Control of pepper and tomato diseases requires ***multiple tactics*** *used together to manage diseases from transplant production to harvest.*

Figure 1. Wilting green leaves that initially recover overnight are among the early symptoms of crown & root rot caused by the soilborne pathogen *Fusarium oxysporum* f. sp. *radicis-lycopersici* . This disease is most effectively managed using multiple tactics including crop rotation, preventing the spread of soil between contaminated fields, nutrient and pH management, selection of resistant cultivars and fumigation. Photograph by: Ken Pernezny.

CORRECTLY IDENTIFY PATHOGEN:

First and foremost, the diseases must be identified correctly. In our experience, many reported failures of control have been linked to misdiagnosis of the problem and not to any inherent defect in the control measures taken. Scouting services are now widely available in Florida. Growers can take advantage of the expertise of professional crop inspectors/advisors who bring diagnostic skills to the farm and who systematically inspect fields for emerging disease problems.

USE RESISTANT CULTIVARS:

Growers should select cultivars that are resistant to diseases when available with horticulturally desirable traits. For example, tomato cultivars with resistance to Fusarium wilt, Verticillium wilt, and gray leaf spot are widely available. Recently, tomato varieties with resistance to the potentially devastating Fusarium crown rot have come on to the market. If one is growing in fields with a history of crown rot, these cultivars should be considered. Similarly, pepper cultivars with resistance to one or more races of the bacterial spot pathogen are commercially available and should be used whenever possible. ***See Chapter 2 for more information on Resistance and Tomato & Pepper Cultivar selection.***

SANITATION: Start Clean...Stay Clean

Transplants should be free of disease when set in the field. There is a greater likelihood that transplants will be disease-free if they are produced outside the areas where field production of tomato and pepper takes place. For example, southern Florida growers may want to contract with central Florida transplant producers to ensure geographical separation of transplant and field production.

Choice of land can be very important in management of several diseases, particularly those that are soilborne. Fields with a history of crown rot of tomato **(Figure 1)** or Phytophthora blight (pepper) will have the problems consistently from year to year. Avoiding cropping of the susceptible hosts in these fields will help break the cycle of yearly outbreaks.

Figure 2. Weeds and especially volunteer crops can harbor diseases like tomato yellow leaf curl pictured above. Photograph by: Ken Pernezny.

Many hand operations are typically used in Florida tomato and pepper production. These include pruning, thinning, and tying. Pathogens, especially the bacterial spot pathogen, can be readily spread throughout fields when these intensive handling operations are carried out.

Mechanical transmission of bacteria has been shown to be reduced by handling plants when driest and periodically disinfesting workers' hands and tools with a topical disinfectant, such as isopropyl alcohol.

Weed management aids in plant disease control. Several pathogens, notably a number of viruses, can reside in weed hosts that serve as inoculum reservoirs for crop plants **(Figure 2)**. Destruction of weeds eliminates these inoculum sources.

Prepared by: Dr. Ken Pernezny

DISEASE MANAGEMENT: Integrated Control

Commercial growers can not rely on only one approach (e.g., chemical control) and expect to successfully cope with the many disease problems that occur in Florida.

Figure 3. Metalized mulch, which reflects UV light, can be used to disrupt the behavior of insects such as thrips, reducing the incidence of tomato spotted wilt. Photograph by: Eric Zamora.

Check with your local cooperative extension personnel for further information on:

Integrated Disease Management

CONTACT INFORMATION:

Dr. Ken Pernezny
UF/IFAS EREC
3200 E. Palm Beach Road
Belle Glade, FL 33430
klp@ifas.ufl.edu
561-993-1599

NUTRIENT AND WATER MANAGMENT:

Some specific steps in the fertilizer program can be taken to mitigate certain diseases. As an example, liming of soil to raise the pH can significantly reduce gray mold problems. Avoidance of excess nitrogen will reduce lush foliage growth which can exacerbate diseases such as bacterial spot of tomato and pepper and target spot of tomato.

Water management is critical to overall disease management. For example, Phytophthora blight of pepper can decimate fields that become flooded. It is imperative that excess water be pumped off farms as quickly as possible, especially following tropical storm events.

Overhead irrigation can contribute to increases in bacterial spot. UF/IFAS research has shown that drip irrigation is an excellent method for reducing bacterial spot compared to overhead irrigation.

CHEMICAL CONTROL:

Chemical control is an important part of the disease management scheme on traditional commercial farms. Many of the standard fungicides, which have been available for a while, are protectants; i.e., they must be on the foliar surface before pathogen propagules arrive if they are to be effective.

Some of the newer fungicides, e.g., the strobilurins, can have some "kick-back" action, meaning they can help alleviate disease when applied after infection occurs. However, many of these new fungicides are prone to development of resistance in pathogen populations and must be used incombination and/or rotation with more broad-spectrum fungicides.

See FRAC tables in Chemical Control Chapter on pp. 203-204 and Appendix 6) for more information on resistance management.

How does acibenzolar-S-methyl (Actigard ®) work?

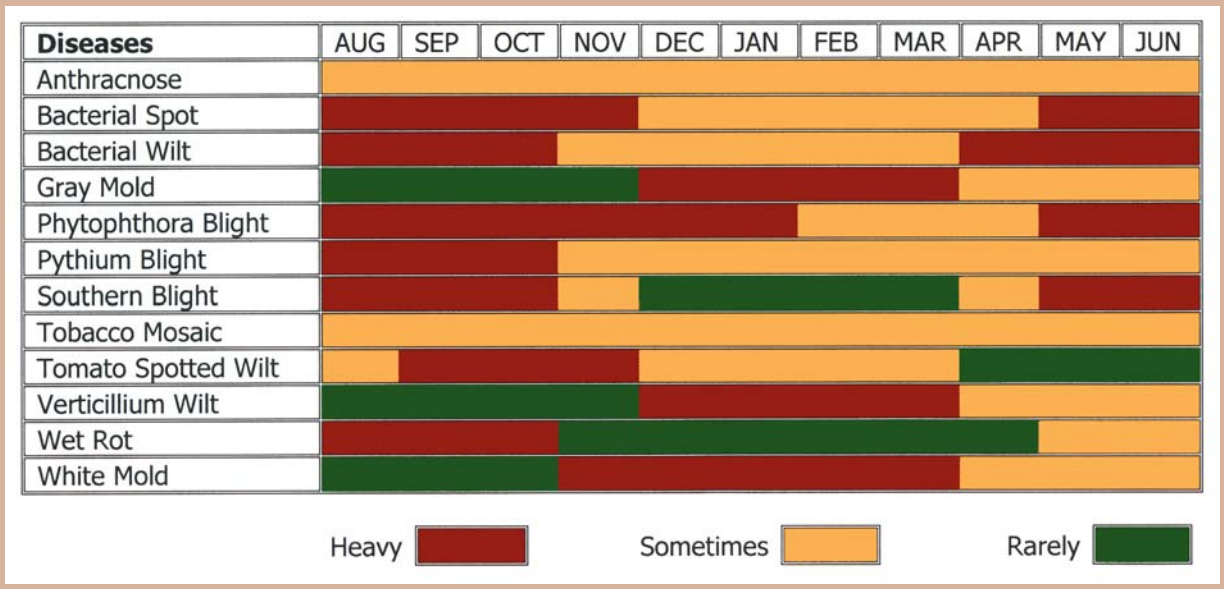
Some new chemicals now available (for example, acibenzolar-S-methyl) do not attack the pathogen, but, instead, elicit a resistance response in the host to ward off the pathogen.

Is acibenzolar-S-methyl (Actigard ®) effective?

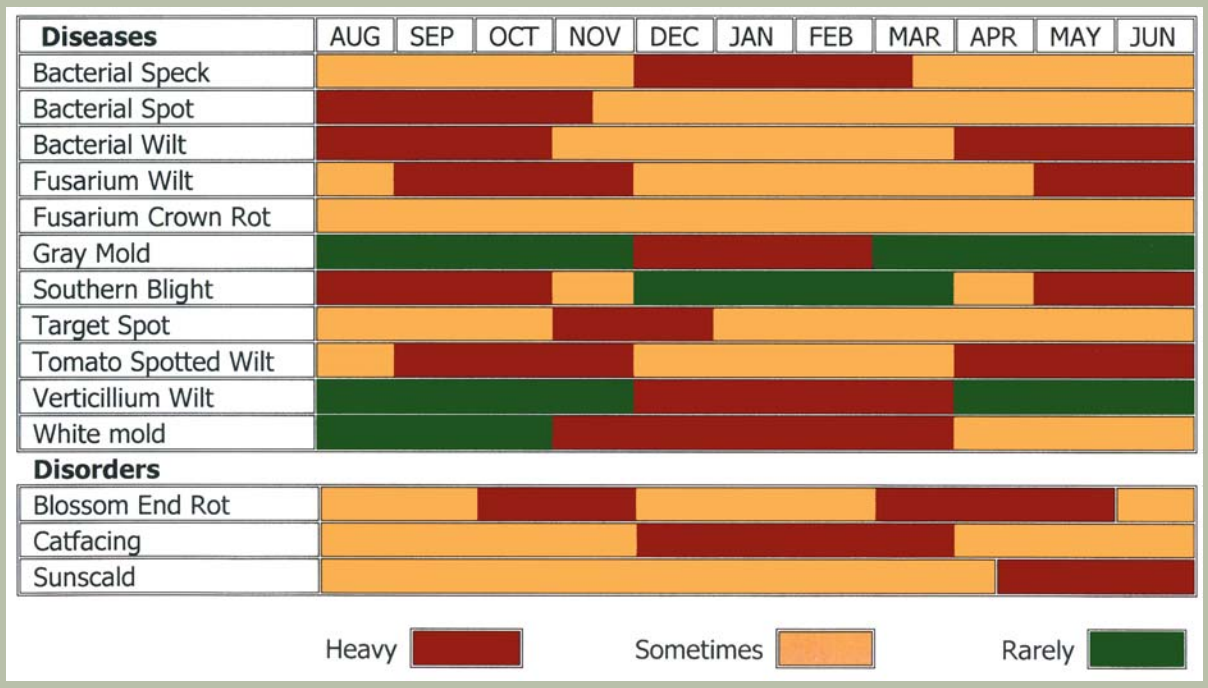
UF/IFAS research shows that this compound, when used in a comprehensive disease managment program, can reduce some diseases of tomato.

When all these and more techniques and materials are used in a well planned program, disease management and crop productivity are enhanced.

PEPPER DISEASE SEASONALITY CHART:



TOMATO DISEASE SEASONALITY CHART:



Notes:

Colletotrichum acutatum
Colletotrichum gleosporioides

SIGNS & SYMPTOMS:

- Fruit lesions are circular and can easily reach 1.5 in. in diameter.
- Fruit lesions are always prominently sunken.
- Concentric rings may appear in lesions and are tan to orange to black.
- Less evident are lesions on stems and leaves, consisting of irregularly shaped gray-brown spots.

DISEASE CYCLE & EPIDEMIOLOGY:

- Both *Colletotrichum* species have been associated with seed.
- These fungi survive well in association with crop debris.
- *C. gleosporioides* is known to have a wide host range, including a number of crop species. *C. acutatum* probably has a wide host range as well.
- Anthracnose is favored by periods of high rainfall and high humidity.
- Optimum temperature for infection is 68-75°F, but it can occur up to 86°F.

FIELD SIGNATURE:

- In Florida, anthracnose affects pepper fruit.
- *C. gleosporioides* is a pathogen that is exclusively associated with mature fruits that are beginning to change to the fully ripened color (red or yellow predominantly).
- *C. acutatum* attacks both green, immature fruit as well as mature fruits.
- Always look for large, sunken lesions often covered with black fungal growth.
- This can be confused with the abiotic problem sunscald.

PHOTOS:

Figure 1. Large, sunken anthracnose lesions on immature green bell pepper. Photograph by: Ken Pernezny.

Figure 2. Fruit lesions with conspicuous pink to tan spore masses. Photograph by: Ken Pernezny.

Figure 3. Anthracnose symptoms on ripe pepper fruit. Photograph by: Ken Pernezny.

Prepared by: Tyler Harp and Dr. Ken Pernezny

DISEASE MANAGEMENT:
Anthracnose of Pepper

CULTURAL CONTROLS:

- Plant pathogen-free seed and practice crop rotation.
- Prompt destruction and burial of crop residue is very, very important.

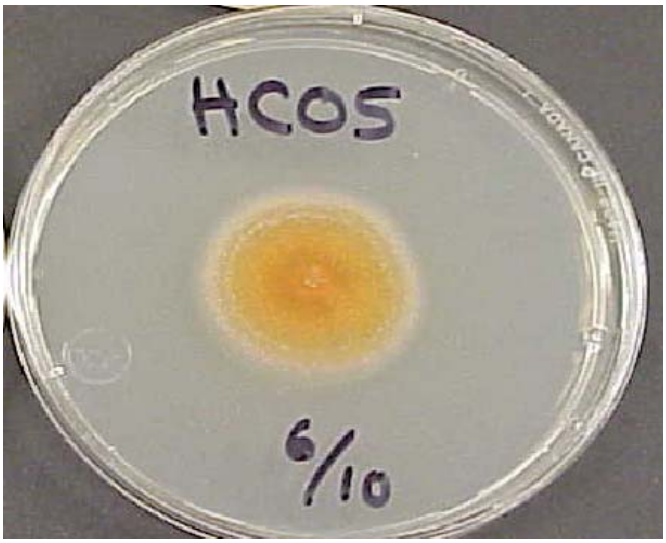


Figure 4. Growth of *Colletotrichum accutatum* on agar plate. Photograph by: Tyler Harp.

CONTACT INFORMATION:

Tyler Harp
UF/IFAS Plant Pathology Dept.
P.O. Box 110680
Gainesville, FL 32611
tlharp@ufl.edu
352-392-3631

Dr. Ken Pernezny
UF/IFAS EREC
3200 E. Palm Beach Road
Belle Glade, FL 33430
klp@ifas.ufl.edu
561-993-1599

CHEMICAL CONTROL:

- Azoxystrobin, famoxadone in mixture with cymoxanil, pyraclostrobin and maneb are currently labeled for pepper anthracnose control.
- Fumigation with methyl bromide may reduce survival of the pathogen in soil debris.

RESISTANCE MANAGEMENT:

- Be sure to rotate strobilurin fungicides, such azoxystrobin,famoxadone or pyraclostrobin, with maneb and/or copper to reduce the potential for development of resistance to strobilurin (Group 11) fungicides.
- Follow all resistant management guidelines on the label.

RESISTANT CULTIVARS:

- Little is known about cultivar susceptibility to anthracnose, especially now that 2 distinct species have been identified as causal agents. In Ohio, some tolerance to anthracnose was identified in some cultivars.
- For now, assume all cultivars are susceptible.

References:

Alexander, S.A. and K. Pernezny. 2003. Anthracnose, pp. 9-10. *In* K. Pernezny, P.D. Roberts, J.F. Murphy and N.P. Goldberg (eds.), Compendium of Pepper Diseases. APS Press, St. Paul, MN.

Lewis Ivey, M.L., C. Nava-Diaz and S.A. Miller. 2004. Identification and management of *Colletotrichum acutatum* on immature bell peppers. Plant Dis. 88: 1198-1204.

Xanthomonas vesicatoria, X. euvesicatoria, X. gardneri and *X. perforans*

SIGNS & SYMPTOMS:

- Produces spots (<3 mm) on leaves stems and fruit.
- Spots are watersoaked when foliage is wet.
- Blighting of the foliage may occur.
- Defoliation of pepper leaves occurs under severe disease.

DISEASE CYCLE & EPIDEMIOLOGY:

- Organism survives on tomato volunteers and diseased plant debris.
- Contaminated seed serves as inoculum source.
- Disease development favored by high temperatures and high precipitation.
- Bacterium disseminated by wind-driven rain droplets, clipping of transplants and aerosols.
- Bacterium penetrates through stomates and wounds.

FIELD SIGNATURE:

- This disease is quite prevalent during warm, moist weather.
- During optimal conditions plants may have a blighted appearance.
- Symptoms are easily seen on the underside of the leaf.
- On tomato the lesions may have a shot-hole appearance.

PHOTOS:

Figure 1. Bacterial spot of tomato. Note: the leaf spots, yellowing and defoliation. Photograph by: Jeff Jones.

Figure 2. Fruit lesions on tomato. Photograph by: Jeff Jones.

Figure 3. Leaf spots on pepper. See Fig. 5 for a close-up view of watersoaking. Photograph by: Ken Pernezny.

Prepared by: Dr. Jeff Jones

DISEASE MANAGEMENT:
Bacterial Spot

CULTURAL CONTROLS:

- Crop rotation to avoid carry-over on volunteers and crop residue.
- Production of disease-free transplants.
- Seed treatment should be used.
- Eliminate any volunteers.
- Cull piles should be avoided near transplant or field production.

CHEMICAL CONTROL:

- Copper bactericides used in combination with mancozeb provides control of many copper-tolerant strains.
- The plant inducer, Actigard ®, provides significant disease control.
- Bacteriophages with specificity to the target bacterial strains provide significant control.

RESISTANCE MANAGEMENT:

- Widespread resistance to copper has been documented for both pepper and tomato strains.

Figure 4. Bacterial spot on pepper. Photograph by: Ken Pernezny.

Figure 5. Close-up view of watersoaked lesions on pepper. Photograph by: Ken Pernezny.

RESISTANT CULTIVARS:

TOMATO: None available

PEPPER: There are quite a few pepper cultivars, especially sweet bell pepper, with resistance to specific races (especially races 1-3) of the spot pathogen. Check with your seed supplier when purchasing hybrid seed to see what resistance is available. **See pg. 13 for resistant cultivars.**

CONTACT INFORMATION:

Dr. Jeff Jones
UF/IFAS Plant Pathology Dept.
Gainesville, FL 32611
jbjones@ifas.ufl.edu
352-392-3631 ext. 348

Dr. Ken Pernezny
UF/IFAS EREC
3200 E. Palm Beach Road
Belle Glade, FL 33430
klp@ifas.ufl.edu
561-993-1599

IPM Integrated Pest Management Florida

UF UNIVERSITY of FLORIDA IFAS Extension

References:

Obradovic, A., J.B. Jones, M.T. Momol, B. Balogh and S.M Olson. 2004. Management of tomato bacterial spot in the field by foliar applications of bacteriophages and SAR inducers. Plant Dis. 88:736-740.

Jones, J. B., K.L Pohronezny, R.E. Stall and J.P. Jones. 1986. Survival of *Xanthomonas campestris* pv. *vesicatoria* in Florida on tomato crop residue, weeds, seeds, and volunteer tomato plants. Phytopathology 76:430-434.

Ralstonia solanacearum

SIGNS & SYMPTOMS:

- Initial symptom is wilting of upper leaves during the warmest part of the day, which may recover in the evening.
- The whole plant becomes completely wilted or stunted and may die under conditions favorable to the disease.
- Wilted leaves maintain green color usually until desiccated and do not fall as disease progresses **(Figures 1 & 4)**.
- Vascular tissues in the lower stem of diseased plants show a dark brown discoloration **(Figure 3)**.
- As a sign, ooze from lower stem in water is an important indication of this bacterial pathogen.

DISEASE CYCLE & EPIDEMIOLOGY:

- Infested soil and surface water, including irrigation water, are the primary sources of inoculum.
- The pathogen infects roots of susceptible plants, usually through wounds.
- Bacterial wilt is favored by high temperature (85-95°F) and high soil moisture.
- The pathogen has a wide host range, including tomato, pepper, potato, tobacco, eggplant, geranium, hydrangea and many weeds and other plants.

FIELD SIGNATURE:

- The disease usually occurs in foci associated with water accumulation in lower areas.
- In furrow-irrigated crops, it is common to find wilted plants in sequence due to inoculum spread through water channels.

PHOTOS:

Figure 1. Wilted leaves due to bacterial wilt on tomato. Photograph by: Hank Dankers.

Figure 2. Severe bacterial wilt in tomato field. Photograph by: Hank Dankers.

Figure 3. When sliced open, stems of infected plants display dark brown coloration of the vascular tissue. Photograph by: Hank Dankers.

Prepared by: Dr. Tim Momol

CULTURAL CONTROLS:

- Pathogen free soil, irrigation water, transplants, and operation tools are important to exclude or reduce disease.
- Raise soil pH to 7.5-7.6 and increase available calcium (liming).
- Use non-host crops, such as sorghum-sudan, rye and corn, as cover crops or for rotation.

RESISTANT CULTIVARS:

TOMATO:

Some moderately resistant cultivars are commercially available, such as FL7514 and BHN 466.

Resistance may be limited to certain regions since it may fail across locations.

Acibenzolar-*S*-methyl (Actigard ®) was shown to enhance resistance of some moderately resistant cultivars in field experiments in Florida.

PEPPER:

No known resistance to bacterial wilt currently available in commercial cultivars.

Acibenzolar-*S*-methyl should not be used on pepper due to potential adverse effects.

CONTACT INFORMATION:

Drs. Tim Momol and Pingsheng Ji
UF/IFAS NFREC
155 Research Road
Quincy, FL 32351
tmomol@ufl.edu
850-875-7154

CHEMICAL CONTROL:

- Soil fumigation with chloropicrin has been reported to achieve limited success if combined with other control methods.
- Thymol, a plant-derived volatile chemical, was shown to reduce disease incidence and increase yield in field experiments (not commercially available).

RESISTANCE MANAGEMENT:

- Chemical control should be integrated with cultural and other methods to reduce selection pressure for pathogen resistance.

Figure 4. Severe wilt symptoms. Photograph by: Hank Dankers.

References:

Ji, P., M.T. Momol, S.M. Olson, P.M. Pradhanang and J.B. Jones. 2005. Evaluation of thymol as biofumigant for control of bacterial wilt of tomato under field conditions. Plant Dis. 89:497-500.

Momol, M.T., P.M. Pradhanang and C.A. Lopes. 2003. Bacterial wilt, pp. 7-8. *In* K.L. Pernezny, P.D. Roberts, J.F. Murphy and N.P. Goldberg (eds.), Compendium of Pepper Diseases. American Phytopathological Society, St. Paul, MN.

Pradhanang, P.M., P. Ji, M.T. Momol, S.M. Olson, J.L. Mayfield and J.B. Jones. 2005. Application of acibenzolar-S-methyl enhances host resistance in tomato against *Ralstonia solanacearum*. Plant Dis. 89: 989-993.

Alternaria solani

SIGNS & SYMPTOMS:

- Foliar symptoms generally occur on the oldest leaves and start as small, brownish to black lesions. These leaf spots enlarge up to ½ inch (1.3 cm) in diameter in a characteristically concentric fashion. The area around the spot may become yellow, as may entire severely affected leaves. Under favorable conditions, significant defoliation of lower leaves may occur, leading to sunscald of fruit.
- Green or red fruit may be infected by the fungus which invades at the point of attachment between the stem and fruit, and through growth cracks and wounds made by insects. Dark lesions enlarge in a concentric fashion and may affect large areas of the fruit. Mature lesions in fruit are typically covered by a black velvety mass of fungal spores.
- Stem lesions are dark, slightly sunken and enlarge concentrically. Basal girdling and death of seedlings may occur. This manifestation of the disease is called collar rot.

DISEASE CYCLE & EPIDEMIOLOGY:

- Infection by the fungus is most rapid under warm 82-86°F (28-30°C) wet conditions.
- *Alternaria solani* survives between crops in plant debris and on seed. It can also survive on volunteer tomato plants (warm climates) and on other cultivated and wild solanaceous plants (potato, eggplant, horse nettle and black nightshade).

FIELD SIGNATURE:

- Early blight symptoms (leaf spot and defoliation) are most pronounced in the lower canopy.
- Disease severity and prevalence are highest when plants are loaded with fruit.

PHOTOS:

Figure 1. Typical foliar symptoms of early blight. Photograph by: Bob McGovern.

Figure 2. Early blight symptoms in fruit. Photograph by: Bob McGovern.

Figure 3. Collar rot symptoms in a tomato transplant. Photograph by: Bob McGovern.

Prepared by: Dr. Bob McGovern

DISEASE MANAGEMENT:
Early Blight of Tomato

CULTURAL CONTROLS:

- Use pathogen-free seed and transplants.
- Maintain plant vigor through adequate irrigation and fertilization to increase disease resistance.
- Use long rotations away from tomato and other solanaceous crops, avoid planting tomato near related crops that are more mature and eliminate weed hosts of the pathogen.
- Avoid plant injury which allows entry of the pathogen and spread of the fungus through adequate insect management.

Figure 4. Severe foliar damage due to early blight; untreated plants are on the right and those treated preventively with fungicides are on the left. Photograph by: Bob McGovern.

CONTACT INFORMATION:

Dr. Robert McGovern
UF/IFAS Plant Pathology Dept.
1453 Fifield Hall
Gainesville, FL 32611
rjmcgov@ufl.edu
352-392-3631

CHEMICAL CONTROL:

- Contact fungicides such as chlorothalonil and mancozeb provide moderate levels of control when applied preventively.
- Newer chemistries including strobilurin fungicides (azoxystrobin, pyraclostrobin, etc.) have provided excellent control in university trials.

RESISTANCE MANAGEMENT:

- New fungicide chemistries including the strobilurins generally have a narrow mode of action and are prone to the development of resistance by fungi; rotate these with fungicides from different groups.

RESISTANT CULTIVARS:

- Adequate resistance to early blight has not been identified in tomato cultivars.

References:

Jones, J.P. 1991. Early Blight, pp. 13-14. *In* J. B. Jones, J. P. Jones, R.E. Stall and T.A. Zitter (eds.), Compendium of Tomato Diseases. American Phytopathological Society, St. Paul, MN.

McGovern, R.J., T.A. Davis and T.E. Seijo. 1999. Evaluation of fungicides for control of early blight and target spot in tomato. Fungicide & Nematicide Test Reports. 55:279.

McGovern, R.J., T.A. Davis and T.E. Seijo. 1999. Evaluation of fungicides for control of early blight and target spot in tomato. Fungicide & Nematicide Test Reports. 55:280.

Sherf, A.F. and A.A. MacNab. 1986. Vegetable Diseases and Their Control. John Wiley & Sons, New York.

Fusarium oxysporum f. sp. *radicis-lycopersici*

SIGNS & SYMPTOMS:

- Symptoms on tomato plants first appear as yellowing of the oldest leaves about the time that fruit is nearing maturity.
- Symptoms progress up the plant as the yellowed leaves turn brown **(Figure 4)**.
- Plant wilting first occurs during the warmest part of the day, and plants appear to recover at night.
- The entire plant wilts and dies or it may persist in a weakened state.
- Infected plants may be stunted.

DISEASE CYCLE & EPIDEMIOLOGY:

- The fungus invades plants through wounds and natural openings created by newly emerging roots.
- Long-range dissemination of the fungus can occur through infected transplants, contaminated soil, and on contaminated shoes, plant stakes, machinery, transplant trays and other equipment.
- The fungus survives for long periods of time in the soil.
- The disease is favored by cool temperatures 50-68°F, low soil pH, ammoniacal nitrogen and water-logged soil.

FIELD SIGNATURE:

- Crowns and roots, when sectioned lengthwise, have extensive, internal brown discoloration **(Figure 2)**.
- Abnormal amounts of adventitious roots may occur above the infected region **(Figure 5)**.
- Stem lesions may be covered with masses of white fungus with yellow to orange.

PHOTOS:

Figure 1. Severe external stem damage. Photograph by: Ken Pernezny.

Figure 2. Internal damage caused by Fusarium root and crown rot (FCRR), note the brown color of the plant vascular tissue. Photograph by: Ken Pernezny.

Figure 3. Field view of infected tomato plants, note that patches of plants are affected rather than as a uniform pattern throughout the field. Photograph by: Ken Pernezny.

Prepared by: Dr. Pam Roberts

DISEASE MANAGEMENT:
Fusarium Crown and Root Rot on Tomato

CULTURAL CONTROLS:

- Avoid ammoniacal nitrogen and maintain the soil pH at 6 to 7.
- Avoid movement of infested soil or contaminated equipment.
- Disinfect wooden tomato stakes before reuse, or use new stakes.
- Rotate with a nonsusceptible crop.

CHEMICAL CONTROL:

- Use a preplant fumigant.
- Fungicides are not effective to control this soilborne pathogen.

RESISTANT CULTIVARS:

- Some resistant cultivars, such as 'BHN 586', 'Crown Jewel', 'Sebring', and 'Soraya' are available for commercial use. **See pgs. 10-11 for resistant cultivars.**

Figure 4. Wilt symptoms from mild to severe which represent early to late stage infection. Photograph by: Lawrence Datnoff.

Figure 5. Proliferation of adventitious roots caused by FCRR in a non-fumigated plot. Photograph by: Lawrence Datnoff.

CONTACT INFORMATION:

Dr. Pamela D. Roberts
UF/IFAS SWFREC
2686 SR 29 N
Immokalee, FL 34142
pdr@ifas.ufl.edu
239-658-3400.

References:

Paulus, A.O. 1991. Fusarium Crown and Root Rot, pg. 14. *In* J.B. Jones, J.P. Jones, R.E. Stall and T.A. Zitter (eds.), Compendium of tomato diseases. American Phytopathological Society Press, St. Paul, MN.

Roberts, P.D., R.J. McGovern and L.E. Datnoff. 2001 Fusarium Crown and Root Rot of Tomato in Florida. UF/IFAS EDIS pub.PP52. http://edis.ifas.ufl.edu/PG082

Sonoda, R.M. 1976. The occurrence of a Fusarium root rot of tomatoes in South Florida. Plant Dis. Rep. 60:271-274.

DISEASE MANAGEMENT:
Gray Mold on Tomato and Ghost Spot on Pepper

Botrytis cinerea

SIGNS & SYMPTOMS:

- Symptoms on leaves first appear as a brown, blighted area and progress up the petiole and into the stem.
- Blossoms turn brown and die.
- Infected fruit turn gray-white, soft and rot.
- Fruit may develop light, white halos called 'Ghost spots' which occur from airborne spore infection.

DISEASE CYCLE & EPIDEMIOLOGY:

- The fungus has a very wide host range and spores can be blown from other hosts.
- The fungus survives saprophytically on leftover plant debris.
- Small, black resting bodies (called sclerotia) may be produced, particularly in rotted fruit, which allows survival of the fungus during adverse conditions.
- Conidia from infected tissue are dispersed by wind and by splashing rain.
- The fungus is considered a weak pathogen that typically enters the plant through wounds or aging tissue.

ENVIRONMENTAL CONDITIONS:

- The disease typically begins in cooler weather.
- Disease development is greatest under moderate temperatures of 65-75°F.
- The disease is favored by sufficient humidity in the canopy and, on tomato, is most severe on plants in acidic, sandy soils with high soil moisture.

FIELD SIGNATURE:

- Symptoms appear first on older leaves and then move up the plant to younger leaves.
- A gray, fuzzy mold grows out of the dead tissue and, after periods of high humidity, clouds of spores are released when tissue is shaken.

PHOTOS:

Figure 1. Typical foliar symptoms of gray mold on older leaves of tomato. Photograph by: Phyllis Gilreath.

Figure 2. Dieback of leaflets, petiole and stem on tomato plant. Photograph by: Phyllis Gilreath.

Figure 3. Tomato fruit with white, soft rot symptoms of gray mold. Photograph by: Phyllis Gilreath.

Prepared by: Dr. Pam Roberts

DISEASE MANAGEMENT:
Gray Mold on Tomato and Ghost Spot on Pepper

CULTURAL CONTROLS:

- Since the signs of this fungus may be confused with other saprophytic fungi which colonize dead tissue, the presence of *Botrytris* by microscopic examination should be confirmed.
- Plants should be supplied adequate calcium by liming acidic soils and maintaining uniform soil moisture.
- A calcium-to-phosphorus ratio of 2 or higher in leaf petiole tissue decreases plant susceptibility.

Figure 4. Ghost spot symptoms on pepper fruit. Photograph by: Phyllis Gilreath.

CHEMICAL CONTROL:

- Chlorothalonil, chlorothalonil plus mefenoxam, pyraclostrobin (suppression only), and boscalid are fungicides labeled for field application of gray mold on tomato.
- Also labeled for use on tomato are Pyrimethanil and *Bacillus subtilis* strain QST 713. Both of these compounds should be applied with an appropriately labeled fungicide.
- On pepper, Pyraclostrobin and *Bacillus subtilis* strain QST 713 are labeled for this disease.

RESISTANCE MANAGEMENT:

- Resistant management strategies on fungicide labels (e.g., boscalid and pyraclostrobin) such as tank mixing with another fungicide, rotation of applications, and maximum rate use per application and per season should be followed.

RESISTANT CULTIVARS:

- Resistance in commercial cultivars is not available.

CONTACT INFORMATION:

Dr. Pamela D. Roberts
UF/IFAS SWFREC
2686 SR 29 N
Immokalee, FL 34142
pdr@ifas.ufl.edu
239-658-3400

References:

Stall, R.E. 1991. Gray Mold, pp. 16-17. *In* J.B. Jones, J.P. Jones, R.E. Stall and T.A. Zitter (eds.), Compendium of tomato diseases. American Phytopathological Society Press, St. Paul, MN.

Stall, R.E., C.C. Hortenstine and J.R. Iley. 1965. Incidence of botrytis gray mold on tomato in relation to a calcium-phosphorus balance. Phytopathology 55:447-449.

Black, L.L. 2003. Gray Mold, pp. 16-17. *In* K. Pernezny, P.D. Roberts, J.F. Murphy, and N.P. Goldberg (eds.), Compendium of pepper diseases. American Phytopathological Society Press, St. Paul, MN.

Phytophthora infestans

SIGNS & SYMPTOMS:

- On leaves, symptoms are large lesions that are irregular in shape. Initially, the lesions are dark green with water-soaked areas.
- The lesions will enlarge and turn brown and papery **(Figure 2)**.
- The lesion on the underside of the leaf may have white, sporulating fungal growth early in the morning or during wet periods **(Figure 1)**.
- On the fruit, the lesions are dark and olive colored with a greasy appearance **(Figure 3)**.

DISEASE CYCLE & EPIDEMIOLOGY:

- The pathogen overseasons on cull piles, plant debris and volunteer tomatoes
- Sporangia are carried long distances by wind and rain.
- Late blight development is favored by cool nights in the 50's, mild days in the 70's and high humidity.
- Disease progresses rapidly and can completely destroy a mature tomato field within days.

FIELD SIGNATURE:

- Large, blighted areas on leaves.
- White sporulation around lesion margins **(Figure 1)**.
- Fruit symptoms.

PHOTOS:

Figure 1. Underside of tomato leaf exhibiting blighted area and white sporulation of *P. infestans*. Photograph by: Pam Roberts.

Figure 2. Tomato leaves in field showing blighted leaves. Photograph by: Pam Roberts.

Figure 3. Tomato fruit with symptoms of late blight. Photograph by: Pam Roberts.

CULTURAL CONTROLS:

- Scout fields particularly in wetter parts of fields or where spray applications might miss.
- Use only disease-free transplants.
- Avoid adjacent plantings with older, infected crops.
- Eliminate cull piles and volunteers.
- Control solanaceous weeds such as nightshade.

Figure 4. Tomato seedling stunted. Photograph by: Pam Roberts.

CONTACT INFORMATION:

Dr. Pamela D. Roberts
UF/IFAS SWFREC
2686 SR 29 N
Immokalee, FL 34142
pdr@ifas.ufl.edu
239-658-3400

CHEMICAL CONTROL:

- Maintain a preventative spray program with good coverage.
- There are many fungicides labeled for this disease.
- Chemistries include dimethomorph (Group 15), chlorothalonil (Group M4), copper (Group M1), strobuliruns (Group 11), cymoxanil (Group 27), zoxamide + mancozeb (Groups 22 & M2), mancozeb and maneb (Group M2), Fenamidone (Group 11), propamocarb hydrochloride (Group U) mefenoxam (Group 4), *Bacillus subtillis* bacteria, famoxadone + cymoxanil (Groups 11 & 27).

RESISTANCE MANAGEMENT:

- Follow fungicide labels.
- Some fungicides must be tank mixed with another fungicide.
- Resistance management strategies such as tank mixing with another fungicide, rotation of applications of fungicides in different groups, and maximum rate use per application and per season as stated on fungicide labels must be followed.

RESISTANT CULTIVARS:

- Resistance to late blight in tomatoes is not currently available in commercial cultivars.

References:

Stevenson, W.R. 1991. Late Blight, pp. 17-18. *In* J.B. Jones, J.P. Jones, R.E. Stall and T.A. Zitter (eds.), Compendium of tomato diseases. American Phytopathological Society Press, St. Paul, MN.

IPM Integrated Pest Management Florida
UF UNIVERSITY of FLORIDA IFAS Extension

SIGNS & SYMPTOMS:

- Intervenial chlorosis seen on young leaves.
- Leaves along midrib do not expand properly.
- Flattened fruit with radial cracks from calyx to the blossom scar.
- Almost no seed set in affected fruit.
- Blooms fail to set in more severely affected plant.

DISEASE CYCLE & EPIDEMIOLOGY:

- The causative agent is unknown, but symptoms are similar to frenching of tobacco where, under certain conditions, a nonparasitic soil microorganism disturbs the protein metabolism of the plant.
- Little Leaf (frenching) in tobbaco is favored by moderate temperatures (70-95°F).
- Symptoms are more severe on neutral or alkaline soils, rarely in soil with a pH of 6.3 or less.
- Symptoms are more prevalent in wet areas.
- The problem does not carryover, and drying the field will result in normal growth of the plant.

FIELD SIGNATURE:

- Plants with improperly developed leaves will be found in wet parts of the field, and may be adjacent to normal plants.
- Leaf veins are dark green.
- Fruit is distorted and cracked.
- Later symptoms can be confused with cucumber mosaic virus.

PHOTOS:

Figure. 1. Early foliar symptoms of Little Leaf. Photograph by: Steve Olson.

Figure 2. More severe Little Leaf plant symptoms. Photograph by: Steve Olson.

Figure 3. Fruit symptoms from Little Leaf. Photograph by: Steve Olson.

Prepared by: Dr. Stephen Olson

DISEASE MANAGEMENT:
Tomato Little Leaf

CULTURAL CONTROLS:

- Dry out wet areas of the field.
- Reduce soil pH to 6.3 or less or use ammonium sulfate as the nitrogen source to lower pH around the roots.
- Because the causative agent has not been defined, there are no suggestions for radical changes in tomato culture for disease avoidance.

Figure 4. Severe foliar damage due to Little Leaf. Photograph by: Steve Olson.

CHEMICAL CONTROL:

none

RESISTANCE MANAGEMENT:

none

Figure 5. Affected plant next to normal plant. Photograph by: Steve Olson.

RESISTANT CULTIVARS:

- No known resistance to Little Leaf is currently available in commercial cultivars.

CONTACT INFORMATION:

Dr. Stephen M. Olson
Horticultural Sciences Dept.
UF/IFAS NFREC
155 Research Road
Quincy, FL 32351-5677
smolson@ufl.edu
850-875-714

References:

Olson, S.E. 2002. Tomato Little Leaf. HS-883. University of Florida, IFAS, Cooperative Extension Service. http://edis.ifas.ufl.edu/CV278.

NEMATODE MANAGEMENT:
Root-Knot Nematode of Tomato and Pepper

***Meloidogyne* spp.** *M. incognita, M. javanica, M. arenaria, M. floridensis* and *M. mayaquensis.*

Root-knot nematodes (RKN) pose the greatest overall nematode threat to tomato and pepper on a global basis. They are obligate parasites requiring living plant tissue. Life stages include the egg, four juvenile stages and the adult male or female. Females reproduce without mating, laying upwards of 2000 eggs. With a life cycle of as little as 21 days, populations are capable of increasing rapidly to cause extensive damage.

SIGNS & SYMPTOMS:

- Plant symptoms occur because of root dysfunction, reducing rooting volume and foraging and utilization efficiency of roots for water and nutrients.
- Foliar symptoms include stunting, a general unthrifty appearance, leaf chlorosis (yellowing) and general symptoms of nutrient deficiency.
- Leaves wilt, particularly during hot afternoon sun, recovering slowly when irrigated.
- Stunted or declining plants occur in patches rather than uniformly throughout entire field.
- Positive diagnostic confirmation is provided by symptoms of root galling, where gall size may range from a few spherical swellings to extensive areas of elongated, convoluted, tumorous swellings along the entire surface of roots.

DISEASE CYCLE & EPIDEMIOLOGY:

- RKN attack almost all plant species and reproduce at very rapid rates, resulting in many billions of eggs and juveniles per acre of soil. In Florida, RKN problems are particularly severe because soil moisture and soil temperature seldom deviate from the nematode's optimal range.
- RKN is infamous for its predisposition of wilt susceptible tomato cultivars to infection by *Fusarium*, and of increased incidence and severity of bacterial wilt of tomato caused by *Ralstonia solanacearum*.

DAMAGE THRESHOLDS & MONITORING

- Yield losses are directly related to initial preplant soil population levels and interaction with soilborne pathogens and environmental stresses imposed on the plant during crop growth.
- The mere presence of RKN in soil or plant samples suggests a potentially serious problem, particularly with fall plantings when soil temperatures favor high levels of nematode reproduction.
- In-field soil samples and root bioassay is used to determine whether management is required.

PHOTOS:

Figure 1. RKN on pepper causing leaf chlorsis and stunting. Photograph by: Joe Noling.

Figure 2. RKN causing differnt levels of galling in tomato. Photograph by: Joe Noling.

Figure 3. Severe galling in tomato. Photograph by: Joe Noling.

Prepared by: Dr. Joe Noling

NEMATODE MANAGEMENT:
Root-Knot Nematode of Tomato and Pepper

CULTURAL CONTROLS:

- Clean fallow during the off-season is an important and effective control measure for root-knot nematode.
- Due to the wide host range of RKN, weeds and crop volunteers must be controlled during the fallow period and production season to minimize nematode reproduction and further population increase.
- Quickly destroy the infested pepper, tomato or double crop root system after harvest, thereby preventing further nematode population growth and exposing existing populations to killing actions of sun and wind.
- Avoid use of ditch or pond waters which might contain nematodes for irrigation or spray mixtures.
- Use nematode-free transplants.

CHEMICAL CONTROL:

- Root-knot nematode management must be viewed as a preplant consideration because once root infection occurs and plant damage becomes visible, it is not possible to resolve the problem completely so as to avoid potentially significant crop yield losses.

- As a preplant treatment, use a multi-purpose fumigant such as methyl bromide or Telone C35 to reduce RKN populations and soilborne disease pressure to avoid significant yield loss.

RESISTANCE MANAGEMENT:

- Although response to use of a post-plant nematicide is inconsistent, the sooner the nematode problem is recognized in the field and oxamyl applications started, the greater the improvement to tomato or pepper yields.

Figure 4. RKN interacting with Fusarium wilt in tomato. Photograph by: Joe Noling.

RESISTANT CULTIVARS:

- Use nematode-resistant cultivars containing the *Mi* gene in tomato when possible to limit nematode reproduction and to minimize tomato yield loss. RKN resistant cultivars are not commercially available for pepper.
- RKN-resistant cultivars may not confer resistance to other major soilborne diseases, may breakdown at high soil temperature, and should not be repeatedly planted without alternation with susceptible cultivars to minimize development of resistance breaking nematode populations.

CONTACT INFORMATION:

Dr. Joseph W. Noling
UF/IFAS CREC
700 Experiment Station Rd
Lake Alfred, FL 33850
jnoling@ufl.edu
863-956-1151 ext.1262

IPM Integrated Pest Management Florida

UF UNIVERSITY of FLORIDA IFAS Extension

References:

Duncan, L.W. and J.W. Noling. Agricultural sustainability and nematode IPM. *In* K.R. Barker, G.A. Pederson, and G.L. Windham (eds.) Plant-Nematode Interactions. Chapter 13. Agronomy Society of America. Monograph Series. Madison, WI, USA. 1998. Pp. 251-287.

Ferris, H., P.A. Roberts and I.J. Thomason. 1990. Nematodes, pp. 60-65. *In* Integrated Pest Management for Tomatoes. University of California, Statewide Integrated Pest Management Project, Division of Agriculture and Natural Resources. Publication 3274. 105 p.

Noling, J.W. Nematode-incited disease. *In* J.B. Jones American Phytopathological Society Compendium of Tomato Diseases. 2nd Edition. Minneapolis MN: APS Press.

Phytophthora capsici

SIGNS AND SYMPTOMS:

- On the stems or crown, a brown to dark purplish lesion quickly elongates, girdling and killing the plant or plants parts.
- On roots, brown discoloration and thinning of roots can be observed. Top lateral root growth may be more prevalent since lower roots are rotted and degraded.
- On leaves, circular to oval water-soaked lesions are observed and sporulating mycelia is common.
- On fruits, a small water-soaked lesion can quickly expand and white sporulating mycelia may be observed.

DISEASE CYCLE & EPIDEMIOLOGY:

- *P. capsici* can infect any part of the plant and quickly spread throughout.
- Pathogen is spread by splashing rains, surface water, wind, and wet soil which allows for the movement of motile zoospores to surrounding roots.
- Phytophthora blight and rot of pepper is favored by humid and warm conditions where the optimum temperature is around 82°F.
- *P. capsici* has a wide host range, which includes tomato, eggplant, watermelon, squash and cucumbers. Some common weeds have been found to potentially serve as alternative hosts.

FIELD SIGNATURE:

- Phytophthora blight and rot of pepper normally occurs first where soil is waterlogged or down the slope of a field where water tends to accumulate.
- First symptom of this disease is usually a rapid wilting of the pepper plant as a result of root and/or crown rot.
- Crown lesions are common, even before wilting may be fully observed.

PHOTOS:

Figure 1. Blighted leaf and crown of pepper plant caused by *Phytophthora capsici*. Photograph by: Pam Roberts.

Figure 2. Crown and stem lesion on pepper plant caused by *P. capsici*. Photograph by: Pam Roberts.

Figure 3. Plant loss in field caused by *P. capsici*. Photograph by: Pam Roberts.

Prepared by: Drs. Pam Roberts and Ronald French-Monar

DISEASE MANAGEMENT:
Phytophthora Blight of Pepper

CULTURAL CONTROLS:

- Field preparation should allow for irrigation practices which minimize water accumulation and allow for good soil drainage.
- Crop rotations should be conducted with non-hosts for *P. capsici*.
- Weeds should be adequately managed, especially common purslane, Carolina geranium and nightshades.

Figure 4. Pepper fruit with symptoms of Phytophtora blight. Photograph by: UF/IFAS.

CONTACT INFORMATION:

Dr. Pamela D. Roberts
UF/IFAS SWFREC
2686 SR 29 N
Immokalee, FL 34142
pdr@ifas.ufl.edu
239-658-3400

Dr. Ronald D. French-Monar
UF/IFAS SWFREC
2686 SR 29 N
Immokalee, FL 34142
rdf@ifas.ufl.edu
239-658-3400

CHEMICAL CONTROL:

- Regular applications of copper fungicides should supplement the use of other chemicals labeled against *P. capsici*.

RESISTANCE MANAGEMENT:

- If chemicals used for the management of *P. capsici* are known to develop resistance by the pathogen population, these compounds should be rotated with other chemistries.

RESISTANT CULTIVARS:

- Some differences in resistance of pepper cultivars to Phytophthora blight have been noted in the literature.

References:

Erwin, D.C. and O.K. Ribeiro. 1996. Phytophthora Diseases Worldwide. APS Press. St. Paul, MN 562 pp.

French-Monar, R.D., J.B. Jones and P.D. Roberts. 2006. Characterization of *Phytophthora capsici* associated with roots of weeds on Florida vegetable farms. Plant Dis. 90:345-350.

Ristaino, J.B. 2003.Phytophthora blight ,pp. 17-19. *In* K. Pernezny, P.D. Roberts, J.F. Murphy and N. P. Goldberg (eds.), Compendium of Pepper Diseases. American Phytopathological Society Press. St. Paul, MN.

Ristaino, J.B. and S.A. Johnston. 1999. Ecologically based approaches to management of Phytophthora blight on bell pepper. Plant Dis. 83: 1080-1088.

Roberts, P.D., R.R. Urs, R.D. French-Monar, M.S. Hoffine, T.E. Seijo and R.J. McGovern. 2005. Survival and recovery of *Phytophthora capsici* and oomycetes in tailwater and soil from vegetable fields in Florida. Ann. Appl. Biol. 146:351-359.

Pythium spp.

SIGNS & SYMPTOMS:

- On seeds, infected seeds may not germinate and seeds may turn brown and decompose.
- The stems of young seedlings are constricted near the soil line, develop a soft, dark lesion, and frequently topple over.
- On roots, brown discoloration and thinning of roots can be observed. Top lateral root growth may be more prevalent since lower roots are rotted and degraded.
- A less severe root infection of older plants may result in stunted growth only.
- Fruit rot caused by *Pythium* spp. usually starts as a small water-soaked lesion on mature green or ripe fruit in contact with or in proximity to the soil.
- *Pythium myriotylum* has been associated with dark, aerial lesions on tomato stems or leaves.

DISEASE CYCLE & EPIDEMIOLOGY:

- *Pythium* spp. are good soil saprophytes and can grow as vegetative mycelium in the soil indefinitely on various types of organic substrates.
- Tomato fruit growing in very wet soil conditions may be invaded by certain *Pythium* spp. when the fruit touch the soil or soil is splashed onto the fruit surface.
- Sporangia and zoospores are produced when conditions are optimal, particularly in regards to free moisture.

FIELD SIGNATURE:

- White, cottony mycelial growth may be visible on plant parts under humid and moist conditions.
- Some plants will show stunted growth but no other symptoms.
- Infected tissue, particularly roots and stems, is usually dark brown, soft and rotted.

PHOTOS:

Figure 1. Seedling damping off caused by *Pythium* sp. on pepper in a pepper. Photograph by: Shubin Saha.

Figure 2. Root rot and stem rot of infected seedlings. Photograph by: Richard Cullin.

Figure 3. Stem rot of tomato. Photograph by: Pam Roberts.

Prepared by: Drs. Pam Roberts and Ronald French-Monar

DISEASE MANAGEMENT:
Pythium Damping-off, Root Rot and Stem Rot

CULTURAL CONTROLS:

- Use disease-free transplants.
- In transplant production, sterilize soil and production equipment, such as flats and benches.
- Avoid excessive water and maintain good soil drainage.
- Plant when temperatures are favorable for rapid plant growth to avoid plants 'sitting' in the field.
- Use plastic mulch to prevent splashing of soil onto fruit.

Figure 4. Topple from stem rot in tomato. Photograph by: Pamela Roberts.

CHEMICAL CONTROL:

- Use a pre-plant soil fumigant.
- Apply a fungicide drench at transplanting.
- Several fungi and bacteria in addition to *Pythium* spp. cause damping-off symptoms on seeds and seedlings; therefore, proper identification of the causal agent is necessary prior to fungicide selection.
- Fungicides containing mefenoxam, fludioxonil and copper compounds are labeled for this disease. Some of these are labeled for use as a soil drench at time of transplanting.

RESISTANT MANAGEMENT:

- If chemicals used for the management of *Pythium* spp. are known to develop resistance by the pathogen population, these compounds should be rotated with other chemistries.

CONTACT INFORMATION:

Dr. Pamela D. Roberts
UF/IFAS SWFREC
2686 SR 29 N
Immokalee, FL 34142
pdr@ifas.ufl.edu
239-658-3400

Dr. Ronald D. French-Monar
UF/IFAS SWFREC
2686 SR 29 N
Immokalee, FL 34142
rdf@ifas.ufl.edu
239-658-3400

References:

McCarter, S.M. 1991. *Pythium* Diseases. *In* J.B. Jones, J.P. Jones, R.E. Stall and T.A. Zitter (eds). Compendium of Tomato Diseases. APS Press. St. Paul, MN. 73 pp.

MacNab, A. A. and A.F. Sherf. 1986. Vegetable Diseases and Their Control, 2nd Ed. John Wiley & Sons, New York. 728 pp.

Roberts, P.D. 2003. Damping-off and root rot. *In* K. Pernezny, P.D. Roberts, J.F. Murphy and N.P. Goldberg (eds), Compendium of Pepper Diseases. APS Press. St. Paul, MN.

Roberts, P.D., R.R. Urs, R.D. French-Monar, M.S. Hoffine, T.E. Seijo and R.J. McGovern. 2005. Survival and recovery of Phytophthora capsici and oomycetes in tailwater and soil from vegetable fields in Florida. Ann. Appl. Biol. 146:351-359.

Sclerotium rolfsii

SIGNS & SYMPTOMS

- Mature plants are attacked just below the soil surface and are completely girdled.
- The mycelium often grows over the diseased tissue and surrounding soil forming a white mat of mycelial threads with the typical tan-to-brown, mustard-seed-sized sclerotia.
- The tops wilt and die rapidly, often the entire root system is destroyed.
- Slightly sunken, yellow spots develop on invaded fruit, which rapidly decay, collapse, and become covered by a white fungal mass with numerous sclerotia.

DISEASE CYCLE & EPIDEMIOLOGY:

- The fungus can survive as sclerotia in soil for a long time, which may serve as the primary inoculum.
- Southern blight is favored by moist conditions and high temperatures (80-95°F).
- Southern blight is usually not a problem in plants growing in calcareous soils with high pH.

FIELD SIGNATURE:

- Entire plants are killed often in spots within the field or in a linear fashion following the row.

PHOTOS:

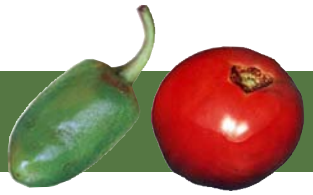
Figure 1. The mycelium growing over the diseased tissue on tomato. Photograph by: Hank Dankers.

Figure 2. Southern blight on tomato in the field. Photograph by: Hank Dankers.

Figure 3. Sclerotia on diseased tissue of pepper. Photograph by: Hank Dankers.

Prepared by: Dr. Tim Momol

DISEASE MANAGEMENT:
Southern Blight



CULTURAL CONTROLS:

- Whenever diseased fruit or plants are found in a field they should be collected and disposed of, preferably by burying 2 or 3 feet deep or by burning.
- Use a well-designed irrigation-drainage system to prevent excessive soil moisture.
- Plants should be staked to keep the fruit from touching the ground, and turn soil at least 6 inches deep when plowing.
- Crop rotation with non-susceptible grass crops, such as corn and small grains, for the best results use long rotations for several years.

Figure 4. Southern blight on pepper in the field. Photograph by: Hank Dankers.

CONTACT INFORMATION:

Drs. Tim Momol and Pingsheng Ji
UF/IFAS NFREC
155 Research Road
Quincy, FL 32351
tmomol@ufl.edu
850-875-7154

CHEMICAL CONTROL:

- Use of multipurpose soil fumigants such as metam-sodium or methyl bromide/chloropicrin provides control of southern blight.

RESISTANCE MANAGEMENT:

- Chemical control should be integrated with cultural and other methods to reduce selection pressure for resistance development.

RESISTANT CULTIVARS:

- There are few, if any, resistant cultivars commercially available.

References:

Momol, T. and K. Pernezny. 2005. 2006 Florida Plant Disease Management Guide: Tomato. PDMG-V3-53. University of Florida, IFAS, Cooperative Extension Service. http://edis.ifas.ufl.edu.

Roberts, P. D. 2003. Southern Blight, pp. 20-21. *In* K.L. Pernezny, P.D. Roberts, J.F. Murphy and N.P. Goldberg (eds.), Compendium of Pepper Diseases. American Phytopathological Society, St. Paul, MN.

Corynespora cassiicola

SIGNS & SYMPTOMS:

- On leaves, the disease first appears as small, necrotic lesions with light-brown centers and dark margins.
- Symptoms often begin deep within the tomato canopy.
- On fruit, lesions first appear as brown, slightly sunken flecks. As lesions develop, large, pitted areas appear on fruit.

DISEASE CYCLE & EPIDEMIOLOGY:

- Target spot is favored by moderate temperatures (70-80°F).
- Sandblasting of fruit predisposes tomato fruit to infection.
- *C. cassiicola* has a wide host range, which includes cucumber, papaya and a number of ornamentals. Several common weed species also serve as alternate hosts.

FIELD SIGNATURE:

- Always inspect the interior of the tomato canopy for the "melting out" effect often seen with target spot. This refers to the loss of foliage in the inside of the canopy which operates to thin out the interior foliage due to premature defoliation.
- Pitted fruit may appear to have been damaged by hail or other abiotic stress.

PHOTOS:

Figure. 1. Typical foliar symptoms of target spot. Photograph by: Ken Pernezny.

Figure 2. Severe pitting of tomato fruit due to target spot. Photograph by: Ken Pernezny.

Figure 3. Small pits in green fruit associated with target spot. Photograph by: Ken Pernezny.

Prepared by: Dr. Ken Pernezny

DISEASE MANAGEMENT:
Target Spot of Tomato

CULTURAL CONTROLS:

- Destroy crop residues promptly.
- Avoid overfertilization, especially with nitrogen, as this leads to a lush growth habit, with more likelihood of significant "melting out".
- Be certain that fields are scouted thoroughly and that target spot is not misdiagnosed as bacterial spot, early blight, or other foliar diseases.

Figure 4. Severe foliar damage due to target spot epidemic. Photograph by: Ken Pernezny.

CONTACT INFORMATION:

Dr. Ken Pernezny
UF/IFAS EREC
3200 E. Palm Beach Road
Belle Glade, FL 33430
klp@ifas.ufl.edu
561-993-1599

CHEMICAL CONTROL:

- Chlorothalonil and mancozeb (maneb) provide fairly good control of target spot when applied on a preventative basis.
- New chemistries, including the strobilurins and related compounds (e.g., azoxystrobin and famoxadone + cymoxanil), have given excellent control of target spot in University research trials.

RESISTANCE MANAGEMENT:

- Strobilurins and related compounds are prone to the development of resistance and should be rotated with other chemistries.

RESISTANT CULTIVARS:

- No known resistance to target spot is currently available in commercial cultivars.
- Current University of Florida research is aimed at identifying sources of resistance to this disease.

References:

Pernezny, K. and G.W. Simone. Target spot of several vegetable crops. PP-39. http://plantpath.ifas.ufl.edu.

Pernezny, K., P. Stoffella, J. Collins, A. Carroll and A. Beany. 2003. Control of target spot of tomato with fungicides, systemic acquired resistance activators, and a biocontrol agent. Plant Protect. Sci. 38: 81-88.

Pernezny, K., P. Stoffella, N. Havranek, J. Sanchez and A. Beany. 2005. BAM! Kicking control of target spot up a notch. Acta. Hortic. 695: 175-180.

IPM Integrated Pest Management Florida
UF UNIVERSITY of FLORIDA IFAS Extension

Tomato spotted wilt virus (TSWV)

SIGNS & SYMPTOMS:

- Small, light brown flecks first appear on leaves.
- These spots later turn brown, followed by a general browning of leaves that die and appear drooped on stems.
- Plant are often stunted, and with the droopy leaves, give one the impression that they are wilted.
- Green fruit show concentric rings of yellow or brown alternating with the background green color, and striking brown rings occur on red-ripe fruit.

DISEASE CYCLE & EPIDEMIOLOGY:

- The virus is transmitted from plant to plant by different species of thrips.
- Thrips can only transmit the virus if it is acquired during their larval stages, although both larval and adult thrips are able to transmit the virus.
- The virus has very wide host range, including tomato, pepper, potato, tobacco, lettuce and many other plants.

FIELD SIGNATURE:

- It occurs randomly. Although sometimes, plants in a row will get infected.

PHOTOS:

Figure 1. Leaf symptoms caused by TSWV on tomato. Photograph by: Hank Dankers.

Figure 2. Fruit symptoms caused by TSWV on tomato. Photograph by: Hank Dankers.

Figure 3. Leaf symptoms caused by TSWV on pepper. Photograph by: Hank Dankers.

Prepared by: Dr. Tim Momol

DISEASE MANAGEMENT:
Tomato Spotted Wilt

CULTURAL CONTROLS:

- Use highly reflective UV mulch (metalized mulch) on tomato.
- Conduct effective weed control in and around tomato or pepper fields.
- Do not plant tomatoes and peppers near TSWV susceptible crops (i.e. peanut, tobacco).

CHEMICAL CONTROL:

- Apply insecticides specific to vector thrips. Do not use broad-spectrum insecticides that kill natural enemies of thrips like minute pirate bug on peppers.
- Acibenzolar-*S*-methyl was shown to reduce incidence of TSW when used with other management tools (i.e. UV metalized mulch).
- Acibenzolar-*S*-methyl (Actigard) should not be used on pepper due to potential adverse effects.

RESISTANCE MANAGEMENT:

- Chemical control should be integrated with cultural and other methods to reduce selection pressure for resistance development.

Figure 4. Fruit symptoms caused by TSWV on pepper. Photograph by: Hank Dankers.

RESISTANT CULTIVARS:

TOMATO:

Some resistant cultivars are commercially available, such as Amelia, Bella Rosa, BHN 555, BHN 602, BHN 640, Crista, Quincy and Talladega. However, resistance-breaking isolates of TSWV overcoming resistance on tomato have been identified. **See pgs. 10-11 for resistant tomato cultivars.**

PEPPER:

There are a few resistant pepper cultivars commercially available, such as Heritage VR and Stiletto. However, resistance-breaking isolates of TSWV overcoming resistance on pepper have been identified. **See pg. 13 for resistant pepper cultivars.**

CONTACT INFORMATION:

Drs. Tim Momol and Pingsheng Ji
UF/IFAS NFREC
155 Research Road
Quincy, FL 32351
tmomol@ufl.edu
850-875-7154

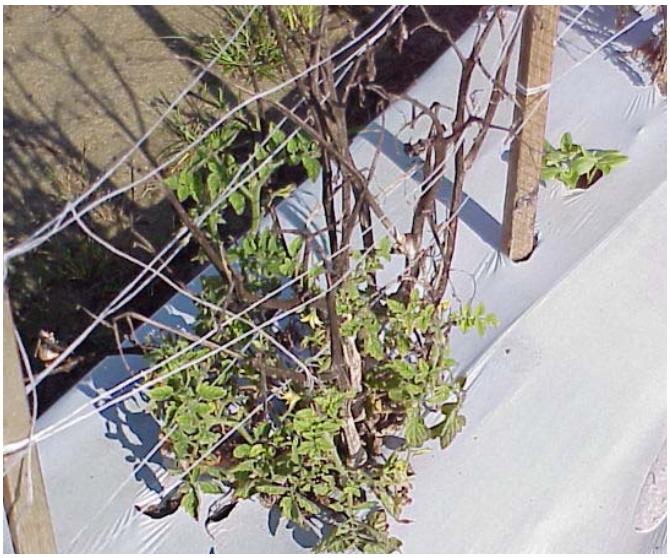
References:

Funderburk, J., S. Olson, J. Stavisky and Y. Avila. 2004. Managing thrips and tomato spotted wilt in pepper. ENY-658. University of Florida, IFAS, Cooperative Extension Service, http://edis.ifas.ufl.edu/IN401.

Momol, M.T., S.M Olson and J.E. Funderburk. 2005. Recommended management strategies for tomato spotted wilt on tomato caused by *Tomato spotted wilt virus* (TSWV). NFREC Extension Report No. 2005-9. http://nfrec.ifas.ufl.edu/tomato3.htm.

Momol, M.T., S.M. Olson, J.E. Funderburk, J. Stavisky and J.J. Marois. 2004. Integrated management of tomato spotted wilt on field-grown tomatoes. Plant Dis. 88: 882-890.

Roberts, P.D. and K.L. Pernezny. 2003. Varieties of vegetables with resistance to disease. PPP-63. University of Florida, IFAS, Cooperative Extension Service. http://edis.ifas.ufl.edu/VH100.



Tomato yellow leaf curl virus (TYLCV)

SIGNS & SYMPTOMS:

- In tomato, symptoms are more severe when infected at an earier age and vary somewhat among the different cultivars.
- In tomato, upward curling of leaves; mottling and often chlorotic leaf margins.
- In tomato, leaves are reduced in size.
- In tomato, plants are stunted.
- Flower abscission in tomato resulting in greatly reduced fruit set.
- No symptoms are observed in pepper.

DISEASE CYCLE & EPIDEMIOLOGY:

- Virus is acquired by immature and adult whiteflies (*Bemisia tabaci* species complex) and transmitted by adult whiteflies.
- Whiteflies are efficient vectors and one whitefly can inoculate more than one plant.
- TYLCV has alternate crop hosts – beans, pepper, tobacco, lisianthus, petunia and tomato.
- Crop and weed hosts are potential virus reservoirs; old or abandoned fields of known hosts are the most effective reservoirs of TYLCV.

FIELD SIGNATURE:

- Symptomatic tomato plants may be distributed randomly in a field or may be more frequent on the upwind side of a field or may be found in clusters.
- Symptoms in tomato are very obvious, but are not unique to TYLCV; other begomoviruses can cause the same symptoms.
- Infected pepper plants will show no symptoms of virus infection but may show some chlorotic veins due to feeding of whiteflies.

PHOTOS:

Figure 1. Symptoms that are typical for this disease are: yellow leaf edges, leaf cupping, reduced leaf size and flower or fruit drop. Photograph by: Tim Momol.

Figure 2. The impact of TYLC on tomato production can be severe. If plants are infected at an early stage, they won't bear fruit and their growth will be severely stunted. Photograph by: Phyllis Gilreath.

Figure 3. *Tomato yellow leaf curl virus* (TYLCV) infected re-growth from tomatoes in a double-cropped field seeded to cucumber. Infected tomato re-growth can serve as a reservoir for virus which can then be carried to neighboring new fields. Photograph by: Phyllis Gilreath.

Prepared by: Dr. Jane Polston

DISEASE MANAGEMENT:
Tomato Yellow Leaf Curl

CULTURAL CONTROLS:

- Use reflective mulches.
- Use resistant cultivars in tomato when whitefly populations are expected to be high.
- Use virus-free transplants.
- Do not plant new tomato fields next to old fields of tomato, pepper or tobacco.
- Do not plant new tomato fields downwind of old fields of tomato, pepper or tobacco.
- Use TYLCV-immune cultivars of pepper when planting near tomato fields.
- Manage weeds in tomato fields.
- Clean up old fields as soon as possible after harvest.
- Establish and maintain a tomato-free period in tomato production regions.

Figure 4. A tomato plant infected with *Tomato yellow leaf curl virus*, left, stands next to a disease-resistant plant developed by UF/IFAS. Once infected with the disease, tomato plants no longer grow normally, and no longer produce marketable fruit. Photograph by: Ernest Hiebert.

CONTACT INFORMATION:

Dr. Jane E. Polston
UF/IFAS Plant Pathology Dept.
1453 Fifield, PO Box 110680
Gainesville, FL 32611-0680
jep@ufl.edu
352-392-3631 x341

IPM Florida Integrated Pest Management — UF UNIVERSITY of FLORIDA IFAS Extension

CHEMICAL CONTROL:

- Use a nicotinoid in the transplant house one week before transplanting to the field.
- Use a nicotinoid in the setting water at a rate that will give 8 weeks of efficacy.
- Once whiteflies begin to reproduce in field, continue a rotation of non-nicotinoid insecticides such as insect growth regulators, contact insecticides, anti-feedants such as pymetrozine, oils and soaps and other IPM management strategies through final harvest.
- Use growth regulators at the end of season to reduce whitefly populations.

RESISTANCE MANAGEMENT:

Since whiteflies have been shown capable of developing resistance to nicotinoid insecticides, and nicotioids have been shown to be highly effective in reducing incidences of TYLCV-infected plants, growers are encouraged to follow the guidelines for management of resistance to neonicotinoids recommended by the Insecticide Resistance Action Committee (IRAC) **(Appendix 5)**.

RESISTANT CULTIVARS:

TOMATO: Tygress (Seminis), HA-3068, HA-3073, HA-3074, HA-3371, TY02-1155, TY02-1184, TY02-1276, TY02-1298, TY02-1314 (Hazera).

PEPPER:
Aladdin X3R (Seminis), Aristotle X3R (Seminis), Double Up (Sakata), El Jefe (Sakata), Heritage HMX 1640 (Ferry Morse), Hungarian Hot Wax (Desert Seeds), Mulato Isleno (Ball Seeds), Patriot HMX 640 (Harris Moran), Red Rooster, Sweet Banana (Ferry Morse), Tiburon (Sakata).

References:

Polston, J.E. 2003. *Tomato yellow leaf curl virus*-Revisted, pp. 9-11. *In* Proc.of the Florida Tomato Institute PRO520. September, 2003, Naples, FL.

Polston, J.E. 2002. *Tomato yellow leaf curl virus*: Breaking the cycle, pp. 29-33. *In* Proc. of the Florida Tomato Institute, PRO519. September, 2002, Naples, FL.

Polston, J.E. and T.A. Sherwood. 2003. Pymetrozine interferes with transmission of *Tomato yellow leaf curl virus* by the whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae). Phytoparasitica 31:490-498.

Verticillium albo-atrum
Verticillium dahliae

SIGNS & SYMPTOMS:

- Verticillium wilt can easily be confused with Fusarium wilt and other wilt diseases of tomato and pepper.
- Infected plants usually show mild to moderate wilt during the warmest part of the day, but recover at night.
- Lower leaflets or leaves may show characteristic V-shaped lesions, with yellowing in a fan pattern that narrows down from the leaf margins.
- Vascular discoloration is evident in lower stems when they are cut open longitudinally.
- This discoloration is said to be a lighter shade of brown than Fusarium wilt diseases, but in our experience, this is not a reliable characteristic for diagnosis.

DISEASE CYCLE & EPIDEMIOLOGY:

- Verticillium wilt is a cool weather disease. It occurs in southern Florida during the winter months when daytime temperatures are 68-75°F.
- *Verticillium* can survive in soil for up to 8 years as microsclerotia (hard, resting structures).

FIELD SIGNATURE:

- Look for wilted plants that recover at night.

PHOTOS:

Figure 1. Symptoms of wilting of tomato plant due to Verticillium infection. Courtesy of: FDACS.

Figure 2. V-shaped lesions characteristic of Verticillium wilt of tomato. Courtesy of: FDACS.

Figure 3. Vascular browning associated with Verticillium wilt of tomato. Courtesy of: University of California Statewide IPM Program.

Prepared by: Dr. Ken Pernezny

CULTURAL CONTROLS:

- Crop rotation may be helpful but limited because of the wide host range of these two species.

CHEMICAL CONTROL:

- Fumigation with broad-spectrum chemicals (mostly methyl bromide/chloropicrin) has been the major means of controlling Verticillium wilt.

RESISTANT CULTIVARS:

- Resistant cultivars are available for race 1 of *V. albo-atrum*, but "new" races have been identified. **See pgs. 10-12 for resistant tomato cultivars.**

Figure 4. Symptoms of wilting of tomato plant due to Verticillium infection. Photograph by: UF/IFAS.

Figure 5. Chlorosis of tomato seedling infected with *Verticillium albo-atrum*. Photograph by: FDACS/DPI.

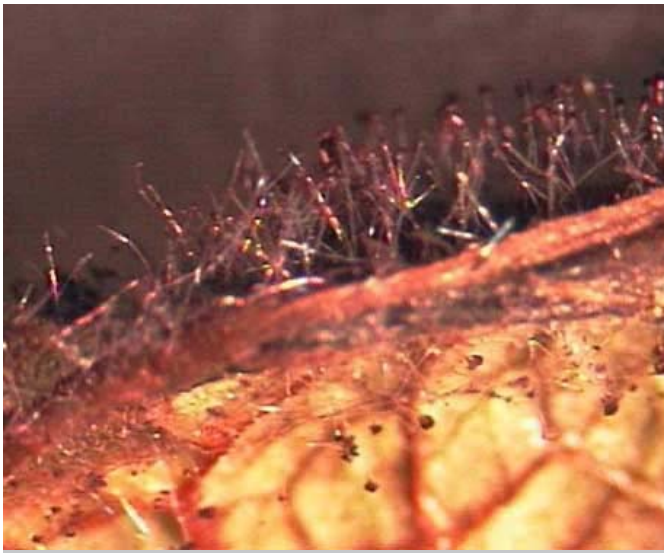
CONTACT INFORMATION:

Dr. Ken Pernezny
UF/IFAS EREC
3200 E. Palm Beach Road
Belle Glade, FL 33430
klp@ifas.ufl.edu
561-993-1599

References:

Pohronezny, K. 1991. Verticillium wilt, pp. 12-24. *In* J. B. Jones, J.P. Jones, R. E. Stall and T. A. Zitter (eds.), Compendium of Tomato Diseases. APS Press, St. Paul, MN.

Sanogo, S. 2003. Chile pepper and the threat of wilt diseases. Online. Plant Health Progress doi:10.1094/PHP-2003-0430-01-RV.



Choanephora cucurbitarum

SIGNS & SYMPTOMS:

- Water soaked lesions appear on the leaves and the margins and leaf tips are blighted.
- Older lesions turn necrotic and appear dried out.
- The entire plant may wilt.
- Flowers and flower buds turn dark and wilt.
- Young fruit can be infected.

DISEASE CYCLE & EPIDEMIOLOGY:

- This disease is not common on pepper plants in Florida.
- The fungus has a wide host range such as yellow squash and some common weeds.
- Outbreaks of this disease occur during extended rainy periods and high temperatures.

FIELD SIGNATURE:

- 'Whiskers' of the fungus, which are fungal strands, with dark-colored, knobby sporangiola, can be seen with a hand lens.
- Morning is the best time to look for the fungus.
- Symptoms may be confused with Phytophthora blight (*Phytophthora capsici*).

PHOTOS:

Figure 1. Silvery whiskers grow out of infected areas, topped with black spore masses. Courtesy of: AVRDC.

Figure 2. Most of the time, it seems to start in senescing flower petals. Once established, entire flowers are overgrown, resulting in a brown to black mass of soft tissue. Flower stalks, buds, and leaves may subsequently be invaded. Photograph by: UF/IFAS.

Figure 3. Close-up of sporulating fungus on leaf surface. Photograph by: UF/IFAS.

Prepared by: Dr. Pam Roberts

DISEASE MANAGEMENT:
Wet Rot, *Choanephora* blight

CULTURAL CONTROLS:

- Any method which increases air movement in the crop canopy to reduce the humidity may aid in management. Examples include:
  - Increase plant spacing
  - Adequate drainage
  - Avoid overhead irrigation
  - Avoid excess nutrition which creates a dense canopy

CHEMICAL CONTROL:

- There are no fungicides labeled for this disease. Sprays for other fungal diseases may reduce disease damage.

RESISTANT CULTIVARS:

- There are no resistant cultivars for tomatoes or peppers.

Figure 4. Symptoms of Choanephora blight on pepper showing tip die-back. Courtesy of: UF/IFAS.

CONTACT INFORMATION:

Dr. Pamela D. Roberts
UF/IFAS SWFREC
2686 SR 29 N
Immokalee, FL 34142
pdr@ifas.ufl.edu
239-658-3400

Dr. Ken Pernezny
UF/IFAS EREC
3200 E. Palm Beach Road
Belle Glade, FL 33430
klp@ifas.ufl.edu
561-993-1599

Dr. Tom Kucharek
UF/IFAS Plant Pathology Dept.
1453 Fifield Hall
Gainesville, FL 32611
tak@ifas.ufl.edu
352-392-3631

References:

Kucharek, T.A., G.L. Benny and K. Pernezny. 2003. Choanephora Blight (Wet Rot), pp. 11-12. *In* K. Pernezny, P.D. Roberts, J.F. Murphy and N.P. Goldberg (eds.), Compendium of pepper diseases. American Phytopathological Society Press, St. Paul, MN.

Sclerotinia sclerotiorum

SIGNS & SYMPTOMS:

- Sclerotia can form on plant surfaces, but are particularly abundant inside infected stems.
- Fruit exhibit a watery soft rot.
- Water-soaked lesions appear on stems. Stems turn to a bleached gray-white, causing them to appear like animal bones left in the sun **(Figure 2)**.
- All or portions of plants with infected stems develop a general wilting symptom.
- The best indicators of white mold are signs of the pathogen, consisting of white fungal growth (mycelium) and sclerotia **(Figures 1-3)**.
- Sclerotia are small, hard resistant structures that look like bits of black coal **(Figure 3)**.

DISEASE CYCLE & EPIDEMIOLOGY:

- White mold is a cool, moist weather disease; ideal temperatures for white mold are 60-70°F.
- High humidity, rainfall, and heavy due periods favor disease development.
- Small, mushroom-like structures develop from sclerotia **(Figure 4)**. These produce spores in abundance which are carried on air currents to tomato and pepper plants.

FIELD SIGNATURE:

- Be on the lookout for white mold when daytime highs are consistently in the 70's or lower.
- Blooming periods are critical times for *Sclerotinia* infection, because the pathogen invades dying flower petals caught in crooks of stems.
- The presence of mycelium and, especially, black sclerotia confirm white mold **(Figures 2 & 3)**.

PHOTOS:

Figure 1. Poor stand in pepper field with white mold. Photograph by: Ken Pernezny.

Figure 2. White mold growth evident on damaged pepper stem. Photograph by: Ken Pernezny.

Figure 3. Sclerotia inside infected tomato stem. Photograph by: Ken Pernezny.

Prepared by: Dr. Ken Pernezny

DISEASE MANAGEMENT:
White Mold of Tomato & Pepper

CULTURAL CONTROLS:

- Every effort must be taken to avoid overly dense plant canopies, as poor air circulation aggravates white mold.
- Rotation with crops other than tomato, pepper, potato, and snap bean may help reduce levels of initial inoculum.

CHEMICAL CONTROL:

- Very specific fungicides are needed to control white mold.
- Several special exemptions for fungicides (e.g., thiophanate-methyl) have been granted in the last few seasons for white mold control. Check with your cooperative extension agent for current legal alternatives.

Figure 4. Apothecia of *Sclerotinia sclerotiorum* germinating from a sclerotium, these can be found in the field while scouting. They are about the size of a grain of rice. Photograph by: Pete Adams.

RESISTANT CULTIVARS:

No known resistance to white mold is currently available for either tomato or pepper.

CONTACT INFORMATION:

Dr. Ken Pernezny
UF/IFAS EREC
3200 E. Palm Beach Road
Belle Glade, FL 33430
klp@ifas.ufl.edu
561-993-1599

References:

Pernezny, K., M.T. Momol and C.A. Lopes. 2003. White mold, pp. 22-23. *In* K. Pernezny, P.D. Roberts, J.F. Murphy, and N.P. Goldberg (eds.), Compendium of Pepper Diseases. APS Press, St. Paul, MN.

Yanar, Y., F. Sahin and S.A. Miller. 1996. First report of stem and fruit rot of pepper caused by *Sclerotinia sclerotiorum* in Ohio. Plant Dis. 80: 342.

Pernezny, K. and L.H. Purdy. 2000. Sclerotinia diseases of vegetable and field crops in Florida. Univ. Fla. Ext. Plant Path. Fact sheet No PP-22.

DISORDERS OF PEPPER: Blossom End Rot (BER)

SYMPTOMS:

- Sunken, collapsed tissue near the blossom end of the pepper fruit.
- Often forms on or between lobes and can occur on sidewalls.
- Quickly invaded by bacteria and fungi that can lead to further decay.

CAUSES:

- Lack of calcium in the soil has an important role in causing BER.
- BER is most often associated with inadequate soil moisture content.

PREVENTION:

- Maintain adequate irrigation, especially during periods of hot, dry, and windy weather.
- Test soil for calcium levels before planting and if needed add lime or dolomite prior to preparing plant beds.
- Applying calcium products to the foliage probably won't help.

PHOTOS:

Figure 1. Isolated areas of collapsed tissue beginning to coalesce into larger and more obvious symptoms of BER. Photograph by: Kent Cushman.

Figure 2. Mild and severe symptoms of BER on blossom end of two peppers. Discolored tissue around injury due to accelerated ripening in response to injury. Photograph by: Kent Cushman.

Figure 3. Later stage of BER on immature green pepper. Collapsed tissue of BER injury has dried. Photograph by: Kent Cushman.

Figure 4. Later stage of BER on yellow-mature pepper. Collapsed tissue of BER injury has dried. Photograph by: Kent Cushman.

Prepared by: Dr. Kent Cushman

DISORDERS OF PEPPER:
Sunscald

SYMPTOMS:

- Discolored or bleached areas on fruit in areas directly exposed to the sun.
- Sunken, collapsed tissue.

CAUSES:

- Direct sunlight on the fruit.
- Inadequate foliage growth to cover and protect fruit.

PREVENTION:

- Provide adequate irrigation and fertilization to produce a strong plant with adequate foliage.
- Grow two rows of peppers about 12 inches apart. Rows will grow together and protect fruits.

PHOTOS:

Figure 1. Discolored pepper tissue indicating stress from too much sun. Also some tissue already damaged and dried out. Photograph by: Kent Cushman.

Figure 2. Discolored and soft tissue of exposed fruit. Photograph by: Kent Cushman.

Figure 3. Severe sunscald showing bleached and soft tissue that hasn't yet begun to dry out. Photograph by: Kent Cushman.

Figure 4. Discolored and bleached tissue of exposed fruit. Collapsed tissue of sunscald injury has begun to dry and heal over. Photograph by: Kent Cushman.

Prepared by: Dr. Kent Cushman

DISORDERS OF PEPPER: Misshapen Fruit

SYMPTOMS:

- Misshapen fruit.

CAUSES:

- Physical barriers encountered by pepper fruit during expansion.
- Irregular, uneven growth during expansion.

PREVENTION:

- None. A low percentage of fruit will always become wedged between stems, stakes, and/or twine.

PHOTO:

Figure 1. Misshapen fruit that formed within a pepper plant canopy and became wedged between two branches. As the fruit expanded, it became increasingly deformed. This fruit also has an abnormal growth protruding from where the stem attached to the fruit. This was not caused by the deformation, but this occurs in a low percentage of fruit and is a normal physiological defect. Small physiological errors in how the fruit expands can lead to large changes in fruit shape and oddly shaped peppers. Photograph by: Kent Cushman.

CONTACT INFORMATION:

Dr. Kent Cushman
Vegetable Specialist
UF/IFAS SWFREC
2686 SR 29 N
Immokalee FL 34142-9515
kcushman@ufl.edu
239-658-3429

IPM Integrated Pest Management Florida

UF UNIVERSITY of FLORIDA IFAS Extension

Notes:

Notes:

DISORDERS OF TOMATO: Blossom End Rot (BER)

SYMPTOMS:

- Light tan, water-soaked areas which can then enlarge and turn black and leathery in appearance **(Figure 1)**.
- Usually occurs at the blossom end of the fruit.
- Occasionally occurs on the side of the fruit or internally with no visible symptoms on outside of fruit **(Figures 2 & 3)**.

CAUSES:

- Blossom-end rot (BER) is caused by a localized Ca deficiency in the developing fruit.
- The following conditions may increase BER: low soil Ca, high N rates, using ammoniacal sources of N, high concentrations of soluble K and Mg in the soil, high salinity, low humidity, inadequate soil moisture, damage to root system by nematodes, disease, mechanical means or heavy pruning.
- In greenhouse production not cycling the irrigation system at night can increase BER, since night is an important time of Ca uptake.

PREVENTION:

- Proper fertilization and good water management.
- In Florida, adequate soil Ca is considered to be 300 ppm or higher by Mehlich-1 index. Foliar applications of Ca materials have not proven to reduce BER since very little Ca is taken up by the fruit and that taken up by the leaves can not be translocated to the fruit.

The following conditions may increase BER:

- Low soil Ca
- High N rates
- Ammoniacal sources of N
- High concentrations of soluble K and Mg in the soil
- High salinity
- Low humidity
- Inadequate soil moisture
- Damage to root system by nematodes, disease, mechanical means or heavy pruning

PHOTOS:

Figure 1. Fruit showing symptoms of BER, top left fruit showing mild BER, others showing severe BER. Photograph by: Steve Olson.

Figure 2. Several fruit showing sidewall BER. Photograph by: Steve Olson.

Figure 3. Cross-section of fruit showing internal BER. Photograph by: Steve Olson.

Prepared by: Dr. Steve Olson

DISORDERS OF TOMATO:
Catfacing

SYMPTOMS:

- Catfacing is a generic term used to describe a tomato fruit that has a gross deformity and is usually not marketable.
- The defect is usually located on the blossom end of the fruit **(Figure 1)**.

CAUSES:

The deformity is caused by something (internal or external) that occurs during the formation of the flower that results in the fruit not developing normally. There is little published information as to the exact cause and there actually may be more than a single cause. Increases in catfacing occur when:

- Cool or cold temperatures about 3 weeks before bloom.
- Heavy pruning in indeterminate varieties.
- Drifts of herbicides such as 2,4-D **(Figure 2)**.
- Heavy thrips feeding on young fruit.
- Plants that are mildly affected by Tomato little leaf have severely catfaced fruit **(Figure 3)**.

PREVENTION:

- Select varieties that historically have had little problem for catfacing.
- Prevent spray drift from undesirable chemicals.
- Prevent soils from becoming waterlogged **(see Tomato Little Leaf, pp. 109-110).**

PHOTOS:

Figure 1. Fruit showing catfacing on blossom end. Photograph by: Steve Olson.

Figure 2. Fruit damage due to exposure to 2,4-D. Photograph by: Steve Olson.

Figure 3. Distorted fruit due to Tomato little leaf. Photograph by: Steve Olson.

Prepared by: Dr. Steve Olson

Cracking

SYMPTOMS:

- Two different forms of cracking occur in tomato fruit. Radial cracking originates from the stem end and progresses toward the blossom end. Concentric cracking occurs in a ring or rings around the stem scar. It is possible to have both types on the same fruit.
- Cracking is more of a problem in a vine-ripe operation versus a mature green operation.

CAUSES:

- Cracking occurs when the internal expansion is faster than the expansion of the epidermis and the epidermis splits.
- Can occur at all stages of fruit growth but as fruit matures they become more susceptible, especially as color develops.
- Wide fluctuation in air temperature can also increase cracking.

PREVENTION:

- Select tolerant varieties.
- Reduce fluctuations in soil moisture.
- Maintain a good foliage cover, since exposed fruit are more susceptible.

Photograph by: Steve Olson.

Graywall (blotchy ripening)

SYMPTOMS:

- Internally graywall is characterized by dark necrotic areas usually in the vascular tissue of the outer walls.
- Necrosis is sometimes present in the cross-walls and very infrequently in the center pith area of the fruit.
- Outward symptoms show up as grayish in appearance caused by partial collapse of the wall tissue hence the term graywall.
- It typically develops on green fruit prior to harvest but can show up later. Fruit affected are typically not marketable due to a blotchy appearance as fruit ripens.

CAUSES:

- Cause is not completely understood.
- Graywall is more of a problem during cool and short days.
- High N may increase problem and adequate K may reduce the problem.

PREVENTION:

- There are variety differences in susceptibility.

Photograph by: Steve Olson.

Internal White Tissue

SYMPTOMS:

- Fruit affected by this disorder usually show no outward symptoms.
- When ripe fruit are cut, white hard areas especially in the vascular region are present in the outer walls. Under severe conditions, fruit may also show white tissue in cross-walls and center of fruit.
- Problem may be so severe that fruit are unmarketable.

CAUSES:

- The problem is more of a concern with vine-ripe or u-pick producers since fruit picked mature-green and gassed rarely show the problem.
- High temperatures during the ripening period in the field seem to trigger this disorder.

PREVENTION:

- Adequate K fertilization has shown to reduce but may not eliminate it.
- Some varieties are more resistant to the problem, especially the highly colored varieties.

Photograph by: Steve Olson.

Tomato Irregular Ripening (TIR)

SYMPTOMS:

- Green fruit show no symptoms but as fruit ripens, color fails to develop uniformly.
- Color often develops along locule walls with intermediate areas remaining green or yellow, producing a star-burst appearance.
- With sufficient time, nearly normal external color develops on most fruit but internal areas remain hard with little or no color development.
- Fruit affected are unmarketable.

CAUSES:

- Feeding of nymphs of the Silverleaf whitefly (*Bemisia argentifolii*) on the tomato foliage induces irregular ripening.
- Can occur with as few as four Silverleaf whitefly nymphs per terminal leaf.

PREVENTION:

- Use multiple approaches to manage *Bemisia tabaci* populations **(see Sweetpotato Whitefly, pg. 81)**.

Photograph by: Steve Olson.

Prepared by: Dr. Steve Olson

Pox and Fleck

In most cases when a fruit is affected, both disorders are found together but are considered separate problems.

SYMPTOMS:

- Pox is described as small cuticular disruptions found at random on the fruit surface. The number can vary from a few to many.
- Fleck, also know as Gold Fleck, shows up as small irregular shaped green spots at random on the surface of immature fruit which turn to a gold color as fruit ripens. Number of spots can vary from few to many.
- Fruit severely affected with pox and fleck are not marketable.

CAUSES:

- Both conditions seem to be genetic in nature, but are difficult to breed out of a variety since the symptoms only show up under certain environmental conditions. There seems to be some differences of opinion as to the conditions for the problem to show up. There are differences between varieties as to susceptibility to pox and fleck.

PREVENTION:

- Keep a record of field observations.

PHOTOS:

Fig. 1. Several fruit showing severe pox and fleck. Photograph by: Steve Olson.

Fig. 2. Closeup of pox and fleck. Photograph by: Steve Olson.

Puffiness

SYMPTOMS:

- When this problem is slight, it may be impossible to detect puffiness until fruit are cut.
- Severe puffy fruit will appear to be flat sided or angular in nature.
- When fruit are cut, open cavities open are observed between the seed gel area and the outer wall. Fruit also weigh little in relation to size.

CAUSES:

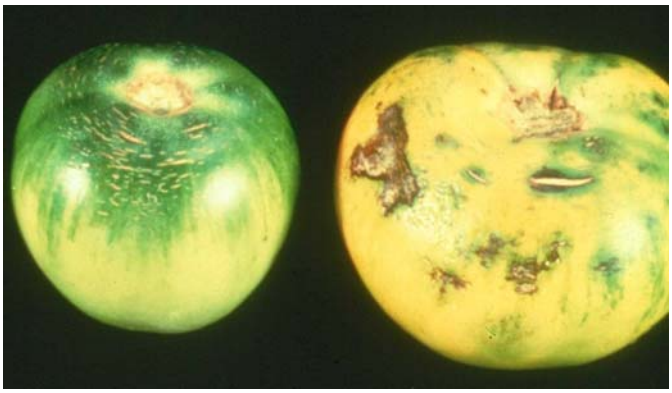
- Any factor that affects fruit set: inadequate pollination, fertilization or seed development
- Most common causes in Florida are too low or high of temperatures during fruit set.
- Other factors such as high N, low light or rainy conditions can also cause seed set problems.

PREVENTION:

- Use of "hot set" varieties can reduce the problem but even these have limitations when night temperatures get above about 75°F.

Photograph by: Steve Olson.

Rain Check



SYMPTOMS:

- Tiny cracks that develop on the shoulder of fruit; these cracks can vary from just a few to almost complete coverage of the shoulder.
- The cracks feel rough to the touch and affected areas can take on a leathery appearance and not develop proper color as fruit ripens.
- Green fruit are most susceptible, followed by breakers and ripe fruit are not affected at all.
- Damage occurs most often on exposed fruit after a rain.

CAUSES:

- Exact cause is not known, but appears to be related to exposure of the fruit to water.
- Problem is more severe when heavy rains occur after a long dry period.

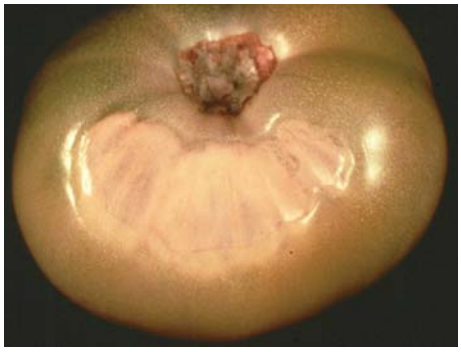
PREVENTION:

- There are differences among varieties to susceptibility to rain check.
- Also varieties with good leaf coverage usually have less rain check.

Photograph by: Steve Olson.

Sunscald

Sub lethal scalding



Lethal scalding

SYMPTOMS:

Two types:

Sub lethal— a yellow, hard area usually on the shoulder of the fruit

- Occurs when tissue temperatures rise above 86°F. The high tissue temperatures will not allow the red pigment to develop nor flesh to soften but allows the yellow pigments to develop.

Lethal— the tissue turns white and dies; many times the dead tissue will turn black from fungi that grows feeding on the dead tissue

- Occurs when tissue temperatures rise above 104°F.

CAUSES:

- Damage usually occurs when fruit are suddenly exposed to sunlight.
- This most frequently occurs after a harvest or a storm when leaves are moved around and fruit exposed.
- Over pruning can also increase sunscald problems especially with fruit in the upper part of the plant.

PREVENTION:

- Good spray programs to ensure good foliage cover can reduce problem.
- Growers at times may use a sun screen material such as Snow or Surround to help reduce sunscald.

Photographs by: Steve Olson.

Prepared by: Dr. Steve Olson

Western Flower Thrips Oviposition Damage

SYMPTOMS:

- This injury is characterized by a small dimple often with a white halo around the dimple.
- Caused by the female Western Flower Thrips (*Frankliniella occidintalis*) (WFT) inserting an egg into the fruit when the fruit is very small.
- Many times the bloom has not yet shed the corolla when the injury occurs.
- The number of dimples can vary from a few to very many. Numerous dimples can result in the fruit being reduced in grade.
- Damage is mostly on the surface and does not go very deep into the fruit.
- Dimple does persist throughout the life of the fruit but halo area may go away when fruit ripens.

PREVENTION:

- Control is through management of WFT.

Zebra Stripe

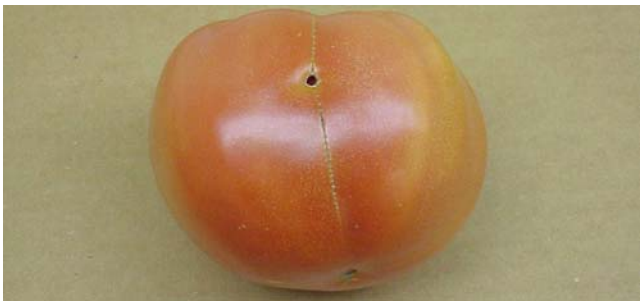
SYMPTOMS:

- Characterized as a series of dark green spots arranged in a line from the stem end to the bloom end.
- At times it seems the spots coalesce together and form elongated markings.
- Many times the dark green areas will disappear when fruit ripens.

CAUSES:

- This problem seems to be variety related.
- It is probably a genetic defect that only shows up under certain environmental conditions.
- Zebra stripe may be linked to pox and fleck.

Zippering



SYMPTOMS:

- Described as a fruit having thin scars that extend partially or fully from the stem scar area to the blossom end.
- The longitudinal scar has small transverse scars.
- At times there may be open holes in the locules in addition to the zipper scar.

CAUSES:

- Cause is usually an anther that is attached to the newly forming fruit causing the scar.
- Some people feel that a zipper is formed when the "bloom" sticks to the fruit and does not shed properly, but this may not be a cause.

PREVENTION:

- Only control is to select varieties that are not prone to zippering.

Photographs by: Steve Olson.

CONTACT INFORMATION:
Dr. Steve Olson
Vegetable Specialist
UF/IFAS NFREC- Quincy
155 Research Rd
Quincy, FL 32351-5684
smolson@ifas.ufl.edu
850-875-7188

DISEASE MANAGEMENT:
Postharvest Diseases of Tomato

Florida tomato production is often challenged by an array of plant diseases promoted by a warm and humid climate. The conditions that promote plant diseases also favor the development of fruit rots, both in the field and during handling and shipping.

Figure 1. Even a thin coating of water, such as on a wet fruit, leaf, field bin, or on packinghouse machinery, can support rapid movement and growth of bacteria causing disorders such as bacterial soft rot Phtotgraph by: UF/IFAS.

Figure 2. A carton of tomatoes with "nested" *Rhizopus* rot (and some secondary fungi). Photograph by: Michael Mahovic.

Fruit rots are generally caused by opportunistic pathogens, those that cannot directly infect fruit tissues unless the tissues are stressed. These pathogens are ubiquitous (found everywhere) in the natural environment. Mechanical injuries (e.g., bruises, cuts, punctures) that occur during harvest and handling are a predominant cause for decay because they provide infection courts (protected sites) for decay pathogens. Once it initiates a lesion, a decay pathogen often can engulf the rest of the fruit. During the process of invasion, infection, colonization and reproduction, the pathogen usually produces structures and materials that promote the infection and decay of adjacent and nearby fruit. Fruits and vegetables vary in their innate resistance to decay; those crops that have active wound-healing processes are more resistant. Tomatoes form a natural abscission zone at the stem scar and are more resistant to pathogen attack than other crops, such as broccoli, that don't form an abscission zone and must be cut from the plant.

Once harvested, fruits and vegetables have a limited postharvest life. They no longer receive water or nutrition from the plant. Naturally occurring senescence in produce leads to a softening of the tissues and often a loss of preformed antimicrobial substances. These changes in the fruit or vegetable quality also make it less desirable to consumers. This correlation between senescence, susceptibility to decay and loss of edible quality has a great impact on decay control methods. Therefore, handling methods that preserve the fresh-harvest quality of the product are also likely to minimize the development of decay.

FIELD SANITATION:

The implementation of good agricultural practices (GAPs) in the field and at harvest greatly aids in the prevention of most postharvest fruit rots. However, periods of persistent rainfall or chilling temperatures can increase decay losses despite the GAPs. In addition to disease control strategies, the GAPs should include control of chewing insects that create wounds in fruit. Plant management should promote air movement over plant surfaces, particularly those hidden beneath the outer leaf canopy of the plant. This air movement is necessary to dry dew or rainfall from plant surfaces. Tying and harvest operations should be postponed until free moisture has dried from the plant canopies, since wet plants are more prone to mechanical injury (creating wounds), and the free water promotes the spread, survival, and growth of decay pathogens. Drip, furrow, or seep irrigation is preferred to overhead irrigation because overhead irrigation moistens plant surfaces.

FOOD SAFETY CONSIDERATIONS:

Certain human pathogens, including bacteria belonging to species of *Salmonella*, *Shigella*, *Escherichia*, or *Listeria* and certain viruses, may survive on or in fresh tomato fruit. Under certain conditions, bacteria may actually multiply. Sources of the human pathogens include infected workers, domestic and wild animals, raw manure, contaminated equipment/containers/trucks, nearby pastures, or animal confinements as well as open surface water such as swamps or lakes. Dispersal to developing or harvested fruit occurs by direct contact or through contact with rain splash, aerosol drift, run-off water and overhead irrigation with surface water.

Since human pathogens do not visibly affect the fruit, their presence may be unknown at the time of packing and marketing. However, consumers can be infected and an outbreak can have a devastating effect on not only the implicated packinghouse, but also the entire industry. Fortunately, the same sanitation steps that control fruit-rotting pathogens normally control human pathogens.

Prepared by: Dr. Michael Mahovic

PACKINGHOUSE SANITATION:

The potential for development of fruit decay after harvest is least if the plants are dry and free of decay at the time of harvest. However, since harvested fruit will virtually always have some level of contamination by decay pathogens, steps must be taken to prevent fruit contamination when the tomatoes are transferred into the dump tank. Sufficient sanitation requires the inactivation of freshly introduced microbes within about 10 seconds of initial contact in the dump tank water. Suspended microbes that are not killed within 10 seconds may internalize in wounds or stem scars on tomatoes and thus be protected from antimicrobial treatments. "Vigilance" is the key word in preventing decay.

Figure 3. Infiltration of soft rot bacteria through the blossom end led to development of this decay during storage. Photograph by: Michael Mahovic.

Microbe infiltration: Dry surfaces may be penetrated by water suspensions through a process called infiltration. *Infiltration* occurs when the external pressure of the liquid contacting the fruit surface overcomes the natural hydrophobic resistance of the wax and/or presence of air bubbles in openings in the tomato surface. For example, infiltration occurs when warm tomatoes are submerged in cool water as briefly as 5 to 10 minutes. As the fruit cools, air inside its tissues contracts, creating a vacuum that allows the surrounding water (and suspended microbes) to enter openings such as the stem scar or catfaces at the blossom end. Infiltration can also occur when fruit are struck by a high-pressure stream of water such as when tomatoes are flumed from a gondola. We have noticed that some tomato cultivars are more likely to absorb water during postharvest handling than others and we are currently screening the most widely grown cultivars.

Several procedures can minimize infiltration into tomatoes:

- Heating dump-tank water 10°F (about 5°C) above the incoming tomato pulp temperature eliminates fruit cooling.
- Limiting tomato residence time in dump tanks and flumes to less than 2 minutes, and minimizing contact of tomatoes in gondolas with large streams of water will reduce the potential for infiltration.

RECIRCULATED WATER SANITATION:

Chlorine has been widely used in water sanitation for many years. Alternatives to water chlorination for tomato dump tanks have been proposed and several have been tested, however, none of the alternatives appear to be as efficient, inexpensive, easy to apply, and effective as chlorine. A major factor in the effectiveness of chlorine is how rapidly it kills microbes. In laboratory tests, soft rot bacteria were mixed in water that simulated packinghouse conditions. Tomatoes with wounds and stem scars were then immersed in the water. Decay later developed on tomatoes that were immersed for only 5 to 10 seconds. As a result of this rapid internalization, the bacteria were not affected by drying or other surface treatments; they were able to grow and initiate soft rots. But when chlorine was present in the water before soft rot bacteria were added, the immersed fruit were protected from contamination and never developed decay.

The following recommendations are given for effective sanitation of recycled water systems:

Figure 4. An infected tomato can spread inculum to healthy tomatoes in the dump tank. Photograph by: Steve Sargent.

- Maintain free chlorine concentration at 150 to 200 ppm and pH of 6.5 to 7.5.
- Heat dump tank water and flumes at least 10°F (about 5°C) above tomato pulp temperature.
- Keep immersion time less than 2 minutes to minimize water infiltration into the tomato.
- Do not allow tomatoes to float in stagnant water during crew breaks or for longer periods of time; eliminate "dead spots" in the flume system where tomatoes can remain caught.
- Do not allow tomatoes to accumulate to more than a single layer in the dump tank, to minimize water pressure and infiltration into the fruit.
- Use an automated system for continuous chlorine and pH control, with manual measurements recorded hourly. If the manual measurements suggest the automated system is unreliable, the readings should be made more frequently.
- Drain dump tank daily, remove sediments, sanitize, rinse, and refill with potable water.
- Follow local regulations on disposal of treated water, and comply with all chemical labels (for chlorine, acidifier, etc.); *the container label is the law*!

Prepared by: Dr. Michael Mahovic

DISEASE MANAGEMENT:
Postharvest Diseases of Tomato

Sanitation must be effective at each step from harvest through handling. An effective GAP/GMP strategy for sanitation incorporates the recommendations for adequate control of decay pathogens.

Figure 5. A fruit with a fingernail wound (arrow) that later developed into black mold rot. Photograph by: Michael Mahovic.

OTHER SOURCES OF INOCULATION:

Pathogens can be dispersed to fruit through *contaminated equipment or workers*. Therefore, field bins, gondolas, harvest aides and harvest containers should be regularly cleaned and disinfected. All workers should be instructed on the importance of sanitation and on proper personal habits including hand washing. Restrooms should be regularly cleaned and sanitized. Hand washing stations should be conveniently located outside of restrooms as well as near the sorting belts on packing lines. Workers should be encouraged to wash frequently throughout the day. Workers who are or have been recently ill should not be allowed to work directly with fruit.

Mechanical injuries, such as cuts, punctures, abrasions, and bruises provide likely sites for infection to occur **(Figure 5)**. Gentle handling procedures during harvest operations should be enforced to minimize fruit injuries. *Thorough sorting* of injured fruit is essential to minimizing later development of postharvest decays. The sorting area of the packing line should have good lighting so that damaged fruit are easily sorted out. Tomatoes can be *cross-contaminated* by certain types of decay pathogens and other undesirable microorganisms via air movement, insects, and animals. Therefore, the packing area, ripening rooms, and storage areas must be kept free of rodents, birds, and insects, which can disperse various undesirable microorganisms or even be the source of such organisms.

Culled fruit can harbor pathogens and should never be allowed to accumulate near the packing facility. *Trucks and trailers* used to transport tomatoes should be inspected for cleanliness and cleaned and sanitized, if necessary, prior to being loaded. If the truck has previously hauled animal products, it should be steam cleaned before it is allowed to haul tomatoes.

Tomatoes are often harvested at temperatures that are ideal for decay development, e.g. above 86°F (30°C). In our tests, tomatoes that were inoculated with soft rot bacteria developed decay after 18 hours at 86°F. By contrast, when inoculated tomatoes were held at 68°F (20°C), the recommended ripening room temperature, soft rot lesions did not appear until 3 days or more had passed. In fact, inoculated tomatoes often do not develop any soft rot decay when stored at 68°F. Consequently, efforts should be made to remove field heat from freshly harvested tomatoes as soon as possible to reduce postharvest decays.

RECOMMENDATIONS:

- Tomatoes should not be gassed longer than 5 days; 3 days is the preferred maximum for best quality. Extended gassing time (due to unusually high proportion of immature-harvested tomatoes) favors mold growth during gassing and storage.
- Plastic bins are more easily sanitized than unpainted wooden bins. Surfaces that directly or indirectly contact tomatoes should be regularly cleaned and sanitized (picking buckets, bins, gondolas, packing line components, pallets); gassing and holding rooms, walls, floors and refrigeration coils should also be regularly cleaned.
- Quaternary ammonia compounds are effective sanitizers on equipment but may not be approved for direct contact with foods. Bin and packing line surfaces treated with these compounds can cause chemical injury to tomatoes. Prior to reuse, all treated surfaces should be thoroughly rinsed with potable water. *In particular, dump tanks cleaned with ammonia compounds should be thoroughly rinsed with water prior to filling with chlorinated water. Ammonia compounds react quickly with chlorine to form noxious gases.*
- Hand washing facilities should be available at all handling points, beginning in the field. Employees should wash their hands *thoroughly* with soap after each restroom use. "Waterless" hand sanitizers are good supplements to proper hand washing, but are not effective sanitizers when used alone.

IPM Integrated Pest Management Florida | UF UNIVERSITY of FLORIDA IFAS Extension

References:

Information excerpted from http://edis.ifas.ufl.edu/HS131.

Prepared by: Dr. Michael Mahovic

Erwinia carotovora subsp. *carotovora* and certain other bacteria

SIGNS & SYMPTOMS:

Fruit: Water soaking, with or without brown discoloration beginning at wounds, edges of stem scar or blossom end followed by rapid softening and liquefaction of the affected tissues. Juices from damaged tissues will spread disease to adjacent or nearby fruit. Lesions may begin internally if fruit absorbs water or wet stem scar contacts inoculum.

Stems and petioles: During wet weather (when plants remain wet for several days), stems and petioles may develop soft rot at injuries associated with tying the plants or where stems are bent due to canopy weight or development. The infected tissues are soft and may show evidence of soupy bacterial development.

DISEASE CYCLE & EPIDEMIOLOGY:

Bacterial soft rot is favored by warm (77-95°F), wet conditions. The bacterium is ubiquitous. Attacks on the plant are favored by injuries including those caused by chewing insects, stink bugs or storm damage. Water penetration of wounds, the stem scar or the blossom scar greatly favors infection.

FIELD SIGNATURE:

- Touch suspect areas with hard probe such as pencil, screwdriver, etc. Affected tissue will be soft and slimy.
- Cut open fruit with a water-soaked spot around or beneath stem scar or stem attachment. Internal lesions are obvious, soft and slimy.

PHOTOS:

Figure 1. Soft rot beginning at old stem puncure. Photograph by: Jerry Bartz.

Figure 2. Cross-section of soft rot infected through blossom pore. Photograph by: Jerry Bartz.

Figure 3. Surface soft rot lesion caused by *Pseudomonas aeruginosa*. Photograph by: Jerry Bartz.

POSTHARVEST DISEASES OF TOMATO: Bacterial Soft Rot

CULTURAL CONTROLS:

- Avoid working with or harvesting wet plants or fruit.
- Cool freshly harvested fruit promptly to 60-68 °F.
- Control insects and weeds.
- Do not expose freshly harvested fruit to rainfall.
- Remove decaying fruit from field and/or packinghouse.
- Do not allow harvested fruit to absorb water such as by prolonged immersion, immersion too deeply, or immersion where the fruit cools.
- Do not apply high pressure water streams directly to fruit surfaces.
- Make sure fruit surfaces are dry before packaging them.

Figure 4. Soft rot beginning beneath the stem attachment. Risk of bacterial soft rot can be reduced by limiting postharvest fruit exposure to water. Photograph by: Jerry Bartz.

CONTACT INFORMATION:

Dr. Jerry Bartz
UF/IFAS Plant Pathology Dept.
Fifield Hall
Gainesville, FL 32611
JaBartz@ifas.ufl.edu
352-392-7247

CHEMICAL CONTROL:

- Nothing available that is effective for controlling bacterial soft rot preharvest.
- Chemicals that sanitize water or fruit surfaces are helpful for minimizing populations of soft rot bacteria in postharvest handling.
- Maintain a minimum of 200 ppm free chlorine at pH 6.5 to 7.5 in dump tanks and flumes.
- Wash field containers and picking buckets with chlorinated water or appropriate surface sanitizer after unloads and prior to taking them back to field.

RESISTANT CULTIVARS:

- None with complete resistance.
- Avoid growing cultivars such as Florida MH-1,47 or 91 that are likely to take up water during times of the year when rainfall is expected (early or late summer into early fall).

FIELD CREW MANAGEMENT:

- Encourage field crews to wear latex or rubber gloves and gloves should be periodically washed in chlorinated water.
- Workers that are ill should not be picking or handling tomatoes.
- Encourage field crews to toss decayed fruit away from healthy ones.
- Minimize injuries.

References:

Bartz, J.A. 1980. Causes of postharvest losses in Florida tomato shipment. Plant Dis. 64: 934-937.

Bartz, J. A., C.G. Eayre, M.J. Mahovic, D.E. Concelmo, J.K. Brecht and S.A. Sargent. 2001. Chlorine concentration and the inoculation of tomato fruit in packinghouse dump tanks. Plant Dis. 85: 885-889.

McColloch, L.P., H.T. Cook and W.R. Wright. 1968. Market diseases of tomatoes, peppers, and eggplants. U.S. Dept. Agric., Agric. Handb. 28. 88 pp.

Wingard, S.A. 1924. Bacterial soft-rot of tomato. Phytopathology 14: 451-459.

IPM Integrated Pest Management Florida | UF UNIVERSITY of FLORIDA IFAS Extension

Geotrichum candidum or infrequently species of *Lactobacillus* or *Leuconostoc*

SIGNS AND SYMPTOMS:

Fruit: Pink or ripe fruit are more susceptible, whereas green fruit will develop lesions if chilled, are otherwise stressed or if the inoculum is internalized. In green fruit, lesions are relatively firm and have a pickled odor. With pink or ripe fruit, skin over lesions cracks open and lesion contents may spill out. Most lesion contents are relatively clear and have an acidic pH. White crusty growth often develops on the stem scar or open areas of the fruit surface.

Stems, leaves or petioles: Not described as a pathogen on these organs, but will likely grow on injuries during wet weather.

EPIDEMIOLOGY AND DISEASE CYCLE:

Common inhabitant of soil, wet areas and of decaying plant material. Readily spread by insects such as fruit flies. Will spread among fruit in storage and may accompany bacterial soft rot. Optimum temperature is 85°F. Is strictly a wound pathogen but will infect internal tissues.

FIELD SIGNATURE:

Crusty yeast like growth over ruptures in the lesion surface and odor of pickled tomatoes. Juices from lesions are often clear.

PHOTOS:

Figure 1. Several rough/injured fruit with sour rot beginning at wounds and open stylar pore. Photograph by: Jerry Bartz.

Figure 2. Red fruit that were inoculated by infiltration of the stem scar with spores of *G. candidum*. Photograph by: Jerry Bartz.

Figure 3. Cross section of above infiltrated fruit. Photograph by: Jerry Bartz.

POSTHARVEST DISEASES OF TOMATO: Sour Rot

CULTURAL CONTROLS:

- Keep fields clean, bury debris especially cull tomatoes.
- Make sure field has adequate drainage and avoid situations and cultivars prone to fruit cracking or the development of fruit roughness.
- Practices that help manage bacterial soft rot will help to minimize this pathogen as well.

CHEMICAL CONTROL:

Fungicide sprays are not useful for controlling *G. candidum* even if registered on tomato for control of other fungal pathogens. Chemicals used for sanitation during harvest and at the packinghouse will help to prevent initial infections by both *G. candidum* as well as the lactic acid bacteria (see disease management for bacterial soft rot).

RESISTANCE CULTIVARS:

No resistance known but varieties that resist water uptake and cracking or rough, open blossom pores are less likely to be infected.

Figure 4. Close-up of fruit with sour rot at wounds and stylar pore. Photograph by: Jerry Bartz.

Figure 5. Decay caused by an attack of certain lactic acid bacteria, *Leuconostoc* and *Lactobacillus* sp. Photograph by: Jerry Bartz.

CONTACT INFORMATION:

Dr. Jerry Bartz
UF/IFAS Plant Pathology Dept.
Fifield Hall
Gainesville, FL 32611
JaBartz@ifas.ufl.edu
352-392-7247

References:

Butler, E. E. 1960. Pathogenicity and taxonomy of *Geotrichum candidum*. Phytopathology 50:665-672.

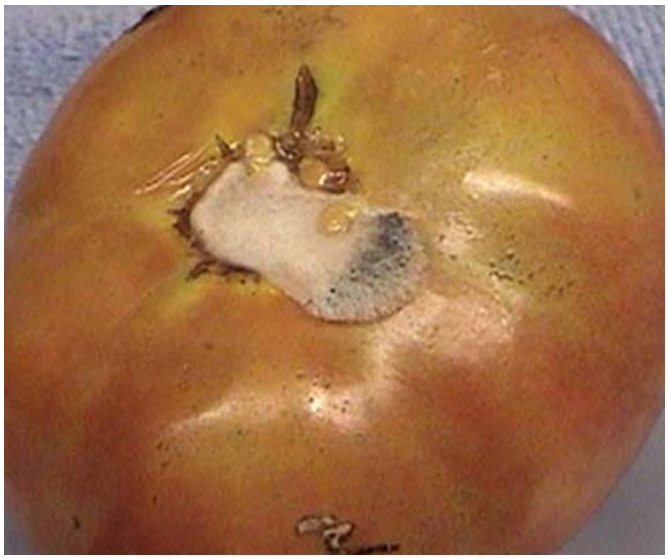
Conn, K. E., J.M. Ogawa, B.T. Manji and J.E. Adaskaveg. 1995. *Leuconostoc mesenteroides* susp. *mesenteroides*, the first report of a coccoid bacterium causing a plant disease. Phytopathology 85:593-599.

McColloch, L. P., H.T. Cook and W.R. Wright. 1968. Market diseases of tomatoes, peppers, and eggplants. U.S. Dept. Agric., Agric. Handb. 28. 88 pp.

Moline, H. E. 1984. Comparative studies with two *Geotrichum* species inciting postharvest decays of tomato fruit. Plant Dis. 68:46-48.

IPM Integrated Pest Management Florida

UF UNIVERSITY of FLORIDA IFAS Extension



Rhizopus stolonifer

SIGNS & SYMPTOMS:

Fruit: Fully developed lesions on fruit in high humidity have extensive surface coverage by a coarse gray to white mold. Younger lesions develop near wounds, stem scars, or open blossom pores as water soaked areas that rapidly enlarge. The lesion is relatively soft but has some consistency. Nests of decaying fruit and fungal growth may develop in boxes of fruit. Ripe fruit are more susceptible than green ones.

Plant: *R. stolonifer* is not listed as a pathogen of leaves or stems but damage to those organs along with wet conditions may enable this opportunist to develop.

DISEASE CYCLE & EPIDEMIOLOGY:

This pathogen is a common saprophyte and has been found to survive for up to 30 yrs in dried deposits of decayed fruit. It is strictly a wound invader but may directly penetrate an unbroken fruit surface during fruit to fruit spread. The optimum temperature for the disease is 75-80°F. The pathogen may be carried to cracks on fruit by fruit flies, whereas the spores can be carried long distances by air currents. Wet storage conditions favor the disease.

FIELD SIGNATURE:

Water soaked lesions with watery content and coarse mycelium ramifying throughout. There are nests of mold in stored fruit. The liquid from decaying fruit is relatively clear. The aroma associated with this decay has overtones of rotten eggs.

PHOTOS:

Figure 1. Rhizopus rot that likely began at the stem scar. Photograph by: Jerry Bartz.

Figure 2. Rhizopus lesions that began at wound on side of green fruit. Photograph by: Jerry Bartz.

Figure 3. Nest of Rhizopus rot in tomato box. Photograph by: Jerry Bartz.

POSTHARVEST DISEASES OF TOMATO: Rhizopus Rot (Fungal Nests)

CULTURAL CONTROLS:

- Bury all debris from previous crops and damaged fruit from the current crop.
- Clean and disinfect fruit containers on a daily basis. Make sure there are no fruit residues left in containers.
- Clean and disinfect the packing line equipment on a daily basis.
- Remove plant debris from around packingline at least daily.

Figure 4. Rhizopus lesion on grape tomato. Photograph by: Jerry Bartz.

CHEMICAL CONTROL:

- Field applications of registered fungicides are not known to affect this disease.
- The water used to wash or handle tomatoes should contain a minimum of 150 ppm free chlorine at pH 6.5 to 7.5 and the chlorine and pH should be uniform throughout the water system.
- Packingline equipment and packing containers should be cleaned and sanitized daily.
- Note label on sanitizers as some may require rinse with potable water. Surface sanitizers containing quaternary ammonium compounds must never drain into or otherwise contact chlorinated water as an exothermic (gives off heat) reaction will occur that generates hazardous fumes.
- Chemicals used to clean surfaces may not always kill microbes attached to those surfaces. However, relatively concentrated solutions of bleach (diluted to 0.5 to 1% NaOCl) will both clean (good for removal of fatty or proteinaceous soils) and sanitize if the bleach is allowed to stand on the treated surface for several minutes. However, bleach will remove lignin from wood surfaces and will cause corrosion on metal surfaces (not as likely on stainless steel).

RESISTANT CULTIVARS:

Resistance to Rhizopus rot is unknown, but cultivars yielding fruit that resist cracking, roughness or water uptake are less likely to become infected.

CONTACT INFORMATION:

Dr. Jerry Bartz
UF/IFAS Plant Pathology Dept.
Fifield Hall
Gainesville, FL 32611
JaBartz@ifas.ufl.edu
352-392-7247

References:

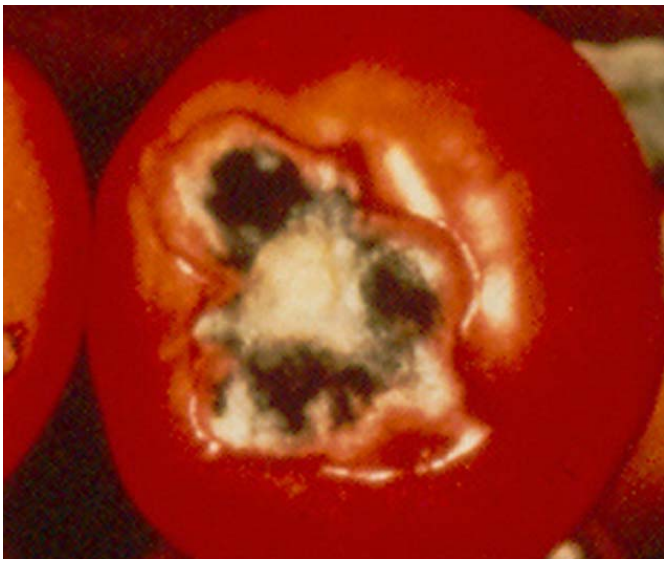
Baker, K. F. 1946. An epidemic of Rhizopus soft rot of green-wrap tomatoes in California. Plant Dis. Rep. 30:20-26.

Butler, E. E. and C.E. Bracker. 1963. The role of *Drosophila melanogaster* in the epidemiology of *Geotrichum*, *Rhizopus* and other fruit rots of tomato. Phytopathology 53:1016-1020.

McColloch, L. P., H.T. Cook and W.R. Wright. 1968. Market diseases of tomatoes, peppers, and eggplants. U.S.D.A. Agric. Handb. 28. 88p.

IPM Integrated Pest Management Florida
UF UNIVERSITY of FLORIDA IFAS Extension

POSTHARVEST DISEASES OF TOMATO: Black Mold Rots



SIGNS & SYMPTOMS:

Black mold rots on fruit can be caused by several different pathogens including *Alternaria alternata*, *Stemphylium botryosum*, *Pleospora lycopersici* and *S. consortiale*. Early blight caused by *A. solani* and target spot caused by *Corynespora cassicola* may produce similar symptoms. The first four pathogens are all weak, opportunists that attack weak tissues. None of the six is likely to spread among fruit during storage or marketing. The lesions are usually firm and dark in color with a covering of black mold on their surfaces. However, one or more of these fungi can grow down the stylar pore and may initiate an internal lesion, which appears as a moldy mass in cross-section. Early blight and target spot lesions usually show concentric rings.

DISEASE CYCLE & EPIDEMIOLOGY:

A. alternata, *S. botryosum*, *P. lycopersici* and *S. consortiale* are common saprophytes and are found in plant debris or on damaged plant tissues. Radial or concentric cracking, blossom end rot, sun scald, heat or field chilling injuries provide infection courts on fruit. Infection of senescing flowers may lead to colonization of the style and internal pockets of decay. Persistently wet areas (from condensation) in ripening rooms may promote growth of these pathogens on walls or other surfaces leading to high levels of inocula. Fruit stored under such conditions for several days are likely to develop mold growth on stem scars, with or without penetration into the fruit flesh. Chilling injury during storage will promote fruit infections.

FIELD SIGNATURE:

Blackened firm lesions often near the stem attachment, particularly if radial or concentric cracks have formed. Internal lesions may first draw attention by dark areas appearing on the fruit surface. When the fruit is sliced open, an internal area of blackened necrosis will be observed as the reason for surface symptom. The necrosis is often linked to the stylar pore, which will appear as a blackened stripe from the blossom scar to the lesion. Early blight lesions often appear to have originated on or beneath the calyx and can become quite large with zonate rings. Target spot lesions can range in size from small freckles to large zonate rings located anywhere on the fruit. Typically, the small lesions enlarge during storage.

PHOTOS:

Figure 1. Typical black rot lesions around stem scar caused by *Alternaria alternata*. Photograph by: Jerry Bartz.

Figure 2. Three fruit with typical zonate early blight lesions that began at the stem attachment. Photograph by: Jerry Bartz.

Figure 3. Fruit with target spot lesion; these lesions may also appear zonate. Photograph by: Jerry Bartz.

Prepared by: Dr. Jerry Bartz

POSTHARVEST DISEASES OF TOMATO:
Black Mold Rots

CULTURAL CONTROLS:

- Avoid growing tomatoes at times when fruit may be chilled just prior to harvest.
- Check recommendations to avoid blossom end rot, sunscald, or fruit cracking as these factors predispose fruit to attack by the black mold rot pathogens.
- Do not store green tomatoes below about 15°C.
- Check recommendations for controlling early blight and target spot.

CHEMICAL CONTROL:

- Fungicide recommendations for controlling early blight and target spot in the field will reduce postharvest losses to these pathogens.
- Fungicides are not recommended for controlling the weak black mold rot pathogens.

RESISTANT CULTIVARS:

Select cultivars that are considered resistant to cracking.

Figure 4. A fruit with a fingernail wound (arrow) that later developed into black mold rot. Photograph by: Michael Mahovic.

CONTACT INFORMATION:

Dr. Jerry Bartz
UF/IFAS Plant Pathology Dept.
Fifield Hall
Gainesville, FL 32611
JaBartz@ifas.ufl.edu
352-392-7247

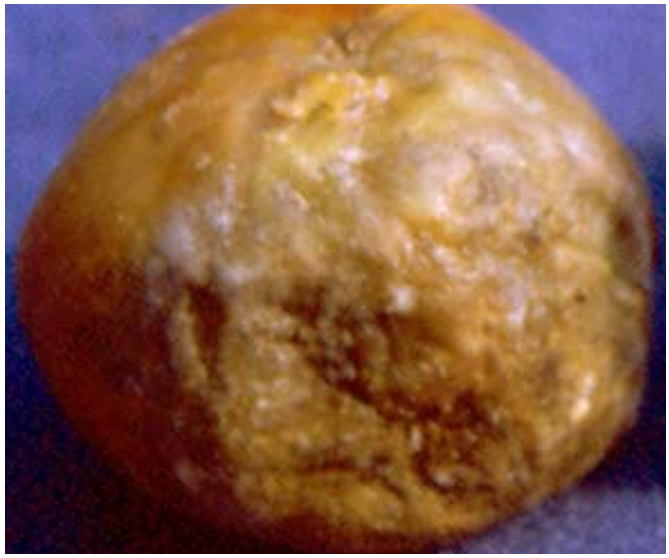
References:

Bartz, J. A. 1991. Postharvest diseases and disorders of tomato fruit, pp. 44-48. *In* J B. Jones, J.P. Jones, R.E. Stall and T.A. Zitter (eds.), Compendium of Tomato Diseases. APS Press. St. Paul, Mn.

McColloch, L.P., H.T. Cook and W.R. Wright. 1968. Market diseases of tomatoes, peppers, and eggplants. U.S.D.A. Agric. Handb. 28. 88p.

IPM Integrated Pest Management Florida
UF UNIVERSITY of FLORIDA IFAS Extension

POSTHARVEST DISEASES OF TOMATO: Buckeye Rot and Late Blight



SIGNS & SYMPTOMS:

Sporadically develops on tomato fruit in warm wet weather that have been exposed in the field to standing water, direct contact with the soil or late blight. Buckeye rot is caused in fruit by *Phytophthora capsici* or *P. parasitica*. Neither of these attack the plant. Late blight caused by *P. infestans* may also appear as similar symptoms in the fruit, which may be confused with buckeye. Buckeye may spread from fruit to fruit in humid storage conditions.

DISEASE CYCLE & EPIDEMIOLOGY:

The causal organisms for buckeye rot live in the soil, but require warm wet conditions to infect the fruit. Standing water is most conducive to infection. Fruit in contact with the soil or water are most likely to be infected; however, rain splash also can move zoospores in the standing water up onto fruit surfaces. Storage temperatures below 60°F slow the development of disease, whereas about 80°F is ideal for infection. Signs (diffuse mycelium) are not likely to appear on the surface of lesions unless the humidity is very high or the lesion has advanced to cover most of the fruit. Late blight is a severe above ground disease that is often harbored in volunteer tomato plants or, in some cases, in volunteer or nearby potato crops (see late blight for more information). Late blight is unlikely to spread from fruit to fruit in storage.

FIELD SIGNATURE:

Small olive-green to light brown spots appear on green tomato fruit, usually on areas in contact with the soil or facing the soil. The spots have diffuse edges, are usually not sunken, remain firm and can enlarge rapidly. The spots often appear water soaked and darken in color. Large dark brown bands may appear in the lesion. The lesion surface is usually smooth for buckeye and roughened for late blight. A diffuse fungal growth may develop over the lesion surfaces under humid conditions.

PHOTOS:

Figure 1. Relatively small buckeye lesion with smooth surface. Photograph by: Jerry Bartz.

Figure 2. Late buckeye lesion with sparse mycelium and roughened surface. Photograph by: Jerry Bartz.

Figure 3. Late blight lesion showing roughened surface. Photograph by: Jerry Bartz.

Prepared by: Dr. Jerry Bartz

POSTHARVEST DISEASES OF TOMATO:
Buckeye Rot and Late Blight

CULTURAL CONTROLS:

At least a three-year rotation recommended for buckeye. Avoid planting tomatoes after peppers or eggplant. Make sure field is well-drained and does not have areas prone to accumulate standing water. Grow tomatoes in dry climates or during drier times of the year.

CHEMICAL CONTROL:

Spray applications that are effective for controlling late blight should also be effective for controlling buckeye rot. Make sure label on any fungicide applied has instructions for application to tomatoes.

RESISTANT CULTIVARS:

None reported although certain cultivars are more prone to become infected.

Figure 4. Late blight of tomato. Photograph by: Jerry Bartz.

Figure 5. Cross-section of late blight of tomato. Photograph by: Jerry Bartz.

CONTACT INFORMATION:

Dr. Jerry Bartz
UF/IFAS Plant Pathology Dept.
Fifield Hall
Gainesville, FL 32611
JaBartz@ifas.ufl.edu
352-392-7247

References:

Barksdale, T.H., J.M. Good, and L.L. Danielson. 1972. Tomato Diseases and Their Control. Agric. Handbk No. 203. A. R. S., U.S.D.A. Washington, D.C.

McColloch, L.P., H.T. Cook and W.R. Wright. 1968. Market Diseases of Tomatoes, Peppers, and Eggplants. A.R.S., U.S.D.A., Agric. Handbk No. 28, Washington, D. C.

Stevenson, W.R. 1991. Buckeye rot and Phytophthora Root Rot, pg. 11. *In* J.B. Jones, J.P. Jones, R.E. Stall and T.A. Zitter (eds.), Compendium of Tomato Diseases. APS Press. St. Paul, Mn.

Botrytis cinerea

SIGNS & SYMPTOMS:

This is often the most important postharvest disease in fruit produced in cool moist climates (particularly coastal growing areas) although it can be found in the late spring season in Florida after the second or third harvests when plant canopy injuries have accumulated. Formerly, it was described as a major problem in south Florida, particularly during cool, wet growing periods. The disease is usually not a problem when crops are produced on high calcium or well-limed soils.

DISEASE CYCLE & EPIDEMIOLOGY:

The causal organism is an excellent saprophyte and grows on a wide range of hosts. The organism grows best at 75-79°F, whereas disease progress is most rapid at 64-75°F. Tomatoes exposed to chilling temperatures in the field or in storage become quite susceptible to infection. Germinated spores may directly penetrate the fruit surface, but if temperatures warm much above the ideal range, the infections are aborted. These arrested lesions remain white to yellow in fully red fruit giving a halo or "ghost-spot" symptom.

FIELD SIGNATURE:

Gray-green to gray-brown, slightly water-soaked spots often initially appear near the stem-end of the fruit or at the point of contact between a lesion and a healthy fruit. The lesion contents are softened but not mushy. A grayish mold develops at breaks in the tomato skin or sparsely over the surface of older lesions. The mold coating appears velvet-like due to numerous spore clusters that develop like clusters of grapes.

PHOTOS:

Figure 1. Red fruit with large gray mold lesion that is covered by typical mycelium and sporulation. Photograph by: Jerry Bartz.

Figure 2. Early stages of *Botrytis* on a postharvest tomato. Photograph by: Denise Thomas.

Figure 3. Gray mold starting at the fruit calyx from ruptured tissue. Photograph by: UF/IFAS.

Prepared by: Dr. Jerry Bartz

POSTHARVEST DISEASES OF TOMATO: Gray Mold Rot (Botrytis Fruit Rot)

CULTURAL CONTROLS:

For management of the disease postharvest:

- Avoid allowing free moisture to develop on packed fruit by maintaining uniform storage temperatures.
- Note recommendations for chlorinating the packinghouse water systems and for minimizing the chances for absorption of water by fruit (prevent infiltration) **(pg. 143)**.

See pgs. 105-106 for cultural controls in the field.

CHEMICAL CONTROL (in the field):

- Chlorothalonil, chlorothalonil plus mefenoxam, pyraclostrobin (suppression only), and boscalid are fungicides labeled for field application of gray mold on tomato.
- Also labeled for use on tomato are Pyrimethanil and *Bacillus subtilis* strain QST 713. Both of these compounds should be applied with an appropriately labeled fungicide.
- On pepper, Pyraclostrobin and *Bacillus subtilis* strain QST 713 are labeled for this disease.

Figure 4. Gray mold in the field typically does not produce harvestable fruit. Photograph by: Phyllis Gilreath.

Figure 5. Close up of *Botrytis* showing grape-like clusters of conidia as seen through a dissecting scope. Photograph by: Jerry Bartz.

CONTACT INFORMATION:

Dr. Jerry Bartz
UF/IFAS Plant Pathology Dept.
Fifield Hall
Gainesville, FL 32611
JaBartz@ifas.ufl.edu
352-392-7247

References:

Barksdale, T.H., J.M. Good, and L.L. Danielson. 1972. Tomato Diseases and Their Control. Agric. Handbk No. 203. A. R. S., U.S.D.A. Washington, D.C.

McColloch, L.P., H.T. Cook and W.R. Wright. 1968. Market Diseases of Tomatoes, Peppers, and Eggplants. A.R.S., U.S.D.A., Agric. Handbk No. 28, Washington, D. C.

Stall, R.E. 1991. Gray Mold, pp. 16-17. *In* J. B. Jones, J.P. Jones, R.E. Stall and T.A. Zitter (eds.), Compendium of Tomato Diseases. APS Press. St. Paul, Mn.