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PREPARING A NEW GENERATION
OF ILLINOIS FRUIT AND VEGETABLE FARMERS

PLANT DISEASE MANAGEMENT

in Vegetable and Fruit Production

Rick Weinzierl
(with slides and contributions from
Darin Eastburn and Suzanne Bissonnette)
June, 2014

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Objectives

- Today …
  - Develop an increased awareness of different types of diseases and disease-causing organisms
  - Understand the key practices that prevent or reduce the likelihood and severity of plant disease outbreaks
  - Know the major diseases that warrant concern in vegetable and fruit production in Illinois and where to find recommendations for their management
- Your longer-term goals …
  - Develop plans for disease management in your crops

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Integrated Pest Management (IPM)

- An approach that uses a range of practices that limit losses to pests (insects, pathogens, weeds, vertebrates) while minimizing the environmental damage, human health risks, and dollar costs associated with pest suppression.
  - Tactics include biological control, cultural controls, pest-resistant varieties, regulatory programs … and pesticides where needed and in ways that minimize their adverse effects

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What is plant disease?

- A condition in which a plant differs from a normal or healthy plant
- Occurs over time

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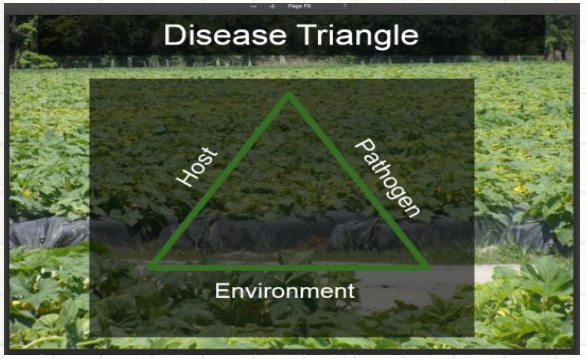
Basic Concepts in Plant Pathology, by J.R. Hartman.
http://www.hort.purdue.edu/mg/pubs/DiagnosisBasicConcepts.pdf



- Types of plant diseases
  - Abiotic noninfectious diseases
  - Infectious diseases
    - The disease triangle
      - Susceptible host plant, infective pathogen, and conducive environment
    - Diseases caused by fungi, bacteria, viruses, and nematodes
  - Disease symptoms and signs
  - Controlling diseases
    - Avoidance, exclusion, eradication, resistance, protection, and therapy

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Two types of plant disease

Non-infectious

- Non-living: Can not be transmitted
- For example: drought, flooding, chemical injury, nutrient stress, environmental stress


Air Pollution: ozone

Infectious disease:

- Living cause, biotic,
- can be transmitted


Stem rot

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Non-Infectious

Glyphosate injury,
sunscald on
pepper,
hail damage

Plant pathogens cause infectious plant diseases

- Fungi & FLO's
- Bacteria
- Viruses
- Nematodes
- Phytoplasma-like organisms (PLO)

(Phytoplasmas are bacteria-like organisms that have a cell membrane instead of cell walls and can assume a variety of shapes, but are parasitic solely in plants. In many plants, phytoplasmas invade cells of the food-carrying tissue known as phloem and are usually spread by plant-sucking insects, such as the leafhopper, which draws its food from phloem. Phytoplasmas cause some 200 plant diseases affecting several hundred genera of plants.)

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Disease organisms

A. Fungi: spores spread by rain and wind; "resting structures" may persist in the soil for multiple seasons

- rusts
- cankers
- leaf spots
- smuts
- root rots

Apple scab, caused by the fungus *Venturia inaequalis*

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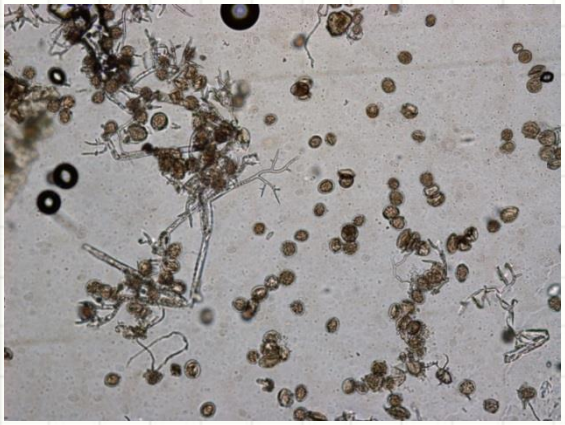
Basil Downy Mildew - *Peronospora belbahri*

- Host specific pathogen – a fungus
- Grows best under moderate-warm temperatures
- Yellowing of leaves, fuzzy white to purple underside growth, curling, brown-blackening lesions
- Can be confused with nutrient deficiency
- Management: Plant disease free seed, varieties vary in susceptibility, minimize leaf wetness / humidity, scout regularly, and protectant commercial fungicides



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Disease organisms

B. Bacteria: single celled, enter wounds

- wilts
- blights
- soft rots

Fire blight of apple, caused by *Erwinia amylovora*

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Bacterial diseases

- Three bacterial pathogens cause spots on tomato fruits …
  - Bacterial Canker – *Clavibacter michiganensis* subsp. *michiganensis*
  - Bacterial Speck – *Pseudomonas syringae* pv. *tomato (not common in IL)*
  - Bacterial Spot – *Xanthamonas campestris* pv. *vesicatoria*
- No cure for canker
- Management for speck and spot is the same:
- Plant disease free seed, plant less susceptible varieties (no completely resistant varieties), minimize canopy / foliage moisture, do not handle wet plants, rotate crops, regular scouting, and protectant commercial bactericides

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Canker

- Older leaves become scorched
- Can be localized to one side and cause sudden wilting
- Only one that causes vascular discoloration and cankers
- White spots with raised dark lesions on fruit (Bird's eye) about 3mm in diameter
- Favored by splashing

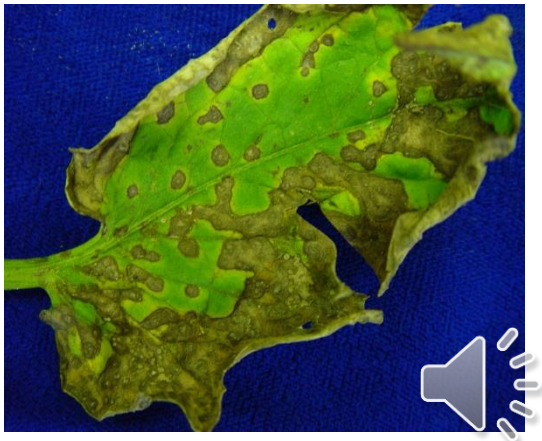
Speck

- Similar to bacterial spot, smaller 1/16" dark specks with halos
  - Can coalesce and kill leaf tissue
- Raised, flat, or sunken lesions (specks) appear on fruits with dark green halos – usually 1mm or smaller
- Prefers cooler temperatures and humidity, spread by splash

Gerald Holmes, Valent USA Corporation, Bugwood.org

Spot

- Causes round / irregular spots 1/8" on leaves
  - Sometimes with halos and will lead to scorching / defoliation
- Fruit symptoms start as tiny (3mm) black, water soaked, pimple like dots. Become raised, scab-like, brown lesions
- Favored by warm temp and precipitation
- Also affects pepper



Disease organisms

C. Viruses: genetic particles; spread by insects & seed

- mosaic
- mottles
- ringspots

Cucumber mosaic virus infection of bell pepper

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Disease organisms

D. Nematodes: microscopic roundworms; live on plant roots or other plant parts

- foliar
- pine wilt
- root knot

Carrot damaged by root-knot nematodes

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Disease cycles:

- Monocyclic (single cycle)
  - one generation, no reinfection within the same growing season

- Polycyclic (multiple cycles)
  - many generations, and reinfection within the same growing season

At what stages in the disease cycle are there ways to manage the disease?

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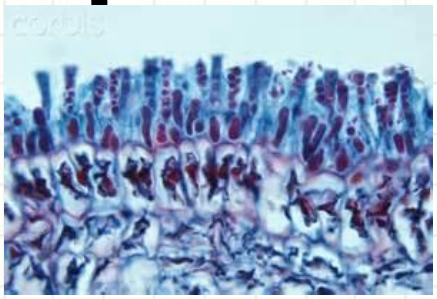
Disease cycle: monocyclic

"Simple Interest"

Overwintering



Inoculum Production

Peach leaf curl

Inoculum

Infection

Symptoms

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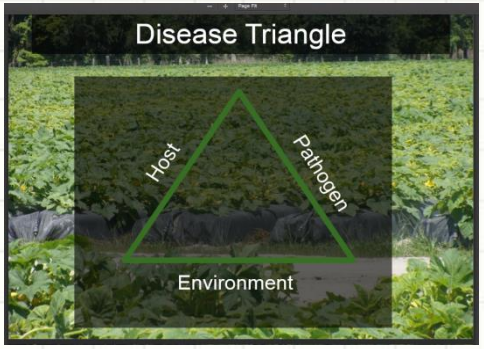
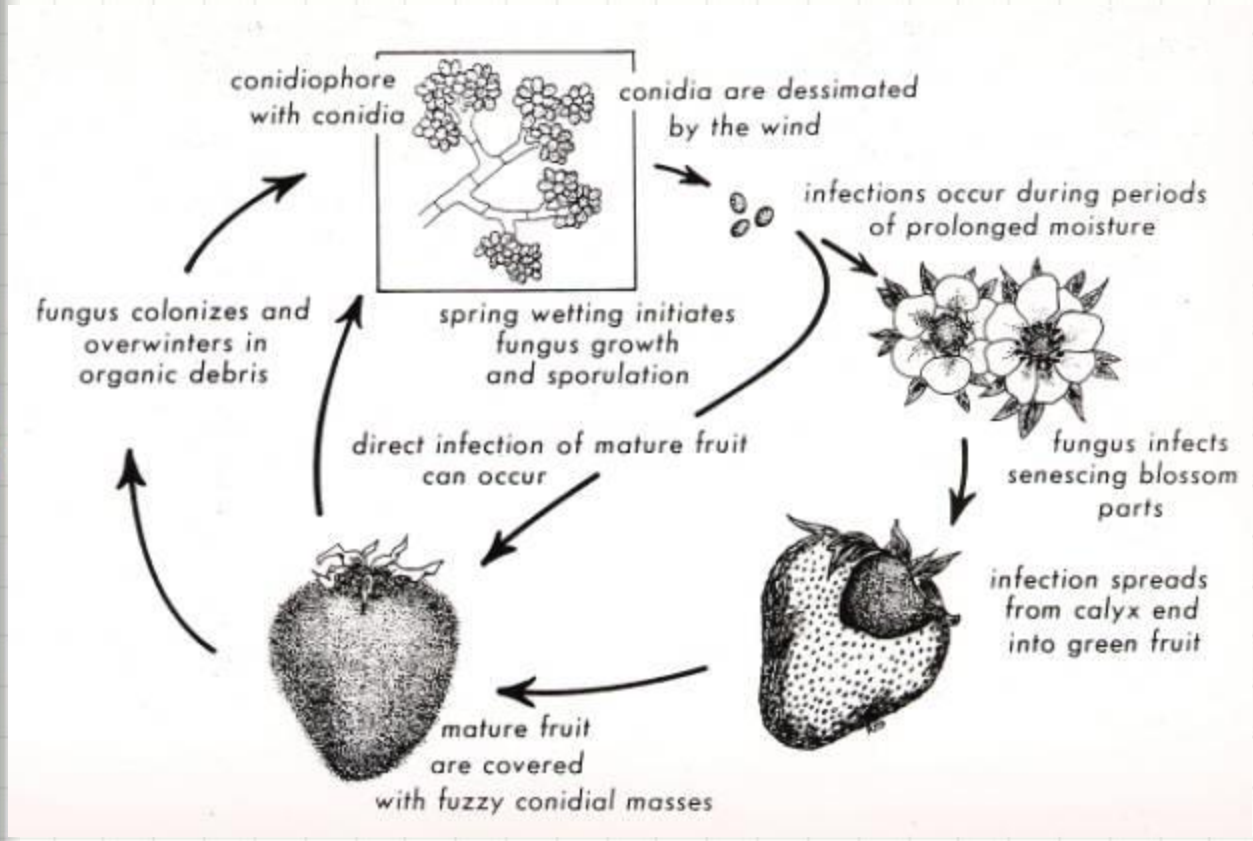
Disease cycle: Gray mold (*Botrytis*) on strawberries

(a polycyclic or compound interest disease)





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Prevention versus Rescue

- Most disease management strategies are preventive; many are implemented at or before the time of planting
- Why “scout” to identify and quantify diseases?
  - To make choices about control for the remainder of the season
  - To make plans for cultural practices for successive crop seasons

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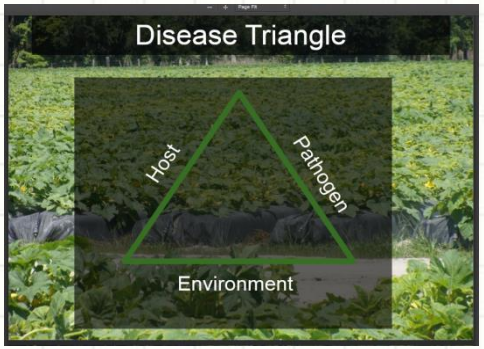
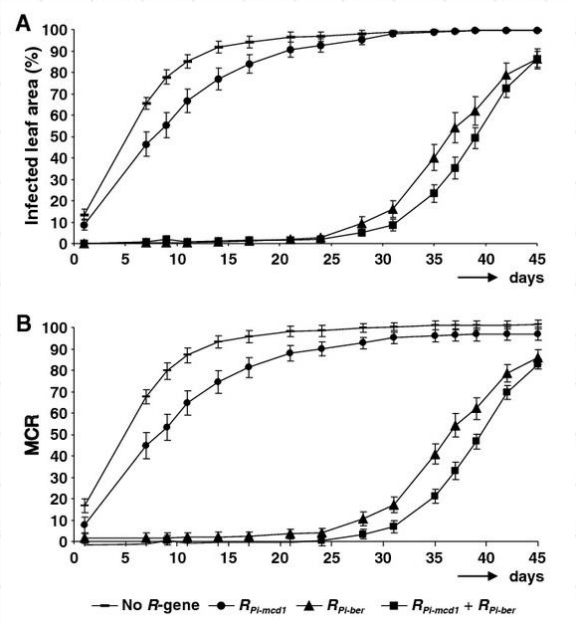
Controlling plant diseases …



- Avoidance
- Exclusion
- Eradication
- Resistance
- Protection
- Therapy



The effect of pyramiding Phytophthora infestans resistance genes R Pi-mcd1 and R Pi-ber in potato , by Tan, M. Y. Adillah; Hutten, Ronald C. B.; Visser, Richard G. F.; Eck, Herman J. Theoretical and Applied Genetics **Vol.** 121 **Issue** 1.

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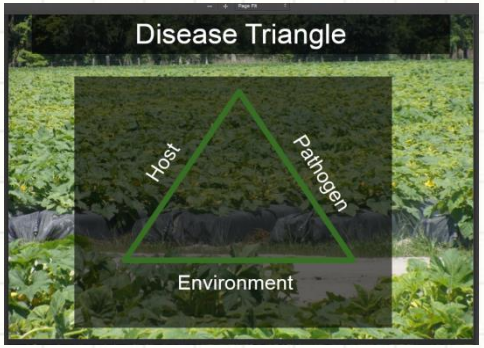
Controlling plant diseases …



- Avoidance
  - By geographic area (climate), planting date, topography and drainage, disease-free planting stock, crop rotations
- Exclusion
  - By disease-free planting stock, quarantines, exclusion of insect vectors

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Site selection

- Cropping history
- Disease history
- Environmental conditions

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Avoiding disease by modifying the environment

- Water management
  - To avoid leaf wetness needed for infections
  - To manage blossom end rot in tomatoes and peppers
- Row orientation, plant densities, pruning
  - Air movement, leaf wetness
- Use of mulches
  - Reduces splash dispersal and protects fruit some soil-borne pathogens
- Growing in high tunnels
  - No overhead water on plants
  - Temperature fluctuations are muted

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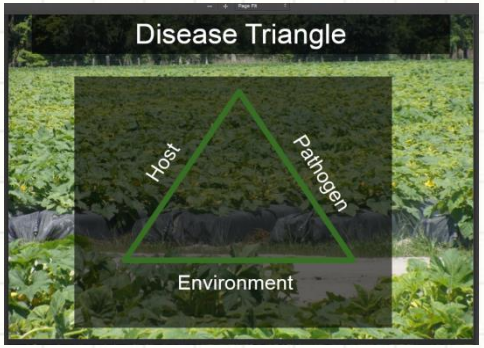
Controlling plant diseases …



- Eradication
  - (Or at least reduction in inoculum) By crop destruction, crop rotation, fumigation or other soil treatments

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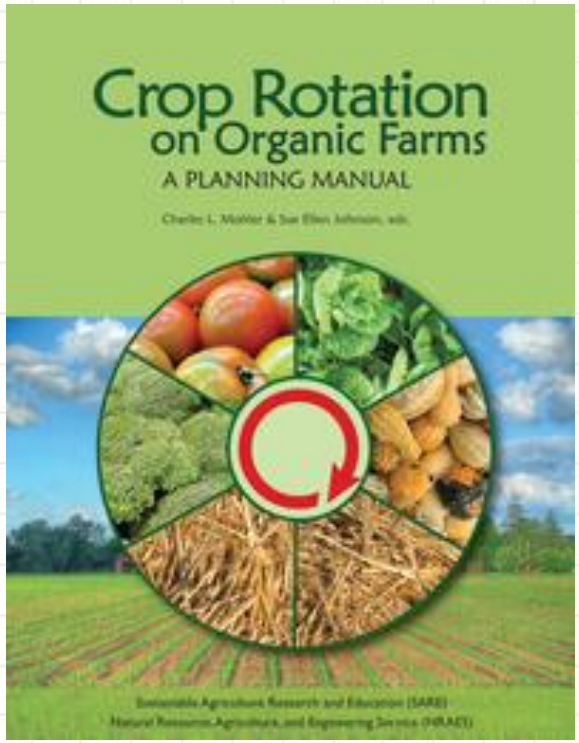
Crop rotation for inoculum reduction and disease avoidance

- Most effective against …
  - Pathogens that survive in the soil or on plant debris
  - Pathogens that do not survive well as saprophytes (growing on dead plant debris)
  - Pathogens with a narrow host range
  - Pathogens that do not spread over long distances by wind
- Rotate among plant families over 3 to 4 (or more) years
- Effectiveness is reduced if equipment, run-off, or wind-blown rain carries soil and pathogens from one plot or field to another



http://www.sare.org/Learning-Center/Books/Crop-Rotation-on-Organic-Farms

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Crop Rotation - Effective

Crop rotation is very effective for reducing pathogen survival and subsequent losses to root-knot nematode in susceptible crops such as carrots and black rot, a bacterial disease in cabbage and related crucifers.

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Crop Rotation – Not Effective

Crop rotation is not effective for management of powdery mildew of cucurbits because spores of the fungus survive long-range dispersal by wind. Likewise rotations do not reduce the incidence of cucumber mosaic virus in peppers and many other plants because aphids carry the pathogen from plant to plant over considerable distances.

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Soil improvement with cover crops and amendments

- Promote disease-suppressive soils
- Biofumigants … primarily mustards
- Composts
- Improve soil properties
  - tilth
  - water holding capacity
  - nutrient holding capacity

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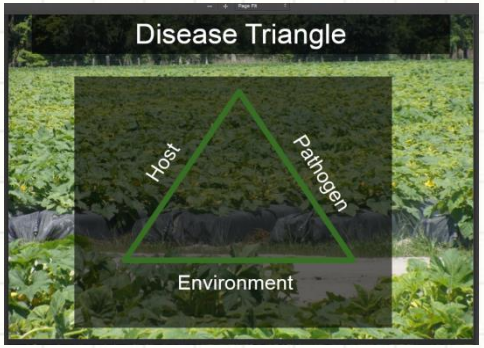
Controlling plant diseases …



- Resistance
- Often the easiest management strategy
  - cost effective
  - usually consistent
  - integrates with other management options
  - not available for all crops/diseases
- Use as much as practical for all vegetables, apples
- Especially important for organic growers

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Vegetable MD Online

Department of Plant Pathology, Ithaca, NY 14853

Listing of disease resistant vegetable cultivars at http://vegetablemdonline.ppath.cornell.edu/Tables/TableList.htm

See companies list disease resistance characteristics whenever available.

Crimson Crisp, an apple with great flavor and texture, is resistant to apple scab and certain other diseases. See https://www.extension.purdue.edu/extmedia/BP/BP-132-W.pdf.

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Disease Resistant Tomatoes

Tomato Variety	Resistance to Diseases and Physiological Disorders																			
	Angular Leaf Spot	Alternaria Leaf Blight	Alternaria Stem Canker	Black Rot	Bacterial Leaf Spot	Bacterial Speck	Bacterial Wilt	Corky Root Rot	Crown Rot	Downy Mildew	Early Blight	Fusarium Wilt	Fusarium Wilt 1	Fusarium Wilt 2	Fusarium Wilt 3	Fusarium Crown Rot	Fruit Soft Rot	Gray Leaf Spot	Late Blight	Leaf Spot
	ALS	AB	ASC	BR	BLS	BS	BW	CoR	CR	DM	EB	F	F1	F2	F3	FCR	FSR	GLS	LB	LS
Abe Lincoln			X									X								
Abuelo													X	X						
Arbason												X	X							
Ace 55 (cherry)												X								
Agatha							X					X	X	X				X		
Agriset 334													X	X						
Agriset 8279 F1 (grape)													X	X						
Albatross													X	X						
Aligote (grape)													X	X	X					
Amelia VR F1													X	X	X					
Andino (NUN3149)						X							X	X	X					
Angelina F1													X	X						

[Vegetable MD Online]

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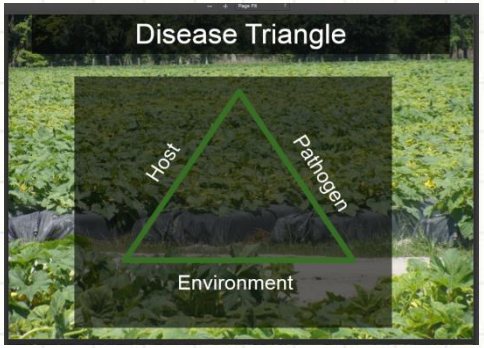
Controlling plant diseases …



- Protection
  - By application of fungicides or bactericides
  - Must be EPA-registered or classified as “Generally Regarded as Safe” (GRAS)
  - For organic production, products must be approved by the National Organic Program (and are labeled as OMRI-approved)
- The safety of fungicides and bactericides is evaluated in part in comparison with the risks that mycotoxins and bacterial toxins pose to food safety

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Fungicides

- *What are Fungicides?* … Chemicals used to kill or prevent growth of fungi, specifically plant pathogens. They are described by …
  - Mobility in Plant – contact or systemic
  - Role in protection – preventive or curative
  - Breadth of activity – single site or multiple site
    - Newer compounds with single-site activity are more likely to trigger resistance in plant pathogens
  - Mode of action – FRAC code
  - Type of chemical – inorganic or organic (carbon)

https://www.apsnet.org/edcenter/intropp/topics/Pages/Fungicides.aspx

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- Copper Fungicides for Organic Disease Management in Vegetables http://extension.psu.edu/plants/vegetable-fruit/news/2013/copper-fungicides-for-organic-disease-management-in-vegetables

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Bactericides

- Antibiotics (streptomycin and oxytetracycline)
- Biologicals that induce plant resistance (SAR)
- Copper compounds

Fungicides, Bactericides, and Nematicides

- For a summary of trade names, chemical names, type of activity, FRAC code, and a general description of uses, see
  - http://pnwhandbooks.org/plantdisease/sites/default/files/pdf/fungicides_bactericides_and_nematicides.pdf

Fungicides, Bactericides, and Nematicides

Not all chemicals listed are recommended or currently registered for use.
See listings for individual crops for recommended uses.

Common or Trade Name	Trade or Common Name	Action*	Fungicide Group #**	Use
Abound	azoxystrobin	B, F, Ls, P	11	Effective against a large number of fungi including powdery and downy mildews. Severe phytotoxicity on apples with a Macintosh heritage.
Absolute	tebuconazole +trifloxystrobin	B, C, F, Ls, P	3 + 11	For rust and powdery mildew control in grasses grown for seed in the PNW.
Accrue	spiroxamine	F, N, P	5	Effective against powdery mildew on hops.
acibenzolar-S-methyl	Actigard, Blockade	A	P1	Labeled for certain vegetable crops.
Acquire	metalaxyl	Fs, N, P, S	4	For seed treatment to control ooymcetes in specified row crops and vegetables.
Acrobat	dimethomorph	F, P	40	**Discontinued**.
Acrobat MZ	dimethomorph + mancozeb	F, P	40 + M3	**Discontinued**.
Acti-dione	cycloheximide	F		**Discontinued**. Antibiotic and fungicide.
Actigard	acibenzolar-S-methyl	A	P1	Labeled for certain vegetable crops.
Actinovate	*Streptomyces lydicus*	F	NC	Filamentous bacteria as a Biological control agent.
Adament	tebuconazole + trifloxystrobin	B, C, F, Ls, P	3 + 11	Label for tree fruits and nuts.
Adorn	fluopicolide	F, N, P	43	Ornamental label for control of oomycetes. Must be tank mixed with another fungicide.
Affirm	Polyoxin D zinc salt	F	19	Antibiotic active against certain fungi and bacteria.
Agclor	sodium hypochlorite	B, Bact, E, F		Used as postharvest dip. Many fruits and vegetables on label.

Disease Management Alternatives for Organic Tomatoes. Miller 2007

Treatment	% Foliar Disease
Control- water to run off	66.0 ab
Humega	75.9 a
Timor	67.6 ab
StorOx	61.4 ab
Biodynamic 508- *Equisetum arvense*	59.0 ab
Kaligreen	47.9 abc
Sonata + Champion WP	45.6 abc
Serenade	44.3 abc
Timorex	44.1 abc
Trilogy	39.5 bcd
Garlic Barrier	39.4 bcd
SW-3	37.1 bcd
Sonata	37.0 bcd
StorOx alternated with Champion WP	25.0 cde
Serenade + Champion WP	21.4 cde
Champion WP	10.8 de
Bordeaux mixture	5.0 e

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Evaluation of fungicides allowed for organic production on foliar diseases of tomato, 2012. Lange et al. 2013

Treatment	AUDPC
Sporatec AG	80.7 ab
Sonata	72.9 ab
Serenade Max	97.4 ab
OxiDate FL + Yucca Ag Aide FL	88.5 ab
Yucca Ag Aide FL	111.2 ab
OxiDate FL	182.4 a
Cueva FL	52.4 b
Non-treated control	141.1 a

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Squash Powdery Mildew Management. Miller 2007

Treatment and rate	% Powdery mildew
Serenade Max 1 lb/A + Kocide 2 lb/A	2.9 g
Serenade Max 2 lb/A + Kocide 2 lb/A	2.2 g
Sulfur 16 lb/A	5.0 g
Whole milk 50%	5.9 g
Mineral oil (stylet-oil) 3.5 qts/100 gals	11.8 ef
Armicarb- 100 5.0 lb/A+ Biolink 1.5 qt/100 gal	11.6 f
Armicarb-100 2.5 lb/A + Biolink 1.5 qt/100 gal	14.7 ef
Soil soup compost tea 100%	17.0 e
Neem oil 0.75 %	23.1 d
Soil soup compost tea 33%	31.8 c
Untreated control, protected	52.9 b
Untreated control, non-protected	80.7 a

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Compost teas

- Compost “brewed” in water
- Aerated and non-aerated processes
- Some use additives (molasses)
- Significant batch to batch variation
- Inconsistent results for disease control
- Problem of human pathogens

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National Organic Standards Board - Compost Tea Task Force Recommendations - April 6, 2004

- Use only potable water to make compost tea or to dilute it.
- Sanitize all of the equipment used to prepare compost tea.
- Make compost tea only from compost that has maintained a temperature of at least131 °F for 3 days and has been mixed so all of the pile or windrow has heated up.
- Do not use additives when fermenting compost tea, as these can promote the growth of harmful organisms. In particular, simple sugar sources, like molasses, should be avoided. If compost tea is made with additives (and not tested for pathogens or toxins), it should not be applied to food crops within 90to 120 days after application (as with raw manure).

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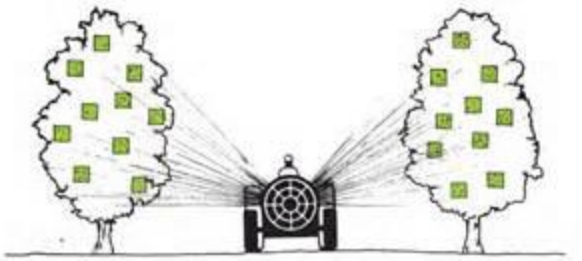
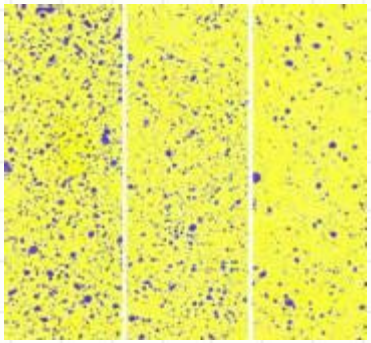
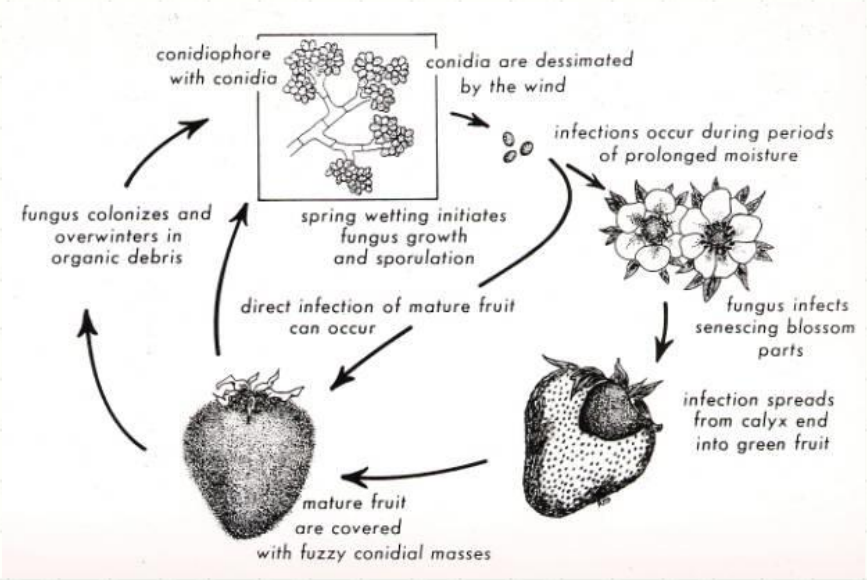
Coverage and timing

- Thorough coverage is essential
  - Adequate water
  - Spreaders, stickers
  - Airblast and air-assisted sprayers
  - Use spray deposit spot cards to monitor
- Timing … before infection







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Models and forecasting systems

- Disease forecasting models for …
  - Stewart's wilt of sweet corn
  - Potato late blight
  - Apple scab, fireblight, and sooty blotch and flyspeck of apples
  - Early blight, Septoria, and anthracnose of tomato (TOMcast)
  - Alternaria leaf blight, gummy stem blight, and anthracnose of muskmelon and watermelon (MELCAST).

Especially important if sprays must be applied before any signs of infection or infestation are present

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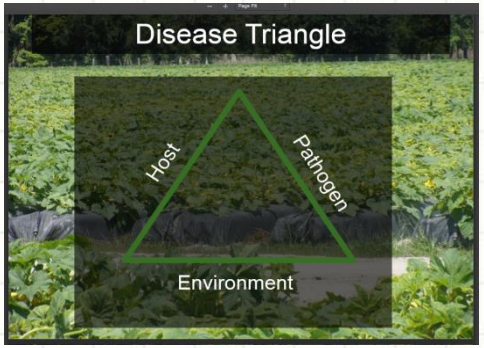
Controlling plant diseases …



- Therapy
  - Removal of diseased plant parts
    - Pruning out fireblight-infected shoots (well below the lowest visible evidence of infection)
  - Hot water seed treatment
    - http://ohioline.osu.edu/hyg-fact/3000/pdf/3085.pdf (by Miller and Ivey, 2005)

Hot Water Seed Treatment

Seed	°F	Minutes
Brussels sprouts, eggplant, spinach, cabbage, tomato	122	25
Broccoli, cauliflower, cucumber*, carrot, collard, kale, kohlrabi, rutabaga, turnip	122	20
Mustard, cress, radish	122	15
Pepper	125	30
Lettuce, celery, celeriac	118	30

* Cucurbit seeds may be damaged by hot water treatment

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Common important diseases of Illinois vegetable crops

- See pp. 67-68 of the 2014 Midwest Vegetable Production Guide at http://www.btny.purdue.edu/pubs/id/id-56/ID-56.pdf

Table 28: Summary of Cultural Management Strategies for Disease

This table describes several diseases listed by crop. This list is not exhaustive, but represents important Midwest diseases. Also listed are the cultural management options available for each disease. The management options are described in more detail in the text. Note that some pathogens have races. The reaction of a particular race of fungus or bacterium will depend on the cultivar or variety grown. Rotation refers to the number of years that the field should be planted to a different crop.

Crop	Disease	Tillage[1]	Seedborne	Rotation	Resistance	Comments
Cabbage	Alternaria Leaf Spot	3	Yes	3-4	No	
	Black Rot	3	Yes	2-3	No	
	Yellows	2	Yes	>6	Yes	Fusarium fungus is soilborne.
Cantaloupe	Alternaria Leaf Blight	3	No	2	No	
	Anthracnose	3	Yes	2	No	
	Bacterial Wilt	1	No	NE[2]	No	Spread by cucumber beetles.
	Gummy Stem Blight	3	Yes	3	No	Also affects pumpkin, watermelon.
	Phytophthora Blight	2	No	>3	No	Water management is important. Avoid rotations with solanaceous crops.
	Powdery Mildew	2	No	2	Yes	
	Root Knot	2	No	>6	No	Wide host range.
Carrot	Alternaria Leaf Blight	3	Yes	2	Yes	
	Bacterial Blight	3	Yes	2-3	No	
Cucumber	Angular Leaf Spot	3	Yes	2	Yes	
	Anthracnose	3	Yes	2	Yes	Race 1 affects cucumber.
	Bacterial Wilt	1	No	NE[2]	No	Spread by cucumber beetles.
	Phytophthora Blight	2	No	>3	No	Water management is important. Avoid rotations with solanaceous crops.

Common important diseases of Illinois fruit crops

- Apples and pears
  - Apple scab, cedar apple rust, powdery mildew, fire blight, sooty blotch, flyspeck, fruit rots
- Peaches and related stone fruits
  - Peach leaf curl, brown rot, peach scab, bacterial spot
- Grapes
  - Black rot, powdery mildew, downy mildew, Botrytis bunch rot
- Blueberries
  - Mummy berry, Botrytis blight, stem canker, stem blight, anthracnose
- Brambles
  - Phytophthora root rot, rust diseases, powdery mildew, Botrytis fruit rot,
- Strawberries
  - Botrytis blossom blight and fruit rot, leather rot, anthracnose, black root rot

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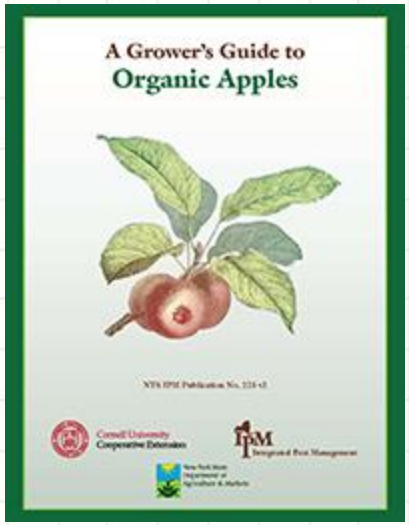
How do you know what to spray against what pest in a given crop?

- Midwest Tree Fruit Spray Guide
  - http://www.extension.iastate.edu/Publications/PM1282.pdf
- Cornell Production Guide for Organic Apples
  - http://nysipm.cornell.edu/nysipm/organic_guide/fruit_org_guide.asp



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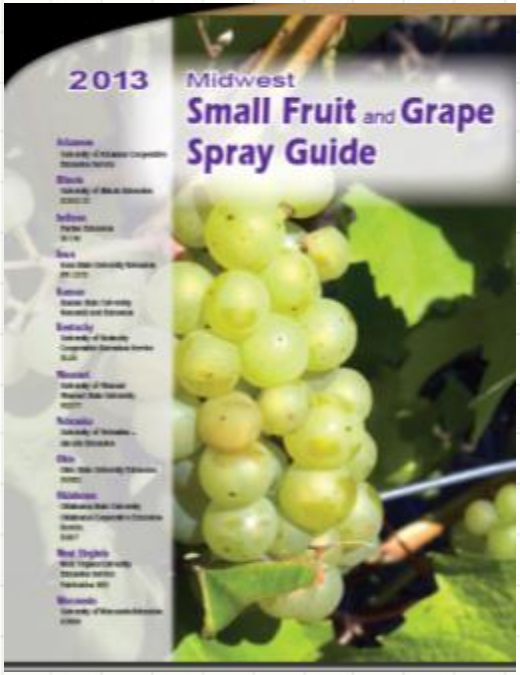
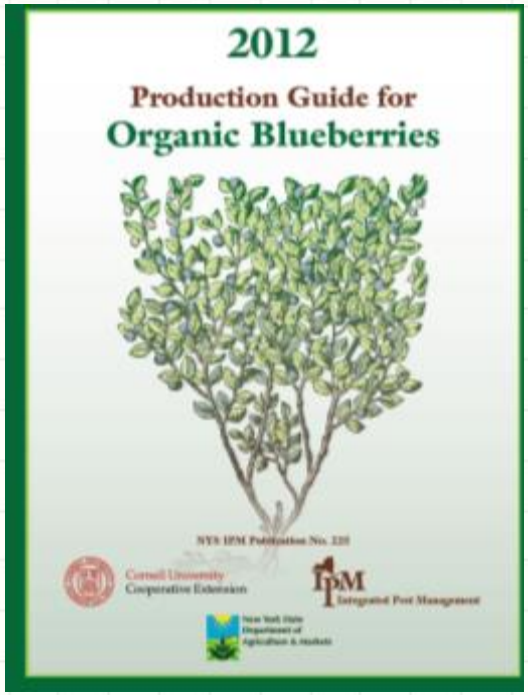


Spray Guides for Small Fruits

- Midwest Small Fruit and Grape Spray Guide:

https://ag.purdue.edu/hla/Hort/documents/ID-169-2013.pdf



- Cornell Organic Production Guides (blueberries, grapes, strawberries)

http://nysipm.cornell.edu/organic_guide/

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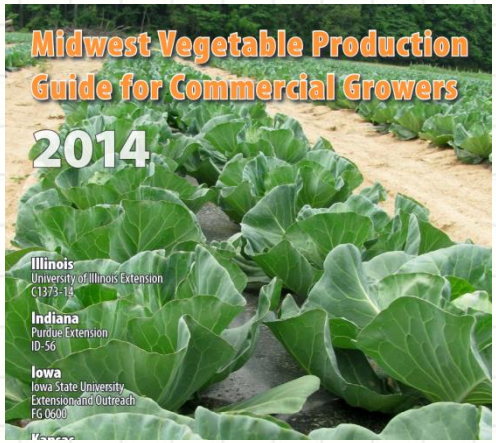
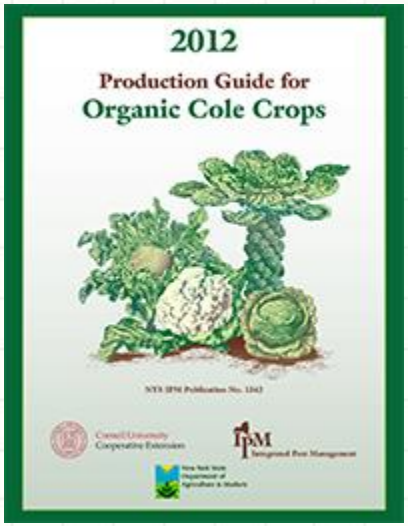
For Vegetables …

- Midwest Vegetable Production Guide
  - http://www.btny.purdue.edu/pubs/id/id-56/ID-56.pdf
  - See pages 66-72 for a summary of disease control practices
- Cornell's Organic Production Guides for Vegetables
  - http://nysipm.cornell.edu/nysipm/organic_guide/veg_org_guide.asp





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Examples of plant disease resources

- ***Cornell's Vegetable MD*** online site focusing on plant diseases http://vegetablemdonline.ppath.cornell.edu/
- ***Midwest Small Fruit Pest Management Handbook***
  - http://pested.osu.edu/documents/CommStudy/2b%20Midwest%20Small%20Fruit%20Pest%20Mgmt..pdf
- ***Midwest Tree Fruit Pest Management Handbook***
  - http://www2.ca.uky.edu/agc/pubs/id/id93/id93.htm
- Tomato diseases
  - http://www.extension.iastate.edu/publications/pm1266.pdf
  - http://aggie-horticulture.tamu.edu/vegetable/tomato-problem-solver/

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Diagnostic aids

http://nfrec.ifas.ufl.edu/paret/u-scout/Lab_Profile.html

CORNELL UNIVERSITY

Vegetable MD Online

Department of Plant Pathology, Ithaca, NY 14853

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- The University of Illinois Plant Clinic
  - http://web.extension.illinois.edu/plantclinic/

Additional resources

- Resource Guide for Organic Insect and Disease Management – 2nd Ed.
  - http://web.pppmb.cals.cornell.edu/resourceguide/
- Organic Management of Vegetable Diseases, Parts I (soil) and II (foliar).
  - http://edis.ifas.ufl.edu/pp169 and http://edis.ifas.ufl.edu/pdffiles/PP/PP17000.pdf
- Plant Disease Management for Organic Crops.
  - http://anrcatalog.ucdavis.edu/pdf/7252.pdf

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Newsletters

- Illinois Fruit and Vegetable News
  - http://ipm.illinois.edu/ifvn/
- Facts for Fancy Fruit (Indiana)
  - http://www.hort.purdue.edu/fff/fff.shtml
- Vegetable Crops Hotline (Indiana)
  - http://www.btny.purdue.edu/pubs/vegcrop/index2013.html
- VegNet (Ohio)
  - http://vegnet.osu.edu/newsletter

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Archived webinars and presentations

- University of Illinois Small Farms webinars …
  - http://web.extension.illinois.edu/hkmw/cat88_3926.html
  - Topics include …
    - 3 webinars on insect, disease, and weed management in organic vegetable production
    - 3 webinars on small orchard management … overall management, insect management, disease management
    - 2 webinars on the basics of fruit insect management and common vegetable insects
    - Many more topics of interest for small- to medium-scale farmers
- Illinois Specialty Crops, Agritourism, and Organics Conference presentations
  - See links on the right at http://www.specialtygrowers.org/

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Take-home messages:

- Think like a plant disease. Use available references to understand the challenges that plant diseases pose.
- Plan ahead … use preventive cultural practices
- Keep up-to-date through newsletters and other references; scout regularly, get positive identifications, respond effectively, document disease history
- Be skeptical of untested rescue treatments
- Integrate multiple management strategies

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