Anaerobic Soil Disinfestation (ASD): Suppressing *Macrophomina phaseolina* in Organic Strawberries

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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
- Integrating principles of **solarization** and **flooding** for creating a fermentation process in the soil to suppress soilborne pathogens and weeds in places where either practice is not effective or feasible

(Van Bruggen, 2014)

(Chiba prefecture, 2002)

ASD has been adopted in California organic strawberries at commercial scale

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

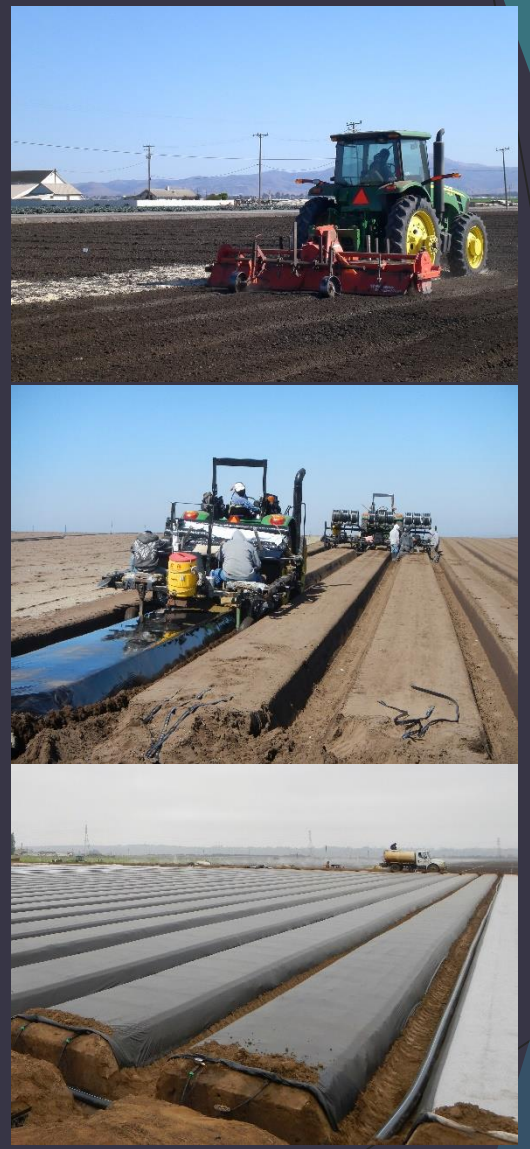
- Provides C source for soil microbes (rice bran 6-9 T/A in coastal CA)

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

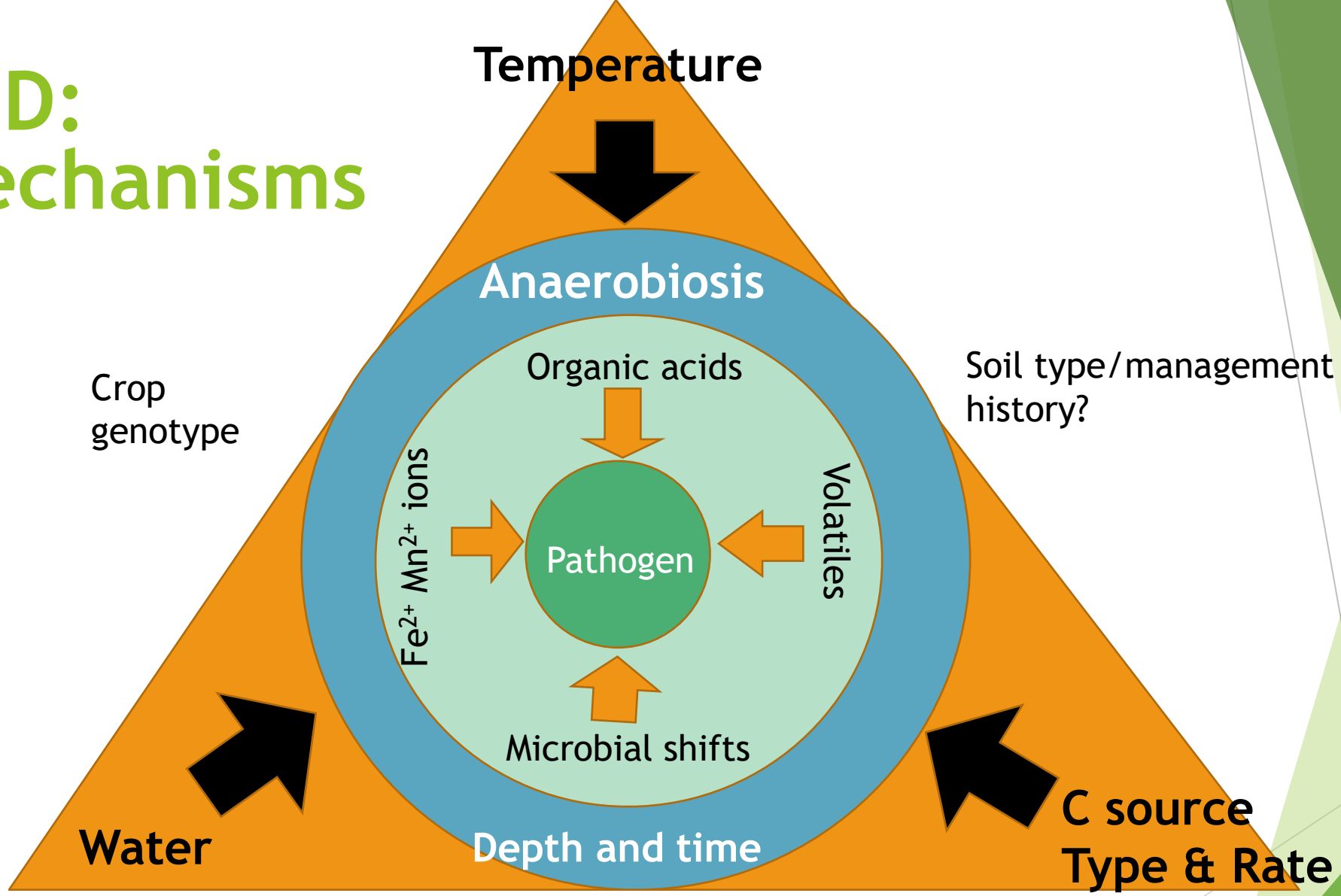
- Maintain above the field capacity
- Create anaerobic conditions and stimulate anaerobic decomposition of incorporated organic material



Open field in CA

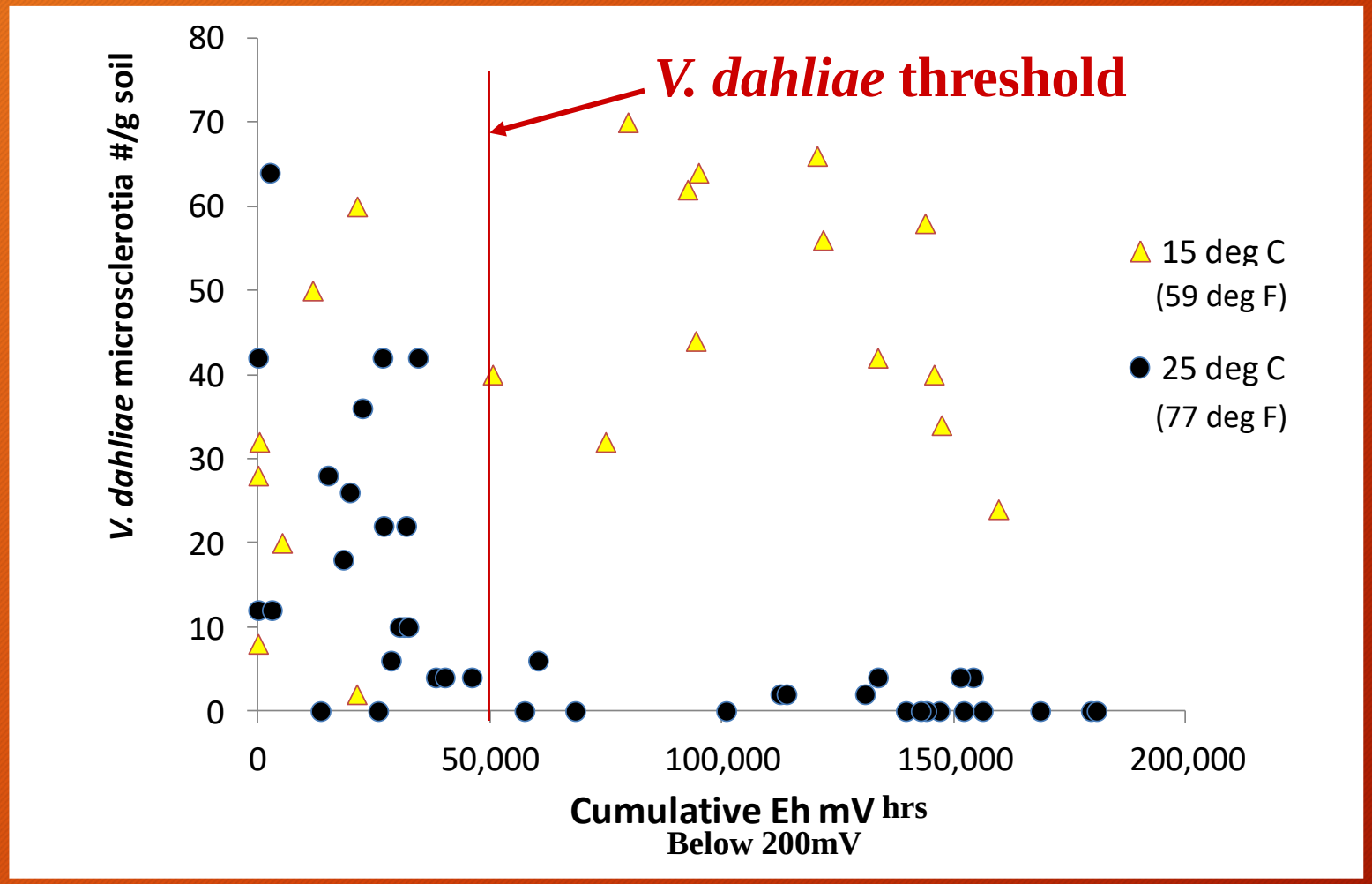
High tunnel in PA

ASD: Mechanisms



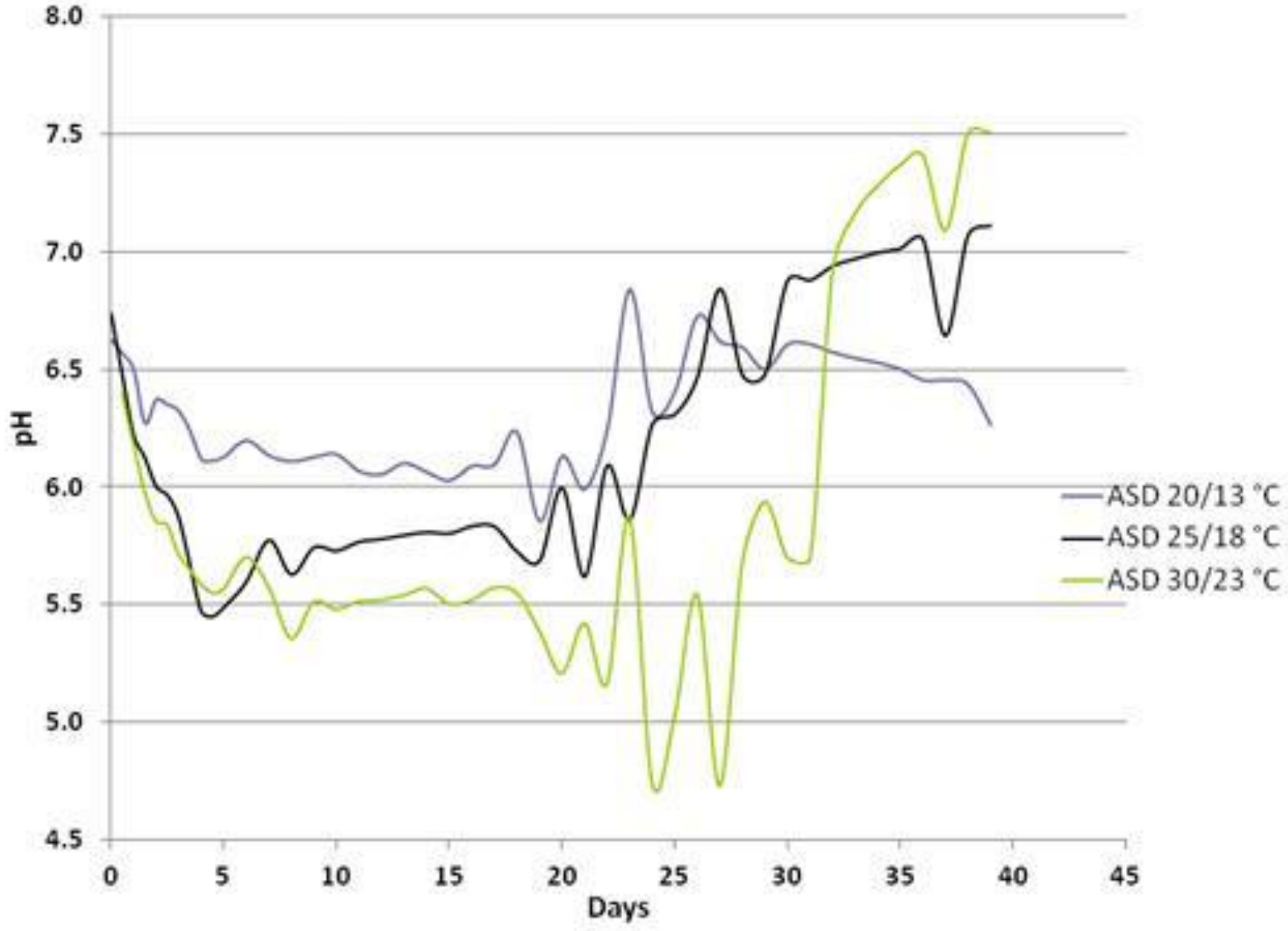
ASD Management Triangle (Shennan et al, 2014)

Level of Anaerobicity and Temperature Matter in ASD



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

Organic acid production increases with soil temperature



Thresholds to control soilborne pathogens in strawberries by ASD

Environmental threshold	*Verticillium dahliae*	*Fusarium oxysporum*	*Macrophomina phaseolina*
Cumulative Eh < 0.2 V (V hrs)	50 V hrs (Shennan et al, 2018)	100 V 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 f. sp. *fragariae-infested* fields! Use summer-ASD!!

UTC

ASD Summer
RB 9t/ac

ASD Fall
RB 9t/ac

Field Trial (USDA Spence, Salinas. Apr. 2022-Oct. 2023)

- *Mp* naturally Infested degraded granite sandy loam soil
- Split plot design w/ 4 replicates (4’ x 60’ plot)
  - Main: Fallow, Wheat (Summit 515), ASD rice bran 9T/ac, ASD- Wheat 2.5 T/ac + Rice bran 6.5 T/ac
  - Sub: w/ and w/o bed fumigation (Pic-Clor 60EC 25 gal/ac)

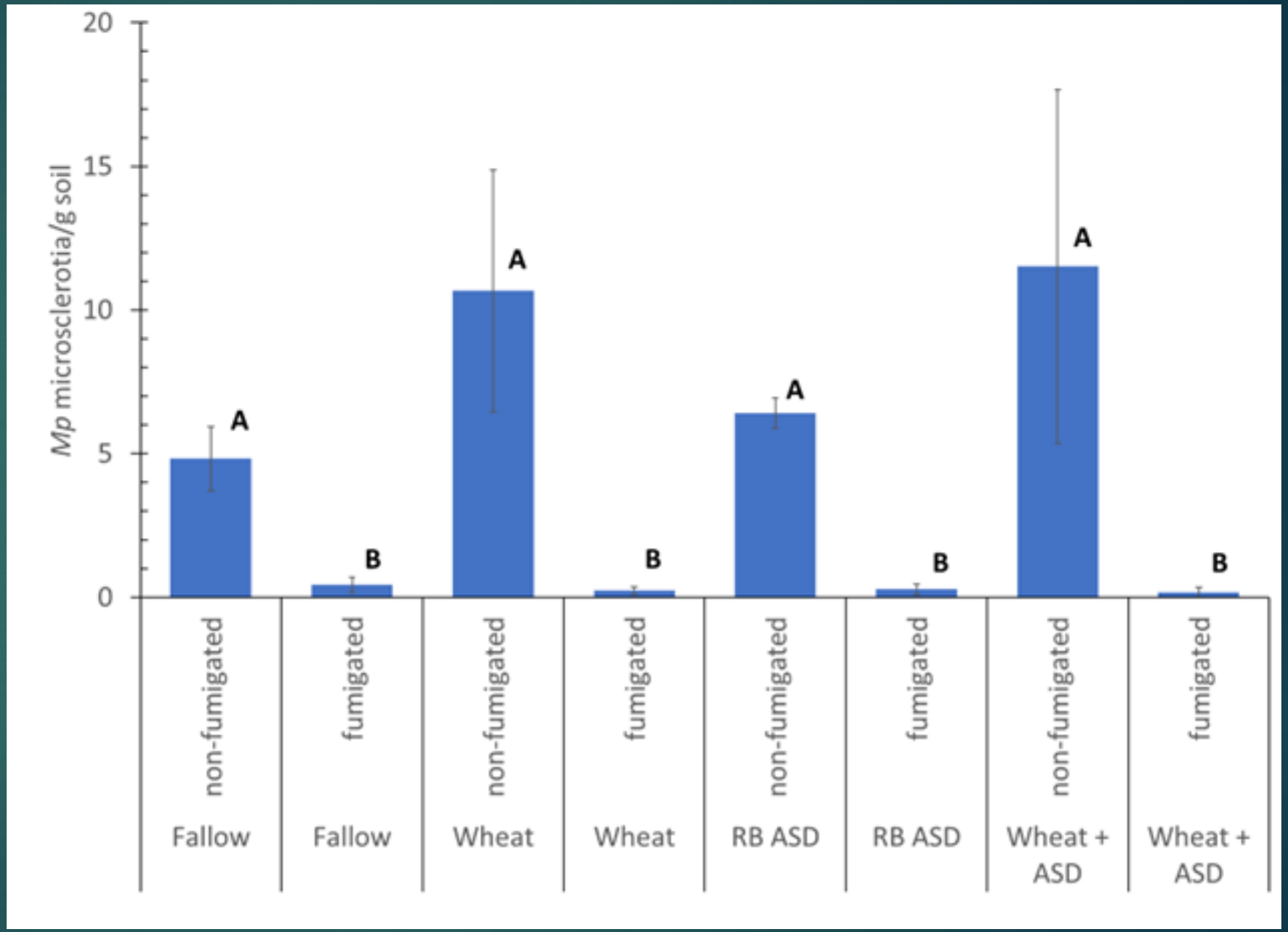
- May-Jul. 22: Summit 515 wheat (2.5 T/ac dry mass)
- July-Aug. 22: Summer Broadcast ASD
- Oct. 22: Fumigation
- Nov. 22: Strawberry (Monterey) planting
- June-Oct. 23: Fruit yield monitoring
- Soil *Mp* test: pre/post-ASD, and May 2023

Cumulative soil Eh and cumulative soil temperature in ASD treatments

Trial	Cumulative soil Eh below 0.2V Mean (min.-max.) V hrs.	Cumulative soil temp. above 30 °C Mean (min.-max.) hrs.	ASD duration Weeks (period)
USDA Field trial	278 (230-327)	1224 (1200-1248)	7.8 (Jul-Aug)
Threshold for Fof	> 100 (Henry et al., 2020)	> 467 (Muramoto et al., 2020)	

Mp Field Trial

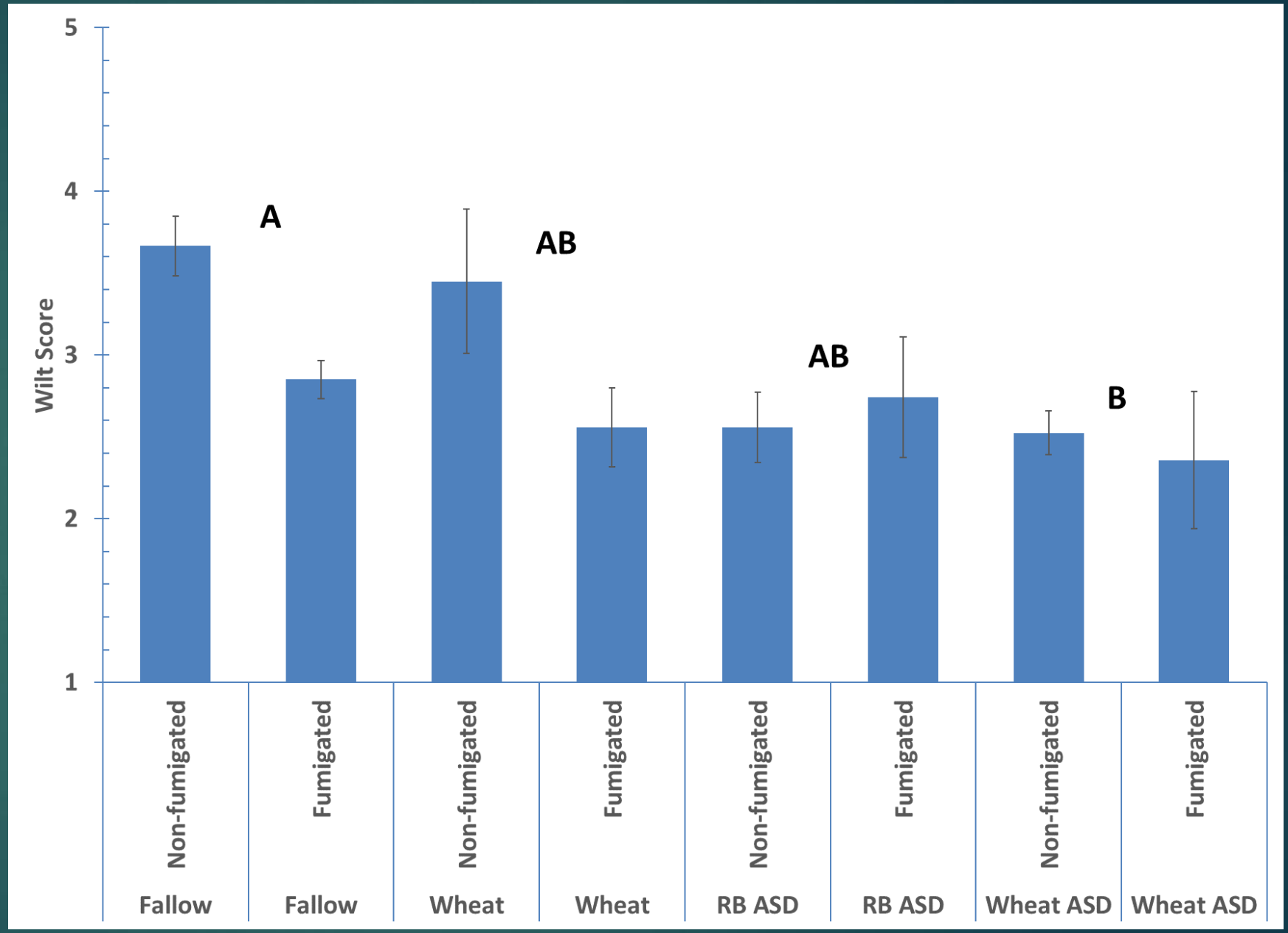
Soil *Mp* Post-ASD and Fumigation (May 2023)



Mp Field Trial

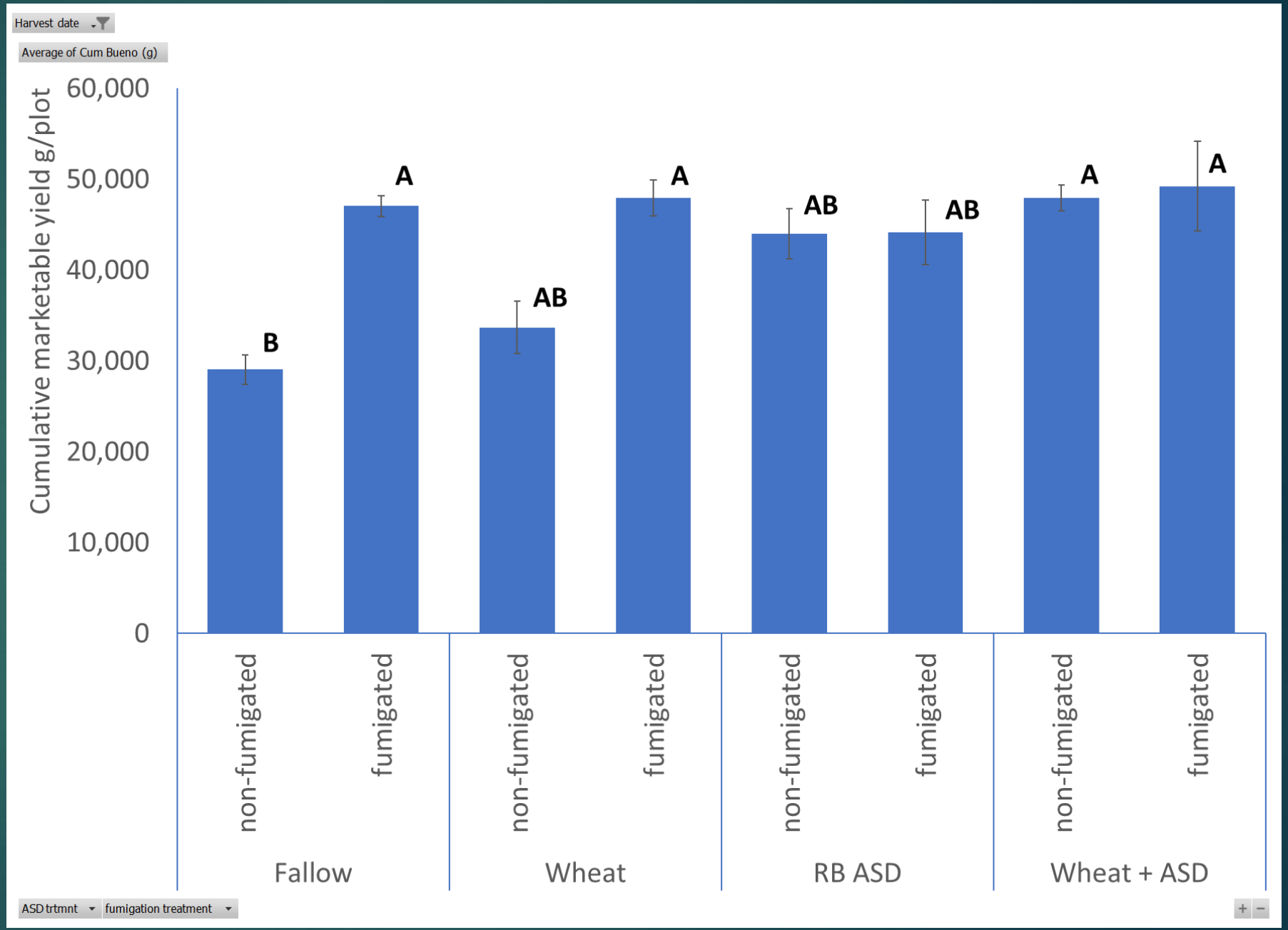
Wilt score (Sep 2023)

1: healthy –
5: dead



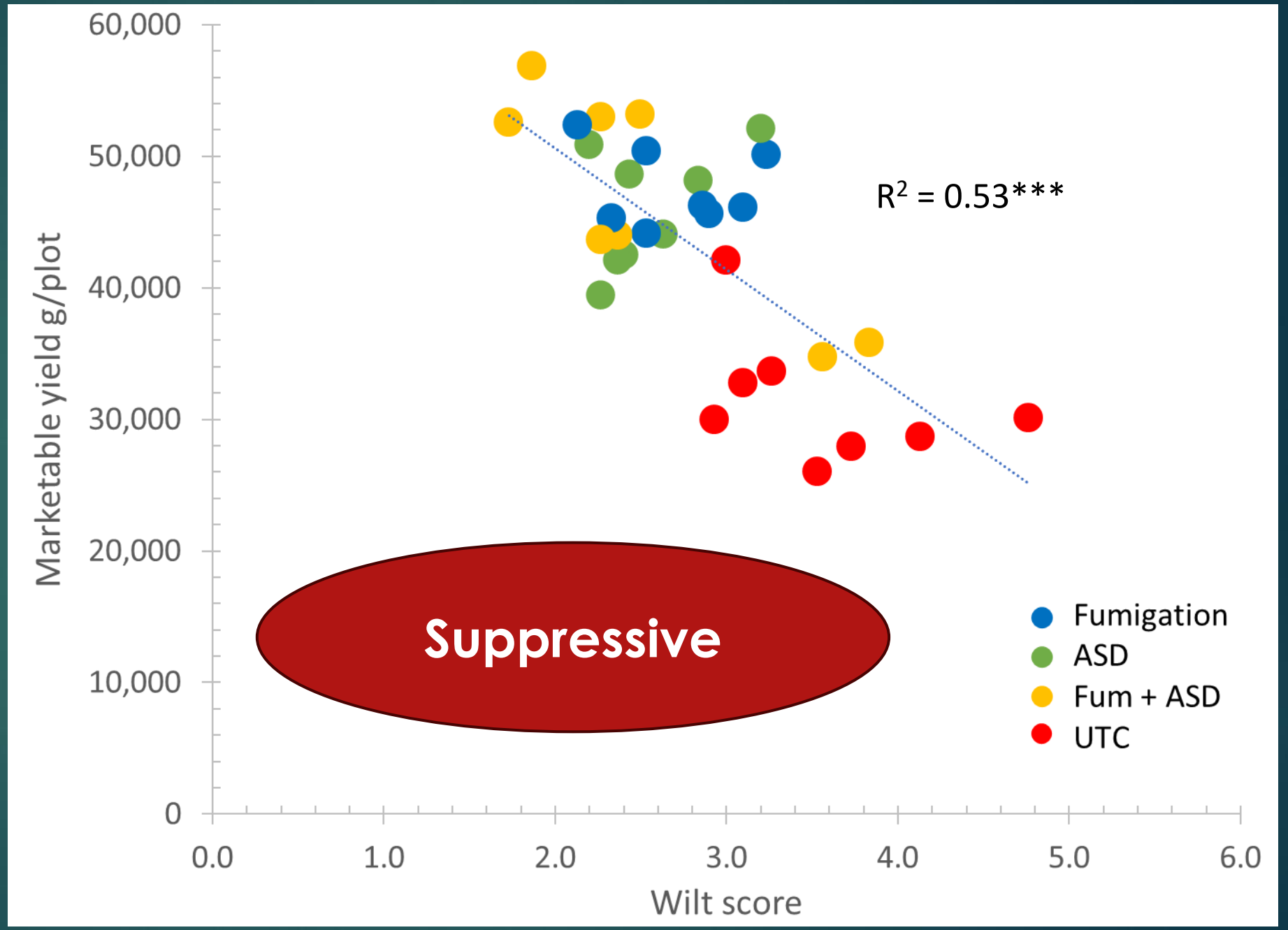
Mp Field Trial

Mkt fruit yield (g/30 plant plot)



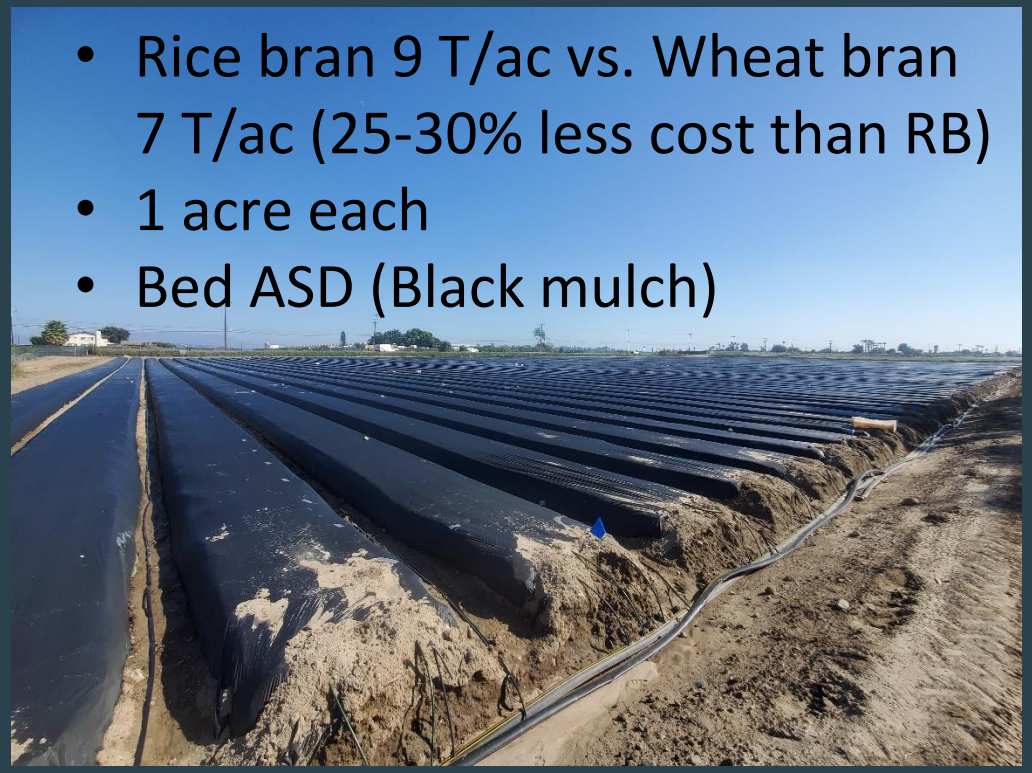
Mp Field Trial

Mkt yield vs. Wilt score

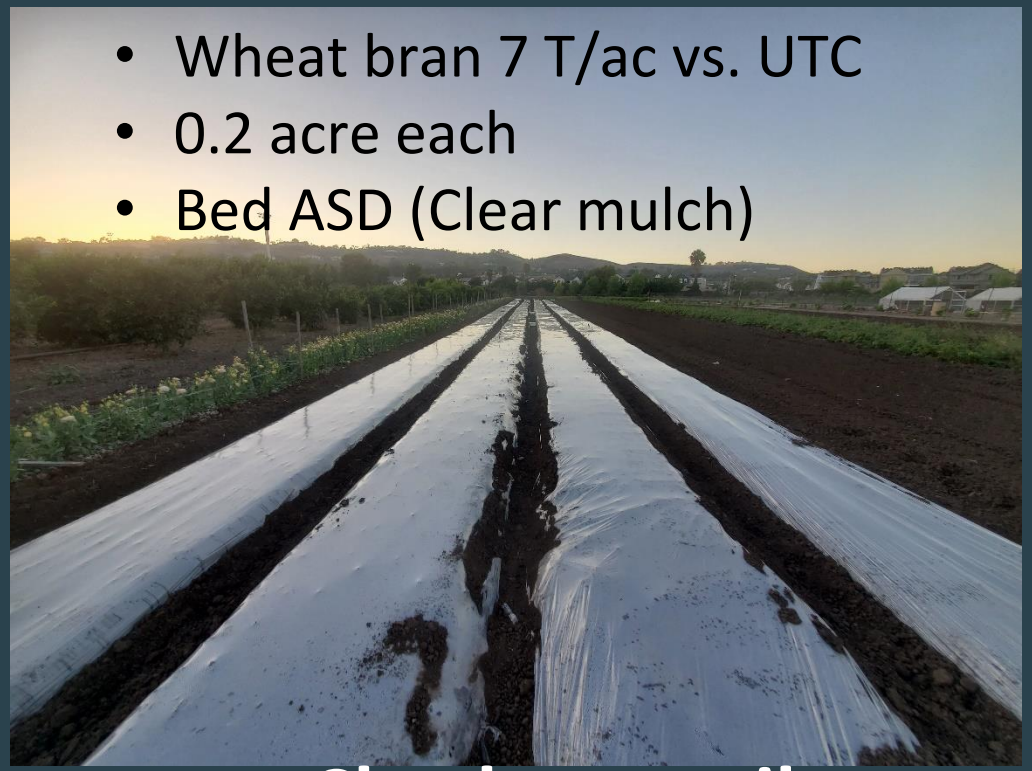


Ongoing Demonstration Trials

- Two demonstration trials for *Mp* control by ASD (Aug. 23 – Sep. 24)
  Mp naturally infested fields in Ventura and Orange Counties, CA



Sandy loam soil

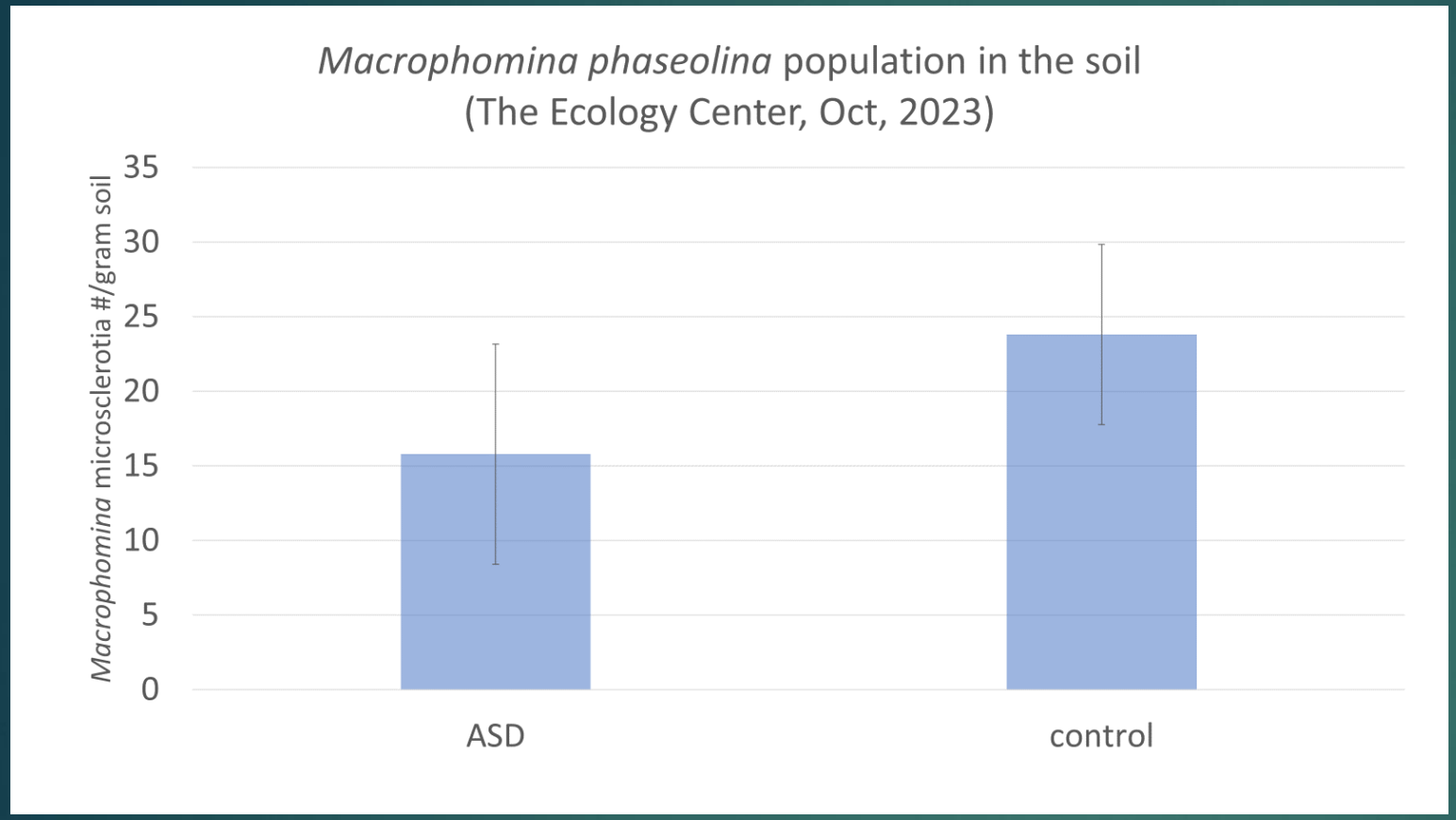


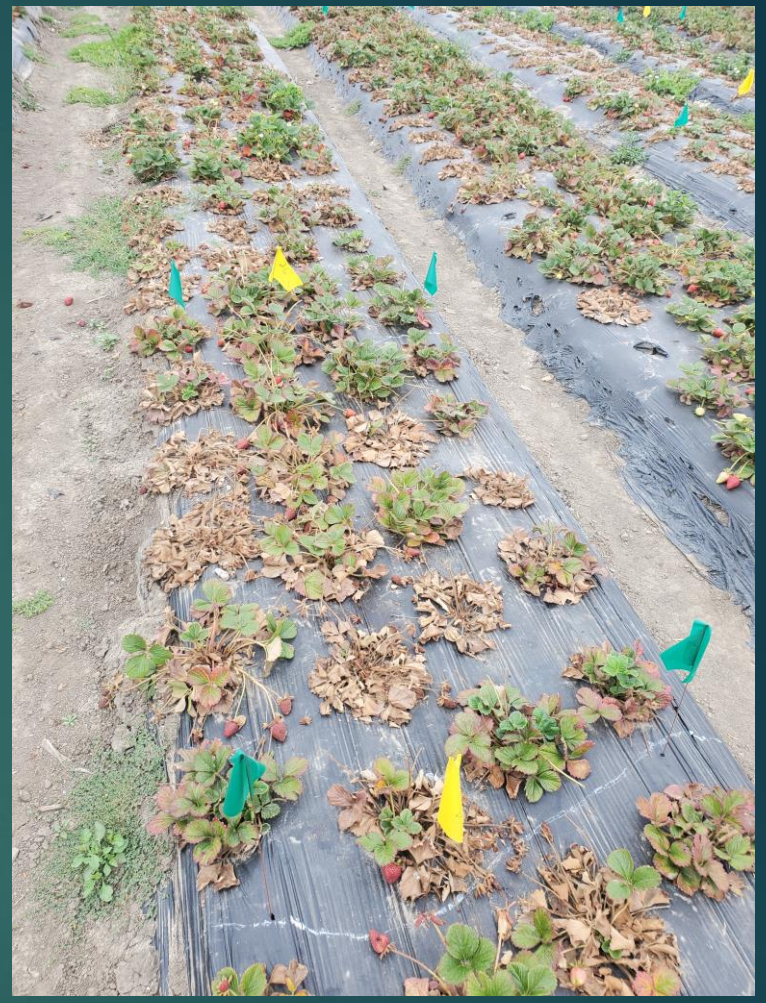
Clay loam soil

Cumulative soil Eh and cumulative soil temperature in Mp-infested ASD field trials

Trial's soil type (County)	ASD type (mulch color)	ASD duration Weeks (time)	Cumulative soil Eh below 0.2V Mean (min.-max.) V hrs.	Cumulative soil temp. above 30 °C Mean (min.-max.) hrs.
Sandy loam (Monterey)	Broadcast (Clear)	7.8 (Jul-Aug)	278 (230-327)	1224 (1200-1248)
Sandy loam (Ventura)	Bed (Black)	7.0 (Aug-Oct)	470 (329-558)	190 (145-237)
Clay loam (Orange)	Bed (Clear)	6.3 (Aug-Oct)	50 (12-136)	584 (509-702)
Threshold for Fof			>100 (Henry et al., 2020)	>467 (Muramoto et al., 2020)

Clay loam field





Clay loam field

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Sandy loam (Monterey)				(1200-1248)
Sandy loam (Ventura)				(145-237)
Clay loam (Orange)	Bed (Clear)	(Aug-Oct)	50 (12-136)	584 (509-702)
Threshold for reducing Fof			>100 (Henry et al., 2020)	>467 (Muramoto et al., 2020)

Mp suppressive

Mp reduction

Microbiome shift?

Volatiles?

Integrated Soil-borne Disease Management in Organic Strawberries

- 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 year break; Verticillium: avoid host plants or ASD after host crop)

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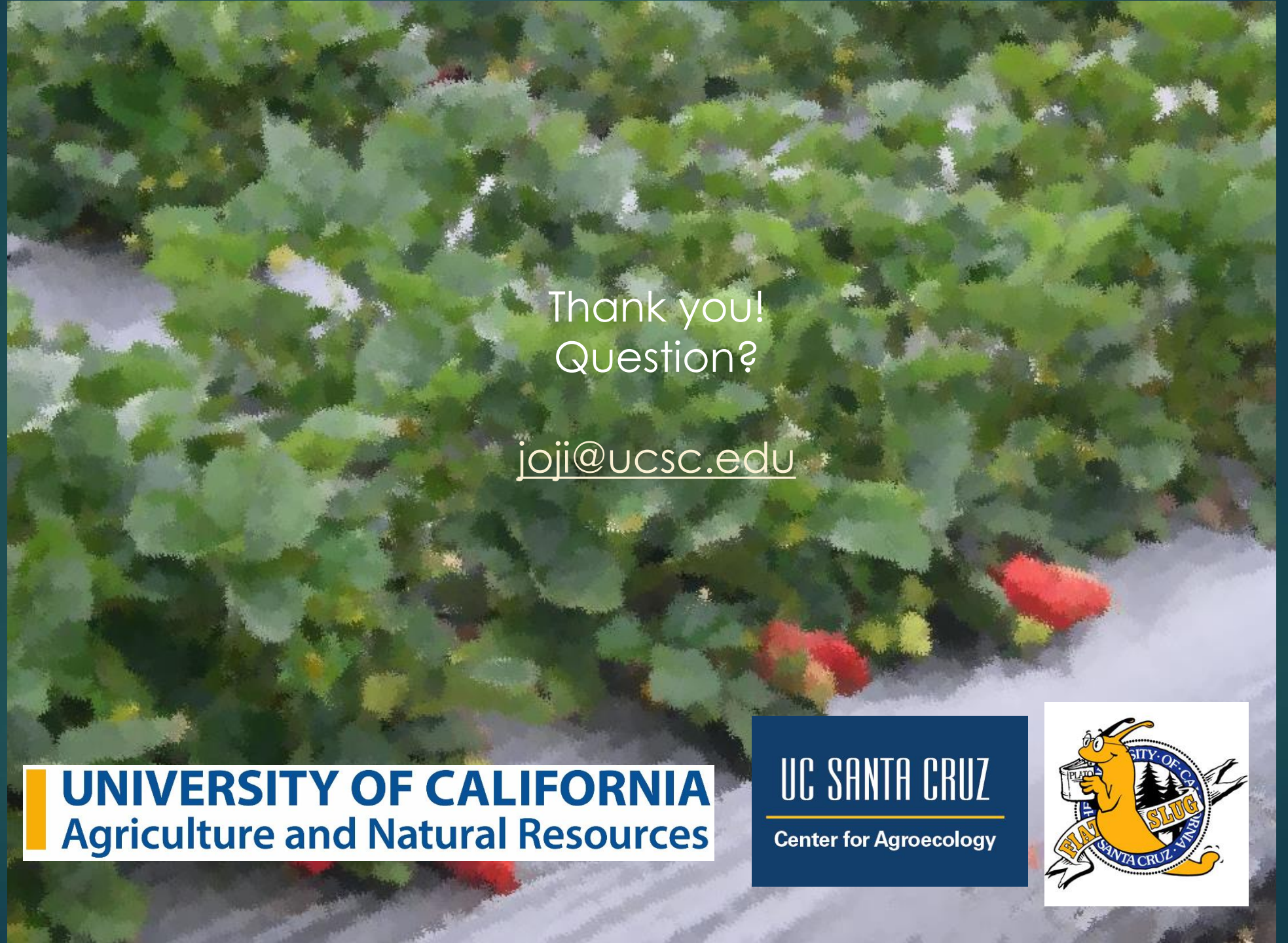

Thank you!
Question?

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