Soil-borne Disease Management in Organic Strawberries

UCCE Annual Strawberry Meeting
Salinas Sports Complex, Salinas, CA 2/05/2020

Joji Muramoto Ph.D.
UC Cooperative Extension Organic Production Specialist
Center for Agroecology and Sustainable Food Systems (CASFS)
Department of Environmental Studies
UC Santa Cruz

Outline

1. Three common soil-borne pathogens in CA strawberries
2. Needs of diagnostics
3. Organically acceptable practices
    - Crop rotation
    - Anaerobic soil disinfestation (ASD)
    - Resistant varieties
    - Integrated approaches

Three Common Lethal Soil-borne Pathogens in California Strawberry

Disease	Pathogen	Host plant	Survival in soil without a host	Saprophytic
Verticillium wilt (1932)*	*Verticillium dahliae*	>300 species incl. >100 weed species	8-10 years	No
Fusarium wilt (2009)	*Fusarium oxysporum* f. sp. *fragariae*	Strawberry only	< 3 years	Yes (50-68 °F)
Charcoal rot (2008)	*Macrophomina phaseolina*	Strawberry only	2-15 years	Yes (50-68 °F)

* The year first reported in CA.

Soil-borne diseases in CA strawberries

Verticillium dahliae

Fusarium oxysporum f. sp. *fragariae* (F.o.f.)

Macrophomina phaseolina + F.o.f.

Verticillium dahliae + F.o.f.

No pathogen (ill drainage)

Need diagnostic for disease identification!!

Soil-borne Pathogen Diagnostics

- Plant test → molecular approach available for all 3 pathogens!

- Soil test → quantitative molecular approach
  - Available for *V. dahliae* and *M. phaseolina*, but not for *Fusarium oxysporum* f. sp. *fragariae*(?)
  - Soil test economic threshold: available only for *V. dahliae* (?)

Crop Rotation for Strawberry

- Traditional method to avoid soil-borne diseases in strawberries worldwide
  - Mandatory for organic strawberry production under the National Organic Program
  - Minimum of a 3-year break between two strawberry plantings recommended in EU and Northeast US and Canada
  - Anecdotal local evidence: 2 years or more to avoid Fusarium wilt
  - Anyway to reduce the break period?

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

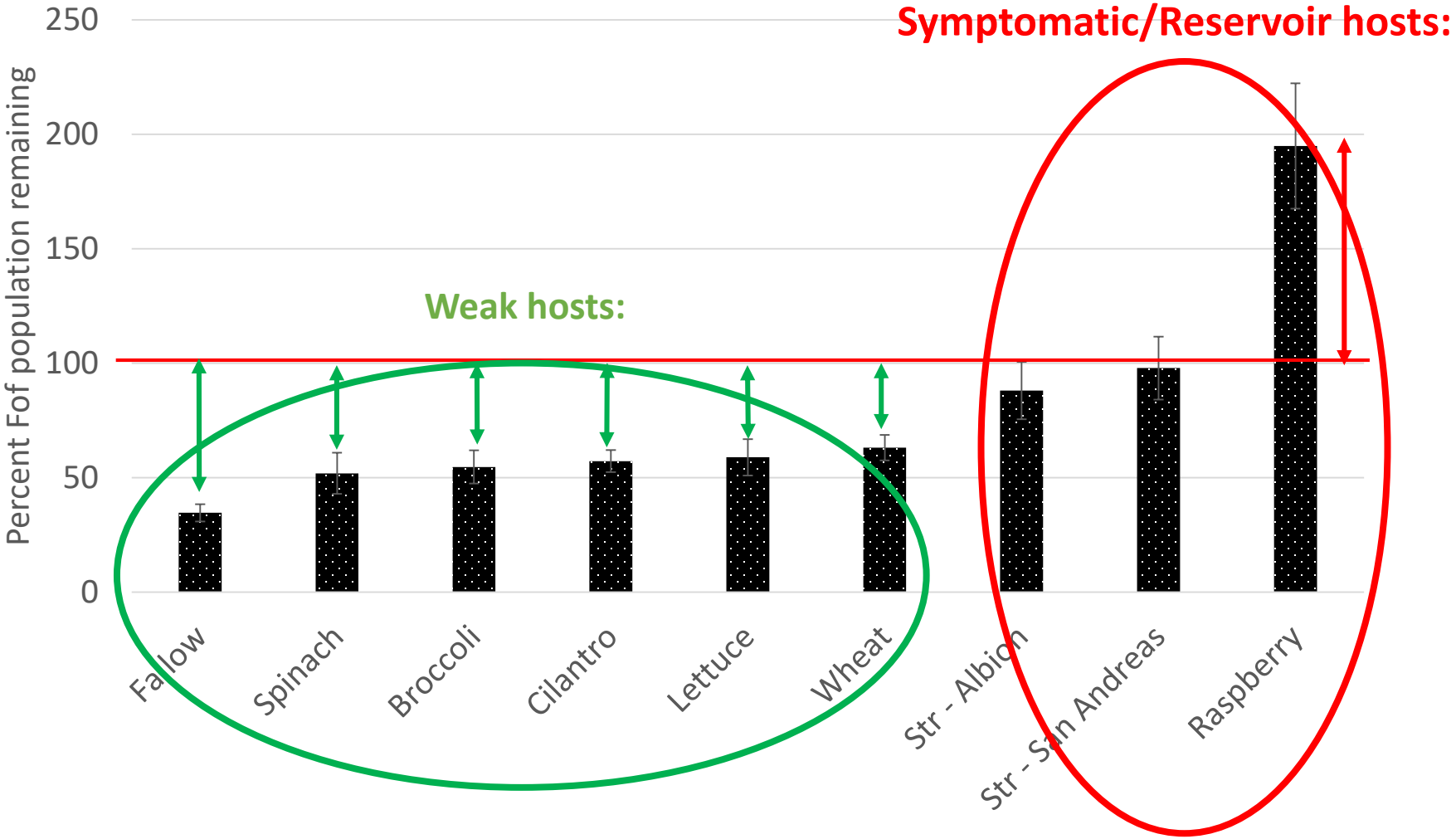
  cauliflower, cabbage, celery, parsley, radicchio, onion, garlic, bean, pea, carrot, sweet potato, asparagus

- Suppressive crop

  broccoli

Change in soil *F.o. fragariae* populations

Inoculated soil, grew 6 weeks, tilled in ➡ 6 months post tillage



(Courtesy of Peter Henry, USDA-ARS. 2018)

Fusarium wilt suppression by Allium crops

Spinach Fusarium wilt suppression by green onion intercropping (Igarashi et al., 2017)

ネギ類の混植によるホウレンソウ萎凋病の抑制

五十嵐千佳[1]・浅野　雄二[2]・西岡　友樹[1]・須賀　晴久[3]・百町　満朗[1]・清水　将文[1]*

ABSTRACT

IGARASHI, C.[1], ASANO, Y.[2], NISHIOKA, T.[1], SUGA, H.[3], HYAKUMACHI, M.[1] and SHIMIZU, M.[1]* (2017). Suppression of spinach

Published in final edited form as:
. 2012 September ; 134(1): 87–95. doi:10.1007/s10658-012-0024-3.

Control of Fusarium wilt in banana with Chinese leek

Y.H. Huang[a,b,c], **R.C. Wang**[c], **C. H. Li**[a,b], **C.W. Zuo**[a,b], **Y. R. Wei**[a,b], **L. Zhang**[a,b], and **G.J. Yi**[a,b]
[a]Key Laboratory of South Subtropical Fruit Biology and Genetic Resource Utilization, Ministry of Agriculture, Guangzhou 510640, China

www.nature.com/scientificreports

SCIENTIFIC REPORTS

OPEN

Microbial basis of Fusarium wilt suppression by *Allium* cultivation

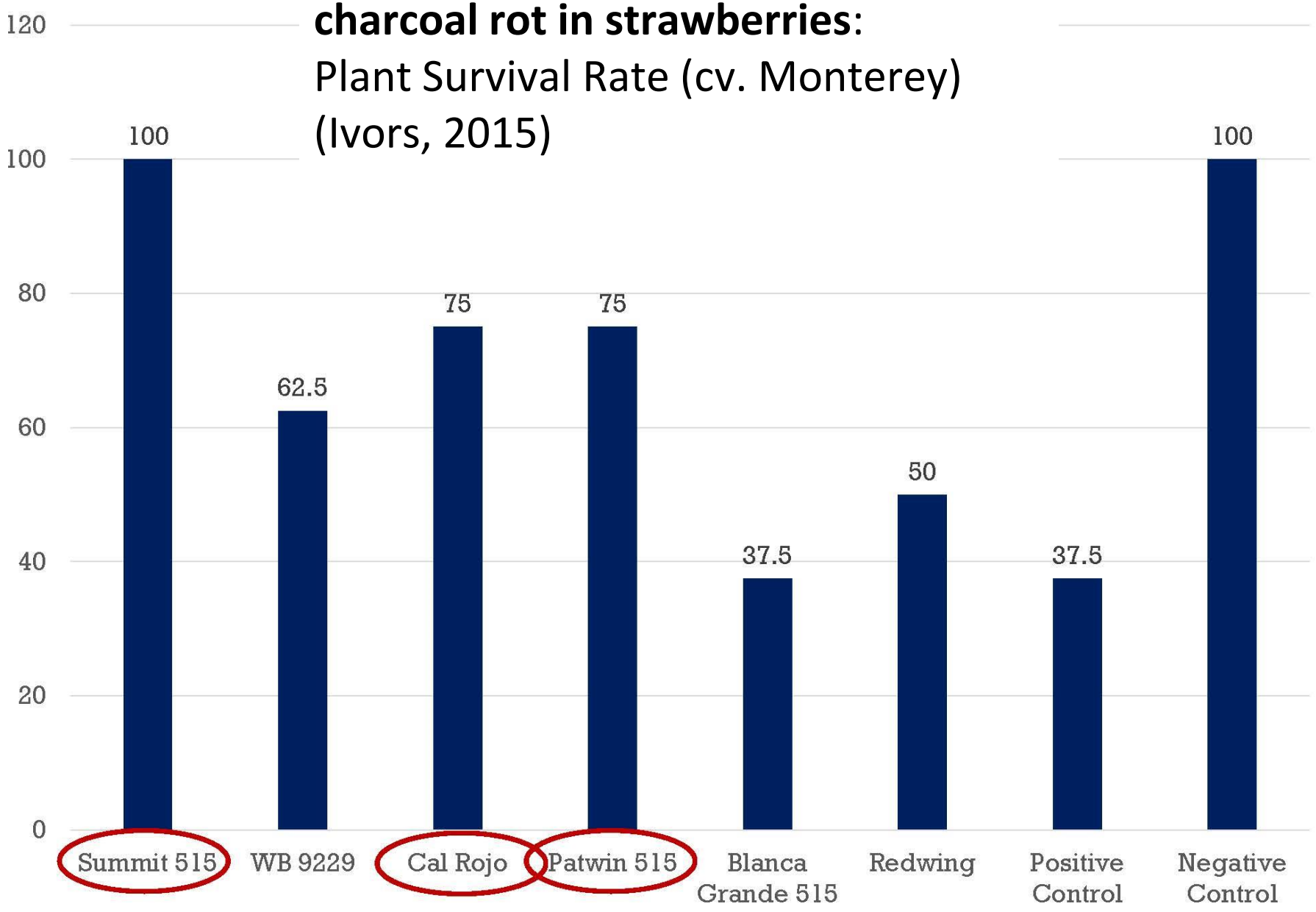
Tomoki Nishioka[1], Malek Marian[1], Issei Kobayashi[2], Yuhko Kobayashi[2], Kyosuke Yamamoto[3], Hideyuki Tamaki[3], Haruhisa Suga[4] & Masafumi Shimizu[1]

Received: 1 October 2018
Accepted: 10 December 2018
Published online: 08 February 2019

Crop rotation and intercropping with *Allium* plants suppresses Fusarium wilt in various crops. However, the mechanisms underlying this phenomenon have not been fully elucidated. This study was designed to assess the role of microorganisms inhabiting *Allium* rhizospheres and antifungal compounds produced by *Allium* roots in Fusarium wilt suppression by *Allium* cultivation. Suppression of cucumber Fusarium wilt and the pathogen multiplication by *Allium* (Welsh onion and/or onion)-cultivated soils

Allium roots -> gamma-Glutamyl-S-allylcysteine -> *Flavobacterium* --> *Fusarium wilt suppression*

Specific wheat varieties can suppress charcoal rot in strawberries:
Plant Survival Rate (cv. Monterey)
(Ivors, 2015)



Anaerobic Soil Disinfestation (ASD)

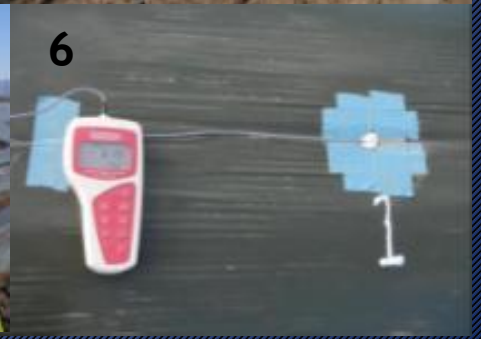
- Developed in the Netherlands and Japan independently ~2000 as a biological alternative to fumigation
- Principle: Acid fermentation in anaerobic soil

(Van Bruggen, 2014)

(Chiba prefecture, 2002)

Autumn-Anaerobic Soil Disinfestation (ASD) in California Strawberries

1. Broadcast rice bran at 6 - 9 tons/acre
2. Incorporate bran
3. List beds
4. Cover w/ plastic mulch
5. Drip irrigate total 1 to 2 ac-in over 3 wks
6. Leave 3 wks and **monitor soil Eh (redox potential)**



Temporal changes in soil metabolome and microbiome during ASD treatment

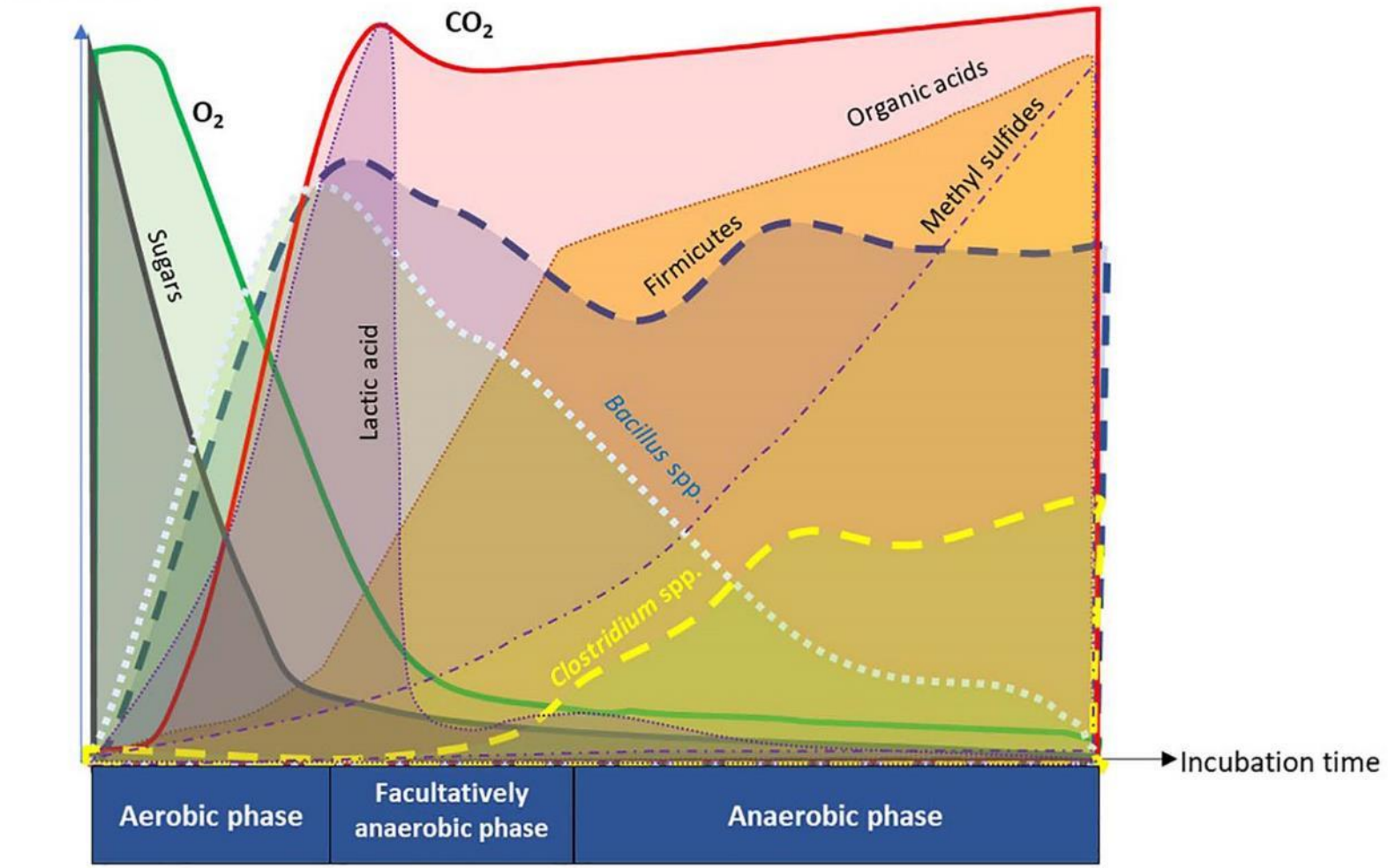


FIGURE 9 | Summary diagram of key functional attributes of anaerobic soil disinfestation (ASD) discerned by temporal dynamics of soil metabolome and microbiome. ASD incubation consists of sequential changes in soil physiology from aerobic, facultatively anaerobic, to anaerobic phases in response to dynamics of O_2 and CO_2. Depletion of O_2 in the soil atmosphere was caused by proliferation of aerobic microorganisms consuming easily degradable organic matter such as sugars. The trend of initial proliferation of *Bacillus* spp. followed by decline was inverse for *Clostridium* spp. in phylum Firmicutes. Population dynamics of *Clostridium* spp. was associated with temporal trends in generation of organic acids and methyl sulfides that are crucial in suppression of soil-borne pathogens.

(Hewavitharana et al., 2019. Frontier in microbio.)

Soil-borne disease control by ASD in California strawberries

- Verticillium wilt by *Verticillium dahliae;* 80 to 100% decrease in *V. dahliae* microsclerotia in soil in field trials (Shennan et al., 2018)---**Autumn ASD**

- Charcoal rot by *Macrophomina phaseolina*; ~50% reduction of plant mortality compared to un-treated control (Muramoto et al., 2017)---**Summer ASD**

- Fusarium wilt by *Fusarium oxysporum* f. sp. *fragariea* can be controlled by **summer-ASD** but **autumn-ASD can make the disease worse** (Muramoto et al., 2017) ---**Rice bran can feed F.o.f!!**

Fusarium oxysporum f. sp. *fragariae** infested field *Strawberry plants (8/14/14)*

UTC

ASD Summer
RB 9t/ac

ASD Fall
RB 9t/ac

Higher temperature threshold for *Fusarium oxysporum*

(>460 hours above 86°F at 8" soil depth (Muramoto et al., Acta Hort. In Press))

Cover Crop-Based Summer Flat ASD Treatment (July-Aug 2017)

1. Mowing cover crops

2. Adding rice bran

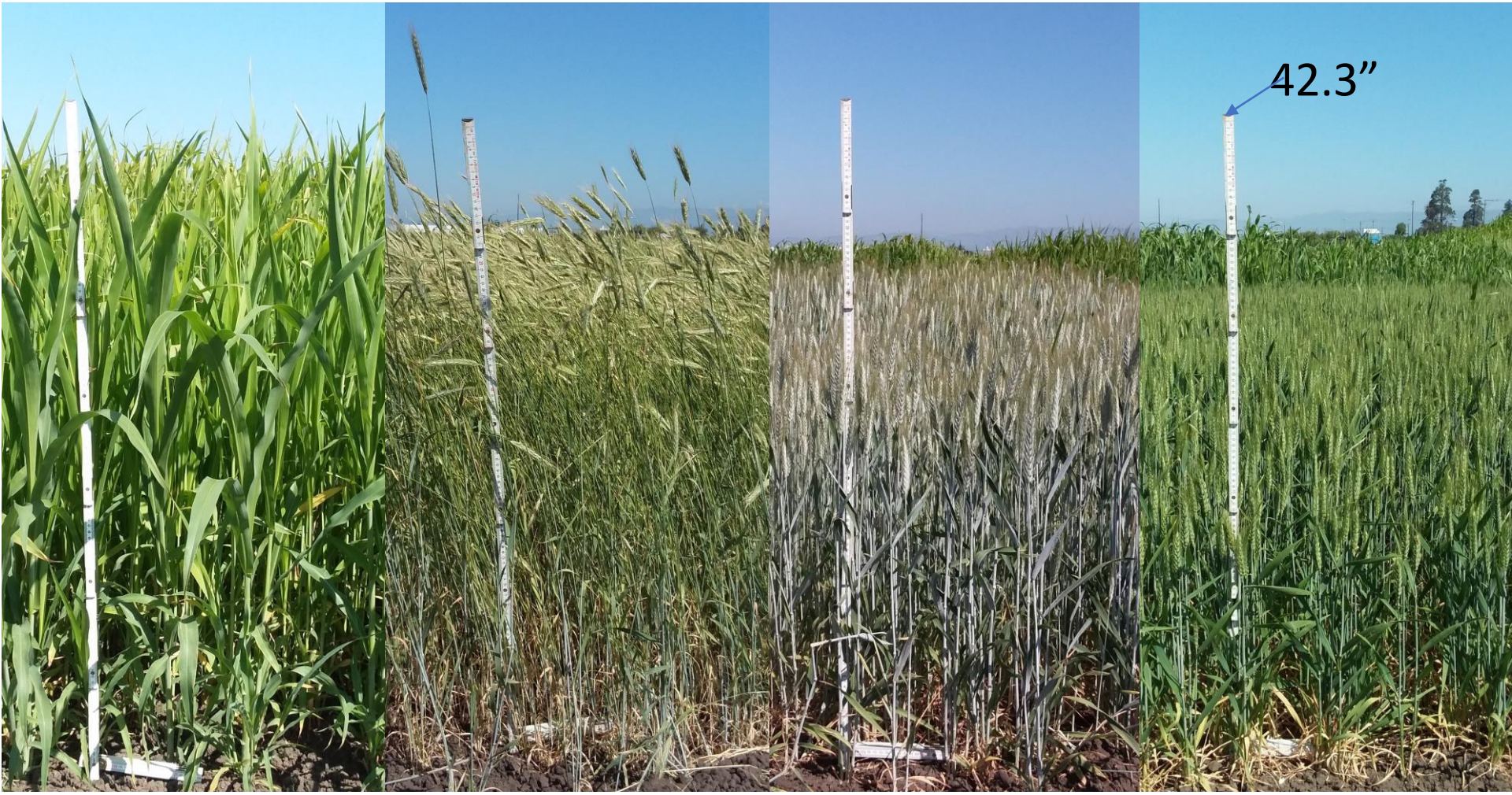
3. Chiseling and rototilling

4. Applying clear TIF and drip tapes

5. Drip irrigation (1.5 ac-inches)

6. Summer flat ASD w/ clear TIF (July 19 – August 28, 2017)

Summer Cover Crops (planted: 5/24/18, harvested: 7/30/18)



Sudan grass
(Sweet’n honey)
3.9 t-d.w./acre

Merced rye
3.2 t-d.w./ac

Triticale
(Pancho)
3.5 t-d.w./ac

Wheat
(Summit 515)
3.8 t-d.w./ac

DN or SD

- Select all
- Day Neutral
- Short Day

Variety

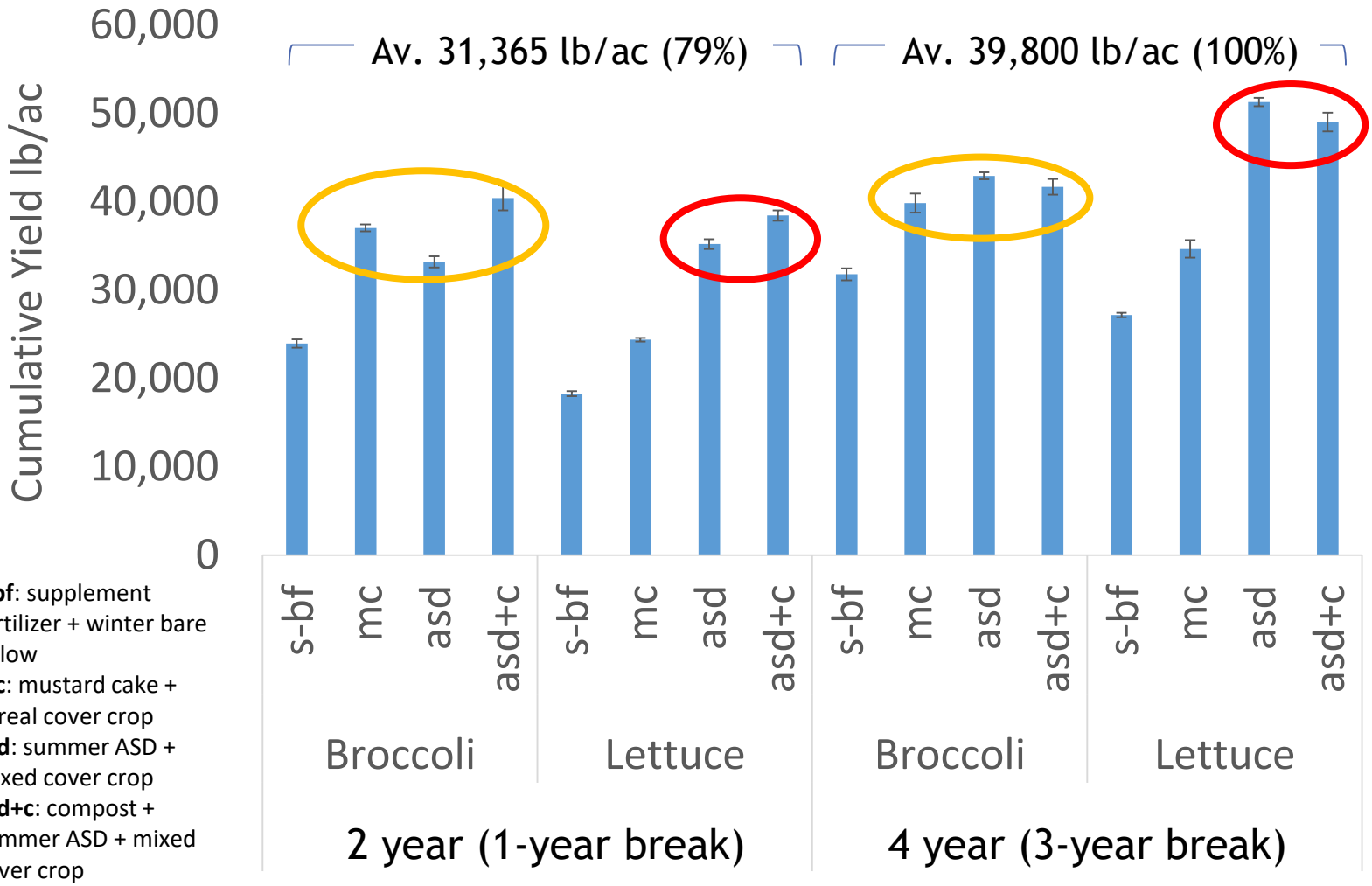
- Select all
- Albion
- Benicia
- Cabrillo
- Camarosa
- Camino Real
- Diamante
- Fronteras
- Gaviota
- Grenada
- Merced
- Mojave
- Monterey
- Palomar
- Petaluma
- Portola
- San Andreas
- Seascape
- Selva
- UCD Moxie
- UCD Royal Royce
- UCD Valiant
- UCD Victor
- UCD Warrior
- Ventana

Legend Acronym	Legend	Resistance Numerical Category
R	Resistant	1
MR	Moderate Resistance	2
MS	Moderate Susceptibilty	3
S	Susceptible	4

Variety	Type	Macrophomina	Verticillium	Fusarium	Phytophthora
UCD Warrior	SD	2	3	1	2
Portola	DN	4	2	1	2
UCD Victor	SD	3	3	1	2
Camino Real	SD	4	1	3	2
Diamante	DN	3	3	1	3
Fronteras	SD	3	3	1	3
San Andreas	DN	4	2	1	3
UCD Moxie	DN	4	2	1	3
Grenada	SD	2	2	4	3
Petaluma	SD	3	2	3	3
Ventana	SD	4	3	1	3
Palomar	SD	3	3	3	3
Selva	DN	3	2	4	3
UCD Royal Royce	DN	3	2	4	3
Albion	DN	4	2	4	3
Cabrillo	DN	4	2	4	3
Merced	SD	4	3	4	2
UCD Valiant	DN	4	2	4	3
Gaviota	SD	4	3	4	3
Mojave	SD	4	3	4	3
Monterey	DN	4	3	4	3
Benicia	SD	4	4	4	3
Camarosa	SD	4	4	4	3
Seascape	DN	4	4	4	3

https://www.calstrawberry.com/en-us/Pest-Management/Breeding

8 year organic rotation trial at UCSC farm
Marketable Fruit Yield at year 8 (cv. Albion)
(*V. dahliae, F. oxysporum* f. sp. *fragariae*, *and M. phaseolina* infested site)



s-bf: supplement fertilizer + winter bare fallow
mc: mustard cake + cereal cover crop
asd: summer ASD + mixed cover crop
asd+c: compost + summer ASD + mixed cover crop

Soil-borne disease management in organic strawberries

1. Diagnostics

- Plant test → Identify the pathogen!

2. Management practices

- Verticillium wilt (*Verticillium dahliae*)
  - Resistant variety
  - Broccoli rotation (avoid host crops)
  - Autumn ASD
- Fusarium wilt (*Fusarium oxysporum* f. sp. *fragariae*)
  - Resistant variety
  - 2-3 year break; avoid raspberry, include allium crops (?)
  - Summer ASD
- Charcoal rot (*Macrophomina phaseolina*)
  - (Resistant variety)
  - Wheat Summit 515 rotation (?)
  - Summer ASD (?)

ACKNOWLEDGEMENTS

- USDA-Organic Research and Extension Initiative Grant 2011-51300-30677
- USDA-Methyl Bromide Transition Grant 2016-51102-25815
- USDA-Specialty Crop Research Initiative Grant 2017-51181-26832
- California Strawberry Commission Research Grants
- Carol Shennan, Margherita Zavatta, Dept. Environmental Studies, UCSC.
- Mark Mazzola, USDA-ARS, WA
- Rod Koda, Shinta Kawahara Co
- Miranda Ganci, Jenny Broome, Kelly Ivors, Driscoll Strawberry Associates
- Steven Koike, Mike Stanghellini, TriCal, Inc
- Richard Smith, UCCE, Salinas
- Peter Henry, Eric Brennan, USDA-ARS, Salinas
- Darryl Wong, CASFS, UCSC
- Students and volunteers, the Shennan lab, UCSC

Thank you!
Question?
joji@ucsc.edu

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

CASFS

SLUG
SANTA CRUZ