Lettuce Fusarium Wilt

Santosh Nayak
Postdoctoral Researcher
USDA-ARS, Salinas, CA

December 5, 2023
2023 Pest Management Meeting

Outline

- Introduction
- Characterization of Fusarium isolates
- An update on USDA breeding efforts
- Conclusion

Introduction to Fusarium

- *Fusarium* spp. is one of the most abundant microorganism in soil
- Approximately 70% are *F. oxysporum*
  - Within *F. oxysporum*, there are >100 different **formae specialis** (f. sp.)

    (f.sp. = sub-species categorization based on pathogenicity and host range)
  - In 1960's, banana industry devasted by Fusarium wilt caused by *F. oxysporum* f.sp. *cubense* (Panama disease)
- In Lettuce, Fusarium wilt is caused by *F. oxysporum* f. sp. *lactucae* (FOL)

Symptoms

Varies based on the cultivar's susceptibility, inoculum density, and environment.

- ❖ <u>Above ground symptoms</u>
  - ➢ Stunting and deformation of head
  - ➢ Chlorosis (yellowing) and necrosis of leaves
  - ➢ Wilting
  - ➢ Plant death

- ❖ <u>Below ground symptoms</u>
  - ➢ Reddish-brown discoloration of root
  - ➢ Complete rotting of root in severe case

History and Distribution of FOL

- History
  - First detected in Japan (1955)
  - In USA first identified in California (1990), later found in Arizona (2001), and Florida (2017)

- Distribution of FOL
  - Race 1 - Worldwide distribution
  - Race 2 – Japan
  - Race 3 - Japan, Taiwan
  - Race 4 - Several European countries

- In the United States only race 1 reported to date
  - Changes in FOL incidence and severity have recently experienced

Characterization of Fusarium Isolates

- **Fol321**
- **Fol621**

Recovered from infected lettuce of two different fields in Salinas

- **Fol621s**

Single spore culture of Fol621

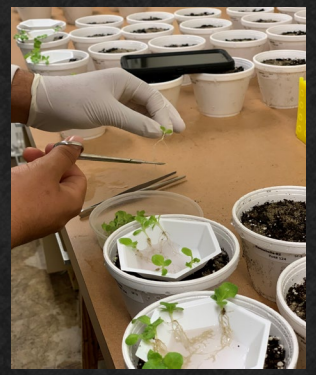
- **916**
- **794**

Received from Alex Putman, UC Riverside

Pathogenicity Test: Root Dip Inoculation

Grow seedlings in pasteurized sand

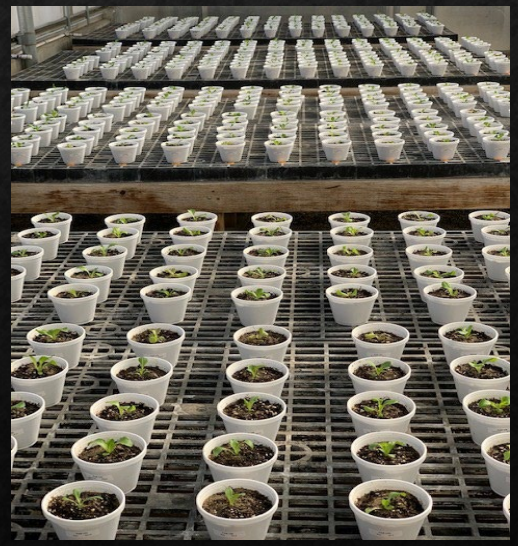
14 to 18 days old seedlings



Trim root ~ 5 mm

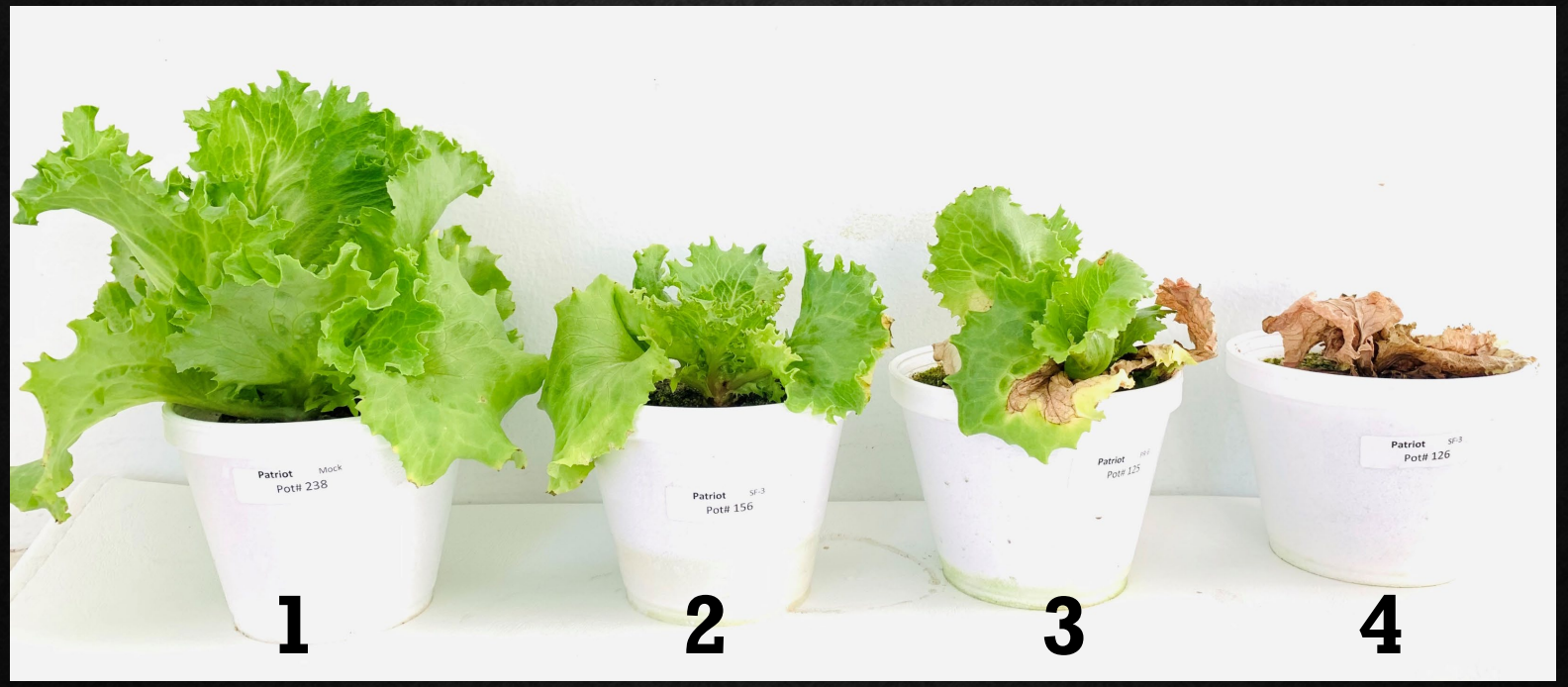
Dip root for 20 min
(Treatments: FOL isolates and Mock)

Transplant in cups filled with pasteurized potting mix



Greenhouse / growth room
(25 °C / 16 h photoperiod)

Disease Rating



Courtesy: Santosh Nayak

1= No symptom

2 = Mild stunting

3 = Stunting and some leaf yellowing and/or necrosis

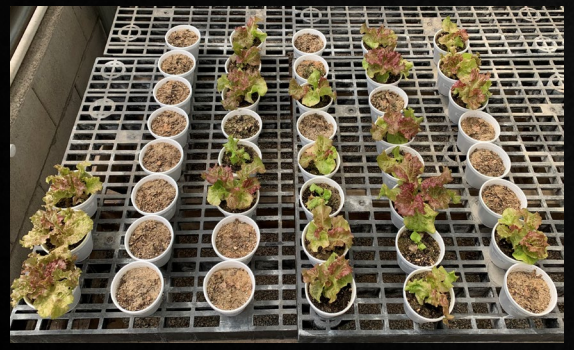
4 = Dead plant

Race Identification of FOL Isolates

	Observed reaction					Expected reaction			
Cultivar	Fol321	Fol621	Fol621s	916	794	Race 1	Race 2	Race 3	Race 4
Banchu Red Fire	3.4	1.8	2.5	2.7	3.0	S	HR	S	IR
Costa Rica no. 4	1	1	1	3.7	1	HR	S	S	S
Patriot	4	4	4	4	4	S	S	S	IR
Romabella	1	1	1	1	1	HR	HR	S	IR

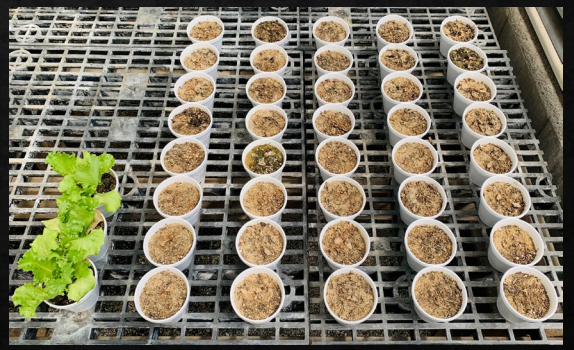
- Fol321 and 794: **Race 1**
- Fol621/621s and 916: **(Likely variant/novel races)**

Banchu Red Fire



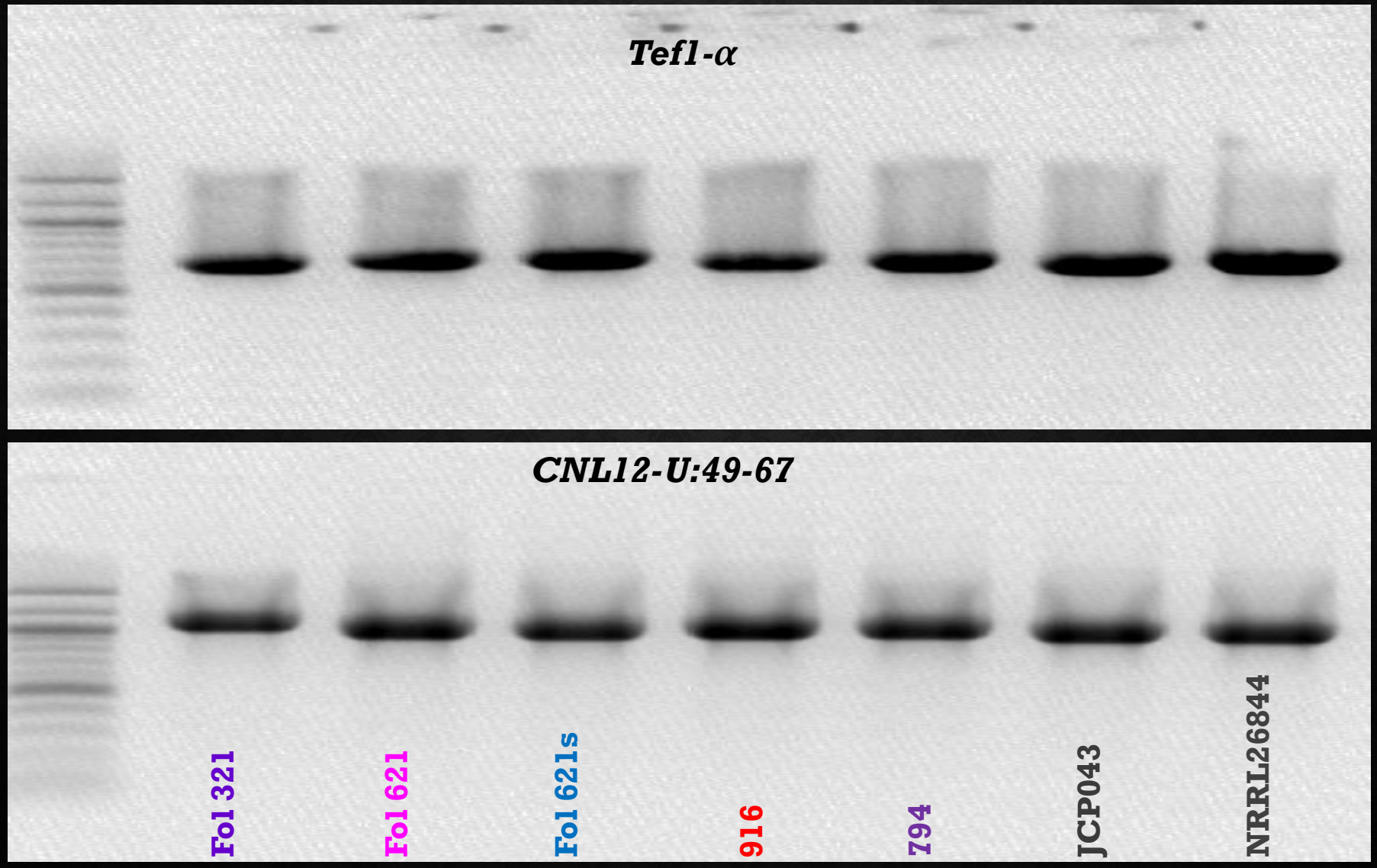
Costa Rica No. 4

Patriot

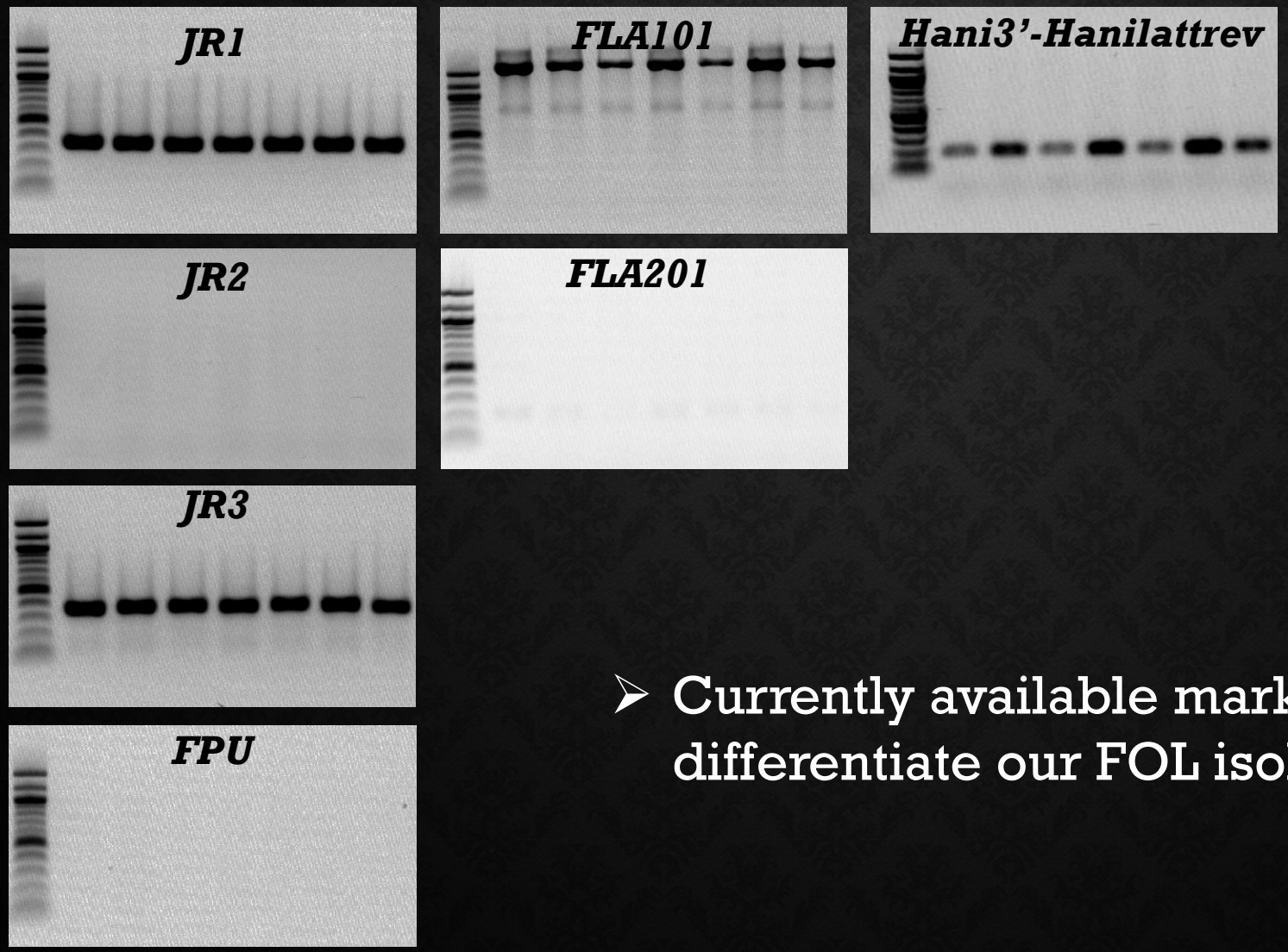


Romabella

Molecular Analysis of FOL Isolates



Molecular Analysis of FOL Isolates



TaqMan qPCR assay – Race 1	
Sample	Ave. Ct value
Fol321	29.36
Fol621	27.82
Fol621s	28.42
916	28.15
794	26.80
JCP043	27.51
NRRL 26844	29.28
Water control	not detectable

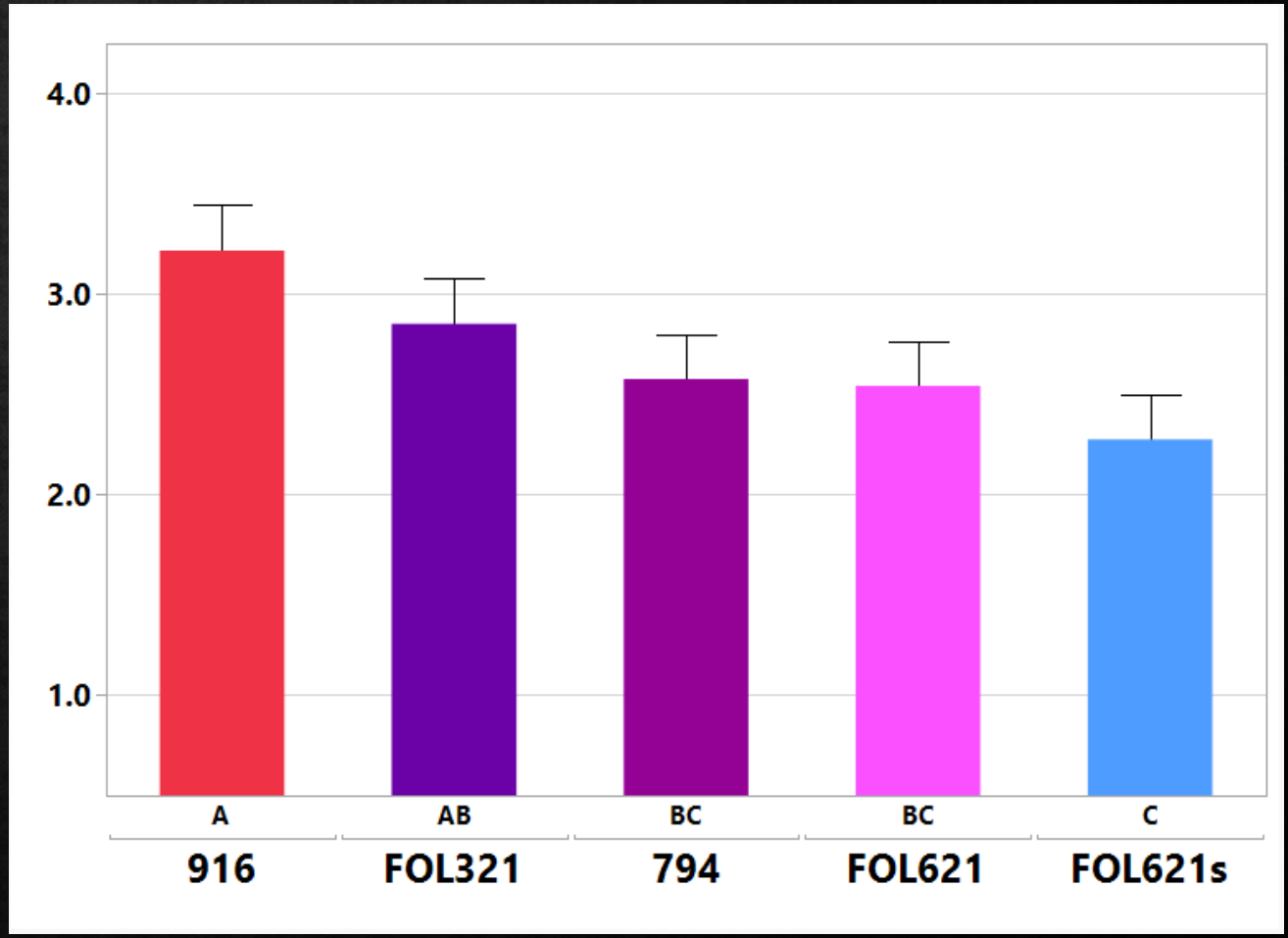
Ningxiao Li and Frank Martin

- Currently available marker system can not differentiate our FOL isolates.

Aggressiveness of FOL Isolates

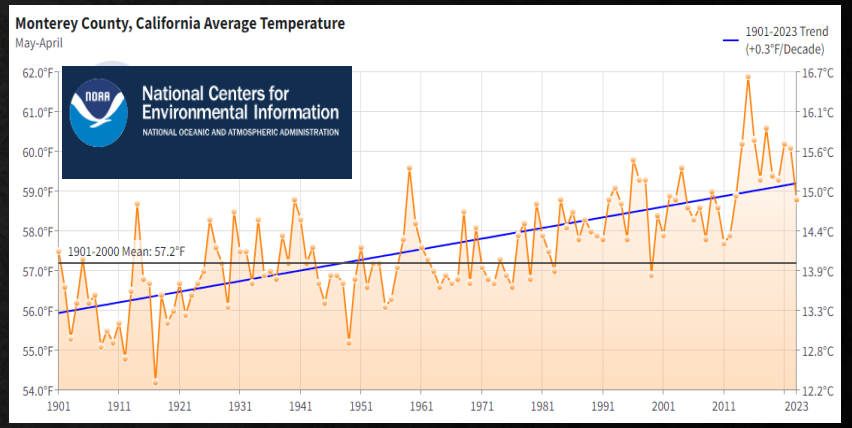
- Ranked isolates based on disease severity of 9 cultivars across two experiments

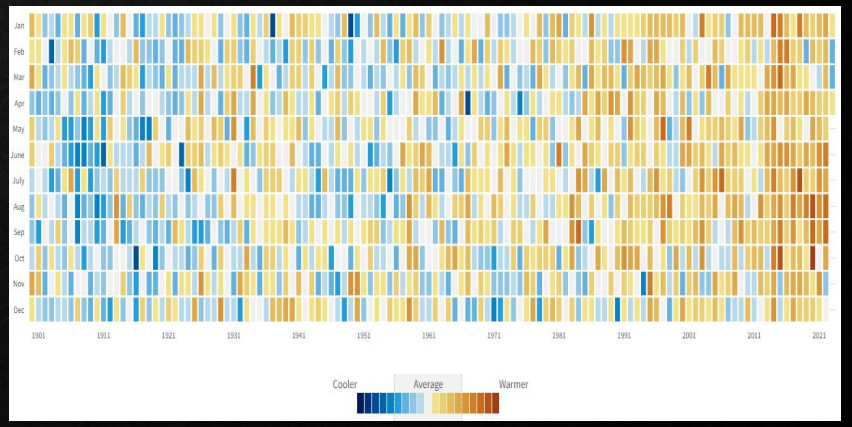
- **916 is highly** aggressive and race-1 resistant breaking



Challenges

- Lettuce growers may need to deal with multiple variants/races of FOL
  - Distribution of variant races of FOL is not fully understood
- Changes in weather pattern
  - Warmer air and soil temperature favor Fusarium infection
- Germplasm with broad-spectrum resistance is currently unknown





USDA Breeding Efforts

- Germplasm evaluation and development of mapping populations for genetic studies of broad-spectrum resistance

- Evaluating Race-1 resistant breeding lines (King Louie × Autumn Gold) under multiple isolates
  - 15631
  - 15632
  - 15633
  - 15634
  - 15669
  - 15670

USDA Breeding Efforts

Variety	Fol321								Fol621						Fol621s					794			916			JCP043
	Sep22 GH	Sep22 GR	Oct22 GH	Oct22 GR	Jan23 GH	May23 GH	Jul23 GH	Aug23 GH	Oct22 GH	Oct22 GR	Jan23 GH	May23 GH	Jul23 GH	Aug23 GH	Sept22 GH	Sept22 GR	May23 GH	Jul23 GH	Aug23 GH	May23 GH	Jul23 GH	Aug23 GH	May23 GH	Jul23 GH	Aug23 GH	Aug23 GH
22-101 (Primo)	3	4	2.5	4	3	2.5	4	-	2.5	4	2	3	2.5	-	1	3.5	1	2.5	-	1.5	2	-	4	4	-	-
22-105 (San Miguel)	4	4	4	4	4	4	4	-	4	4	4	4	4	-	4	4	4	4	-	4	4	-	2	1.5	-	-
22-102	2	4	3.5	4	3	-	-	-	1	3.5	4	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-
22-103	4	4	4	4	4	-	-	-	2	2.5	4	-	-	-	4	4	-	-	-	-	-	-	-	-	-	-
22-104	3	4	3.5	4	4	-	-	-	1	2.5	2.5	-	-	-	4	4	-	-	-	-	-	-	-	-	-	-
22-106	4	4	4	4	4	-	-	-	3.5	4	4	-	-	-	4	4	-	-	-	-	-	-	-	-	-	-
22-107	2	4	1.5	3.5	2.5	-	-	-	1	1.5	1	-	-	-	2	3.5	-	-	-	-	-	-	-	-	-	-
Grizzly	4	4	4	4	4	4	4	-	4	4	4	4	4	-	4	4	3	4	-	4	4	-	4	4	-	-
Blas	1	4	1	1	1	-	-	-	1	1	2	-	-	-	1	4	-	-	-	-	-	-	-	-	-	-
El Guapo	2	4	4	4	4	-	-	-	2	3.5	4	-	-	-	4	4	-	-	-	-	-	-	-	-	-	-
Tamarack	3	4	4	4	3	-	-	-	4	4	3.5	-	-	-	4	4	-	-	-	-	-	-	-	-	-	-
Ballerina	-	-	4	4	4	-	-	-	4	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lomeria	-	-	4	3	4	-	-	-	1	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gisela	-	-	4	4	4	-	-	-	4	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Palmos	-	-	1	1	1	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eruption	-	-	3.5	-	3	4	4	-	2	-	1	4	2	-	-	-	1.5	2	-	4	4	-	4	3.5	2	2
PI 171674	-	-	4	-	2.5	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salinas	-	-	2.5	-	2.5	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reine des Glaces	-	-	1	-	1	1	1	-	1	-	1	1	1	-	-	-	1	1	-	1	1	-	4	4	3	1
Patriot	4	4	4	4	4	4	4	3.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3
Banchu Red Fire	2	4	4	4	3	3	4	-	2	1.5	1	1.5	3	-	2	4	1	3	-	3	3	-	4	2	2	1
Romabella	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Costa Rica no. 4	1	1	1	1	1	1	1	-	1	1	1	1	1	-	1	1	1	1	-	1	1	-	4	4	3	1
River Green	-	-	-	-	-	-	-	1.5	-	-	-	-	-	2	-	-	-	-	2	-	-	3	-	-	4	2
King Louie	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-	-	1	1
15631	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-	-	2.5	1
15632	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-	-	1	1
15633	-	-	-	-	-	-	-	1.5	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-	-	1	1
15634	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-	-	1.5	1
15669	-	-	-	-	-	-	-	1.5	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-	-	1	1
15670	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-	1.5	-	-	1	1

River Green

15631

15634

King Louie

15632

15669

Patriot

Mock | Fol 321 | Fol 621 | Fol 621s | 916 | 794 | JCP 043

15633

Mock | Fol 321 | Fol 621 | Fol 621s | 916 | 794 | JCP 043

15670

Mock | Fol 321 | Fol 621 | Fol 621s | 916 | 794 | JCP 043

Conclusion

- Fol321 and 794 (race 1), but Fol621 and 916 (likely variant/novel races)
- Currently available marker system is not effective to determine physiological race of tested isolates
- More studies needed to characterize difference at molecular level in relation to host-pathogen interactions
- Evaluating germplasm and developing resistant breeding lines

Acknowledgements

Dr. Kelley Richardson

Dr. Jim McCreight

Dr. Ningxiao Li

Dr. Frank Martin

Dr. Nick LeBlanc

Dr. Alex Putman

Jose Orozco

Patti Fashing

Jewel Henry

David Saavedra

Lorraine Meza


Thank you!