Optimizing Anaerobic Soil Disinfestation (ASD) for California Strawberries

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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

ASD: some target Pests and Crops

- *Soil-borne pathogens*
  - *Verticillium dahliae*[1,2,4]
  - *Fusarium oxysporum*[1,2]
  - *Fusarium redolens*[2]
  - *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]
  - Strawberries[2,4]
  - Eggplant[2, 3]
  - Spinach[2]
  - Peppers[3]
  - Maple[1]
  - Catalpa[1]

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

ASD: Three Steps

1. Incorporate organic material
   - **Provides C source for soil microbes**
2. Cover with tarp
3. Irrigate to field capacity
   - **Water-filled pore space**
   - **Create anaerobic (no oxygen) conditions and stimulate anaerobic decomposition of incorporated organic material**

Spreading rice bran – broadcast with manure spreader


10/10/2008


CATERPILLAR
WIDE
LOAD
10/11/2008

Applying rice bran to beds only, then rototilling to incorporate

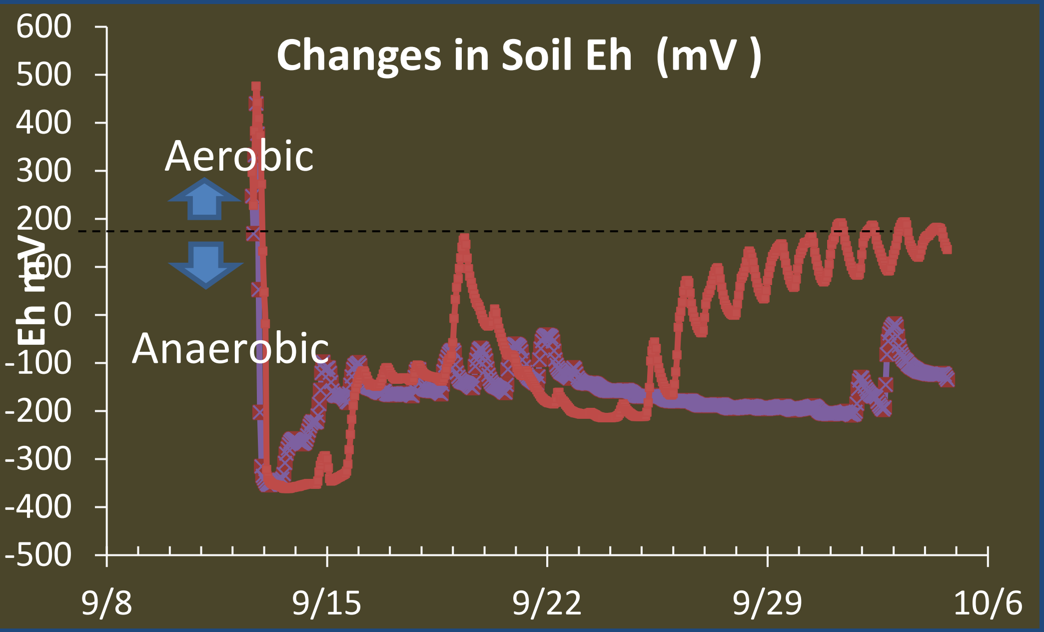

11/7/2008

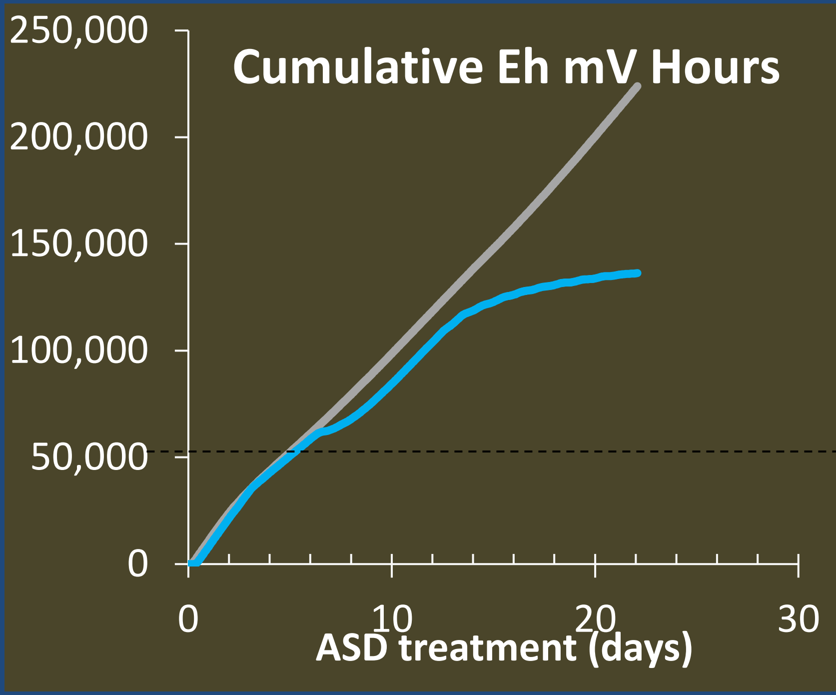
Findings to 2011

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
2. Can get consistently good *V. dahliae* suppression - 80 to 100% decrease in # microsclerotia in soil, using a range of C sources
3. Standard tarp as effective as TIF and VIF
4. Weed suppression limited in the central coast of CA

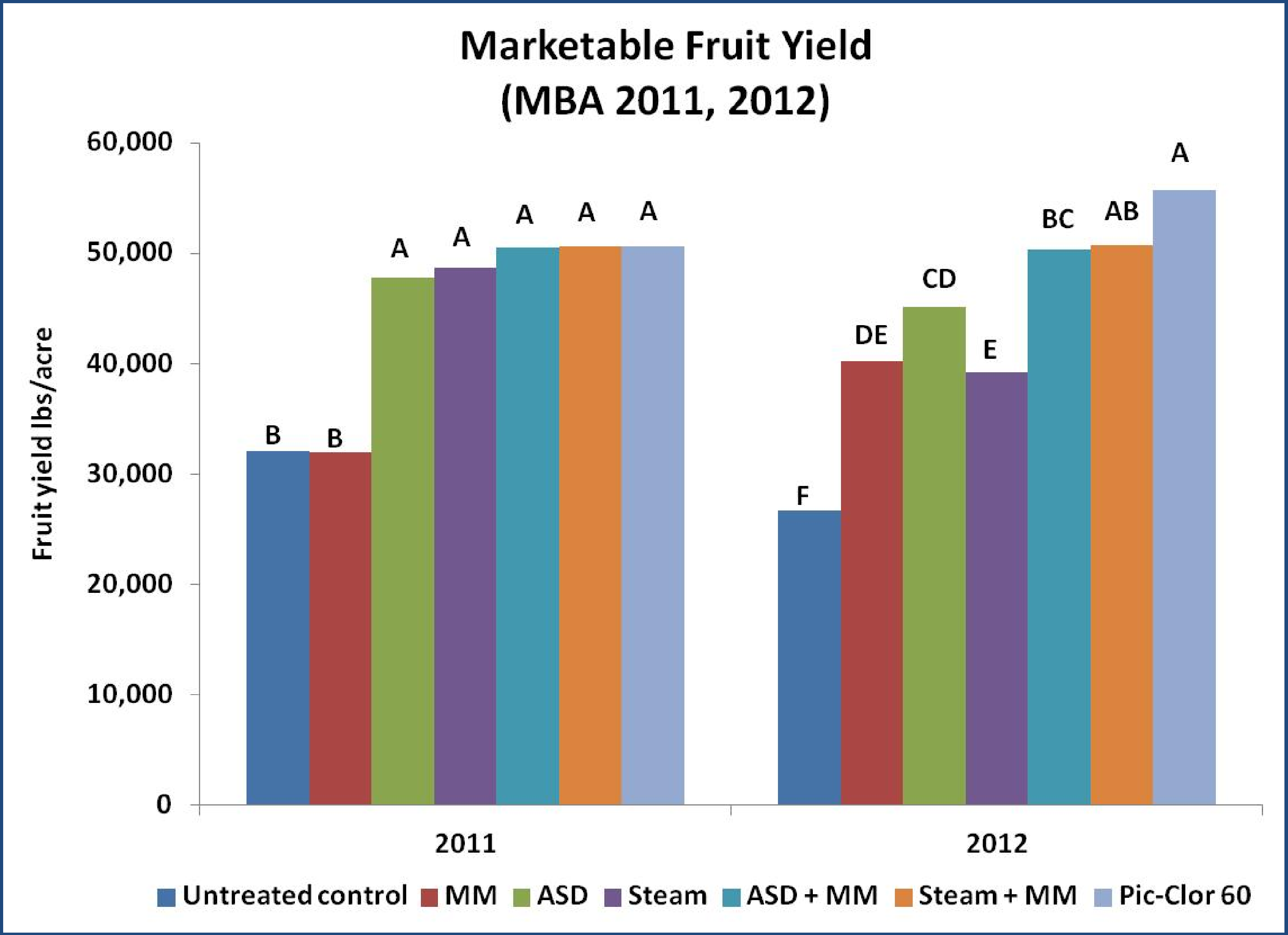
Findings to 2011 (contd):

5. Need to accumulate 50,000 mVhr of Eh below 200mV to get suppression, and for soil temps to be above 65^{o}F for at least first week of ASD treatment

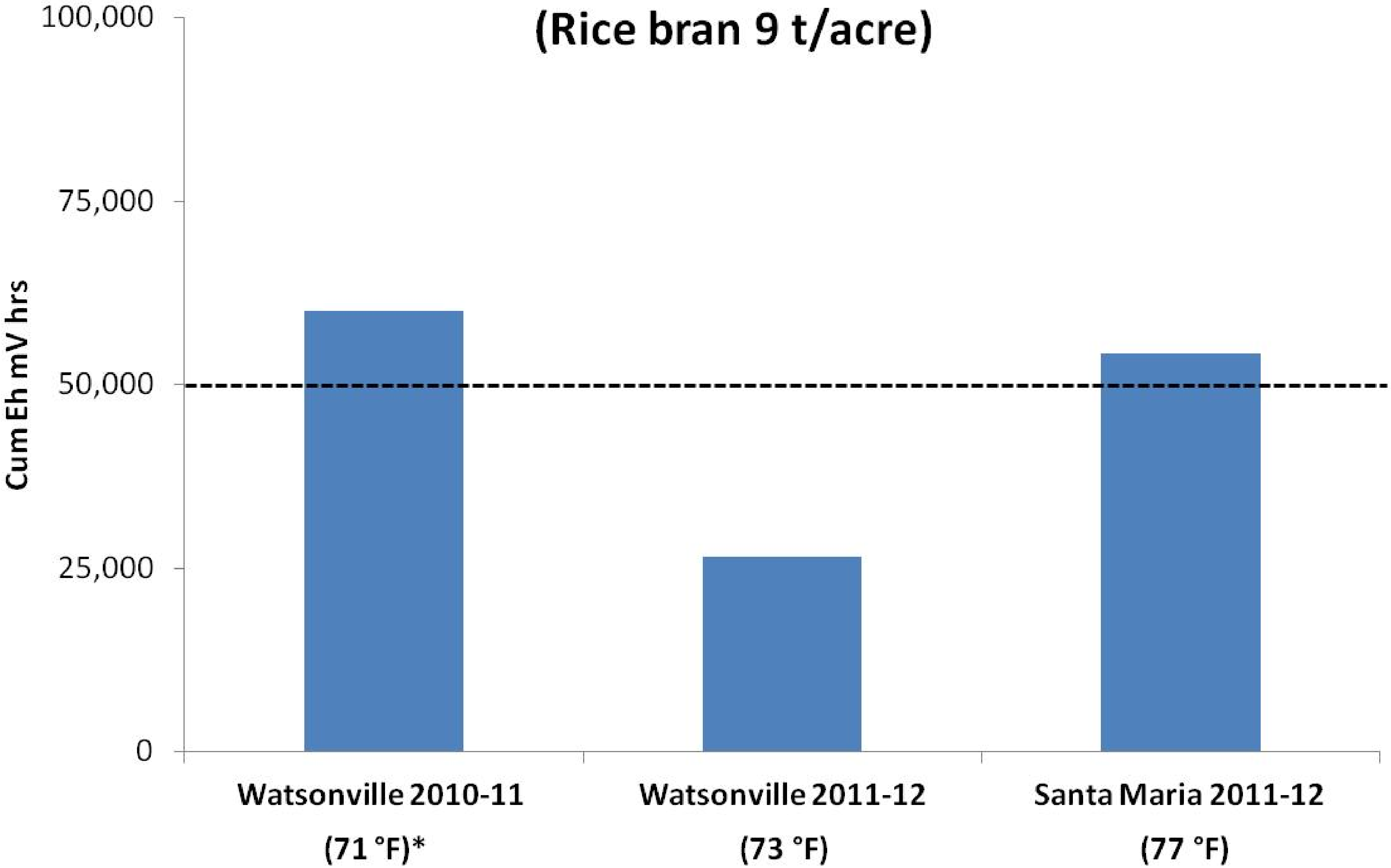




Watsonville 2010/11, 2011/12

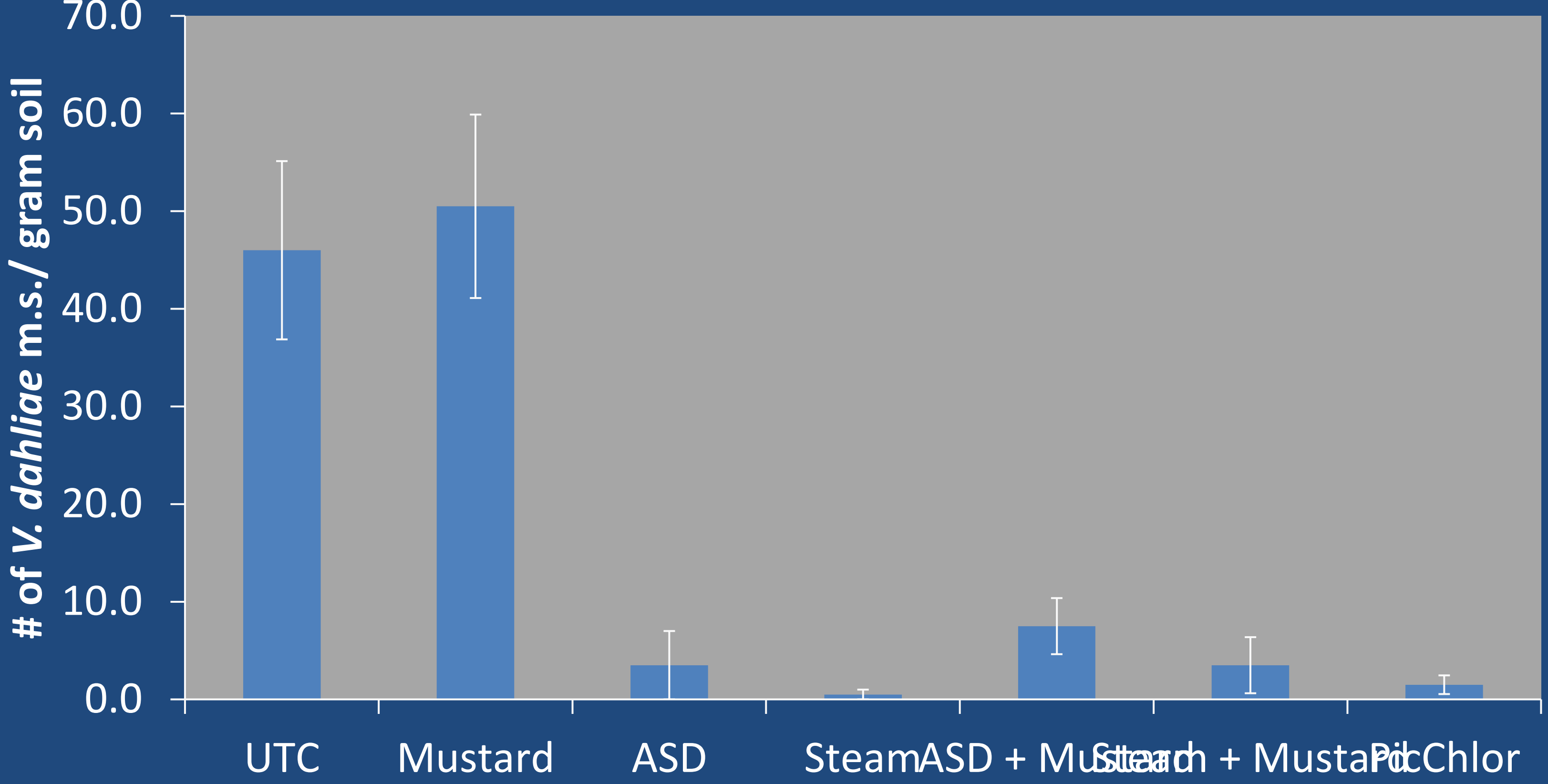


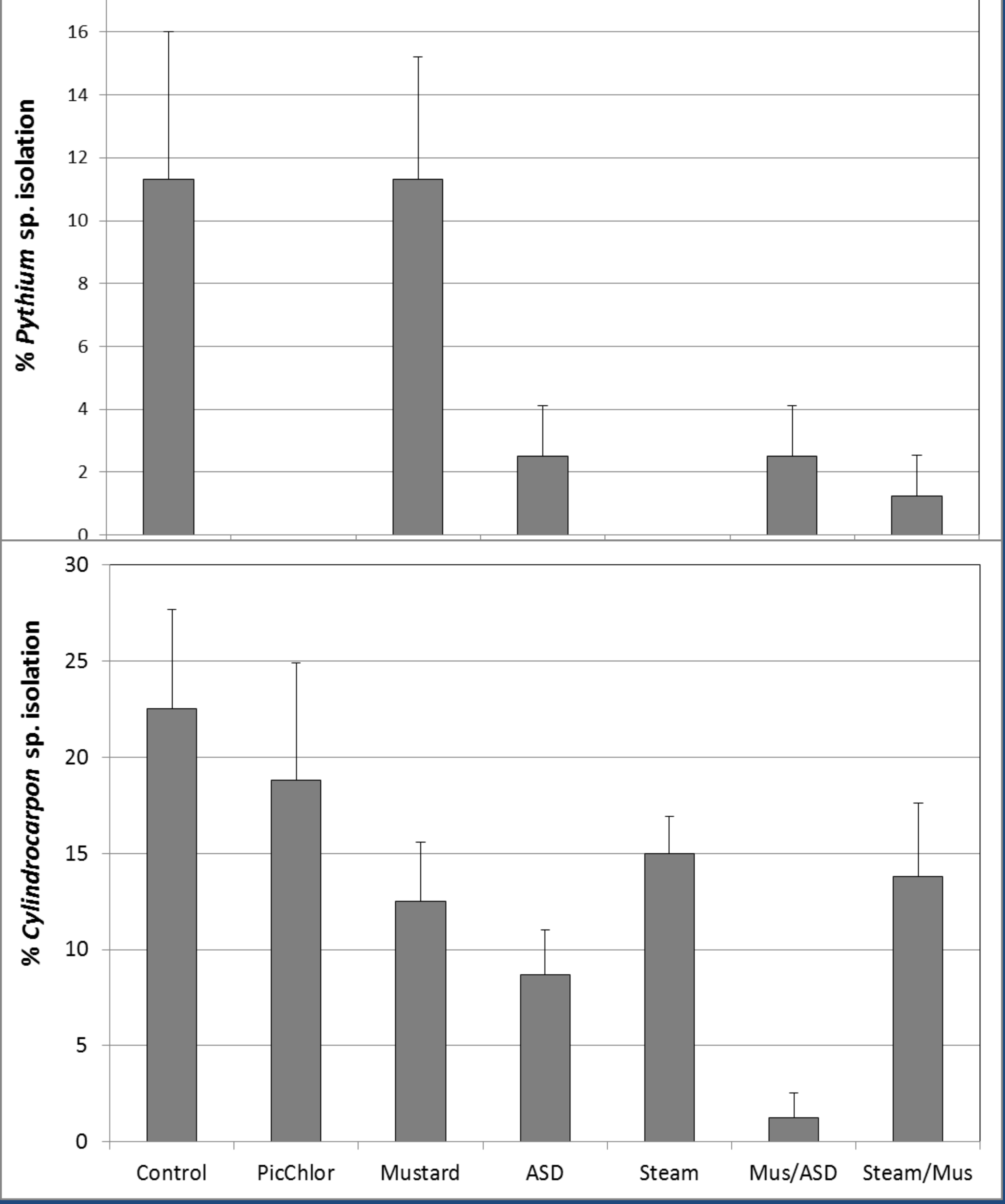
Cumulative Eh mV hrs at 21 days at ASD plots (Rice bran 9 t/acre)



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

2011 Verticillium inoculum suppression post treatment



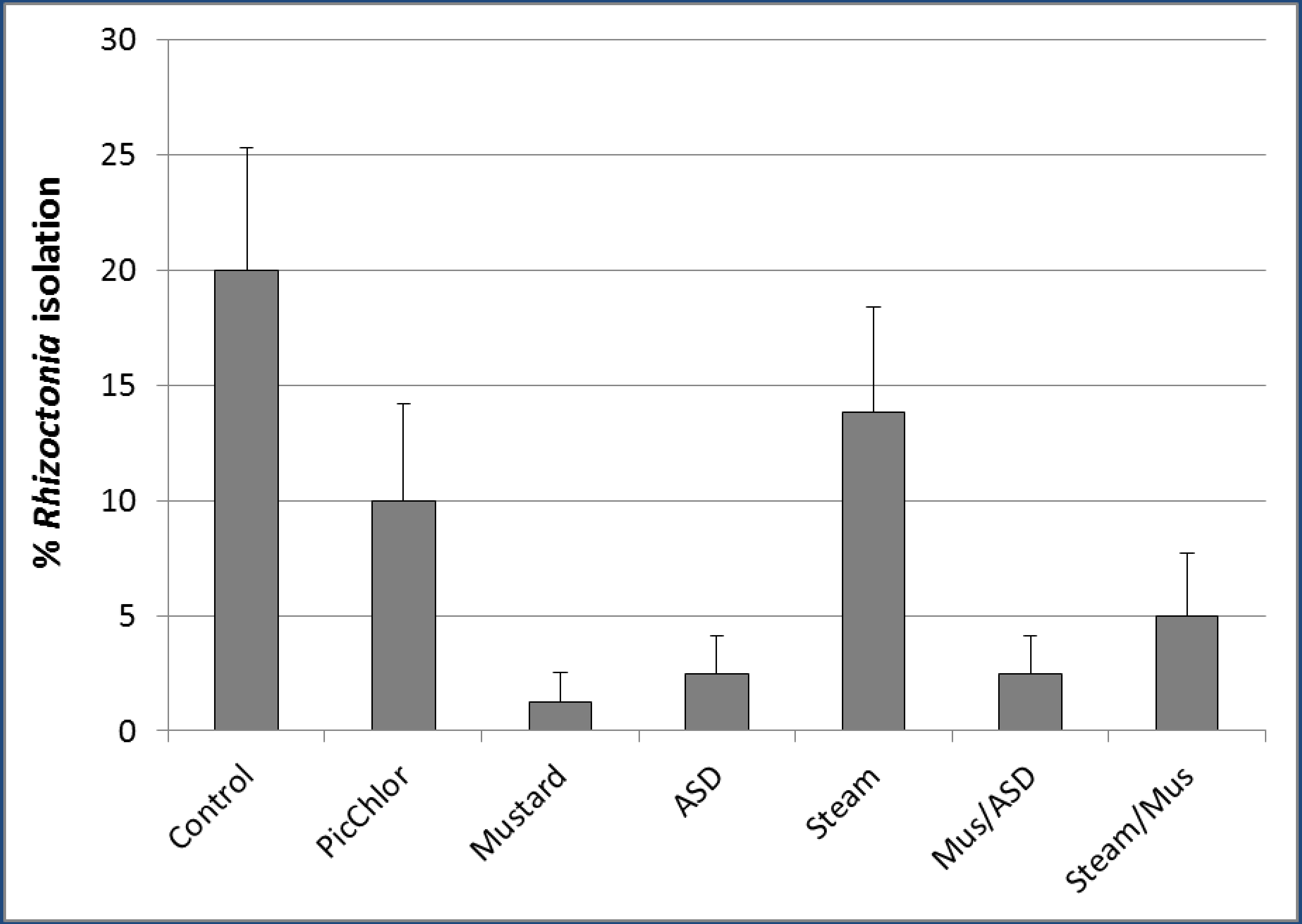


Pythium spp.

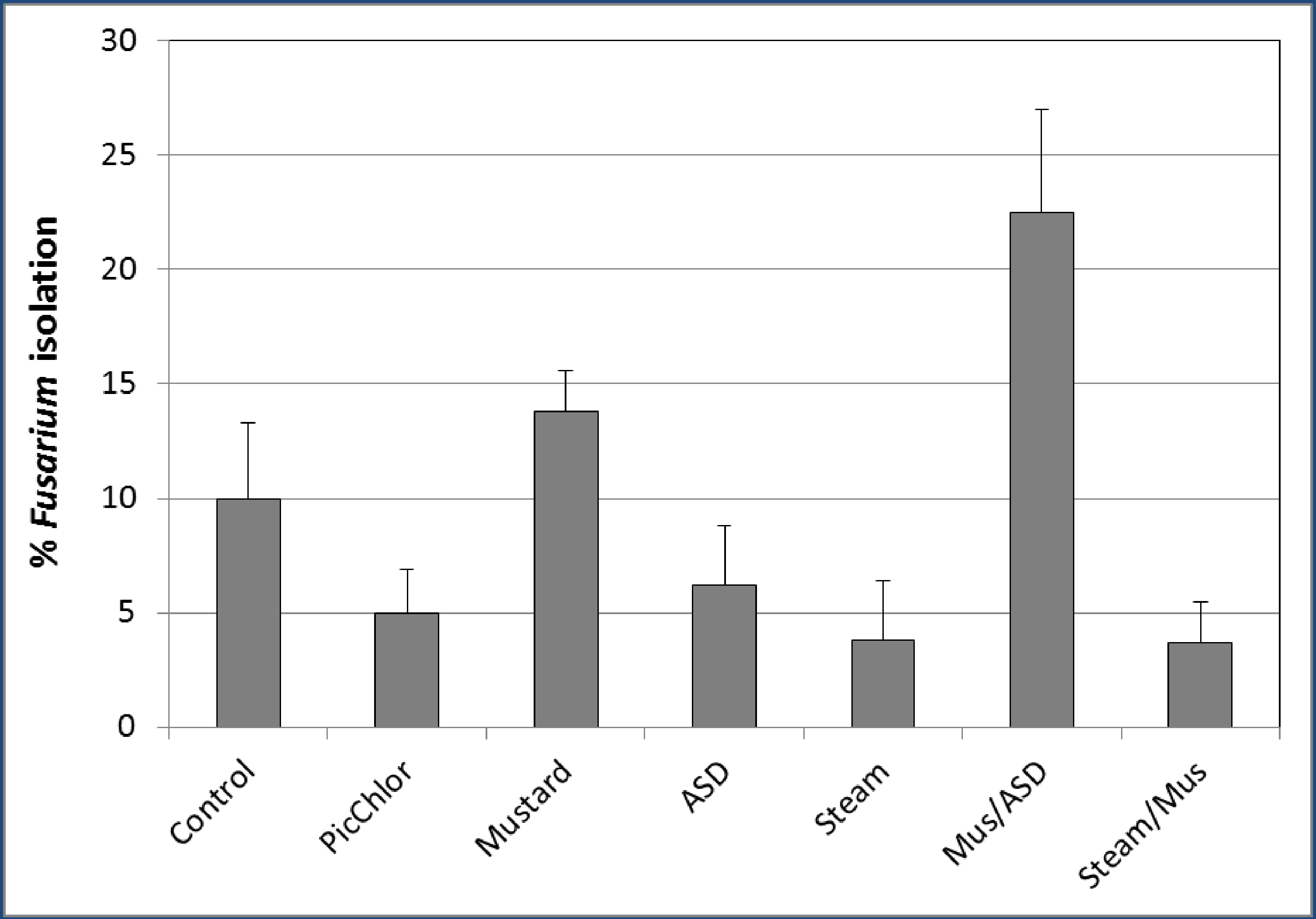
% roots from which fungi was isolated

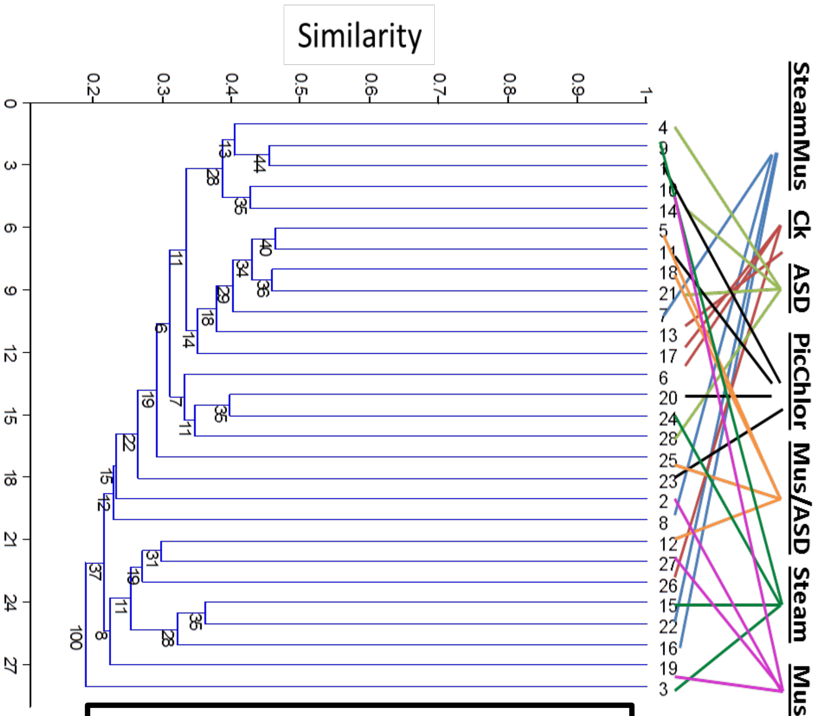
Cylindrocarpon spp.

% roots from which Rhizoctonia was isolated

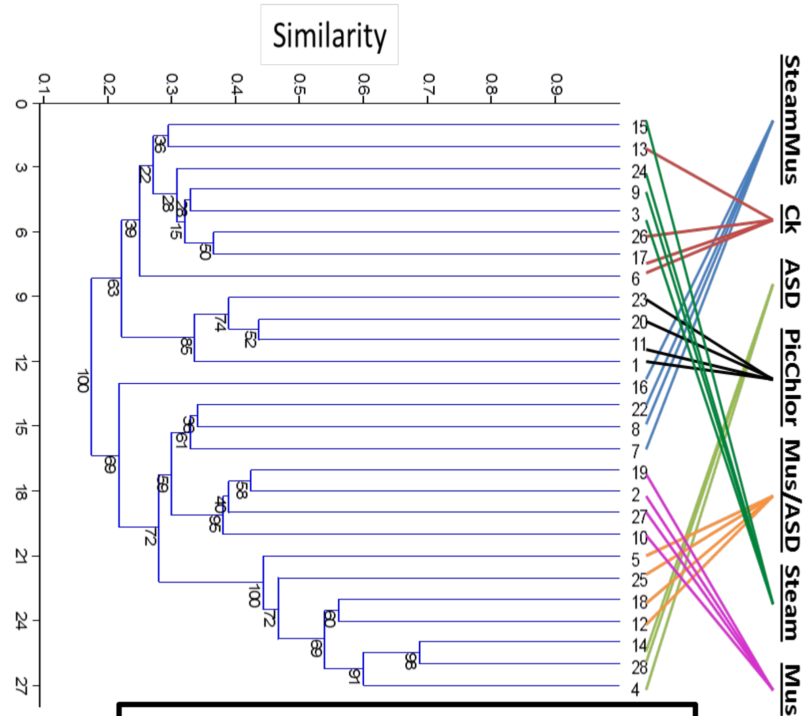


% roots from which Fusarium spp. were isolated



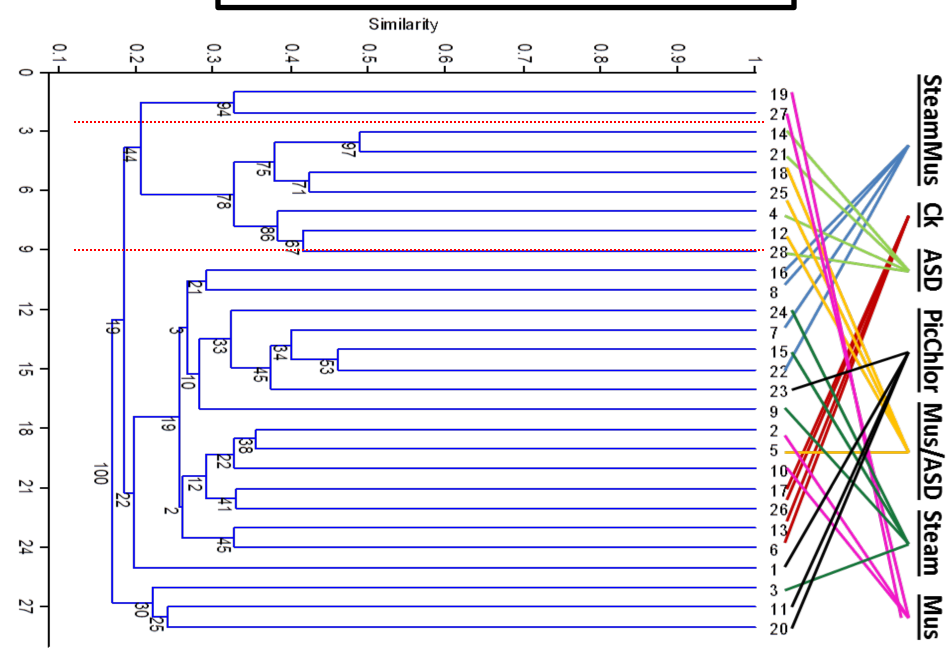


Pre treatment Oct 2011



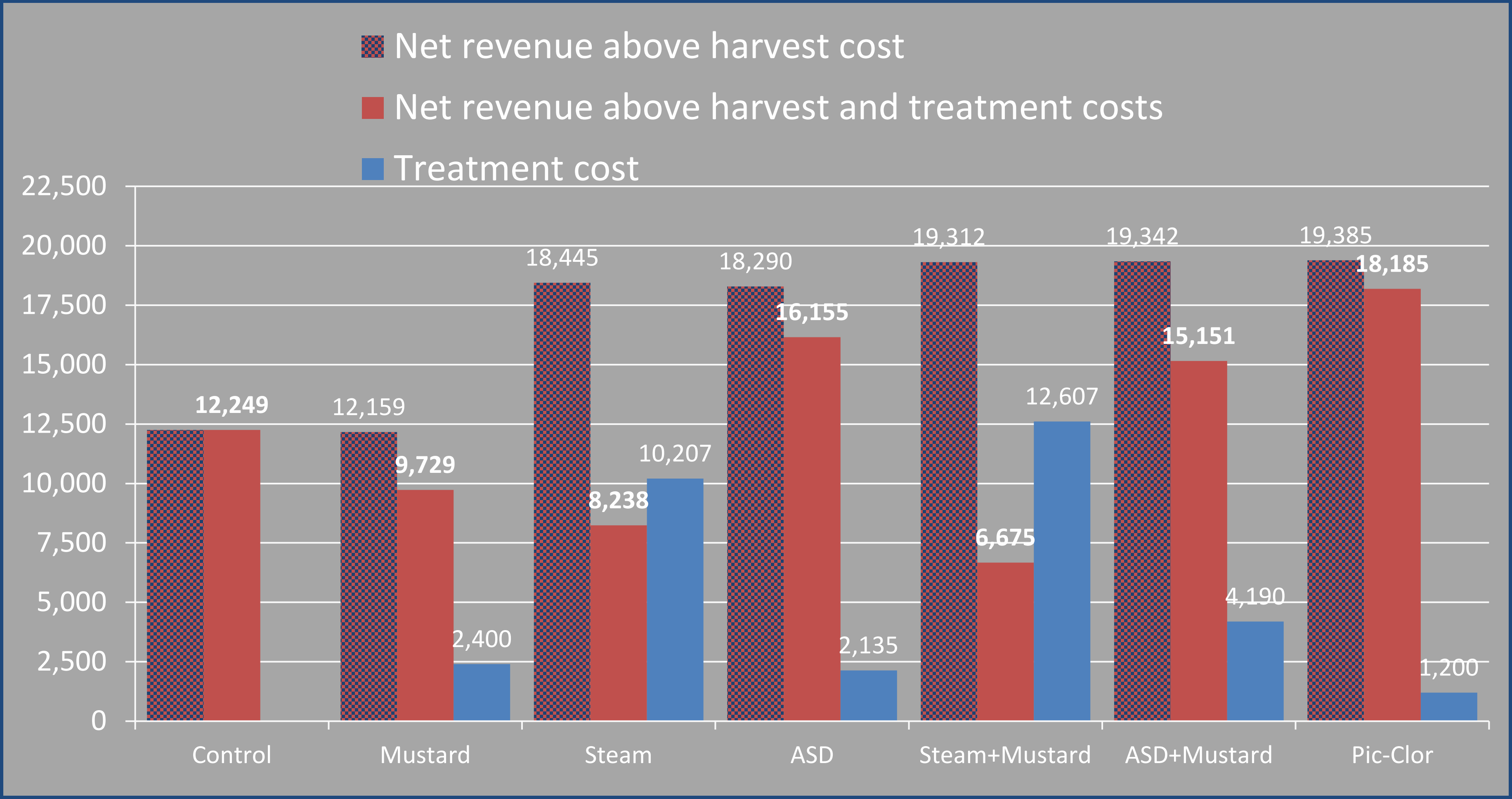
Post treatment – Nov 2011

Fungal community composition determined by T-RFLP analysis MBA, Watsonville. 2011/12

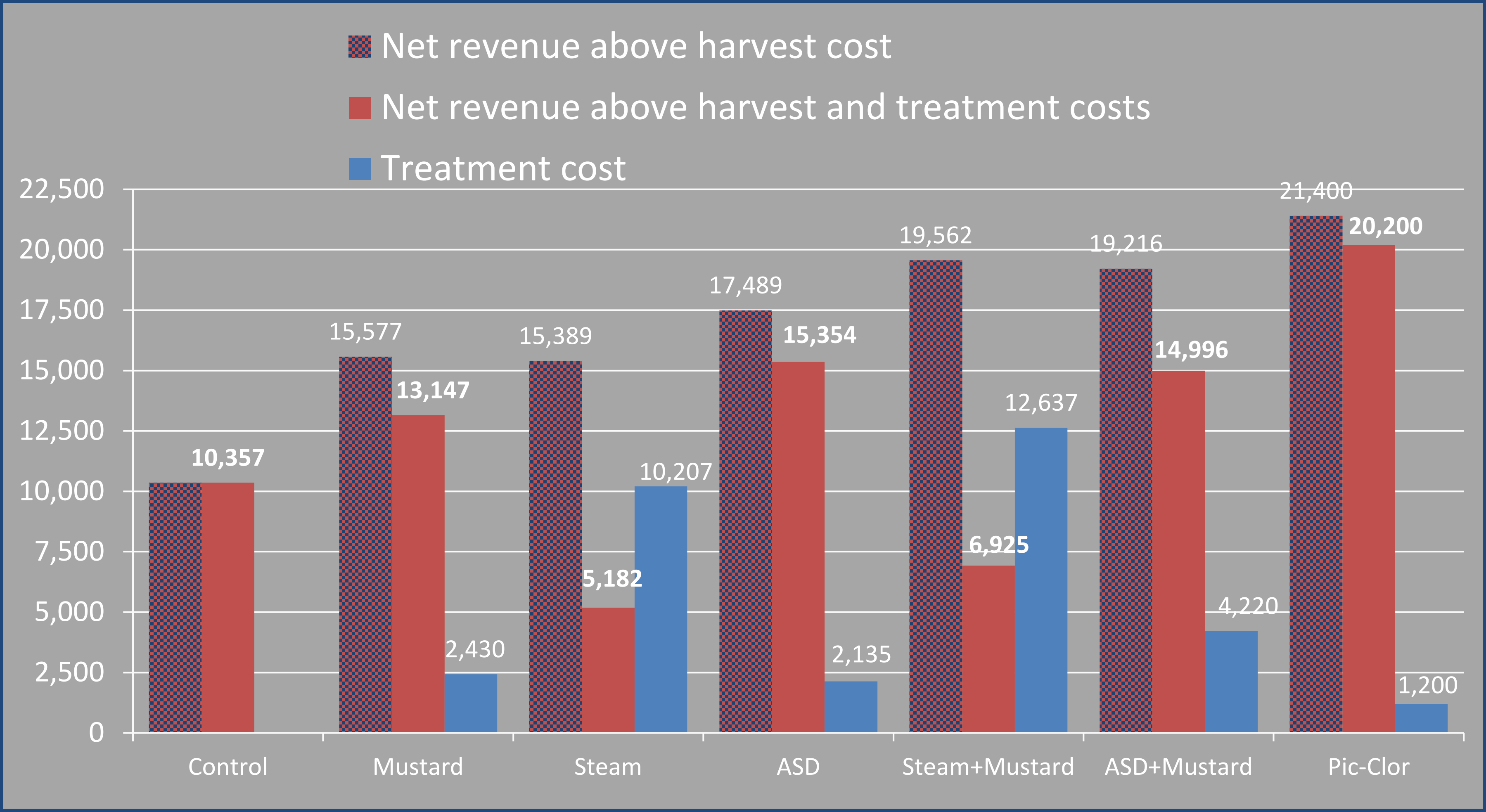


Post harvest Sept 2012

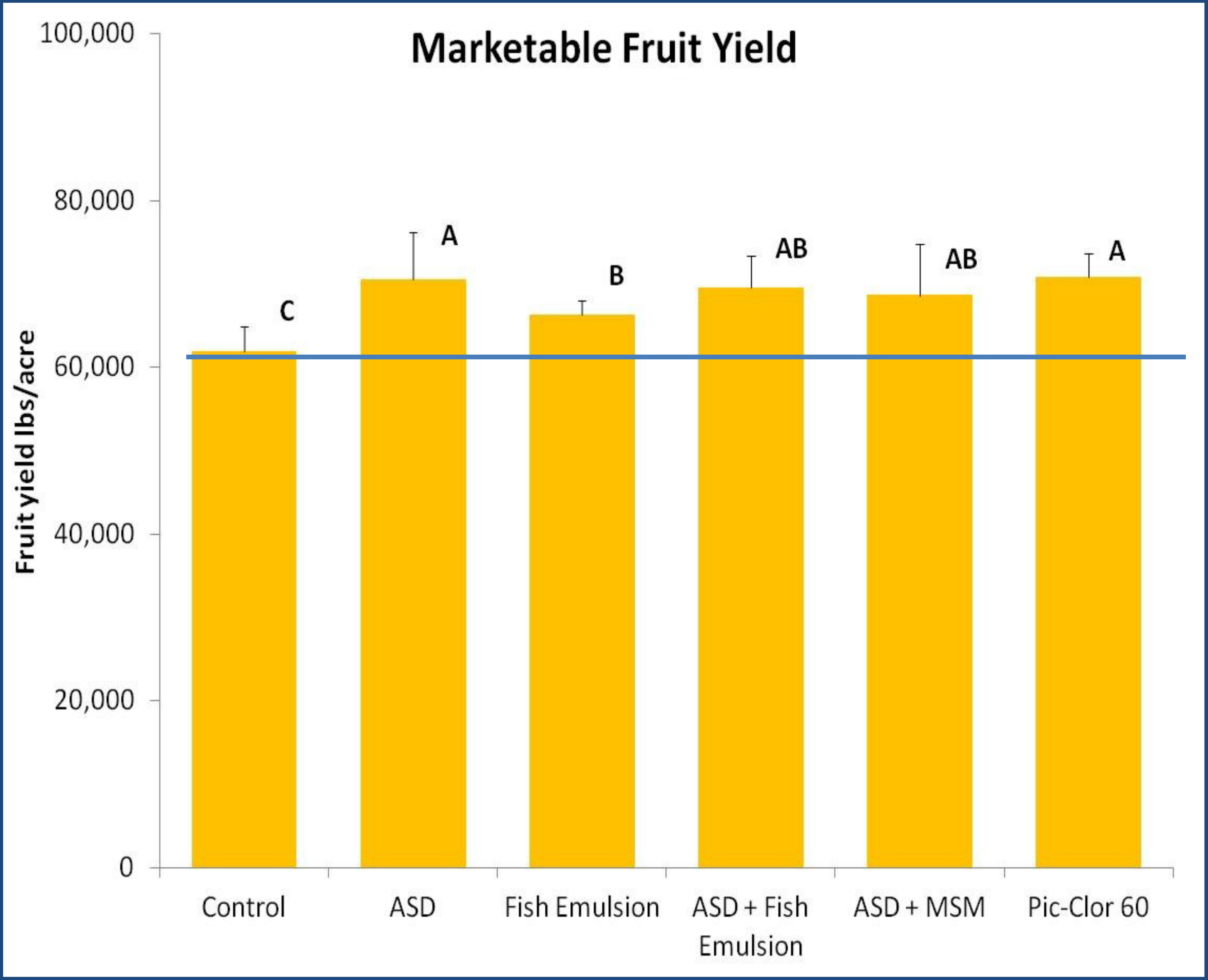
Monterey bay academy – Watsonville 2011 Partial Costs and Net Returns ($ per Acre)



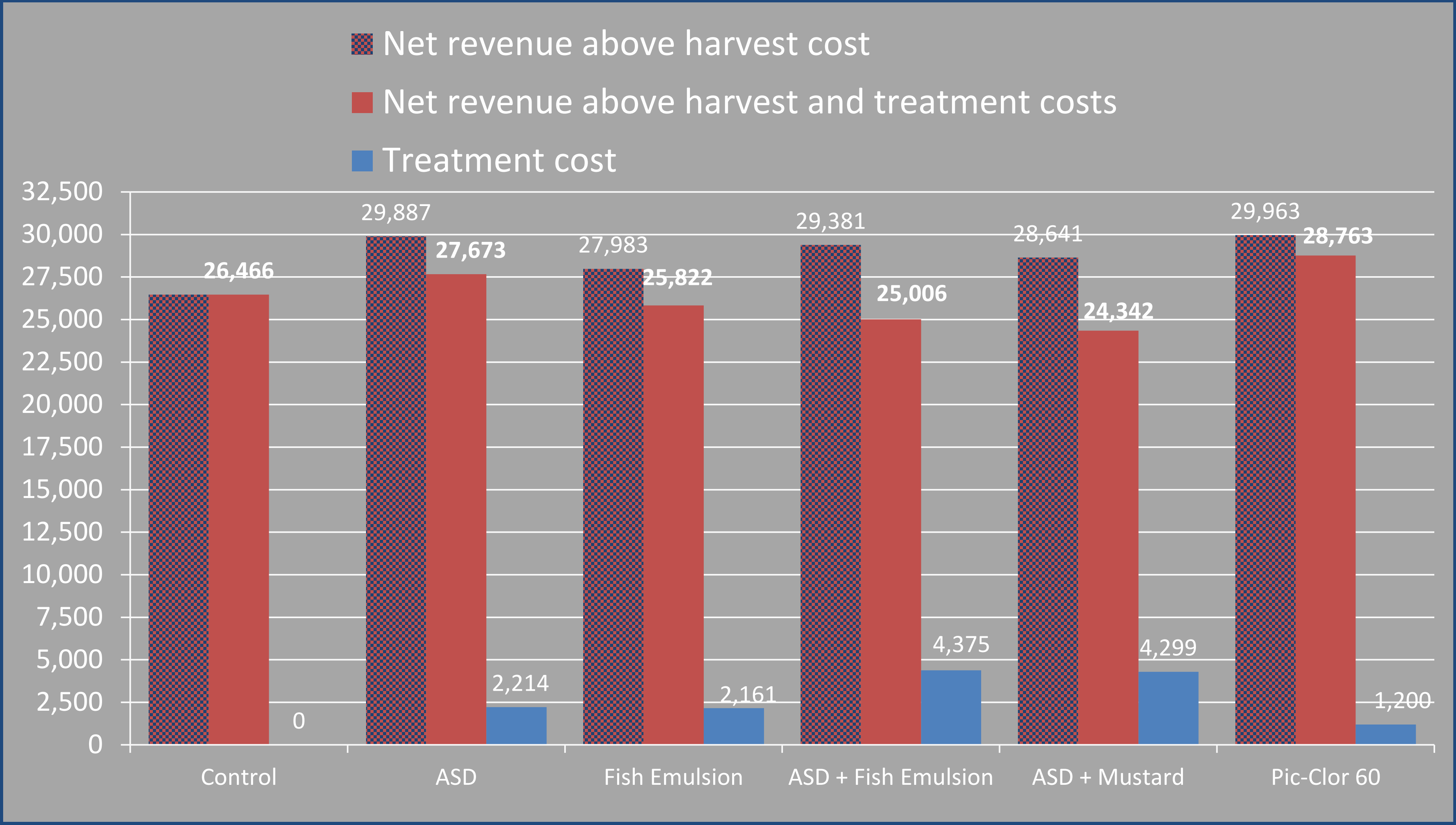
Monterey bay academy – Watsonville 2012
Partial Costs and Net Returns ($ per Acre)



Santa Maria 2011/12



Santa Maria 2012
Partial Costs and Net Returns ($ per Acre)



2012-2013 season

Commercial Implementation 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

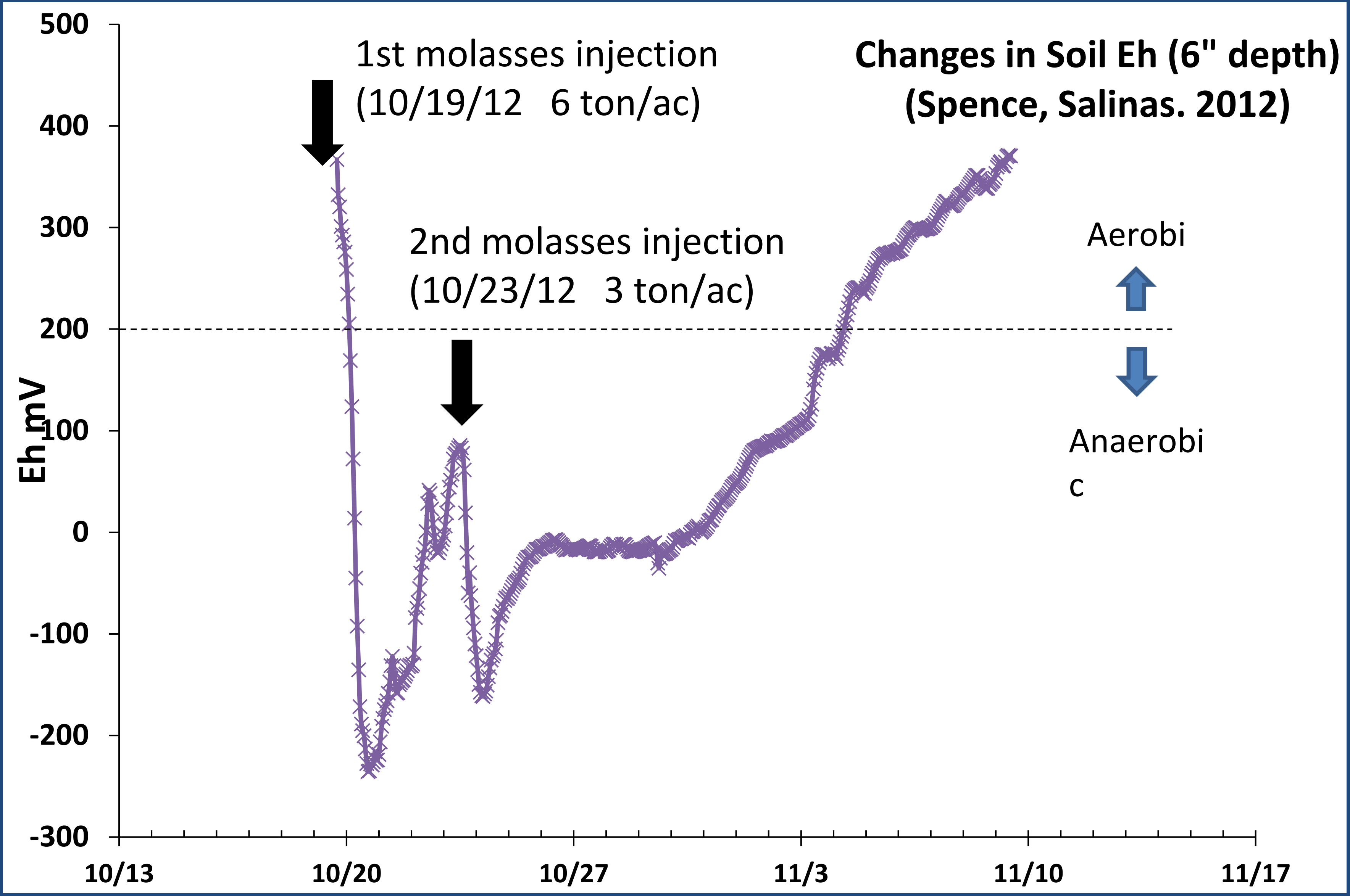
Location	C-source	Acre age	type
Watsonville	9t/ac Rice Bran or 4.5t/ac RB+4.5t/ac Molasses +/- preplant fertilizer	1 0.5	Organic Conventional
Salinas	9 t/ac Molasses	0.5	Conventional
Salinas	9 t/ac Molasses	1	Conventional
Santa Maria	9 t/ac Molasses	0.5	Conventional

2012-2013 replicated trials

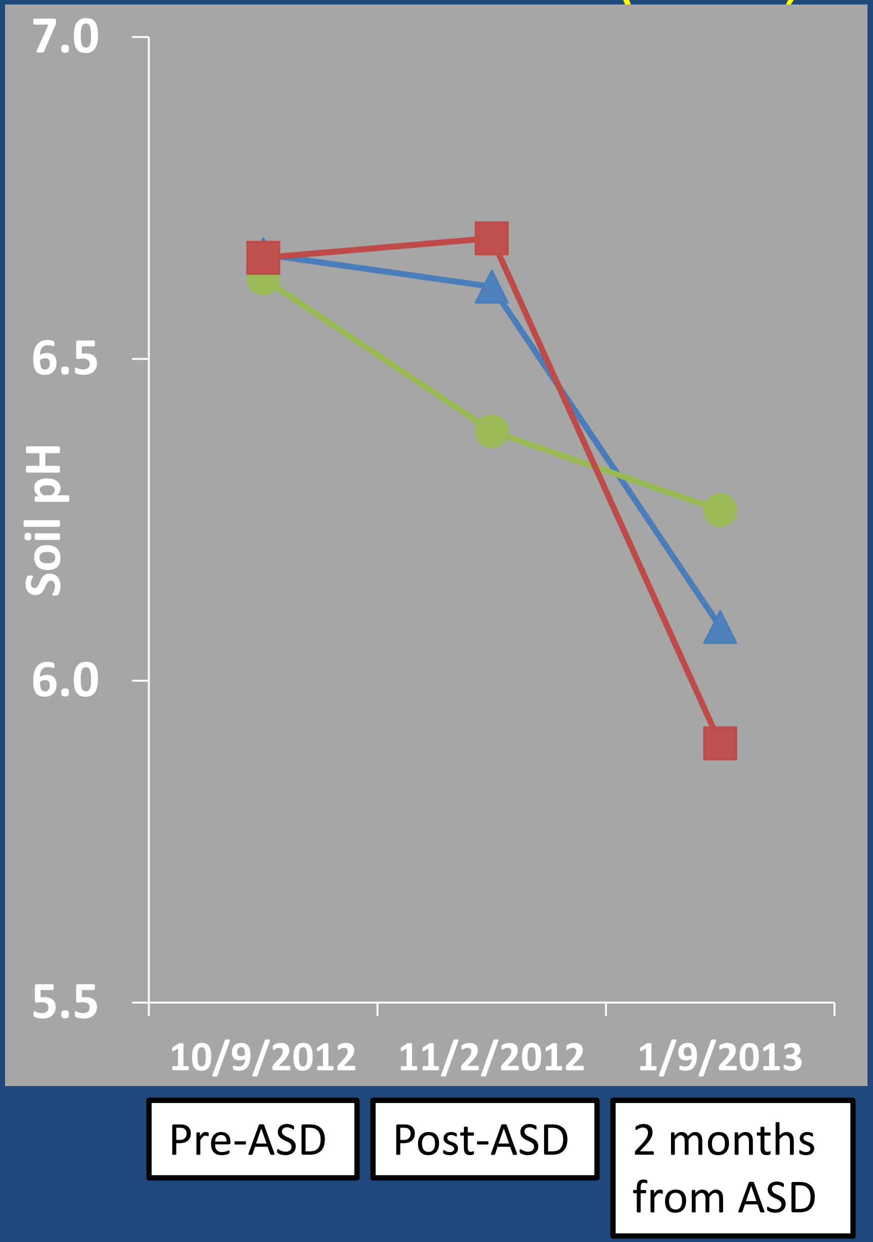
Location	C-source/treatments	type
Watsonville	Rice bran 6, 9 t/ac Molasses 6, 9 t/ac RB 4.5 + Mol 4.5 t/ac UTC	Conventional
Watsonville	Rice bran 6, 9 t/ac Molasses 6, 9 t/ac RB 4.5 + Mol 4.5 t/ac Controls: UTC, Water only, Rice bran 9 t/ac – no water	Conventional
Watsonville	Rice Bran 9 t/ac Molasses 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

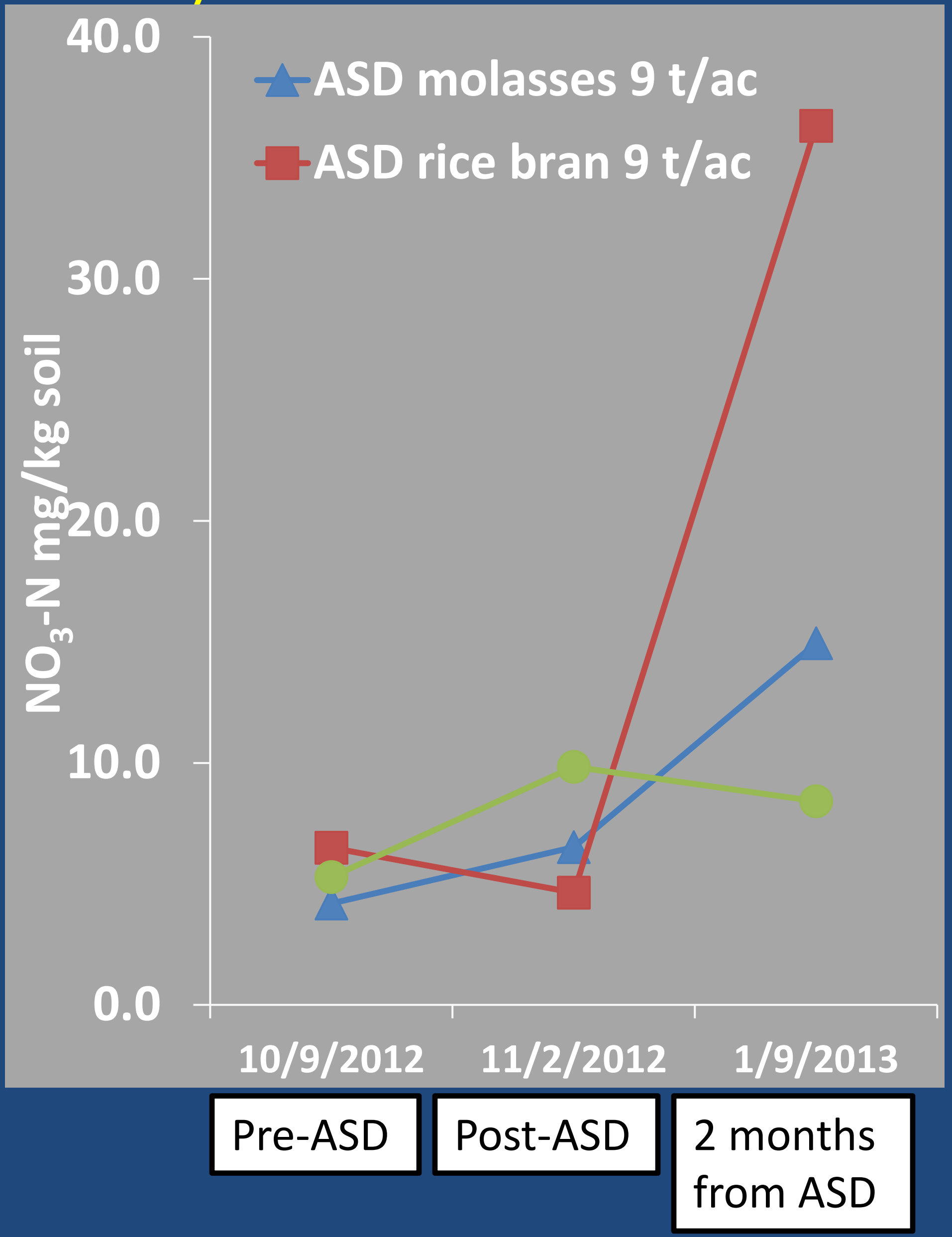
Injecting molasses

Spence Field - Salinas Fall 2012



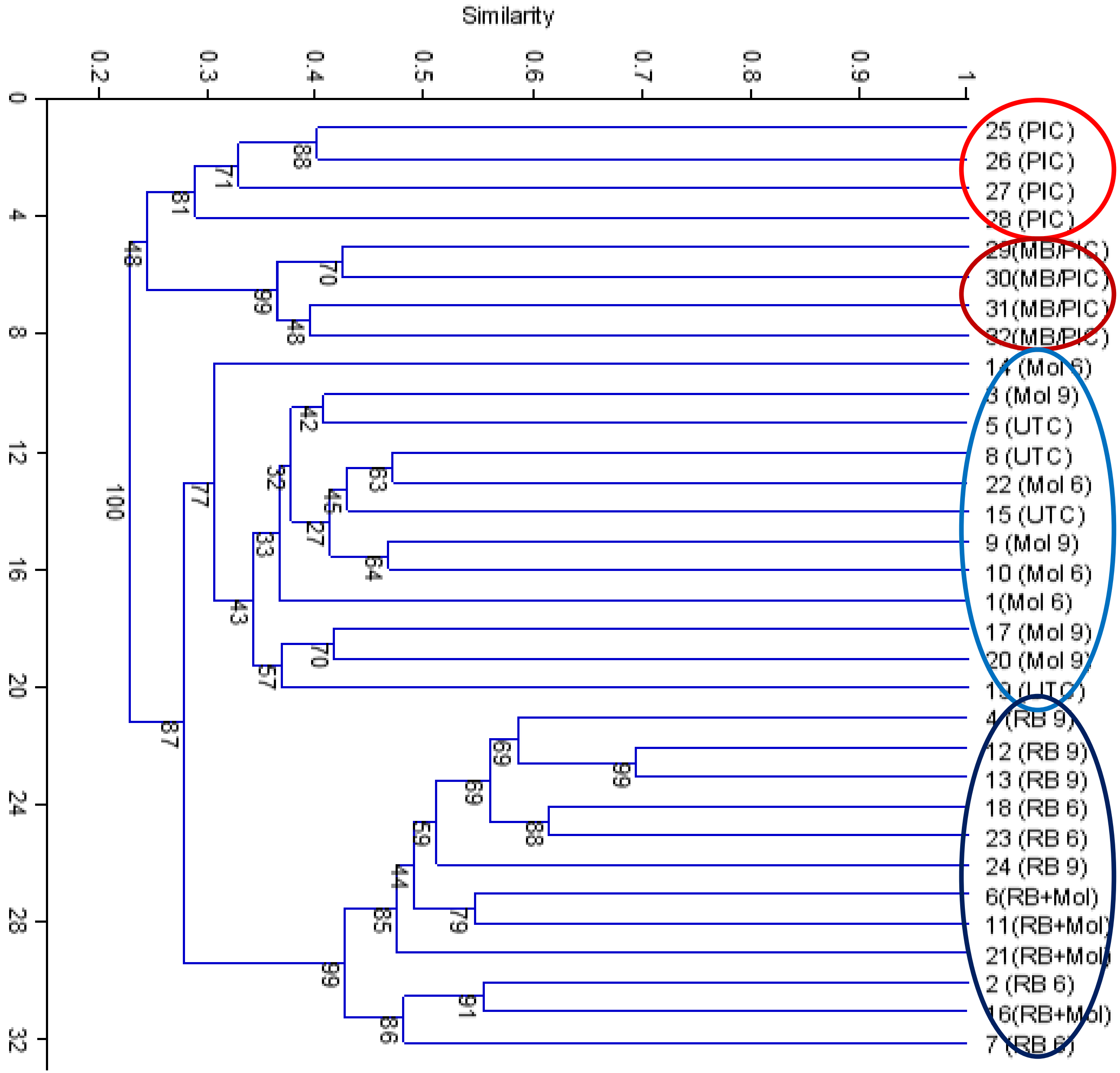
- Soil pH and Nitrate Content Changes at ASD Plots (MBA, 2012-13)



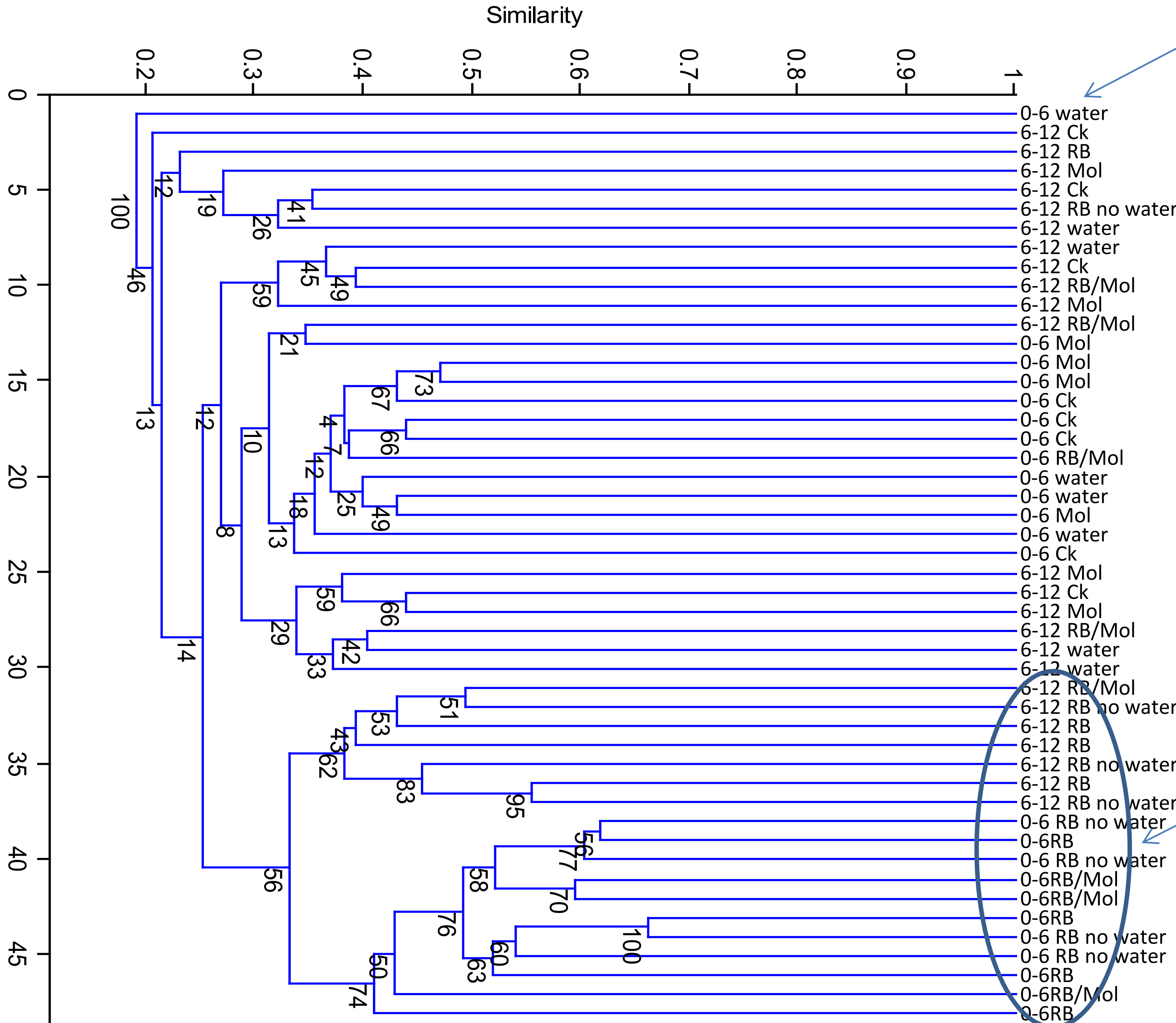


Treatment effects on soil chemical characteristics MBA trial, Watsonville (0”-6” depth. 5/2/2012). Numbers with the same letter are not significantly different (*P*=0.05).

Treatment	pH	EC 1:2 dS/m	Olsen-P_2O_5 ppm	Ex. Ca ppm	Ex. Mg ppm	Ex. K ppm	Ex. Na ppm
UTC	6.7	0.14	44.8 b	10500	3125 bc	1328 b	305
MM	6.6	0.16	46.5 b	9800	2925 c	1298 b	270
ASD	**6.3**	**0.31**	**79.8 a**	9800	**3775** a	**2362** a	270
Steam	6.6	0.18	44.0 b	10100	3138 bc	1995 b	310
MM+ASD	**6.4**	**0.29**	**74.3 a**	10275	**3863** a	**2420** a	295
Steam+MM	6.4	0.27	45.8 b	10725	3325 b	1463 b	323
Pic-Clor	6.7	0.14	43.3 b	10025	3175 bc	1188 b	308
P value	0.07	0.05	0.0001	0.77	0.0001	<0.0001	0.48



Fungal community composition determined by T-RFLP analysis
Plant Sciences, Watsonville. Post-ASD, Nov. 2012



Outlier, need to check

Rice bran treatments represent 1 distinct cluster, with depth representing a sub-cluster

Fungal community composition determined by T-RFLP analysis MBA, Watsonville. Post-ASD, Nov. 2012

Conclusions

- When get sufficient anaerobic conditions yields equivalent or better than Pic-Clor
- Cost for ASD around $1000/ac higher than Pic-Chlor with 9ton/ac rice bran
- Get good control with ASD of number of pathogens – Verticillium, Rhizoctonia, and Pythium
- Some control of Fusarium with rice bran, but not if use mustard meal in ASD.
- Can get long term decrease in soil pH due to production of nitrate from the rice bran carbon source
- Use of rice bran also increases soil phosphate, potassium, and magnesium levels

Future work planned

- Continue to evaluate ASD for control of other pathogens including Macrophomina
- 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
- Further explore mechanism of action of ASD and suppressiveness of soil following ASD
- Document nitrogen dynamics for different ASD options
- Monitor N_2O, CH_4, and CO_2 emission during ASD and NO_3 leaching during the winter after ASD

QUESTIONS?

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