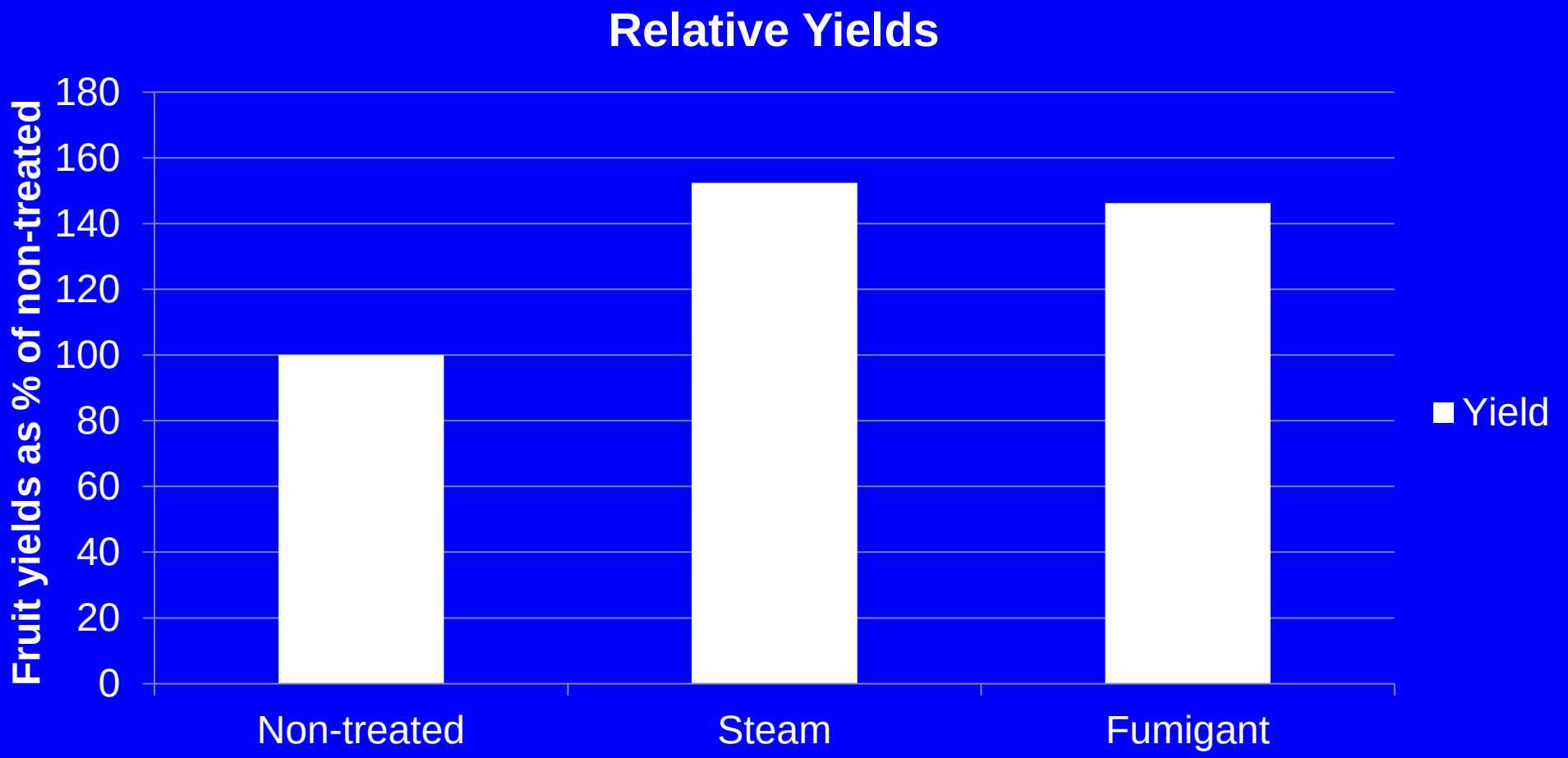
Strawberry yields with steam 2007-13



Means from 13 field trials at Salinas and Watsonville

Steam – It Really is A Viable Nonfumigant Alternative

Steve Fennimore, Extension Specialist
U.C. Davis, at Salinas, CA

CSC Nonfumigant Dec. 5, 2013

Collaborators

- Tom Miller
- Krishna Subbarao
- Rachael Goodhue
- Oleg Daugovish
- Joji Muramoto
- Carol Shennan
- Frank Martin
- Karen Klonsky
- Nathan Dorn, RAC
- Ian Greene, Ramco Norcal
- Jenny Broome, DSA
- Clint Miller
- Myra Miller-Spahn
- Marty Madesko, DSA
- Sophie Yu

Financial support

- USDA NIFA Methyl Bromide Transitions
  - 2010-51102-21648,
  - 2013 -51102-21524
- California Strawberry Commission
- Propane Education and Research Council
- In-kind support from Reiter Affiliated Companies, Driscoll's, NorCal Ramco

Assumptions

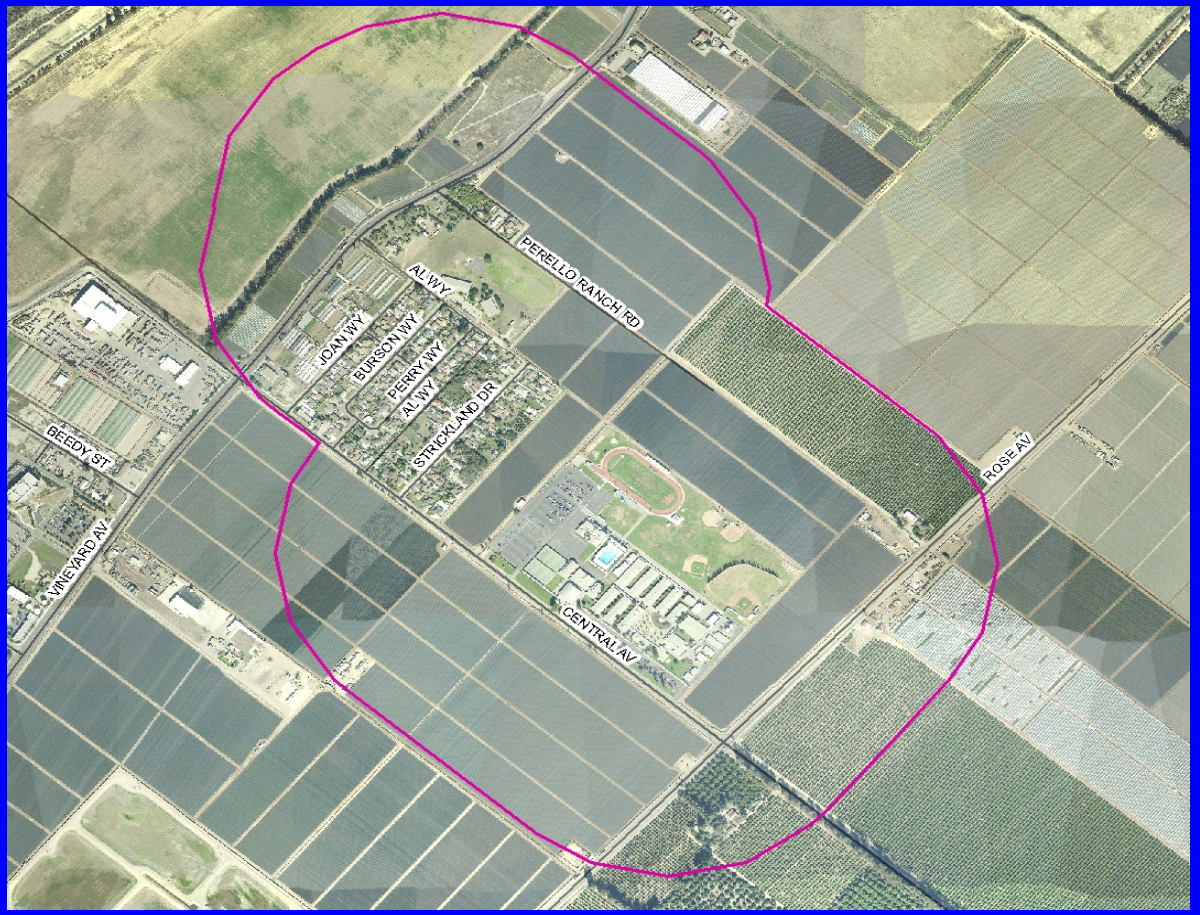
- New steam generation/application technology is an improvement over steam boilers
- Energy sources for steam production are interchangeable – eg. fuel reformers
- Future soil disinfestation methods will include a mix of pesticidal and non-pesticidal methods
- Multiple pest management tactics will be needed to produce strawberry with fumigants

Introduction

- Role of steam – what it does & why needed?
- Results from 2012-13 work
- Business role for steam
- New steam generator technology
- Summary

Why We Need Non-fumigant Alternatives

- For soil disinfestation in:
  - Buffer-zones
  - Organic fields
  - Prepare for future



AUTOMATIC STEAM APPLICATION

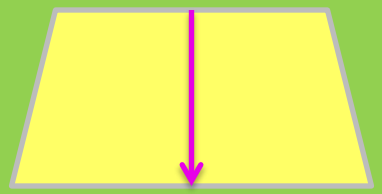
McFadden Rd.
Salinas, CA
9/27/13

Trial Setup

- Conducted near Salinas and Watsonville, CA during 2011-12 and 2012-13.
- Target temperature/dwell - 70˚C for 20 min.
- Treatments were replicated 4 times RCBD
- Economic analysis included material costs, labor and machine costs
- 2012-13 trials included ASD (anaerobic soil disinfestation).

Treatments Ranch 1	Dose
1. Steam - Clayton steam applicator	158˚F for 20 min
2. Steam + mustard seed meal	158˚F for 20 min + 1.5 tons/A
3. ASD + rice bran	9 tons/A rice bran
4. Untreated Control	

Note: ASD was not successful in this test



Soil Temperature by Depth Ranch 1, Watsonville, Sept. 2012

Temperature (degrees C)

90
80
70
60
50
40
30
20
10
0

0 10 20 30 40 50 60 70

Time (min)

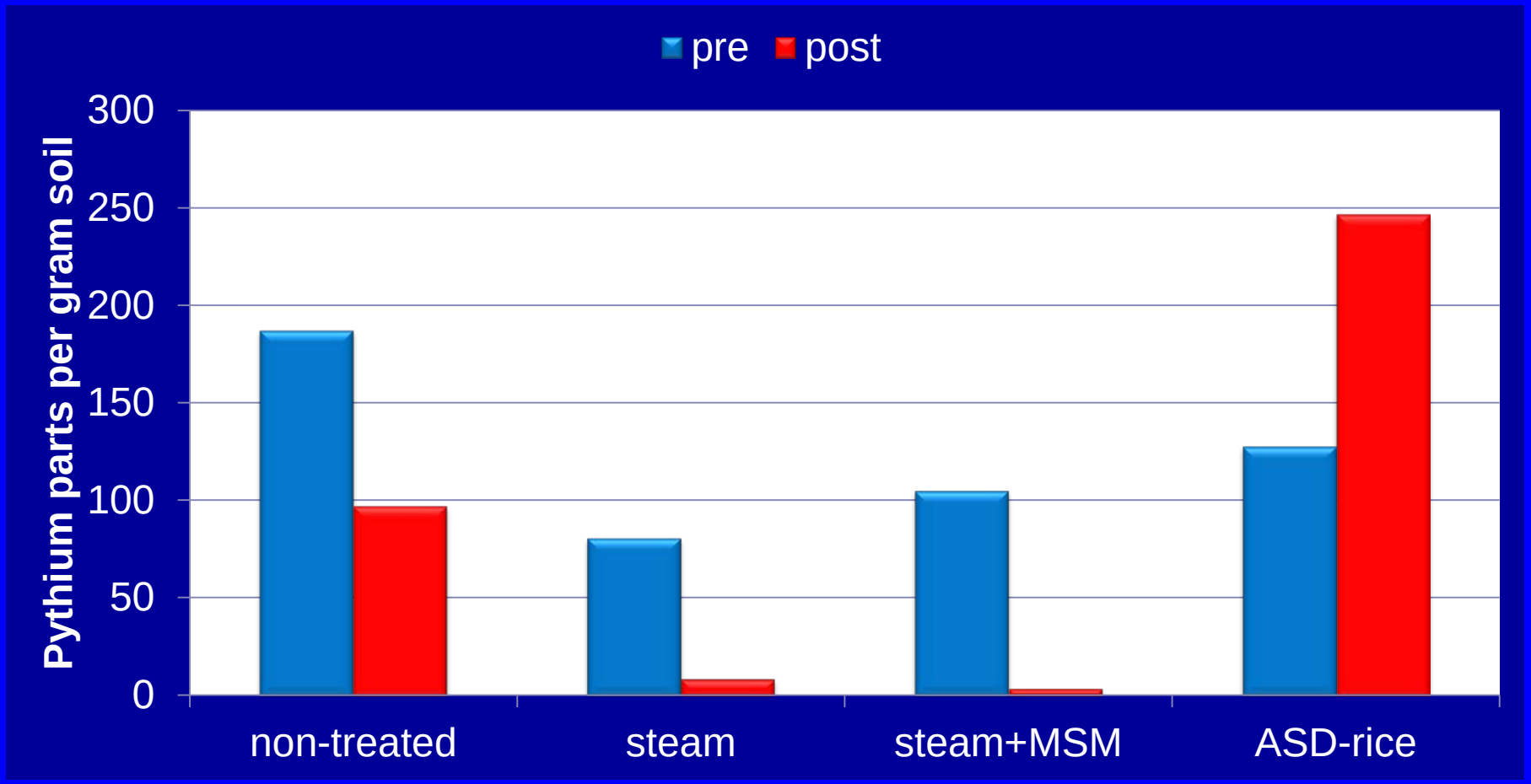
2 inches
6 inches
10 inches

Weed Densities & Hand Weeding Times 2012-13

Treatment	Watsonville-Ranch 1	
	Weeds (no./Acre)	Time (hr. /Acre)
Steam + mustard	6,071 b	21 b
Steam	2,024 b	12 b
ASD + rice	130,313 a	196 a
Non-treated	101,175 a	167 a

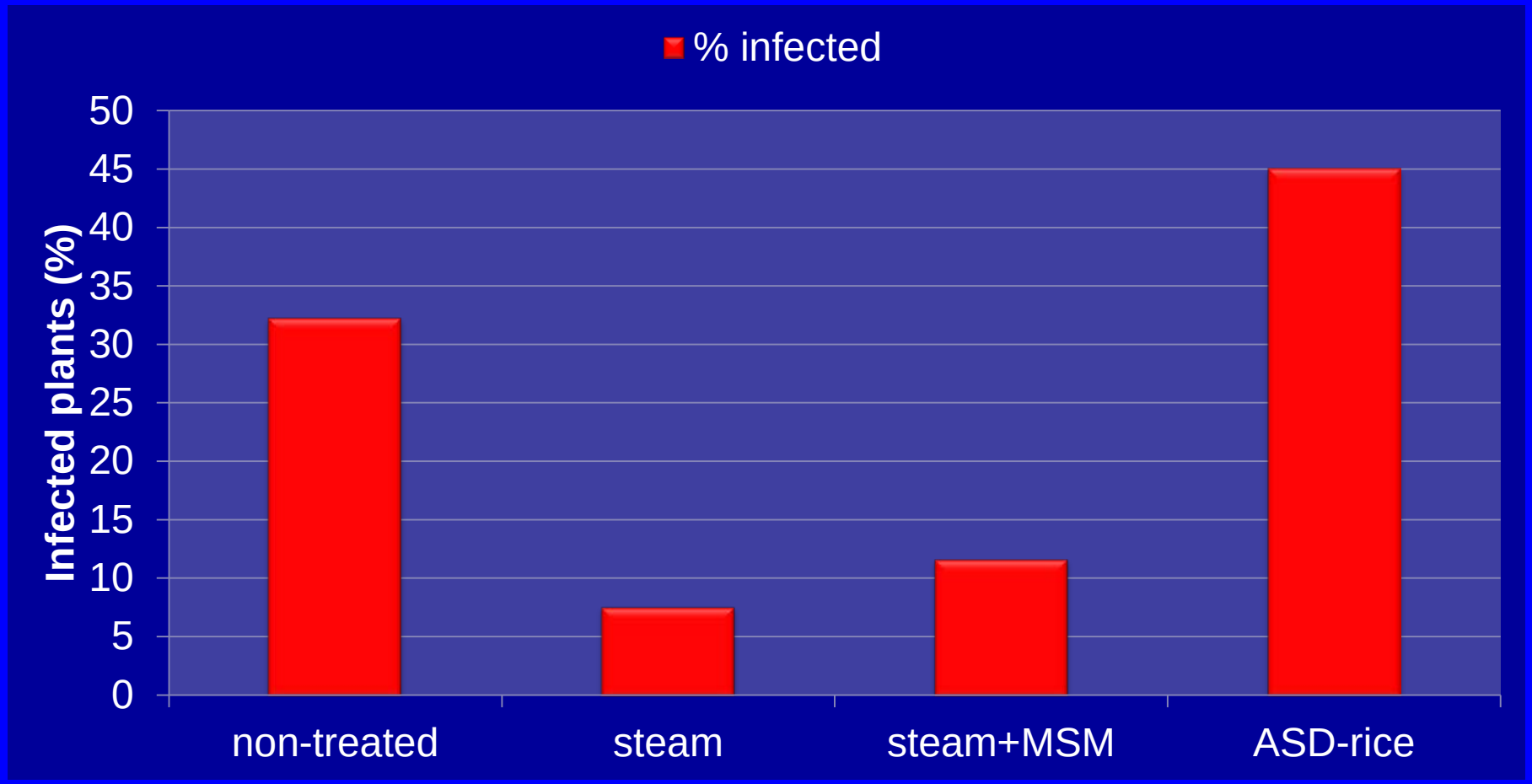
Mean separation using Fisher's Protected LSD P =0.05

Pythium Control Ranch 1 2012



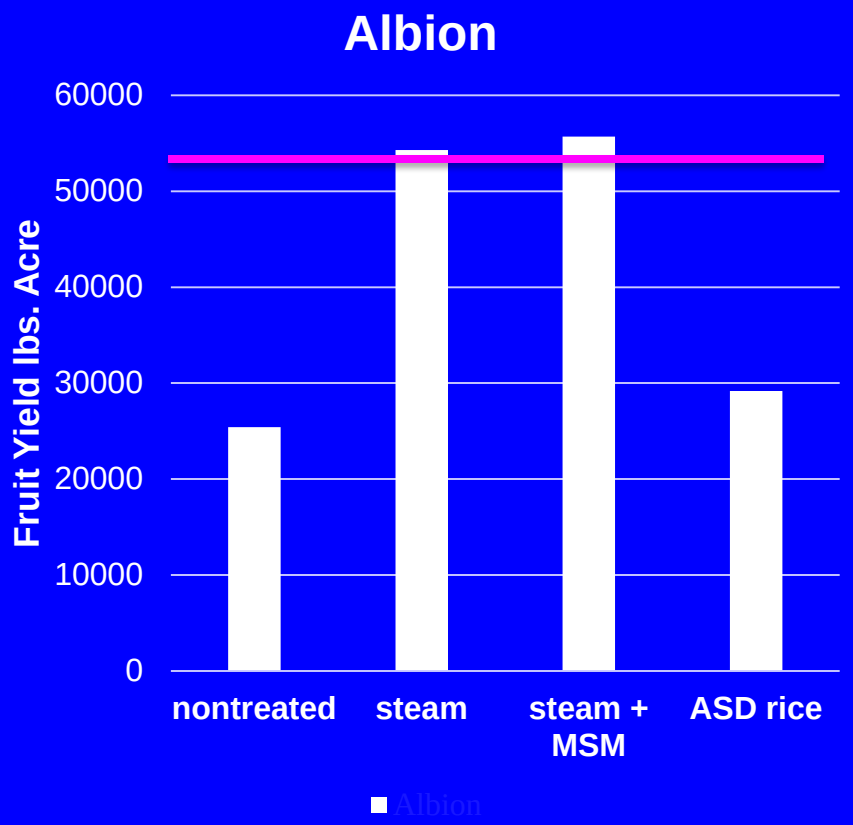
AB B B A

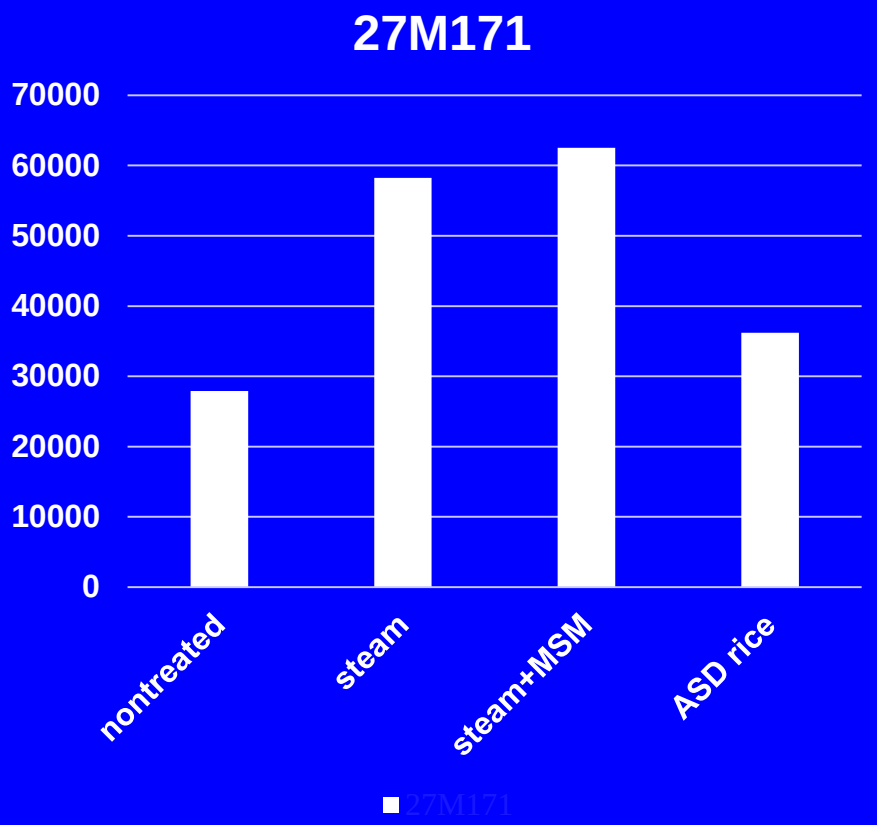
Albion: % Plants With *Macrophomina p.* at Season End



a b b a

Seasonal Fruit Yields Ranch 1





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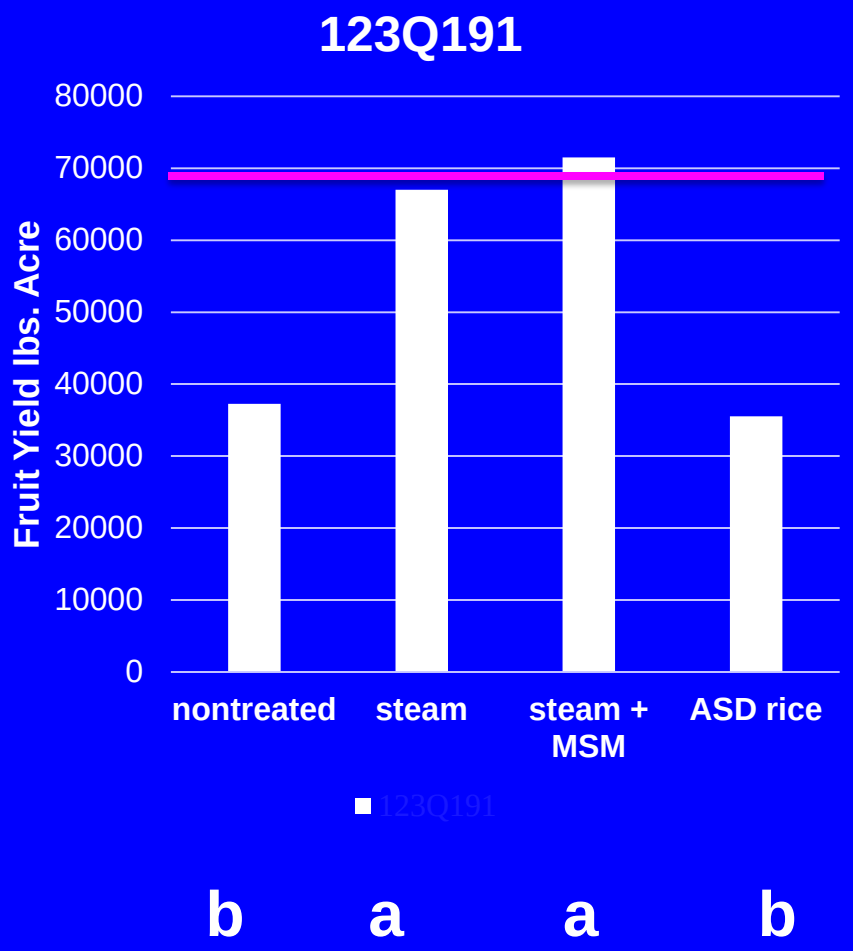
c a a b

Seasonal Fruit Yields Ranches 1 & 2



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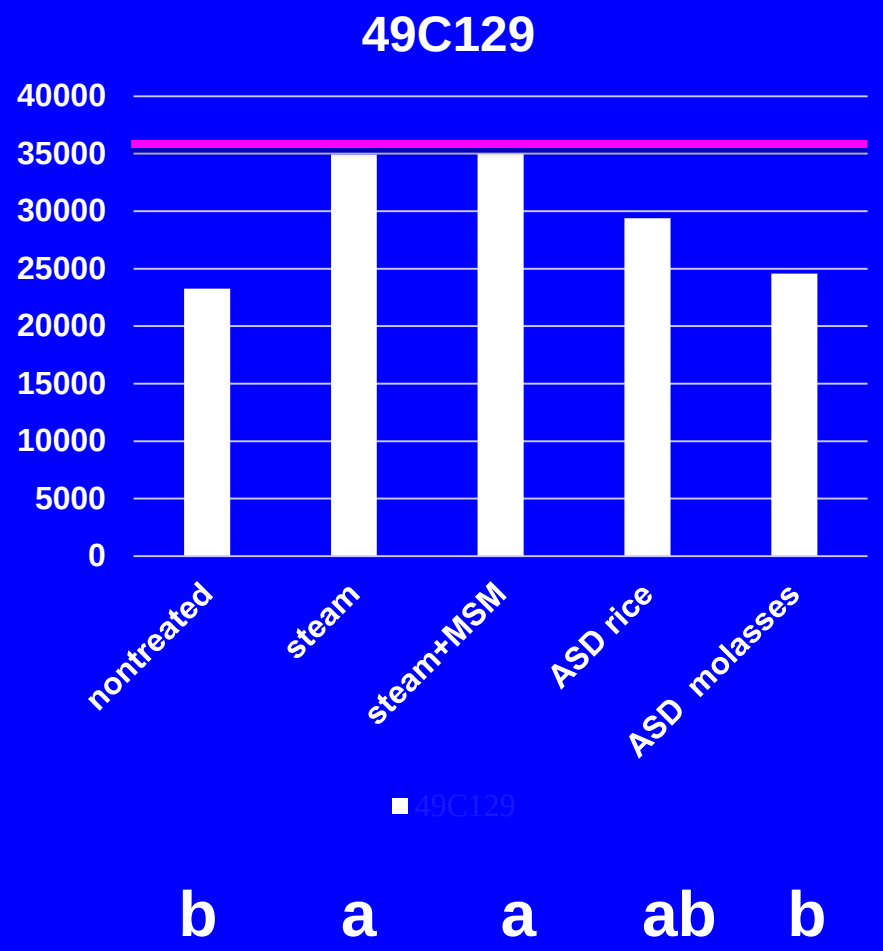

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2010-2012 Findings

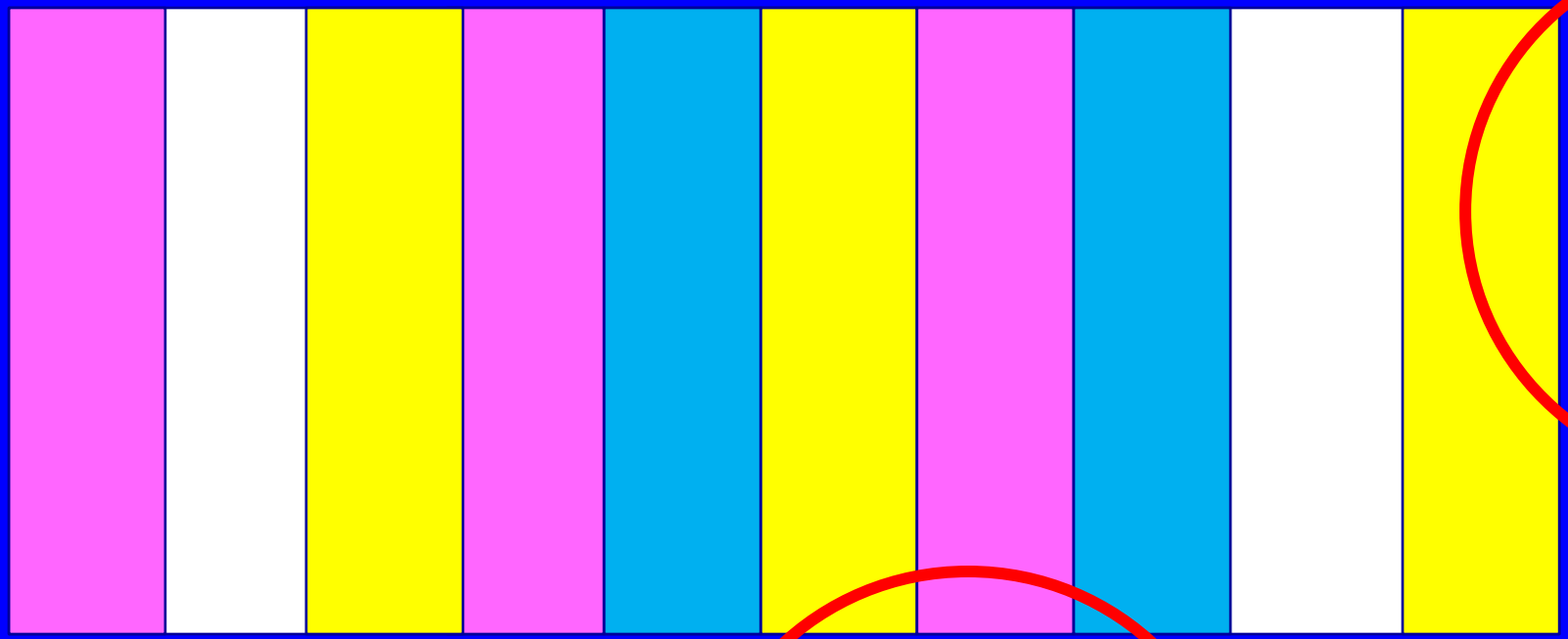
- **Steam controls soil pests such as *Verticillium dahliae*, *Macrophomina phaseolina*, *Pythium* spp. and weeds.**
- **Strawberry yields in steam treated soils are comparable to yields in fumigated soils.**

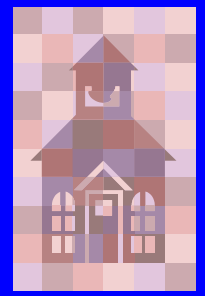
Samtani et al. 2012;
Fennimore et al. 2013

Steam business model

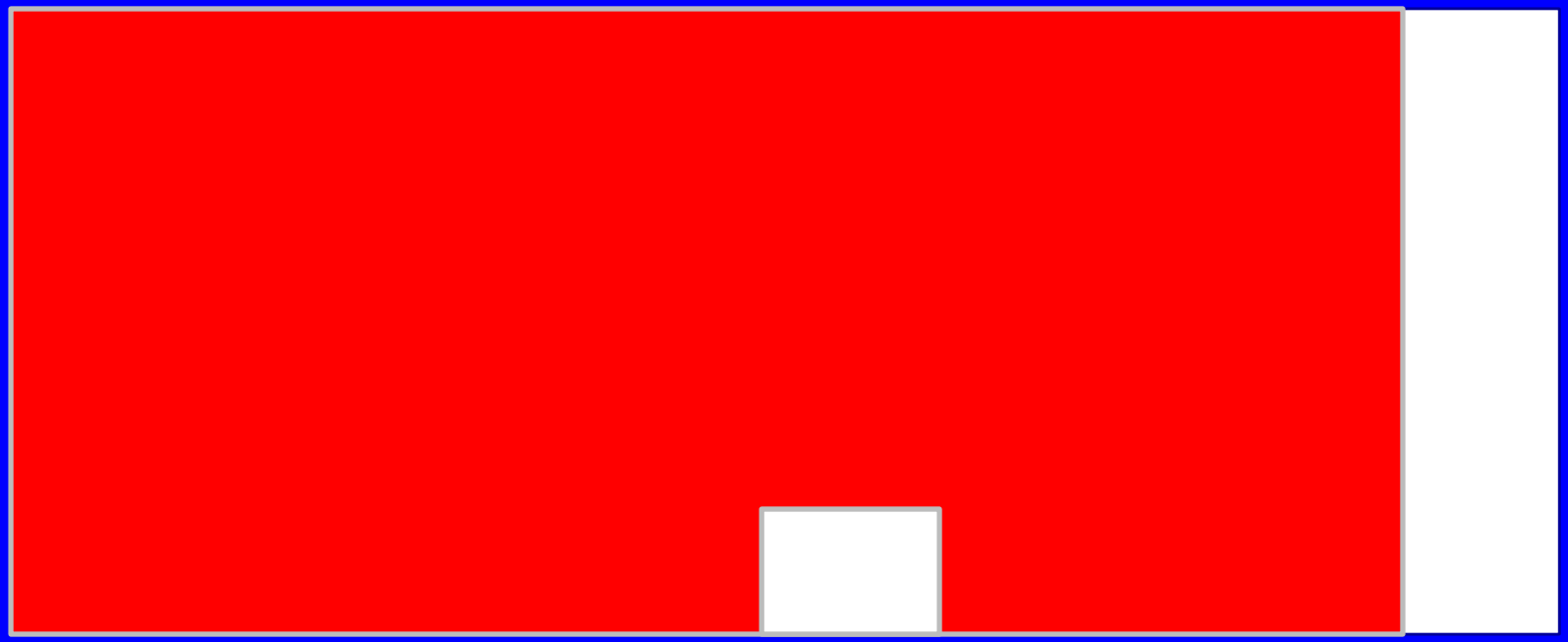
- The assumption is that fumigants would continue to be used where possible.
- Steam would be used where fumigants cannot.
- Crop management is the same across fumigated and steamed blocks.

An 80 acre field impacted by sensitive sites





An 80 acre field impacted by sensitive sites



White = steam 7 acres
Red = fumigate 65 acres

A business role for steam

- An 80 acre farm with 72 acres farmable
- 65 acres can be fumigated, 7 acres cannot
- Fumigant cost $1,900/A or $123,500; steam costs $5,000/A or $35,000 for total treatment cost of $158,500.
- Net returns above operating costs for 7 acres $25,399 based on Albion yields

Daugovish et al. 2011.

Varying Field Sizes and Buffer Widths – Time for One Steam Applicator

Field Size/ Buffer Width	5 Acres		10 Acres		20 Acres		40 Acres	
	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours
25 ft	.3	2.1	.4	3.0	.5	4.3	.8	6.1
50 ft	.5	4.3	.8	6.1	1.1	8.6	1.5	12.1
100 ft	1.1	8.6	1.5	12.1	2.1	17.1	3.0	24.2
200 ft	2.1	17.1	3.0	24.2	4.3	34.3	6.1	48.5
300 ft	3.2	25.7	4.5	36.4	6.4	51.4	9.1	72.7

Klonsky 2013 MBAO

Steam Operating Costs

	Units/acre	$/Unit	$/Acre
Fuel	1,561 gallons	$2.61	$4,074
Labor	8 hours	$14.52	$211
Total			$4,285

Klonsky 2013 MBAO

New Steam Generation Technology

- Downhole steam generator – oil field technology.

- Advantages
  - No steam boiler
  - Does not require softened water
  - Small size

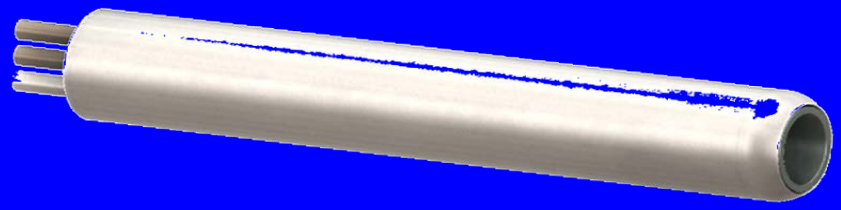
Steam Generator input/output

Proof of Concept, steam works, just requires more energy output and smaller footprint

2.5 MM Btu/hr.
Clayton Steam Generator

6.4 Gallons Water to Propane

10 MM Btu/hr.
PCI Steam Generator



10.4 Gallons Water to Propane

Steam Costs

- Estimated costs with the Clayton Steam prototype was $5,400 to $5,700 /A
- Target rate is 8 hours/A
- We are proposing to build a commercial-scale unit and cost estimates for operation are $3,182 to $3,832/A.

Summary - Steam

- Steam kills soil pathogens and weeds in field soils.
- Strawberry yields are similar in fumigated and steamed soils.
- Steam can be used as a component in a multi-tactic soil disinfestation program.