Pepper Disease Control – It Starts with the Seed

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Plant diseases can be a limiting factor in pepper production wherever the crop is grown. Moisture in the form of wind blown rain, saturated soils and high humidity plays a major role in the occurrence of both bacterial and fungal diseases. Insects that attack pepper serve to create wounds favorable for bacterial soft rot and spread several virus diseases. Clean seed, greenhouse sanitation, crop rotation, and cultural measures in the field are all key components for disease control, but it all starts with the seed! This is especially true for the first disease discussed, bacterial leaf spot. All major seed companies are incorporating disease resistance into most released varieties with emphasis placed on bacterial leaf spot, Phytophthora blight, and assorted virus diseases.

Bacteria

Bacterial Leaf Spot (BLS)

Bacterial leaf spot is caused by two major groups of bacteria, *Xanthomonas campestris* pv. *vesicatoria* and *Xanthomonas vesicatoria* (some literature will also mention *Xanthomonas axonopodis* pv. *vesicatoria*). A number of races occur for each of these pathogens, with some occurring more commonly on pepper and others on tomato. Both bacteria are gram-negative rods, have a single polar flagellum used for mobility, and are found only in association with plants or plant materials. The BLS pathogens are seedborne, both within the seed and on the seed surface. BLS may also survive on plant debris in the soil for 1-2 years, therefore a 2-year rotation out of pepper and tomato is essential.

Seed can be treated with hot water (122°F for 25 minutes) or with Clorox® (EPA Reg. No. 5813-1; label available from Clorox at 800-446-4686). Hot water is more effective for controlling bacteria on and within seed, but hot water can adversely affect germination if not properly performed (see ref. 3). Treating the seed yourself nullifies the seed company's liability and voids their guarantees. Mix 1 quart of Clorox® bleach (calcium hypochlorite) with 4 quarts of water to treat up to 1 pound of seed in a cheesecloth bag, add _ tsp. of surfactant (dishwashing detergent), and submerge in the solution with agitation for 40 minutes, rinse under running tap water for 5 min, and dry seed thoroughly. Treated seed should be dusted with Thiram 75W [dithiocarbamate] (1 tsp. per pound of seed), and planted soon after treatment.

Some varieties currently have resistance to all three races of BLS (BLSR1, 2, 3) that commonly occur in our area. These include Boynton Bell, Aristotle, Commandant, Enterprise, Revolution, X3R Camelot, and X3R Wizard. King Arthur is resistant to race 2 and Admiral is resistant to races 1 and 2. Resistance to races 1 and 3 are most important for the Northeast.

Use of disease-free seed and a 2-year rotation in the field should solve most of the BLS problems, but some persistent cases may require chemical treatments. Streptomycin (Agri-Mycin 17, Agri-Strep) sprays (1 lb per 100 gallons or 1 _ tsp per gallon) may be applied to transplants prior to transplanting. In the field, applying fixed copper (1 lb active ingredient per acre) plus maneb (1 _ lb 80WP per acre) has been shown to reduce the spread of BLS.

Bacterial Soft Rot (BSR)

Bacterial soft rot is caused primarily by *Erwinia carotovora* subsp. *carotovora*. The bacterium is commonly associated with plants, soils and surface water, and thus is a common contaminant. BSR is primarily a post-harvest problem except when fruit are injured in the field by insect feeding. The European corn borer larvae tunnel under the calyx (cap), and their entry holes are marked by sawdust-like frass. Insecticide treatments should coincide with peaks in adult activity as determined by pheromone or light traps. Registered insecticides include cyfluthrin (Baythroid 2), esfenvalerate (Asana XL), permethrin (Ambush), and spinosad (SpinTor 2SC). Hot pepper varieties are most resistant to larval feeding, while green bell peppers are most susceptible.

Post-harvest wash water can spread the bacterium from contaminated to healthy fruit, therefore most peppers are packed dry to minimize BSR. If wash water is used, maintaining 25 ppm chlorine in the wash water (1 TBS of Clorox®, 5.25% sodium hypochlorite, per 8 gallons of water). Make sure that the wash water is not cooler than the fruit temperature, or bacteria will move into the fruit or stem end.

Oomycetes

Pythium Damping Off (also caused by *Phytophthora* spp., and *Rhizoctonia solani*)

Growing media can be a source of various soil-borne fungi, so care must be exercised in selection of the appropriate media and attention paid to characteristics that will allow the growing media to remain moist but not continually wet. Addition of soil amendments that contribute to suppression of soil-borne pathogens can be considered. SoilGard 12G, containing the naturally occurring fungus *Gliocladium virens* is known to be antagonistic to fungi such as *Pythium* and *Rhizoctonia*, two of the more common fungi responsible for damping off.

Pythium Root Rot

Pythium root rot generally occurs after peppers are transplanted in polyethylene mulch/drip irrigation culture. Cultural practices that contribute to Pythium root rot are planting in low areas of the field, overwatering in an attempt to reduce wilting, and planting into beds with fresh plant material (cover crop, weeds, etc.) before microbial breakdown of the plant material has occurred. The infected roots of infected plants will appear brown rather than white, and the cortical tissue of the main affected roots can easily be removed from the central steele with a finger nail. After removing transplants from the greenhouse and prior to transplanting, plants can be drenched with the systemic fungicide mefenoxam (**Group 4** fungicide) (Ridomil Gold 4E or Ultra Flourish 2E). Apply Ridomil 4E at 0.75 fl.oz. /2,000 ft^2/100 gallons of water or Ultra Flourish 2E at 1.5 fl.oz. /200ft^2/100 gallons of water.

Phytophthora Crown Rot and Aerial Blight

Phytophthora blight can be one of the most serious diseases affecting pepper as well as eggplants, tomatoes, and the entire cucurbit family. Because it affects such a wide range of vegetables, growers are challenged to develop adequate rotational strategies. Consequently, control must depend upon cultural, chemical and selection of resistant varieties when available. Phytophthora blight is caused by the soil borne oomycete *Phytophthora capsici*. The disease can be divided into two distinct phases, a crown rot phase and an aerial blight phase.

In the crown rot phase of the disease, a black girdling lesion occurs at the soil line. In some plants the lower tissue of the wilted plants must be removed to expose the girdling lesion in the cortical tissue beneath the epidermis. Most cases of the crown rot phase occur in July and August in the lower areas of the field and from there the disease can spread to adjoining areas of the field. Phytophthora is considered a weather event disease, meaning that heavy rainfall (in excess of 2 inches) leading to saturated soils is critical for infections to occur. Generally soil temperatures are > 65°F and air temperatures are in the range of 75-85°F.

The aerial phase of Phytophthora blight occurs later in the season as the spores produced on the lesions of plants infected in the crown rot phase are spread by heavy, wind driven rains. These typically occur following a tropical storm or hurricane, another major weather event. Infection occurs at the axil of a branch and stem with a 2-3 inch black, girdling lesion developing on the stem. All of the leaves on the branch above the lesion will wilt and eventually the entire plant dies.

Cultural control measures aim to mitigate the affects of the weather events mentioned above. Avoid planting in low-lying areas of the field that are prone to standing water following rain events. Raised and dome shaped beds without depressions in the top will allow for speedy movement of moisture away from the crown region of the plants. Provide drainage at the end of the field to allow excess water to flow out of the fields. When crown rot infected plants occur in the field, remove infected plants to avoid production of spores leading to the aerial phase of the disease.

Chemical control measures may be necessary to augment the cultural practices mentioned above. This is especially true in fields with a history of Phytophthora blight and that are likely to experience saturated soils following heavy rains. The fungicide mefenoxam (**Group 4** fungicide) (Ridomil Gold 4E, Ultra Flourish 2E) can be applied as a banded spray over the row shortly after transplanting or it can be injected through the drip irrigation system to protect against the crown rot phase of the disease. Mefenoxam needs to be reapplied twice at 30-day intervals after the transplant application. Two weeks after the last application of mefenoxam, begin foliar applications of a fixed copper fungicide with a spreader sticker to provide protection against the foliar phase of the disease. Tanos (a mixture of famoxadone [**Group 11**] and cymoxanil [**Group 27**]) is also labeled for peppers. For best results tank mix Tanos with a copper fungicide, and for resistance management do not make more than one application of this mixture before alternating with a fungicide with a different mode of action.

Resistant varieties are being developed to reduce the incidence of Phytophthora blight in pepper. Resistance genes are required for both the crown rot and aerial phases of the disease, and these must be bred into commercially acceptable varieties. The varieties ‘Emerald Isle’ and ‘Reinger’ possess resistance to the crown rot phase of Phytophthora, but do not possess sufficient horticultural characteristics to be commercially acceptable. The variety ‘Paladin has excellent resistance to the crown rot phase of Phytophthora but does not provide sufficient resistance toward the aerial phase. The variety ‘Aristotle’ provides only tolerance to the crown rot phase and like ‘Paladin’ has insufficient resistance for the aerial phase. Both ‘Paladin’ and ‘Aristotle’ do have excellent horticultural characteristics similar to the variety ‘Camelot’. One occasional flaw in both ‘Paladin’ and ‘Aristotle’, and possibly related to Phytophthora resistance, is the development of a “silvering’ pattern on the fruit. ‘Paladin’ also develops fine shoulder cracks when allowed to mature to the red stage, and is therefore not recommended for the red fruit market. Additional Phytophthora tolerant hybrids include ‘Conquest’ and ‘Revolution’.

Fungi

White Mold

White mold is caused by the soil borne fungus *Sclerotinia sclerotiorum*. Many vegetable crops are susceptible to this fungus, although corn and grasses are not. Leading susceptible crops include tomato, cabbage, lettuce, carrot, celery, snap bean, several cucurbits, and of course pepper. The pathogen produces hard, black sclerotia, like small, flattened and elongated raisins which serve as the overwintering means for the fungus. These sclerotia, which can survive in the soil for years, may be produced inside of the stems or on the surface of affected areas. Sclerotia germinate at an optimal temperature of 52°F; *Sclerotinia* is a low-temperature fungus, able to cause infection from 32-82°F. The fungus also requires abundant moisture for a week or longer for infection to occur. Sclerotia germinate to produce slender stalks that end in an apothecia (cup-shaped structure in which asci and ascospores are produced) or they may germinate by mycelium in some *Sclerotia* species. Although ascospores are short lived, they are blown within a field, landing on senescent or injured susceptible tissue and penetrate directly. In pepper, infections occur on stems or in the axil of branches.

Pepper growers in western NY lost 5% of their pepper crop due to white mold infections during the cool and wet growing conditions for summer 2003. Rotation out of pepper and not using other susceptible crops in rotational scheduling will be critical for next season and into the foreseeable future. Mycoparasites are known to destroy existing sclerotia and inhibit the development of new sclerotia. The commercial product Contans WG (*Coniothyrium minitans*, EPA Reg. No. 7244-1, and OMRI listed) has shown great promise in significantly reducing sclerotial populations. The product needs to be applied to the soil prior to planting (1-4 lb/A), and once applied, incorporated into the top 2 inches. If incorporation will be greater than 2 inches, then the application rate should be increased to 2-6 lb/A.

Anthracnose

Anthracnose, also known as ripe fruit disease, is potentially caused by three species of the fungus *Colletotrichum*: *C. coccodes*, *C. capsici*, and *C. gloeosporioides*. Although most commonly seen on maturing hot and sweet peppers, under appropriate conditions infections can occur on immature fruit, stems, and even leaves. Infections appear as sunken lesions on the fruit. The lesions may turn black with the formation of setae and sclerotia, or the center of the lesion may develop pustules (acervuli) that contain a salmon-colored spore mass. *Colletotrichum* typically produces microsclerotia that allows the fungus to overwinter in the soil. Microsclerotia can survive for many years, but even a 2 or 3-year rotation out of susceptible crops (mainly solanaceous) can significantly reduce inoculum.

For late maturing red peppers the following fungicides are registered: maneb (**Group M3**), 7DTH; Quadris and Cabrio (both **Group 11** fungicides), 0DTH.

Viruses

Cucumber Mosaic Virus (cucumovirus, aphid transmitted, not seed transmitted in pepper, many weed hosts)

Cucumber mosaic virus (CMV) is the most common virus infecting peppers in the Northeast. The virus can infect more than 800 plant species worldwide. CMV is readily transmitted from perennial weeds by aphids in a nonpersistent method. It is often the earliest virus transmitted in the spring. Important weed hosts include common milkweed (Perennial), common chickweed (Winter Annual, but can become perennialized in cool moist areas, also

CMV is seedborne in this species), marsh yellow cress (A, Biennial, short-lived P), and yellow rocket (Win A, Bie) and more (3, a more complete list is provided). As aphid populations develop on peppers during the spring and summer, extensive spread may occur. Pepper plants on the edge of fields and rows are frequently the first plants to be infected.

Destroy important weeds before the crop is established in the field. Intercropping with corn or other nonsusceptible tall barrier crops have been used keep virus from invading the crop. Rouging infected plants especially from the ends of rows before secondary spread occurs may be helpful. Because of the nonpersistent manner of transmission, control of aphids to prevent spread within the crop is not an option. Inheritance of resistance to CMV is very complex, so it is doubtful there are of any truly CMV-resistant peppers.

Tobacco Mosaic Virus (tobamovirus, mechanical transmission, seed transmitted, solanaceous weed hosts)

TMV is worldwide in distribution and can readily be transmitted by physical contact. No insect vectors are known. TMV is one of the most stable plant viruses, capable of surviving on dried plant debris and roots of tomato and probably pepper for many years. It is known to be seedborne in pepper and tomato. Although the natural host range of TMV is wide, it is primarily a problem for solanaceous crops (pepper and tomato).

Sanitation is important for the control of TMV. This is particularly true in greenhouse settings where the virus has been diagnosed previously. Dispose of all plant material including roots. Sanitize all flats and bench surfaces with a strong disinfectant prior to establishing a new crop and make sure the greenhouse and surrounding areas are free of weeds that may harbor the virus. Some key perennial weed species include marsh yellowcress (*Rorippa islandica*), broadleaf plantain (*Plantago major*), horsenettle (*Solanum carolinense*), and smooth (*Physalis subglabrata*) and clammy groundcherry (*P. heterophylla*), to name a few (3). Because TMV is seedborne in pepper and other solanaceous crops, make sure to purchase disease-free seed from a reputable seed company. If seed is of questionable quality, the seed should be soaked for 30 minutes in a 10% solution of household bleach or for 15 minutes in a 10% solution of trisodium phosphate (Na_3P04), often used to soften dried paint brushes. Either of these treatments will remove most virus from the surface, unless the virus is in the seed endosperm. Recently released varieties have moderate to high tolerance to some strains of TMV.

Tomato Spotted Wilt Virus (tospovirus, thrips transmission, not seed transmitted, many weed hosts)

Tomato spotted wilt virus (TSWV) causes brown spotting or dark ringspots on foliage and fruit, and stunting and distortion of the young growth of pepper plants. TSWV is transmitted by at least 8 species of thrips, with the tobacco thrips (*Frankliniella fusca*) and western flower thrips (*F. occidentalis*) considered to be the most important vectors. Thrips acquire TSWV by feeding on infected plants only as larvae. After a latent period of 3-7 days, they are then able to transmit the virus to uninfected plants for the remainder of their lives. TSWV has a host range in excess of 600 plant species, but many of these plants do not support thrips reproduction and are considered "dead ends" for virus spread.

A recent survey of the role of weed hosts for TSWV and the tobacco thrips in North Caroline concluded that key weeds included mouseear (P) and common chickweed (Win A, but can become perennialized in cool, moist areas), spiny sowthistle (A), dandelion (P), blackseed plantain (P), and a buttercup species (A) (3). Sanitation around greenhouses is essential as well as growing vegetable transplants in a greenhouse separate from ornamentals that commonly serve as reservoirs. There is no cure for infected plants, which should be removed from the greenhouse or the field as soon as they are detected. SpinTor (spinosad) has been one of the most effective controls for thrips on labeled crops (such as tomatoes and peppers) and applications on peppers for European corn borer will also provide incidental control of thrips present.

References

1. Compendium of Pepper Diseases. 2003. Ed. K. Pernezny, P. D. Roberts, J. F. Murphy, and N. P. Goldberg. APS Press, St. Paul, MN. 63pp.

2. Northeast Pepper Integrated Pest Management (IPM) Manual. 2001. Ed. T. Jude Boucher and Richard A. Ashley. University of Connecticut, Cooperative Extension System.136pp.

3. Vegetable MD online web site: http://vegetablemdonline.ppath.cornell.edu for selected fact sheets, news articles (ie. Managing Bacterial Leaf Spot in Pepper), and images.

4. Fungicide Resistance Action Committee site for Fungicide Groups: http://www.frac.info/publications/FRACCODE_sept2002.pdf