Identification and Organic Control of Greenhouse Diseases

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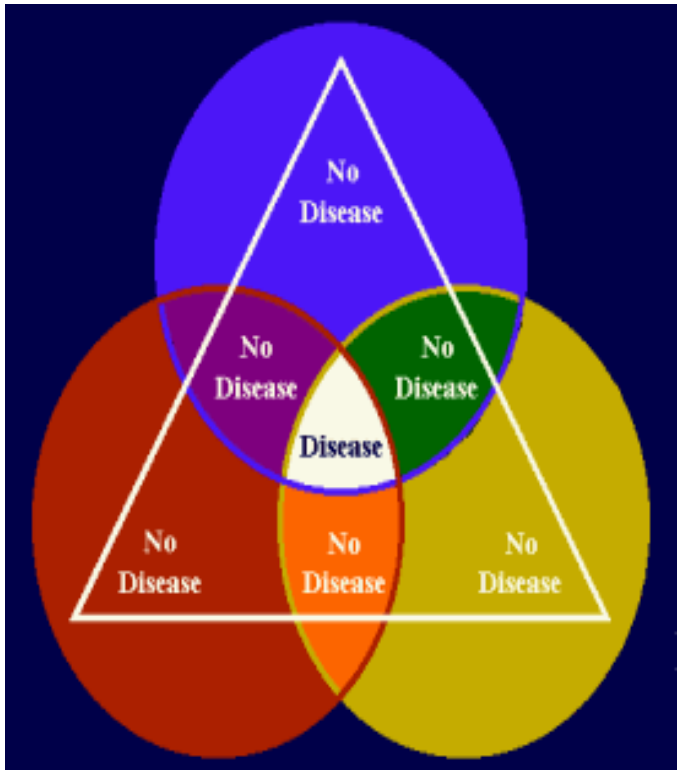
Plant Disorder Vs. Plant Disease

- 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

Virulent Pathogen



Susceptible Host

Favorable Environment

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

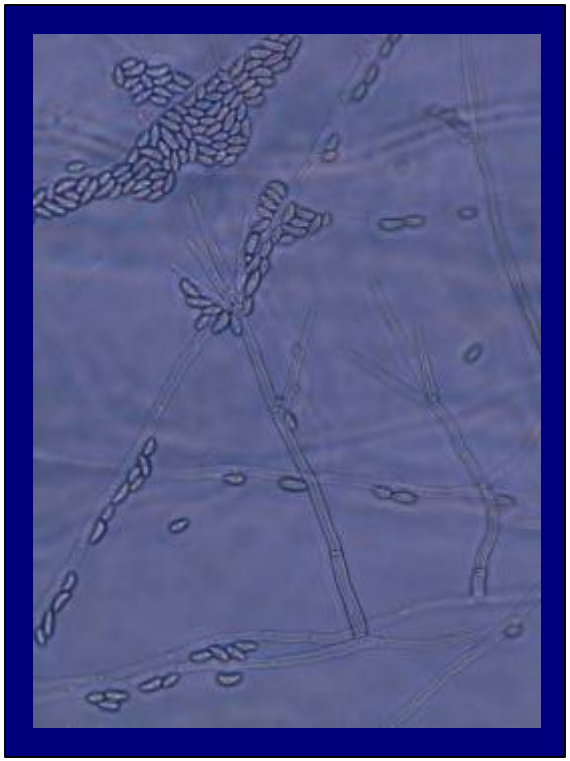
* Disease outbreaks can “explode”

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.

USDA CSREES

NPDN National Plant Diagnostic Network

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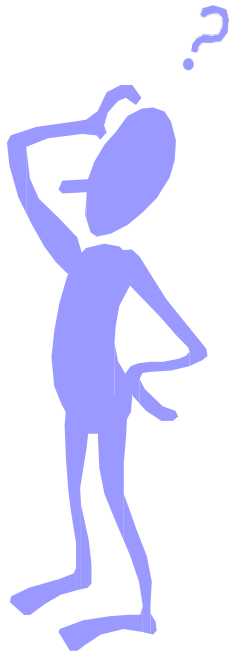
The Diagnostic Process

- 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

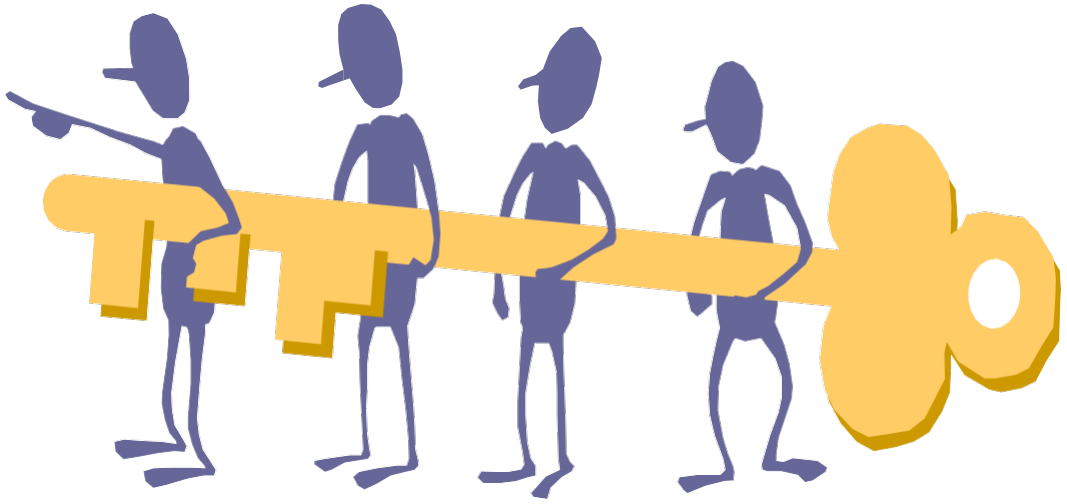
Disease Management in an Organic System

- 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 stray 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*
  - *Psuedomonas*
- 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 subtillis* (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
- 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

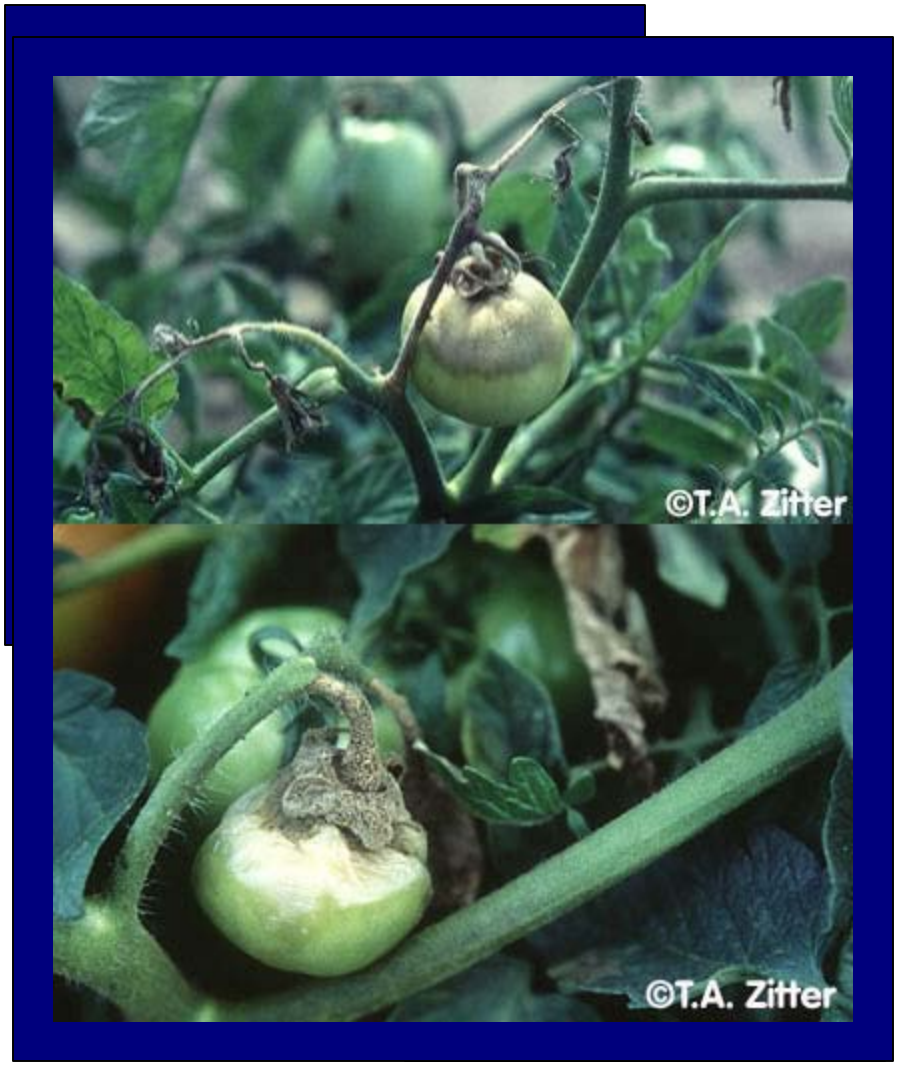
- Sign:
  - Gray, dusty spores

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.

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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

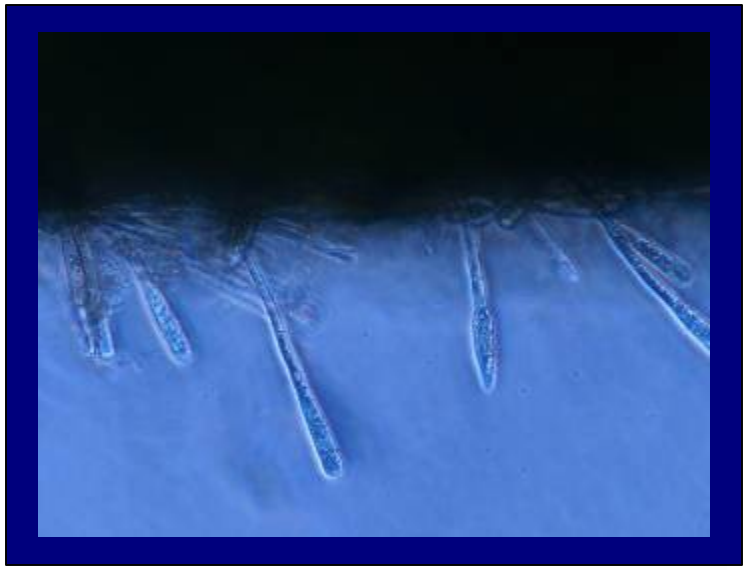
- Severely affected leaves curl exposing fruit.

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 Humi dity
- Leaf wetne ss
- Low light
- Overcrowd ing

- 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

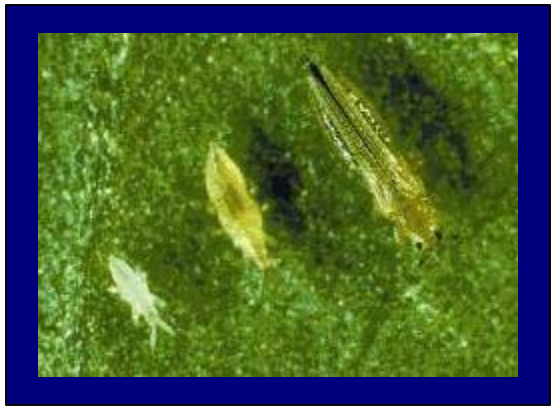
- Common disease on many greenhouse plants
- Symptoms include: mosaic, mottling, chlorosis, necrosis, leaf curl, formation of bumps and other deformities, stunting, color breaking, uneven ripening.

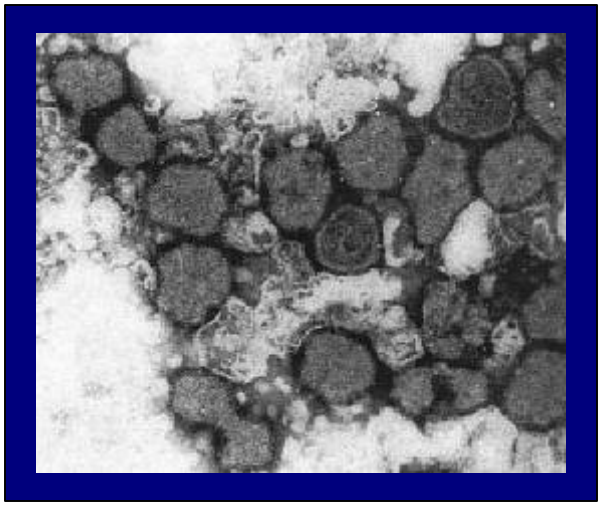
Tobacco Mosaic Virus Management

- 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

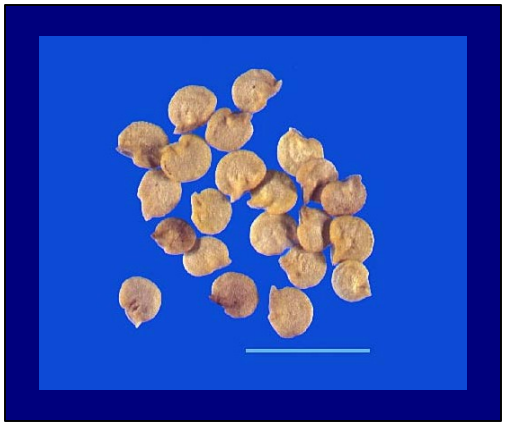
Bacterial Leaf Spot

- 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