Anaerobic Soil Disinfestation (ASD) in CA strawberries

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], S. Fennimore[5] and J. Samtani[5]

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

Funded by USDA-CSREES MBTP 2007-51102-03854, 2010-51102-21707 and CA Strawberry Commission

Acknowledgements

- Hector Gutierrez with Tri-Cal/Otillo Farms and UC Hansen staff and volunteers
- Gary Tanimura, and Glenn Noma, Tanimura & Antle Fresh Foods, Inc.
- Dave Peck. Manzanita Berry Farms
- Dole Food Company, Inc.
- Monise Sheehan, Kat Kammeijer, Laura Murphy, Patty Ayala at UCCE
- Margherita Zavatta and student workers, interns, and volunteers of the Shennan lab, UCSC
- Hilary Thomas, Alex Orozco and Dan Legard, CA Strawberry Commission

Project Goals

- To test ability of ASD to consistently control *V. dahliae* and other pathogens and monitor effect on strawberry yields
- To assess the economic feasibility of ASD
- To determine the mechanisms of disease reduction by ASD
- To determine effect of ASD on N fertility and cycling with different C-sources
- To test ASD at commercial scales

2012-2013 season

Commercial Implementations of ASD in CA

Crop	# of site	C-source * (# of site)	Acreage per site Ave. (Min. – Max.)	Acreage Total
Strawberry	16	RB 6-9 t/ac (14) ML 6 t/ac (2)	5.8 (1-20)	94
Raspberry	11	RB 6-9 t/ac (11)	2.2 (1-5)	24
Blueberry	1	RB 6-9 t/ac (1)	5.0 (5-5)	5
Total	**28****	**RB 6-9 t/ac (26)** **ML 6 t/ac (2)**	**4.4 (1-20)**	**123**

* RB: rice bran, ML: molasses. ** 26 organic sites and 2 conventional sites.

As of Sep. 26, 2012. Courtesy of K. Jacobsen, Farm Fuel, Inc.

2012-2013 demonstration trials – detailed monitoring

Location	C-source	Acre age	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

Spreading rice bran – broadcast with manure spreader

Applying rice bran to beds only, then rototilling to incorporate

Injecting molasses

Findings from pot and field trials to 2011:

1. Can get consistently good *V. dahliae* suppression - 80 to 100% decrease in # microslerotia in soil, using a range of C-sources
2. Need to accumulate 50,000 mVhr of Eh below 200mV to get suppression, and for soil temps to be above 65°F for at least first week of ASD treatment
3. 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, similar $ returns above treatment and harvest cost as Pic-Clor
4. Standard tarp appears as effective as TIF and VIF (from pot and field studies)
5. Weed suppression is limited in the central coast of CA

Remaining questions

1. Does ASD effectively control other soil pathogens like *Macrophomina phaseolina* and *Fusarium oxysporum?*

2. Can ASD be scaled up to full field level?

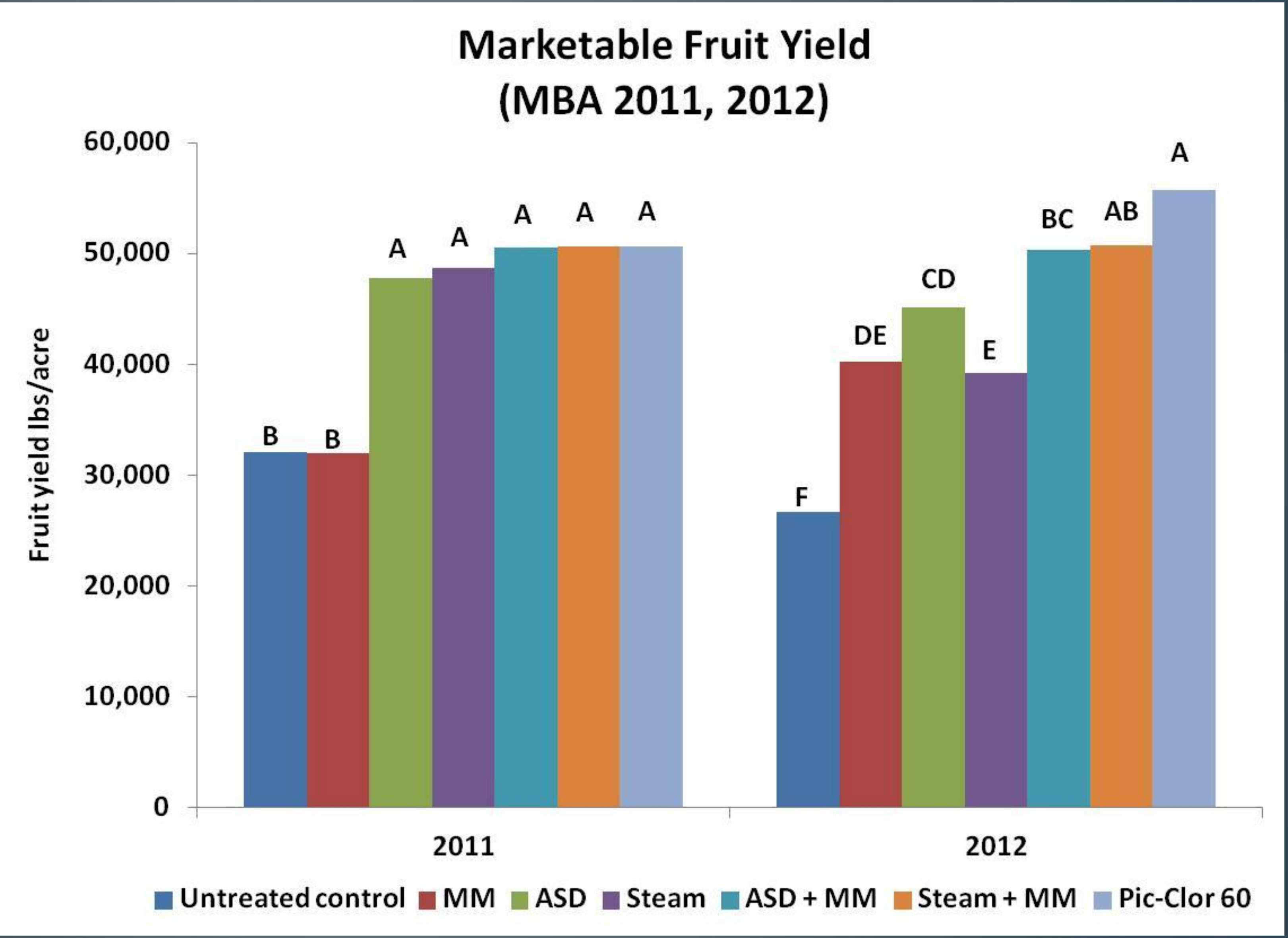
3. Economic assessment for more trials?

4. Mechanism of action?

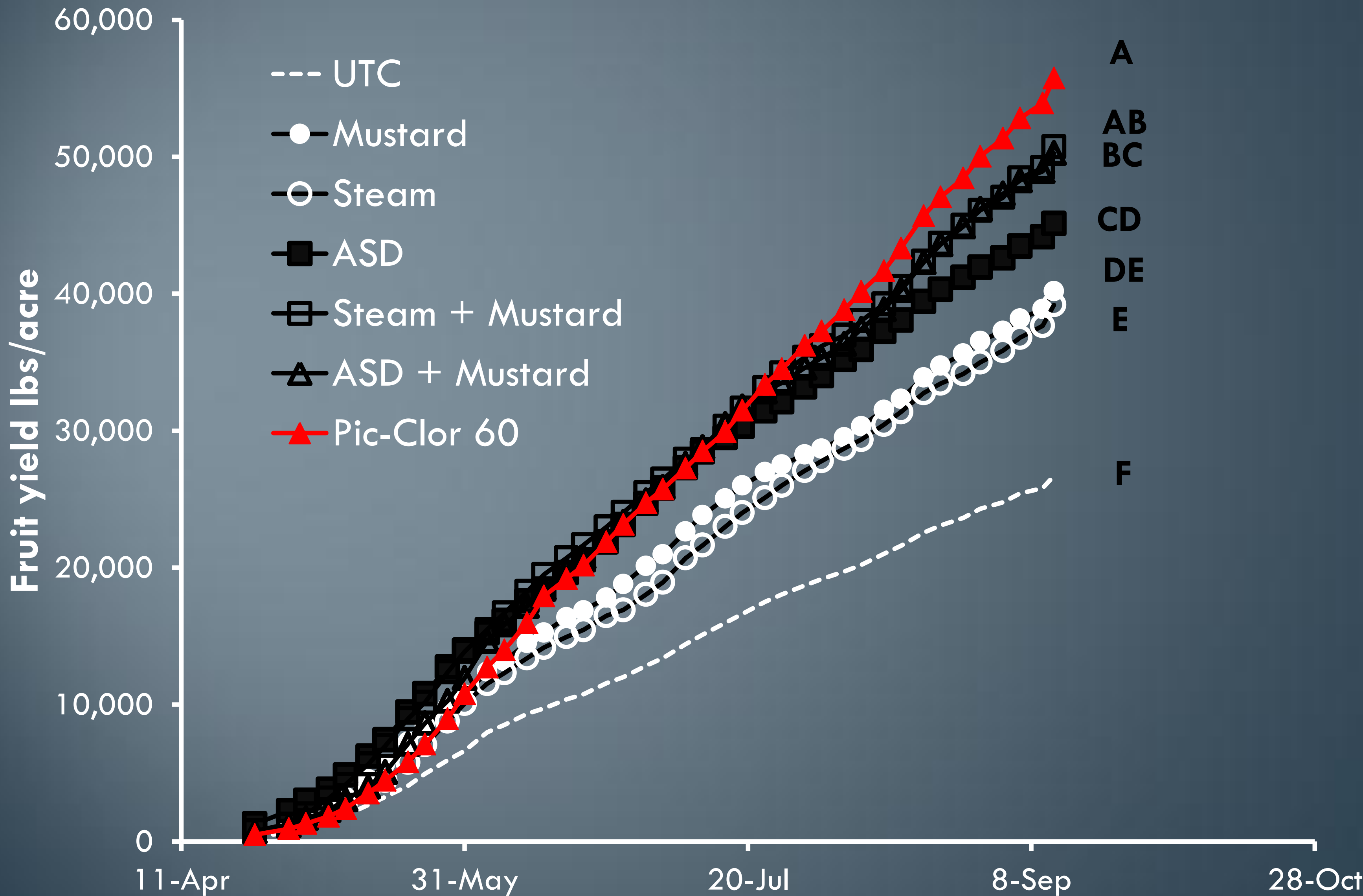
    What is ASD doing to soil microbial communities?

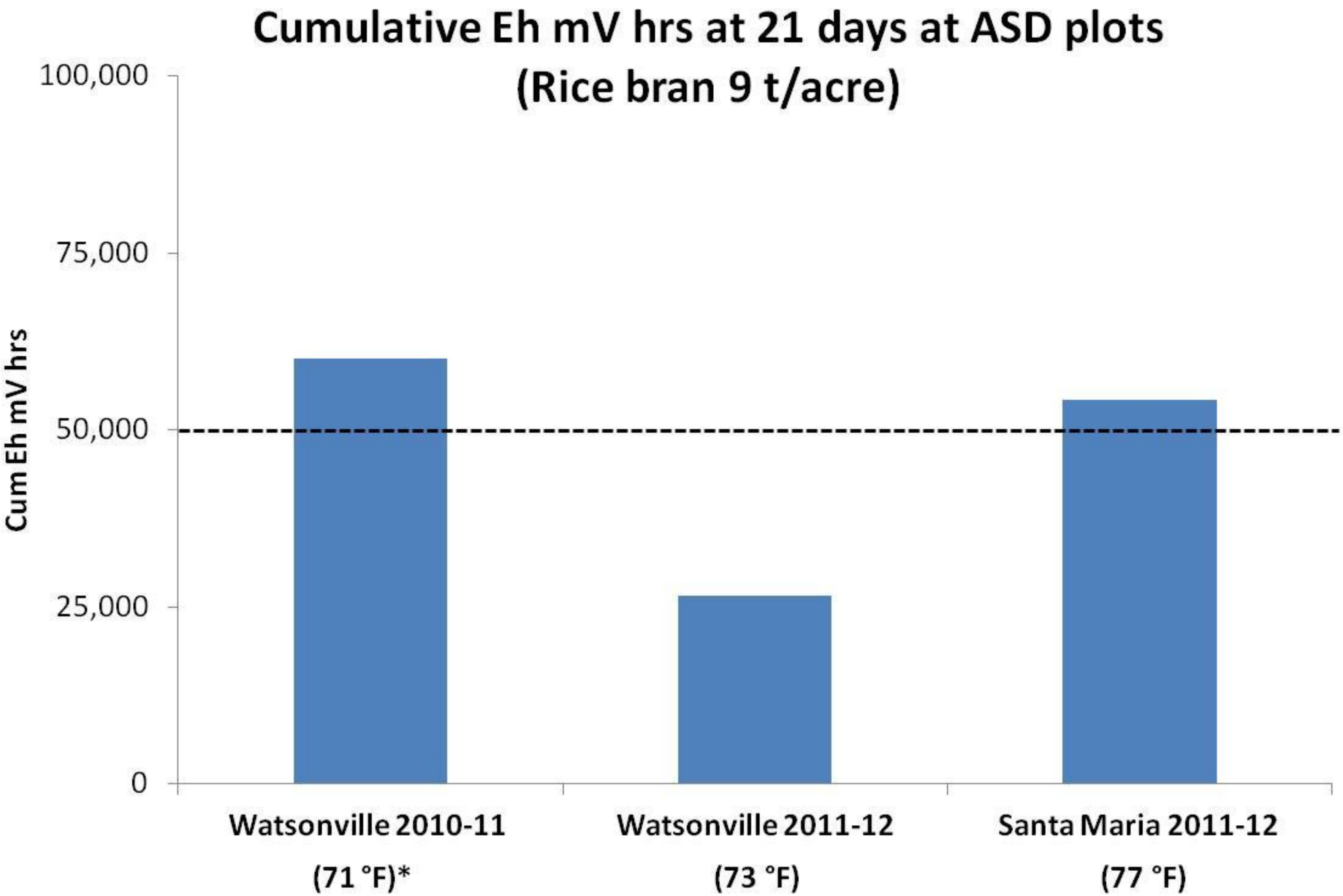
    Effects on soil chemistry?

Watsonville 2010/11, 2011/12



Cumulative Strawberry yields 2012 Watsonville

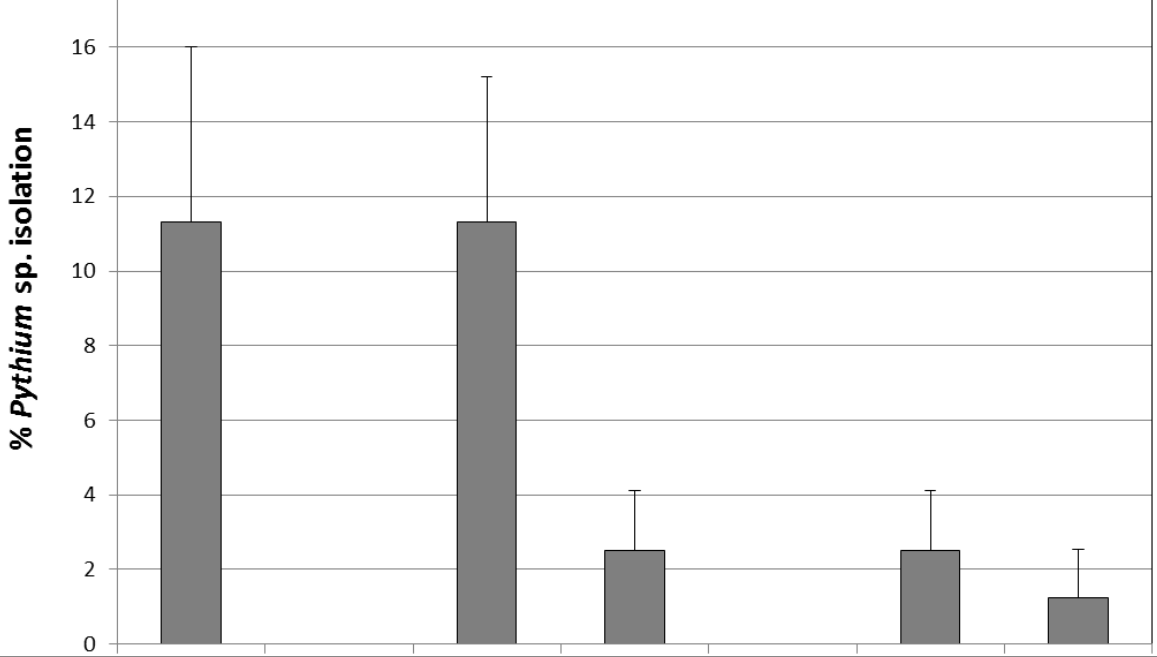


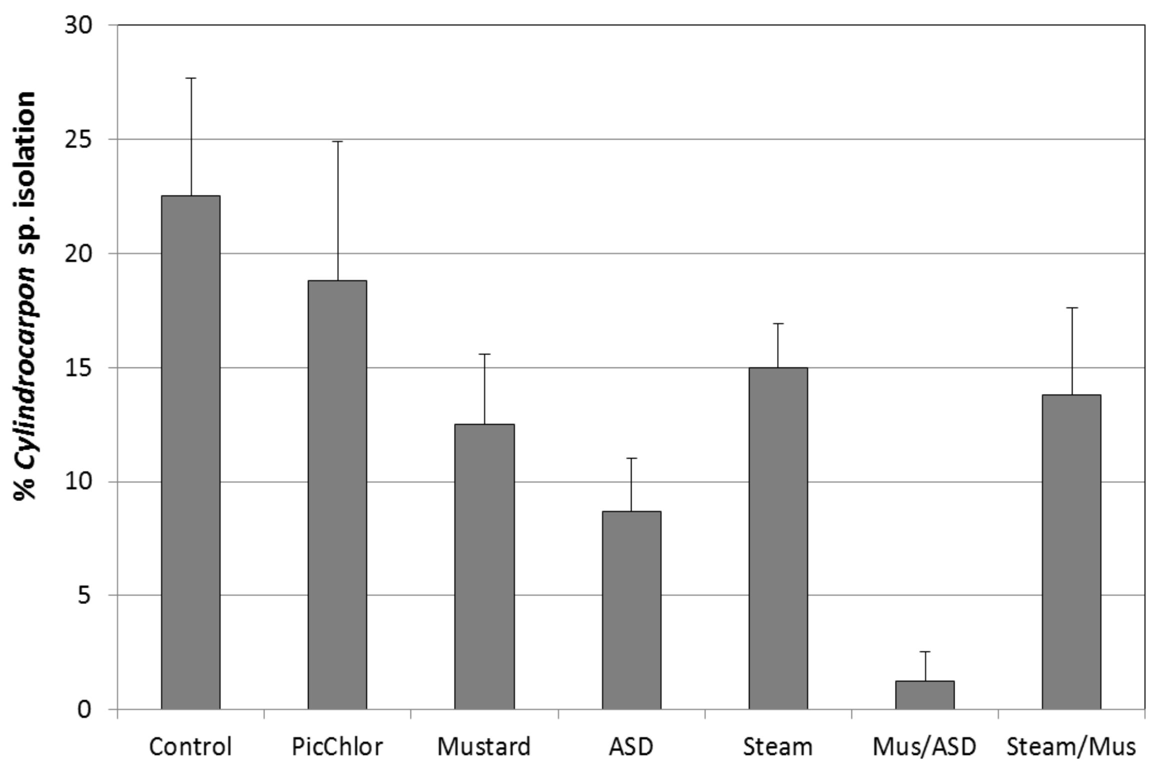


* Average soil temperature at 6" depth during the first week of ASD treatment.
Threshold is >65 °F.

Watsonville pathogen profile

- *Pythium* and *Cylindrocarpon* spp. Main fungi recovered from strawberry roots.
- *Pythium* were *P. ultimum* or *P. sylvaticum*, both highly virulent pathogens.
- *Cylindrocarpon* spp. dominated in steam, MM, ASD, and PicChlor, but *Pythium* spp. in the ASD+MM treatment.
- *Cylindrocarpon* spp. can act with *Pythium* spp. to cause damage greater than either pathogen alone (Tewoldemedhin et al., 2011).
- *Fusarium* spp. recovered from all treatments, identified as *F. oxysporum* or *F. equiseti*, the former a pathogen of strawberry and the latter known to promote plant growth.



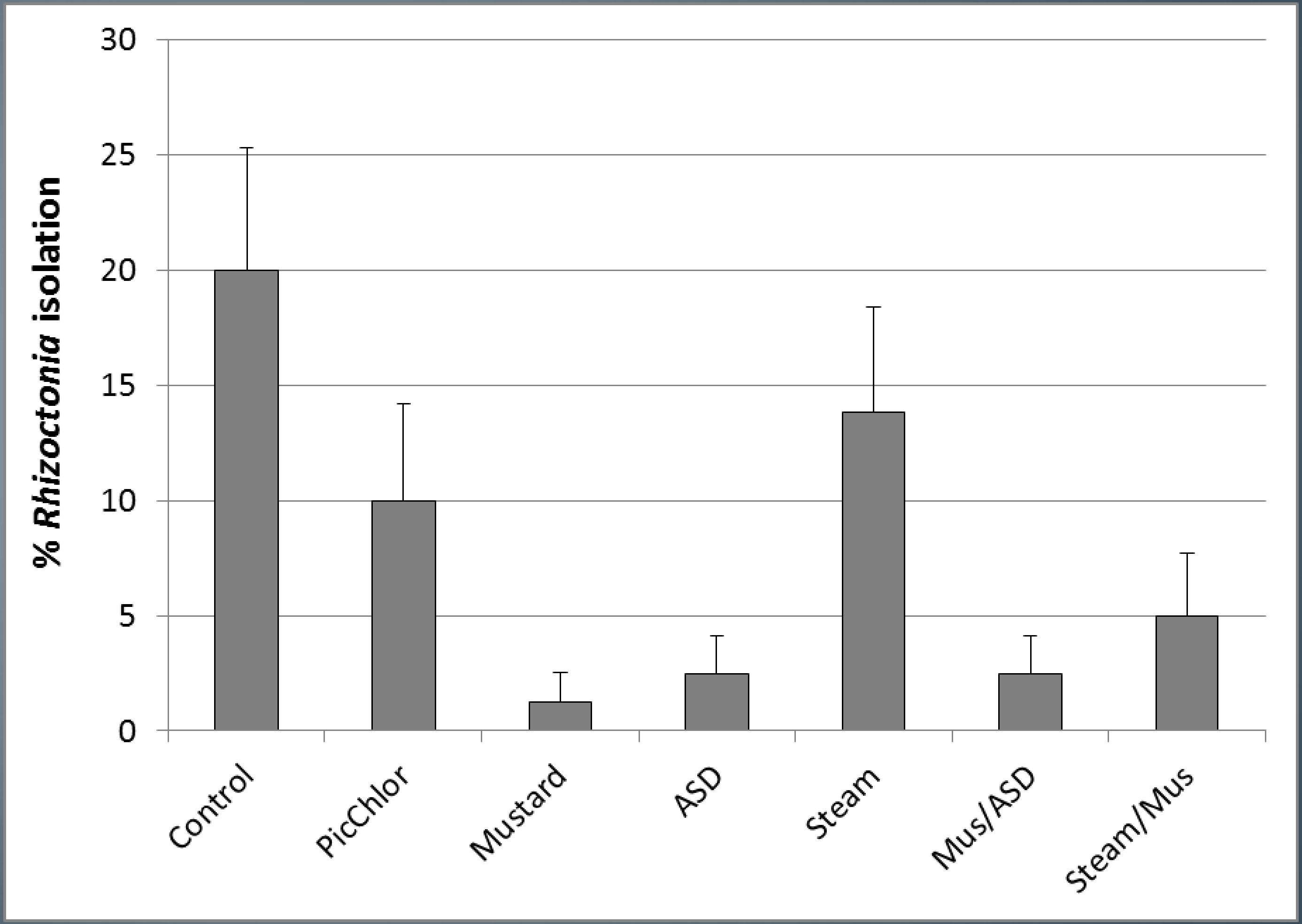


Pythium spp.

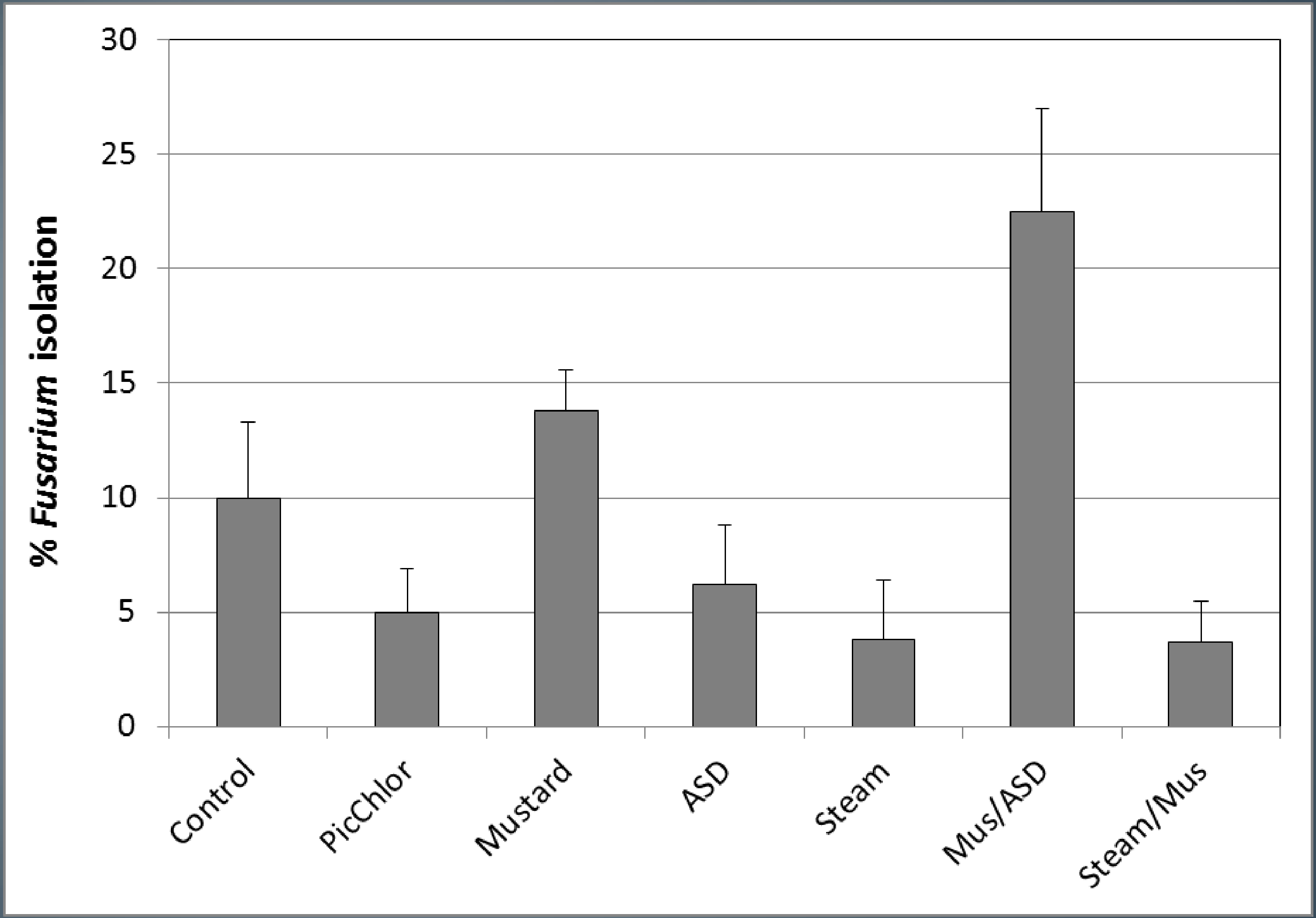
% roots from which fungi was isolated

Cylindrocarpon spp.

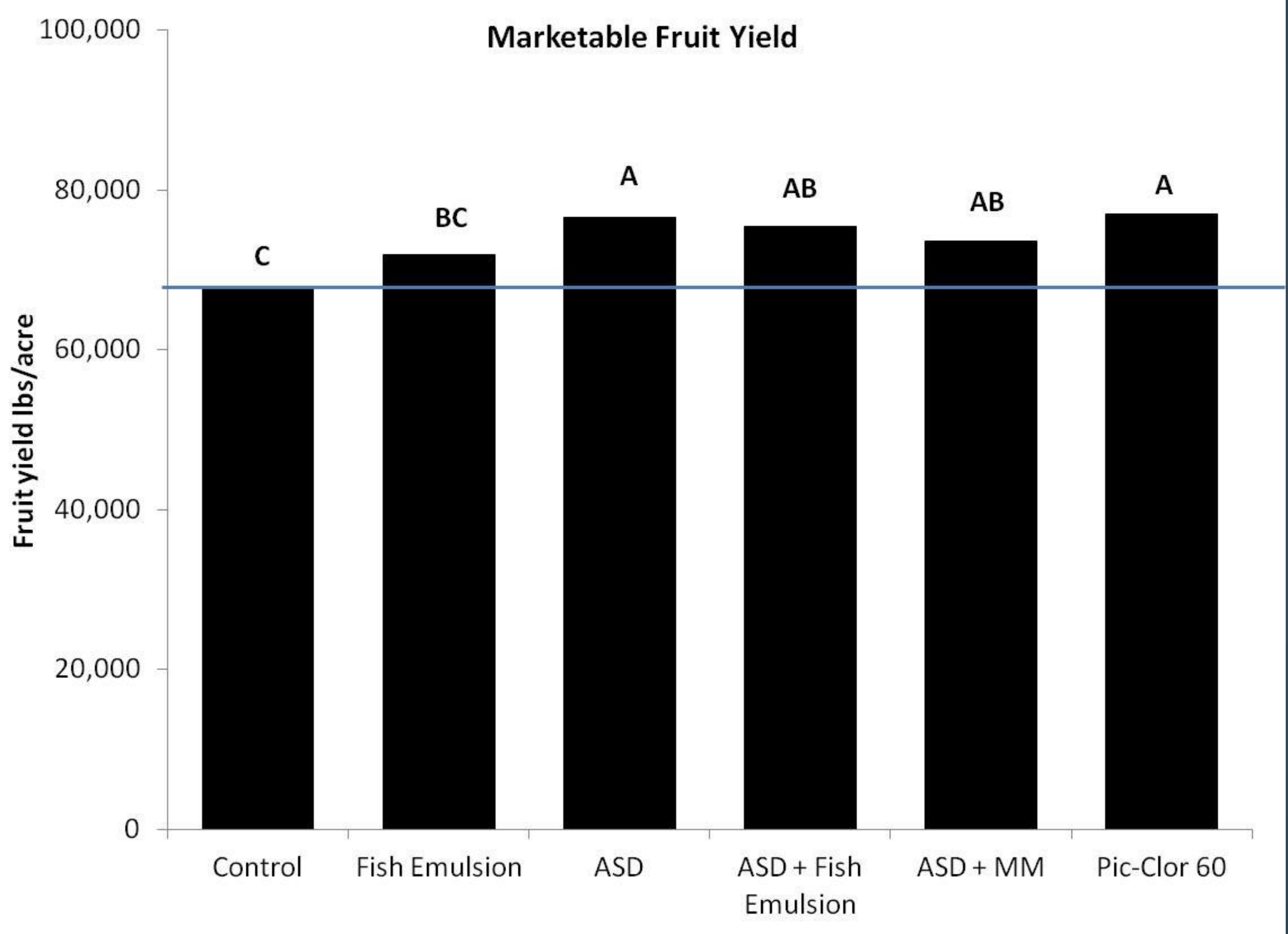
% roots from which Rhizoctonia was isolated



% roots from which Fusarium spp. were isolated



Santa Maria 2011/12



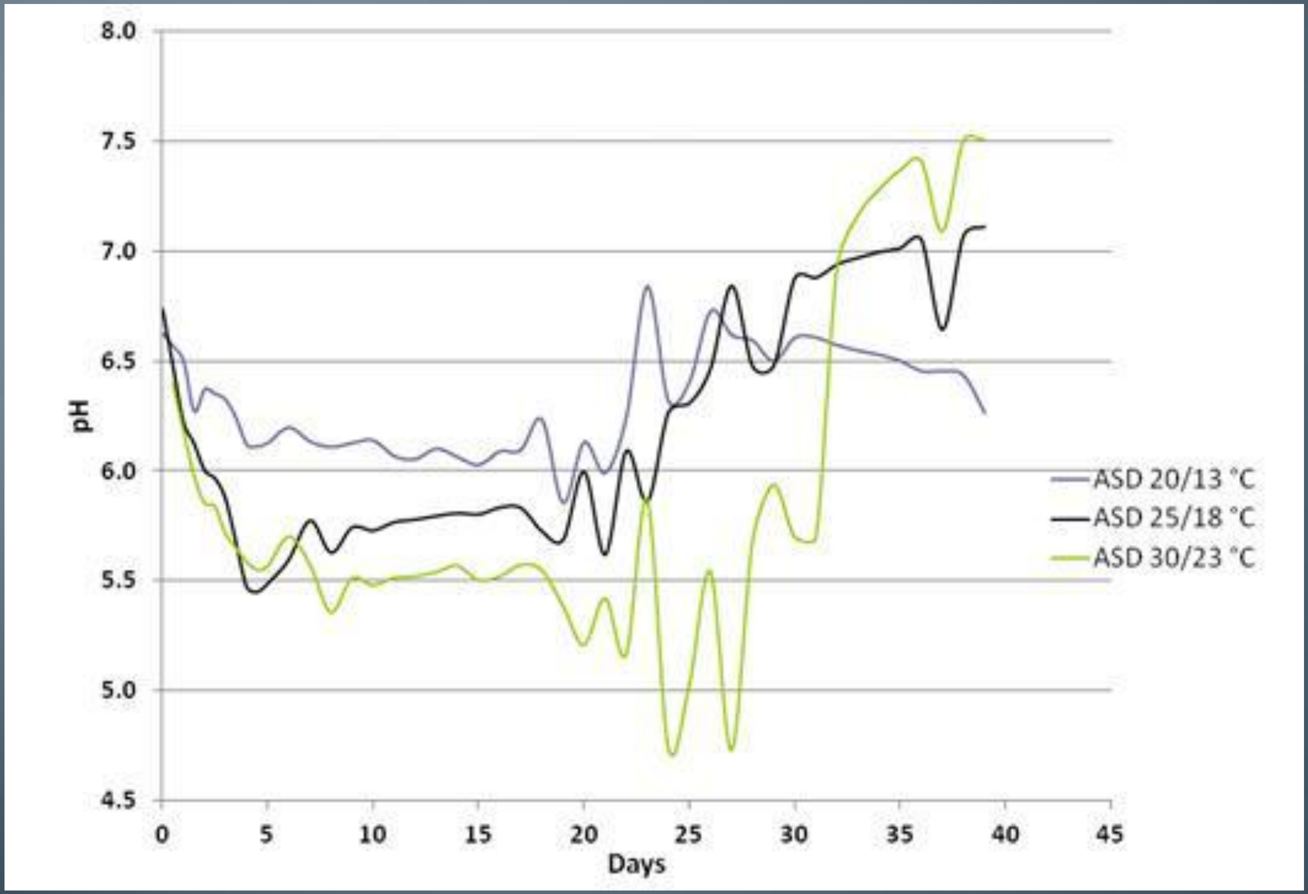
Santa Maria pathogen profile from plant roots

- *Fusarium solani* or *Fusarium tabacinum* recovered in all treatments , but no isolates of *Fusarium oxysporum.*
- *Rhizoctonia* spp. recovered from roots in control and fumigated soils, but not in ASD treatment.
- *Pythium* spp. not recovered from roots in fumigated soils but were from 2.5% of roots from ASD treated soils – all were *Pythium spinosum*, *Pythium megacarpum* or *Pythium violae,* none of which are pathogens of strawberry.

ASD: Mechanisms

- Accumulation of toxic products from anaerobic decomposition (e.g. organic acids, volatiles)
- Biocontrol by anaerobic microorganisms
- Low pH
- Lack of oxygen
- Combination of all of these

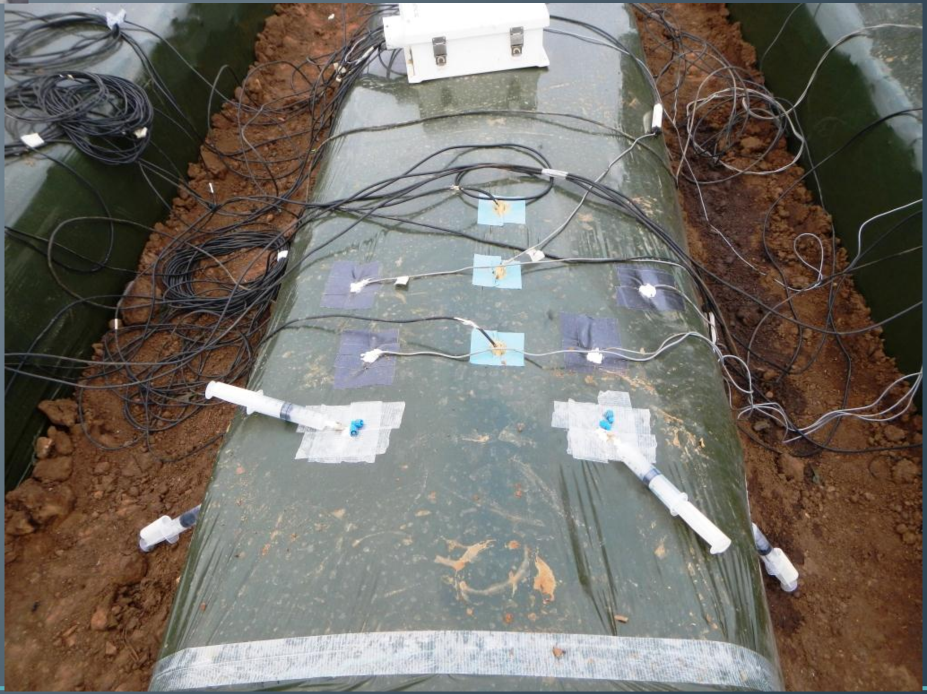
Mechanisms

- Lower pH and organic acid production
- 

Instrumentation: monitor conditions across bed and at different depths

Measure:

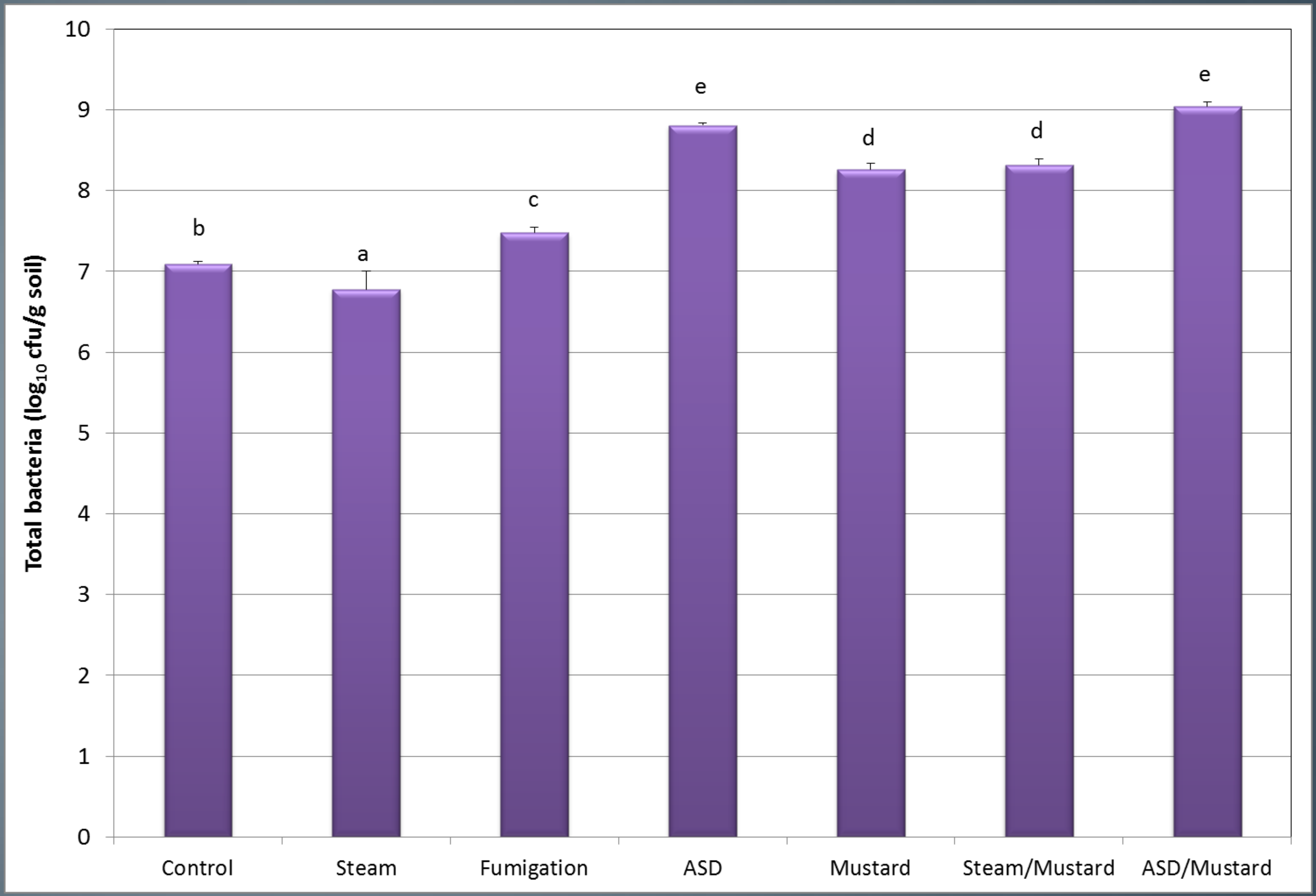
- pH
- Eh
- EC
- temperature
- moisture
- Fe^{2+}



Mechanisms

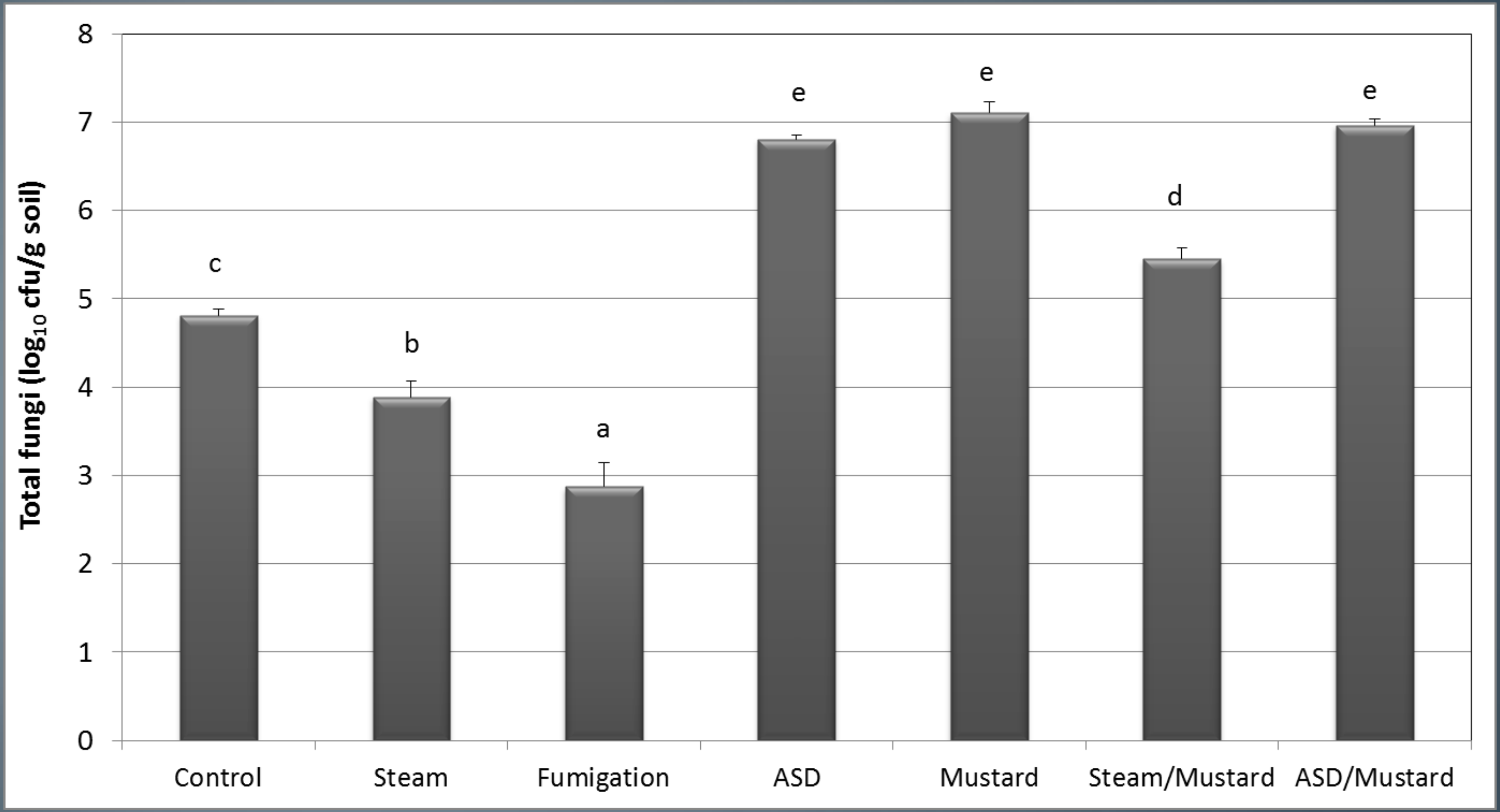
- Lower pH and organic acid production
- Changing soil microbial communities

MBA, Post-treatment Total bacteria: November 2011

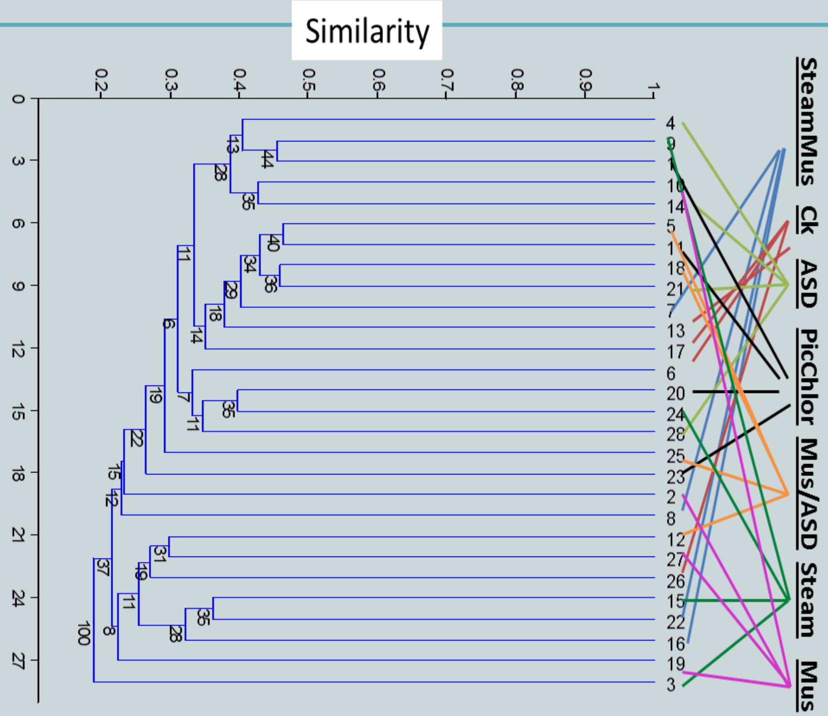


All ASD and mustard-based treatments stimulated bacterial communities, - likely inducing an elevated competitive environment.

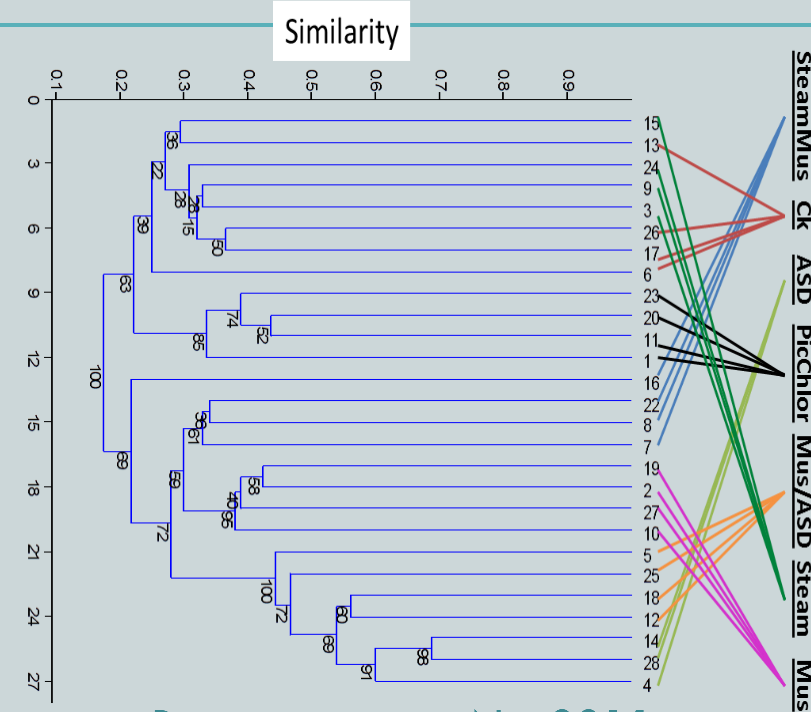
MBA, CA Post-treatment Total fungi: November 2011



All ASD and mustard-based treatments stimulated total fungal densities, likely inducing an elevated competitive environment.

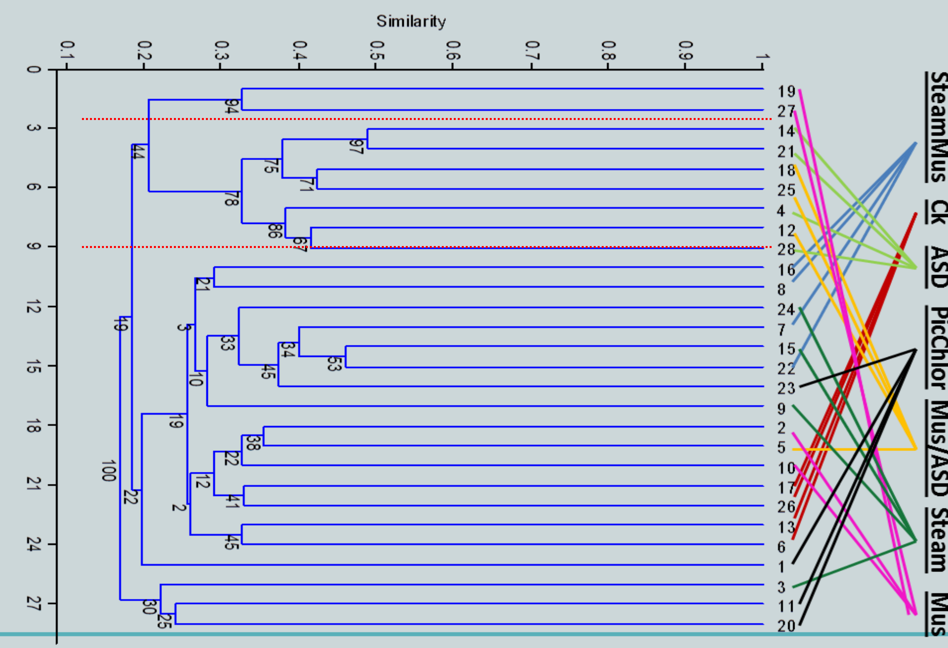


Pre treatment Oct 2011



Post treatment – Nov2011

Fungal ITS Watsonville trial 2011/12



Post harvest Sept 2012

Future work planned

- Continue to evaluate ASD for control of other pathogens
- Test alternative C sources such as molasses, cover crops, alone and in combination with rice bran
- Do more large field demonstrations – assess uniformity
- Continue economic analysis of various ASD options
- Document nitrogen dynamics for different ASD options
- Further explore mechanism of action of ASD and suppressiveness of soil following ASD

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	Conventional
Watsonville	Rice bran 9 t/ac Molasses 9 t/ac RB 4.5 + Mol 4.5 t/ac Controls: UTC, Water only, Rice bran 9 t/ac – no water	Conventional
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

Questions?