Insects and Diseases

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Overview

- Insects
  - Why study insects
  - Beneficial aspects of insects
  - Injurious aspects of insects
  - Insect biology
  - Insects by order
  - Insect control
- Diseases
  - Plant disease development
  - Disease causal agents
  - Diagnosis and confirmation
  - Managing plant diseases

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Why Study Insects?

- **Insects are the most numerous animal**
- **They have tremendous impact on people's lives**
- **Better understanding of the environment**
- **Preservation of beneficial insects**
- **Reduced economic losses due to insect damage**

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"Insects, not humans, dominate the earth"

E. O. Wilson

Beneficial Aspects Of Insects

- **Pollinators**

- **Honeybee**
- **Butterflies and Moths**
- **Flower Flies**
- **Beetles**

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BENEFICIAL ASPECTS OF INSECTS

- **Commercial Products**

- **Silk**
- **Honey**

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BENEFICIAL ASPECTS OF INSECTS

- Natural Recycling of Nutrients
- Dung Beetles
- Flies - Decay of Dead Animals
- Termites - Decay of Dead Wood

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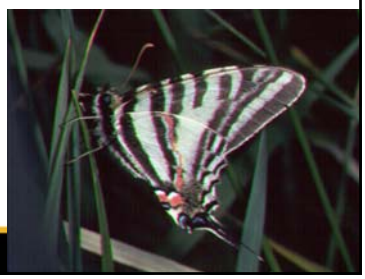
BENEFICIAL ASPECTS OF INSECTS

- Insects in Food Web of Wildlife
- Water Quality
- Research
- Aesthetic
- Butterfly gardening



Beneficial Aspects Of Insects

- Biological Control
  - Phytophagous Insects
  - Entomophagous Insects

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Injurious Aspects Of Insects

- Horticultural Pests
  - feeding injury
  - oviposition injury
  - disease

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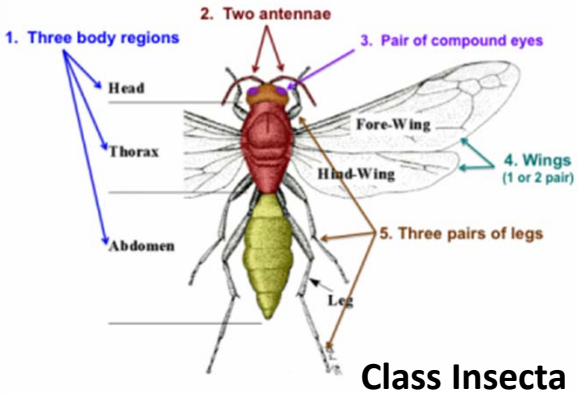
Insect Biology

- Classification

kingdom	Animalia
phylum	Arthropoda
class	Insecta
order	Hymenoptera
family	Apidae
genus	*Apis*
species	*mellifera*



Class Insecta

INSECT BIOLOGY

- Mouthparts

Chewing Mouthparts

- Bite or rasp off and swallow solid food Symptoms include holes, missing leaves, windowpanes, scraped areas
- Insects with chewing mouthparts:
  - Beetles
  - Caterpillars
  - Grasshoppers
  - Bees and Wasps
  - Flies

Sucking Mouthparts

- Feed on plant sap by piercing plant tissue Symptoms include spotting, curling, wilting, tissue death
- Insects with sucking mouthparts:
  - Aphids
  - Scales
  - True Bugs
  - Leafhoppers
  - Thrips
  - Mites

INSECT BIOLOGY

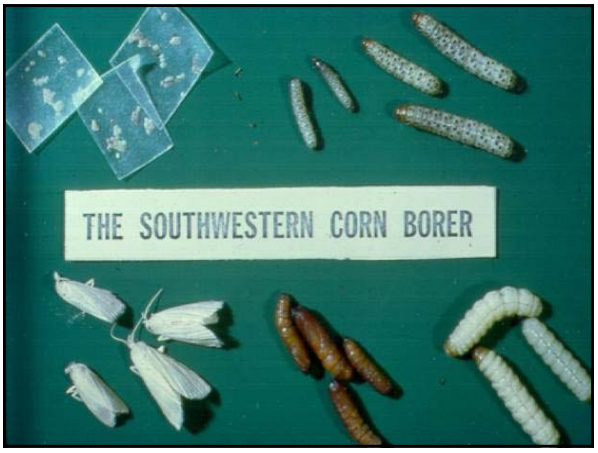
- Metamorphosis

a succession of changes in body form in the life history of an insect

Complete Metamorphosis (85% species)

Egg - Larva - Pupa - Adult

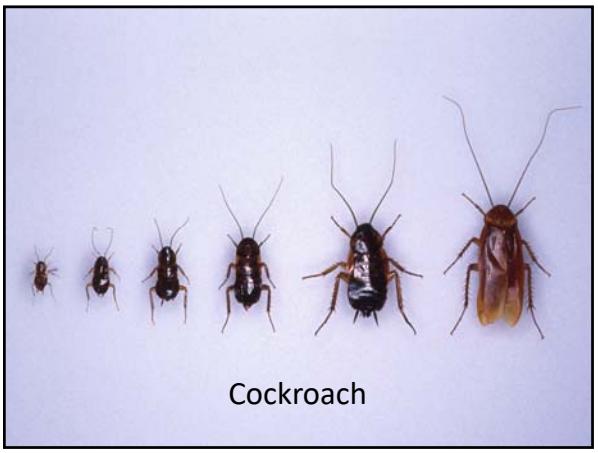
Coleoptera (Beetles)
Hymenoptera (Bees and Wasps)
Lepidoptera (Butterflies and Moths)
Diptera (Flies)



Incomplete Metamorphosis (15% species)

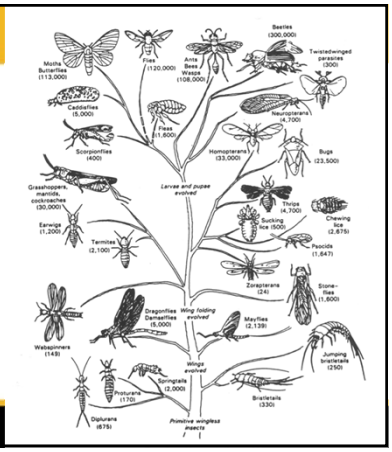
Egg - Nymph - Adult

Homoptera (Aphids and Scales)
Hemiptera (True Bugs)
Orthoptera (Grasshoppers, Katydids)



Cockroach

Insect Orders



WHY ACCURATE INSECT IDENTIFICATION IS IMPORTANT!!

- The vast majority of insects are not pests (less than 1% of all species)
- Not all pest species are equally susceptible to insecticides
- Some insects have developed resistance to some insecticides
- The behavior of related species can differ a great deal; this affects control

COLEOPTERA Beetles

"Sheath Winged"

Complete Metamorphosis
Chewing Mouthparts

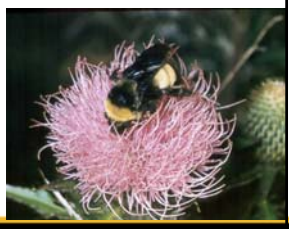
DIPTERA Flies

"Two Winged"

Complete Metamorphosis
Chewing Mouthparts

HYMENOPTERA
Bees and Wasps

- Complete Metamorphosis
- Chewing Mouthparts



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LEPIDOPTERA
Butterflies and Moths

Complete Metamorphosis
Siphoning Mouthparts (adults)
Chewing Mouthparts (larvae)

HEMIPTERA
True Bugs

Incomplete metamorphosis
Piercing-sucking mouthparts

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HOMOPTERA

Incomplete metamorphosis
Piercing-sucking mouthparts

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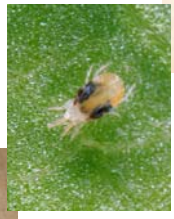
Other Insect Orders

- Odonata – dragonflies and damsonflies
- Orthoptera – grasshopper and crickets
- Thysanoptera - thrips

Insect Relatives

- Mites
- Spiders
- Ticks



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Plant Disease

- Malfunction resulting from a continuous irritation by environmental factors or pathogenic organisms that cause negative changes in the plant



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Significance of Plant Health

- World's dependence on plants and plant products for human existence
  - Source of all food, directly or indirectly

- Home Landscape
  - Edible fruits and vegetables
  - Value: functional, aesthetic ($)

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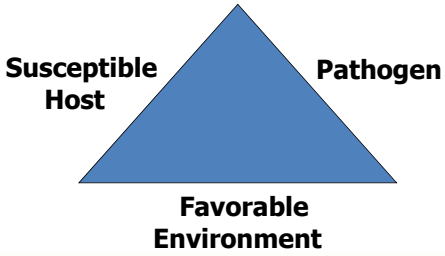
Plant Disease Triangle

- A disease will only occur when 3 conditions are met:



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Disease Cycle

- Describes the chain of events involved in disease development by a biotic pathogen.
- Disease Cycle includes the following events:
  - Production of infectious inoculum
  - Spread of the inoculum
  - Penetration of the inoculum
  - Infection within the host plant
  - Colonization – additional cycles to produce new inoculum. Stage when symptoms first show.
  - Survival/overwintering between growing seasons

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Significant Plant Diseases

- Late Blight of Potato-Irish Potato Famine (1844)
- Ergotism "St. Anthony's Fire": 600 B.C. early 1900's
- Chestnut Blight (1904-1940)
- Dutch Elm Disease (1930-present)
- Sudden Oak Death and Ramorum Blight (1995-present)

4 billion dollars a year in overall crop losses.

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Two Causes Of Plant Damage

- Abiotic Disorders or Stresses

- Infectious Diseases (Biotic)

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Abiotic Disorders

Also called non-infectious diseases

- Temperature and moisture extremes
- Nutrient deficiencies
- Pesticide injury
- Improper cultural practices
- Genetic factors
- **Not contagious**
  - Analogous to a back ache

Common Causes of Abiotic Disorders

Chemical burn (fertilizers & pesticides)

Soil (compaction, pH)

Salt Damage

Mechanical Injury

Environment (Flood, Drought)

Genetic Variability

Non-Infectious Problems of Tomato

Environment

Blossom End Rot

Catfacing

Non-Infectious Problem

Winter Trunk Injury

- Southwest sides of thin-barked trees such as maple and fruit trees
- Winter sun during day (warms cambium layer) & extreme cold after sunset (cells vulnerable)
- Prevention: tree wrap

Trunk Crack

Non-Infectious Problem: Nutritional

Pin Oak (Fe Deficiency)

Red Maple (Mn Deficiency)

Chlorosis

Noninfectious Problems *Will Not* Move from Plant to Plant

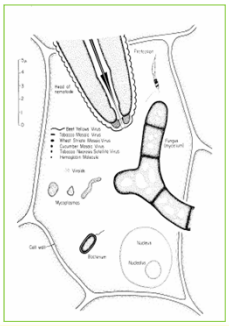
Fluoride Toxicity

Herbicide Injury

Cultural (Watering Injury)

Infectious Causal Agents

- Fungi
  - *Stramenopiles*
- Bacteria
  - *Phytoplasmas*
- Viruses
- Nematodes



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Symptoms and Signs

- **Symptom**
  - Reaction of a plant to a disease
- **Sign**
  - Observed pathogen or pathogen parts on plant

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Sign

Physical Evidence of a Living Causal Agent

Nectria Canker Trunk and Branches

Sign:
orange spore fruiting bodies

Symptom:
sunken canker

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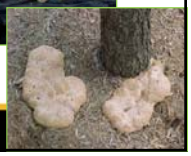
Parasite

An organism living on or in another living organism and obtaining its nutrients from it.



Saprophyte

An organism that obtains its nutrients from dead organic material.

Fungi

- Multi-cellular organisms that lack chlorophyll
- Fungi comprise more than 100,000 known species. Most are saprophytes
- Largest plant pathogen group: More than 10,000 species are plant pathogens.

Tar Spot

90% of Fungi are Saprophytes


Slime Molds


Fairy Ring

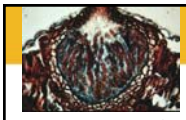

Puffball

Fungi

- Some have reproductive structures that can be seen with the naked eye (e.g. mushrooms)

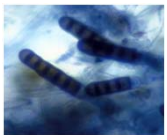
Fungi

- A spore is to a fungus like a seed is to a plant.
- Reproduce by spores, sclerotia, or mycelial

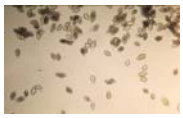

Ascospores of *Venturia inaequalis* (Apple Scab)


Conidia of *Powdery mildew*


Conidia of *Bipolaris zeicola* (Northern corn leaf spot)


Chlamydospores of *Thielaviopsis basicola* (Black Rot)


Urideniospores of *Puccinia hemerocallidis* (Daylily Rust)


Sporangia of *Phytophthora capsici* (Phytopthora blight)

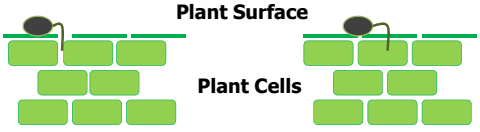
Fungi Are Spread By:

- Infected plants, plant debris, soil
- Wind
- Water splash
- Seed
- Insects
- Animals
- People

Infection of Plants by Fungi: How?

Entrance through natural openings or wounds

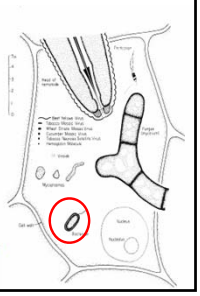
Direct penetration via enzymes



Common Fungal Diseases

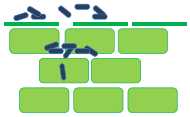
Bacteria as a Cause of Plant Disease

- Can be seen with a light microscope
- Simple, one-celled
- ~200 pathogenic species



Bacteria

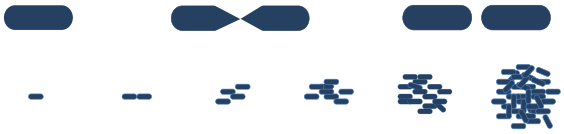
- Moves in water or films of moisture with flagellae
- Infection through wounds or natural openings
- Account for 15% of plant diseases



A single bacterial cell, with flagellae

Magnified with an electron microscope

Bacteria Reproduce by Binary Division (One Cell Divides into Two)



20 min. 40 min. 60 min. 80 min. 10-12 hrs.

Individual cells cannot be seen with the naked eye

1 cell → 24hrs → 17 million cells

Bacteria are Spread By:

- Infected Plant Material and Soil
- Water splash
- Pruning tools
- Insects
- Seed

Common Bacterial Diseases

Viruses as Causes of Plant Disease

- Can only be seen using an electron microscope
- Extremely simple - nucleic acid with a protein coat
- Cannot reproduce on their own. Virus "hijacks" the host plant's reproductive machinery. Multiplies only in host plant
- Account for 5% of plant diseases

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Viruses

- Are Spread By:
  - Infected Plants
  - Grafting
  - Insect Vectors
  - Nematodes
  - Humans
  - Seeds

- Viral Diseases are Systemic: Once Infected There is no Cure

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Common Virus Diseases

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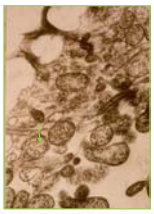
Phytoplasmas as Causes of Plant Disease

- Somewhat like bacteria but much smaller and have no cell wall
- Reproduce by cell division (binary fission)
- Phloem-limited



Ash Yellows phytoplasma as seen with an electron microscope

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Phytoplasmas

- **Transmitted by Phloem-Feeding Insects Ex. Leafhoppers**
- **Obligate Parasites – Must Live in Host or Vector**

Leafhopper Vector of Phytoplasmas

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Common Phytoplasma Diseases

- Aster yellows

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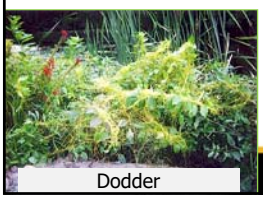
Parasitic Seed Plants as Causes of Plant Disease

- Plants that live on and obtain nutrients from other plants
- Reproduce through seeds
- Spread by exploding fruit, birds, infested crop seed lots


Dodder


Mistletoe

Mistletoe

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Lichens are NOT Parasitic

- A lichen is composed of two organisms, a fungus and an algae, living symbiotically

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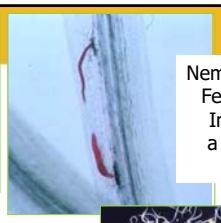
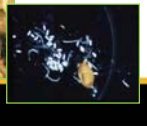
Nematodes as Causes of Plant Disease

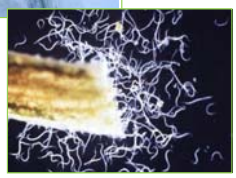
- Parasitic, unsegmented worms
- Usually seen only with a light microscope
- Only 10% are plant parasites
- Stylet-specialized mouthpart
- Reproduce by eggs
- Most infect roots
- Spread by infected soil, plants and plant debris


Nematodes Feeding on the Outside of a Root Hair


Nematodes Feeding Inside a Root


Cyst Nematodes




Foliar Nematodes

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What is IPM?

- **I**ntegrated – a whole in which the parts work together
- **P**est – a problem
- **M**anagement – control, direct, influence
- EPA definition of IPM – "Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices."

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Steps of Effective IPM

- **Establish a policy**
  - Do you follow organic practices? Organic guidelines will help define IPM in your garden
  - Learn what IPM is and how it differs from non-IPM, calendar-based pesticide applications.
  - Educate yourself about the benefits that IPM can deliver.
  - Pesticides - discuss how your pesticides will be selected, applied and stored.

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Steps of Effective IPM

- Establish a policy.
- **Identify pests correctly.**
  - The development of a management strategy depends on accurate diagnosis of a problem
  - What is perceived as a problem may not be a problem at all
  - It may not be a detrimental pest after all, and no control measures will be necessary
  - Sometimes, there is nothing to be done
  - Saves time, energy, and money

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Identify Pests Correctly

Abiotic Stresses
- Environmental
- Nutritional
- Cultural
- Chemical

Biotic Stresses
- Fungal diseases
- Bacterial diseases
- Viral and other diseases
- Insects
- Mites and other arthropods
- Nematodes
- Birds, mammals
- Weeds

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Problem Diagnosis

- Need help with diagnosis?
  - Extension resources
  - Other governmental resources – Department of Agriculture, University plant/insect/nematode/weed diagnostic services
  - Develop a reference library, use internet

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Steps of Effective IPM

- Establish a policy.
- Identify pests correctly.
- **Monitor pest populations on a regular basis.**
  - Watch your plants for signs of problems
  - Is the pest expected each year?
  - Keep an open mind
  - Phenology is important
  - What is the real cause of the symptoms?

Steps of Effective IPM

- Establish a policy.
- Identify pests correctly.
- Monitor pest populations on a regular basis.
- **Determine action threshold.**
  - Pest population
  - Damage threshold
  - Significant injury level

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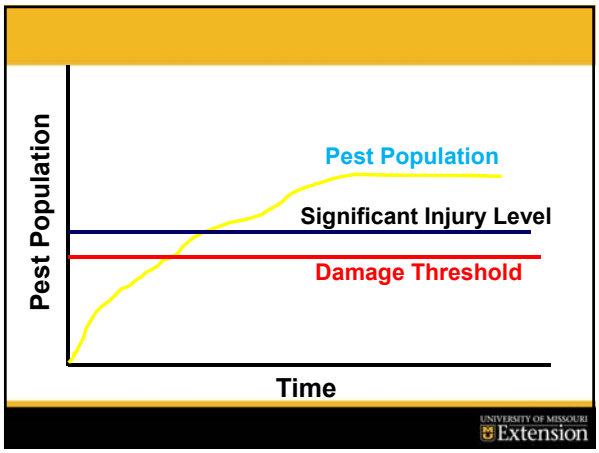

Steps of Effective IPM

- Establish a policy.
- Identify pests correctly.
- Monitor pest populations on a regular basis.
- Determine action threshold.
- **Choose the proper management tactic or combination of tactics.**

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IPM Strategies

- Biological control
- Mechanical control
- Cultural control
- Genetic control
- Chemical control

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Biological Controls

- Take advantage of the environment, weather can be your friend or foe
- Using beneficial organisms, such as natural pest predators, parasites and diseases to suppress pest organisms.
  - *Bacillus thuringiensis* - caterpillars
  - Biological nematicides - plant parasitic nematodes
  - Natural enemies, such as lady beetles, lacewings and beneficial wasps
- Natural control products: pyrethrins, neem, spinosad
- Biological controls and reality
  - Control is slow, not complete

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Biological Controls

Presence of beneficials

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Mechanical Control

- Using barriers or traps and altering pest habitat to diminish pest pressure
- Insects
  - Hand removal, trapping
- Diseases
  - Prune out diseased parts
  - Removal of overwintering sites or stages
- Weeds
  - Cultivate or hand pull weeds
- Other problems – trap mice/voles
- Significant cost to these production inputs – money, time

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Insect Pheromone Trapping

Cultural Control

- Crop rotation
- Cover cropping
- Correctly prepare sites before planting
- Use proper planting techniques
- Provide optimum conditions for growth – watering, fertilizing, mulching, weed control
- Proper pruning and training
- Sanitation

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Genetic Control

- Use adapted cultivars
- Use pest resistant cultivars
- Use rootstocks that are pest resistant
- Genetically modified cultivars?

Chemical Control

- Using pesticides to prevent or suppress a pest outbreak.
  - The selection of chemicals used in IPM programs considers that the pesticide is as specific to the pest as possible
  - Used at the lowest effective rate
  - Short-lived in the environment
  - Least toxic to beneficial organisms and the environment
  - Alternated with other chemical modes of action to help prevent resistance
  - General applications are often followed with spot applications as needed

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Chemical Control

- The use of chemical pesticides is sometimes needed even when other, nonchemical practices are followed.
- Must know the proper use of chemicals – labels, rates, timing, safe applications
- Pesticides are just one choice
  - Do not use products indiscriminately
  - Pesticides are a choice only after deliberation
  - Often an economic choice – save money

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Steps of Effective IPM

- Establish a policy.
- Identify pests correctly.
- Monitor pest populations on a regular basis.
- Determine action threshold.
- Choose the proper management tactic or combination of tactics.
- **Evaluate the effectiveness of the management plan.**
  - What worked well?
  - Which aspects need improvement?
  - Which should be eliminated?
  - What are the benefits of the program in environmental or social value?

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Steps of Effective IPM

- **Establish a policy.**
- **Identify pests correctly.**
- **Monitor pest populations on a regular basis.**
- **Determine action threshold.**
- **Choose the proper management tactic or combination of tactics.**
- **Evaluate the effectiveness of the management plan.**

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What is Necessary to Practice IPM?

- Gain an education
  - Must know your plants
  - Must be able to identify problems
  - Must know all control strategies
- You must stay current…
  - Attend seminars
  - Talk among yourselves
  - Attend conferences
  - Keep a library of reference books
  - Watch out for the internet – trash is there
  - Watch out for "feelings" vs "facts"
  - Remember – you are a student forever

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IPM Strategies and Tomato

- Establish a policy.
- **Identify pests correctly.**
- Monitor pest populations on a regular basis.
- Determine action threshold.
- Choose the proper management tactic or combination of tactics.
- Evaluate the effectiveness of the management plan.

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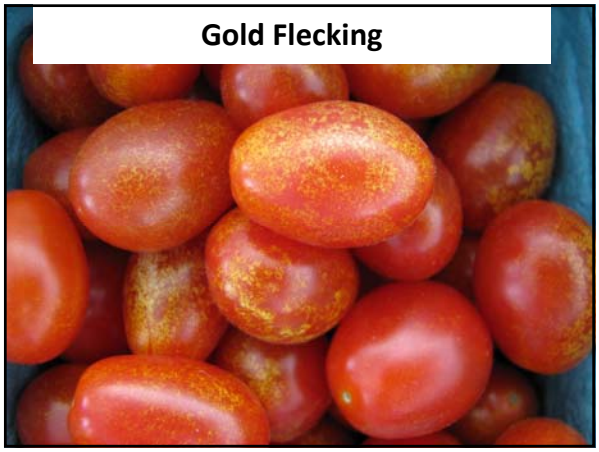
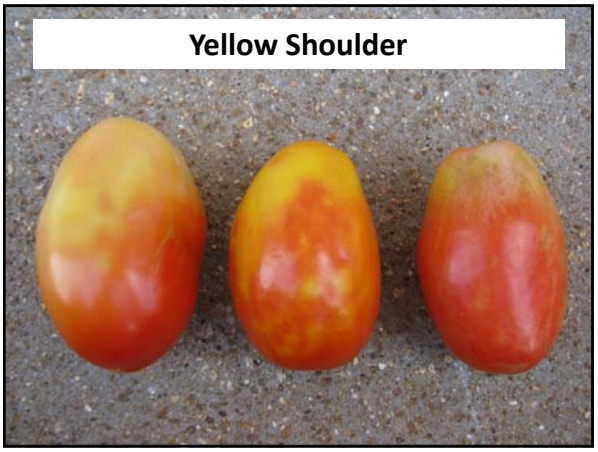
Radial Fruit Cracking

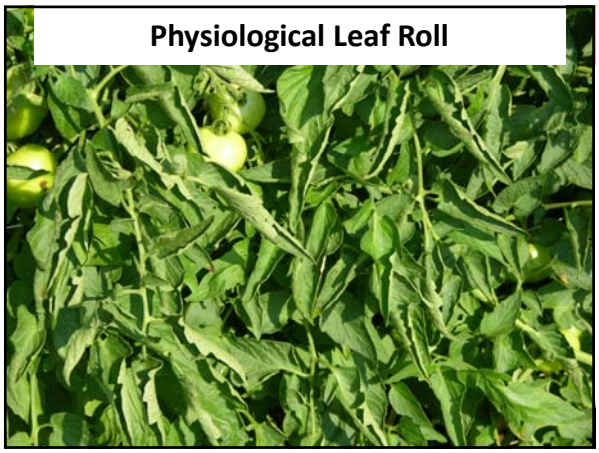
Gold Flecking



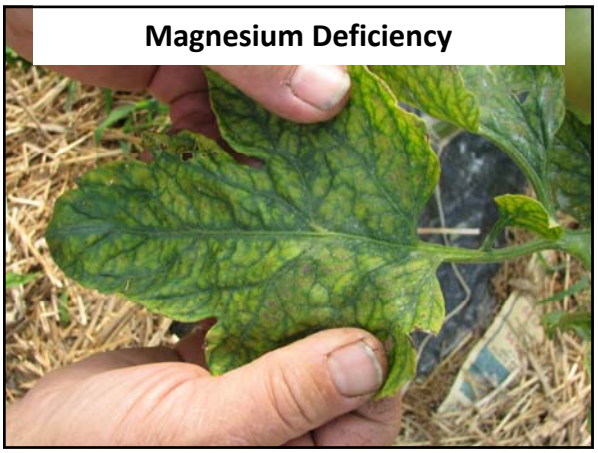
Yellow Shoulder



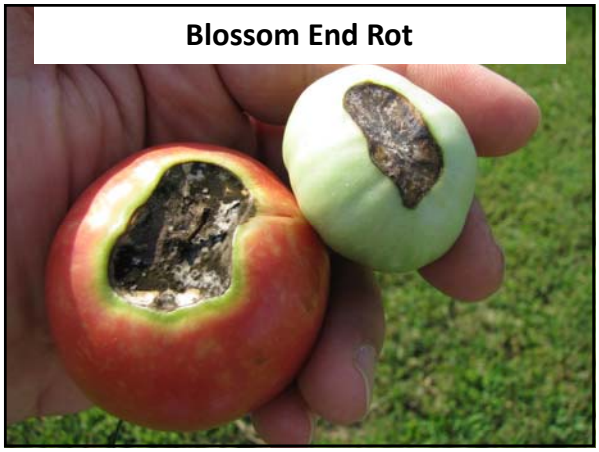
Physiological Leaf Roll



Magnesium Deficiency



Blossom End Rot



Phenoxy Herbicide Injury

Identify Pests Correctly

Early blight

Identify Pests Correctly

Pythium stem rot

Southern blight

Identify Pests Correctly

Bacterial spot

Tomato Anthracnose

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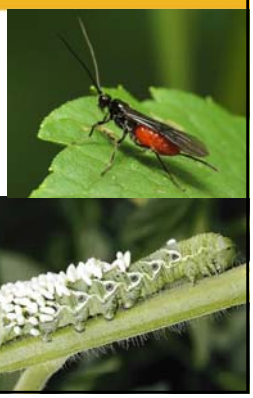
Stink Bug Injury

Tomato Pinworm

IPM Strategies and Tomato

- Biological control
  - Bt for tomato fruitworm and hornworm control
  - Beneficial insect control of aphids, hornworms and other insects



IPM Strategies and Tomato

- Biological control
- Mechanical control
  - Insects
    - Hand removal of tomato hornworms
    - Barriers for cutworms
    - Water blasts for aphids
    - Row covers for exclusion
  - Diseases
    - Prune out diseased parts
    - Removal of overwintering sites or stages (weeds, debris)
  - Weeds
    - Cultivate or hand pull weeds

IPM Strategies and Tomato

- Biological control
- Mechanical control
- Cultural control
  - Rotation of planting sites
  - Establishment of plantings
    - Clean seed, media, containers
    - Clean transplants
  - Trellising and pruning
  - Use of drip irrigation
  - Use of plastic or organic mulches
  - Use of protected structures (tunnels)
  - Sanitation – removal of plant debris (early blight), incorporation into the soil (southern blight)
  - Disinfection of cages and stakes

IPM Strategies and Tomato

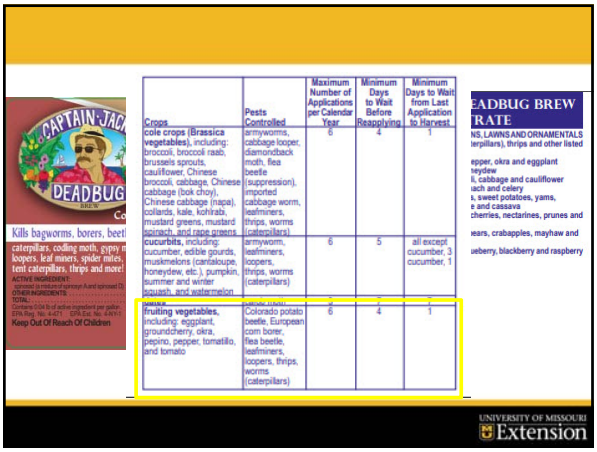
- Biological control
- Mechanical control
- Cultural control
- Genetic control
  - Disease resistant cultivars
    - V: verticillium wilt
    - A, AL, AB: alternaria early blight
    - F + 1-3: races of fusarium wilt
    - N or RN: root knot nematode
    - BW: bacterial wilt
    - EB: early blight
  - Disease resistant rootstocks

IPM Strategies and Tomato

- 'Juliet' tomato
  - F1 hybrid
  - Vigorous growth
  - Productive
  - Paste-type tomato
  - Good crack resistance
  - Disease Resistance Codes: AB, LB

IPM Strategies and Tomato

- Biological control
- Mechanical control
- Cultural control
- Genetic control
- Chemical control
  - Use the Midwest Vegetable Production Guide
  - Follow labels
  - Watch reentry times
  - Watch postharvest interval



Steps of Effective IPM

- Establish a policy.
- Identify pests correctly.
- Monitor pest populations on a regular basis.
- Determine action threshold.
- Choose the proper management tactic or combination of tactics.
- **Evaluate the effectiveness of the management plan.**

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Resources

- Cornell University Organic Guides for Vegetables - http://nysipm.cornell.edu/organic_guide/veg_org_guide.asp
- Midwest Vegetable Production Guide - https://btny.purdue.edu/Pubs/ID/ID-56/
- Organic Vegetable Production (Purdue University) - https://www.extension.purdue.edu/extmedia/id/id_316.pdf
- Organic Vegetable Production (Penn State U) - http://extension.psu.edu/business/ag-alternatives/horticulture/horticultural-production-options/organic-vegetable-production
- Organic Materials Review Institute (OMRI) www.omri.org/omri-lists

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Any Questions?

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