Organic
Insect and Disease Management

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Outline

- Insect Management
- Disease Management
- Resource List

What the NOP Says about Pest Management

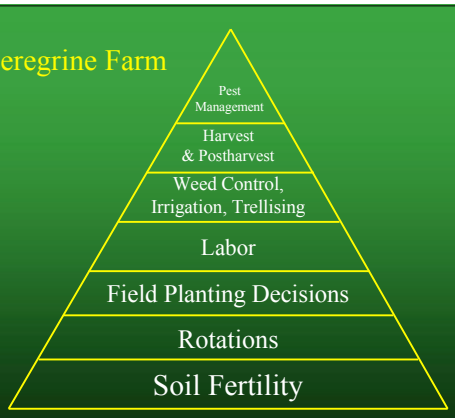
- When cultural, mechanical, and biological strategies are insufficient to prevent or control crop pests, a biological or botanical substance or a substance included on the National List of synthetic substances allowed for use in organic crop production (www.ams.usda.gov/nop/NationalList/FinalRule.html) may be applied to prevent, suppress, or control pests, weeds, or diseases
- The conditions for using the substance *must* be documented in the organic system plan

Organic Pest Management Philosophy

Organic Pest Management Approach

- pests are indicators of how far a production system has strayed from the natural ecosystems it should imitate
- insect pests are attracted to a plant that is weak or inferior
- in a well-balanced system, massive pest outbreaks are rare due to the presence of natural predators, parasites, and disease agents

Peregrine Farm



Organic Pest Management Approach

- prophylactic, holistic approach vs. remedial approach
- not just treating symptoms
- pest problem usually indicates sub-optimal growing conditions and imbalance
- emphasis on biodiversity and optimal cultural practices

Organic Pest Management: Example

- Conventional approach: spray insecticide to control caterpillars, which often results in a secondary outbreak of aphids or spider mites because beneficial insects such as lady beetles and other predators are also killed
- Organic approach: enhance habitat for beneficial insects to increase population, reduce stress on crop plant, use adapted varieties, and use non-chemical methods to control pests (Bt, hand-picking, row covers, alternating planting dates, traps, etc.)

Insects

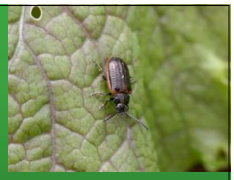
Cultural Controls

Physical Controls

Biological Controls

Organic Pesticides

Cultural Controls



The goals of cultural practices:

1. reduce initial pest levels by making the crop environment unfavorable for pest development
2. produce favorable conditions for natural enemies
3. increase the plant host's ability to withstand pest damage

In organic systems, cultural practices that *prevent* pest problems are the first line of defense for farmers

Cultural Controls

- Resistant cultivars
- Crop rotation
- Companion planting
- Timing of planting
- Sanitation
- Soil Management
- Mulches
- Composting
- Tillage
- Flaming
- Trap crops

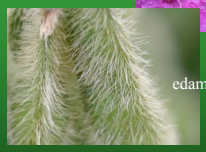
Resistant Cultivars

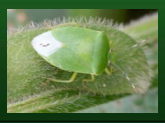
- Some varieties may be less attractive to pest species or tolerate more damage than others
- Plant size, shape, coloration, leaf hair, cuticle thickness, and natural chemicals (attractants and repellents) can all affect pest susceptibility

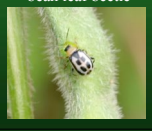
Resistant Cultivars

- *Morphological characteristics* include those plant structures that interfere with insect movement, feeding, or reproduction associated with that plant
- Examples include color, thickness of the cell walls and plant tissue, surface wax, spines and trichomes


waxy cabbage leaf


edamame


stink bug


bean leaf beetle

Resistant Cultivars

- *Physiological defenses* include plant-produced compounds that deter certain pests – e.g., pyrethrum, is derived from the blooms of an African chrysanthemum
- Some plants have specific color-related resistance
- Most insects are attracted to leaves in the yellow-green color range. Healthy, dark green leaves are less attractive than yellowing plants under stress

pyrethrum pesticide

Crop Rotation

- insects overwinter in soil and debris, reinfest new crop if susceptible and build up populations
- 3 questions to consider when deciding whether crop rotation will help manage a pest:
  - How long can the pest persist in the field without any host
  - How capable is it of invading from other areas
  - How well does it survive on other hosts when the crop is not present
- design your rotation plan to present a non-host to pest insects
- know your botanical families; leave as much time as possible between related crops

Companion Planting

- attractant crops - small-flowered - carrot family, daisy family, mint family - catnip, caraway, dill, fennel, hyssop, lemon balm, parsley, rosemary, thyme, yarrow, etc.
- repellent crops - catnip and tansy repel aphids, Artemesia repels flea beetles???
- Lots of recommendations out there with little scientific evidence; need more study before recommending; some companion plants increase pest populations

Timing of Planting

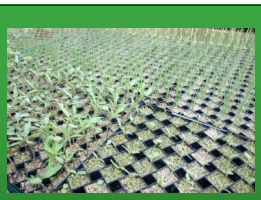
- keep notes to record pest and disease outbreak patterns - the first date you see a problem and the coinciding phenological events
- adjust planting schedule accordingly to avoid peak pressure
- experiment with different planting dates - e.g., to avoid corn earworm or flea beetle or squash bug
- plant crops susceptible to nematodes early or late while soil temperatures are cooler

Timing of Planting: Peregrine Farm Example

winter squash is planted before June 1 to reduce pickleworm damage

pickleworm larva

adult moth



Method of Planting

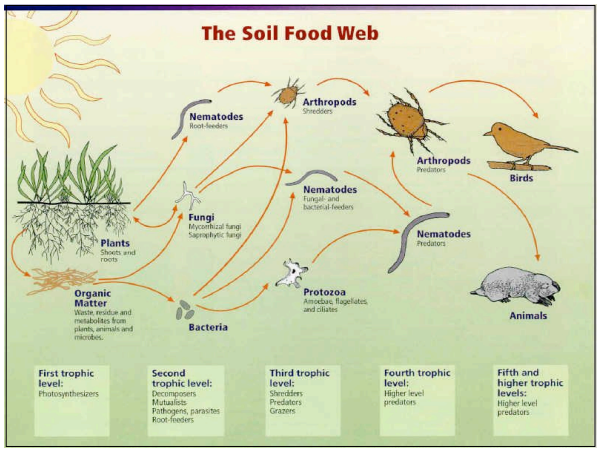
- The method of planting – direct-seeded vs. transplants – can also affect a crop's ability to resist pests.
- Direct-seeded crops require the right conditions to emerge quickly and grow fast.
- The use of transplants when possible can speed crop development.
- Plants struggling to survive or under stress will be more attractive to insect pests and more affected by damage.

Sanitation

- select healthy plants
- rogue and prune
- remove crop debris promptly to reduce overwintering sites for pests
- eliminate alternate hosts, but be careful about timing

Soil Management

- Healthy soils high in OM and with a biologically diverse food web support plant health and nutrition better than soils low in organic matter and species diversity. Healthy plants are generally less susceptible to pest damage.
- Approximately 75% of insect pests spend part of their life cycle in the soil. Healthy soils contain many natural enemies of insect pests, including insect predators, pathogenic fungi, and insect-parasitic nematodes.



Tillage

- disrupts life cycle of pests and beneficials
- can expose pests to predators, the elements
- till before planting to control weeds that harbor armyworms, cutworms, plant bugs, aphids
- till in the fall to destroy overwintering sites for flea beetles, corn borers, squash bugs, etc.
- balance with need to maintain groundcover and not burn organic matter – remember what Alex said about tilling when cool and dry!

Soil Management

- A soil's physical condition – its level of compaction, water-holding capacity, and drainage – all affect soil and plant health.
- The chemical aspects of soils – pH, salt content, availability of nutrients, etc. – can affect crop health and pest susceptibility.

Strategies for Improving Soil Health

- Increase soil organic matter
- Keep soils covered with cover crops and/or crop residue to reduce erosion and protect from extremes of moisture and temperature
- Plan tillage operations carefully

Example of Soil Management Affecting Pests

wilted broccoli plant

seedcorn maggots feeding on root ball

crimson clover cover crop next to beds

Nutrient Management

- Both the type and amount of fertilizer can have a significant impact on a crop's susceptibility to pests.
- Increasing soluble nitrogen levels in plants can decrease resistance and increase pest numbers and crop damage.
- Research has shown that organic systems that rely on more slow-release nutrient sources tend to be less susceptible to insect pests.

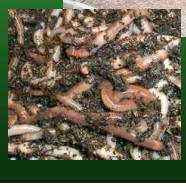
One example from California found that organically fertilized broccoli developed lower populations of flea beetles and cabbage aphids than conventionally fertilized broccoli.

Mulches

- Plastic mulches that speed early season crop growth can enhance plant's ability to withstand insect feeding
- Reflective mulches can reduce thrips and aphid populations in crops
- Straw mulch can reduce problems with Colorado potato beetle

Composting

- helps control pests above- and below-ground
- improves structure, moisture-holding capacity, nutrient content, beneficial organisms



Flaming

- technique aimed at overwintering Colorado potato beetle
- propane burners used to quickly pass a flame over young potato plants when beetles are on top
- does little harm to the crop when the plants are less than 4-5" tall

Trap Crops

- A trap crop is a crop that is planted to lure insect pests away from the cash crop.
- Successful use of trap crops can be challenging. Trap crops are not effective against pests that are weak fliers (e.g., aphids) or are wind-dispersed (e.g., spider mites).
- In organic systems with fewer insecticidal options, pests in trap crops are often killed through crop destruction. But the timing of crop destruction is critical.
- Research on trap crops has revealed mixed results for its use as a pest management strategy.

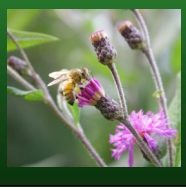
Trap Crop in Organic Broccoli in NC

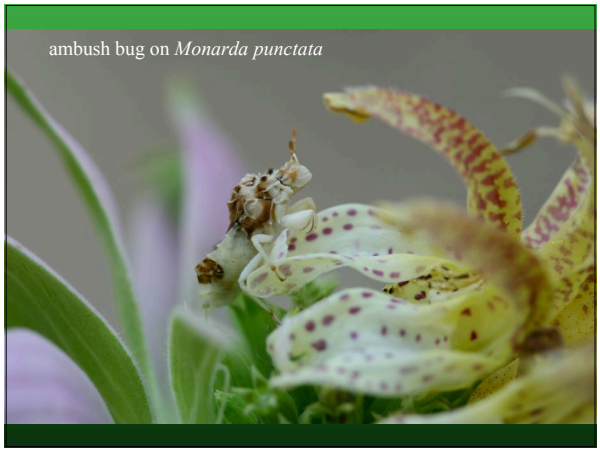
mustard trap crop

striped flea beetles

Harlequin bugs

Farmscaping to Attract Beneficials



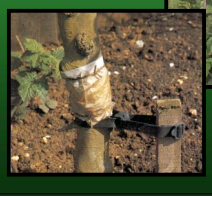


ambush bug on *Monarda punctata*

Physical Controls

Physical Controls

- Manual controls
- Physical barriers
- Baits, traps, and lures



Manual Controls

- Hand-picking
- Mowing
- Pruning
- Shaking
- Water sprays

Physical Barriers

- Bagging fruit
- Copper strips
- Crawling pest barriers
- Cutworm collars
- Floating row covers
- Mulches
- Trenches
- Trunk bands

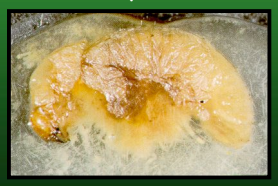
Baits, Traps, and Lures

- Bait traps
- Japanese beetle traps
- Pheromone traps
- Slug and snail traps
- Sticky boards
- Trap crops
- Water traps

Biological Controls

Biological Controls

- Beneficial animals and insects
- Beneficial microorganisms - Bt, milky spore, *Beauveria bassiana* (fungus), *Nosema* (protozoan)



Biological Control in Action

Augmentation
increase population through purchase & release

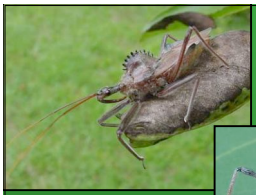
Conservation
increase existing populations through habitat conservation & other means

Beneficial Organisms

- Predators: larva or adult hunts, attacks, and consumes prey; examples include lady beetles, lacewings, praying mantids, syrphid flies, assassin bugs, minute pirate bugs, spiders, and predatory mites
- Each one eats many insects in its lifetime
- Not picky eaters

Predators: Examples

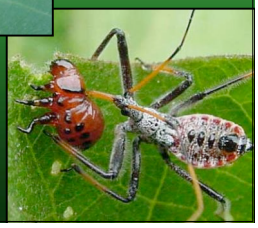
Wheel Bug



wheel bug nymph

nymph feeds on Colorado potato beetle larva

wheel bug molting



Lady Beetles

pink-spotted lady beetle

larva and eggs

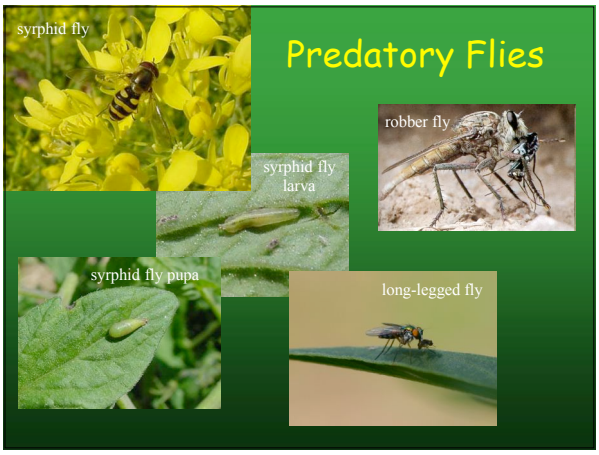
convergent lady beetle

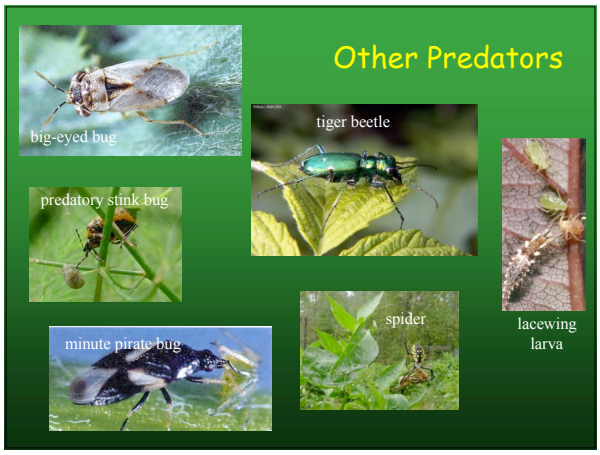
larvae hatching

aphid dinner

seven-spotted lady beetle

larva feasting on aphid

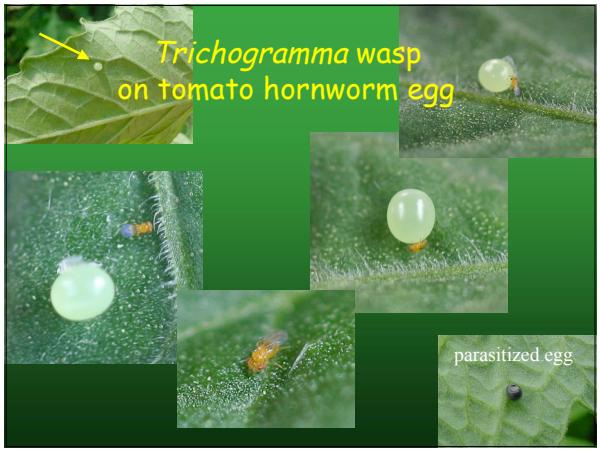


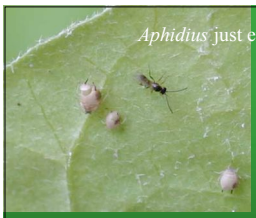


Beneficial Organisms

- Parasitoids: immatures develop on or inside a host, killing it as they mature; they emerge as adults and continue the cycle; examples include parasitic flies and wasps
- Each one eats only one insect in its lifetime
- Usually very picky eaters

Parasitoids: Examples



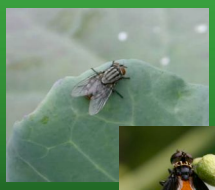


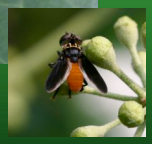
Aphidius just emerged from aphid mummy

More Parasitic Wasps

Scelionid wasp parasitizing stink bug egg cluster

Tachinid Fly





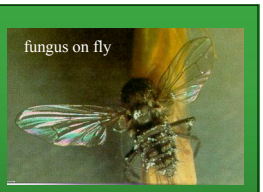
Tachinid fly egg laid on spined soldier bug!

Beneficial Organisms

- Pathogens: colonize and kill host; examples include nematodes, bacteria, viruses, fungi and protozoa
- Weed Feeders: weeds can be attacked by arthropods, vertebrates, and pathogens (fungi, viruses, bacteria, and nematodes)

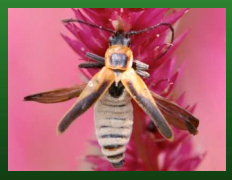
Insect Pathogens

nematodes on larva



fungus on fly

fungus on loopers



fungus on soldier beetle

Organic Pesticides: Rescue Treatments

Organic Pesticides for Insect Management

- Botanical pesticides
- Microbial pesticides
- Inorganic pesticides

Botanical Pesticides

- Plant-derived materials such as neem, pyrethrum, rotenone, ryannia, and sabadilla

Characteristics of botanical insecticides:

- break down rapidly in the environment
- some are more toxic (mammalian) than synthetic pesticides
- broad spectrum
- must be used carefully
- many are not approved for organic production; only neem and pyrethrum, and they are regulated and to be used only as a last resort after other strategies have failed

Toxicity of Botanical Pesticides

Insecticide	LD_{50}
Parathion	18-50
Sevin, Nicotine	246-283
Ryania	1,200
Aspirin	1,200
Rotenone	1,500
Pyrethrin	1,500
Malathion	2,800
Table Salt	3,320
Sabadilla	5,000
Neem, pyrethroids	>5,000

Microbial Pesticides

- Microbials tend to not be as toxic as botanicals and are more selective and softer on beneficials
- *Bacillus thuringiensis* (Bt)
- parasitic fungi - e.g., *Beauveria bassiana*
- parasitic nematodes – e.g., *Heterorhabditis*
- Spinosad

Microbial Pesticides

Limitations of microbials

- Slow host death
- High dosages required
- Need favorable environment
- UV light and temperature affect persistance

Bacillus thuringiensis (Bt)

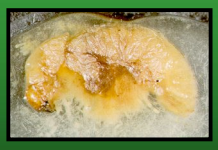
- *Bacillus thuringiensis* (Bt) – contains a toxin made by a soil bacterium; choose appropriate formulation for the pest
- has been incorporated into commercial plants to make them insecticidal (these GMOs are not allowed in organic production)
- sprayed formulations sensitive to UV light; best applied late in the day
- must be ingested to work
- several OMRI-approved formulations

Parasitic Fungi

- parasitic fungi - e.g., *Beauveria bassiana*
- The spores of the fungus germinate once they come into contact with the insect pest, then the fungus must penetrate the cuticle and infect the body cavity to kill the pest
- Effective on many insects including aphids, thrips, whiteflies, and grasshoppers
- Work best when applied at onset of infestation
- Takes a week or more after application to see evidence of control
- OMRI-approved formulations include Mycotrol™, Naturalis L

Parasitic Nematodes

- naturally occur in soil
- semi-aquatic; live and move in soil water
- sensitive to UV radiation and desiccation
- *Heterorhabditis* (Hb) for control of deep-dwelling lethargic pests like Japanese and June beetles
- *Steinernema* (Sc) nematodes for control of shallow-dwelling active pests such as fungus gnat larvae, shore flies, etc.



Parasitic Nematodes

- application - spray or irrigation; drip, fertigation; aerial, watering can; application should be followed by irrigation; don't apply during hottest part of day but soils should be >60°
- soil physical properties affect efficacy
- works well in labs; poor understanding of why failures occur in field
- not sure how to increase control to provide economic pest control
- important to follow instructions

Spinosad

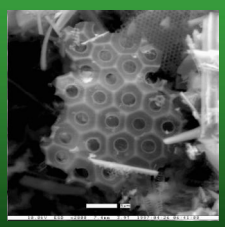
- Spinosad gets its name from the microbe that produces it, a soil-dwelling bacterium called *Saccharopolyspora spinosa*. Controls beetle larvae, caterpillars, thrips, etc. Most effective when ingested rather than as a contact insecticide
- Fast-acting, better than Bt on caterpillars; supposedly not as soft on beneficials so use in targeted areas
- Entrust™ - Formulation approved for organic production in many vegetables

Inorganic Pesticides

- Diatomaceous earth
- Cryolite – not allowed in organics
- Kaolin
- Insecticidal soap
- Horticultural oil

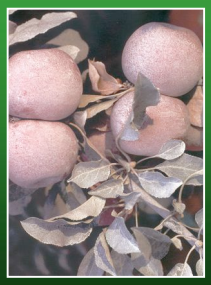
Diatomaceous Earth

- Diatomaceous earth (silicon dioxide) - finely milled fossilized remains of diatoms; product can scratch insect exoskeleton or puncture gut lining (if ingested); can be used as a desiccant; can be put on wet foliage to get it to stick
- Insects: aphids, mites, caterpillars



Particle Film Barrier

- Kaolin - clay material (e.g., Surround™) ground to a uniform size; when sprayed forms a particle barrier on plant surfaces that is effective for both insects and some diseases; coating repels insects or prevents pathogen spores from germinating; must be sprayed ahead of time on a 7-14 day schedule; washes off easily & must be reapplied after rain; agitation is required to keep it suspended
- it is a proven product, just need to sort out what it works on
- Residue can pose a problem for some vegetables and is not useful on flowers because it can't be washed off



Horticultural Oils

- used more now that refining methods have reduced chance of phytotoxicity
- kill by smothering eggs or insects
- summer oils are used at 0.5% - 3% finished solution
- testing for phytotoxicity is important
- dormant oils used in the winter and must be applied at the proper time
- check to see if formulation allowed for organic production

Insecticidal Soap

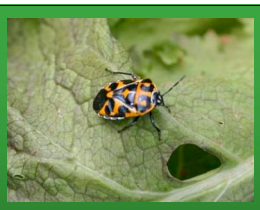
- used to control soft-bodied insects; effective only on contact so thorough coverage is needed - not residual so will not provide long-lasting control
- home-made soaps not recommended as they can be phytotoxic
- commercial products may perform better as they are especially formulated for insect control
- can help control aphids, some caterpillars, scale crawlers, leafhopper nymphs, mealybugs, thrips, whiteflies

A Few of the South's Most Wanted Insect Pests (and how to control them!)

Flea Beetles

- Row covers
- Sanitation to control weedy hosts
- Trap crops
- Crop rotation
- Timing of planting
- Organic pesticides: insecticidal soap, Spinosad, neem, pyrethrum, particle film barrier?
- Hb nematodes

Harlequin Bugs



- Sanitation
- Trap crops
- Pesticides: Insecticidal soap, pyrethrum

Colorado Potato Beetle

- Crop rotation
- Resistant varieties
- Straw mulch
- Flaming
- Trenches
- Row covers
- Organic pesticides: Spinosad, neem
- *Beauveria bassiana*
- Parasitic nematodes?

For More Info on Pest Management…

Photos and Fact Sheets
of NC Insects Pests and Beneficials:

http://chatham.ces.ncsu.edu/growingsmallfarms/insects.html

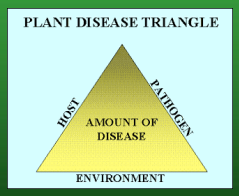
Coming Soon to the GSF Website: Organic Pest Management Strategies for Specific Pests:

http://chatham.ces.ncsu.edu/growingsmallfarms/pestmanagement.html

Diseases

Address the Three Conditions Required for Pathogens

- Susceptible host plant – avoid with resistant and tolerant cultivars, crop rotation
- Presence of inoculum – reduce through sanitation
- Environmental conditions – limit with cultural practices



Site Selection Considerations

- Soil type and associated drainage patterns
- Field layout and exposure
- Soil compaction

Plan for Diversity over Time

- Rotation - soil inhabitant or soil invader
- Crop-free periods - obligate parasites
- Sowing dates and harvest time can be adjusted

Plan for Diversity over Space

- Most garden-scale plots are already diverse!
- Use variety mixtures
- Employ intercropping

Plan for Genetic Diversity

- Host plants
- Soil microbial communities
- Use of cover crops, no-till

broccoli with rye/vetch cover crop

Exclusion and Evasion

- Use of plant quarantines
- Don't import diseases on seeds or in soil
- Control weeds and alternative hosts
- Evade problems by growing seed plants in areas of low or no disease pressure for that particular plant

Variety Selection

- Disease resistance vs. disease tolerance
- Select cultivars that have disease resistance/tolerance characteristics that are appropriate for your climate
- Local/regional heirloom varieties have often evolved with particular disease-resistant characteristics
- Keep good records of a cultivar's performance and the disease pressure for each season

Resistant Varieties

- Host resistance is the easiest, cheapest, safest, and most effective means of managing diseases!
- Especially important for soil-borne diseases such as fusarium wilt, verticillium wilt, bacterial wilt, nematodes, Phytophthora crown and root rot of peppers

Sanitation to Reduce Inoculum

- Start with clean seed
- Hot water treatment
- Disease-tested certified seed
- Western-grown

Transplant Production

- Buy from a reputable producer
- Use clean, sterile containers and growing structures
- Use soilless mix
- Provide good air movement, temperature control and optimal germinating conditions
- Keep seedling flats up off the ground avoiding contact with soil-borne pathogens

General Strategies

- Rogue isolated infected plants from the field during the growing season
- Increase air movement by staking, pruning, and using wide-row spacing
- Use drip irrigation to minimize leaf wetness period
- Use mulch to prevent soil splashing onto foliage and fruit
- Avoid working in the field when foliage is wet to reduce the spread of inoculum

General Strategies

- Use tunnels or greenhouses to reduce moisture on foliage and soil splashing

Vegetable Grafting

- It started in Japan and Korea in the 1920s to control soil-borne diseases in the greenhouse – watermelon grafted onto gourd
- Today almost 95% of the watermelons, oriental melons, cucumbers, tomato and eggplant crops are grafted before being transplanted to the field or greenhouse in Japan
- Grafting can give the best of both worlds: it allows the grower to combine the good genetic disease-resistance of hybrid rootstock without hindering fruit quality

Benefits of Vegetable Grafting

- Disease resistance
- Improved stress tolerance
  - Salt-tolerant
  - Extreme moisture
  - Season extension
- Improved yields – vigorous rootstock varieties can improve water & nutrient uptake

North Carolina State University Grafting Research

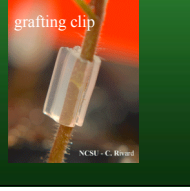
- Dr. Frank Louws and grad student Cary Rivard are grafting heirloom tomato varieties onto hybrid disease-resistant rootstock

Download publication from GSF website at http://chatham.ces.ncsu.edu/growingsmallfarms/diseaselinks.html

Tomato Grafting

scion graveyard

graft union



General Strategies

- Use raised beds to improve drainage
- Cultivate carefully to promote healthy root growth
- Use floating row covers and reflective mulches to reduce insect vector activity
- Harvest gently to minimize cuts and bruises on the produce
- Cool produce rapidly after harvest to slow microbial activity; store at cool temperatures

General Strategies

- Optimize NPK fertility to reduce stress
- Rotate crops and incorporate crop residues to reduce inoculum buildup
- Plow, disk or roto-till immediately after harvest to speed up the decomposition of plant tissue
- Wash equipment frequently to reduce the spread of inoculum

Organic Pesticides for Disease Management

Organic Pesticides for Disease Management

- Copper & Sulfur
- Plant extracts
- Biofungicides
- Microorganisms
- Particle Film Barrier
- Peroxides & Bicarbonates
- Compost Tea

Some of the South's Most Wanted Vegetable Diseases (and how to control them!)

Early Blight

Use crop rotations of at least 3 years to non-hosts.

Provide optimum growing conditions and fertility.

Allow for good air circulation.

Use drip irrigation to keep the period of leaf wetness to a minimum.

Apply mulch to help prevent splashing of spores from soil up to lower leaves; Stake or cage plants to keep fruit and foliage away from soil.

Treat seed at 122°F for 25 minutes.

Disinfect stakes or cages with an approved product each season before using.

Early Blight: Pesticides

- Serenade® - *Bacillis subtilis*
- *Trichoderma* products (e.g., PlantShield®)
- Copper?

Southern Stem Blight

Remove and destroy infected fruit

Prevent excessive moisture

Stake plants to prevent the fruit from touching the ground

Deep disking will bury host plant debris and sclerotia

Soil solarization

Crop rotation

Southern stem blight on pepper; note white mycelium and sclerotia at soil line

Southern Stem Blight

- Biorationals: *Trichoderma*® products
- *Gliocladium* products: SoilGard® sprayed against base of young plants provides some protection

Bacterial Wilt

- Resistant varieties
- Water management
- Avoid problem areas
- Grafting?

Grower Resource List on the Growing Small Farms Website

http://chatham.ces.ncsu.edu/growingsmallfarms/resourcelist.html

- Books and publications
- Organic seeds
- Fertilizers and soil amendments
- Equipment & supplies for season extension, pest management, cut flowers, etc.
- Transplants, plants, & bulbs
- Livestock & pastured poultry
- Beekeeping

Questions?