

# Identification and Organic Control of Greenhouse Diseases

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# Plant Disorder Vs. Plant Disease

- Plant disorder

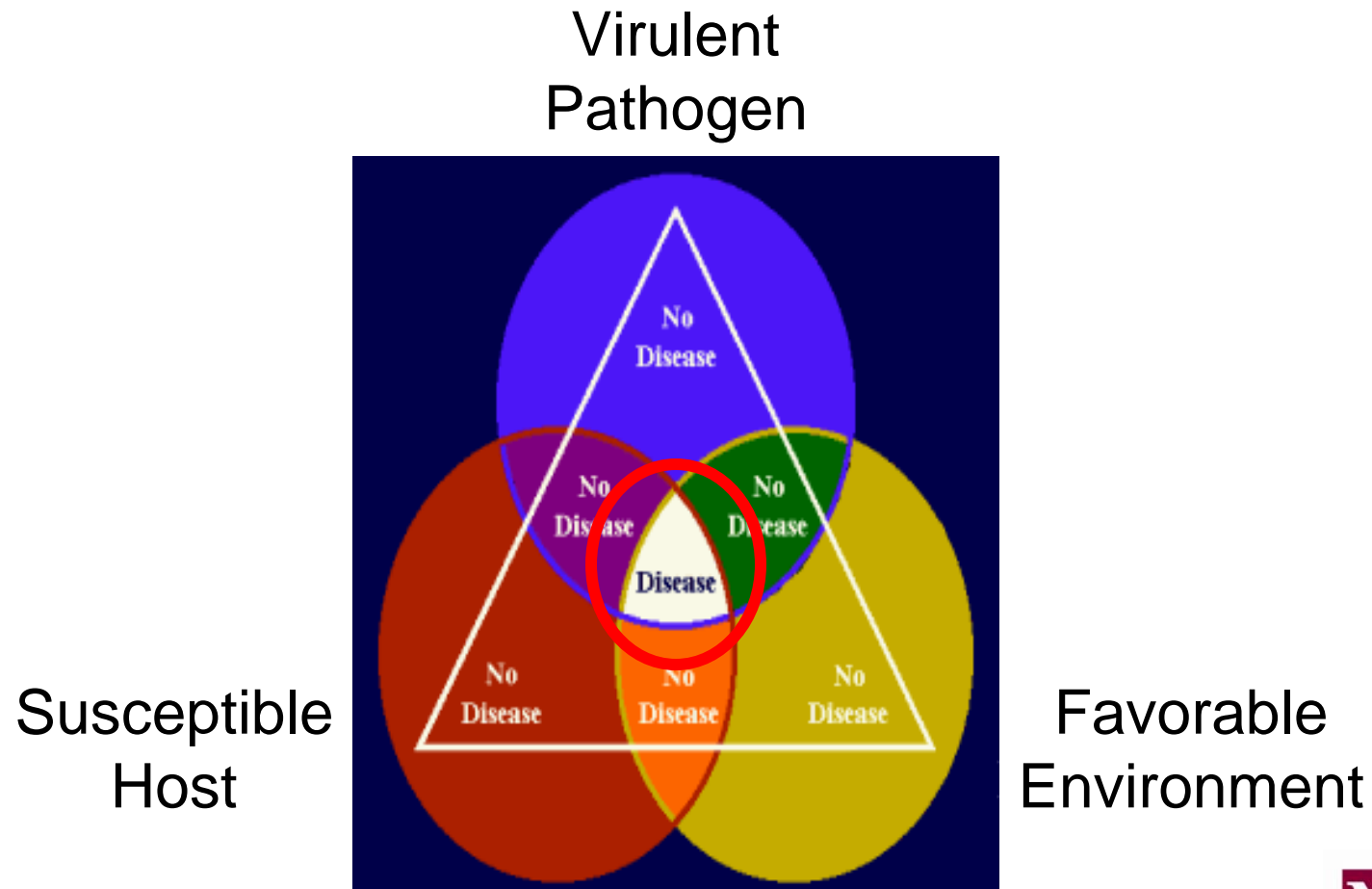
- Any abnormal growth or development in a plant

- Plant disease

- Any abnormal growth or development in a plant specifically caused by an ***infectious microorganism*** (pathogen).

- Fungi
    - Bacteria
    - Viruses
    - Nematodes

# The Plant Disease Triangle



# Greenhouse Environment

- More consistent environment
    - Exception – equipment failure (cooler, heater, vents, etc.)
  - Environment is generally good for diseases
    - Moderate (warm) temperature
    - High humidity / moisture
    - Air movement (spread)
  - Overcrowded conditions
  - Rapid lush growth
- ★ Disease outbreaks can “explode”



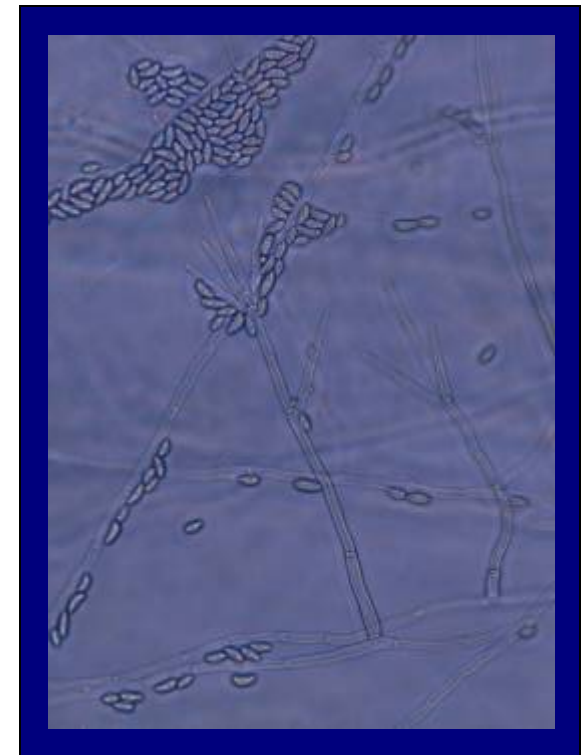


# Managing Greenhouse Diseases

- Accurate Diagnosis
- Understanding of pathogen sources
- Understanding of pathogen biology:
  - life cycle
  - environmental requirements
  - spread.
- Develop appropriate and effective management strategies

# Diagnosing Plant Diseases

- Causal agents are ***small*** (microscopic).
- “Field” diagnosis may not be possible:
  - Positive identification may require laboratory tests and specialized equipment.



# Diagnosing Plant Disorders

- Diagnosis is a team effort.
  - ☐ Grower
  - ☐ Submitting Agent
  - ☐ Diagnostic Lab
- NMSU Plant Diagnostic Clinic:
  - ☐ <http://plantclinic.nmsu.edu>
  - ☐ Forms and information for submitting samples.
  - ☐ Publications, links, etc.
  - ☐ Image gallery (coming attraction!)



# NMSU Plant Diagnostic Clinic

- Support lab for the National Plant Diagnostic Network.
  - Partnership between USDA, State Depts. of Ag and Land Grant Universities.
  - Overall objective: Establish a functional **national network** of existing diagnostic laboratories to rapidly and accurately **detect** and **report** pathogens, pests and weeds of national interest, whether intentionally introduced or not.
    - First Detector Training
  - Provides financial support to plant diagnostic clinics.
- Provides diagnostic serves at no charge when samples are submitted through the county extension offices.





# The Diagnostic Process

- An accurate diagnosis depends on:
  - Early detection of plant problem – routine examination of the plant.
  - Examination of good specimens and/or photos.
  - Obtaining accurate information.



# Diagnosing Plant Problems

- ***Ask questions!***
- Identify the plant species affected – genus, species, cultivar, common name.
- Observe and document the symptoms.
- Observe and document the plants' growing environment.
- Document the environmental conditions prior to and during symptom development

**\* Take good, thorough notes and photos**



# Diagnosing Plant Problems

- Isolate and identify associated microorganisms.
- Determine if any of the associated microorganisms are likely to be responsible for the symptoms – references, host indexes, experience.
- Make recommendations.



# Pathogen Sources

## ■ “Soil”

- ☐ Soil
- ☐ Sand
- ☐ Peat
- ☐ Potting mixes

## ■ Plant debris



## ■ “Soil” debris

- ☐ Used pots or flats
- ☐ On benches
- ☐ Under benches
- ☐ In aisles
- ☐ On shoes
- ☐ Equipment
- ☐ Hose ends

# Pathogen Sources

- Plants kept all year
  - Residents
- Stock “mother” plants
  - Vegetative propagation
    - Cuttings
    - Buds
    - Scion wood (grafting)
- New plant introductions



# Pathogen Sources


- Water
- Air
- Insects
  - External carriers
  - Internal carriers
- Weeds



# Pathogen Spread

- Water
  - ☐ Overhead irrigation
  - ☐ Splash
  - ☐ Recycled water
- Plant to Plant contact
- Air currents
- Vectors
  - ☐ Man
  - ☐ Equipment
  - ☐ Insects





# Disease Management in an Organic System

- Ecologically sound.
- Encourage growth and diversity of soil and plant microorganisms (potential beneficials).
- Plant genetic diversity.
- Integration of disease management decisions with insect and weed management.



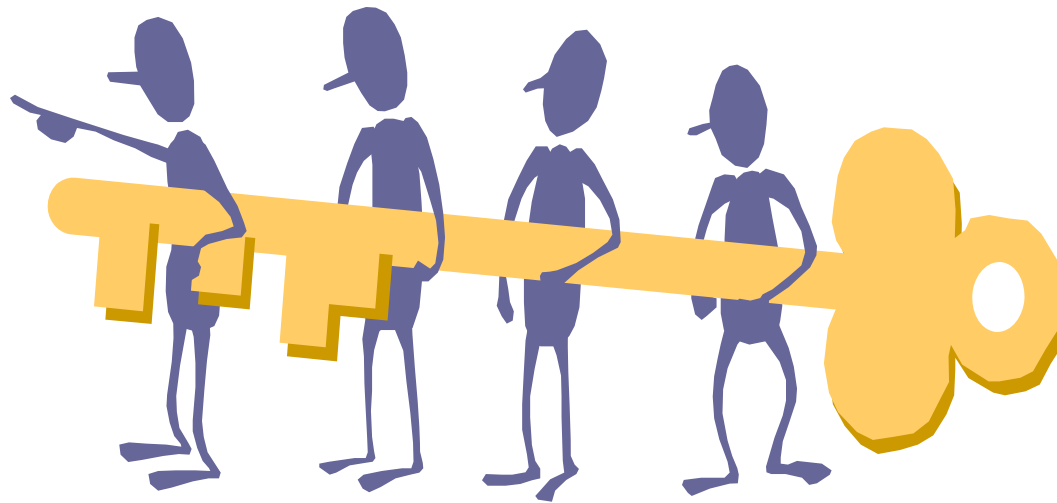
# Disease Management Strategies

- Genetic Resistance
- Cultural Management
- Biological Management
- Chemical Management
  - Approved for organic production





# The Key to Disease Management is **Prevention!**



# Genetic Resistance

- Resistance – ability to suppress or retard the activity and progress of a pathogen (absence or reduction of symptoms)
- Tolerance – ability to endure severe disease without suffering significant losses in quality or yield (do not inhibit pathogen and symptoms may be present)



# Genetic Resistance

- First line of defense.
- Must be continually monitored as pathogens will develop virulence to resistant and tolerant plant material.
- Look for cultivars well adapted to you conditions and with resistance to the most common diseases you face.



# Genetic Resistance

## ■ Advantages:

- Non-disruptive to the environment
- Compatible with other management strategies (fits well into IPM systems)

## ■ Disadvantages:

- Not available for all diseases on all crops
- Pathogens may become virulent to tolerant varieties (over time)
- Varieties resistant to one pathogen may be highly susceptible to another



# Cultural Management Practices

- Exclusion
- Planting time
- Water management
- Fertilizer management
- Sanitation
- Insect and weed management
- Manipulation of the environment





# Cultural Management Practices

- Exclusion – Keep pathogen sources out of the greenhouse.
  - Plant material – source plants, transplants, seed, etc.
  - Soil-less pasteurized potting media
  - Treat recycled water
  - Keep door closed and vents covered





# Cultural Management Practices

## ■ Sanitation

- ☐ Removal and destruction of dead plants, diseased plants and plant debris (cull piles should be far away from production areas)
- ☐ New or clean pots, trays, tools, etc.
  - Alcohols
  - Chlorine – residual must stay below 4 ppm (safe water drinking act)
  - Hydrogen peroxide
  - Soap-based algicide/demisters
- ☐ New potting mix
- ☐ Keep hose ends off the ground
- ☐ Wash hands
- ☐ Clean shoes





# Cultural Management Practices

- Water Management – timing and duration of irrigations should satisfy crop needs without allowing excess water.
  - Reduce saturated soil conditions
  - Reduce leafwetness
- Fertilizer management – Grow plants at a moderate pace, reduce lush, succulent growth.
  - Help to reduce activity of pathogens by managing nitrogen.

# Cultural Management Practices

- Insect and weed management
  - Screening vents and doorways
- Manipulation of the Environment
  - Temperature
  - Humidity
  - Air circulation
  - Shade





# Biological Management

- Management of pathogens by other microorganisms.
- Biological control is constantly occurring in nature.
- Use may include rearing and releasing microorganisms or manipulating existing populations.
  - Disease-suppressive microorganisms



# Disease Suppressive Microorganisms

- Fungi and bacteria can help to suppress diseases:
  - *Trichoderma*
  - *Streptomyces*
  - *Bacillus*
  - *Pseudomonas*
- Only a few strains are commercially available
- Bacteriophages - viruses of bacteria



# Trichoderma

- Soil-borne fungus.
- Season long control of root diseases.
  - Colonizes the root system.
- Use on vegetables and ornamentals.
- Protects against Pythium, Rhizoctonia, and Fusarium and many others.
- Also used as a plant growth regulator.
- Rootshield® and Plantshield®



# *Streptomyces*

- Soil-borne fungus
- Disease suppressing and disease causing strains (even in the same species).
- Suppresses activity of *Pythium*, *Fusarium* and *Phomopsis*.
- *Streptomyces griseoviridis* (Mycostop®):
  - Seed rot
  - Damping-off
  - Root rots
- Greenhouse vegetables and ornamentals
- Applied as a seed treatment, soil drench or through drip systems.



# *Bacillus*

- Many species have strains that have been identified with the ability to suppress many fungi and bacteria
  - *Bacillus subtilis* (Serenade®)
  - *Bacillus pumilis* (Sonata®)
- Fruit and Vegetable crops, Ornamentals
- Broad spectrum of activity:
  - Mildews, molds, blights, leaf spots, rusts



# Chemical Management

- Options limited in organic production systems.
  - ☐ Pest, crop, site (greenhouse)
  - ☐ Confirm use for organic production
- Timing is critical:
  - ☐ Preventative (prior to extensive infection)
- Application methods are critical:
  - ☐ Proper equipment
  - ☐ Spray volume
  - ☐ Plant coverage





# Chemical Management

- Copper- and Sulfur-based fungicides

- Advantages:

- Inexpensive
    - Widely available
    - Minimal threat to environment

- Disadvantages:

- Phytotoxic at temperatures above 85 F.
    - Affect a wide range of fungal and bacterial pathogens; but disease controls varies depending on host and pathogen.
    - Overuse may result in development of pathogen resistance



# Chemical Management

- Oils and Plant Extracts / Natural Plant Products
  - Some are compatible with organic production.
  - Reliable disease control has not been demonstrated.
- Bicarbonate-based fungicides
  - Used preventatively - acceptable levels of control against powdery mildews and a few other diseases.
  - Season-long disease control questionable.
- Manure composts
  - Some (not all) have been shown to induce disease resistance in some plants.
  - Variable batch to batch



# Pesticide Precautions

- Pesticides are governed by EPA and the New Mexico Department of Agriculture.
  - Products must be registered by both
  - NM product registration: <http://state.ceris.purdue.edu>
  - Contact Cary Hamilton: [chamilton@nmda.nmsu.edu](mailto:chamilton@nmda.nmsu.edu)
- Product label is a legal document:
  - Site of application: host and greenhouse approved
  - Disease/pathogen
- Product labels and registrations change frequently:
  - <http://www.cdms.net>





# Greenhouse Diseases

## ■ Fungi

- ☐ Gray mold
- ☐ Leaf mold
- ☐ Powdery mildew
- ☐ Downy mildew
- ☐ Early blight
- ☐ Root and crown rots
  - Pythium
  - Rhizoctonia
  - Fusarium

## ■ Viruses

- ☐ Tobacco Mosaic Virus
- ☐ Tomato Spotted Wilt Virus /  
Impatiens Necrotic Spot  
Virus

## ■ Bacteria

- ☐ Bacterial leaf spot

# Gray Mold

- *Botrytis cinerea* (fungus)
- Affects almost every type of greenhouse crop
- Symptoms:
  - Leaf spots
  - Flower spots and blight
  - Stem and crown rot
  - Damping-off



# Gray Mold

- Sign:
  - Gray, dusty spores



# Gray Mold

- Weak pathogen
  - Stressed tissue
  - Wounded tissue
  - Old tissue
- Flowers!
- Favored by:
  - High relative humidity (>85%)
  - Cool (65 F) temperature
  - Poor air circulation
  - Overcrowded conditions





# Gray Mold on Tomato

- All above ground plant parts:
  - Leaves
  - Stems
  - Flowers and fruit
- Lesions expand eventually blighting (killing) affected tissue.
- Easily spread by air, water, tools, hands, and insects.







# Gray Mold Management

- Manipulate greenhouse environment to make it less favorable for disease:
  - Reduce humidity (<85%) and leaf wetness
  - Increase air circulation
  - Reduce overcrowding and plant-to-plant contact
    - Prune out suckers below first fruit set
    - Periodically remove the bottom leaves (cut 1 inch from the stem and then snap off the stub at the next pruning)
  - Increase temperature (within tolerable range for the crop)
- Good sanitation practices
  - Cleaning tools and hands
  - Removal and destruction of debris
- Organic fungicides: Coppers, biofungicides and hydrogen dioxide.



# Leaf Mold on Tomato

- *Fulvia* (=Cladosporium) *fulva* (fungus).
- Usually only a problem under highly humid conditions.
- Poor air circulation.
- Cool temperatures.
- Spreads by air, water, tools, hands, and insects.

# Leaf Mold on Tomato

- Chlorotic spots on upper surface of older leaves.
- Olive-green spores on under leaf surface.
- Spots merge to affect the entire leaf.
- Usually only the foliage is affected.
- Older leaves are affected first.





# Leaf Mold Management

- Use resistant varieties
- Other management - same as gray mold:
  - Sanitation
  - Manipulate the greenhouse environment
  - Hydrogen dioxide
  - Biofungicides

# Powdery Mildew

- Common greenhouse disease
  - Tomatoes, peppers, ornamentals
- Rarely kill plants, reduces aesthetic value and salability
- Symptoms: chlorosis, necrosis, distortion
- Sign: white, powdery growth



# Powdery Mildew on Peppers

- Begins are brown blisters on the top of the leaves.
- Fungus sporulates on the underside of the leaf.





# Powdery Mildew on Peppers

- Severely affected leaves curl exposing fruit.



# Powdery Mildew on Tomato

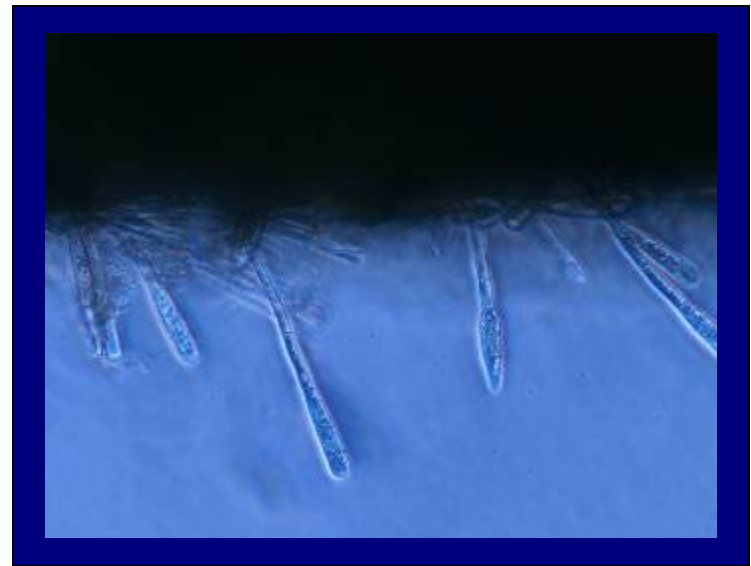
- Same fungus that infects peppers.
- Begins as irregular, bright yellow blotches.
- Mildew sporulates on leaf and stem surfaces.
- Infected leaves eventually die





# Powdery Mildew

- Spreads by air currents, water splash, people and equipment.
- Requires high humidity for infection (near 100%).
- Disease develops under a wide range of humidity levels (>30%).
- Low light.
- Overcrowding.



# Powdery Mildew Management

- Reduce Humidity
- Increase air circulation
- Preventative sprays
  - Sulfur
  - Biofungicides
  - Bicarbonate fungicides
  - Copper fungicides



# Downy Mildew

- Cause foliar blight
- Common on: Vegetables and ornamentals (snapdragon, salvia, pansy, rose, geraniums).
- Symptoms:
  - Yellowing
  - Mottling
  - Purplish blotches



# Downy Mildew

- Sign: Fluffy gray brown to purple growth on underside of the leaves



# Downy Mildew

- Favored by cool, wet conditions with high relative humidity
- Leaf wetness is required for germination and infection
- Spread by splashing water and air





# Downy Mildew Conditions and Management

- High Humidity
- Leaf wetness
- Low light
- Overcrowding
- Reduce humidity
- Increase air circulation
- Increase light
- Reduce overcrowding



# Early Blight

- Caused by two species of *Alternaria*.
- A serious disease on greenhouse tomatoes.
- Soil- and seed-borne.
- All above ground plant parts are affected.
- Disease starts on the lower leaves.



# Early Blight

- Small, circular spots often with a dark margin or yellow halo.
- Spots enlarge and develop a target appearance (concentric rings).
- Stem lesions are elongated and enlarge to girdle the stem.





# Early Blight

- Fruit may rot at the stem end.





# Early Blight Conditions

- Temperatures between 47 and 90 F.
- Leaf wetness
- High humidity
- Overcrowding
- Spread by air currents and water splash

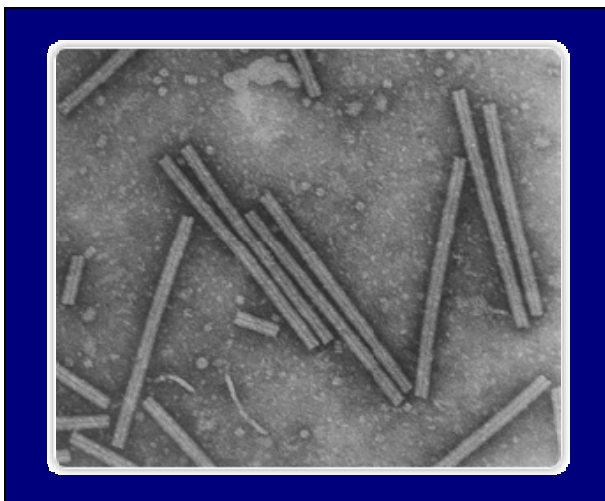


# Early Blight Management

- Resistant cultivars
- Sanitation
- Reduce humidity
- Increase air circulation
- Seed treatment (same as bacterial leaf spot)
- Organically approved chemicals

# Tobacco Mosaic Virus (TMV)

- RNA surrounded by a coat protein
- Highly infectious
- Sap transmitted: hands, tools, plant-to-plant contact
- Common disease on many greenhouse plants



# Tobacco Mosaic Virus

- Common disease on many greenhouse plants
- Symptoms include: mosaic, mottling, chlorosis, necrosis, leaf curl, formation of bumps and other deformities, stunting, color breaking, uneven ripening.





# Tobacco Mosaic Virus Management

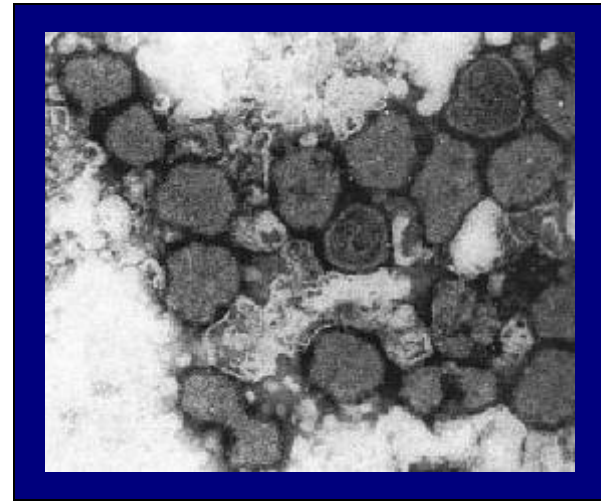
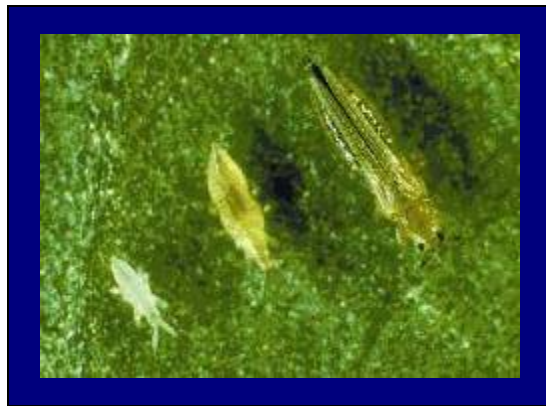
- Sanitation!

- ☐ Destroy infected plants
- ☐ Wash hands
- ☐ Wash clothing
- ☐ Clean tools

- Do not allow smoking in or around plants.

# Tomato Spotted Wilt Virus

- RNA virus
- Transmitted primarily by thrips
  - Cuttings
- Huge host range





# Tomato Spotted Wilt Virus

- Symptoms:
  - Spots and rings
  - Necrosis
  - Streaking
  - Stunting
  - Wilted appearance
  - Uneven ripening





# Tomato Spotted Wilt Virus



# Tomato Spotted Wilt Virus



# Bacterial Leaf Spot

- Caused by *Xanthomonas campestris* pv. *vesicatoria*.
- Primary hosts:
  - Peppers
  - Tomatoes
- Generally on leaves
- May occur on stems or fruit



# Bacterial Leaf Spot on tomato





# Bacterial Leaf Spot

- Bacterium is seed-borne!
  - On and in seed.
- Favored by temperatures between 75-86 F and high humidity and leaf wetness.
- Spread by air currents, water splash, and people



# Bacterial Leaf Spot Management Prevention

- Start with clean seed and transplants!



# Bacterial Leaf Spot Management

## Seed treatments

- Clorox seed treatment (EPA Reg. No. 5813-1):
  - Dose: 2 pts 5.25% sodium hypochlorite / 8 pts. Water
  - Use 1 gallon of solution per pound of seed
  - Wash with continuous agitation for 40 mins.
  - Promptly air dry
  - Prepare fresh solution for each batch of seed
- Only kills bacteria on the *outside* of the seed.





# Bacterial Leaf Spot Management

## Seed treatments

- Hot water treatment
  - 122 F for 25 minutes (check temp. constantly)
  - Continuous agitation
  - After treatment, cool seed under tap water
  - Promptly air dry at room temperature (70-75 F)
- Kills bacteria on the outside *and* on the inside of the seed.
- Can reduce germination if temperature is too hot.





# Bacterial Leaf Spot Management

- Avoid overhead irrigation
- Reduce humidity (increase air circulation)
- Sanitation
- Organically improved chemicals
  - Copper fungicides
  - Hydrogen dioxide
  - Biofungicides

# Bacterial Leaf Spot Management

- Bacteriophage (AgriPhage):
  - Virus specific to particular strains of *Xanthomonas campestris* pv. *vesicatoria*.
  - Identification of strain is required – tests conducted by the manufacturer.
  - Adequate control may require frequent applications.





# Disease Management Summary

- Integrated pest management
  - Good scouting – early detection
- Resistant varieties
- Sanitation:
  - Routine and “year-end” cleanup
    - Remove diseased leaves, fallen leaves and flowers, etc.
  - Removal of diseased and dead plants
  - Clean tools
  - Clean hands
  - Clean pots, flats, benches, etc.
  - “Sterilize” soil – heat (dry or steam), solarization



# Disease Management Summary

- Isolation of new plants (Quarantine)
- Improve greenhouse environment:
  - Reduce relative humidity – increase air flow
  - Reduce overcrowded conditions
  - Alter cultural practices
- Control weeds and insects inside and outside the greenhouse
- Chemical control
  - Biopesticides
  - “Regular” chemicals