Transition from methyl bromide to fumigant & nonfumigant alternatives for strawberry production in California

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UCCE Santa Cruz, February 4, 2016

The big picture

California situation

- Land & labor costs are increasing, & profitability requires high return: blackberry, cut flowers, raspberry, & strawberry …
- At present strawberry producers need fumigants to suppress soilborne diseases
- Strawberry requires a long-term plan to reduce fumigant use
- Strawberry growers need short- and medium- term solutions to suppress soil-borne pests

What to do?

- Public/private research teams need to help develop short-, medium- & long-term solutions
- No one <u>knows</u> the short path to successful strawberry production w/o fumigants
- Short- & medium-term research -suppress soil pests with fumigants, & non-fumigants
- Long-term research must be based on IPM fundamentals

pest management Fundamentals

- **Strategy – action plan based on needs of the crop & pest biology**
- **Tactics – pest control methods**

pest management strategies

- **Prevention- exclude the pest from the non-infested field**
- **Management – pest is established and must be managed by multiple tactics**
- **Area wide pest management – requires regional cooperation**
- **Eradication – elimination of the pest**

pest management Tactics

- Manipulation of the pest so it does not harm the crop
- Manipulate the crop so that it tolerates the pest
- Manipulate the environment to suppress the pest

Pest manipulation

- Prevention – keep the pest out of the field
- Pesticides – control the pests
- Physical controls – substrate production, steam disinfestation

Pest manipulation - prevention

- Reduce pathogen in rotational crops e.g. lettuce
- Use modern molecular techniques and aerial surveillance to identify where the pest is located in field

Pest manipulation – Verticillium prevention in lettuce

- **One tactic being tried in lettuce – fumigate at crop termination**
- **We should also be looking at other crop termination methods that do not involve fumigants e.g.**
  - Steam
  - Flaming

Pest manipulation- Spatial pest variation

- **Pathogens are not uniformly distributed yet we treat them as uniform**

Theoretical Pic dose required to control a known pest population

Area	Acres (Field %)	Pathogen severity (10=severe, 0= none)	Chloropicrin dose needed (lbs./A)	Chloropicrin used (lbs.)
A	12 (15%)	9	300	3,600
B	24 (30%)	4	100	2,400
C	44 (55%)	0	0	0
TOTAL	80 (100%)			6,000

80 acres receiving 250 lbs./A of Pic = 20,000 lbs. Pic

Diagnostic testing of soilborne pests

- Poole et al. 2015 Phytopathology 105:1069-1079 used DNA testing of soil for pathogens to predict root diseases in wheat with a high degree of accuracy
- At what point will the cost of field mapping of soilborne diseases become cheap enough to pay for with reduced fumigant expense?

Pest manipulation - Fumigation

Pest Control Efficacy of the fumigant TRX-58 in Flower, Mellano & Co.

Carlsbad, CA. Fumigation: 10/2/2014

160 ft.

11 ft.

231 ft.

7 Treatments, 3 Replicates

Treatment	Rate
MB Pic	350 lbs./a
Pic Clor 60	350 lbs./a
Dominus + Pic 67:33	40 g/a
Dominus	40 g/a
TRX-58	500 lbs./a
TRX-58 + Pic 67:33	400 lbs. /a
non-treated	-

Pathogen control
Carlsbad, ca

Treatment	Rate	Fusarium (p/g soil)		Pythium (p/g soil)	
		PRE	POST	PRE	POST
MBPic	350 lbs./A	183	0	17	0 c
Pic-Clor 60	350 lb./A	1365	0	17	0 c
Dominus	40 GPA	259	47	35	80 a
Dominus/Pic	40 GPA	328	38	28	36 b
TRX-58	500 lb./A	469	201	16	0 c
TRX-58/Pic	400 lbs./A	210	74	35	1 c
Nontreated	0	350	721	13	39 b

Jim Gerik, USDA-ARS

Weed control Carlsbad

Treatment	Rate	Ranunculus	Delphinium	Weed time
		Weeds (no./A)		Hrs. /A
MBPic	350 lb/A	8,349 c	6,587 b	69 e
Pic-Clor 60	350 lb/A	1,597 c	2,569 b	99 cde
Dominus	40 GPA	61,976 a	54,629 a	223 ab
Dominus/Pic	40 GPA	30,686 abc	43,319 a	169 bc
TRX-58	500 lb/A	17,134 bc	1,742 b	87 de
TRX-58/Pic	400 lb/A	27,564 abc	7,050 b	157 bcd
Nontreated	0	52,708 ab	51,480 a	266 a

Strawberry results

Dominus (AITC) K-Pam evaluation in strawberry

- Treatments 2014-15 – Drip applied
  - Control
  - K-Pam 31 & 62 GPA
  - Dominus 20 & 40 GPA
  - Pic Clor 60 20 GPA
  - Pic Clor 60 fb K-Pam 20 fb 31 GPA
  - Pic Clor 60 fb Dominus 20 fb 20 GPA
  - K-Pam fb Dominus 31 fb 20 GPA
- 4 replicates per treatment, Oct 11 & 15, 2014
- Weed seed bioassay, local weeds, nematodes, pythium, Verticillium 9 & 18 inches deep

Pathogen control

Treatment	Rate GPA	Nematode No./ 50 g soil	Pythium PPg soil	Verticillium MS/g soil
K-Pam	31	18 c	42 bc	3 bc
K-Pam	62	65 bc	27 bc	5 bc
Dominus	20	179 bc	149 bc	8 bc
Dominus	40	252 b	221 b	11 b
Pic fb K-Pam	20 fb 31	1 c	0 c	2 c
Pic fb Dominus	20 fb 20	1 c	0 c	1 c
K-Pam fb Dominus	31 fb 20	3 c	0 c	8 bc
Nontreated	0	1806 a	1239 a	40 a

Becky Westerdahl, nematodes; Frank Martin, pythium; and Steve Koike, Verticillium.

Weed densities & strawberry fruit yield

Treatment	Rate GPA	Weeds No./ A	Fruit Lbs./A
K-Pam	31	13,068 b	53,462 c
K-Pam	62	17,424 b	58,314 abc
Dominus	20	13,068 b	58,494 ab
Dominus	40	8,712 b	56,978 bc
Pic fb K-Pam	20 fb 31	13,068 b	60,103 ab
Pic fb Dominus	20 fb 20	8,712 b	62,206 a
K-Pam fb Dominus	31 fb 20	13,068 b	58,499 ab
Nontreated	0	165,528 a	56,422 bc

Weed propagule control

Treatment	Rate	B. Nettle	Knotweed	Common Purslane	Yellow nutsedge
	GPA	------------------------ Viability (%) ------------------------			
K-Pam	31	17 c	3 c	6 b	2 c
K-Pam	62	13 cd	4 c	3 bc	0 c
Dominus	20	16 c	4 c	4 bc	14 b
Dominus	40	11 cde	12 b	3 bc	0 c
Pic fb K-Pam	20 fb 31	2 e	5 bc	3 bc	1 c
Pic fb Dominus	20 fb 20	3 de	1 c	1 c	1 c
K-Pam fb Dominus	31 fb 20	32 b	8 bc	4 bc	3 c
Nontreated	0	81 a	77 a	79 a	81 a

Summary, strawberry

- **Dominus**
  - **Weak control of nematodes, Pythium**
  - **Suppresses Verticillium & weeds**
  - **Fruit yields were highest when Pic was included in the treatment**

Summary, strawberry II

- K-Pam
  - Weak control of nematodes,
  - Suppresses Pythium, Verticillium & weeds
  - Fruit yields were highest when Pic was included in the treatment

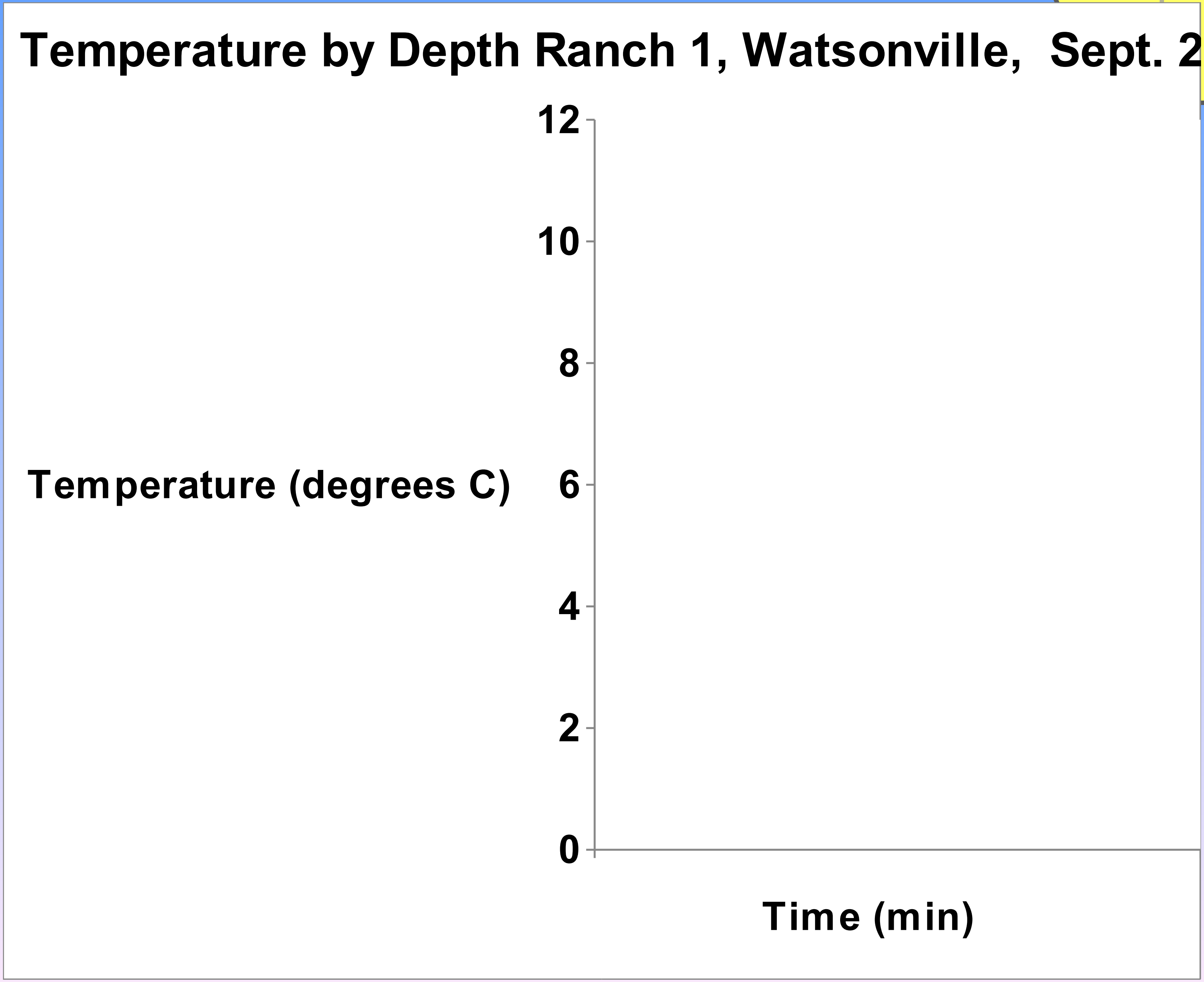
Pest manipulation soil disinfestation with Steam

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

Automatic steam application

San Juan Rd.
Watsonville, CA
9/10/12


Temperature by Depth Ranch 1, Watsonville, Sept. 2
Temperature (degrees C)
12
10
8
6
4
2
0
Time (min)

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

b a a

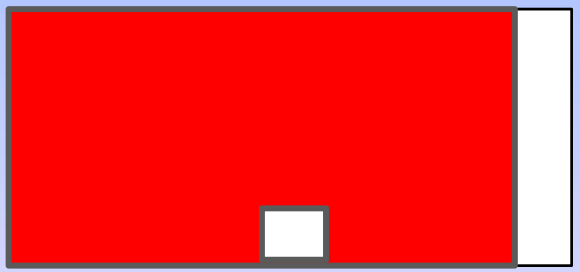
2010-2013 Findings

- **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

A business role for steam

- An 80 acre farm with 72 acres cropped
- 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 $129,745 based on Albion yields vs $16,604 for no treatment



Yu et al. 2015

Direct-fire Steam Generators

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

Johnson Gas Appliance, Cedar Rapids, IA

Steaming oct. 9 , 2015 Salinas, CA

Steam costs – direct fire

- Our Oct. 2015 fuel use numbers were 862 GPA propane (100% coverage)
- Propane cost $1.44-1.52/Gal (Oct. 2015) $1,287/A
- We are confident that we can improve upon this a great deal

crop manipulation - ASD

crop manipulation ASD

- Insert photo of Fuji

Control	Steam

Fuji Ranch, Salinas, CA Sept. 2015

Steam

ASD

crop manipulation

- **Cultural tactics – modification of cultural practices used to grow the crop to suppress the pest. Eg. Mustard cover crops**
- **Host plant resistance – breed for increased resistance to pests**

Environmental manipulation - Substrate production

one

two

three

Substrate production - challenges

- High costs – >$20,000/A more than in soil strawberry production
- High maintenance – eg. Need for watering 10 times per day
- Little room for error. If the water is unavailable eg. Pump needs repair, the crop is imperiled

What to do?

- Public/private research teams need to help develop short-, medium- & long-term solutions
- No one knows the short path to success
- Short- & medium-term research -suppress soil pests with fumigants, & non-fumigants
- Long-term research must be based on IPM fundamentals

summary

- Dealing with a crisis involves going back to the fundamentals and building up
- The California strawberry industry is dealing with a slow moving crisis
- Long-term strategies to reduce fumigant use by the strawberry industry must be based on the fundamentals of IPM

Questions?   Ideas?

University of California Value to the California Strawberry industry 2014 & 2015*

Fruit quality
Yield
Disease resistance
Pest management
Plant nutrition
Crop Physiology

Breeding since 1930

No. extension publications 128

UC IPM & Publications

No. extension events 120
No. of field experiments 56
Funding (non CSC) $2.5 million

Extension & Research

Training for future industry personnel

Graduate Students & Postdoctoral Researchers

2014, 2015 M. Bolda, S. Dara, O. Daugovish, S. Fennimore, S. Koike

Proposed UC Extension position

- **At Salinas field station, within 4 hours of most California strawberries**
- **Possible areas of focus:**
  - Strawberry breeding – collaborate with UC Davis breeder
  - Management of organic strawberry
  - Sustainable small fruit production
  - Strawberry nurseries
  - Fumigant research
- **Form a research cluster with new USDA Salinas hires**