Anaerobic Soil Disinfestation (ASD) for suppressing Verticillium dahliae in CA strawberries

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Funded by USDA-CSREES MBTP 2007-51102-03854 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
- Student workers, interns, and volunteers of the Shennan lab, UCSC
- Surendra Dara, UCCE

ASD: Background

- Developed as alternative to Methyl bromide fumigation in Netherlands (Blok et al., 2000; Doug et al., 2004) and Japan (Shinmura & Sakamoto, 1998; Shinmura, 2000, 2004)
- Controls range of soilborne pathogens and nematodes across a range of crops
- In Japan, used by hundreds of farmers in greenhouse production (small scale)

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. Irrigate to field capacity
   - **Water-filled pore space**
3. Cover with oxygen impermeable tarp
   - **Create anaerobic (no oxygen) conditions and stimulate anaerobic decomposition of incorporated organic material**


10/10/2008


10/10/2008


CATERPILLAR
10/11/2008

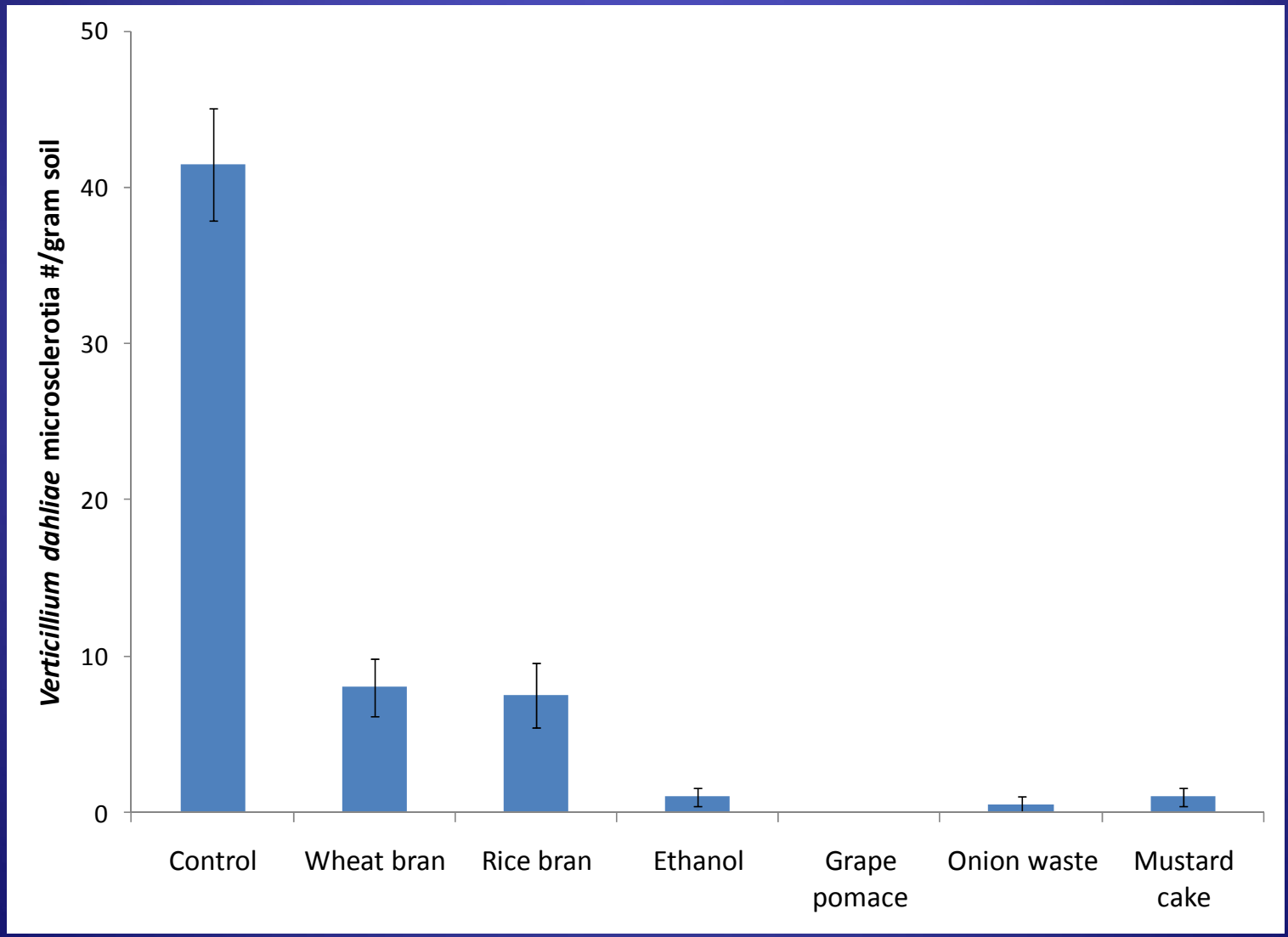

08.18.2010


11/7/2008

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

Different C sources effectively reduce *V. Dahliae* microsclerotia – pot studies



Field trials

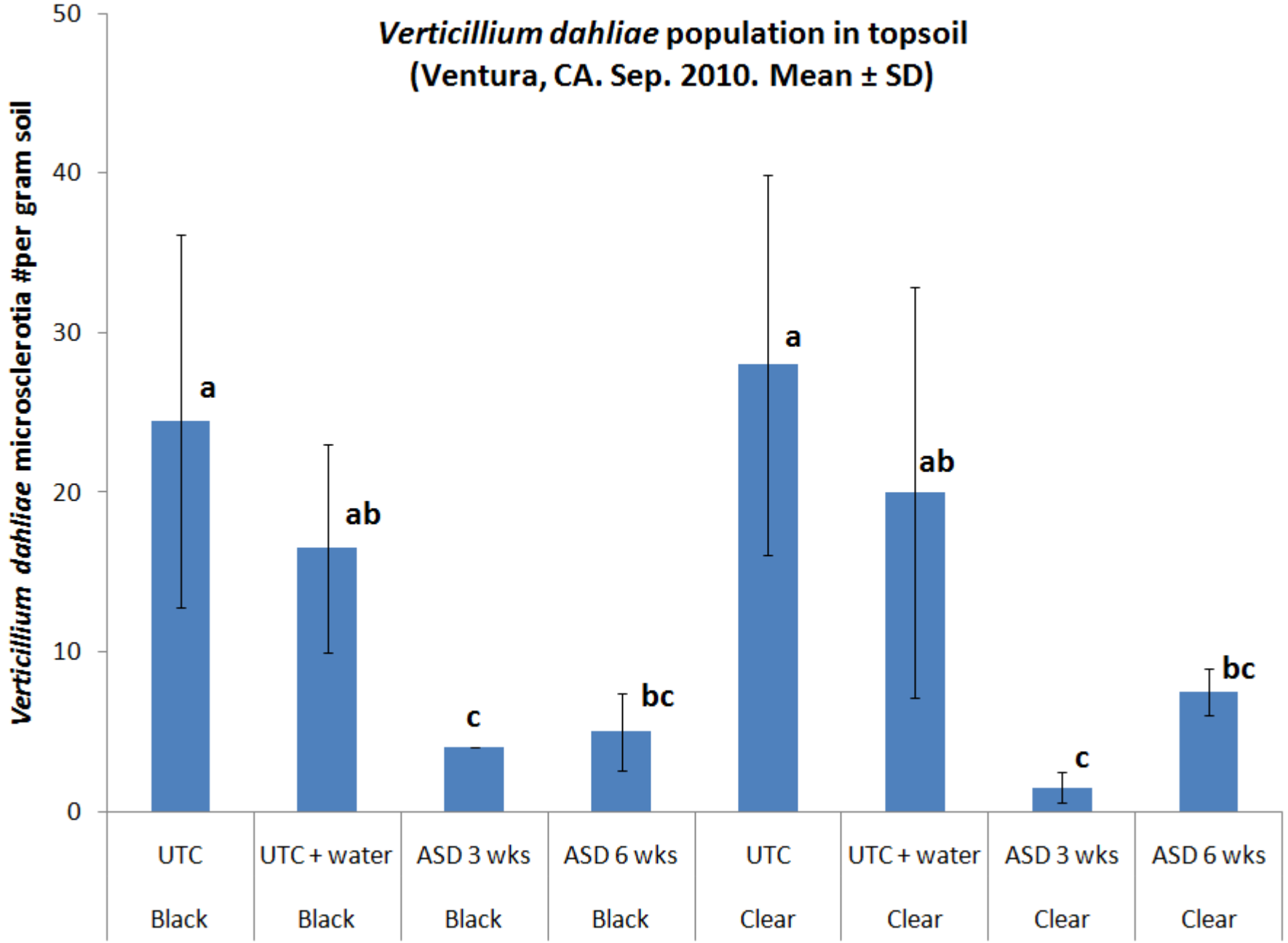
- To test ability of ASD to consistently control *V. dahliae* across multiple locations and years
- To determine effect of ASD on strawberry yields
- To assess the economic feasibility of ASD

Ventura 2010/11

- UC Hansen Agricultural Center, Santa Paula.
- Silty clay loam soil with native *V. dahliae*: 25 microsclerotia/gram soil
- Randomized block split plot design with 4 reps.

  Main plot: type of tarp (standard black 1.5 mil, and clear 1.25 mil)

  Sub plot: Untreated check (UTC), UTC + water, ASD 3 weeks (8/18 – 9/09), and ASD 6 weeks (8/18 –9/30)
- C source: Rice bran 9 tons/acre in all ASD plots.
- Irrigation: 3 ac-inches except UTC plots.


Verticillium dahliae population in topsoil
(Ventura, CA. Sep. 2010. Mean ± SD)
Verticillium dahliae microsclerotia #per gram soil
50
40
30
20
10
0
a
ab
c
bc
a
ab
c
bc
UTC
Black
UTC + water
Black
ASD 3 wks
Black
ASD 6 wks
Black
UTC
Clear
UTC + water
Clear
ASD 3 wks
Clear
ASD 6 wks
Clear

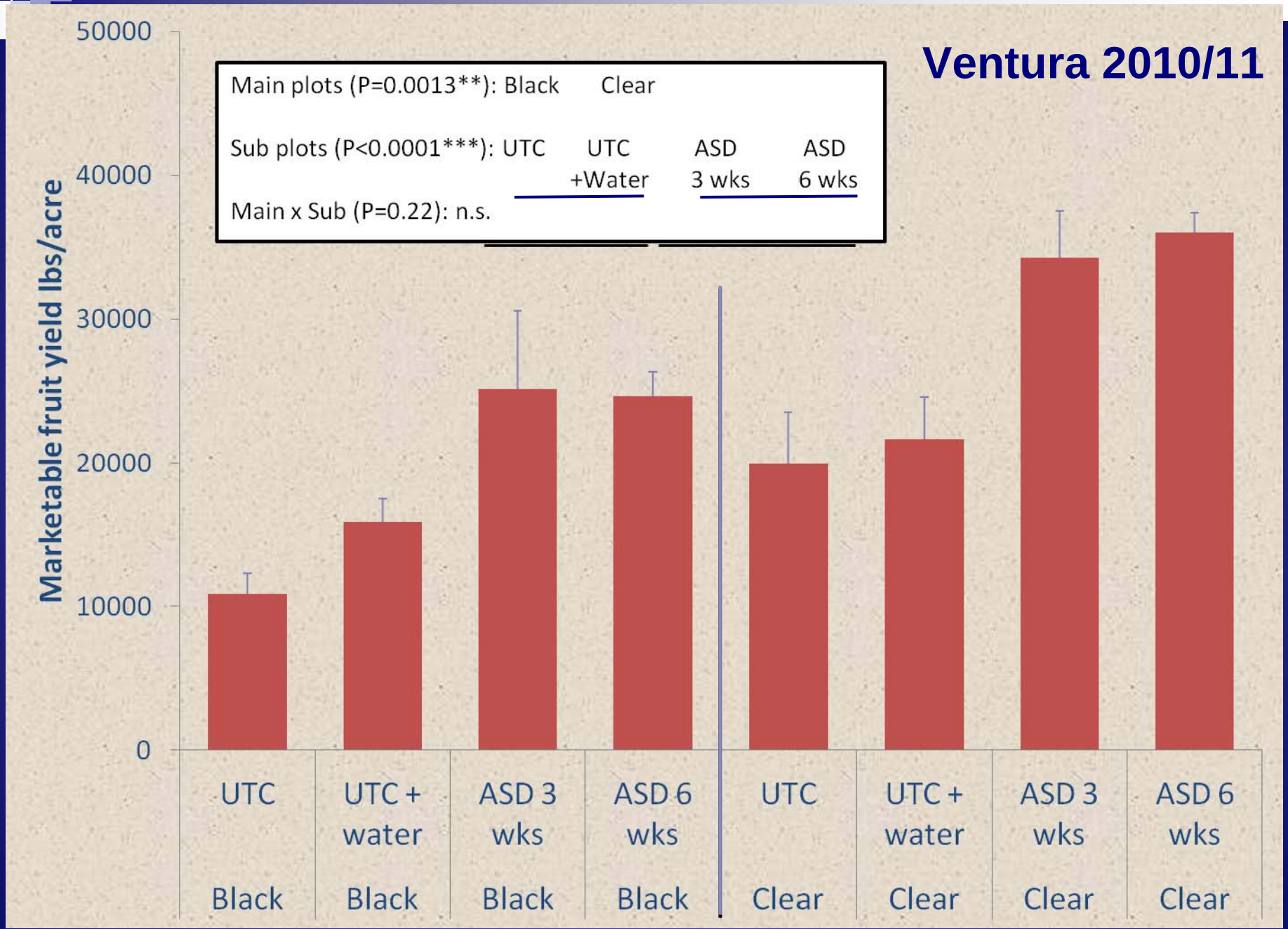
Strawberry plants April 19, 2011 Ventura County

ASD 3 weeks/clear

Untreated/clear

9 ton/ac rice bran used in ASD

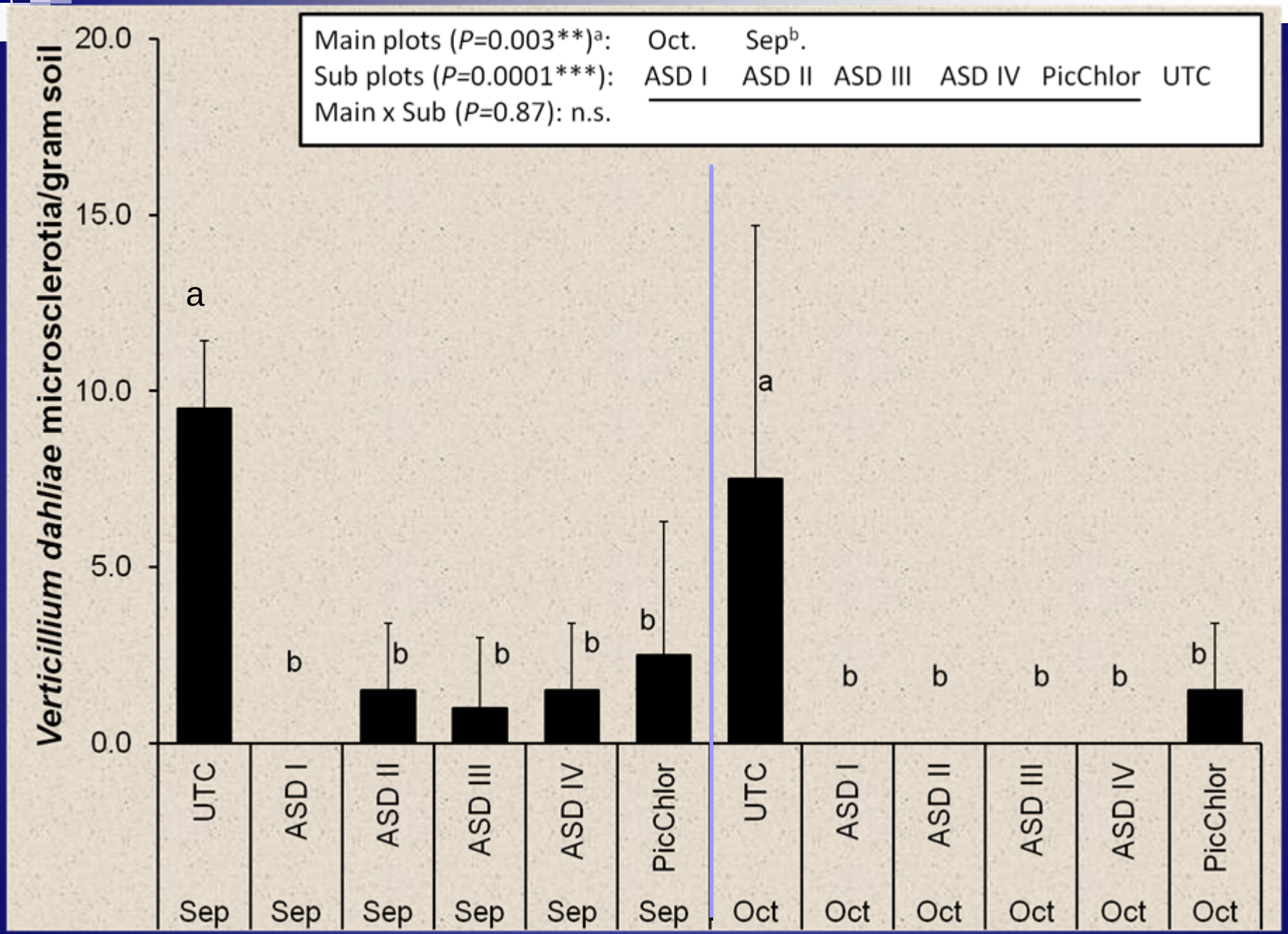
Ventura 2010/11

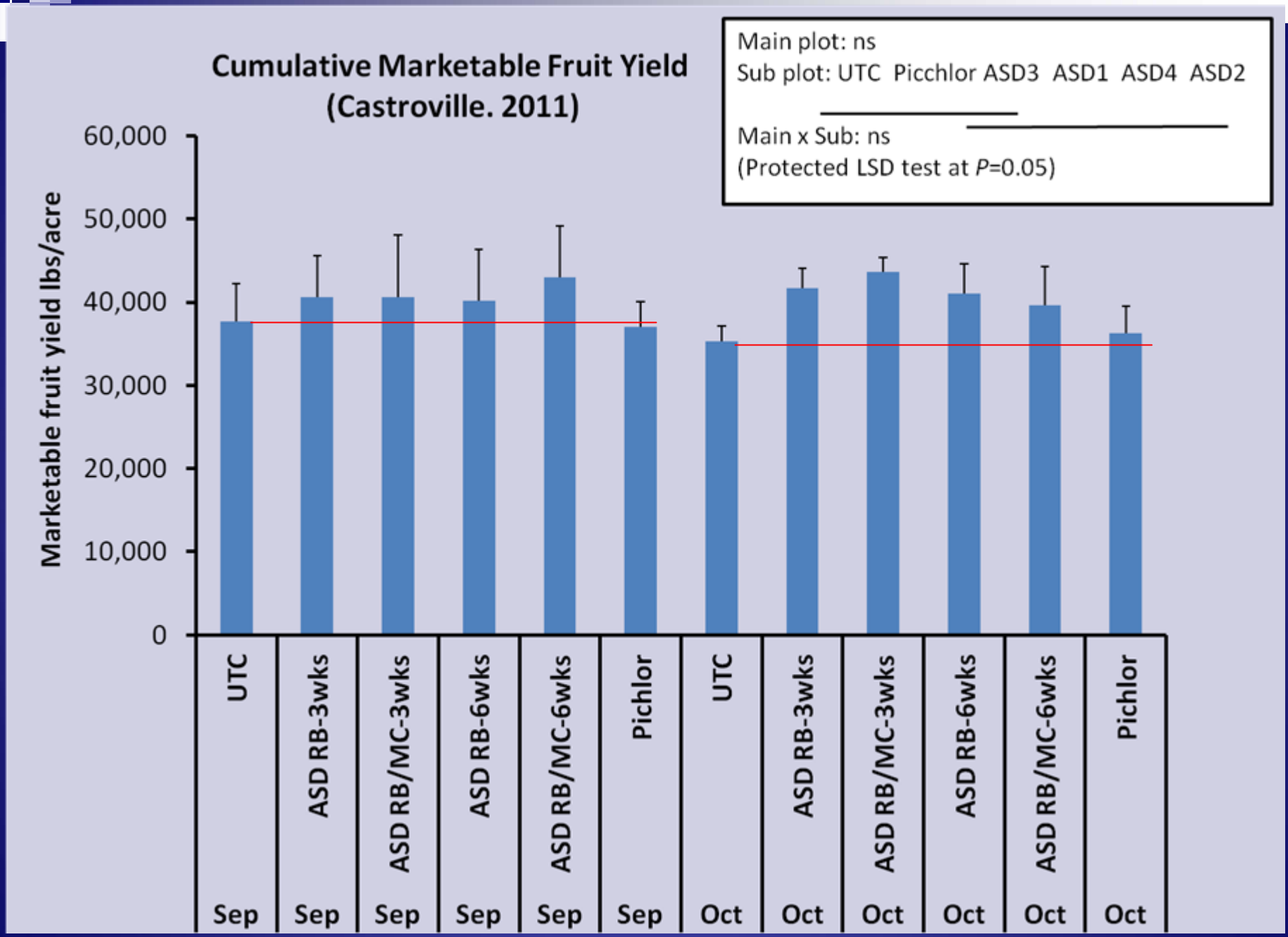


2010 -11 Castroville

- Soil – clay loam, native V*. dahliae* – 11 microsclerotia/g soil

  - C source – 9 t/ac rice bran, 8 t/ac rice bran + 1 t/ac mustard cake
  - two dates – Sept and Oct
  - two tarping lengths – 3 weeks and 6 weeks
  - Compare ASD against Pichlor 60 and untreated control


Main plots (P=0.003**)[a]: Oct. Sep[b].
Sub plots (P=0.0001***): ASD I ASD II ASD III ASD IV PicChlor UTC
Main x Sub (P=0.87): n.s.
Verticillium dahliae microsclerotia/gram soil
20.0
15.0
10.0
5.0
0.0
a
b
b
b
b
b
a
b
b
b
b
b
UTC
ASD I
ASD II
ASD III
ASD IV
PicChlor
UTC
ASD I
ASD II
ASD III
ASD IV
PicChlor
Sep
Sep
Sep
Sep
Sep
Sep
Oct
Oct
Oct
Oct
Oct
Oct

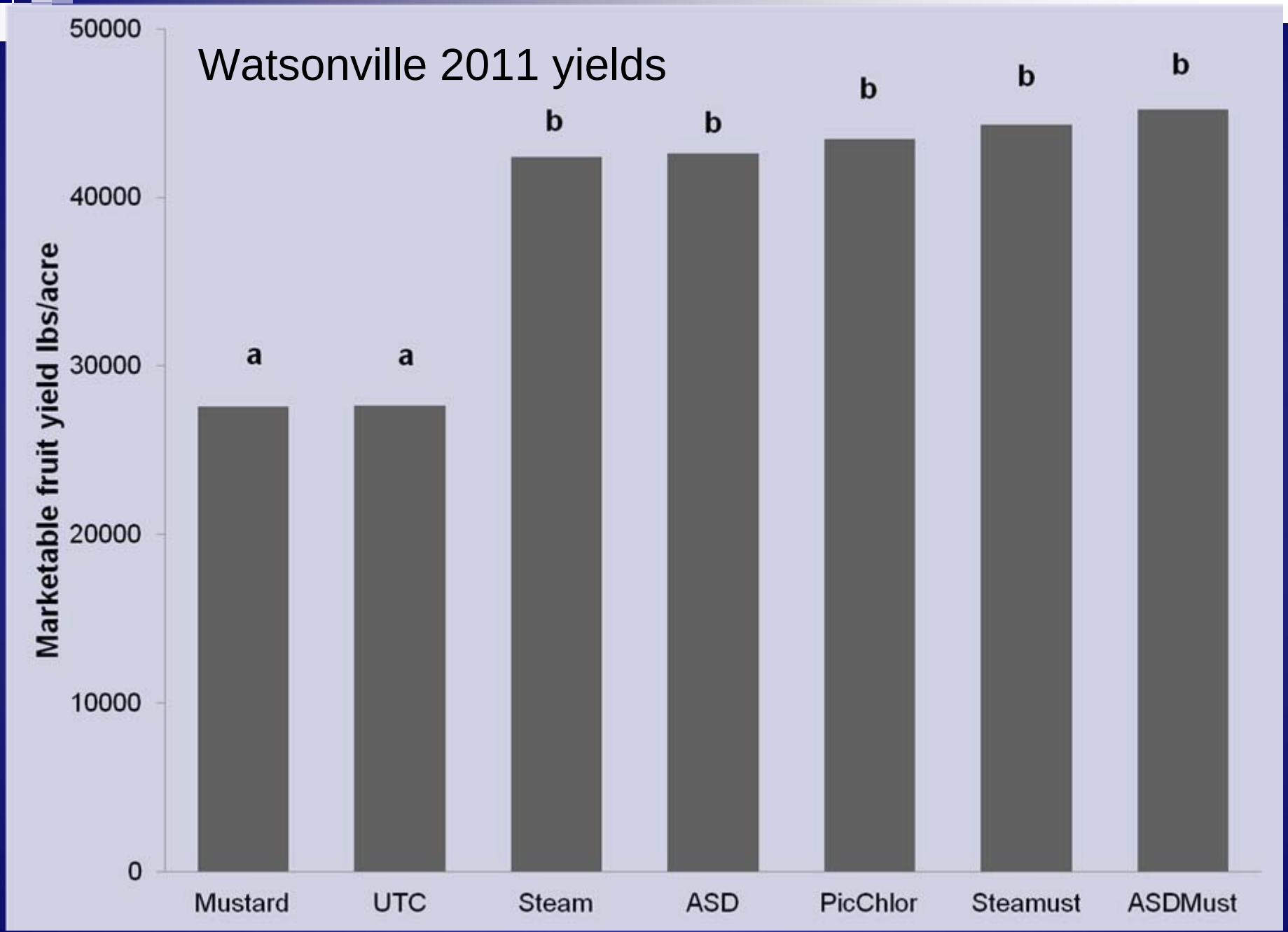

Cumulative Marketable Fruit Yield
(Castroville. 2011)
Main plot: ns
Sub plot: UTC Picchlor ASD3 ASD1 ASD4 ASD2
Main x Sub: ns
(Protected LSD test at P=0.05)
Marketable fruit yield lbs/acre
60,000
50,000
40,000
30,000
20,000
10,000
0
UTC
ASD RB-3wks
ASD RB/MC-3wks
ASD RB-6wks
ASD RB/MC-6wks
Pichlor
UTC
ASD RB-3wks
ASD RB/MC-3wks
ASD RB-6wks
ASD RB/MC-6wks
Pichlor
Sep
Sep
Sep
Sep
Sep
Sep
Oct
Oct
Oct
Oct
Oct
Oct

Watsonville 2010-11

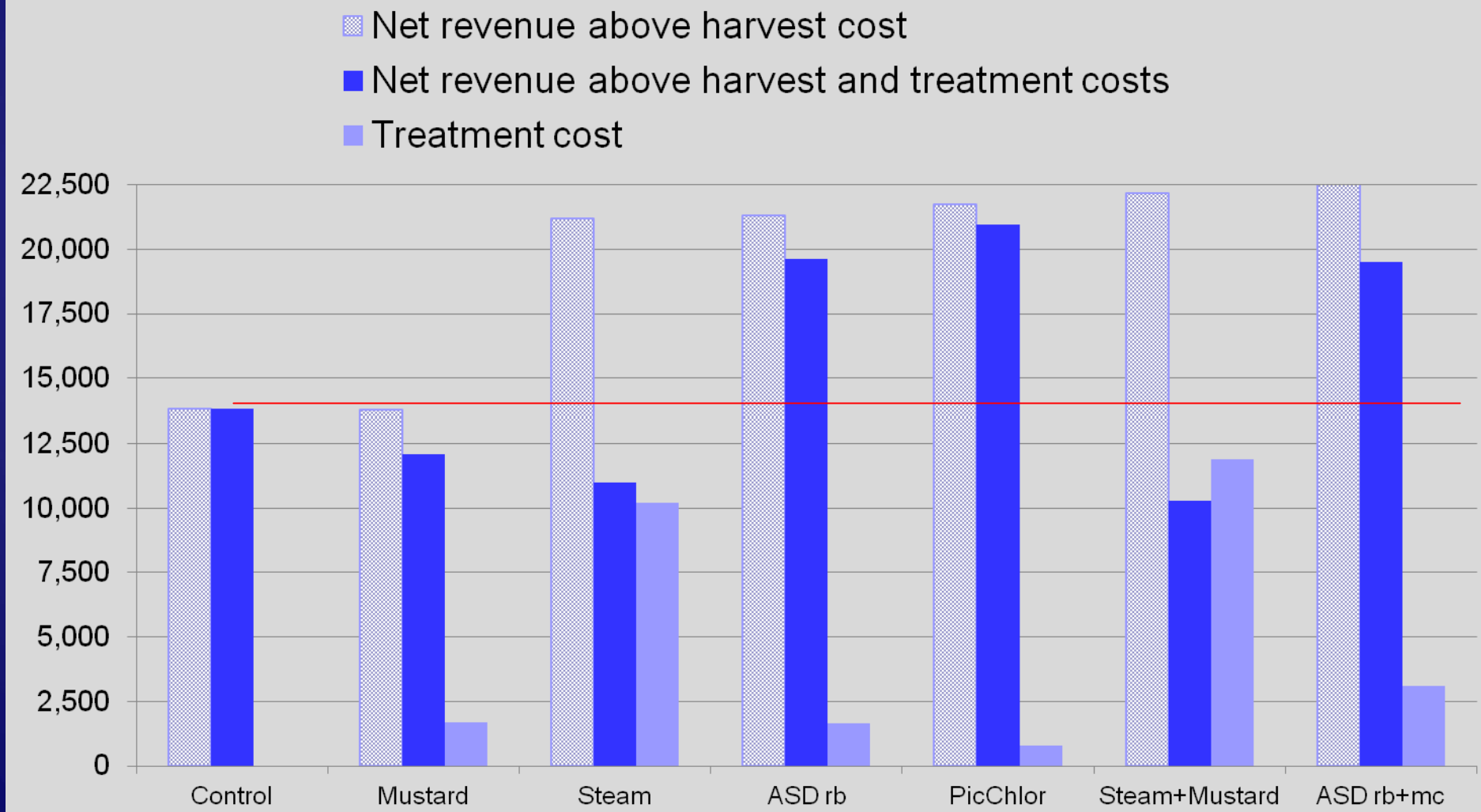
Soil - sandy loam, native *V. dahliae* – non detectable

C source – 9 t/ac rice bran, 8 t/ac rice bran + 1 t/ac mustard cake

Compare ASD against steam, Pichlor 60 and untreated control


Watsonville 2011 yields
Marketable fruit yield lbs/acre
50000
40000
30000
20000
10000
0
a
a
b
b
b
b
b
Mustard
UTC
Steam
ASD
PicChlor
Steamust
ASDMust

Watsonville Costs and Net Returns
($ per Acre)



Findings to date:

1. 1. Can get consistently good V. dahliae suppression - 80 to 100%

2. 2. Good yields obtained
    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 pichlor
    5. Watsonville 2011 – equal to pichlor and steam

3. 3. Standard tarp appears as effective as TIF and VIF (from pot and field studies)

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. Is ASD economic?

4. What is ASD doing to soil microbe communities?

2011-2012 season trials

1. Ventura: *Macrophomina* infested field

   ASD, steam, solarization, mustard cake, and UTC

2. Santa Maria: Sandy loam field

   ASD, PicChlor, fish emulsion, mustard cake, and UTC

3. Watsonville: MBA

   ASD, PicChlor, steam, mustard cake, and UTC

4. Salinas: 0.5 ac ASD demonstration at USDA-Spence site

5. *Salinas: clay soil*

   ASD, broccoli rotation, mustard meal, alone or in combination, PicChlor, and UTC

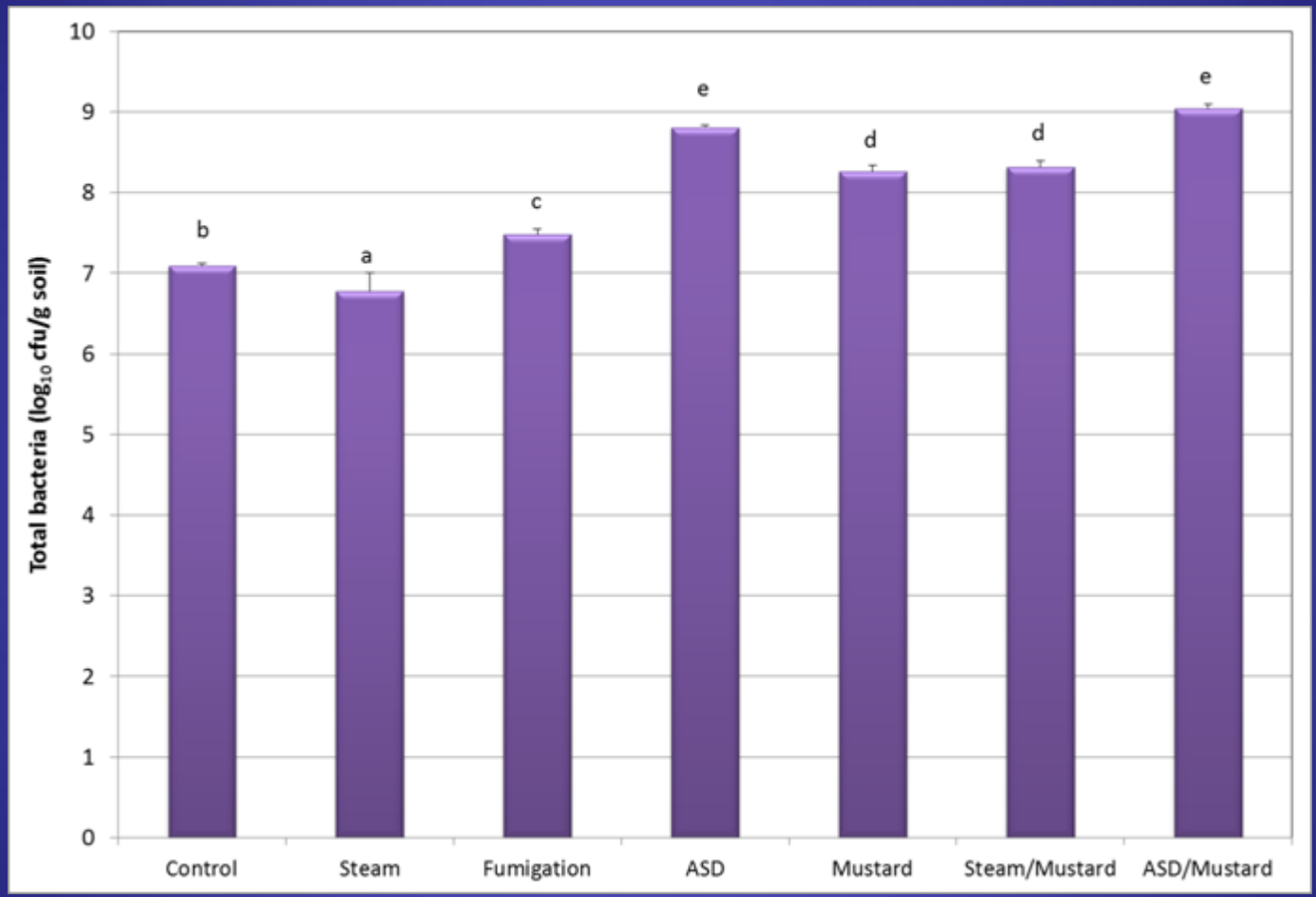
6. *Santa Cruz: UCSC Organic farm*

   ASD, broccoli rotation, mustard meal, alone or in combination, UTC

Scaling up

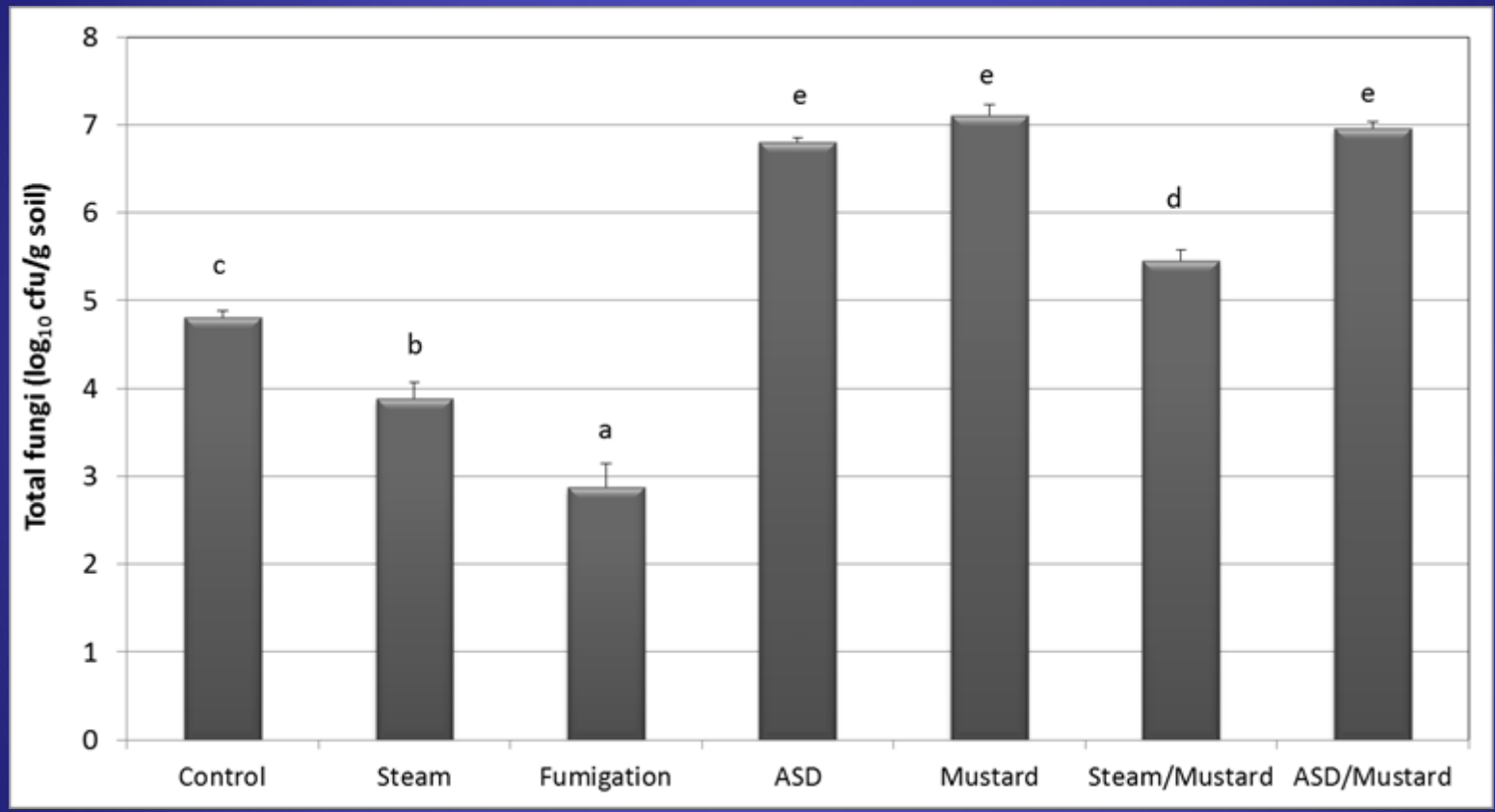
- **What is happening to soil microbes with ASD?**

MBA, CA Post-treatment Total bacteria: November 2011



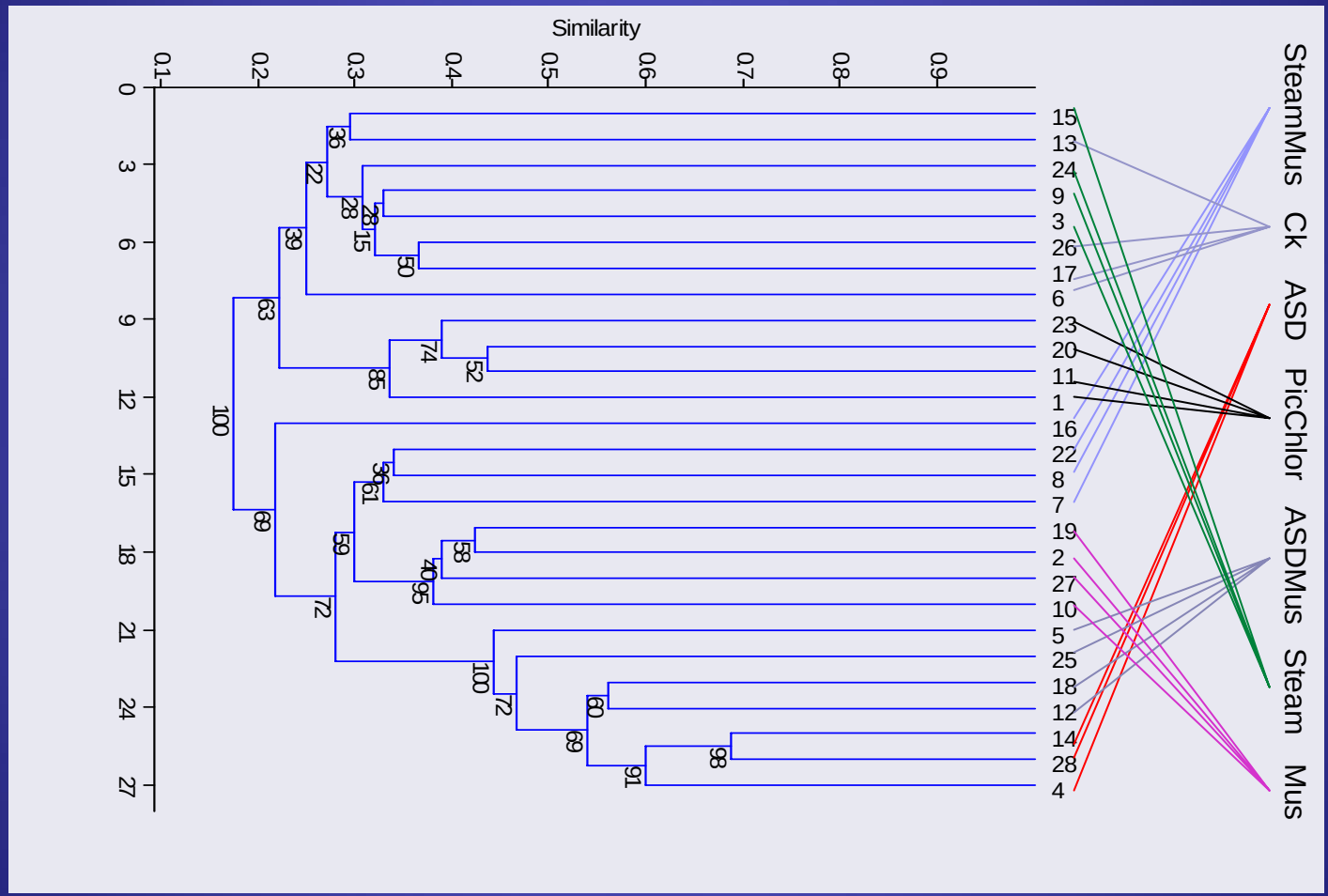
All ASD and mustard-based treatments stimulated bacterial communities,
- likely inducing an elevated competitive environment.

MBA, CA Post-treatment Total fungi: November 2011



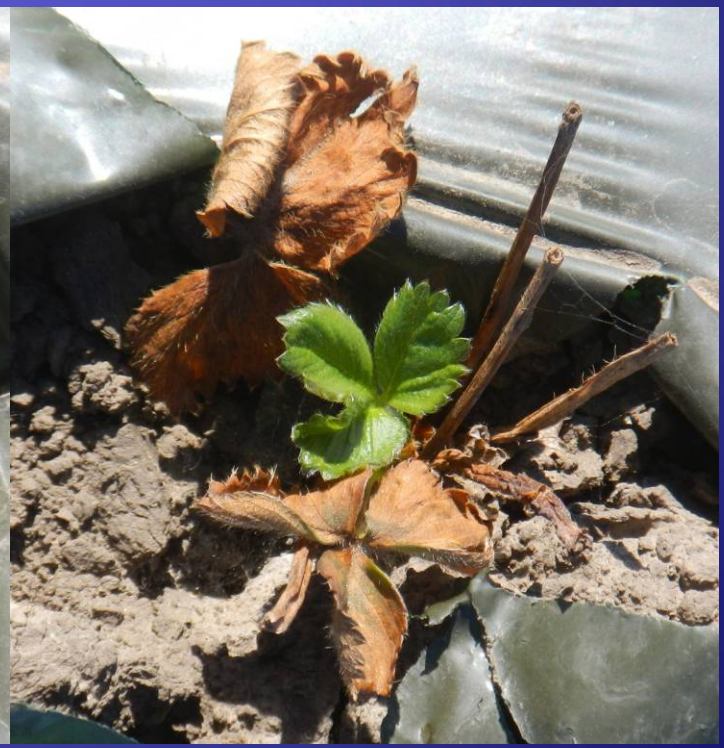
All ASD and mustard-based treatments stimulated total fungal densities, likely inducing an elevated competitive environment.

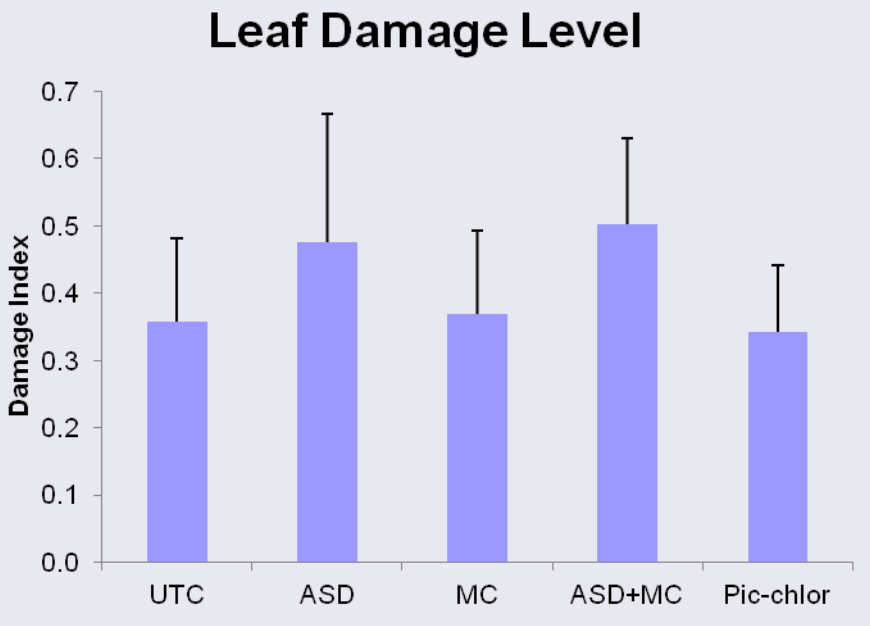
Fungal community similarity post-treatment

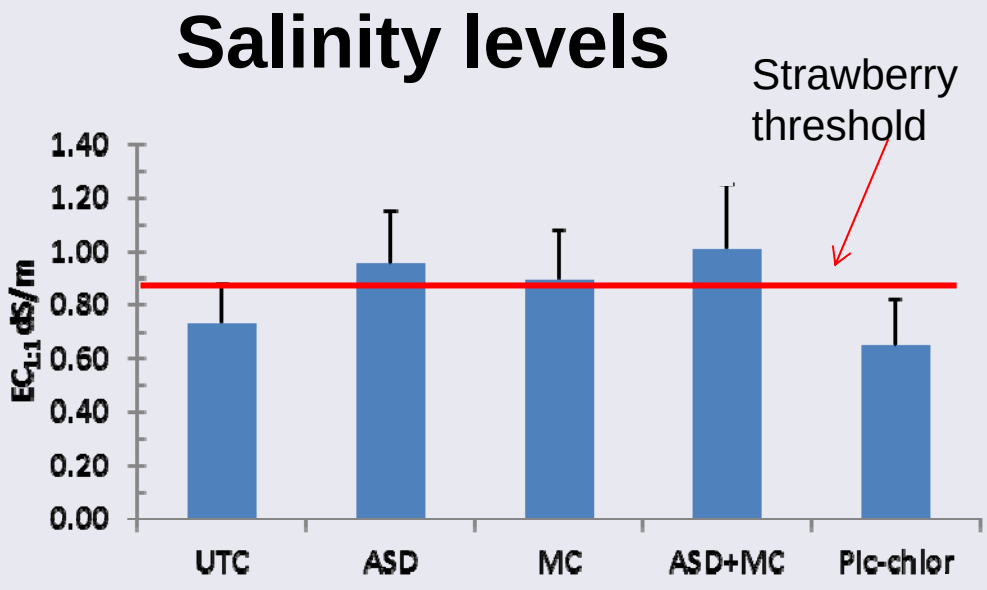


Salinity issue - winter 2012

- Observed problems in some ASD fields
- Very dry weather led to salt-build up







Salt level in part due to nitrate accumulation - maybe reduce amount of rice bran used?