Soilborne pathogens of lettuce and research updates on Fusarium wilt

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December 2, 2025
UCCE Monterey Pest Management Meeting

University of California
Agriculture and Natural Resources

		Vascular wilt diseases (internal)		Root diseases (external)			Crown diseases	
	Symptoms	**Fusarium**	**Verticillium**	**Pythium**	**Black root rot (Thielaviopsis)**	**Corky root**	**Grey mold (Botrytis)**	**Drop (Sclerotinia)**
Leaves	Stunting	YES	no	YES	YES	YES	YES	YES
	Wilting	YES	YES	YES	no	YES	YES	YES
	Yellowing	YES	YES	YES	no	no	YES	YES
	Collapse	YES	YES	YES	no	no	YES	YES
Crown	Crown rot (external)	no	no	no	no	no	YES	YES
Roots	External	no	no	Large areas of rot	Discrete bands on secondary roots	Bands of cracking on taproot	no	no
	Vascular discoloration (internal)	YES	YES	no	no	no	no	no

Adapted from S. Koike

Vascular wilts – typical symptoms

Can appear very early
Stunting, wilting, yellowing, death
Plants end at different sizes (or are killed as seedlings)

Mostly appears close to harvest
Wilt, yellowing of outer leaves
All plants make mature size

Vascular wilts – typical symptoms

Fusarium wilt

Disclaimer: Foliar symptoms are not diagnostic

K. Subbarao

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Vascular wilts – typical symptoms

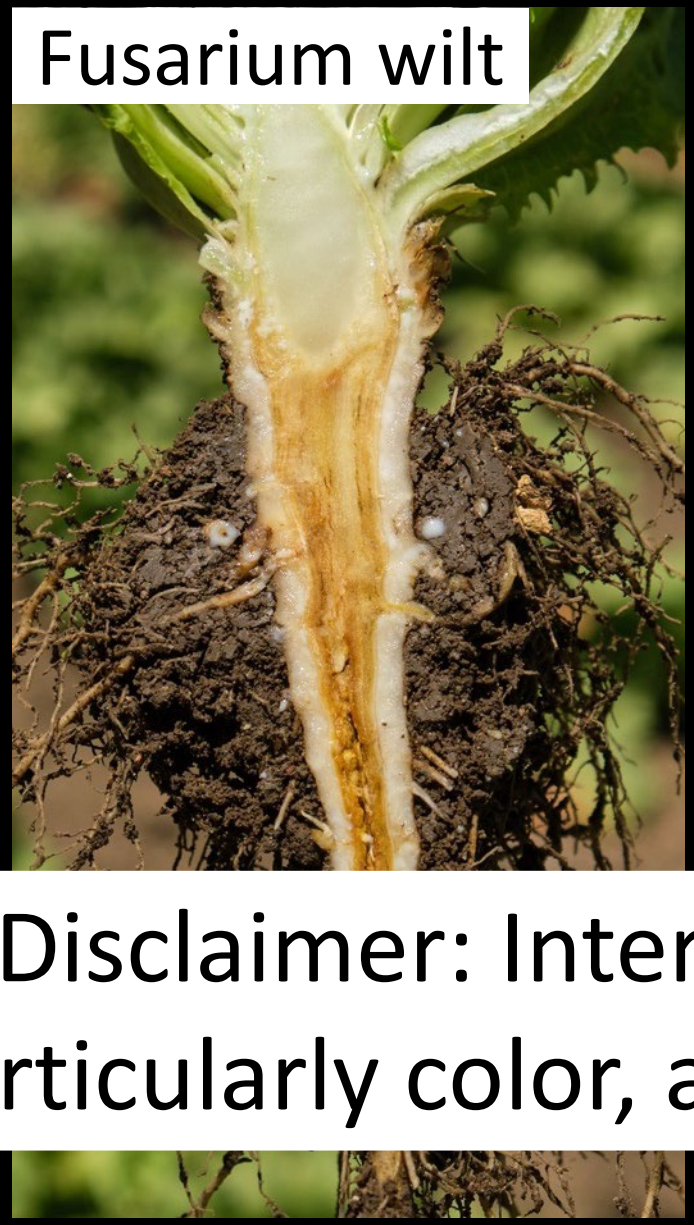
Reddish (orange/brown) discoloration, hollowing, white residue

Olive green/black discoloration, dark streaking little-no hollowing

K. Subbarao

Vascular wilts – typical symptoms

Reddish (orange/brown) discoloration, hollowing, white residue



Olive green/black discoloration, little-no hollowing

Disclaimer: Internal symptoms, particularly color, are not diagnostic

K. Subbarao

Typical symptoms of Fusarium wilt

Healthy Discoloration Hollowing out Rot, white residue

Diseases causing external rots, spots, or bands

Pythium wilt

Can appear early
Stunting, wilting, yellowing
Outer leaves lay evenly flat

Corky root

No image

Poor, uneven growth
Stunting, wilting

Black root rot

Can appear at any stage
Unevenness, stunting
*Minimal yellowing
*NO wilt or collapse

Diseases causing external rots, spots, or bands

Pythium wilt

Large areas of soft rot on secondary roots
Rot of taproot

Corky root

Yellow bands on taproot
Green-brown discoloration with cracking

Black root rot

Black, discrete bands on secondary roots
Taproot only affected when severe

Diseases causing external rots, spots, or bands

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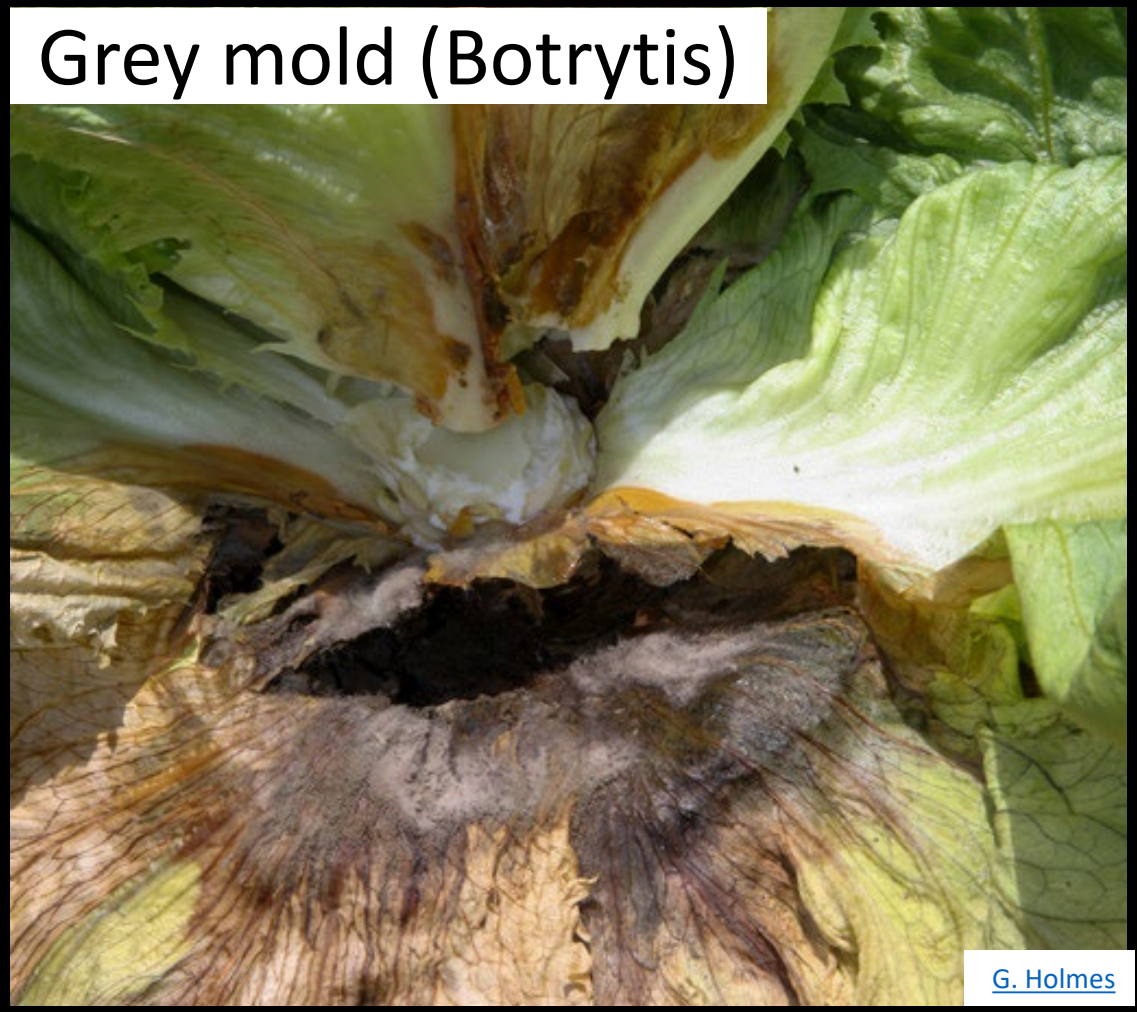
Crown rots

Drop (Sclerotinia)

G. Holmes

Head easily detached from roots
White mycelium
Black sclerotia (1/8th inch)

Grey mold (Botrytis)



G. Holmes

Head easily detached from roots
Grey mycelium

Fusarium oxysporum f. sp. *lactucae*

- Disease-causing ability is host specific
  - *F. oxysporum* f. sp. *lactucae* will only cause disease of lettuce
  - f. sp. = “special form”

- Can grow and reproduce on:
  - Plants on which it cannot cause disease
  - Resistant cultivars of its host plant

- There are many special forms of other hosts
  - Also, there are probably many *F. oxysporum* populations that are non-pathogenic

Colonization of lettuce cultivars and rotation crops by the Fusarium wilt pathogen

Plant	Root cortex[1]		Root stele[1]	
	% pieces infected	Pathogen colonies per gram	% pieces infected	Pathogen colonies per gram
Spinach	67 ab[3]	11.5 a	50.0 b	8.8 b
Cauliflower	33 a	2.6 a	7.4 a	1.1 a
Broccoli	33 a	3.0 a	0.0 a	0.0 a
Lettuce King Henry[2]	93 b	576.0 b	71.0 b	17.0 b
Lettuce Salinas[2]	100 b	1312.0 b	77.0 b	325.0 c

[1] Cortex = outer layer of root, Stele = inner cylinder of vascular tissue
[2] King Henry = Romaine, resistant; Salinas = iceberg, susceptible to Fusarium wilt
[3] Within each column, values the same letter are not significantly different

Scott, McRoberts, Gordon. 2014 10.1111/ppa.12135

Non-host rotation crops can be colonized, but less than lettuce

Within lettuce, resistant cultivar is colonized less than susceptible cultivar

Pathogenic races of FOL

Variety	UC Riverside CR4 variant*	Described Races			
		race 1	race 2	race 3	race 4
Gisela	S	S	S	S	S
Ballerina	S	S	S	S	IR
Patriot	S	S	S	S	IR
Costa Rica No. 4	S	HR	S	S	S
Romabella	HR	HR	HR	S	IR
Lomeria	IR	S	HR	HR	HR
Palmos	HR	HR	S	IR	HR

HR = highly resistant; IR = intermediate resistance; S = susceptible

*"Costa Rica variant" is a temporary name (="CR4 variant")

Race = unique pattern of resistant or susceptible reactions on differential varieties

Race survey – Distribution of FOL Isolates

		Collected			Evaluated in Greenhouse			
District	County	Total	No Data	In-complete	Race 1	CR4 variant	Non-Path	Suspected Non-Path
					# isolates			
Central Valley	Fresno	15	12	0	3	0	0	0
Low Desert	Imperial	23	20	0	0	2	0	1
Low Desert	Yuma (AZ)	57	28	0	6	18	4	1
Salinas	Monterey	788	660	12	42	44	8	34
Salinas	San Benito	10	10	0	-	-	0	0
Salinas	Santa Cruz	11	11	0	-	-	0	0
Santa Maria	Santa Barbara	125	106	1	11	7	0	1
n/a	n/a	93	90	0	0	4	0	0
	Total	**1122**	**937**	**13**	**62**	**75**	**12**	**37**

Majority of isolates consistent with CR4 variant

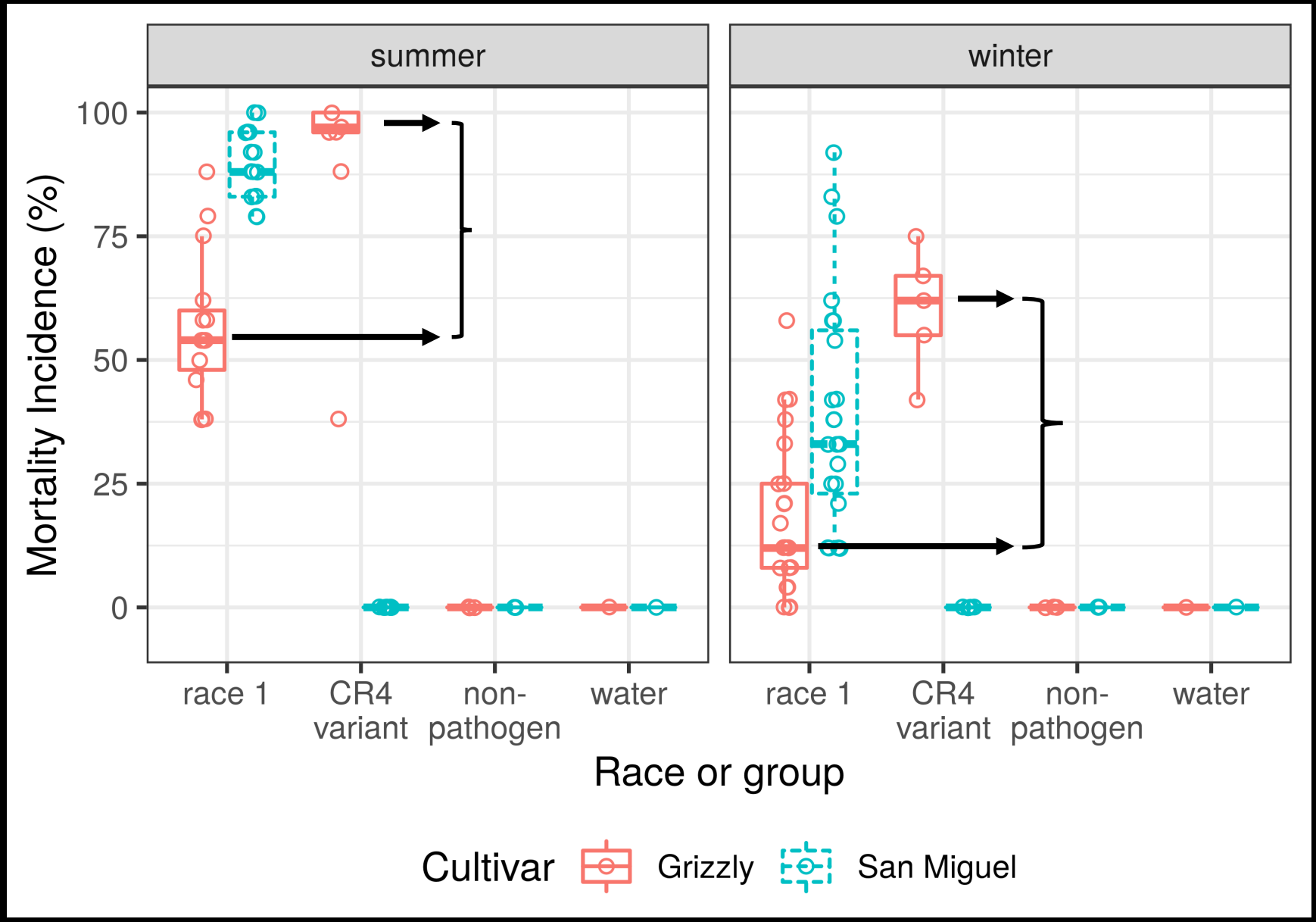
CR4 variant present in Yuma and Imperial

Race survey – Distribution by site or sample

		Collected		Evaluated in Greenhouse			
District	County	Total	No Data	Race 1	CR4 variant	Both race 1 and CR4	Weak Path
				# sites or samples*			
Central Valley	Fresno	2	0	2	0	0	0
Low Desert	Imperial	3	1	0	2	0	0
Low Desert	Yuma (AZ)	8	0	3	4	1	0
Salinas	Monterey	133	79	15	23	2	14
Salinas	San Benito	2	2	-	-	-	-
Salinas	Santa Cruz	4	4	-	-	-	-
Santa Maria	Santa Barbara	26	18	4	3	1	0
n/a	n/a	43	42	0	1	0	0
	Total	**221**	**146**	**24**	**33**	**4**	**14**

*Site = known ranch/lot
Sample = source location not known

Quantitative differences among races? (in greenhouse)



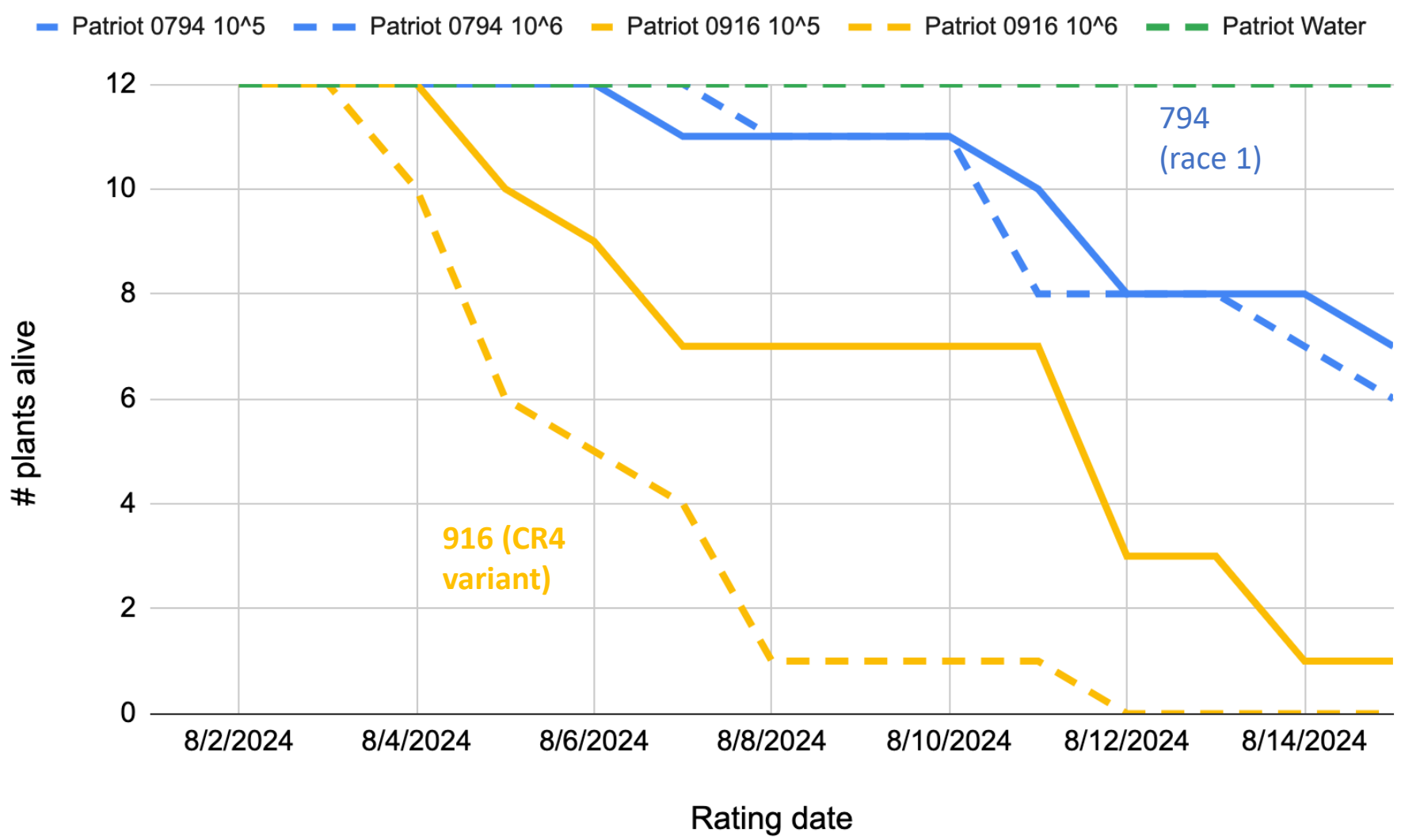
Apparent difference in aggressiveness to Grizzly between race 1 and the CR4 variant

Disease pressure lower for experiments done in winter

- Each point = 1 isolate
- Isolates between summer/winter not same

% mortality of 24 plants

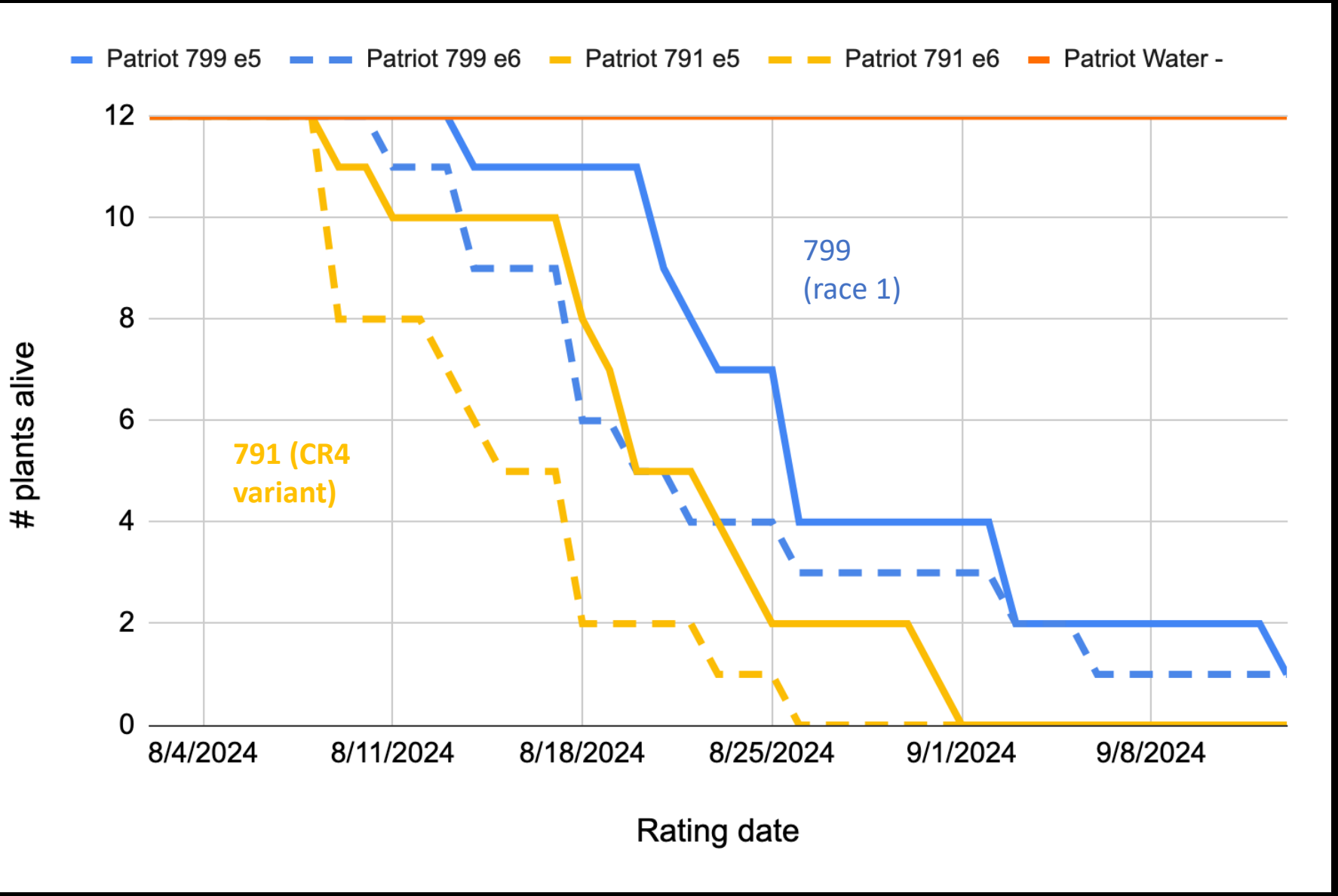
Apparent differences in aggressiveness between races



<u>Greenhouse pots</u>

In variety susceptible to both races, CR4 variant isolate kills more plants and faster than race 1 isolate

Apparent differences in aggressiveness between races



<u>Greenhouse pots</u>

In variety susceptible to both races, CR4 variant isolate kills more plants and faster than race 1 isolate

Pattern seen in three pairs of isolates

Fusarium race survey – Summary

- Two races of the Fusarium wilt pathogen are present on the Central Coast
- CR4 variant was more common in the sample tested to date
- Underway
  - Diagnostic marker development (F. Martin)

Fusarium wilt variety trial 2025 – Iceberg

Variety	Greenfield	Soledad	Variety	Greenfield	Soledad
	% Marketable heads			% Marketable heads	
Paraiso	97.0 a	98.5 a	TLE002	51.5 fghij	89.9 abc
SVX 150027	94.9 a	99.5 a	Fresco	50.5 fghij	48.2 gh
San Angelo	94.1 a	96.6 a	Lucia	50.3 ijkl	73.9 cdef
San Clemente	93.2 a	98.6 a	Fronterra	48.5 fghij	58.8 fg
SVX 150035	91.5 a	95.2 a	Meridian	48.5 ghij	95.0 a
San Miguel	91.0 a	99.0 a	Balboa	46.4 hijk	98.5 a
PS1541	90.9 a	99.0 a	Iceman	40.7 hijkl	98.5 a
Sakata-1	89.3 a	96.1 a	Paulie	39.3 hijkl	96.0 a
San Andreas	87.8 ab	97.1 a	25FT-003	39.3 hijkl	na
SVX 150031A	85.9 abc	98.1 a	Fredonia	39.1 hijkl	83.0 abcde
Friesian	85.3 abcd	90.5 ab	Pismo	39.1 hijkl	91.8 a
SVX 150038	71.8 bcde	75.4 bcdef	25FT-006	38.3 hijkl	na
Newcastle	70.2 defg	66.0 efg	25FT-002	36.5 ijkl	na
Ortega	69.9 cdef	72.4 ef	PS1534	33.0 jkl	95.0 a
TLE001	59.3 efgh	89.6 abcd	Telluride	26.6 kl	62.0 fg
SVX 150031	57.2 efghi	67.3 efg	25FT-005	26.1 kl	na
Powerpack	56.3 efghi	98.0 a	PS1546	24.4 l	96.7 def
Adrian	54.7 efghi	89.9 abc	Primo	24.2 l	66.7 efg
Mickey	54.7 efghij	98.5 a	Tamarack	6.6 m	34.5 h
Fremont	54.5 efghi	93.2 a	Rhodenas	2.5 m	9.5 i
Powerball	52.5 efghij	95.0 a			

Fusarium race typing

CR4 variant present at both location

Greenfield

- Verticillium appeared more prevalent
- Severe corky root
- Significant Sclerotinia

Fusarium wilt variety trial 2025 – Romaine

Variety	Greenfield	Soledad	Variety	Greenfield	Soledad
	% Marketable heads			% Marketable heads	
Alamanor	73.9 a	98.5 a	Grackle	36.0 defghij	99.0 a
Inferno	70.8 ab	71.8 b	Iverson	34.5 efghij	99.5 a
Cardinal	58.0 abc	98.5 a	25FT-008	31.7 fghij	
Green Thunder	54.5 bcd	97.5 a	Warbler	26.0 fghij	98.0 a
Holbrook	52.5 bcde	98.0 a	Sparrow	25.0 ghij	99.5 a
Abilene	43.5 cdef	98.0 a	Ranchero	25.0 ghij	
Boronda	41.5 cdefg	99.5 a	Salvius	24.0 ghij	58.5 b
PS1432	39.2 cdefgh	98.0 a	25FT-010	21.5 hij	
Rio Bravo	39.0 cdefgh	98.5 a	Kanaka	20.5 ij	
Duquesne	38.0 defghi	98.5 a	Bluerock	19.5 jk	
Rawhide	38.0 defghi	95.5 a	iceberg check	6.0 kl	33.0 c
Stampede	38.0 defghi	99.0 a	25FT-009	5.5 l	

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Acknowledgements

Alex Putman, Valentina Valencia Bernal, Nicole Lukasko, Nethmini Wijesundara, Renee Rincon, Alyssa Monroy, Evelyn Martinez Lopez, Jared Colton, Bayron Vazquez, Maylin Reyes, Daera Aguinaldo, Bailey Vontoure; Jason Stajich	*UC Riverside, Riverside, CA*
Kelley Richardson, Santosh Nayak, Frank Martin, Ningxiao Li	*USDA-ARS Salinas*
Yu-Chen Wang, Chris Greer	*University of California Cooperative Extension*
Jim Correll, Hannah Zima, Maria Villarroel-Zeballos	*University of Arkansas*
Stephanie Slinski	*Univ. of Arizona, Yuma Center of Excellence for Desert Agriculture*
Steve Koike, Hanane Stanghellini	*TriCal Diagnostics*

Additional Thanks

D'Arrigo Bros of California, anonymous grower

Holaday Seed (Dan Riley), Salinas Valley Seeds (David Duke)

Growers, shippers, PCAs, seed companies, others who sent samples and/or invited us into fields

Collaborators

Richard Smith, JP Dundore-Arias

Jim McCreight, Nick LeBlanc

Funding

CA Leafy Greens Research Program (PD Putman)

CDFA Specialty Crop Block Grant Program (PD Putman)

CA Leafy Greens Research Program Annual Conference (March 25, 2025)