The Impacts of Anaerobic Soil Disinfestation (ASD) on Weeds

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

Acknowledgements

- **Chris Matthews**, Garroutte Farms, Inc.
- **Gary Tanimura** and **Glenn Noma**, Tanimura & Antle Fresh Foods, Inc.
- **Hector Gutierrez** with Tri-Cal/Otillo Farms and **UC Hansen staff and volunteers**
- **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**

Outline

- What is ASD?
- Current status of ASD implementation
- Impacts of ASD on weeds
  - Field trials in the Central Coast of CA and FL
- Future works planned

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: Three Steps

1. Incorporate organic material
   - ➢ **Provides C source for soil microbes**
2. Cover with plastic tarp
   - ➢ **Limit oxygen supply to the bed soil**
3. Irrigate to saturation and maintain above the field capacity for 3 weeks
   - ➢ **Deplete oxygen, initiate anaerobic decomposition, produce organic acids and volatiles, temporarily lower pH, and shift soil microbial communities**

Findings to Date

1. Can get consistently good *V. dahliae* suppression 80 to 100% of microsclerotia in topsoil
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 Pic-Clor 60
    5. Watsonville 2011 – equal to Pic-Clor 60 and steam
3. Standard tarp appears as effective as TIF and VIF (from pot and field studies)
4. Limited weed suppression in open field conditions in the Central coast of CA


QUINN

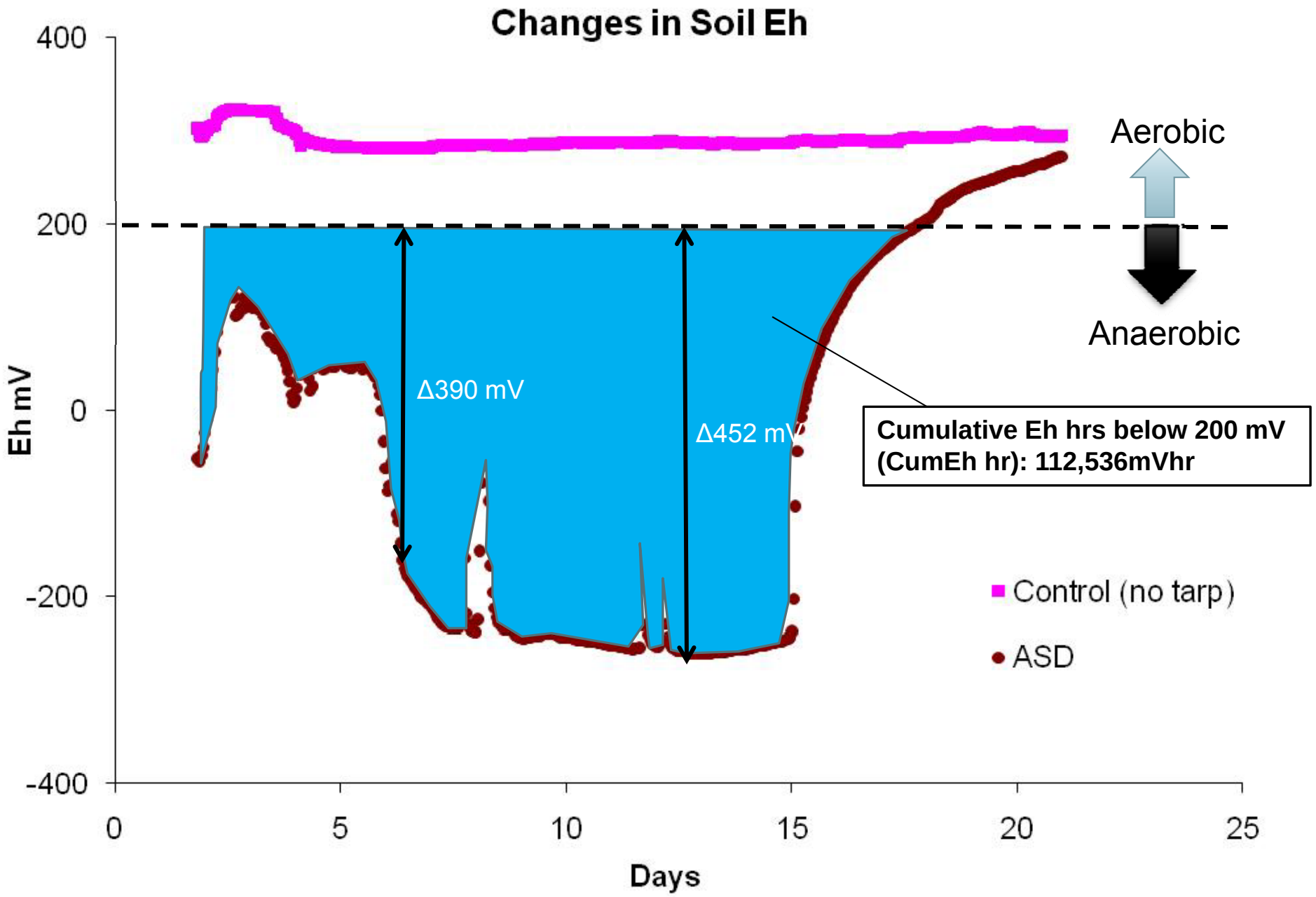
Commercial Implementations of ASD in CA in the 2012-2013 Season

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
Blue berry	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**

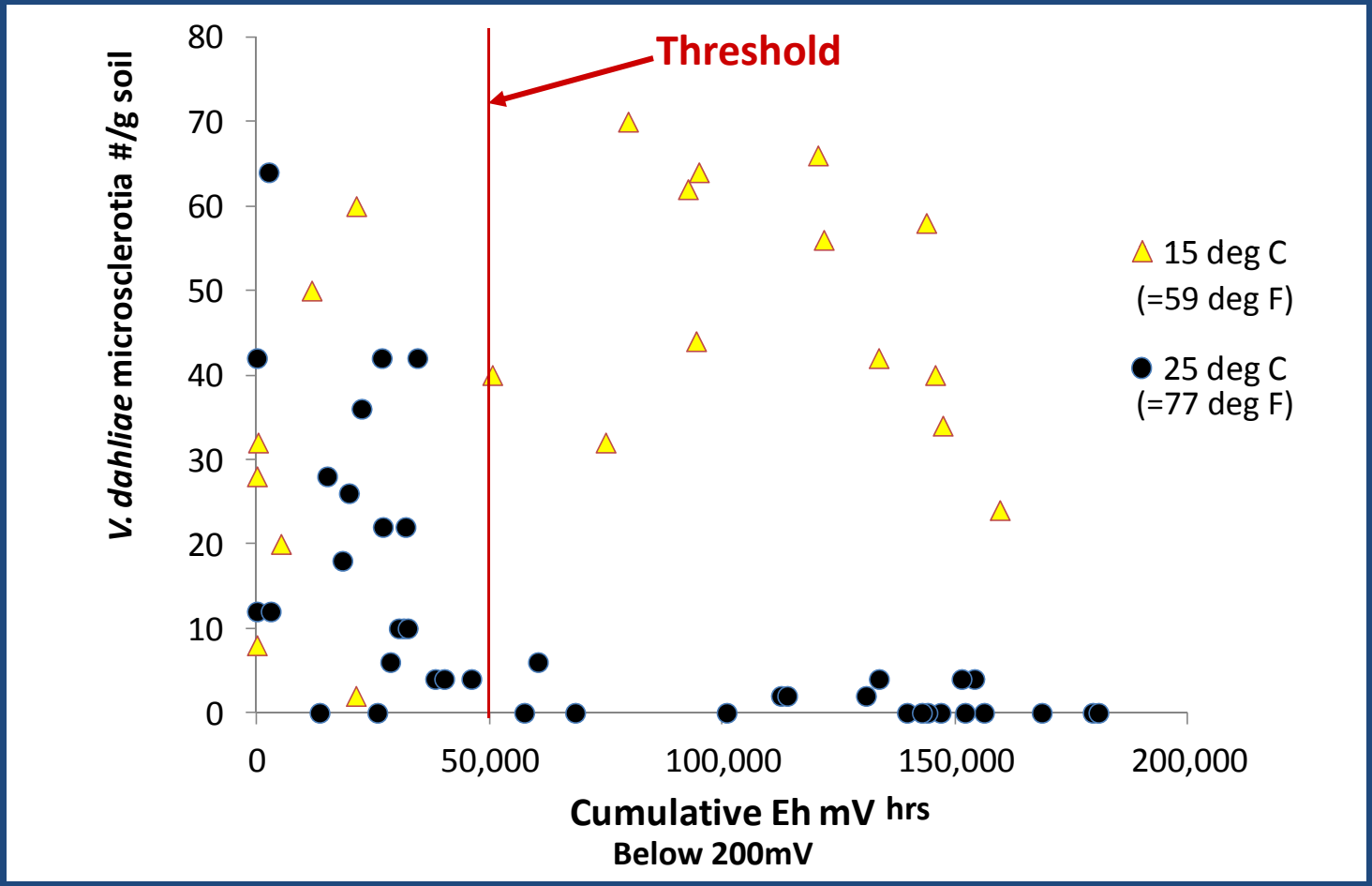
*** RB: rice bran, ML: molasses.**

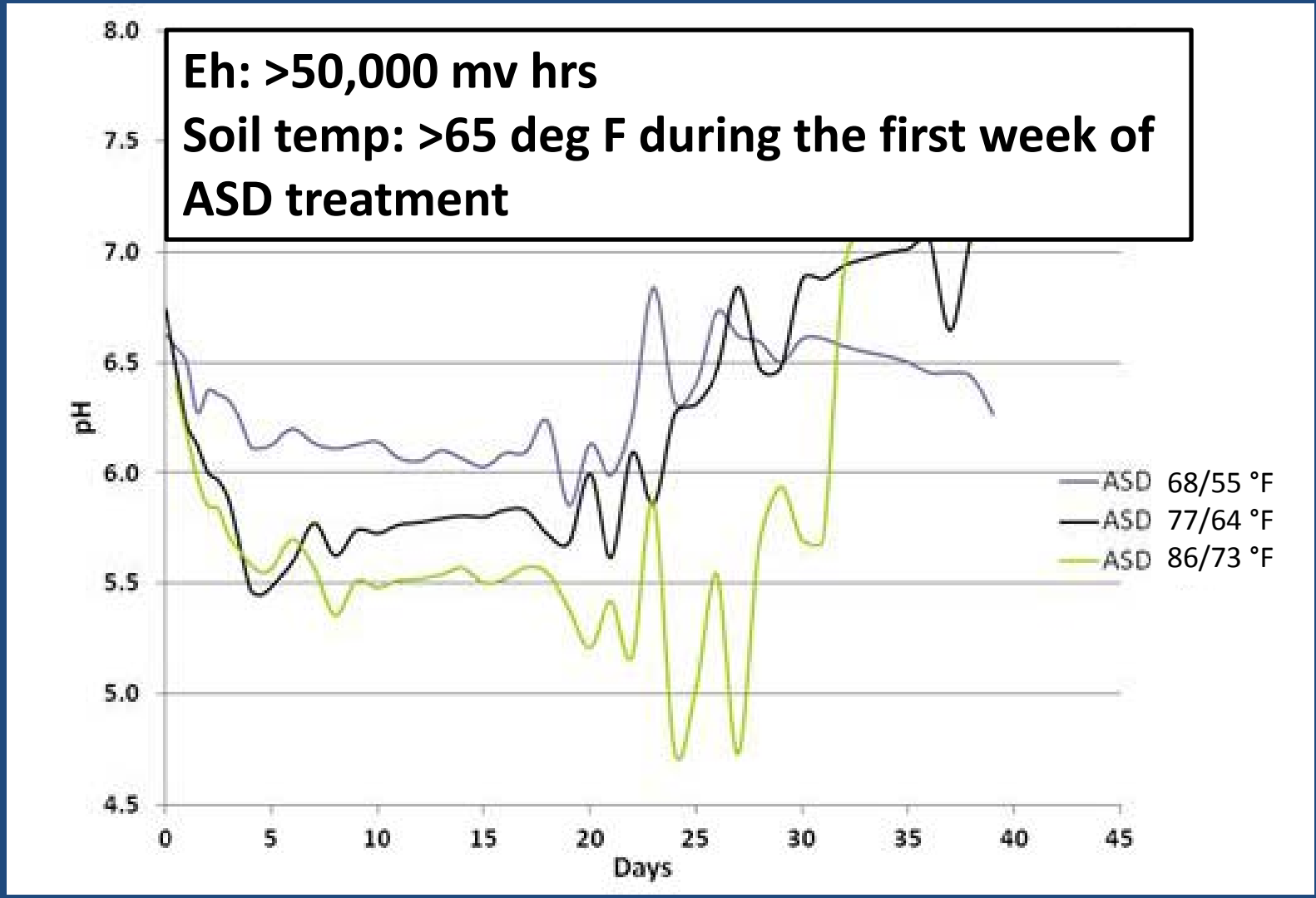
**** 26 organic sites and 2 conventional sites.**

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


Changes in Soil Eh
400
200
0
-200
-400
Eh mV
0
5
10
15
20
25
Days
Aerobic
Anaerobic
Δ390 mV
Δ452 mV
Cumulative Eh hrs below 200 mV
(CumEh hr): 112,536mVhr
Control (no tarp)
ASD

Cumulative mV hrs with Eh below 200mV – threshold for Vert. control at ~50,000 (77 °F)





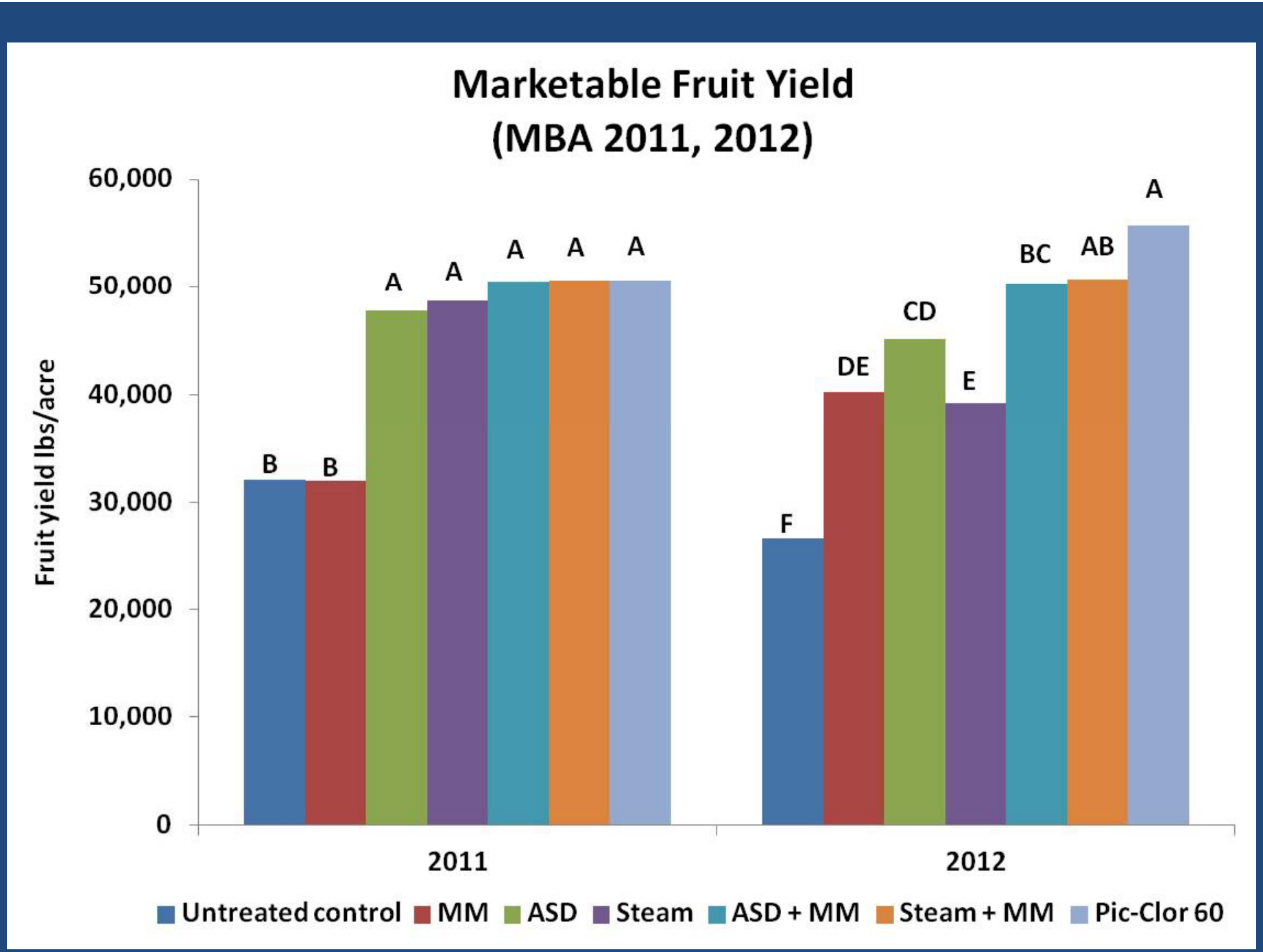
Soil pH changes during ASD treatment under three different temperature regimes; 68°F (day time12hrs)/55°F (night time12 hrs), 77°F /64°F , and 86 °F /73°F (pot experiment).

Field Trials in CA

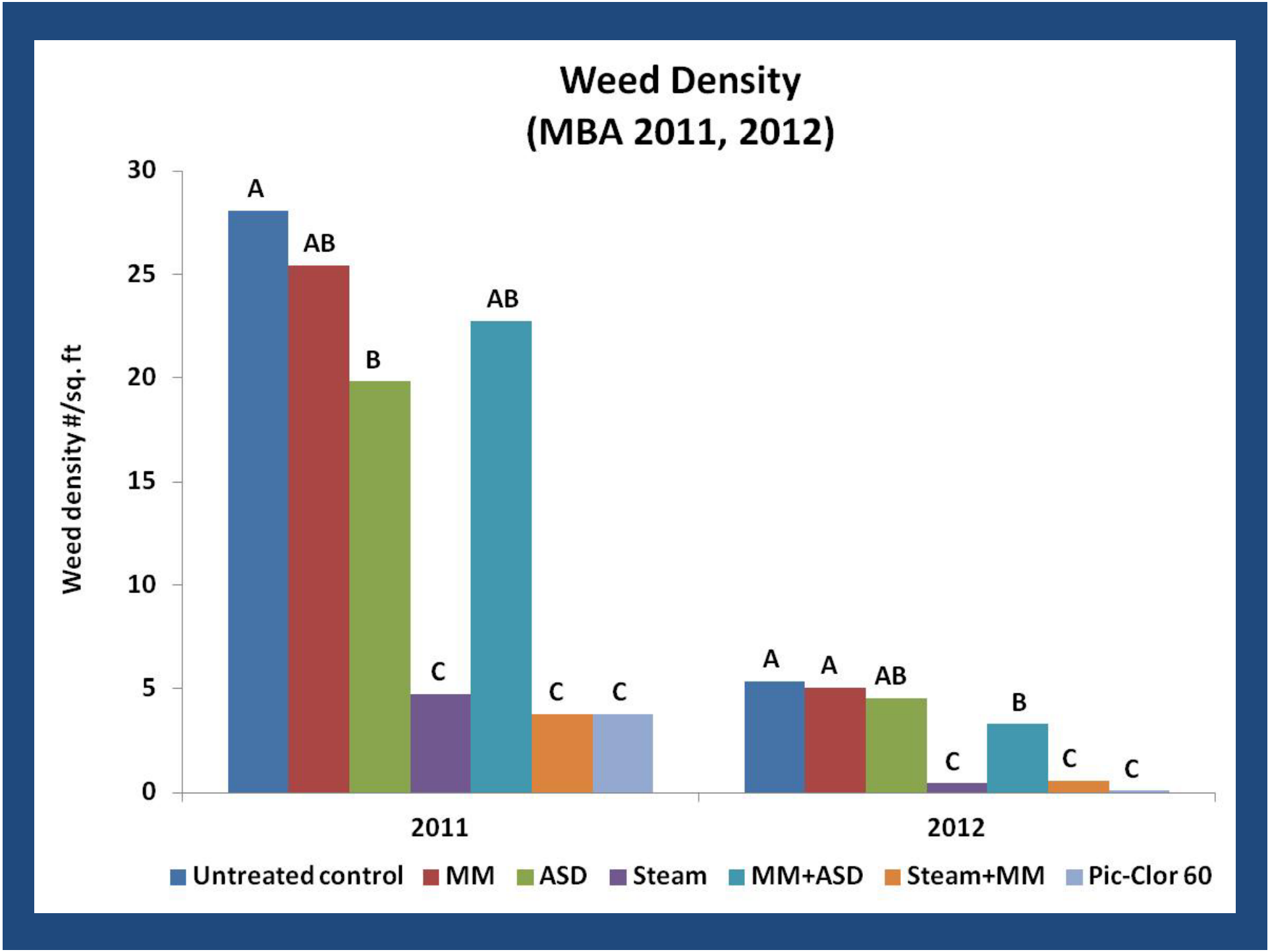
1. **<u>MBA trial in Watsonville (2010-11, 2011-12)</u>**

   Completely randomized block design with 4 reps

   - Untreated control
   - Mustard seed meal (MM) 1.5 t/ac
   - ASD-rice bran 9 t/ac
   - Steam
   - ASD-rice bran 7.5 t/ac +MM 1.5 t/ac
   - Steam+MM 1.5 t/ac
   - Pic-Clor 60


Marketable Fruit Yield
(MBA 2011, 2012)
Fruit yield lbs/acre
60,000
50,000
40,000
30,000
20,000
10,000
0
B
B
A
A
A
A
A
F
DE
CD
E
BC
AB
A
2011
2012
Untreated control
MM
ASD
Steam
ASD + MM
Steam + MM
Pic-Clor 60

Weed observation window (clear plastic mulch) for weed density measurement

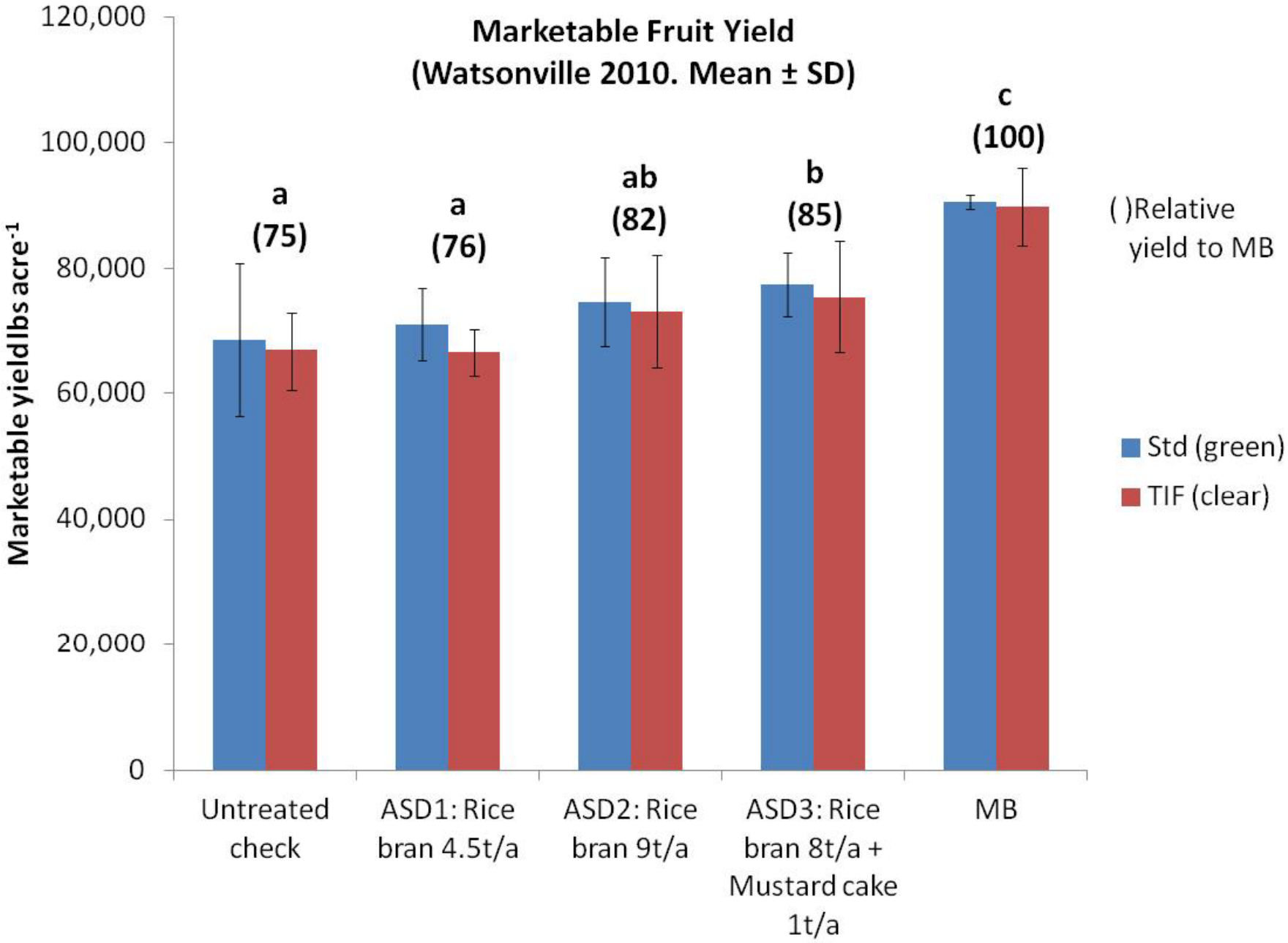

Weed Density
(MBA 2011, 2012)
Weed density #/sq. ft
30
25
20
15
10
5
0
A
AB
B
C
AB
C
C
A
A
AB
C
B
C
C
2011
2012
Untreated control
MM
ASD
Steam
MM+ASD
Steam+MM
Pic-Clor 60

Field Trials in CA

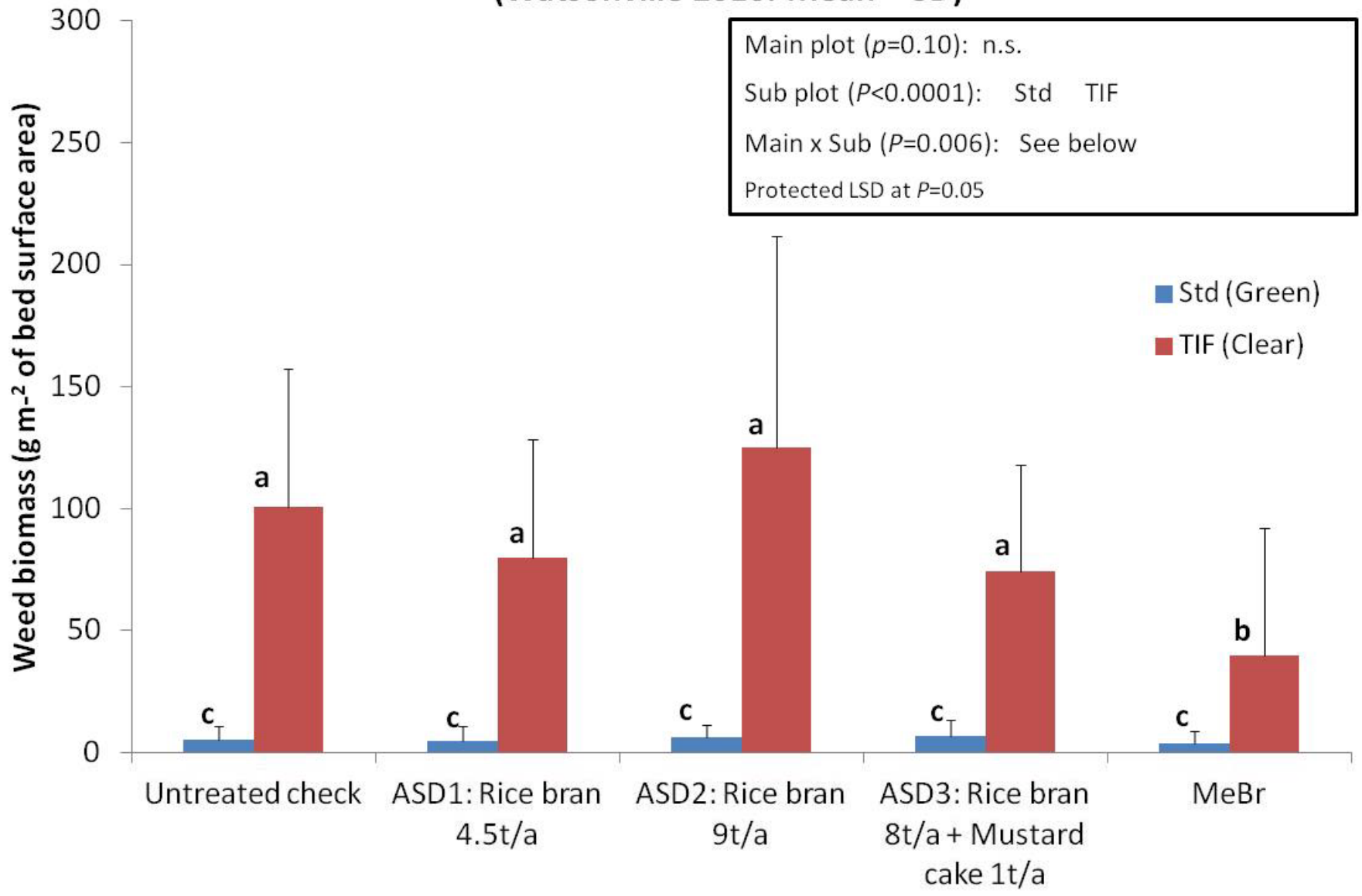
2. Holohan trial in Watsonville (2009-10)

Completely randomized block split design with 4 reps

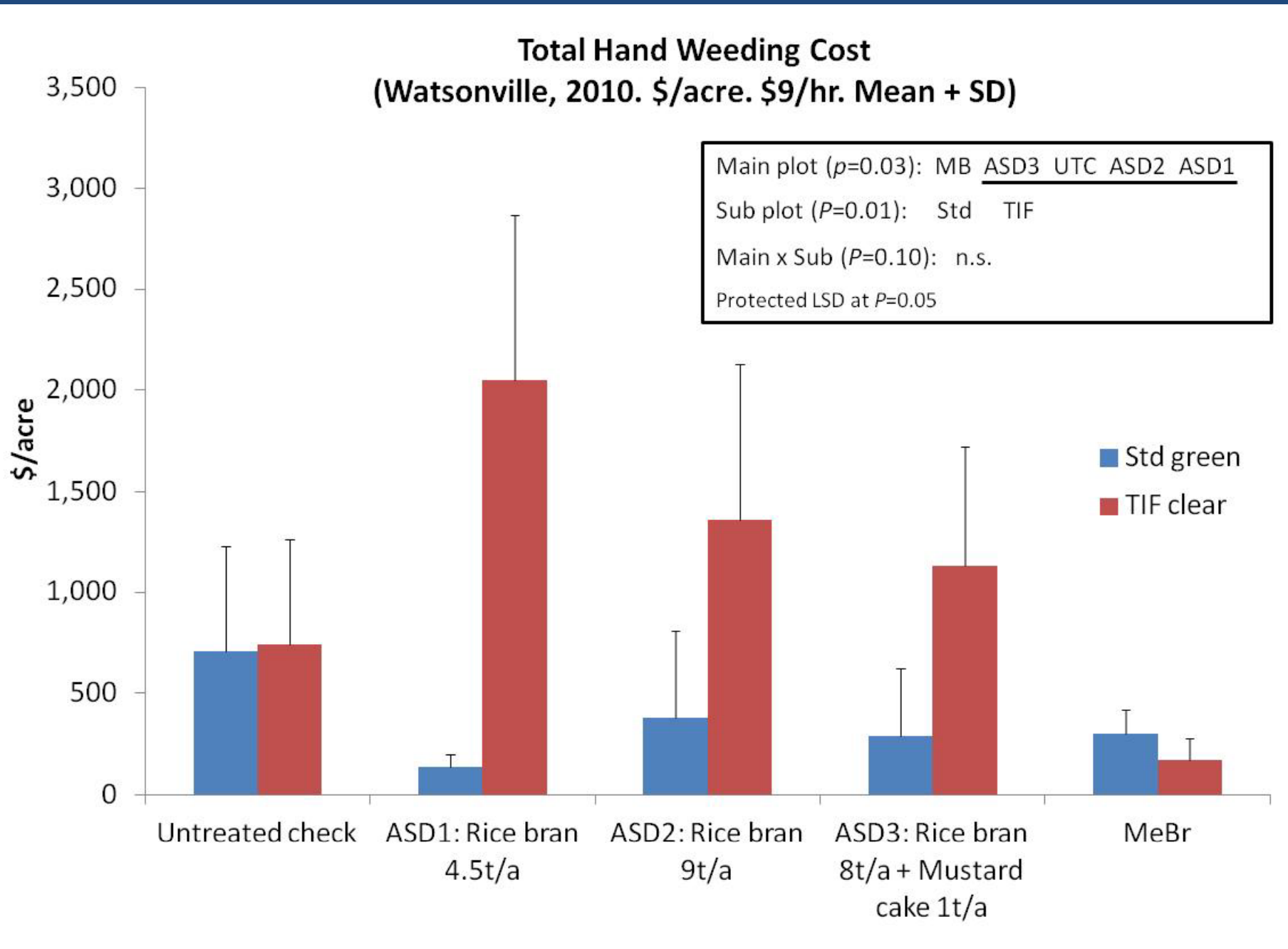
- Main Plots:
  - Untreated control
  - ASD-rice bran 4.5 t/ac
  - ASD-rice bran 9 t/ac
  - ASD-rice bran 8 t/ac +MM 1 t/ac
  - Methyl Bromide
- Sub Plots:
  - Standard green plastic mulch
  - TIF clear plastic mulch


Marketable Fruit Yield
(Watsonville 2010. Mean ± SD)
Marketable yield lbs acre-1
120,000
100,000
80,000
60,000
40,000
20,000
0
a
(75)
a
(76)
ab
(82)
b
(85)
c
(100)
Untreated check
ASD1: Rice bran 4.5t/a
ASD2: Rice bran 9t/a
ASD3: Rice bran 8t/a + Mustard cake 1t/a
MB
( )Relative yield to MB
Std (green)
TIF (clear)

Cumulative Weed Biomass during the Strawberry Growth Season (Watsonville 2010. Mean + SD)

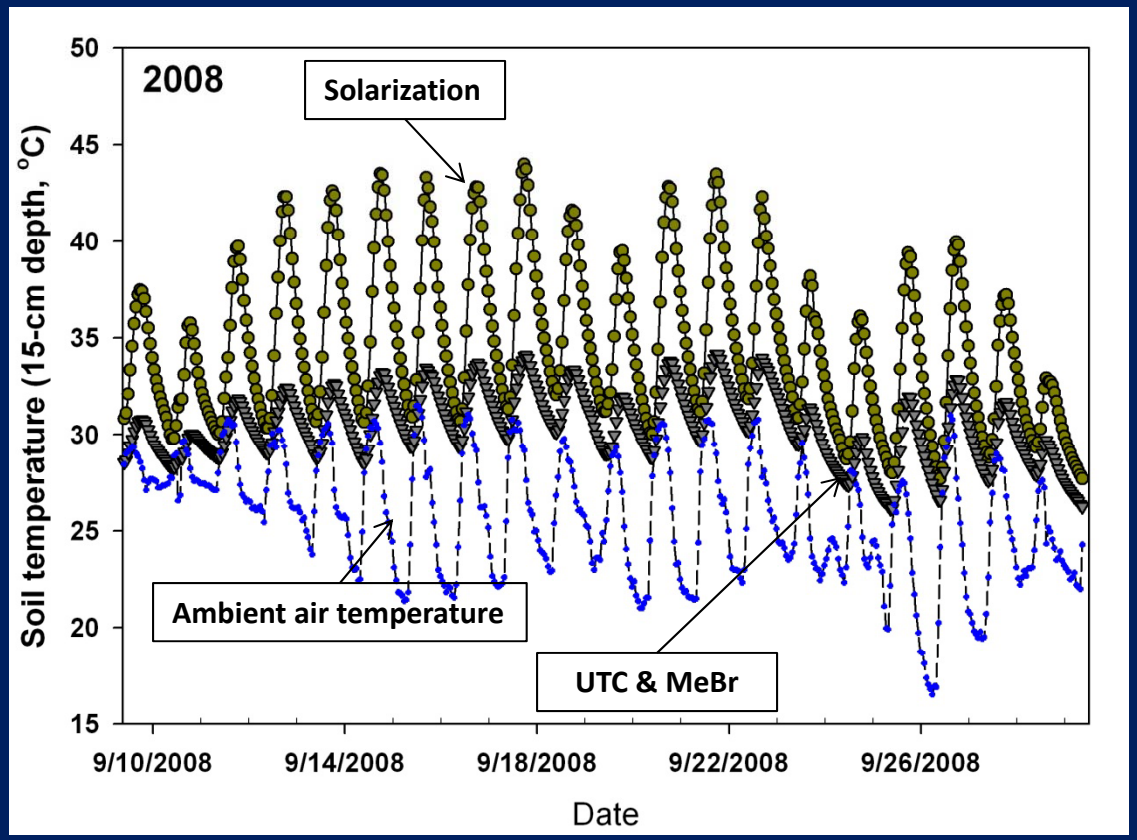



1/27/2010


Total Hand Weeding Cost
(Watsonville, 2010. $/acre. $9/hr. Mean + SD)
Main plot (p=0.03): MB ASD3 UTC ASD2 ASD1
Sub plot (P=0.01): Std TIF
Main x Sub (P=0.10): n.s.
Protected LSD at P=0.05
$/acre
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Std green
TIF clear
Untreated check
ASD1: Rice bran 4.5t/a
ASD2: Rice bran 9t/a
ASD3: Rice bran 8t/a + Mustard cake 1t/a
MeBr

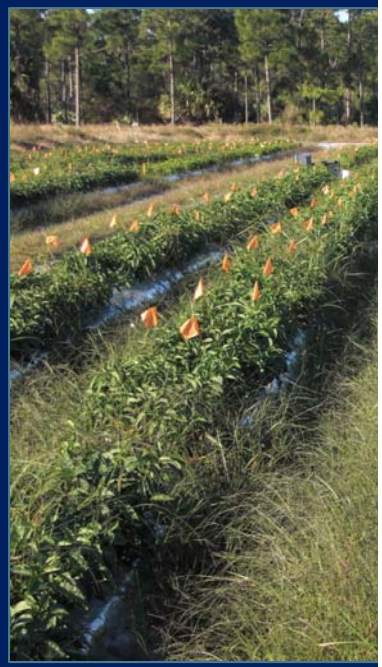
Solarization + ASD in Florida (Butler et al., 2011)

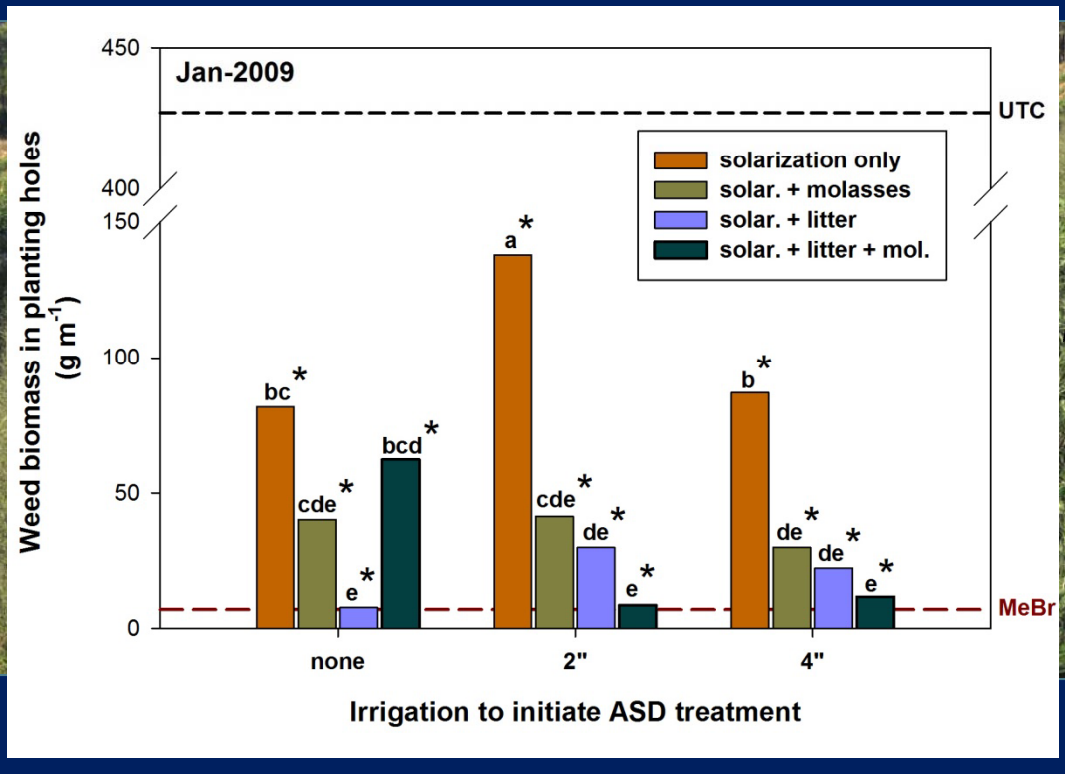
- Daily maximum temperatures at **15-cm depth**
  - ~45°C (115°F) with solarization
  - < 33°C (~90°F) under reflective silver plastics
- Ambient high ~ 90°F
- Mesophilic soil organisms damage threshold beginning ~39°C (102°F)

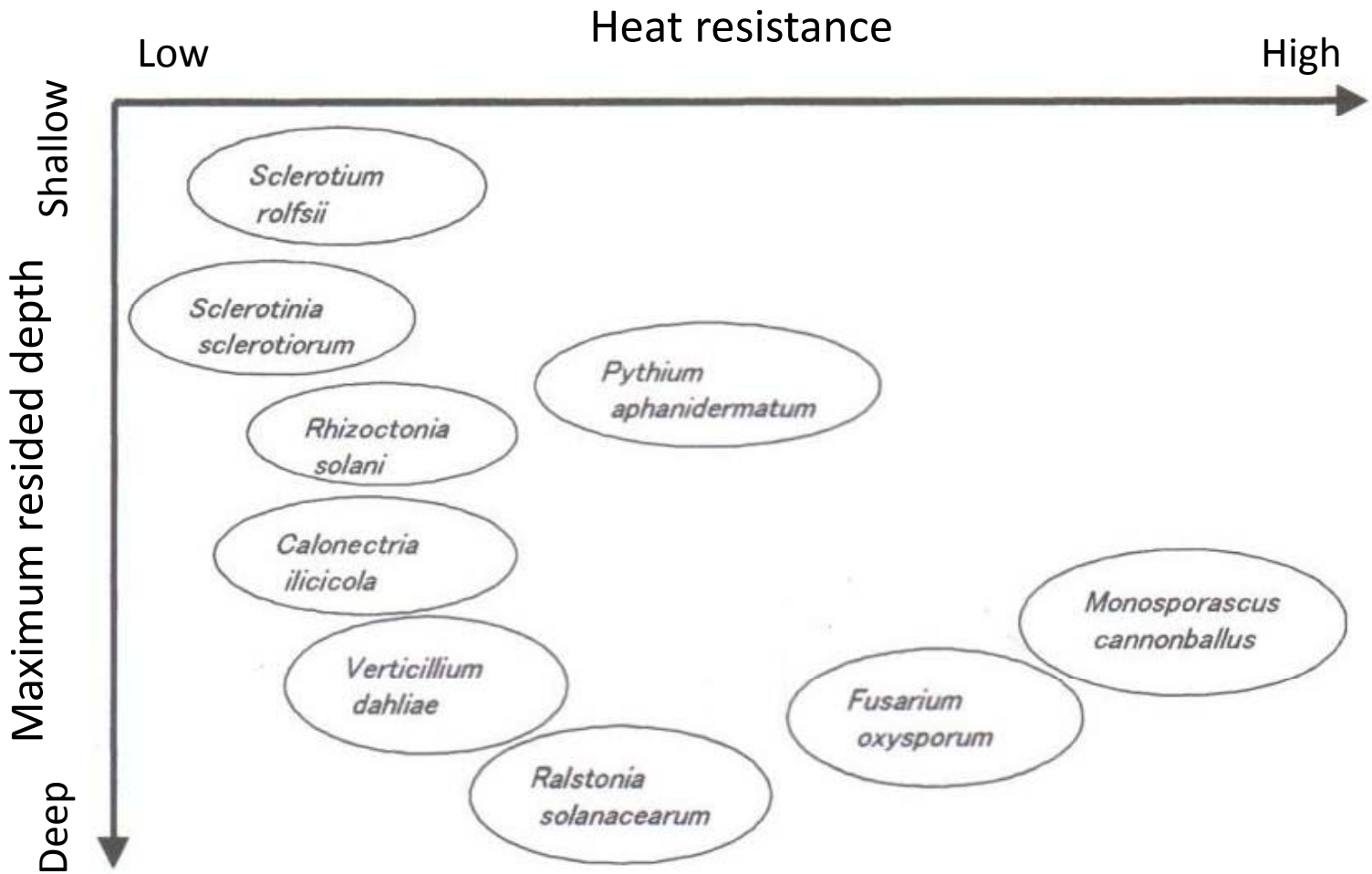


Impact on weeds in Florida (Butler et al., 2011)

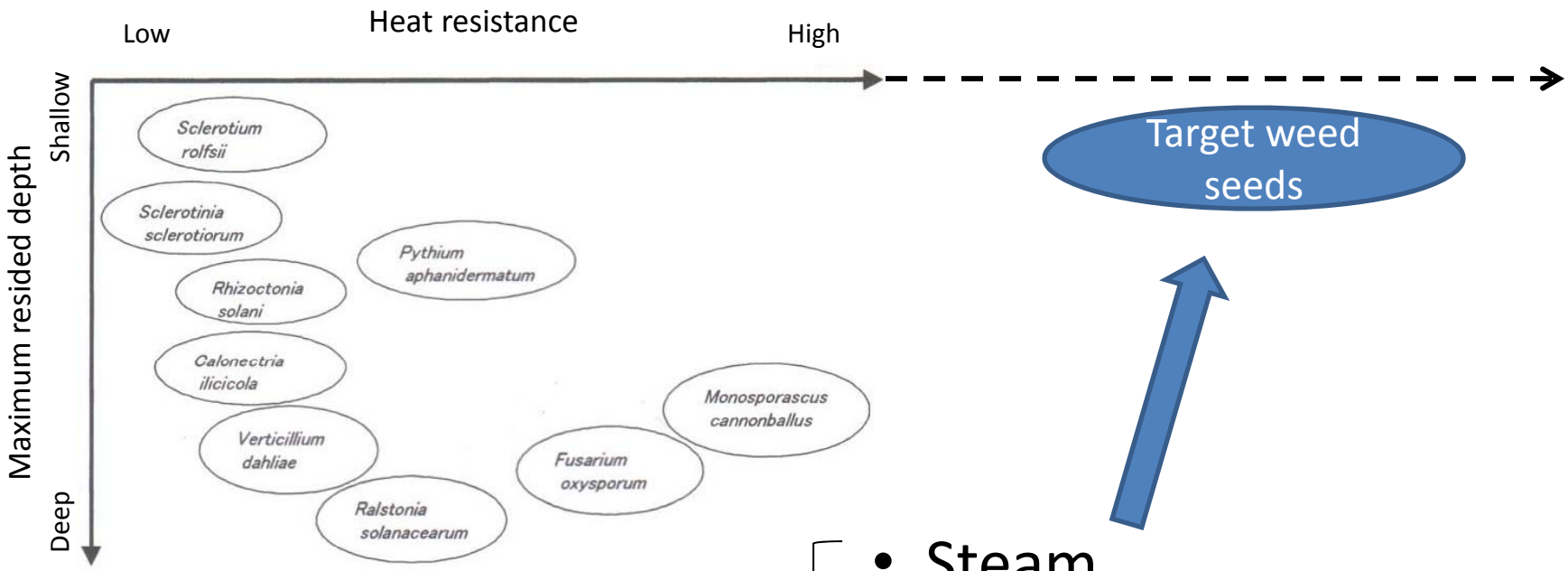
- With 2” or 4” initial irrigation, weed control in planting holes (mostly grasses) improved by litter and/or molasses
- All treatments were equal to the MeBr standard and less than UTC







Maximum resided soil depth and heat resistance of soil-borne pathogens; a conceptual figure **(Takehara, 2004)**



Physical treatment
- Steam
- Solarization

Physical + biological + chemical treatment
- Solarization+ASD
- Solarization+MSM

Conclusions

- Weed control by Anaerobic Soil Disinfestation (ASD)
  - Limited in the Central Coastal CA
    - Conventional systems: herbicide
    - Organic systems: opaque plastic mulch
  - More effective in warmer conditions
    (e.g. greenhouses, the Central Valley and Southern regions in CA, Florida, Japan)
    - Use of clear plastic mulch (solarization effect)

Future work planned

- Evaluate ASD for control of other pathogens
- Test alternative C sources such as molasses, 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 ASD
  - Microbial changes
  - Organic acid production
- Look at ASD in combination with other treatments
  - Mustard meal
  - Biofungicides
- Evaluate potential environmental impacts of ASD

Questions?

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