Fusarium Wilt of Strawberry Management of Soilborne Pathogens

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18th Annual Strawberry Production – Ventura County

September 19, 2019

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Agriculture and Natural Resources

Collaborators:

- Steve Koike
- Mark Bolda
- Steve Knapp
- Glenn Cole

Fusarium wilt

Verticillium wilt

Macrophomina crown rot

Fusarium wilt

Fusarium oxysporum

DETECTION & CONFIRMATION of Fusarium Wilt Pathogens: *Challenges, Errors, and Limitations*

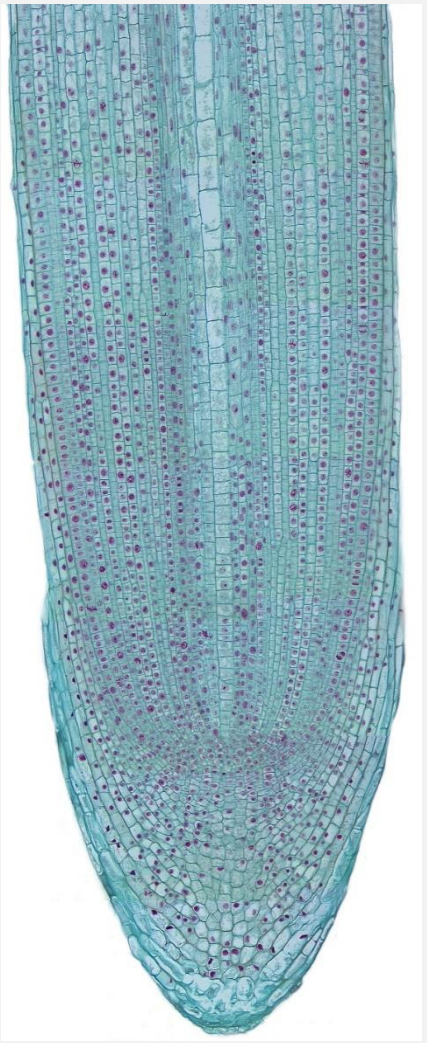
By: Steven T. Koike | Director, TriCal Diagnostics
Tom Gordon | Professor, University of California at Davis

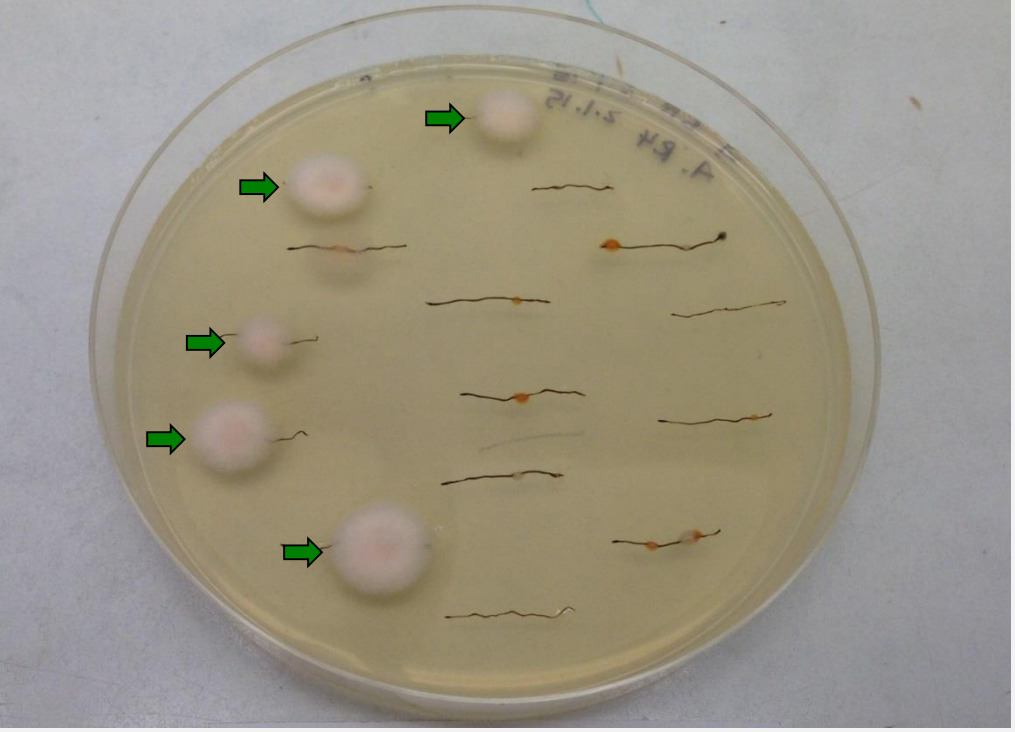
- ✓ ***Fusarium oxysporum*** **is common in soil**
- ✓ **Most strains are not pathogenic**
- ✓ **Non-pathogenic strains colonize roots**
- ✓ **Pathogen ID requires further testing**

Fusarium wilt

Fusarium oxysporum

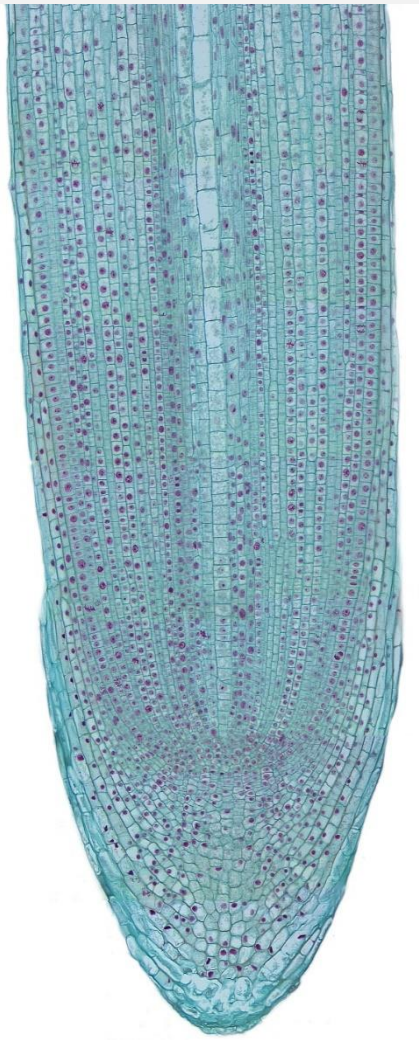
Sugars





Fusarium wilt

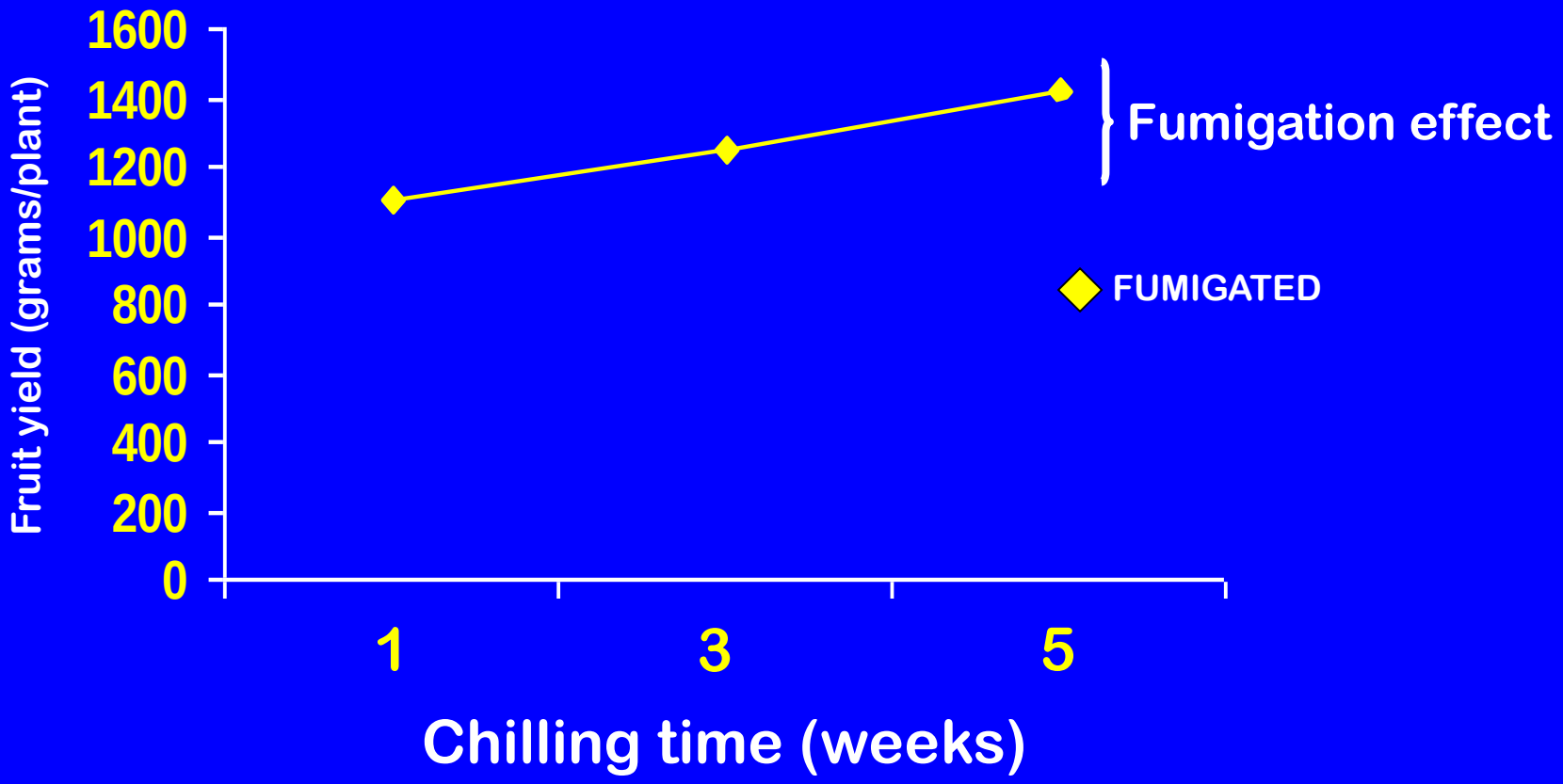
Infection of root tips



Fusarium oxysporum

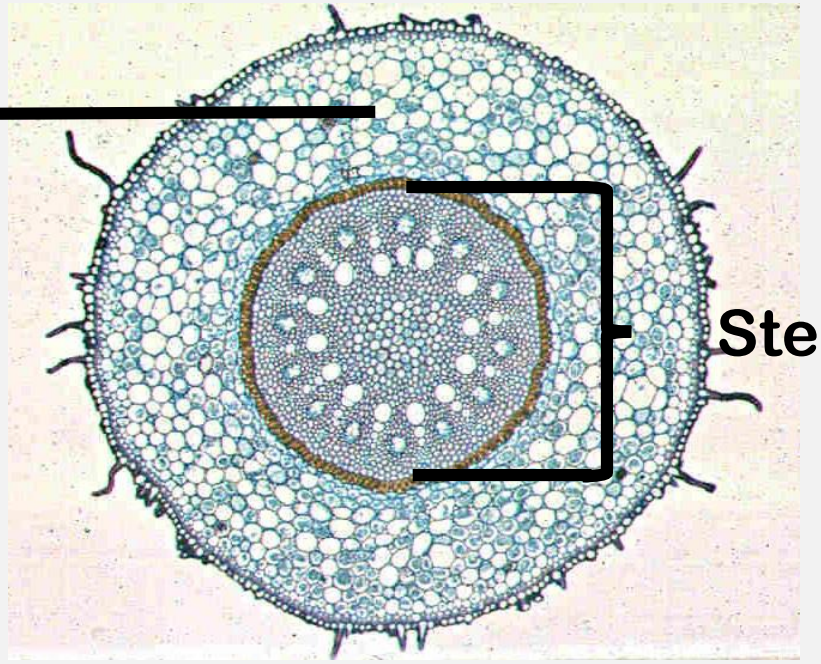
Sugars

Effect Of Fumigation Treatment And Chilling On Fruit Yield Of Strawberry



10-15% yield increase by eliminating non-pathogenic fungi on roots

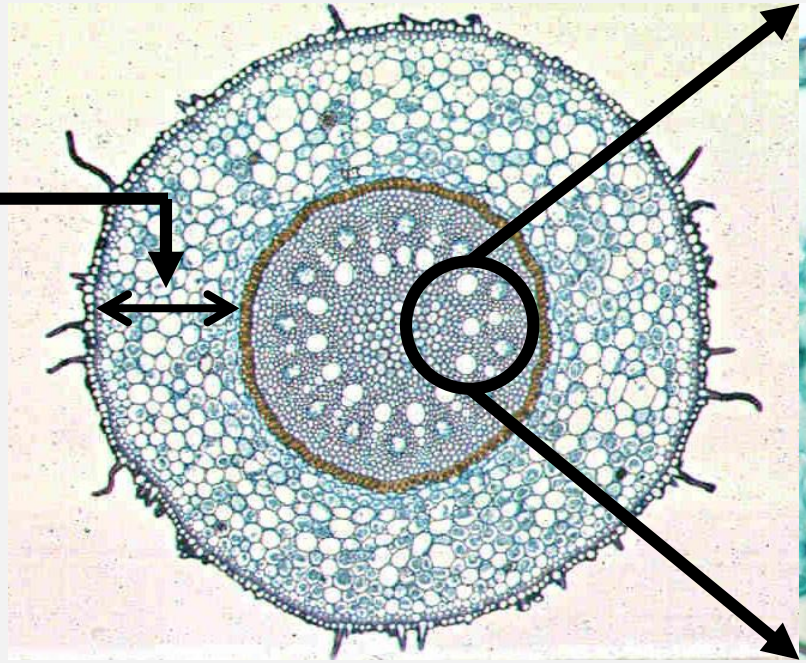
Root Cross Section



Non-pathogenic fungi colonize the root cortex

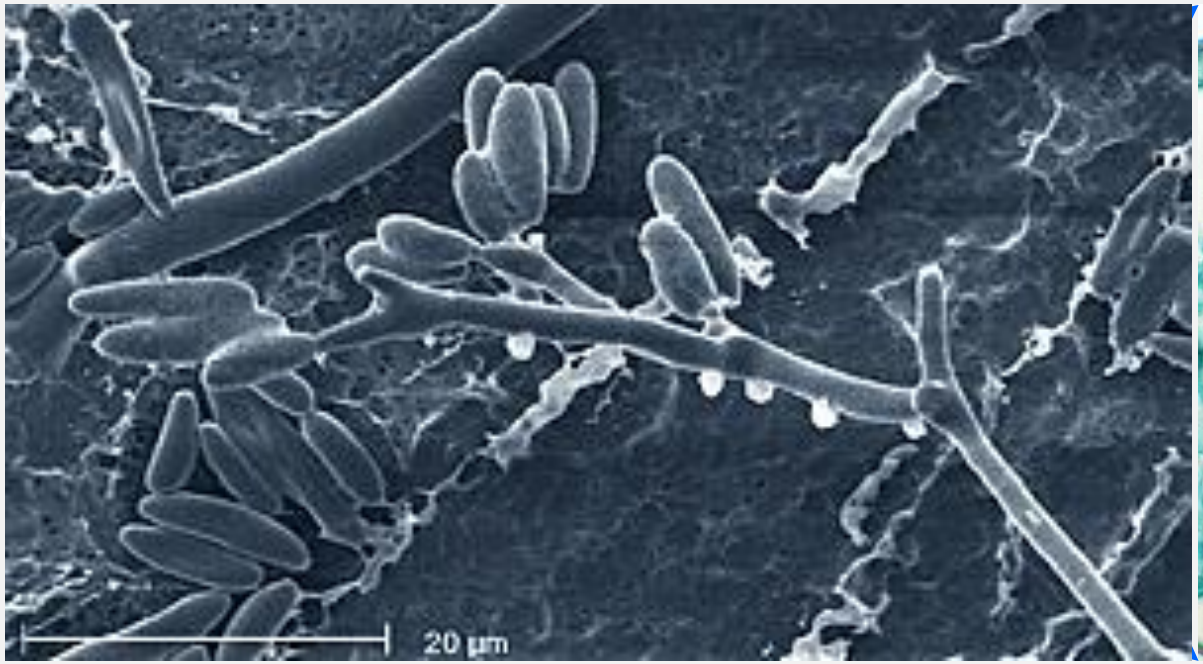
Fusarium oxysporum f. sp. *fragariae*

Region of fungal growth



Xylem vessels

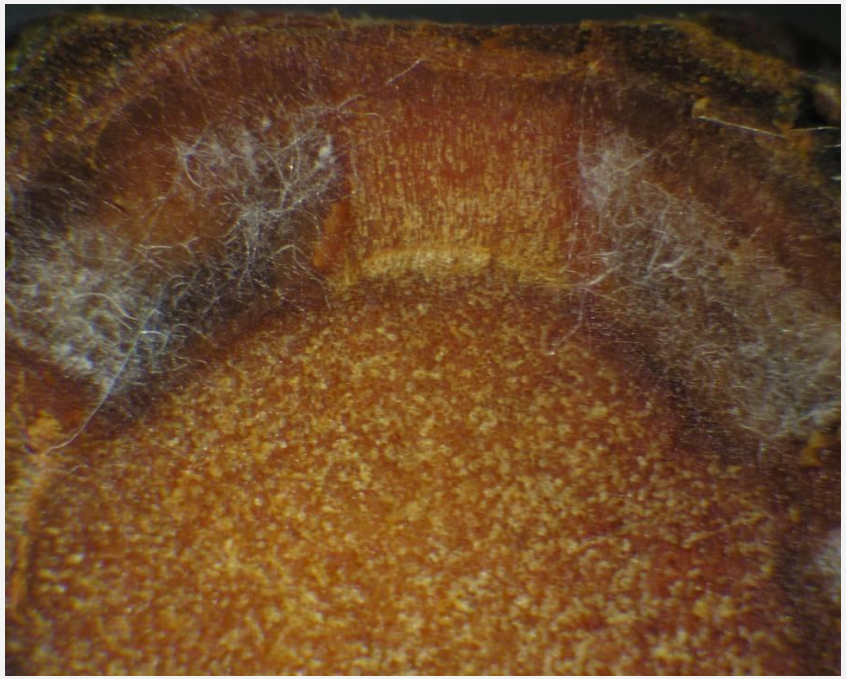
The Pathogen Moves Into The Shoot With Water



Spores

Xylem vessels

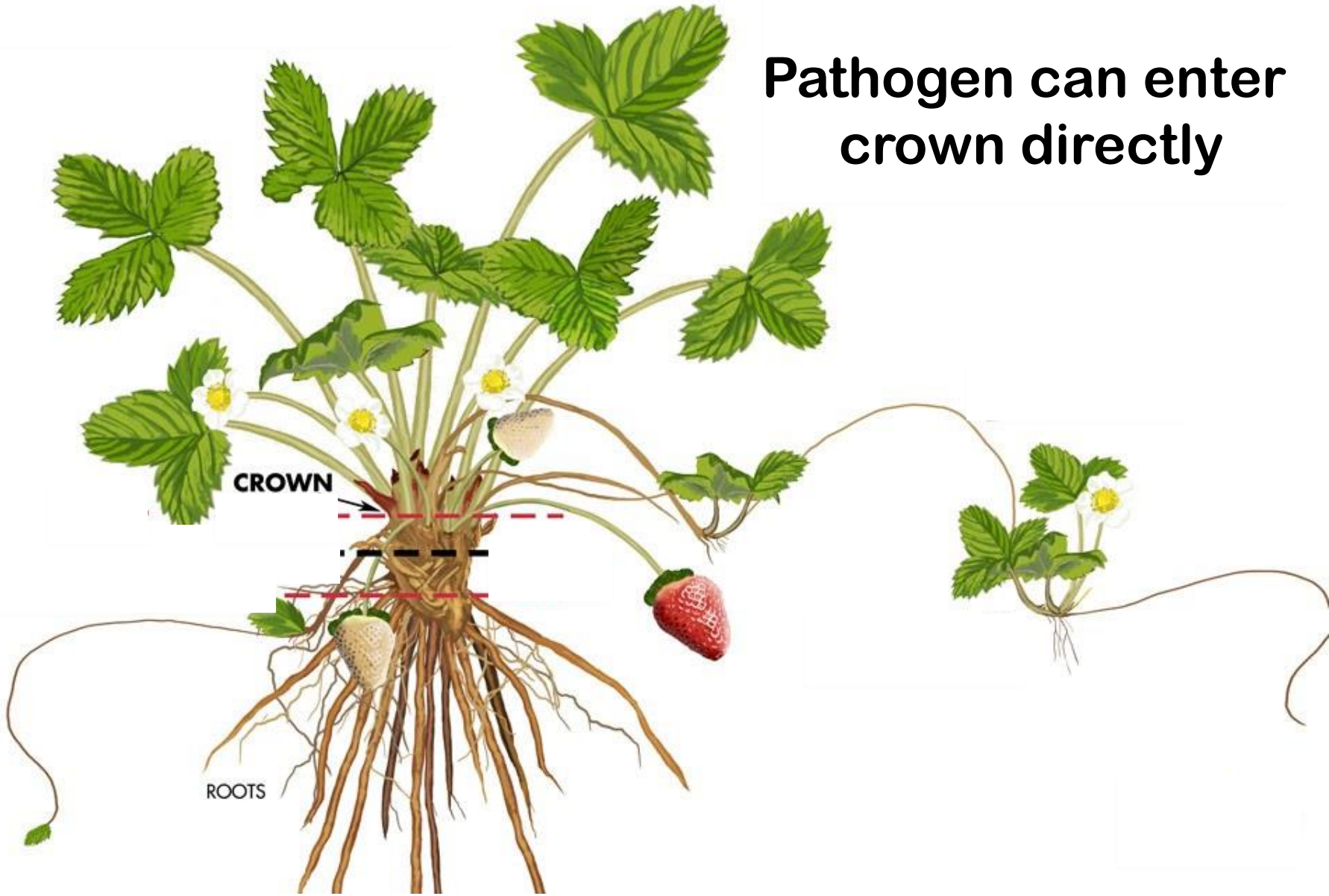
The Pathogen Moves Into The Shoot With **Water**



Colonized vascular tissue

Obstruction of water flow

Pathogen can enter crown directly



Management

NO CURATIVE MEASURES

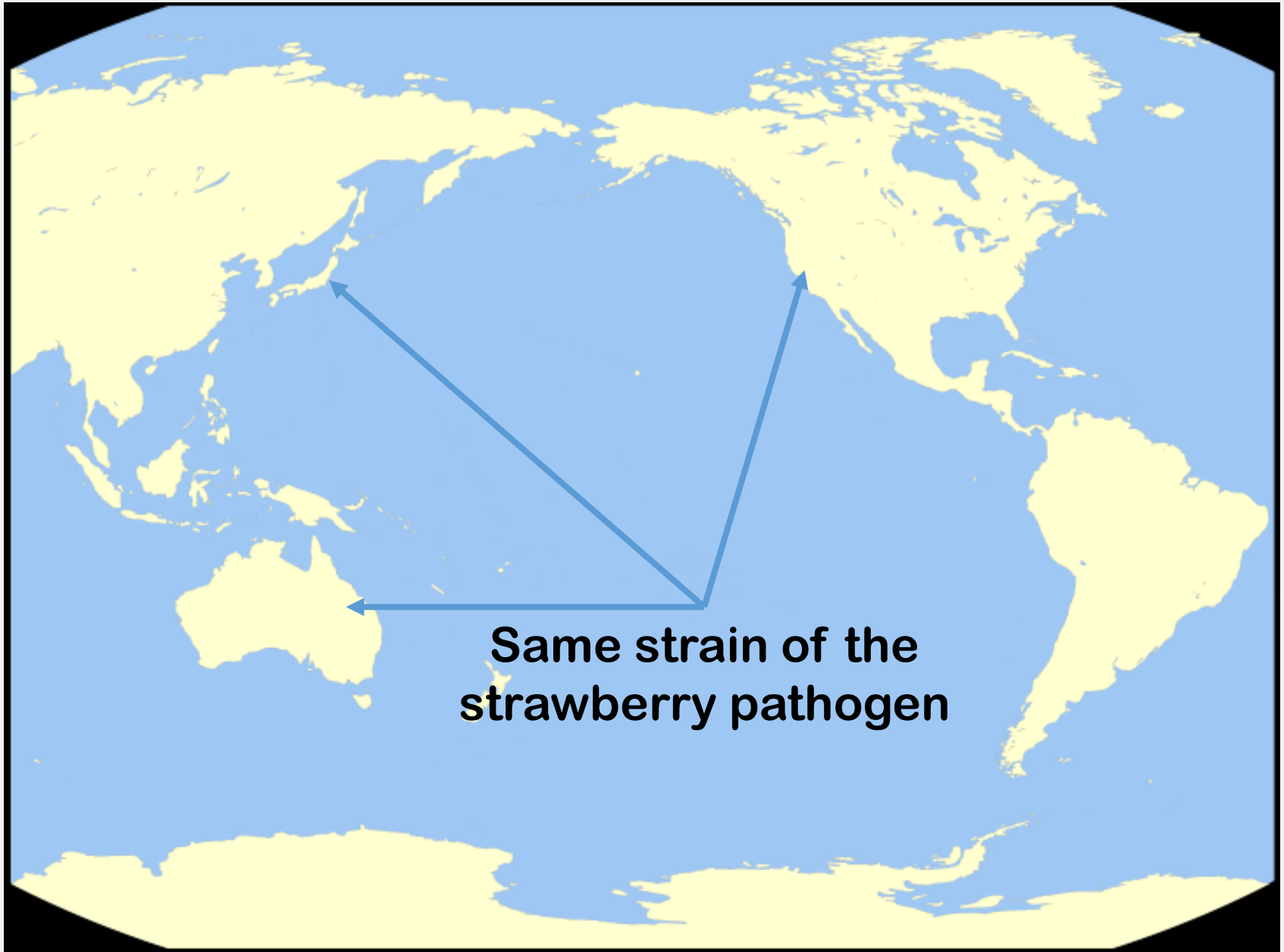
PREVENTION → **AVOID INTRODUCTION**

Avoid Introductions

Clean plants

Don’t move soil

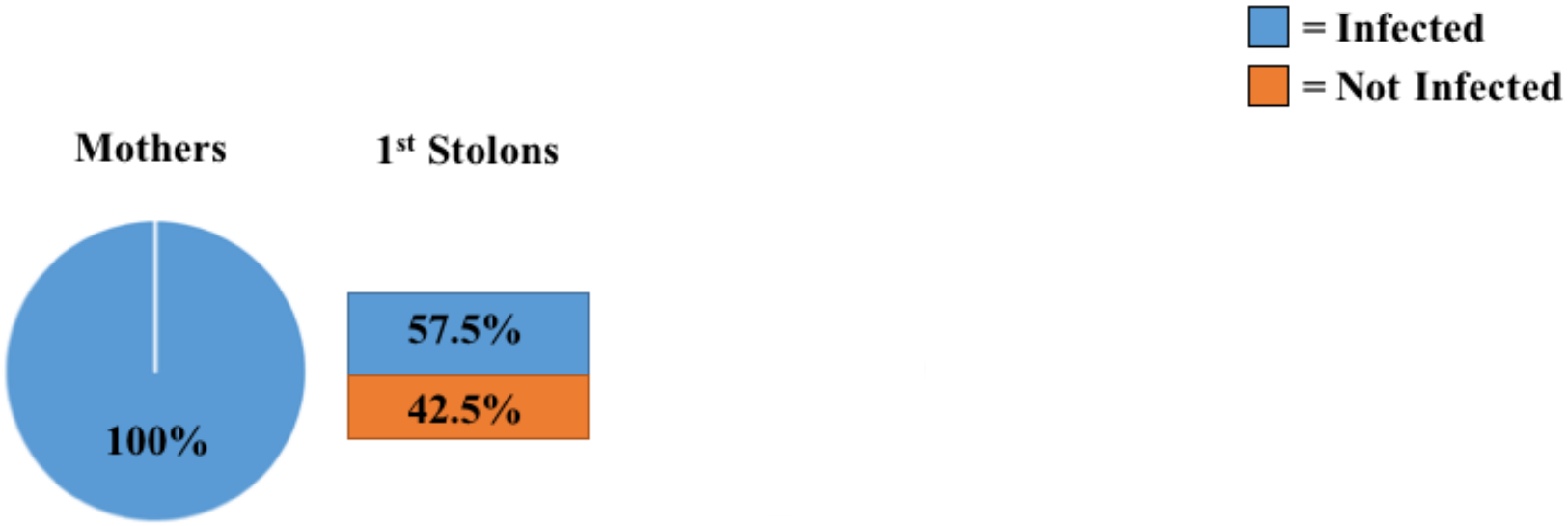
Fusarium Wilt



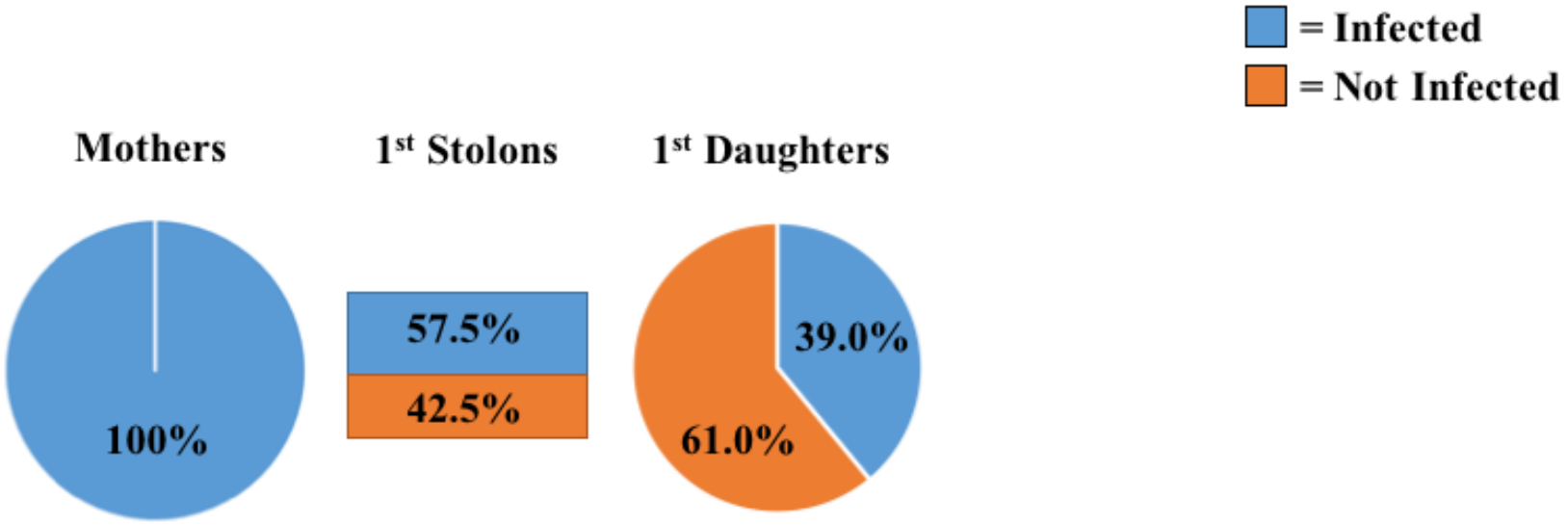

Transmission of *Fusarium*
to daughter plants

Transmission Of *Fusarium* To Daughter Plants

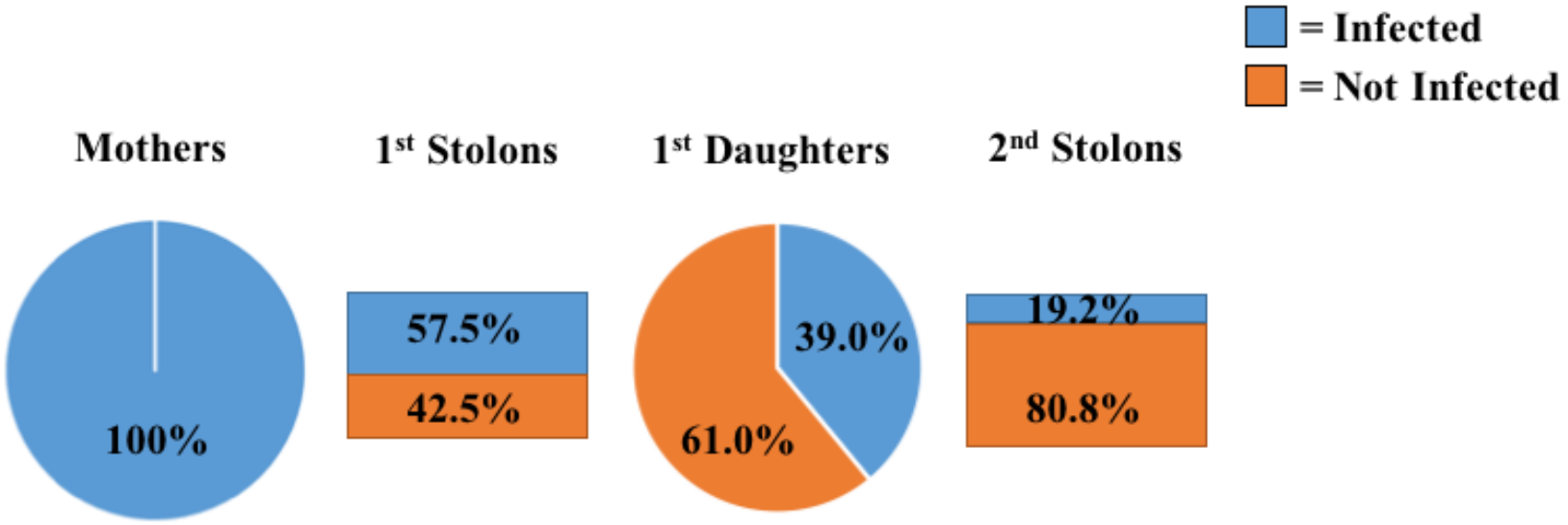
Albion



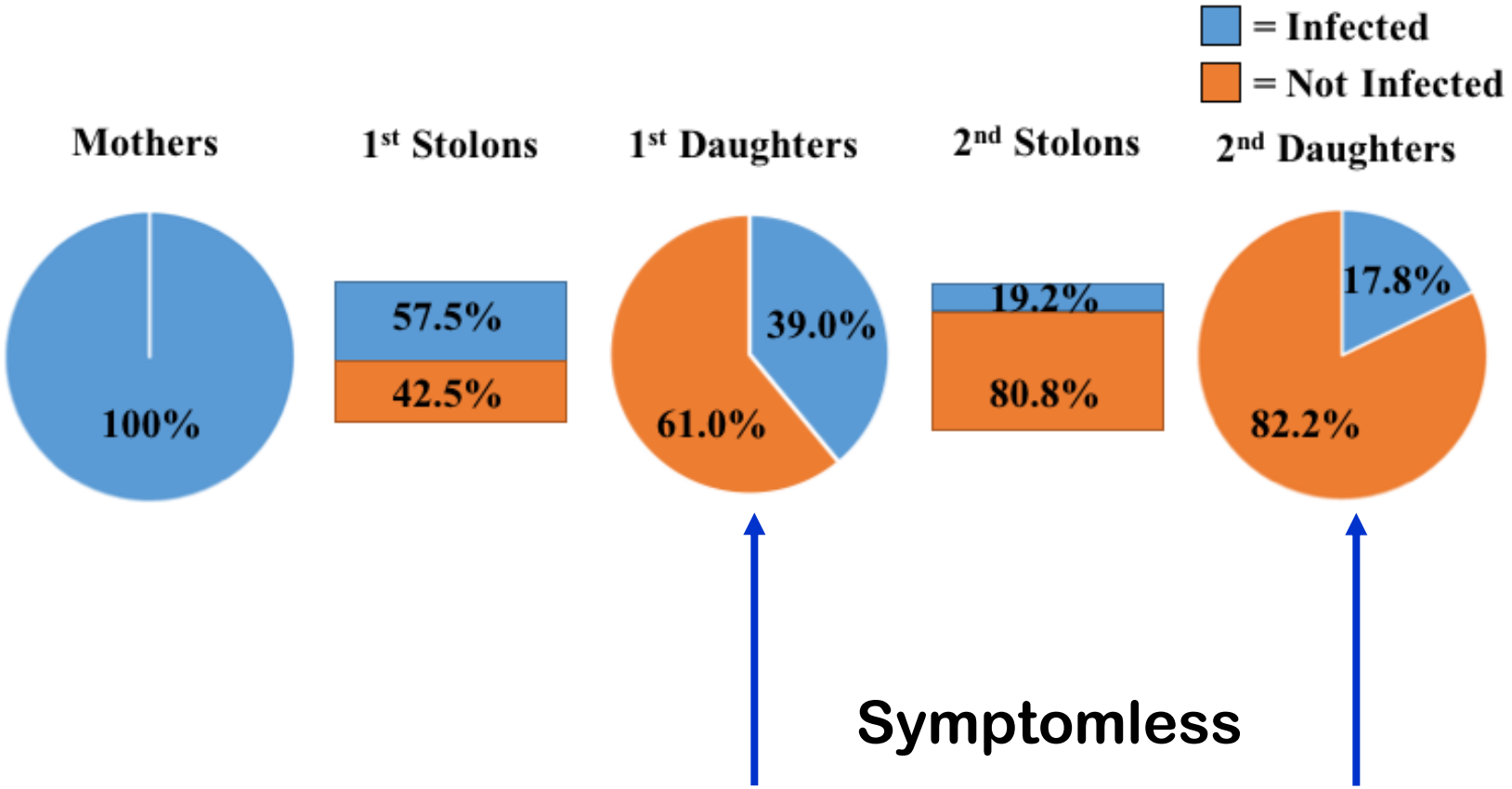
Albion


= Infected
= Not Infected
Mothers
1st Stolons
1st Daughters
100%
57.5%
42.5%
39.0%
61.0%

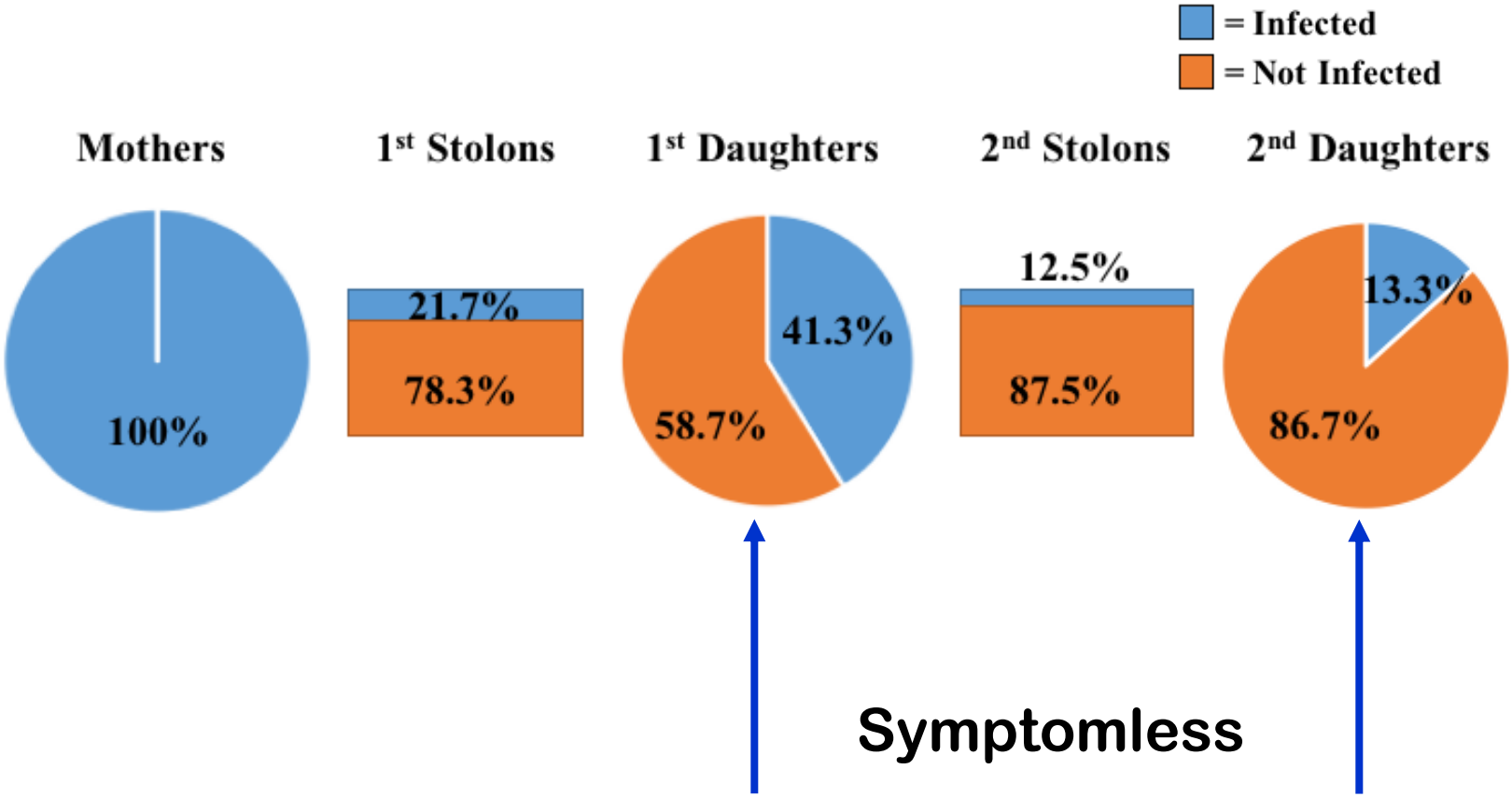
Albion


= Infected
= Not Infected
Mothers
1st Stolons
1st Daughters
2nd Stolons
100%
57.5%
42.5%
39.0%
61.0%
19.2%
80.8%

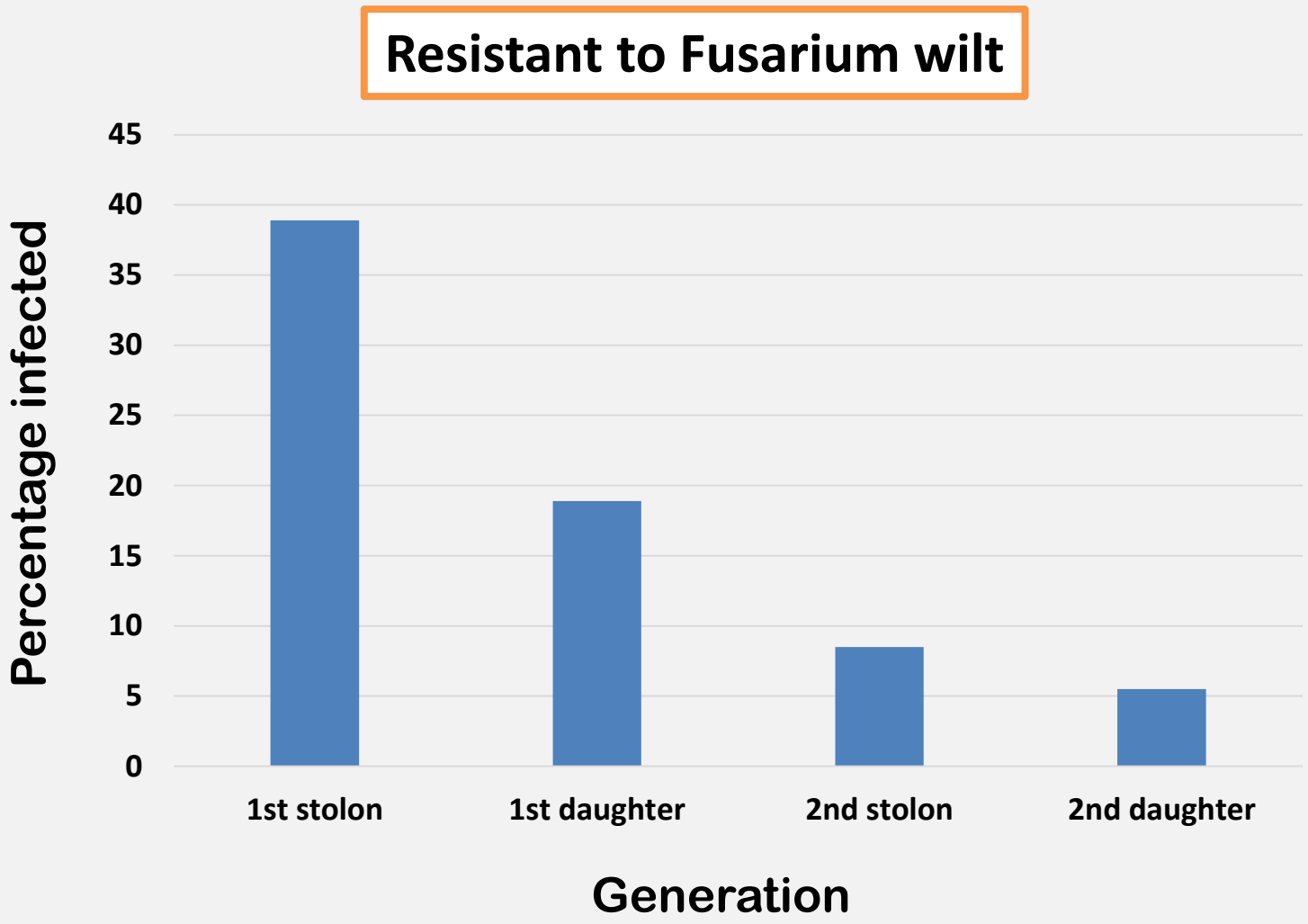
Albion


= Infected
= Not Infected
Mothers
1st Stolons
1st Daughters
2nd Stolons
2nd Daughters
100%
57.5%
42.5%
39.0%
61.0%
19.2%
80.8%
17.8%
82.2%
Symptomless

Monterey


= Infected
= Not Infected
Mothers
1st Stolons
1st Daughters
2nd Stolons
2nd Daughters
100%
21.7%
78.3%
41.3%
58.7%
12.5%
87.5%
13.3%
86.7%
Symptomless

San Andreas


Resistant to Fusarium wilt
Percentage infected
45
40
35
30
25
20
15
10
5
0
1st stolon
1st daughter
2nd stolon
2nd daughter
Generation

Infected Daughter Plants Appear Healthy

Infected Daughter Plants

Show no symptoms
in nurseries

Disease may develop
in a fruit production field

**Prevention of infection
in nurseries is critical**

Management Of Soilborne Pathogens

Reduce inoculum levels

Pre-plant fumigation

Flat fumigation to treat the entire field

Maximize distribution in beds

Efficacy Of Fumigants

Methyl Bromide:Chloropicrin 2:1 @ 350 pounds/acre

Chloropicrin @ 400 pounds/acre

Telone (1,3-Dichloropropene)

Metam sodium / K-Pam / Dominus

INTERNATIONAL JOURNAL OF FRUIT SCIENCE
http://dx.doi.org/10.1080/15538362.2016.1219294

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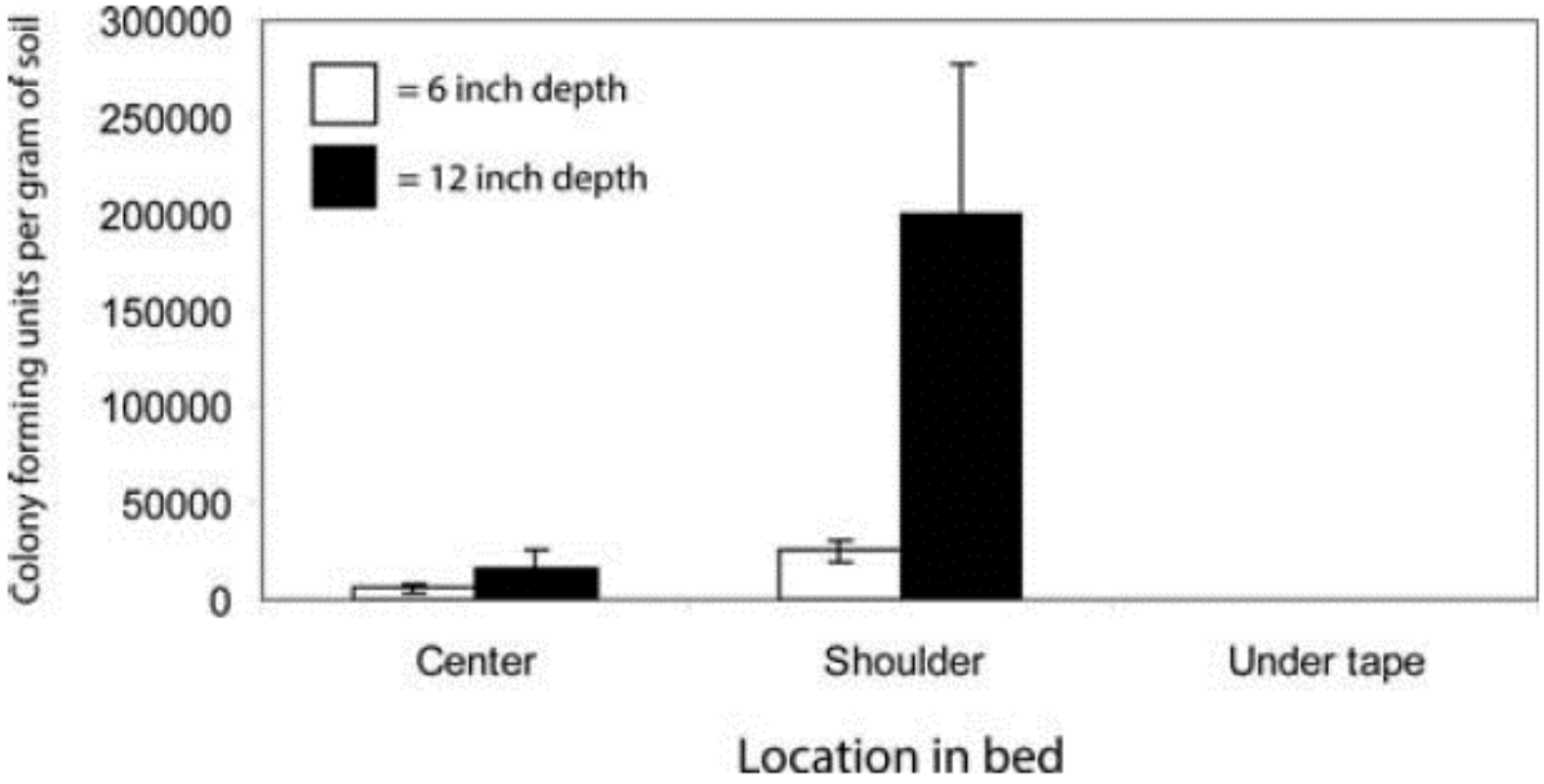
Options for Management of Fusarium Wilt of Strawberry in California

Thomas R. Gordon[a], Oleg Daugovish[b], Steven T. Koike[c], Christina M. Islas[a], Sharon C. Kirkpatrick[a], Jenna A. Yoshisato[a], and Douglas V. Shaw[d]



60:40 mix of chloropicrin:telone

Incomplete treatment

Mortality is not evenly distributed across beds

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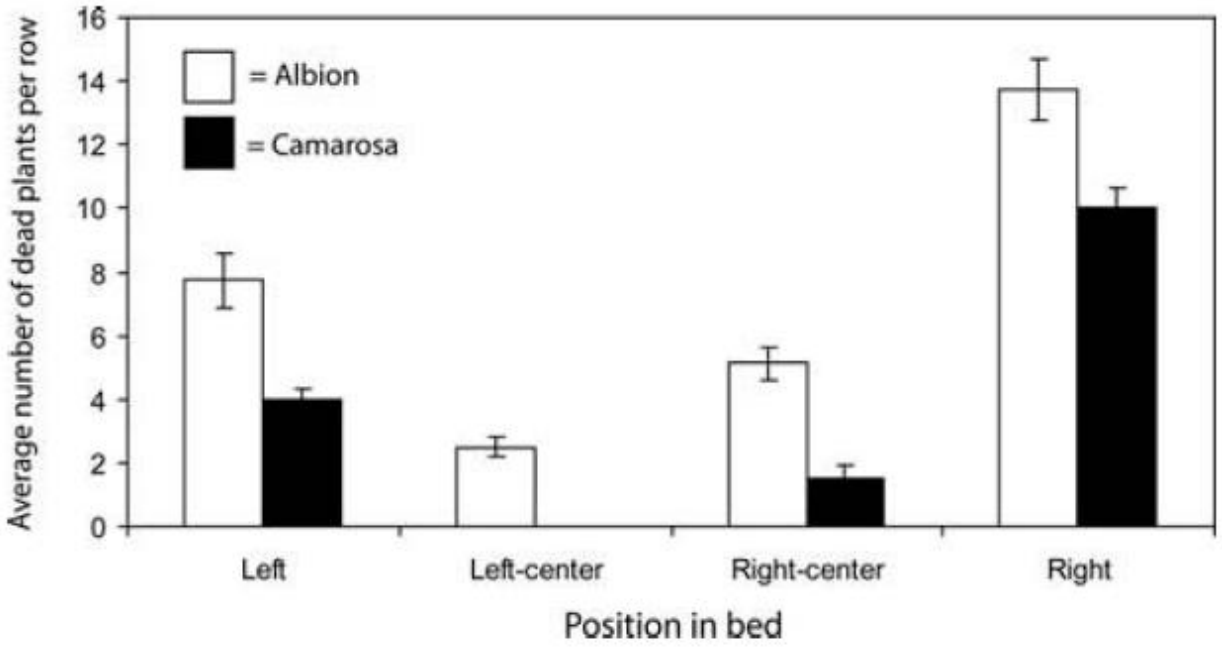


Figure 2. The effect of position in a bed on mortality caused by Fusarium wilt in two strawberry cultivars. Values represent means of four replications and error bars correspond to 2× the standard error of the mean.

60:40 mix of chloropicrin:telone

Conclusions

- ✓ Flat fumigation is best
- ✓ Maximize efficacy of bed fumigation
- ✓ Chloropicrin is good
- ✓ More is better
- ✓ More driplines
- ✓ More water

Don’t plant buffer zones

Management Of Soilborne Pathogens

Reduce inoculum levels

Pre-plant fumigation

Flat fumigation to treat the entire field

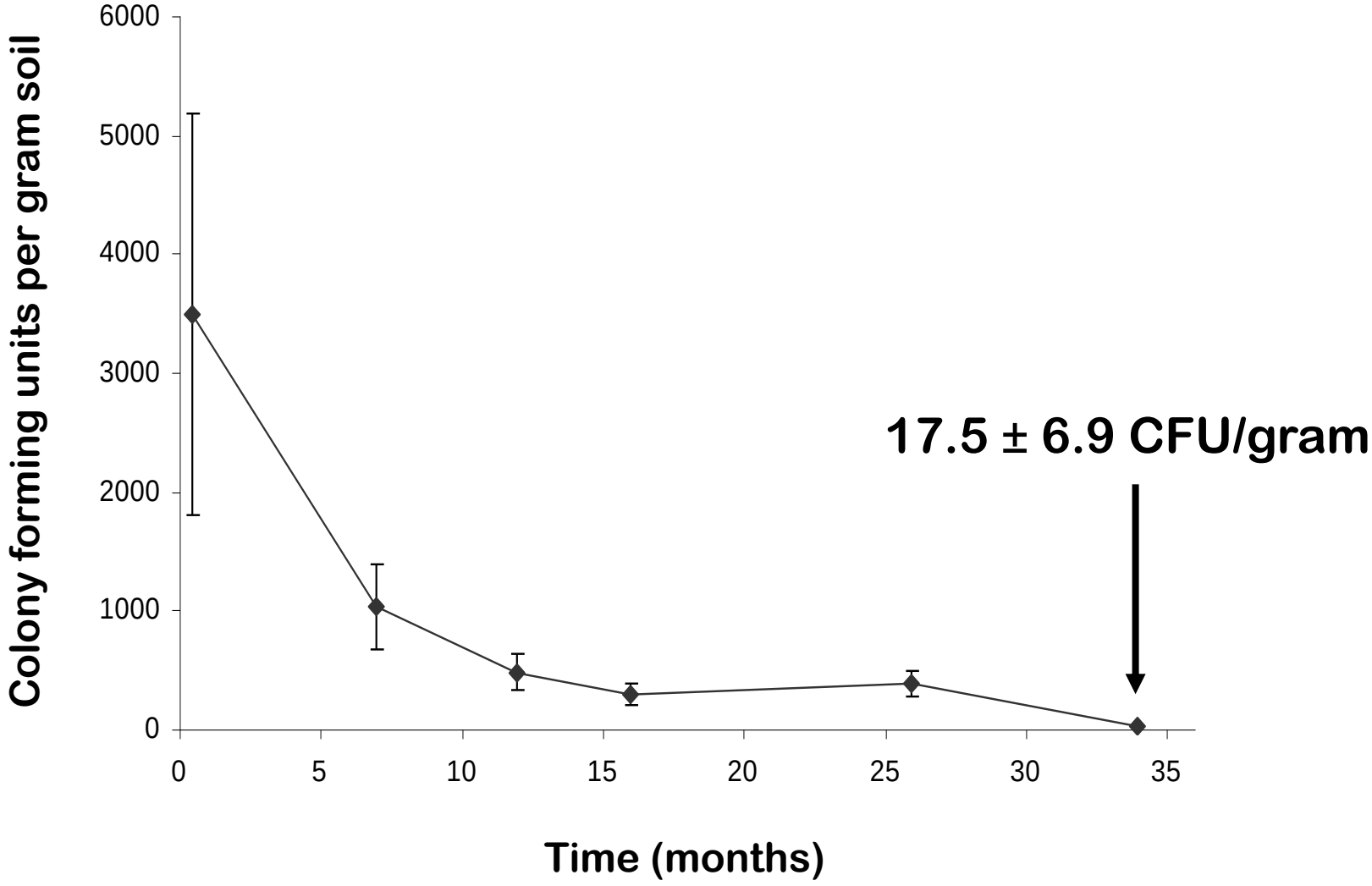
Maximize distribution in beds

Crop rotation

Crop Rotation

- Inoculum levels decline when NO crops are grown

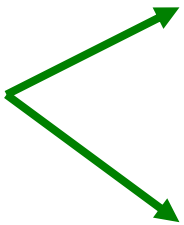
Survival of *F. o. lactucae* in Fallow Soil



Crop Rotation

- Inoculum levels decline when NO crops are grown
- Inoculum levels decline when OTHER crops are grown

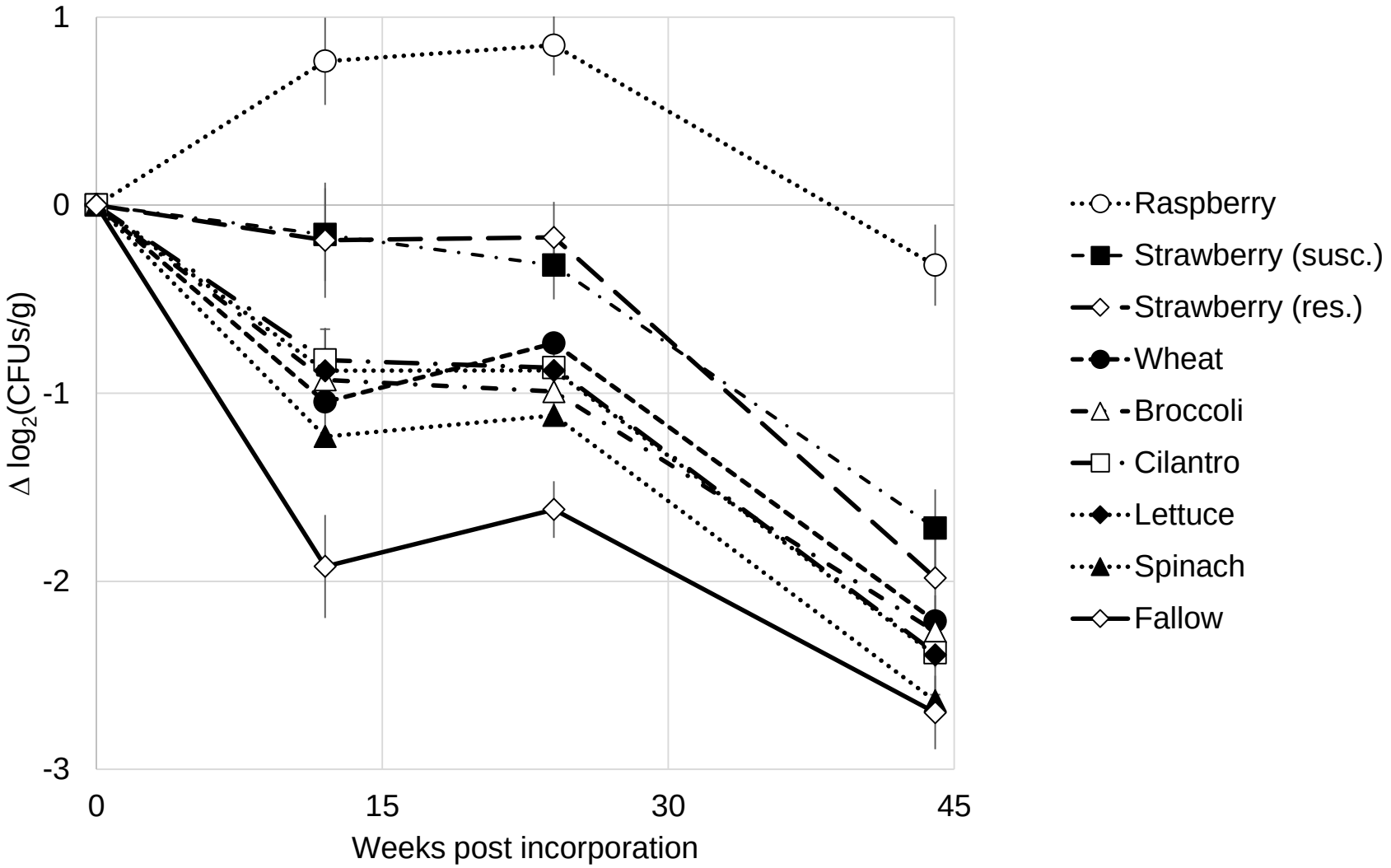
Fusarium oxysporum f. sp. *fragariae*



Colonize rotation crops

Colonize crop residue

Specific to Strawberry


1
0
-1
-2
-3
Δ log2(CFUs/g)
0
15
30
45
Weeks post incorporation
Raspberry
Strawberry (susc.)
Strawberry (res.)
Wheat
Broccoli
Cilantro
Lettuce
Spinach
Fallow

Blackberry

Fusarium wilt

Fusarium oxysporum

Effect of blackberry pathogen on strawberry

Albion
Monterey
San Andreas
Portola
Petaluma

Susceptibility Of Strawberry To Blackberry Pathogen

1 – 5 scale

Cultivar	*F. o. mori*	*F. o. fragariae*
Albion	3.0	5.0
Monterey	2.1	5.0
San Andreas	1.0	1.0
Portola	1.0	1.0
Petaluma	1.0	5.0


Plant 4
MONTEREY
AM_S1 2

Rotation Crops

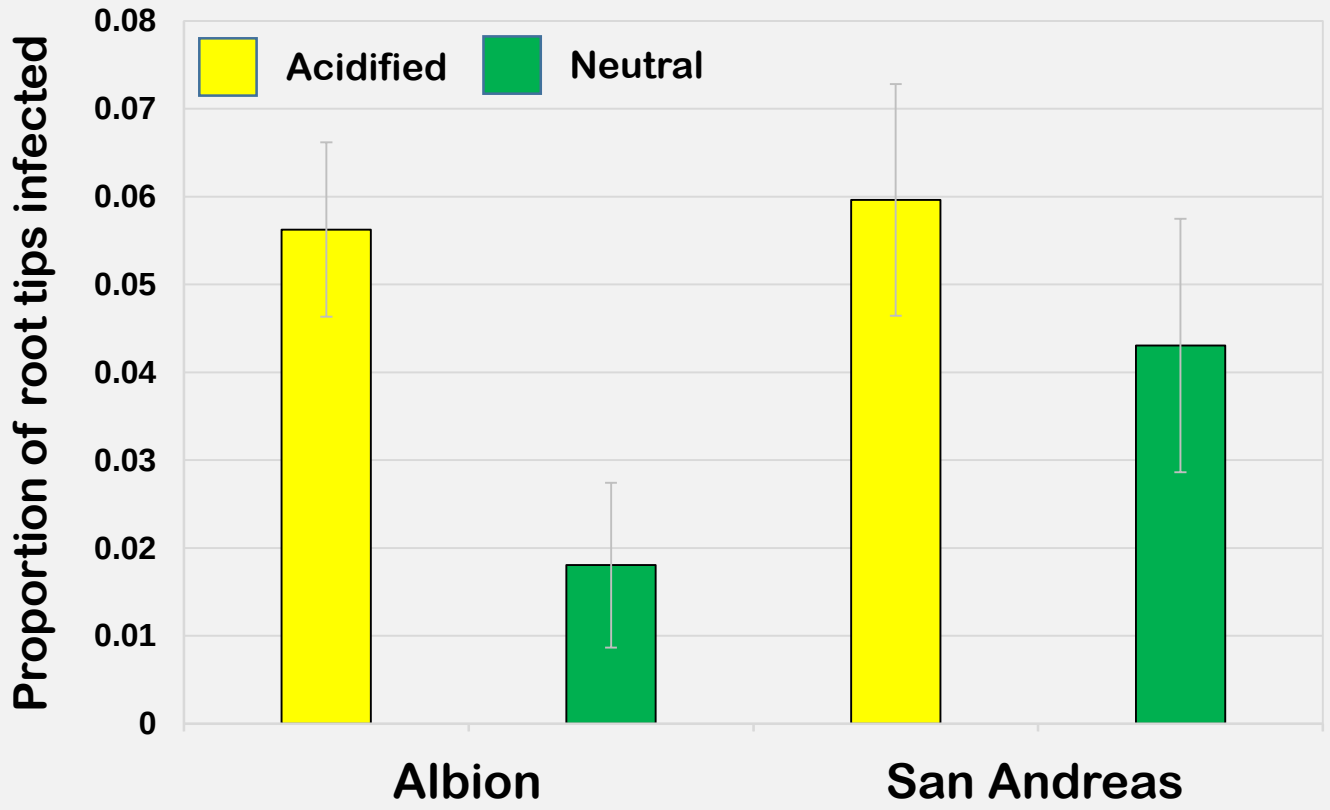
HIGH RISK

- ✓ Raspberry
- ✓ Blackberry

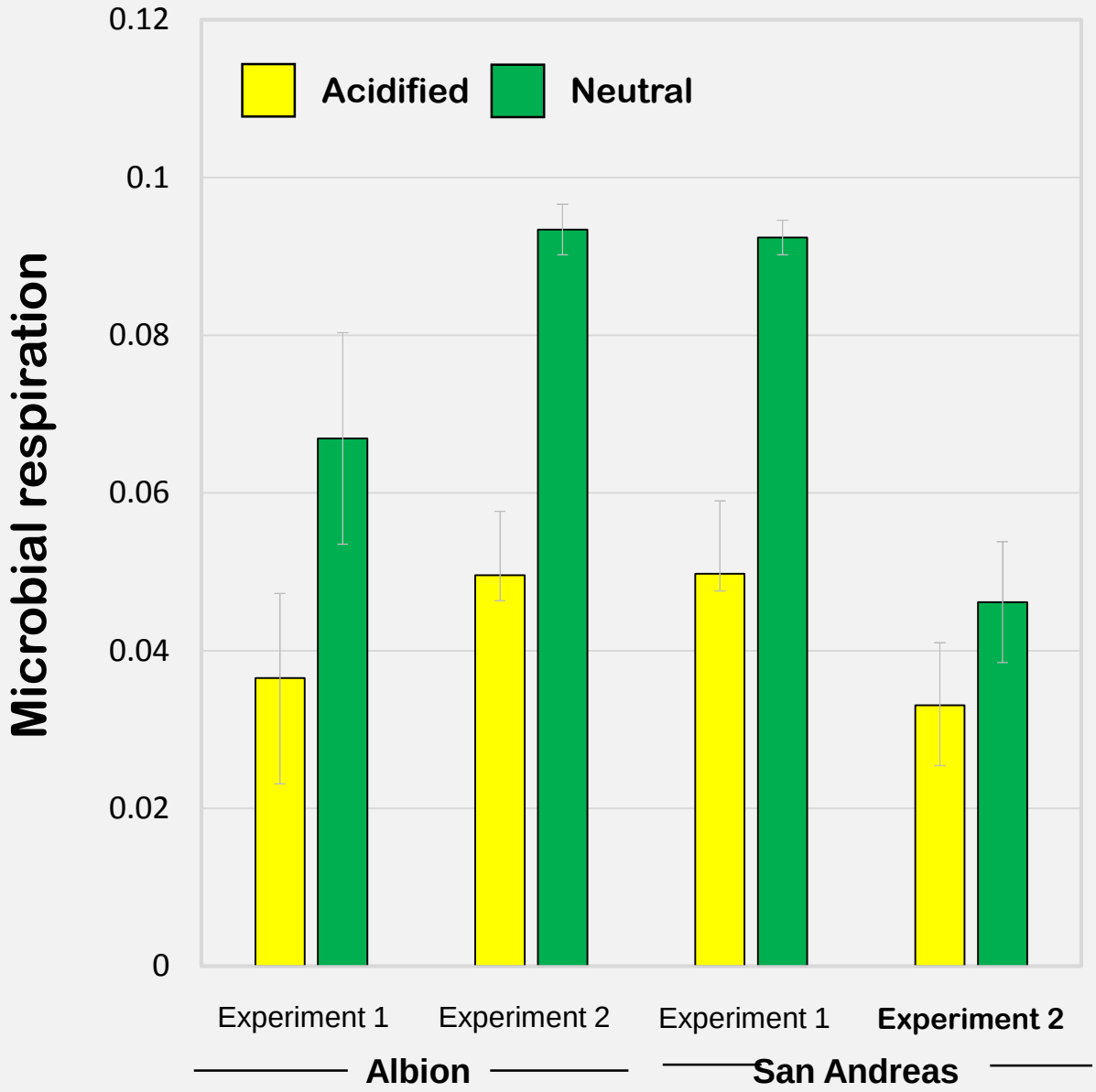
LOW RISK

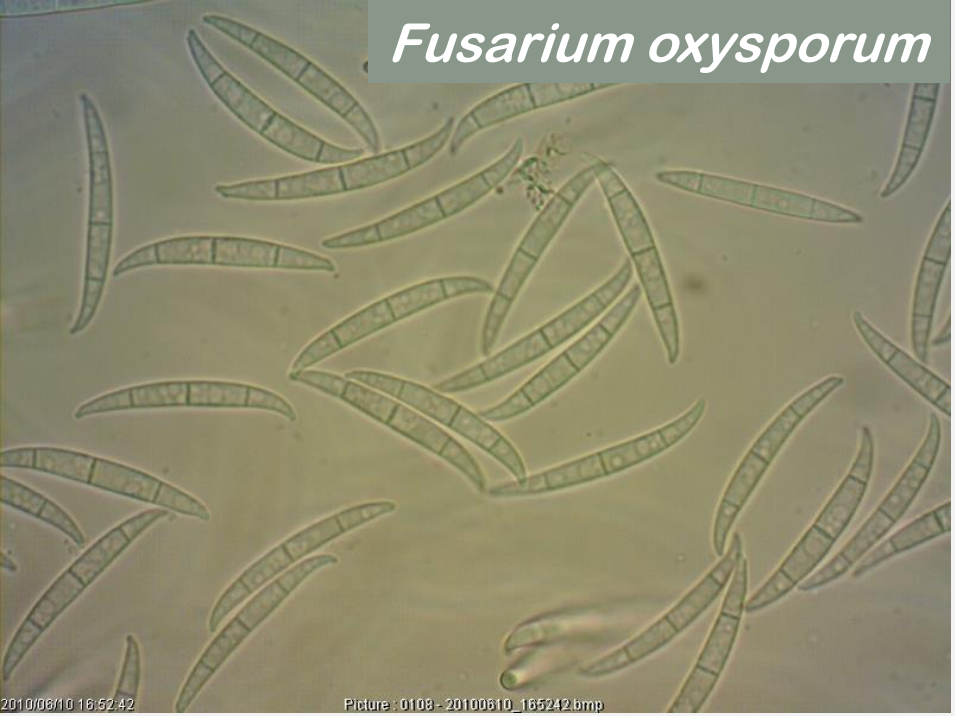
- ✓ Spinach
- ✓ Wheat
- ✓ Broccoli
- ✓ Cilantro

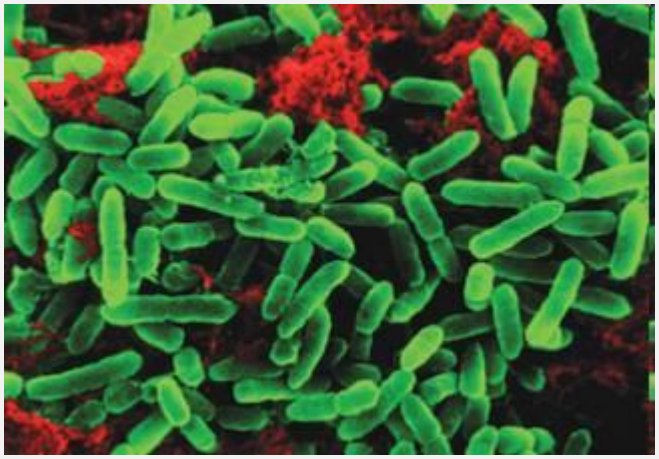
The Effect Of Soil PH On Root Infection

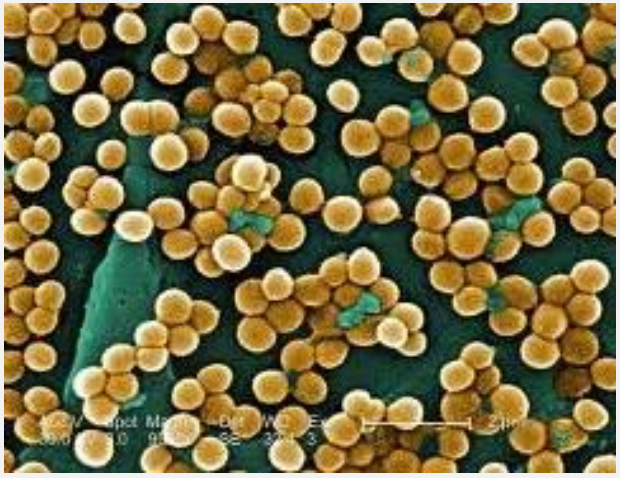


Bacterial respiration is higher in neutral soils









In soil fungi compete with bacteria

pH near neutrality
favors bacteria over fungi

Elevate Microbial Respiration

- ✓ Soil amendments
- ✓ That do not support pathogen growth

Anaerobic soil disinfestation

+

Rice hulls at 9 tons per acre

+

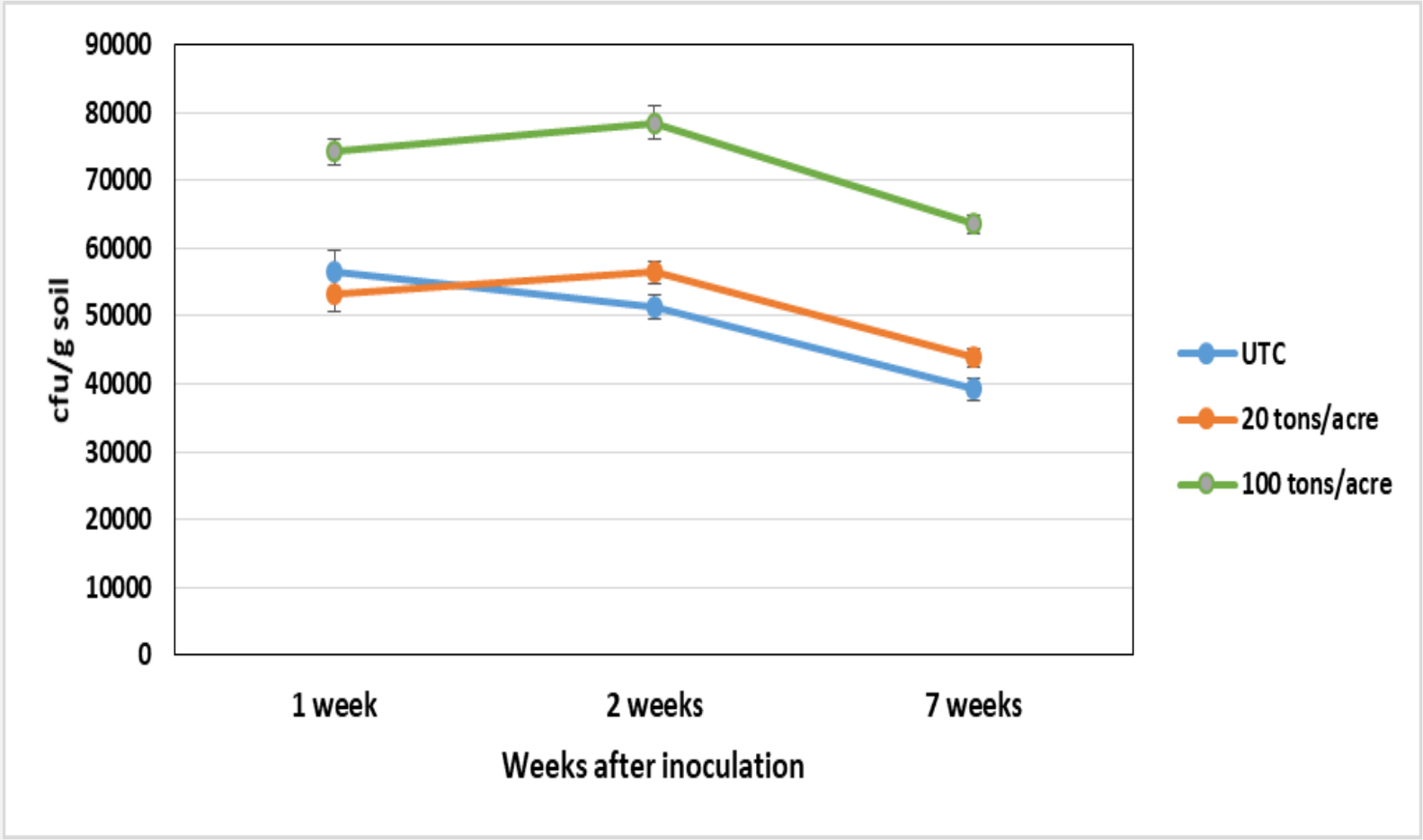
cool conditions
Day/night = 77/64°F

||

+ 310% increase in
F. oxysporum* f. sp. *fragariae
population

Compost

Survival of *F. o. fragariae* in soil



Management Of Soilborne Pathogens

Reduce inoculum levels

Use resistant cultivars

Pre-plant fumigation

Flat fumigation to treat the entire field

Maximize distribution in beds

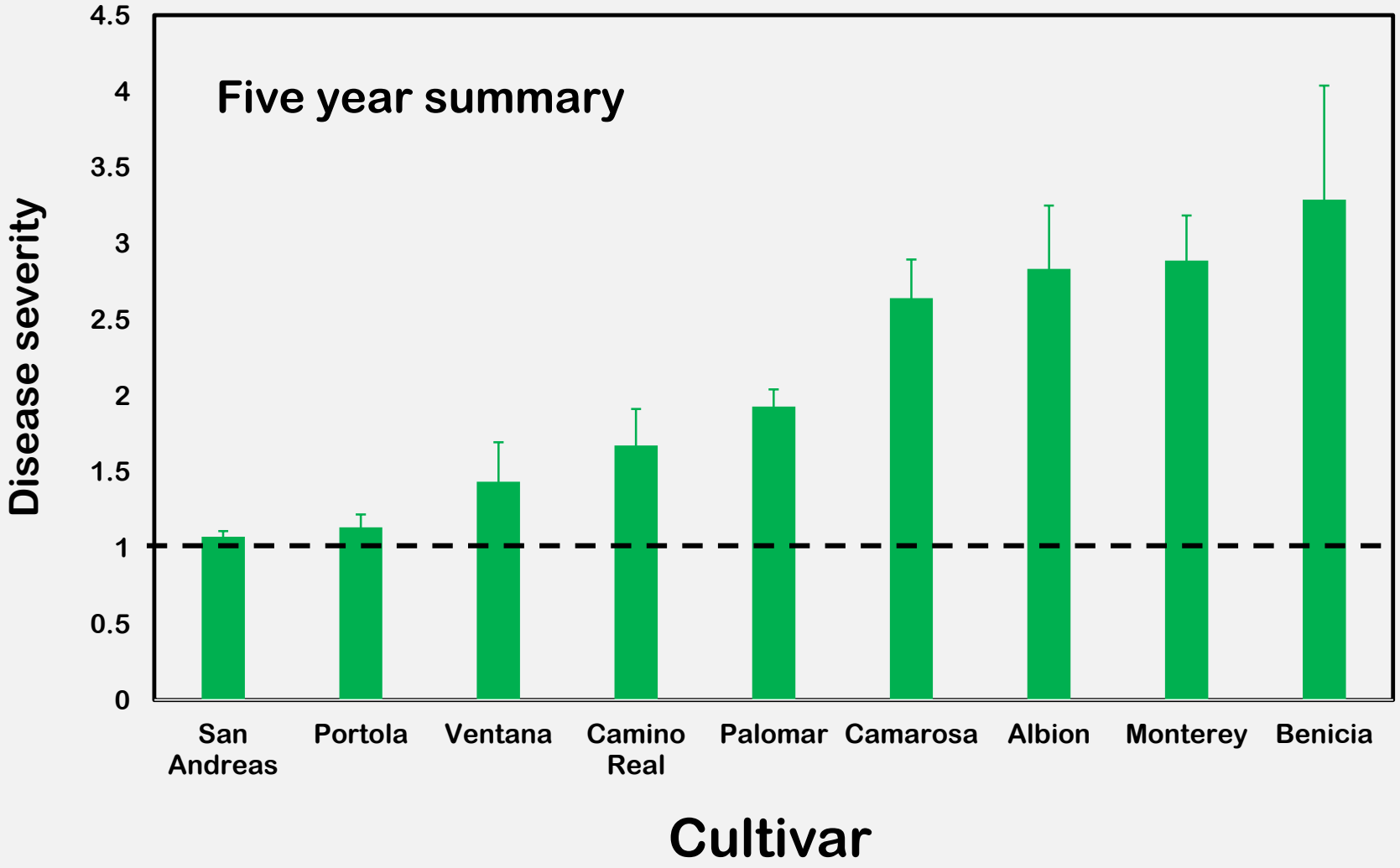
Crop rotation

Differences in susceptibility to Fusarium wilt

Camarosa

Ventana

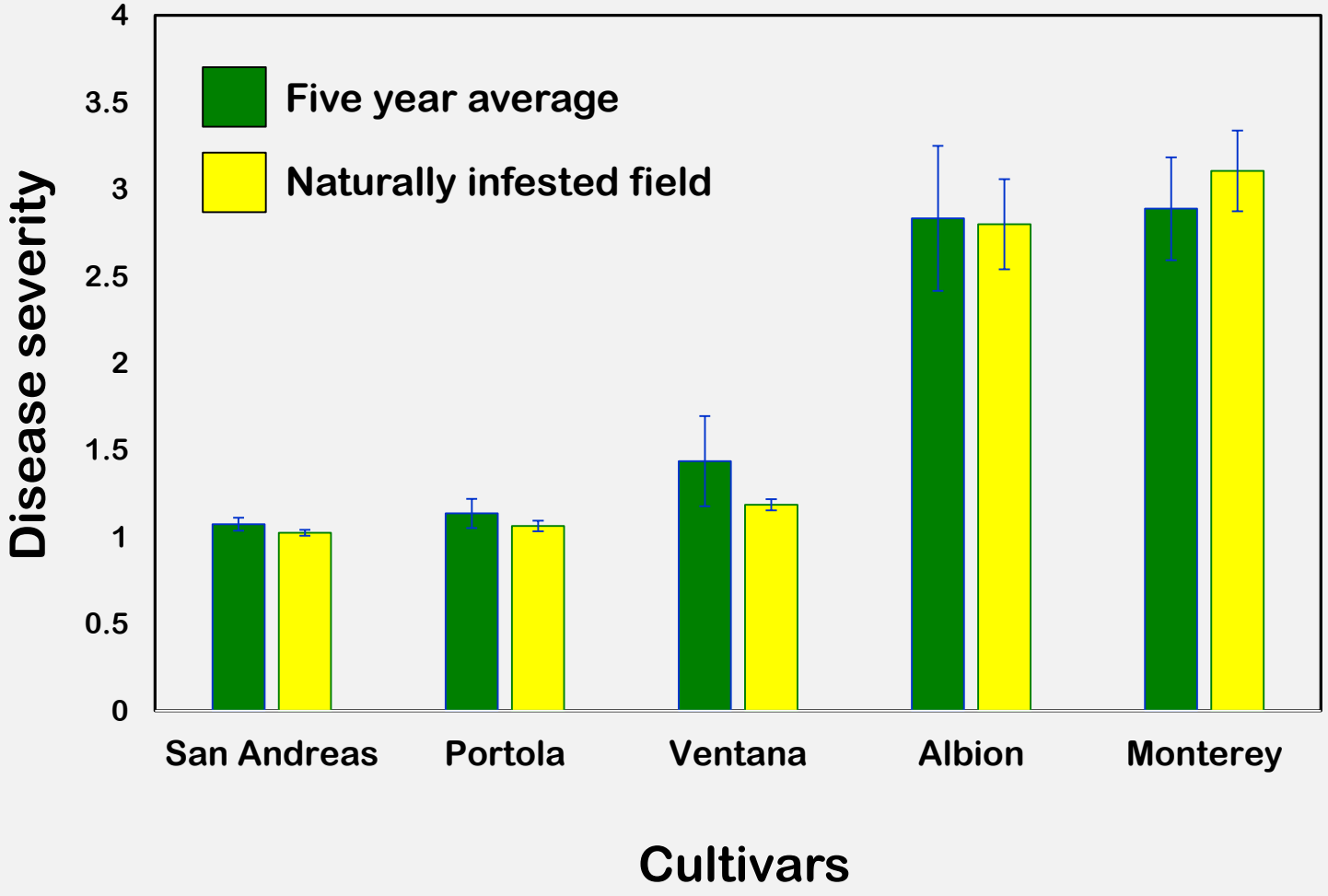
Susceptibility to Fusarium wilt




Naturally Infested Field

Comparison of resistance assessments

Correlation coefficient = 0.9908



Genome-Wide Association Mapping Uncovers *Fw1*, a Dominant Gene Conferring Resistance to Fusarium Wilt in Strawberry

Dominique D. A. Pincot,* Thomas J. Poorten,* Michael A. Hardigan,* Julia M. Harshman,* Charlotte B. Acharya,* Glenn S. Cole,* Thomas R. Gordon,† Michelle Stueven,† Patrick P. Edger,‡ and Steven J. Knapp*,1

*Department of Plant Sciences and †Department of Plant Pathology, University of California, Davis, California, 95616, and ‡Department of Horticulture, Michigan State University, East Lansing, Michigan 48824

ORCID IDs: 0000-0001-9768-0740 (T.J.P.); 0000-0002-5188-8084 (J.M.H.); 0000-0001-6498-5409 (S.J.K.)

- ✓ Major gene resistance
- ✓ Can be moved into other cultivars
- ✓ Does not prevent colonization
- ✓ May allow inoculum build-up in soil

Management Of Soilborne Pathogens

✓ **Avoid introductions**

Clean plants

Don't move soil

✓ **Reduce inoculum levels**

Flat fumigation is best

Maximize distribution in beds

Avoid cane berries and lettuce

✓ **Use resistant cultivars**

Thank You!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STORKAN
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McCASLIN
RESEARCH
FOUNDATION


Sierra-Cascade Nursery
"Quality Strawberry Plants"

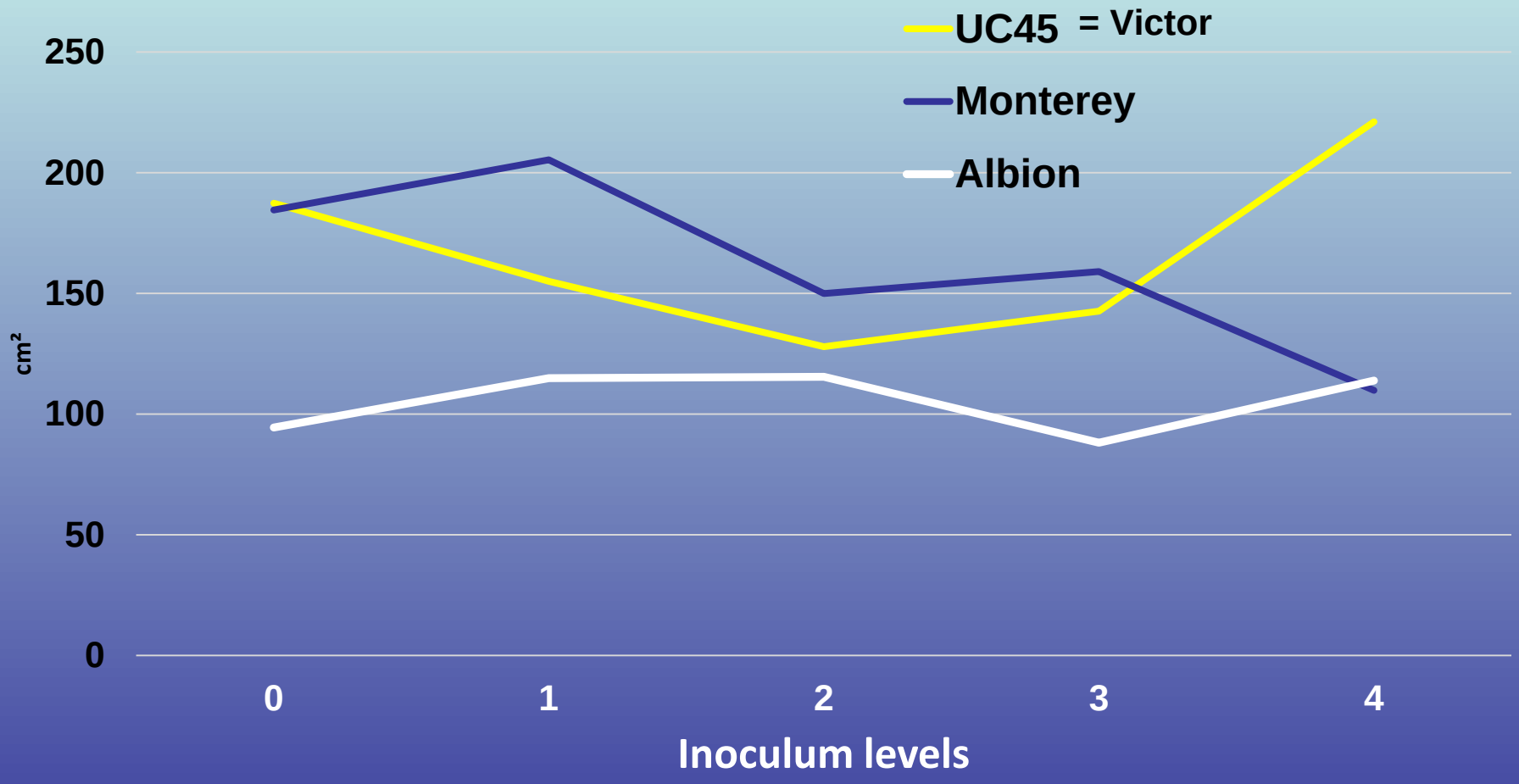
How much Fusarium in soil can my strawberry handle?

2000 CFUs per gram (4),
1000 CFUs per gram (3),
500 CFUs per gram (2),
100 CFUs per gram (1),
0 CFU (just sand) (0).

Treatments

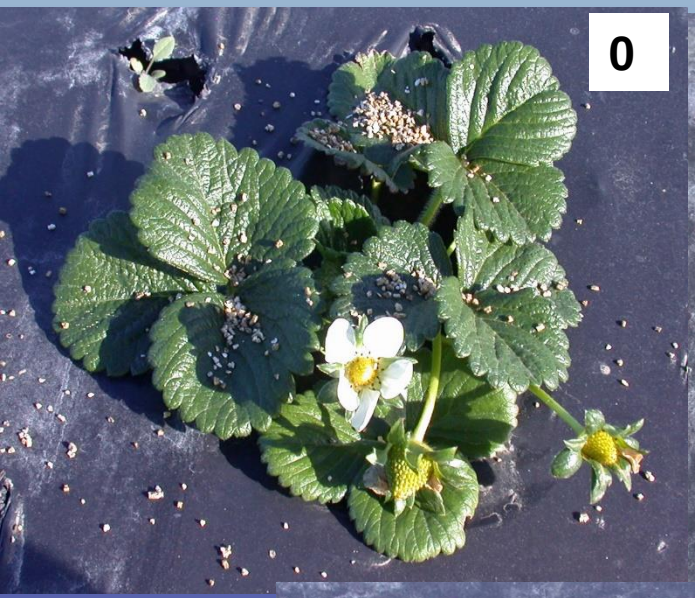
- **Soil excavated from planting holes (1L) is mixed with Fusarium-inoculated sand (0.1L) and returned to planting holes**
- **3 cultivars Planted in RCBD plots with 4 reps**

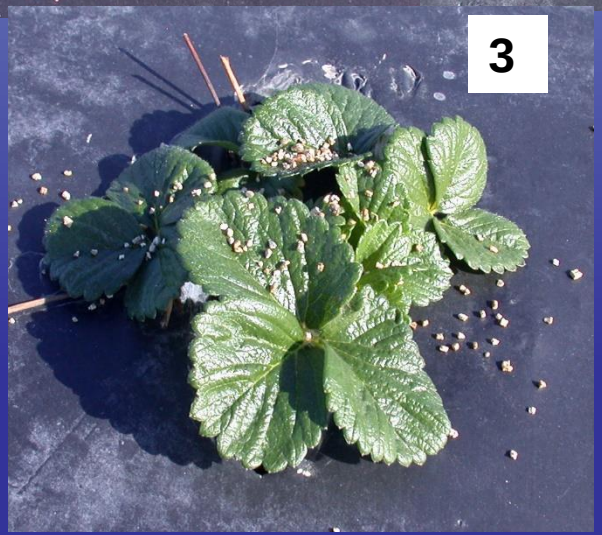
Plant size in response to Fusarium (01/05/2018)



Albion in response to Fusarium (12/02/2018)

Monterey in response to Fusarium (12/02/2018)





Victor in response to Fusarium (12/02/2018)

Albion without Fusarium - May

0

Albion in response to Fusarium - May

1

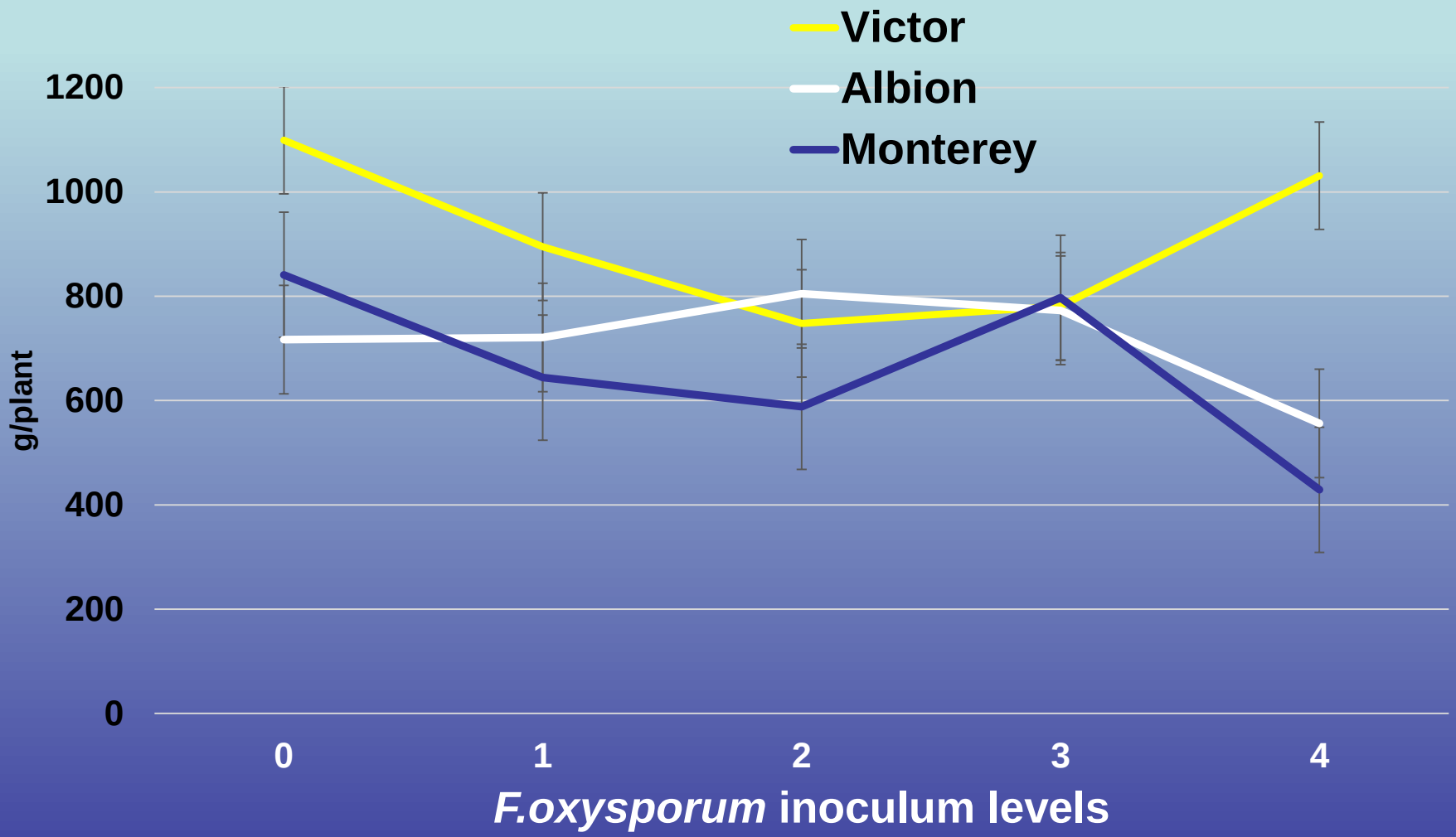
2

Albion in response to Fusarium - May

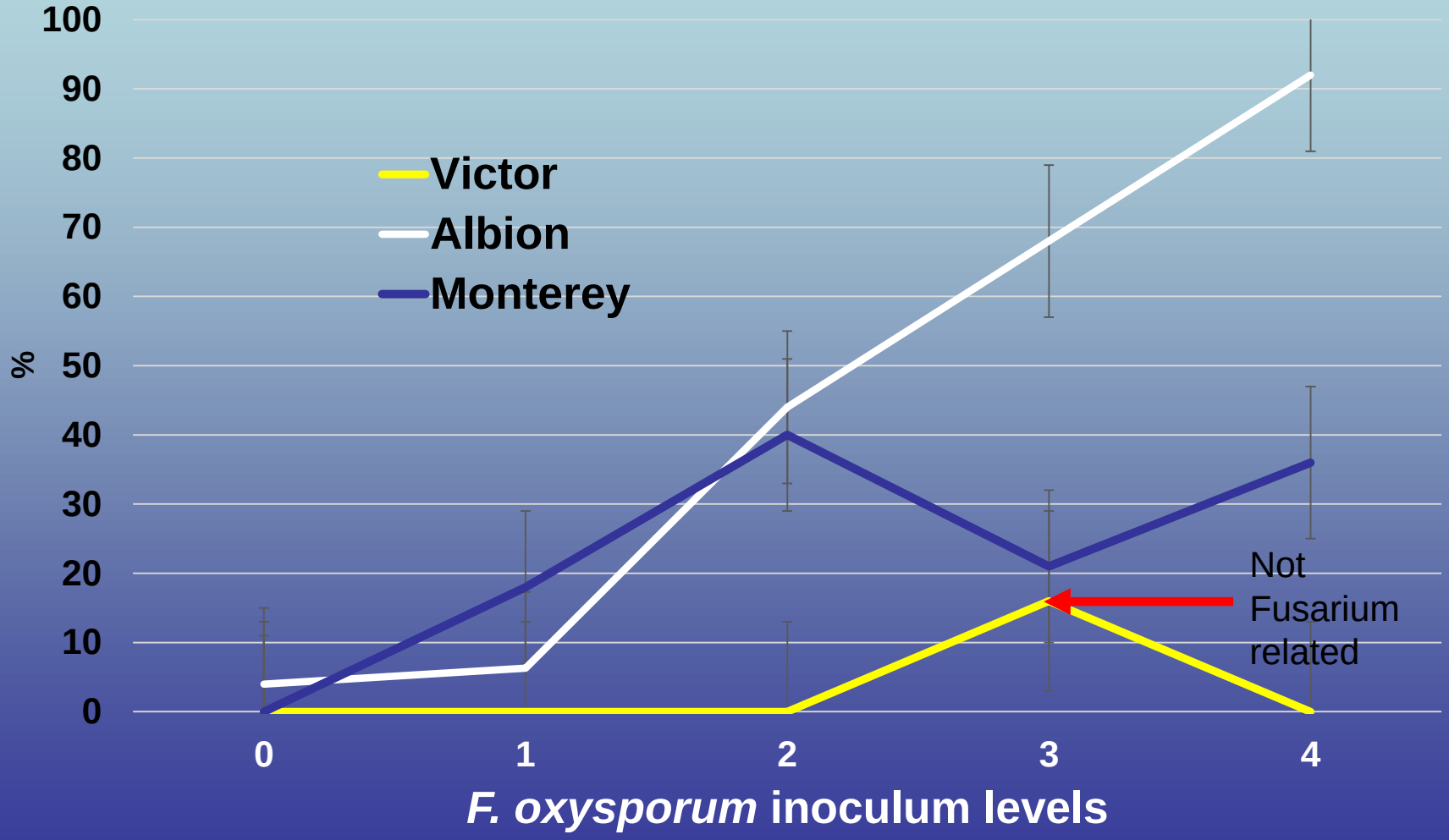
3

4

Fruit yield (total) in response to Fusarium



Percent mortality due to Fusarium, 07/05/2019



What's next?

- Another season of data to help deign prediction models = relationship of pathogen density with cultivar performance
- Do the same for *Macrophomina phase*olina (charcoal rot pathogen)

Thank You

http://ucanr.edu/sites/eskalenlab