NONFUMIGANT EVALUATIONS IN CALIFORNIA STRAWBERRY NURSERIES

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LIMITS OF FUMIGANTS

- **The capacities and the capabilities of the Agricultural chemical industry to solve the fumigant needs of the strawberry industry are limited by:**
  - Small market size
  - High cost/risk of development (reminder Methyl iodide)
  - Strict use regulations
  - Unpopularity of fumigants vs. popularity of organic
- **Fumigants are not organic compliant**

FIELD STEAMING

- **The oldest method of soil disinfestation**
  - Mostly used in greenhouses
  - There are several field steam machines in Europe and Asia
- **There has been limited interest in field steam in the USA. Why?**
  - Fumigants are still available
  - Steam applicators are not available
  - Scale of operations is large in USA vs. Europe

ASSA Mission Statement

Agricultural Soil Steaming Association

Mobilize necessary constituents to make soil steaming technology and related agricultural equipment commercially viable. This will benefit berry nurseries in California, and subsequently other crops and soil treatment applications across North America.

Agricultural Soil Steaming Association

Meeting the Challenge…

- Demonstrate the viability of a large-scale commercial soil steaming technology in 2020-2021
- Set the groundwork for commercial equipment availability before 2021-22
- Establish benefits among all industry constituents for large market adoption in 2022-2023
- Promote steam pasteurization technology to public to create a premium end product

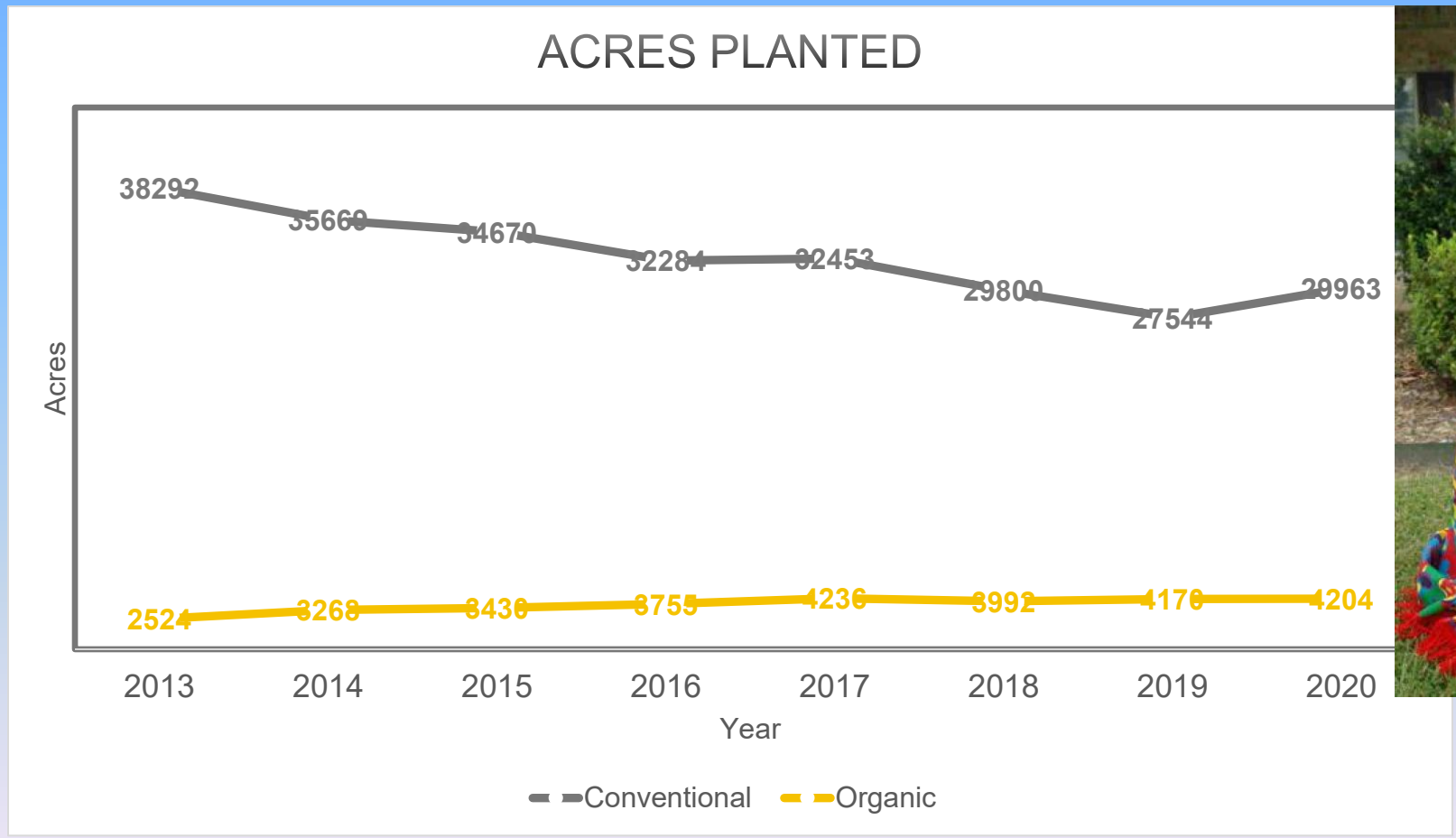
FUMIGANTS CURRENTLY USED IN CALIFORNIA 2017

- **Chloropicrin 86% strawberry plantings**
- **1,3-dichloropropene 47% plantings**
- **Metam sodium 3% plantings**
- **Methyl Bromide 816,000 lbs. used on 3,569 acres nursery (QPS)**

CA Dept. of Pesticide Regulation

MACDOEL, CA

TRENDS IN CONVENTIONAL VS. ORGANIC PLANTINGS - FRUIT



WHY WE NEED STEAM IN CALIFORNIA

- **For soil disinfestation in:**
  - **Buffer-zones**
  - **Organic fields**
  - **Fumigant regulations**

Note: 0.25 mile radius

THE OBJECTIVE OF SOIL TREATMENT WITH STEAM

- Raise the soil temperature to 150-158° F for 20 minutes – DWELL TIME
- Soil pathogens like Pythium and Verticillium are more easily killed than beneficial soil microorganisms
- The objective is not to sterilize soil but to selectively pasteurize it
- Not too hot, not too cold

STEAM TERMS

- Steam is a method of soil disinfestation – a process that kills soil pests by cooking them
- Dwell time is the necessary time above a the target temperatures – 20 minutes at 158°F
- Too hot and the beneficial nitrifying bacteria can be killed
  - Nitrifying bacteria convert ammonium to nitrate
  - If they are killed then ammonium toxicity can result
  - Easy to avoid this overheating problem with the technology we are working with
- Too cold and Verticillium and Macrophomina are not killed

STEAM WORK 2018-2020

- **Three trials in nurseries at MacDoel, CA**
  - Two conventional trials Steam vs. MB
- **Three trials in fruiting fields at Salinas & Watsonville**
  - Steam vs. chloropicrin

PROTOTYPE OPERATING COSTS

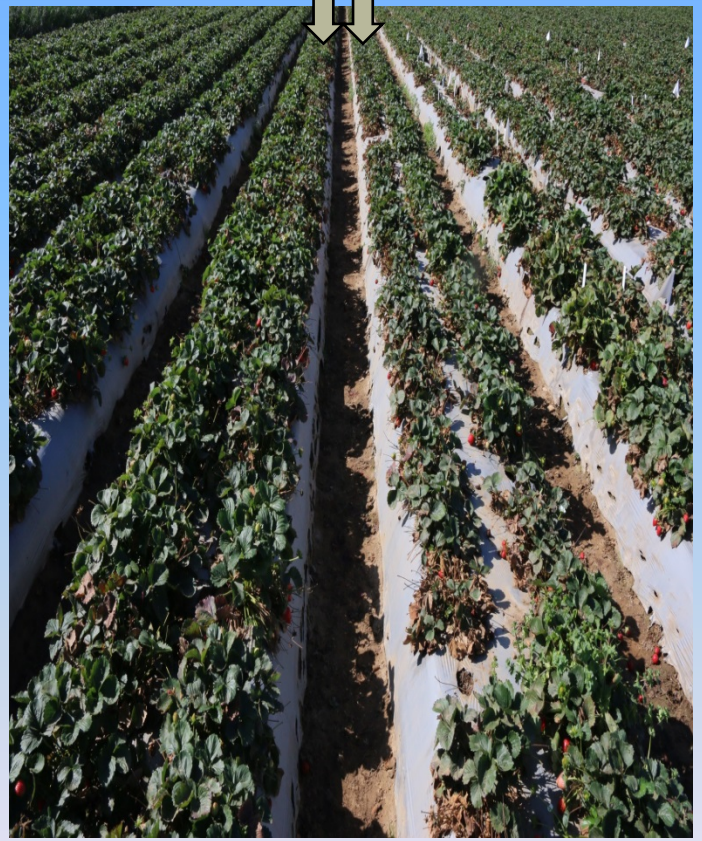
- In field costs $4,050/A (fuel, labor, machine)
- Transportation costs not included
- 10 ft treated by 10-12 inches deep 13.7 hr/A
- Target temperature 158°F for 20 min
- Southern Turf Nurseries

EXAMPLE: VIGOR

Organic Ranch (Fuji Rd., Salinas CA) high salt levels in Spring and *Verticillium dahliae* pressure

Non-Treated | Steam + MSM

Steam + MSM | ASD + Rice



September 2015

OUTLINE

- **Need for steam**
- **Strawberry nurseries**
  - Lassen Canyon Nurseries
  - Sierra Cascade Nurseries
- **Nursery results**
- **Fruit field results**
- **Soil Steam International**
- **JSE South Korea**

LASSEN CANYON NURSERIES

Treatment	Weed densities	Pythium	Daughter plants
	Number/A	#/g	Number/A
MBPic 57:43	769 a	0	922,673
Steam	1416 a	0	857,923

SIERRA CASCADE NURSERIES

Treatment	Weed densities	Verticillium	Nematodes	Daughter plants
	Number/A	% viable	#/50 g	Number/A
MBPic 45:55	9308 a	0	10.8	348,026
MBPic 57:43	27518 a	2.5	2.0	267,089
Steam	16997 a	0	17.0	323,745

WEED CONTROL 2018-19 STEAM TRIAL AT SALINAS, CA

Treatment	Purslane	Nutsedge	Verticillium
	---------- viable % ----------		Ms/g
Control	78 b	84 b	220 b
Steam	3 a	7 a	0 a
Chloropicrin	2 a	2 a	3 a

FRUIT YIELDS 2018-19 STEAM TRIAL AT SALINAS, CA

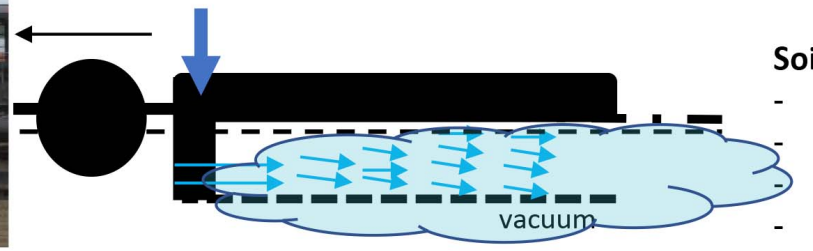
Treatment	Yield
	Lbs./A
Control	20,512 a
Steam	25,468 b
Chloropicrin	28,080 b

CONCLUSIONS

- In nurseries and fruit fields the Southern Turf Nursery steam applicator worked
- Steam efficacy is about the same as fumigants even in strawberry nurseries

Soil Steam International – Sandefjord, Norway

VACUUM STEAMING IN THE FIELD



Soil preparation system

- Continuous – Tractor Drawn
- Up to 14 in”
- Low pressure boiler
- Under vacuum system
- Most efficient – 400 gal propane /acre
- Soil Steam International (NV)

Soil Prep 400 burns 534 gallons diesel per acre

SOILPREP 400

- Results from Lanförden, Germany found that the SoilPrep 400 provided 98% weed control.
- SoilPrep 400 reduced nematode populations by 95%

Dr. Felix Koschnick,
unpublished 2017

SOIL STEAM INTERNATIONAL – SANDEFJORD, NORWAY

MARKET POTENTIAL ASSUMPTIONS SOILPREP 2020

- Soil Steam International 455 GPA propane
- Time per acre estimates 3.4 to 6.7 hours
- 2.7 acres per 18 h day 1,100 gallons per day per applicator
- Estimated cost $1,416 per acre (machine, fuel, labor)

STEAMY FROM JSE – SOUTH KOREA

Steams approximately 0.4 acres in 10 hours

2020 PLANS

- SoilSteam 2020 will be delivered to CA early August –
- Note Soil Steam International now has a California subsidiary
- JSE Steamy applicator will be delivered to CA in July
- Other potential crops: flow renovation, vegetable crops

SUMMARY

- Steam controls soil pathogens and weeds.
- Strawberry plant & fruit yields with steam are equivalent to fumigants
- Strong interest in plant industry to produce strawberry plants for the organic market without using fumigants

QUIZ

- Steam and methyl bromide are both method of soil disinfestation – True or False?
- What is the correct dwell time to disinfest soil?
  - A. 6.7 hours the time it takes to steam an acre
  - B. 20 minutes at 158°F
  - C. 5 min at 180°F
- What happens if nitrifying bacteria are killed?
  - A. nothing
  - B. the field is ruined forever
  - C. Ammonium in the soil is not converted to nitrate

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- Nathan Dorn, Jenny Broome, Melody Meyer-Jertberg
- EB Woerner Enterprises, Elberta, AL
- Soil Steam International, Sandefjord, Norway