Soil Disinfestation With Steam in California Strawberry

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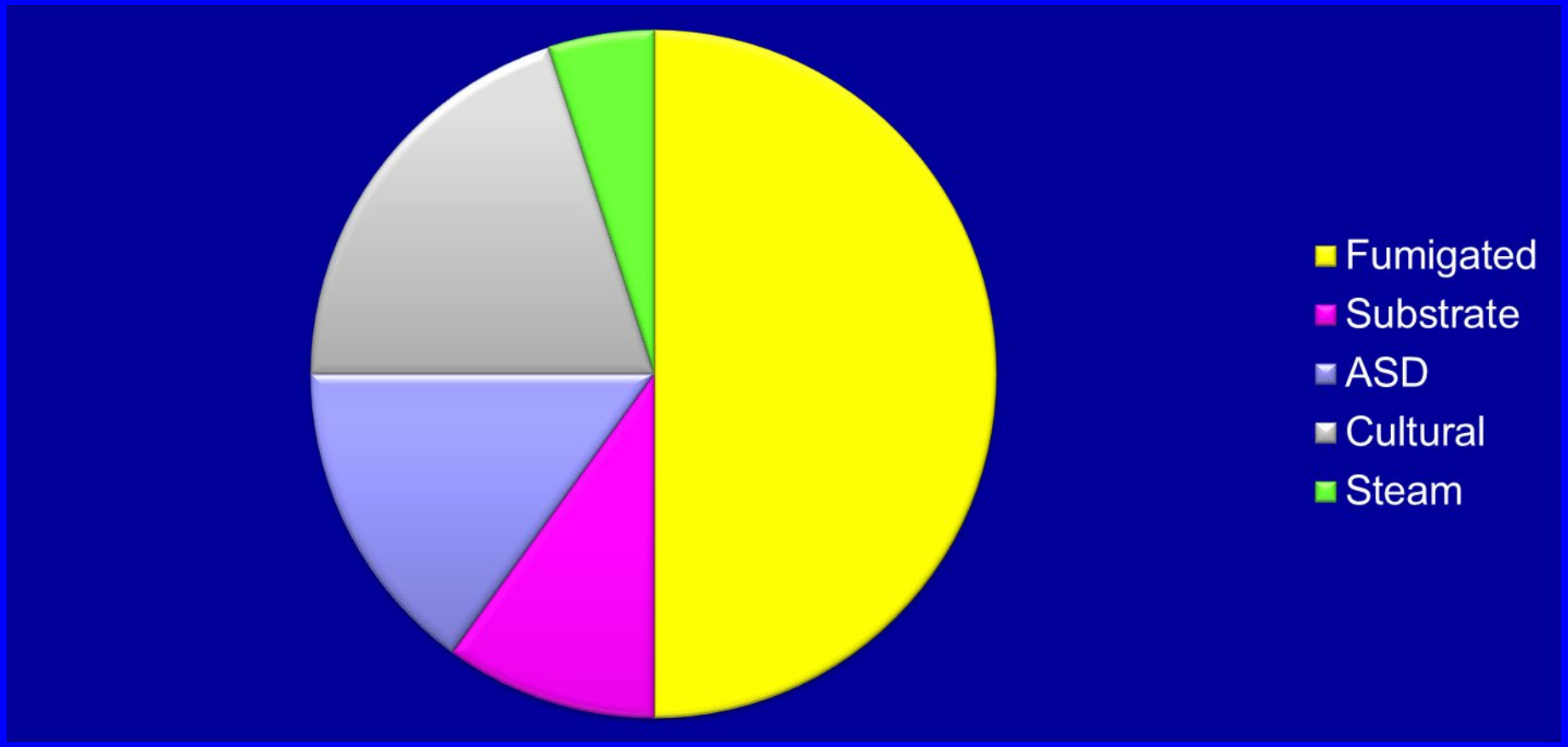
The essential role for steam

- It is a non-fumigant method that kills soil pests in minutes - consistently
- Steam can be a component in a variety of non-fumigant solutions
- Steam is a stand-alone soil disinfestation treatment
- Steam application is compatible with a custom fumigant business

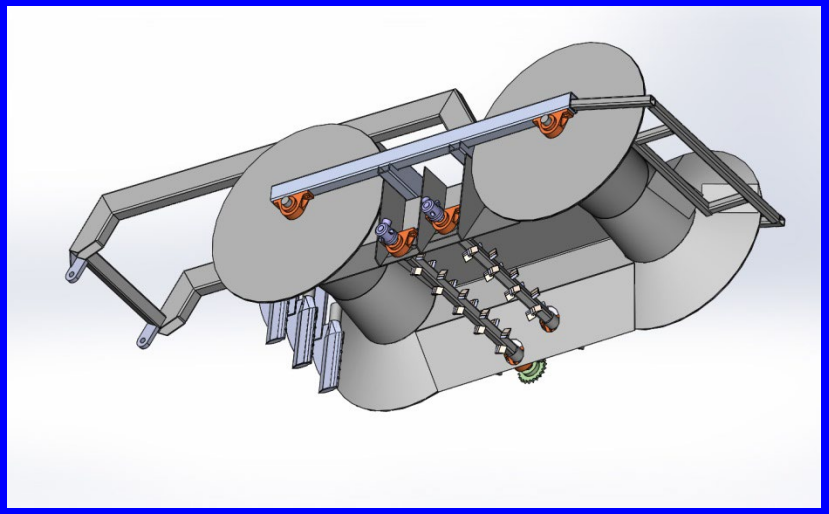
California Strawberry Production in Year 2025 by System



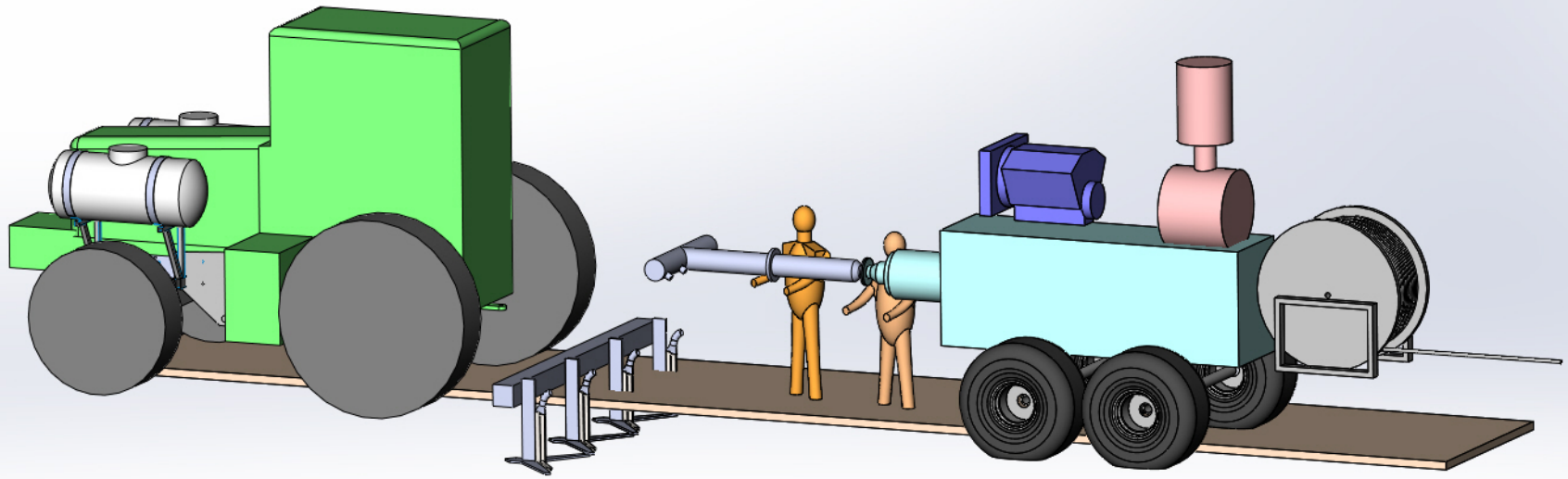
Why Steam?

1. Steam kills soil pests
2. Its not a fumigant
3. It is compatible with biofumigants - AITC
4. Many nonfumigant methods are needed
   a) Steam kills macrophomina & weeds
   b) Uses 0.3 acre inches water
   c) Steam is consistent
5. Steam generator technology has changed and we can make a more efficient applicator

AUTOMATIC STEAM APPLICATION
THE ALPHA MACHINE 2011

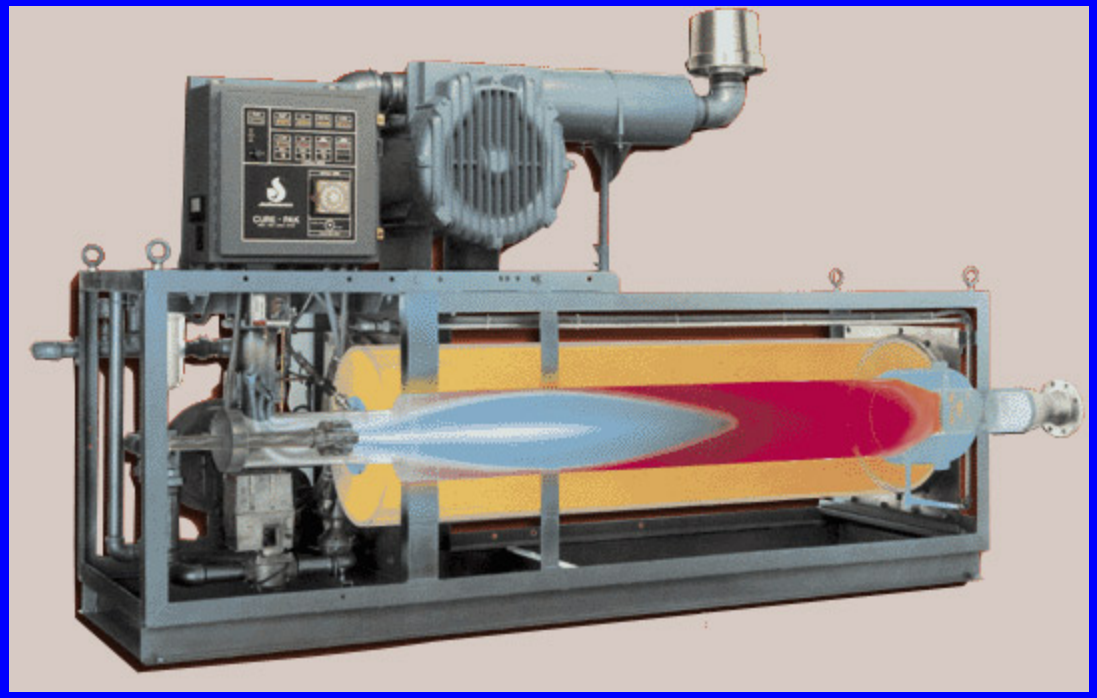


AUTOMATIC STEAM APPLICATION
THE BETA MACHINE 2015



Direct-fire Steam Generators

- Advantages
  - No steam boiler
  - Very efficient
  - Water hardness



Johnson Gas Appliance, Cedar Rapids, IA
Precision Combustion, North Haven, CT

New Steam Applicator Plan

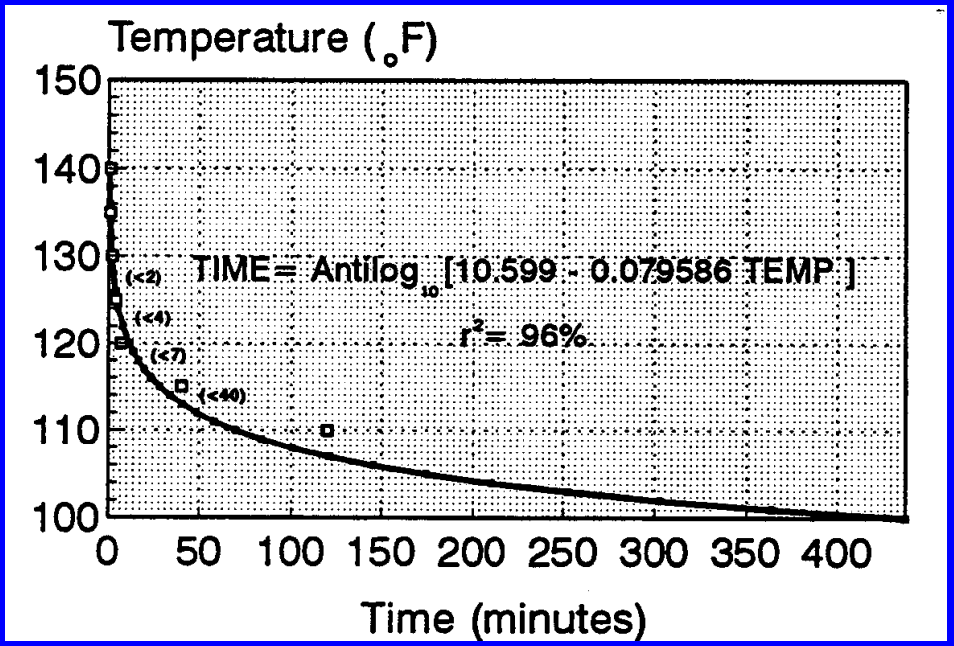
- Flat steam

Introduction

- Soil disinfestation with steam
- A description of the equipment & technology
- Roles for steam in strawberry
- Economics of field steam
- Summary

Time & temperature effect on soil pests

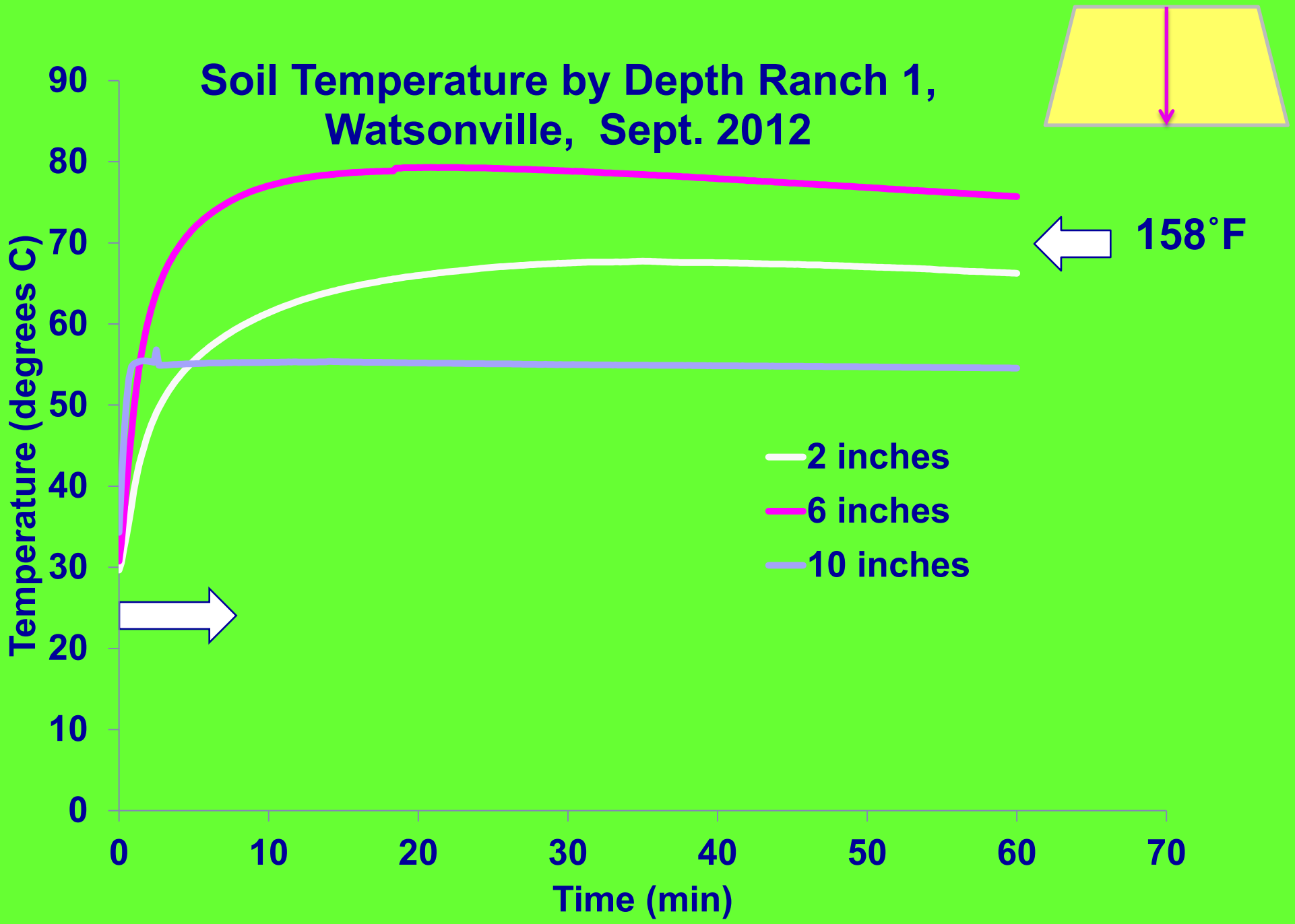
- High temperatures kill soil pests quickly
- Moderately high temperatures require more time to kill pests



J. Noling 1997

Trial setup

- Conducted near Salinas & Watsonville, CA during 2011-12 & 2012-13
- Steam applied with RAC's automatic steam applicator
- Treatments replicated 4 times
- In 2011-12 standard was Pic Clor 60,
- 2012-13 standard was MBPic
- Economic analysis conducted by R. Goodhue at UC Davis: material, labor & machine costs

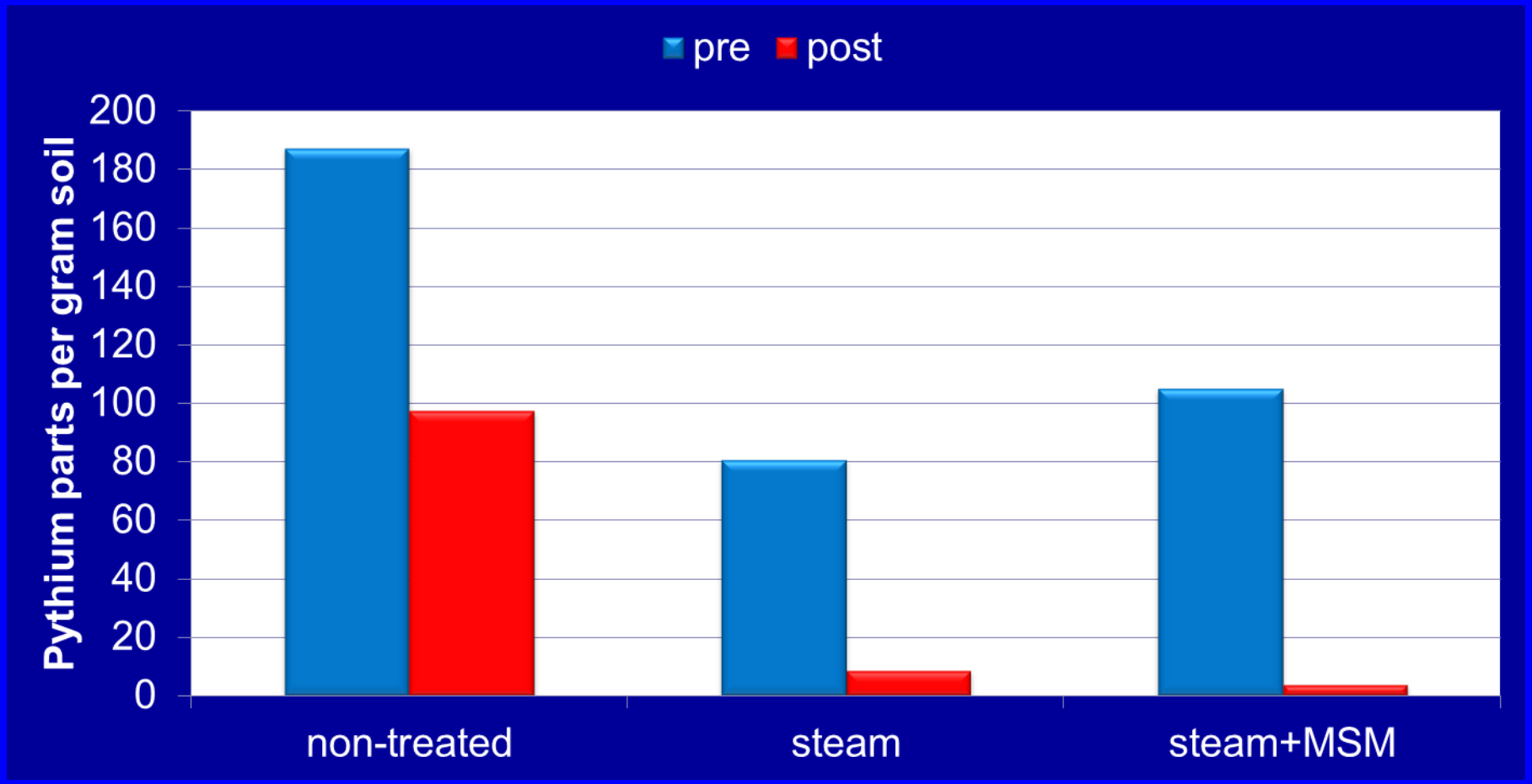

Soil Temperature by Depth Ranch 1, Watsonville, Sept. 2012
Temperature (degrees C)
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
Time (min)
158˚F
2 inches
6 inches
10 inches

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
Non-treated	101,175 a	167 a

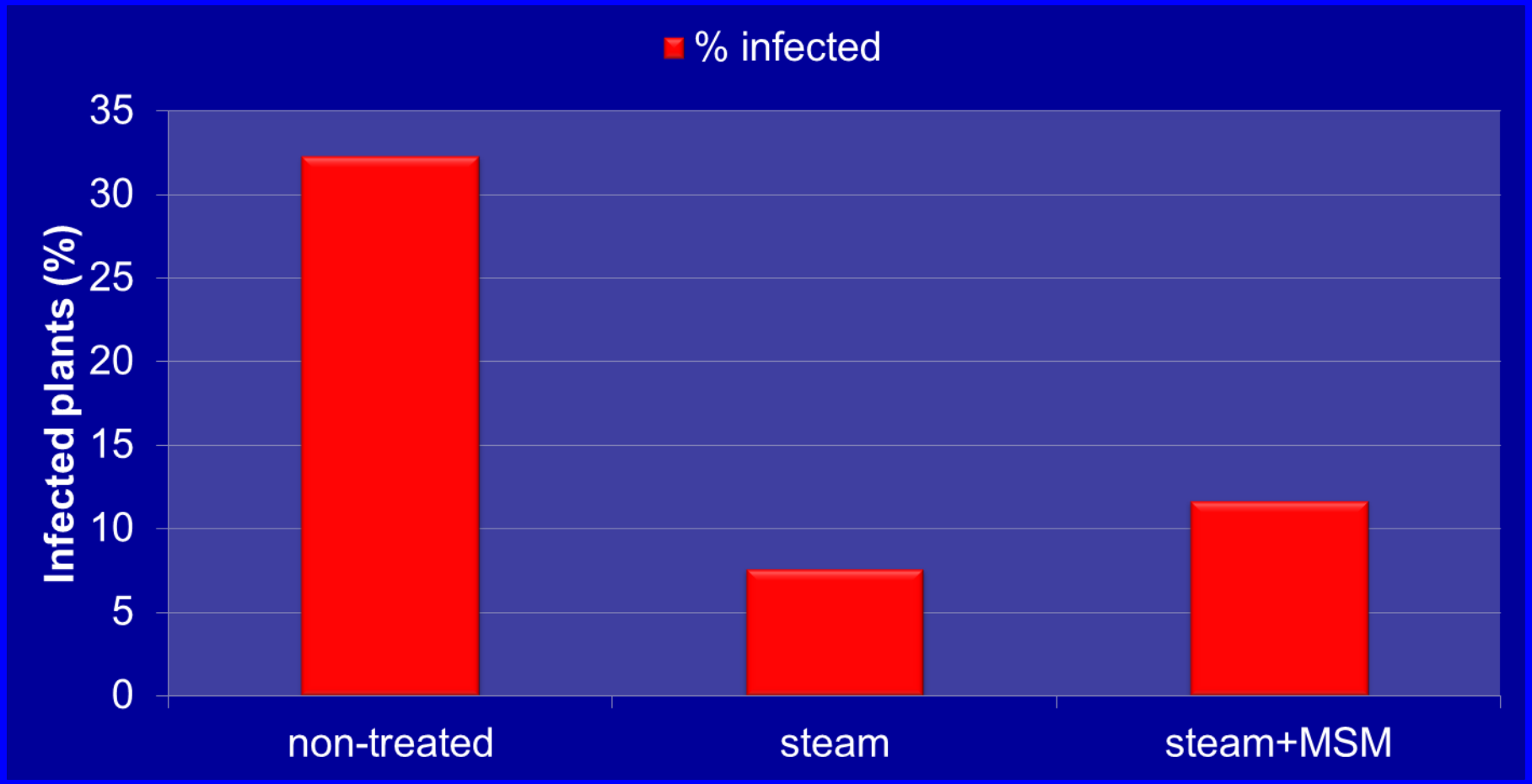
Mean separation using Fisher's Protected LSD P =0.05

Pythium Control Ranch 1 2012



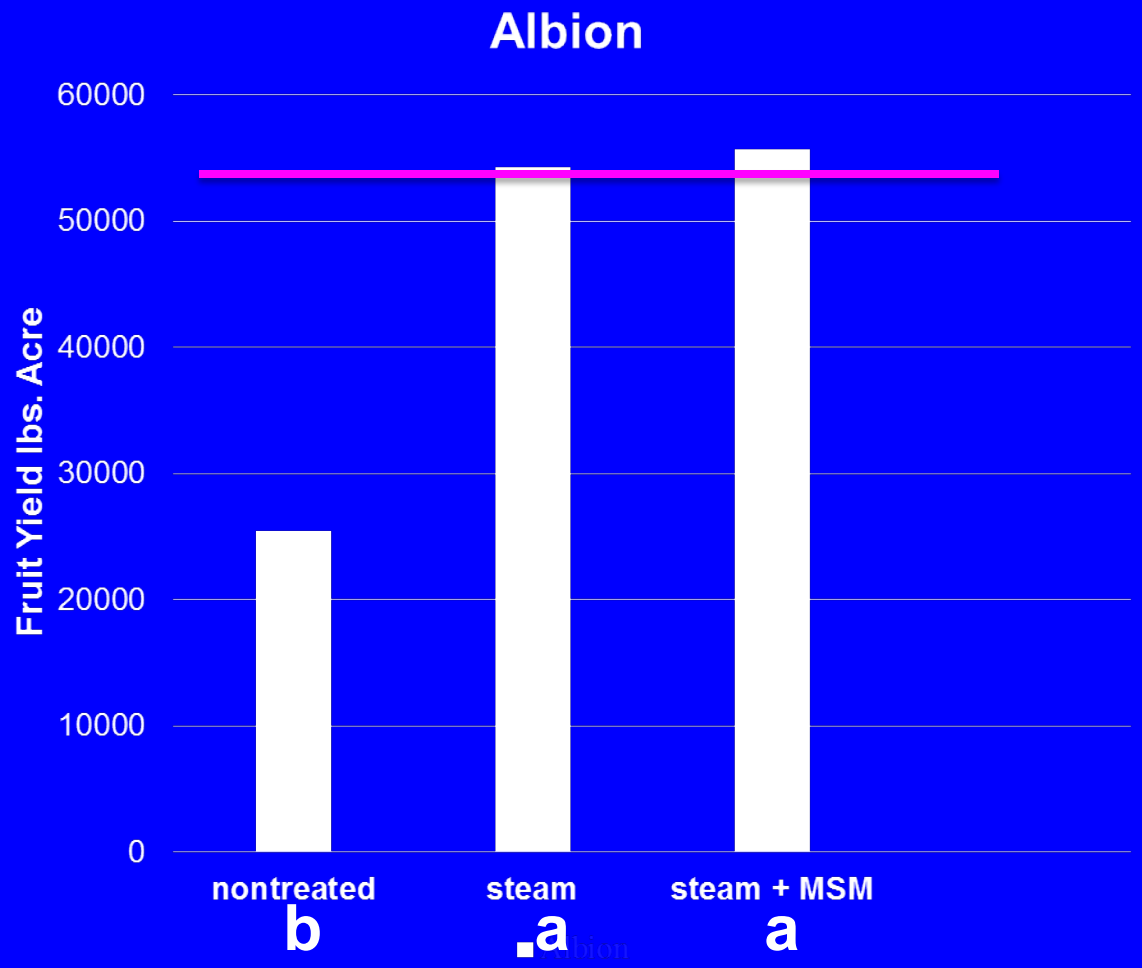
AB B B

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



a b b

Seasonal Fruit Yields Ranch 1



2010-2013 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. 2014

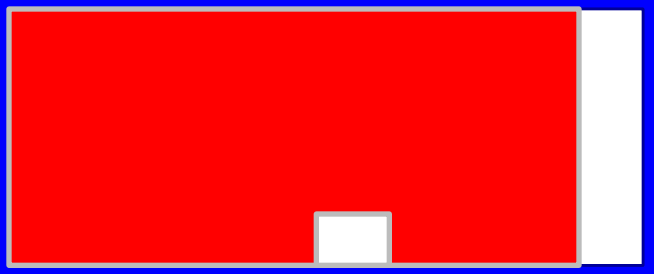
Steam business model

- Assumption: fumigants will continue to be used where possible
- Steam will be used where fumigants cannot
- Crop management is the same in fumigated and steamed blocks

A business role for steam

- An 80 acre farm with 72 acres cropped
- 65 acres can be fumigated, 7 acres cannot
- Combined total treatment cost of $158,006.
- Net returns above operating costs for 7 acres $129,745 based on Albion yields compared to no steam

Fennimore & Goodhue 2015



Steam costs – room for improvement

- Our Oct. 2014 fuel use numbers were 812.7 GPA propane (70% coverage)
- Propane cost $1.56/Gal (Oct. 2014) $1,268/A
- Comparisons indicate that natural gas cost/A would be less than 50% that of propane
- Direct-fire steam generators

Last thoughts

- The ideal soil management system for strawberry will have many different methods
- No one method will dominate
- Methods of pest suppression will be rotated & used in combination
- Plant breeding will play a very important role

Collaborators

- Tom Miller
- Krishna Subbarao
- Rachael Goodhue
- Oleg Daugovish
- Frank Martin
- Sophie Yu
- Nathan Dorn, Reiter Affiliated Cos.
- Ian Greene, Ramco Norcal
- Jenny Broome, DSA
- Mike Stangellini, TriCal

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