On-farm Organic Strawberry Trials in Santa Cruz and Monterey Counties

Organic Strawberry Production Grower Meeting

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Outline

I. A 5-year organic strawberry/vegetable rotation trial in Monterey County

II. N fertility trials in organic strawberries in Santa Cruz County
Challenge 1: Fertility Management to Optimize Fertility Input Use.

- Lack of information equivalent to best management practices developed for conventional systems.
- Compost and cover crops are often inadequate to fulfill the late N demand of long-season crops.
- Many organic strawberry and vegetable growers have intensified their use of relatively soluble organic fertilizers—"High input organic agriculture" (ATTRA*, 2003). * USDA supported program for sustainable agriculture.
- Few studies on nutrient budget and nitrate leaching from organic row crop farms.
Challenge 2: Soil-Borne Disease Management without Use of Chemical Fumigants.

- Verticillium wilt caused by *Verticillium dahliae*.
  - A wide range of host crops including lettuce, tomatoes, potatoes, cauliflower, artichokes, apple, cotton, and strawberries.
  - Resilient overwintering structures
  - can survive for several years without host plants.
  - Requires rotating land out of host crops for 5 years or more.
Elkhorn Ranch Project

- Elkhorn Ranch.
  - Moss Landing, CA.
  - 120 acres of certified organic fields.
  - Adjacent to Elkhorn slough national estuarine research reserve.

- Grower & the landowner proposed the project and instigated the collaboration.

- A systems approach by multidisciplinary researchers.
  - Agroecologists, plant pathologists, soil scientist, entomologist, ag-economist
Goal

To demonstrate effects of diverse organic strawberry/vegetable rotations and integrated ecological practices on agroecosystem health.
Integrating Ecological Practices

- Compost application.
- Biofumigation with mustard cover crop and broccoli residues.
- Crop rotation with vegetables that do not host *Verticillium dahliae*.
- Use of relatively resistant strawberry cultivar.
On-Farm Rotation Experiment

- Randomized block design with four replicates.
  - 5 year rotation study (2001-2006).
  - Main plot (n=5): number of years between strawberry crops.
  - Split plot (n=2): strawberry cultivar.
  - Plot size: 91.3m² x 20 plots.
  - Total area: 0.19 ha.
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (0 yr.*+ br.res.)</td>
<td>st-----st-------st-------st-------st-------st-----</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>B (1 yr.*)</td>
<td>st------cc-vegs-st--------cc-vegs-st--------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C (2 yrs.*)</td>
<td>cc-vegs-st--------cc-vegs--cc-vegs-st--------</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>D (3 yrs.*)</td>
<td>st--------cc-vegs-cc-vegs--cc-vegs-st--------</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>E (Control)</td>
<td>cc-vegs-cc-vegs-cc-vegs--cc-vegs-st--------</td>
<td></td>
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</table>

Number of years between strawberry crops.
br.res.: applying broccoli residues before planting strawberries.
cc-vegs: cover crops and vegetables (spinach and broccoli).
st: strawberries.
Soil Characteristics

- Soil type: *Santa Ynez fine sandy loam*, 2 to 9 percent slopes (fine, montmorillonitic, thermic Ultic Palexerolls) with low SOM content (~1 %) in the topsoil.
- Thick claypan below ~40cm from the surface. – Low leaching potential.
- Very few *Verticillium dahliae* propagules in the topsoil….residual effect of fumigation?
Plant Pathological Diagnosis at the End of the Fifth Year

- Regardless of treatment, no major strawberry pathogens (Phytophthora, Verticillium, Colletotrichum) were recovered from any of the samples.

- A few plants had the following fungi (all from cv. Aromas): Cylindrocarpon, Pythium, Fusarium (secondary type) --- “Sub-lethal” pathogens?

- Soil analysis by PLFA and molecular biological methods are in progress --- Difference in soil microbial communities?
Changes in Numbers of *Verticillium dahliae* Microsclerotia in Soils in Different Treatments. The mean ± SEM. **Broccoli residues or mustard incorporation.**

Strawberry Root Profile Survey
1 foot deep

Drip tape
N Dynamics and N Loss During the Rainy Season in a Strawberry Plot (year 1, treatment A).

**Basal N: 315 kg ha\(^{-1}\)**

- N uptake by strawberry plants
- Soil inorg. N in bed 0-30cm deep
- Residual soil inorg. N in 0-30cm deep
- Precipitation

\[
N \text{-Loss}_{20\text{wks}} = 214 \text{ kg ha}^{-1} = (\text{Soil inorg. } N_0 - \text{Soil inorg. } N_{20\text{wks}}) - (\text{Plant uptake } N_{20\text{wks}} - \text{Plant input } N_0)
\]
Nitrogen Dynamics in Strawberry Plots During the First Three Years.

Yr. 1, Trt. A
- N res: 140 kg ha⁻¹
- Ncom/bro+pel: 233+82 kg ha⁻¹
- N loss₂₀wks: 214 kg ha⁻¹

Fertigation (36)

Yr. 2, Trt. C
- N res: 15 kg ha⁻¹
- Ncom/bro+pel: 260+43 kg ha⁻¹
- N loss₂₀wks: 13 kg ha⁻¹

Fertigation (52)

Yr. 3, Trt. A
- N res: 20 kg ha⁻¹
- Ncom/bro+pel: 464+67 kg ha⁻¹
- N loss₂₀wks: 180 kg ha⁻¹

Fertigation (79)

Plastic mulch application.
- Cumulative N uptake by strawberry plants.
- Inorganic N in soil 0-30cm deep.
- Precipitation.

Nitrogen Dynamics in Strawberry Plots During the First Three Years.
Year 4. Trt. A

N res: 25 kg ha\(^{-1}\)

Ncom/bro+pel: 176+52 kg ha\(^{-1}\)

N-Loss\(_{20wks}\): 14 kg ha\(^{-1}\)

Fertigation N: 73 kg ha\(^{-1}\)
In organic production systems, under low Verticillium pressure and by using the integrated ecological practices, strawberry cultivar Aromas and Seascape can be grown in 1 to 3 year-break rotation without statistically significant yield difference from 7 year-break rotation.

Fruit yield difference observed among different rotations in the final year appears to be attributed not to Verticillium dahliae but to other factors such as "none-lethal" pathogens that were not monitored in the experiment and/or improved soil N fertility in longer rotation plots.
Conclusions

- Analysis of the effect of different rotations on soil microbial diversity by PLFA and molecular biological methods are in progress.
- “High input organic farming” can have significant environmental N load.
- Pre-plant N rate + residual inorganic N level seem to affect most to the amount of N loss during the winter.
- How much is too much?
N Fertility Trial for Organic Strawberries

- Two sites in Watsonville
- Two years in each site
- Different N rates (pre-plant and supplement)
- Split-plot design
- Monitor soil inorganic N (0-30, and 30-60 cm. Monthly), mite population, tissue N, petiole NO$_3$
Site 1: Redman Farm, Watsonville, Yr 1 (2005-06)

Steve Pedersen @ High Ground Organics
- Soil type: Clear lake clay
- Variety: Seascape

Main plots (3 levels):
- Supplemental N application; **50, 100, or 150 lbs-N/acre**
  during **January and August** through fertigation

Subplots (3 levels):
- Basal fertilizer; **none, compost 5 tons/acre, or feather meal 50 lbs-N/acre**

Reps: 4, Total plots: 36
Cumulative Marketable Fruit Yield

Supplemental N Treatment

Marketable Fruit Yield grams/plant

Supplemental N Treatment

Marketable Fruit Yield grams/plant

Supplemental N Treatment

Marketable Fruit Yield grams/plant

None

Feather Meal

Compost

Cumulative Marketable Fruit Yield

50 lbs

100 lbs

150 lbs

Supplemental N Treatment

Marketable Fruit Yield grams/plant

50 lbs

100 lbs

150 lbs

Supplemental N Treatment

Marketable Fruit Yield grams/plant

50 lbs

100 lbs

150 lbs

Supplemental N Treatment

Marketable Fruit Yield grams/plant

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100 lbs

150 lbs

Supplemental N Treatment

Marketable Fruit Yield grams/plant

50 lbs

100 lbs

150 lbs

Supplemental N Treatment

Marketable Fruit Yield grams/plant

50 lbs

100 lbs

150 lbs

Supplemental N Treatment
Soil Inorganic N: 10/11/05
[Pre-fertilizer application]

Average of Inorg. N lbs/acre-30cm dry soil

Main plot
Split plot
Depth cm

Drop More Series Fields Here
### Soil Inorganic N: 12/09/05

[5 weeks after planting]

<table>
<thead>
<tr>
<th>Depth cm</th>
<th>0-30</th>
<th>30-60</th>
</tr>
</thead>
<tbody>
<tr>
<td>1_None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2_Compost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3_Feather meal</td>
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</tbody>
</table>

**Average of Inorg N lbs/A**

- **Main plot**
- **Split plot**
- **Depth cm**
Soil Inorganic N: 01/30/06
[12 weeks after planting]

Average of Inorg N lbs/A

Main plot
Split plot
Depth cm
Soil Inorganic N: 03/10/06
[18 weeks after planting]

Average of Inorg N lbs/A

Main plot
Split plot
Depth cm

0-30 30-60
1_50 lbs-N 2_100 lbs-N 3_150 lbs-N
1_None 2_Compost 3_Feather meal
Site 1: Redman Farm, Watsonville, Yr 2 (2006-07)

– Steve Pedersen @ High Ground Organics
– Soil type: Clear lake clay
– Variety: Seascape

Main plots (3 levels):
– Supplemental N application; 75, 150, or 225 lbs-N/acre during March and July through fertigation

Subplots (3 levels):
– Basal fertilizer; Sudan grass roots, Sudan grass whole plants, or compost 10 tons/acre

Reps: 4, Total plots: 36
Site 2: Farris Ranch, Watsonville, Yr 1 (2007-08)

- Reiter and Driscoll’s. (Kevin Healy and Fred Cook)
- Soil type: Canejo loam
- Varieties: Seascape, Albion, Two Driscoll’s varieties,

Main plots (3 levels):
- Supplemental N application; **0, 150, or 300 lbs-N/acre***
during **March and October*** through fertigation
  (*tentative. for Seascape only)

Subplots (3 levels):
- Basal fertilizer; **None, Blood meal 75 lbs-N/acre, or Blood meal 150 lbs-N/acre**

Reps: 4, Total plots: 36
Summary

- In the first site, pre-plant N (compost, cover crop, or feather meal) and supplemental N rates tested did not affect marketable fruit yield significantly during the two-year trails in an organic farm.

- Currently testing different rates of pre-plant and supplemental N in the second site.
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Questions?

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