Anaerobic Soil Disinfestation (ASD): Updates on Research and Implementation

C. Shennan[1], J. Muramoto[1], G. Baird[1], M. Mazzola[6], M. Bolda[4], S. T. Koike[4], O. Daugovish[4], M. Mochizuki[4], S. Dara[4], K. Klonsky[5], E. Rosskopf[3], N. K. Burelle[3] , D. Butler[2,3]

[1]Univ. of California, Santa Cruz,
[2]Univ. Tennessee
[3]USDA-ARS, U.S. Horticultural Research Lab, Florida,
[4]Univ. of California Cooperative Extension
[5] *Univ. of California, Davis*
[6]*USDA ARS Wenatchee, WA.*

Funded by USDA-NIFA MBTP 2012-51102-20294 and CA Strawberry Commission

Acknowledgements

- Margherita Zavatta, Lucy Toyama, and student workers, interns, and volunteers of the Shennan lab, UCSC
- Monise Sheehan, Kat Kammeijer, Laura Murphy, Patty Ayala at UCCE
- Hillary Thomas, Alex Orozco, Mark Edsall, and Dan Legard, CA Strawberry Commission
- Steve Fennimore, UC Davis.
- Thomas Flewell and crew, Dole Food Company, Inc.
- Dave Peck, Manzanita Berry Farms
- Jenny Broome, Dan Chellemi, Natalia Neerdaels, Emily Paddock and Marty Madesko, Driscoll's
- Mike Nelson, Patti Wallace and Luis Rodriguez, Plant Sciences
- Rod Koda, Shinta Kawahara Farm
- Bryan Gresser, Central West Produce
- Will Doyle, W.D. Berry Farms
- Jonathon Winslow, Stephanie Bourcier, Farm Fuel Inc. and Frontier Ag Company Inc.

Outline – Anaerobic Soil Disinfestation

- What we know:
  - ASD and *V. dahliae* suppression
  - Yield responses in past field trials
  - Economics
- Recent trials:
  - N issues and pre-plant fertilizer
  - C-source makes a difference
  - Efficacy against different pathogens?
  - Issues with scaling up and site differences
- Future needs and ongoing trials

ASD: Some Target Pests and Crops

- *Soil-borne pathogens*
  - *Verticillium dahliae*[1,2,4]
  - *Fusarium oxysporum*[1,2,3]
  - *Fusarium redolens*[2]
  - *Macrophomina phaseolina*[3]
  - *Ralstonia solanacearum*[2]
  - *Rhizoctonia solani*[1]
  - *Sclerotium rolsfii*[3]
- *Nematode*
  - *Meloidogyne incognita*[1]
  - *Pratylenchus fallax*[2]
- *Weed*
  - *Nutsedge*[3]

- Crops tested
  - Welsh onion[2]
  - Tomatoes[2,3]
  - Strawberries[2,4]
  - Eggplant[2, 3]
  - Spinach[2]
  - Peppers[3]
  - Maple[1]
  - Catalpa[1]
  - Cut flowers[3]

[1] Dutch studies; [2] Japanese studies; [3]Florida studies; [4] California studies

ASD: Three Steps

1. Incorporate organic material
   - **Provides C source for soil microbes**
2. Cover with oxygen impermeable tarp
3. Irrigate to saturation and maintain field capacity for 3 weeks
   - **Water-filled pore space**
   - **Create anaerobic conditions and stimulate anaerobic decomposition of incorporated organic material**


2011 10 04


10/10/


08.18.2010


08.18.2010

Total irrigation rate: at least 3 acre-inches

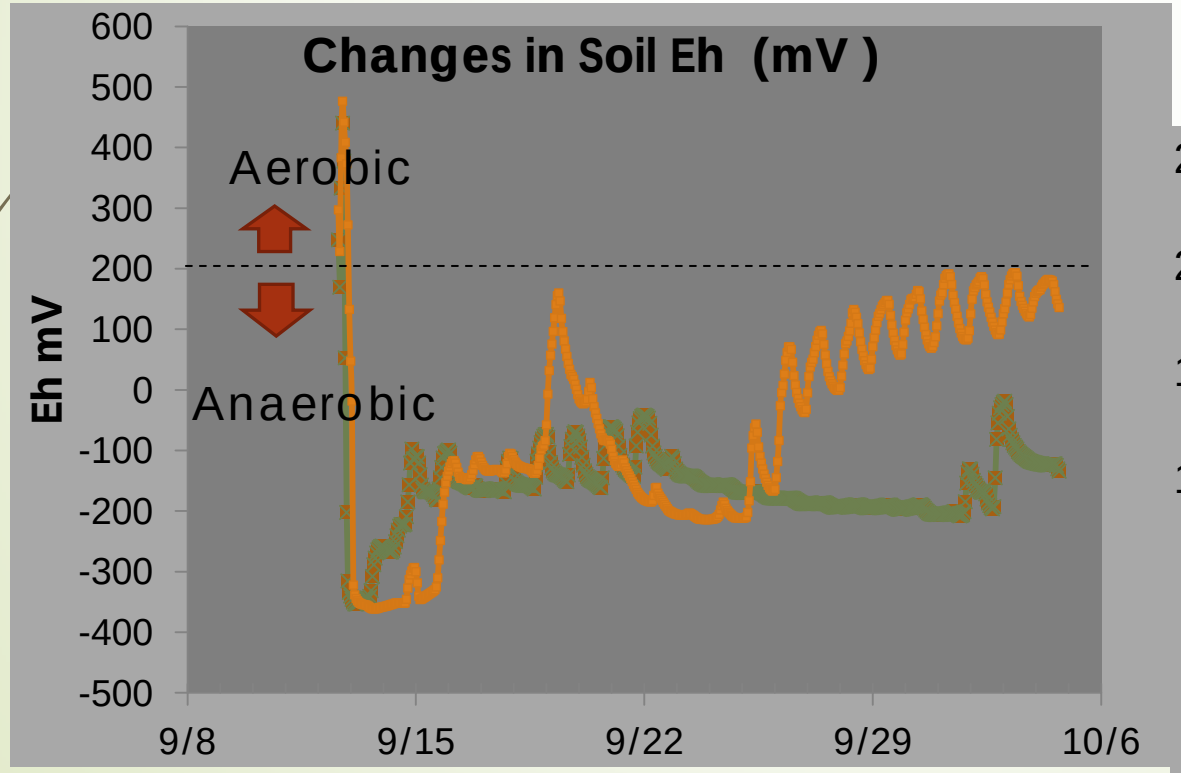
Findings to 2012

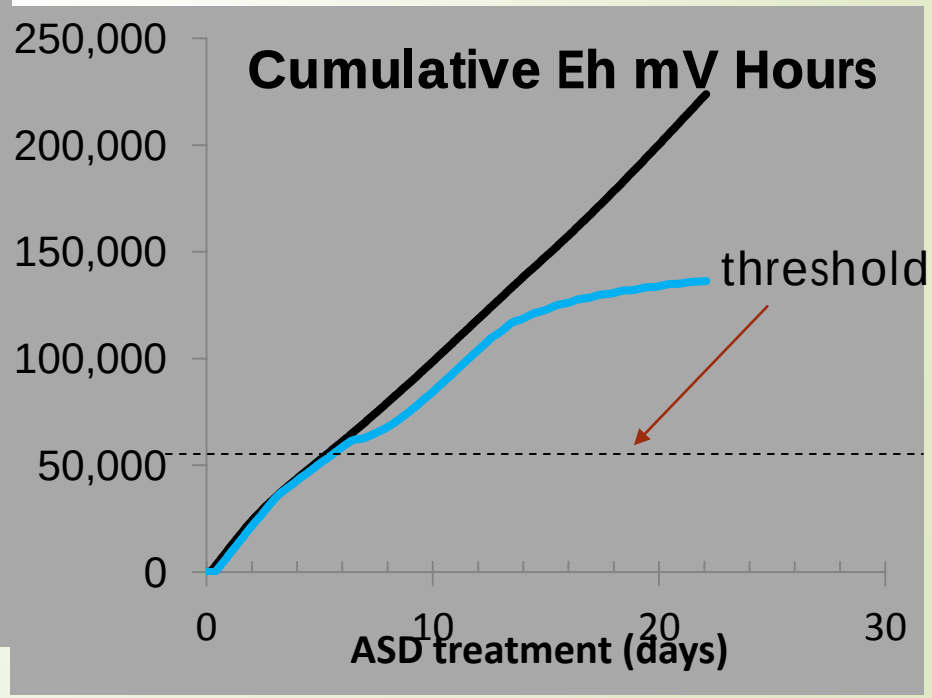
1. Good yields obtained with 9ton/ac rice bran
    1. Salinas 2010 - equal to MeBr (and UTC) yields
    2. Watsonville 2010 - within 15% of MeBr yields
    3. Ventura 2011 – 75% increase yield over UTC
    4. Castroville 2011- as good or better than Pic-Clor
    5. Watsonville 2011 – equal to Pic-Clor and steam
    6. Santa Maria 2012 – equal to Pic-Clor
    7. Watsonville 2012 – lower yield than steam/Pic-Clor but higher than UTC – poor anaerobic conditions
2. Got consistently good *V. dahliae* suppression - 80 to 100% decrease in # microslerotia in soil, using a range of C sources provided good anaerobic conditions

3. Weed suppression limited in the central coast of CA

Findings to 2012 (contd):

4. Need to accumulate 50,000 mV hrs of Eh below 200mV to get *V. dahliae* suppression, and for soil temps to be above 65ºF for at least first week of ASD treatment





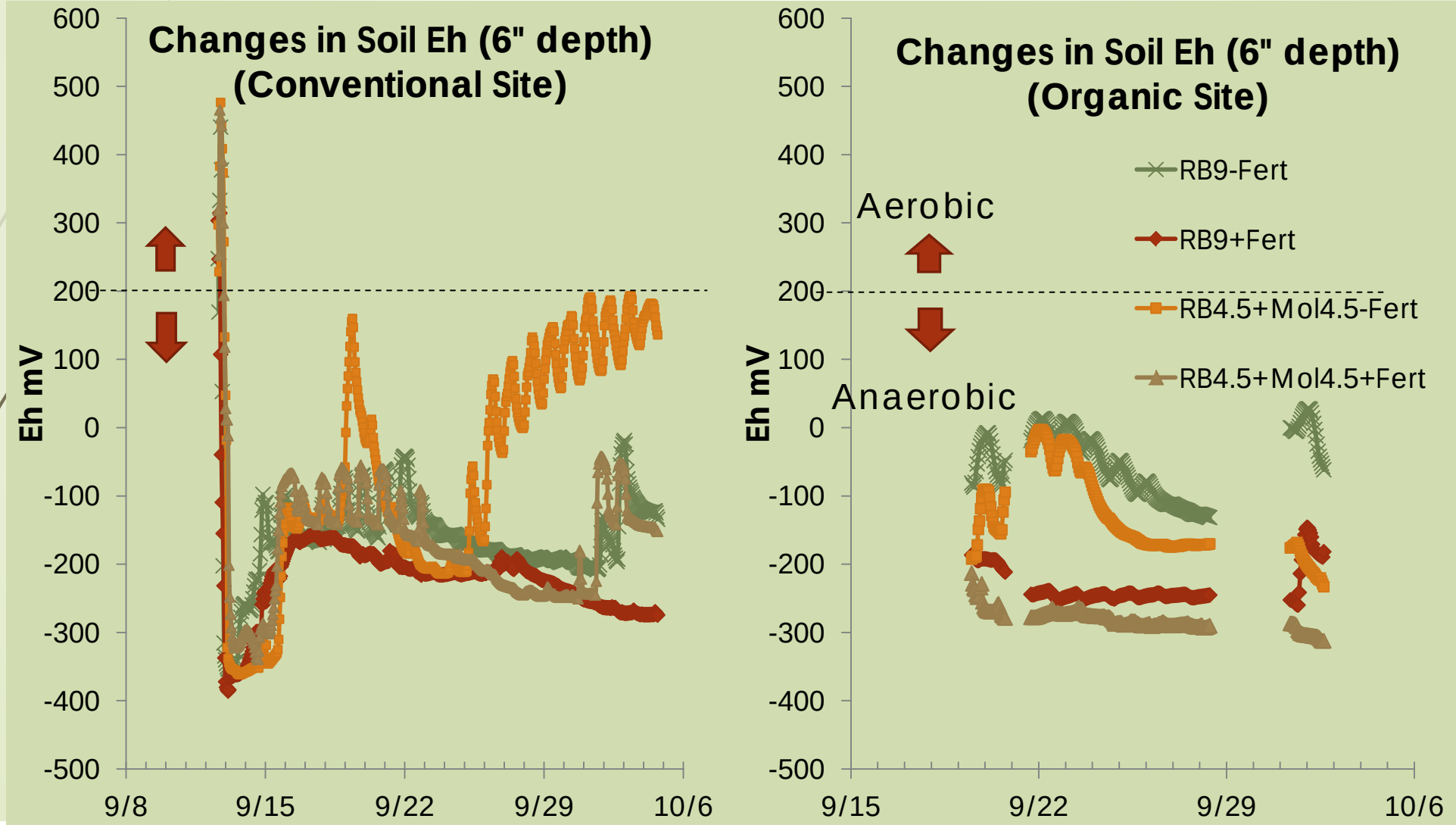
2012-2013 Replicated Trials

Location	C-source/treatments	type
Watsonville	Rice bran 6, 9 t/ac Molasses 6, 9 t/ac RB 4.5 + Mol 4.5 t/ac UTC	2x Conventional
Watsonville	Rice bran 6, 9 t/ac Molasses 6, 9 t/ac RB 4.5 + Mol 4.5 t/ac Controls: UTC, Water only, Rice bran 9 t/ac – no water	Conventional - MBA
Watsonville	Rice Bran 9 t/ac Molasses 9 t/ac Steam Steam + Mustard Seed meal UTC	Conventional
Santa Cruz	RB 4.5 + Mol 4.5 t/ac +/- compost Mustard Seed meal UTC	Organic

2012-2013 Demonstration Trials – Monitoring

Location	C-source	Acreage	type
Watsonville	9t/ac Rice Bran or 4.5t/ac RB+4.5t/ac Molasses +/- preplant fertilizer	1 0.5	Organic Conventional
Salinas	9 t/ac Molasses	0.5	Conventional
Salinas	9 t/ac Molasses	1	Conventional
Santa Maria	9 t/ac Molasses	0.5	Conventional

2013 - 0.5 -1ac Demonstration Sites – Sandy Soil
Good ASD Established

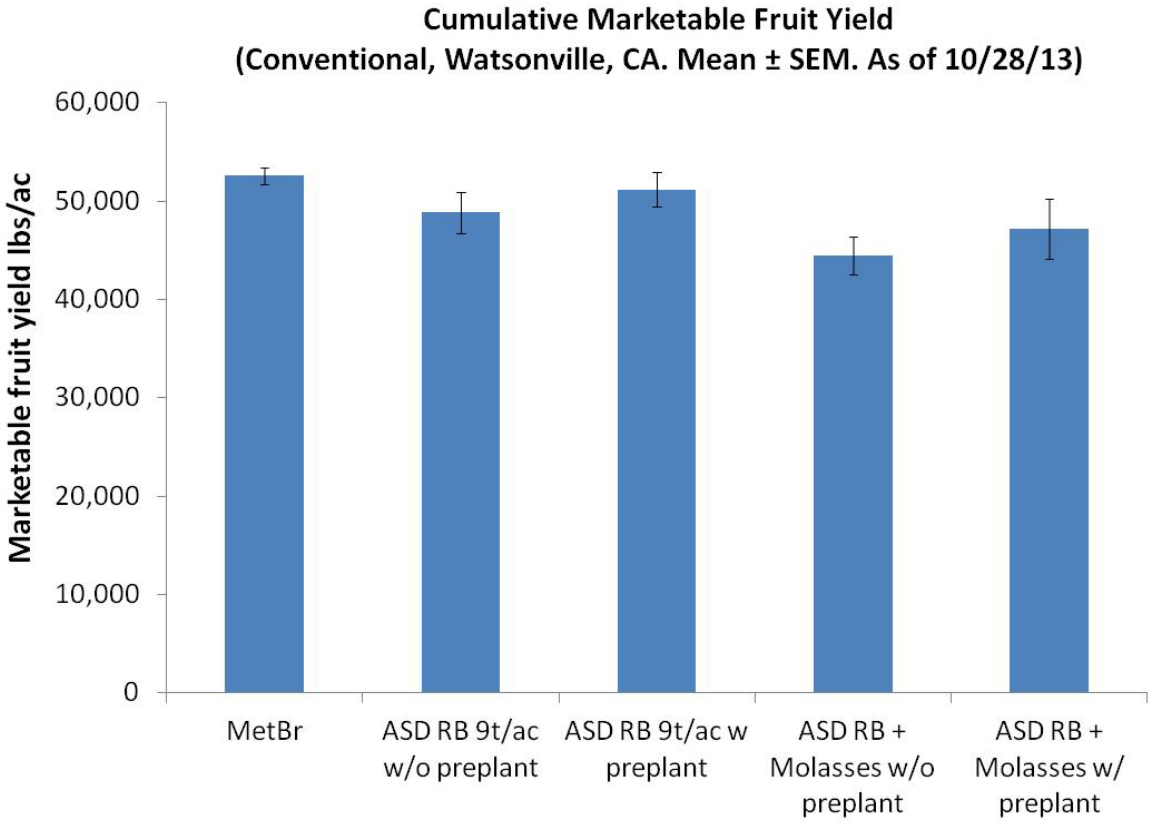


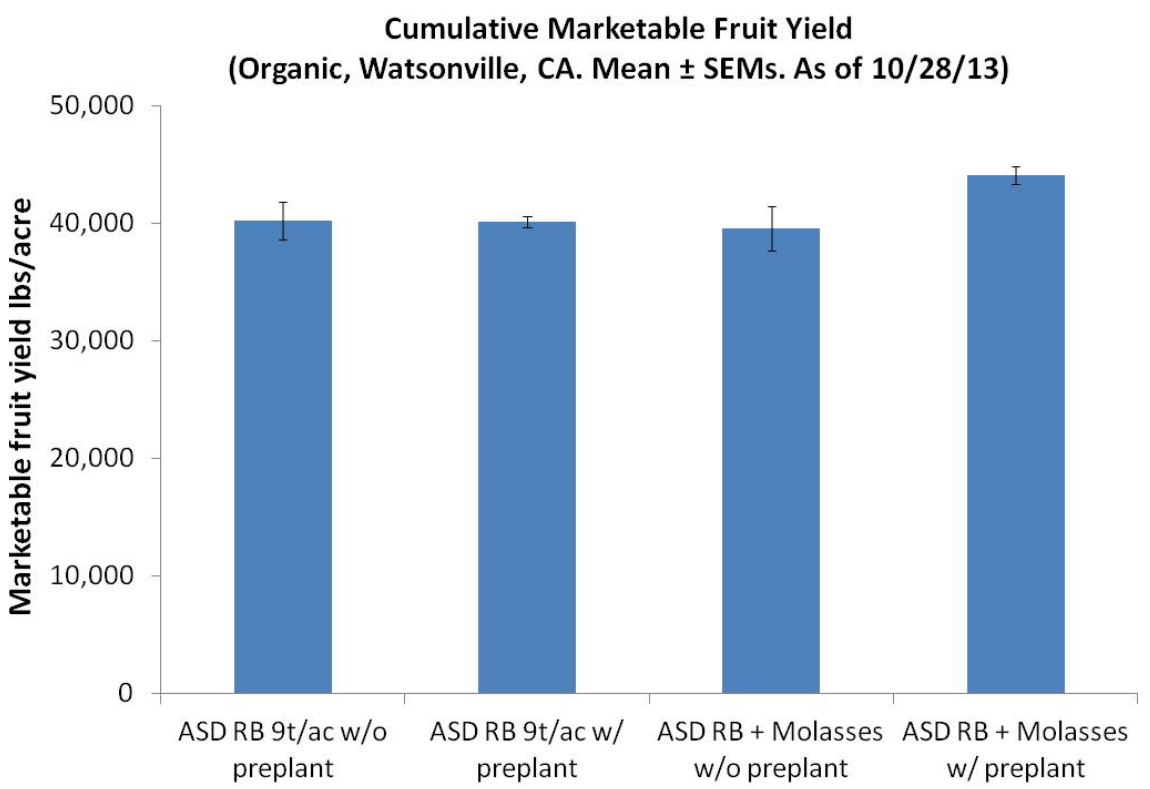
- Fertility management?

ASD with 9ton/ac Rice Bran equal yields to MeBr in conventional site

Little effect of pre-plant fertilizer in conventional (slow release 18-6-12 600 lbs/ac) or organic site (feather meal 1000 lbs/ac)

RB+Molasses worked well at organic site – better with pre-plant?

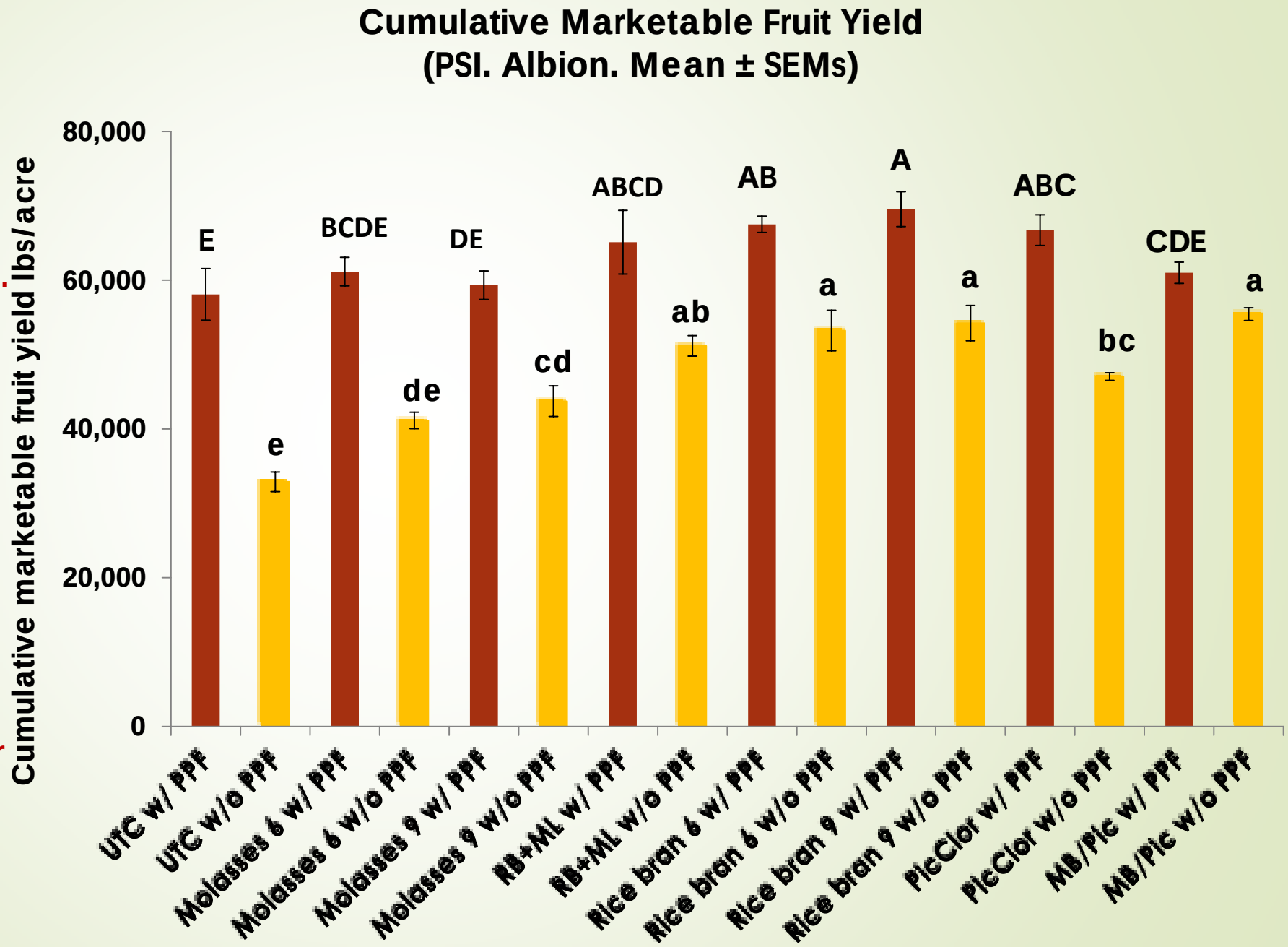




But …….

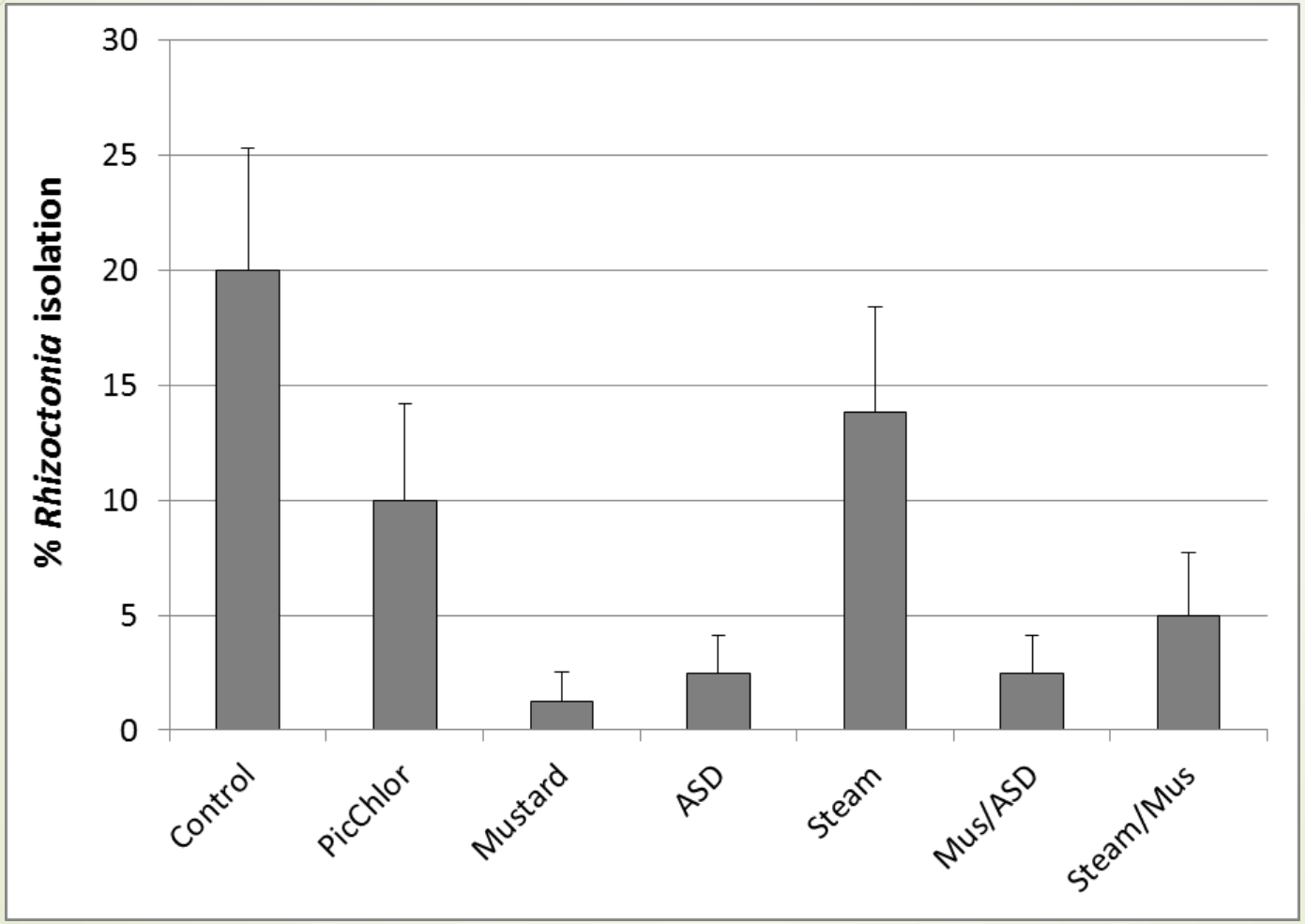
Strong pre-plant fertilizer effect at another site…

Yields in ASD w/RB, or RB+Molasses same or better than MeBr or Pic-Clor

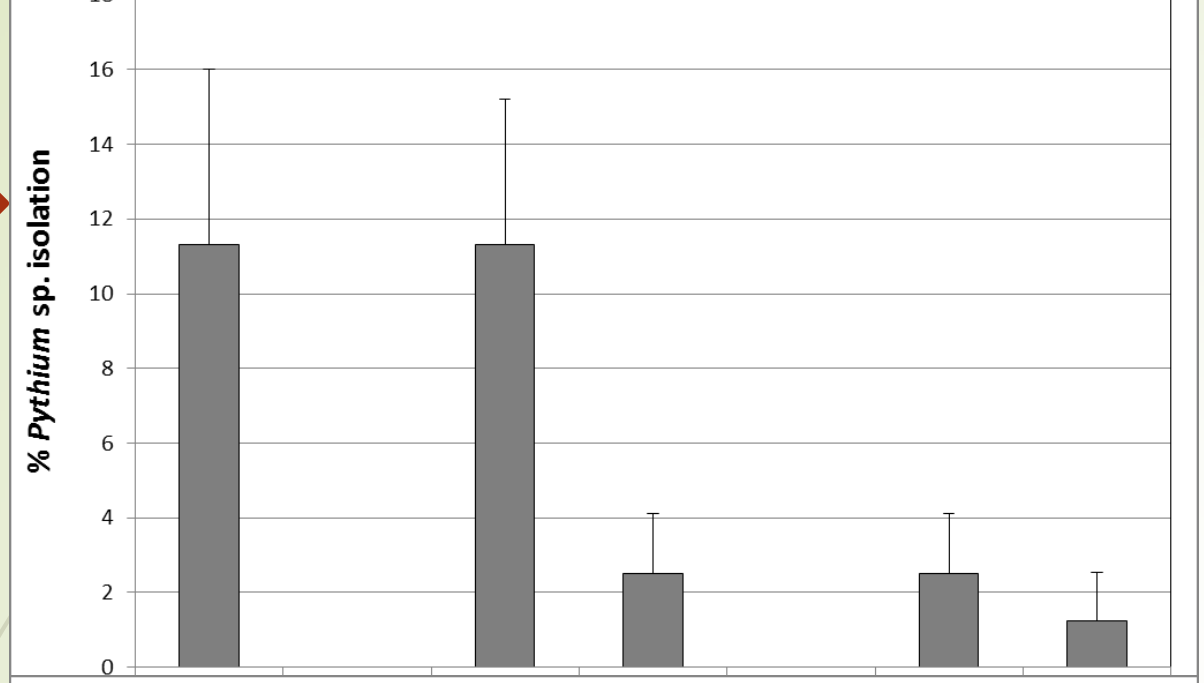


Efficacy against other pathogens:

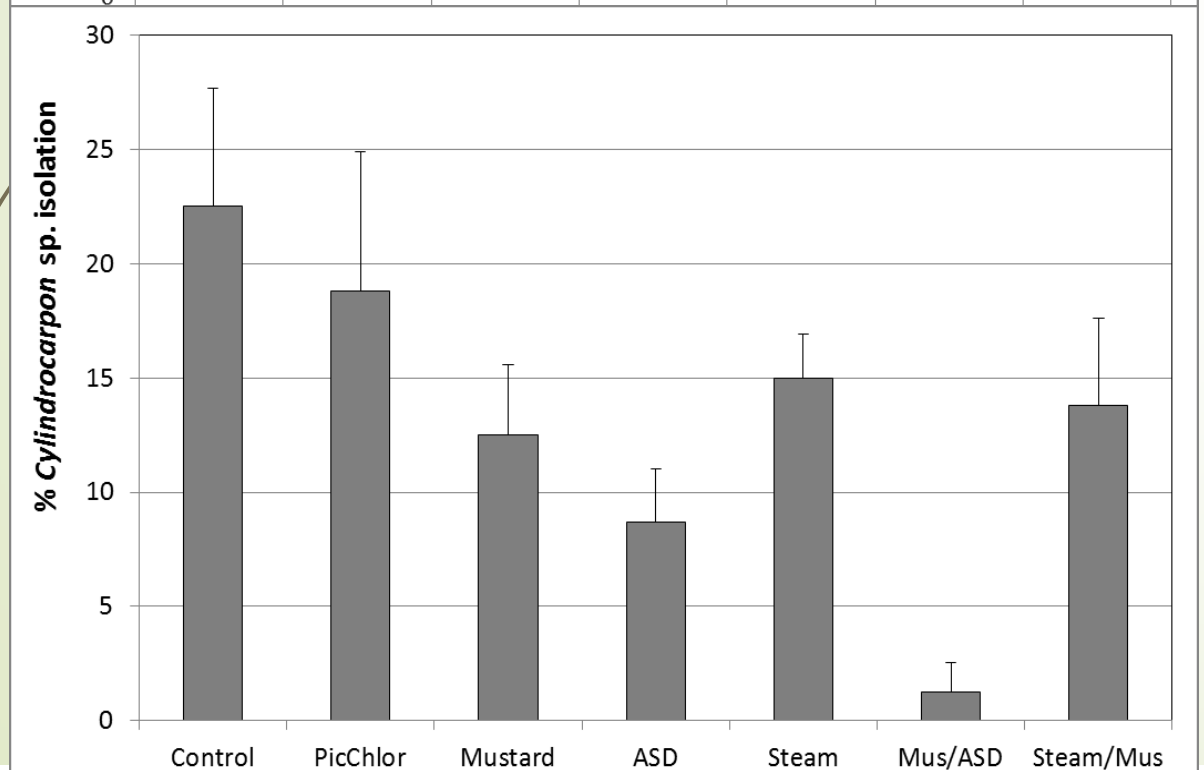
% roots from which *Rhizoctonia* was isolated



- Watsonville 2011



Pythium spp.



% roots from which fungi was isolated Watsonville 2011

Cylindrocarpon spp.

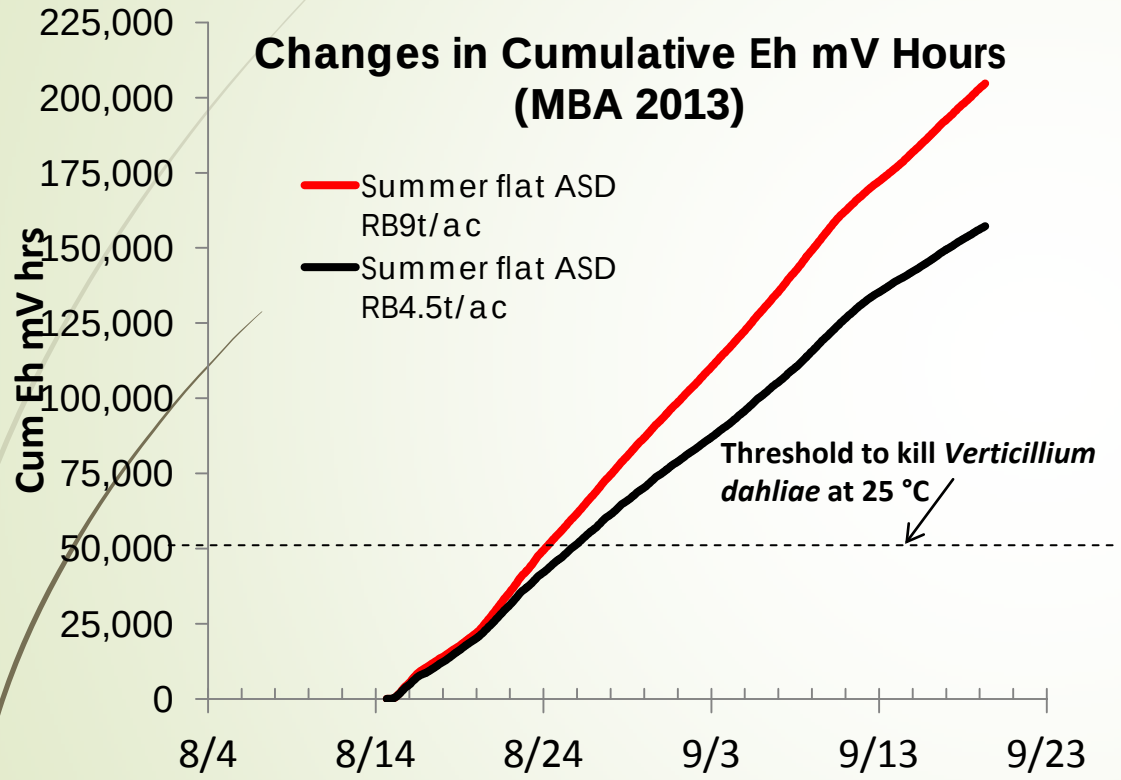
Progress of *Fusarium* wilt at MBA 2013

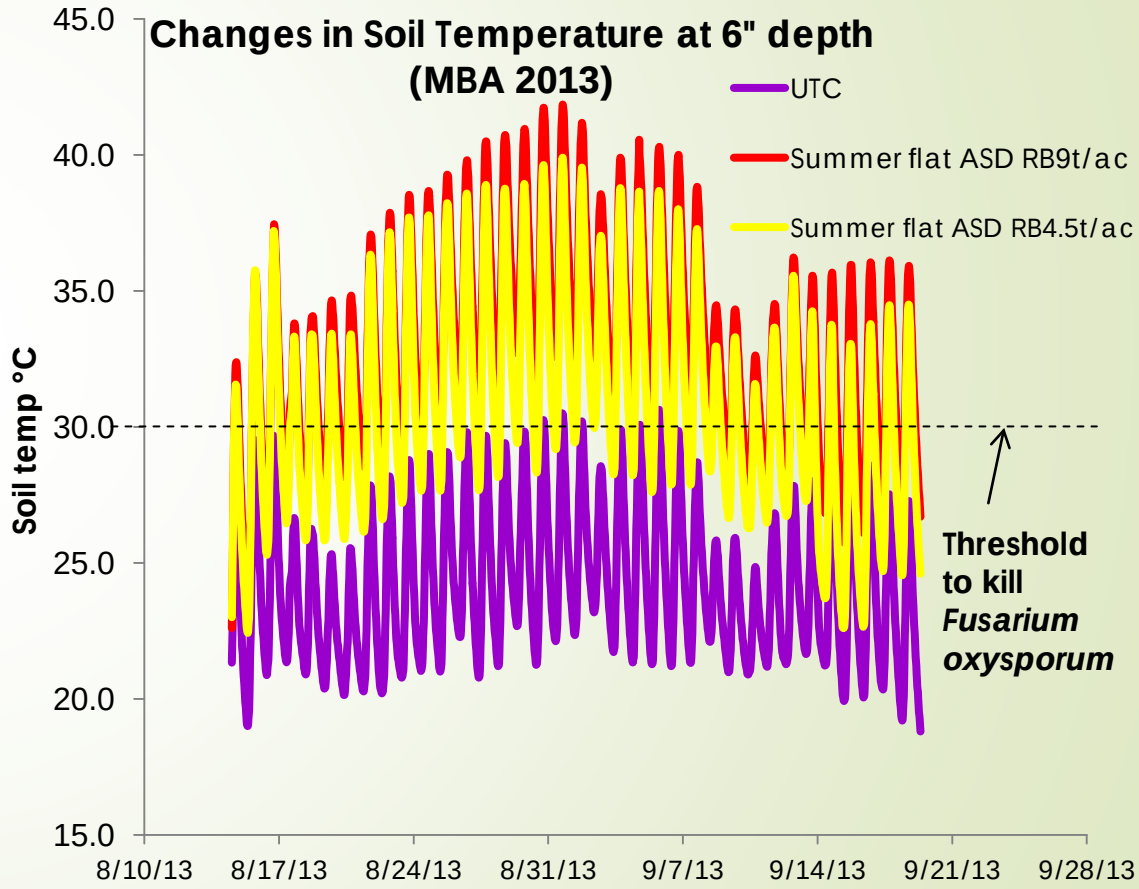
5/08/2013 6/21/2013 8/02/2013

- **Fall Bed ASD** does not control *Fusarium*
- Works elsewhere when soil temperature higher Threshold 86 deg F (30 deg C)

Summer flat ASD w/ clear TIF MBA 2013

Summer flat ASD w/ clear TIF MBA 2013 – control *Fusarium*?





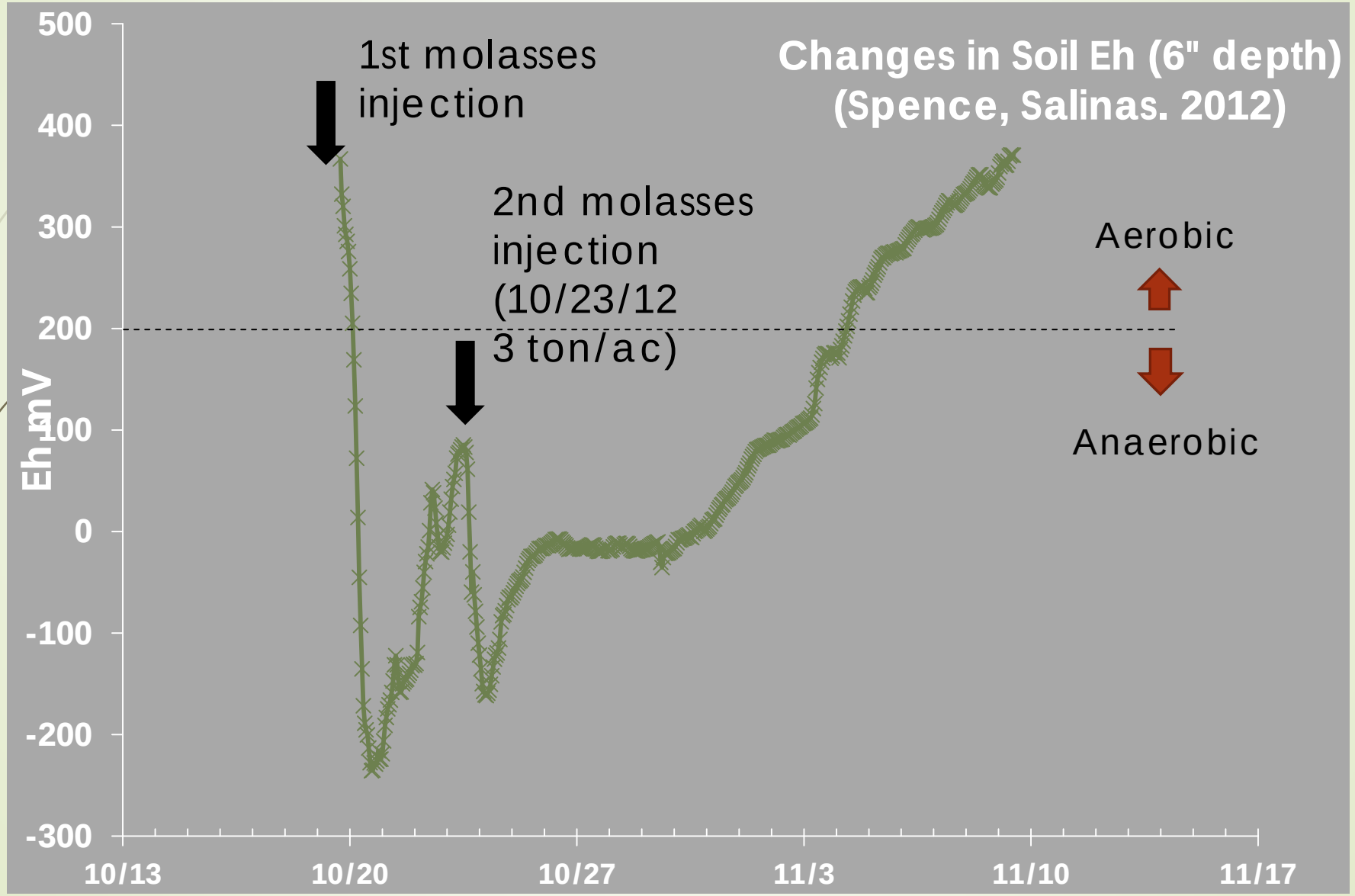
Oct. 2012 Sugarcane Molasses Injection

(1:1 to 1:3 dilution with H_2O)

C sources and efficacy?

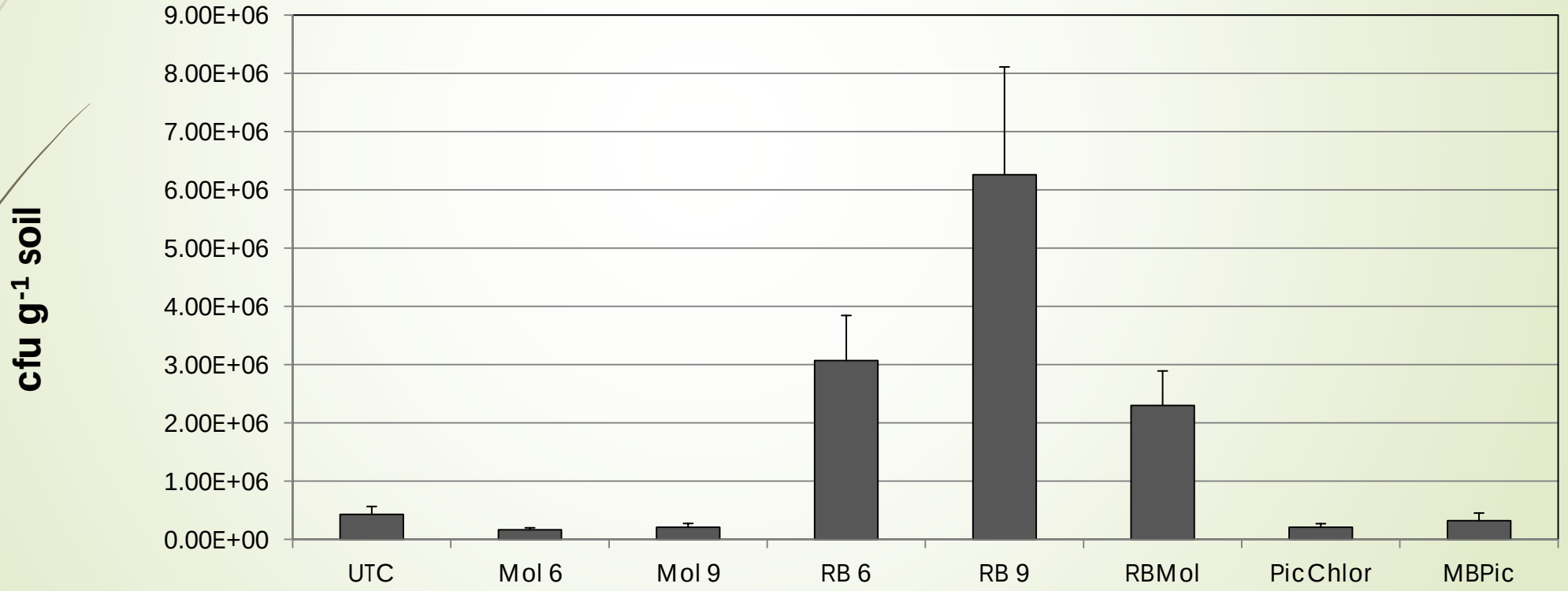
- Efficacy of molasses not good in CA, although works in Fl and Japan
  - Fruit yield ~70% of fumigated control
  - Temperature issue?
  - Distribution issue?
  - Short-lived anaerobic conditions - split applications needed to sustain anaerobic conditions at lower temperatures?
  - Mix molasses and rice bran - promising?
- Need to assess different C sources on various organisms at different temperature regimes

Spence Field - Salinas Fall 2012



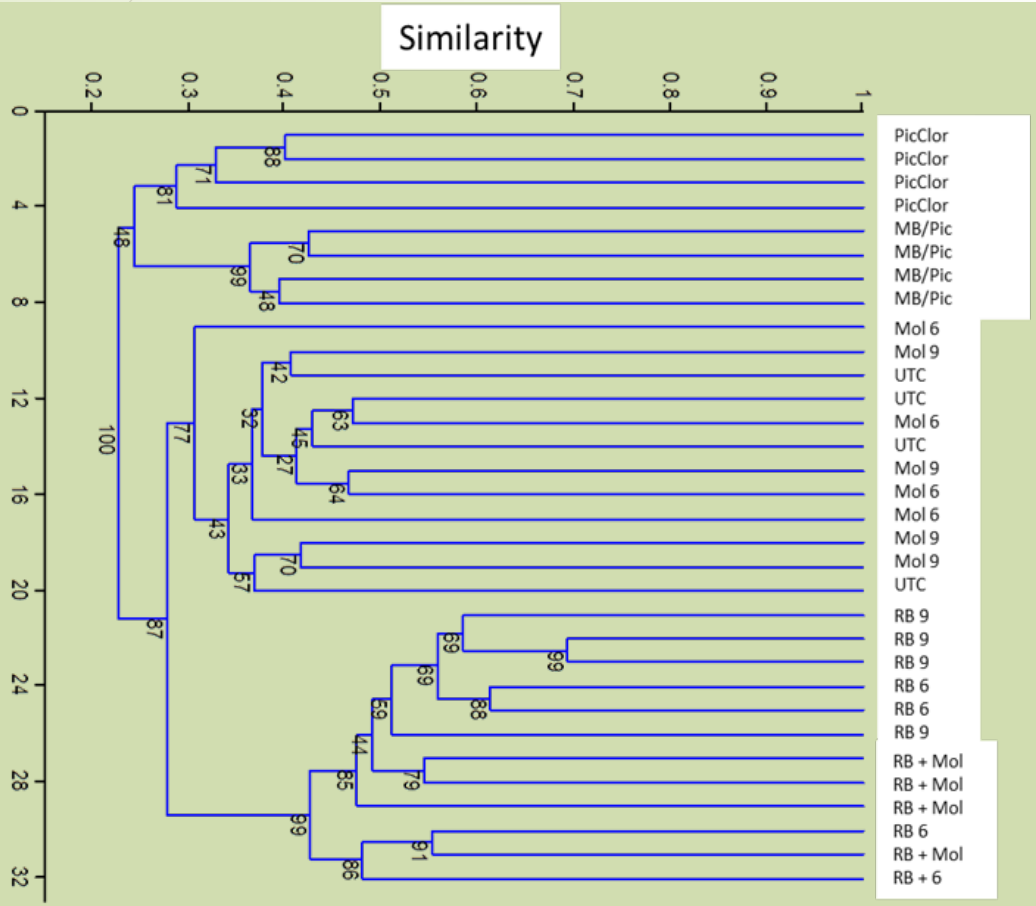
C- Source efficacy?

Differential effects of Molasses versus Rice Bran ASD on fungal communities



M. Mazzola 2013

ASD effects on fungal community composition also depends on C source (T-RFLP analysis)



Fumigant

UTC and Molasses

RB or RB + Mol

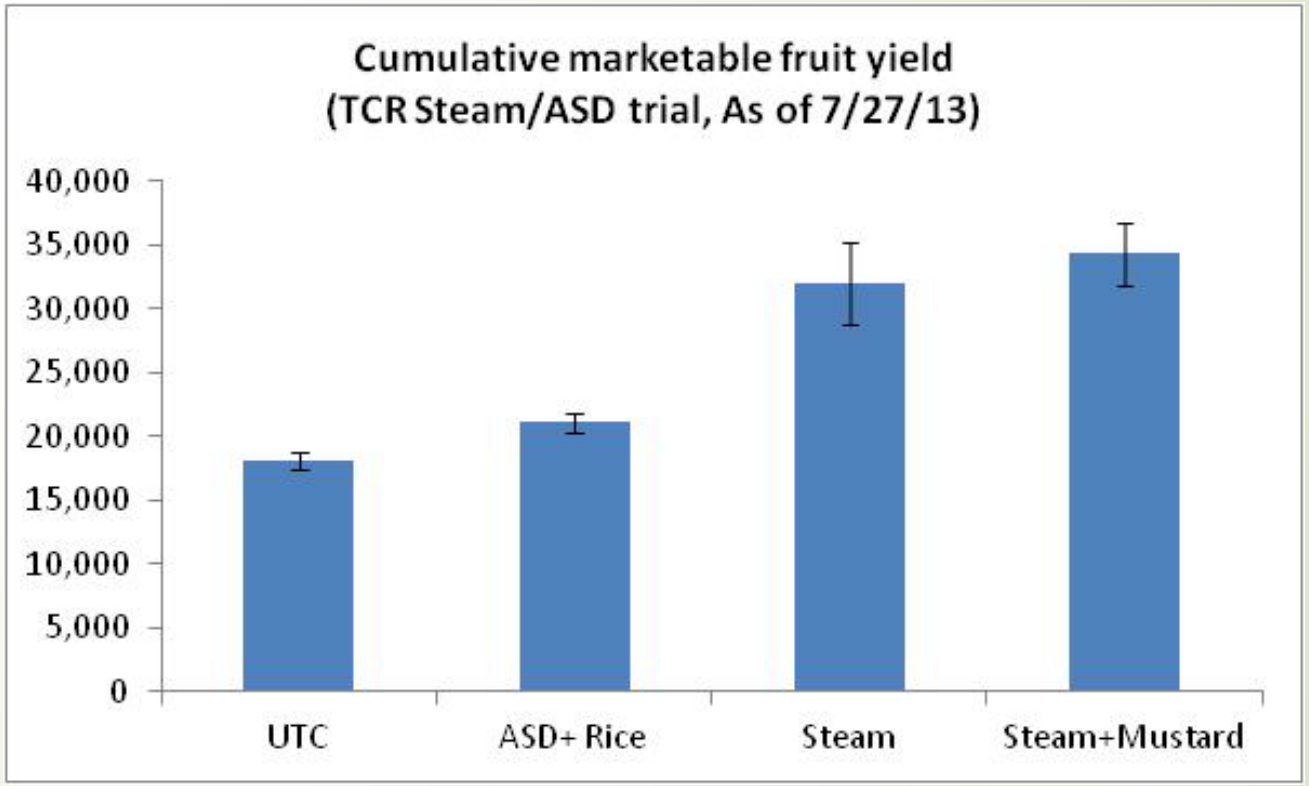
M. Mazzola, 2013

Practical issues to be addressed

- Scaling up:
  - 2012; **120 acres under ASD**
  - 2013; **430 acres under ASD** – 29 ac Conventional
    401 ac Organic
  - 67% of growers who did ASD in 2012 continued to use it in 2013
- Variability in achieving good anaerobic conditions

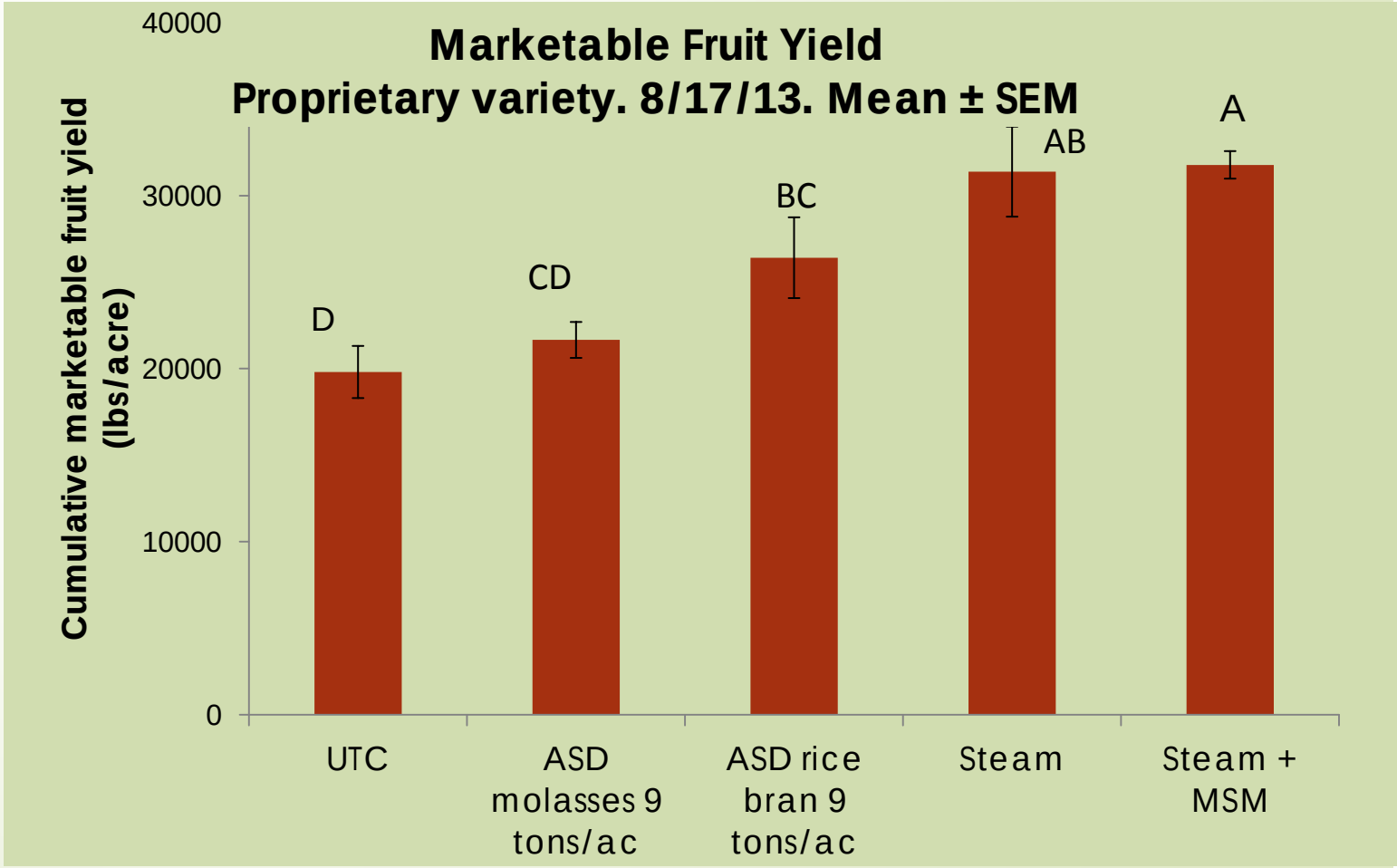
- Porous soil structure in heavy soil (large clods) prevented good ASD conditions

- *Macrophomina* and other pathogens not controlled



- When *Verticillium* levels in soil very high (30+ microsclerotia/g soil), ASD may not completely eliminate disease

- Watsonville field



Alternatives to rice bran as C source?

- Bed application costs with 9 ton/ac rice bran typically around $2000-2400 per acre compared with about $1200/ac for Pic-Clor
- High total N addition – about 360lb/ac

- Other C-sources to reduce costs and N application?
- Flat application and reduced rate options?
- Reduce fertility applications to account for C source nutrients

Future work

- **Effectiveness for controlling different pathogens needs much more work** – what temperature, anaerobic thresholds and C-sources work for each pathogen
- **Cost and nitrogen issues – other options for C-sources**:
  - Molasses – can efficacy be improved?
  - Grape pomace not promising - other options?
  - Summer cover crops may work as partial C-source
  - Flat application may allow reduction of RB application rate?
  - Degree of N_2O emission?
- **Limitations of bed application** – challenges of creating anaerobic conditions in heavier soils.
  - Options for flat application and reduced C input rates?
- **Possible combination of ASD with other strategies?**
  - Sequential with MSM?
  - With low rate of fumigants?

Questions?

joji@ucsc.edu

cshennan@ucsc.edu