Anaerobic Soil Disinfestation (ASD) and Non-fumigant Integrated Soil-borne Disease Management in Strawberries

UCCE Fumigants and Non-Fumigant Alternatives Meeting
May 19, 2023

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Anaerobic Soil Disinfestation (ASD)

Also known as…

- Biological Soil Disinfestation (BSD)
- Reductive Soil Disinfestation (RSD)

~2000: Developed as alternative to methyl bromide fumigation in Netherlands and Japan independently
2002- : Optimizing ASD for CA strawberries

Principles

- Acid fermentation in anaerobic soil
- Integration of **solarization** and **flooding** for places where either practice is not effective or feasible

(Van Bruggen, 2014)

(Chiba prefecture, 2002)

2022: **~2,400 acres treated by ASD in CA** (mainly organic berries representing 30-40% of organic strawberries and 4-5% of total strawberry acreages in CA)

ASD research in CA, FL, TN, NC, WA, OR, OH, PA, SC, MI, and VA in the US, and in the Netherlands, Japan, China, Italy, Spain, Mexico, Argentina, Sri Lanka, and Nepal for strawberries, vegetables (greenhouses and open fields), tree nuts and fruits, and nurseries

ASD: Three Steps

1.Incorporate organic material

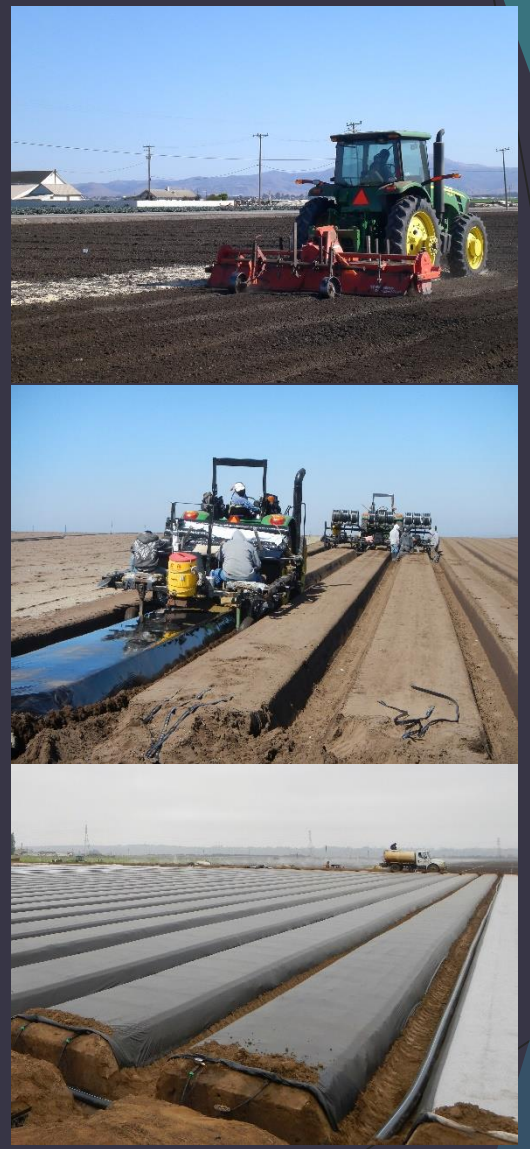
- Provides C source for soil microbes (rice bran 6-9 T/A in coastal CA)

2.Cover with oxygen impermeable tarp

- Limit the gas exchange and oxygen supply

3.Irrigate to saturation -NOT FLOODING- and maintain the fermentation process for 3 weeks

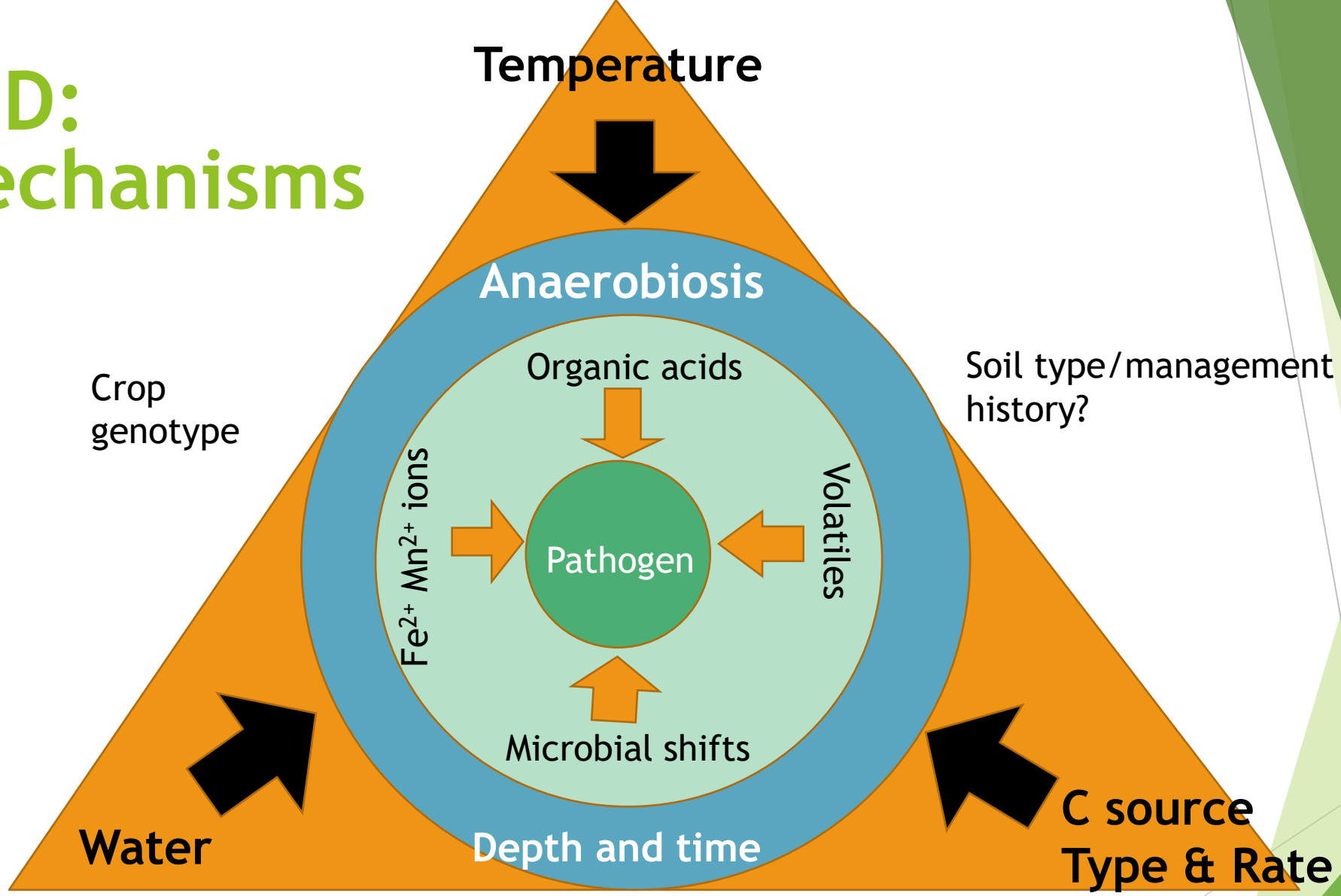
- Maintain above the field capacity
- Create anaerobic conditions and stimulate anaerobic decomposition of incorporated organic material



Open field in CA

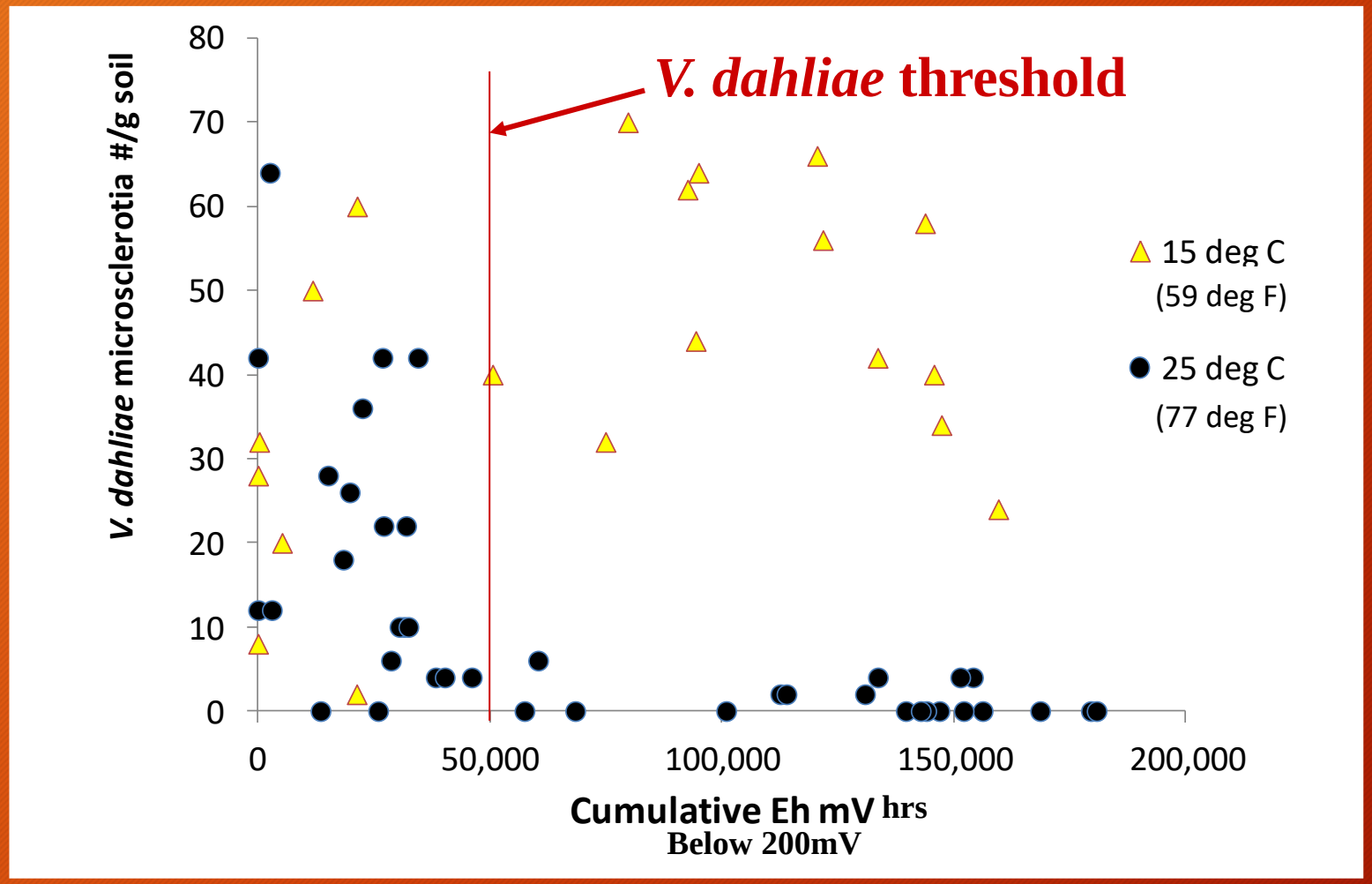
High tunnel in PA

ASD: Mechanisms



ASD Management Triangle (Shennan et al, 2014)

Level of Anaerobicity and Temperature Matter in ASD



(Shennan et al., 2018, Plant Path.)

Thresholds to control soilborne pathogens in strawberries by ASD

Environmental threshold	*Verticillium dahliae*	*Fusarium oxysporum*	*Macrophomina phaseolina*
Cumulative Eh < 200 mV (mV hrs)	50,000 mV hrs (Shennan et al, 2018)	100,000 mV hrs (Henry et al, 2020)	To be developed
Soil temperature (20 cm depth)	[> ~68 °F]	>467 hrs above 86 °F (Muramoto et al, 2020)	To be developed

Fall ASD

Summer ASD

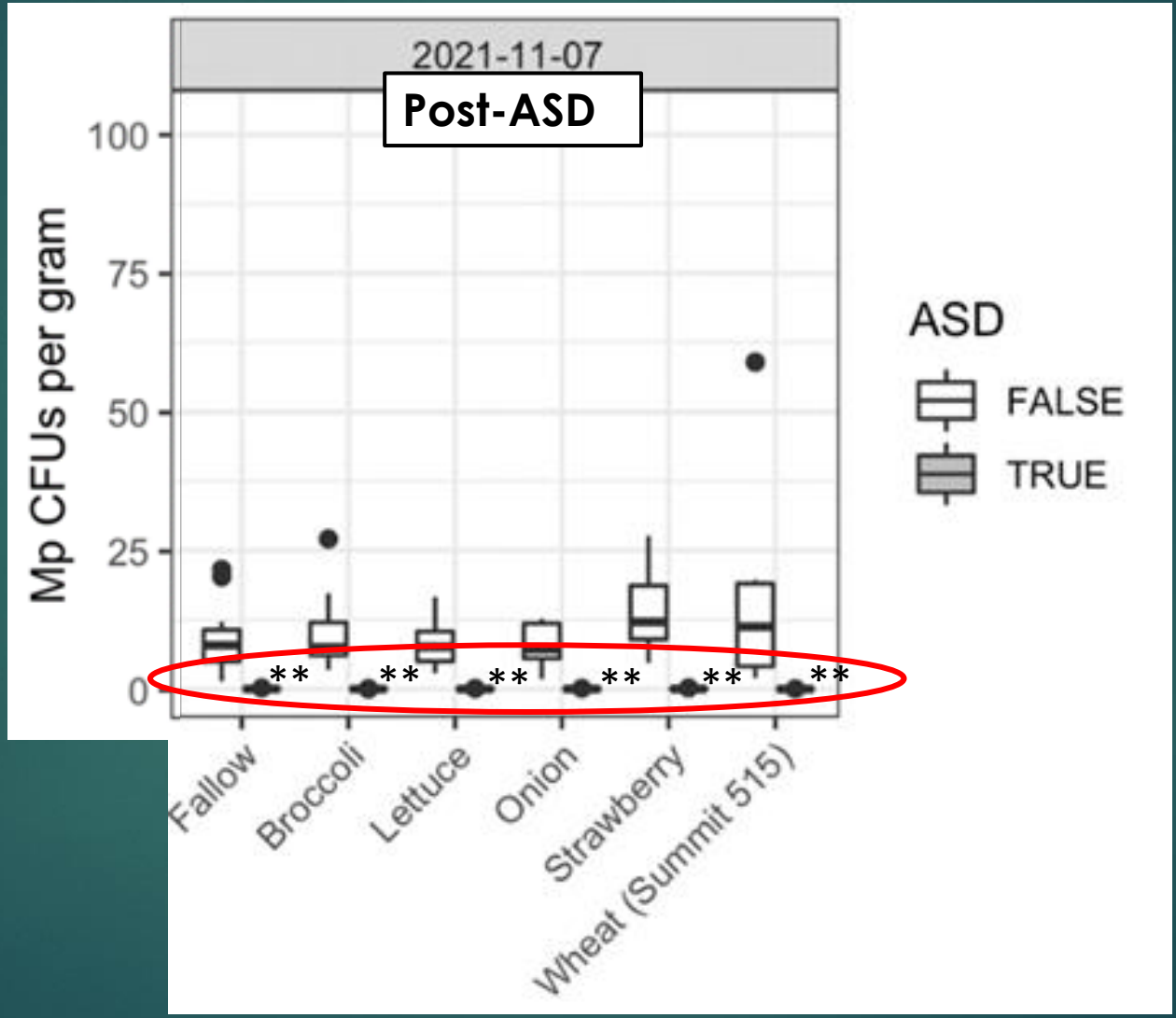
Caution: Don't Use Fall-ASD at Fusarium oxysporum infested fields! Use summer-ASD!!

UTC

ASD Summer
RB 9t/ac

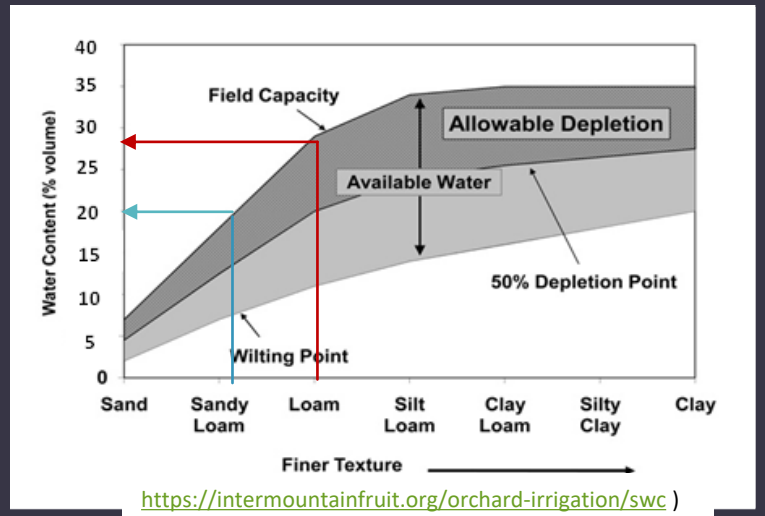
ASD Fall
RB 9t/ac

Effect of ASD on *Macrophomina phaseolina* (*Mp*) population in the soil

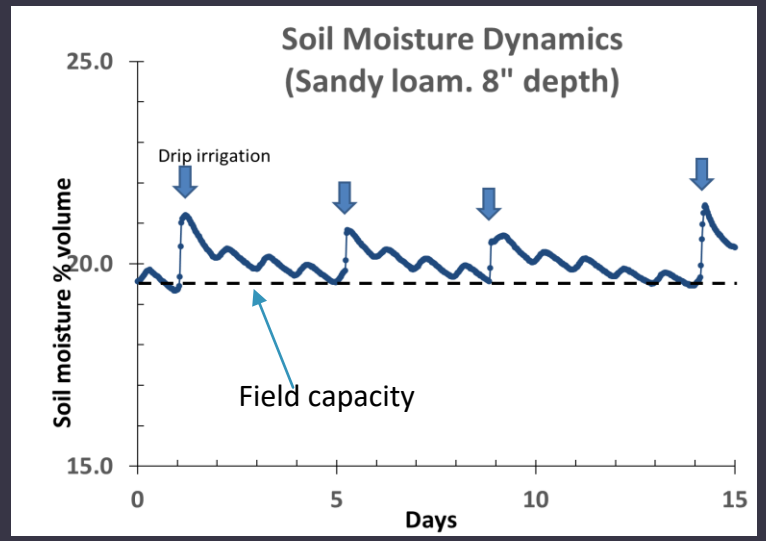


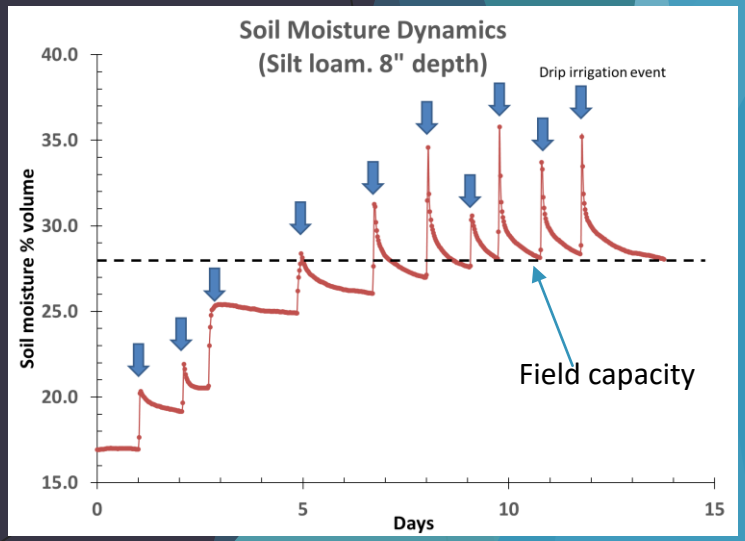
ASD: Key Practices

- Goal: **Rice bran incorporation**, bed listing, drip tape/multi application, and **the first irrigation** (1-acre inch) **within 2-3 days** (the shorter the better)
  - < 5 acres block at a time
- Clay soil requires more water than loamy and sandy soil to create anaerobic condition
  - Apply rice bran when the soil moisture is ready for bed listing
- Monitor soil Eh with ORP sensors (Contact me for more details!)



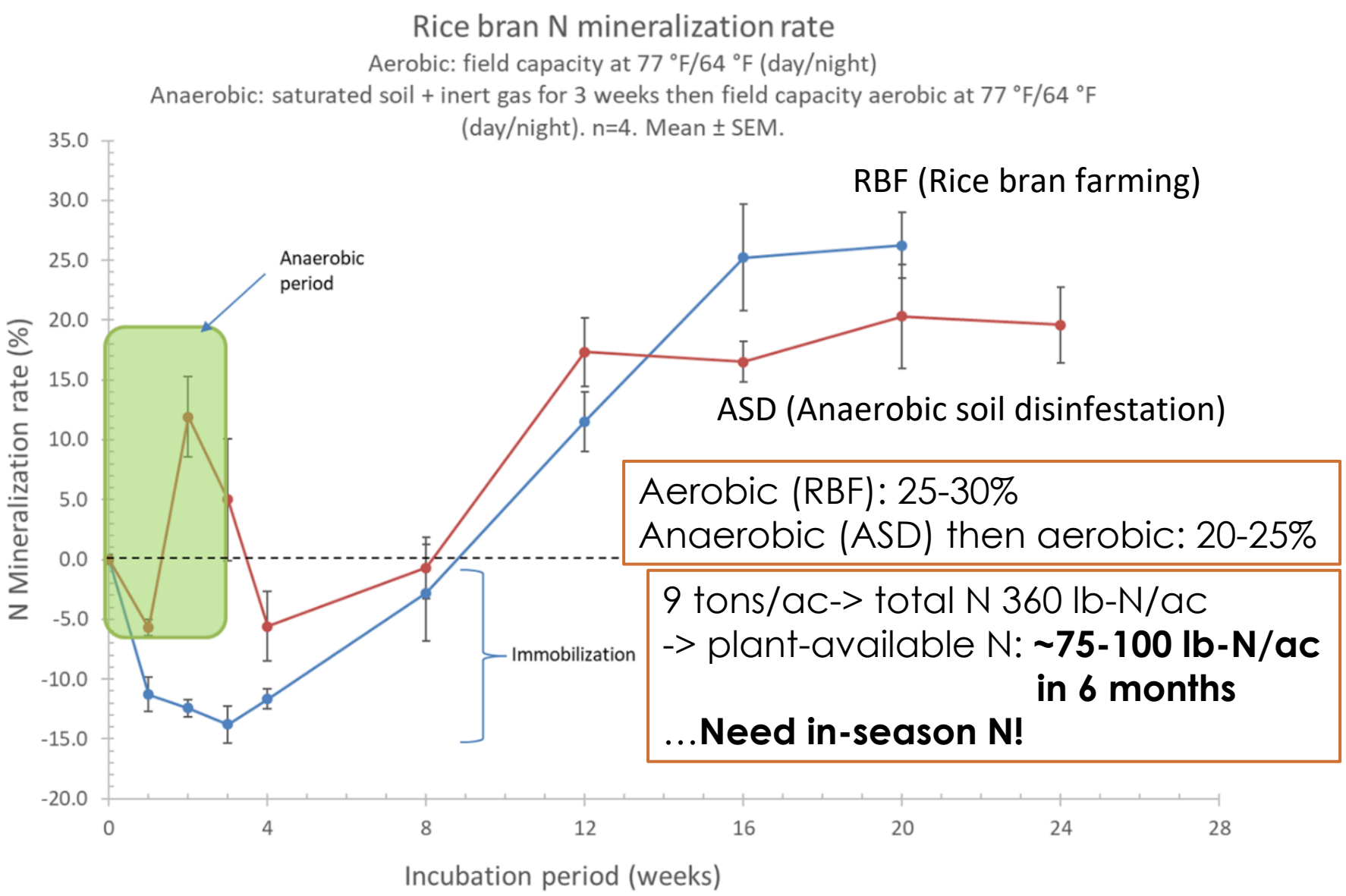
https://intermountainfruit.org/orchard-irrigation/swc)





N MINERALIZATION FROM RICE BRAN

(N: 2%, P_2O_5: 3%, K_2O: 1%, CN: 20)



Aerobic (RBF): 25-30%
Anaerobic (ASD) then aerobic: 20-25%

9 tons/ac-> total N 360 lb-N/ac
-> plant-available N: **~75-100 lb-N/ac in 6 months**
…**Need in-season N!**

Integrated Soil-borne Disease Management in Organic Systems

- Use ASD as a part of integrated soilborne disease management
- Should be integrated with
  - Sanitation and prevention (washing equipment, using clean plant stocks)
  - Disease identification (molecular approach)
  - Host resistance (use of resistant or tolerant cultivars)
  - Crop rotation (Fusarium and Macrophomina: minimum 2-3 year break; Verticillium: avoid host plants)

Verticillium dahliae; Host Crops vs. Non-host Crops

- Host crops

  cane berry (raspberry, blackberry), blueberry, artichoke, cucumber, watermelon, pumpkin, mint, eggplant, lettuce, pepper, potato, spinach, tomato

- Non-host crops

  cauliflower, cabbage, celery, parsley, radicchio, onion, garlic, carrot, sweet potato, asparagus

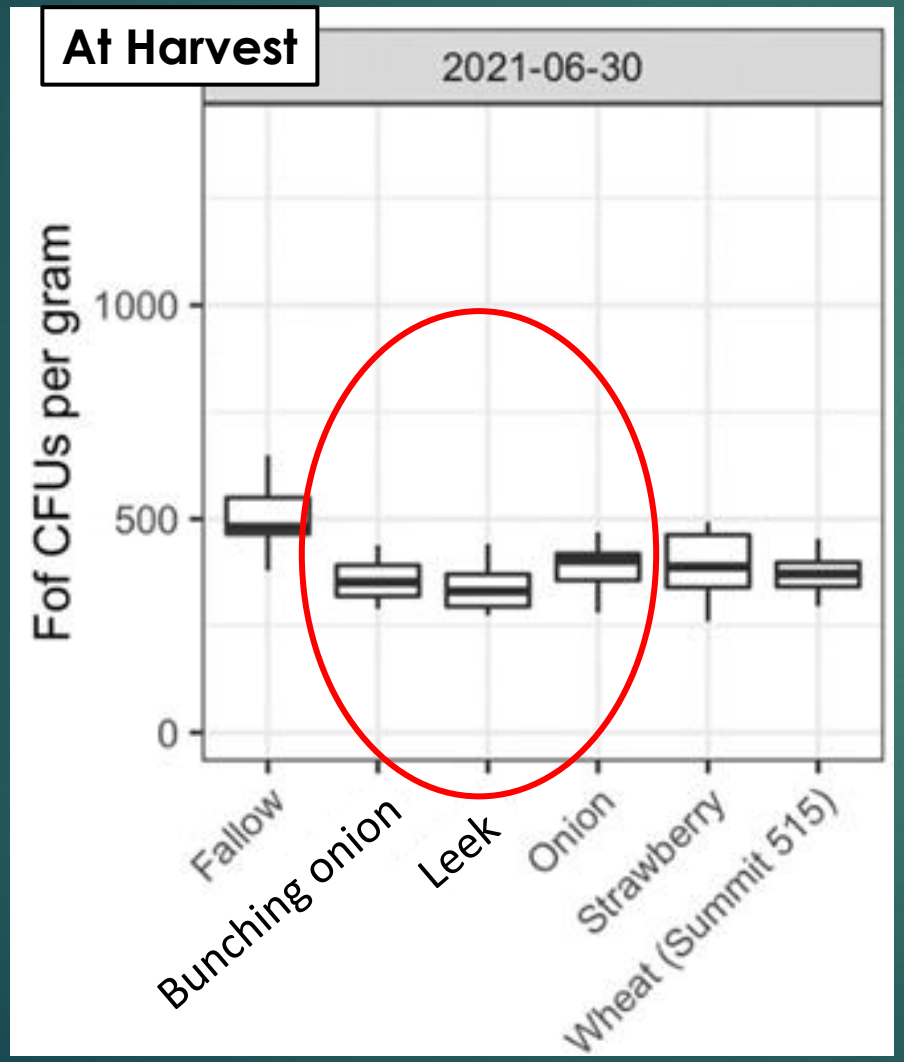
- Suppressive crop

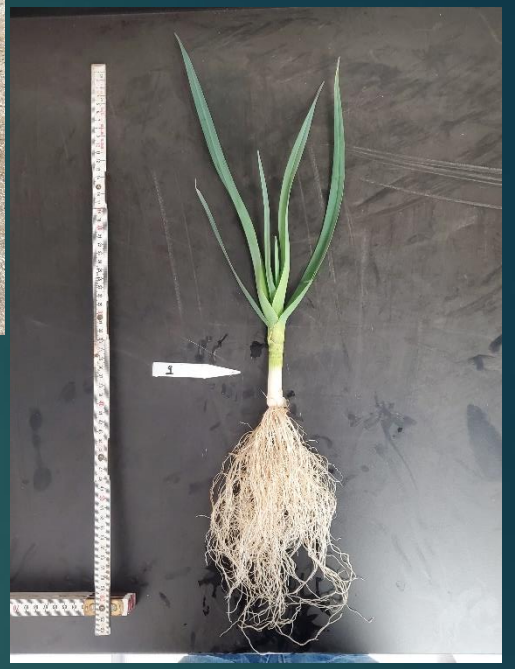
  broccoli

Fusarium wilt suppression by Allium crops

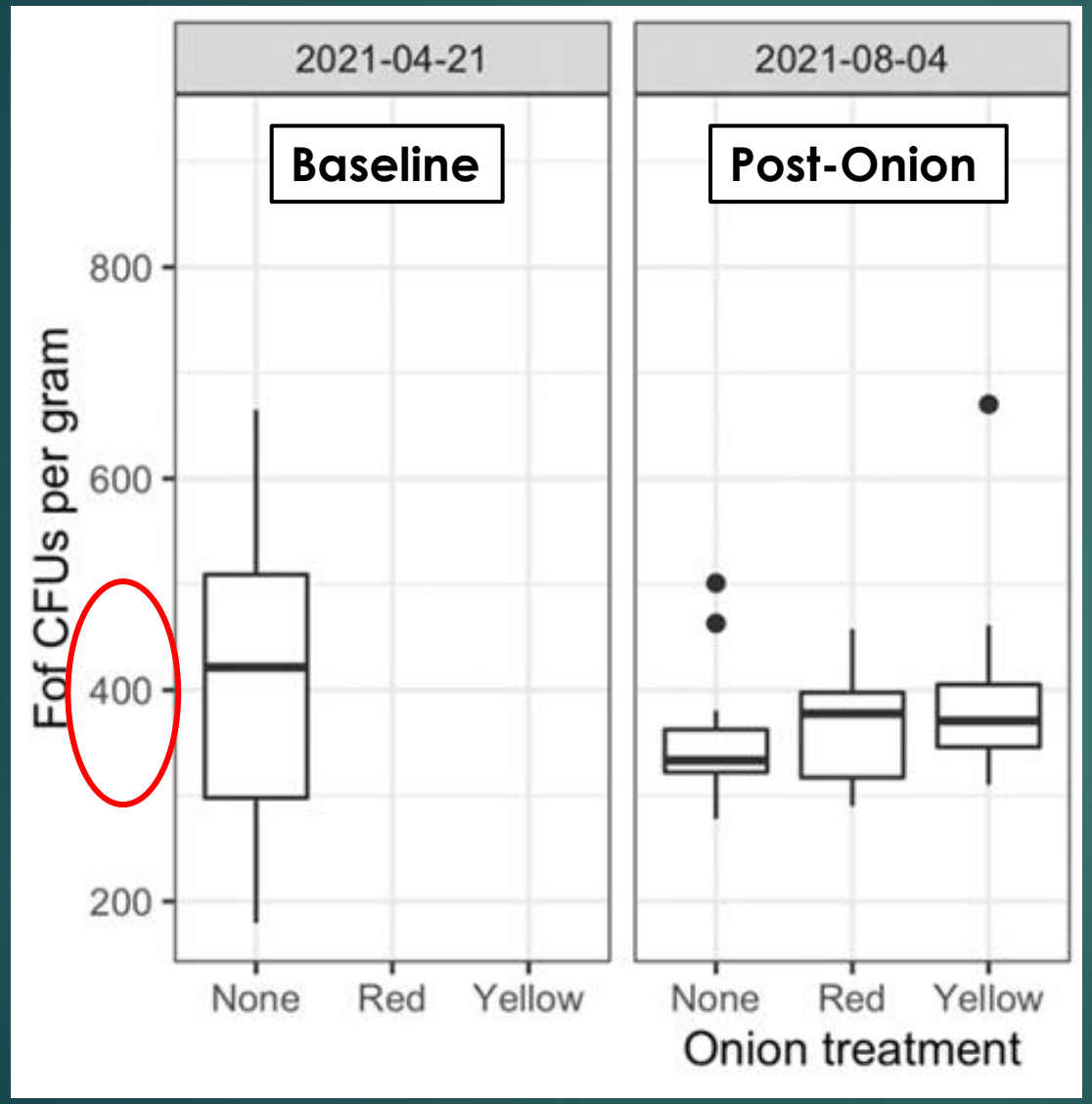
- Asian studies showed Fusarium wilt suppression by onions, leaks, etc.
- Allium roots -> gamma-Glutamyl-S-allylcysteine -> *Flavobacterium* --> *Fusarium wilt suppression*
- *Research Project in CA (2020-2024)*
  - *Onion as a rotational crop*
  - *Onion as a cover crop*
  - *Co-planting strawberry and bunch onion*

Effect of growing alliums and other crops (April-June 2021) on the *Fusarium oxysporum* f. sp. *fragariae* (*Fof*) population in the soil

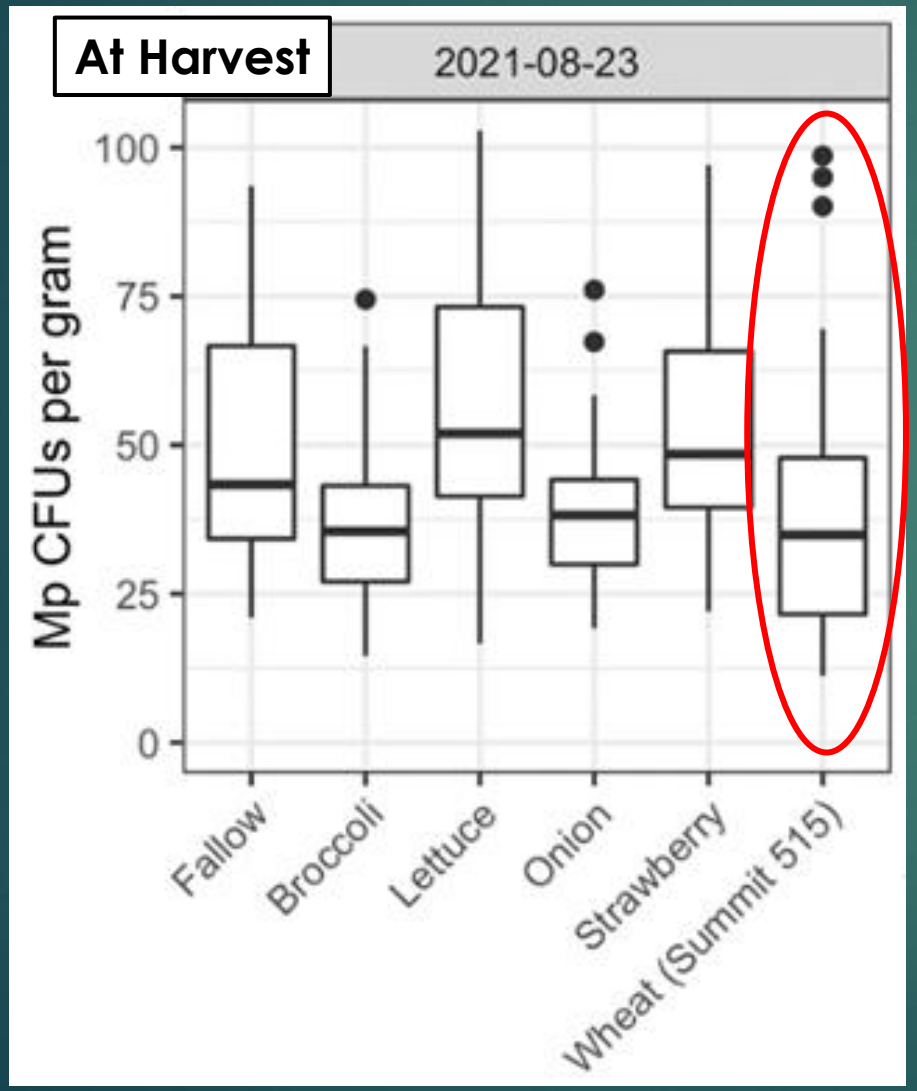




Effect of growing red and yellow onions on the *Fusarium oxysporum* f. sp. *fragariae* (*Fof*) population in the soil

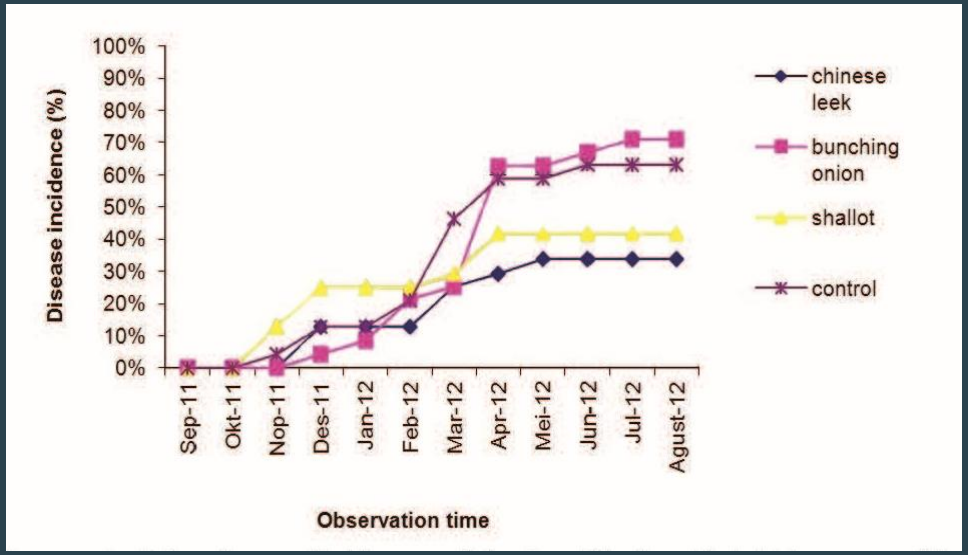


Effect of growing wheat (Summit 515) and other crops (June-Aug 2021) on *Macrophomina phaseolina* (Mp) population in the soil



Next Steps

- Pot trials for Fof and Mp have been repeated (results pending)
- Explore other alliums
  - Chinese leak (Li et al. 2020; Zhang et al. 2020), Shallot?



Wibowo et al. 2015

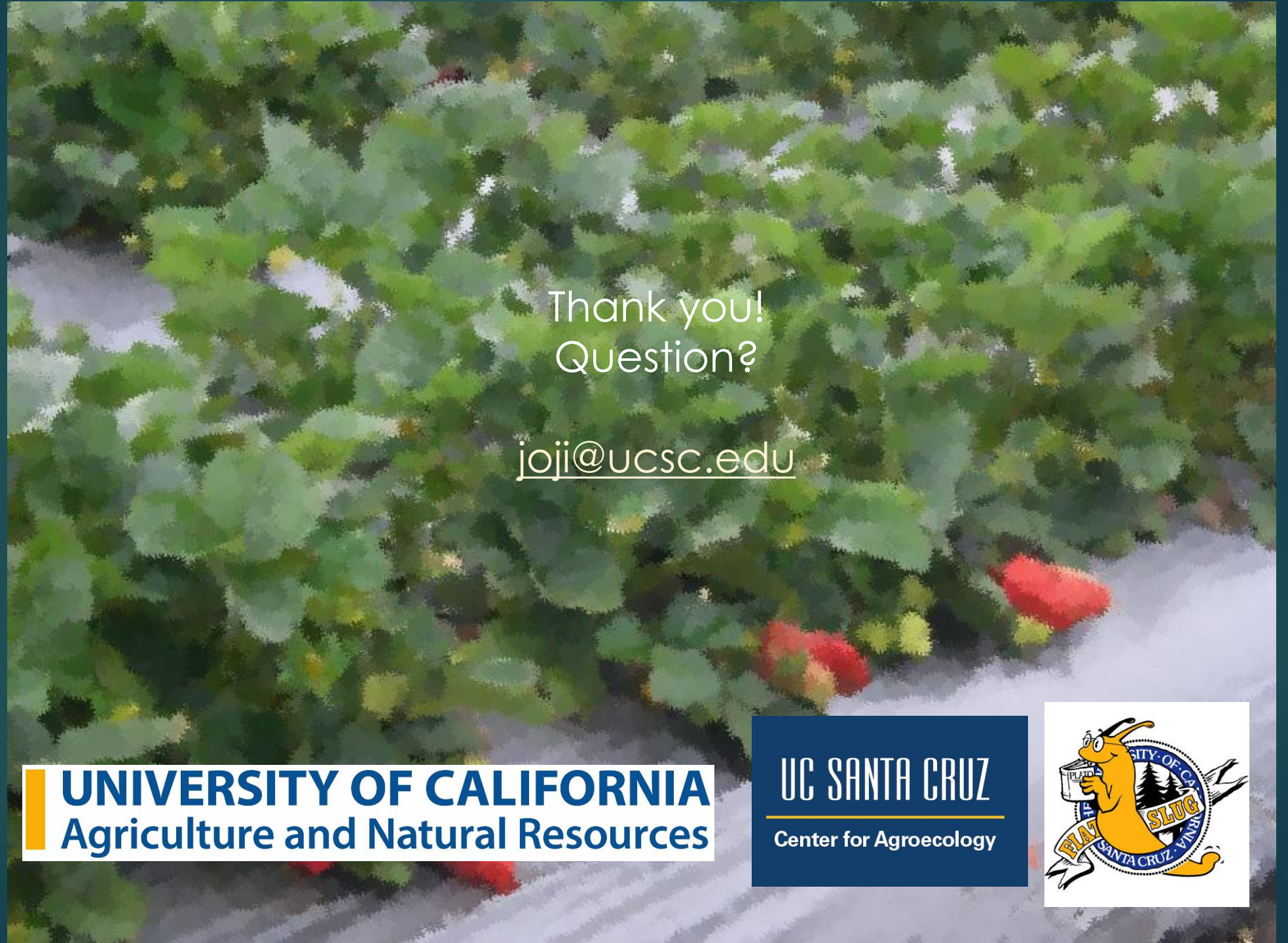
- Demonstration trials for *Macrophomina* control by ASD: Watsonville/Salinas and Oxnard in Summer 2023

Acknowledgements

- USDA-Methyl Bromide Transition Grants 2020-51102-32955
- Miguel and Irene Ramos, Ramos Farms
- Peter Henry, Polly Goldman, USDA-ARS, Salinas
- Darryl Wong, Jan Perez, Center for Agroecology, UCSC
- Oleg Daugovish, Mark Bolda, Chris Greer, UCCE
- Rachael Goodhue, UCD
- Carol Shennan, Clara Qin, Margherita Zavatta, Students and volunteers, Dept. Environmental Studies, UCSC

USDA NIFA

United States Department of Agriculture
National Institute of Food and Agriculture



Thank you!
Question?

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