Anaerobic Soil Disinfestation (ASD) Research Update

Fumigants/non-fumigant alternatives: Regulatory/research updates
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Outline

1. ASD: basics and summary of past studies in CA
2. Cover crop-based ASD trial in Santa Cruz, CA
3. ASD went bad: Fusarium wilt control by ASD in Watsonville, CA
4. Nitrogen mineralization from rice bran

What is ASD?

- Developed in the Netherlands and Japan independently ~2000 as a biological alternative to fumigation
- Principle: Acid fermentation in anaerobic soil

(Van Bruggen, 2014)

<u>Four-step process</u>

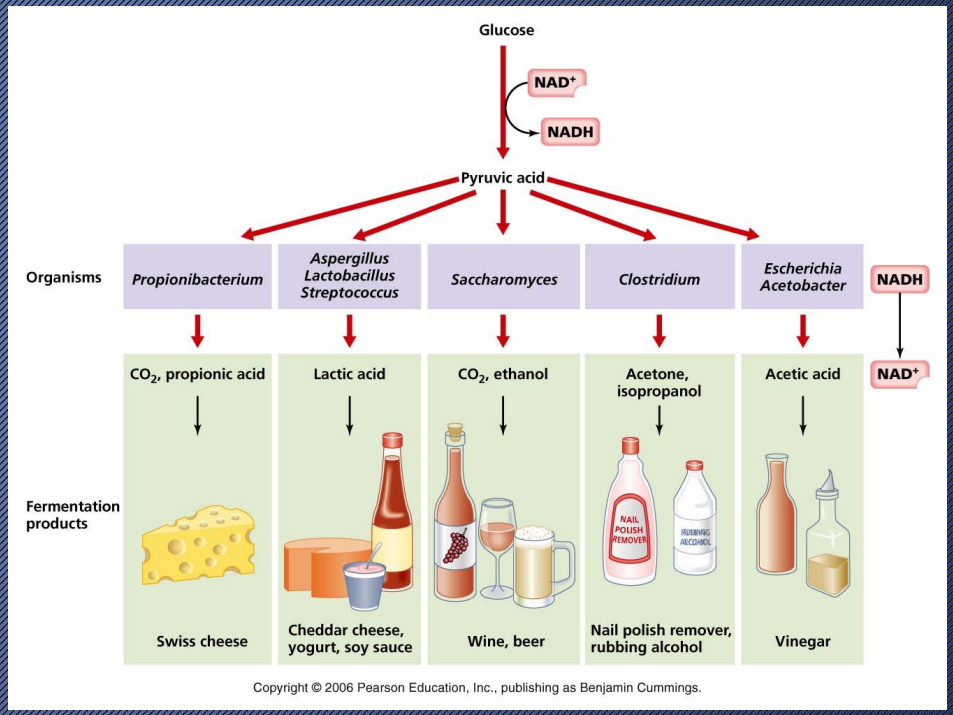
1. Incorporate labile C-source
2. Moisten the amended soil
3. Cover by plastic mulch to shut down oxygen supply
4. Maintain anaerobic decomposition

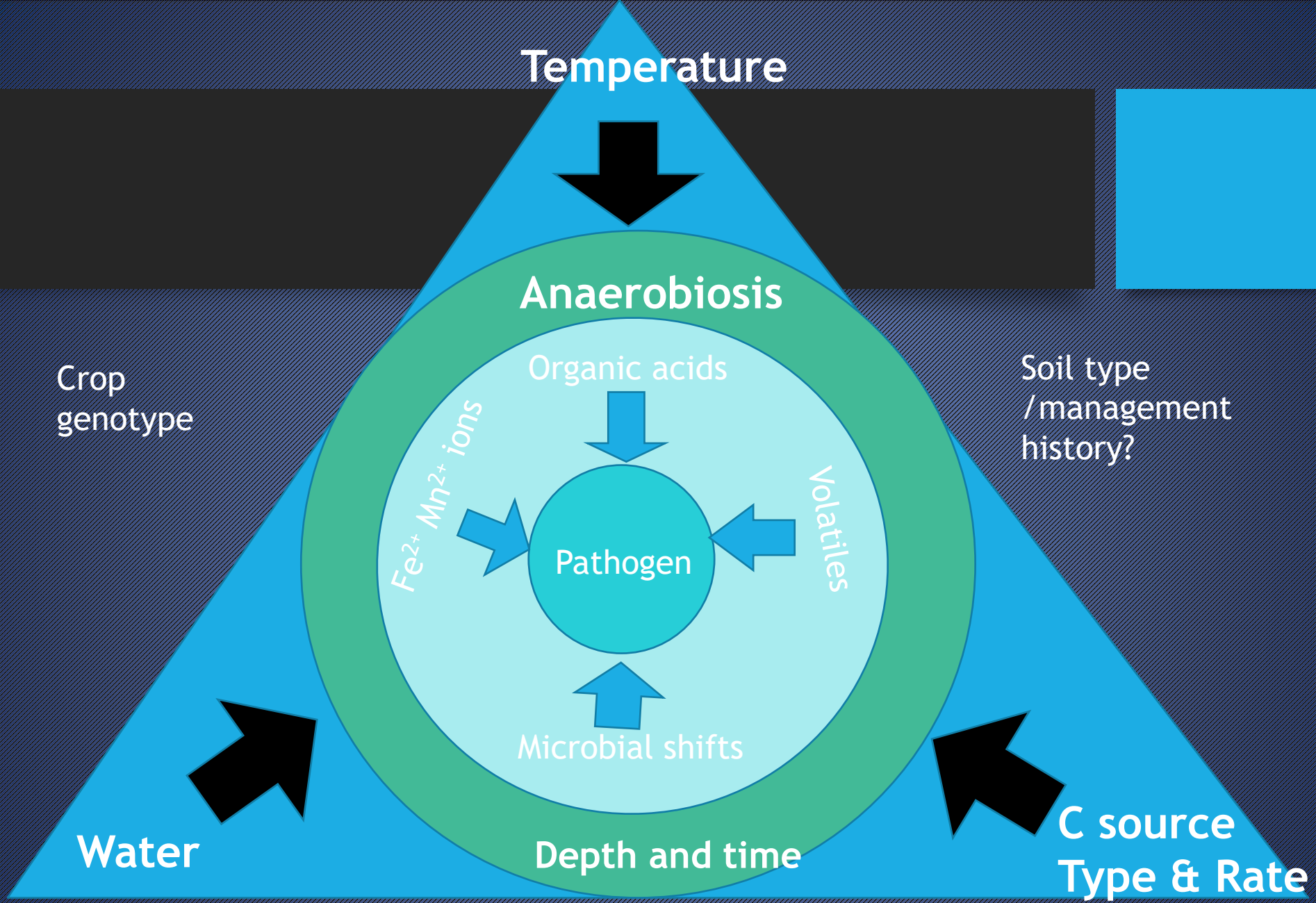
(Chiba prefecture, 2002)

Fermentation ~key process in ASD~

- An anaerobic (lack of oxygen)
- bacteria, yeast or other microorganisms convert organic foods into simpler compounds

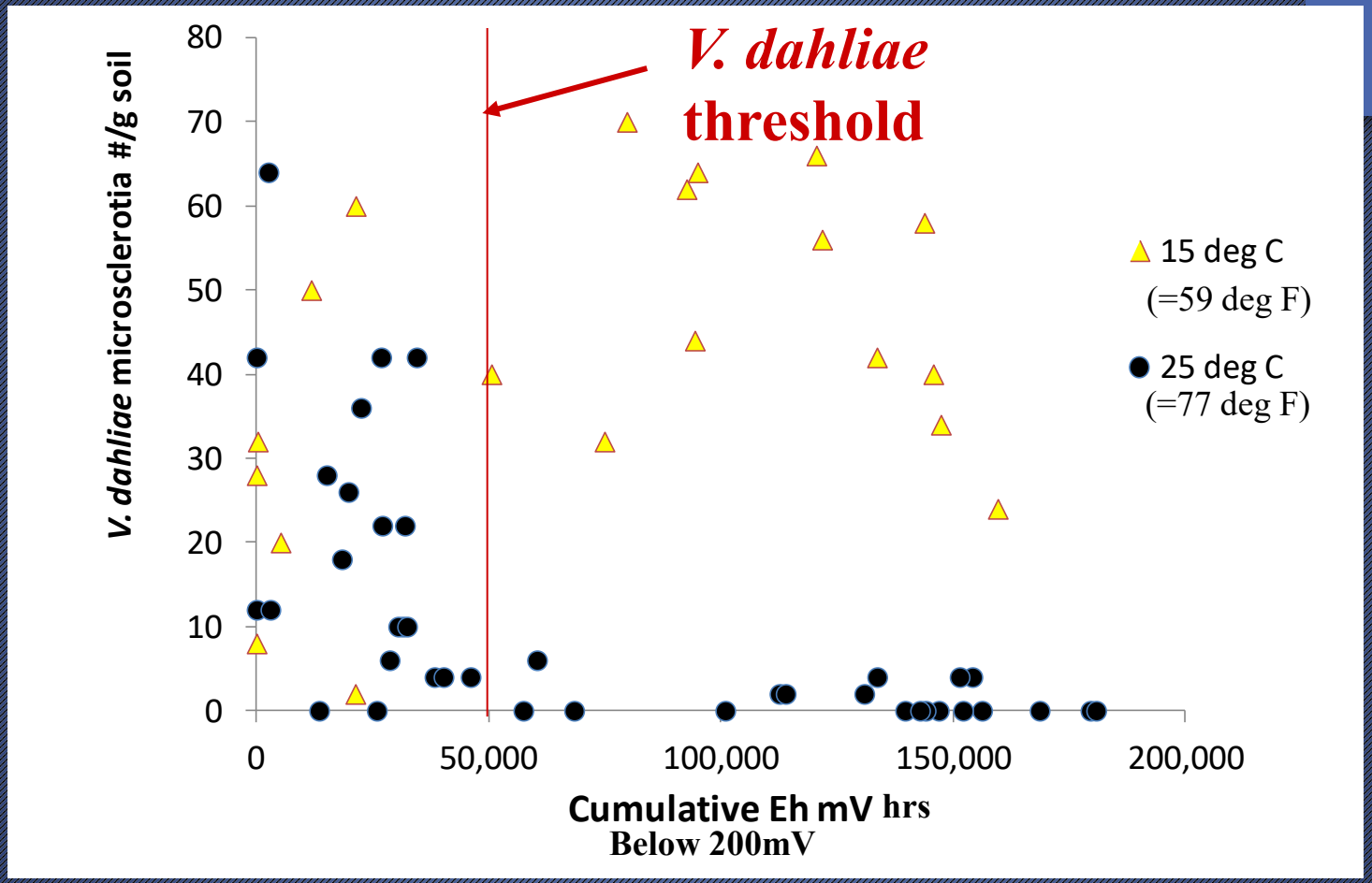
ASD process
- use native microorganisms in soil
- acetic acid
- butyric acid
- propionic acid
- lactic acid
- some other volatiles





ASD Management Triangle (Shennan et al, 2014)

Both anaerobic condition and temperature are important for disease control in ASD



Cumulative mV hrs with Eh below 200mV - threshold for *V. dahliae* control at ~50,000 (25 °C)

(Shennan et al., 2010)

Fusarium infested field
Strawberry plants (8/14/14)

UTC

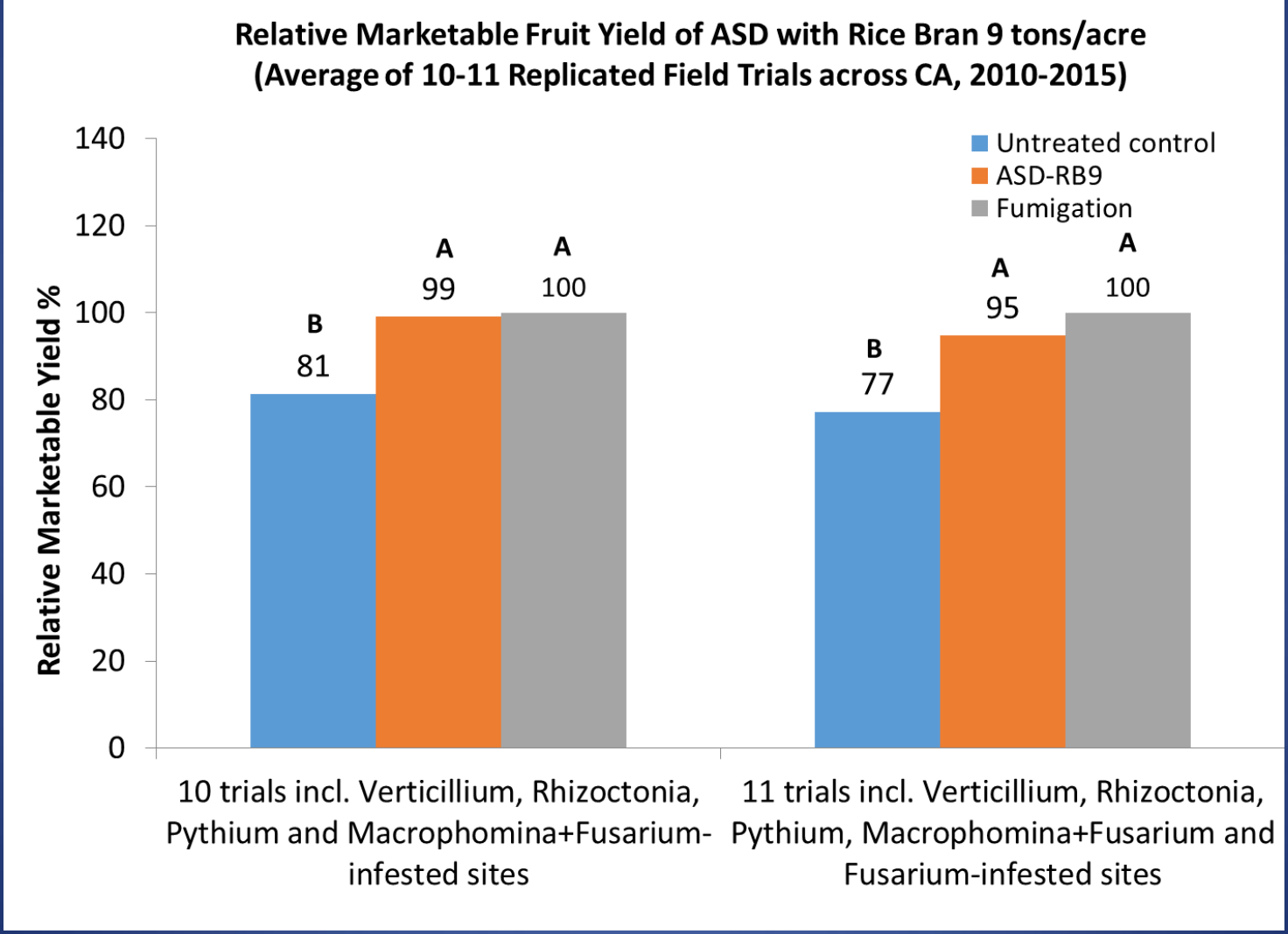
ASD Summer
RB 9t/ac

ASD Fall
RB 9t/ac

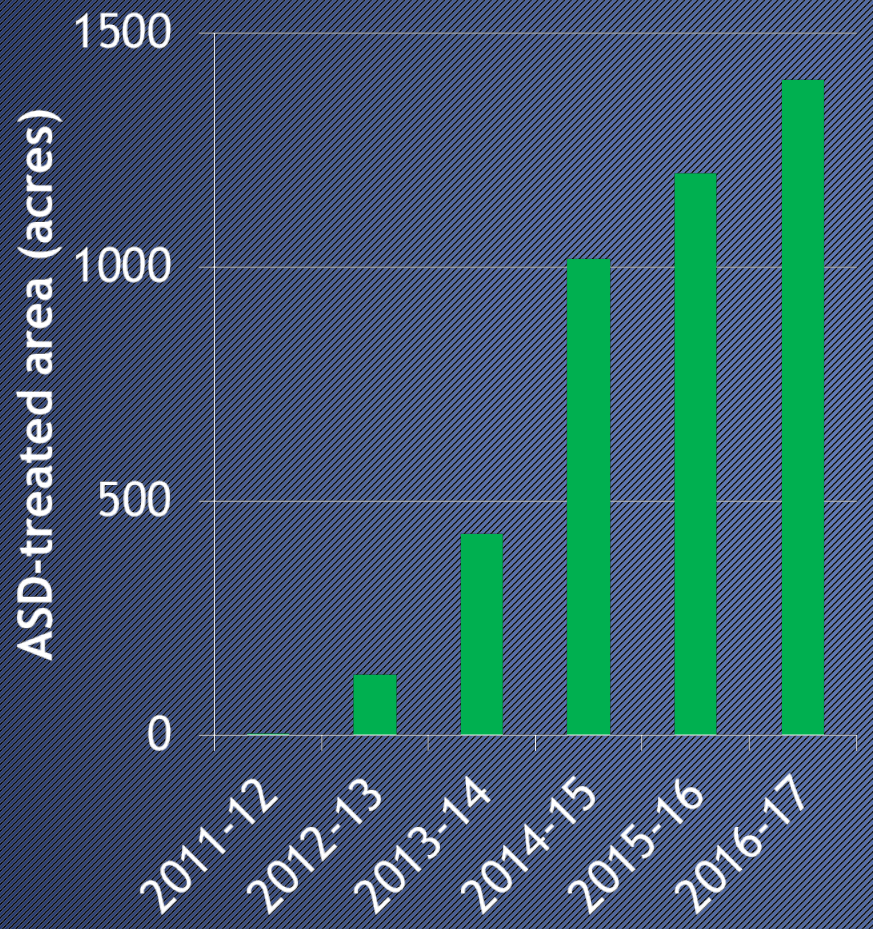
Higher temperature threshold for *Fusarium oxysporum*

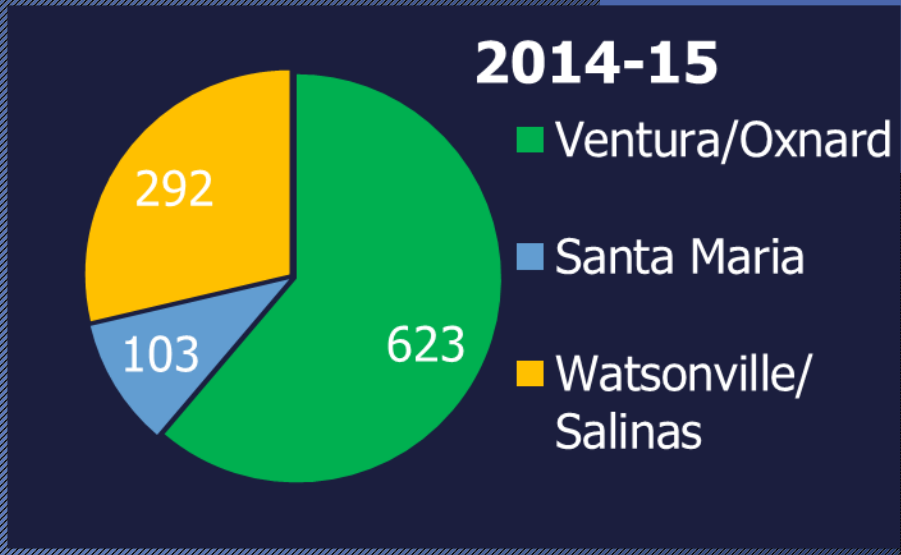
(>300 hours above 86˚F at 8" soil depth (Yonemoto et al., 2006))

ASD provides comparable fruit yield with fumigant



ASD-treated strawberry fields in California





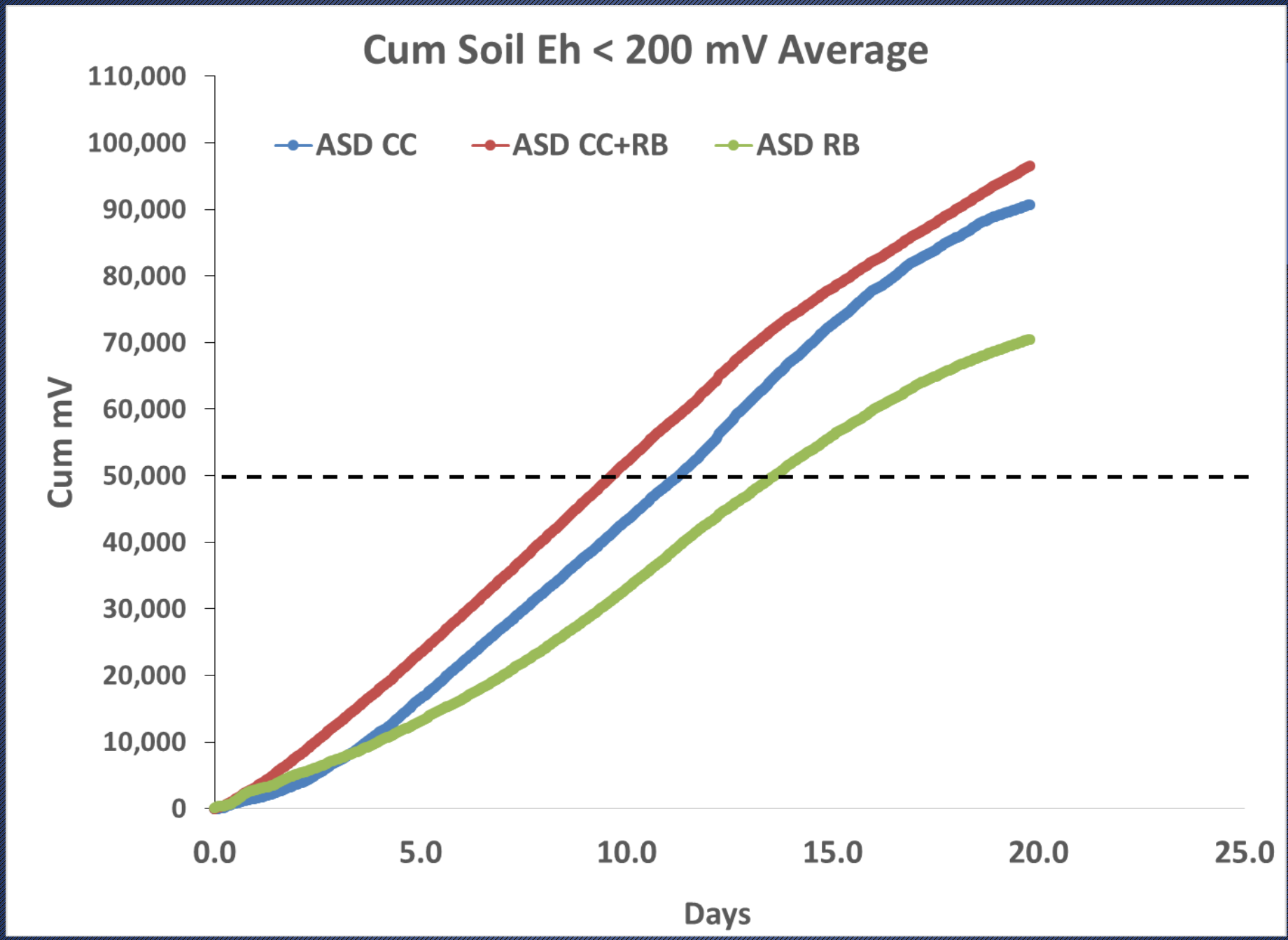
- 80% organic sites
- 20% conventional sites

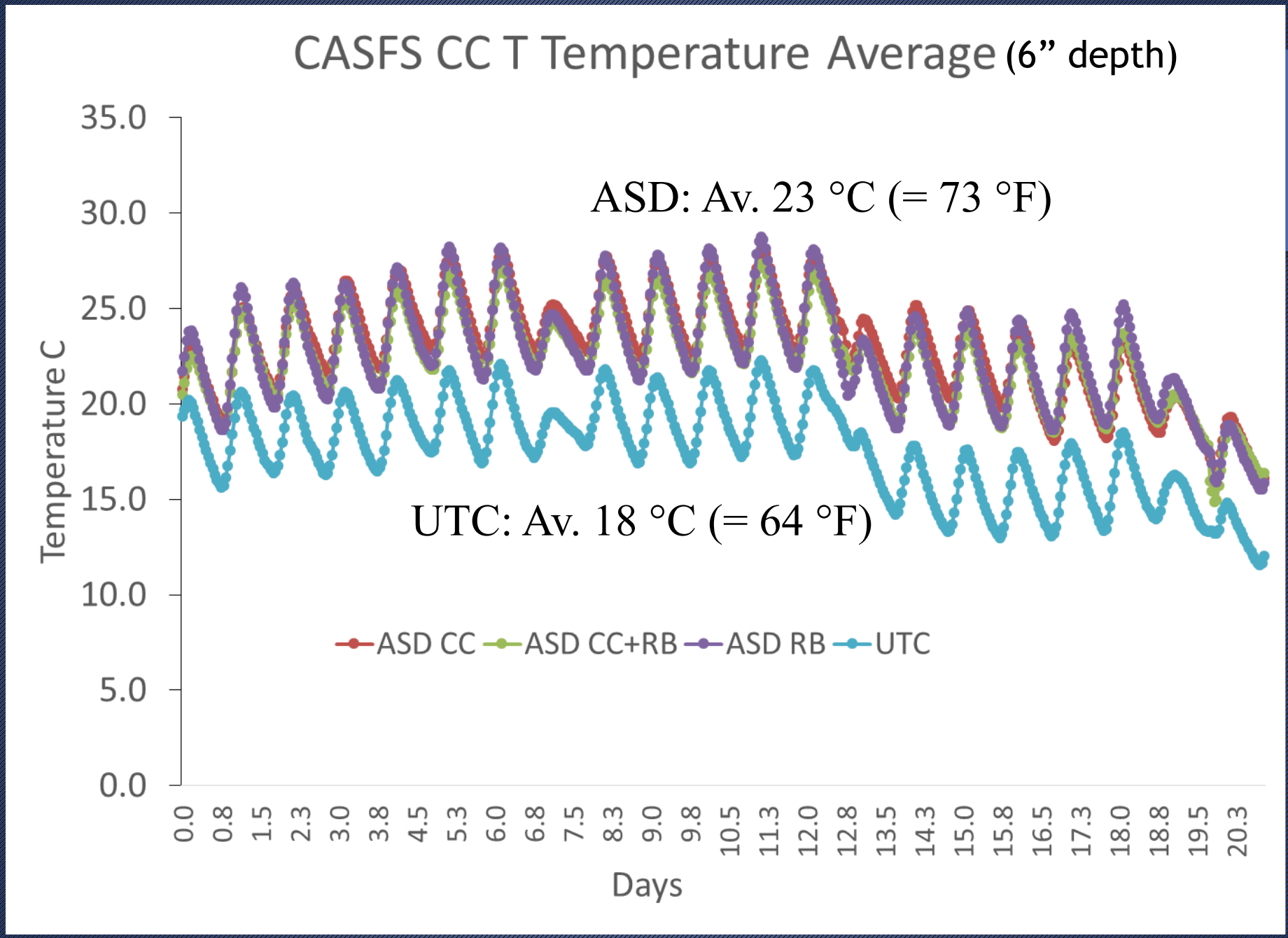
- ~20% of CA organic strawberry acreage
- ~2.5% of CA total strawberry acreage

Cover Crop-Based ASD Trial
(Santa Cruz, 2015-16)

- UCSC Organic Farm (Elkhorn Sandy loam)
  - Verticillium wilt history
- Piper Sudan grass 90 lb/ac
  - Aug - Oct, 2015
  - Biomass 3.5 t/ac d.w.
- Treatments (CRB, 4 reps)
  - ASD cover crop only (7 t/ac)
  - ASD cover crop (7 t/ac) + rice bran (2 t/ac)
  - ASD rice bran (9 t/ac)
  - Untreated control
- Albion (Dec. 2015 – Sep. 2016)

Flat ASD Treatment (the Dutch method)


Cum Soil Eh < 200 mV Average
ASD CC
ASD CC+RB
ASD RB
Cum mV
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0.0
5.0
10.0
15.0
20.0
25.0
Days


CASFS CC T Temperature Average (6” depth)
ASD: Av. 23 °C (= 73 °F)
UTC: Av. 18 °C (= 64 °F)
Temperature C
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
ASD CC
ASD CC+RB
ASD RB
UTC
0.0
0.8
1.5
2.3
3.0
3.8
4.5
5.3
6.0
6.8
7.5
8.3
9.0
9.8
10.5
11.3
12.0
12.8
13.5
14.3
15.0
15.8
16.5
17.3
18.0
18.8
19.5
20.3
Days

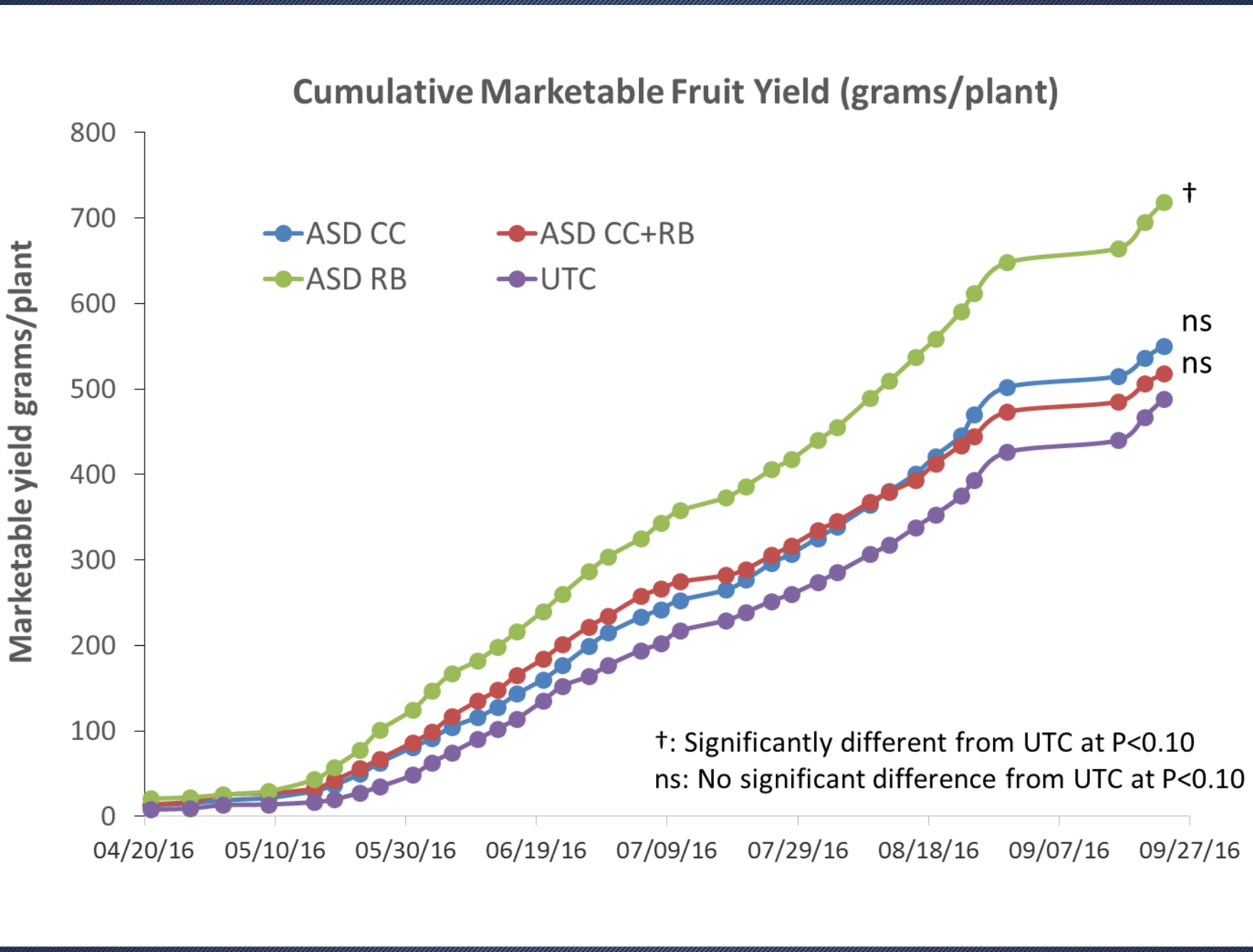
UTC

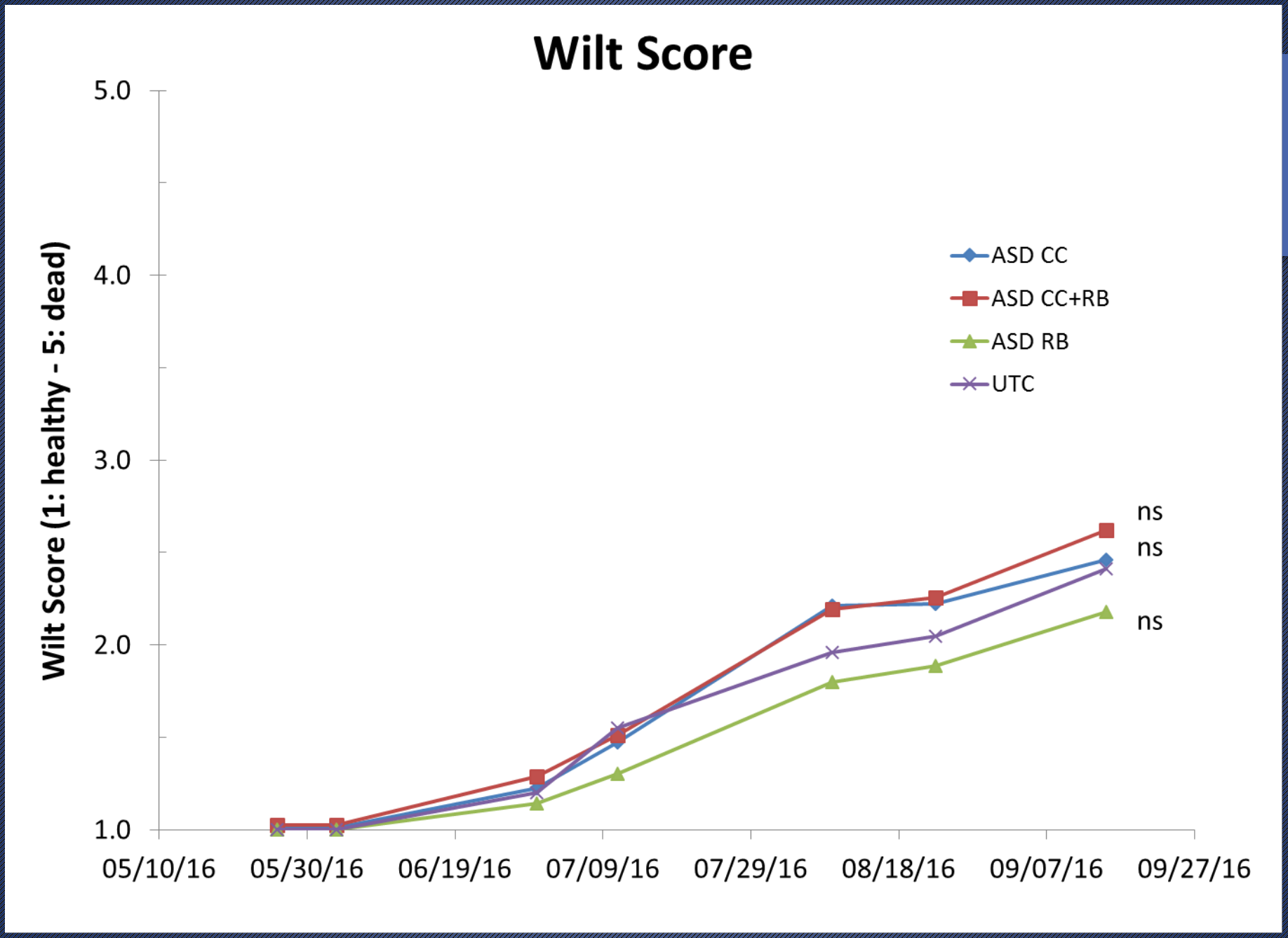
ASD-CC

ASD-CC+RB

ASD-RB

5/26/2016


Cumulative Marketable Fruit Yield (grams/plant)
Marketable yield grams/plant
800
700
600
500
400
300
200
100
0
ASD CC
ASD CC+RB
ASD RB
UTC
†
ns
ns
†: Significantly different from UTC at P<0.10
ns: No significant difference from UTC at P<0.10
04/20/16
05/10/16
05/30/16
06/19/16
07/09/16
07/29/16
08/18/16
09/07/16
09/27/16


Wilt Score
Wilt Score (1: healthy - 5: dead)
5.0
4.0
3.0
2.0
1.0
05/10/16
05/30/16
06/19/16
07/09/16
07/29/16
08/18/16
09/07/16
09/27/16
ASD CC
ASD CC+RB
ASD RB
UTC
ns
ns
ns

Summary: *Cover Crop-Based ASD Trial*

- Yield was highest at ASD RB9 and no difference between UTC, ASD-CC, and ASD-CC+RB
- Overall low disease symptom
- Type of summer cover crops and rates need to be further examined
- A trial comparing 2 x ryes, triticale, Sudan grass, open pollinated broccoli, and mustard as summer cover crops for ASD will start soon

ASD went bad! *Fusarium control in Northern CA*

- **Fusarium wilt control by ASD need higher soil temp**
  - **>300 hrs above 86 ˚F at 8" depth** (Yonemoto et al., 2006)
- **With higher C rate ASD can control Fusarium under lower temp** (Butler et al., 2014)

High C-rate fall-bed ASD trial at Fusarium-infested field (Watsonville, RCB, 4 reps)

· ASD w/ grape pomace 12 t/ac (GP12)*
· ASD w/ grape pomace 15 t/ac (GP15)*
· ASD w/ grass hay 12 t/ac (GH12)*
· ASD w/ grass hay 15 t/ac (GH15)*
· ASD w/ rice bran 9 t/ac + grape pomace 6 t/ac (RB9+GP6)
· ASD w/ wheat bran 9 t/ac + grape pomace 6 t/ac (WB9+GP6)
· ASD w/ rice bran 9 t/ac + grass hay 6 t/ac (RB9+GH6)
· ASD w/ rice bran 9 t/ac + almond hull 6 t/ac (RB9+AH6)
· Chloropicrin 300 lb/ac*

* pre-plant fertilizer (18-8-13, 700 lb/ac) was applied only at these plots.

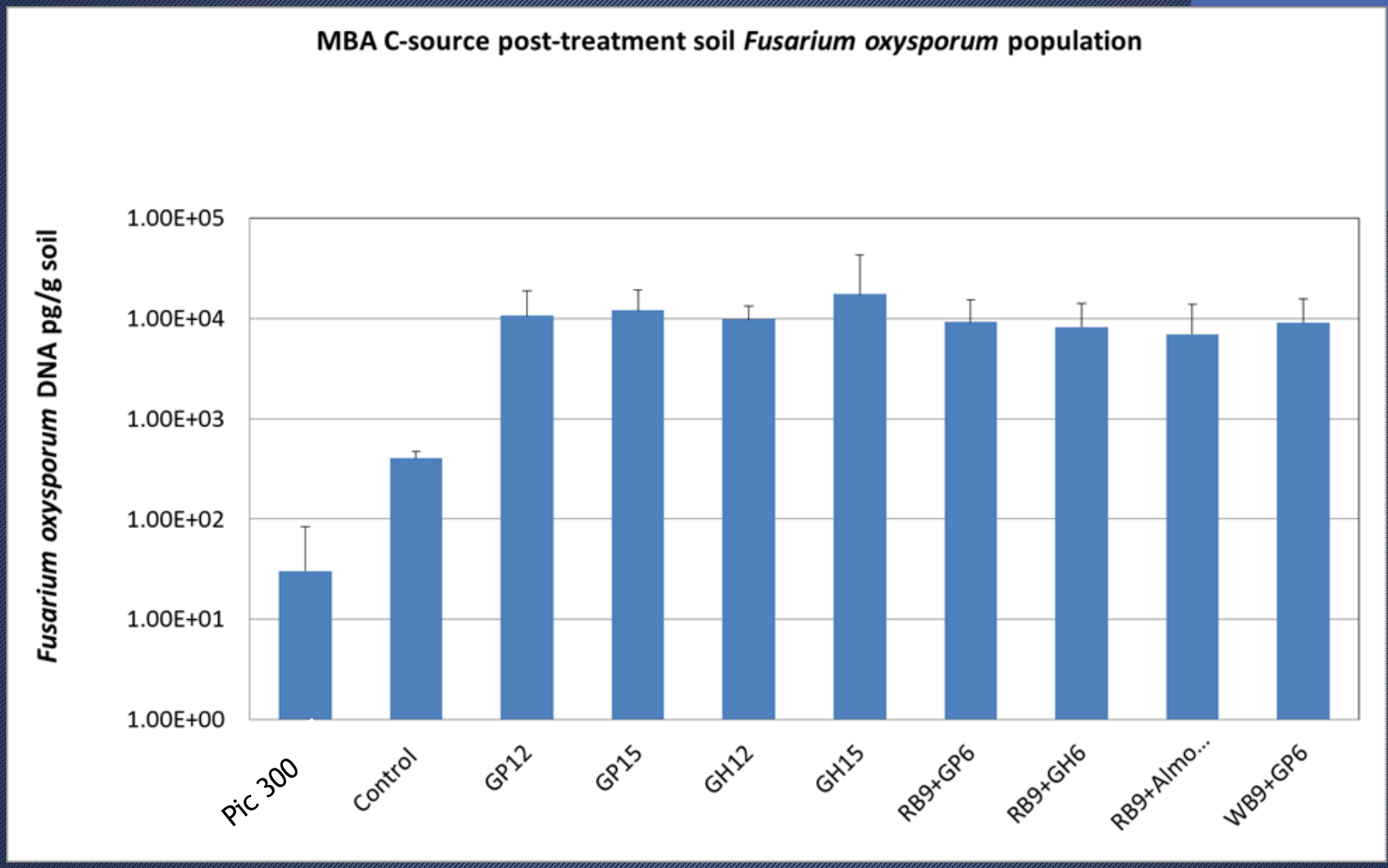
· Variety: Monterey

ASD Conditions

Year	Treatment	Period (days)	Cum Eh < 200 mV hrs	Cum soil temp > 86 ° F hrs	Water added ac-inches
2015-16	ASD all plots	10/15 - 11/3 (19)	91,140 (56,387 - 137,149)	10 (0-33)	1.4
Threshold			> 50,000*	> 300**	

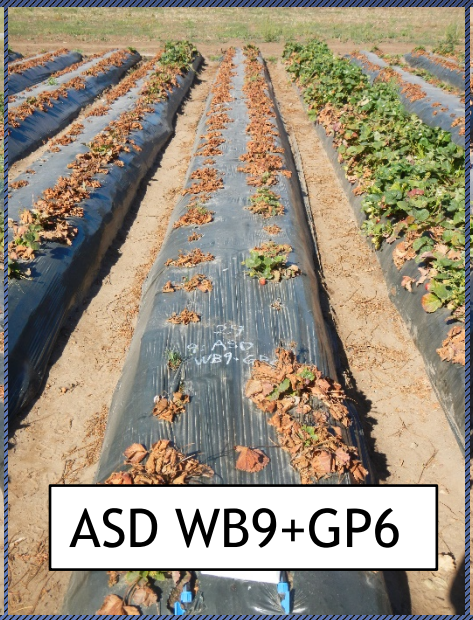
* Threshold to control *Verticillium dahliae* at 77°F (Shennan et al., 2009).

** Threshold to control F.o.f. at 8" soil depth (Yonemoto et al., 2006).


MBA C-source post-treatment soil Fusarium oxysporum population
Fusarium oxysporum DNA pg/g soil
1.00E+05
1.00E+04
1.00E+03
1.00E+02
1.00E+01
1.00E+00
Pic 300
Control
GP12
GP15
GH12
GH15
RB9+GP6
RB9+GH6
RB9+Almo...
WB9+GP6

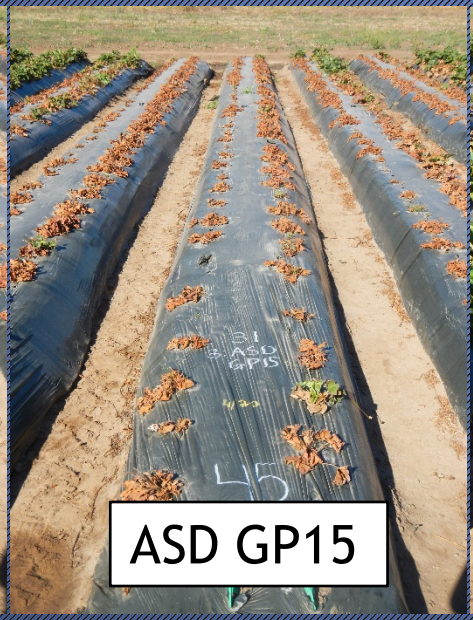

Pic 300

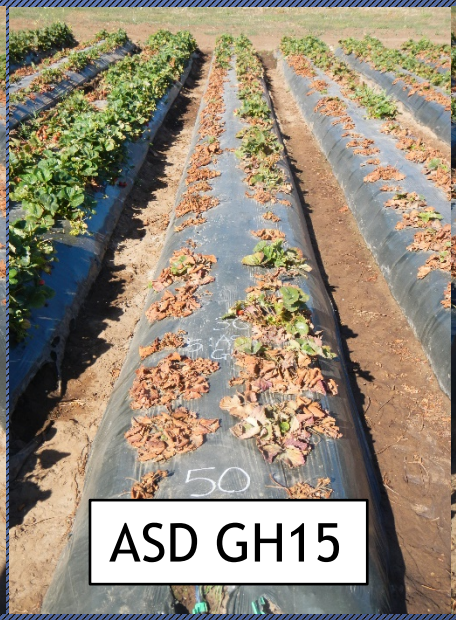

ASD RB9+GH6

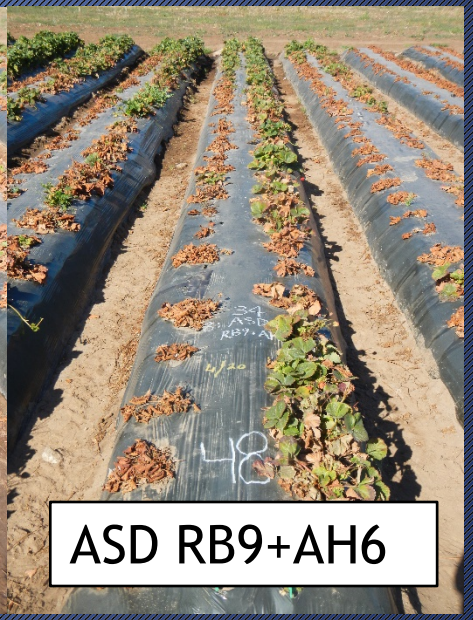

ASD WB9+GP6


ASD GH12

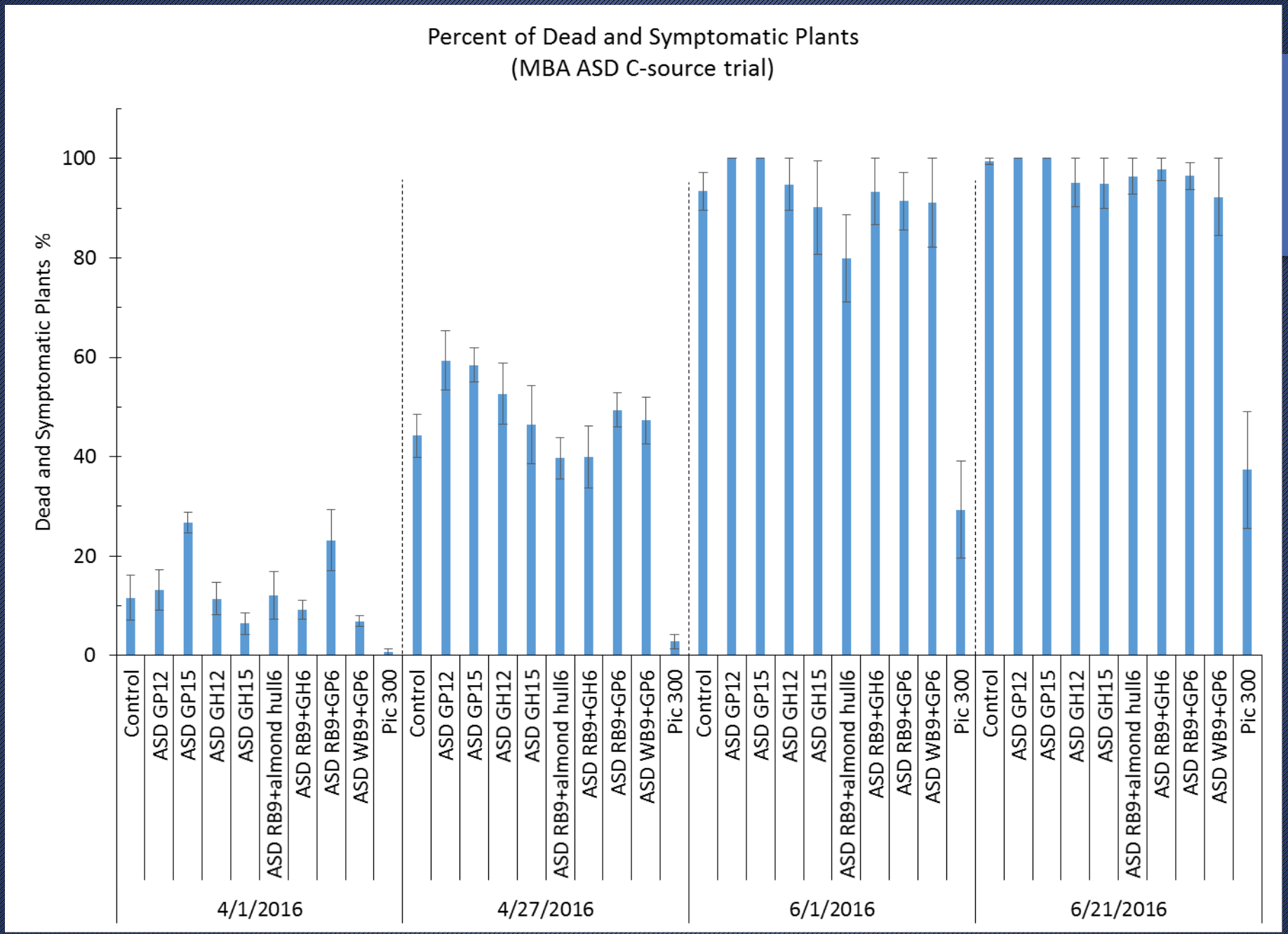

UTC

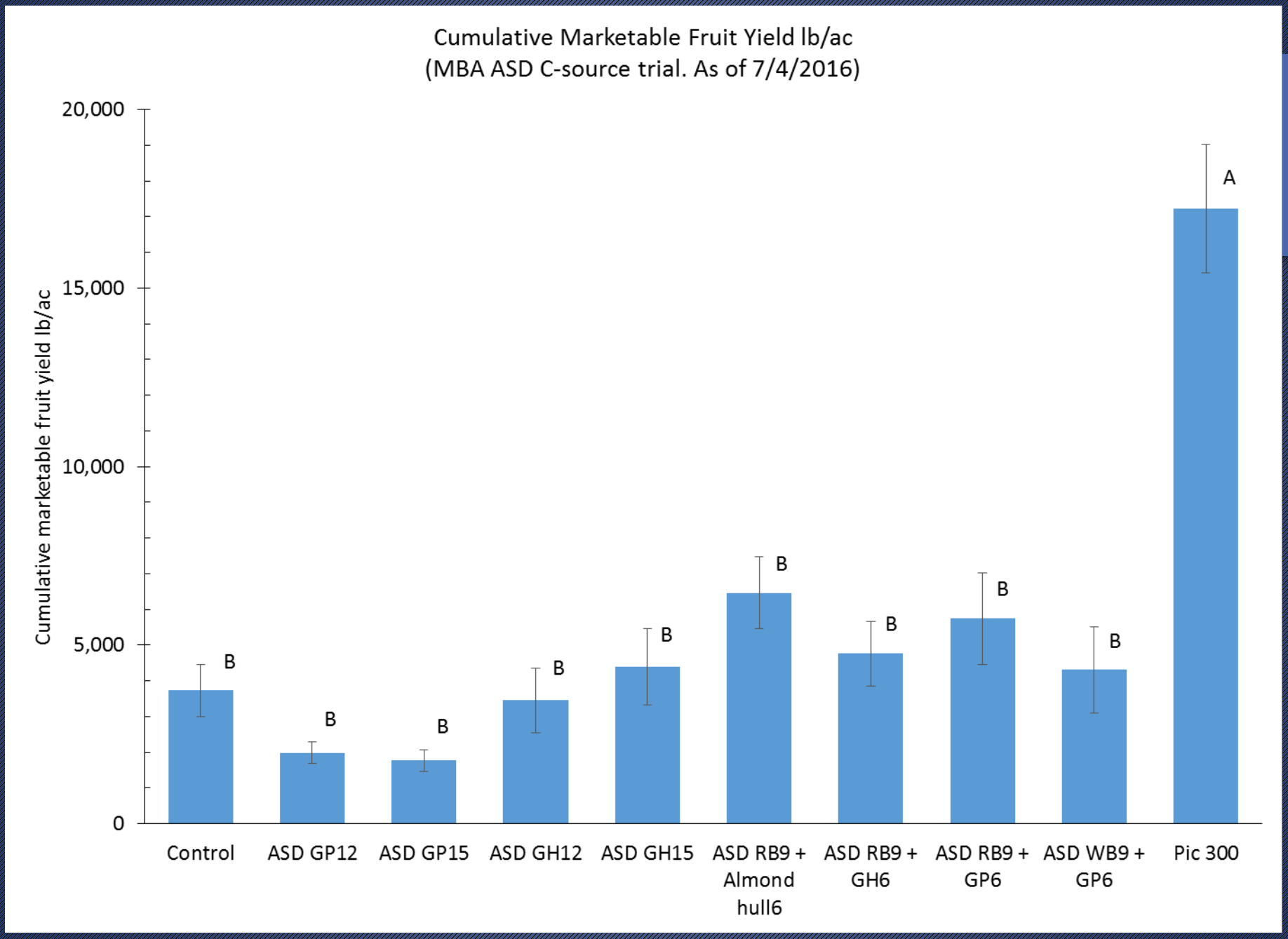

ASD GP15


ASD GH15


ASD RB9+AH6

6/21/2016


Percent of Dead and Symptomatic Plants
(MBA ASD C-source trial)
Dead and Symptomatic Plants %
100
80
60
40
20
0
Control
ASD GP12
ASD GP15
ASD GH12
ASD GH15
ASD RB9+almond hull6
ASD RB9+GH6
ASD RB9+GP6
ASD WB9+GP6
Pic 300
4/1/2016
4/27/2016
6/1/2016
6/21/2016


Cumulative Marketable Fruit Yield lb/ac
(MBA ASD C-source trial. As of 7/4/2016)
Cumulative marketable fruit yield lb/ac
20,000
15,000
10,000
5,000
0
B
B
B
B
B
B
B
B
B
A
Control
ASD GP12
ASD GP15
ASD GH12
ASD GH15
ASD RB9 + Almond hull6
ASD RB9 + GH6
ASD RB9 + GP6
ASD WB9 + GP6
Pic 300

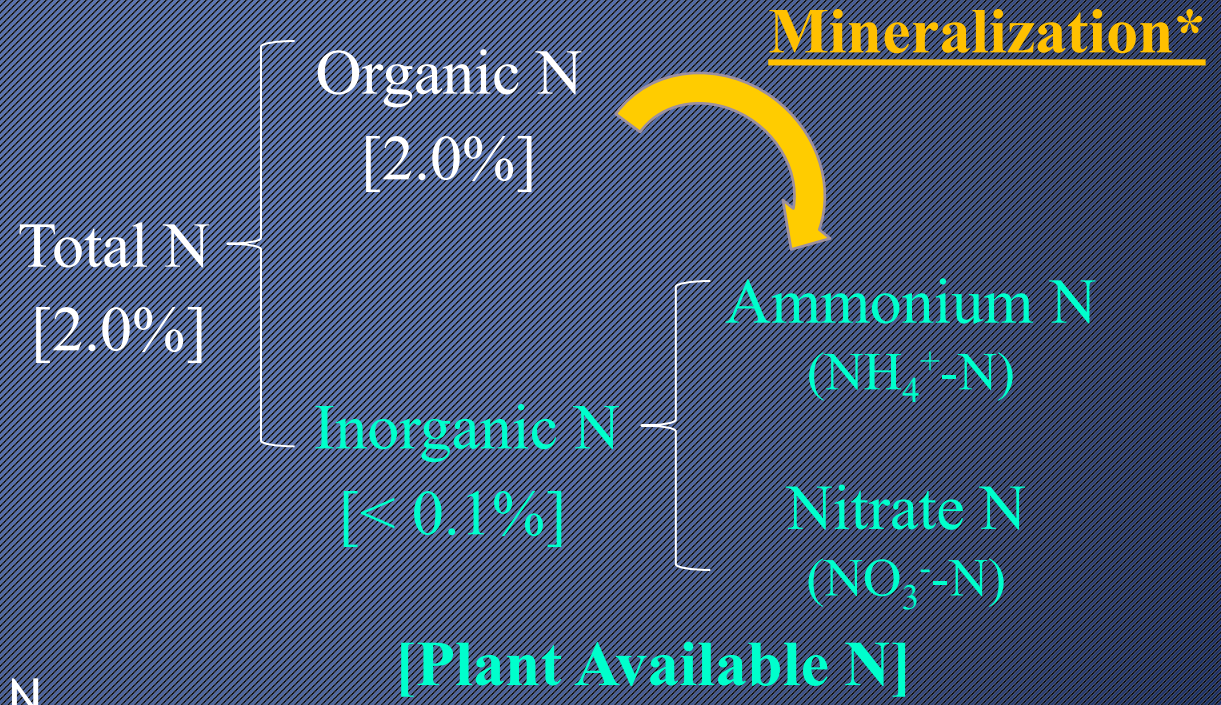
Summary: *High C-rate ASD Trial*

- Fusarium oxysporum population increased by adding high rate of C-sources for ASD in fall
  - This pathogen can be fed by readily decomposable C-sources at low soil temperature (< 86°F at 8” soil depth)
- <u>Do Not Use ASD in fall at Fusarium infested fields</u>
- Summer flat ASD with clear-TIF can reduce Fusarium wilt in the coastal CA (Shennan et al., 2015)
- Use Fusarium resistant variety (e.g. San Andreas) and sound crop rotation for Fusarium-infested organic fields

Nitrogen management considerations

- Rice bran: **N**-P_2O_5-K_2O: **2**-3-1
- N mineralization rate: 20-30% per season (further study in progress)
- 20-30% of TN becomes available to plants per season
- e.g. RB 9 tons/acre:
  18,000 lb x 0.02 =
  Total N: 360 lb-N/ac

  360 x 0.2–0.3 = 72-108 lb-N/ac of plant available N



* Biological process

Questions/Discussion

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