

# Crop Profile for Peppers in Kentucky

*Capsicum annuum*

Prepared: July 2001



## General Production Information

### Production Statistics

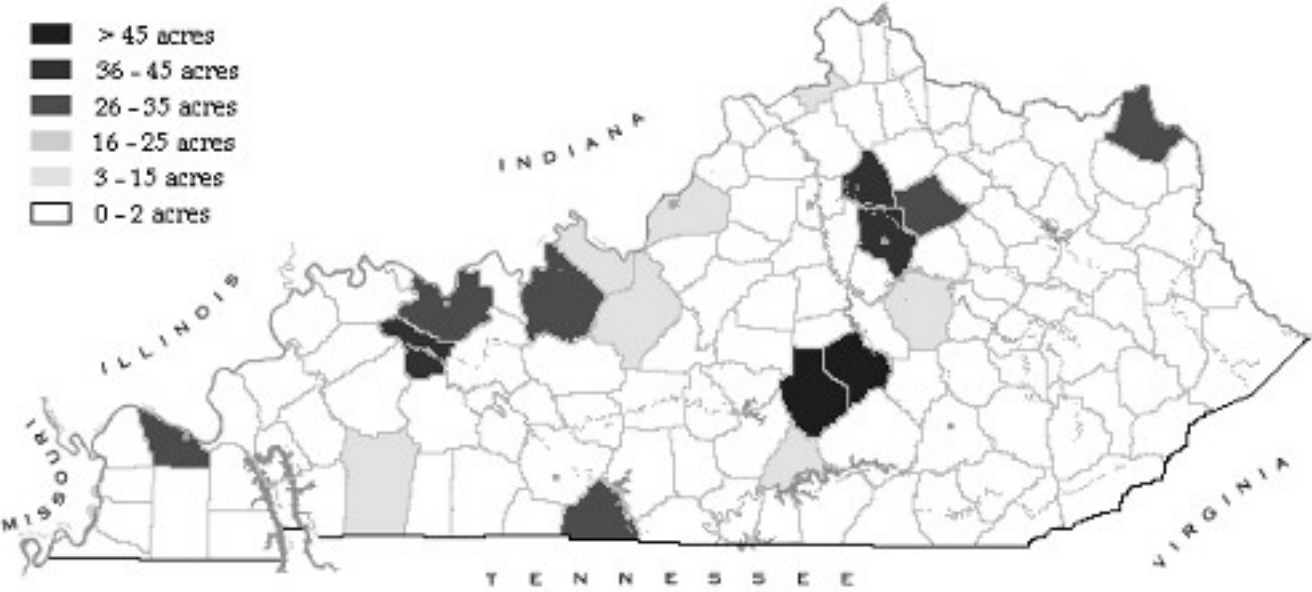
The total pepper acreage in Kentucky is estimated to be approximately 1,850 acres in 2000. The pepper production in Kentucky during 2000 was valued at US \$8,003,000. Growers sell pepper to roadside and local customers but also utilize cooperatives in south central, central western Kentucky for wholesale marketing.

### Production Regions

In the early 1980's Kentucky produced over 8,000 acres of bell peppers each year for 5 processing

companies and several fresh market cooperatives, but due to bacterial leaf spot, the acreage declined dramatically.

Today there is one bell pepper processor contracting in Kentucky, and fresh market bell pepper acreage, through the use of leaf spot resistant cultivars, is just beginning to recover. Peppers production generally occurs on small farms scattered across the state. Cooperatives in south central, central, and western Kentucky have increased the concentration of fresh market pepper production in those areas. The map below indicates the commercial pepper acreage by county reported for 1998 by the Purdue University Center for New Crops and Plant Products.



**Recommended Varieties**

**Bell (all are F1 hybrids)**

- Merlin
- King Arthur
- Summer Sweet 890
- Yorktown
- X3R Wizard
- Red Knight
- North Star
- Boynton Bell
- Enterprise
- X3R Aladdin
- Lexington
- Paladin

**Specialty Bell**

- Ivory
- Valencia
- Ledoro
- Early Sunsation
- Oriole
- Mandarin

Purple Beauty                      Lilac

### **Pimento**

Pimento L

### **Hot**

Hungarian Wax                      Grande (hybrid jalapeno)

Mitla (hybrid jalapeno)      Delicias (hybrid jalapeno)

Senorita (hybrid jalapeno) Large Red Cherry

### **Sweet**

Banana Supreme                      Super Sweet Cherry

## **Cultural Practices**

Peppers are grown in Kentucky for both fresh market and processing. To be successful and to make money, it is extremely important to begin with a good field location. Low lying fields, next to creeks and rivers, are subject to high humidity and moisture conditions resulting in serious disease pressure; these areas are especially prone to bacterial spot epidemics. Growers should also avoid poorly drained fields or fields where herbicides such as Scepter or atrazine products may have been used the previous season. Herbicide carryover (especially from corn and soybean herbicides) can cause serious injury to peppers.

Growers need to locate pepper plantings as far away from tobacco plantings as possible because of the danger of aphid movement and virus disease spread from tobacco to peppers. Although tobacco ground may represent some of the best land on a farm, it is also not advisable to grow peppers after tobacco, tomatoes or potatoes for a period of three years as these crops are susceptible to many of the same diseases.

Soils known to be high in residual nitrogen should also be avoided to prevent peppers from producing excessive foliage at the expense of fruit. Consider the previous crop when deciding how much nitrogen to apply; there will probably be some residual nitrogen following a crop which received heavy doses of nitrogen fertilizer during the previous season. Simple, hand-held electronic meters are now available which growers can use to quickly determine the nitrate nitrogen status of soils and plants. These Cardy meters can be used to determine residual nitrate levels in soils prior to planting as well as to measure nitrate levels in plant sap in order to assess the efficiency of fertilization.

Plow soil 8 to 10 inches deep several weeks in advance of the transplanting date. Peppers do extremely well following fescue sod. Prepare a fine seedbed by discing or rototilling. At this time herbicide can also be incorporated in the top 1 to 2 inches of soil.

Planting hybrid bell pepper plants on 6 to 8 inch raised beds covered with black plastic mulch using drip irrigation has resulted in high yields of excellent quality peppers for fresh market sales in Kentucky. A bed shaper/plastic layer and a setter that will transplant through plastic are essential for this production system. Two rows of peppers spaced 15 inches apart are planted on each bed; plants are spaced 12 inches apart within each row. The beds are usually six feet from center to center (14,500 plants per acre). Much of the fresh market pepper production in the state is now using raised beds, plastic mulch, trickle irrigation, and bacterial-spot resistant hybrids transplants.

## **Insect Pests**

Pepper production in Kentucky is plagued by moderate levels of insect pests. This includes European corn borer and beet armyworm that attack the fruit (direct pests) as well as insects attacking the foliage such as aphids (indirect pests). However, as with most insects encountered in the Midwest, populations of individual pests vary from year to year and location to location, reinforcing the need to routinely monitor pepper fields.

### **Aphids**



Several aphid species may be commonly found infesting peppers during most of the growing season. The most common aphid on peppers is the green peach aphid. Large numbers of aphids can affect pepper production in two ways. Honeydew produced by aphids can leave a sticky film on the surface of

the fruit and cause the development of sooty mold fungi. Various species of aphids can also transmit viruses, notably potato virus Y, that can reduce yields. Aphid infestations may begin in the greenhouse on pepper transplants.

As aphid colonies begin to form on the leaves, development occurs rapidly. Aphids reproduce without mating and individual generations may be completed within one week during the summer. Winged adult aphids develop periodically and disperse from fields following periods of overcrowding. Colonies are found on the undersides of leaves, usually in the lower canopy.

Many of the insecticides used to control other pepper insect pests can contribute to rapid increases of aphids. Natural enemies such as lady beetles, green lacewings, damsel bugs, and hover fly larvae usually control aphid populations adequately. Broad spectrum insecticides, particularly pyrethroid insecticides, can delete these natural enemies and allow aphid populations to develop unchecked. Insecticides should only be applied for other insects when necessary, as determined by trap catches and scouting, and care should be taken to select insecticides that do not favor secondary aphid problems.

## Controls

**Biological:** Aphids are preyed upon by lady beetles, green lacewing and syrphid larvae, these usually can control aphid populations. In fact, high populations of aphids on peppers are typically associated with over reliance on pyrethroid insecticides that deplete populations of natural enemies while providing little aphid control. Minute wasp parasites are also attack aphids and help to reduce their numbers in Kentucky.

**Monitoring:** Aphids should be monitored on a weekly basis. Growers should note any changes in the rate of aphid buildup. Aphid populations do not commonly build to levels that require treatment where insecticides sprays have been managed properly.

### Chemical:

Many of the insecticides used to control other pepper insect pests can contribute to rapid increases of aphids. Natural enemies such as lady beetles, green lacewings, damsel bugs, and hover fly larvae usually control aphid populations adequately. Broad spectrum insecticides, particularly pyrethroid insecticides, can deplete these natural enemies and allow aphid populations to develop unchecked. Insecticides should only be applied for other insects when necessary, as determined by pheromone trap catches and scouting, and care should be taken to select insecticides that do not favor secondary aphid problems.

### Application Alternatives Used in Kentucky:

**Endosulfan 3 EC** (Thiodan, Phaser) - Apply as a foliar treatment at 1-1/3 to 2-2/3 pt per acre with a limit of 2 applications per season.

**Orthene 75 S** (acephate) - Apply as a foliar treatment at 2/3 to 1-1/3 lb per acre. For use on bell peppers.

## **Beet Armyworm**

*(Spodoptera exigua)*



The beet armyworm is a major pest in the southwestern and southern US attacking alfalfa, beans, beets, cole crops, corn, lettuce, onion, peppers, potatoes, peas, and tomatoes. It is an occasional invader of vegetable crops in the Ohio River Valley. Although it cannot overwinter in Kentucky, it is a significant pest for vegetable growers because of its wide host range and resistance to most insecticides. This insect is killed by the first hard frosts in the fall. Producers of fall vegetable crops need to watch out for this pest during August and September.

The beet armyworm is a light-green to black larva with four pairs of abdominal prolegs and a dark head. There are many fine, white wavy lines along the back and a broader stripe along each side. There is usually a distinctive dark spot on each side just above the second pair of true legs. Female moths lay masses of up to 80 eggs underneath a covering of cottony-white scales, as many as 600 eggs over a 3 to 7-day period. These eggs hatch in 2 to 3 days and the larvae first feed together in a group near the egg cluster. As they grow, they gradually move away from the egg masses. Many small larvae die during this wandering stage but the behavior tends to spread out the infestation. Beet armyworm is quite mobile; one larvae may attack several plants in a row. Older larvae may feed on fruit as well as leaves. After they complete their feeding, the 1-1/4 inch larvae pupate in the soil in a loose cocoon containing soil particles and leaf fragments. The life cycle takes about a month to complete.

Beet armyworm feeding on young tender growth can be very damaging to small transplants. Often a fine webbing is produced by smaller larvae near these feeding sites. Older plants can become rapidly defoliated. Vegetable growers should pay particular attention to fall plantings of beans, tomatoes,

crucifers, other truck crops.

## Controls

**Biological:** Beet armyworm has few effective parasites or predators which can effectively reduce its numbers.

**Monitoring:** A southern insect that doesn't usually occur in Kentucky, but can cause serious pepper losses when present. Timing of insecticide applications is very important. Once larvae are 1/2 inch or longer, they become very difficult to kill with insecticides. So treatment must be targeted against young larvae. Only with frequent field surveys can these pests be detected and controlled effectively. Regular scouting of fields to detect the first indications of a beet armyworm infestation is critical. Growers in Kentucky should scout their fields weekly and watch for small beet armyworm larvae feeding in groups on young leaves. If any beet armyworm larvae are found, a spray is justified.

**Chemical:** Beet armyworm is not controlled by the insecticides that are commonly used to control European corn borer, yellowstriped armyworm, and aphids. Sprays for beet armyworm are also more expensive than those for other pests, so growers use the beet armyworm sprays only when necessary to correct beet armyworm problems.

### Application Alternatives Used in Kentucky:

**Agree** (Bt var azawai) - Apply as a foliar treatment at a rate of 1/2 to 2 lb per acre.

**Baythroid 2** (cyfluthrin) - Apply as a foliar treatment at a rate of 2.8 fl oz per acre with a limit of 16.8 fl oz per acre per season.

**Confirm 2F** (tebufenozide) - Apply as a foliar treatment at 6 to 16 fl oz per acre with a limit of 64 fl oz per acre per season.

**Spintor 2SC** (spinosad) - Apply as a foliar treatment at a rate of 4 to 8 fl oz per acre with a limit of 0.45 lb ai per acre per season.

**Xen Tari** (Bt var azawai) - Apply as a foliar treatment at a rate of 1/2 to 2 lb per acre.

## European Corn Borer

*(Ostrinia nubilalis)*



European corn borer can cause severe damage to peppers in commercial fields throughout Kentucky. Feeding by corn borer larvae can cause several problems, the most serious of which is direct damage to the fruit and premature drop of small fruit. Borer entrance holes in larger pods allow water to enter, resulting in fruit rot. When rotting begins, borers often leave and move to infest new fruit. In this way, one larva can damage several pods. In addition, plants may break due to tunneling by the borers in the stems.

European corn borer moths tend to congregate in tall grassy areas around field margins, called action sites. Females fly into fields at night to lay their eggs. Weather conditions during egg laying can greatly affect the severity of corn borer problems. Calm warm nights are most favorable for moth activity while few eggs are laid on windy, stormy nights.

European corn borer eggs are laid in masses of 15 to 30 eggs per mass. Eggs are round and flattened and overlap each other like fish scales. Often they are placed on the underside of the pepper leaf near the midrib. Age of the egg mass is indicated by its color: freshly laid eggs are white, then cream. When a distinct black spot, the head of the larva, can be seen in the egg, it will hatch in about 24 hours.

Newly hatched larvae, about 1/16 inch long, leave the mass and crawl toward the developing pods. They do little feeding on pepper leaves. Within 2 to 24 hours after hatch, young larvae reach the calyx of the pepper pods. Once under the calyx, they are protected from insecticides and natural enemies.

There are two to three generations of this pest each year. The first appears in late May through early June. The second generation develops from late July through August. A partial third generation may occur in some years in early September. The second, or midsummer generation, is most likely to cause problems for commercial pepper producers.



## Controls

**Biological:** Over reliance on pyrethroid insecticides can lead to the rapid buildup of aphids on pepper foliage through the reduction of natural enemies. While pyrethroid insecticides can provide effective corn borer control, they should be used in rotation with other classes of insecticides to prevent aphid outbreaks.

**Monitoring:** Abundance of European corn borers varies from year to year. Inspection of pepper leaves for corn borer egg masses and young larvae is impractical and ineffective. Growers are encouraged to use pheromone traps to determine if corn borer moths are active and when treatments should be applied to control small larvae before they enter the pepper fruit. If corn borers are caught in traps, then begin looking in grassy areas around near your field. If moths are found in these action sites, then a spray is justified.

A degree day model that predicts the occurrence of the corn borer life stages is available at the University of Kentucky. It is recommended that these predictions be used in combination with field scouting of moth activity in action sites or pheromone trapping in order to make management decisions.

Begin applications when trap catches exceed 10 moths per week. Advisories are also issued to county Extension offices on when the damaging second generation borer larvae are likely to appear in Kentucky.

**Chemical:** European corn borer is difficult to control because of the short interval between egg hatch and larval tunneling of the fruit. An insecticide must be applied before larvae have entered the fruit or stems, and spray coverage must be thorough.

Insecticides are frequently needed during the harvest period as this is when the second generation of European corn borer attacks. For this reason, insecticides are often selected based on their associated pre harvest interval.

### Application Alternatives Used in Kentucky:

**Ambush 2 E** (permethrin) - Applied as a foliar treatment at 12.8 fl oz to a limit of 102.4 fl oz per acre. Use on bell peppers only.

**Asana XL** (esfenvalerate) - Applied as a foliar treatment at 5.8 to 9.6 fl oz to a limit of 67.2 fl oz per acre.

**Baythroid 2** (cyfluthrin) - Applied as a foliar treatment at 1.6 to 2.8 fl oz per acre to a limit of 16.8 fl oz per acre. Allow 7 days between applications.

**Orthene 75 S** (acephate) - Applied as a foliar treatment at 1 to 1-1/3 lb per acre. Use for bell peppers

only.

**Pounce 3.2 EC** (permethrin) - Applied as a foliar treatment at 8 fl oz to a limit of 64 fl oz per acre. For bell peppers only.

**Sevin 80 S** (carbaryl) - Applied as a foliar treatment at 1 ¼ to 2 ½ lb per acre to a limit of 7 applications and allow at least 7 days between sprays.

**Spintor 2 SC** (spinosad) - Applied as a foliar treatment at 4 to 8 oz per acre to a limit of 29 fl oz per acre.

## **Yellowstriped Armyworm**

*(Spodoptera ornithogalli)*



Yellowstriped armyworm is a sporadic pest of peppers, tomatoes, and tobacco in Kentucky and occasionally requires control. These brown to black caterpillars have a distinct yellow stripe running along each side of the body and a pair of dark triangles on the top of each segment. Full grown larvae are about 1-1/2 inches long. Overwintering as pupae in the soil, yellowstriped armyworms emerge as moths in the spring. Adults are brown, black, and white moths with a 1-1/2 inch wingspread.

Yellowstriped armyworm is a direct pest, it feeds directly on the surface of the fruit as well as some minor feeding on the foliage. Although these are uncommon, one caterpillar can damage several fruits.

## **Control**

**Chemical:** Insecticides sprays directed at yellowstriped armyworm are rarely needed. Typically, sprays directed toward European corn borer will effectively control yellowstriped armyworm.

### **Application Alternatives Used in Kentucky:**

**Ambush 2 E** (permethrin) - Applied as a foliar treatment at 12.8 fl oz to a limit of 102.4 fl oz per acre. Use on bell peppers only.

**Asana XL** (esfenvalerate) - Applied as a foliar treatment at 5.8 to 9.6 fl oz to a limit of 67.2 fl oz per acre.

**Baythroid 2** (cyfluthrin) - Applied as a foliar treatment at 1.6 to 2.8 fl oz per acre to a limit of 16.8 fl oz per acre. Allow 7 days between applications.

**Orthene 75 S** (acephate) - Applied as a foliar treatment at 1 to 1-1/3 lb per acre. Use for bell peppers only.

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**Sevin 80 S** (carbaryl) - Applied as a foliar treatment at 1 ¼ to 2 ½ lb per acre to a limit of 7 applications and allow at least 7 days between sprays.

### **Thrips**



Several species of thrips feed on a wide variety of field and vegetable crops, and weeds. In Kentucky,

the most severe damage by thrips usually occurs in years following mild winters. Pepper plants can become infested with thrips in the seedling stage while in the greenhouse. Thrips are important for several reasons; they injury expanding foliage causing distorted growth, feeding in the flowers can result in surface blemishes on the fruit, and they transmit Tomato Spotted Wilt Virus and Impatiens Necrotic Spot Virus.

Thrips feed by rasping the plant surface and sucking up the exuding sap. Heavily infested leaves have a mottled or silvery appearance. Female thrips insert eggs into slits in the leaf. Eggs hatch in two to seven days. Nymphs feed much like adults and molt four times during development. They are inactive during the last nymphal stage before becoming an adult.

Adults are small slender insects about 1/20 inch long. They vary in color from light to dark brown. Wings are narrow and fringed, giving them a feathery appearance. The males of some species are wingless. Eggs are thrust into plant tissues. Nymphs are active, light-colored, wingless insects. The mouthparts of adults and nymphs are similar and unusual; they are designed to rasp plant tissues then suck the juices. The last nymphal stage is spent in the soil. Adults and nymphs pass the winter on plant tissue.

## **Control**

**Cultural:** Pepper transplants should be grown in greenhouses that are free of ornamental plants and weeds. Ventilators and other openings to the greenhouse should be screened, however, most screening material is too coarse to exclude thrips. New plant material brought into the greenhouse should be isolated or inspected for thrips.

**Monitoring:** Colored sticky cards are used in greenhouse to monitor for adult thrips. Both yellow and blue cards are available. Yellow cards are most commonly used as they are attractive to greatest number of greenhouse insect pests.

**Chemical:** Often several insecticide applications are required as the eggs and last nymphal stage are more difficult to control.

### **Application Alternatives Used in Kentucky:**

**Baythroid 2** (cyfluthrin) - Applied as a foliar treatment at 2.8 fl oz per acre to a limit of 16.8 fl oz per acre. Allow 7 days between applications.

**Orthene 75 S** (acephate) - Applied as a foliar treatment at 1 to 1-1/3 lb per acre. Use for bell peppers only.

**Spintor 2 SC** (spinosad) - Applied as a foliar treatment at 4 to 8 oz per acre to a limit of 29 fl oz per acre.

## **Brown Stink Bug**

*(Euschistus servus)*



Stink bugs have a distinctive shield shape and produce an odor when handled. There are several species of stink bugs that feed on the pepper fruit, but the brown stink bug is the most serious. Stink bugs feed with piercing sucking mouthparts which cause yellow corky spots underneath the skin of the fruit. This damage is serious for fresh market peppers and processing peppers because they render the fruit unmarketable.

Adult stink bugs migrate from weedy areas into pepper fields, particularly when the weeds begin to decline in mid to late summer. On green fruit, stink bug damage appears as a pin prick, surrounded by a light discolored area. This may turn yellow or remain green on ripe fruit and the tissue below these spots corky.

## **Control**

**Cultural:** Weed management and crop management around pepper fields can affect the potential for stink bug damage in peppers. Often movement of stink bugs into peppers takes place after adjacent fields are harvested or after tall weeds around pepper fields have been moved. Weeds need to be moved around these fields regularly in order to prevent the buildup on stink bugs.

**Application Alternatives Used in Kentucky:**

**Endosulfan 3 EC** (Thiodan, Phaser) - Apply as a foliar treatment at 1-1/3 to 2-2/3 pt per acre with a limit of 2 applications per season.

## Diseases

Growers need to use certified seed and treat seed with bleach to reduce seed borne pathogens. Greenhouses should be free of ornamentals during all stages of transplant production. Selected sites that have excellent air and soil drainage and that have not been planted with other crops in the nightshade family (tomatoes, potatoes, eggplants, tobacco) for three or more years.

### **Alternaria Fruit Rot**

*(Alternaria solani or A. Tenuis)*

Part of a complex with anthracnose and cercospora leaf spot, alternaria fruit rot is caused by a fungus, *Alternaria solani* or *Alternaria tenuis*. It frequently develops on injured or over-ripe fruit. Protecting fruit from the effects of bacterial leaf spot and sunscald and harvesting carefully will reduce problems from this fruit disease. Alternaria develops as a black mass of spores on damaged areas of the fruits.

### **Controls**

**Cultural:** Use disease-free seed and or transplants. Rotate for 3 to 4 years to crops not related to pepper, controlling solanaceous weeds during the rotation. Plow down crop residues immediately after harvest.

### **Application Alternatives Used in Kentucky:**

**Copper fungicides are labeled but have limited value.**

**Maneb 80 WP** (maneb) - Apply as a foliar treatment at a rate of 1.5 to 3.0 lbs per acre per week. Most effective if sprays start prior to or at the time when first symptoms appear and are maintained past bloom.

## **Anthracnose**

*(Colletotrichum piperatum and C. capsici)*

Part of a complex with cercospora leaf rot and alternaria fruit rot, anthracnose is caused by the fungi *Colletotrichum piperatum* and *Colletotrichum capsici*. It occurs as sunken spots on green and ripe fruit. Its pinkish to yellowish masses of glue-like spores are sometimes accompanied by tiny black bristles (setae). The fungus overwinters on and in pepper seed as well as in residue from diseased plants. Disease is promoted by wet conditions (heavy fog, dew and drizzle) and relatively high temperatures (90°F). Anthracnose frequently develops on injured or overly-ripe fruit. Protecting fruit from the effects of bacterial leaf spot, sunscald and harvesting carefully will reduce problems from these fruit diseases.

### **Controls**

**Cultural:** Use disease-free seed and or transplants. Rotate for 3 to 4 years to crops not related to pepper, controlling solanaceous weeds during the rotation. Plow down crop residues immediately after harvest.

**Chemical:** Copper fungicides are labeled but have limited value.

### **Application Alternatives Used in Kentucky:**

**Maneb 80 WP** (maneb)- Apply as a foliar treatment at a rate of 1.5 to 3.0 lbs per acre per week. Most effective if sprays start prior to or at the time when first symptoms appear and are maintained past bloom.

## **Bacterial Leaf Spot**

*(Xanthomonas vesicatoria)*

Bacterial leaf spot, caused by the bacterium *Xanthomonas vesicatoria*, occurs as water-soaked, black to tan, irregular shaped spots on the leaf, especially the margins, and on fruits as raised spots. Leaf spots appear first on lower surfaces of leaves as small irregular water-soaked areas. Spots enlarge up to ¼ inch in diameter, become purplish gray with black centers and may have narrow yellow halos. Spots on upper surfaces of leaves are depressed; those on the lower surfaces are raised. Spotted leaves may become ragged. Uneven marginal leaf growth may cause twisting and many leaves turn yellow and drop off, thus exposing fruit to direct sunlight which may cause sunscald. Defoliation of infected leaves can be extensive, greatly impacting fruit quality. Bacterial leaf spot is favored by warm, wet weather, and its

spread is aided by driving rain or wind-blown soil and debris.

The bacterium causing this disease is seed-borne, transplant-borne and overwinters on site and nearby in weeds such as nightshade, horse nettle, ground cherry and residues. Bacterial leaf spot remains viable on plant residues as long as there is any residue left. The bacterium may survive as latent epiphytes (living without causing an infection) on the leaves of "healthy" plants. Bacteria are spread from plant to plant by splashing water and by implements and workers in fields when foliage is wet. Once it is introduced into planting and under prolonged wet conditions, control is limited because of the rapid rate of reproduction and limitation of available chemicals.

This disease can be a limiting factor in pepper production in Kentucky, and chemical controls have been marginal under strong disease pressure. Fortunately, major improvements in control options have recently become available in the form of resistant varieties. Bacterial leaf spot can result in severe damage to pepper crops. It has been one of the most serious and costly problems affecting peppers in Kentucky, causing thousands of dollars worth of damage. The successful grower must understand and appreciate this disease's potential in order to successfully grow peppers.

## **Controls**

**Cultural:** Control is centered around preventing introduction of the bacterium rather than eradication of it once present!

Plant bacterial spot resistant varieties of peppers for both fresh market and processing where possible. Follow other control options diligently to avoid impact from susceptible pepper varieties which will continue to be released as well as to manage strains of the bacterium that may not be controlled by resistant varieties.

Use crop rotations of 2 to 3 years, excluding peppers, eggplant, tomatoes and tobacco from the total rotation. Also, exclude small grains in the rotation the season before peppers are to be planted.

Control broadleaf weeds during the rotation and around the field borders. Disk all crop residues into the soil promptly after harvest to encourage more rapid decline of the bacterium and plow cover crops very early in the spring to minimize carry-over.

Do not work plantings while wet. Spraying plants while wet with high pressure may encourage spread by blowing bacteria about the field.

Use disease-free seed and transplants. Pre-treat seed by washing with household bleach (2 pt household bleach to 1 gallon of water per lb of seed, washing for 40 minutes with continuous agitation). Air dry and dust seed with Thiram 65 W at 1 tsp per lb of seed. Sow promptly to control damping off. While in the seedbeds and starting with the first true leaf stage, make frequent applications (3-5 days) of the antibiotic Streptomycin 17% at 200 ppm or 2 teaspoons per gallon of water. (Note: Streptomycin is



labeled only *for use prior to transplanting* and *is not* labeled for use in the field and *should not* be used in the field.) Also, note that streptomycin is not specifically labeled for greenhouse use, so use fixed coppers in greenhouse transplant production, but do not expect the high degree of control available with streptomycin.

If transplants are purchased from off the farm, obtain only certified disease-free transplants and assume that you probably have still purchased some low level of infection. Plant them into soil with recommended rates of N and K, but at the high end of the scale. Losses from bacterial spot are greatest when peppers become deficient in N or K, and the disease can be minimized by maintaining high fertility, being careful not to get the plants into an overly vegetative state or fruit set will be seriously reduced.

**Monitoring:** Although management of bacterial spot must be preventative, fields need to be monitored weekly. Bacterial spot resistant hybrids are not resistant to all races of the bacteria.

**Chemical:** Early season sprays before symptoms are evident are the most valuable at keeping populations of the bacteria low. Start sprays immediately after transplanting.

### **Application Alternatives Used in Kentucky:**

**Fixed Copper-** Applied as a foliar treatment at a rate of 1 lb of active ingredient per acre (mixed with **Maneb 80**).

**Maneb 80 WP** (maneb) - Applied as a foliar treatment (mixed with **Fixed Copper**) at a rate of 1.5 lb per acre and continue at 7-day intervals during wet weather to reduce buildup and spread of the bacterium in the field. *After mixing Maneb and fixed copper in the spray tank, let it sit for 30 minutes with agitation. During this period a new chemical compound will be formed that is more effective at controlling bacterial spot than either of the two individual materials.* Note: the copper material can be applied more frequently, but maneb is labeled for no closer than 7-day intervals, plus note that maneb has a 7-day preharvest interval while coppers have zero.

## **Bacterial Soft Rot**

*(Xanthomonas vesicatoria)*

Bacterial soft rot, caused by the bacterium *Xanthomonas vesicatoria*, produces a very soft, slimy rot with a strong odor which affects leaves and fruit of peppers. Leaf spots appear first on lower surfaces of leaves as small, irregular, water-soaked areas. Spots enlarge up to ¼ inch in diameter, become purplish gray with black centers and may have narrow yellow halos. Spots on the upper surfaces of leaves are depressed; those on the lower surfaces are raised. Spotted leaves may become ragged. Uneven marginal

leaf growth may cause twisting, and many leaves turn yellow and drop off, thus exposing fruit to direct sunlight which may cause sunscald.

Fruit spots caused by the bacteria begin as water-soaked areas and then become raised and scab-like. The bacteria are commonly on the fruit surface and enter the fruit through wounds, especially those near the stem end.

Causal bacteria are seed-borne. Seed and infected transplants are the principal sources of initial inoculum. The bacteria can survive for about a year in residue from diseased plants. Bacteria are spread from plant to plant by splashing water and by implements and workers in fields when foliage is wet. Disease development is promoted by moist conditions. Controlling insect pests (especially corn borers) and spotting diseases are important to minimize wounding.

### **Controls**

**Cultural:** Where acceptable, pack fruit without washing. If wash water is used in packing operations, it should contain 25 ppm of available chlorine. A number of chlorine sources are available, but a practical option for small producers is to use household bleach (containing 5.25% sodium chlorite) at the rate of 1 tablespoon of bleach per 8 gallons of water or 1 pt/264 gallons of water. To keep the chlorine available, it is important that the initial water pH be 6.0 to 7.5, that it remain clean and be changed often. Water temperature must also be close to the temperature of the fruit (no colder than 10°F below that of the harvested fruit) to avoid "sucking" bacteria into the fruit.

### **Blossom End Rot**

Blossom end rot is not an infectious disease, but rather a physiological condition caused by inadequate calcium available in the fruit tissues during certain critical stages of cell development. The deficiency has its first impact when fruit are forming. The condition develops at the blossom end of the fruit and may affect up to half a fruit. Affected areas are first water-soaked, but soon become dry, light-colored and papery. The lack of adequate calcium can be due to low levels in soil, but is most often caused by poor calcium up take and movement associated with uneven soil moisture and/or root damage.

### **Controls**

**Cultural:** The most effective control is to maintain uniform soil moisture conditions throughout the growing season and to avoid damaging roots during cultivation or fertilization.

**Chemical:** Foliar calcium sprays are not considered an effective treatment, but proper soil calcium levels should be maintained.

## **Cercospora Leaf Spot**

*(Cercospora capsici)*

Cercospora leaf spot, caused by the fungus *Cercospora capsici*, is part of a complex with anthracnose and alternaria fruit rot. It is characterized by large circular to oblong spots on leaves and stems. Usually, spots have white to light-gray centers with dark brown margins and may be up to ¼ inch in diameter. Severely affected leaves turn yellow and drop. The causal fungus is carried on seed and possibly survives one season in residue from diseased plants. Disease usually gets started in seedbeds. Disease development is promoted by prolonged periods of hot, wet weather.

### **Controls**

**Cultural:** Use disease-free seed and or transplants. Rotate for 3 to 4 years to crops not related to pepper, controlling solanaceous weeds during the rotation. Plow down crop residues immediately after harvest.

**Chemical:** Copper fungicides are labeled but have limited value.

### **Application Alternatives Used in Kentucky:**

**Maneb 80** (maneb) - Apply as a foliar treatment at a rate of 1.5 to 3.0 lbs per acre per week. Most effective if sprays start prior to or at the time when first symptoms appear and are maintained past bloom.

## **Pepper Virus Complex**

**(Alfalfa Mosaic, Cucumber Mosaic, Potato X and Y and Tobacco Etch Viruses)**

Pepper virus complex is the name given to several virus diseases that attack peppers in Kentucky. Viruses are the second most important disease problem threatening Kentucky peppers because of the production of tobacco. At least four viruses may occur, alfalfa mosaic virus (AMV), cucumber mosaic virus (CMV), potato virus (PVY), tobacco etch virus (TEV) and tobacco mosaic virus (TMV), Symptoms vary, depending on the virus or strain, the plant, time of year and environmental conditions. The range of virus symptoms may include leaf mottling, puckering or curling; stem and petiole streaking; rough, deformed or spotted fruit; stunted plants and blossom and fruit drop.

AMV symptoms depend on the virus strain and the environmental conditions under which the crop grows. Yellow blotches or sometimes mosaic mottling, yellowish rings, spots and other patterns appear

on infected leaves. Severe leaf death also may occur. AMV overwinters in alfalfa plants; it is transmitted most commonly by the green peach aphid.

CMV causes severe mosaic on pepper foliage; older leaves sometimes exhibit large dead rings. Fruit may be malformed, and conspicuous yellow concentric rings and/or spots are frequently observed on infected green fruit. Limited spread may occur in the field through handling plants. By far the most efficient and widespread vector is the green peach aphid; other aphids also may spread CMV. The virus overwinters in susceptible perennial plants such as catnip, chickweed, jimson weed, mallow, nightshade, pokeweed, wild lettuce and others. CMV may persist in a very small percentage of seed from infected chickweed.

PVY causes mild to severe mottling, depending on the particular virus strain involved. The virus is not see-transmitted, but is spread by several aphid species; the green peach aphid probably is the most efficient vector.

TEV causes a very mild chlorotic mottle, with some foliar distortion. Large concentric rings and line patterns may be produced on leaves and on fruit. Fruit often becomes misshapen. Root necrosis occurs, causing some wilting. Wilted plants recover, but usually are stunted and bushy. Stems on old plants sometimes have reddish brown spots and are streaked. Bud drop may occur. TEV overwinters in weeds belonging to the potato-tomato family and is spread mostly by green peach aphids and occasionally by potato aphids.

TMV, on some pepper cultivars, causes very pronounced mosaic symptoms on the foliage, accompanied by leaf puckering and reduction in leaf size. Vein clearing of the young leaves becomes extremely pronounced. Older leaves fall prematurely. Yield is reduced because fewer fruit set and those that do set are small and misshapen. Many bell-shaped peppers are resistant to TMV. TMV commonly is transmitted by mechanical means--during handling, on tools, through infected debris in soil and by seeds. TMV, the most persistent and highly infectious of all plant viruses, withstands heat and retains its infective capacity in a dry condition for many years

All except TMV are transmitted primarily by aphids. On occasion, tomato spotted wilt virus (TSWV) which is transmitted by the adult thrip has been found. Aphids carry these viruses to pepper fields from perennial weeds growing nearby. Plants infected early in their life may be stunted, have deformed leaves with mosaic or mottling patterns and produce small, discolored, misshapen fruit. Plants infected later in the season are not as badly stunted. Pepper viruses may also cause flower drop in peppers which also contributes to lower yields.

## **Controls**

**Cultural:** Plant peppers in and surrounded by fields used for row crops, "barrier crops". Six rows of corn around a pepper planting will reduce virus transmission to the peppers by 80% and delay the time of aphid infection and development. Eliminate broadleaf weeds, particularly in the nightshade family,

and other hosts of these viruses within 150 ft of the field prior to transplanting. Peppers planted near woods, fence rows, hay or pastures may be exposed to virus-carrying aphids from nearby weedy perennial hosts. Partial isolation from infected aphids can be accomplished by locating fields between plantings of corn or other non-host, field crops where the weeds are killed before peppers are transplanted. Do not grow peppers within 150 ft of virus susceptible tobacco. Controlling aphids in tobacco located near peppers, especially at the times of tobacco topping and harvest, may help to reduce movement of aphids and viruses to peppers.

Plant peppers as early as possible. Virus diseases normally show up in early summer. Since aphids feeding for only a short time will introduce viruses into the plant, aphid controls are not effective.

Grow virus-resistant varieties if these have horticulturally acceptable yields and fruit characteristics. Also take into account resistance to bacterial spot (see variety list). In addition to the varieties listed, Gator Belle, Bell Boy, Bell Captain, and Super Sweet 860 are resistant to tobacco mosaic and Tam Mild Chile<sup>2</sup> has resistance to tobacco mosaic, potato virus Y, and tobacco etch. Observations from recent surveys indicate that growing tobacco varieties resistant to the aphid-borne virus complex may be helpful in reducing these diseases in peppers, probably because the pathogen level in the nearby plant community is greatly reduced.

Maintain aphid control in peppers. Controlling aphids in nearby tobacco plantings, especially at the time of tobacco harvest, may help to reduce movement of aphids and viruses into peppers. In problem fields, with a high value fresh market crop, spraying weekly with stylet oils can be helpful (using 3 qt / 100 gallons), but the value of this treatment has not been evaluated in Kentucky. Reflective mulches show promise in reducing the incidence or delaying the onset of these diseases in some tests.

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## **Phytophthora Blight**

*(Phytophthora capsici, P. parasitica)*

Phytophthora blight, caused by the fungus *Phytophthora capsici*, can affect all parts of the plant and can cause serious losses. Damping-off can develop on seedlings. Symptoms on older plants include root rot, stem canker, leaf blight and fruit rot. Fruit rot occurs as a water-soaked, dark rot usually surrounded by a halo of lighter color. Affected areas may be bordered by a white mold growth. Other above ground characteristics include rapid wilting and death of affected pepper plants. Disease most frequently appears in the wettest areas of a field. Warm, wet weather promotes disease development.

For some reason, phytophthora blight has caused limited problems in Kentucky. This advantage could

rapidly change with alterations in production, especially water management. This disease is essentially **black shank** of peppers. Tobacco growers can expect to lose pepper crops if they are treated like tobacco, i.e., by using poorly drained sites, irrigating from contaminated water sources and abandoning crop rotations. This disease cannot be controlled under such conditions with chemicals.

Close examination of the roots and stems of affected plants is necessary to confirm the cause of disease. The disease can develop at any plant growth stage. Tap roots and smaller lateral roots show water soaked, very dark brown discoloration. Stem lesions are first dark green and water soaked, then dry and turn brown.

Factors that influence the development of root and crown rot in peppers in a given season include varietal susceptibility, amount and frequency of irrigation, soil compaction and drainage. The phytophthora fungus survives in the soil for several years. In addition, the black shank fungus itself can also cause a fruit rot of peppers. Predisposing factors and tools for control are basically the same for both fungi.

### **Controls**

**Cultural:** Phytophthora blight can be effectively prevented by a program integrating crop rotations to non-solanaceous and non-cucurbit crops for 3 to 4 years, irrigation management and clean seed and transplants. In heavy soils that are poorly drained, root and crown rot may be reduced by carefully managed drip irrigation. Practices that reduce or alleviate soil compaction may improve control; for example, growing plants on raised beds.

One variety of pepper, which is resistant to Phytophthora, but not bacterial leaf spot, is available in Kentucky.

**Chemical:** Copper/maneb sprays used for bacterial spot control should also reduce phytophthora fruit and upper stem infections, but will not control the root and stem phases of this disease.

If planting into fields with a history of disease, make a preplant incorporated application of mefanoxam before transplanting and follow up with additional applications after transplanting.

### **Application Alternatives Used in Kentucky:**

**Fixed Copper-** Applied as a foliar treatment at a rate of 1 lb of active ingredient per acre (mixed with **Maneb 80**).

**Maneb 80 WP** (maneb) - Applied as a foliar treatment (mixed with **Fixed Copper**) at a rate of 1.5 lb per acre and continue at 7-day intervals. Note: the copper material can be applied more frequently, but maneb is labeled for no closer than 7-day intervals, plus note that maneb has a 7-day preharvest interval while coppers have zero.

**Ridomil Gold** (mefanoxam)- Apply preplant incorporated at a rate of 0.5 lbs pt per acre with additional applications applied as bands sprayed on either side of the plant at 30 and 60 days after transplanting.

**Ridomil Gold/Copper 70 W** (mefanoxam/copper) - Applied as a foliar treatment at a rate of 2.5 lbs per acre at 10 to 14 day intervals providing that the 3<sup>rd</sup> application of mefanoxam is omitted.

## **Southern Stem Blight**

*(Sclerotium rolfsii)*

Southern stem blight can be a problem where rotation includes soybeans, tomatoes or other susceptible crops. Affected pepper plants wilt suddenly, turn yellow and finally brown. *Sclerotium* is a soil-borne fungus that attacks the crown of the plant. *Sclerotium rolfsii* has a wide host range and is common in Kentucky on tobacco, soybeans, peppers and tomatoes. The fungus attacks the stem near or at the soil line and forms white mold on the stem. Crown tissue and external root tissue first become soft; fungus mold with tiny brown sclerotia (fungus reproductive and survival structures), which resemble mustard seeds, then grows over the base of the stem and nearby soil. Plants wilt and die due to girdling of the stem by this fungus. The fungus overwinters as sclerotia in soil.

### **Controls**

**Cultural:** This disease is often found in lots of transplants, so set clean plants. Avoid fields with a history of this disease and rotate problem fields with sod crops.

Deep plow to bury sclerotia and crop debris. Incorporate cover crops early to ensure they are well rotted before transplanting into the site. Maintain good weed and grass control through preventive means because the fungus can attack dying weeds then move into pepper transplants.

### **Application Alternatives Used in Kentucky:**

**PCNB** (Terrachlor 75 WP) - Applied in the transplant water at a rate of 3 to 5 lbs per 100 gallons of water or for better results applied as a spray to transplant furrow at a rate of 10 lbs per 100 gallons of water over 14,500 ft of row. Must maintain agitation.

## **Tomato Spotted Wilt [TSWV] and**

## Impatiens Necrotic Spot Viruses [INSV]

Tomato spotted wilt and impatiens necrotic spot viruses are carried by thrips and can cause serious losses in transplant production or when infected transplants are used in field plantings. Transplants stunted by INSV will yield few fruits.

### Controls

**Cultural:** Ensure that transplants are from fields or greenhouses certified to be free of TSWV. Local transplant producers should take steps to reduce spread of TSWV and INSV by following recommended thrips control measures and *by not producing pepper transplants in houses where ornamentals are being produced or sold*. Rogue out infected plants as soon as they are found and maintain a good thrips control program. Most strains of INSV do not damage the plant to the same extent as TSWV.

## Weeds

As with many other major Kentucky crops, peppers present an ongoing management issue regarding weed control. For economy and efficiency, it is of utmost importance for farmers to view weed pests as a complex. Specific plant pests which interfere with sweet corn production are both diverse and unpredictable in their colonization of fields. A specific plant or two may present more of a challenge for a period of time only to be replaced by another dominant pest or a mixture of weeds with individually low populations.

Overall, thinking in terms of creating a good field management history is central to making decisions about addressing the weed population presented during any specific year. Pepper production needs to be supported by a balance involving intelligent cultural practices and modest chemical weed control practices.

If farmers were to try to focus on one pest in isolation, they would lose their target; it is that essential to deal with weeds as a complex. While they may feel an urge to focus on one major pest at one time or another, to limit themselves to such treatments would more likely backfire when the complex of invaders made a resurgence after a brief period of time. Thus, they expect to go for "the best shot" rather than a "perfect shot".

Beyond the obvious issue of pest presence, a farmer's decisions are strongly impacted by costs. Many farmers, knowing that they can neither afford to apply herbicides for each and every significant plant pest nor expect weed free fields, are strongly impacted by manufacturer's marketing strategies.



## Common Weeds in Kentucky Peppers

Common Name	Scientific Name	Life Cycle
<b><i>Monocots: Grasses and Grass-like Plants</i></b>		
Broadleaf Signalgrass	<i>Brachiaria platyphaylla</i>	Annual
Crabgrass, Large	<i>Digitaria sanguinalis</i>	Annual
Foxtail, Giant	<i>Setaria faberi</i>	Annual
Johnsongrass	<i>Sorghum halepense</i>	Perennial
Fall Panicum	<i>Panicum dichotomiflorum</i>	Annual
Ryegrass, Italian	<i>Lolium multiflorum</i>	Annual
Shattercane	<i>Sorghum bicolor</i>	Annual
<b><i>Dicots: Broadleaf Plants</i></b>		
Burcucumber	<i>Sicyos angulatus</i>	Annual
Cocklebur, Common	<i>Xanthium strumarium</i>	Annual
Milkweed, Honeyvine	<i>Ampelamus ambidus</i>	Perennial
Morningglory, Bigroot	<i>Ipomoea pandurata</i>	Perennial
Morningglory, Ivyleaf	<i>Ipomoea hederacea</i>	Annual
Pigweed, Smooth	<i>Amaranthus hybridus</i>	Annual
Pokeweed, Common	<i>Phytolacca americana</i>	Perennial
Ragweed, Giant	<i>Ambrosia trifida</i>	Annual
Trumpetcreeper	<i>Campsis radicans</i>	Perennial

### Controls

**Cultural:** Practice clean cultivation and destroy crop residues after harvesting.

#### Application Alternatives Used in Kentucky:

**Command 4EC** (clomazone) - Apply 1 to 2 pt per acre and incorporate 1 to 2 inches before transplanting. Used in combination with other herbicides like Treflan or Devrinol to broaden the weed control spectrum. Can be used on bell, hot, pimento, and sweet peppers but not on banana peppers. Be

sure to set transplants with their roots below chemical barrier when transplanting.

**Devrinol 50 DF** (napropamide) - Apply 2 to 4 lb per acre before planting and water-in or incorporate to a depth of 1 to 2 inches; see incorporation directions on label. Can be applied on bare ground middles between beds of plastic 24 hrs prior to rain or if watered-in or incorporated. To avoid injury, do not replant with crops not specified on the label until 12 months after the last Devrinol application.

**Dual Magnum 7.6E** (s-metolachlor) - Apply 0.5 to 1.33 pt per acre as a surface broadcast application prior to transplanting or within 48 hours after transplanting. Use a minimum of 10 gallons of water per acre. Use low rate on coarse, sandy soils and the high rate on silt and clay soils or high organic matter soils. This special needs label is held by the Kentucky Vegetable Growers Assn. and *you must be a member to use this herbicide on peppers* and receive a copy of the label. To receive a copy call the Dept. of Horticulture at UK at 606-257-2909.

**Gramoxone Extra** (paraquat) - Apply 1.5 pint per acre. For control or suppression of emerged weeds. Use shielded application equipment to prevent spray contact with crop. Do not exceed 30 psi nozzle pressure. Apply when weeds are succulent and less than 6 in. tall. Most effective when grasses or less than 4 in. tall.

**Poast 1.5E** (sethoxydim) - Apply 1-1.5 pt per acre to actively growing grasses. Include 1 qt crop oil concentrate/acre. Limit 4.5 pt maximum/acre/season. There is a 20 day pre-harvest interval.

2 to 3 qt Roundup (4 lb/gal) 2 to 3 glyphosate Apply to emerged perennials at least 3 days before transplanting in spring or after harvest. Check label for rates for different weed species. Do not apply over plastic mulch unless residues will be removed by rainfall or sprinkler irrigation prior to transplanting. Include 1 pt nonionic surfactant per acre

**Roundup** (glyphosate) - Apply 2 to 3 qt per acre to emerged perennials at least 3 days before transplanting in spring or after harvest. Check label for rates for different weed species. Do not apply over plastic mulch unless residues will be removed by rainfall or sprinkler irrigation prior to transplanting. Include 1 pt nonionic surfactant per acre

**Treflan 4E** (trifluralin) - Apply 1 to 2 pt per acre before planting and incorporate immediately. Specific rates will vary for different soil textures and incorporation practices.

## Nematodes

Root knot nematodes, *Meloidogyne incognita*, *M. hapla* and *M. arenaria* cause economic damage to peppers when present. Nematodes are tiny worm-like invertebrates that live in soil. They overwinter in a dormant stage, and often have multiple crop and weed hosts. Nematodes attack roots of plants and feed off of plant fluids. They can be spread by the movement of infected soil or water. Root-knot nematodes enter young pepper feeder roots during their common feeding process, causing the roots to swell. They are usually a problem in sandy soils such as those in a river bottom fields.

Nematodes cause physical damage to root systems and open up wounds that allow disease to become established. Nematode injury interferes with the uptake of water and nutrients, thus giving the top portion of the plants an appearance which resembles a lack of moisture or a fertilizer deficiency. Nematode infested plants are generally stunted with pale green to light yellow foliage and have reduced yields. Nematode feeding damage may also predispose plants to other soilborne diseases. Soils infested with root knot nematodes should either be treated with chemicals (fumigated) or avoided.

## Control

**Cultural:** Long rotations with cereals, grasses, and other non-hosts are the most practical means of control.

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