Fusarium Wilt of Strawberry

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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

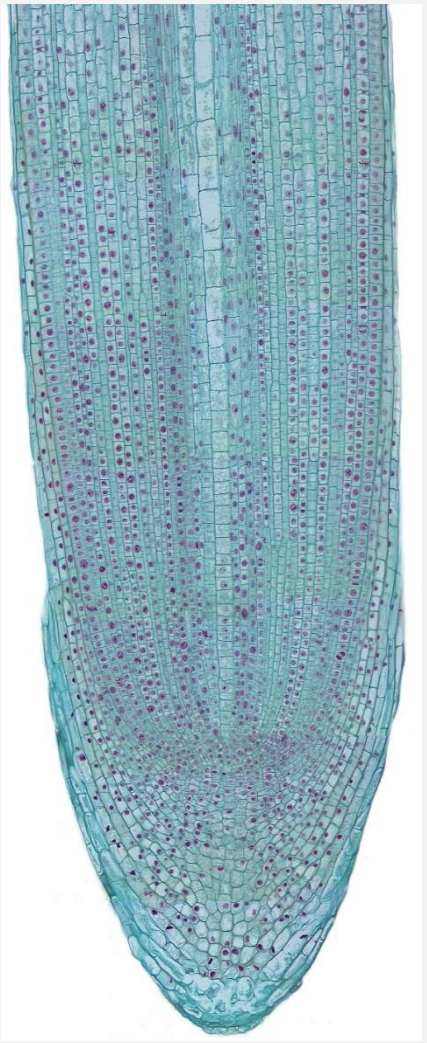
Non-pathogenic strains colonize roots

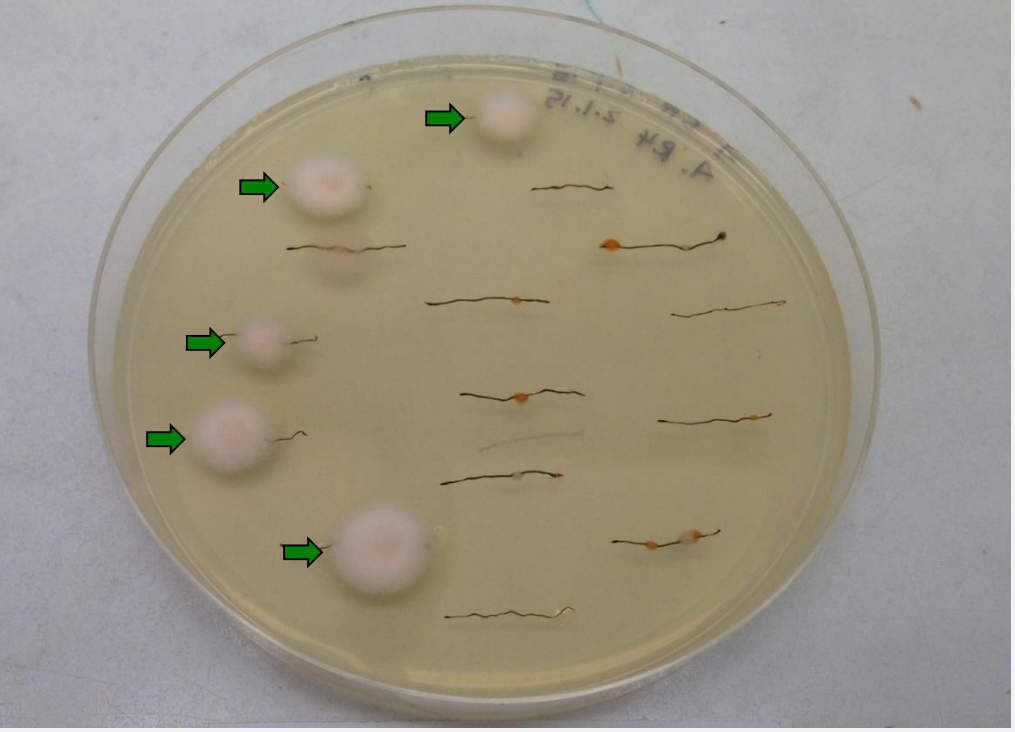
Pathogen ID requires further testing

Fusarium wilt

Sugars

Fusarium oxysporum



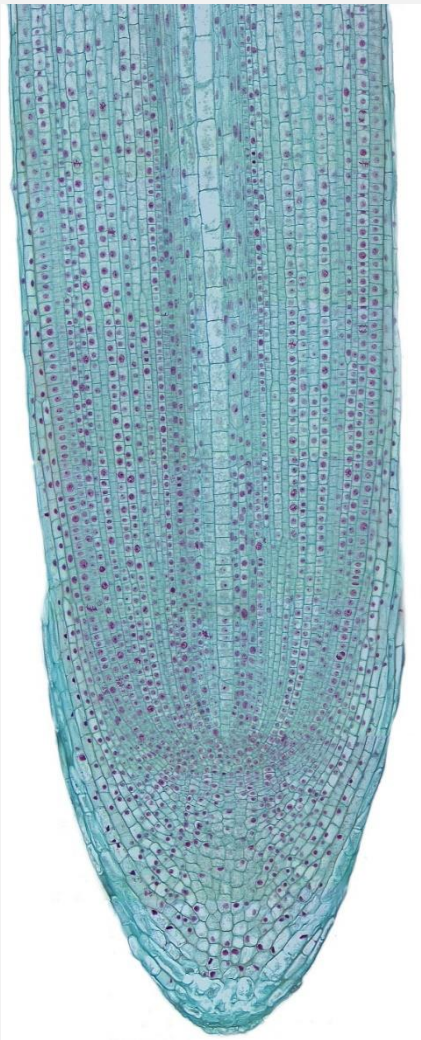


Fusarium wilt

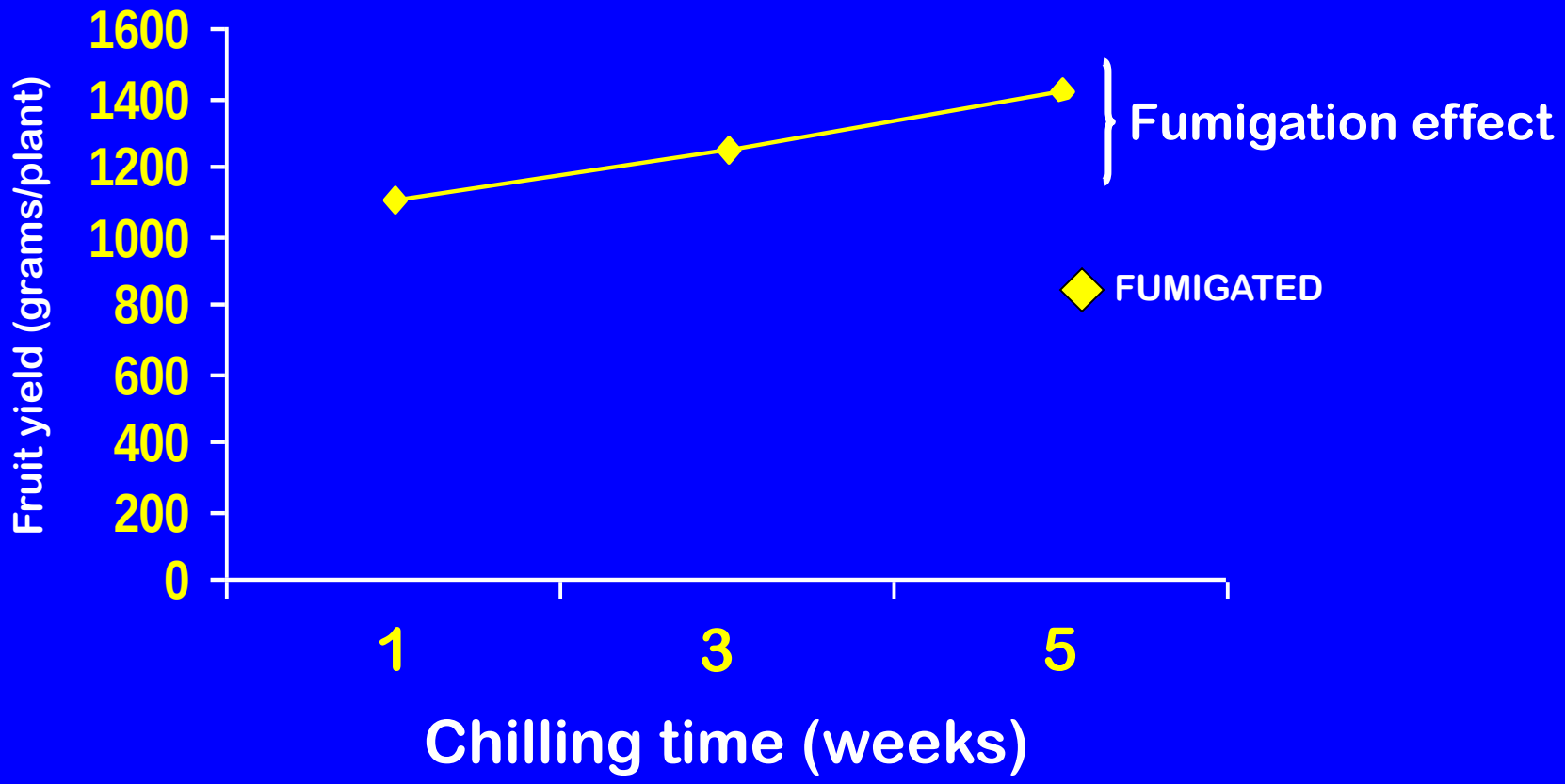
Infection of root tips

Fusarium oxysporum

Sugars



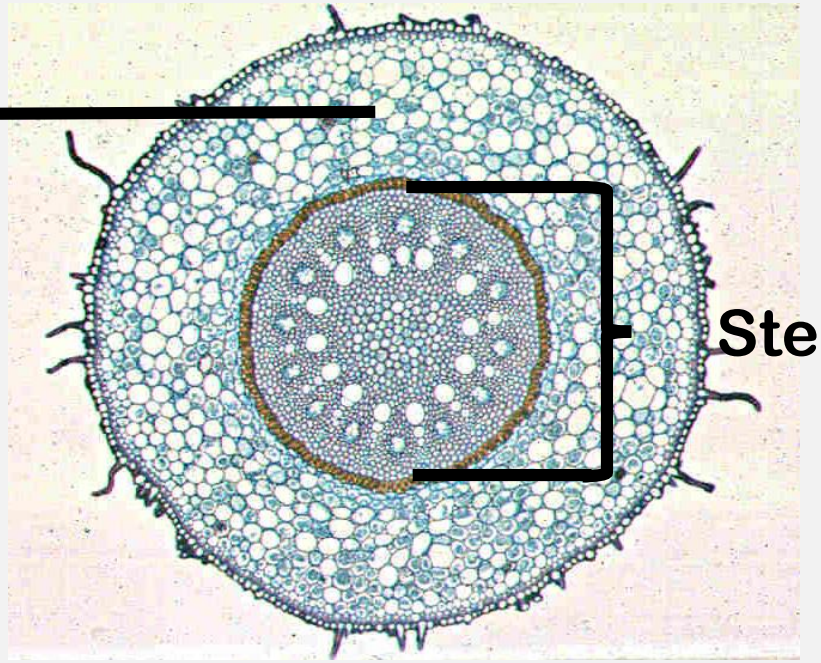
Effect Of Fumigation Treatment And Chilling On Fruit Yield Of Strawberry



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

Root Cross Section

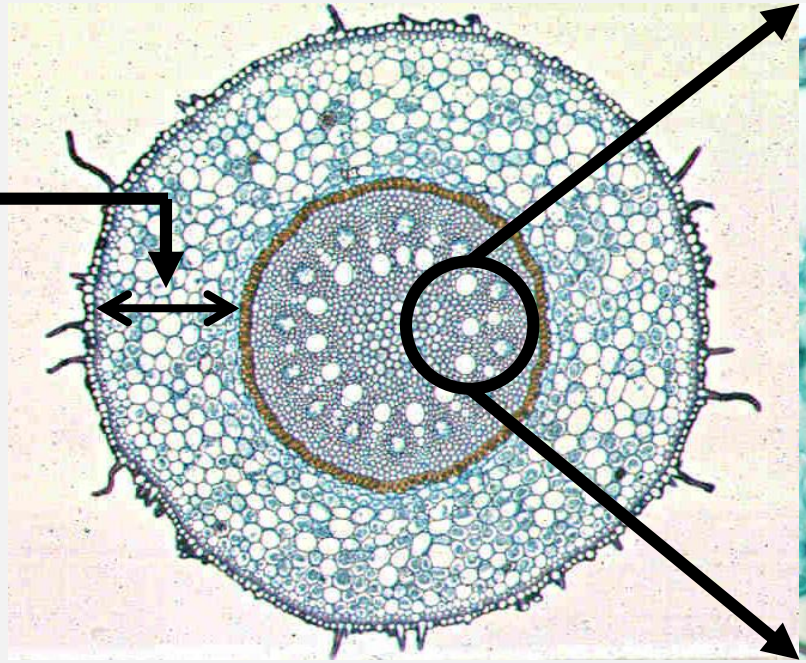
Cortex



Stele

Non-pathogenic fungi colonize the root cortex

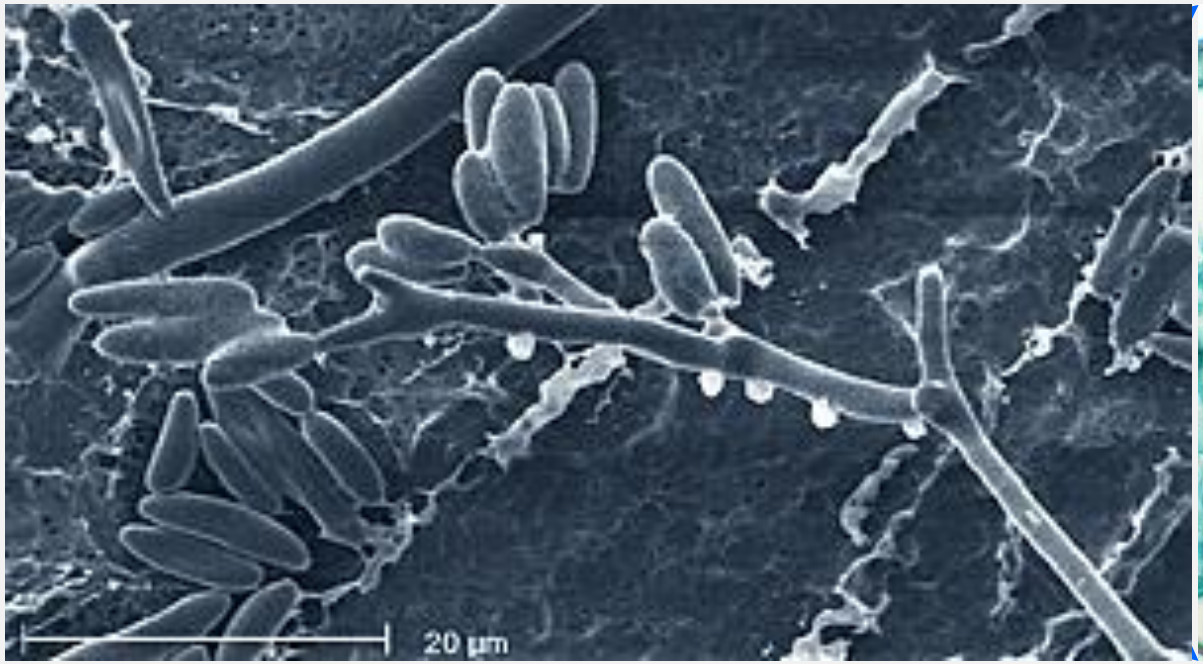
Region of fungal growth



Fusarium oxysporum f. sp. *fragariae*

Xylem vessels

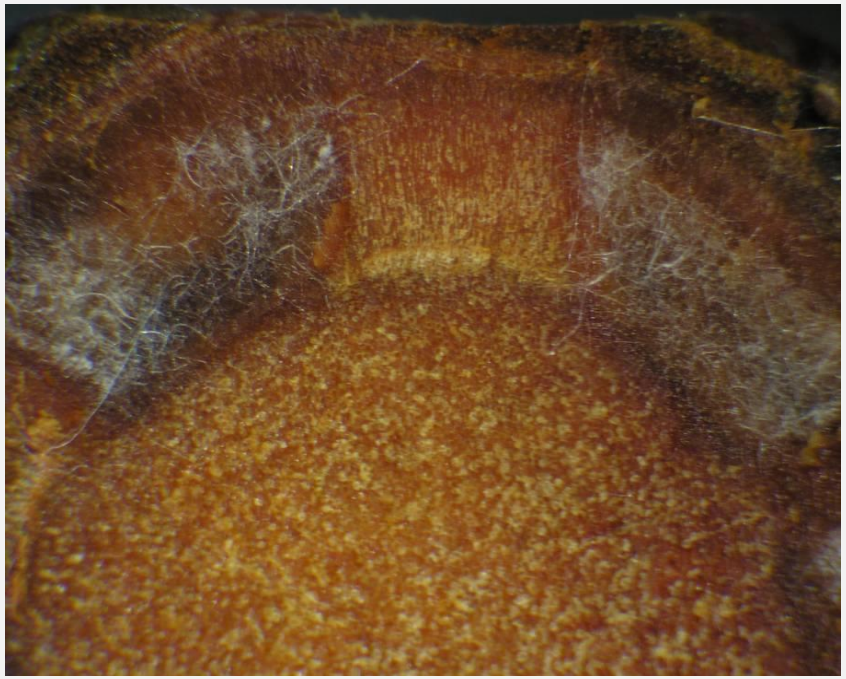
The Pathogen Moves Into The Shoot With Water



Spores

Xylem vessels

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



Colonized vascular tissue

Obstruction of water flow

Management

NO CURATIVE MEASURES

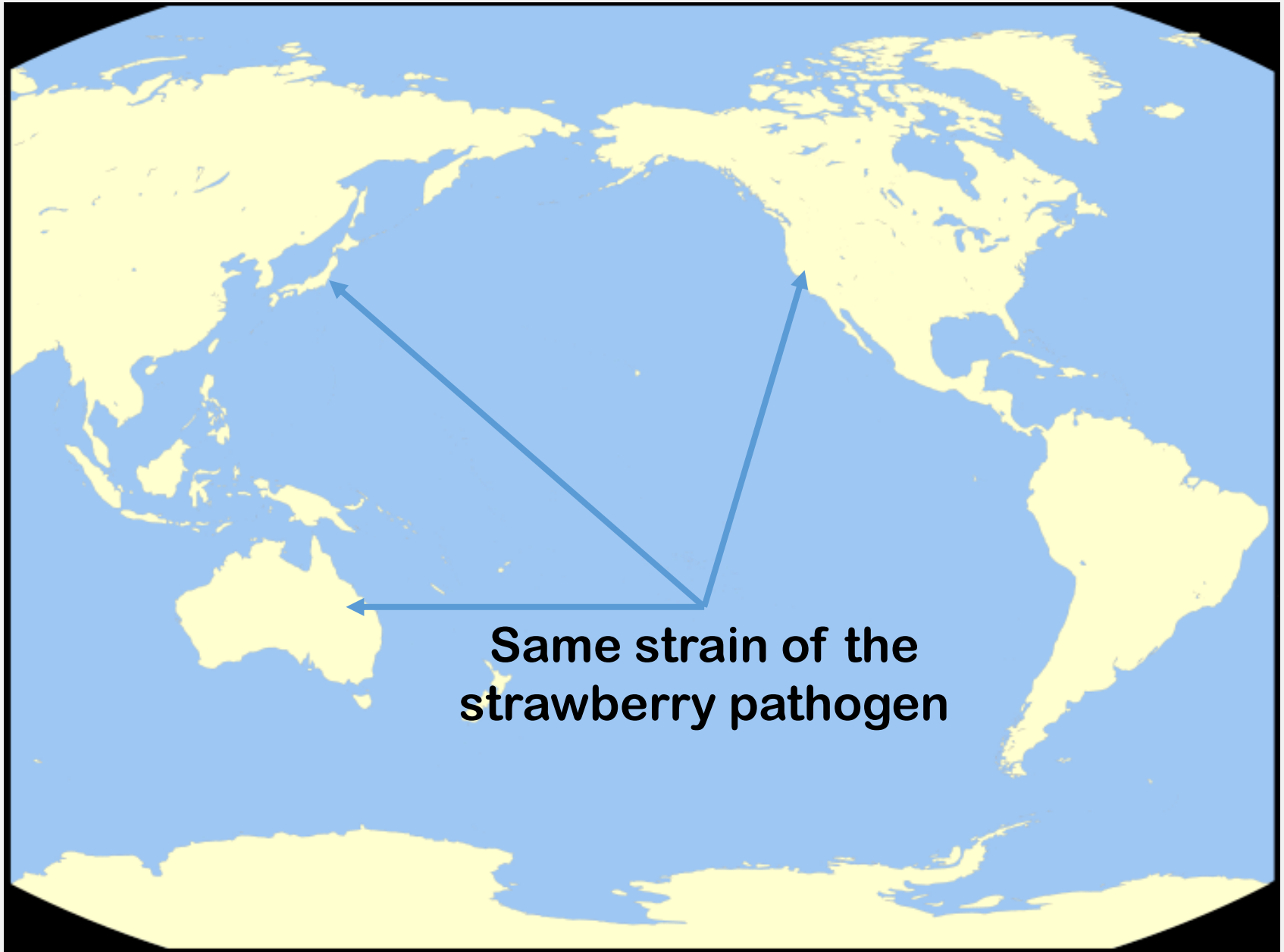
PREVENTION → **AVOID INTRODUCTION**

Avoid Introductions

Clean plants

Don’t move soil

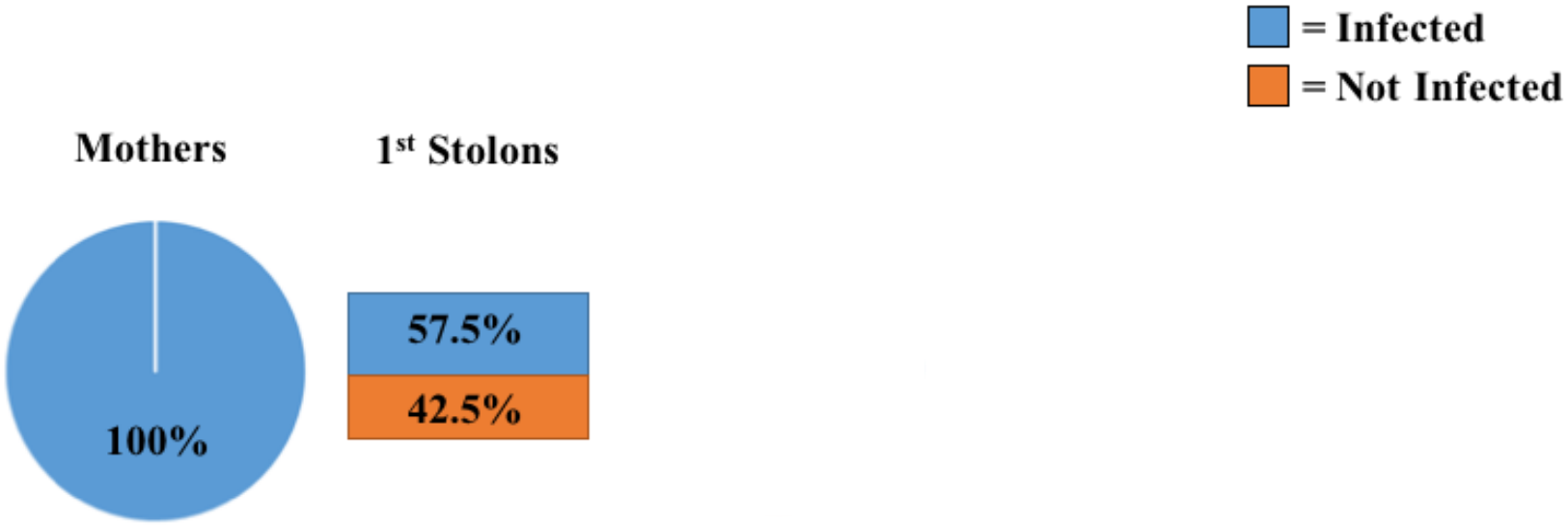
Fusarium Wilt



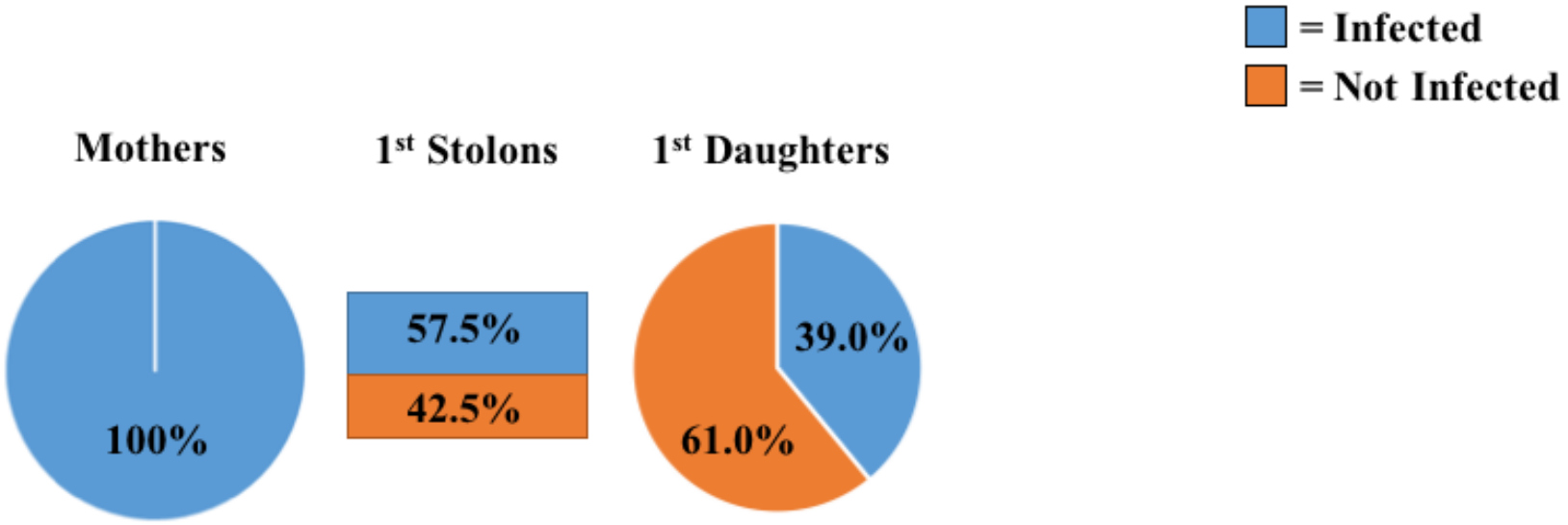

Transmission of *Fusarium*
to daughter plants

Transmission Of *Fusarium* To Daughter Plants

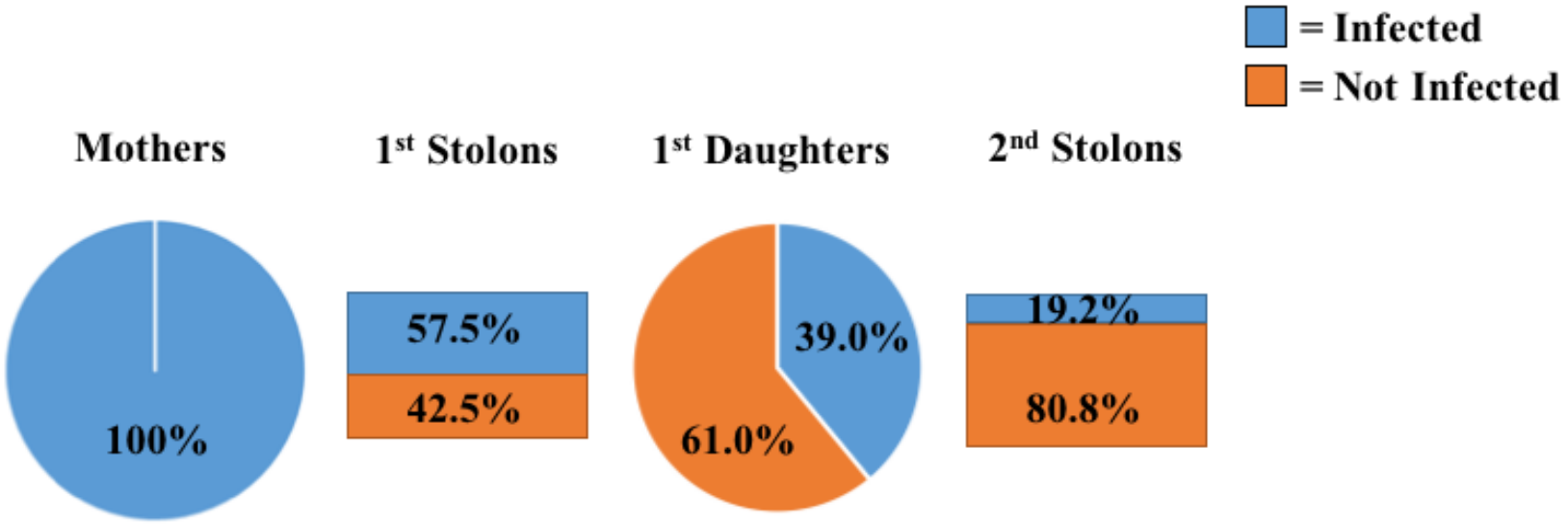
Albion



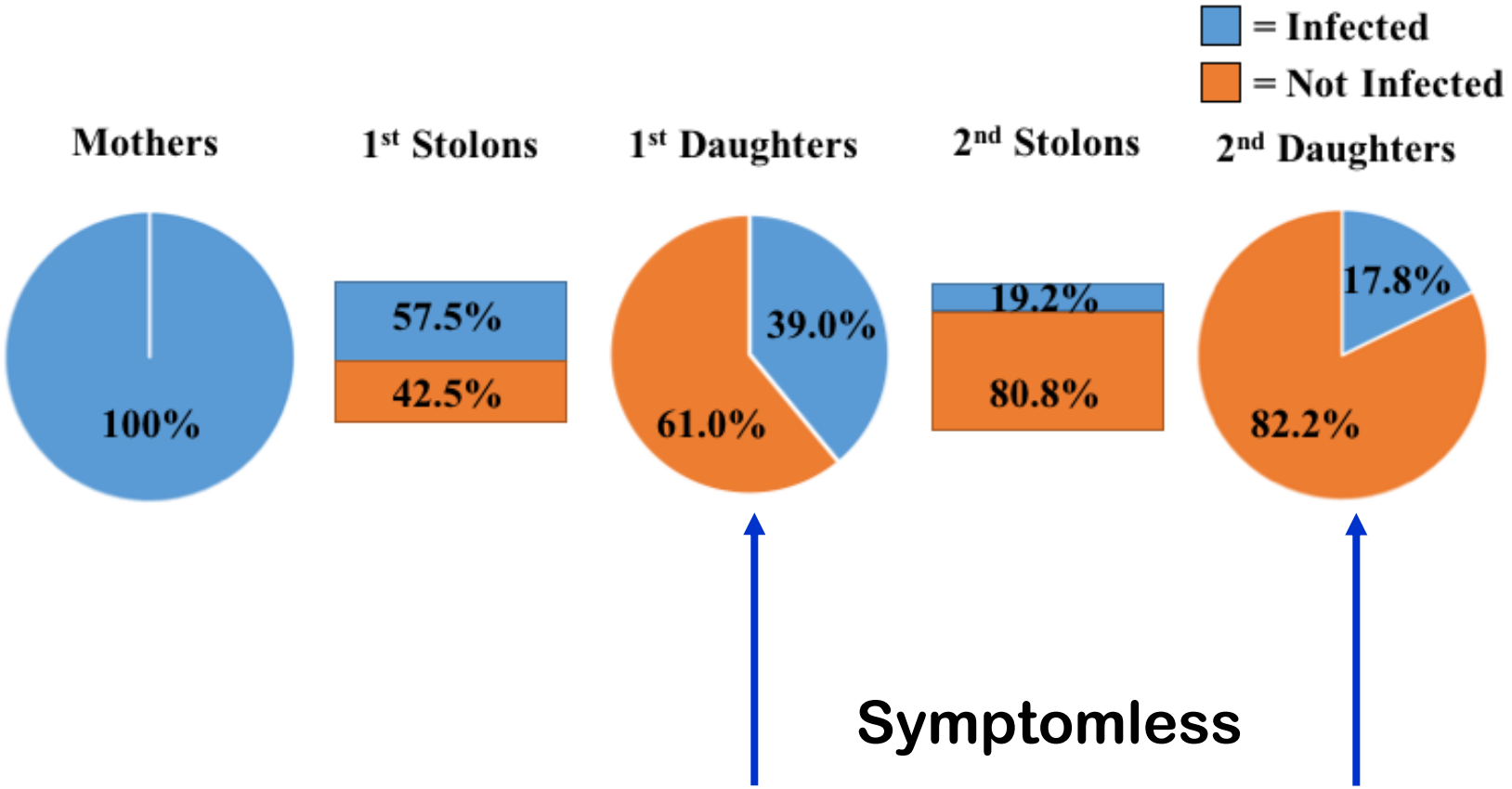
Albion


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

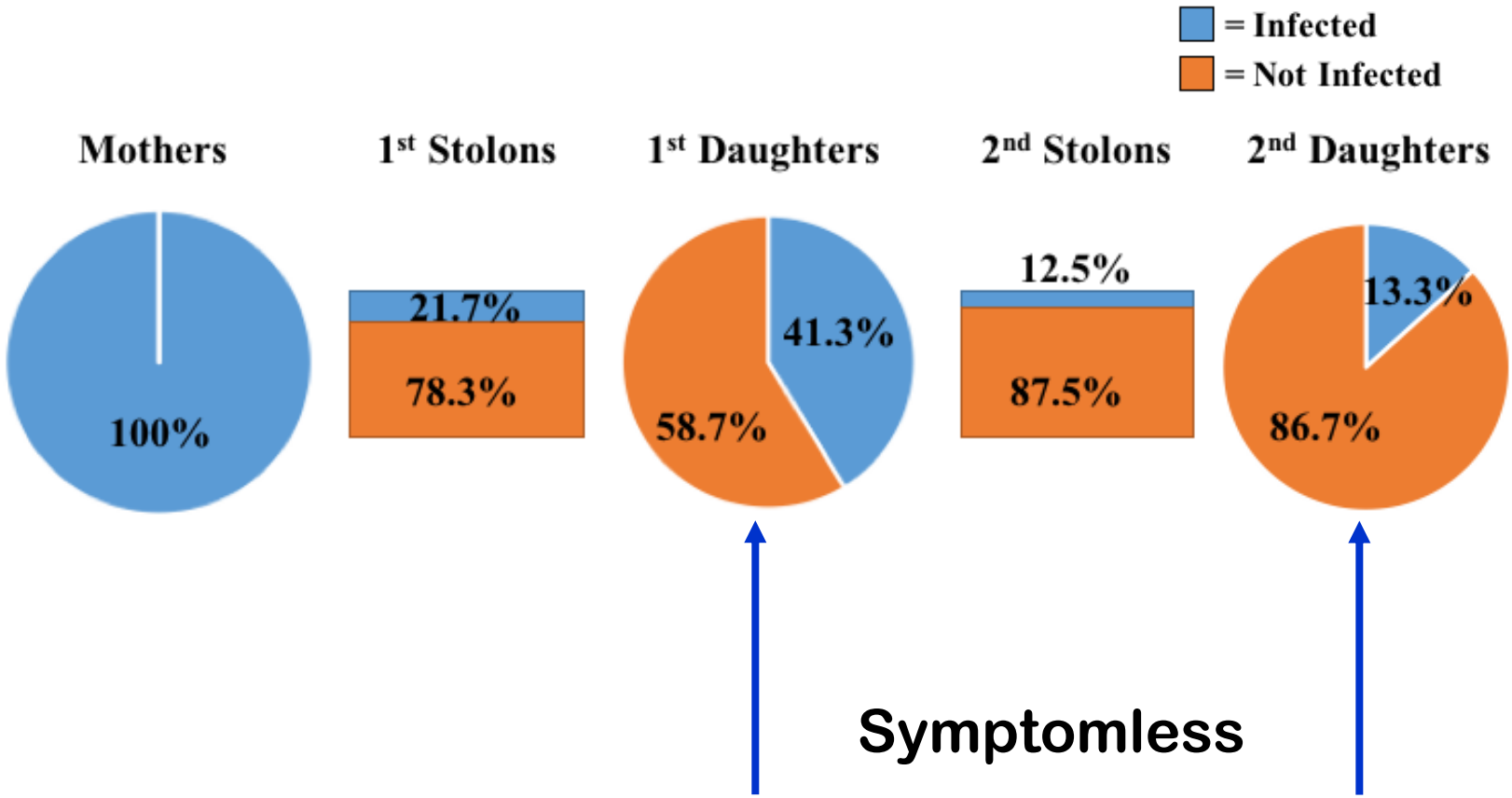
Albion


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

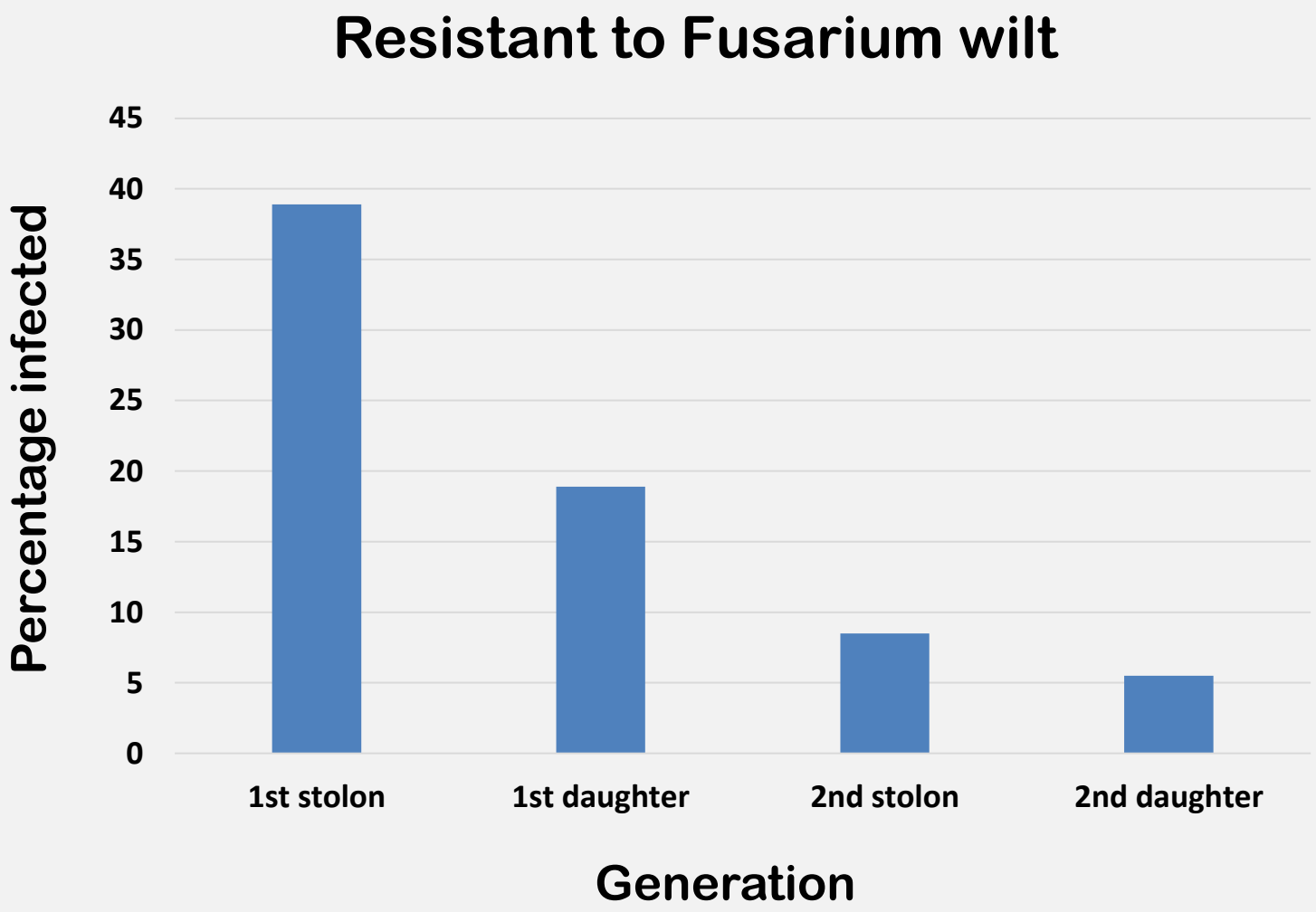
Albion


= 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

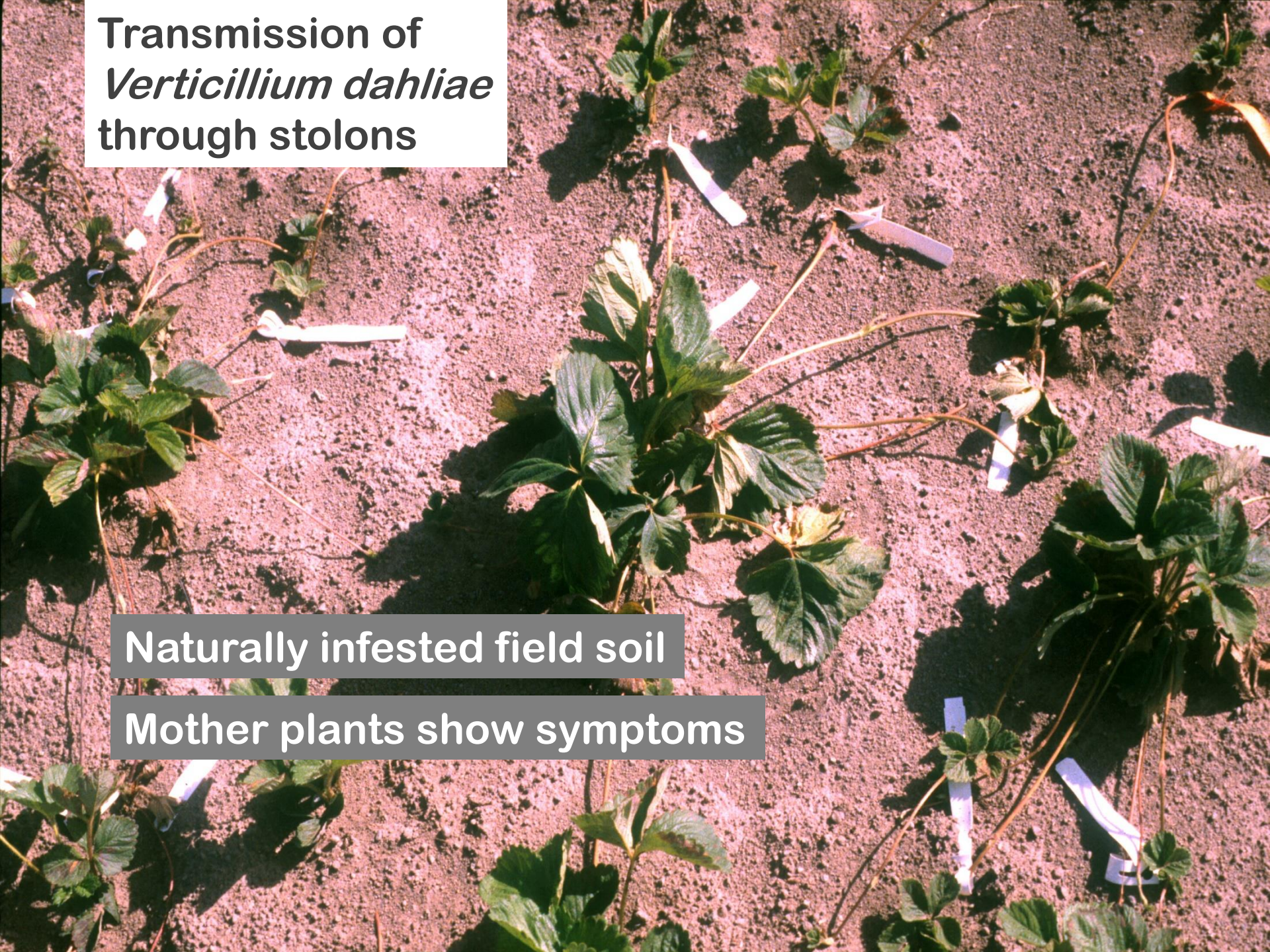
Monterey


= 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


Transmission of
Verticillium dahliae
through stolons
Naturally infested field soil
Mother plants show symptoms

Infected Daughter Plants

Show no symptoms

Disease may develop
in a fruit production field

**Prevention of infection
in nurseries is critical**

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

Efficacy Of Fumigants

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

Chloropicrin @ 400 pounds/acre

Telone (1,3-Dichloropropene)

Metam sodium / K-Pam / Dominus

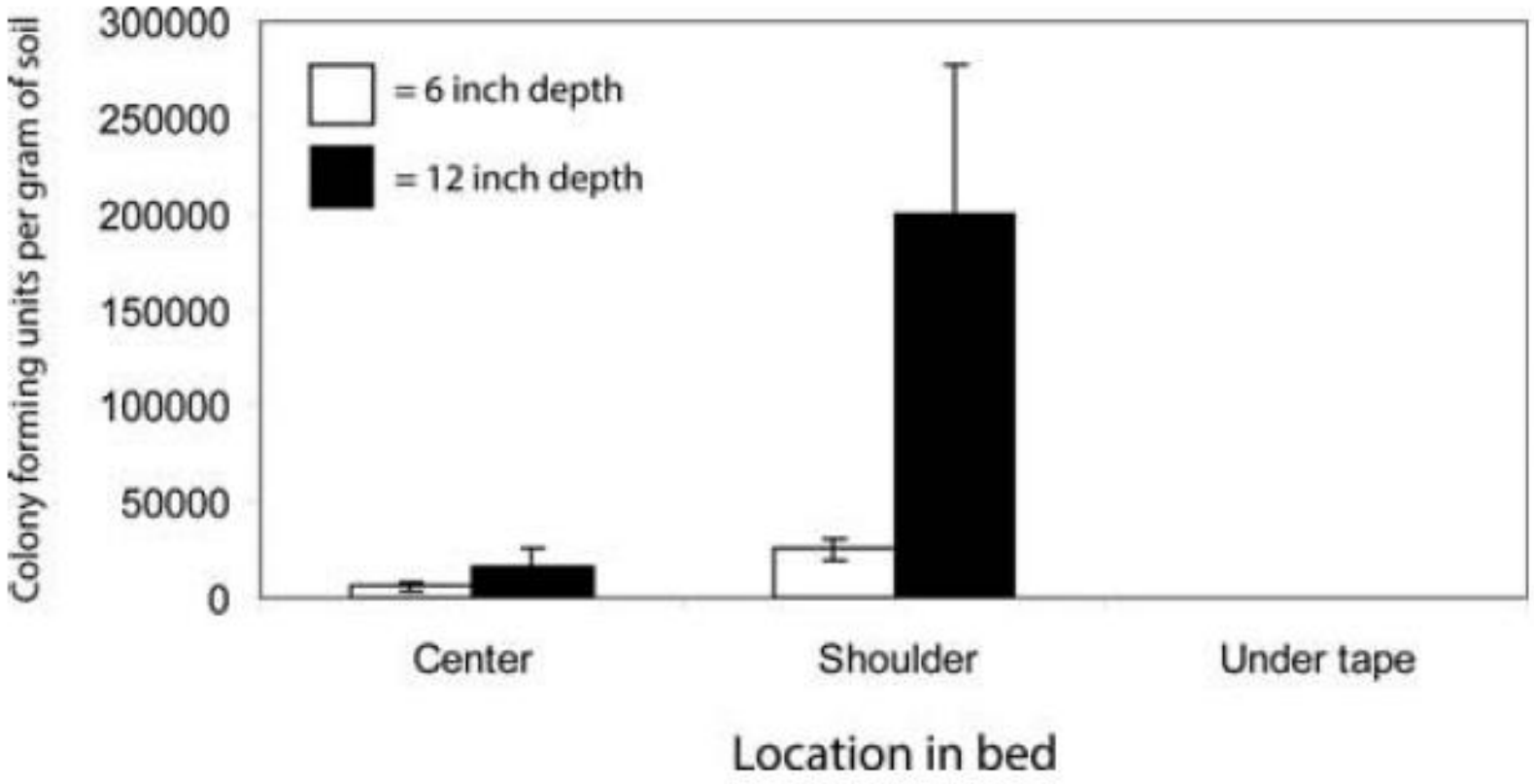
Bed fumigation

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

Taylor & Francis
Taylor & Francis Group

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]



Incomplete treatment

Mortality is not evenly distributed across beds

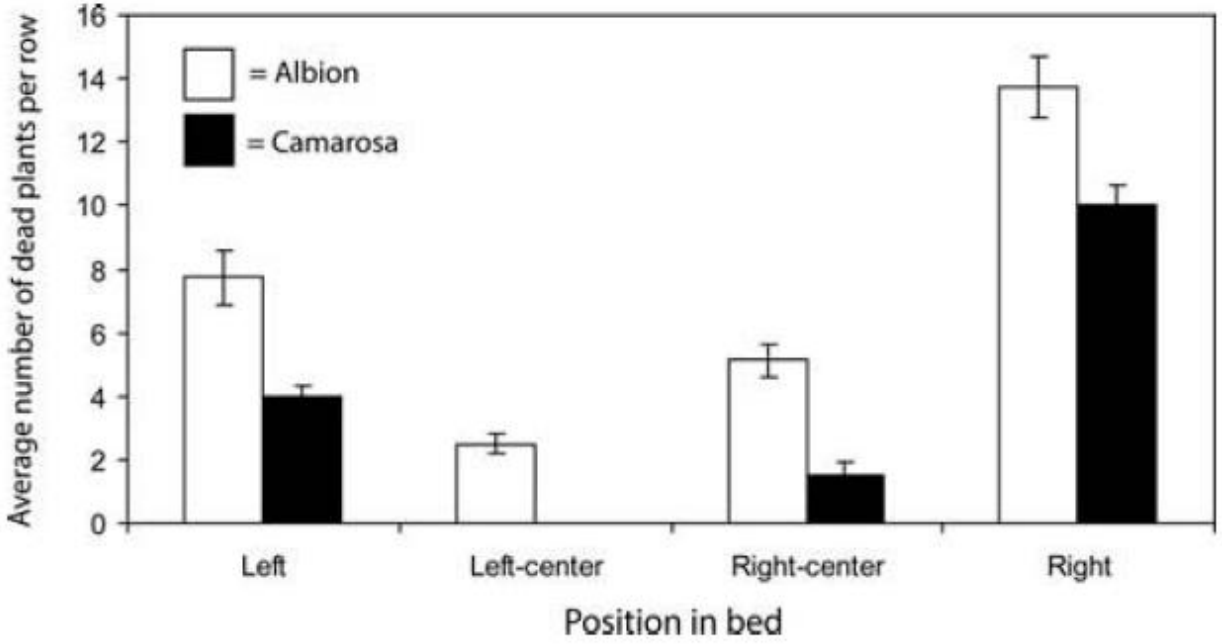


Figure 2. The effect of position in a bed on mortality caused by Fusarium wilt in two strawberry cultivars. Values represent means of four replications and error bars correspond to 2× the standard error of the mean.

Flat fumigation is best

Maximize efficacy of bed fumigation

Chloropicrin is good

More is better

More driplines

More water

Don’t plant buffer zones

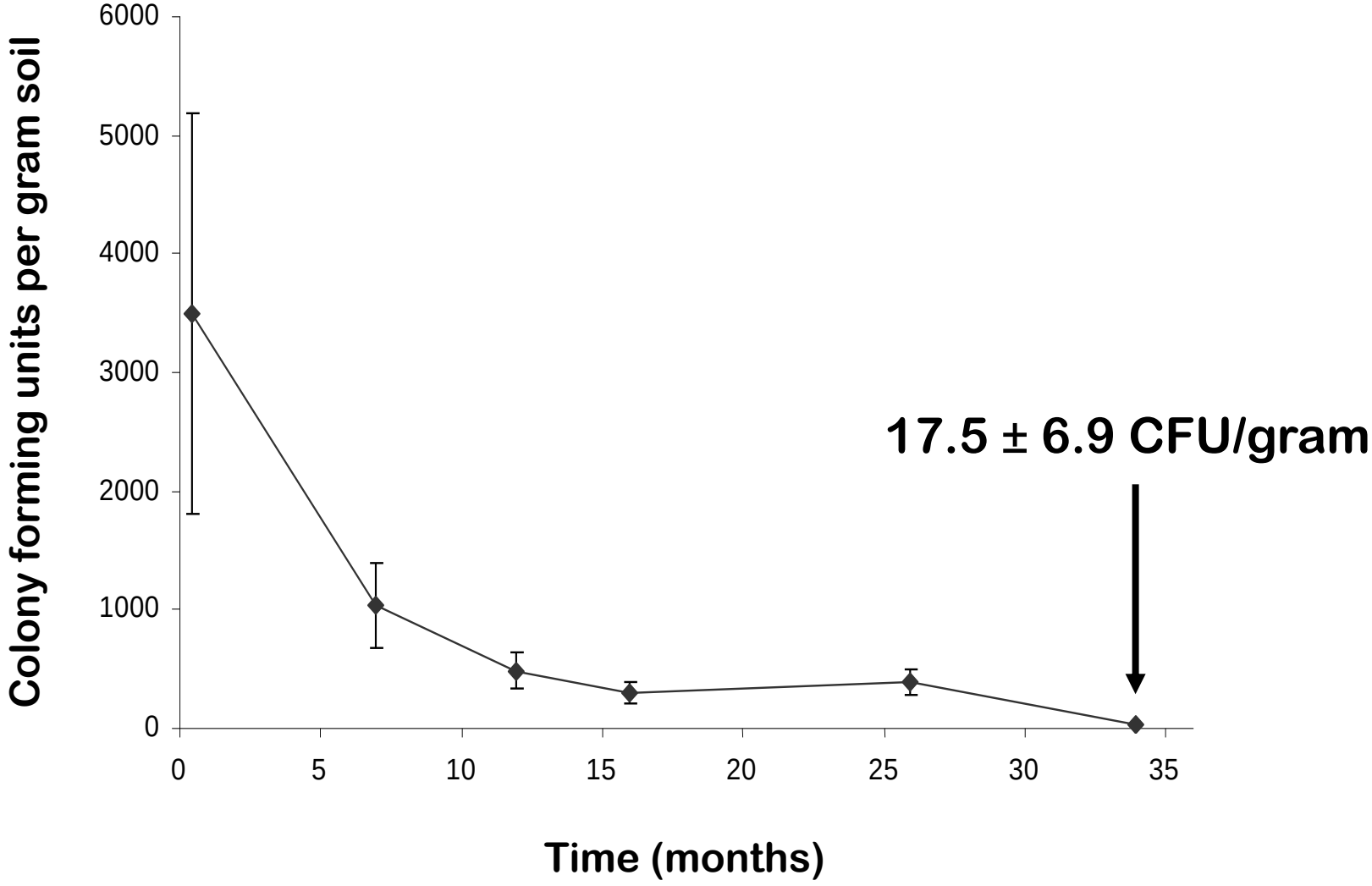
Crop rotation

Inoculum levels decline when other crops are grown

Fusarium wilt

Specific to strawberry

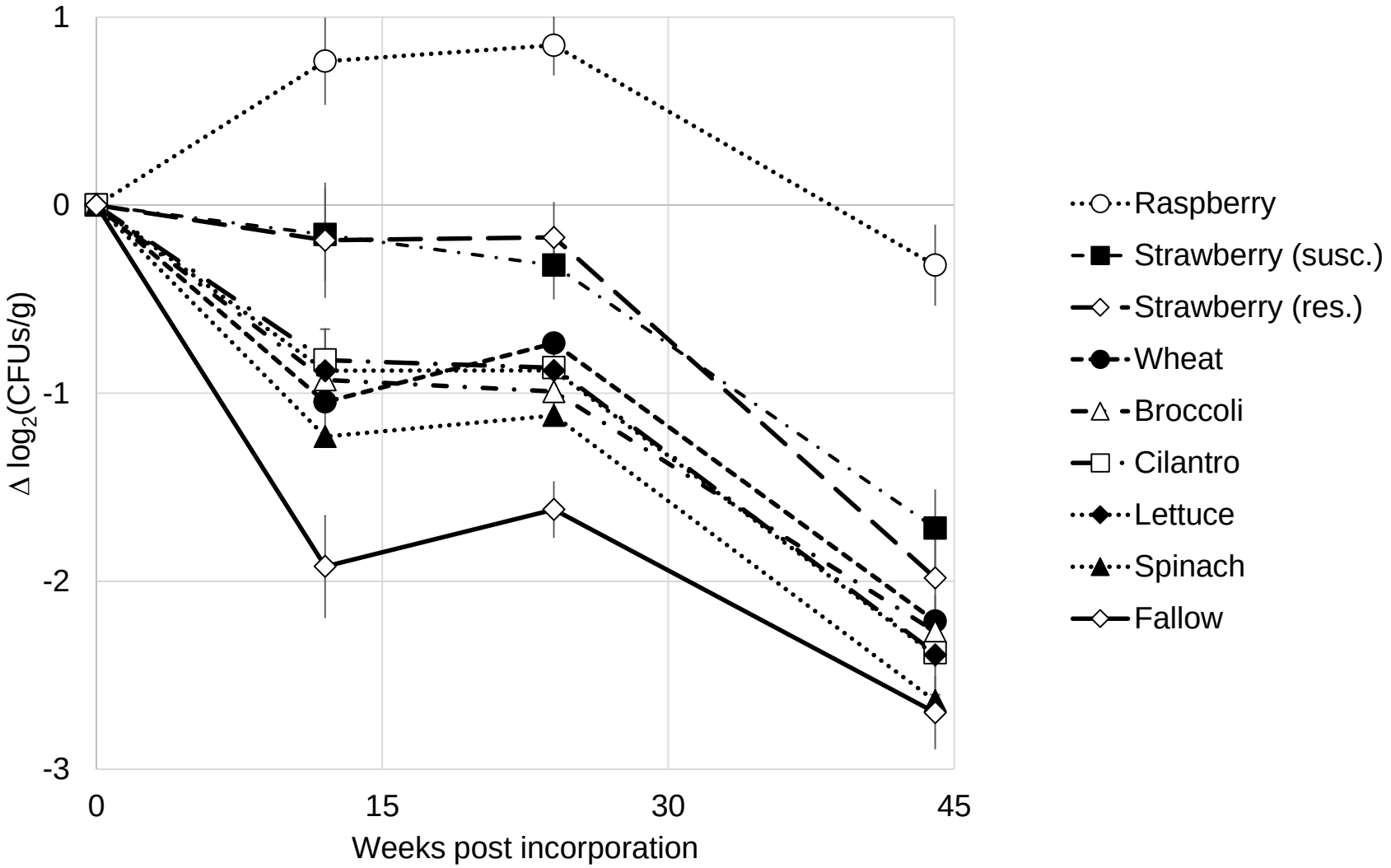
Survival of *F. o. lactucae* in fallow soil



Fusarium oxysporum f. sp. *fragariae*

Colonize rotation crops

Colonize crop residue


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

Rotation crops

High risk

Raspberry

Blackberry

Low risk

Spinach

Wheat

Broccoli

Cilantro

Rotation crops

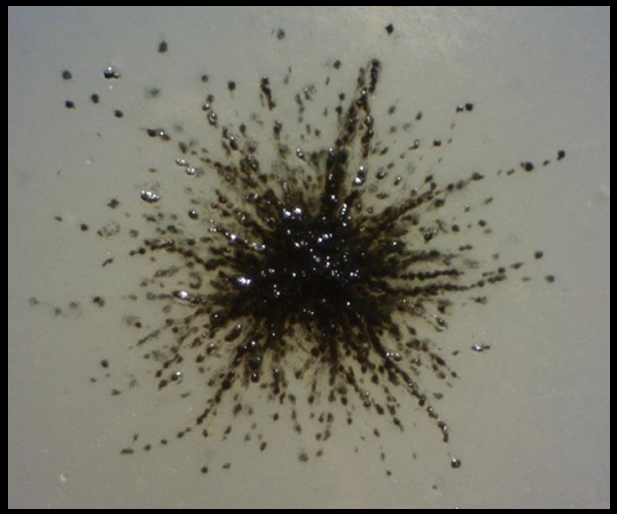
Lettuce

Susceptible to Verticillium wilt

Cover crops

Cryptic hosts for *Verticillium dahliae*

Common vetch	+
Field pea	+
Hairy vetch	+
Purple vetch	+
Wollypod vetch	+
Fava bean	+



Microsclerotia

Bell bean

Not a reproductive host

Management

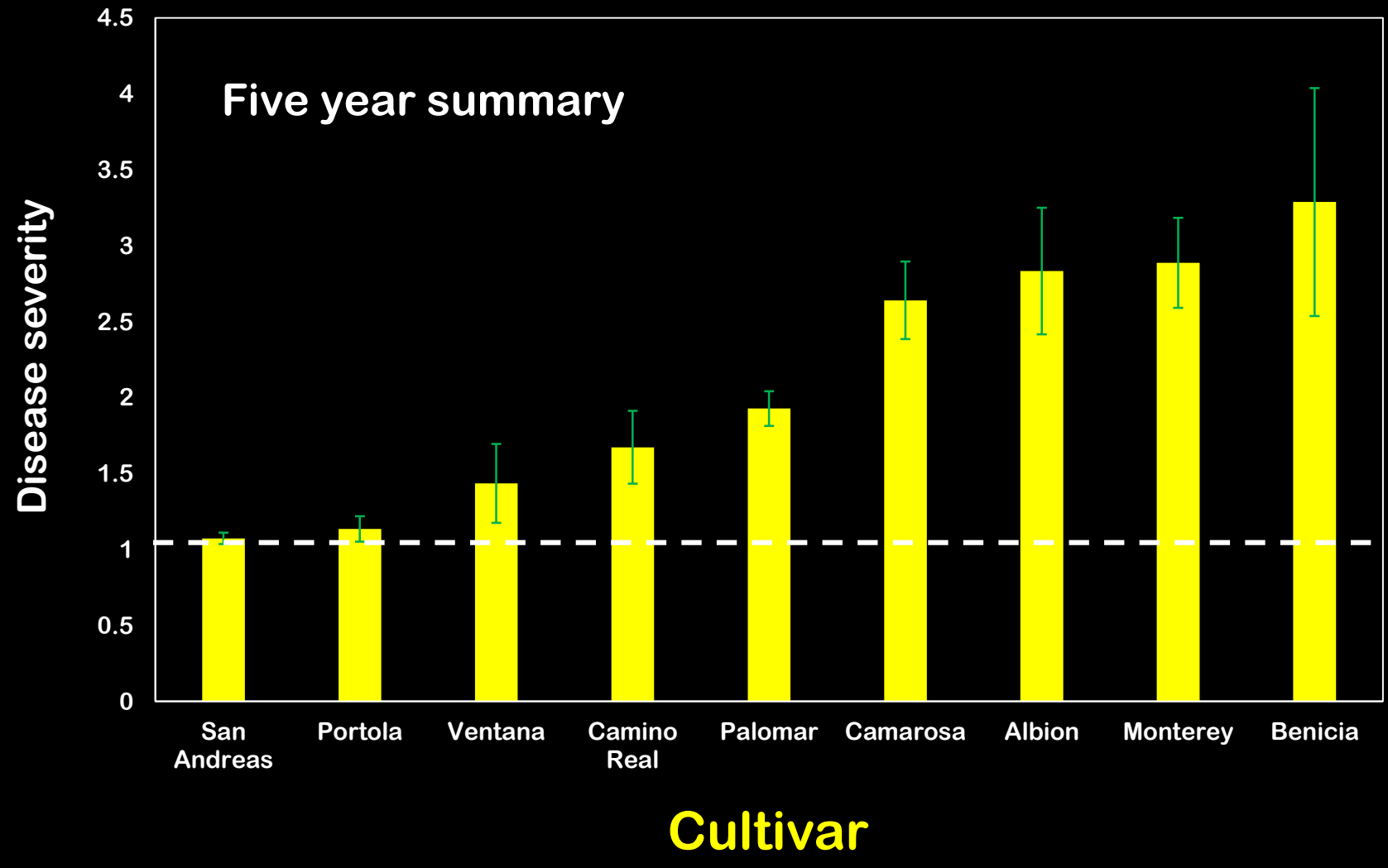
Genetic resistance

Differences in susceptibility to Fusarium wilt

Camarosa

Ventana

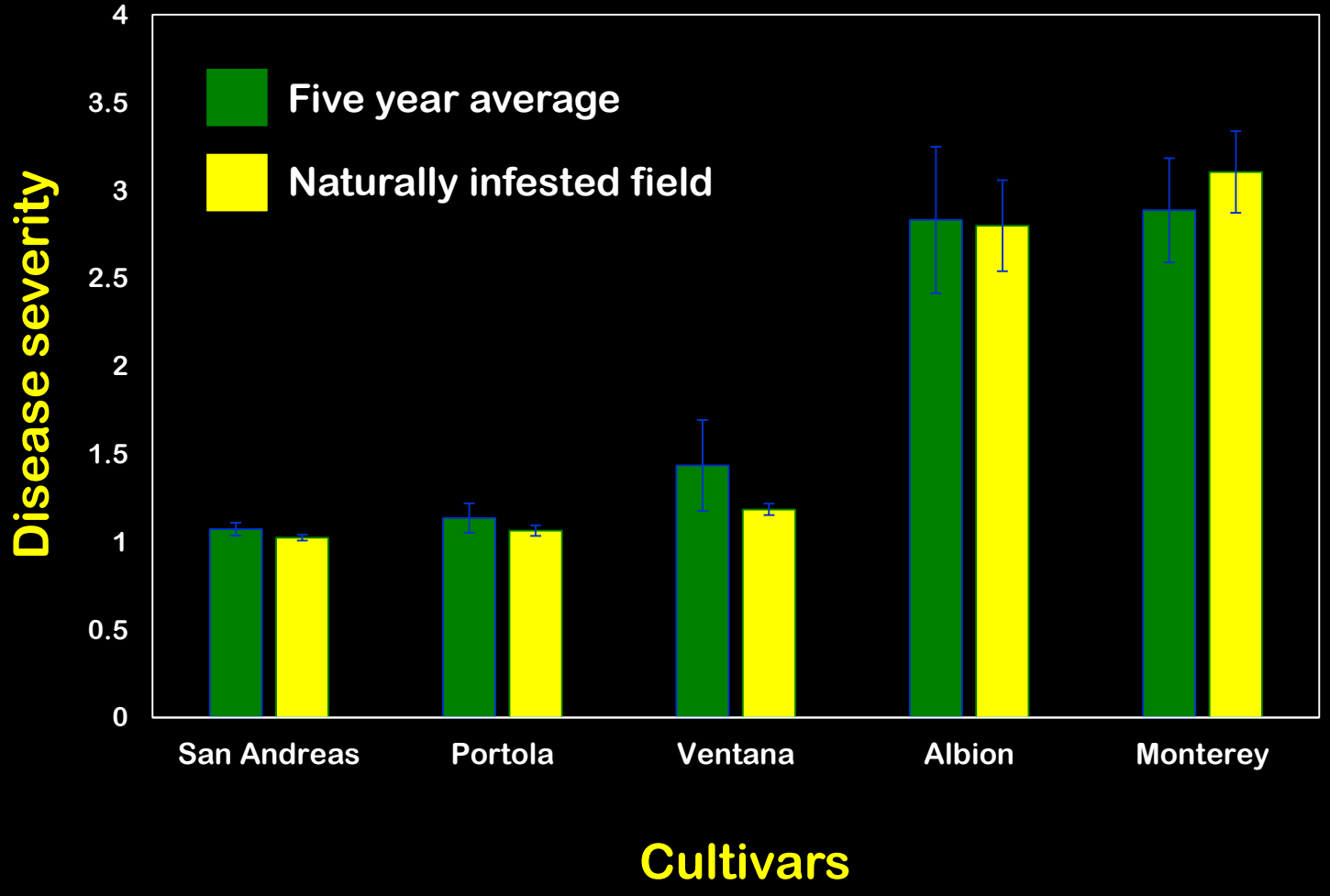
Susceptibility to Fusarium wilt




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.)

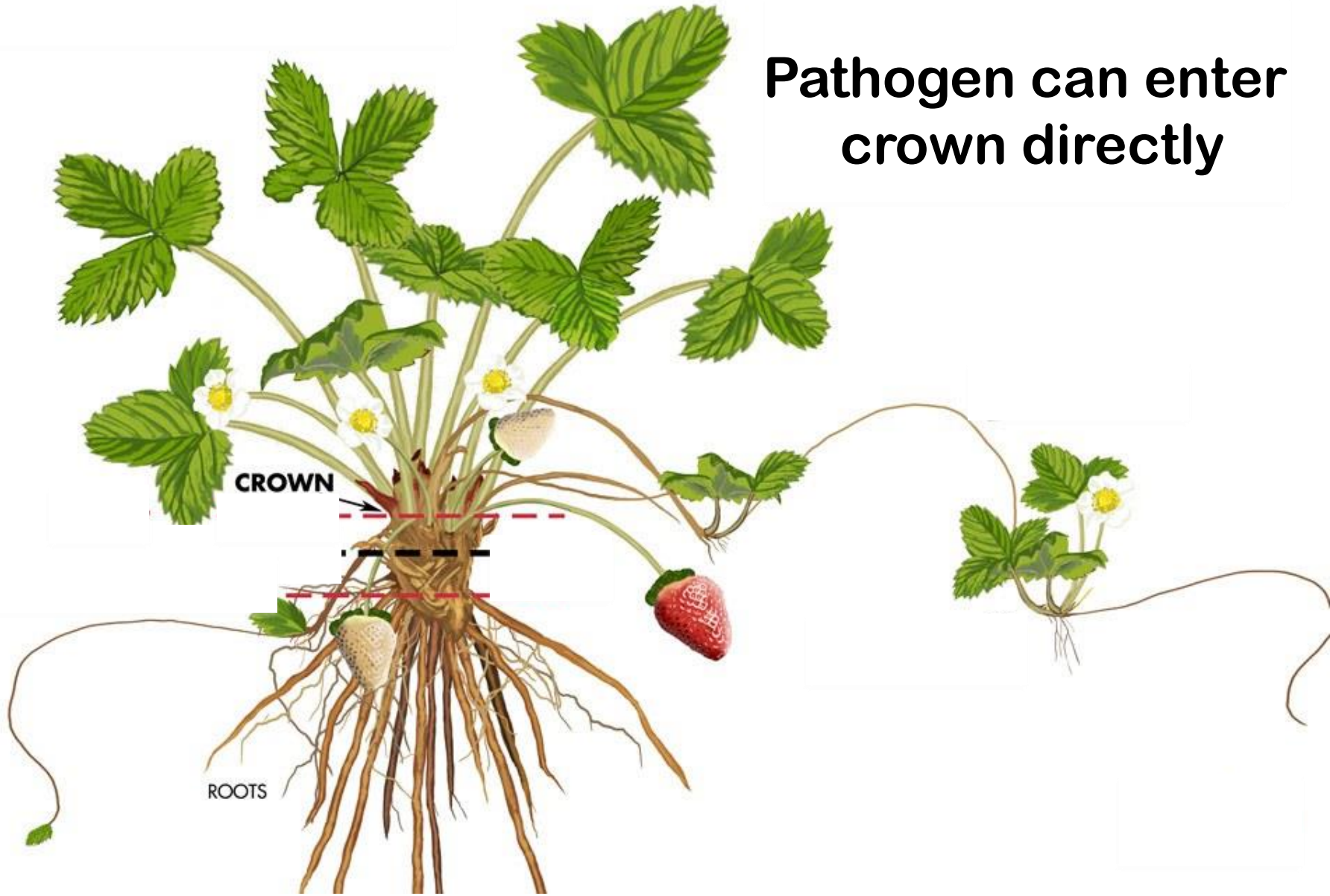
Major gene resistance

Can be moved into other cultivars

Does not prevent colonization

May allow inoculum build-up in soil

Pathogen can enter crown directly



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

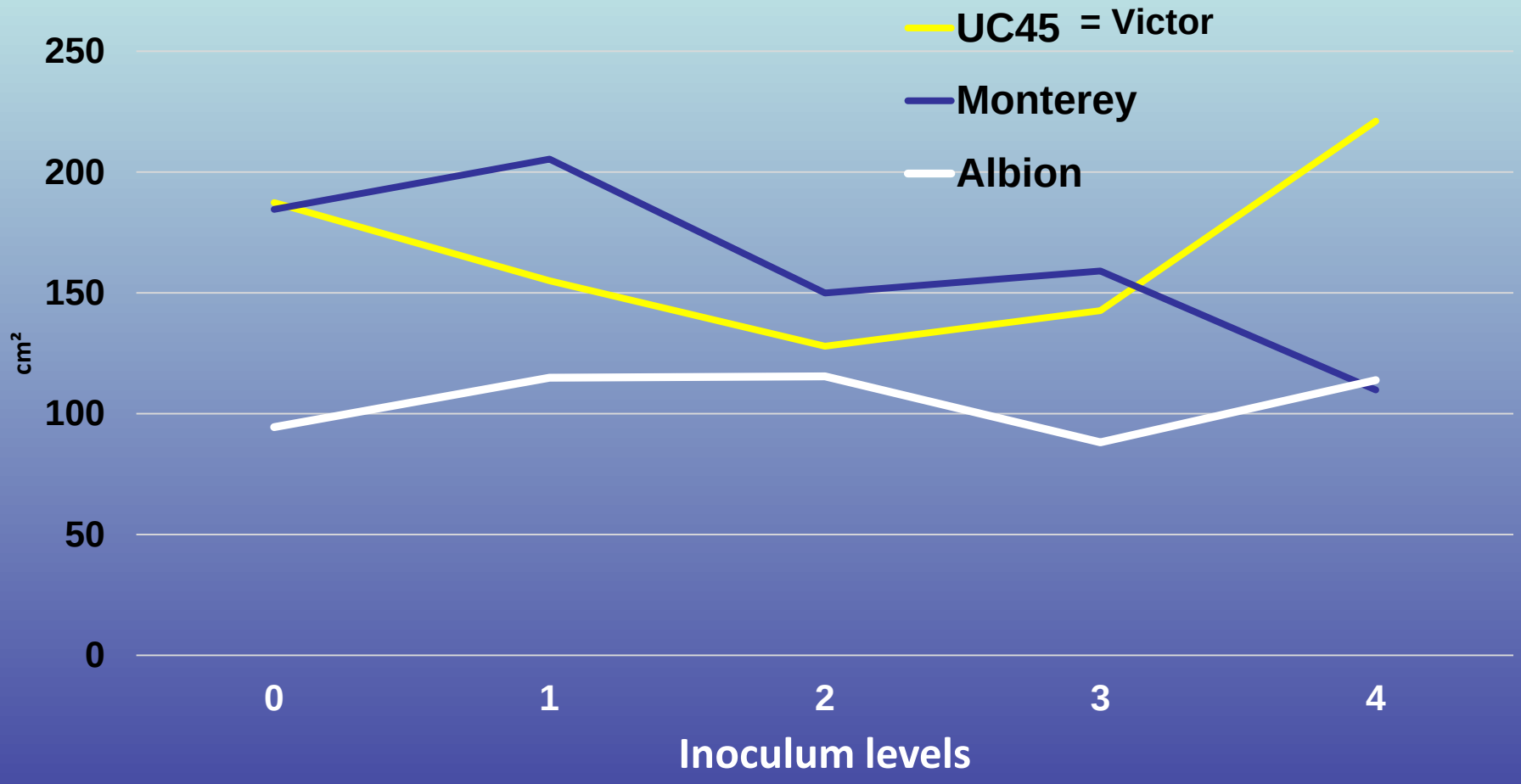
How much Fusarium in soil can my strawberry handle?

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).

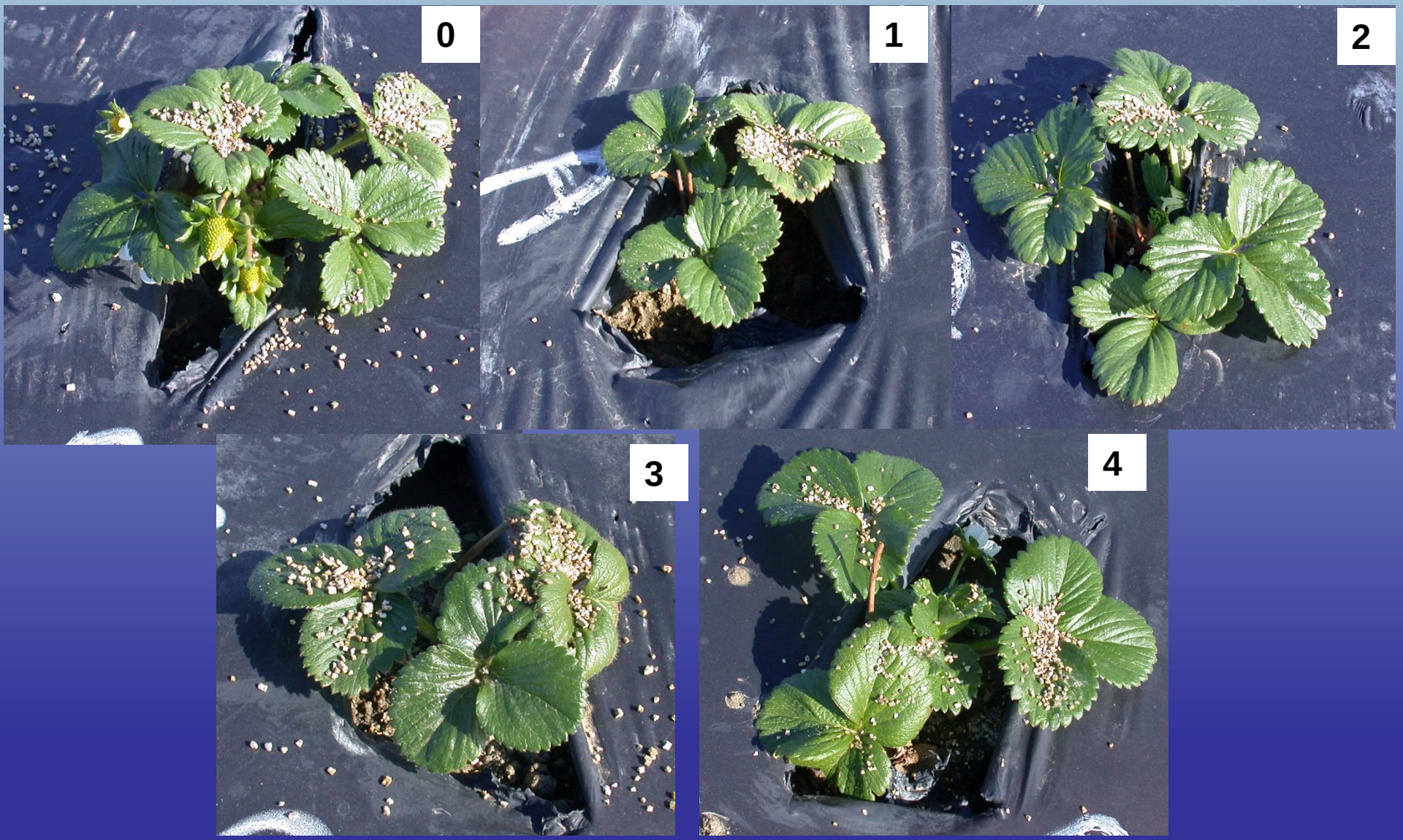
Treatments

- **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**

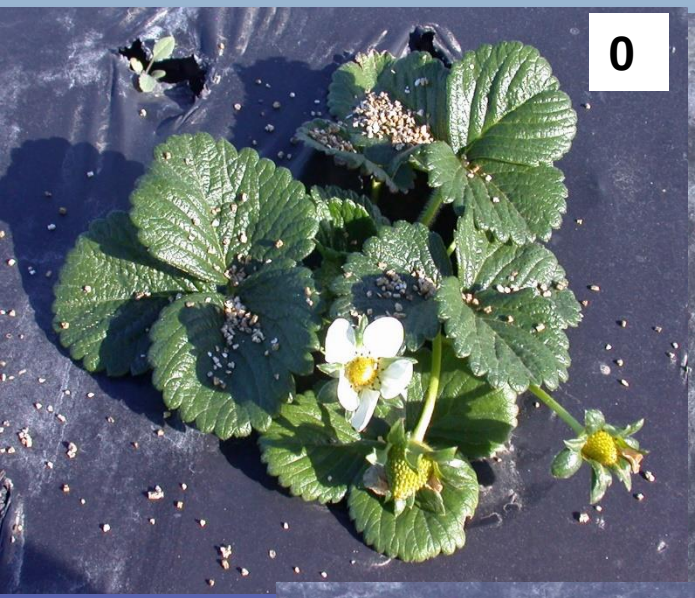
Plant size in response to Fusarium (01/05/2018)

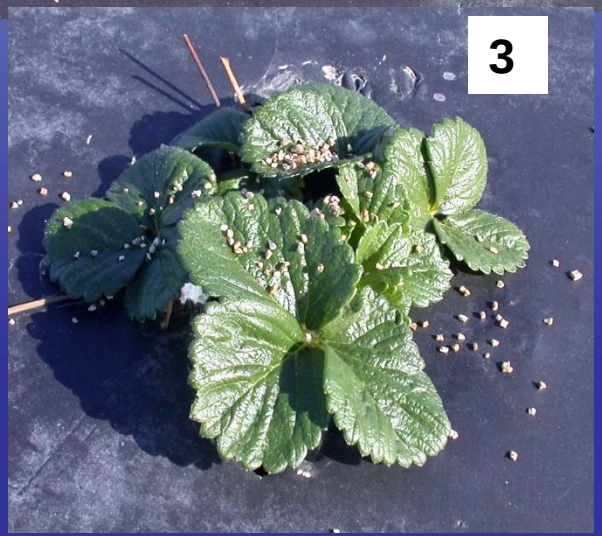


Albion in response to Fusarium (12/02/2018)



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

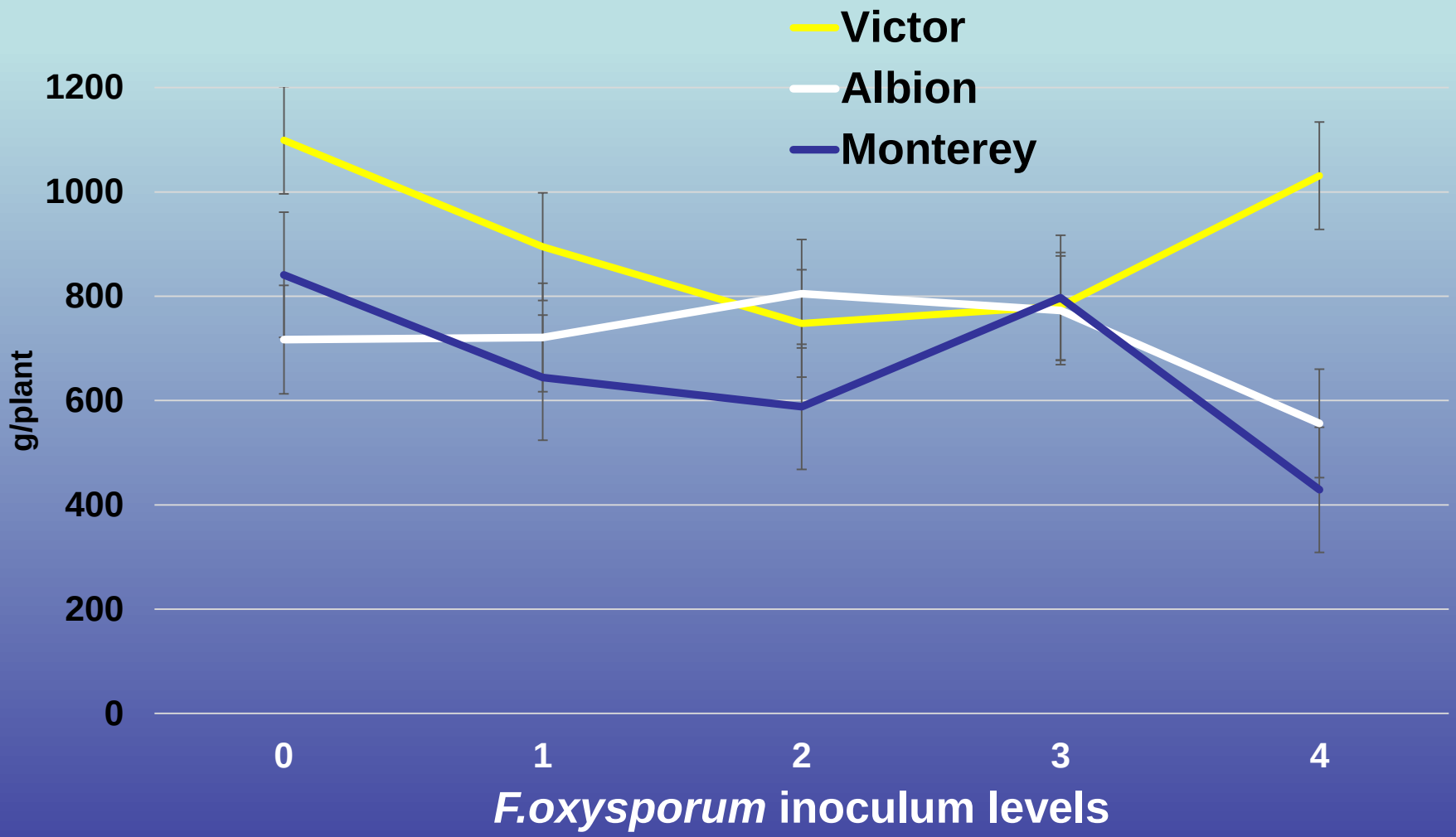
2

Albion in response to Fusarium - May

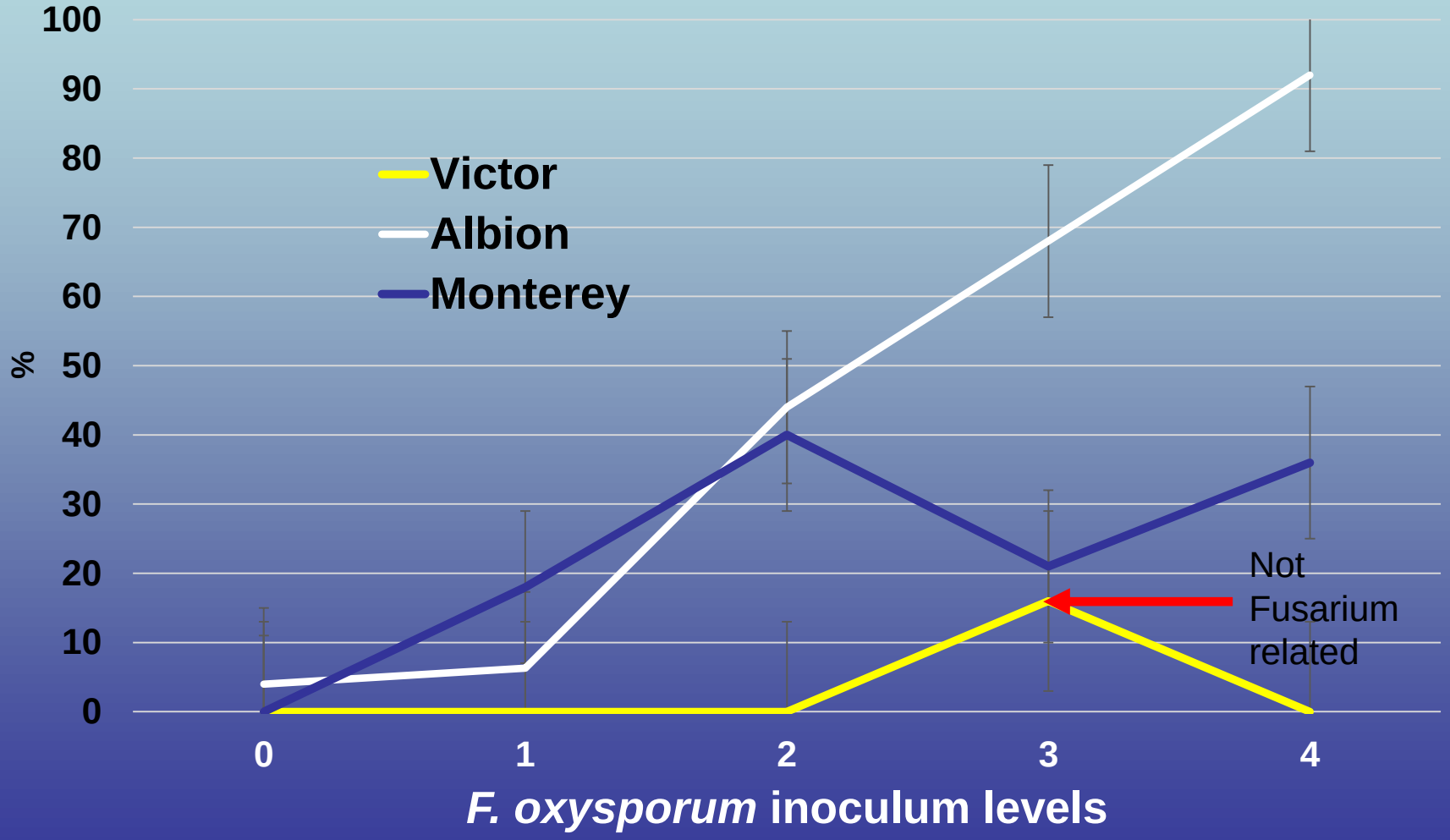
3

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)

Leaf blotch (*Zythia fragariae*) an emerging problem to California strawberry industry

Elfar K[1]., Hewavitharana, S.S. [2], Holmes, G. [2], Bolda, M. [3], Eskalen, A[1]

[1]Department of Plan Pathology, UC Davis

[2]UCCE, Farm Advisor, Monterey and Santa Cruz Co.

[3]CalPolly , San Luis Obispo

September 19th, 2019

Leaf blotch

- It has been considered a minor problem
- It is an emerging problem especially in **wet years** like 2019

Bolda, M

Symptoms

- Leaf spots that vary from purplish to brownish blotches to light brown necrotic spots

- The blotches are irregular in shape

Eskalen, A

Symptoms

- The blotches can cover pretty well the whole leaf

- Petiole blight

Eskalen, A

Symptoms

- Lesions on the sepals to completely infected calyx that turned to necrotic and brittle
- As the calyx infections appear those fruits become **unmarketable** causing economic loss to growers and shippers

Steven Koike, UCCE

Symptoms

- Fairly firm water-soaked brown rot on nearly ripe fruits, very like the early non-sporulating stage *Botrytis cinerea* infection

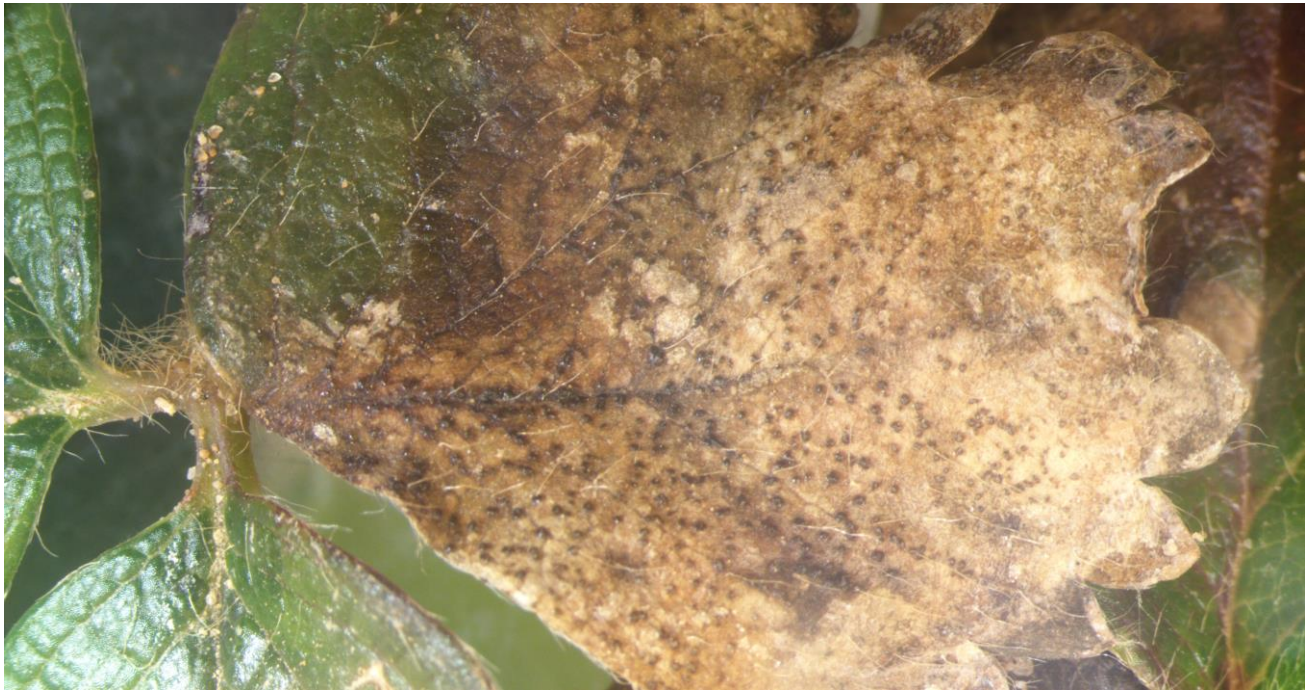
- Infected fruit are often invaded by secondary rotting organisms as *B.cinerea*

- Losses due *Z. fragariae* can been attributed to *B. cinerea* due the similarity of symptoms in the early stage

Frank J. Louws

Signs

- The pathogen can produce numerous **pycnidia** containing conidia.



Eskalen, A

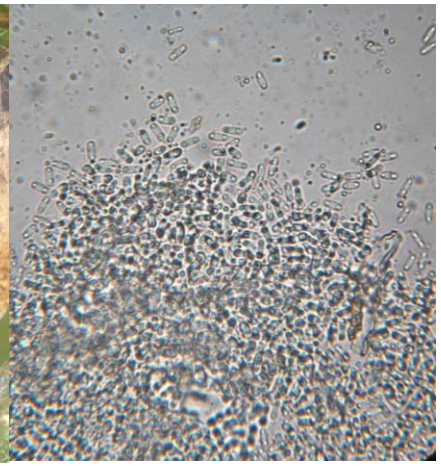
Causal organism

- Anamorph: *Zythia fragariae*
- Teleomorph: *Gnomonia comari*

Pycnidia

Eskalen, A

Conidia

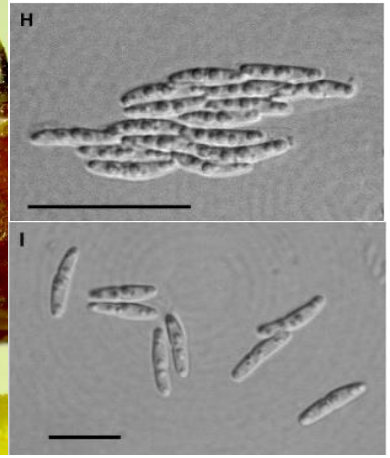


Steven Koike, UCCE

Perithecia

Scott Mattner DPI Vic, 2019

Ascospores



Moročko and Fatehi, 2007

- Leaf blotch is considered a minor disease, nevertheless, **minor disease could get to be a major issue** when appropriate environmental conditions arise.

- It is necessary to be prepared and know the etiology and epidemiology of the disease to be able to control it correctly if necessary

Proposal (Elfar K., Hewavitharana, S.S., Holmes, G., Bolda, M., Eskalen,A.)

- We propose to study this disease and its pathogen by

1. collecting and identifying (morphologically and molecularly) isolates from all growing districts

2. determining optimum growth temperature and moisture requirements and when and under what environmental conditions spores of *Zythia* sp. are released in California strawberry fields

3. screening for host plant resistance

4. determining the efficacy of currently labeled fungicides

Thank You

http://ucanr.edu/sites/eskalenlab