

Tips on Managing Vegetable Diseases Accumulated over a Career

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34-year career as a Vegetable Pathologist



Tips on Managing Vegetable Diseases

Cultural management practices:

- vary among diseases.
- based on knowledge about pathogen's biology.
- some (ex. rotation) best implemented before pathogen population has built up.

Foundation of a good plant disease management program.

Cultural Disease Management Practices

Resistant varieties.

Pathogen-free seed.

Rotate crop plantings. Target = pathogens that survive in soil.

Separate crops susceptible to same water- or wind-dispersed pathogens.

Mulch: plastic and organic.

Sanitation in greenhouse (target surviving pathogens):

- clean + disinfect benches + planting materials.
- don't reuse trays following bacterial disease.

Sanitation in field (target surviving pathogens; spread):

- clean + disinfect equipment and boots between fields.
- clean + disinfect tomato stakes. Discard after tomato canker.
- don't work in crops when leaves wet, esp with bacterial disease.

Avoid wounds.

Managing Vegetable Diseases

General management program:

- Resistant varieties.
- Cultural practices to avoid and minimize pathogen:
ex. Pathogen-free seed. Sanitation. Rotation. Weed control.
- Cultural practices to minimize favorable conditions:
ex. Drip irrigation. Weed control. Soil moisture management.
- Fungicides applied preventively or first sign, and regularly.

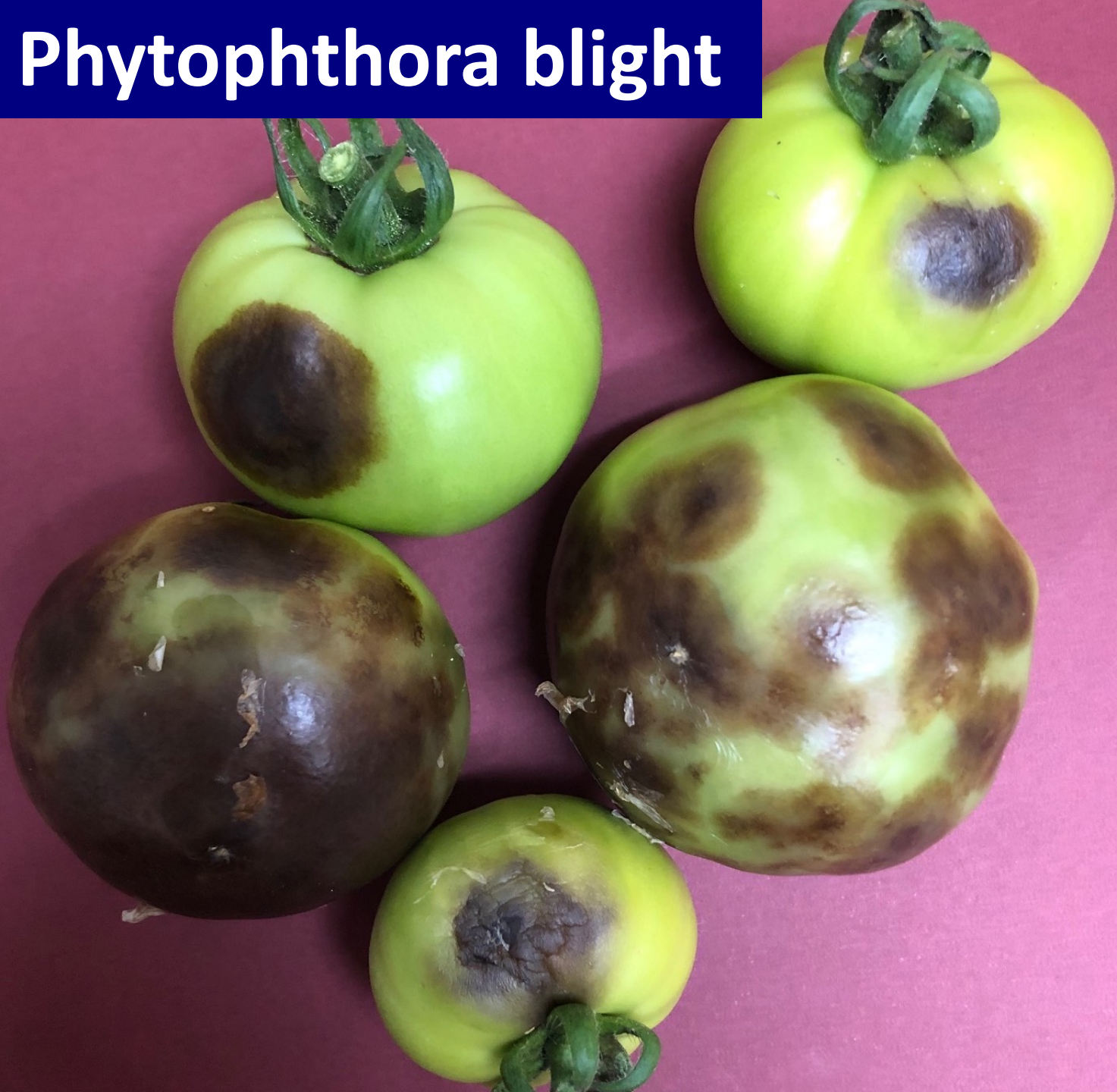
Success requires:

- Accurate identification.
- Knowledge of pathogen biology. Pathogens vary in how they survive and spread plus favorable conditions.

Late blight??



Phytophthora blight



Late Blight



Tips on Managing Vegetable Diseases

Resistant varieties vary substantially in:

- Ability to suppress disease development.
- Durability of their efficacy. Pathogens can evolve to overcome.

Betternut 1744



Copyright © Rupp Seeds

Powdery mildew tolerant. Developed by Rupp breeders. Slightly larger than Betternutt 900 for farm markets and roadside stands.

Taybelle PM



Copyright © Seminis

A direct conversion from Taybelle to include intermediate resistance to powdery mildew.



HARRIS
EST SEEDS 1879

Pumpkin Gladiator

Our #1 variety! Its improved disease protection and grower-preferred fruit size have made Gladiator the number one variety of growers across the country. Raised next to other varieties in field comparisons, Gladiator shows improved homozygous intermediate resistance to powdery mildew. The round, deep orange fruit have moderate ribbing and measure 13" wide x 12" high. Gladiator's long handles are thick and firmly rooted to the 20 to 25 lb. fruit. Vigorous, semi-vine plants produce good yields of these classic, attractive pumpkins that are uniform for size and shape. US Patent 7,166,772.

Squashes and Pumpkins
Intermediate resistance
Powdery mildew tolerant
Homozygous best
control improved with fungicides

Cantaloupe: **Race specific resistance.** Excellent but specific

Arangina



Copyright © Seminis

Arangina is a delicious mid-season ESL Italian melon. Strong plant vigor with good and uniform fruit setting. The fruit is blocky shaped, hard course netting, deep green sutures, dark orange flesh with great firmness and small cavity. Outstanding eating quality. Harvest indicator is when rind changes colors.

Disease Resistance

Fusarium Wilt (0,1,2)

Powdery Mildew (1,2)

Disease Resistance

Fusarium Wilt 0,1,2

Powdery Mildew 1,2,3,5

Athena



Copyright © Syngenta

Firm flesh, harvest closer to slip than Super Star. Resembles Saticoy. Excellent disease tolerance.

Melon Powdery Mildew Resistant Variety Evaluation 2021

8-19-21



Funded by the Friends of Long Island Horticulture Grant Program

Powdery Mildew Resistant Cantaloupe Variety Evaluation

% Control based on AUDPC on lower leaf surfaces 2021

Variety	Lower	
Hales Best (susceptible)	0	a
Ambrosia	99	b
Sugar Rush	100	b
Edisto 47	100	b
Trifecta	100	b

Values in column with same letter not statistically different. **a=ineffective.**

A photograph of a melon field with rows of plants growing on black plastic mulch. The plants show signs of downy mildew, with some leaves turning yellow and brown. Several green melons are visible on the ground. The background shows a dirt path and more plants.

Melon Downy Mildew Resistant Variety Evaluation 2021

9-9-21

Funded by the Friends of Long Island Horticulture Grant Program

Downy Mildew Resistant Cantaloupe Variety Evaluation

% Control of Incidence (% leaves affected) and Severity; AUDPC values

Variety	Incidence		Severity	
Hales Best (susceptible)	0	ab	0	a
Sugar Rush (susceptible)	0	a	0	a
Edisto 47	19	c	47	b
Trifecta	11	bc	52	b

Values in column with same letter not statistically different. **a=ineffective**.
Evaluation conducted in 2021.



19
Races
so far



Spinach Downy Mildew:

Race specific resistance. Excellent.



Corvair

Organic (F1) Spinach Seed

Product ID: 2571G

Organic all-season spinach.

Very dark green, uniform, round leaves. Slow-bolting plants for baby and full size. High resistance to downy mildew races 1–11, 13, 15, 16, 18. USDA Certified Organic. Avg. 44,700 seeds/lb. Packet: 1,000 seeds.

Races 1 - 11, 13, 15, 16, 18

Races 1 – 19; 10 IR



Sunangel

(F1) Spinach Seed

Product ID: 4542

Heavily savoyed DMR spinach for spring, fall, and winter.

A good balance of speed, dark color, savoy, and bolt tolerance for ample harvests through most of the year. More uniform and upright than Emperor, with a less cupped leaf. High resistance to downy mildew races 1–9, 11–19 and intermediate resistance to race 10; intermediate resistance to white rust. Avg. 25,500 seeds/lb. Packet: 1,000 seeds.

<https://www.vegetables.cornell.edu/pest-management/disease-factsheets/>



Cornell Vegetables

Resources for commercial growers

HOME ABOUT CROPS SOIL PEST MANAGEMENT FOOD SAFETY



[Home](#) > [Pest management](#) > Disease factsheets and articles

Disease factsheets and articles

If you were a big fan of the pioneering [Vegetable MD Online](#) website, much of that content has been moved here. We are in the process of moving over the rest.

- **(LIHREC)** indicates information from the Long Island Horticultural Research and Extension Center Vegetable Pathology website.
- List also **includes some herbs** (parsley, basil) and **abiotic disorder**
- Some content is available as printer-friendly .pdf versions.

Diseases and management practices affecting multiple crops

- [Phytophthora Blight and Its Management in Cucurbit Crops and Other Vegetables](#)
- [Reduced-tillage for Managing Phytophthora Blight and Other Soil-Borne Pathogens](#)
- [Biofumigation for Managing Phytophthora Blight and Other Soil-Borne Pathogens](#)
- [White Mold and Its Management in Cabbage, Beans, and Other Vegetables](#)
- [Diseases of Winter Greens: Downy Mildews, Powdery Mildews, Cladosporium Leaf Spot, and Root Rot](#)
- [Table: Fungicides for Cucurbit Crops](#)
- [Table: Mobile Fungicides for Managing Three Major Cucurbit Diseases: Powdery Mildew, Downy Mildew, and Phytophthora Blight](#)
- [Weeds and Crops Susceptible to Viruses](#)
- [Disease-resistant varieties](#)
- [Managing Pathogens Inside Seed with Hot Water Treatment](#)
- [Treatments for Managing Bacterial Pathogens in Vegetable Seed](#)
- [Do Rotations Matter within Disease Management Programs?](#)
- [Cropping Sequences and Root Health](#)
- [On-Farm Soil Bioassays for Assessing Root Pathogens](#)
- [General Guidelines for Managing Fungicide Resistance](#)
- [When is the Best Time to Apply Fungicides for Foliar Diseases?](#)
- [Managing Diseases With Sulfur: Is There A Role For Burners + Evaporators?](#)
- [Organic Management of Vegetable Diseases](#)
- [Biopesticides for Organic and Conventional Disease Management in Vegetables](#)
- [Copper Fungicides for Organic and Conventional Disease Management in Vegetables](#)
- [Minimizing Injury from Copper Fungicides](#)



Disease-resistant varieties

Disease Resistant Vegetable Varieties

See also: [Tips on Using Resistant Varieties](#)

Disease resistance reported in these lists is based on information obtained from seed company catalogs. If you see an error, please contact mtm3@cornell.edu.

- Beans
- Beets
Article: [Evaluations of Beet Varieties Resistant to Cercospora Leaf Spot](#)
- Broccoli
- Brussels Sprouts
- Cabbage
- Carrots
- Corn (sweet)
- Cucurbits (cucumbers, melons, pumpkins, squash)
Cucurbit variety evaluations: [downy mildew](#) (cantaloupe, cucumber LIHREC) | [powdery mildew](#) (cantaloupe, pumpkin, squash LIHREC)
Article: [Cucumber and Cantaloupe Varieties Resistant to Downy Mildew](#)
- Eggplant
- Leeks
- Lettuce
- Onion
- Peas
- Peppers
Article: [Pepper Varieties Resistant to Phytophthora Blight and Bacterial Leaf Spot](#)
- Spinach
- Tomato
Article: [Tomato varieties with multiple disease resistance from Cornell](#)
Article: [Late blight resistant tomato variety evaluations](#)

Prefer to view disease-resistant variety information in spreadsheets? [Download disease-resistant variety spreadsheets from this Box folder](#).

Disease-resistant tomato varieties

- Information is from seed catalogs for 2018, 2019, 2021 and 2022. Occasionally varieties are listed as resistant without the disease(s) or disorder(s) specified.
- Follow links below to tables with more details about these varieties including seed companies marketing them and whether organic seed is available, as well as variety resistance to disorders.
- Prefer to view disease-resistant variety information in spreadsheets? [Download disease-resistant variety spreadsheets from this Box folder](#)

Cherry Tomato

- **Aligote F1:** Fusarium Wilt 1, Fusarium Wilt 2, Fusarium Wilt 3
- **Amarillo F1:** Fusarium Wilt 2, Tobacco Mosaic Virus, Verticillium Wilt
- **Apero F1:** Fusarium Wilt, **Leaf Mold**, Root Knot Nematode, Tobacco Mosaic Virus
- **Apple Yellow F1:** Fusarium Crown & Root Rot, Late Blight, Tomato Mosaic Virus, Tobacco Mosaic Virus, Tomato Yellow Leaf Curl Virus
- **Apricot Zebra:** Disease resistance not specified
- **Artemis F1:** Fusarium Wilt 1, Fusarium Wilt 2, Root Knot Nematode, Tomato Mosaic Virus, Tobacco Mosaic Virus
- **Astoria:** Bacterial Speck, Fusarium Wilt, Fusarium Wilt 1, Tomato Spotted Wilt Virus, Verticillium Wilt, Verticillium Wilt 1, Verticillium Wilt 2
- **Baby Cakes F1:** Fusarium Wilt 2, Tomato Spotted Wilt Virus, Verticillium Wilt
- **Bartelly F1:** **Leaf Mold**, Tobacco Mosaic Virus
- **Baxters Bush:** Resistant to disorders
- **Bellini F1 (orange):** Resistant to disorders
- **BHN-268 F1:** Fusarium Wilt 1, Fusarium Wilt 2, Verticillium Wilt
- **BHN-762 F1:** Fusarium Wilt 1, Fusarium Wilt 2, Verticillium Wilt
- **BHN-968 F1:** Fusarium Wilt, Root Knot Nematode, Tobacco Mosaic Virus, Tomato Spotted Wilt Virus, Verticillium Wilt
- **Bing:** Resistant to disorders
- **Black Cherry:** Resistant to disorders
- **Blush (oval cherry):** Resistant to disorders
- **Braveheart F1:** Fusarium Wilt 1, Gray Leaf Spot, **Leaf Mold**, Tomato Mosaic Virus
- **Bumble Bee Pink:** Resistant to disorders
- **Camelia F1:** Fusarium Wilt 1, Tobacco Mosaic Virus, Verticillium Wilt, Verticillium Wilt 2
- **Chadwick Cherry:** Disease resistance not specified
- **Cherry Bomb F1:** Late Blight
- **Cherry Buzz:** Resistant to disorders
- **Cherry Ember:** Resistant to disorders
- **Chocolate Sprinkles:** Fusarium Wilt, Root Knot Nematode, Tomato Mosaic Virus, Tobacco Mosaic Virus

[illegible]

Contact, protectant fungicides:

- Usually broad-spectrum activity.
- Coverage important because do not re-distribute.
- Removed by rain especially when intense.

Mobile fungicides (translaminar, systemic):

- Enter the plant and re-distribute.
- Control pathogens developing on leaf underside.
- Targeted activity. Prone to resistance development.

Fungicides vary substantially in:

- Ability to suppress disease development.
- Durability of their efficacy, reflecting pathogen ability to develop resistance.

Most fungicides act on pathogens before infection.

- Apply before rain. Most foliar pathogens need wet leaves to infect. Some dispersed by splashing water. (exception = powdery mildew).

Reapplication on weekly interval typically needed.

Fungicide Efficacy Data - What to look for:

- Laboratory or field study
- Replicated experiment or observational
- Inoculated or natural infection
- Disease pressure; spreader row
- Preventive or after symptoms seen
- Comparisons meaningful
- Conventional standard
- Mean comparison letters

Tips on Managing Vegetable Diseases

Important facts about foliar pathogens:

- Most have short cycles (polycyclic).
- Often about 1 week from infection to symptoms.
- Reproduce asexually and sexually (fungi, oomycetes).
- Most pathogens need wet leaves to infect.

Some dispersed by splashing water.

(exception = powdery mildew).



18 Aug 05



25 Aug 05



29 Aug 05

Tips on Managing Vegetable Diseases

Pathogens change a lot!

- Stay up to date.
- Contact extension specialist when you see something unusual.



Some pathogens change A LOT!

Spinach Downy Mildew

**Continually evolving to overcome
race specific resistance.**

1988 – 3 named races

2022 – 19 named races

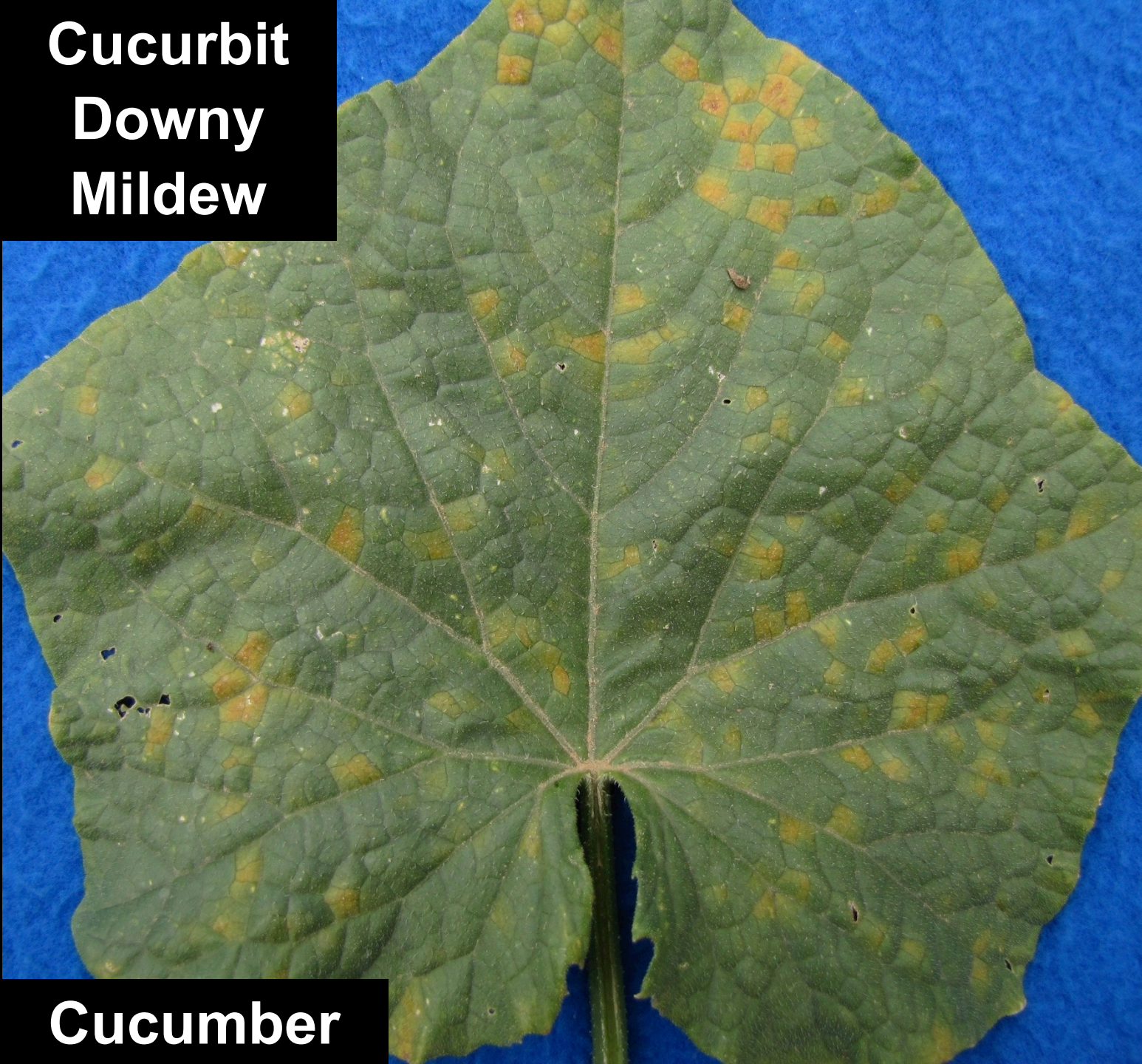
**Detected recently in northeast: 12, 14,
15, novel. 13, 16, 17 suspected.**



Factors Contributing to Ability of Some Pathogens to Change

- Reproduce asexually
- Short life cycle: about 1 week from infection to spore production
- Sexual reproduction important for some

**Cucurbit
Downy
Mildew**



Cucumber

Re-emerged in 2004

Pathogen change:

- Virulent on resistant cucumber varieties.

- Resistant to key fungicides: Ridomil and Quadris.

Continues to occur widely and affecting more than cucumber.



Phytophthora Blight

cucurbits

pepper, eggplant

tomato



2008 - Beans - *Phytophthora* blight





Late blight re-emerged in 2009

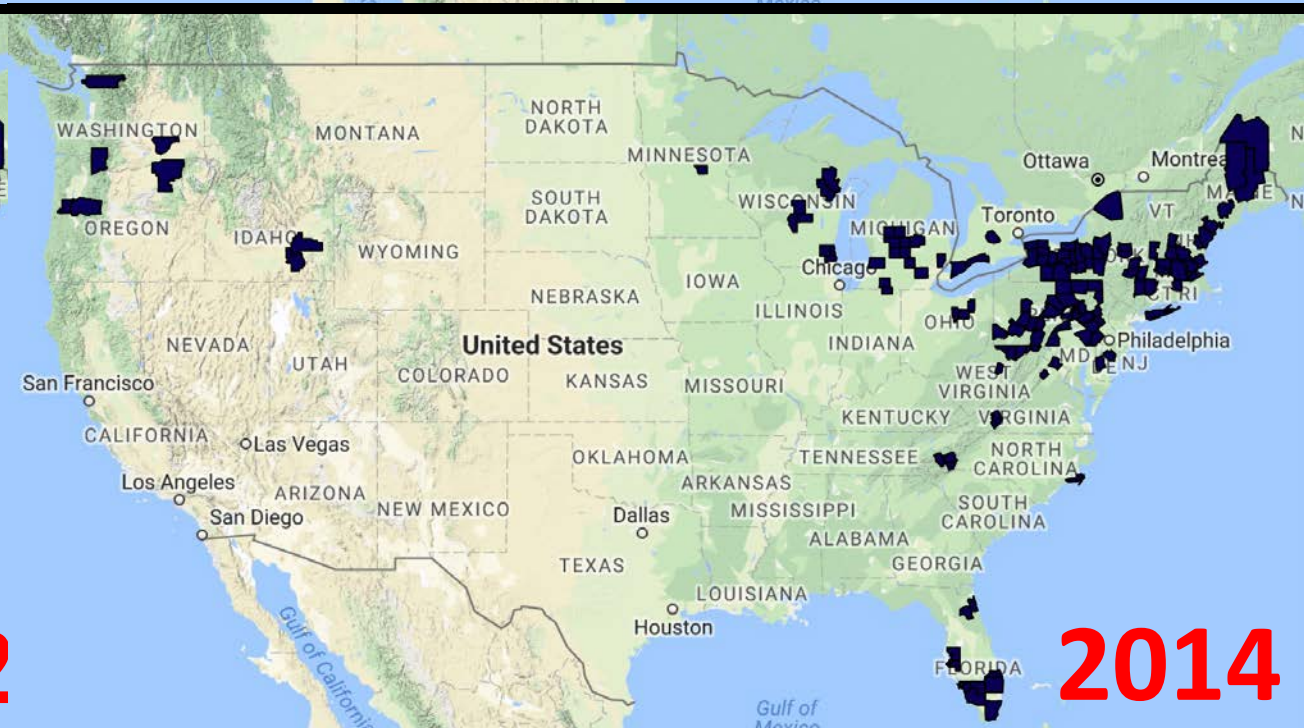
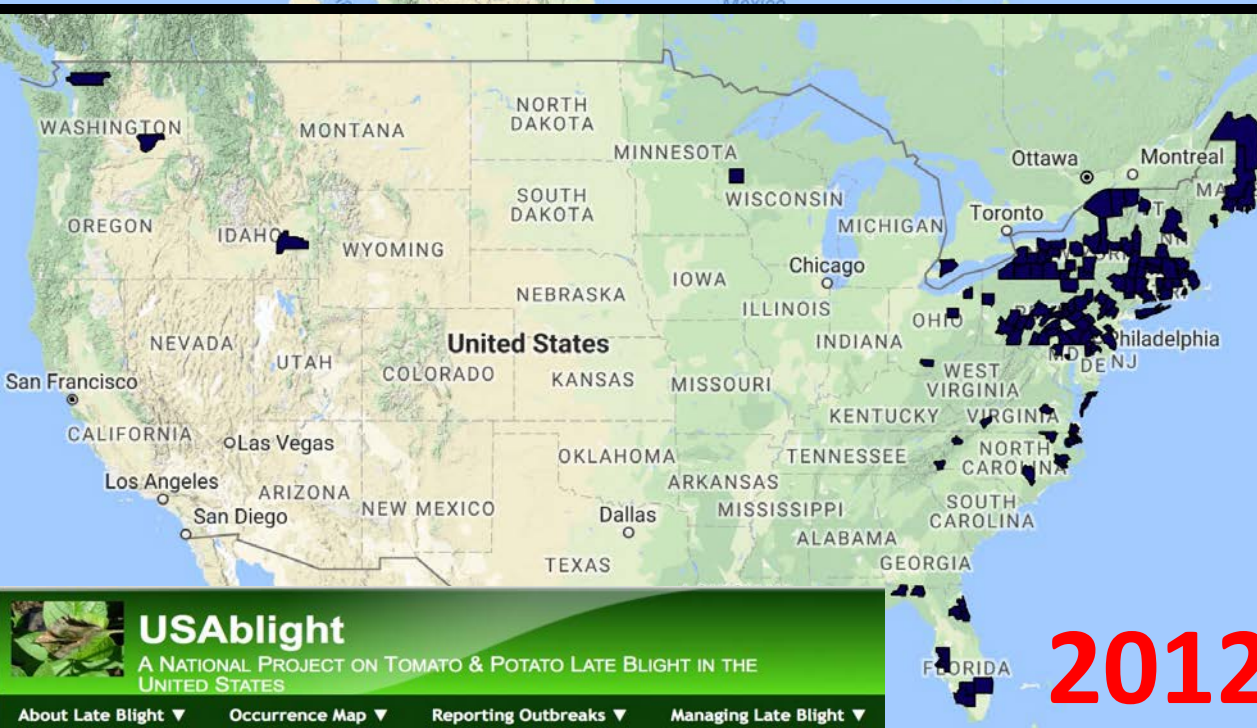
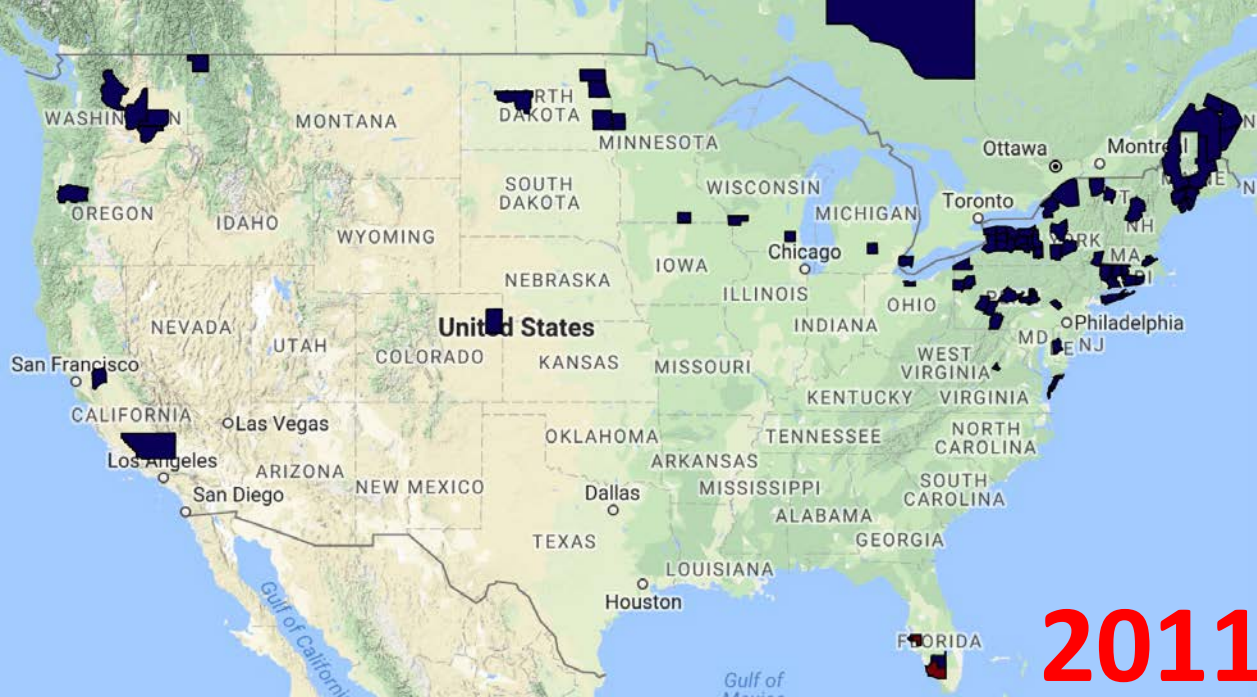
Pathogen change:

- More virulent on tomato.

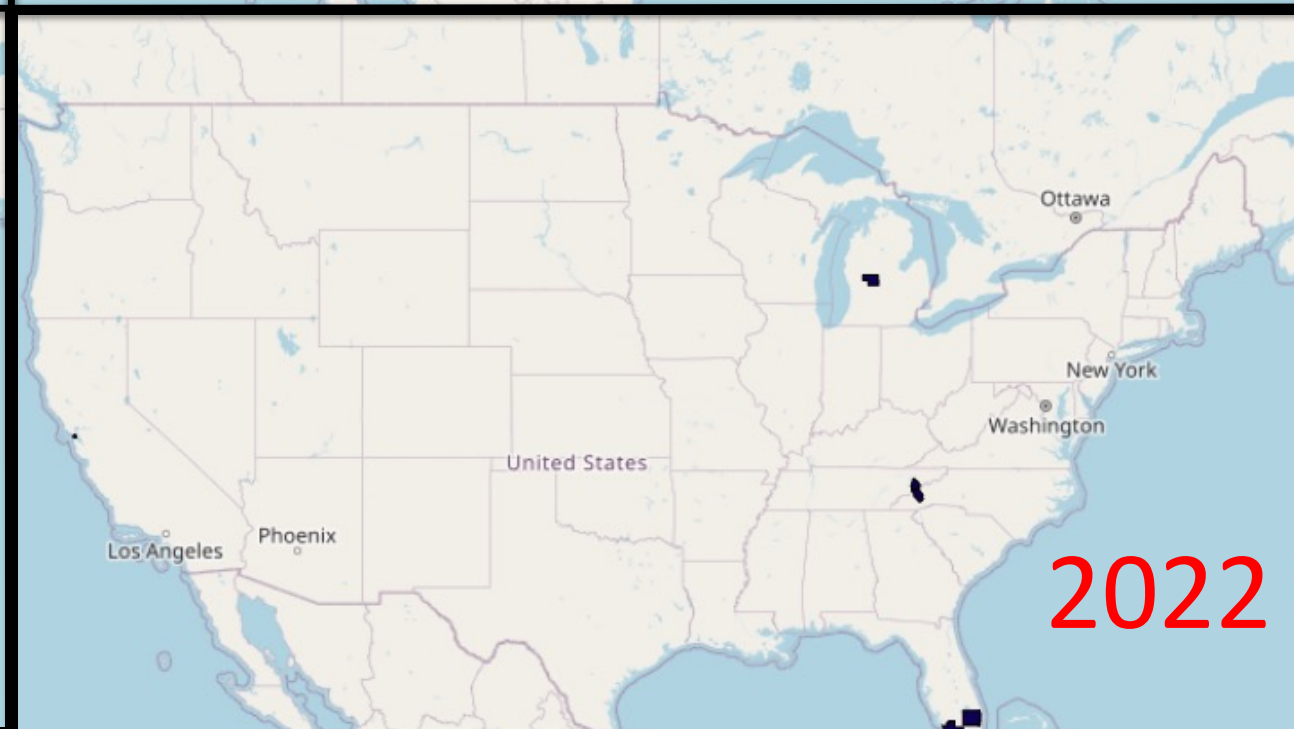
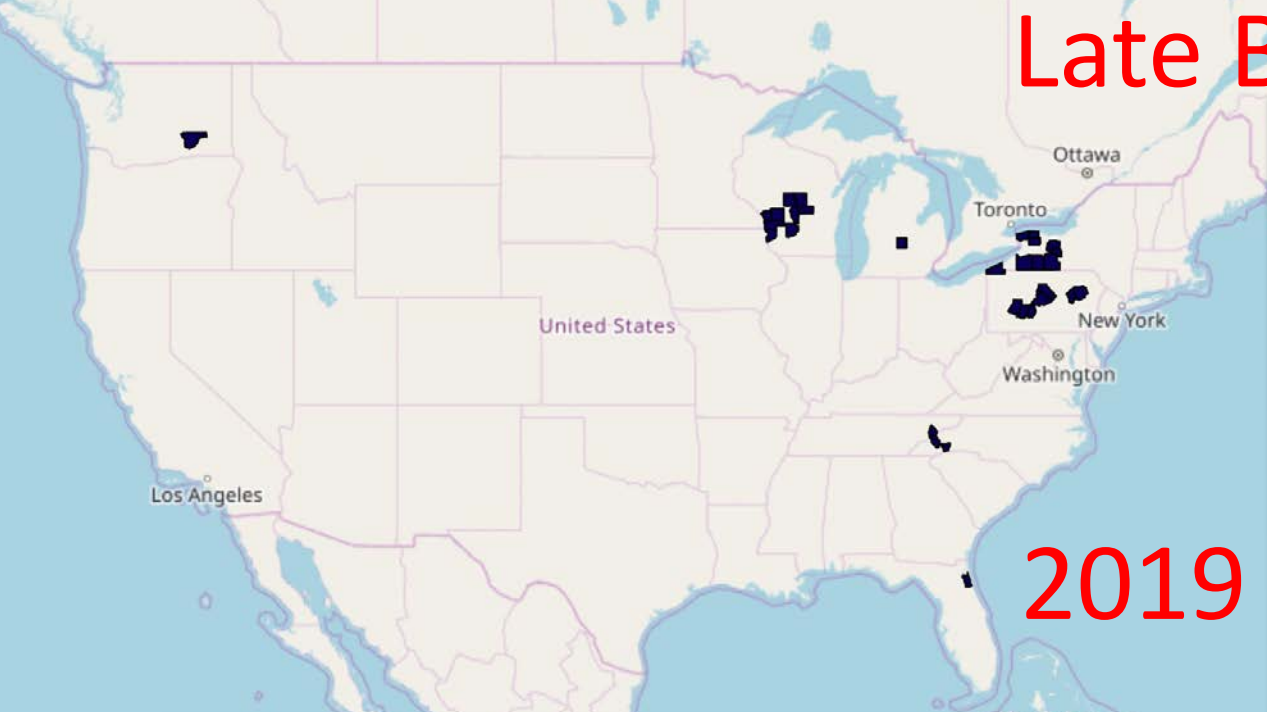
Unique outbreak:

- Gardens source of pathogen for farms.

- Started very early (June).



Late Blight Reported Occurrences





Spinach Stemphylium leaf spot

**New diseases
can appear!**



Pepper powdery mildew



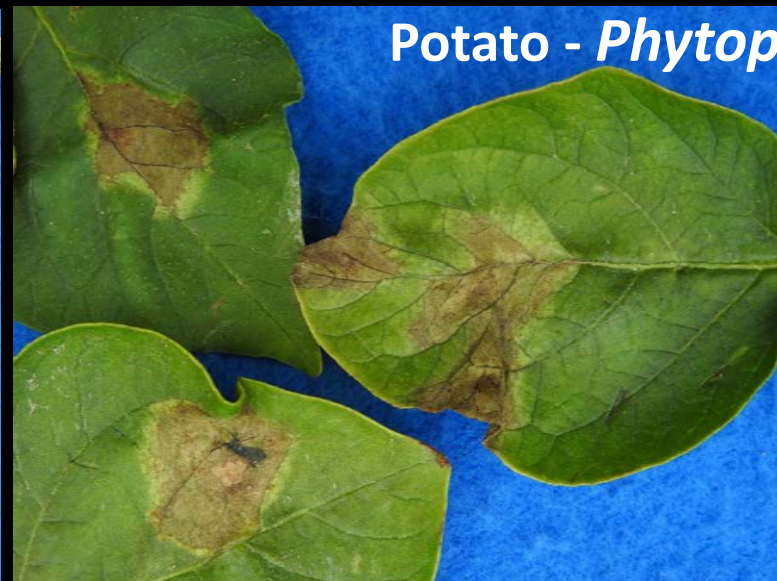
Garlic Rust



Basil downy mildew



Potato - *Dickeya*



Potato - *Phytophthora nicotianae*





Basil Downy Mildew

2007 – first seen in USA.

2001 – first seen in Europe.

1933 – reported in Uganda.

Now most important, common disease of basil worldwide.







**Stemphylium
(gray) leaf
spot**

**Septoria
leaf spot**



Stemphylium (gray) leaf spot

**Can become severe in
high tunnels**

Rhode Island, cf Andy Radin

2013-19 – Potato – *Dickeya*, *Plectosporium*



cf. Sandy Menasha

2 Seedlots

Dickeya

No
Dickeya

14 June 2016



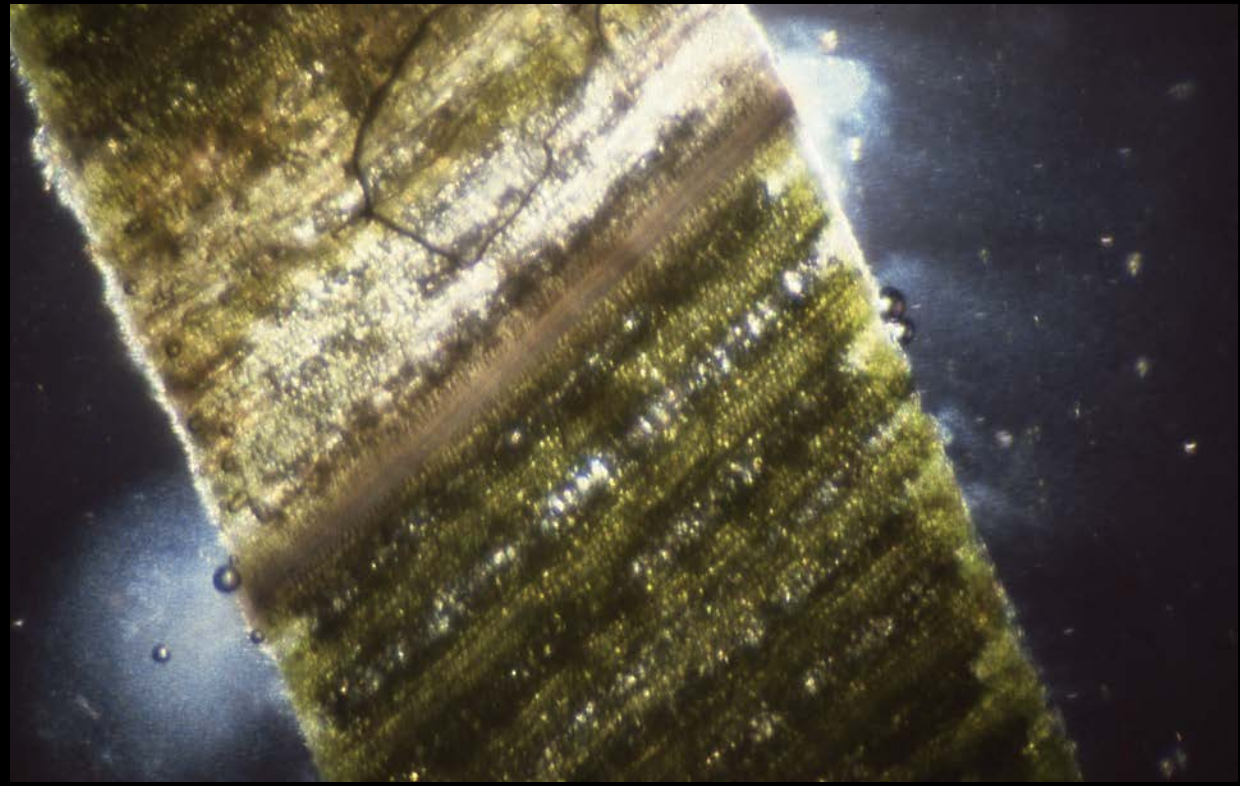


Impact

Politics

**Some diseases disappear
with effective management**

Stewart's Wilt – Sweet Corn



Tips on Managing Vegetable Diseases

Knowledge changes about pathogens which can affect management:

- Example: Spinach downy mildew pathogen recently documented to be seed-borne.

Fungicide Resistance – Lessons Learned

- Resistance often is result of a simple genetic change in pathogen.
- Resistant pathogens usually are not less fit than susceptible ones.
- Resistance potential of fungicide can be hard to predict. Ex. Qols.
- Resistance potential of pathogen can be hard to predict.
Ex. Cucurbit gummy stem blight/black rot pathogen.
- Goal of resistance management is delaying its development.
- Resistance can still develop despite label use restrictions and good resistance management program. Ex. Torino.

Fungicide Resistance – TORINO – Cucurbit Powdery Mildew

2012. Registered for this use in USA.

Label restrictions stronger than any other at-risk fungicide:
no consecutive applications allowed; maximum 2 applications.

Other at-risk fungicides not yet impacted by resistance available
to use in a sound resistance management program:
Quintec and DMIs plus Vivando 2 years later.

2017. Fully resistant isolates detected.

Resistance detected to Qols after 3 yrs, Endura after 6 yrs, and
Quintec after 8 yrs.

Fungicide Resistance – Cucurbit Powdery Mildew

Pathogen has developed resistance to:

Fungicides in FRAC groups: 1, 3, 7, 11, 13, and U6.

Cross resistance is typical.

Resistance is partial among fungicides for some chemistries:

DMIs (FRAC 3). Most newer products still highly effective (ex. Proline, Procure). Some differences in inherent activity.

SDHIs (FRAC 7). Endura, Pristine, Fontelis, and Merivon are cross resistant. Luna fungicides, Aprovia Top, and Miravis Prime bind differently from others (different active ingredient).

Fungicide Resistance – Lessons Learned

- Resistance can be qualitative (isolates sensitive or resistant) or quantitative (isolates exhibit range in sensitivity).
- Occurrence of resistance in a commercial crop can change substantially with fungicide use during a growing season.
- Resistance can be hard to detect in a crop based on control impact.
- Pathogen isolates can develop resistance to multiple unrelated fungicides. Ex. cucurbit powdery mildew pathogen – 5 chemistries.
- Resistance usually remains in pathogen population, but not always. Ex. cucurbit powdery mildew pathogen – FRAC 1 and 11 fungicides.



Late blight – Potato and Tomato

1980s re-emerged when pathogen developed resistance to Ridomil (metalaxyl).

Recent genotypes are sensitive.

Pathogen is uniquely clonal.

MAJOR potential future pathogen change:

Both mating types occurring together and reproducing sexually.

Outcome: Oospores and consequent increased pathogen variation and ability to survive in absence of living plant tissue.

Fungicide Resistance – Lessons Learned

- Occurrence of resistance in a commercial crop can change substantially with fungicide use during a growing season.
- Resistance can be hard to detect in a crop based on control impact.
- Pathogen isolates can develop resistance to multiple unrelated fungicides. Ex. cucurbit powdery mildew pathogen – 5 chemistries.
- Resistance usually remains in pathogen population.
- Sound fungicide recommendations require knowledge of resistance.
- Knowledge of resistance requires testing pathogen isolates.
- Label uses are not changed when resistance becomes common.

Fungicide Resistance – Cucurbit Powdery Mildew

2023 Long Island results:

- Isolates from research field treated with DMIs and Vivando.
- Resistance detected to boscalid (Endura, Pristine) and Torino; not to Quintec.
- Sensitivity to DMIs has not changed. Isolates are not as sensitive as they were when first DMI (Bayleton) was released.
- Isolates detected with reduced sensitivity to Vivando, but not enough to affect efficacy.

Tips for Success in Disease Management

Be Proactive!

Know what diseases have + could occur.

Become familiar with symptoms.

Understand biology of pathogen; survival and dispersal.

Learn practices for managing main diseases.

Implement Basic Cultural Management Practices.

Rotation, separation. Minimize leaf wetness.

Manage weeds. Sanitation: before + after crop.

Be Observant!

Look for disease symptoms. Record with camera.

Ensure Diseases are Accurately Identified.

Be Prepared to Act!

Rogue diseased plants when appropriate.

Have sprayer ready to apply fungicides.

