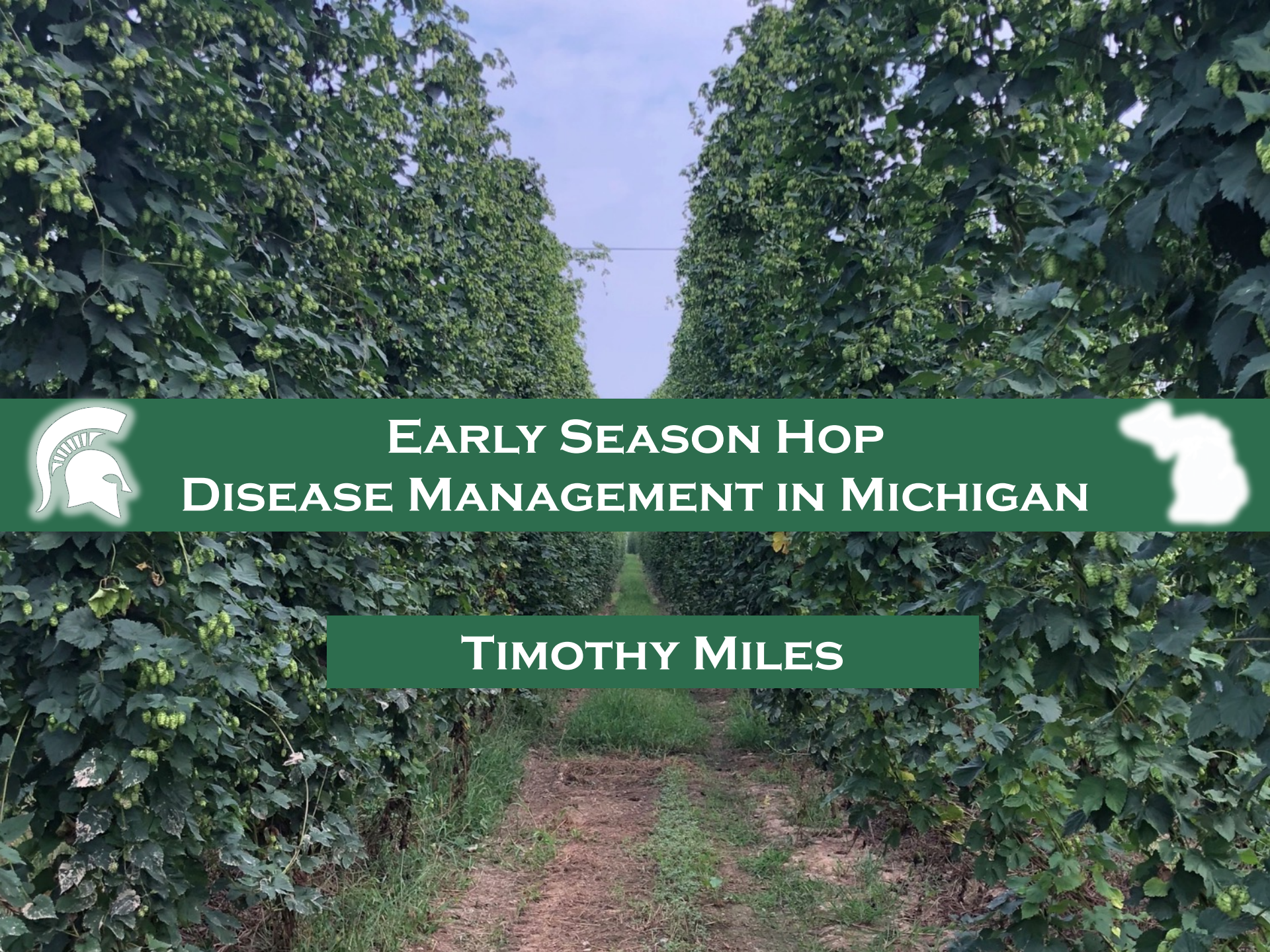

Early Season Hop Disease Management in Michigan

Timothy Miles

Talk outline

- Downy mildew management in hops
- MSU Pathology Research
- Halo blight

Talk outline

- Downy mildew management in hops
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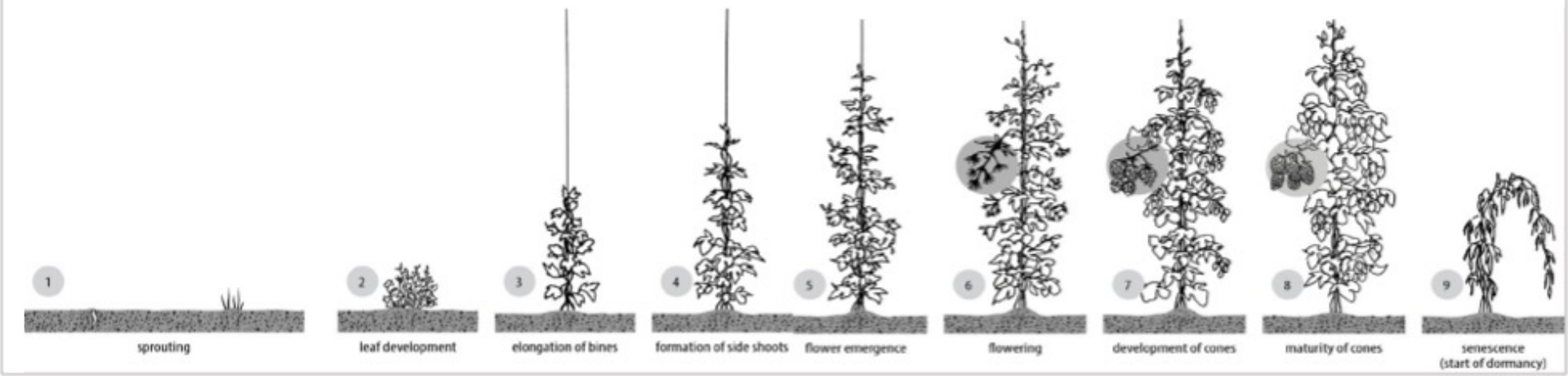
Hop diseases: The usual suspects

- Diseases
  - **Fungal or fungal-like**
    - Powdery mildew
    - **Downy mildew**
    - Fusarium
    - Black root rot
    - Gray mold
    - Cone tip blight
    - Halo blight*
  - **Viruses**
    - Hop stunt viroid
    - Hop mosaic virus
    - Apple mosaic virus

Growth stages of hop and the major diseases to consider

March				April				May				June				July				August				September			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Dormancy				Spring Regrowth				Vegetative Growth								Reproductive Growth								Preparation for Dormancy			
				sprouting		leaf development						side shoots				burr stage		flowering		cone development				maturity of cones			
								elongation of bines																			



Downy mildew

Powdery mildew

Halo blight*

Halo blight*

Other cone diseases*

Hops: **A tale of two diseases**

- Downy mildew and powdery mildew are the most critical diseases of hops
- Cultural Management
  - e.g. DM favors humidity and mild temperatures
- Chemical Control Management Options
  - Resistant management is important

Photos by Erin Lizotte and Dave Gent

Downy Mildew

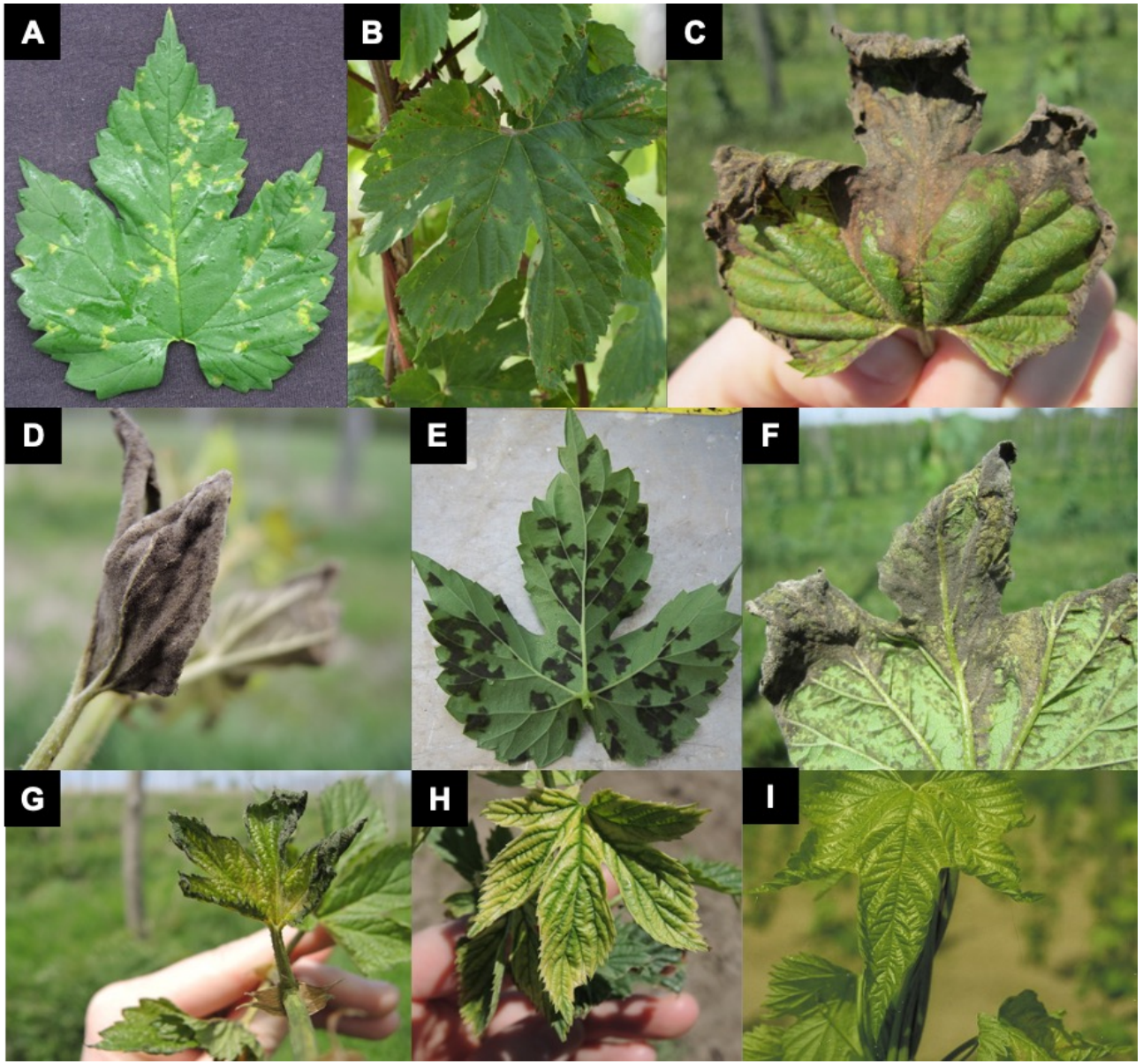
- Caused by a fungus-like organism called *Pseudoperonospora humuli*
- Can cause significant yield and quality losses depending on variety and when infection becomes established
- In extreme cases cones can become infected and the crown may die
- **Biggest challenge** to production in the Great Lakes Region

Downy mildew

- Spore masses appear fuzzy and black on the underside of infected leaves
- As bines expand new tissue becomes infected and fails to climb the string
- Can retrain new shoots but often incur yield loss as a result
- Appearance may vary based on variety and timing

Diagnostic features of hop downy mildew

Downy mildew



Frost injury

Herbicide injury

Zinc deficiency

Purayannur et al., 2020 Plant Health Progress

Downy Mildew Management

Requires multiple tactics that **delay** onset of disease and reduce disease development

1. Source of planting material
2. Variety selection
3. Pruning and canopy management
4. Protectant fungicides season long
5. Harvest timing

Canopy Management: **Pruning**

- Early spring pruning (e.g. crowning, scratching) synchronizes growth
- Removes plant remnants from the previous season
- Can eliminate infected crowns / buds with powdery and downy mildew inoculum (and halo blight?)
- Do not do this to “babies”

Gent, USDA ARS

Downy management with fungicides

Apply fungicide treatments on a protectant basis as soon as bines emerge in the spring (or reflush after pruning) regardless of symptoms

Applications continue season long on a 7-10 d reapplication interval until harvest or senescence

Several periods in the season are particularly critical for disease control:

Before and after training; lateral branch development; bloom; and cone development	Covering young, developing bracts before cones close up is critical to protecting against downy mildew on cones when conditions for disease are favorable

Downy mildew management - More fungicide notes

Ranman (cyazofamid, FRAC 21), Presidio (FRAC 43, new!), Zampro (ametoctradin + dimethomorph, FRAC 45 + 40), and Revus (mandipropamid, FRAC 40) make up the backbone of downy mildew management.

Orondis Ultra (FRAC 49/40) was labeld in 2020. Orondis Gold was also labeled in 2021 as a drench (effective in a trial).

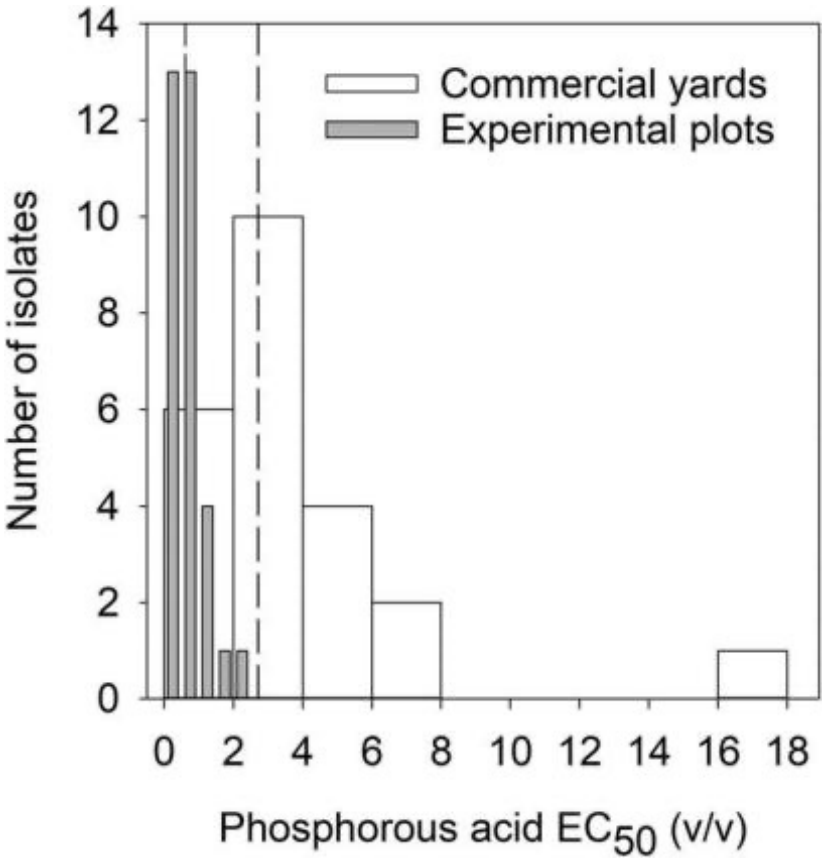
Rotate or mixed with Curzate (cymoxanil, FRAC 27), Tanos (famoxadone + cymoxanil, FRAC 11 +27), and phosphonate products such as Aliette (fosetyl-Al, FRAC 33) to help prevent resistance development.

Copper-based fungicides may also be rotated in during periods of low disease pressure and as tank mix partners.

FRAC 40 compounds (e.g. Revus and Zampro) have the same mode of action and should not be tank-mixed or rotated.

Reduced sensitivity to phosphonate fungicides reported in Oregon

These fungicides include: AgriFos, Phostrol and other chemistries in FRAC 33



Gent et al., 2020 Plant Disease

Example spray program for a mature yard

Growth stage	Fungicide (FRAC code) – Target (PHI)
Sprout: mid to late April	Ridomil Gold SL (4) – Downy mildew (135d)
Veg 1: early May	Revus (40) – Downy mildew (7d)
Veg 2: late May	Curzate 60DF (27) – Downy mildew (7d) Pristine (11/7) – Powdery mildew (14d)
Veg 3: early June	Ranman (21) – Downy mildew (3d)
Veg 4: mid June	Alliette (33) – Downy mildew (24d) Torino (U6) – Powdery mildew (7d)
Veg 5: late June	Tanos (11/27) – Downy and powdery mildew (7d)
Repro 1: early to mid July	Zampro (40/45) – Downy mildew (7d) Quintec (13) – Powdery mildew (21d)
Repro 2: late July	Cueva (M1) – Downy and powdery mildew (0d)
Repro 3: early to mid Aug	Ranman (21) – Downy mildew (3d) Luna Experience (3/7) – Powdery mildew (14d)
Repro 4: late Aug	Cueva (M1) – Downy and powdery mildew (0d)

Talk outline

- Downy mildew management in hops
- MSU Pathology Research
- Halo blight

Field plots planted at MSU for hop pathology research

- Yard 1 - Low trellised Centennial yard in August of 2019. Location of DM efficacy research.
- Yard 2 – Centennial yard planted in June of 2020. Location of future efficacy work.
- Yard 3 – Cultivar block for future research work.
- Yard 4 – Prior drench trial, now a DM inoculum source.
- Yard 5 – Cultivar block for future research work. Clarksville Research Center (not shown)




Downy mildew efficacy trial in 2019

Application # / Stage	Growth Stage
1 = May 7th	6 inches, sprout
2 = May 16th	vegetative growth 1
3 = May 23rd	vegetative growth 2
4 = June 3rd	vegetative growth 3
5 = June 12th	vegetative growth 4
6 = June 21st	vegetative growth 5
7 = July 3rd	reproductive growth 1
8 = July 11	reproductive growth 2
9 = July 18th	reproductive growth 3
10 = July 25th	reproductive growth 4

Untreated

Ridomil Gold SL (4) (1)
Revus (40) (2)
Presidio (43) (3,6)
Ranman (21) (4,7,9)
Zampro (40/45) (5,8,10)

Field Day in 2022

- We are planning on MSU field day in 2022 in East Lansing MI
- July 13th from 10am to 2pm in East Lansing Michigan
- Come check out our fields and hear about hop research!

Talk outline

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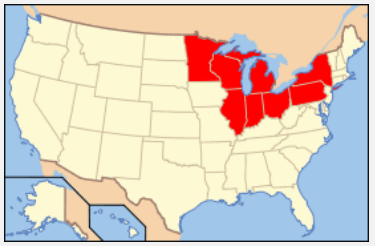
Is this Phoma Wilt? The short answer is no… the long answer is to keep listening

- Symptoms for Phoma Wilt involve infections with small chlorotic leaf spots and develop into greyish brown lesions that have a distinct target or concentric ring appearance.
- "Phoma Wilt" is caused by several fungal species, none of which we are finding
  - *Phoma herbarum* Westend.
  - *Phoma herbarum* f. *humuli*
  - *Phoma exigua* Desm. var. *exigua*
    Diaporthe perexigua Sacc. [teleomorph]
  - *Phoma aliena* (Fr.) Aa & Boerema



Here are some blighted and dried out cones we are seeing in the Great Lakes region



The main issue is that dried cones easily shatter

Healthy bract tissue post processing

Dried bract tissue post processing

If you look close…

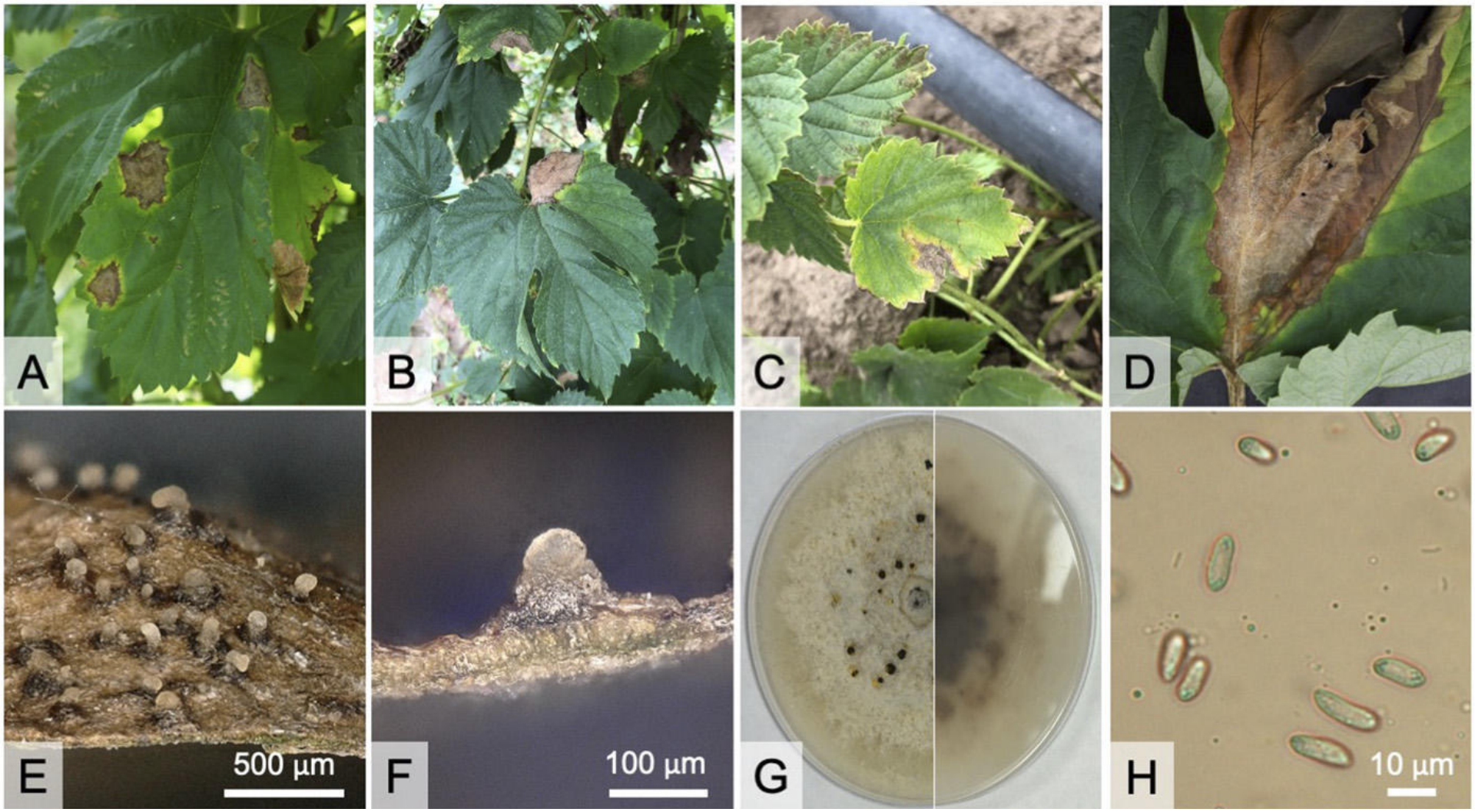
Pycnidia oozing on hop leaves

Pycnidia oozing on hop cones

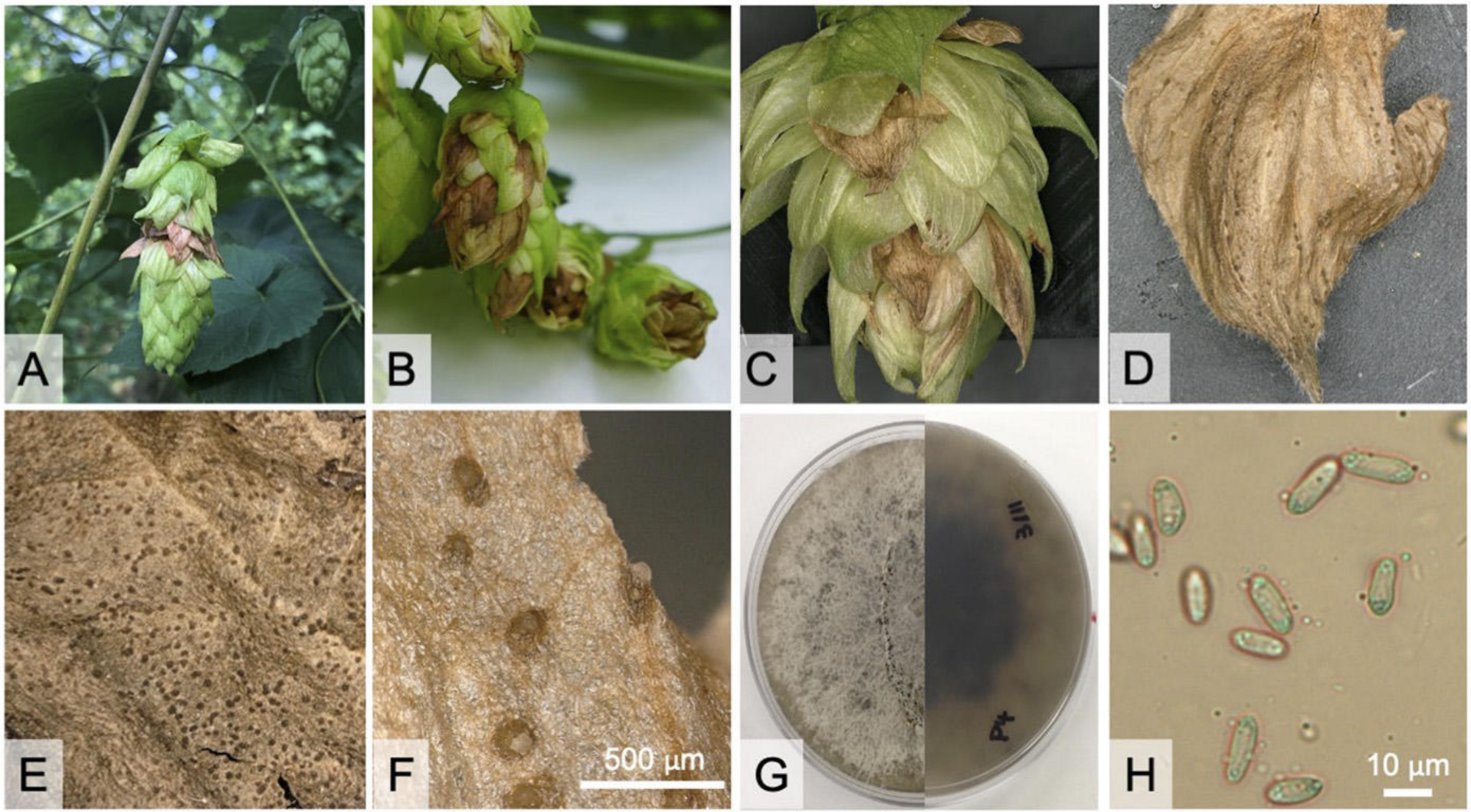
Higgins et al., 2020. Plant Disease in First Look

This disease seems to be a real issue in certain yards

- It appears to be fairly widespread
- Young transplants appear to get foliar infections if they are near an established yard
- Growers have reported up to 50% yield loss due to ‘shatter’



We call this disease halo blight and it is caused by *Diaporthe humulicola* (leaves)

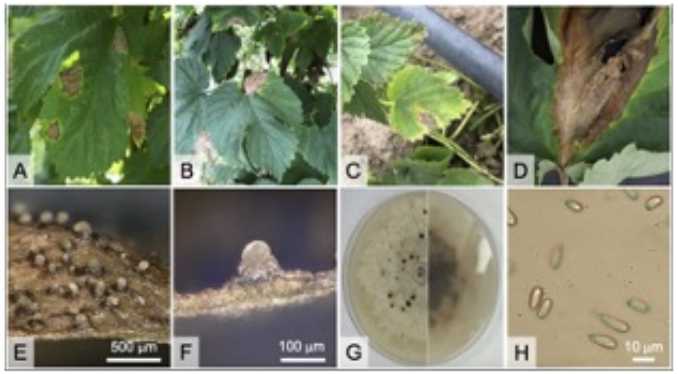


We call this disease halo blight and it is caused by *Diaporthe humulicola* (cones)

Halo blight history

Michigan

- *Diaporthe* sp 1-MI
- Halo blight
- Southern, MI
- ITS, TEF, Histone, Beta-tubulin(TI/Bt-2b)



Higgins et al. 2020

Connecticut

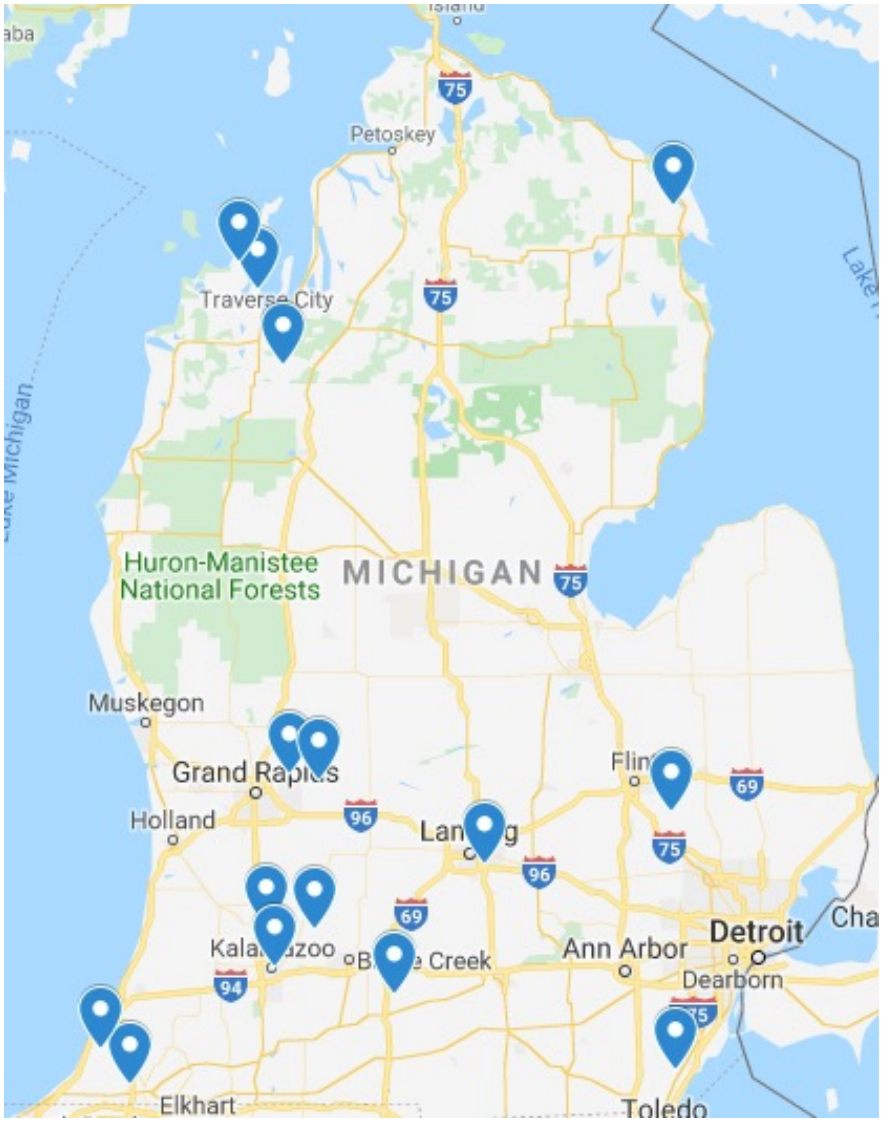
- *Diaporthe humulicola*
- Diaporthe Leaf Spot
- Hamden, CT
- ITS, TEF, Histone, Beta-tubulin(TUBUF2/TUBUR1, T12/T22)

Allan-Perkins et al. 2020

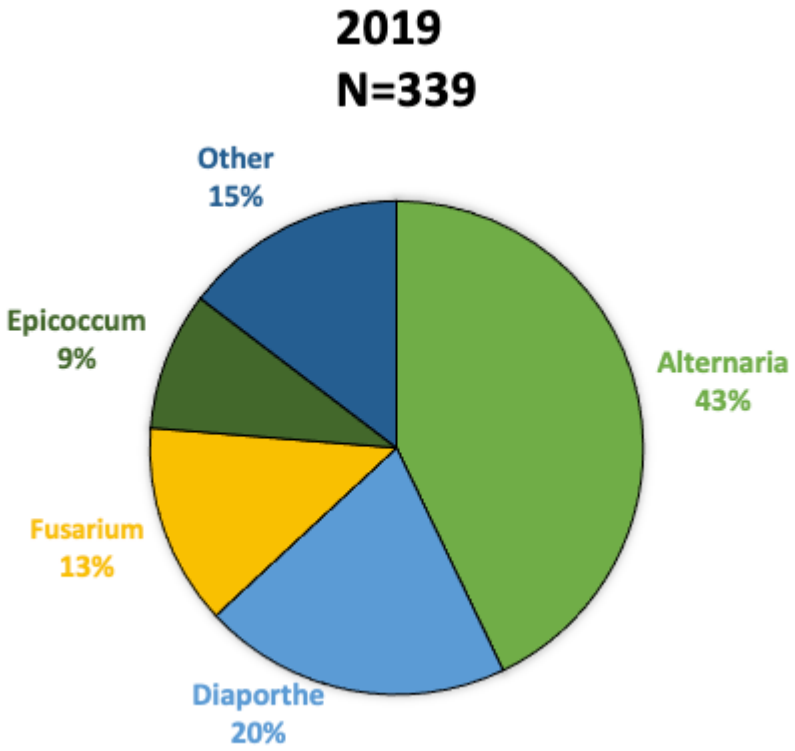
Halo blight likely overwinters on stems perhaps in the crown?

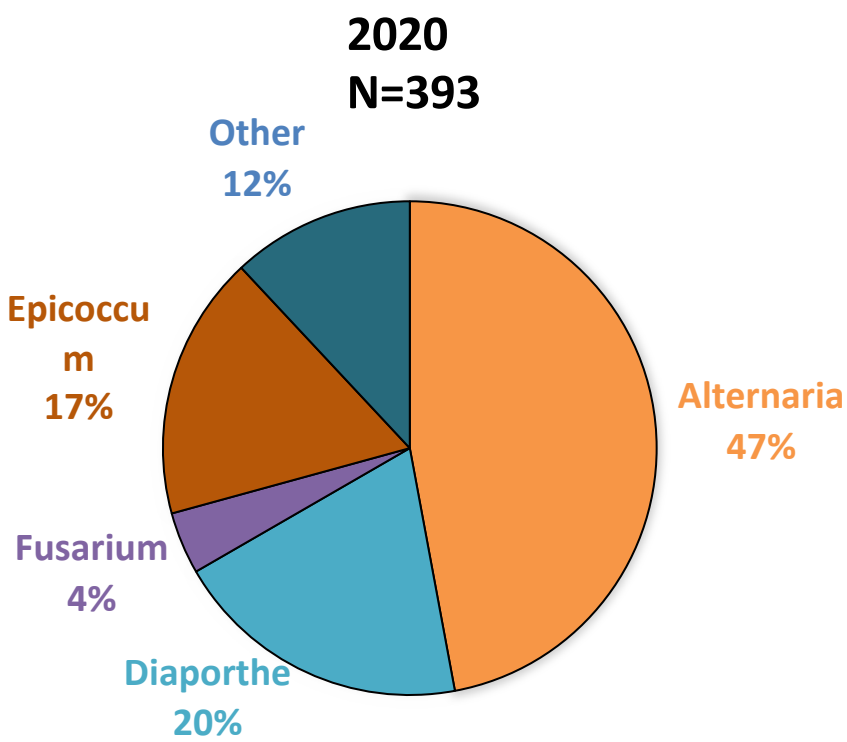
Survey of Michigan hop yards

- 2 years of surveying Michigan hop cone diseases
- Samples collected close to harvest, with a bias on fully developed cones
- In 2019, 19 out of 20 yards had *Diaporthe* and in 2020 all yards had *Diaporthe*



Diseased cone survey





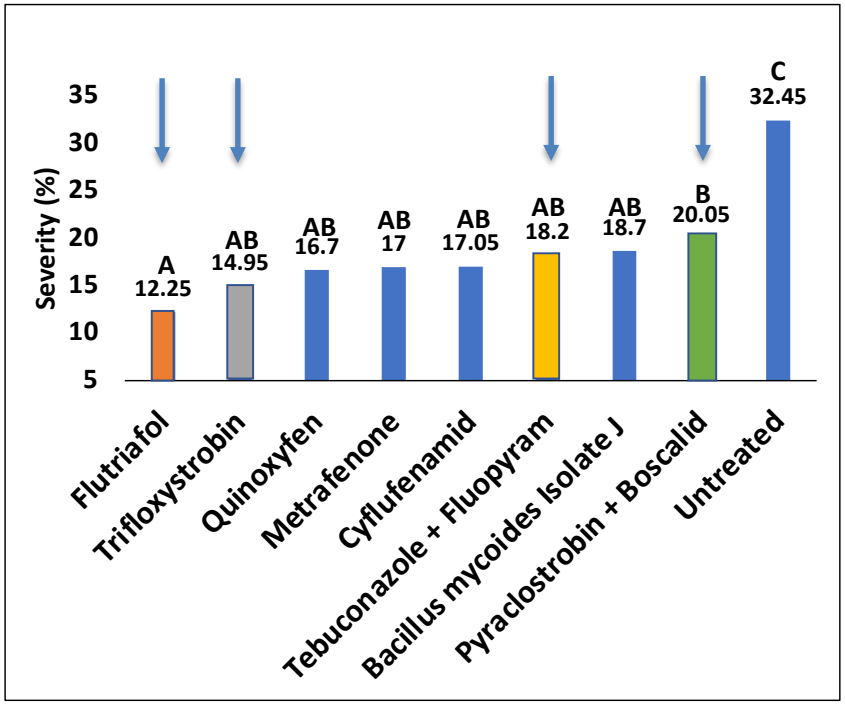
Published in Higgins et al. 2020

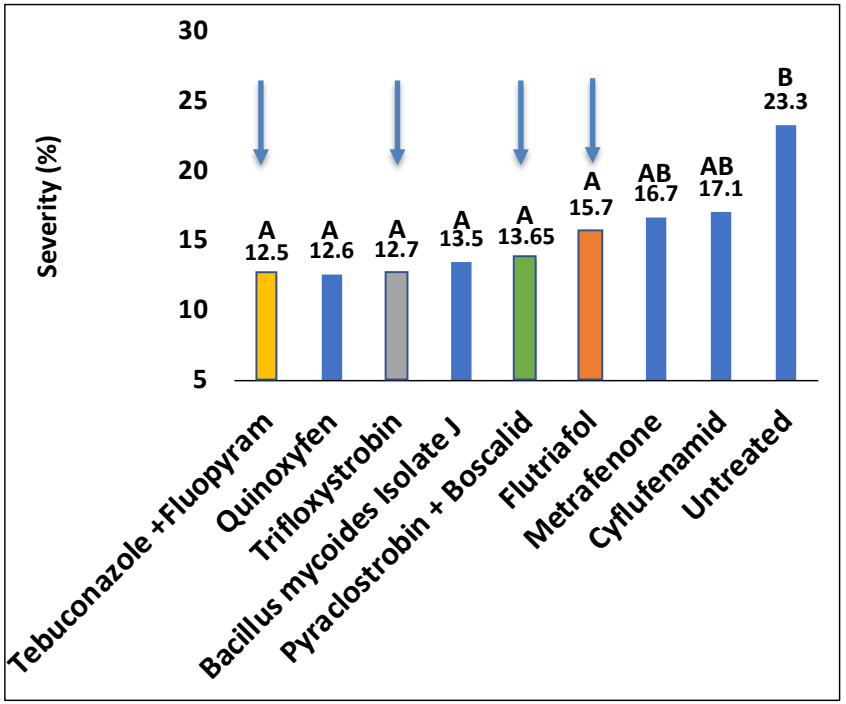
2020 and 2021
Fungicide testing in small plot trials

Active ingredient	FRAC group	Treatment	Manufacturer	Activity
Quinoxyfen	13	Quintec	Dow AgroSciences	Powdery mildew
Flutriafol	3	Rhyme	FMC	Broad spectrum
Trifloxystrobin	11	Flint Extra	Bayer	Broad spectrum
Metrafenone	U8	Vivando	BASF Ag Products	Powdery mildew
Tebuconazole Fluopyram	7/3	Luna experience	Agrian	Broad spectrum
Pyraclostrobin Boscalid	7/11	Pristine	BASF Ag Products	Broad spectrum
Cyflufenamid	U6	Torino	Gowan	Powdery mildew
Bacillus mycoides Isolate J	P6	Lifegard WG	Certis	?? (Incudes SAR)
Untreated				

= FRAC 3, 7 and 11 products

Most fungicides will decrease the severity of disease but not consistently across both years





Summary of Fungicide testing

- Frac 3, 7, and 11 fungicides seem to best decrease the severity and incidence of halo blight
- All chemicals except Vivando and Torino significantly decreased severity of infections
- Luna Experience greatly decreased severity in 2021
- Experiment needs to be repeated for another year and we still aren't getting "great" control
- Removing plant material is likely critical to manage this disease

Mechanical/chemical pruning article

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Pruning hops for disease management and yield benefits

Rob Sirrine, Michigan State University Extension - May 1, 2018

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> Timing and method are important when considering pruning hops for disease management and yield benefits.

Figure 1. Hop crowning. Photo by Dr. Dave Gent, USDA ARS

Questions?

- Thanks for all of the support, a special thanks to:
  - **Erin Lizotte,** MSU Extension
  - **Rob Sirrine**, MSU Extension
  - **Dr. Hausbeck, Doug Higgins**, MSU PSM Dept.
  - **Dr. Dave Gent**, Oregon State University / USDA-ARS
  - **Matt Gura, Rick Kawalski and Brent C.**, Hop Head Farms
  - **Mark Trowbridge** Top Hops
  - **Sandy Ridge Farms**
  - **Hop Growers of Michigan**

- Go Green!
- Contact me at milesti2@msu.edu if you have additional questions

Support from:

MICHIGAN CRAFT Beverage Council

HOP GROWERS OF MICHIGAN EST. 2014

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