

Fusarium wilt of strawberry

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Collaborators:

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Steve Koike

Steve Knapp

Glenn Cole



Fusarium wilt

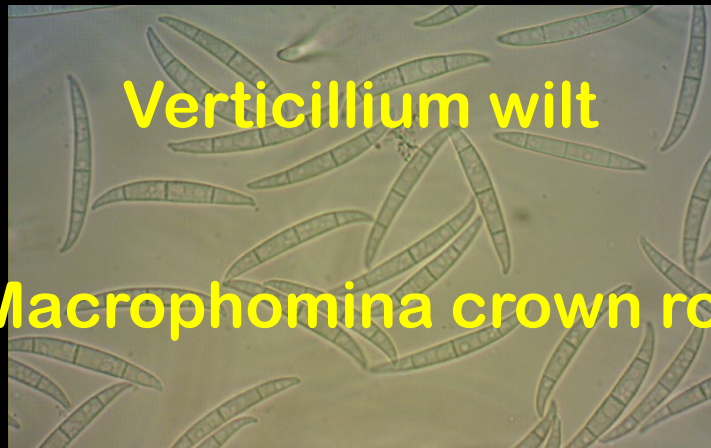
Verticillium wilt

Macrophomina crown rot





Fusarium wilt



Verticillium wilt

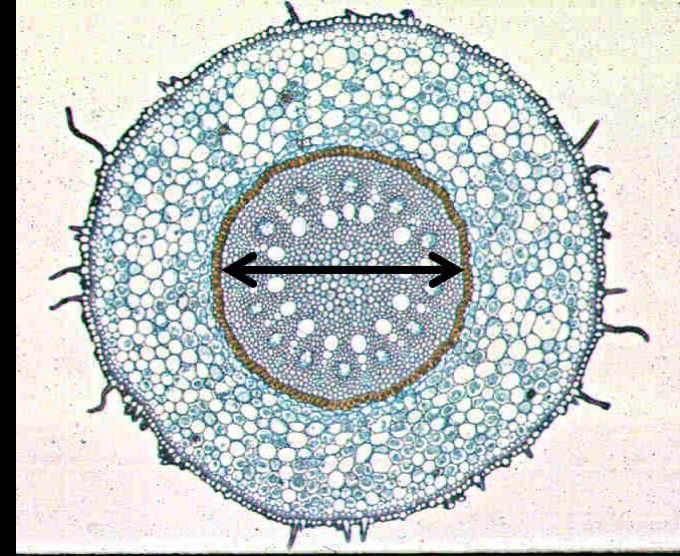
Macrophomina crown rot

Fusarium oxysporum



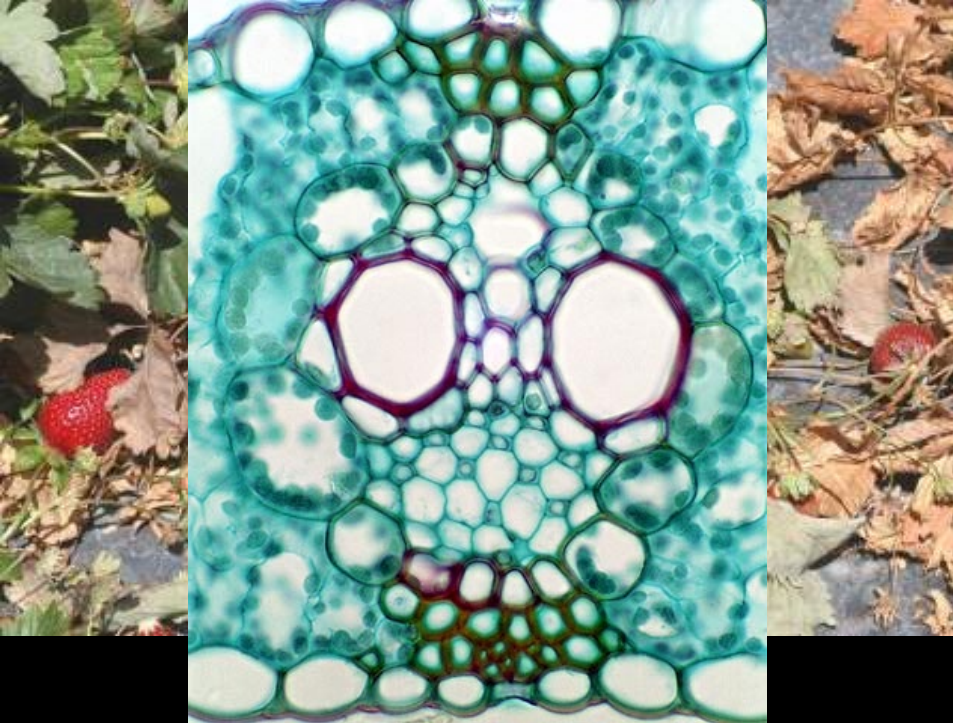


Fusarium wilt

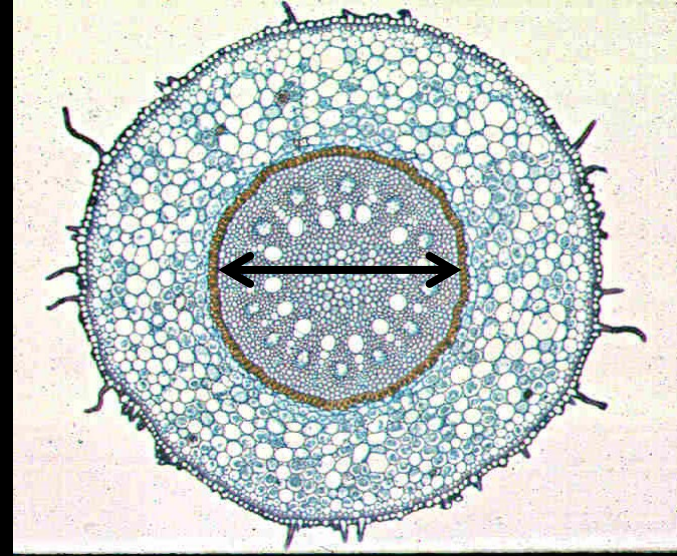


Fusarium oxysporum



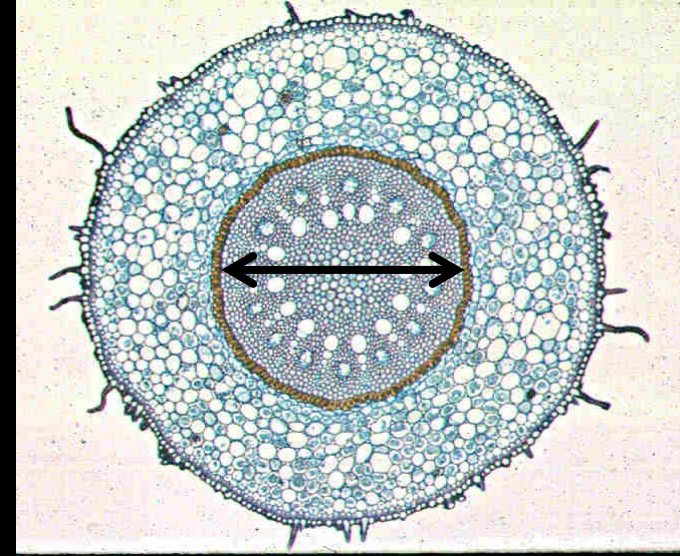
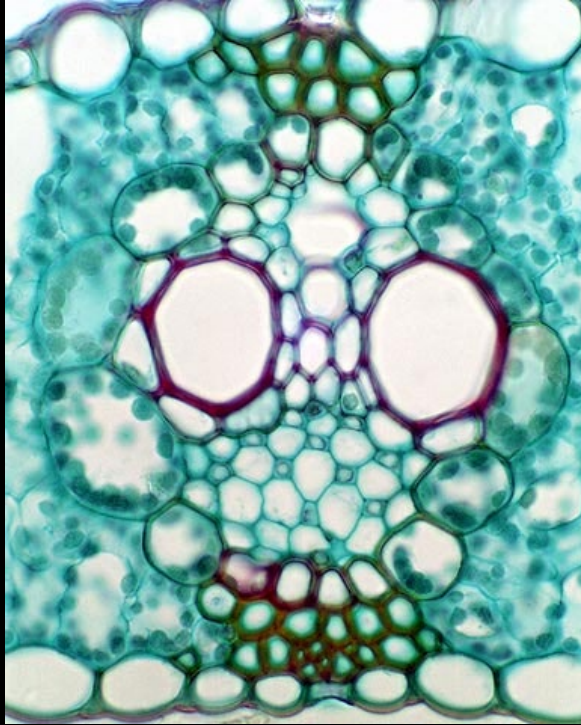


Fusarium wilt

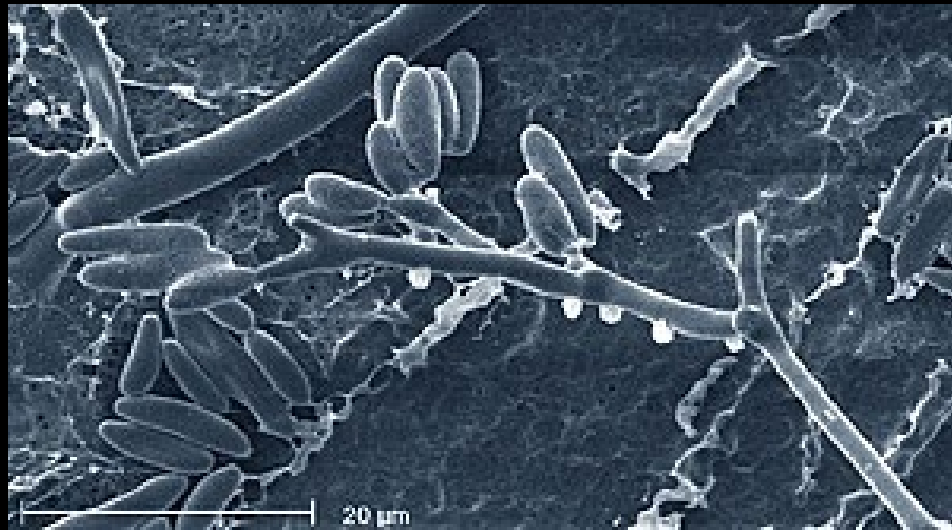


Fusarium oxysporum

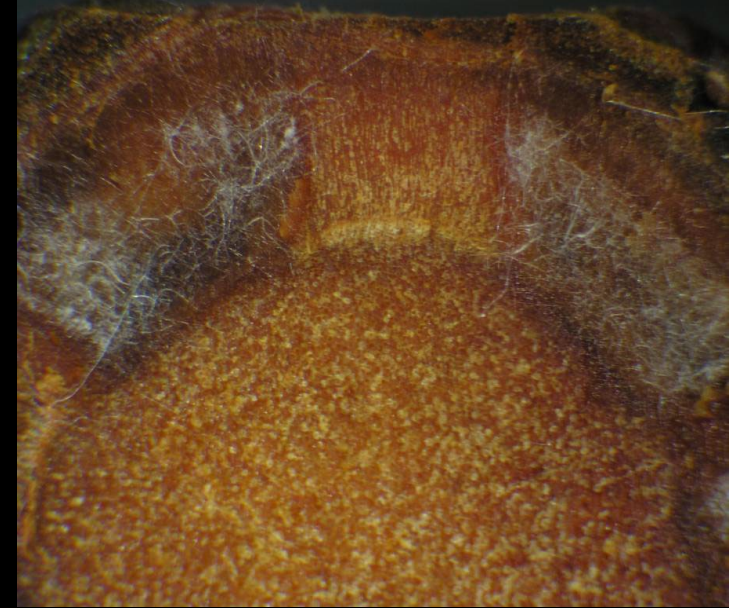




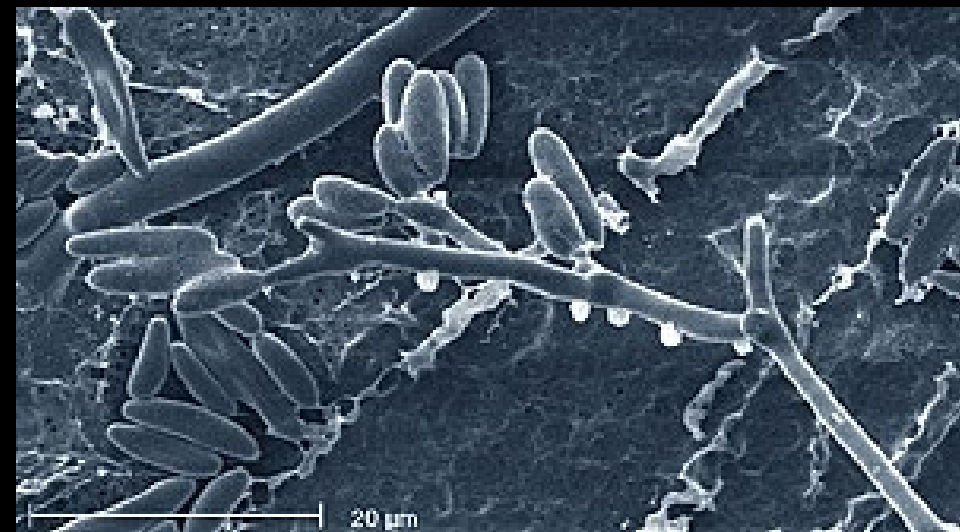
Microconidia carried
upward in xylem vessels



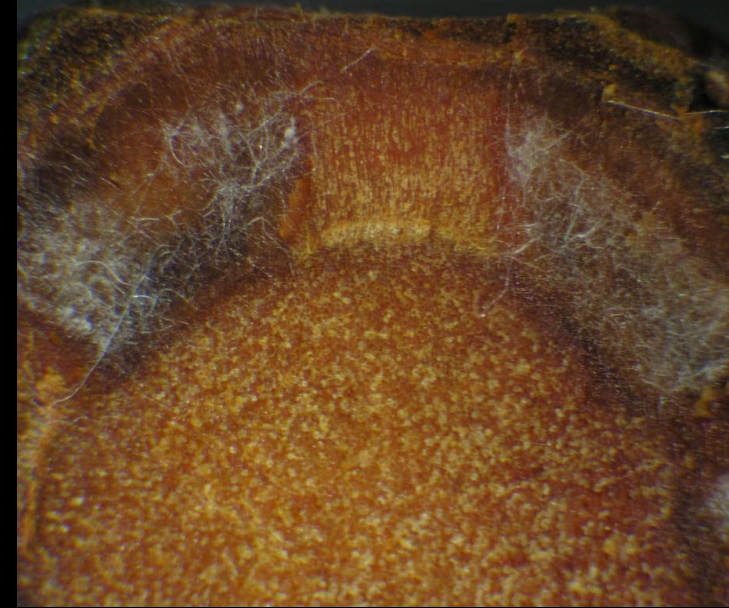
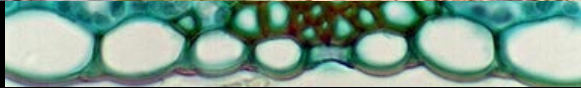
Fusarium oxysporum



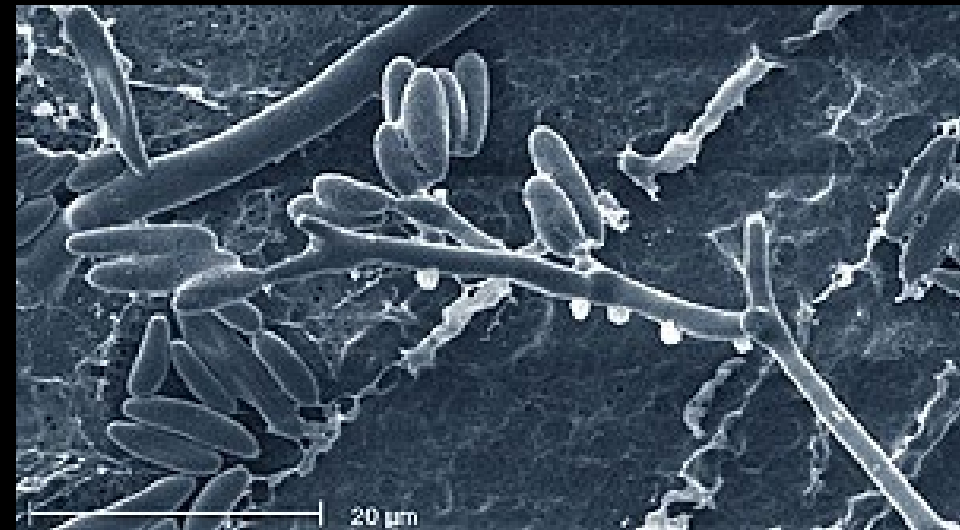
**Colonized
vascular tissue**



**Microconidia carried
upward in xylem vessels**



**Colonized
vascular tissue**



**Microconidia carried
upward in xylem vessels**



Macrophomina



Photo credit: Steven Koike

Management

Avoid introduction

Soil on equipment

Clean plants

Transmission of *Fusarium*
to daughter plants



Transmission of *Fusarium* to daughter plants



Inoculation

Infected

Remain vigorous

Transmission of *Fusarium* to daughter plants





**Tag stolons and
daughter plants**

Transmission of *Fusarium* to daughter plants

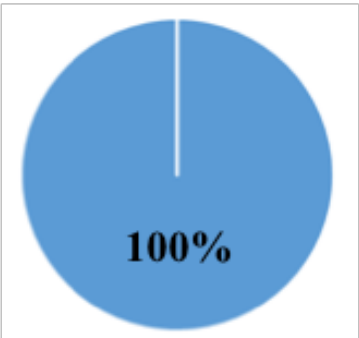


**Test for infection
by the pathogen**

Albion

 = Infected
 = Not Infected

Mothers



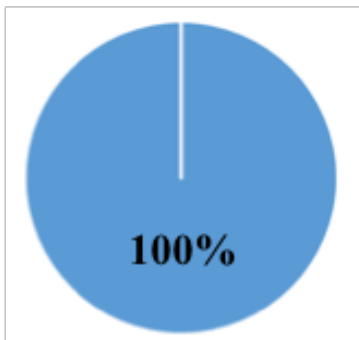
1st Stolons



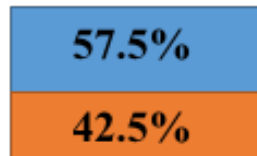
Albion

■ = Infected
■ = Not Infected

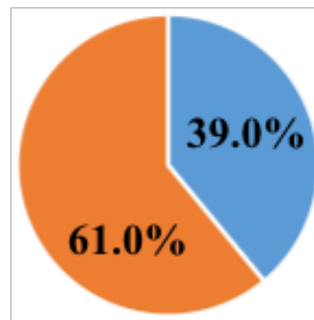
Mothers



1st Stolons



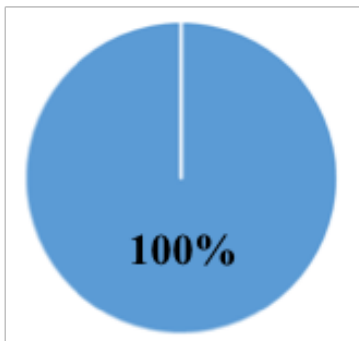
1st Daughters



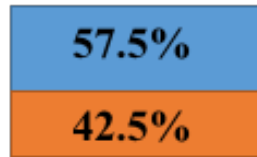
Albion

■ = Infected
■ = Not Infected

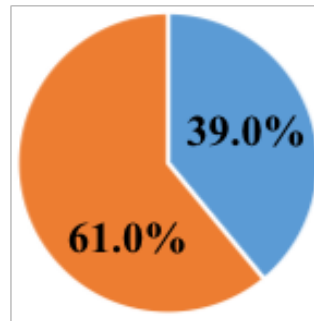
Mothers



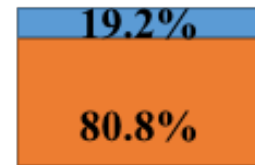
1st Stolons



1st Daughters



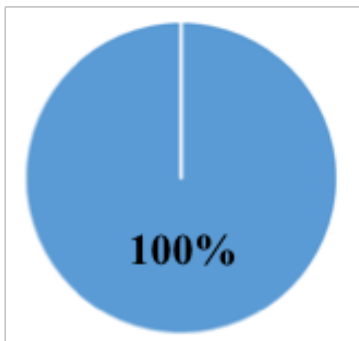
2nd Stolons



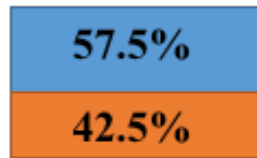
Albion

■ = Infected
■ = Not Infected

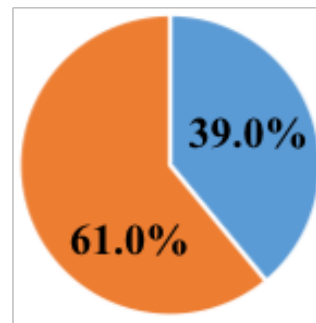
Mothers



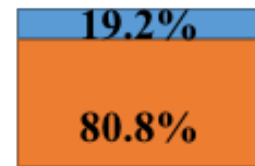
1st Stolons



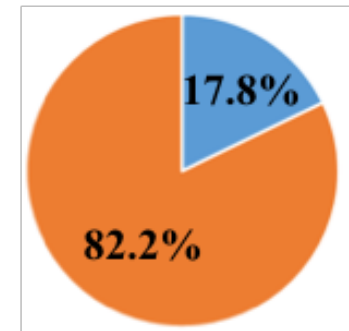
1st Daughters



2nd Stolons



2nd Daughters



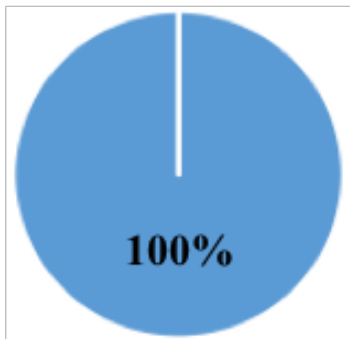
Symptomless



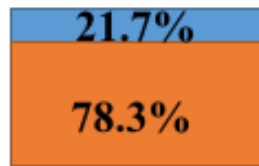
Monterey

■ = Infected
■ = Not Infected

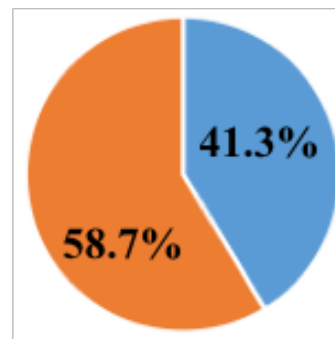
Mothers



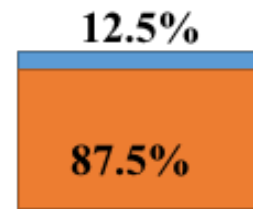
1st Stolons



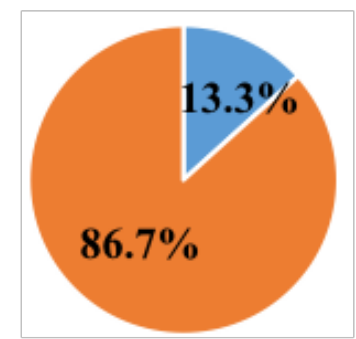
1st Daughters



2nd Stolons



2nd Daughters



Symptomless



No transmission in resistant cultivars

Cultivar	Crown	Petiole	Runner	Daughter
Albion	+	+	+	+
San Andreas	+	-	-	-
Fronteras	+	-	-	-
Petaluma	+	+	+	+

Transmission of
Verticillium dahliae
through stolons



Verticillium wilt in high elevation nurseries



**Mother plants may show
show symptoms only
late in the season**

**Overgrown by
daughter plants**



Infected daughter plants



Show no symptoms

Disease may develop
in fruit production field



Management

Avoid introduction

→ Reduce inoculum levels in soil

Pre-plant fumigation

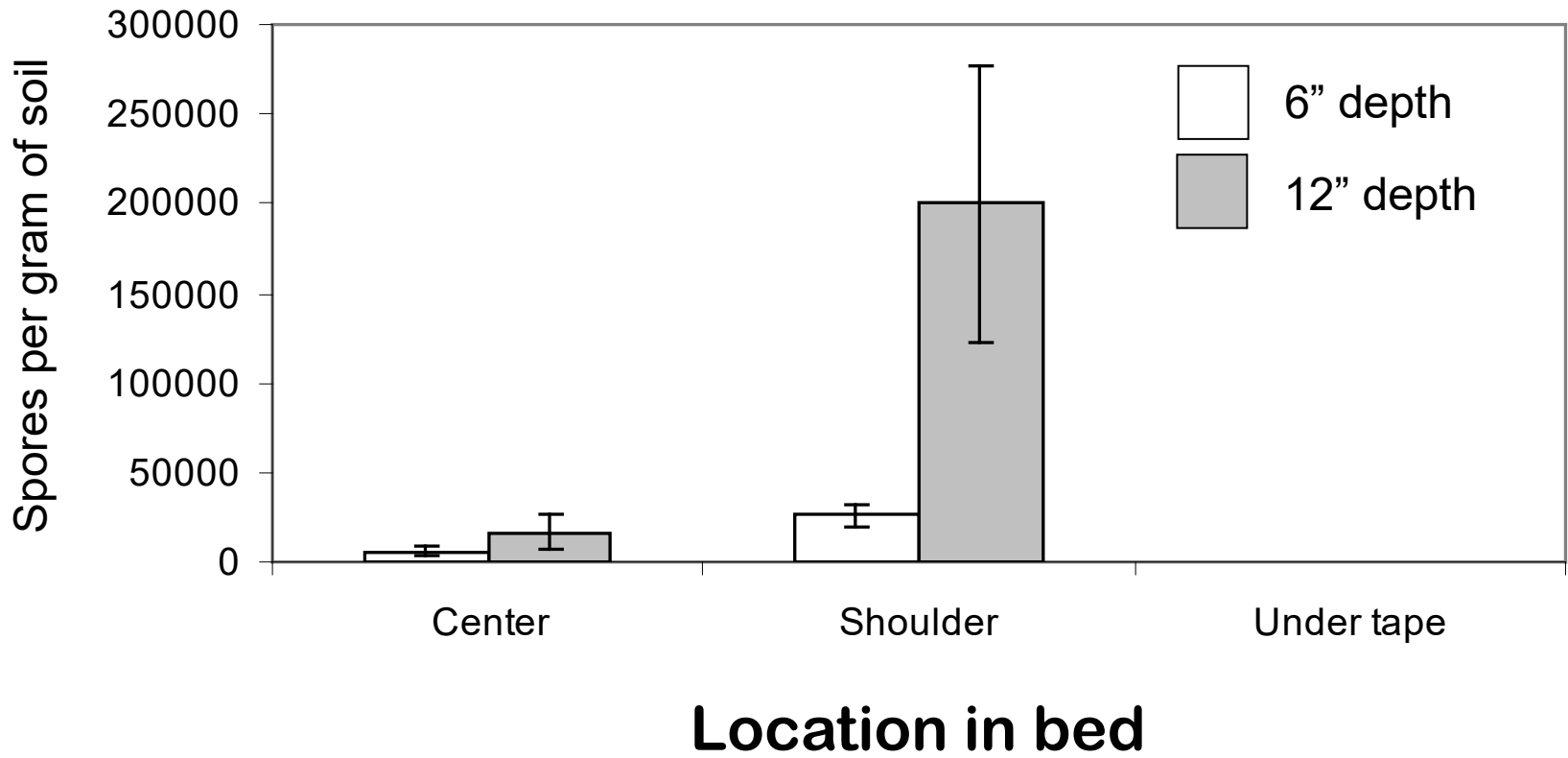
Flat fumigation to treat the entire field



Mortality is not evenly distributed across beds

Incomplete treatment

Beds fumigated with Pic-60



Anaerobic soil disinfestation

Effect on survival of *Fusarium oxysporum*

Rice hulls at 9 tons per acre

cool conditions

Day/night = 77/64°F

+ 310%

warm conditions

Day/night = 82/68°F

+0.01%

Anaerobic soil disinfestation

Effect on survival of *Fusarium oxysporum*

Rice hulls at 9 tons per acre

cool conditions
Day/night = 77/64°F

warm conditions
Day/night = 82/68°F

Cool conditions
Day/night = 77/64°F

+ 310%

+0.01%

Anaerobic soil disinfestation

Effect on survival of *Fusarium oxysporum*

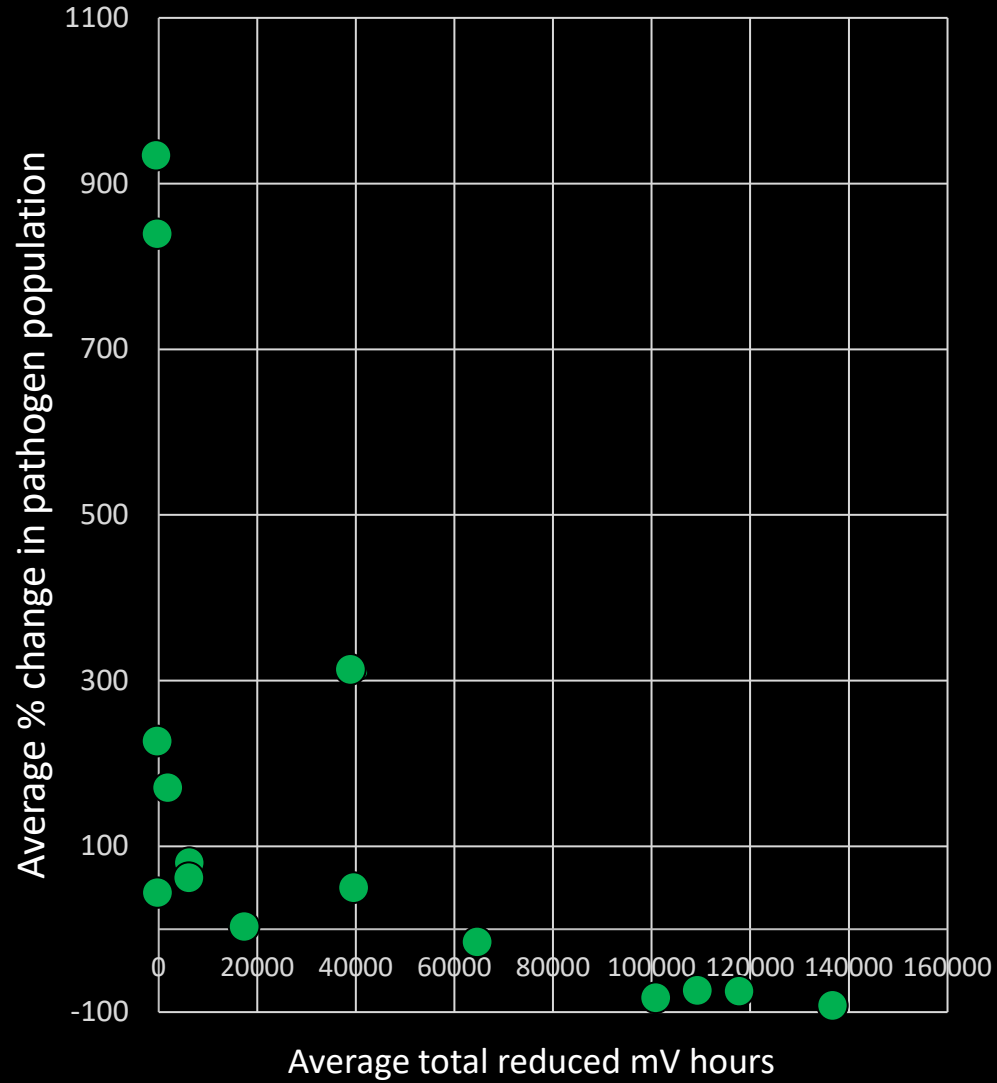
Rice hulls at 9 tons per acre

Cool conditions
Day/night = 77/64°F

Mustard seed meal

None	3 tons/acre
+ 310%	- 74%

Duration of anaerobic conditions



Crop rotation

Inoculum levels decline when other crops are grown

Rotation crops do not support pathogen development

Colonization of rotation crops



Colonization of rotation crops

Broccoli

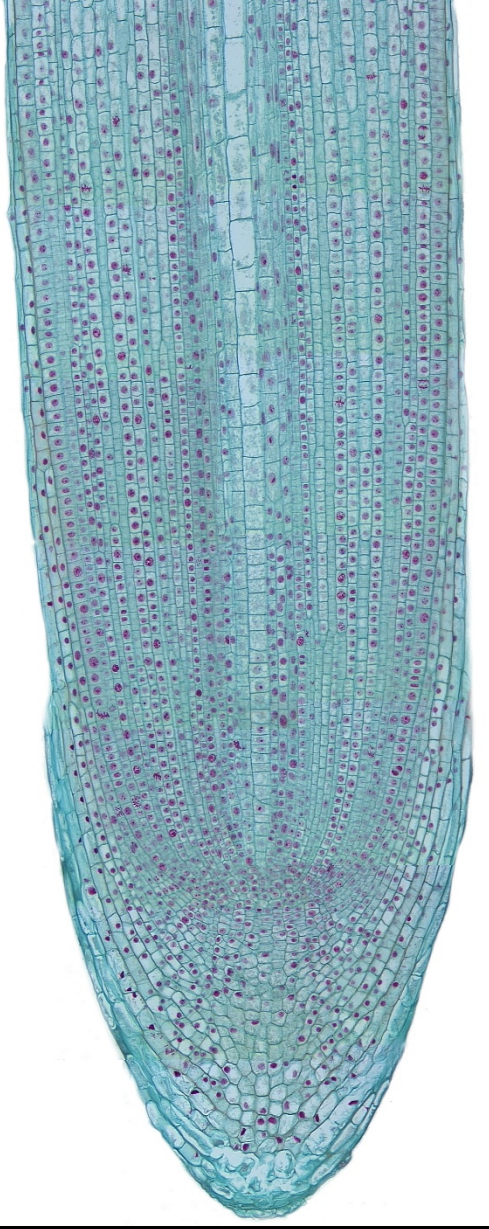
Lettuce

Spinach

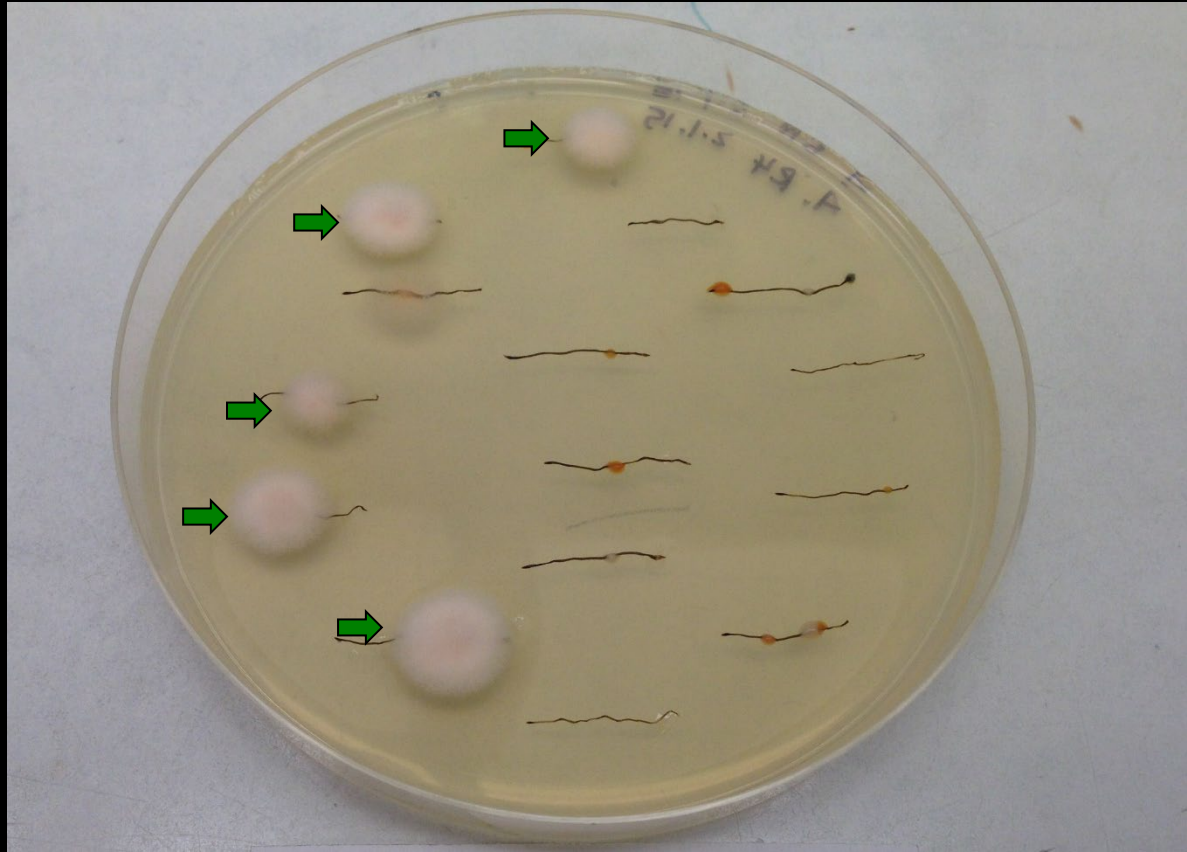
Cilantro

Wheat

Raspberry

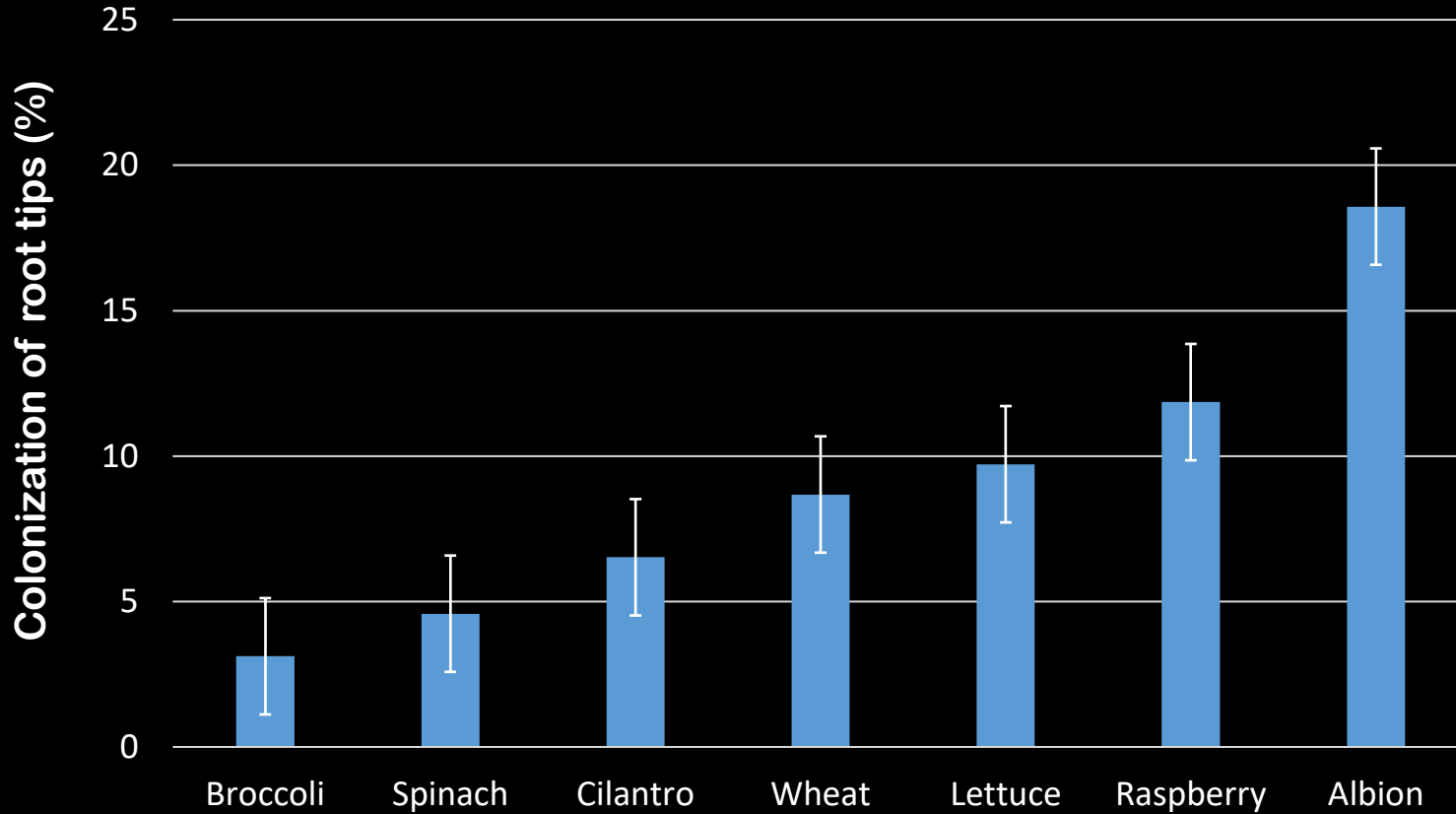


Root tip



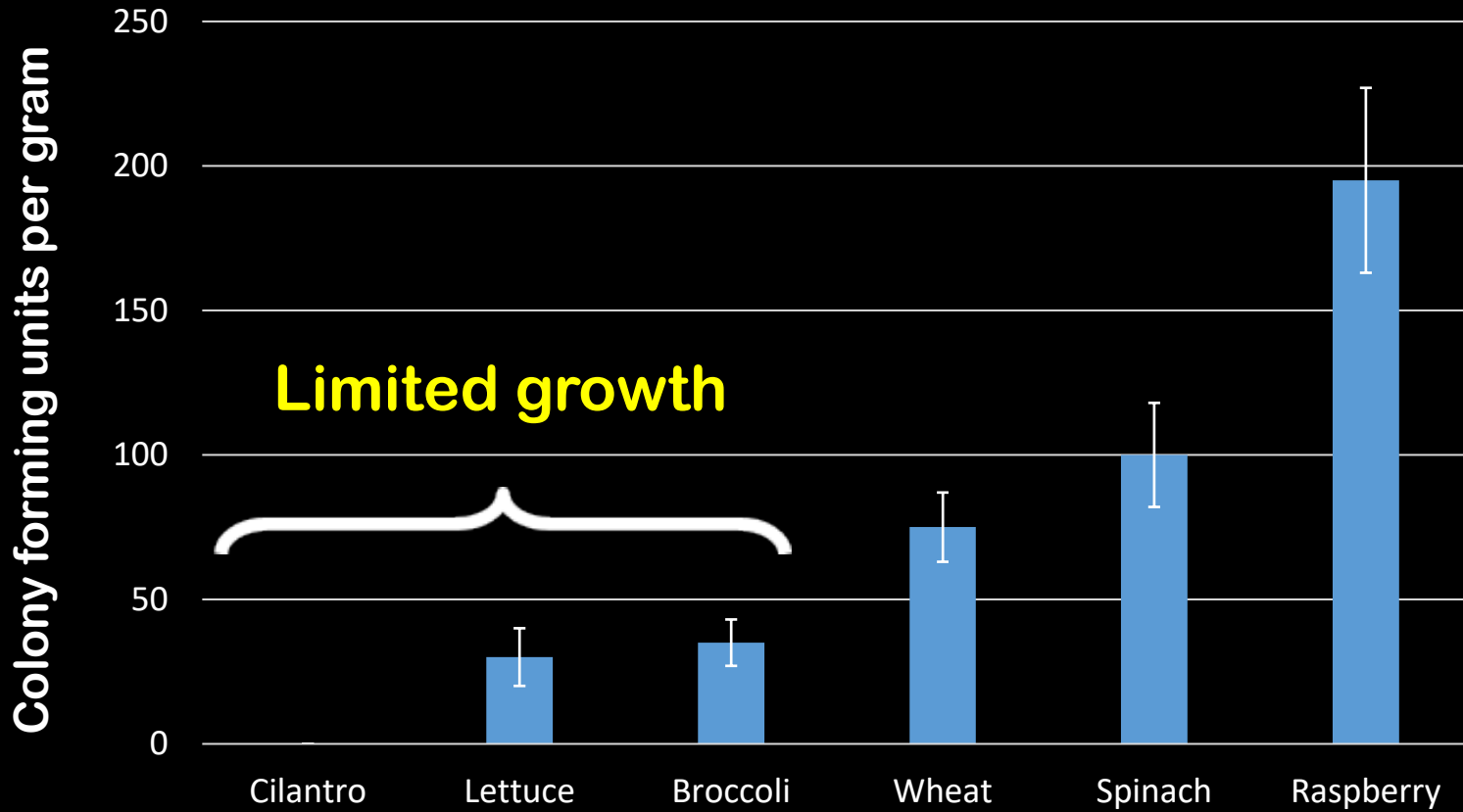
Percentage of root tips infected

Percentage of root tips infected



Extent of colonization?

Pathogen biomass in root cortex





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

Susceptibility of strawberry to blackberry pathogen

1 – 5 scale



Susceptibility of strawberry to blackberry pathogen

1 – 5 scale



Susceptibility of strawberry to blackberry pathogen

1 – 5 scale

Cultivar

F. o. mori

Albion

3.0

Monterey

2.1

5.0

Increase inoculum
of blackberry pathogen



Susceptibility of strawberry to blackberry pathogen

1 – 5 scale

Cultivar	<i>F. o. mori</i>	<i>F. o. fragariae</i>
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

Management

Disease resistance

The Population of *Fusarium oxysporum* f. sp. *fragariae*, Cause of Fusarium Wilt of Strawberry, in California

P. M. Henry, **S. C. Kirkpatrick**, **C. M. Islas**, **A. M. Pastrana**, and **J. A. Yoshisato**, Department of Plant Pathology, University of California, Davis 95616; **S. T. Koike**, University of California Cooperative Extension, Salinas 93901; **O. Daugovish**, University of California Cooperative Extension, Ventura 93003; and **T. R. Gordon**, Department of Plant Pathology, University of California, Davis

Abstract

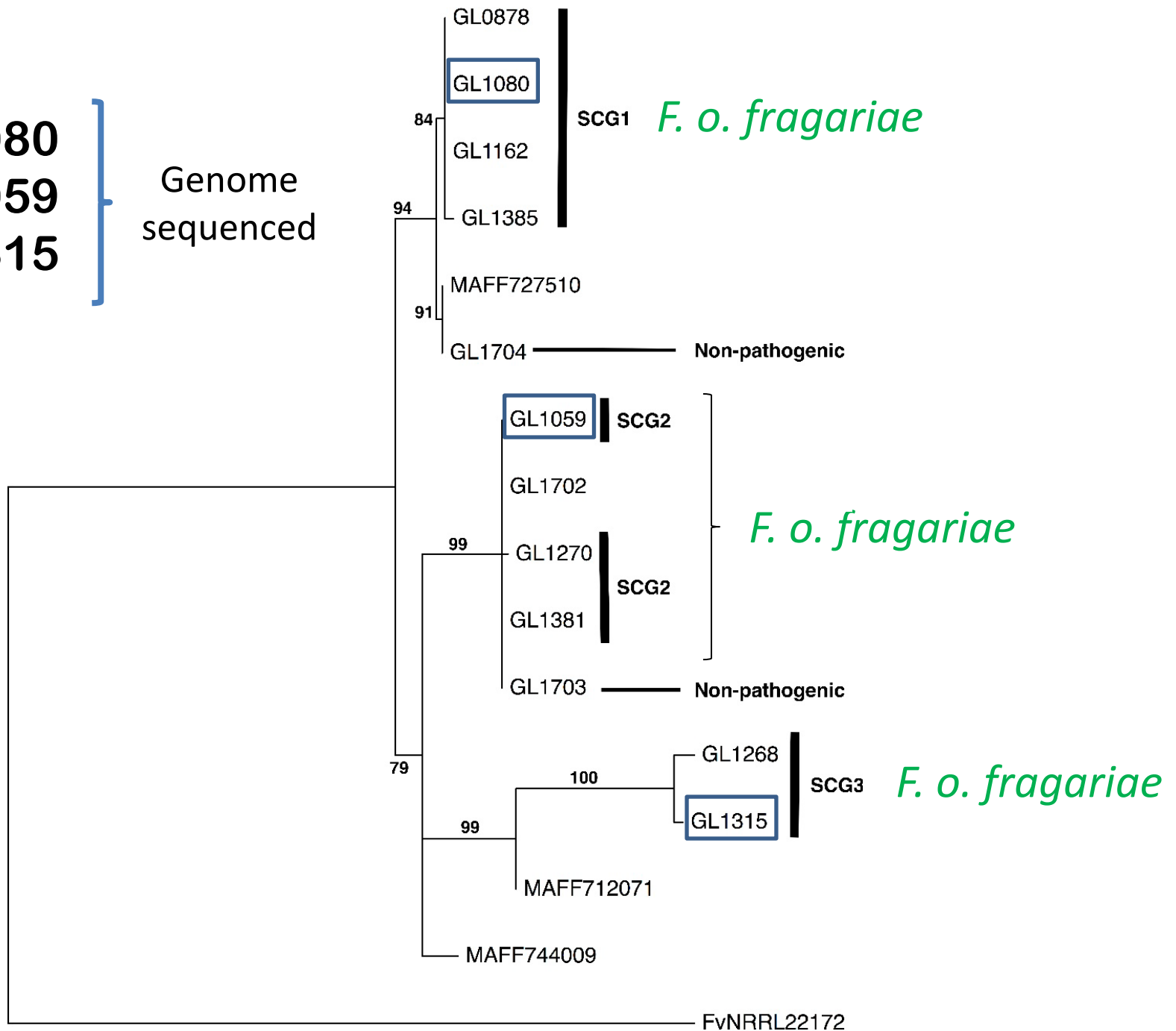
The objectives of this study were to investigate the structure of the population of *Fusarium oxysporum* f. sp. *fragariae* in California and to evaluate methods for its detection. Fifty-nine isolates of *F. oxysporum* f. sp. *fragariae* were obtained from diseased strawberry plants and their identity was confirmed by pathogenicity testing. The full nuclear ribosomal intergenic spacer (IGS) and elongation factor 1- α gene (EF-1 α) were amplified by polymerase chain reaction (PCR) and sequenced to elucidate phylogenetic relationships among isolates. IGS and EF-1 α sequences revealed three main lineages, which corresponded to three somatic compatibility groups. Primers designed to detect *F. oxysporum* f. sp.

fragariae in Japan amplified a 239-bp product from 55 of 59 California isolates of *F. oxysporum* f. sp. *fragariae* and from no nonpathogenic isolates of *F. oxysporum*. The sequence of this PCR product was identical to the sequence obtained from *F. oxysporum* f. sp. *fragariae* isolates in Japan. Intensive sampling at two locations in California showed results of tests based on PCR and somatic compatibility to be in agreement for 97% (257 of 264) of isolates tested. Our findings revealed considerable diversity in the California population of *F. oxysporum* f. sp. *fragariae*, and indications that horizontal gene transfer may have occurred.

Three strains of *Fusarium oxysporum* f. sp. *fragariae*

GL 1080
GL 1059
GL 1315

Genome
sequenced



0.005 substitutions/site

Multiple introductions



Source of introduction to California?



California
2008

Do *F. o. fragariae* strains differ in virulence?

Genotype * strain test

Albion

Benicia

GL 1315

Fronteras

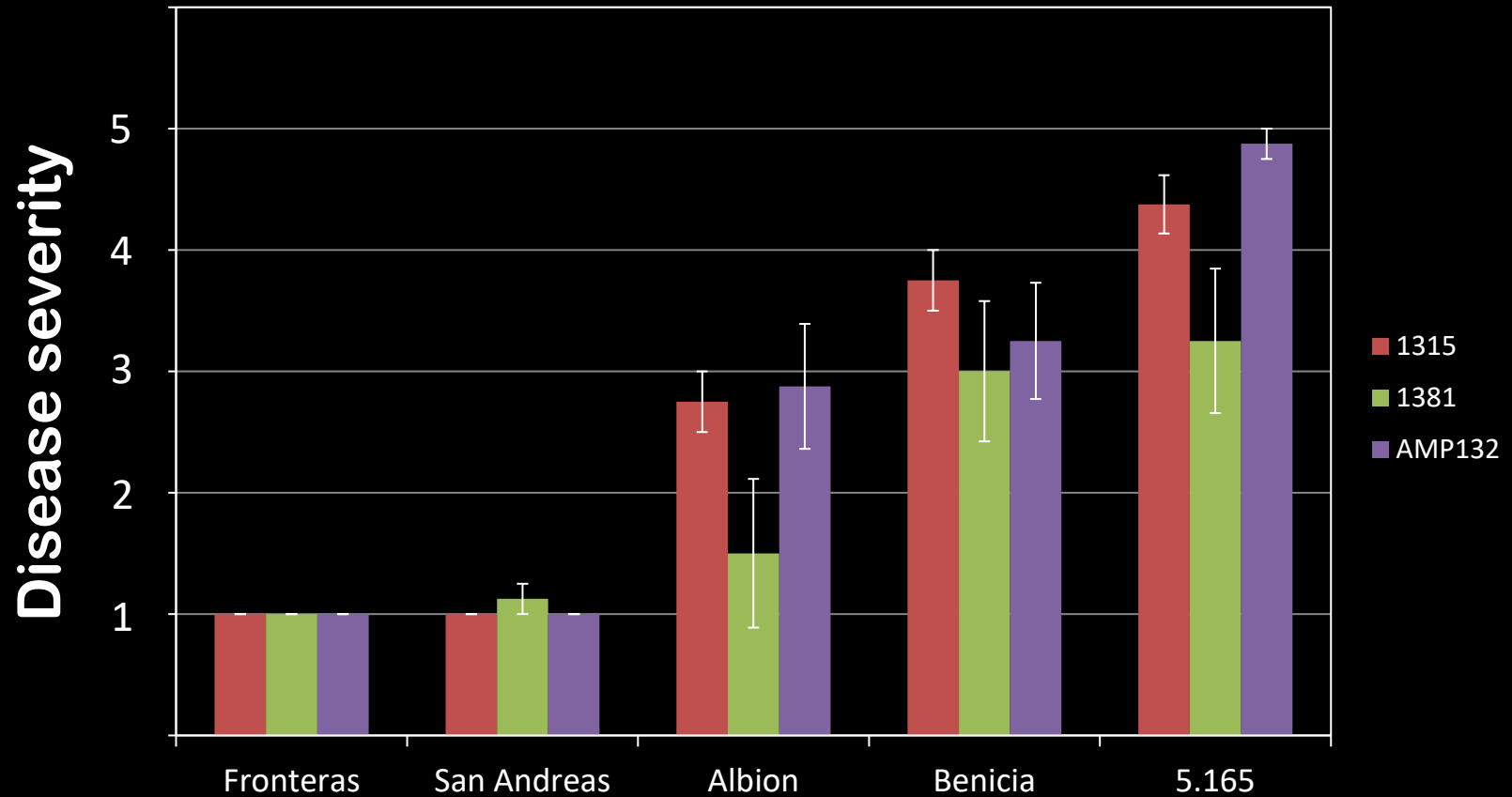
GL 1381

San Andreas

AMP 132

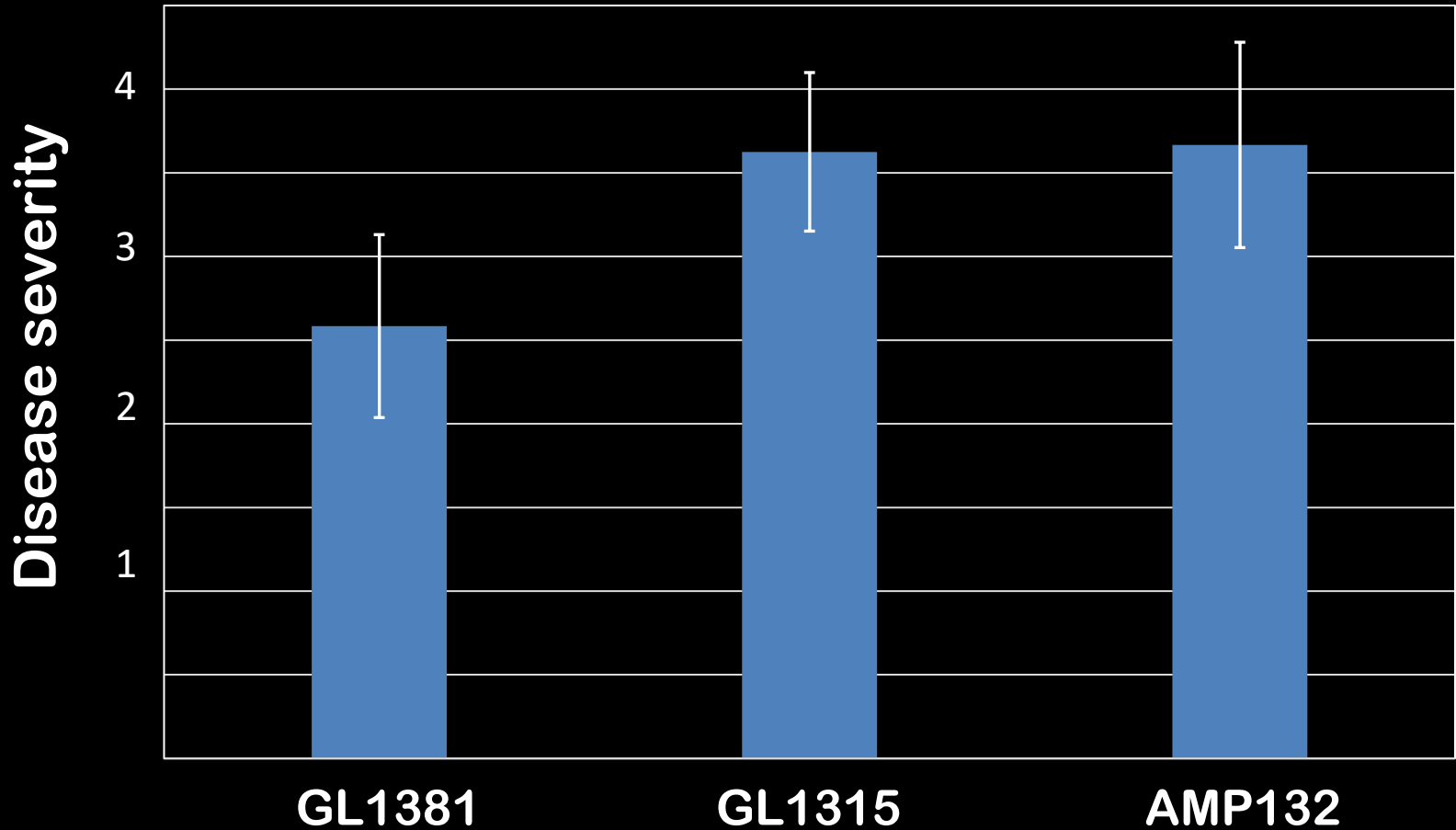
5.165

Genotype * strain test



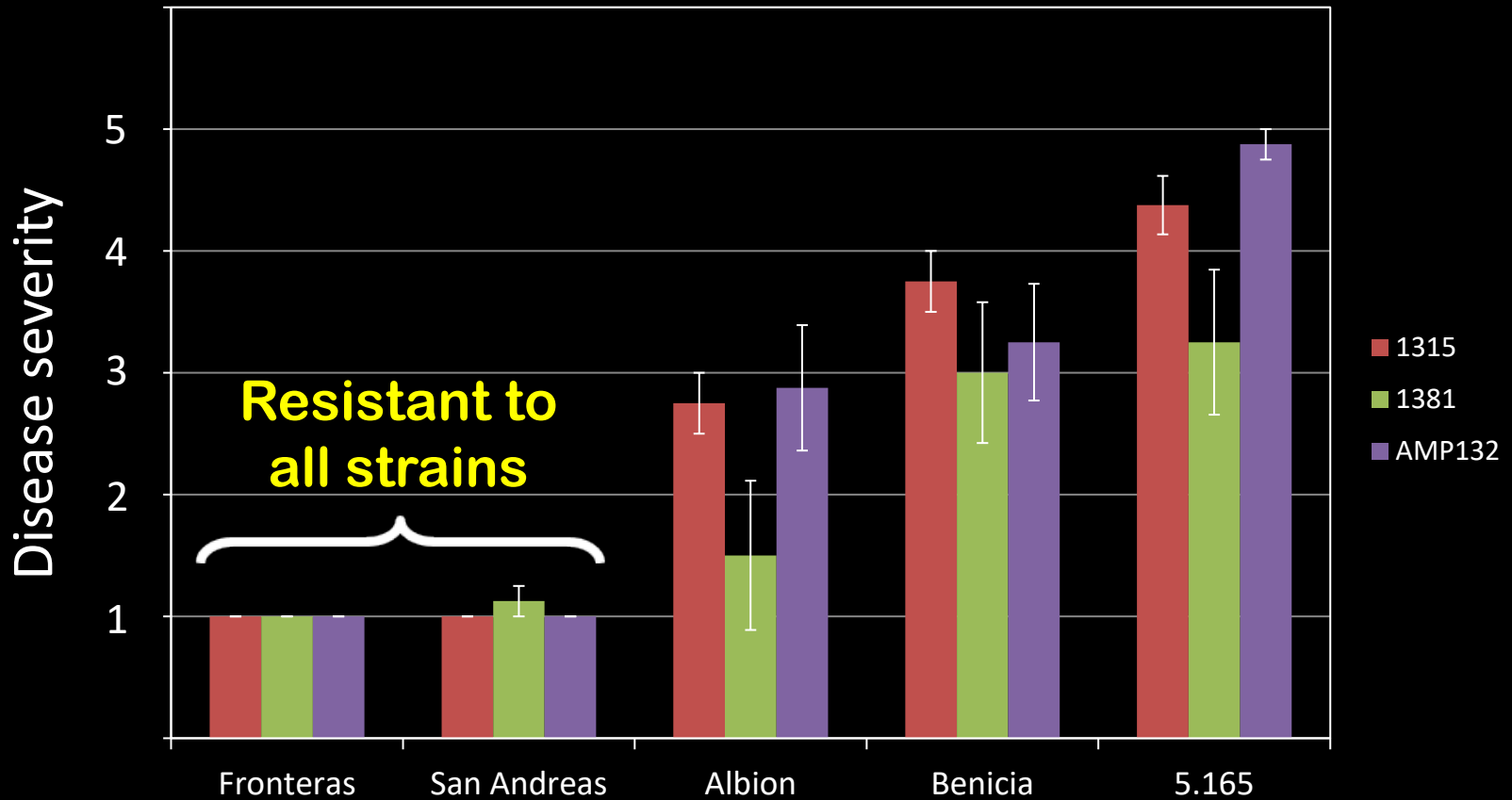
Strains differ in virulence

Genotype * strain test



Strains differ in virulence

Genotype * strain test

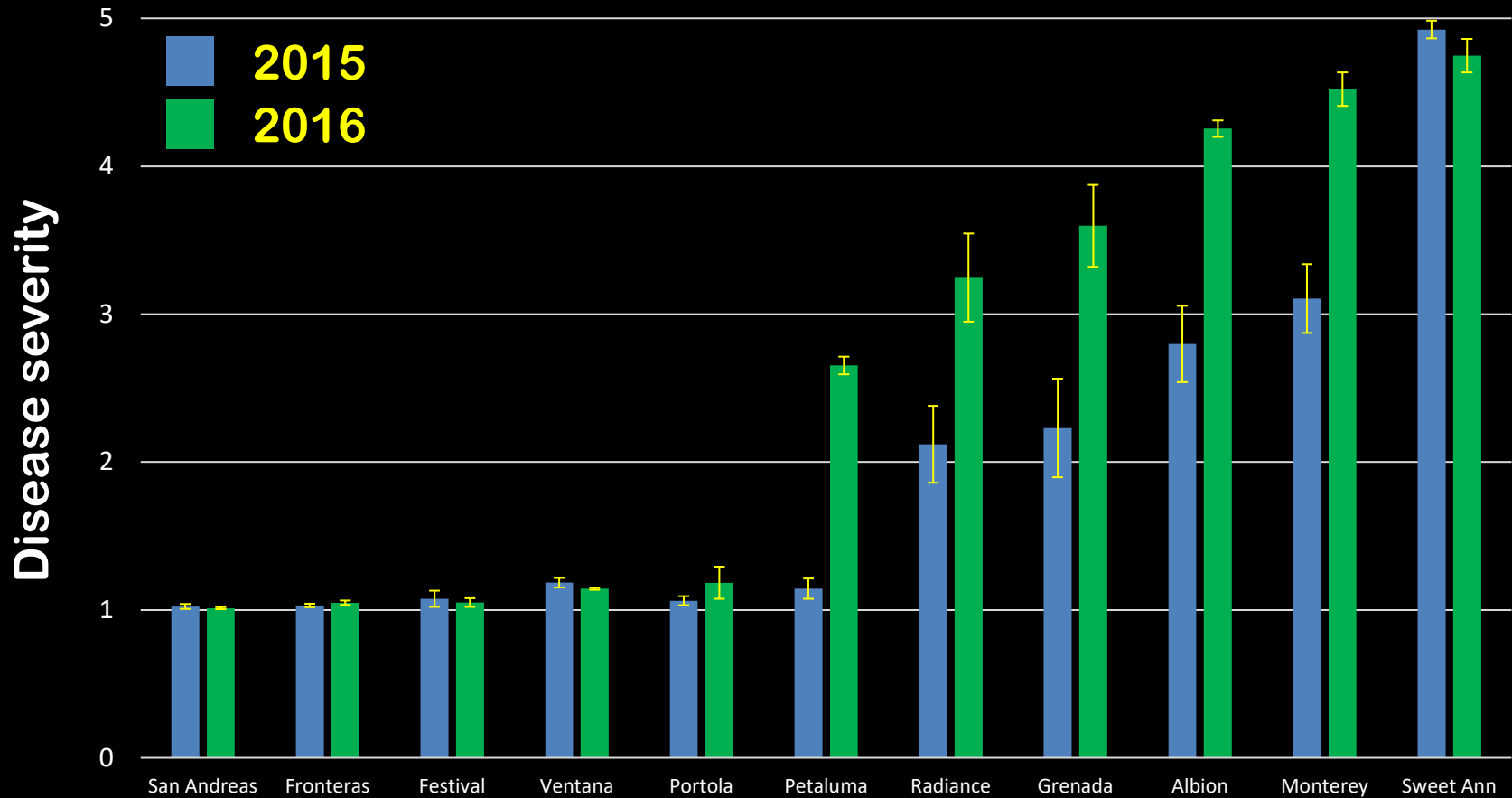


Strains differ in virulence

Naturally infested field



Susceptibility to Fusarium wilt



Susceptibility to Fusarium wilt

San Andreas
Portola
Fronteras



Highly resistant

Ventana



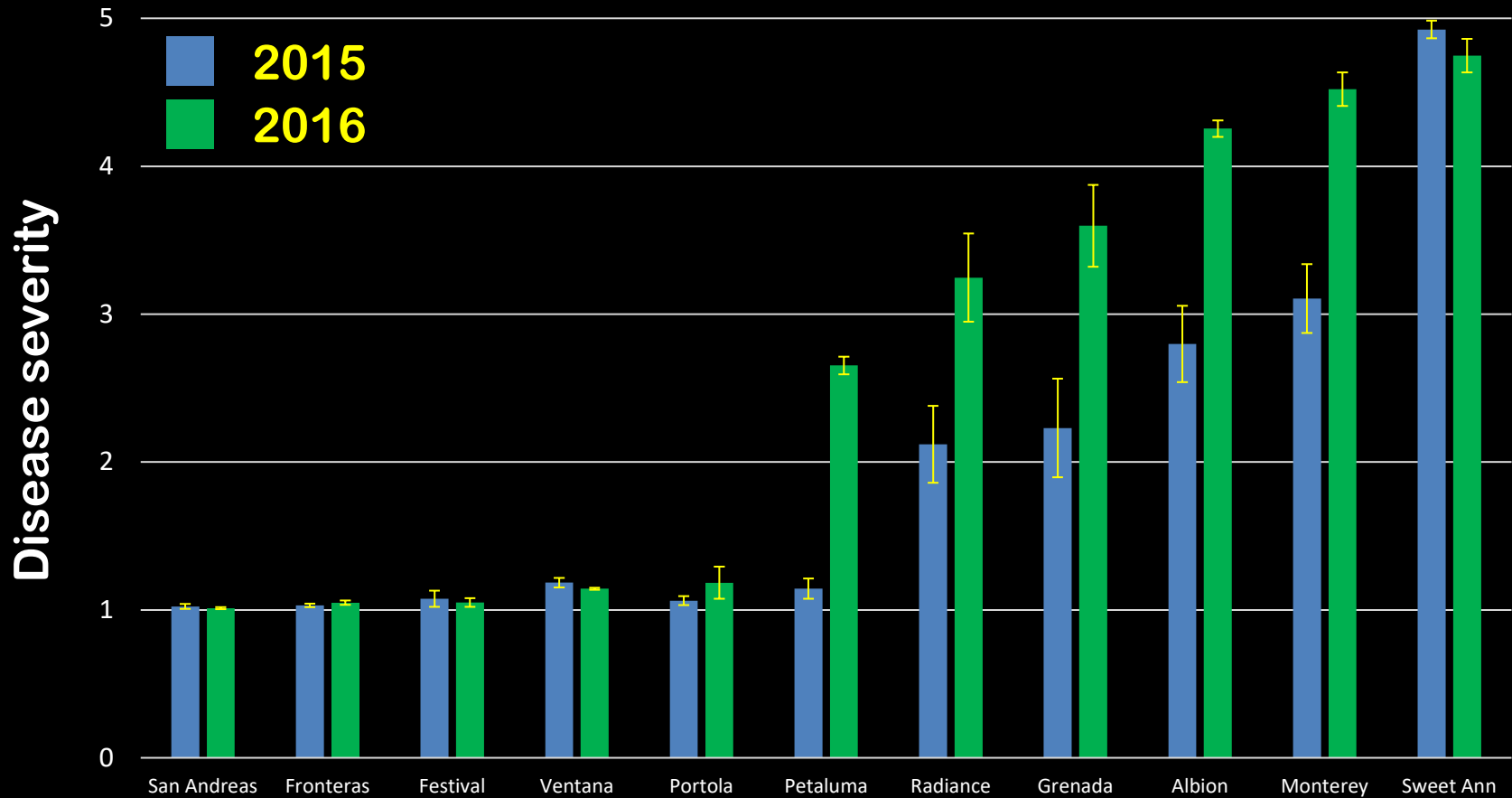
Resistant

Monterey
Albion

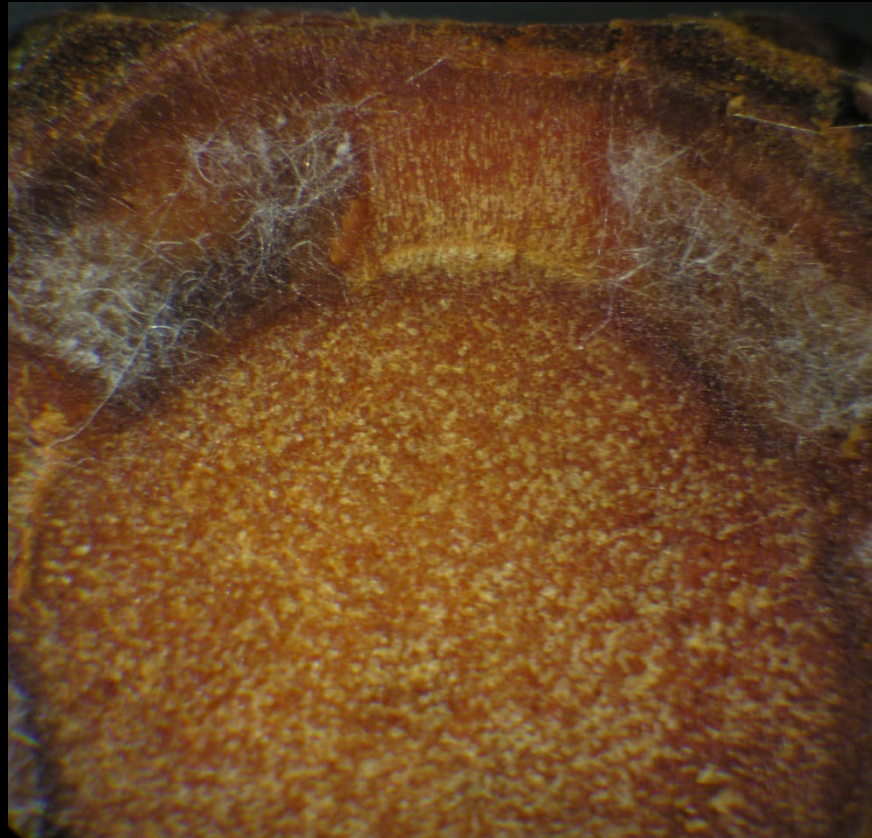


Susceptible

Susceptibility to Fusarium wilt

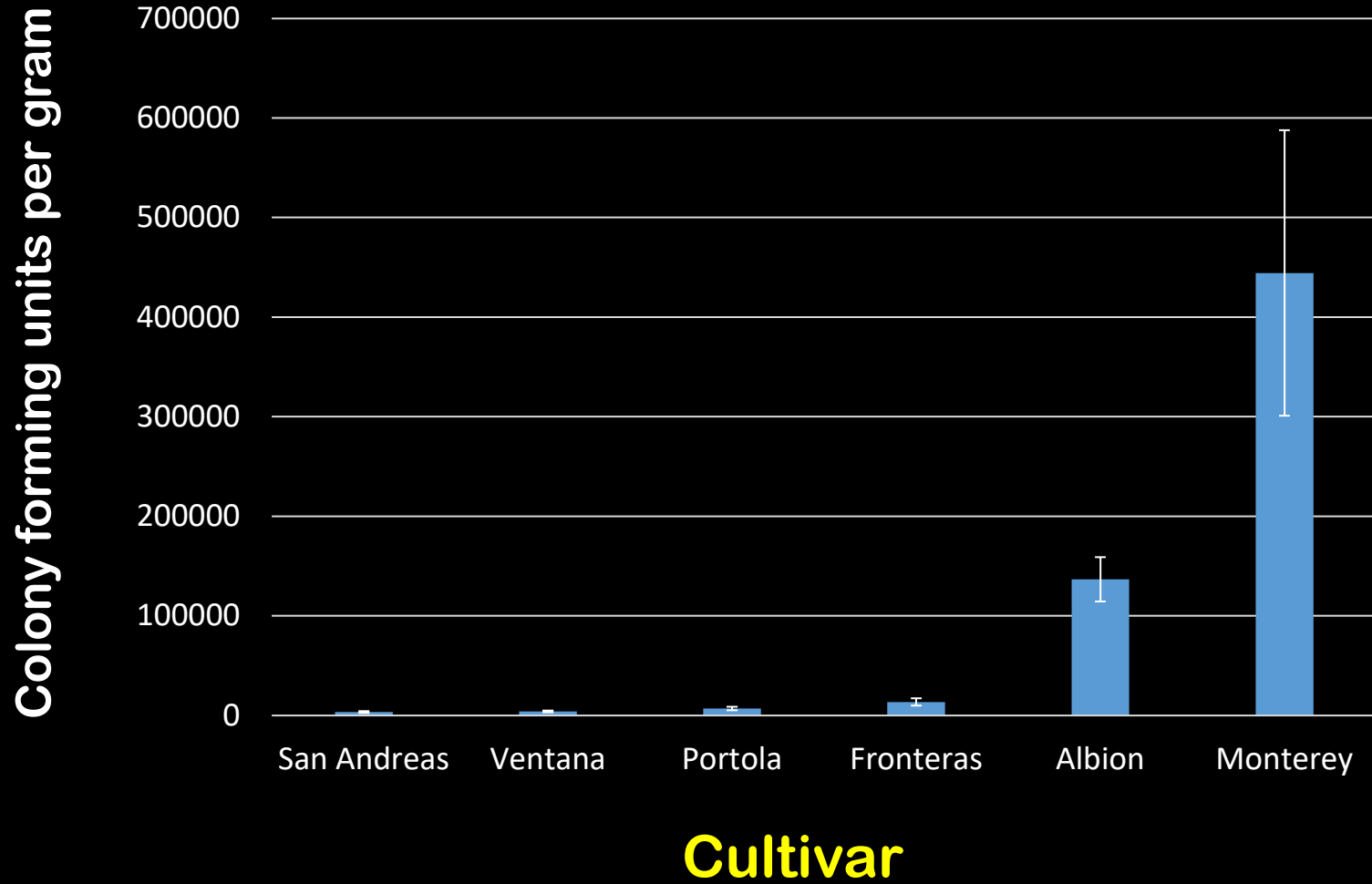


Pathogen can colonize resistant crops

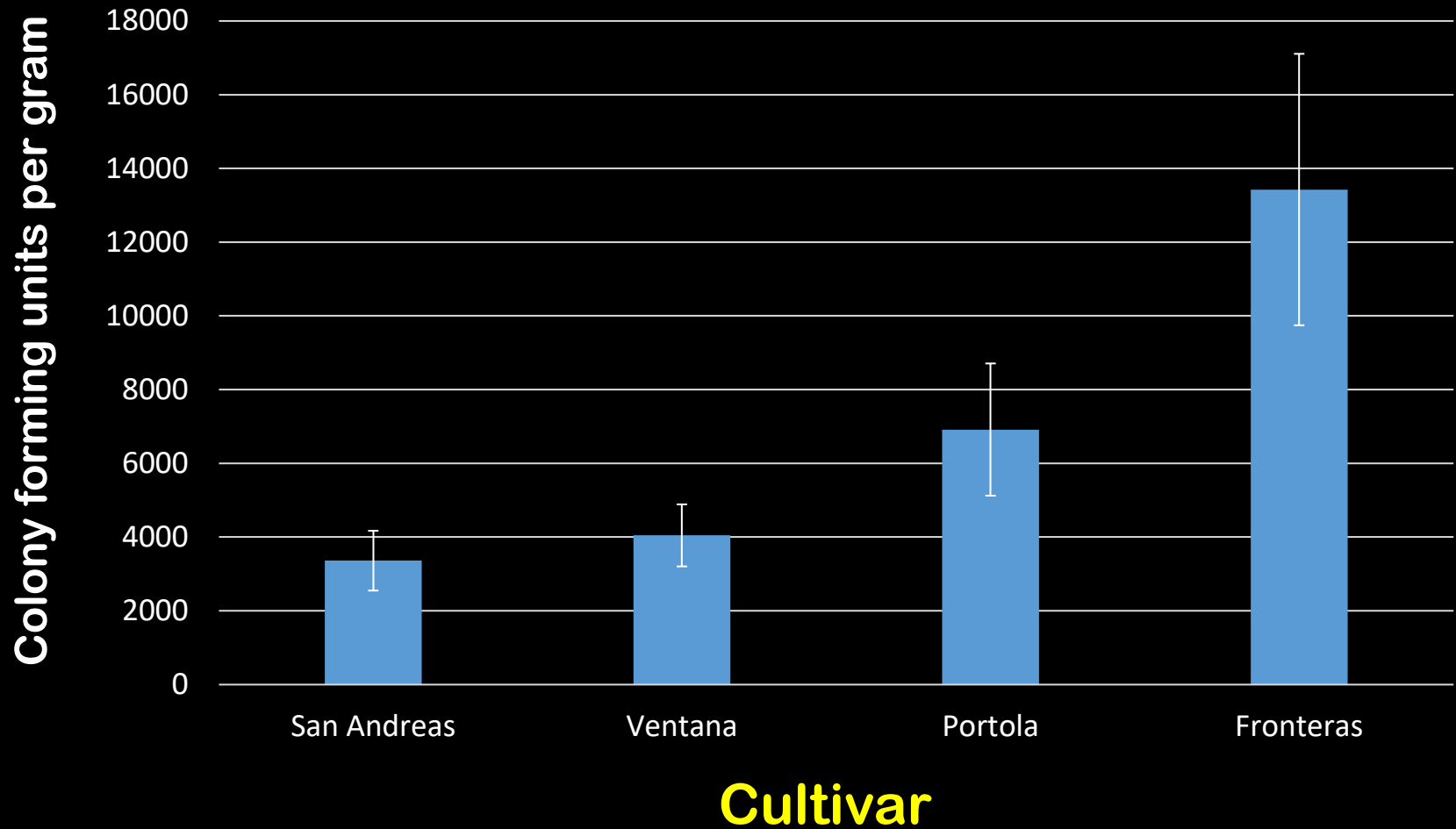


May allow inoculum build-up in soil

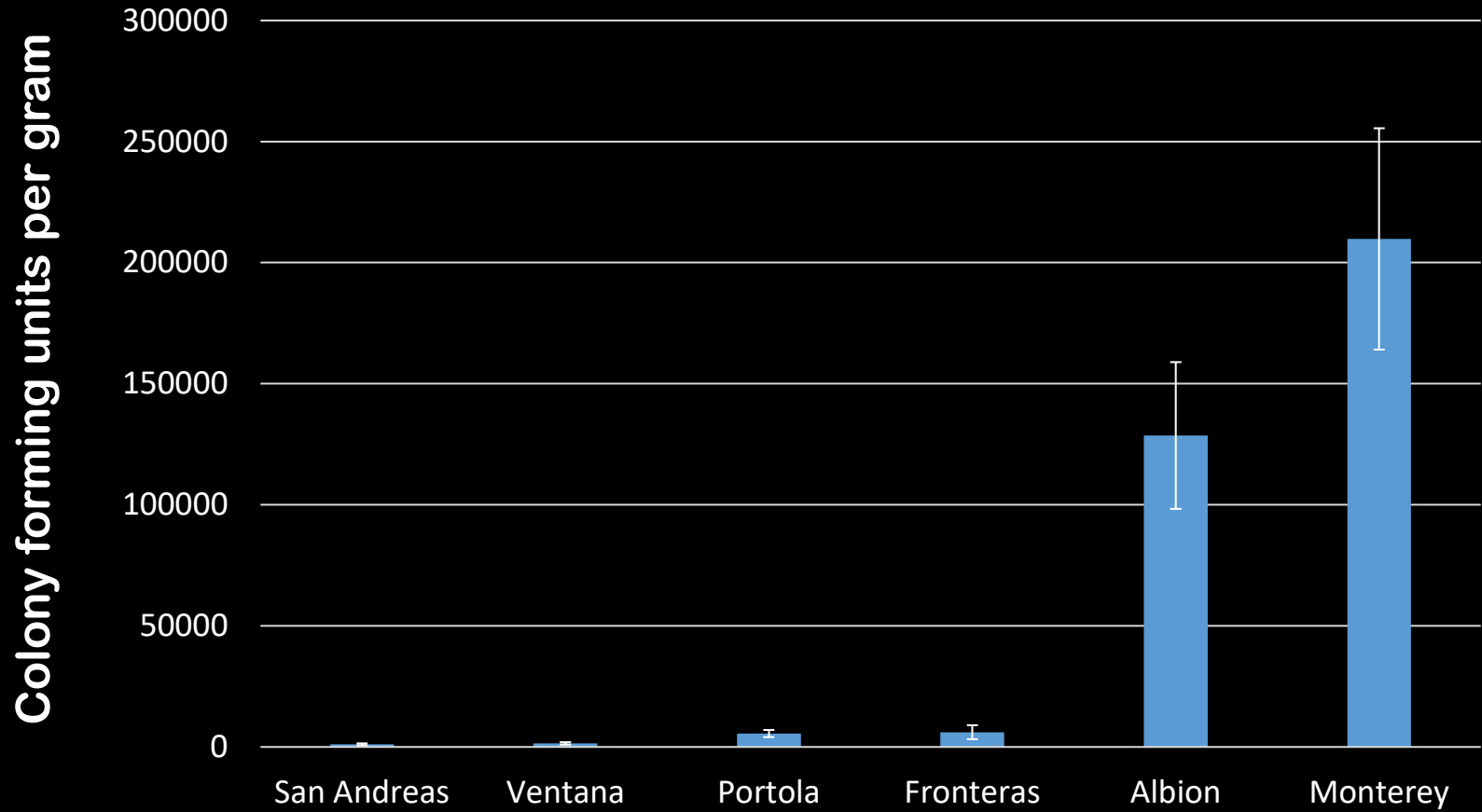
Colonization of roots



Colonization of roots

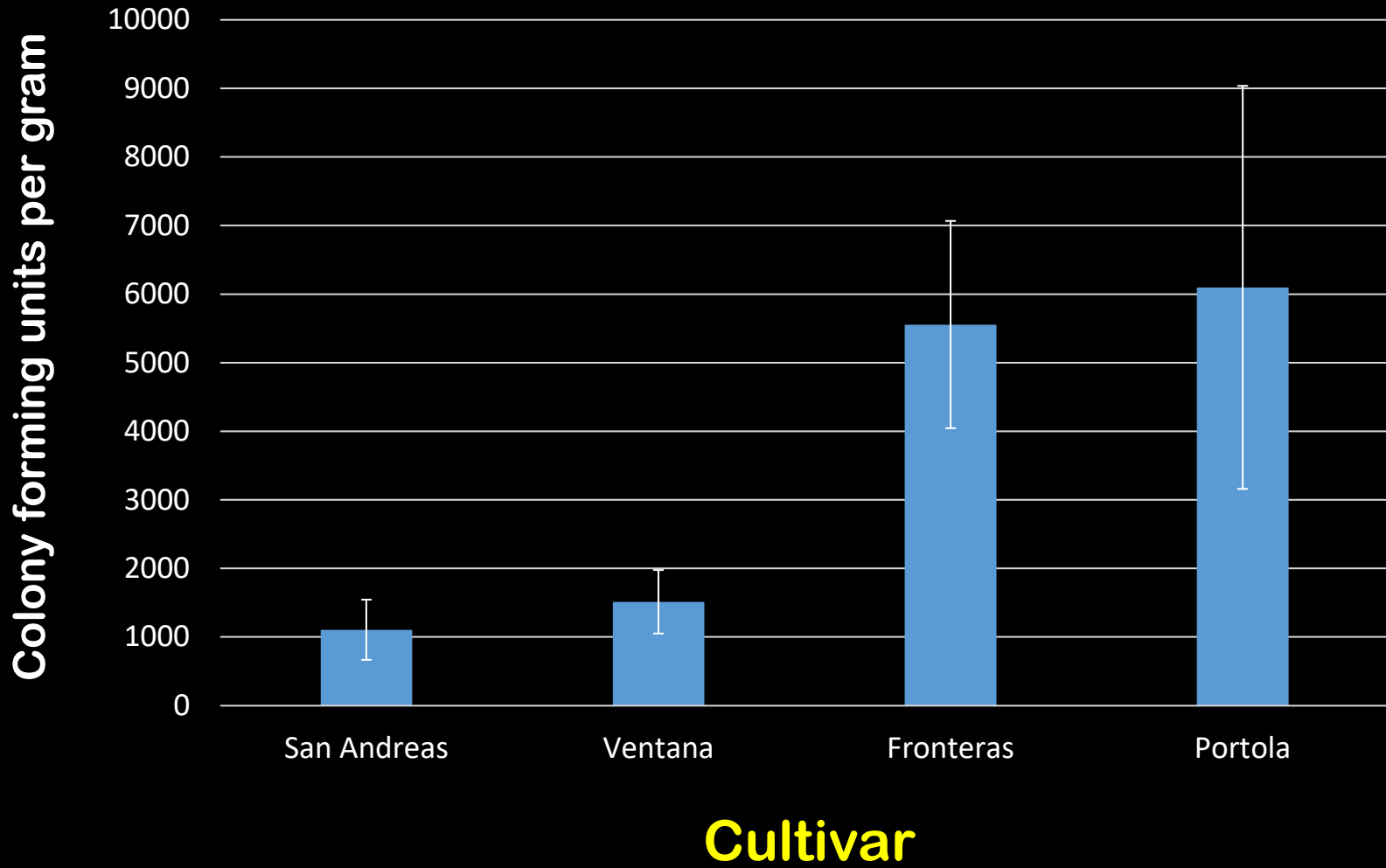


Colonization of crowns



Cultivar

Colonization of crowns



Resistance may be overcome

**Risk is proportional to pathogen
growth and reproduction**

Every cell is a reproductive unit

**Suppression of pathogen
populations still important**

Management of soilborne pathogens

Reduce inoculum levels

Avoid introductions

Disease resistance



Thanks

california
STRAWBERRY COMMISSION





Jim Gaffigan



Dan Legard

?

Thanks

california
STRAWBERRY COMMISSION

