Prevalence of cranberry fruit rots in commercial production beds in Oregon and Washington

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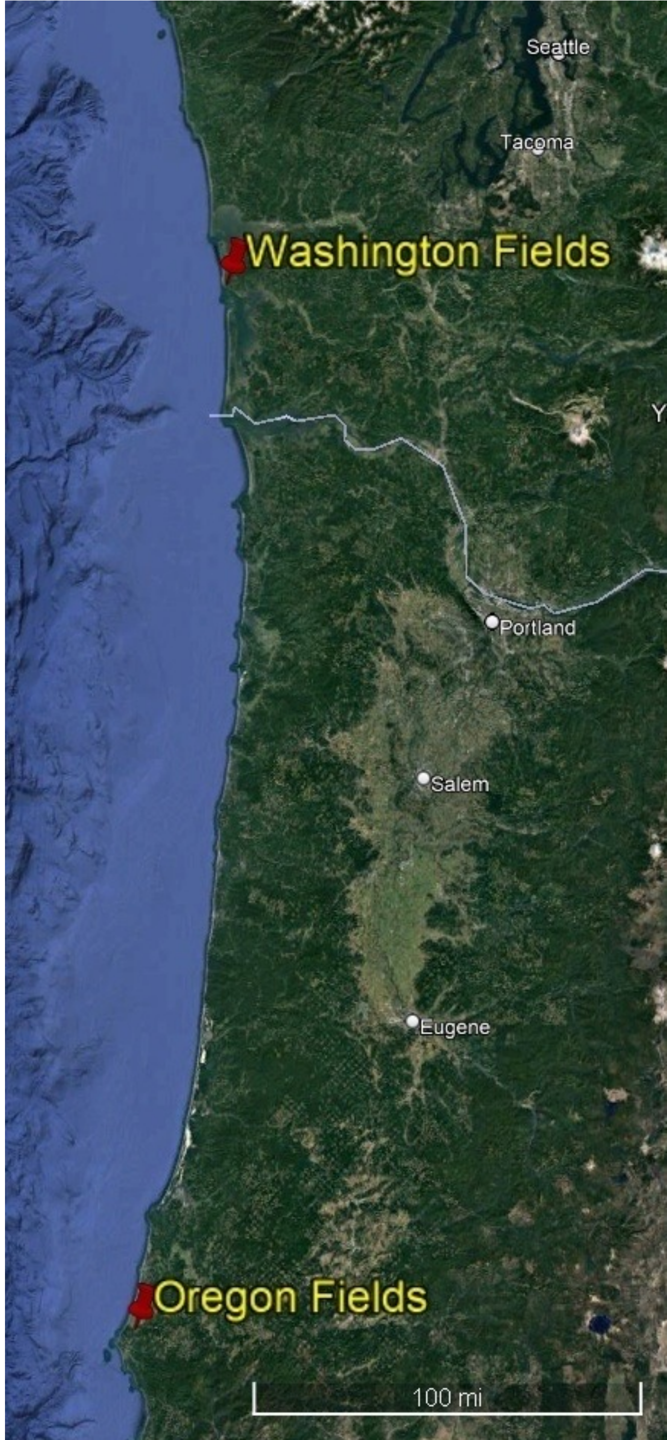
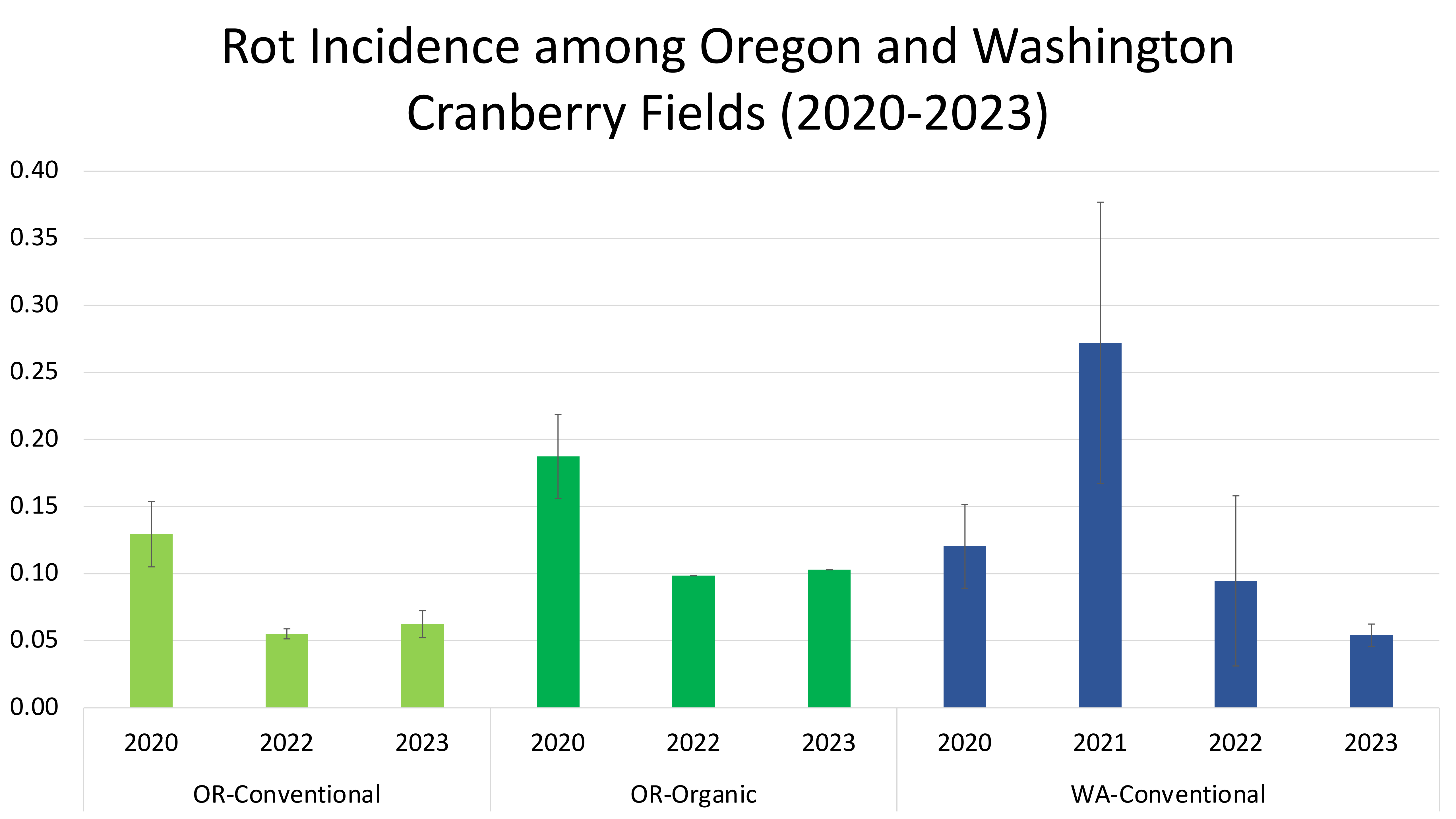
Overview of Project

- Sampling of 7 Cranberry farms across Oregon & Washington from 2020-2023
- Estimated fruit rot incidence
- Pathogen Identification
- Fungicide resistance testing
- 3-year grant funded by Northwest Center for Small Fruit Research and base funds from USDA Project 2072-22000-045-00D



Field sampling

Berry Sorting


Rot Incidence among Oregon and Washington Cranberry Fields (2020-2023)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2020
2022
2023
2020
2022
2023
2020
2021
2022
2023
OR-Conventional
OR-Organic
WA-Conventional

Culturing and Identifying Fungal Rots

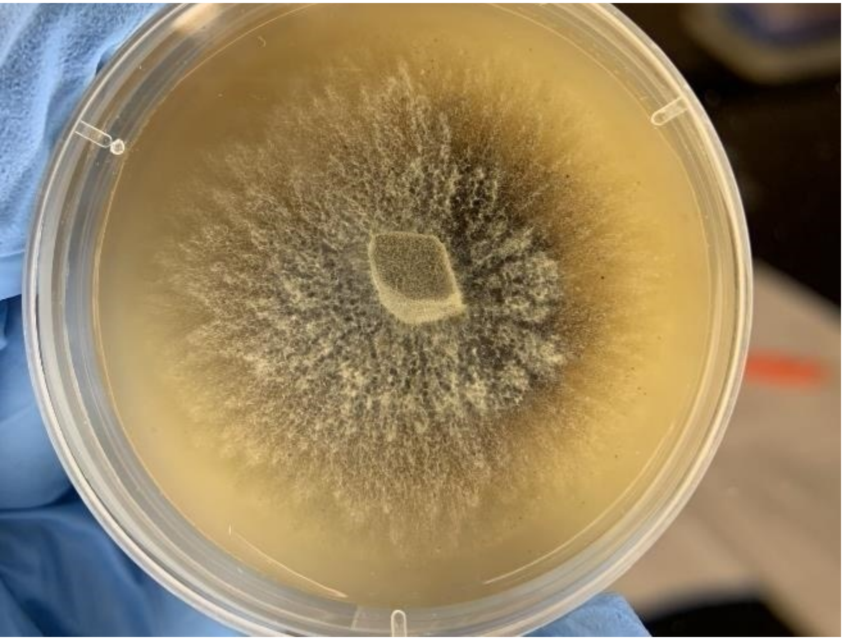
- Why plate rots?
  - Accurate ID
  - Fungicide tests

- Surface disinfest
  - 10 min 10% bleach
  - 1 min 70% Ethanol
  - 1 min DI Water
- Pinch of rot onto V8 plate
  - Multiple rounds of isolation
  - Some berries have more than one pathogen

Fruits Rots and Associated Pathogens
from WA & OR cranberry beds 2020-2023

Cranberry fruit rot disease	Fungal Pathogen
Berry speckle	*Phyllosticta elongata*
Bitter rot	*Colletotrichum fructivorum*
	Colletotrichum fiorinae
Black rot	*Allantophomopsis cytisporea*
	Allantophomopsis lycopodina
	Strasseria geniculata
Blotch rot	*Physalospora vaccinii*
End rot	*Godronia cassandrae*
Ripe rot	*Coleophoma empetri*
Viscid rot	*Phomopsis vaccinii*
Yellow rot	*Botrytis* sp.

Physalospora (Blotch rot)



Coleophoma (Ripe rot)

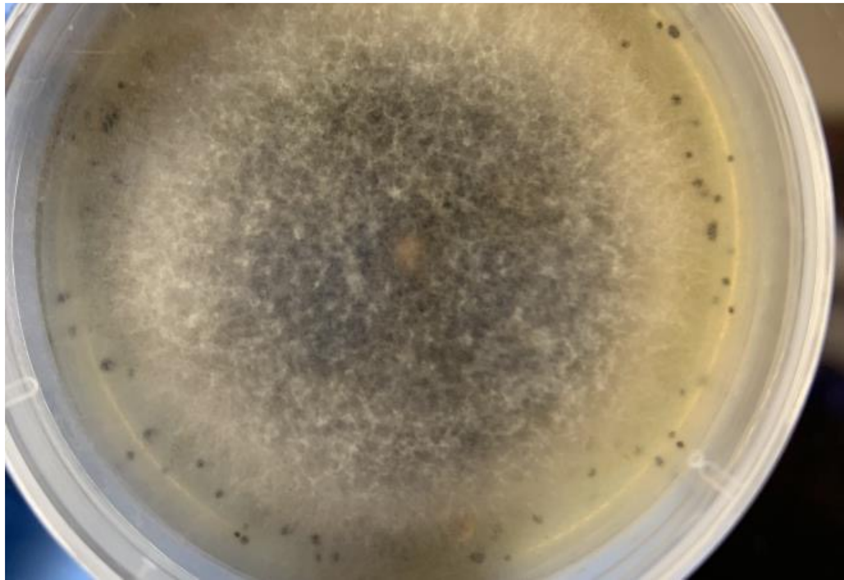
Diaporthe (Viscid rot)

Phyllosticta (Berry speckle)

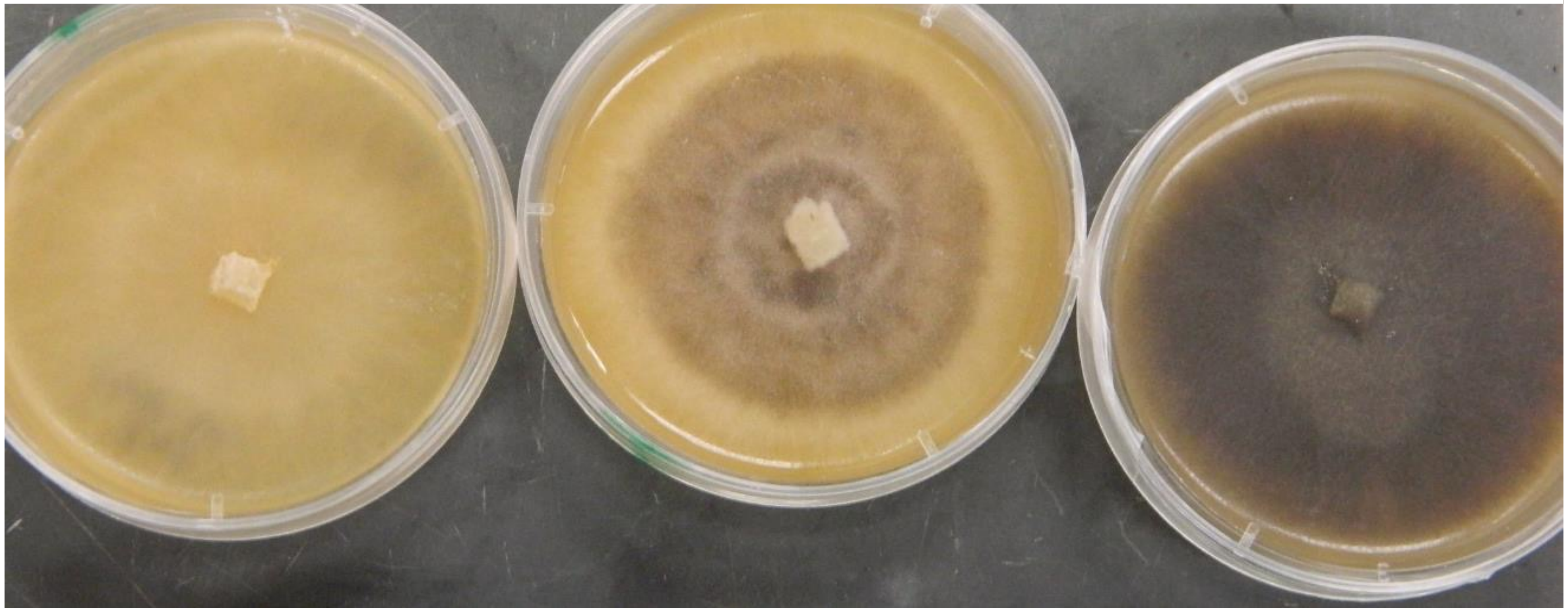
Colletotrichum (Bitter rots)

acutatum species

gloeosporioides species

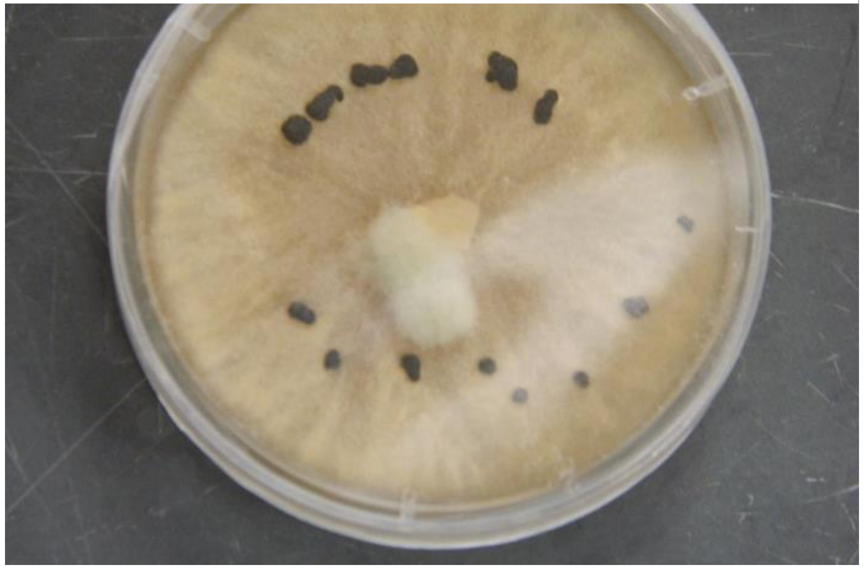


Black rots



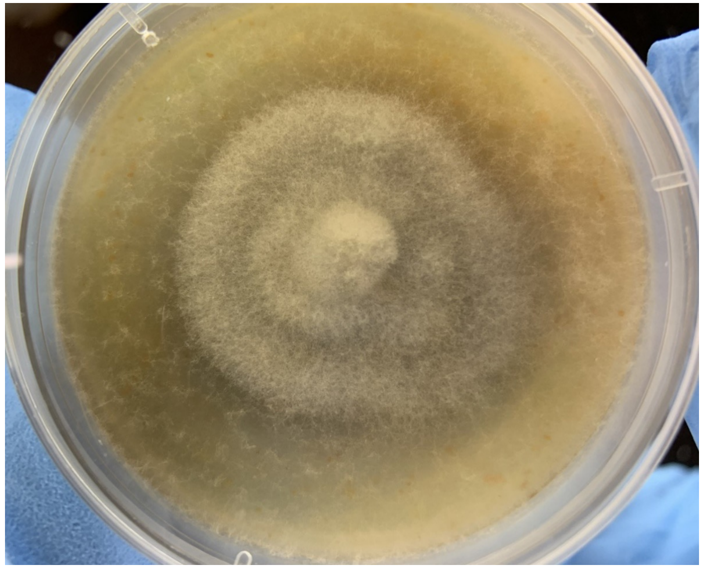
Neofabraea actinidiae

Botrytis (Yellow rot)

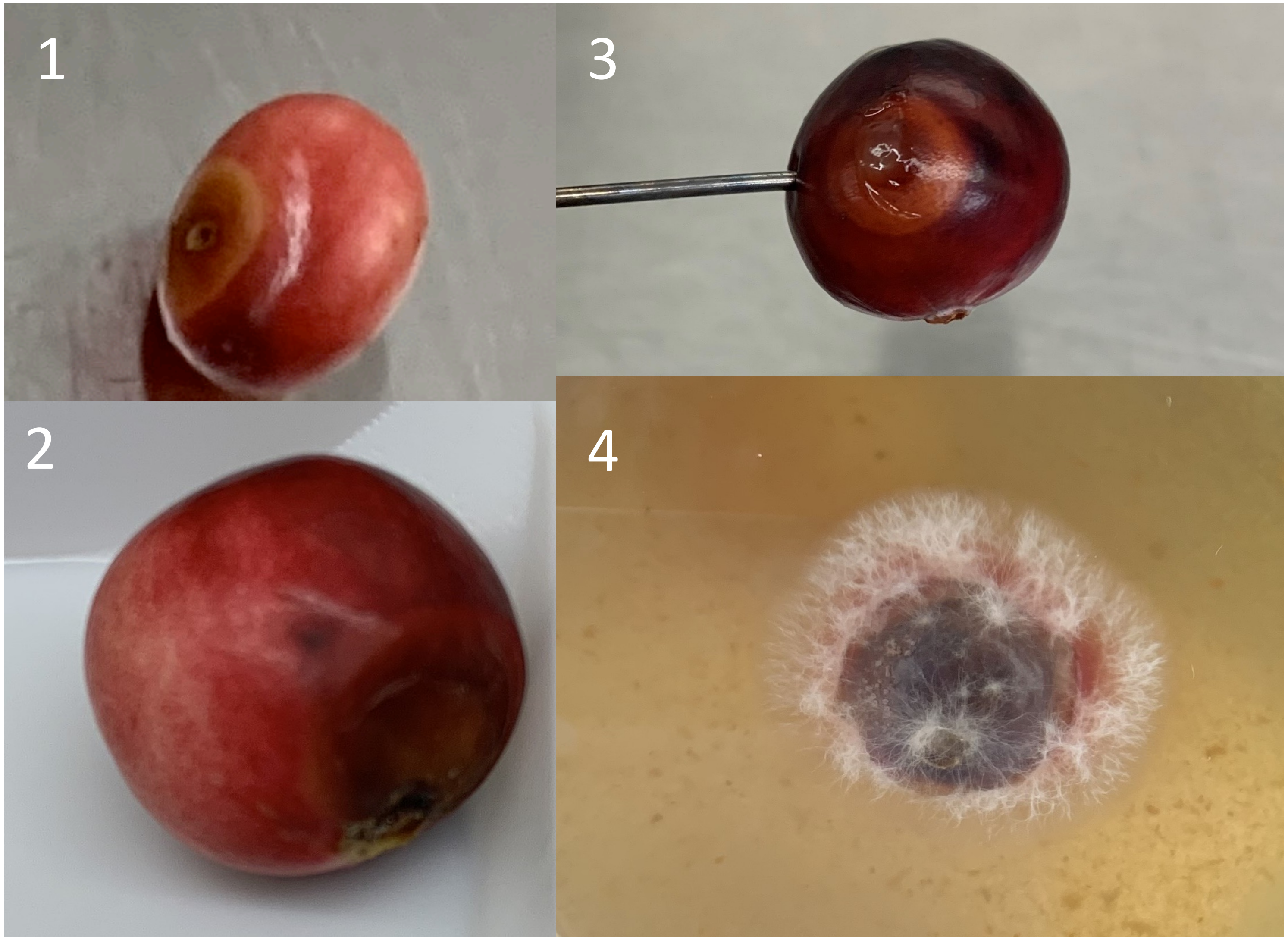


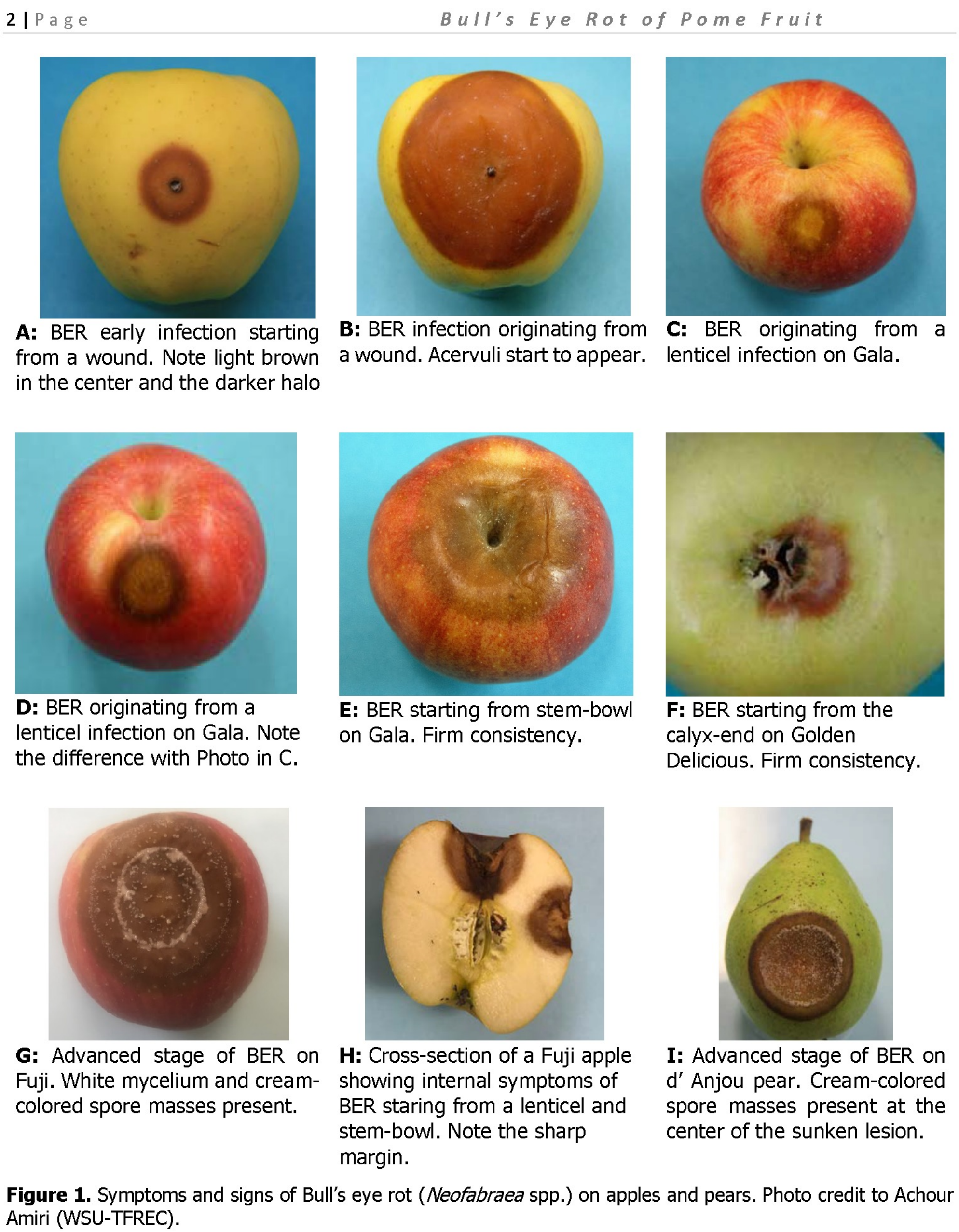
Godronia (End rot)

Cadophora



Neofabraea actinidiae as a cranberry fruit rot





A: BER early infection starting from a wound. Note light brown in the center and the darker halo

B: BER infection originating from a wound. Acervuli start to appear.

C: BER originating from a lenticel infection on Gala.

D: BER originating from a lenticel infection on Gala. Note the difference with Photo in C.

E: BER starting from stem-bowl on Gala. Firm consistency.

F: BER starting from the calyx-end on Golden Delicious. Firm consistency.

G: Advanced stage of BER on Fuji. White mycelium and cream-colored spore masses present.

H: Cross-section of a Fuji apple showing internal symptoms of BER staring from a lenticel and stem-bowl. Note the sharp margin.

I: Advanced stage of BER on d' Anjou pear. Cream-colored spore masses present at the center of the sunken lesion.

Figure 1. Symptoms and signs of Bull's eye rot (*Neofabraea* spp.) on apples and pears. Photo credit to Achour Amiri (WSU-TFREC).

"Bull's Eye Rot", Amiri, A, 2020.

Neofabraea lesions on 2023 cranberries

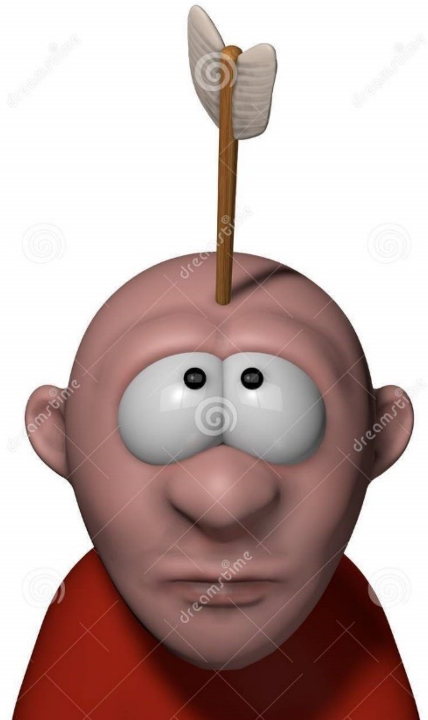
Tools for Cranberry Fruit Rot Management

- Cultural practices
  - Upkeep of beds, removal of detritus
  - Moisture/Nutrient levels
  - Shading?
- Fungicides
  - Multi-site (Chlorothalonil, Mancozeb, copper)
  - Site-specific (FRAC 3s, FRAC 11)

Multi-site Fungicides

(Chlorothalonil, Mancozeb, copper)

- Multiple avenues for effective action (not just hitting one target)
- Much lower chance of resistance developing to multi-site fungicides
- "Beyond protecting and prolonging the lifespan of highly effective medium to high resistance risk fungicides, multisite fungicides provide added levels and spectrum of disease control. With this they can also support the single sites to be even more efficient"-FRAC (Fungicide Resistance Action Committee)
- More likely to affect non-target organisms



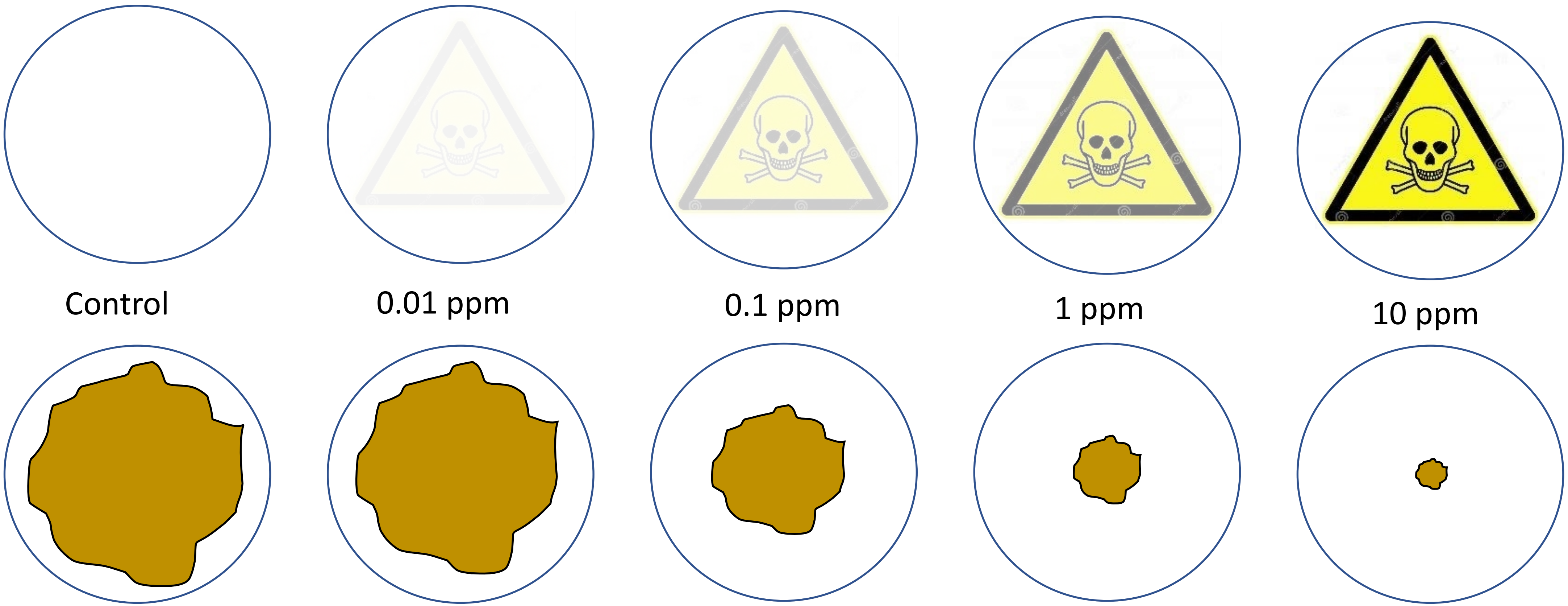
Site-specific Fungicides

- Associated with lower impact on environment and non-target organisms, but likelihood of developing resistance is higher than in multi-site fungicides

- FRAC 3-Fenbuconazole, Difenoconazole, Prothioconazole
  - Demethylation Inhibitors (DMIs)-targets cell membrane production
  - “Generally wise to accept that cross resistance is present between DMI fungicides active against the same fungus”-FRAC

FRAC 11-Azoxystrobin
  - Quinone Outside Inhibitor (QoI)- targets “respiration” of fungi
  - Several mutations known to confer resistance
  - Cross-resistance between all FRAC 11s (switching to another FRAC 11 won’t avoid resistance)

Fungicide Assays



AAT Bioquest, Inc. (2023, March 20). *Quest Graph™ EC50 Calculator*. AAT Bioquest. https://www.aatbio.com/tools/ec50-calculator.

Coleophoma vs. FRAC 3 & 11

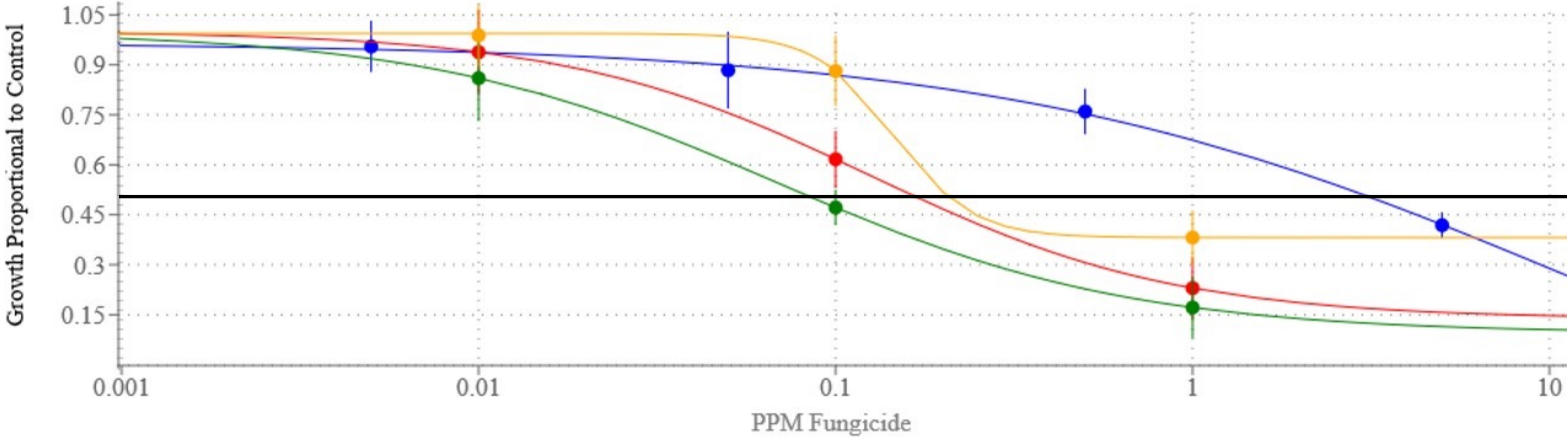
EC_{50} (ppm)

0.09------ Difenoconazole

0.17------ Fenbuconazole

0.21------ Prothioconazole

3.19------ Azoxystrobin



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Coleophoma vs. FRAC 3 & 11

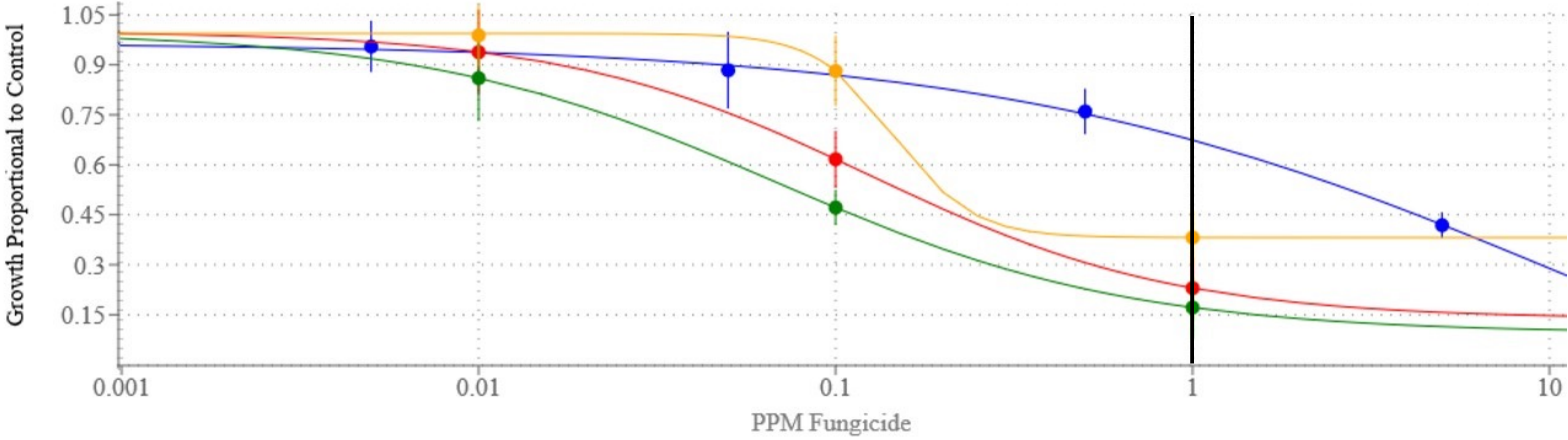
Growth Proportional to Control

0.17------ Difenoconazole

0.23------ Fenbuconazole

0.39------ Prothioconazole

0.66------ Azoxystrobin



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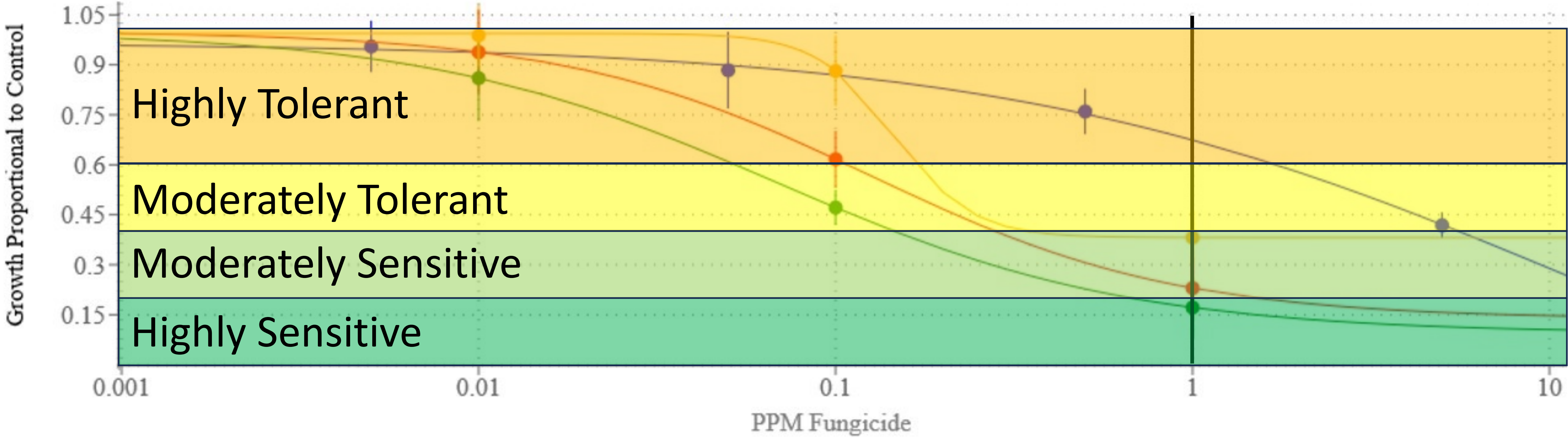

	Fenbuconazole	Prothioconazole	Azoxystrobin
Black Rots	HS	HS	HS → HT
Diaporthe sp.	HS → MS	HS → MS	HS → MT
Colletotrichum sp.	MS → HT	HS → HT	MS → MT
Coleophoma sp.	MS	MS	MT → HT
Physalospora vaccinii	MS	HS	HS → MS
Phyllosticta elongata	HS	HS	HS
Godronia	MS → MT	HS → MT	HS → MS
Neofabraea actinidiae	MS	MT	MT
Cadophora sp.	HT	MS	MS → MT

Sensitivity	Growth proportional to Control
Highly sensitive	<0.20
Moderately sensitive	0.20-0.40
Moderately tolerant	0.40-0.60
Highly tolerant	0.60<

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- 3 Main species- sensitivity/tolerance is consistent regardless of any other factors (species, farm, field or storage rot).
- In fields where Azoxystrobin is sprayed, we see a larger proportion of *Coleophoma sp.* as a CFR (not an increase in rot overall).

	Fenbuconazole	Prothioconazole	Azoxystrobin
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Colletotrichum sp.	MS → HT	HS → HT	MS → MT
Coleophoma sp.	MS	MS	MT → HT

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Highly tolerant	0.60<

- Many *Diaporthe* species alongside *Diaporthe vaccinii*.
- Variability, largely with FRAC 11-appears to be species-specific rather than spray history (acquired).

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- Two complexes: gloeosporioides and acutatum.
  - Multiple species within each complex
- Tolerance to Fenbuconazole for many *gloeopsorioides* species (Wells et al, 2014,"Fungicide Efficacy and Specificity Toward Fungi in the Cranberry Fruit Rot Disease Complex")
- Mainly see 2 *acutatum* species- both have specific sensitivities based soley on species.

To Date

- No evidence of resistance developing among strains tested
  - Low application frequency of single-site fungicides (1-2 times per year)
  - Fungicide tolerance appears species-dependent within complexes
- Some fungi are naturally tolerant to certain classes of site-specific fungicides
  - Need to know what management tools work for which rot types
- Consistency of CFR species year-to-year in beds.
  - Similar to NJ, unlike Wisconsin (Wells-Hansen & McManus, 2017).
  - Tend to be diverse populations
- Continued testing on 2023 isolates
  - Spore germination assays
  - 2024 Isolates…
  - Keeping an eye out for resistance development

New Project: S.A.M.E.(Systems Approach in Managing the Expression of CFRs)

- Across all 5 cranberry-producing states (Wisconsin, Massachusetts, New Jersey, Oregon, Washington).
- Isolating Cranberry Fruit Rots from bloom through harvest
  - Identification, testing fungicides & molecular ID tools

Acknowledgements

- Funding for the project was provided by a grant from the Northwest Center for Small Fruit Research and base funds from USDA Project 2072-22000-045-00D.

- Sincere thanks to the growers who allowed us to sample their cranberry beds and to Rod Keller, Gayle McGhee and Brenda Shaffer for excellent technical assistance!


Questions?