Fusarium yellows on celery

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History of fusarium yellows on celery in California

1906 -1978

Fusarium yellows is apparently caused by *Fusarium oxysporum* f. sp. *apii* “race 1”

“Race 1” is virulent on self blanching (yellow) celery

Late 1950’s: Tall Utah 52-70 is introduced

1978 – 2013

Fusarium yellows is apparently caused by *Fusarium oxysporum* f. sp. *apii* “race 2”

Race 2 is highly virulent on Tall Utah, and to a lesser extent on Sonora & Conquistador

“Resistance” (or really tolerance) is primarily due to a single dominant gene from celeriac (PI 169001) (Orton et al. 1984) .
The gene(s) is in Challenger, Stix, Sabroso, Green Bay, & Picador
Tolerant plants are actually infected but are asymptomatic

We used DNA sequencing to ID “race 2,” (we call it “clade 3”), which is a single strain

Race 2/clade 3 causes the classic vascular discoloration

Brayford D. 1996. *Fusarium oxysporum* f. sp. *apii*. Mycopathologia 133:35-36.

Some cultivars from the CCRAB trial in Oxnard, CA in November 2013 in *Fusarium*-infested soil

Two of the *Fusarium*-tolerant varieties in development by the UC Davis Breeding Program: UC390S-2 & UC12A45

A commercial, *Fusarium*-tolerant variety developed using material from the UC Davis Breeding Program

Fusarium-susceptible Tall Utah 52-70 Improved

Fusarium yellows

Symptomatic plants are yellowed & stunted

The xylem has an orange-brown discoloration

Fusarium ratings in the CCRAB Field trials from 2003 to 2012

	Year of Field Trial in Oxnard, CA								
	2003	2004	2006	2007	2008	2009	2010	2011	2012
Cultivar	Fusarium rating: 0, no discoloration; 5, nearly dead								
Tall Utah[v].	1.7 a	0.6 a	2.8 a	1.9 a	4.5 a	4.6 a	4.2 a	4.6 a	4.2 a
Tall Utah[v]	1.7 a	0.5 a							
(Sonora)	1.4 ab				2.8 b				
Conquistador	1.2 ab	0.4 a	1.2 b	0.5 b	2.6 b	3.2 b	2.0 b	3.2 b	2.3 b
Command[w]	0.7 ab	0.3 a			2.4 bc	2.8 b		2.8 b	2.0 bc
Sonora		0.2 a	0.7 b	0.4 b		2.5 bc	1.8 bc	2.5 bc	2.0 bc
Stix[w]			0.7 b	0.3 b	1.6 cd				1.4 bcd
(Command[w])			0.6 b	0.3 b			1.8 bc		
(Stix[w])							1.0 bc		
Promise[x]	0.4 b				1.1 d				1.0 de
Green Bay[w]	0.4 b								
Challenger[y]	0.3 b	0.1 a	0.4 b	0.2 b	0.9 d	1.3 cd	0.5 c	1.3 cd	0.5 e
(Stix[w])						1.1 d		1.1 d	
(Green Bay[w])		0.1 a	0.3 b						
(Promise[x])		0.1 a							
UC040A[z]						1.0 d		1.0 d	

Data from Richard Hurstak from the CCRAB trials

Results from the CCRAB field trials 2003 – 2013: the more Fusarium-sensitive varieties have a significant negative correlation between yield and the Fusarium rating system

		Celery weight & Fusarium rating	Celery height & Fusarium rating	Celery weight & height
Cultivar	*Fusarium*-sensitivity	Correlation r, if P<0.05		
Tall Utah	Highly susceptible	-0.86	-0.72	0.83
Sonora	Susceptible	-0.66	-0.48	0.74
Conquistador	Susceptible	-0.59	-0.55	0.82
Green Bay	Somewhat tolerant?	-0.59	-0.69	0.58
Command	Somewhat tolerant?	-0.29	NS	0.52
Stix	Tolerant?	NS	NS	0.47
Promise	Tolerant	NS	NS	0.67
Challenger	Tolerant	NS	NS	0.63

Greenhouse assay of the *Fusarium*-susceptible **Tall Utah**

Clade 3 Mock-inoculated

6 inches

Clade 3

1 inch

Mock-inoculated

1 inch

Greenhouse assay of the *Fusarium*-tolerant Challenger

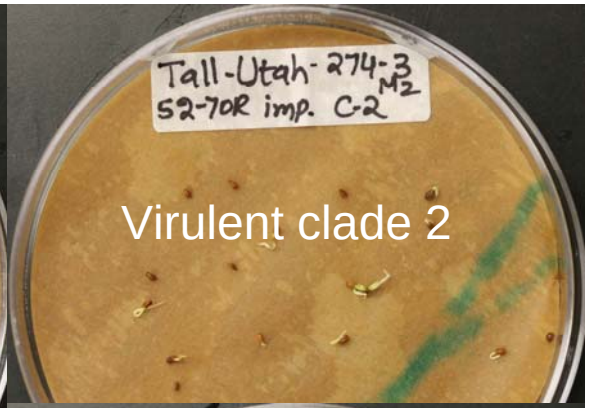
The story becomes more complicated

We (and previously Krishna Subbarao) consistently isolate both “race 2” (which we call “clade 3”) and a set of related but diverse *Fusarium oxysporum* isolates (which we call “clade 2”) from symptomatic tissue.

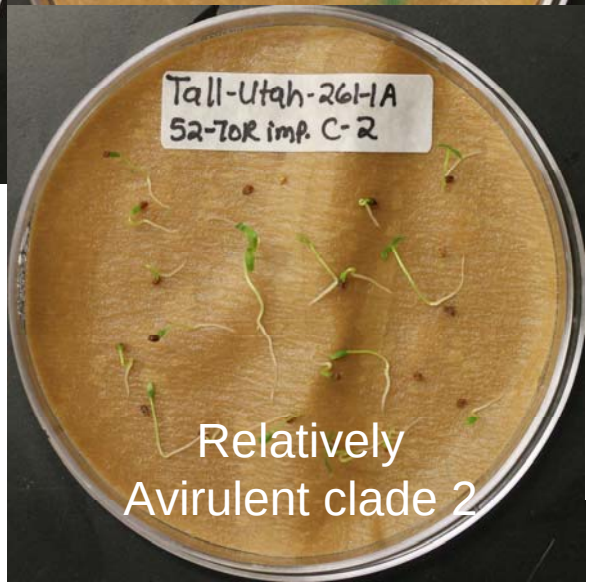
These “clade 2” isolates do not cause discoloration but they have a range of virulence in a new seedling assay, from causing no disease to highly virulent

Mock-inoculated

Virulent clade 3



Virulent clade 2



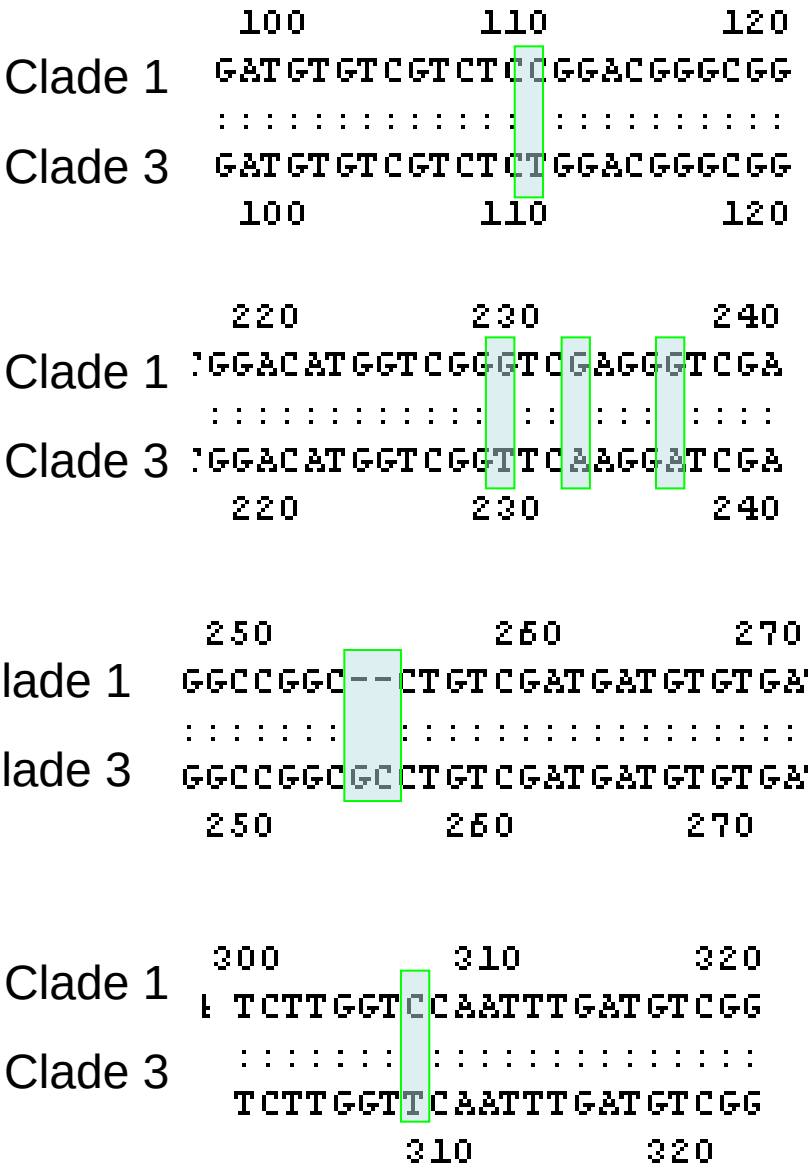
Relatively Avirulent clade 2

The story becomes more complicated #2

Oxnard, Celery Research Advisory Board trial, 28 May 2013: total loss

We identify a different strain(s) of *Fusarium oxysporum* f. sp. *apii* that is highly virulent & causes vascular discoloration. It is unrelated to race 2/our "clade 3;" we call it "clade 1.

IGS polymorphisms in Clade 1 and Clade 3

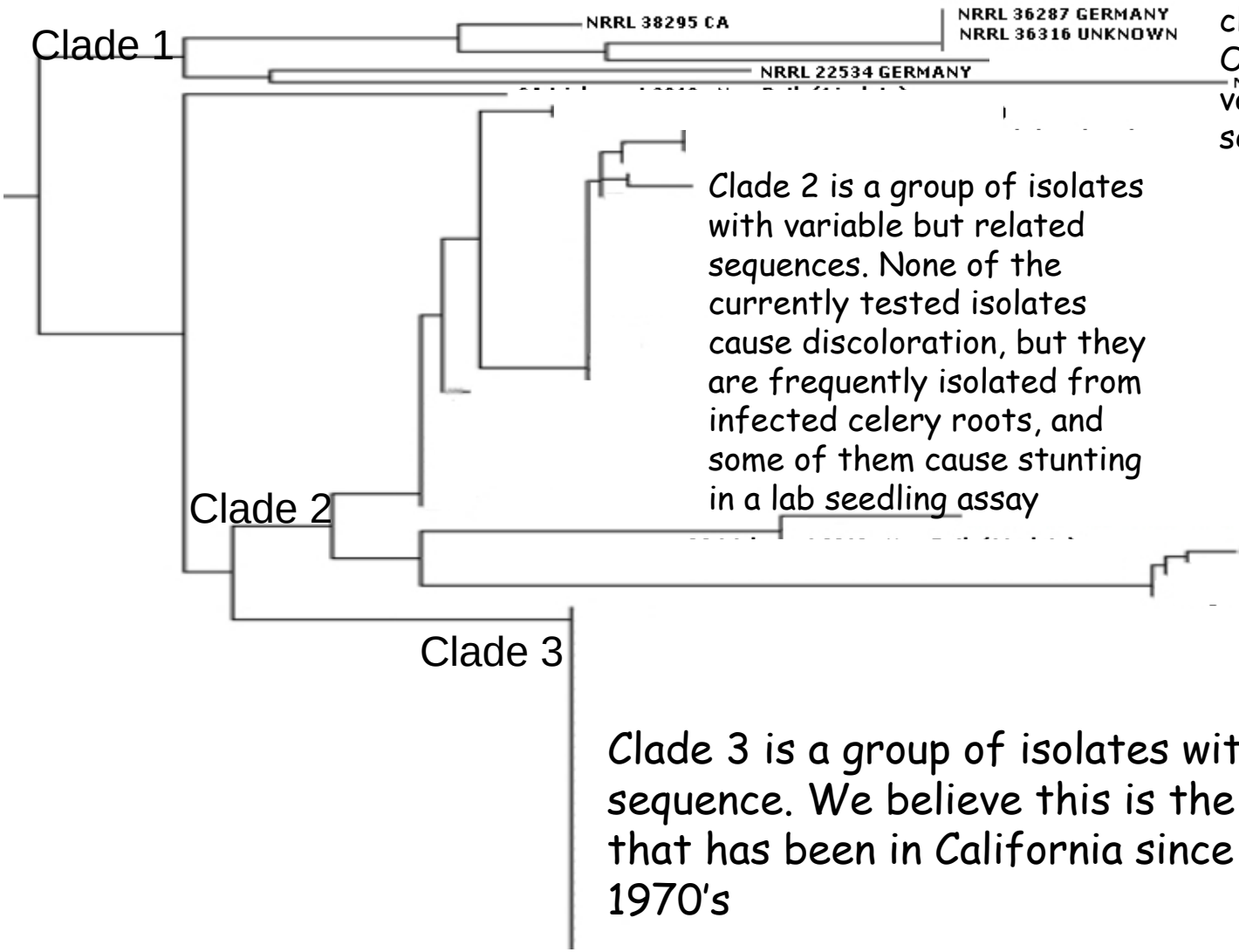


etc.

1 cm

Tall Utah planted in soil apparently only with clade 1 and clade 2 isolates

Phylogenetic tree of the ef1 DNA sequence of 209 *Fusarium oxysporum* isolates from symptomatic celery



Clade 1 is a group of highly divergent international isolates. We have recently isolated a highly virulent clade 1 in 3 fields in the Oxnard area. There is some variability in clade 1 sequence.

Clade 2 is a group of isolates with variable but related sequences. None of the currently tested isolates cause discoloration, but they are frequently isolated from infected celery roots, and some of them cause stunting in a lab seedling assay

Clade 3 is a group of isolates with identical sequence. We believe this is the classic "race 2" that has been in California since at least the late 1970's

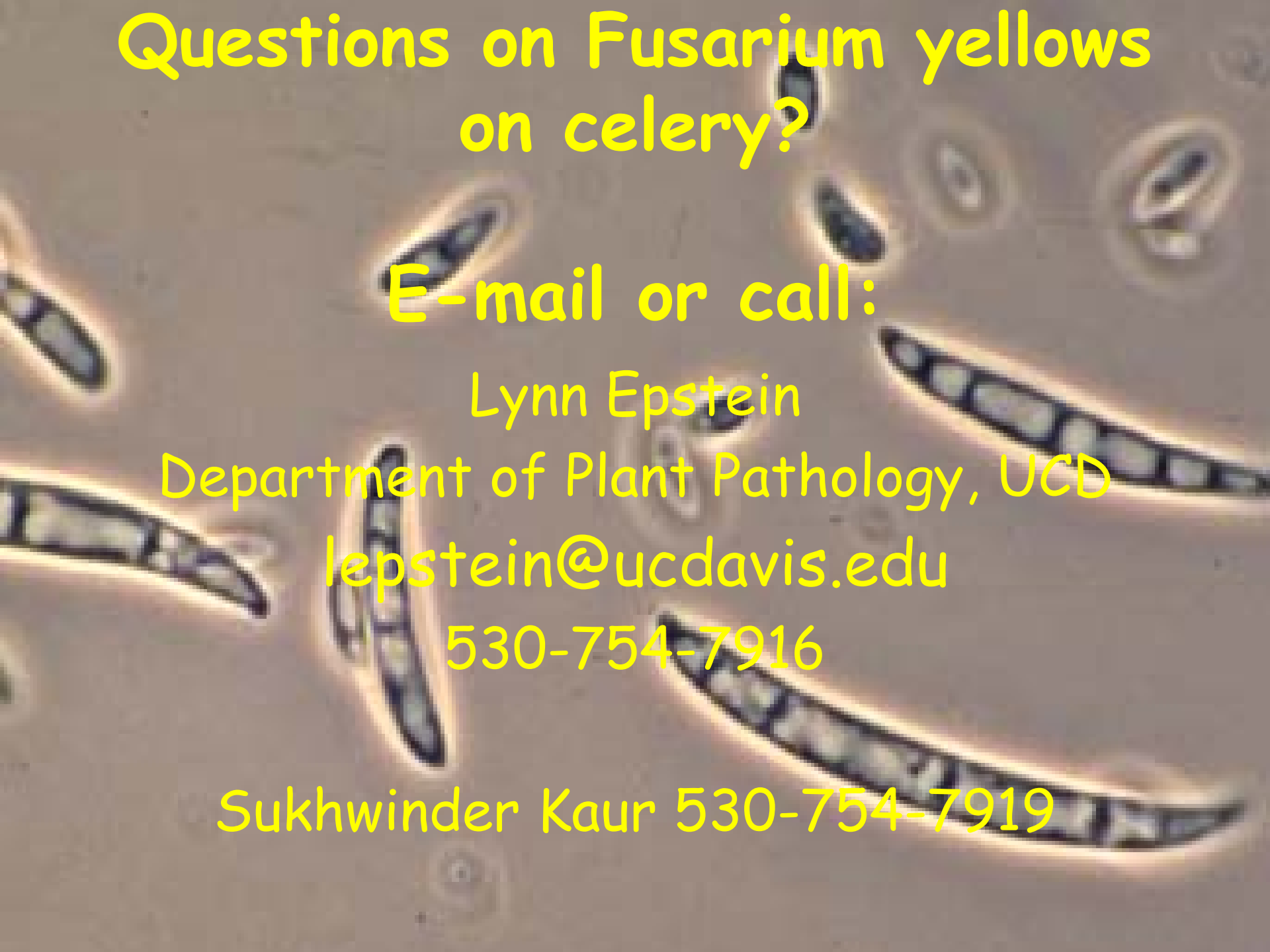
Many *Fusarium oxysporum* isolates in soil are either non-pathogenic (presumably mostly saprophytic) or pathogenic on other crops, and are not in any of the clades shown above

What are we doing now?

- We’re screening the entire UC Davis celery germplasm (including related wild species) for tolerance/resistance to both clade 1 and for additional genes for tolerance/resistance to “race 2”
- We’re collecting sufficient DNA sequence of the different strains so that we can determine for growers the pre-plant inoculum concentration of the different strains in soil
- We’re determining the role of the “clade 2” isolates in fusarium yellows

What should you do?

- Keep records of fusarium yellows incidence in particular fields
- Avoid moving soil from infested to presumably clean fields
- Maintain a rotation out of celery
- Control chewing insects and reduce plant water stress
- Plant Fusarium-tolerant varieties (for “race 2”):
  - Challenger or Mission are fusarium-tolerant
  - Sabroso (a traditionally a juicing variety), Samba, Green Bay, Stix, & Picador are also fusarium-tolerant (but I don’t know how well they produce in Oxnard)
    - Command seems less tolerant of fusarium than Challenger
    - Sonata & Conquistator are even less tolerant of fusarium than Command
- Contact us if you think you might have “clade 1”-infected plants
  - “Clade 1” appears to be virulent on formerly Fusarium-tolerant cultivars
  - So far, we have only isolated “clade 1” in some fields in Oxnard



Questions on Fusarium yellows on celery?

E-mail or call:

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