they mature before Mexican bean beetles build up and cause damage.

- Use a row covers over cucurbits from time of planting to just before bloom to avoid squash vine borer.

- Keep a record of the dates insect problems occur to use as a guide for following years.

- Inspect plants for egg clusters, beetles, caterpillars, and other insects as often as possible. Handpick as many pests as you can. Avoid sprays until the population of insects has reached a critical threshold level.

- Where slugs are a problem, use approved baits and traps and try to create drier conditions. *Heavy mulches may encourage slugs*. Diatomaceous earth, crushed eggshells, beer baits, and hydrated lime near plants may help deter slug activity.

- Insecticides are valuable tools for dealing with insect problems, make sure the insecticide is labeled for the crop you are protecting and be sure to read the label before mixing and applying.

- Encourage Beneficial Insects by tolerating insect damage and not spraying. Naturally occurring predators and parasites are found in gardens, orchards, and fields. Learn to properly identify these species as benefits of your environment. Avoid using pesticides around them. They are as susceptible to insecticides as the pests.

Organic Controls for Insects

Eric R. Day, Extension Entomologist, Virginia Tech

Table 2.1 - Organic Products and Predators

Product[1]	Insects Controlled	Remarks
Azadirachtin	Beetles, Aphids, Caterpillars, Others	Various Trade names
Bacillus thuringiensis	Most caterpillars, loopers, hornworms, bagworms	This product, also known as *Bt*, is sold under many trade names.
Beauveria bassiana	Beetles, Aphids, Others	Various Trade names
Foil, M-One, M-Track, Novodor	Colorado potato beetle	Two strains of *Bt* will control potato beetles: *Bacillus thuringiensis* ssp. *san diego* is genetically engineered and therefore is not allowed in certified organic production. On the other hand, *B. thuringiensis* ssp. *tenebrionis*, a form of *Bt* that is not genetically engineered, can be used by organic producers.
Hot Pepper Wax	Aphids, mites, thrips	See label for precautions.
Insecticidal soap	Works well on soft bodied insects, in particular aphids, mites, mealybugs	This product is sold under many trade names and is a fatty acid soap.
Kaolin clay	Beetles, Aphids, Caterpillars, Others	Various Trade names
Neem	Broad spectrum	See label for precautions.
Pyrethrin	Broad spectrum; works on a wide variety of insects	Usually sold mixed with other botanical insecticides such as rotenone.
Pyrethrum/Diatomaceous Earth	Whiteflies, fireants	See label for precautions.
Spinosad	Caterpillars, beetles	See label for precautions.

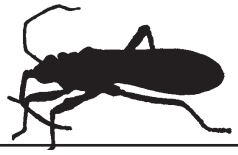
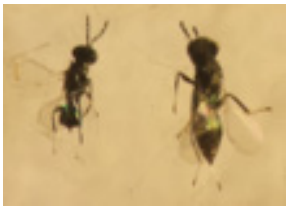
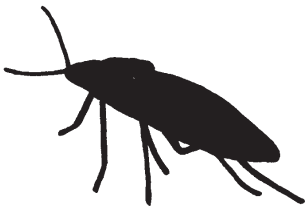
[1]Botanical insecticides are derived from various plant parts and are commonly used in organic control situations. It is important to read the label and follow all precautions regarding protective clothing, mixing, and labeled plants. Just because they are derived from plants doesn't mean that safety can be disregarded. Biological control is in two major forms. Microbial, which is a formulation containing a microorganism such as *Bacillus thuringiensis*, or the other form, which involves the release of predatory insects or mites, such as lady beetles. Use caution with insecticides when a release of predators is planned.

Table 2.1 - Organic Products and Predators (cont.)

Organic Predators

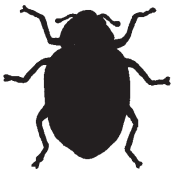
Encourage Beneficial Insects: Naturally occurring predators and parasites are found in gardens, orchards, and fields. Learn to properly identify these species as benefits of your environment. Avoid using pesticides around them. They are as susceptible to insecticides as the pests. The key to keeping native or purchased natural enemies it to eliminate spraying insecticides including organic insecticides.

Beneficial Insects and Mites: Many species of beneficial insects and mites can be purchased although many occur naturally. Beneficial insects are target specific, and require gardener knowledge of existing pests. Timing of release is an important factor, and if pests are not present, neighboring gardens may benefit more than your garden. In general, these insects have specific requirements for long-term survival, and may need to be released anew each season.

Beneficial Insects and Mites	Remarks
	Assassin bug - *Reduviidae* - The assassin bug feeds mainly on aphids, caterpillars, Colorado potato beetles, Japanese beetles, leafhoppers, and Mexican bean beetles. Naturally occurring also.
	Bean Beetle Parasite (*Pediobius foveolatus*) for Mexican bean Beetle. These wasps are shipped to you inside their host—Mexican bean beetle larvae. Once the adults emerge, the females deposit their eggs in the larvae of the Mexican bean beetle. Release rate: timing is critical; release one unit (6 mummies/unit, 20-25 wasps/mummy=120-150 wasps/unit) for every 400 sq ft of beans or 100 units/A when the bean beetle larvae are present. These wasps do not overwinter. See: *https://pubs.ext.vt.edu/ENTO/ENTO-170/ENTO-170-PDF.pdf*
	Damsel bug - *Nabidae* - The damsel bug feeds on aphids, leafhoppers, mites, and caterpillars.
	Big-eyed bug - *Gocoridae* - Big-eyed bugs feed on aphids, caterpillar eggs and larvae, immature bugs, leafhoppers, and spider mites.
	Predacious stink bug - *Pentatomidae* - Predacious stink bugs feed on Colorado potato beetles and various caterpillar larvae. Most commonly sold is the Spined Soldier Bug but it occurs naturally as well.

Adapted from VCE Publication 426-708

Table 2.1 - Organic Products and Predators (cont.)

Beneficial Insects and Mites (cont.)	Remarks
	Syrphid fly larvae - *Syrphidae* - Fly larvae of this species feed on aphids and mealybugs.
	Lady beetles - Hippodamia convergens - Naturally occurring lady beetles feeds mainly on aphids and other soft-bodied insects, such as mealybugs and spider mites. *Hippodamia convergens* is commonly sold for use in gardens but is not recommended because they leave the garden area soon after release.
	Green lacewing larvae - *Chrysoperla sp.* - Lacewing larvae, known as aphid lions, feed on insect eggs, aphids, spider mites, thrips, leafhopper nymphs, and small caterpillar larvae. Adult lacewings are not predacious.
	Predatory mites - *Phytoseiulus persimilus* and several other species feed on many mite pests, including the two-spotted spider mite. Release at the rate of 2/square foot.
	Predatory Nematodes: For wood boring and ground dwelling insects. These nematods will see host insects and not harm plants or humans.
	Trichogramma wasp - *Trichogrammatidae* - This tiny wasp attacks eggs of more than 200 pest species, including cutworms, corn borers, corn earworms, armyworms, codling moths, and cabbage moths. Release time is critical for their effectiveness since they only attack pest eggs.
	Encarsia wasp - *Encyrtidae* - The greenhouse whitefly is parasitized by this wasp in third and fourth larval instars when Encarsia lay their eggs inside the whitefly pupa.

Adapted from VCE Publication 426-708

Vegetable Insects

Eric R. Day, Extension Entomologist, Virginia Tech

Table 2.2 - Insecticides

Vegetable	Insect	Common Name	Wait Period before harvest
Asparagus	Asparagus Beetle	Carbaryl	Do not apply within one day of harvest
		Malathion	Do not apply within one day of harvest
		Permethrin	PHI = 3 days
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
	Grasshopper	Carbaryl	Do not apply within one day of harvest
		Malathion	Do not apply within one day of harvest
		Permethrin	PHI = 3 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied up to the day of harvest
Beans (snaps and limas)	Aphid	Acephate	PHI = 21 days
		Acetamiprid	PHI = 7 days
		Bifenthrin	See label for instructions
		Imidacloprid	PHI = 21 days
		Malathion	Do not apply within one day of harvest
		Canola oil	Can be applied on day of harvest, must be allowed to dry
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
	Corn Earworm	Acephate	PHI = 21 days
		Bifenthrin	See label for instructions
		Carbaryl	Do not apply within one day of harvest
		Imidacloprid	PHI = 21 days
		Malathion	Do not apply within one day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Spinosad	PHI = 3 days
	Grasshopper	Acephate	PHI = 21 days
		Bifenthrin	See label for instructions
		Carbaryl	Do not apply within one day of harvest
		Imidacloprid	PHI = 21 days
		Malathion	Do not apply within one day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Spinosad	PHI = 3 days

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Beans (snaps and limas) (cont.)	Mexican bean beetle	Acephate	PHI = 21 days
		Acetamiprid	PHI = 7 days
		Carbaryl	Do not apply within one day of harvest
		Malathion	Do not apply within one day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
	Spider mite	Bifenthrin	See label for instructions
		Malathion	Do not apply within one day of harvest
		Canola oil	Can be applied on day of harvest, must be allowed to dry
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Soybean Oil	See label for instructions
		Spinosad	PHI = 3 days
	Stink bug	Acephate	PHI = 21 days
		Acetamiprid	PHI = 7 days
		Bifenthrin	See label for instructions
		Carbaryl	Do not apply within one day of harvest
		Imidacloprid	PHI = 21 days
		Malathion	Do not apply within one day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
	Thrips	Acephate	PHI = 21 days
		Acetamiprid	PHI = 7 days
		Carbaryl	Do not apply within one day of harvest
		Imidacloprid	PHI = 21 days
		Malathion	Do not apply within one day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied up to the day of harvest
		Spinosad	PHI = 3 days
Beets	Flea beetle	Carbaryl	Do not apply within one day of harvest
		Imidacloprid	PHI = 21 days
		Malathion	Do not apply within one day of harvest
		Thiamethoxam	See label for instructions
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Kaolin clay	See label for instructions
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
Cabbage (broccoli, cauliflower, brussels sprouts, cabbage etc.)	Aphid (plant lice)	Acetamiprid	PHI = 7 days
		Beauveria bassiana	Can be applied on day of harvest, must be allowed to dry
		Cyfluthrin	See label for instructions
		Esfenvalerate	See label for instructions

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Cabbage (broc-coli, cauliflower, brussels sprouts, cabbage etc.) cont.	Aphid (plant lice) cont.	Lambda-Cyhalothrin	Can be applied up to the day of harvest
		Malathion	PHI = 7 days
		Paraffin oil	Can be applied up to the day of harvest
		Permethrin	
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
	Cabbage looper, Imported cabbage worm, diamond-back moth larvae	Acetamiprid	PHI = 7 days
		Beauveria bassiana	Can be applied on day of harvest, must be allowed to dry
		Carbaryl	PHI = 3 days
		Esfenvalerate	See label for instructions
		Lambda-Cyhalothrin	Do not apply within one day of harvest
		Malathion	PHI = 7 days
		Permethrin	Do not apply within one day of harvest
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Bacillus thuringiensis	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied on day of harvest, must be allowed to dry
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Spinosad	Do not apply within one day of harvest
	Cabbage root maggot	Permethrin	Do not apply within one day of harvest
	Flea beetle	Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Esfenvalerate	See label for instructions
		Malathion	PHI = 7 days
		Permethrin	PHI = 1 day
		Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
Carrots	Aphid	*Beauveria bassiana*	
		Capsaicin & Oil of Mustardaicin & Allyl Isothiocynanate	Can be applied on day of harvest, must be allowed to dry
		Cyfluthrin	Can be applied up to the day of harvest
		Esfenvalerate	See label for instructions
		Imidacloprid	PHI = 7 days

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Carrots cont.	Aphid cont.	Azadirachtin	Can be applied up to the day of harvest
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
Cucurbits (cantaloupes, cucumbers, squash, pumpkins, & watermelons)	Aphid (plant lice)	Acetamiprid	Can be applied up to the day of harvest
		Beauveria bassiana	Can be applied up to the day of harvest
		Imidacloprid	PHI = 21 days
		Permethrin	Can be applied up to the day of harvest
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Canola oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
	Cucumber beetle	Carbaryl	PHI = 3 days
		Imidacloprid	PHI = 21 days
		Permethrin	Can be applied up to the day of harvest
		Azadirachtin	Can be applied up to the day of harvest
		Kaolin clay	See label for instructions
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
	Leafhopper, leafminer	Permethrin	Can be applied up to the day of harvest
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Canola oil	Can be applied on day of harvest, must be allowed to dry
		Spinosad	PHI = 3 days
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Kaolin clay	Can be applied up to the day of harvest
	Squash bug, Pickleworm, Stink bugs	Permethrin	Can be applied up to the day of harvest
		Kaolin clay	See label for instructions
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Cucurbits (cantaloupes, cucumbers, squash, pumpkins, & watermelons) cont.	Squash vine borer	Acetamiprid	Can be applied up to the day of harvest
		Permethrin	Can be applied up to the day of harvest
		Kaolin clay	Can be applied up to the day of harvest
	Spider mite	Permethrin	Can be applied on day of harvest, must be allowed to dry
		Canola oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Spinosad	PHI = 3 days
	Whitefly	Horticultural oil	See label for instructions
		Imidacloprid	PHI = 21 days
		Permethrin	Can be applied up to the day of harvest
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Canola oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
Eggplant	Flea beetle, Colorado potato beetle, grasshopper	*Beauveria bassiana*	Can be applied up to the day of harvest
		Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Carbaryl	PHI = 3 days
		Esfenvalerate	See label for instructions
		Imidacloprid	PHI = 21 days
		Permethrin	PHI = 3 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
Greens or Leaf Crops (turnips, kale, spinach, collards)	Aphid (plant lice)	*Insecticidal Soap*	Can be applied up to the day of harvest
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Malathion	PHI = 7 days
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Acetamiprid	PHI = 7 days
		Imidacloprid	PHI = 21 days
		Beauveria bassiana	Can be applied up to the day of harvest
		Horticultural oil	See label for instructions

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Greens or Leaf Crops (turnips, kale, spinach, collards) cont.	Caterpillar looper, imported cabbage worm, and diamond-back larva	Acetamiprid	PHI = 7 days
		Beauveria bassiana	Can be applied up to the day of harvest
		Cyfluthrin	See label for instructions
		Malathion	PHI = 7 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Spinosad	Can be applied up to the day of harvest
	Flea beetle, Harlequin bug	Acetamiprid	PHI = 7 days
		Beauveria bassiana	Can be applied up to the day of harvest
		Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Carbaryl	PHI = 14 days
		Imidacloprid	PHI = 21 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Azadirachtin & *Pyrethrins*	Can be applied up to the day of harvest
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied up to the day of harvest
	Grasshopper	*Beauveria bassiana*	Can be applied up to the day of harvest
		Capsaicin & Oil of Mustard	Can be applied up to the day of harvest
		Carbaryl	PHI = 14 days
		Cyfluthrin	See label for instructions
		Imidacloprid	PHI = 21 days
		Azadirachtin	Can be applied up to the day of harvest
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
Lettuce	Aphid (plant lice)	*Beauveria bassiana*	Can be applied up to the day of harvest
		Capsaicin & Oil of Mustard	Can be applied up to the day of harvest
		Horticultural oil	See label for instructions
		Imidacloprid	PHI = 21 days
		Malathion	PHI = 14 days
		Permethrin	Can be applied up to the day of harvest
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Canola oil	Can be applied on day of harvest, must be allowed to dry

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Lettuce cont.	Aphid (plant lice) cont.	*Pyrethrins*	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied up to the day of harvest
	Flea beetle, harlequin bug, stink bug	*Beauveria bassiana*	Can be applied up to the day of harvest
		Capsaicin & Oil of Mustard	Can be applied up to the day of harvest
		Malathion	PHI = 14 days
		Permethrin	Can be applied up to the day of harvest
		Neem Oil *& Potassium laurate & Pyrethrins*	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied up to the day of harvest
Mushroom	Gnat, rove beetle	Azadirachtin	Can be applied on day of harvest, must be allowed to dry
Okra	Aphid (plant lice)	*Beauveria bassiana*	Can be applied up to the day of harvest
		Horticultural oil	Can be applied up to the day of harvest
		Imidacloprid	PHI = 21 days
		Malathion	Can be applied up to the day of harvest
		Permethrin	PHI= 3 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Pyrethrins	Can be applied up to the day of harvest
Onion	Onion Maggot	Malathion	PHI= 3 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
	Thrips, aphid	Acetamiprid	PHI = 7 days
		Beauveria bassiana	Can be applied up to the day of harvest
		Horticultural oil	See label for instructions
		Malathion	PHI= 3 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Kaolin clay	Can be applied up to the day of harvest
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Pea	Aphid (plant lice)	Acetamiprid	PHI = 7 days
		Imidacloprid	PHI = 21 days
		Azadirachtin & *Pyrethrins*	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
	Earworm, cowpea curculio, grasshopper	Carbaryl	PHI = 4 days
		Esfenvalerate	See label for instructions
		Spinosad	Can be applied up to the day of harvest
Pepper (bell or hot)	Aphids (plant lice), thrips, stink bugs	Acephate	PHI = 7 days
		Acetamiprid	PHI = 7 days
		Capsaicin & Oil of Mustard	Can be applied up to the day of harvest
		Imidacloprid	See label for instructions
		Malathion	PHI= 3 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Azadirachtin & *Pyrethrins*	Can be applied up to the day of harvest
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
	European corn borer, grasshopper	Acephate	PHI = 7 days
		Acetamiprid	PHI = 7 days
		Carbaryl	PHI = 7 days
		Permethrin	PHI= 3 days
		Azadirachtin & *Pyrethrins*	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
Potato	Aphids	Horticultural oil	See label for instructions
		Imidacloprid	See label for instructions
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
	Colorado potato beetle	Carbaryl	PHI = 7 days
		Cryolite	See label for instructions
		Imidacloprid	PHI = 21 days
		Permethrin	PHI = 7 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Canola oil & *Pyrethrins*	Can be applied on day of harvest, must be allowed to dry
		Neem Oil	Can be applied on day of harvest, must be allowed to dry

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Potato cont.	Colorado potato beetle cont.	Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
		Spinosad	Can be applied up to the day of harvest
	European corn borer	Carbaryl	PHI = 7 days
		Esfenvalerate	See label for instructions
		Permethrin	PHI = 7 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Azadirachtin & *Pyrethrins*	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
		Spinosad	Can be applied up to the day of harvest
	Grasshopper	Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Esfenvalerate	See label for instructions
		Permethrin	PHI = 7 days
		Thiamethoxam	See label for instructions
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Azadirachtin & *Pyrethrins*	Can be applied up to the day of harvest
		Kaolin clay	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied up to the day of harvest
	Potato leafhopper	Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Malathion	Can be applied up to the day of harvest
		Permethrin	PHI = 7 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Carbaryl	PHI = 7 days
		Malathion	Can be applied up to the day of harvest
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied up to the day of harvest
	Potato tuberworm	Esfenvalerate	See label for instructions
		Permethrin	PHI = 14 days
		Pyrethrins	Can be applied up to the day of harvest
	Whitefly	Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Esfenvalerate	See label for instructions
		Horticultural oil	See label for instructions
		Imidacloprid	See label for instructions
		Malathion	Can be applied up to the day of harvest

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Potato cont.	Whitefly cont.	Permethrin	PHI = 7 days
		Azadirachtin	Can be applied on day of harvest, must be allowed to dry
		Canola oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
Strawberry	Aphid (plant lice)	Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Imidacloprid	See label for instructions
		Malathion	PHI = 3 days
		Permethrin	PHI = 14
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
	Cyclamen mite	*Insecticidal Soap*	Can be applied up to the day of harvest
	Leafroller, root lice (root aphid)	Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Carbaryl	PHI = 7 days
		Horticultural oil	See label for instructions
		Malathion	PHI = 3 days
		Permethrin	PHI = 7 days
		Azadirachtin	Can be applied up to the day of harvest
		Canola oil & *Pyrethrins*	Can be applied on day of harvest, must be allowed to dry
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Spinosad	Can be applied up to the day of harvest
	Spider mite	Horticultural oil	See label for instructions
		Malathion	PHI= 3 days
		Permethrin	PHI = 14
		Azadirachtin & *Pyrethrins*	Can be applied up to the day of harvest
		Canola oil & *Pyrethrins*	Can be applied up to the day of harvest
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Strawberry cont.	Spider mite cont.	*Insecticidal Soap*	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
	Strawberry weevil "Clipper" & Strawberry rootworms	Carbaryl	PHI = 7 days
		Permethrin	See label for instructions
		Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
Sweet corn	Corn earworm	Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Carbaryl	See label for instructions
		Cyfluthrin	See label for instructions
		Esfenvalerate	PHI = 1 days
		Esfenvalerate	See label for instructions
		Horticultural oil	Can be applied up to the day of harvest
		Permethrin	PHI = 1 days
		Pyrethrins	Can be applied up to the day of harvest
	Corn sap beetle, European corn borer in the ear, Japanese beetle	Carbaryl	PHI= 3 days
		Esfenvalerate	See label for instructions
		Malathion	PHI = 5 days
		Permethrin	PHI = 3 days
		Pyrethrins	Can be applied up to the day of harvest
	European corn borer, Stink bugs	Carbaryl	See label for instructions
		Esfenvalerate	PHI = 1 days
		Permethrin	PHI = 3 days
		Pyrethrins	Can be applied up to the day of harvest
	Fall armyworm	Carbaryl	See label for instructions
		Horticultural oil	Can be applied up to the day of harvest
		Permethrin	PHI = 3 days
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
	Flea beetle, grasshoppers	Carbaryl	See label for instructions
		Cyfluthrin	See label for instructions
		Esfenvalerate	PHI = 1 days
		Permethrin	PHI = 3 days
		Azadirachtin	Can be applied up to the day of harvest
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
	Seedcorn maggot	*Pyrethrins*	Can be applied up to the day of harvest

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Tomato	Blister beetles, hornworm, tomato russet mite, cabbage looper	Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Carbaryl	PHI = 3 days
		Malathion	PHI = 1 day
		Beauveria bassiana	Can be applied up to the day of harvest
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
	Colorado potato beetle	Acetamiprid	See label for instructions
		Carbaryl	PHI = 3 days
		Esfenvalerate	PHI = 1 days
		Imidacloprid	Can be applied up to the day of harvest
		Imidacloprid	See label for instructions
		Permethrin	PHI = 3 days
		Beauveria bassiana	Can be applied up to the day of harvest
		Neem Oil	Can be applied up to the day of harvest
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
		Spinosad	Can be applied up to the day of harvest
	Cutworms	Bifenthrin	See label for instructions
		Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Carbaryl	PHI = 3 days
		Cyfluthrin	See label for instructions
		Esfenvalerate	See label for instructions
		Imidacloprid	See label for instructions
		Malathion	PHI = 1 day
		Permethrin	PHI = 3 days
		Azadirachtin	Can be applied up to the day of harvest
		Spinosad	Can be applied up to the day of harvest
	Flea beetle, stink bugs, grasshoppers, leaf-footed bugs	Carbaryl	PHI = 3 days
		Cyfluthrin	See label for instructions
		Esfenvalerate	PHI = 1 days
		Malathion	See label for instructions
		Permethrin	PHI = 3 days
		Azadirachtin	Can be applied up to the day of harvest
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied on day of harvest, must be allowed to dry
		Insecticidal Soap	Can be applied up to the day of harvest

Italicized pesticides are organic control measures.

Table 2.2 - Insecticides (cont.)

Vegetable	Insect	Common Name	Wait Period before harvest
Tomato cont.	Fruitworm	Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Carbaryl	PHI = 3 days
		Esfenvalerate	PHI = 1 days
		Malathion	PHI = 1 day
		Azadirachtin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
		Spinosad	Can be applied up to the day of harvest
	Spider mites	Horticultural oil	See label for instructions
		Malathion	PHI = 1 day
		Permethrin	Can be applied up to the day of harvest
		Canola oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil	Can be applied on day of harvest, must be allowed to dry
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Insecticidal Soap & Pyrethrin	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
		Spinosad	Can be applied up to the day of harvest
	Thrips, aphids	Acetamiprid	PHI = 7 days
		Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Esfenvalerate	PHI = 1 days
		Imidacloprid	Can be applied up to the day of harvest
		Malathion	Can be applied up to the day of harvest
		Permethrin	PHI = 3 days
		Beauveria bassiana	Can be applied up to the day of harvest
		Neem Oil	Can be applied up to the day of harvest
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Insecticidal Soap	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
	Whiteflies	*Insecticidal Soap*	Can be applied up to the day of harvest
		Capsaicin & Oil of Mustard	Can be applied on day of harvest, must be allowed to dry
		Malathion	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest
		Esfenvalerate	PHI = 1 days
		Neem Oil & Azadirachtin	Can be applied up to the day of harvest
		Imidacloprid	Can be applied up to the day of harvest
		Beauveria bassiana	Can be applied up to the day of harvest
		Neem Oil	Can be applied up to the day of harvest
		Pyrethrins	Can be applied up to the day of harvest

Italicized pesticides are organic control measures.

Vegetable Diseases

Steven L. Rideout, Vegetable Plant Pathologist, Eastern Shore AREC
Elizabeth Bush, Research Associate Senior, Department of Plant Pathology, Physiology, and Weed Science

Overview

Home gardeners can avoid many disease problems in their vegetable gardens by practicing cultural and other preventative tactics. If a disorder is found, the first step in controlling the disease is to accurately identify the pathogen. Often abiotic (non-living) problems or insect problems are mistaken for plant diseases and pesticides are used needlessly. Accurate identification of the pathogen ensures that pesticides are used appropriately and only when other control tactics can't control the problem. Accurate identification of the pathogen also allows formulation of an integrated pest management approach to control the disease based on the pathogen's life cycle. Use pesticides in conjunction with cultural and other control tactics.

General Cultural Controls

- Provide optimal growing conditions: Healthy plants are less likely to become diseased than stressed plants.
  - Provide adequate water and fertilization, but avoid over-fertilization, which creates succulent tissue that is prone to disease and pest problems. Also do not apply fertilizer close to tender root and stem tissue, since this can seriously injure or kill plants.
  - Ensure soil pH is optimal for nutrient uptake by plants by submitting a soil sample for analysis to the Virginia Tech Soil Testing Laboratory when starting a new garden. Re-test every two to three years.
  - Plant crops at recommended planting times. Planting too early, in particular, predisposes seedlings and transplants to disease.
  - Space plants adequately to ensure vigor and to promote foliar drying—wet foliage favors most foliar diseases.
  - Stake or cage tomato plants.
  - Check the soil drainage and if drainage is poor, correct before planting. Excessively wet soils can cause soilborne diseases and poor growth even in the absence of a pathogen.
  - Irrigation: Most plant diseases favor high humidity and wet foliage. Avoid overhead irrigation when possible, as it creates wet foliage. If irrigating overhead, do so early in the day to promote foliar drying. Also avoid over-irrigation; this can cause root problems and favors the development of certain pathogens.
- Sanitation:
  - Rotate crops: Avoid growing the same crop species AND same crop family (e.g. solanaceous family: potato, tomato, pepper, eggplant) in the same garden location for consecutive years, since this may result in a build-up of pathogen inoculum in the soil.
  - Use disease-free seed and/or transplants. Certain pathogens survive in seed, so purchase certified seed and be mindful when saving your own seed, as it may harbor pathogens. Do not save seed from diseased plants.
  - Some plant pathogens can survive on plant debris. Therefore, removing diseased plants and crop debris from the garden reduces inoculum for new infections in the next season's garden. Compost crop debris or till it into the soil at the end of the growing season; however, some pathogens produce survival structures that are not killed by composting or burying in soil.
  - Stakes, rototillers, and gardening tools can be infested with pathogen inoculum; stakes, equipment and tools must be cleaned and disinfected. Also, some pathogens may be present in soil, so avoid any practice that moves infested soil to non-infested areas.
  - Avoid working or harvesting in the garden when plants are wet. This spreads pathogens.
  - Weeds are alternate hosts for many pathogens, so controlling weeds reduces the likelihood of some diseases.
- Resistance:
  - To avoid commonly occurring disease problems use disease-resistant plants if they are available (e.g. late blight-resistant tomato).

General Biological Controls

- Disease-resistant plants: Resistant cultivars are available for some common plant disease problems. For example, tomato varieties designated with the letters "VFN" are resistant to Verticillium and Fusarium species, soil borne fungi with no chemical controls. The 'N' indicates root-knot nematode resistance, another soil-borne pathogen with no available chemical controls.
- Soil amendments: Adding compost or other organic matter to garden soil may increase populations of beneficial microbes in the soil. Some of these microbes may be antagonistic, predatory, or may simply out-compete pathogens, and reduce the likelihood of disease.
- Biological pesticides: Biological pesticides are formulated from living organisms, such as fungi, bacteria, and nematodes that may be antagonistic, predatory, parasitic or may simply out-compete pathogens. The number of biological control products available to homeowners for disease control is growing. These products are safer to handle, break down quickly, and are considered to be environmentally friendly compared to other pesticides. Some biological pesticides are ineffective or less effective compared to other pesticide products for controlling certain plant diseases. However, when biological pesticides are used in conjunction with cultural and other control tactics, or when disease pressure is low, disease may be controlled to an acceptable level with these pesticides.
- Naturally-occurring organisms: Using broad-spectrum pesticides may reduce populations of naturally occurring organisms that are beneficial to crops or have an adverse effect on plant pathogens and other pests. Use these pesticides only when necessary.

General Mechanical Controls

- Most plant disease problems are made worse by wet foliage. Staking crops, like tomatoes, reduces leaf wetness and promotes foliar drying. Staking also reduces spread of inoculum that may splash onto foliage and fruit from the soil.
- Reflective row covers deter insects that carry plant pathogens.
- Organic and plastic mulches reduce the spread of some soil-borne pathogens and also reduce weeds that may host plant pathogens.

General Chemical Controls

- Fungicides can also be used to manage disease problems in the home garden. When using fungicides, it is important that you read and follow the fungicide product label. The active ingredients in the fungicides listed in this section are available under many different commercial names and may be found in garden centers or ordered over the Internet. Because different manufacturers' labels vary widely, always check the label carefully before purchasing a particular brand to make sure it is labeled for both your crop and the disease you are trying to control. For disease problems not covered in the recommendations, contact your local Extension agent.
- Calibrate sprayers and spreaders.
- Wear Personal Protective Equipment (PPE) when applying chemicals, as specified on the pesticide label. Each pesticide product varies in toxicity and must be evaluated individually regarding re-entry and preharvest intervals.
- Most homeowner pesticides are protectants and must be applied preventatively, before infection occurs. It is important to completely cover the plants when using these pesticides. Most homeowner pesticides cannot cure plants that are already diseased and do not have systemic activity.
- Each pesticide has different amounts of toxicity and each can have a different negative effect on the environment and other organisms. Pesticides receiving EPA approval today are generally less toxic and have reduced negative impact on the environment than those approved prior to the late 1990s.

Precautions

- Humans: Protect yourself when applying chemicals: read the product label to determine the proper PPE and accessories you need before using any chemicals. Do not assume that because a product is labeled "organic" it is non-toxic to humans. Products vary in human toxicity and each pesticide product must be assessed according to its product label.
- Bees: In general broad-spectrum insecticides are toxic to bees. Read each product label and determine what precautions to take to protect bees and other beneficial insects when applying pesticides.

- Animals (pets, birds, etc.) and water: Read the specific product label to determine what precautions to take to protect the health of other animals and aquatic invertebrates when applying pesticides.
- Pesticide resistance: Over-using pesticides may make pests resistant to the pesticide. Pesticides containing thiophanate-methyl, for example, often develop resistance. Broad-spectrum pesticides have a low risk of developing resistance. Read the pesticide product label to determine if a pesticide is at risk of developing pesticide resistance. To avoid pesticide resistance:
  - Limit applications of the pesticides (the number of allowed applications is usually specified on the label for at-risk pesticides),
  - Use pesticide products with different modes of action or use a mix of pesticides with different modes of action
  - Use the recommended rate as specified on the product label.

Factsheets

- Virginia Cooperative Extension Plant Disease Factsheets http://pubs.ext.vt.edu/category/plant-diseases.html

Virginia Tech Diagnostic and Identification Laboratories

- Plant Disease Clinic http://www.ppws.vt.edu/extension/plant-disease-clinic/index.html
- Insect Identification Lab http://www.idlab.ento.vt.edu/
- Nematode Assay Lab http://www.ppws.vt.edu/extension/nematode-laboratory/index.html
- Soil Testing Lab http://www.soiltest.vt.edu/
- Weed Identification Lab http://www.ppws.vt.edu/extension/weedid-clinic/index.html

Table 2.3 – Fungicide brands available for Home Vegetable Gardens

Chemical Name	Product Name
Captan	American Captan Garden Fungicide Bonide Captan 50W Dragon Captan Wettable Hi-Yield Captan Fungicide 50W Orthocide Garden Fungicide Southern Agricultural Home and Garden Captan Fungicide
Chlorothalonil	Bonide Fung-onil Dragon Daconil 2787 Earl May Fung-onil Ferti-Lome Liquid Fungicide Fung-onil Multipurpose Gordon's Multi-Purpose Fungicide Ortho Daconil 2787 Ortho Garden Disease Control Southern Agricultural Lawn, Ornamental, & Vegetable Fungicide
Basic copper	Acme Bordeaux Mix Bonide Garden Dust Cooke Copper Fungicide Cooke KopRSpray Conc. Dragon Bordeaux Mix Fertilome Bordeaux Mixture Gordon's Bordeaux Mix Hi-Yield Bordeaux Mix Lilly Miller Microcop Fungicide – Basic $CuSO_4$ Southern Agricultural Neutral Copper Fungicide Southern Agricultural Tomato Dust
Fixed copper	American Copper Fungicide Bonide Liquid Copper Fungicide Dragon Copper Fungicide Hi-Yield Copper Fungicide Southern Agricultural Liquid Copper Fungicide
Mancozeb	Bonide Mancozeb Flowable with Zinc Dragon Mancozeb Green Light Broad Spectrum Mancozeb Fungicide Southern Agricultural Dithane M-45
Maneb	Earl May Tomato Blight Control Earl May Tomato and Vegetable Dust Gordon's Maneb Tomato and Vegetable Fungicide Hi-Yield Maneb Garden Fungicide
Neem oil	Green light Powdery Mildew Killer Garden Safe Fungicide 3
PNCB (pentachloro-nitrobenzene)	Hi-Yield Terraclor Granule Southern Agriculture Terraclor
Potassium bicarbonate	Bonide Remedy Cleary First Step
Sulfur	Bonide Liquid Sulfur Bonide Sulfur Fungicide Dragon Garden Sulfur Green Light Wettable Dusting Sulfur Hi-Yield Lime Sulfur Ortho Garden Sulfur Dust Safer Garden Fungicide Southern Agricultural Wettable or Dusting Sulfur

Table 2.4 - Disease Management Tools for Specific Crops and Diseases

Crop Disease	Treatment (PHI)[1]	Rate/Gal. (Unless otherwise Stated)	Remarks
Asparagus Rust	Maneb or Mancozeb	2.0 tbsp	Use resistant varieties or apply 3-4 post-harvest sprays at 7- to 10-day intervals beginning in late June.
Beans (Snaps or Lima) Anthracnose (Lima bean only)	chlorothalonil 12.5% (7)	2.0 tbsp	Begin early bloom – reapply every 7 to 10 days. For use only on beans to be harvested dry with pods removed.
Bacterial Blights	copper	1.5 tbsp powder	Use certified western-grown seed. Begin with 4.0 tsp liquid at tri-foliage and reapply every 7 to 10 days.
Botrytis Blight (Gray mold)	chlorothalonil 12.5% (7) chlorothalonil 30% (7)	4.0 tbsp 1.0 tbsp	Begin at early bloom; apply after extended wet periods.
Downy mildew (Lima beans only)	chlorothalonil 12.5% (7)	2.0 tsp	Begin early bloom – reapply every 7 to 10 days. For use only on beans to be harvested dry with pods removed.
Powdery mildew	Neem Oil Wettable Sulfur or Sulfur dust	2.0 tbsp 2.5 tbsp or 6.0 tbsp dust	Spray or dust at first sign and reapply every 7 days. Sulfur may injure blossoms and some varieties of beans.
Rhizoctonia root and stem rot	PCNB	4.0 tbsp/gal for 1000 ft row	Apply at planting only. Direct spray in the seed furrow or over the planted row.
Rust	chlorothalonil 12.5% (7) chlorothalonil 30% (7) Wettable Sulfur or Sulfur dust	2.0-4.0 tbsp 1.0 tbsp 2.5 tbsp 6.0 tbsp dust	Spray or dust at first sign and reapply every 7 days. Sulfur may injure blossoms and some varieties of beans.
Seed rot and damping off	Captan	0.5 tsp/1lb seed	Mix thoroughly in paper bag or glass jar.
Viruses	No chemicals registered		Clover control around edge of garden areas is important to reduce spread of virus from clover to beans. Some bean varieties are resistant. Aluminum foil mulch may prevent aphid feeding.
Beets *Cercospora*	copper leaf spot	2.0 tbsp	Spray at 7- to 10-day intervals beginning when disease first appears.
Seed rot and damping off	Captan	2.5 tsp/1 lb seed	Mix thoroughly in paper bag or glass jar.
Cabbage, Broccoli, Brussels Sprout, Cauliflower, Turnips, Kale, Collards Black leg, Black rot	copper	2.0 tbsp	Use western-grown, hot-water treated seed. Use resistant varieties for black rot control. Apply copper at 7- to 10-day intervals. Copper sprays may reduce spread of blackrot.
Club root	PCNB	1.0 tbsp	Apply in transplant water. Use 0.5 pt per plant. Thoroughly mix with the soil.
Downy mildew, *Alternaria* leaf spot	chlorothalonil 12.5% chlorothalonil 30% copper maneb (7)	2.5 tbsp 1.0 tbsp 1.0 tsp 1.0 tbsp	Begin when disease threatens and reapply every 7 days. Do not spray copper when plants are stressed.
Seed rot and damping off	Captan	0.5 tsp/1 lb seed	Mix thoroughly in paper bag or glass jar.
Carrots Leaf Blight	chlorothalonil 12.5% chlorothalonil 30% copper	2.5 tbsp 1.0 tbsp 2.0 tbsp	Start applications when disease threatens and reapply every 7 to 10 days if needed.

[1]PHI = post-harvest interval and indicates the number of days before harvest that the last fungicide application can be made.

Table 2.4 - Disease Management Tools for Specific Crops and Diseases (cont.)

Crop Disease	Treatment (PHI)[1]	Rate/Gal. (Unless otherwise Stated)	Remarks
Celery Bacterial Blight	copper	2.0 tbsp	Apply at first sign of disease; reapply every 7 to 10 days.
Cercospora (Early Blight)	chlorothalonil 12.5% (7) chlorothalonil 30% (7) copper	3.0-4.0 tbsp 1.0 tbsp 2.0 tbsp	Apply at first sign of disease; reapply every 7 days.
Septoria (Late blight) or Stalk rot (*Rhizoctonia*)	chlorothalonil 12.5% (7) chlorothalonil 30% (7)	3.0 tbsp 1.0 tbsp	Apply at first sign of disease; reapply every 7 days.
Cucurbits (Cucumbers, Summer Squash, Cantalopes, Pumpkins) *Alternaria* leaf spot; Anthracnose; Downy mildew; Gummy stem blight	chlorothalonil 12.5% chlorothalonil 30% mancozeb (5) maneb (5) copper	2.0-3.0 tbsp 1.0 tbsp 2.0 tbsp 1.0 tbsp 2.0 tbsp	Apply at first sign of disease or after runners are formed and reapply every 7 days. Shorten the spray interval to 5 days if disease pressure is high. Some melon varieties may be sensitive to maneb.
Angular leaf spot (cucumbers only)	copper	1.0-2.0 tbsp	Apply at first sign of disease and reapply every 7 days. Copper may injure some young plants.
Belly rot (*Rhizoctonia*)-suppression only	chlorothalonil 30%	1.0 tbsp	Use mulch to keep fruit off soil surface. For plants in bare soil, begin when plants are in first true leaf stage. Apply during wet soil conditions.
Powdery mildew	chlorothalonil 12.5% chlorothalonil 30% copper Neem Oil potassium bicarbonate	3.0 tbsp 1.0 tbsp 2.0 tbsp 2.0 tbsp 2.0 tbsp	Begin at first sign of disease. Reapply every 7 days. Shorten interval if disease is severe.
Seed rot and damping off (melons and squash)	Captan	0.5 tsp/1 lb seed	Mix thoroughly in paper bag or glass jar.
Eggplant Anthracnose; fruit rot	maneb (5)	1.0 tbsp	Begin at fruit set. Reapply every 7 days.
Irish Potatoes Early blight, late blight, and *Botrytis* vine rot	chlorothalonil 12.5% chlorothalonil 30% mancozeb (14) maneb (14) copper	2.0 tbsp 1.5 tbsp 2.0 tbsp 1.0 tbsp 2.5 tbsp	Apply at first sign of disease and reapply every 7 days.
Onion Bacterial Soft rot	copper	2.0 tbsp	Apply during extended periods of wet soil. Reapply every 7 days up to harvest.
Onion (dry bulb) *Botrytis* leaf blight, Downy mildew, Purple blotch	chlorothalonil 12.5% (7) chlorothalonil 30% (7) maneb (7)	2.0 tbsp 1.0 tbsp 2.0 tbsp	Apply at first sign of disease and reapply every 7 days. Do not apply to exposed bulbs.
Onion (green bunching), leeks, shallots	chlorothalonil 12.5% (14) chlorothalonil 30% (14) maneb (7) copper	2.0-4.0 tbsp 1.0 tbsp 2.0 tbsp 2.0 tbsp	See above. Do not apply chlorothalonil more than 3 times per season and maneb more than 7 times per season.
Peas Powdery mildew and Bacterial blight	copper Neem Oil	2.0 tbsp 2.0 tbsp	Apply at first sign of disease and reapply every 7 days up to harvest.
Seed rot and damping off	captan	0.5 tsp/1 lb seed	Mix thoroughly in paper bag or glass jar.

[1]PHI = post-harvest interval and indicates the number of days before harvest that the last fungicide application can be made.

Table 2.4 - Disease Management Tools for Specific Crops and Diseases (cont.)

Crop Disease	Treatment (PHI)*	Rate/Gal. (Unless otherwise Stated)	Remarks
Peppers Anthracnose, fruit rot	maneb (7)	2.0 tbsp	Begin when fruit are half size. Spray on a 7- to 10-day interval.
Bacterial spot and *Cercospora* leaf spot	copper	2.0 tbsp	Apply at first sign of disease and reapply every 7 days up to harvest.
Phytophthora blight	No chemicals registered		Avoid planting in low land. Grow resistant varieties, 'Paladin' or 'Aristotle'.
Southern Blight	PCNB	1.0 tbsp	Apply at transplant. Apply 0.5 pt/plant.
Sweet Corn Bacterial wilt	No chemicals registered		Plant resistant varieties. Spray with approved insecticide to control flea beetles.
Leaf blight, Rust	chlorothalonil 12.5% (14) chlorothalonil 30% (14) mancozeb (7)	1.0-2.5 tbsp 1.0 tbsp 1.5 tbsp	Apply after observing disease and reapply every 7 days.
Tomatoes Early blight, late blight, *Septoria* leaf spot, gray mold, Anthracnose and *Rhizoctonia* fruit rot	chlorothalonil 12.5% chlorothalonil 30% mancozeb (5) maneb (5) copper	3.0-4.0 tbsp 1.0 tbsp 3.0 tbsp 2.0 tbsp 2.0 tbsp	Repeat at 7- to 10-day intervals throughout the season. Under severe conditions shorten spray intervals.
Bacterial spot and speck	copper plus maneb (5)	2.0 tbsp 2.0 tbsp	Apply after observing disease and reapply every 7 days.
Fusarium wilt and *Verticillium* wilt			Use resistant varieties. Maintain soil pH from 6.5-7.0. Rotate out of area.
Southern Blight	PCNB	1.0 tbsp	Apply at transplanting. Apply 0.5 pt/plant
Watermelon Anthracnose, gummy stem blight, *Alternaria* leaf blight, downy mildew and powdery mildew	chlorothalonil 12.5% chlorothalonil 30% mancozeb (5) maneb (5) copper Neem Oil (powdery mildew)	3.0-4.0 tbsp 1.0 tbsp 2.0 tbsp 2.0 tbsp 2.0 tbsp 2.0 tbsp	Apply at first sign of disease or when runners meet within the row and reapply every 7 days. Shorten interval under severe conditions.

[1]PHI = post-harvest interval and indicates the number of days before harvest that the last fungicide application can be made.

Table 2.5 - Nematode Disease Control in Home Vegetables

Nematode	Remarks
Root knot and other plant parasitic nematodes	Plant parasitic nematodes may cause reduced yield and stunted or weakened plants. There are no chemical controls for nematodes in home gardens. Root knot nematodes cause galls to form on roots. They are soil-borne and are difficult to control. The host range of the root knot nematode is very broad, so using crop rotation to control them is challenging. Several tactics can be implemented to minimize nematode problems in the home garden. 1) Avoid transporting nematodes to new areas on tillers, tools, soil, plant debris, etc. 2) Early, cool season crops are generally less affected by root knot nematode, because populations of nematodes are lower in the early part of the growing season. 3) Consider using certain cover crops that can reduce nematode populations, e.g. cover crop radish. 4) Control weeds, which may harbor nematode populations. 5) Ideally, the whole garden should be rotated to a different area each year, with any known nematode-infested areas being used only once every three years; however, this is impractical for most situations. Alternatively, rotating crops among plant families within a vegetable garden will minimize the chance of nematode problems. For example, rotate solanaceous crops with cucurbit crops, solanaceous crops with cruciferous crops, etc. 6) Incorporate hardwood leaf litter mulch into soil to increase beneficial fungi that kill nematodes and to increase tannins that inhibit nematode reproduction. Increasing the amount of organic matter in the garden soil is generally a good approach. 7) Root knot-resistant cultivars are available for tomato. These varieties are usually designated by the letters "VFN" after the variety name (the "V" designates Verticillium wilt, the "F" Fusarium wilt and the "N" root-knot nematode).

Weed Management in Home Vegetable Gardens

Jeffrey F. Derr, Extension Weed Scientist, Hampton Roads AREC

Overview

Weed management is necessary in vegetable gardens. Weeds compete with vegetable crops for water, nutrients, and light, and can harbor insect and disease pests. Start a weed control program before planting and then continue weeding throughout the growing season. Keeping weeds down early in the season, when they are small, reduces the amount of hand weeding required later in the summer when higher temperatures and humidity make this task more difficult. Weeds are difficult to eradicate. Their seeds can remain dormant but viable for five, 10, 20, or more years in the soil, depending on species. Control weeds in areas near the garden to limit the movement of weed seed or weed propagules into the garden. Prevent weeds from flowering, as this helps reduce the amount of weed seed in the soil over time.

Cultural control of weeds in vegetable gardens is preferred because there are few chemical control options. Not many herbicides can be applied to a wide range of vegetables. For information related to larger areas planted with an individual vegetable species, such as a planting of an acre or more, consult the Commercial Vegetable Production Recommendations guide (Va. Coop Ext. Pub. 456-420).

General Cultural Controls

Winter cover crop: Plant rye, annual ryegrass, or other cover crops in the fall after the final harvest. Till the cover crop into the soil in spring prior to planting vegetables.

Cultivation/Hoeing/Hand weeding: Tilling the garden in spring controls winter annual weeds like common chickweed and controls or suppresses perennial weeds. Troublesome perennial weeds like bermudagrass, quackgrass, yellow nutsedge, and other creeping perennials need repeated tilling. Hoe weeds out of the alleyways between vegetable rows. Cut annual weeds at or slightly below the soil surface to minimize soil disturbance. Deeper hoeing brings weed seed from greater depths in the soil to the surface where they can germinate. Controlling weeds prior to flowering reduces weed populations in future years by depleting the weed seed reservoir in the soil.

Organic mulches: Pine bark, pine straw, sawdust, and grass clippings are good mulching materials. Do not use grass clippings from a lawn or pasture that has been recently treated with an herbicide, especially herbicides used for controlling broadleaf weeds. Monitor soil fertility, as nitrogen tie-up can occur when using mulches like sawdust. Organic mulches conserve soil moisture and cool the soil. Spread mulch two to four inches deep. Place newspaper on the soil surface prior to applying mulch in order to suppress weeds. Organic mulches suppress or control annual weeds but will not control perennial weeds. Use mulches that are free of weed seed and that do not have a rotten egg or ammonia odor. Improperly composted mulch can have a low pH and contain chemicals that injure crop plants.

Synthetic mulches: Using solid black plastic or a landscape fabric improves weed control compared to mulch alone. Solid black plastic is more effective for weed control than the available landscape fabrics but water cannot pass through it. Place drip irrigation under solid black plastic to allow water to reach plant roots. Landscape fabrics allow for air and water movement but weed roots and/or shoots can penetrate through openings in the material. Place plastic or fabric on the soil surface and then cut an X or a hole into the material to transplant plants or vegetable seeds. One can place organic mulch over these materials; however, weeds may germinate in the mulch layer and then send roots through the fabric to the soil below. Black plastic and landscape fabrics control annual weeds and suppress perennial weeds like yellow nutsedge.

General Biological Controls

There currently are no biological control options for weed control in vegetable gardens.

General Chemical Controls

Organic

Postemergence: Acetic acid (Weed Pharm 20% acetic acid or other labeled formulation). Contact nonselective herbicide. Do not use unlabeled forms of acetic acid. Wear eye protection, a long-sleeved shirt, long pants, shoes, socks, and waterproof gloves since this product is corrosive. Cover the weed foliage thoroughly. Treat weeds when small, as large annual weeds may require retreatment. Perennial weeds need retreatment, as this is a contact herbicide and does not affect underground plant parts such as roots, bulbs, and rhizomes. Keep the spray off the foliage and stems of desired plants by using a shield. No residual control.

Conventional

After final harvest in fall or prior to planting: Glyphosate (Roundup and other trade names). Apply at least one week before planting. Rinse glyphosate off plastic prior to transplanting vegetables through the black plastic or do not use glyphosate at all when using plastic mulch. Use glyphosate to control perennial weeds like bermudagrass, quackgrass, and horsenettle. Apply to weed foliage before frost, when the weeds are still actively growing.

At planting: Trifluralin (Preen Garden Weed Preventer, Miracle-Gro Garden Weed Preventer, or other labeled formulation). Apply at seeding of broccoli, Brussels sprouts, cabbage, carrots, cauliflower, celery, collards, black-eyed peas, field peas, garden peas, lima beans, mustard greens, snap beans, and turnip greens. Apply before transplanting celery, broccoli, Brussels sprouts, cabbage, cauliflower, eggplant, peppers, onions, and tomatoes. Apply to established cantaloupe, cucumber, and watermelon that have at least four true leaves. Apply to established asparagus prior to spear emergence. Apply after planting potatoes. Trifluralin will not control existing weeds. It does provide preemergence control of annual grasses like crabgrass, foxtail, and goosegrass, and small-seeded broadleaf weeds like purslane and pigweed.

Perennial weeds

Perennial vines and weeds (bermudagrass, poison ivy, dock, honeysuckle, etc.) around the garden borders or in the tilled area may be controlled with a postemergence application of glyphosate (Roundup or other labeled formulations) after completion of the summer vegetable harvest. For small areas or individual weed treatments, the Roundup formulation is packaged in small quantities suitable for home use and does not require special sprayers. Many of the perennial weeds are more effectively controlled when treated in late summer or fall before frost causes the leaves to drop. Since glyphosate is not biologically active in the soil, it cannot result in residue problems.

Do not spray vegetables with a sprayer that has been used to apply 2,4-D or other broadleaf herbicides to turfgrass.

Index

A

Alternaria leaf spot....2-22, 2-23
Angular leaf spot....2-23
Anthracnose....2-22, 2-23, 2-24
Aphid.....2-5, 2-6, 2-7, 2-8, 2-9, 2-10, 2-11, 2-12, 2-14, 2-22
Asparagus....2-5, 2-22
Asparagus Beetle....2-5
Assassin bug....2-3

B

Bacillus thuringiensis....2-2, 2-7
Bacterial blight....2-22, 2-23
Bacterial spot....2-24
Bacterial wilt....2-24
Bagworms....2-2
Bean beetle parasite (*Pediobius foveolatus*)....2-3
Beans
  Lima beans....2-22, 2-26
  Snap beans....2-26
Beauveria bassiana.....2-2, 2-6, 2-7, 2-8, 2-9, 2-10, 2-11, 2-16, 2-17
Bees....2-19
Beetle
  Colorado potato beetle....2-2
  Lady beetles....2-4
Beets....2-6, 2-22
Belly rot....2-23
Bermudagrass....2-25, 2-26
Big-eyed bug....2-3
Black-eyed peas....2-26
Black leg....2-22
Black rot....2-22
Blight
  Bacterial blight....2-23
  Botrytis leaf blight....2-23
  Early blight....2-23, 2-24
  Late blight....2-23, 2-24
  Leaf blight....2-23, 2-24
  Phytophthora blight....2-24
  Southern blight....2-24
  Tomato blight....2-21
Blister beetles....2-16
Botanical insecticide....2-2
Botrytis vine rot....2-23
Broadleaf weeds....2-25, 2-26
Broccoli....2-26
Brussels sprout....2-6, 2-7, 2-22

C

Cabbage....2-6, 2-7, 2-22
Cabbage looper....2-7
Cabbage root maggot....2-7
Cantaloupe....2-8, 2-9, 2-26
Captan....2-21, 2-22, 2-23
Carrots....2-7, 2-8, 2-22, 2-26
Caterpillar looper....2-10
Caterpillars....2-2
Cauliflower....2-6, 2-7, 2-22
Celery....2-23
Cercospora....2-22, 2-23, 2-24
Chickweed....2-25
Chlorothalonil....2-21
Clover....2-22
Club root....2-22
Collard....2-22, 2-26
Colorado potato beetle....2-2, 2-9, 2-12, 2-13, 2-16
Copper....2-21, 2-22, 2-23, 2-24
Corn Earworm....2-5
Corn sap beetle....2-15
Cowpea curculio....2-12
Crabgrass....2-26
Cucumber....2-8, 2-9, 2-23, 2-26

Cucumber beetle. 2-8
Cucurbits. 2-8, 2-9, 2-23
Cutworms. 2-16
Cyclamen mite. 2-14

D

Damsel bug. 2-3
Diamond-back moth larvae. 2-7, 2-10
Diatomaceous earth. 2-2
Diseases. 2-18, 2-22, 2-23, 2-24
Dock. 2-26
Downy mildew. 2-22, 2-23

E

Early blight. 2-23
Earworm. 2-5, 2-12
Eggplant. 2-9, 2-23
European corn borer. 2-12, 2-13, 2-15

F

Fall armyworm. 2-15
Field peas. 2-26
Fireants. 2-2
Flea beetles. 2-6, 2-7, 2-9, 2-10, 2-11, 2-15, 2-16, 2-24
Fruit rot. 2-23, 2-24
Fruitworm. 2-17

G

Grasshopper. 2-5, 2-10, 2-12, 2-13, 2-16
Gray mold. 2-22
Green lacewing larvae. 2-4

H

Harlequin bug. 2-10
Herbicide. 2-25
Honeysuckle. 2-26
Hornworm. 2-2, 2-16
Hot pepper wax. 2-2

I

Imported cabbage worm. 2-7, 2-10
Insecticidal soap. 2-2
Insecticide. 2-24
Insects. 2-2, 2-19

J

Japanese beetle. 2-15

K

Kale. 2-22

L

Late blight. 2-23
Leaf blight. 2-23, 2-24
Leaf crops. 2-9, 2-10
Leafhopper. 2-8
Leafminer. 2-8
Leafroller. 2-14
Leaf spot. 2-22, 2-23, 2-24
  Alternaria leaf spot. 2-22, 2-23
  Angular leaf spot. 2-23
  Septoria leaf spot. 2-24
Leeks. 2-23
Lettuce. 2-10, 2-11
Lima beans. 2-22, 2-26
Lime sulfur. 2-21

M

Mancozeb. 2-21, 2-22
Maneb. 2-21, 2-22
Mealybugs. 2-2
Mexican bean beetle. 2-6
Mulch. 2-22, 2-23, 2-25
Mushroom. 2-11
Mustard. 2-26
Mustard greens. 2-26

N

Neem oil. 2-21
Nematode. 2-20, 2-24
Parasitic nematodes. 2-24
Nutsedge. 2-25

O

Okra. 2-11
Onion. 2-11, 2-23
Organic controls. 2-2

P

Pathogens. 2-19
Peas. 2-12, 2-23, 2-26
Pentachloronitrobenzene (PCNB). 2-22, 2-24
Peppers. 2-2, 2-12, 2-24
Hot pepper. 2-2
Pesticide. 2-19, 2-20
Phytophthora blight. 2-24
Pickleworm. 2-8
Pigweed, redroot, spiny. 2-26
Plant lice. 2-6, 2-7, 2-8, 2-9, 2-10, 2-11, 2-12, 2-14
Poison ivy. 2-26
Potassium bicarbonate. 2-21, 2-23
Potato. 2-2, 2-12, 2-13
Powdery mildew. 2-21, 2-22, 2-23
Predacious stink bug. 2-3
Predatory mites. 2-4
Predatory Nematodes. 2-4
Pumpkin. 2-8, 2-9, 2-23
Purple blotch. 2-23
Pyrethrin. 2-2
Pyrethrum. 2-2

R

Rhizoctonia root rot. 2-22
Rhizoctonia stem rot. 2-22
Root knot. 2-24
Root lice. 2-14
Rust. 2-22, 2-24

S

Seedcorn maggot. 2-15
Seed rot. 2-22, 2-23
Septoria leaf spot. 2-24
Shallots. 2-23
Snap beans. 2-26
Southern blight. 2-24
Spider mite. 2-6, 2-9, 2-14, 2-15, 2-17
Spinosan. 2-2
Sprayer. 2-19, 2-26
Squash. 2-8, 2-9, 2-23
Squash bug. 2-8
Squash vine borer. 2-9
Stink bug. 2-6, 2-8, 2-15
Strawberry. 2-14
Strawberry rootworms. 2-15
Strawberry weevil. 2-15
Sulfur. 2-21, 2-22
Sulfur dust. 2-21
Wettable sulfur. 2-22
Summer squash. 2-23
Sweet corn. 2-15, 2-24
Syrphid fly larvae. 2-4

T

Tenebrionis. 2-2
Thrips. 2-2, 2-6, 2-11, 2-12, 2-17
Tomato. 2-16, 2-17, 2-21
Tomato blight. 2-21
Tomato russet mite. 2-16
Turnip greens. 2-26
Turnips. 2-22

V

Vegetables. 2-24
Verticillium wilt. 2-24
Viruses..... 2-24

W

Wasps
  Encarsia wasp. 2-4
  Trichogramma wasp. 2-4
Watermelon. 2-8, 2-9, 2-24
Weeds. 2-25
Wettable sulfur. 2-22
Whiteflies. 2-2, 2-9, 2-13, 2-17
Worm
  Bagworm. 2-2

Y

Yellow nutsedge. 2-25