Bitter Rot of Apple: Fungal Species In Pennsylvania & Managing Fungicide Resistance

Photo: P. Martin

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Mid-Atlantic Fruit & Vegetable Convention **January 30th, 2019**

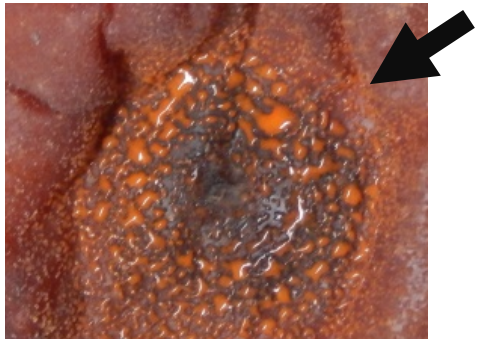
Presentation outline

- What fungi cause bitter rot
- How the fungi works in nature
- Research
  - Bitter rot causing species in PA
  - Fungicide sensitivity assays: In the lab
  - Fungicide efficacy: In the field
  - Management recommendations

The causal fungi: *Colletotrichum* species

Sunken lesion

Orange spores (conidia)



Concentric rings

Bitter rot V-shaped lesion

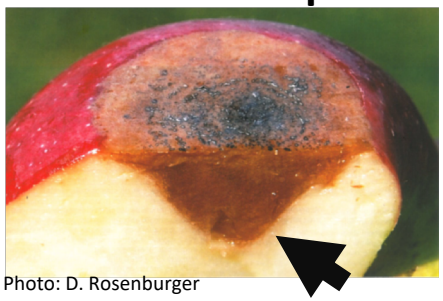
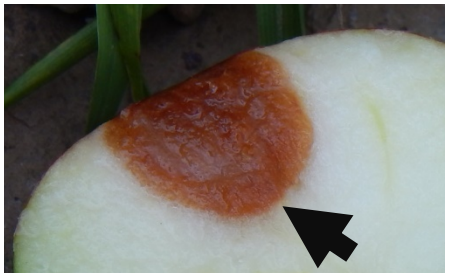
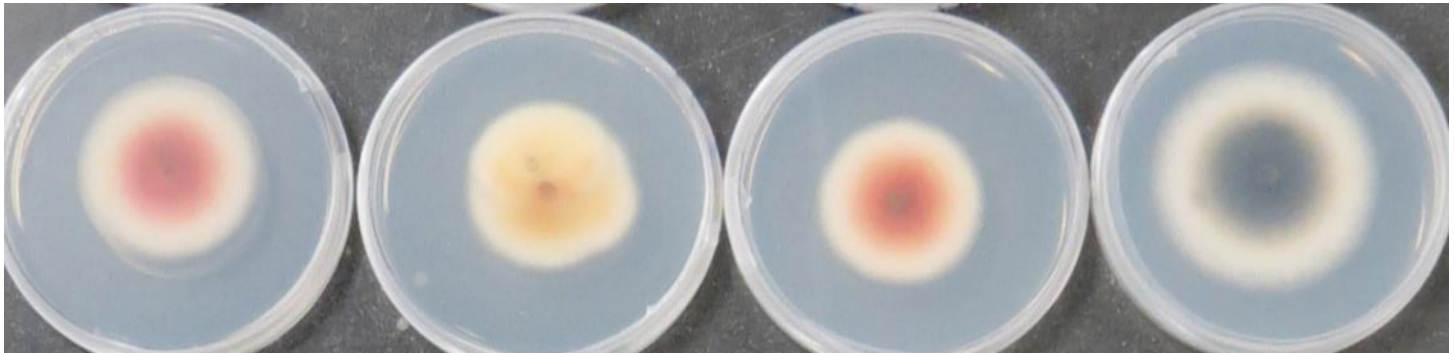


Photo: D. Rosenburger

Black or white rot U-shaped lesion



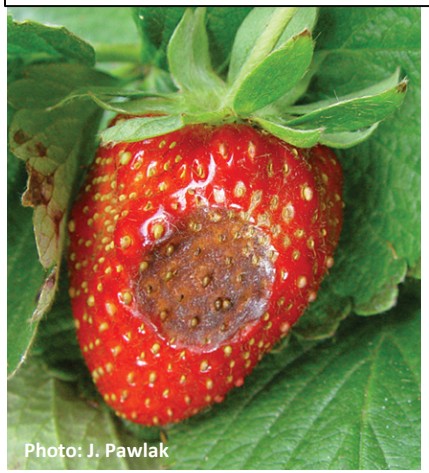
Colletotrichum on growth media



Photos: P. Martin

Colletotrichum fungi infect many plants

Anthracnose



Strawberries

Blueberries

Pears

Photo: P. Martin

Peaches

celery leaf curl

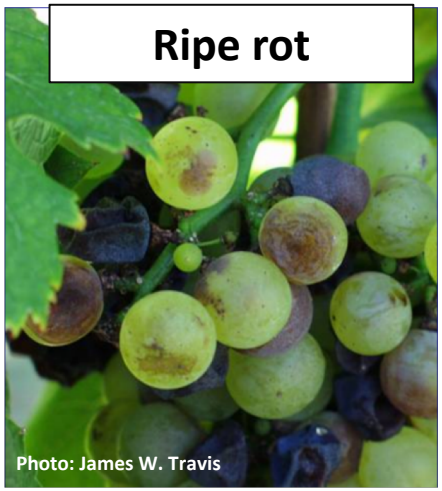
Celery

Blossom end rot

Photo: Greg Miller

Chestnuts

Ripe rot



Grapes

Colletotrichum fungi often have dormant stages

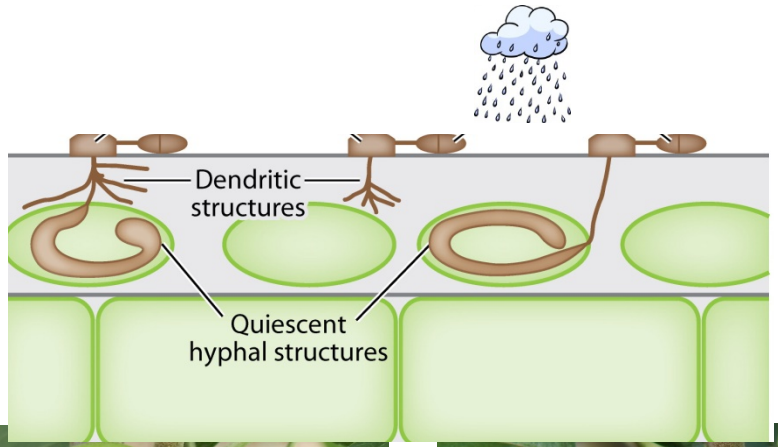
Bitter Rot Fungi Infection Cycle

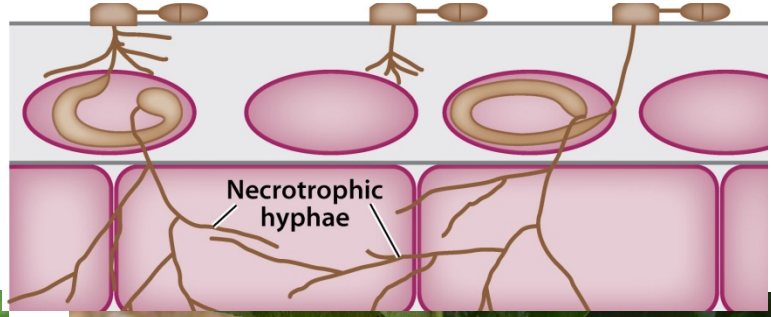
Bitter rot appears late season through post harvest

Spring | Summer | Fall | Winter

Most likely infection period. Bitter rot fungi can directly penetrate the cuticle.

Bitter rot overwinters on infected apples, dead twigs and bark.





June 8, 2018

July 3, 2018

August 2, 2018

Photos: P. Martin

Two species complexes of *Colletotrichum* cause bitter rot

Merivon label

Bitter rot
(*Colletotrichum* spp.)

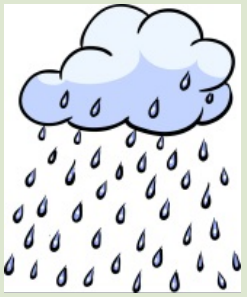
Luna Sensation label

Bitter rot[1]
(Glomerella cingulata)

Asexual spores = conidia

Sexual spores = ascospores

The species complexes are similar to each other in many ways
A few differences are listed below

***C. acutatum* species complex**	***C. gloeosporioides* (*Glomerella cingulata*) species complex**
Produces asexual spores (rain splash dispersed) 	Produces both sexual and asexual spores (wind and rain splash dispersed)  
More common in the north	More common in the south
Less sensitive to fungicides?	More sensitive to fungicides?

Fungal species that cause bitter rot in PA: request for samples

The Pennsylvania State University [US] | https://extension.psu.edu/wanted-bitter-rot-of-apple-samples...

PennState Extension MENU SEARCH ACCOUNT CART

LEARN HOW TO STOP THE INVASIVE SPOTTED LANTERNFLY >

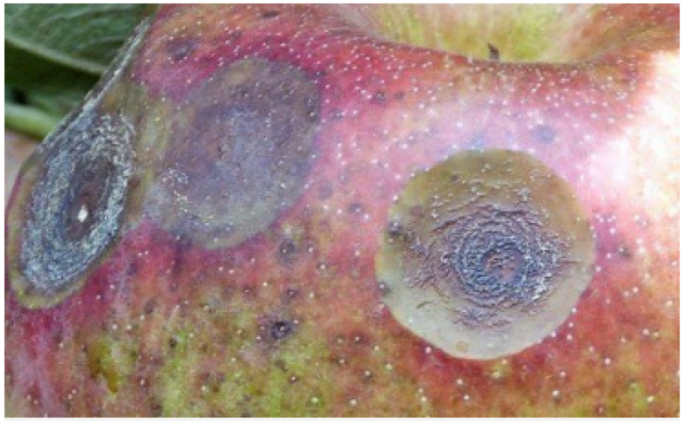
HOME | WANTED: BITTER ROT OF APPLE SAMPLES FROM PENNSYLVANIA GROWERS

Wanted: Bitter Rot of Apple Samples From Pennsylvania Growers

The Tree Fruit Pathology Lab at the Fruit Research and Extension Center is seeking apples infected with the fungus causing bitter rot from around the state of Pennsylvania in commercial orchards.

Save For Later Print

NEWS| UPDATED: AUGUST 27, 2018



Bitter rot on apple and pear fruit is caused by the pathogenic fungi Colletrotrichum gloeosporioides and C. acutatum. Photo: Kari Peter, Penn State

This might very well be the "Year of Bitter Rot." Reports have been rolling in about the high incidence of bitter rot in apple orchards. The conditions this season have favored this explosion of disease activity. Consequently, we want to take advantage of this situation.

We are interested in obtaining apple fruit infected with the bitter rot fungus from around Pennsylvania to understand what species occur in Pennsylvania. We also want to test these fungal isolates for fungicide resistance to the most commonly used fungicides.

This research ultimately will lead to better bitter rot management strategies. Our goal is to collect bitter rot apples from as many PA counties as possible. Pennsylvania is a big state, so we need your help!

RELATED PRODUCTS

Spotted Lanternfly Public Meetings
WORKSHOPS

Blueberry Growers School
WORKSHOPS

Spotted Lanternfly Conference for the Green Industry
WORKSHOPS

Apple Insect and Mite Control Toolbox - Insecticide and...
ARTICLES

Tree Fruit Production Guide 2018-2019

Fungal species that cause bitter rot: >500 samples from ~40 orchards

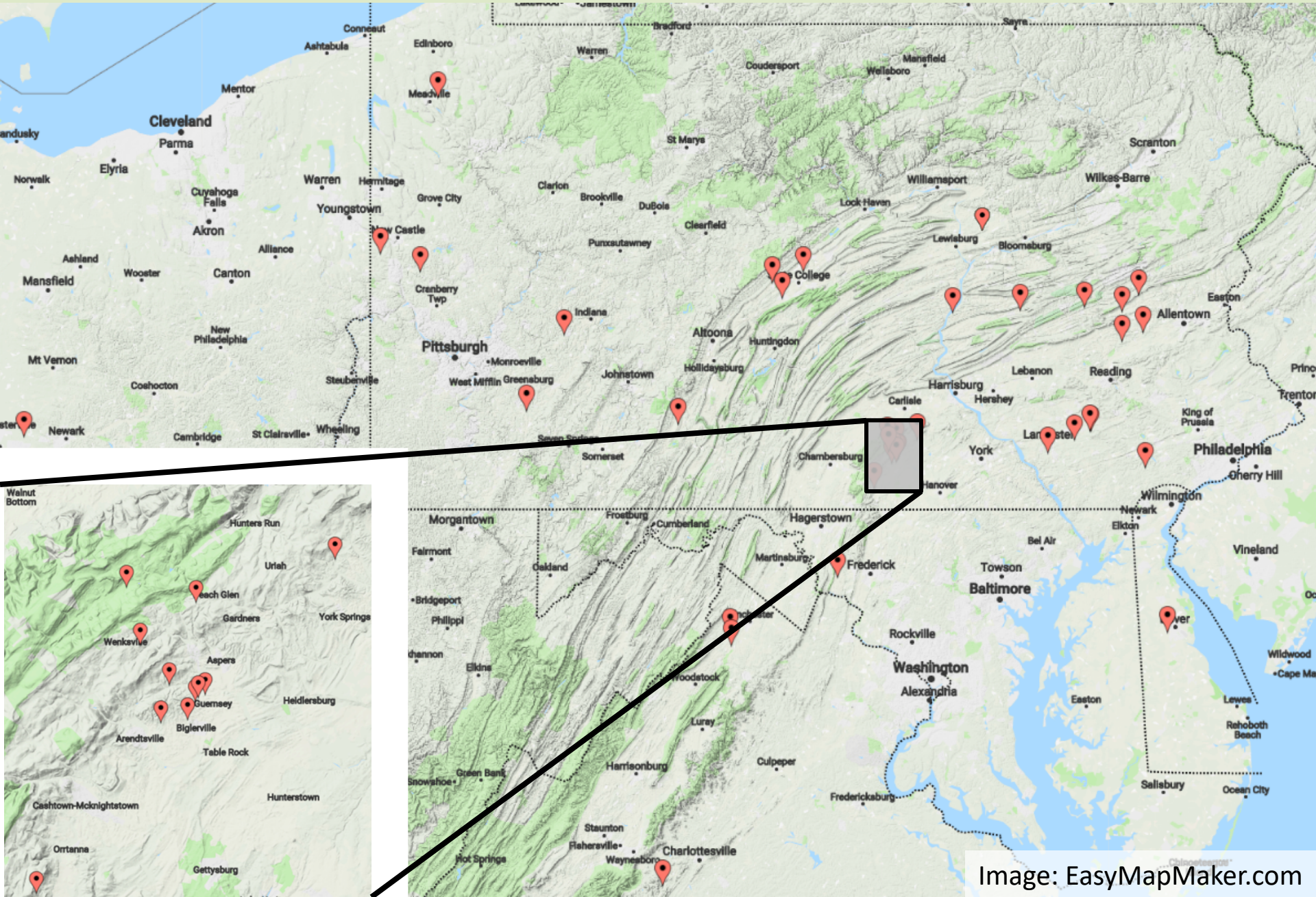


Image: EasyMapMaker.com

What fungal species cause bitter rot in PA? Species survey results

Over 500 fungal isolates collected from nearly 40 orchards

Bitter Rot Species Survey Results

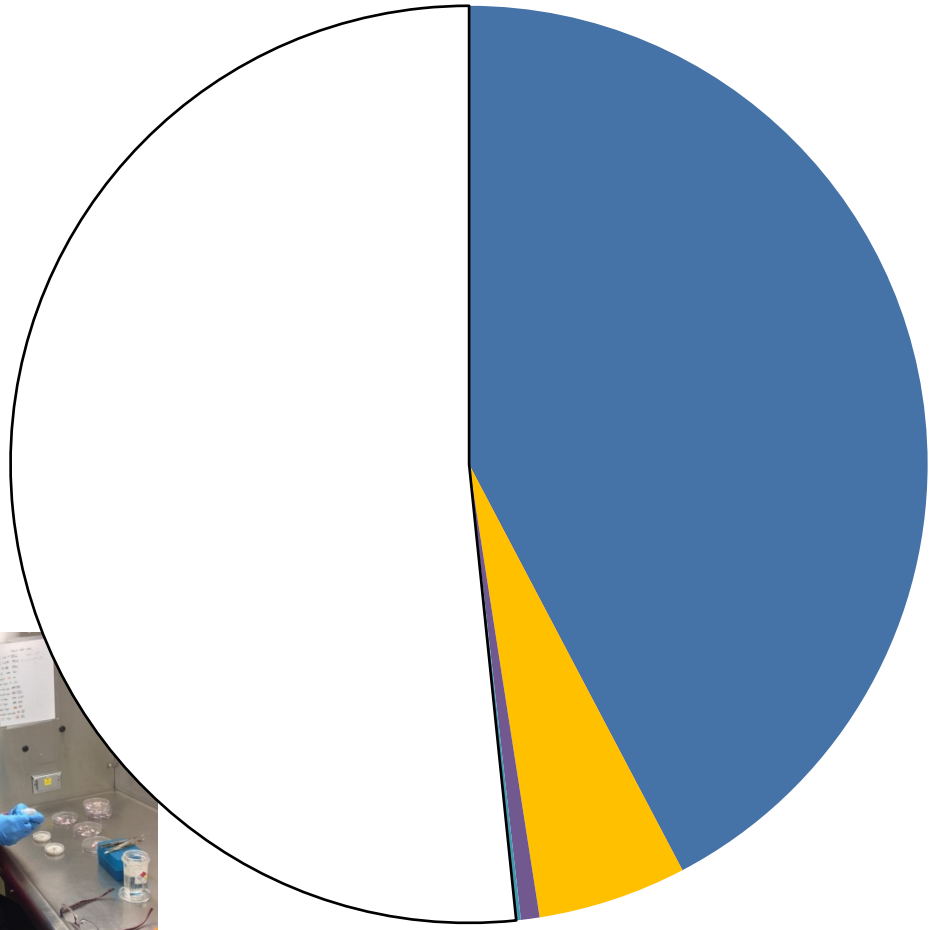



Photo: K. Peter

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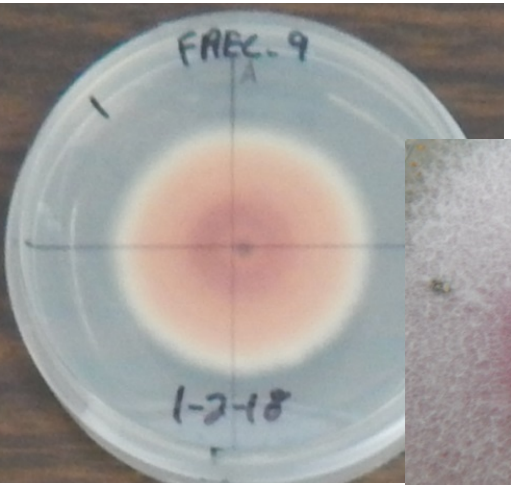
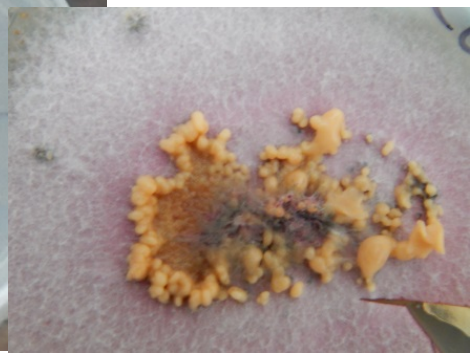
Fungal species that cause bitter rot: characteristics of species

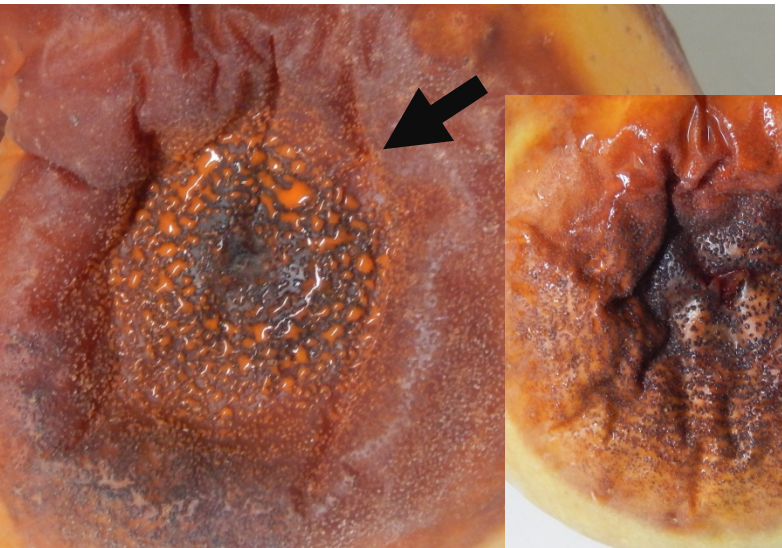
C. acutatum species complex

Sexual stage rare

- *C. fioriniae*



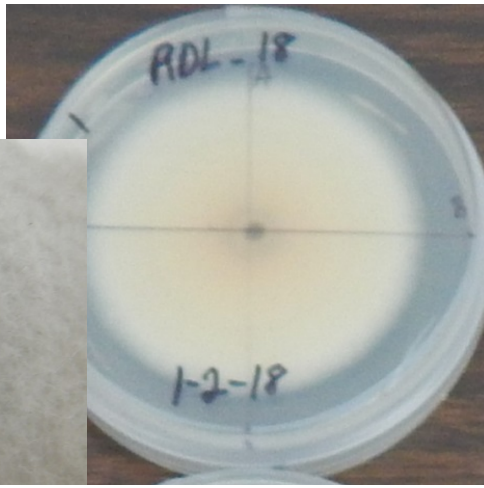




C. gloeosporioides species complex

Sexual stage common

- *C. fructicola S.L.*
- *C. siamense*
- *C. henanense*



Determining fungicide sensitivity of *Colletotrichum* species found in PA

Focusing on fungicides that are commonly used for control of summer rots, especially those labeled for bitter rot

FRAC #	Trade Names	Active ingredient	PHI	Resistance risk
1	Topsin	Thiophanate methyl	1	High
11	Flint Extra Luna Sensation Merivon	Trifloxystrobin Trifloxystrobin Pyraclostrobin	14 14 0	High
12	Scholar	Fludioxonil	post	High
29	Omega	Fluazinam	28	Low - Medium

Photo: Phillip Martin

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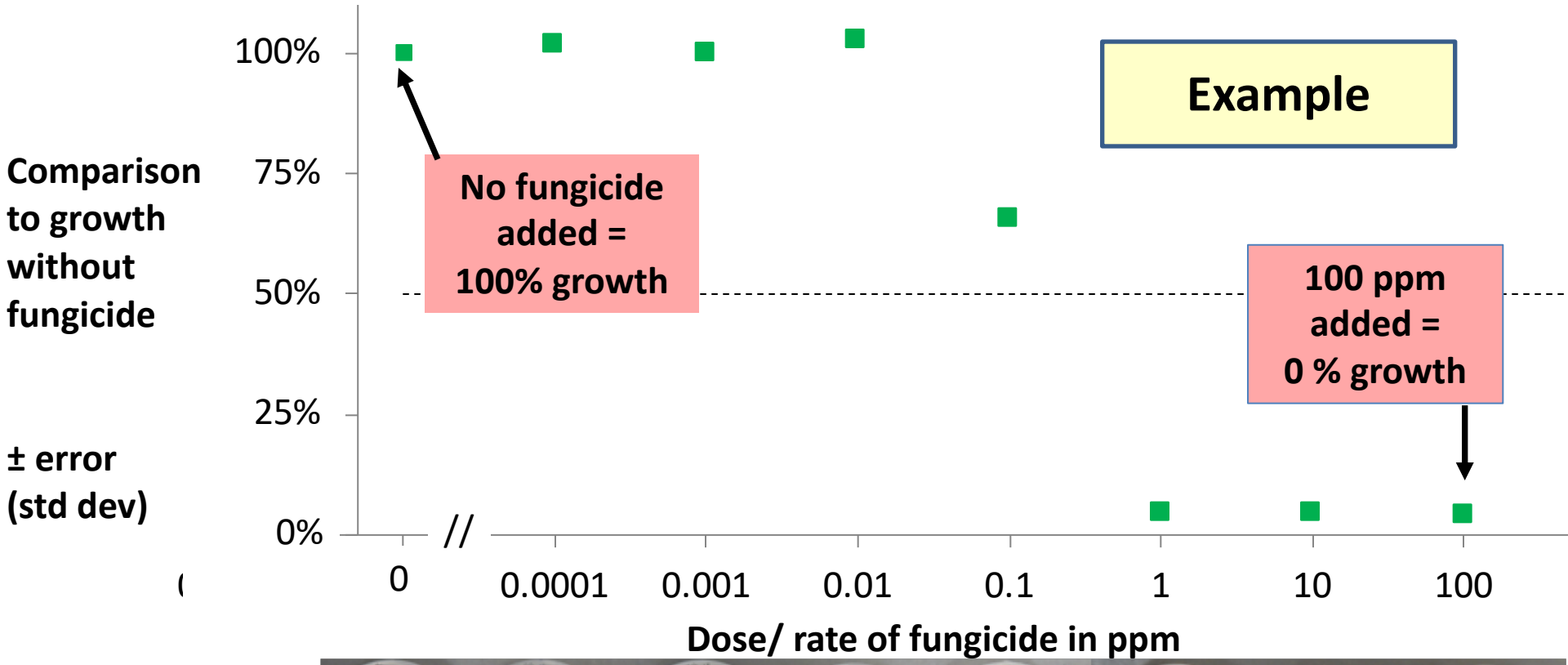
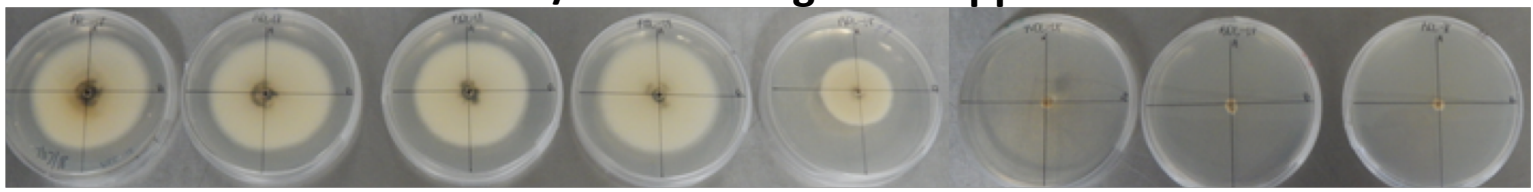
Fungicide sensitivity testing methods

- Lab tests
  - **Use "poison plate" assay**: Various amounts of fungicide is mixed with growth media and fungal growth is measured relative to an untreated control



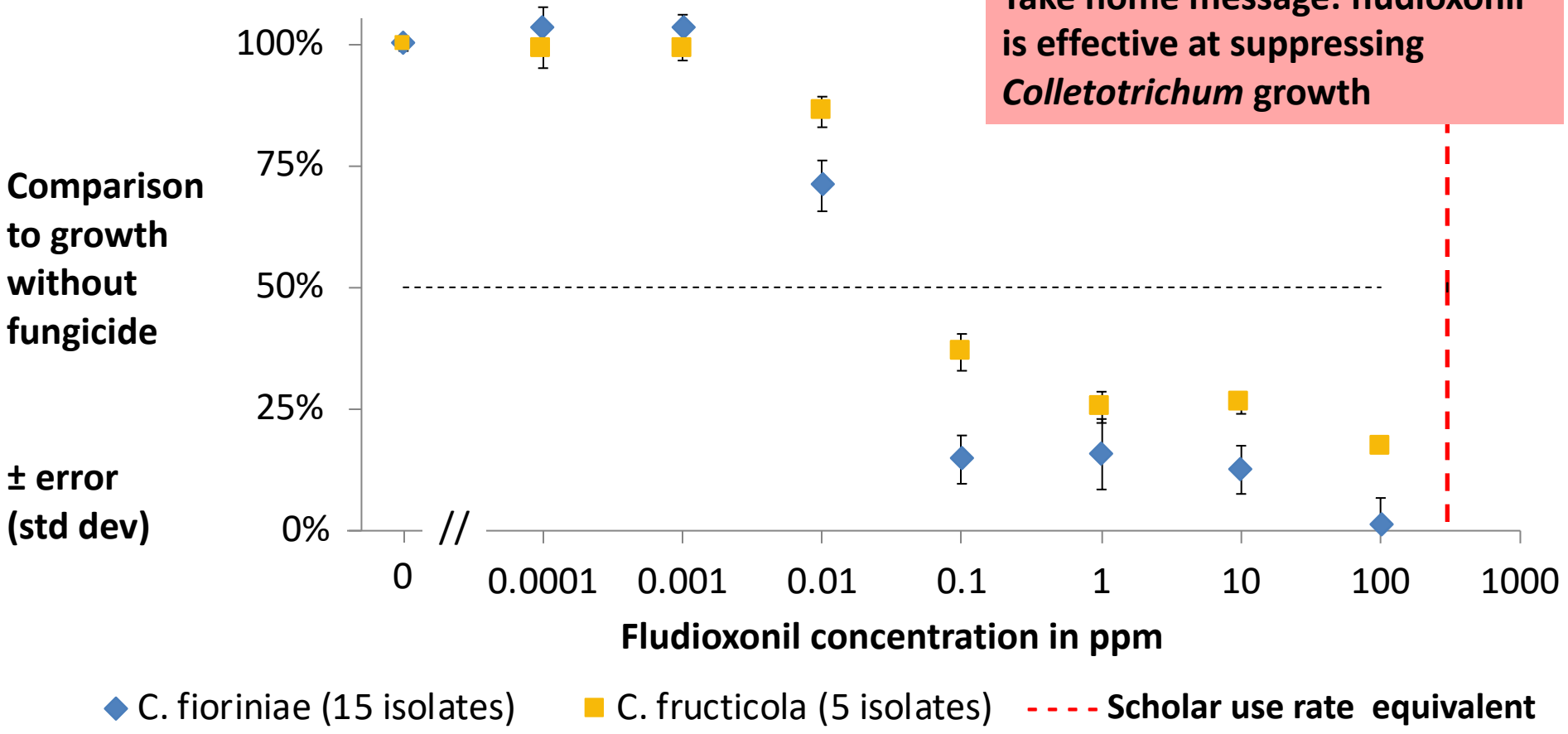


Fungicide sensitivity towards FRAC group 12: fludioxonil

Tested as Scholar (post-harvest)

- What *Colletotrichum* would see when treated in the packhouse (incorporated when processing) or while storage (fogged CA storages)

Take home message: fludioxonil is effective at suppressing *Colletotrichum* growth

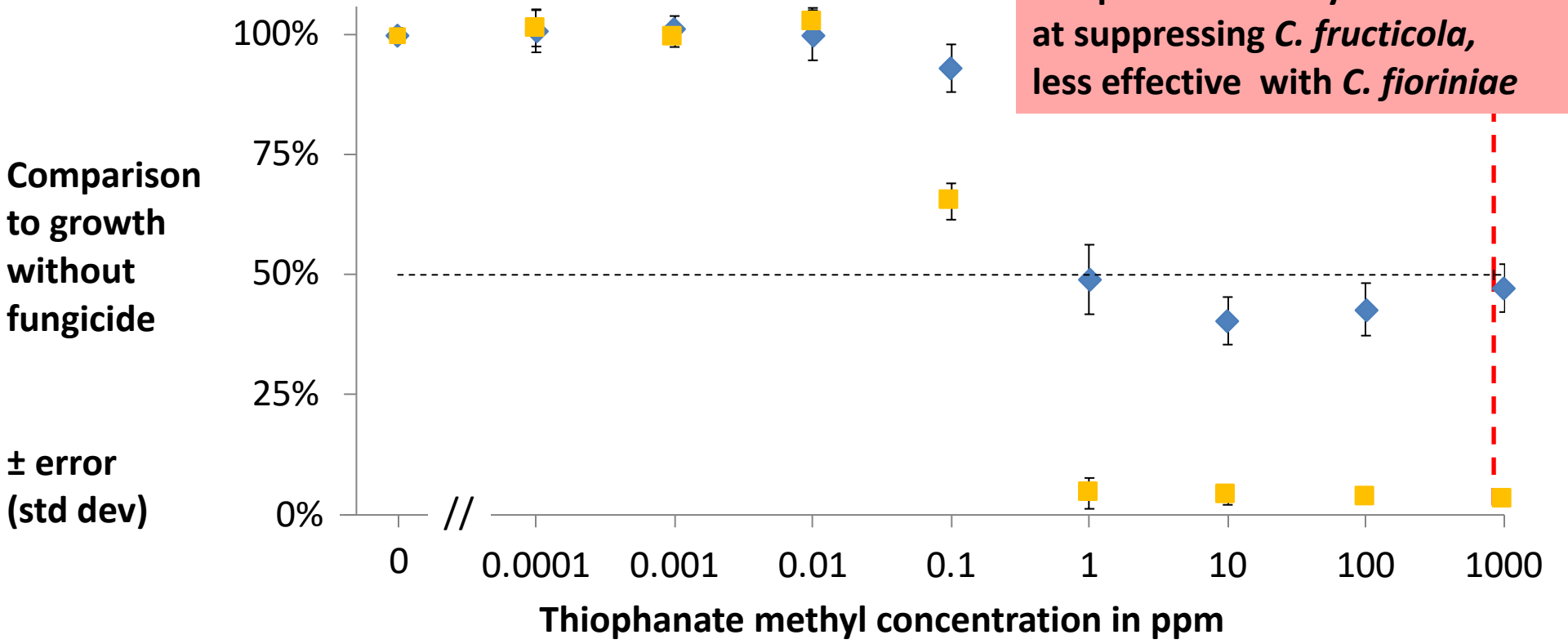


Fungicide sensitivity towards FRAC group 1: thiophanate methyl

Tested as Topsin M (pre-harvest)

- **What Colletotrichum would see in the field**

Take home message: thiophanate methyl is effective at suppressing *C. fructicola*, less effective with *C. fioriniae*



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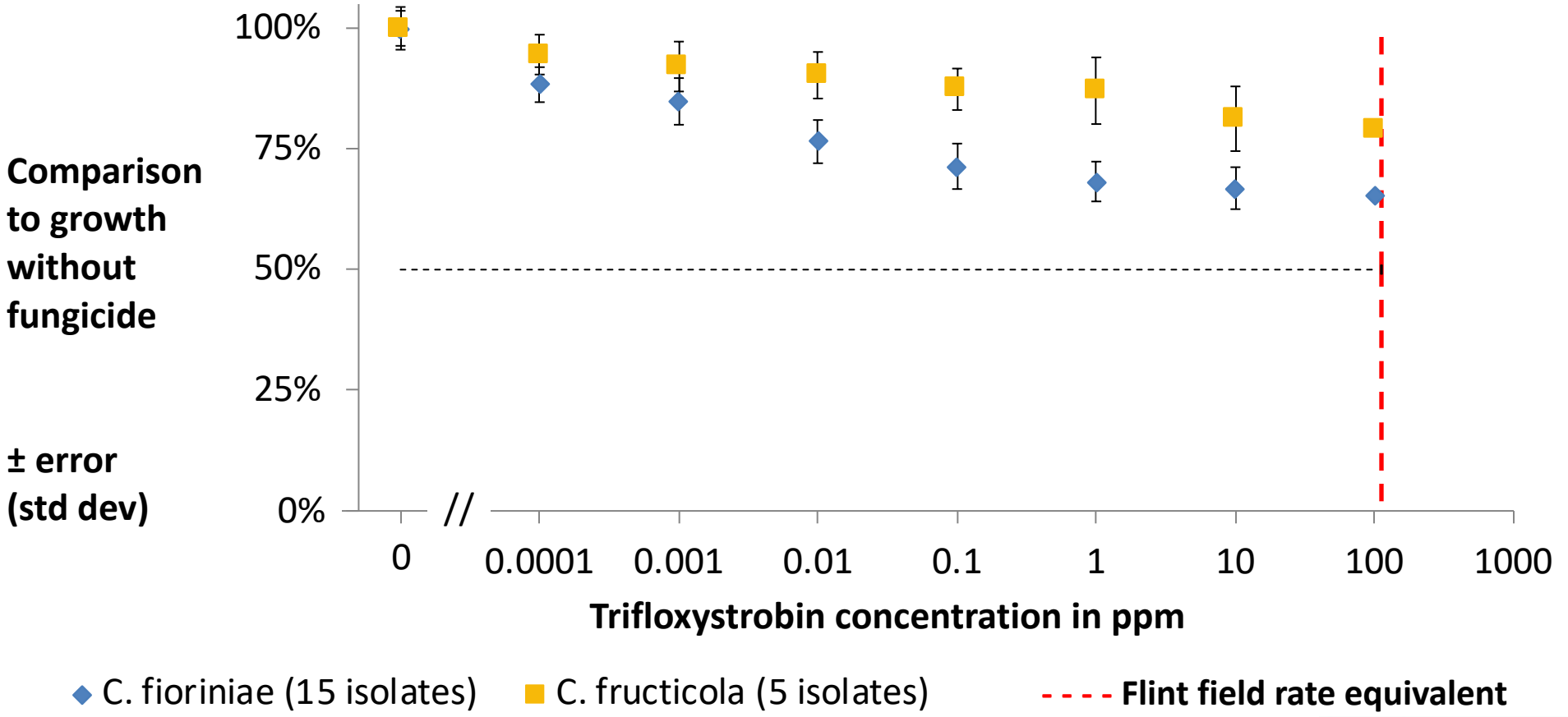
Fungicide sensitivity towards FRAC group 11: trifloxystrobin

Tested as Flint Extra (pre-harvest)

- What Colletotrichum would see in the field

Take home message: trifloxystrobin is not effective at reducing *Colletotrichum* growth



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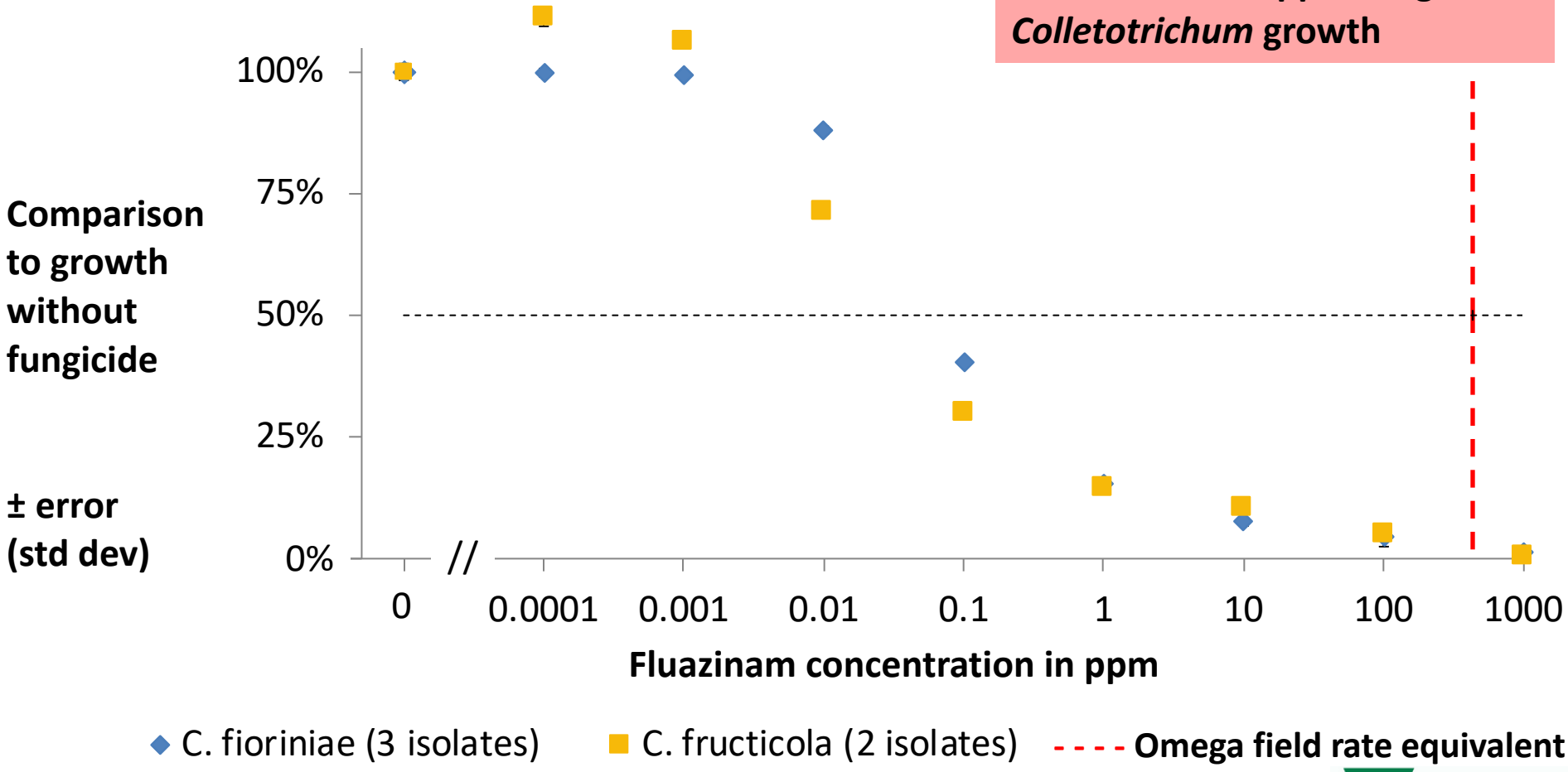
Fungicide sensitivity towards FRAC group 29: fluazinam

Tested as Omega (pre-harvest)

- What Colletotrichum would see in the field

Take home message: fluazinam is effective at suppressing *Colletotrichum* growth



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Fungicide Field Trial in ‘Honeycrisp’ orchard block

Photo: Phillip Martin

Fungicide Field Trial in ‘Honeycrisp’ orchard block: checking for dormant infections

Mid season rating of quiescent infection incidence

Pick asymptomatic apples during the season

Surface disinfest with bleach and ethanol, freeze overnight.

Incubate and observe for characteristic orange spore masses

Harvest rating of bitter rot incidence

Rate apples for visible infections at harvest

Photo: Phillip Martin

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2018 Fungicide Field Trial results: timing of fungicide applications

Treatments			Apples picked July 3rd : % sporulation (via freeze method)	% Bitter Rot Incidence at harvest
FRAC	Formulation	Timing of application		
7&11	Mancozeb Merivon + mancozeb	Tight cluster Pink, Bloom, PF	c	b
7	Mancozeb Sercadis + mancozeb	Tight cluster Pink, Bloom, PF	bc	b
3&9	Mancozeb Inspire Super + mancozeb	Tight cluster Pink, Bloom, PF	bc	b
M	Captan (3 lb/acre)	Covers starting 5/24, every 10 day until harvest (8/30)	ab	a
Untreated		--	a	b

No cover sprays

α = 0.05

Tight cluster: April 18
Pink: May 1
Bloom: May 7
Petal fall: May 14
First cover: May 24

Take home message: Bitter rot infections can start throughout the season. Early fungicide sprays help with early infections, but good summer cover sprays are needed for full control. Merivon and Captan are best.

Published in Pennsylvania Fruit News February 2019

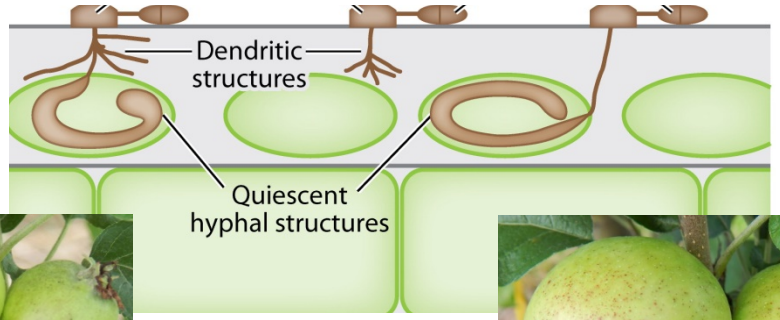
Fungicide Field Trial results: mid/late season reach-back activity

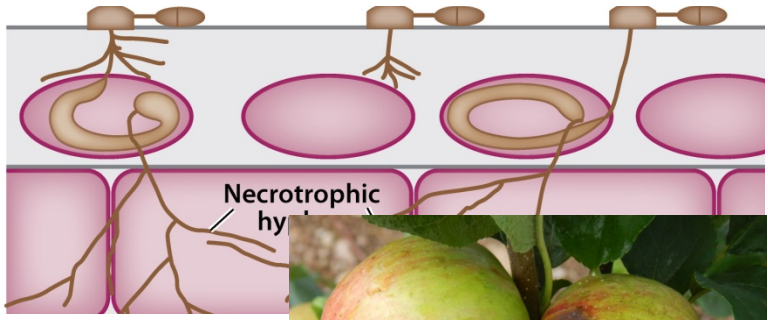
Treatments		Timing	% Bitter Rot Incidence at harvest
FRAC	Formulation		
7&11	Merivon	June 28	b
7&11	Luna Sensation	June 28	ab
3&9	Inspire Super	June 28	ab
Untreated		--	a

α = 0.05

0% 50% 100%

Take home m
activity of the
Merivon m
dormant long
Full season
prevent infec





Published in Pennsylvania Fruit News February 2019

Recommendations are changing

Penn State Tree Fruit Production Guide

Table 4-8. Apples: fungicide and antibiotic efficacy.

	Disease										
	Alternaria leaf blotch	Apple scab	Bitter rot	Black rot	Blossom end rot *(Botrytis)*	Fire blight	Flyspeck	Powdery mildew	Rusts	Sooty blotch	White rot

Degree of control: 1 = best, 2 = good, 3 = fair, 4 = slight, 5 = none, 6 = no registration

2018 -2019 edition	
Luna Sensation	1
Merivon	1
captan	2
Flint	2
mancozeb	2
Omega	2
Inspire Super	6
thiophanate-methyl	6

2020-2021 edition	
Merivon	1-2
Omega	1*
captan	2
mancozeb	2
Luna Sensation	3-4
Flint	3-4
Inspire Super	6
thiophanate-methyl	6

Bitter rot management recommendations*

Complete sprays best; IF ARM = KEEP INTERVALS VERY TIGHT

Bloom	7 days later	7 – 10 days later (if rain = 7 days)	7 – 10 days later (if rain = 7 days)	Covers
Merivon + Mancozeb	Merivon + Mancozeb	Mancozeb + Omega** or Captan 3 lb + Omega**	Merivon + Captan	Mid June: Omega** + Captan 3 lb OR Captan 5 lb (alone) Through August - September: Captan 5 lb (alone) rotated with Captan 3 lb + thiophanate methyl 1 lb Option: 28 day PHI One more app: Omega + Captan 3 lb

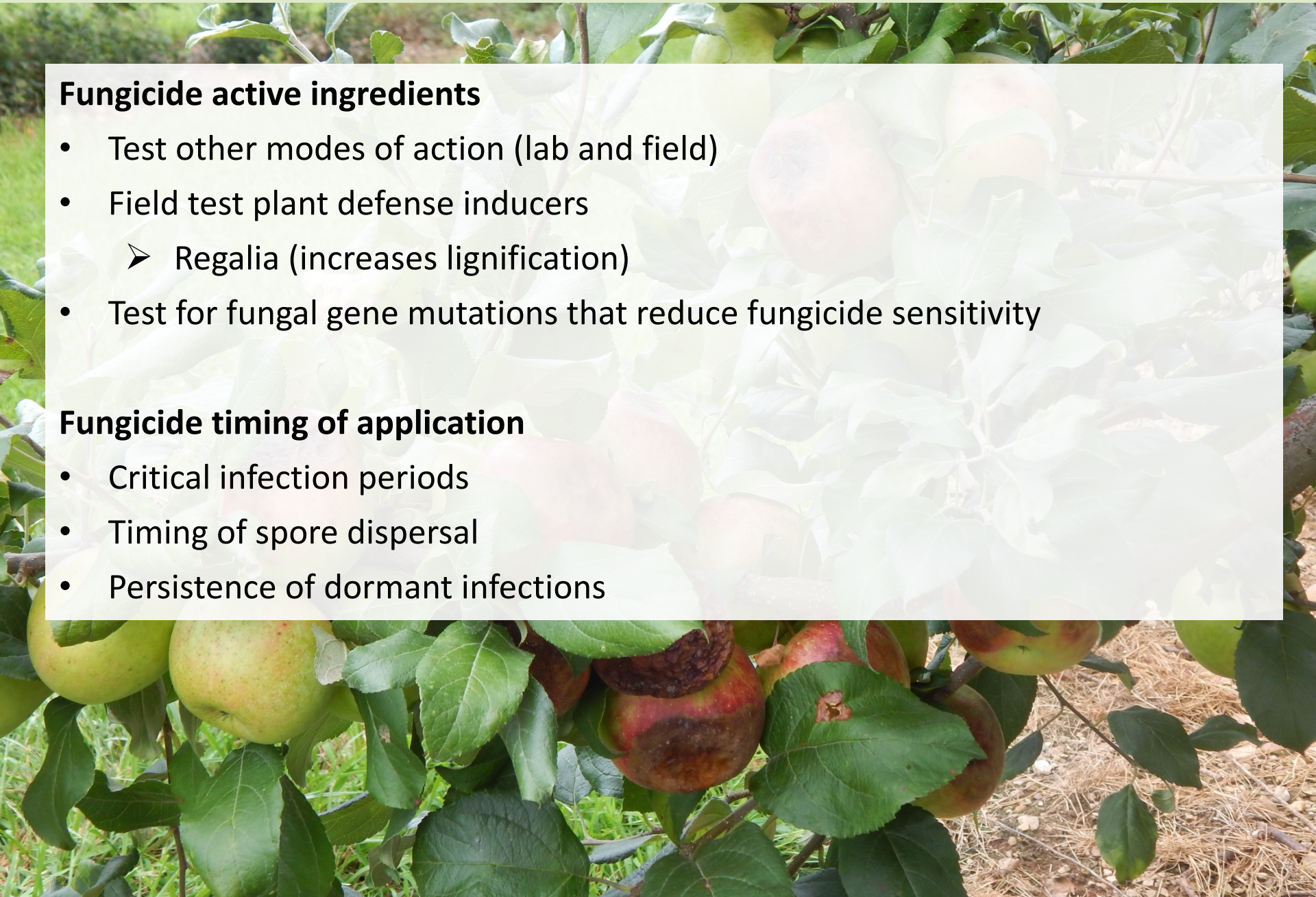
➢ Preharvest: Merivon + captan

Omega: 28 day PHI; $35 - $50 per acre = Very $$$; focus on most problematic blocks
Thiophanate-methyl: 1 d PHI; $5 – 7 per acre

*Per discussions with Dr. Peter

**Lab results look promising; field testing 2019 season

Future research



Fungicide active ingredients

- Test other modes of action (lab and field)
- Field test plant defense inducers
  - Regalia (increases lignification)
- Test for fungal gene mutations that reduce fungicide sensitivity

Fungicide timing of application

- Critical infection periods
- Timing of spore dispersal
- Persistence of dormant infections

Acknowledgments

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Department of Plant Pathology and Environmental Microbiology

Fruit Research and Extension Center

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NORTHEAST SARE Sustainable Agriculture Research & Education

- **Growers who send in bitter rot samples**
- **Fungicides donated by the agro-chemical companies for the lab and field trials**
- **Support from the USDA National Institute of Food and Agriculture Hatch and Smith-Lever Appropriations**

NSF GRFP NSF GRADUATE RESEARCH FELLOWSHIP PROGRAM

Questions?

Photo: P. Martin

Photo: E. Winzeler

Phillip Martin

Mid-Atlantic Fruit & Vegetable Convention January 30th, 2019