Crop Profile for Bell Peppers in Virginia

Prepared: May, 2003

General Production Facts[1]

- In 2001, 1,000 acres of peppers were planted and 700 acres were harvested in Virginia.
- Pepper production in Virginia averaged 61 cwt./acre or 6,100 lbs./acre in 2001.
- A total of 43,000 cwt. or 4,300,000 lbs. of fresh market peppers were produced in Virginia in 2001.
- The 2001 crop was valued at $1,290,000 or roughly $30.00/cwt. ($0.30/lb.).
- Virginia ranked 10th of 11 pepper-growing states, accounting for 0.29% of the national production in 2001.

Production Regions

Both the Eastern Shore and also parts of western Virginia are primary pepper-producing regions within the state. Each of these regions accounts for 500-600 acres annually.

Cultural Practices

Several varieties of bell peppers are recommended for growth in Virginia: *Commandant*, Enterprise*, Marengo*, Paladin*, Renegade, and X3R Camelot**. Variety selection often depends on several factors such as vegetative vigor, resistance to diseases such as bacterial leaf spot (BLS) and Phytophthora blight, and market demand.

Peppers are a warm-season crop that grows best at temperatures of 70°F to 75°F (21.1°C to 23.9°C). This crop is sensitive to temperature extremes. Poor fruit set and blossom drop can be expected when night temperatures drop below 60°F (15.6° C) or day temperatures rise above 85°F (29.4°C). For summer harvest, May 1 to May 30 is usually the recommended time to transplant. In Virginia, transplant July 25 to August 1 for a fall harvest.

Fields should be selected for good drainage. Plant on raised, dome-shaped beds to aid in disease control. To minimize sunscald when growing peppers on sandy soils and on plastic mulch without drip irrigation, plant varieties that have excellent fruit cover. The recommended spacing for peppers is 4-5 feet between rows with 12-18 inches between plants in the row. Also, before mulching, the soil pH should be adjusted to around 6.5 for maximum yield.

When mulching, the use of black plastic with drip irrigation and double rows can greatly increase yields and percentage of No. 1 size peppers. Use opaque, white plastic when planting in the summer for fall harvest. Use 5-foot wide plastic for double rows and 4-foot wide plastic for single-row peppers. Do not use plastic mulch without trickle irrigation on sandy soils.

Staking peppers helps protect fruit from sunburn by holding the plants in an upright position. Use 2- to 2 1/2-foot long by 1 1/4-inch Honduran pine stakes (half-length tomato stakes). Drive stakes 6-8 inches into the soil every 4-5 feet in the plant row. Tie plants with polyethylene string that is used for staked tomatoes. Tie the first string 7-9 inches above the soil when plants are 10-12 inches tall or at first fruit set. A second tie should be made at 6-8 inches above the first string and before peppers enlarge and fall over the first string.

Honeybees and pollinating wild bees are also an important component for this flowering crop. They may improve the yield and quality of peppers, and care should be taken when applying insecticides to ensure optimum pollinator safety.

Maturity is determined by fruit size, color, and firmness. When the fruit is smooth, firm to the touch, and displays a shiny dark-green color, it is ready to be harvested. Bell peppers for fresh market must also be 3 inches in diameter and not less than 3.5 inches long to qualify as USDA Fancy. They can also be harvested red, which are considerably sweeter and more flavorful. Mature yellow, orange, and purple bell peppers, together with red bell peppers, represent a generally higher value product in fresh market channels.

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Most peppers grown in Virginia are harvested by hand two to four times during the growing season, usually within 80-90 days from transplanting. Summer harvest begins around the first or second week of July and runs until early or mid-August. The fall harvest begins in early October and lasts until the first frost, usually mid-November. Price of peppers and weather also play major roles in when to start and how long the harvest lasts. When harvest begins, pickers break the fruit from the plant with stems attached to the fruit and should be encouraged to harvest peppers with intact or nearly intact stems. Peppers with intact stems are more resistant to bacterial soft rot than those with jagged, torn, or no stems at all. Also, because considerable damage can occur during picking and handling, care should be taken to minimize injury to the fruit. Bell peppers should be harvested at cool temperatures, and additional cooling should be provided before shipping to maintain quality.

During the growing season, worker activities in the field include transplanting (May for summer harvest or July for fall harvest), cultivating, staking, scouting, spraying, and harvesting (July-August and October-November). The workers risk potential exposure to pesticides during these activities and should follow all safety procedures determined by the label; mostly, wearing proper personal protective equipment (PPE) and strictly following restricted-entry intervals (REIs) when returning to the field. Activities that bring workers in direct contact with the plants during the growing season are generally limited to staking plants and harvest time because the fruit is handpicked by the workers.

Although several alternatives can be worked in, the basic production system consists of transplanting seedlings into worked ground, fertilization and irrigation, mulching, staking, herbicide application for weed control, pest control, and cultivation, as needed, followed by harvest.

* *Indicates hybrid variety*

Special Use Labels

Section 18 Emergency Use Exemption and Special Local Needs (24C) labels are used to supplement the chemical tools available to producers for pest control. Once the problem or gap in pest control has been identified, specialists submit the proper documentation for the emergency use/special local needs label. Thus far, Extension specialists have been successful in obtaining these labels, which must be applied for annually and are usually only valid for limited time intervals. Without these, pest control in bell peppers as well as other vegetable crops would be extremely difficult for producers.

Insect Pests

Most insect descriptions found below were modified from information presented on the Virginia Tech Insect ID website. [2] *Control recommendations found below were modified from information presented in the 2002 Commercial Vegetable Production Recommendations - Virginia.*[3]

Insects damage to peppers by feeding on the fruit, the leaves, and even by spreading viral diseases. The insects whose feeding affects the fruit are of the most importance and concern for growers and processors. Pepper insect pests can be effectively managed. To help ensure success in pest management, one must incorporate the following practices: selecting proper fields, growing insect-free transplants, planting early, controlling weeds and diseases, operating insect traps, examining fields periodically, timing and applying insecticides properly, and immediately destroying the crop on completion of harvest.[4]

Aphids
Green Peach Aphid, *Myzus persicae*
Melon Aphid, *Aphis gossypii*

The two primary species of aphids that infest peppers in Virginia are the green peach aphid and the melon aphid. Melon aphid adults and immatures are yellow or green to black in color, and green peach aphid adults and immatures are translucent greenish white or pink. All aphids are soft-bodied and very small. The adults may be winged or wingless. Aphids cluster on the underside of leaves or stems and feed on plant sap, which may reduce plant vigor, size, and yield. Leaves may also become curled and distorted, and plants may become stunted. Also, as they feed on the underside of

the leaves, aphids excrete honeydew. This, in turn, leads to the growth of black sooty mold, which may block out sunlight and thus reduce plant yield. Aphids can also have the potential to transmit plant viruses. Each of these species carries a different array of viruses, all of which can be devastating. See *Diseases* section for more information on viruses.

Monitoring: Large aphid populations may be detected by the appearance of cast skins, sooty mold, or shiny honeydew accumulations on lower foliage.

Chemical Control: Begin treatment before aphids appear in damaging numbers. For best control of green peach aphid during periods of drought, apply insecticide 2 to 3 days after irrigation. Thorough spray coverage beneath leaves is important when foliar sprays are used. For best melon aphid control, apply insecticide 2 to 3 days after irrigation. Thorough spray coverage beneath leaves is important. See *Chemical Insect Control* section.

Biological Control: Lady beetles, damsel bugs, and lacewing larvae love to feed on aphids. Flower flies are also effective predators. There are also many tiny wasps that act as parasites of aphids. Natural enemies will often keep aphid populations below damaging numbers and, therefore, should be considered before an insecticide application. However, if the spread of virus is of concern, chemical treatment will be necessary.

Cultural Control: Always check surrounding weeds and other plants for aphids before planting vegetables. Avoid planting fields immediately downwind of a barrier such as hedgerows or wood lots, which reduce wind velocity and increase the number of dispersing aphids falling into fields. After harvest, always remove any crop residues left in the field as soon as possible.

Armyworms
Beet Armyworm (BAW), *Spodoptera exigua*
Fall Armyworm (FAW), *Spodoptera frugiperda*

Fall armyworm larvae, a major pest of peppers in Virginia, cause serious damage to the fruit, resulting in premature drop and fruit rot. The larvae are light green to black with stripes down the body and about 1 1/2 inches long. There is also a distinct inverted "Y" on the front of the head. FAW overwinters in the south and migrates north in late summer. Adults lay eggs on the leaves, and the larvae hatch in about a week. The larvae feed for about 2 weeks before burrowing into the soil to pupate for 2 weeks.

Beet armyworm, although a destructive pest, is not as significant as FAW in Virginia. The larvae feed on both leaves and fruit, resulting in defoliation and fruit loss. BAW caterpillars are smooth skinned and variable in color from pale green to black. BAW has a distinctive dark spot on each side just above the second pair of true legs, but this spot may be hard to see in dark individuals. BAW is a tropical insect. When outbreaks occur in Virginia, it is usually late summer after a prolonged hot, dry season. Resistance is a problem with BAW, but the newer chemistry such as indoxacarb (*Avaunt*) and spinosad (*SpinTor*) works well in Virginia.

Monitoring: No monitoring guidelines have been established in commercial production.

Chemical Control: Timing of insecticide application is very important. Treating small, young larvae is crucial because they are difficult to control once they reach 1/2 inch or more in size. See *Chemical Insect Control* section.

Biological Control: There are many parasitic enemies, like ichneumon, braconid, and chalcid wasps and a tachinid fly that usually reduce populations naturally. Birds and ground beetles are also natural predators of the armyworm. Viral diseases may also be important; however, none of these organisms provide reliable control of armyworms when they feed on the fruit.

Cultural Control: After harvest, plow under soil to destroy pupae.

Cabbage Looper
Trichoplusia ni

Cabbage loopers may be identified by their pale green color and thin white stripes down the back and sides and also by

their doubling-up or looping as they move. These insects feed on the underside of leaves, producing ragged holes of various sizes. Feeding begins in late July or early August and usually continues through harvest. Healthy plants can usually sustain feeding injury unless populations become exceedingly large. Several generations can occur during a year.

Monitoring: Check leaf-feeding levels in the field at least weekly. Healthy and older plants can usually withstand moderate defoliation before economic yield loss to the fruit occurs. Moth activity can be monitored with black light traps, although pheromone traps are more effective.

Chemical Control: See *Chemical Insect Control* section. Cabbage looper is considered a minor, or secondary, pest and usually will be controlled by the same materials used for the primary pests.

Biological Control: There are several parasitic wasps and predators that attack the cabbage looper. Also, a nuclear polyhedrosis virus (NPV) can substantially reduce population levels of larvae, especially after a period of precipitation.

Cultural Control: No current recommendations for commercial production.

Corn Earworm (CEW), *Heliothis zea*
Hornworms, *Manduca spp.*

Corn earworm larvae are the second most economically important pests of peppers in Virginia. CEW generally have 5-6 larval instars and can vary in color. Later instars are greenish yellow, reddish, or brown in color with alternating light and dark longitudinal stripes, raised black spots, and brown to orange heads. All instars have five pairs of prolegs. CEW larvae feed on leaves, buds, and new growth, causing damage early on, but they prefer the fruiting stages of the host plant. Once plants flower and produce fruit, CEW moves to these plant parts to feed, causing large gaping holes on the surface and damage to the cap and stem of the fruit.

Hornworms are also a significant pest of peppers in Virginia. Hornworms are quite distinct from other larval pests due to their bright green color, large size, and rear end horn, but also because of their diagonal white or gray stripes that criss-cross their bodies. Extensive defoliation can occur with large numbers of hornworms present. They also feed on the fruit, creating a shallow but broad feeding scar across the surface.

Monitoring: For CEW, monitoring the field for small, white, single-laid eggs is necessary since sprays are not effective once larvae enter the fruit. Fields should be scouted and undersides of leaves examined from the top of the plant down. Concentrate on areas where there is evidence of feeding. If any eggs are present, the field should be treated. Pheromone traps can also be used to monitor adult populations. For hornworms, scout by searching leaves for damage, frass, or larvae. Often one sees defoliated stalks or the characteristic dark-green droppings (fecal pellets) before the caterpillar is located.[5]

Chemical Control: Timing of insecticide application is very important. Treating small, young larvae is crucial because they are more vulnerable during this part of the life cycle. See *Chemical Insect Control* section. The sprays applied to control European corn borer will usually control this pest as well.

Biological Control: *Trichogramma*, a parasitic wasp, attacks eggs and larvae of CEW. A small braconid wasp is an important enemy of the hornworm. This parasitic wasp lays its eggs inside the body of the caterpillar. If larvae are found with cocoons on their backs, these should not be killed.

Cultural Control: Discing the soil and plant remnants under and removing all pepper plant residues and infected fruit from the field will destroy overwintering pupae.

Cutworms
Black Cutworm, *Agrotis ipsilon*
Variegated Cutworm, *Peridroma saucia*

Cutworm larvae may be dull gray, brown, or black in color, and may be striped or spotted depending on the species. A distinguishing quality of cutworms is their act of rolling into a tight C-shape if disturbed. There are several species of cutworms that feed on pepper plants, cutting them off at ground level. The two major species attacking peppers are

the variegated cutworm, which feeds on lower leaves and petioles, and the black cutworm, which largely feeds at the soil surface and below on roots and lower stems but will occasionally feed on leaves. Typically, however, cutworms are not major pests of pepper producers in Virginia.

Monitoring: Cutworm larvae are present during July and August, although they are not typically seen in the open during the day. Digging up the soil around injured plants may reveal their presence.

Chemical Control: See *Chemical Insect Control* section.

Biological Control: No current recommendations for commercial production.

Cultural Control: No current recommendations for commercial production.

European Corn Borer (ECB)

Ostrinia nubilalis

The European corn borer is the most economically important pest of peppers in Virginia. ECB is particularly destructive for peppers because it is a season-long pest. ECB overwinters as a mature larva inside stems of numerous crops. They pupate in the spring, emerge as moths, and mate. Following mating, the female lays between 500 and 600 eggs in small scale-like masses on the undersides of leaves. Up to 4 or 5 generations can occur each year. The first generation of moths is not usually a serious problem, but the second and third may require weekly sprays to protect developing fruit. The larvae bore into the fruit, causing premature fruit drop and fruit rot. If there is evidence of borer feeding, whole loads of peppers may be rejected, especially for processing peppers.

Monitoring: Eggs can be sampled by visual examination of foliage, but this is a time-consuming and difficult task. Due to the difficulty in scouting for egg masses, monitoring adult populations is recommended. Moth activity and relative abundance can be monitored with a black light or pheromone traps. Close attention must therefore be paid to these traps. Treatments should typically be applied 7-10 days after moth flight. In areas with historically high ECB pressure, treatment should be started when 1- to 1.5- inch diameter fruit is readily observed on the plants. In regions with extreme ECB pressure such as the Eastern Shore, sprays should commence when 0.5- inch diameter fruit is readily observed.

Chemical Control: Proper timing of ECB sprays is critical because most insecticides are effective only during the 2- to 3-day period between egg hatch and when larvae bore into stems or fruit. Six to eight or more applications may be required. See *Chemical Insect Control* section.

Biological Control: Many natural enemies of the ECB occur, including lady beetles, minute pirate bugs, parasitoids, and insect pathogens. However, these natural enemies do not provide adequate commercial control of ECB.

Cultural Control: Destroy and remove all plant residues in the fall after harvest. Also, eliminate weeds around field edges because they often serve as breeding sites.

Flea Beetle

Epitrix cucumeris

Various species of flea beetles exist, and most are tiny, darkly colored beetles 2.5 to 4.5 mm long. The body is usually a dark solid color or dark with pale yellow stripes on each wing cover. These jumping beetles cause damage to the leaves by chewing tiny round "shot holes" in the foliage. The larvae may also feed on the roots but generally do not cause significant damage. Generally, flea beetles are minor pests of peppers in Virginia.

Monitoring: Scout seedlings and young plants for flea beetle damage. At this early stage, the plants are more susceptible to economic damage even when populations are relatively low. Older plants can tolerate several beetles per plant without damage.

Chemical Control: See *Chemical Insect Control* section.

Biological Control: There are some nematodes that are effective agents for the control of flea beetles. Applied to the soil, these nematodes attack the larval stage, preventing root feeding and lowering the number of emerging adults.

Cultural Control: Flea beetles migrate from weedy areas, so it is important to remove weeds along field margins. After harvest, deeply disc plant residues in fields that were infested and practice good sanitation by removing any leftover debris.

Leafminers
Liriomyza trifolii

Leafminers, though not a serious pest in Virginia, damage the leaves of the pepper plant. The yellow larvae, about 1/8 of an inch long, create long, slender, winding, white tunnels in the leaves, which destroy the leaf mesophyll tissue. The adult females lay their eggs within the leaf tissue, and a few days later the eggs hatch and begin to feed. When the larvae have matured, they emerge from the leaf and drop to the ground, where they pupate in the soil. The time span from egg to adult, under optimum conditions, is less than three weeks, allowing many generations to occur annually in Virginia. The first, however, is usually the most damaging.

Monitoring: The economic consequences of leaf mining are not well understood; thus, adequate scouting procedures have not been developed.

Chemical Control: See *Chemical Insect Control* section.

Biological Control: Parasitic wasps often control leafminers.

Cultural Control: No current recommendations for commercial production.

Pepper Maggot
Zonosemata electa

The pepper maggot adults are small yellow flies that emerge from the soil (they overwinter in the pupal form) and are active from June 1 to mid-August. Shortly after mating, the females lay their eggs by inserting them beneath the skin of young peppers. Depending on the growth of the pepper plant, the eggs hatch about 10 days later. The young, white larvae will feed on the tissues inside of the fruit for about 18 days. Once fully grown, the yellow larvae emerge by cutting an exit hole in the fruit and dropping to the soil to pupate. The maggots usually have emerged by the time the peppers are sold to market. If peppers are picked while still green, infested peppers may not be distinguishable from good fruit. Eventually, peppers that have been infested ultimately turn red prematurely and drop off and/or begin to rot, attracting secondary invaders. Only one generation of pepper maggot occurs each season.

Monitoring: The first signs of pepper maggot infestation are the tiny egg punctures made by the females in the immature fruits. As the young peppers mature, the egg punctures become shallow depressions in the fruit. Check for dropped or deformed fruit and monitor adults using yellow sticky traps.

Chemical Control: The use of acephate (*Acephate*) for ECB control will help reduce pepper maggot infestations. See the *Chemical Insect Control* section for other control options.

Biological Control: No effective natural enemies are known at this time.

Cultural Control: Besides crop rotation, there are no current recommendations for commercial production.

Pepper Weevil (PW)
Anthonomus eugenii

The pepper weevil is a pest occasionally imported on older transplants or transplants with flowers or fruit. The adults tend to be reddish brown to black in color with a distinct snout, and the larvae are white grubs with brown heads. The

adults overwinter in warm climates and migrate north in the spring, either by flying or by traveling on pepper transplants or market fruit. Early in the summer, adult weevils feed on fruit and leaf buds and females bore holes in flower buds and fruit, where they lay their eggs protected by brownish excrement. Generally, pepper weevils are considered minor pests of peppers in Virginia.

Monitoring: Due to the clumping pattern of pepper weevil infestations, field scouting becomes very difficult. Pepper weevils are found along field margins more so than in the interior of the field, so scouting for feeding damage along the field margins will give the grower a better idea of infestation and reduce scouting time. Begin scouting fields weekly at transplanting or before first bloom. Sticky traps work well for monitoring pepper weevil adults.

Chemical Control: See *Chemical Insect Control* section.

Biological Control: No effective natural enemies are known at this time.

Cultural Control: After harvest, destroy and remove any pepper plant residues immediately and remove any nearby nightshade plants.

Stinkbugs
Green Stinkbug, *Acrosternum hilare*
Brown Stinkbug, *Euschistus servus*

Stinkbugs are generally minor pests of peppers in Virginia. They are triangular in shape and green or brown in color. When disturbed they release a noxious odor, hence their name. They overwinter in garden debris and other protected areas around the field, emerging in the spring to lay eggs on plant leaves. Both immatures and adults cause damage by sucking sap from pepper plants and causing sunken and seedless peppers. The plants become weakened, and buds and young fruit may become malformed.

Monitoring: Due to their camouflage coloration, stinkbugs are difficult to scout for.

Chemical Control: The use of esfenvalerate (*Asana*), cyfluthrin (*Baythroid*), or methomyl (*Lannate*) for other pests will help reduce stinkbug infestations. See the *Chemical Insect Control* section for other control options.

Biological Control: No effective natural enemies are known at this time.

Cultural Control: To prevent infestations of some species of stink bugs, weed control may help.

Thrips
Eastern Flower Thrips, *Frankliniella tritici*
Tobacco Thrips, *Frankliniella fusca*
Western Flower Thrips, *Frankliniella occidentalis*

Several species of thrips exist and cause damage in peppers; however, they are considered minor pests in Virginia. Damage occurs when the thrips feed on plant tissue and suck on plant juices, causing leaves to become rough and distorting veins on terminals. If heavy damage has occurred, the plants will appear silvery or gray in color. Thrips also have the potential to transmit plant viruses. Each of these species carries a different array of viruses, all of which can be devastating. See *Diseases* section for more information on viruses.

Monitoring: Early detection is very important. To monitor thrip populations, sticky traps can be used. Growers should also be aware that cool, wet weather favors thrip development.

Chemical Control: See *Chemical Insect Control* section.

Biological Control: No effective natural enemies are known at this time.

Cultural Control: Thrips are polyphagous and feed on a wide variety of weed and other crop hosts. Controlling winter

weeds may help, but as with mites, mowing weeds on which populations are established will force thrips into the field.

Two-spotted Spider Mite
Tetranychus urticae

The two-spotted spider mite is considered a minor pest of peppers in Virginia. The mites overwinter in the soil or on host plants and continue to feed and lay eggs in mild weather. Adults emerge after warm weather and begin to mate right away. Damage occurs when the mites pierce the outer surface of the leaves and feeds on plant sap, causing the plants to lose color and fade from green to yellow. Later, the damage may appear reddish in color and "bronzing" of the leaf, along with fine webbing, is characteristic of two-spotted spider mite damage.

Monitoring: Scout fields, especially areas that border roadsides or weedy edges or areas of the field that are sandy. Examine both the upper and lower sides of 5 crown leaves from 5 to 10 locations and look for white stippling. Also note the condition of terminal leaves. Treatment should be made when 10%-15% of the crown leaves are infested early season, or when 50% of the terminal leaves are infested later in the season.

Chemical Control: See *Chemical Insect Control* section.

Biological Control: Natural predators and diseases of mites are present in fields, but rarely at levels high enough for adequate control during outbreaks.

Cultural Control: If possible, avoid mowing field margins and grassy areas until after midsummer since this forces mites into the crop.

Chemical Insect Control

The list below contains products available to producers for insect control in peppers along with the recommended application rates. Always consult the label.

- **acephate** (*Acephate* 75S) - PHI - 7 days. Organophosphates. For control of ECB, apply at a rate of 0.75-1.00 lb. a.i./A. Apply at a rate of 0.50-1.00 lb. a.i./A for control of green peach aphid. Do **NOT** exceed 2 lbs. active ingredient per acre per season. REI - 24 hours.
- **abamectin** (*Agri-Mek* 0.15EC) - PHI - 7 days. Antibiotics - *Avermectins*. For control of leafminers, apply at a rate of 0.01-0.02 lb. a.i./A when adult flies are first present. Apply at a rate of 0.01-0.02 lb. a.i./A for control of mites. Make the application once mites appear. Do **NOT** exceed 0.06 lb. total a.i./A/season. Do **NOT** make more than two sequential applications. REI - 12 hours.
- **carbaryl** (*Sevin* 80S/*Sevin bait*) - PHI - 3 days. Carbamates. For control of cutworms as a postplanting treatment, apply *Sevin Bait* at a rate of 2.0 lb. a.i./A. Do **NOT** apply more than 8.0 lb. a.i./A/season. For control of flea beetles, apply *Sevin* at a rate of 0.50-1.0 lb. a.i./A. For control of CEW and hornworms, apply *Sevin* at a rate of 1.0-2.0 lb. a.i./A. As suppression only, apply *Sevin* at a rate of 1.0-2.0 lb. a.i./A for stinkbugs. Do **NOT** apply more than 8.0 lb. a.i./A/season. REI - 12 hours.
- **cyfluthrin** (*Baythroid* 2E) - PHI - 7 days. Pyrethroids. For control of CEW, ECB, and pepper weevil, apply at a rate of 0.025-0.044 lb. a.i./A. For control of BAW, FAW, cabbage looper, and thrips, apply at a rate of 0.033-0.044 lb. a.i./A. Do **NOT** exceed 16.8 total fluid ounces (0.26 lb. a.i./A) per acre per season. REI - 24 hours.
- Note: Repeated sprays of pyrethroids or carbaryl may flare aphid populations.
- **cyromazine** (*Trigard* 75WSP) - PHI - 0 days. Triazines. For control of leafminers, apply at a rate of 0.02 lb. a.i./A (2.66 oz. or one packet). Do **NOT** exceed six applications per season. REI - 12 hours.
- **dicofol** (*Kelthane* MF EC) - PHI - 2 days. Organochlorines. For control of mites, apply at a rate of 0.38-0.75 lb. a.i./A at first signs of mite buildup. Do **NOT** exceed 0.80 lb. a.i./A (1.6 pints) per season and do **NOT** apply more than two applications per season. REI - 12 hours.
- **dimethoate** (*Dimethoate* 4EC) - PHI - 0 days. Organophosphates. For control of pepper maggot, apply at a rate of 0.25-0.33 lb. a.i./A. REI - 48 hours.
- **disulfoton** (*Di-Syston*) - PHI - 90 days. Organophosphates. For control of green peach aphid, apply at a rate of 1.0-2.0 lb. a. i./A. Place the granules in a soil-incorporated band on each side of seed furrow at planting or at transplanting and do **NOT** apply directly on seed. Do **NOT** apply more than once per crop season. REI - 48 hours.
- **endosulfan** (*Thiodan* 3EC)- PHI - 4 days. Cyclodienes. For control of flea beetles and hornworms, apply at a rate of 0.5-1.0 lb. a.i./A. Do **NOT** harvest within 1 day if 0.5 lb. a.i./A (1.33 pints) are used and within 4 days if over 0.5 lb. a.i./A (1.33

pints) are used. REI - 24 hours. (*Thiodan* 50WP) - PHI - 4 days. For control of pepper maggot, apply at a rate of 0.5-1.0 lb. a.i./A. Do **NOT** exceed a maximum of 2.0 lbs. a.i./A per season. REI - 24 hours.

- **esfenvalerate** (*Asana* XL 0.66EC) - PHI - 7 days. Pyrethroids. For control of flea beetle, ECB, CEW, BAW, and cabbage looper, apply at a rate of 0.03-0.05 lb. a.i./A. Apply when insects are present or when insect damage is observed. Do **NOT** exceed 0.35 lb. a.i./A per season. REI - 12 hours.
- **imidacloprid** (*Admire* 2F, *Provado* 1.6F) - PHI - 21 and 0 days. Nicotinoids. For control of flea beetle, apply *Admire* at a rate of 0.25-0.50 lb. a.i./A. For control of green peach aphid and melon aphid, apply *Admire* at a rate of 0.12-0.38 lb. a.i./A or apply *Provado* at a rate of 0.05 lb. a.i./A. Do **NOT** exceed 0.50 lb. a.i/A per season *Admire* or *Provado*, regardless of application method or formulation. A 12-month plant-back interval must be observed for crops **NOT** on the label. REI - 12 hours.
- **indoxacarb** (*Avaunt* 30WDG) - PHI - 3 days. Carbamates. For control of BAW, apply at a rate of 0.065 lb. a.i./A. For control of cabbage looper, apply at a rate of 0.045-0.065 lb. a.i./A. Do **NOT** apply more than 0.26 lbs. a.i./A/crop. Do **NOT** plant any crop not on the label for food or feed for 30 days after last application. REI - 12 hours.
- **methomyl** (*Lannate* LV) - PHI - 3 days. Carbamates. For control of green peach aphid and melon aphid, apply at a rate of 0.45-0.90 lb. a.i./A. For control of BAW and cabbage looper, apply at a rate of 0.45 lb. a.i./A. And to control ECB, apply 0.90 lb. a.i./A. Do **NOT** apply more than 4.5 lbs. a.i./A per crop or make more than 10 applications per crop. REI - 48 hours.
- **oxamyl** (*Vydate* 2L) - PHI - 7 days. Carbamates. For control of green peach aphid and leafminers, apply at a rate of 0.5-1.0 lb. a.i./A. Do **NOT** apply more than 6.0 lbs. a.i./A per season. REI - 48 hours.
- **oxydemeton-methyl** (*Metasystox-R* 2SC) - PHI - 0 days. Organophosphates. For control of green peach aphids, apply at a rate of 0.5 lb. a.i./A. Do **NOT** make more than two applications per season. REI - 24 hours.
- **permethrin** (*Ambush* 2EC, *Pounce* 3.2EC) - PHI - 3 days. Pyrethroids. For control of flea beetle, pepper weevil, and cabbage looper, apply *Ambush* at a rate of 0.1-0.2 lb. a.i./A or apply *Pounce* at a rate of 0.1-0.2 lb. a.i./A. For control of ECB, apply *Ambush* at a rate of 0.2 lb. a.i./A or apply *Pounce* at a rate of 0.2 lb. a.i./A. Do **NOT** apply more than 1.6 lb. a.i./A per season. REI - 24 hours.
- **pymetrozine** (*Fulfill* 50WDG) - PHI - 14 days. Pyridine Azomethines. For control of green peach aphid and melon aphid, apply at a rate of 0.09 lb. a.i./A. Do **NOT** exceed 0.17 lb. a.i./A per season. REI - 12 hours.
- **sodium fluoaluminate** (*Cryolite* 96W) - PHI - 0 days. Inorganics. For control of pepper weevil, apply at a rate of 9.60-11.52 lb. a.i./A. Do **NOT** apply more than 23.04 lb. a.i./A per season. REI - 12 hours.
- **spinosad** (*SpinTor* 2SC) - PHI - 1 day. Spinosyns. For control of cabbage looper and ECB, apply at a rate of 0.05-0.09 lb. a.i./A. For control of BAW, FAW, and thrips, apply at a rate of 0.06-0.13 lb. a.i./A. For control of leafminers, apply at a rate of 0.09-0.13 lb. a.i./A. Do **NOT** exceed 0.45 lb. a.i./A per season. REI - 4 hours.
- **tebufenozide** (*Confirm* 2F) - PHI - 7 days. Hydrazines. For control of BAW, ECB, FAW, and cabbage looper, apply at a rate of 0.12-0.25 lb. a.i./A. Do **NOT** exceed 1.0 lb. a.i./A per season. REI - 4 hours.
- **thiamethoxam** (*Actara* 25WDG, *Platinum* 2SG) - PHI - 0 days for *Actara* or 30 days for *Platinum*. Nicotinoids. For control of flea beetle, green peach aphid, and melon aphid, apply *Actara* at a rate of 0.03-0.05 lb. a.i./A or apply *Platinum* at a rate of 0.08-0.125 lb. a.i./A. For control of stinkbugs, apply *Actara* at a rate of 0.05-0.06 lb. a.i./A. Do **NOT** exceed 0.13 lb. a.i./A per season of either *Actara* or *Platinum*. REI - 12 hours.

Weeds

Control recommendations were taken from 2002 Commercial Vegetable Production Recommendations - Virginia. [9]

The herbicides currently labeled for weed control in pepper work on annual grasses, certain perennial grasses, and certain broadleaf weeds. However, producers in Virginia are faced with a multitude of additional broadleaf weed problems, including annual morningglories, common lambsquarters, common purslane, jimsonweed, ragweed, and smooth pigweed. If not controlled, weeds can greatly reduce root quality and may interfere with the harvest. To provide additional pest control, a Special Local Needs (24C) label has been approved, in Virginia, for the use of s-metolachlor (*Dual Magnum* 7.62E) to control weeds in transplanted bell peppers only and for the use of paraquat (*Gramoxone* 3SC) for post-harvest desiccation. Recommended rates can be found in the *Chemical Weed Control* section below.

Monitoring: Proper weed identification is an important part of effective weed control. Weeds observed in previous crops within a given field should be noted to aid in future herbicide decisions. It is also important to monitor the effectiveness of preplant incorporated and preemergent herbicides once the crop emerges.

Chemical Control: See *Chemical Weed Control* section below.

Biological Control: No commercially effective controls are available.

Cultural Control: Cultivation is a very important component of weed control. Weeds will outcompete a crop for nutrients, water, and sunlight, reducing yield and making the crop less profitable. Incorporating cultivation with herbicides is the best way to combat weeds and to produce a high yield. Crop rotation is also important to prevent domination of any one weed species year after year. Corn and alfalfa are good rotational crops for peppers along with beans, carrots, lettuce, and cole crops. Avoid crops like tomatoes, potatoes, and eggplant that are in the same family as peppers (Solanaceae). Also, avoiding fields with a history of severe weed infestations may be an appropriate action.

Chemical Weed Control

The list below contains all of the fully labeled products available to producers for weed control in peppers.

- **clethodim** (*Select* 2EC) - PHI - 20 hours. Cyclohexanediones. For control of many annual and certain perennial grasses, including annual bluegrass, apply at a rate of 0.094-0.125 lb. a.i./A. *Select* will not consistently control goosesgrass. Repeated applications may be needed to control certain perennial grasses. Will **NOT** control yellow nutsedge, wild onion, or broadleaf weeds. Do **NOT** apply more than 0.13 lb. a.i./A in a single application. REI - 24 hours.
- **clomazone** (*Command* 3ME) - PHI - N/A. Pyridazinones. For control or suppression of annual grass and most broadleaf weeds, apply at a rate of 0.25-1.00 lb. a.i./A pretransplant. It is **NOT** effective on pigweed sp., carpetweed, morningglory sp., and yellow nutsedge. REI - 12 hours.
- **DCPA** (*Dacthal 75WP*) - PHI - N/A. Phthalic Acids. Apply at a rate of 0.60-10.5 lb. a.i./A after transplanting for preemergence weed control. Apply 4 to 6 weeks after transplanting or on direct-seeded plants at 4 to 6 inches in height when plants are well established and growing conditions are favorable. Emerged weeds will **NOT** be controlled. *Dacthal* will not injure crop foliage. Spray broadcast when crop is grown without plastic mulch or ban between the rows when plastic mulch is used. Controls late-season annual grasses, common purslane, and other broadleaf weeds. REI - 12 hours.
- **napropamide** (*Devrinol* 50DF) - PHI - N/A. Amides. For control of certain annual grasses and annual broadleaf weeds, apply before transplanting or seeding at a rate of 1.0-2.0 lb. a.i./A. Incorporate thoroughly to a depth of 2 to 3 inches on the same day as application. Use the lower rate on light soil (course-textured, sandy) and the higher rate on heavy soil (fine-textured, clay). Does **NOT** control established weeds and may reduce stands of and yield of fall grains. REI - 12 hours.
- **paraquat** (*Gramoxone Max* 3SC) - PHI - 0 days. Bipyridyliums. For control of emerged weeds apply at a rate of 0.5 lb. a.i./A as a directed spray between rows. Do **NOT** allow spray to contact plants as injury or residues may result. Do **NOT** exceed a spray pressure of 30 psi. Apply at a rate of 0.5 lb. a.i./A as a broadcast spray after the last harvest. Add nonionic surfactant according to the labeled instructions. Use to prepare plastic mulch for replanting, or to aid in the removal of the mulch. REI - 12 hours.
- **sethoxydim** (*Poast* 1.5EC) - PHI - 20 days. Cyclohexanediones. For control of annual grasses and certain perennial grasses, apply at a rate of 0.28 lb. a.i./A. For best results, treat annual grasses when they are actively growing and before tillers are present. Control may be reduced if grasses are large or if hot, dry weather or drought conditions occur. Repeated applications may be needed to control certain perennial grasses. Yellow nutsedge, wild onion, or broadleaf weeds will **NOT** be controlled. Do **NOT** tank-mix with or apply within 2 to 3 days of any other pesticide unless labeled, as the risk of crop injury may be increased, or reduced control of grasses may result. Do **NOT** apply more than 0.84 lb. a.i./A per season. REI - 12 hours.
- **s-metolachlor** (*Dual Magnum* 7.62E) - PHI - 65 days. Chloroacetamides. For control of annual grasses, yellow nutsedge, galinsoga, and certain other broadleaf weeds, apply at a rate of 0.63-0.95 lb. a.i./A for transplants only. Do **NOT** preplant incorporate *Dual Magnum*. *Dual Magnum* will **NOT** control emerged weeds. Cultivate and/or hoe to control emerged weeds before treatment. Make only one application during the growing season. REI - 24 hours.
- **trifluralin** (*Treflan* 4E) - PHI - N/A. Dinitroanilines. For control of annual grasses and broadleaf weeds, apply before transplanting at a rate of 0.5-1.0 lb. a.i./A. Use lower rates in coarse soil and higher rates in fine soil. Incorporate into 2 to 3 inches of soil within 8 hours after application. Slight stunting may result if weather is cool and damp. REI - 12 hours.

Table 1: Effectiveness of herbicides recommended for weed control in peppers. [10]

Herbicide	Barnyardgrass	Crabgrass, Large	Fall Panicum	Foxtail sp.	Goosegrass	Johnsongrass (Seedlings)	Yellow Nutsedge	Carpetweed	Cocklebur, Common	Cranesbill	Galinsoga, Hairy	Jimsonweed	Lambsquarters, Common	Morningglory sp.	Shepherdspurse	Pigweed sp.	Purslane, Common	Ragweed, Common	Smartweed, Pennsylvania	Nightshade, Eastern Black	Velvetleaf
Preplant or Preplant Incorporated																					
Command	G	G	G	G	G	G	N	N	N/F	-	F	G	G	P	F	N/P	G	F	G	-	G
Devrinol	G	G	G	G	G	G	N/P	G	N	-	F/P	N	F/G	N	-	F/G	G	P/F	P	N	N
Prefar	G	G	G	G	F/G	G	N	N	N	N	N	N	F/G	N	P/F	F	F	N	N	N	N
Treflan	G	G	G	G	G	G	N	G	N	-	N	N	F/G	P/F	N	F	G	N	P/F	P	N
Preemergence or Preplant Incorporated																					
Dual Magnum	G	G	G	G	G	G	F/G	F	N	-	G	N	P	N	-	G	F/G	N	P	G	P
Postemergence																					
Gramox.Max	F/G	F/G	F/G	G	F/G	-	G	G	G	-	G	G	F/G	F/G	-	G	F/G	G	P	-	-
Poast	G	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Select	G	G	G	G	P	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Herbicide performance is affected by weather, soil type, herbicide rates, weed pressure, and other factors. These ratings indicate ONLY relative effectiveness in tests conducted by the University of Delaware, University of Maryland System, The Pennsylvania State University, Rutgers, The State University of New Jersey, and Virginia Polytechnic Institute and State University. Actual performance may be better or worse than indicated in this chart.

G = good	F = fair	P = poor	N = no control	- = insufficient data

Diseases

Control recommendations found below were modified from information presented in the 2002 Commercial Vegetable Production Recommendations - Virginia.[5]

Production and quality of bell peppers are reduced severely by several of the following diseases. Control or prevention of these diseases is most important for profitable production of peppers. Pepper diseases are classed as parasitic or non-parasitic. Parasitic organisms are the cause of most major diseases (fungi, bacteria, nematodes, and viruses). Unfavorable soil or climatic conditions cause the so-called non-parasitic diseases, such as blossom end rot and sunscald.[6]

Anthracnose Fruit Rot

Colletotrichum gloeosporioides, C. capsici, and C. coccodes

Also known as ripe fruit disease, the characteristic symptoms of this fungal disease are sunken, crater-like spots on the fruit. This becomes apparent when the fruit ripens and turns red. Anthracnose fruit rot thrives in wet conditions and

relatively high temperatures and humidity. This disease generally does not affect green fruit.

Monitoring: Watch for fruit developing circular depressions in the skin and be aware of wet field conditions along with high temperatures and humidity.

Chemical Control: Alternate applications of maneb (*Maneb*) and azoxystrobin (*Quadris*) beginning at flowering and repeat every 7 to 10 days. See *Chemical Disease Control* section.

Biological Control: No current recommendations for commercial production.

Cultural Control: A minimum two-year rotation out of solanaceous crops is recommended. No resistant varieties are available.

Bacterial Leaf Spot (BLS)

Xanthomonas campestris pv. *vesicatoria*

Bacterial leaf spot is the number one bacterial disease affecting peppers in Virginia. BLS may appear as small, circular, necrotic spots on leaves, stems, and fruits. Symptoms first appear on the underside of young leaves as small, yellowish green spots. On older leaves these water-soaked spots can grow up to 1/4 inch in diameter, turn dark brown, and become raised. Eventually, the leaves yellow and fall off, increasing the chance for sunscald on the fruit. The fruit, when infected, develops small, blister-like irregular spots that later turn brown and become raised and scab-like. During warm, rainy weather, this seed-borne organism can spread rapidly.

Monitoring: Watch the underside of young leaves for raised spots. The severely spotted leaves will turn yellow and drop off.

Chemical Control: See *Chemical Disease Control* section.

Biological Control: No current recommendations for commercial production.

Cultural Control: Plant resistant varieties when possible, use disease-free seed or transplants, and rotate crops away from tomato and peppers for at least two years. Crop loss from bacterial leaf spot can be reduced somewhat by maintaining a high level of fertility. Maintaining high fertility levels will stimulate additional leaf formation to replace those lost from bacterial spot infections. However, sufficient restraint must be used to ensure that plants do not become overly vegetative, or fruit set may be severely reduced. Where disease is present or anticipated, do not work in fields when plant surfaces are wet to reduce the spread. Disc fields as soon as possible after the growing season. This will hasten breakdown of the crop debris that is harboring the bacteria and minimize overwintering of the bacteria in the field.

Bacterial Soft Rot

Erwinia caratovora

During periods of humid weather, the stem ends of harvested peppers develop this disease and turn brown. In the field the bacterium usually enters through a wound on the fruit. Internal tissues rapidly become soft and watery, and a depression is formed on the fruit surface. The rot spreads quickly, and within several days the entire fruit may collapse.

Monitoring: This is primarily a post-harvest problem.

Chemical Control: No current recommendations for commercial production.

Biological Control: No current recommendations for commercial production.

Cultural Control: After harvest, pack peppers dry without washing to minimize this disease. If peppers must be washed, then maintain 25 ppm of chlorine (1 tablespoon of Clorox per 8 gallons of water) in the wash water. Avoid washing peppers with water more than 10°F (6°C) cooler than the fruit temperature to prevent movement of bacteria into the stem end of the fruit. As for sanitation, seed selection, and crop rotation there are currently no viable management options.

Blossom End Rot

This physiological disorder is caused by a calcium deficiency in the fruit when soil moisture is low. Calcium is required in relatively large concentrations for normal cell growth. When a rapidly growing fruit is deprived of necessary calcium, the tissues break down, leaving the characteristic dry, shriveled, and poorly developed blossom ends of the fruit. The first symptom is a dark, water-soaked area around the blossom end of the fruit. The area darkens and rapidly enlarges as the fruit ripens, eventually turning brown to black in color. Secondary fungi may invade the affected area, causing the grower to think that a fungus is responsible for the damage. Fruit showing signs of this disorder should be discarded.

Monitoring: Test calcium and nutrient levels in soil and monitor fruit when it is about half-grown.

Chemical Control: No current recommendations for commercial production.

Biological Control: No current recommendations for commercial production.

Cultural Control: To control blossom end rot, maintain proper soil calcium and nutrient balance through liming and fertilization. Avoid root pruning and damage. The most effective control is to maintain uniform, favorable soil moisture. This is especially important when using raised beds for Phytophthora control, since soil in raised beds dries more quickly than in flat culture.

Damping-Off

Phytophthora spp., *Pythium* spp., and *Rhizoctonia solani*

Damping-off generally attacks seedlings in areas with poor drainage or areas with a previous history of the disease. Symptoms include brown, water-soaked stems at the soil line that shrivel and pinch the seedling off at ground level, causing them to topple over. Planting in cold, wet, or poorly prepared soils, low soil fertility, and use of old or poor-quality seeds can all increase the incidence of damping-off.

Monitoring: Seedlings are most vulnerable to attack and should be monitored during damp conditions.

Chemical Control: See *Chemical Disease Control* section.

Biological Control: No current recommendations for commercial production.

Cultural Control: Avoid planting in areas with poor drainage or areas with a previous history of the disease. Do not plant into cold, wet, or poorly prepared soils with low fertility.

Phytophthora Blight

Phytophthora capsici

Phytophthora blight is a highly destructive disease of peppers. This disease tends to develop in low areas of the field after periods of heavy rainfall and soon spreads throughout the entire field. Severe crop losses can result within a very short time. Seedlings that become infected show symptoms similar to damping-off. Mature plants that become infected occur at or below the soil line. Symptoms appear as water-soaked spots or dark brown lesions on the lower stems just above the soil. Sudden wilting of the foliage may occur due to the lack of upward movement of water and nutrients caused by root damage or girdling of the stem. Fruit lesions may also appear as large, water-soaked lesions that shrivel and darken. A whitish, tan mold may also appear over the lesion on the fruit surface under humid conditions.

Monitoring: Seedlings are most vulnerable to attack and should be monitored during damp conditions.

Chemical Control: See *Chemical Disease Control* section.

Biological Control: No current recommendations for commercial production.

Cultural Control: Planting on a ridge or raised, dome-shaped bed will assist in control by providing better soil drainage. Use disease-free seed and a 3-year rotation with crops other than peppers, cucurbits, eggplants, or tomatoes. Use Phytophthora-resistant varieties in fields with a history of infection or fields with low-lying areas. Water management is

crucial in preventing this disease and minimizing its destruction.

Southern Blight
Sclerotium rolfsii

Southern blight, also known as "southern wilt" and "southern stem rot," is a soil-borne fungus that attacks the crown of the plant. Pepper plants begin to wilt suddenly, turning yellow and finally brown before dying. Also, the stems may appear rotted at the soil line. A white, moldy growth is visible on affected stem tissues and adjoining surface soil. Eventually, light tan to dark brown mustard seed-like bodies called sclerotia are evident in the mold. The fungus overwinters as sclerotia in host debris and in the soil. High soil moisture and temperatures, particularly after dry conditions, favor the disease development.

Monitoring: Symptoms begin with yellowing and wilting leaves, eventually spreading to the rest of the plant.

Chemical Control: See *Chemical Disease Control* section.

Biological Control: No current recommendations for commercial production.

Cultural Control: Removing crop debris after harvest, plowing under crop residues, and long crop rotations with corn and small grains will help reduce disease incidence.

Sunscald

Sunscald, a physiological disorder, occurs on any part of fruit exposed to intense direct sunlight. Leaf defoliation caused by other diseases or insects can provide favorable conditions for sunscald. Affected areas first appear as light-colored, soft, and slightly wrinkled. These areas later become dry, sunken, and have a white, paper-like appearance. Secondary fungi may invade the damaged tissue, causing the area to become discolored. By selecting varieties with good foliage cover, sunscald can be prevented. It is also important to maintain vigorous vegetative growth by following the recommended fertilizer program. When harvesting, be careful to avoid breaking foliage and exposing the fruit to too much sun.

Monitoring: Watch for soft, light-colored areas developing on parts of the pepper fruits exposed to direct sunlight.

Chemical Control: No current recommendations for commercial production.

Biological Control: No current recommendations for commercial production.

Cultural Control: To reduce sunscald, select varieties with good foliage cover. Maintain vigorous vegetative growth by following a recommended fertilizer (especially nitrogen) program and irrigating in a timely manner. Harvest carefully to avoid breaking foliage.

Verticillium Wilt
Verticillium dahliae

Verticillium wilt is favored by warm weather and excessive soil moisture, allowing the soil-borne fungus to persist in the soil for many years. Symptoms first appear on older leaves and later develop on younger leaves. The leaves begin to yellow, and eventually the margins and leaf tips will dry, turn brown, and drop prematurely.

Monitoring: Watch for leaf discoloration on older leaves.

Chemical Control: No current recommendations for commercial production.

Biological Control: No current recommendations for commercial production.

Cultural Control: Do not grow tomato, potato, or eggplant as an alternative crop. Rotate to allow one year between

pepper plantings with non-hosts like broccoli, corn, wheat, barley, etc. Do not plant other solanaceous crops, such as eggplants or tomatoes, between pepper plantings. Always use resistant cultivars where available.

Viruses

Aphid-Transmitted (TMV, PVX, CMV, TEV, PVY, and AMV)
Thrips-Transmitted (TSWV and INSV)

Aphid-transmitted viruses in peppers include *alfalfa mosaic virus* (AMV), *cucumber mosaic virus* (CMV), *potato virus X* (PVX), *potato virus Y* (PVY), *tobacco etch* (TEV), and *tobacco mosaic virus* (TMV). Symptoms vary, depending on the virus or strain, the plant, time of year, and environmental conditions. CMV, on older leaves and fruit, exhibits yellowish ring-spots, while younger leaves may appear mottled light and dark green. Plants may also become stunted. In pepper plants, AMV is easily recognizable by the bright, white or yellow, calico-patterned leaves. TEV and PVY are more difficult to distinguish, producing dark-green mosaic bands along the leaf veins. It is very common to find plants simultaneously infected by more than one virus at a time.

Thrip-transmitted viruses can be severe on peppers during both greenhouse production of transplants and during field production of the crop. During transplant production, thrips transmit the virus from infected ornamental plants (flowers). These viruses cause a wide array of symptoms including wilting, stem death, stunting, yellowing, poor flowering, sunken spots on leaves, and many others. TSWV causes sudden yellowing and browning of young leaves that become necrotic. Fruit formed after infection may develop large, necrotic blotches. *Impatiens Necrotic Spot Virus* (INSV) causes similar symptoms on peppers as *Tomato Spotted Wilt Virus* (TSWV); however, the virus is not as severe and does not limit production to the same extent as TSWV.

Monitoring: Viruses are spread by use of infected seed, cuttings, and by insect feeding. Before transplanting plants, monitor greenhouses, scout fields for aphids and thrips, and inspect all incoming plants for symptoms.

Chemical Control: Once thrips are observed in the field, begin an insecticide program. The viral diseases of pepper cannot be adequately controlled with insecticide applications, but symptom expression can be delayed through their use. See *Chemical Insect Control* section.

Biological Control: No current recommendations for commercial production.

Cultural Control: For aphid-transmitted viruses, use resistant varieties to control TMV. Since aphids transmit the virus, growers may wish to use yellow trap pans containing water to determine when mass flights of winged aphids occur. Repeated applications of a contact aphicide at those times are most beneficial. The thrips-transmitted virus is spread by thrips from infected ornamental plants during the transplant production phase. Be sure not to grow any ornamental bedding plants in the same greenhouse as pepper transplants. Methods that should be practiced for virus prevention include using virus-resistant cultivars, mowing weeds around the field, avoiding nearby sources of virus, and avoiding planting in the same field after susceptible earlier-season crops.

Chemical Disease Control

The list below contains all of the products available for disease control in peppers along with the recommended application rates for these chemicals. Always consult the label.

- **azoxystrobin** (*Quadris* 2.1F) - PHI - 0 days. Strobilurins. For control of anthracnose, apply at a rate of 0.10-0.25 lb. a.i./A. Do **NOT** apply more than two sequential applications of *Quadris* before alternating with a fungicide that has a different mode of action. Do **NOT** make more than four applications of *Quadris* per acre per season. Do **NOT** apply more than 1.0 lb. a.i./A per season. REI - 4 hours.
- **copper, fixed** (*various formulations* 77WP, *Champion* 77WP) - PHI - 0 days. Inorganics. For prevention of the stem and fruit rot phase of Phytophthora blight, apply at a rate of 1.54 lb. a.i./A. For control of BLS, apply *Champion* at a rate of 1.0 lb a.i./A *plus* 1.50 lb a.i./A maneb (*Maneb* 80WP) shortly after transplanting and repeat every 7 to 10 days. REI - 24 hours.
- **copper hydroxide** (*Ridomil Gold Copper* 65WP) - PHI - 7 days. Inorganics. For control of the stem and fruit rot phase of Phytophthora blight, apply at a rate of 1.60 lb. a.i./A. Do **NOT** apply more than a total of 1.50 lb. a.i./A per crop per season. REI - 48 hours.
- ***Gliocladium virens*** (*SoilGard* 12G) - PHI - N/A. Myco-fungicides. *SoilGard* is a naturally occurring soil fungus that is

an antagonist to plant pathogenic fungi. For control of damping-off, uniformly add 1.0-1.5 lb./cu yd of *SoilGard* when soilless mixes are being blended by mechanical devices. Allow the treated soil or media to incubate for one day before planting to achieve best results. Do **NOT** use other fungicides with *SoilGard 12G* at time of incorporation. REI - not required.

- **maneb** (*Maneb* 80WP) - PHI - 7 days. Dithiocarbamates. For control of anthracnose fruit rot, apply at a rate of 1.2-2.4 lb. a.i./A. Do **NOT** apply more than 14.4 lbs. a.i./A per season. REI - 24 hours.
- **mefenoxam** (*Ridomil Gold* 4E) - PHI - 7 days. Phenylamides. For control of the crown rot phase of Phytophthora blight, apply at a rate of 0.5 lb. a.i./A. Do **NOT** apply more than 1.5 lb. a.i./A per season. REI - 48 hours. (*Ultra Flourish* 2E) - PHI - 7 days. Phenylamides. For control of the crown rot phase of Phytophthora blight, apply at a rate of 0.5 lb. a.i./A. Do **NOT** apply more than 3.0 lb. a.i./A per season. REI - 48 hours.
- **metam-sodium** (*Busan* or *Vapam* HL) - PHI - N/A. Dithiocarbamates. For control of damping-off when planting mix is not used, pre-treat seedbeds with 0.75 qt./100 sq ft. REI - 48 hours.
- **PCNB** (*Terraclor* 75WP) - PHI - N/A. Substituted aromatics. For control of southern blight, make a transplant solution and apply at the time of transplanting at a rate of 2.25 lb. a.i./A. Do **NOT** exceed 20 lbs. a.i./A per season. Do **NOT** plant root crops in PCNB-treated fields within 12 months of broadcast and banding applications unless PCNB is registered for use on those crops. REI - 12 hours.

Nematode Pests

Control recommendations were taken from 2002 Commercial Vegetable Production Recommendations--Virginia.[7]

The root-knot nematode (*Meloidogyne spp.*) is the most important species of nematode affecting peppers in Virginia. [8] Symptoms and damage can mimic other diseases and pests, making identification nearly impossible to determine on site. Soil and root samples should be collected and analyzed by an expert for determination.

Monitoring: Both diagnostic and predictive nematode assay programs in Virginia provide data to producers on the numbers and kinds of nematodes in soil along with recommendations for control. Soil samples for diagnostic assays are processed without charge to determine the cause of production problems during the growing season. Predictive nematode assays are done on samples collected after harvest. These samples are processed at a cost of $11 per sample and must be collected in the fall no later than November 20.

Chemical Control: When using soil fumigation, it is important that the fields be sufficiently prepared for planting. All crop debris and clods should be removed, and soil moisture should be adequate. Otherwise, soil fumigation will not be effective due to lack of penetration of all soil particles by the gaseous fumigant. It is also necessary to allow an aeration period between fumigant applications and planting; otherwise, crop injury will occur. For recommendations, see the *Chemical Nematode Control* section below.

Biological Control: No commercially effective controls are available.

Cultural Control: Sanitation and good cultural practices are the best preventive measures against nematodes. Examples include obtaining nematode-free roots and washing soil from machinery and tools before using them at different locations. Crop rotation with non-host crops to decrease their population is highly recommended in the event of nematode activity.

Chemical Nematode Control

Several chemicals are currently available for nematode control, although this may change in the next few years. Currently, the multipurpose soil fumigants chloropicrin, metam sodium *(Busan, Nemasol, Vapam HL*), and methyl bromide (*Terr-O-Gas 67, MC-33*) are recommended for use in Virginia. In addition, dichloropropene (*Telone II*) and chloropicrin + dichloropropene (*Telone C-17, Telone C-35*) are soil fumigants used only for nematodes. The non-fumigant nematicide oxamyl (*Vydate L*) is also recommended for use in peppers. Typically, chemical controls are used only when cultural practices are unable to provide adequate control. However, these chemicals are still important tools when other methods of control have failed.

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References

On-Line Resources

C&P Press Online Crop Protection Reference
http://www.greenbook.net/free.asp

Crop Data Management Systems - Pesticide Labels
http://www.cdms.net/pfa/LupdateMsg.asp

Insects and Related Pests of Vegetables
http://ipm.ncsu.edu/AG295/html/

Pests of Vegetables and Fruit Trees
http://everest.ento.vt.edu/~idlab/vegpests/vegfact.html

Virginia Tech Pesticide Programs
http://www.vtpp.ext.vt.edu

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