

Celery Fusarium race 4 and 2 germplasm field evaluation update

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Questions or concerns:

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Celery Fusarium race 2

- Symptoms
 - Stunting
 - Yellowing
 - Root discoloration

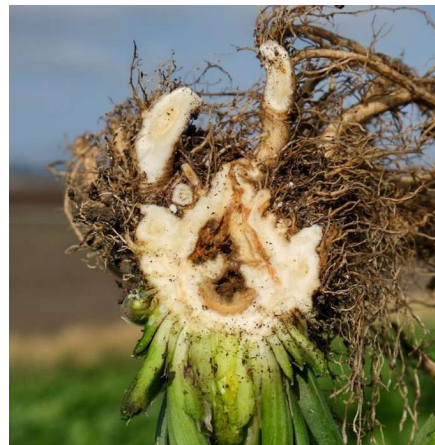


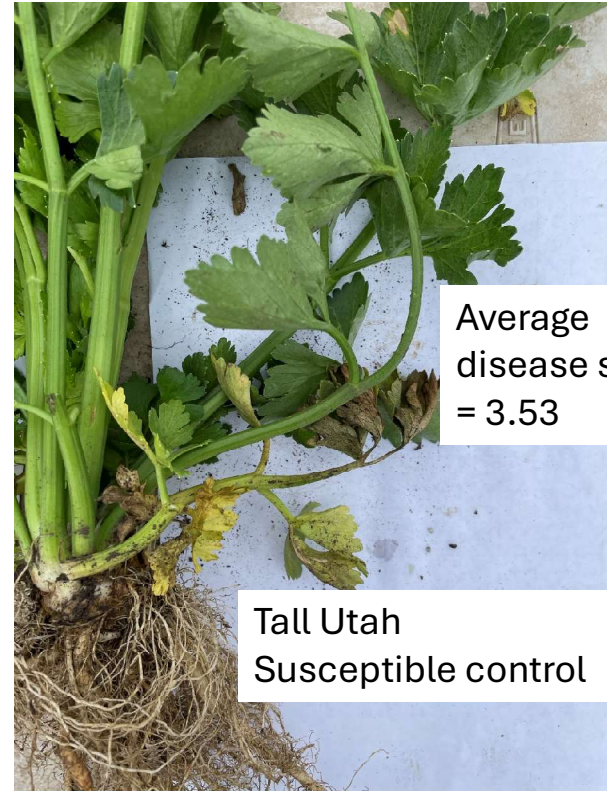
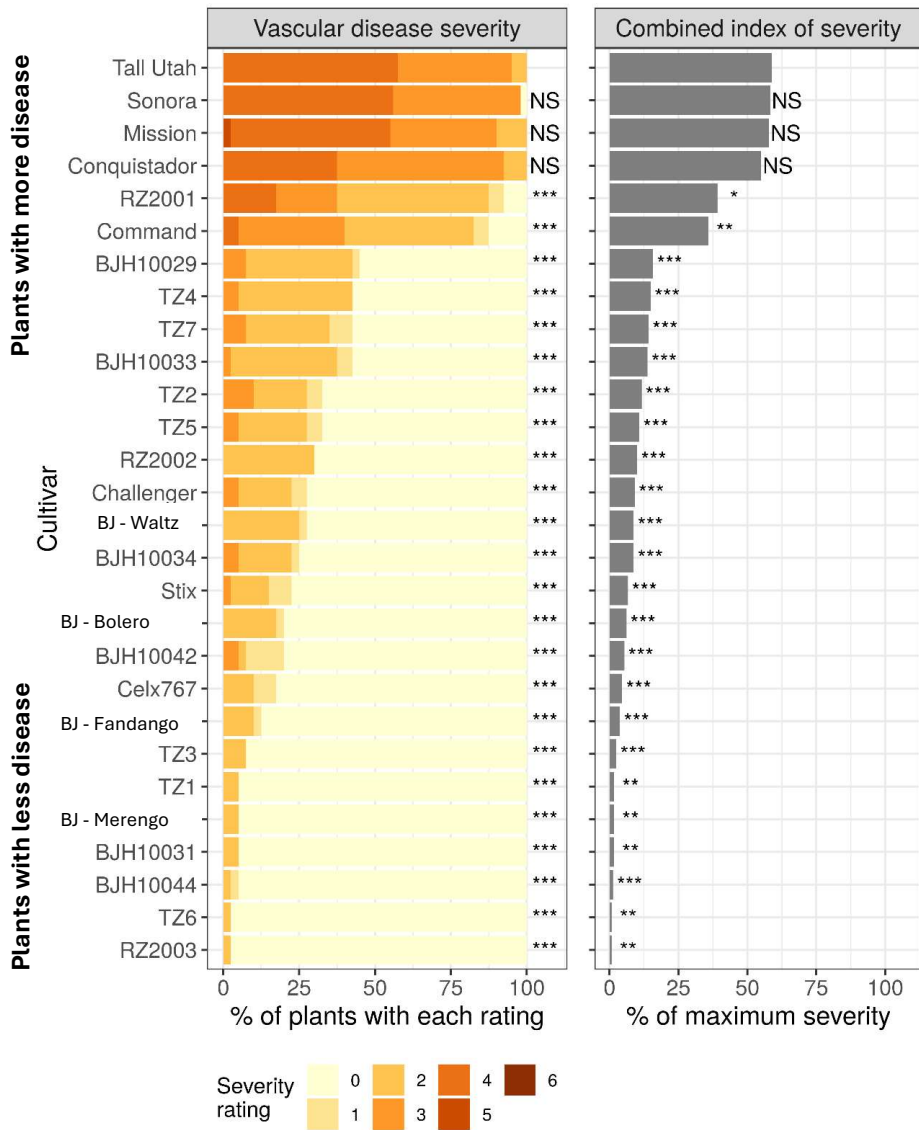
Photo by Chris Greer

Celery Fusarium race 2

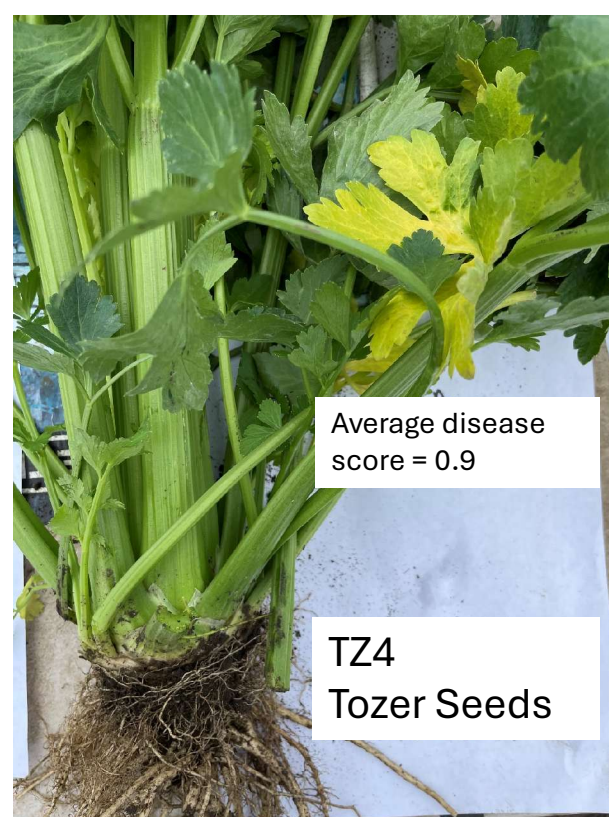
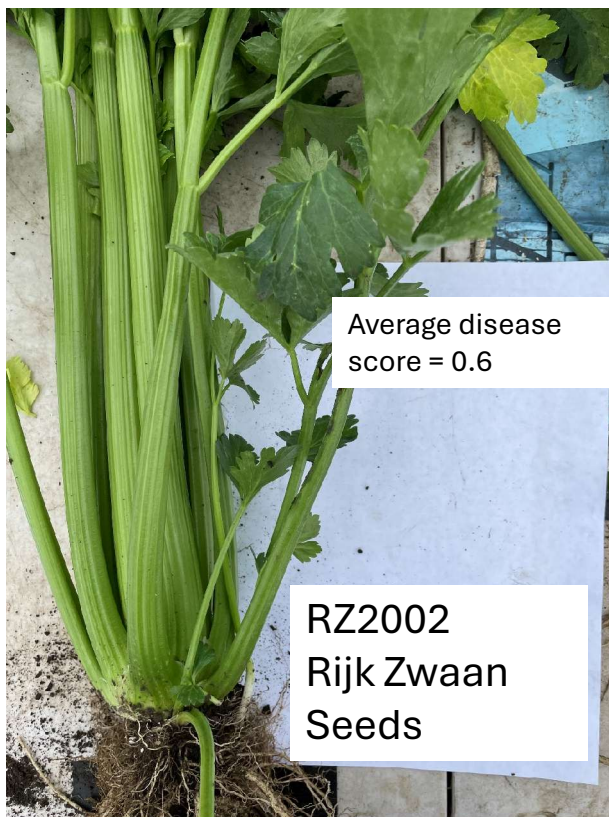
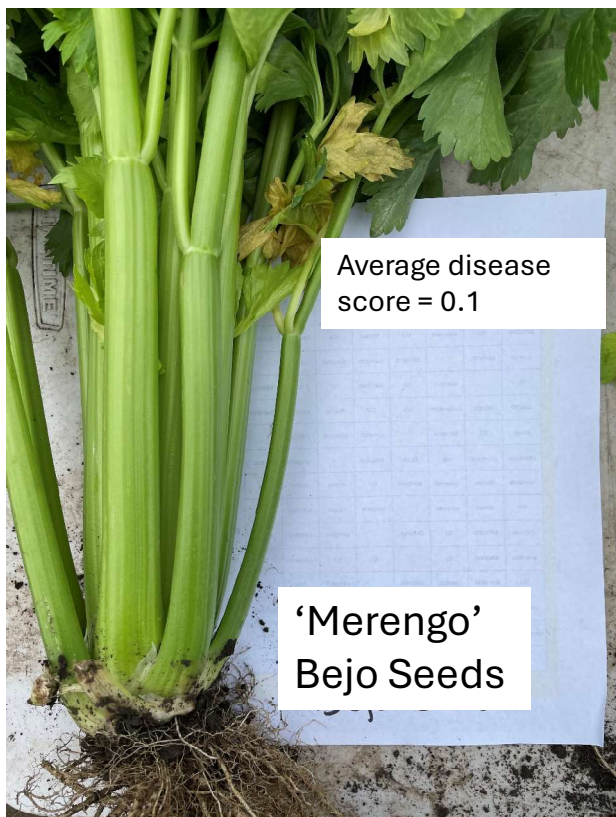
	2022	2023	2024	2025
Seed drop				~ April 7
Transplant	July 7	June 16	June 11	June 10
Harvest	Oct 13+14	Sept 18 + Oct 18	Sept 17+18	

- Seed drop at Plantel Nursery around April 7.
- If interested in contributing, please contact reene.Eriksen@usda.gov or aiputman@ucr.edu or cagreer@ucanr.edu ASAP
- Thanks for Jake Azevedo and Betteravia Farms for providing field space.





SCORE	CRITERIA
0	No browning
1	Browning visible, particularly in feeder roots
2	Browning visible, particularly in primary roots
3	Browning visible, particularly around the crown
4	Browning in and/or around the crown
5	Extensive browning in crown, decay in crown tissue
6	Plant dead or missing due to death



Cultivar	Petiole Length (inches)	Average Plant Weight (lbs)	Ribbiness (score 1-3)	Pithiness (score 1-3)	Bolting (score 1-3)	Greenness (score 1-3)	Suckering (score 1-3)	Petiole Cracking (score 1-3)
BJH10029	10.6	1.0	2.2	1.2	1.0	2.5	1.5	1.0
BJH10031	11.6	1.1	1.1	1.2	1.0	2.5	1.4	1.0
BJH10033	10.6	1.1	2.3	1.9	1.0	2.8	1.6	1.1
BJH10034	11.6	1.2	1.4	1.6	1.0	2.3	1.8	1.2
BJH10036/Bolero	11.4	1.3	1.1	1.7	1.0	2.3	1.3	1.0
BJH10039/Fandango	11.3	1.4	2.4	1.2	1.0	2.5	1.9	1.1
BJH10042	11.4	1.4	1.3	1.4	1.0	2.2	1.4	1.0
BJH10043/Merengo	11.3	1.3	1.4	2.0	1.0	2.5	1.8	1.0
BJH10044	11.2	1.1	2.0	1.6	1.0	2.3	2.1	1.0
BJH10045/Waltz	10.8	1.0	1.2	1.9	1.0	2.5	1.6	1.1
Celx767	12.0	1.1	2.7	1.2	1.0	2.5	2.1	1.1
Challenger	11.5	1.1	2.0	1.5	1.0	2.5	2.0	1.1
Command	10.6	0.7	1.8	1.4	1.0	2.5	2.7	1.0
Conquistador	6.6	0.2	2.6	1.1	1.0	3.0	2.6	1.1
Mission	6.8	0.2	2.7	1.1	1.0	2.7	2.8	1.2
RZ2001	10.5	0.6	2.5	1.7	1.0	2.6	1.5	1.1
RZ2002	13.7	1.1	2.9	2.1	1.0	2.8	1.1	1.0
RZ2003	15.9	1.6	2.1	1.9	1.0	2.5	2.0	1.0
Sonora	6.2	0.2	2.5	1.3	1.0	3.0	2.3	1.1
Stix	14.4	1.4	2.6	1.6	1.0	2.8	1.9	1.1
Tall Utah	5.8	0.1	2.7	1.0	1.0	3.0	2.7	1.1
TZ1	12.3	1.3	2.0	1.9	1.0	2.8	2.0	1.0
TZ2	11.9	1.3	3.0	1.4	1.0	2.5	1.3	1.1
TZ3	14.1	1.5	2.4	2.0	1.0	2.5	1.8	1.1
TZ4	11.5	1.0	1.6	1.6	1.0	2.4	2.1	1.0
TZ5	11.5	1.2	2.9	1.8	1.0	2.5	1.6	1.0
TZ6	13.2	1.4	2.2	1.6	1.0	2.8	2.4	1.1
TZ7	11.3	1.1	2.7	1.7	1.0	2.5	2.1	1.0

Average agronomic scores of cultivar entries in the **Santa Maria FOA2 trial 2024**. The table is sorted alphabetically by cultivar name or germplasm code, not by ranking.

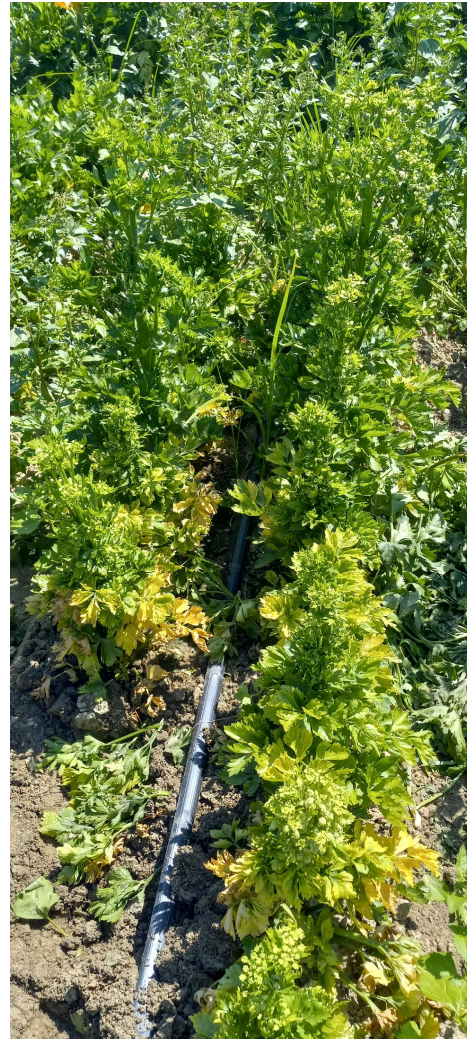
TRAIT	UNITS	METHOD
PETIOLE LENGTH	inches	Petioles were cut at approximately 1-2 inches above the average first petiole node and measured. This trait captured stunting due to disease as well as general agronomic characteristics, and was one of two quantitative measurements.
PLANT WEIGHT	lbs	Ten trimmed plants were weighed to the nearest kg and an average plant weight was calculated. Units were converted to pounds (lbs) for this report. As with petiole length, this trait captured stunting due to disease as well as general agronomic characteristics and was one of two quantitative measurements.
GREENNESS	Score 1-3	This trait describes the color of the stalk. A score of 1 was particularly light or yellow, and a score of 3 was particularly dark. This trait was highly dependent on the individual conducting the scoring and on the light during which the evaluation was made. It could also be highly dependent on nitrogen fertilization, though we assume fertility was consistent among blocks.
PETIOLE CRACKING	Score 1-3	A score of 1 is no cracking at the base, a score of 2 is minor cracking at the base, and a score of 3 is severe cracking at the base.
BOLTING	Score 1-3	A score of 1 indicates no bolting; 2 indicates the beginning of a bolt stalk, 3 indicates active flowering.
PITHINESS	Score 1-3	This trait describes hollow, pithy stems which are common in wild celery or lovage, but a defect in stalk celery. A score of 1 was no observed pithiness at any cut. A score of 2 was a small amount of pithiness in less than half of the stalks. A score of 3 was pithiness in >50% of stalks.
RIBBINESS	Score 1-3	A score of 1 was particularly smooth, and a score of 3 was particularly ribby or rough such that the ribs cast shadows. A score of 2 was intermediate. Ribbiness appeared to increase under disease pressure.
SUCKERING	Score 1-3	A score of 1 had no suckering, 2 had some suckering, and 3 had consistent suckers, similar to wild celery. Suckering seemed to increase with race 4 pressure in some cultivars.

Celery Fusarium race 4

- Symptoms
 - Severe Stunting
 - Root discoloration
 - Plant death

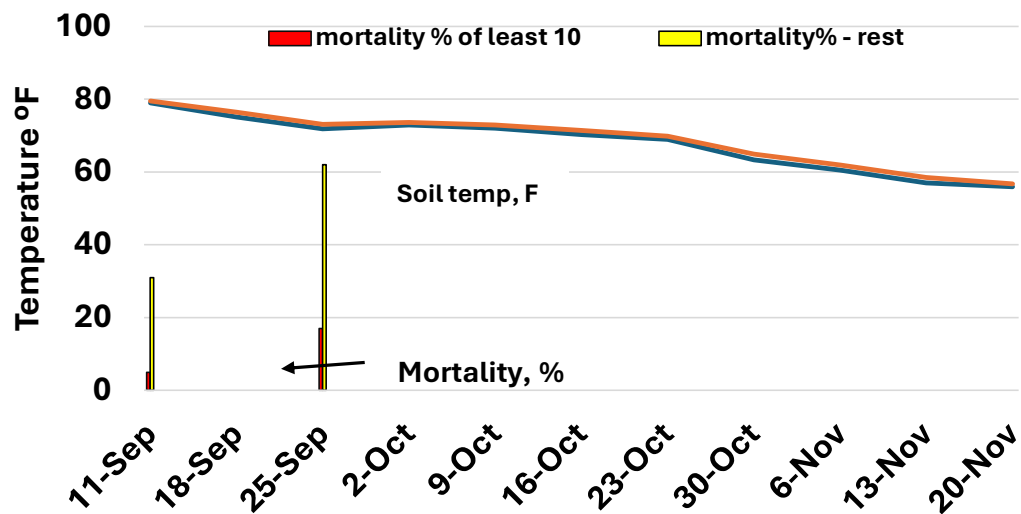


Photo by Daugovish and Valdes-Berriz



Celery Fusarium race 4

- Disease is more virulent when soil temperatures are warm



2022 data courtesy of Daugovich and Valdes-Berriz



Celery Fusarium race 4

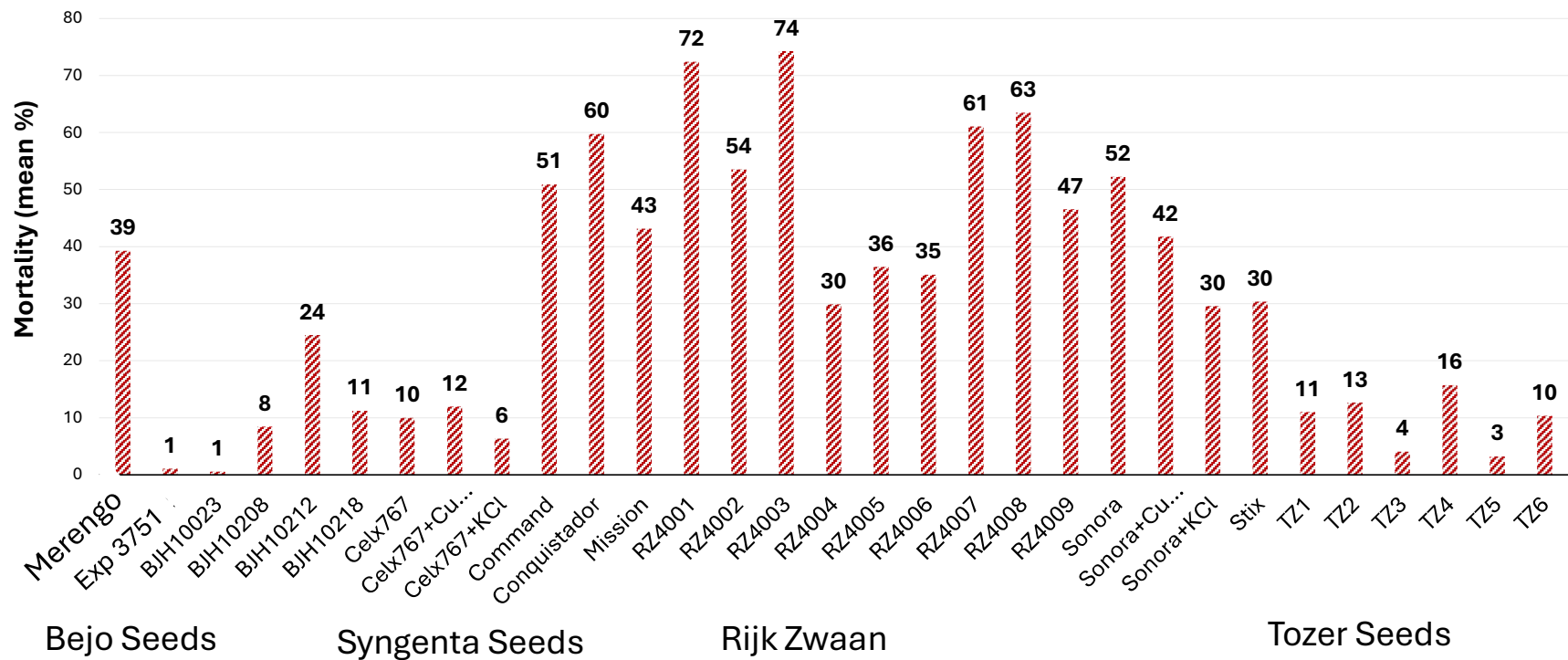
	2022	2023	2024	2025
Seed drop				~ June 9
Transplant	Aug 16	Aug 25	Aug 13	Aug 12
Harvest	Nov 21 + 22	Dec 13 + 15	Dec 5 + 6	

- Seed drop at Plantel Nursery around June 9.
- If interested in contributing, please contact renee.Eriksen@usda.gov or aiputman@ucr.edu or cagreer@ucanr.edu ASAP
- Thanks to Danny Pereira and Rio Farms for providing field space.



Celery Fusarium race 4

Mortality 2024



Data courtesy of Daugovich and Valdes-Berriz

BJH10022 Exp 3751 Bejo Seeds



Celx767 Syngenta Seeds



- Mortality after a heat event

- Photos by Daugovish 9/30/24



TZ1 Tozer Seeds



Mission Syngenta Seeds



SCORE	CRITERIA
0	No browning
1	Browning visible, particularly in feeder roots
2	Browning visible, particularly in primary roots
3	Browning visible, particularly around the crown
4	Browning in and/or around the crown
5	Extensive browning in crown, decay in crown tissue
6	Plant dead or missing due to death

Cultivar	Petiole Length (inches)	Average Plant Weight (lbs)	Ribbiness (score 1-3)	Pithiness (score 1-3)	Bolting (score 1-3)	Greenness (score 1-3)	Suckering (score 1-3)	Petiole Cracking (score 1-3)
BJH10022/Exp 3751	12.5	1.2	2.4	2.3	1.0	2.0	2.7	1.1
BJH10023	11.4	1.3	2.6	1.8	1.0	2.0	2.3	1.0
TZ5	12.0	1.5	3.0	1.3	1.0	3.0	1.2	1.1
TZ3	13.1	2.0	1.7	1.1	1.0	2.9	1.0	1.1
BJH10208	6.7	0.5	3.0	1.0	1.2	2.9	1.5	1.3
TZ6	9.7	0.8	3.0	1.1	1.0	2.8	1.5	1.3
Celx767	12.8	1.4	2.5	1.3	1.0	2.6	2.5	1.2
TZ1	11.6	1.6	2.4	1.1	1.0	2.9	1.2	1.1
BJH10218	8.5	1.1	1.2	1.2	1.0	2.7	1.1	1.2
TZ2	11.3	1.4	2.9	1.5	1.0	3.0	1.2	1.2
TZ4	9.5	1.0	2.6	1.6	1.0	2.6	1.8	1.3
BJH10212	6.0	0.3	2.7	1.0	1.5	2.7	2.0	1.3
Stix	12.9	1.4	2.9	1.3	1.0	2.8	1.5	1.2
RZ4004								
RZ4006								
RZ4005								
BJH10021/Merengo	10.3	1.4	1.5	1.3	1.0	2.8	2.0	1.0
Mission								
RZ4009								
Command	7.5	0.7	3.0	1.0	1.0	3.0	2.2	1.0
Sonora								
RZ4002								
Conquistador								
RZ4007								
RZ4008								
RZ4001								
RZ4003								
Apio21ADS234								
Apio245								
Apio242								
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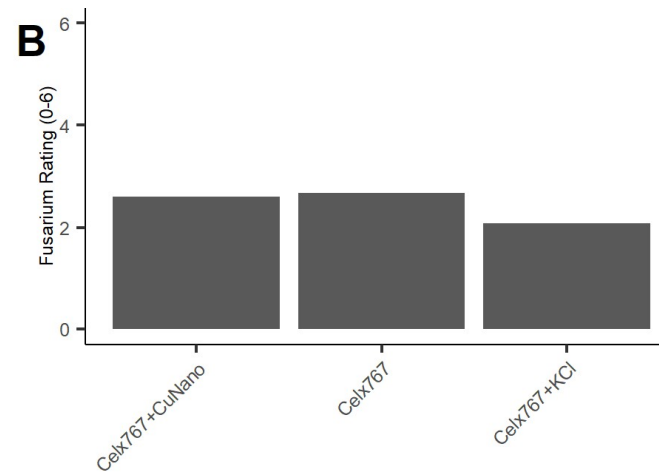
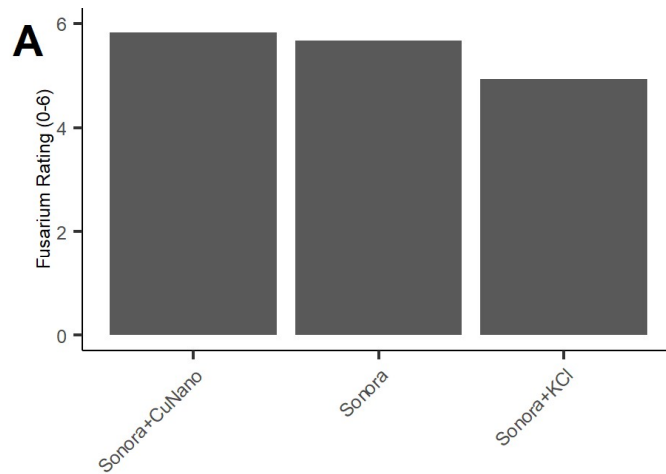
Average agronomic scores of cultivar entries in the **Camarillo FOA4 trial 2024**. Table is sorted alphabetically by cultivar name or code. Blank boxes indicates that too many of the plants were dead to rate.

TRAIT	UNITS	METHOD
PETIOLE LENGTH	inches	Petioles were cut at approximately 1-2 inches above the average first petiole node and measured. This trait captured stunting due to disease as well as general agronomic characteristics, and was one of two quantitative measurements.
PLANT WEIGHT	lbs	Ten trimmed plants were weighed to the nearest kg and an average plant weight was calculated. Units were converted to pounds (lbs) for this report. As with petiole length, this trait captured stunting due to disease as well as general agronomic characteristics and was one of two quantitative measurements.
GREENNESS	Score 1-3	This trait describes the color of the stalk. A score of 1 was particularly light or yellow, and a score of 3 was particularly dark. This trait was highly dependent on the individual conducting the scoring and on the light during which the evaluation was made. It could also be highly dependent on nitrogen fertilization, though we assume fertility was consistent among blocks.
PETIOLE CRACKING	Score 1-3	A score of 1 is no cracking at the base, a score of 2 is minor cracking at the base, and a score of 3 is severe cracking at the base.
BOLTING	Score 1-3	A score of 1 indicates no bolting; 2 indicates the beginning of a bolt stalk, 3 indicates active flowering.
PITHINESS	Score 1-3	This trait describes hollow, pithy stems which are common in wild celery or lovage, but a defect in stalk celery. A score of 1 was no observed pithiness at any cut. A score of 2 was a small amount of pithiness in less than half of the stalks. A score of 3 was pithiness in >50% of stalks.
RIBBINESS	Score 1-3	A score of 1 was particularly smooth, and a score of 3 was particularly ribby or rough such that the ribs cast shadows. A score of 2 was intermediate. Ribbiness appeared to increase under disease pressure.
SUCKERING	Score 1-3	A score of 1 had no suckering, 2 had some suckering, and 3 had consistent suckers, similar to wild celery. Suckering seemed to increase with race 4 pressure in some cultivars.

Germplasm/ Cultivar	Disease Score Less than 2	Mortality Less than 10%	Petiole Length > 10 in	Average Plant Weight >1 lbs	Ribbiness Score < 2	Pithiness Score < 2	Suckering Score < 2
BJH10021/Merengo			X	X	X	X	
BJH10022/Exp 3571	X	X	X	X			
BJH10023	X	X	X	X		X	
BJH10208		X				X	X
BJH10212						X	
BJH10218				X	X	X	X
Celx767		X	X	X		X	
Command						X	
Stix			X	X		X	X
TZ1			X	X		X	X
TZ2	X		X	X		X	X
TZ3	X	X	X	X	X	X	X
TZ4						X	X
TZ5	X	X	X	X		X	X
TZ6		X				X	X

Micronutrient effects

- Copper nanoparticles
- Potassium chloride
- Effect = none



Breeding for Celery Fusarium race 4

- UC Davis release 2022
 - ‘Challenger’ x PI181714
 - PI181714 is available from the USDA Grin Global Germplasm Repository
 - UCDavis lines will soon be available from USDA Grin Global Germplasm
 - 50 seeds each of F1S2 lines 76-8-4, 76-8-27, 76-8-36
 - ~200 seeds of F1S3 line with fixed resistance

Epstein, L. and Kaur, S., 2023. *Apium graveolens* PI 181714 Is a Source of Resistance to *Fusarium oxysporum* f. sp. *apii* Race 4 in Celery (*A. graveolens* Var. *dulce*). *Plant Breeding*, 142(1), pp.109-117.



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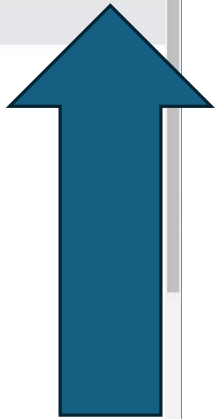
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celery Search



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USDA Celery Breeding program

- Began 2021
- 2023 – Included UCD lines in in Camarillo FOA4 field trial
 - Disease scores were 0-1, very low
 - Selections taken for celery morphology
- 2024 - Selections were self-pollinated or backcrossed
- 2025 – Selections will be grown in the Santa Maria and Camarillo field trials



Acknowledgements

- Funding and Support
 - California Celery Research Advisory Board
- Field and Harvest Help
 - Maripaula Valdes-Berriz, Xiomara Zendejas, and Gina Ferrari (UC ANR); Michelle Soule (USDA-ARS)
- Trial Entry Contributions
 - Pete Compton (Bejo Seeds), Merek Dorf (Rijk Zwaan), Seed Savers Exchange, Alex Quiroz (Syngenta Seeds); and Rick Gracia, Kraig Kuykendall, and Sara Jennings (Tozer Seeds)
 - Transplant production and provided a crew and transplanter for Santa Maria trial - Chris Waldron (Plantel Nursery)
 - Betteravia Farms and Jake Azevedo for hosting and managing Santa Maria trial
 - Rio Farms and Danny Pereira for hosting and managing Camarillo trial and providing planting crew
 - Pete Compton and Josue Mejia for coordinating the transplanting crew in Santa Maria
 - Richard Hurstak - advice and protocols