Anaerobic Soil Disinfestation (ASD) Research Update: Fusarium Wilt Control by ASD

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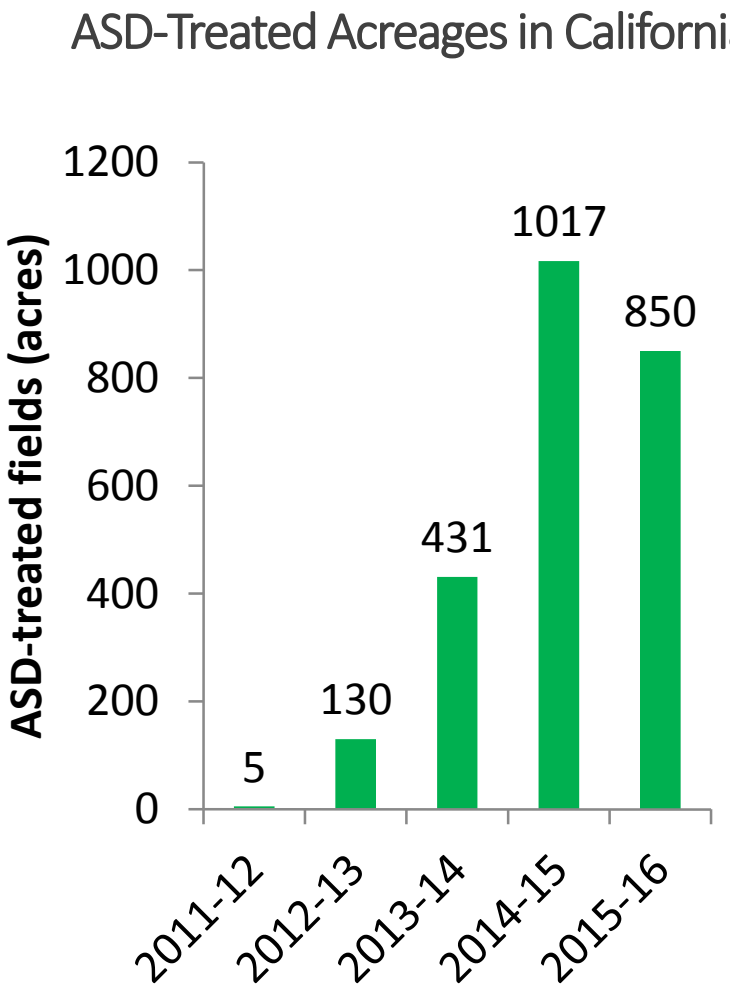
Yield and disease control by ASD in California strawberries

- Marketable yield: Average 99% (82 – 114%) of fumigation plots in 10 replicated field trials from 2010 to 2014 using 9 t/ac of rice bran
- Verticillium wilt by *Verticillium dahliae;* 80 to 100% decrease in *V. dahliae* microsclerotia in soil in field trials (Shennan et al., 2014)
- Charcoal rot by *Macrophomina phaseolina*; ~50% reduction of plant mortality compared to un-treated control (Shennan et al., 2015)



(Farm Fuel Inc. Personal communication)

Can ASD control Fusarium Wilt caused by *Fusarium oxysporum* f. sp. *fragariae* in California strawberries?

Fusarium wilt at ASD plot Watsonville, 2013 (Third year of consecutive strawberry without fumigation)

- Fall bed ASD does not control Fusarium wilt
- Works elsewhere when soil temperature higher (>86 °F)

→ Summer flat ASD trials (2013-14, 2014-15)

Summer Flat ASD trial: 2013-14 (Year 1)

(Shennan et al., 2014)

Split plot trial with 4 replicates

Main plots:

- Summer flat ASD Rice bran (RB) 9 t/ac
- Summer flat ASD RB 4.5 t/ac + fall bed mustard seed meal (MSM) 2 t/ac
- Fall bed MSM 3 t/ac
- Fall bed ASD RB 9 t/ac
- UTC

Split plots:

- Albion (susceptible variety) and San Andreas (resistant variety)

- Monitored marketable yield, soil inorganic N (monthly) and wilt scores

Summer Flat ASD w/ RB 9 tons/acre

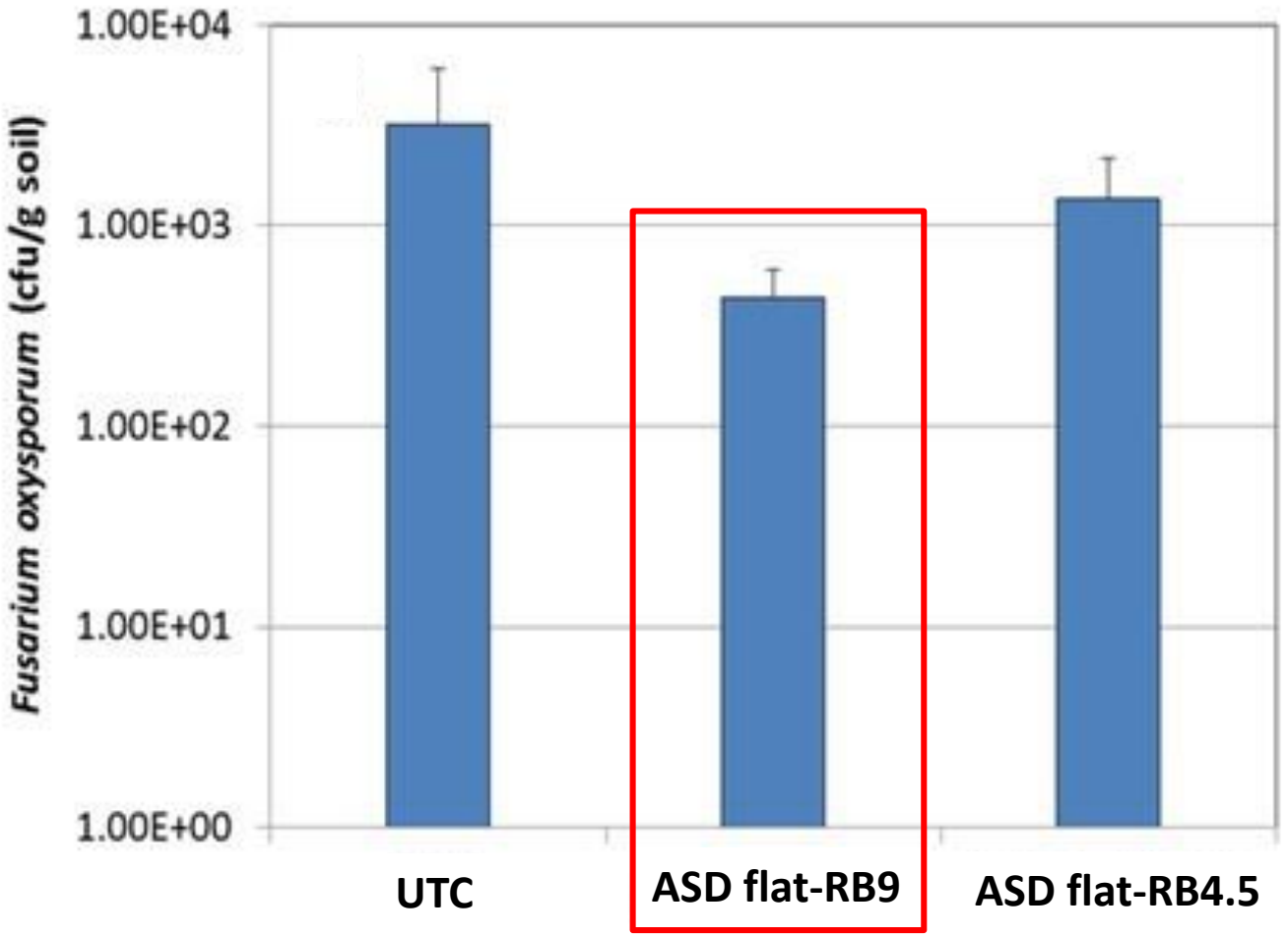
ASD conditions: Year 1

Year	Treatment	Period (days)	Cum Eh < 200 mV hrs	Cum soil temp > 30 ° C hrs	Water added ac-inches
2013-14	Summer flat ASD RB 9 t/ac	8/14 - 9/23 (40)	225,000	980 ✓	3.3
	Summer flat ASD RB 4.5 t/ac (+ fall bed MSM 2t/ac)		166,000	705 ✓	
Threshold			> 50,000*	> 300**	

* For *Verticillium dahliae* at 25 ° C (Shennan et al., 2007).

** For *Fusarium oxysporum* f. sp. *fragariae* at 8” soil depth (Yonemoto et al., 2006).

F.o.f. population in soil at post-treatment: Year 1



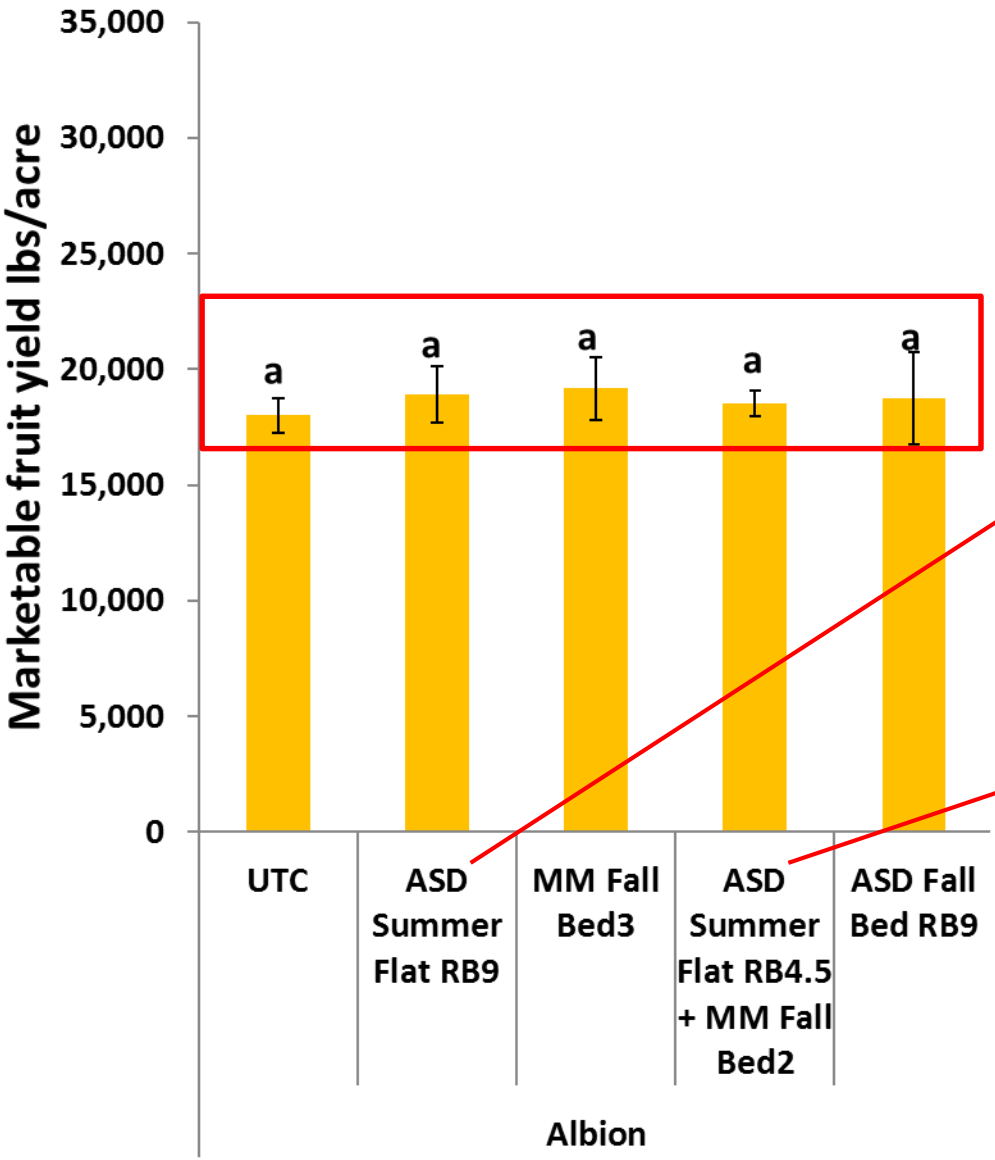
Strawberry plants (8/14/14): Year 1

UTC

ASD Summer
Flat RB 9t/ac

ASD Summer
Flat RB
4.5t/ac +MM
Fall Bed 2t/ac

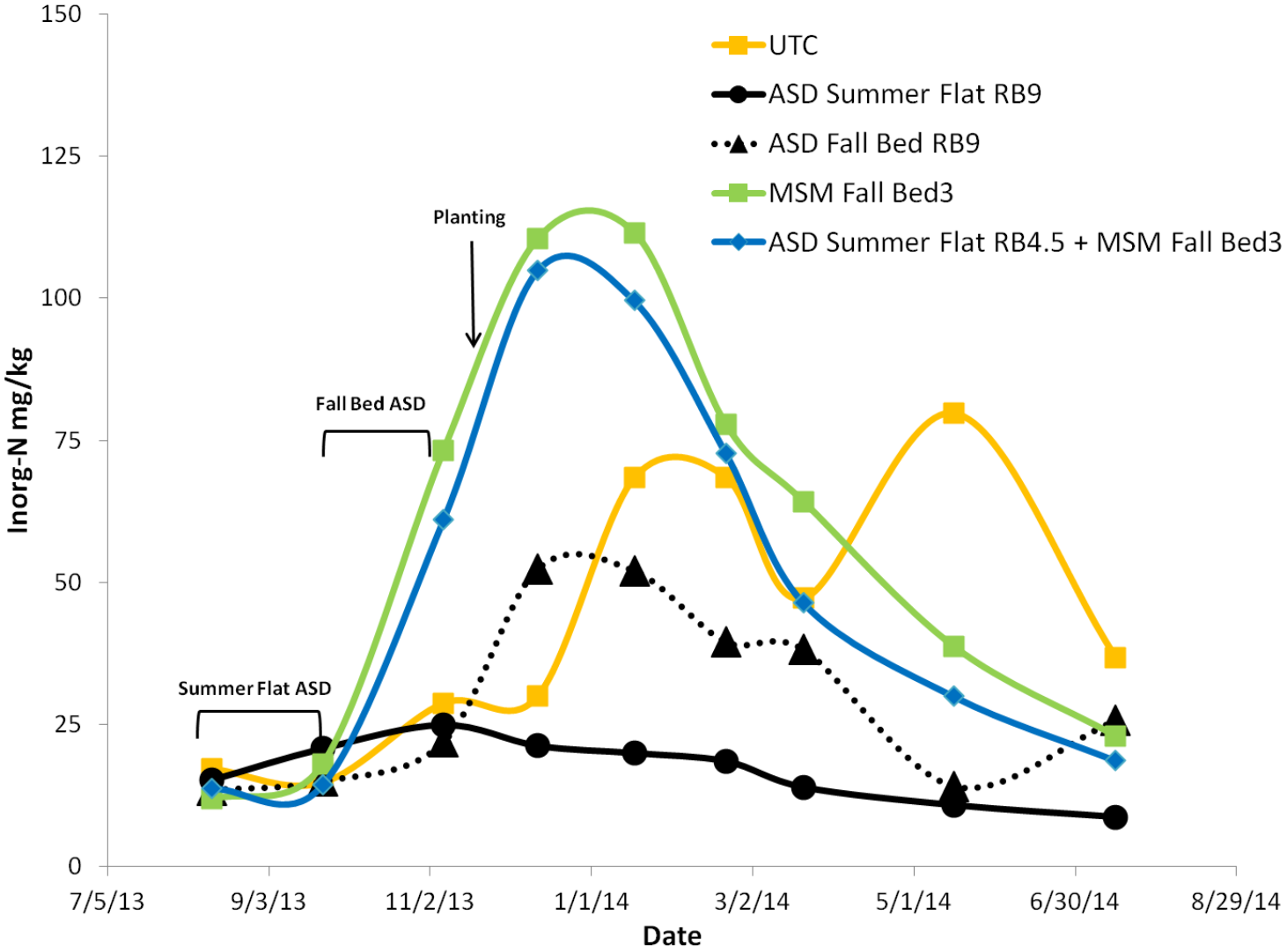
Cumulative Marketable Fruit Yield : Year 1



ASD Summer Flat RB 9t/ac

RB 4.5t/ac +MM Fall Bed 2t/ac

Soil inorganic N dynamics (0”-6” depth): Year 1



In the 2013-14 trial, PPF (640 lbs/ac of 18-6-12, 12-14 months slow release) was applied only to UTC.

Summer Flat ASD trial: 2014-15 (Year 2)

Split plot trial with 4 replicates

Main plots:

- Summer flat ASD Rice bran (RB) 9 t/ac
- Summer flat ASD Molasses (ML) 6 t/ac
- UTC
- Chloropicrin 300 lbs/ac

Split plots:

- With or without pre-plant fertilizer
  (1,000 lbs/ac 18-8-13, 7-9 months slow release)

- Monitored marketable yield, soil inorganic N (monthly) and wilt scores

Summer Flat ASD Trial (Year 2)

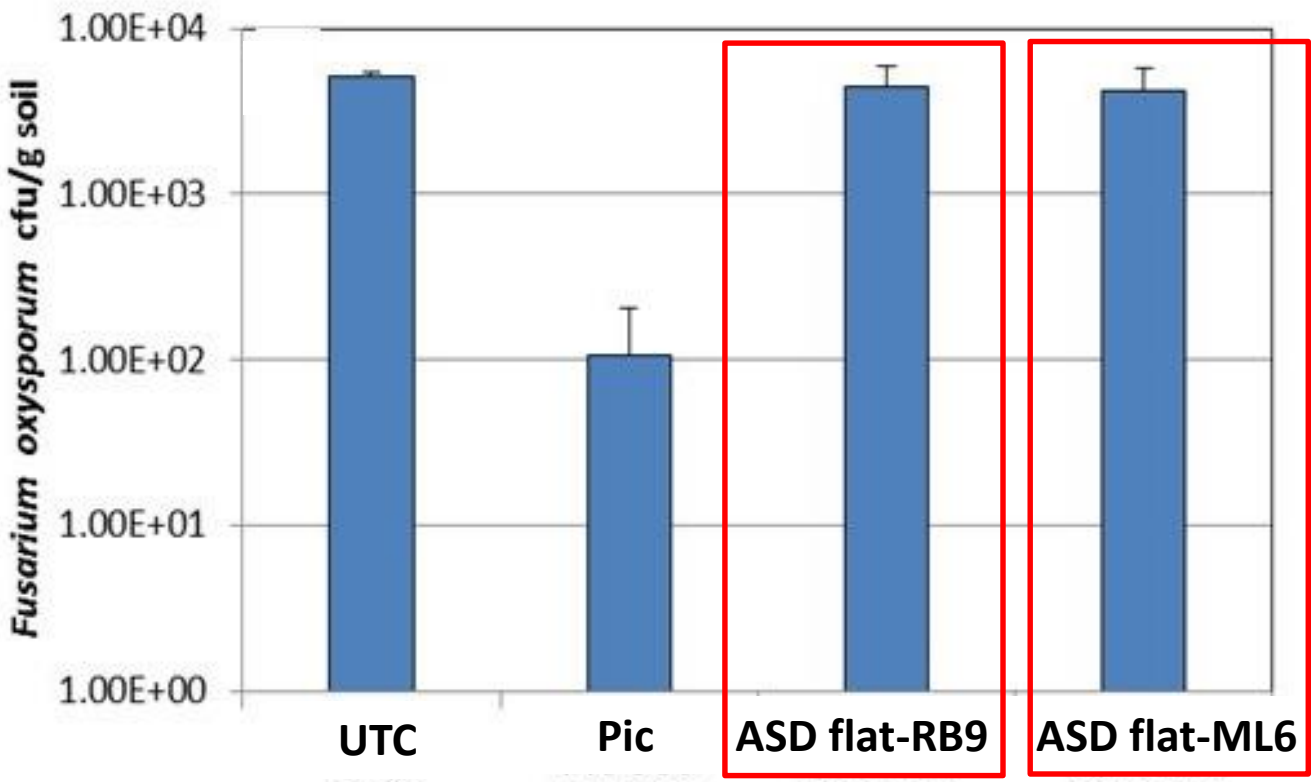
ASD conditions: Year 2

Year	Treatment	Period (days)	Cum Eh < 200 mV hrs	Cum soil temp > 30 ° C hrs	Water added ac-inches
2014-15	Summer flat ASD RB 9t/ac	9/3 - 9/26 (23)	125,000	348 ✓	2.3
	Summer flat ASD ML 6t/ac		116,000	211 X	5.9
2013-14	*Summer flat ASD RB 9 t/ac*	*8/14 - 9/23 (40)*	*225,000*	*980*	*3.3*
Threshold			> 50,000*	> 300**	

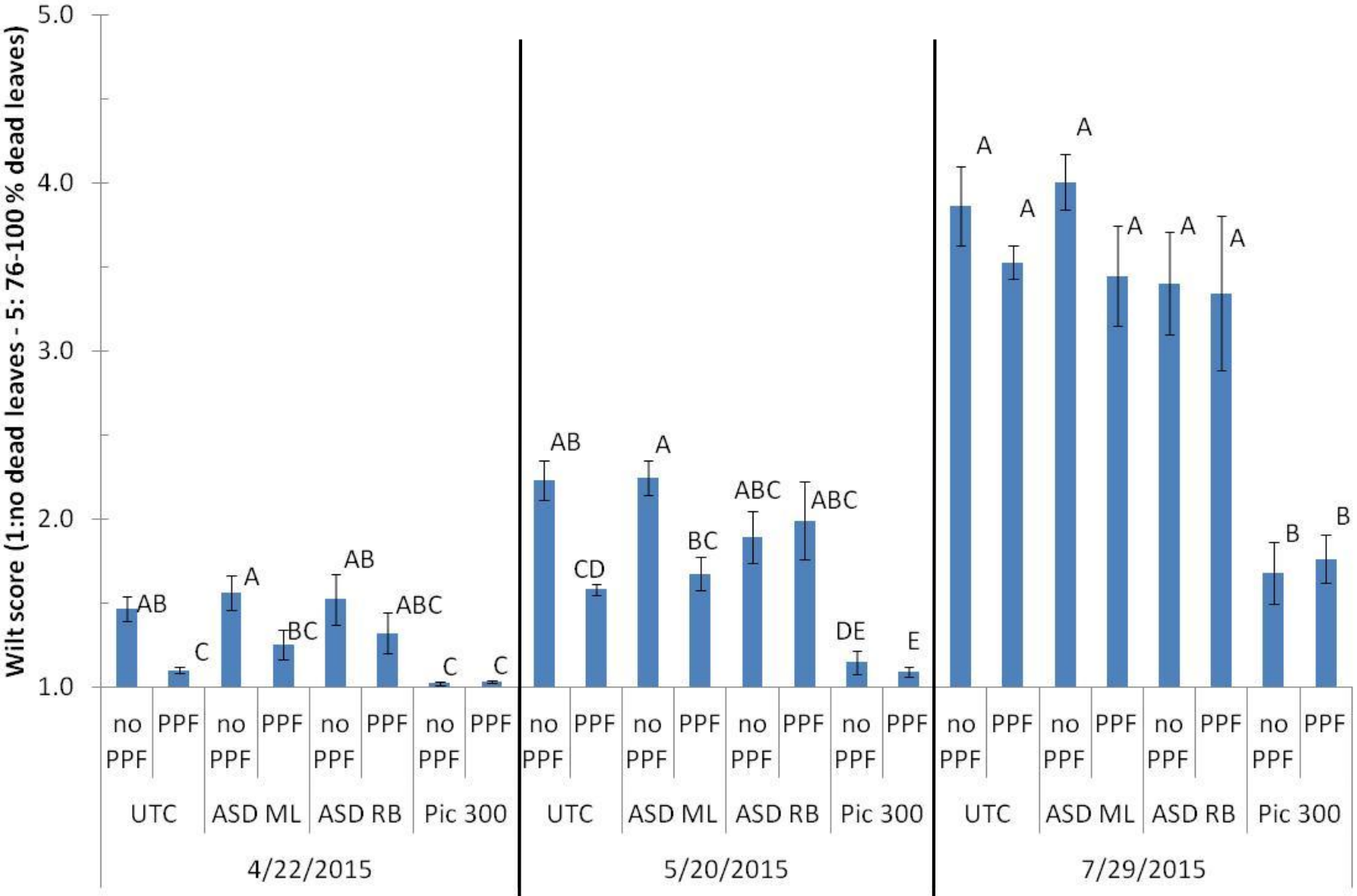
* For *Verticillium dahliae* at 25 ° C (Shennan et al., 2007).

** For *Fusarium oxysporum f.* sp. *fragariae* at 8" soil depth (Yonemoto et al., 2006).

F.o.f. population in soil at post-treatment: Year 2



Wilt score: Year 2

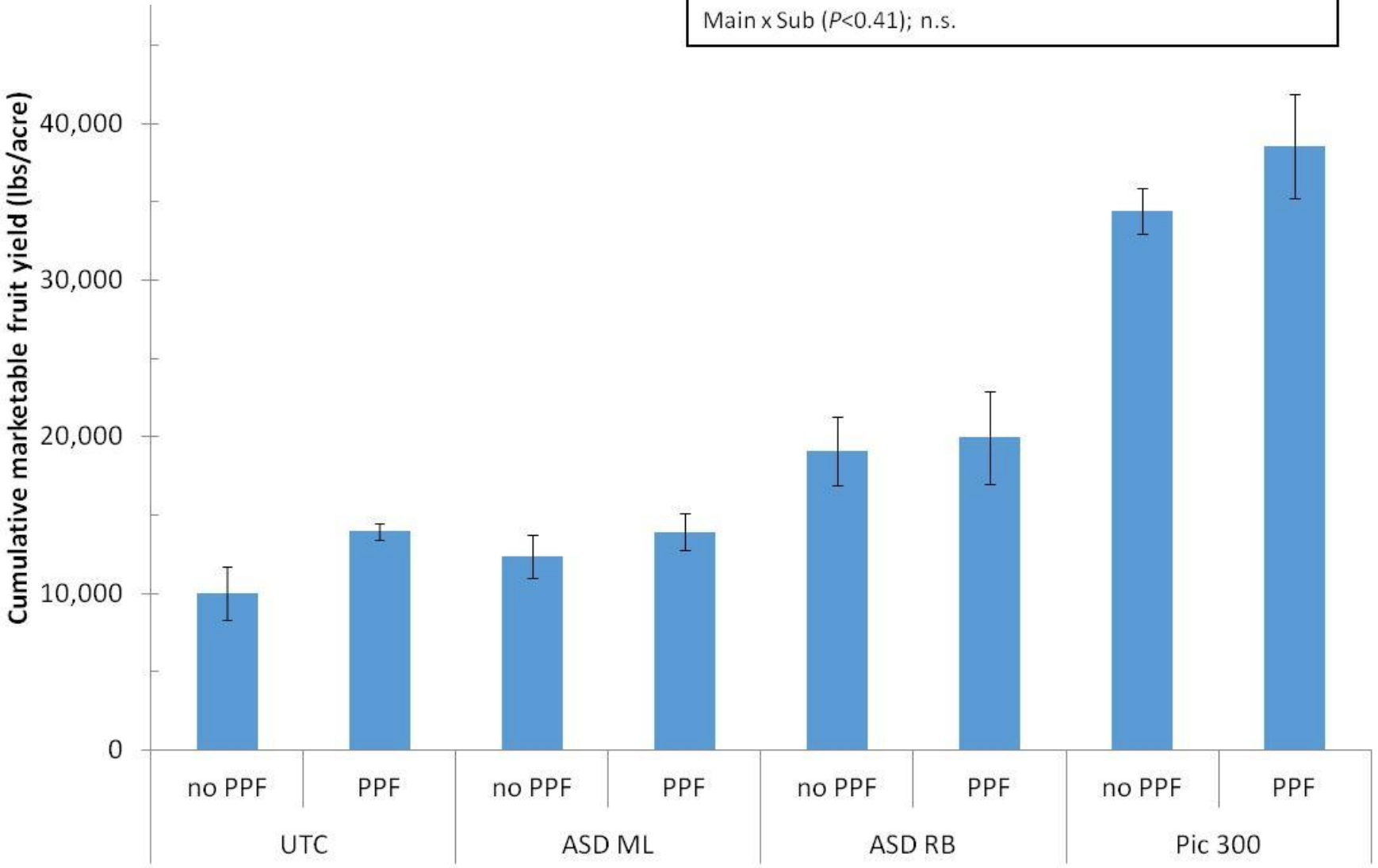


Cumulative Marketable Fruit Yield (8/06/2015): Year 2

Main (*P*<0.0001***); UTC ASD-ML ASD-RB Pic300

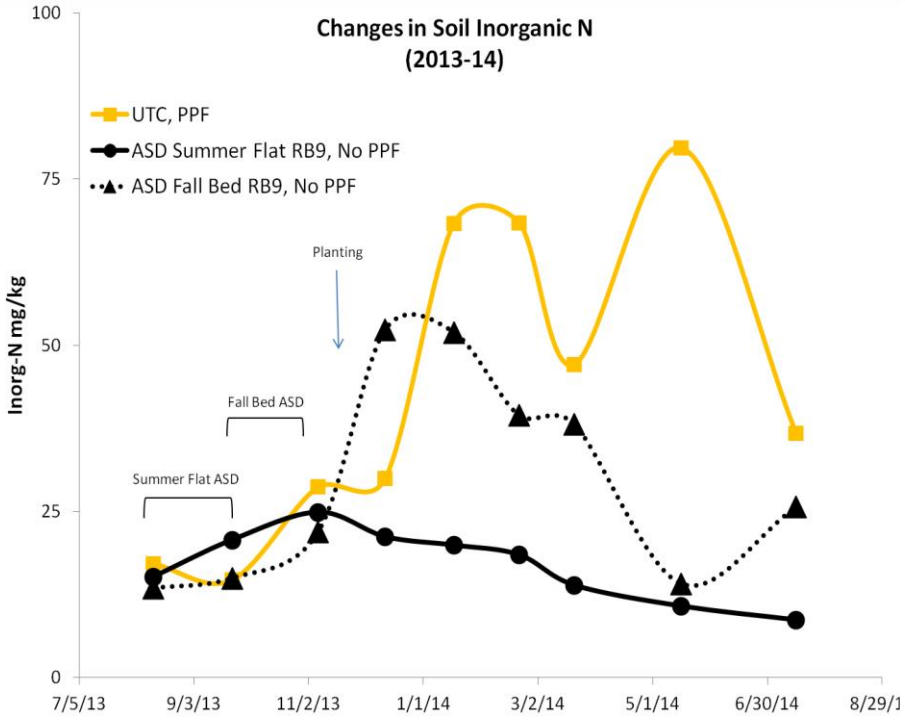
Sub (*P*<0.0075**); no PPF PPF

Main x Sub (*P*<0.41); n.s.

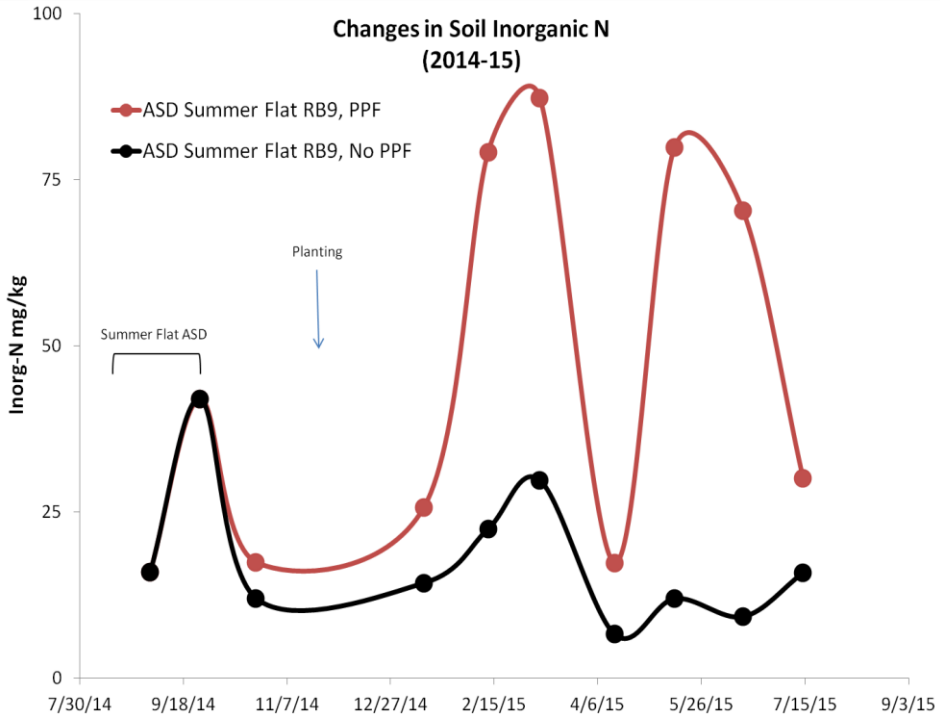


Soil inorganic N dynamics (0”-6” depth)

Year 1



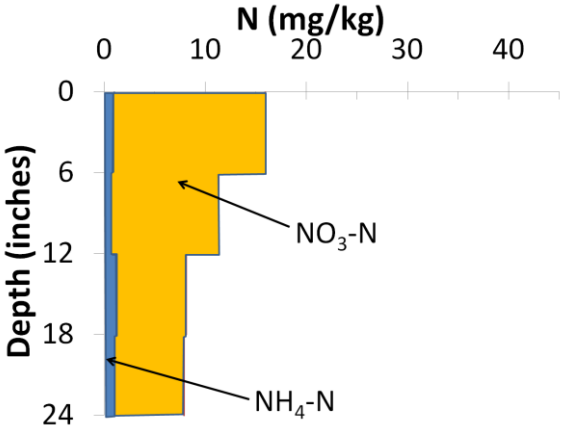
Year 2



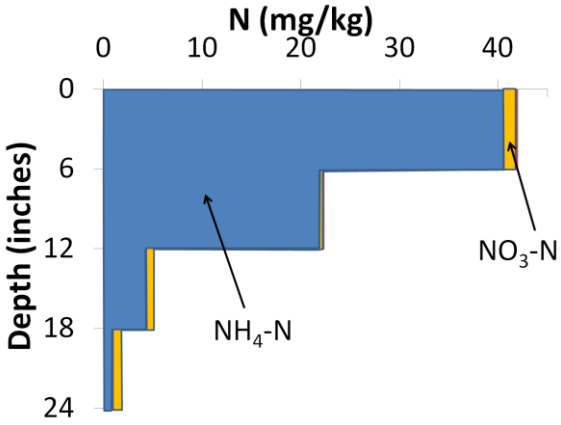
In the 2013-14 trial, PPF (640 lbs/ac of 18-6-12, 12-14 months slow release) was applied only to UTC.

In the 2014-15 trial, PPF (1,000 lbs/ac 18-8-13, 7-9 months slow release) was applied to PPF sub plots.

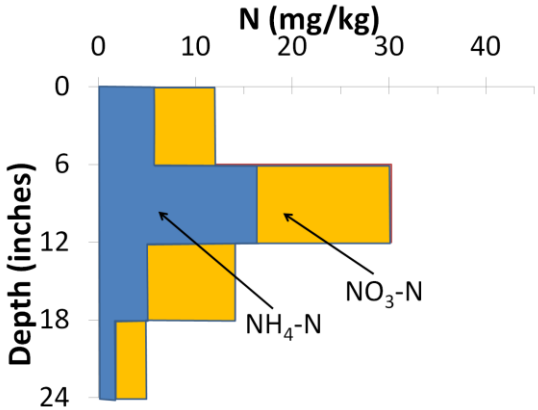
Pre-Treatment
(9/02/2014)

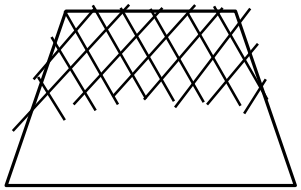


Post-Treatment
(9/26/2014)



Bed listed
(10/23/2014)





vs. fall bed ASD

Inorganic N distribution across the soil profile in summer flat ASD RB9, No PPF plots

Conclusions

- To reduce Fusarium wilt by ASD in central coastal California, summer flat ASD treatment has to start by mid August at latest in order to achieve sufficient temp hrs above 30 °C and have a C-source rate of at least 9t/ac

- N in C-source for summer flat ASD may not be efficiently used by strawberries, resulting in low yields. Low-N C-source would be more appropriate for this approach, in addition to the use of pre-plant fertilizer

- At this point, use of a resistant cultivar, crop rotation, and good sanitation are the most effective non-fumigant Fusarium wilt management strategies for strawberries in the central coastal CA

Next step…

MBA 2015-16 trial: High C-source rate ASD may reduce F.o.f. under typical fall temperatures in the coastal CA

- RCB w/ 4 replicates:
  - ASD grass hay 12 t/ac
  - ASD grass hay 15t/ac
  - ASD grape pomace 12t/ac
  - ASD grape pomace 15t/ac
  - ASD rice bran 9 t/ac + grass hay 6t/ac
  - ASD rice bran 9 t/ac + grape pomace 6 t/ac
  - ASD rice bran 9 t/ac + almond hull 6 t/ac
  - ASD wheat bran 9 t/ac + grape pomace 6 t/ac
  - Pic Clor60 300 lbs/ac
  - Untreated check

- Monitoring yield, soil N dynamics, wilt score, pathogen, soil microbial communities

ASD 2.0

- Reduced water use
  - From ~3 acre-inches to <1.5 acre-inches by conserving soil moisture at bed listing
  - Depending on soil type
- Evaluate the environmental impacts
  - N_2O emission and NO_3 leaching ….depending on soil residual NO_3 level
  - Recycling by summer cover crop, immobilization by high C/N organic amendment application
- New C-source recipes
  - Grape pomace, almond hull, grass hey, summer cover crop (Sudan grass), wheat bran, rice bran…..in combination
  - Reduced costs and improved consistency
- Understanding mechanisms
  - Chemical, **biological**, physical

Acknowledgments

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