Improving the Efficacy of Biologically Mediated Soilborne Disease Management in Strawberry by the use of Reduced Rate Fumigation

Dan Legard
California Strawberry Commission

Research Leaders

- Drs. Joji Muramoto and Carol Shennan, UCSC
- Dr. Mark Mazzola, USDA, Wenatchee
- Dr. Tom Gordon, UC-Davis
- Dr. Kelly Ivors, CalPoly SLO
- Drs. Hillary Thomas and Mercy Olmstead, CSC

Annual Strawberry Production in California

- 36,000 acres of annual strawberry production
- Most of the production is on the coast between Los Angeles and San Francisco
- 90% use pre-plant soil fumigation (annually)
- Regulations in California has made it more challenging to use fumigants
- Fumigants are needed to manage soilborne diseases
- Standard rate is 300 lb/A

Verticillium wilt (*Verticillium dahliae*)

Charcoal Rot (*Macrophomina phaseolina*)

Fusarium Wilt
(*F. oxysporum* f. sp. *fragariae*)

Fumigation Increases Yield (>40%)

Biologically Active Soil Amendments

- Anaerobic Soil Disinfestation (ASD) uses a carbon source like rice bran to suppress soilborne disease by creating anaerobic conditions in the soil
  - Limited efficacy on strawberry diseases in CA
- Mustard Seed Meal (MSM) has also been found to suppress some soilborne diseases
  - Limited efficacy on strawberry disease in CA
- Neither can currently replace fumigants as tools for control of soilborne strawberry diseases in CA

Experimental Questions

- Could the efficacy of biologically active soil amendments like rice bran and mustard seed meal be improved by pre-treating soil with "low" rates of fumigants?
- Could combining the use of soil amendments with the pre-plant soil fumigation reduce the amount of fumigants needed for strawberry fruit production?

Research Site

- Monterey Bay Academy (MBA-Watsonville)
- Infested with Fusarium wilt but not Verticillium wilt or Charcoal Rot (Macrophomina)
- Treatment plots were whole beds (50 ft long)

Data Collected

- Soil chemical characteristics
- Microbial population composition in the soil
- Pathogen populations in the soil
- Plant mortality (Fusarium wilt)
- Marketable yield (harvested twice a week)

2014-2015 Experiment

- Split plot experiment with 4 replicates
- Main Plot treatments:
  - ASD (Anaerobic Soil Disinfestation) with 9 ton/A of rice bran
  - Mustard Seed Meal (MSM) 2 ton/A of *Brassica juncea*
  - Untreated control
- Sub-plot treatments:
  - Untreated control
  - Chloropicrin at 100, 200 and 300 lb/A
  - Allyl isothiocyanate (AITC) at 100 and 200 lb/A

Experimental Treatment Sequence

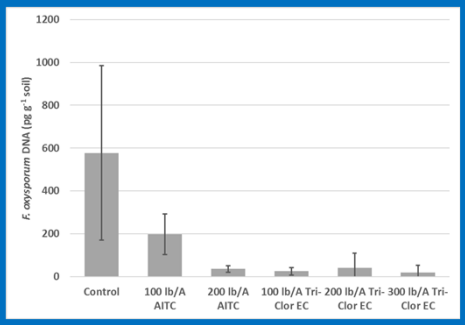
- Beds were formed and covered with TIF film
- Fumigants were applied through the drip irrigation system
- 7 days later the TIF film was removed to allow the fumigants to dissipate
- 4 days later the soil amendments were applied and worked into the beds
- TIF film was reapplied and ASD treatments watered to create anaerobic conditions

Treatments were added sequentially

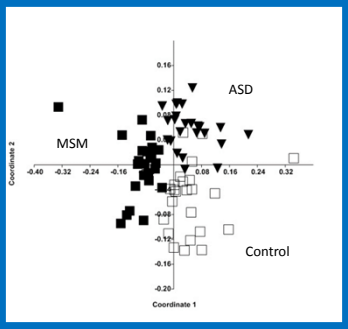
Results

- Results were affected because the ASD and MSM beds became contaminated with *Fusarium oxysporum* f. sp. *fragariae* during incorporation of the rice bran and MSM
- Root knot nematode (*Meloidygne hapla*) was recovered from the experimental site but did not appear to affect the results

Density of *F. oxysporum* as determined by quantitative PCR (post-fumigation)



Fungal Community Composition (Post-Treatment) November 2014



Conclusions – Experiment 1

- Need to change method of incorporating soil amendments (built a tractor mounted rotovator/bed press)
- Dropped ASD from treatment list as other experiments had shown that ASD did not control Fusarium wilt under CA conditions
- Fumigation appeared to improve effectiveness of MSM
- Added Telone (1,3-D) to fumigant treatments to provide control of root knot nematode

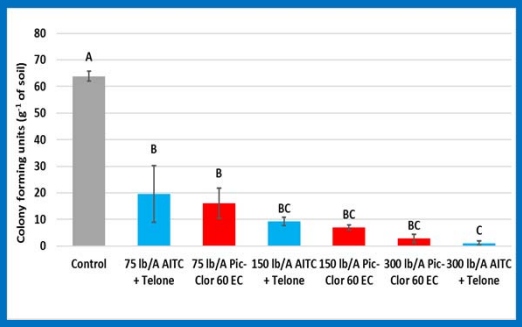
2015-16 Experiments

- Fumigant rate experiment
  - What is the effect of reduced rates on the control of Fusarium wilt?
- MSM + low rate fumigant experiment
  - Can performance of MSM be improved by pre-treating with reduced rates of fumigants?

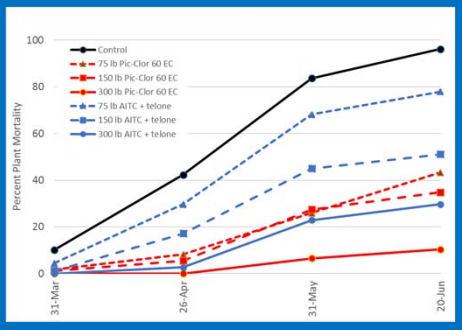
2015-16 Fumigant Rate Experiment

- Randomized complete block (4 reps)
- Chloropicrin (60%) + Telone (40%) at 75, 150 and 300 lb/A
- AITC (60%) + Telone (40%) at 75, 150 and 300 lb/A
- Untreated control

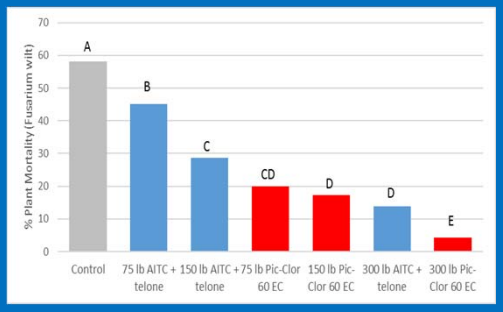
Post-treatment Density of *F. oxysporum f. sp. fragariae*



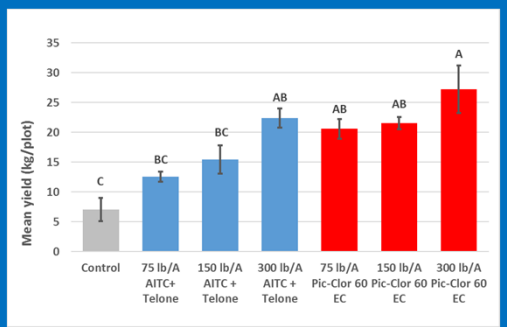
Percent Plant Mortality – Fumigant Rate Experiment



Average Plant Mortality (Fusarium wilt)



Mean Marketable Yield – Fumigant Rate Experiment



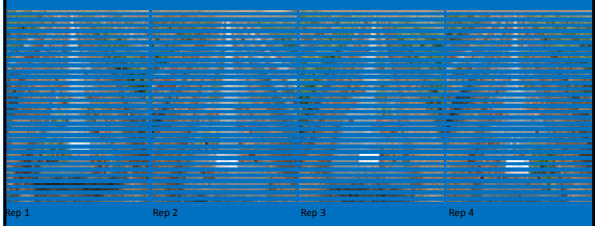
2015-16 MSM + Low Rate Fumigant Experiment

- Randomized complete block (4 reps)
- MSM (mustard seed meal) at 2.5 ton/A
- MSM + 75 and 150 lb/A AITC + Telone
- MSM + 75 and 150 lb/A chloropicrin + Telone
- 150 lb/A chloropicrin + Telone
- Untreated control

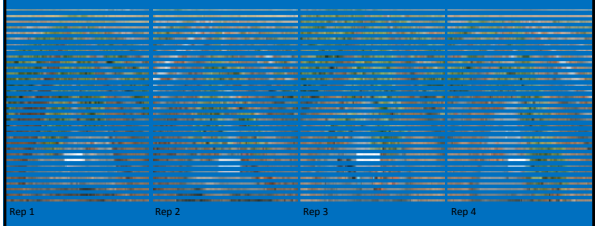
MSM + Fum Trial at MBA: **April 12, 2016** Untreated Control

MSM + Fum Trial at MBA: **April 12, 2016** MSM + 150 lb/A AITC + 1,3-D

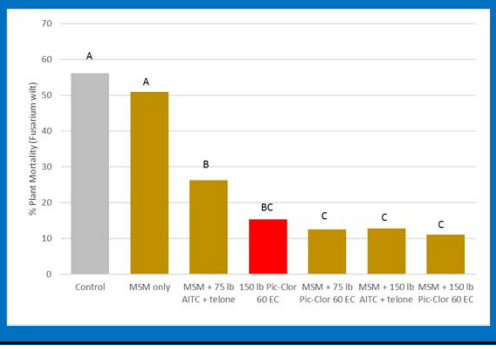
MSM + Fum Trial at MBA: **July 5, 2016**
Untreated Control



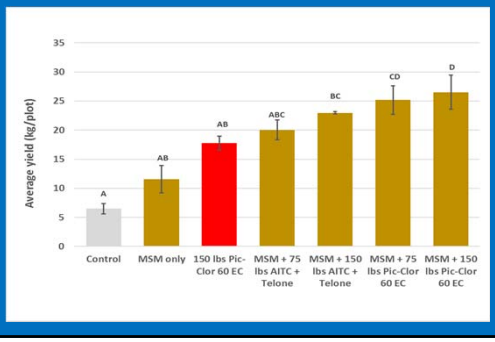
MSM + Fum Trial at MBA: **July 5, 2016**
MSM + 150 lb/A AITC + 1,3-D



Average Plant Mortality (Fusarium wilt) - MSM + Low Fumigation Experiment

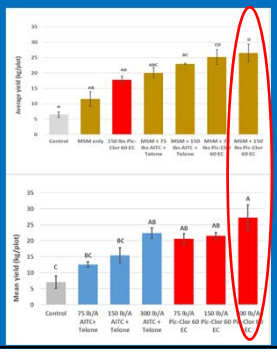


Average Marketable Yield from the MSM + Low Rate Fumigation Experiment



Marketable Yield Comparison Between the Two Experiments

The MSM + 150 lb/A chloropicrin treatment had similar mean marketable yield to the 300 lb/A chloropicrin treatment (26.5 kg vs. 27.2 kg, respectively)



Conclusions 2015-16 Experiments

- ASD using rice bran and MSM are not effective as fumigants in controlling Fusarium wilt and can't be used as stand-alone commercial treatments
- The level of control with MSM was improved when combined with reduced rates of fumigants
- Even the grower standard rate of chloropicrin (300 lb/A) did not provide complete control of Fusarium wilt
- Current inoculum levels at MBA may be too high for meaningful evaluations of experimental treatments

Next Steps

- Repeating MSM + Low Rate Fumigation this season
- Pretreated soil with 150 lb/A chloropicrin + Telone to reduce initial Fusarium populations to more realistic levels