2019 Strawberry Preplant meeting

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Farm Planning

✓ Put sufficient time and thought into planning process.
✓ Know your farm operations well.

Questions to ask yourself:

- Do I have the labor to manage strawberry production from start to finish?
- Do I have a market where I can sell berries?
- In the past three years, have I been able to sell majority of berries produced?
- Are there berries that go unpicked at my site each year?
- What has been the average profit I made in the past three years with berry production?
- What are pest issues that I faced in the past three years?
Planning for Commercial Strawberry Production

Site selection

Row orientation: North-South

Wildlife

Windbreaks
Soils
- Sandy loam to sandy clay-loam.
  Clay or rocky soils difficult to bed.
- pH 6.0 to 6.2.
- Slope of 5 to 7% ideal.
- Avoid sites previously under cultivation with tomato, potato, or eggplant.

Soil amendment and nutrient management:
- Soil test to determine how much limestone needs added.
- Apply 60 lbs N, 60 lbs P$_2$O$_5$ and 120 lbs K$_2$O/acre at preplant if no soil test conducted.
Fumigation

- Annual plasticulture gaining popularity
  - Raised beds
  - Plastic mulch
  - Preplant fumigants

- What is fumigation?
  **Fumigation** is a method to suffocate or poison pests by filling an area with gaseous pesticides.

In the raised beds, fumigation is achieved by:
- Covering the beds with plastic layer.
- Injecting fumigant through the sub-surface (drip) irrigation system or with shanks on a bedder.
- Keeping the fumigant trapped in the soil air space to kill pests.
Bed dimensions

Shallow beds (≤ 4 inch high)
- Can cause temporary flooding.
- Promote crown and root rot.
- Increase incidences of leaf spots and mildew.
- Exposure to standing water at harvest season can result in mushy fruits.
Plant spacing

- 12 Inches = 17,500 plants/A
- 14 Inches = 15,000 plants/A
- 15 Inches = 14,000 plants/A
Planting depths - Left: Too shallow; Center: Correct; Right: Too deep
Cover crop.

Annual ryegrass at 50 lbs/A
<table>
<thead>
<tr>
<th>Activity</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collect soil samples for nutrient analysis</td>
<td>July, week 4</td>
</tr>
<tr>
<td>Delivery of fumigants, check fumigant equipment</td>
<td>Aug., week 1</td>
</tr>
<tr>
<td>Broadcast N-P-K in accordance with soil nutrient results. Disk to 6 inches depth.</td>
<td>Aug., week 2</td>
</tr>
<tr>
<td>Bed shaping. Fumigating + laying plastic and drip</td>
<td>Aug., week 3</td>
</tr>
<tr>
<td>Transplant</td>
<td>Sept., week 2</td>
</tr>
<tr>
<td>Do not remove runners for three to four weeks after transplanting.</td>
<td></td>
</tr>
</tbody>
</table>
Crown and branch

Oct-Nov. with average temp. of 50 F

Vigorous variety: 5-6 crowns by fruiting season
Less vigorous: 4-5 crowns by fruiting season

Leaf

Plant should have 3-4 fully green leaves after the 3 to 4-wk establishment period. 10 leaves by mid-Dec. and 8-inch plant dia.

One can correlate between yield and no. of leaves and total plant area in late fall/early winter.

Roots

Soil temp. above 45 F promotes root growth and health.

Prevent drying of beds/water stress during establishment phase.
Current Research
ASD 3-Steps

- Incorporate organic material (Optimal C:N 20:1 to 30:1, recommend C rate 4mg/g soil).
- Cover with oxygen impermeable tarp.
- Irrigate to field capacity.
ASD mechanisms

- Accumulation of **toxic/suppressive products** deriving from the anaerobic decomposition (e.g. organic acids, volatile organic compounds)
- Biological control by facultative anaerobic microorganisms
- Low pH
- Low oxygen
- Generation of Fe$^{2+}$ and Mn$^{2+}$ ions
- Combination of all of these
Objectives

- Evaluate the effect of **local carbon sources** in ASD treatments under controlled greenhouse environments.
- Evaluate the **optimized ASD methods** in field condition with tested C source.
- Provide relatively inexpensive, consistent and effective **ASD recommendation** for strawberry growers in Virginia and mid-Atlantic conditions.
Hypotheses

- Enhance ASD effect

  Hypothesis: distilled yeast could enhance the efficiency of carbon sources in achieving ASD.

  1. Bioethanol fermentation could be conducted in field using forage crop with enzymes (Honda et al., 2008 and Kitamoto et al., 2011).

  2. Residual organic substances in the bioethanol fermentation products enhanced the effect of the ASD treatment (Horita & Kitamoto, 2015).

  3. BSG could be used to produce bioethanol (Liguori et al., 2015).
Material and Method

**Greenhouse**
- Determine proper C source
- Focus on Eh, pH, T, weed control, nematode bioassays
- Site: AREC

**Small-scale trial**
- Evaluate effect of C source in field
- Focus on weed control, crop yield and fruit quality
- Site: AREC

**Large-scale trial**
- Extended field test
- Focus on yield and cost
- Site: Conventional Farms
Experimental design

- Completely Randomized Design
- Four replicates
- Experiment unit: bioreactor
- Experiment period: 3 weeks

[Diagram of bioreactor with ORP sensor, VIF (Virtually impermeable film), weed inoculum bag 1 and 2, bone voile fabric, and temp sensor.]

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Measurements

- **Redox Potential (Eh)**
  Cumulative soil anaerobicity (mV · hr)
  \[ \sum |Eh - CEh(\text{critical redox potential})| \]

- **Temperature**

* Data were recorded every hour for 3wks
Weed count

Yellow nutsedge (*Cyperus esculentus*) 10 tubers/bag
White clover (*Trifolium repens*) 100 seeds/bag
Redroot pigweed (*Amaranthus retroflexus*) 100 seeds/bag
Common chickweed (*Stellaria media* (L.) Vill.) 100 seeds/bag

*The non-germinated seeds were treated by Tetrazolium Chloride (TZ) test, and then counted.*
## Treatments

**Trial 1 Evaluation of local carbon sources**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Weight per Container (g)</th>
<th>Weight per Acre (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Sorghum-sudangrass</td>
<td>67g</td>
<td>6.4</td>
</tr>
<tr>
<td>2 Cowpea</td>
<td>74g</td>
<td>7.2</td>
</tr>
<tr>
<td>3 Buckwheat</td>
<td>80g</td>
<td>7.6</td>
</tr>
<tr>
<td>4 Paper mulch</td>
<td>32g</td>
<td>3.1</td>
</tr>
<tr>
<td>5 Rice bran</td>
<td>63g</td>
<td>5.9</td>
</tr>
<tr>
<td>6 Nontreated control (NTC)</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

* C rate 4 mg of C/g of soil
Trial 2-1 Evaluation of C-source combined with ethanol

1 Brewer`s spent grain (half dose,32g/pot 3t/acre) + 70% ethanol 50ml applied at 1 wk
2 Brewer`s spent grain (full dose,64g/pot 6t/acre)
3 Coffee ground (half dose,56g/pot 5t/acre) + 70% ethanol 50ml applied at 1 wk
4 Coffee ground (full dose,112g/pot 10t/acre)
5 Paper mulch (half dose,16g/pot 1.5t/acre) + 70% ethanol 50ml applied at 1 wk
6 Paper mulch (full dose,32g/pot 3.1t/acre)
7 Rice bran(half dose,32g/pot 3t/acre) + 70% ethanol 50ml applied at 1 wk
8 Rice bran(full dose,63g/pot 5.9t/acre)
9 NTC

* C rate full dose=4 mg of C/g of soil
Trial 2-2 Evaluation of bioethanol fermentation during ASD

1. Brewer`s spent grain (BSG) + yeast
2. Brewer`s spent grain
3. Coffee ground + yeast
4. Coffee ground
5. Paper mulch + yeast
6. Paper mulch
7. Peanut shell + yeast
8. Peanut shell
9. Rice bran + yeast
10. Rice bran
11. NTC

* C rate 4 mg of C/g of soil    Yeast rate 4.1kg/acre
<table>
<thead>
<tr>
<th>Carbon source or yeast</th>
<th>Average Carbon source Carbon rate</th>
<th>Weight (g/pot)</th>
<th>Weight (t/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum-Sudangrass</td>
<td>0.42</td>
<td>67g</td>
<td>6.4</td>
</tr>
<tr>
<td>Cowpea</td>
<td>0.37</td>
<td>74g</td>
<td>7.2</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>0.35</td>
<td>80g</td>
<td>7.6</td>
</tr>
<tr>
<td>Paper mulch</td>
<td>0.87</td>
<td>32g</td>
<td>3.1</td>
</tr>
<tr>
<td>Brewer`s spent grain</td>
<td>0.44</td>
<td>64g</td>
<td>6.0</td>
</tr>
<tr>
<td>Rice bran</td>
<td>0.45</td>
<td>63g</td>
<td>5.9</td>
</tr>
<tr>
<td>Coffee ground</td>
<td>0.25</td>
<td>112g</td>
<td>10.6</td>
</tr>
<tr>
<td>Peanut shell</td>
<td>0.45</td>
<td>63g</td>
<td>5.9</td>
</tr>
<tr>
<td>Distiller`s dry yeast</td>
<td>0.06g/pot</td>
<td>4.1kg/acre</td>
<td></td>
</tr>
</tbody>
</table>
Results
Table 1. Weed germination rates and cumulative soil anaerobic conditions after anaerobic soil disinfestation (ASD) process with several different carbon sources.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Weed germination rate (%)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Cumulative soil anaerobic conditions (V hr)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Mean temperature(°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Common chickweed</td>
<td>Redroot pigweed</td>
<td></td>
</tr>
<tr>
<td>Buckwheat 80 g</td>
<td>23.0 b</td>
<td>24.0 b</td>
<td>159 ab</td>
</tr>
<tr>
<td>Cowpea 74 g</td>
<td>34.0 b</td>
<td>33.2 b</td>
<td>261 a</td>
</tr>
<tr>
<td>Velvet bean 56 g</td>
<td>32.2 b</td>
<td>26.7 b</td>
<td>100 ab</td>
</tr>
<tr>
<td>Paper mulch 32 g</td>
<td>22.5 b</td>
<td>22.6 b</td>
<td>179 a</td>
</tr>
<tr>
<td>Rice bran 63 g</td>
<td>21.1 b</td>
<td>20.0 b</td>
<td>226 a</td>
</tr>
<tr>
<td>Non-treated control</td>
<td>68.6 a</td>
<td>66.7 a</td>
<td>0 c</td>
</tr>
<tr>
<td>P value</td>
<td>0.010</td>
<td>0.007</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

<sup>a</sup> Means followed by different letters within a column are statistically different using least significance difference at P≤0.05.
Table 2. Weed germination rates and cumulative soil anaerobic conditions after anaerobic soil disinfestation (ASD) process with several different carbon sources and ethanol application.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Weed germination rate (%)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Cumulative soil anaerobic condition (V hr)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Mean temperature(°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common chickweed</td>
<td>Common chickweed</td>
<td>Redroot pigweed</td>
<td>Yellow nutsedge</td>
</tr>
<tr>
<td>Brewer’s spent grain 64 g</td>
<td>22.2 b</td>
<td>24.5 bc</td>
<td>25.0 bc</td>
</tr>
<tr>
<td>Brewer’s spent grain 32 g + 70% ethanol 50 ml</td>
<td>14.0 c</td>
<td>11.9 e</td>
<td>28.8 b</td>
</tr>
<tr>
<td>Paper mulch 32 g</td>
<td>19.5 bc</td>
<td>22.3 bcd</td>
<td>10.0 bc</td>
</tr>
<tr>
<td>Paper mulch 16 g + 70% ethanol 50 ml</td>
<td>17.5 bc</td>
<td>18.9 bcde</td>
<td>5.0 bc</td>
</tr>
<tr>
<td>Rice bran 63 g</td>
<td>15.5 bc</td>
<td>15.2 de</td>
<td>0 c</td>
</tr>
<tr>
<td>Rice bran 31 g + 70% ethanol 50 ml</td>
<td>11.5 c</td>
<td>11.8 e</td>
<td>11.3 bc</td>
</tr>
<tr>
<td>Non-treated control</td>
<td>83.8 a</td>
<td>85.2 a</td>
<td>74.4 a</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

<sup>a</sup> Means followed by different letters within a column are statistically different using least significance difference at P<0.05.
<table>
<thead>
<tr>
<th>Treatments</th>
<th>Common chickweed</th>
<th>Redroot pigweed</th>
<th>White clover</th>
<th>Yellow nutsedge</th>
<th>Cumulative soil anaerobic conditions (V hr)</th>
<th>Mean temperature(°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brewer’s spent grain 64 g</td>
<td>22.0 de</td>
<td>25.5 cd</td>
<td>21.3 bcd</td>
<td>7.5 c</td>
<td>195 a</td>
<td>22.4 a</td>
</tr>
<tr>
<td>Brewer’s spent grain 64 g+ 0.06 g yeast</td>
<td>17.5 ef</td>
<td>19.5 e</td>
<td>10.8 ef</td>
<td>0 d</td>
<td>191 a</td>
<td>21.9 ab</td>
</tr>
<tr>
<td>Coffee grounds 112 g</td>
<td>34.0 b</td>
<td>33.7 b</td>
<td>28.5 b</td>
<td>22.5 b</td>
<td>165 ab</td>
<td>20.7 b</td>
</tr>
<tr>
<td>Coffee grounds 112 g+ 0.06 g yeast</td>
<td>23.0 d</td>
<td>20.0 de</td>
<td>18.0 cde</td>
<td>0 d</td>
<td>116 ab</td>
<td>22.0 ab</td>
</tr>
<tr>
<td>Paper mulch 32 g 32 g</td>
<td>31.5 bc</td>
<td>26.5 c</td>
<td>15.0 def</td>
<td>0 d</td>
<td>91 ab</td>
<td>22.2 ab</td>
</tr>
<tr>
<td>Paper mulch 32 g+ 0.06 g yeast</td>
<td>29.5 bc</td>
<td>25.5 cd</td>
<td>10.0 ef</td>
<td>0 d</td>
<td>51 bc</td>
<td>22.0 a</td>
</tr>
<tr>
<td>Peanut shell 63 g</td>
<td>23.3 d</td>
<td>20.5 de</td>
<td>16.5 def</td>
<td>0 d</td>
<td>80 bc</td>
<td>22.0 ab</td>
</tr>
<tr>
<td>Peanut shell 63 g+ 0.06 g yeast</td>
<td>14.5 f</td>
<td>17.5 e</td>
<td>8.3 f</td>
<td>0 d</td>
<td>206 a</td>
<td>22.2 a</td>
</tr>
<tr>
<td>Rice bran 63 g</td>
<td>28.5 c</td>
<td>26.5 c</td>
<td>26.5 bc</td>
<td>0 d</td>
<td>154 ab</td>
<td>22.1 a</td>
</tr>
<tr>
<td>Rice bran 63 g + 0.06 g yeast</td>
<td>21.5 de</td>
<td>19.5 c</td>
<td>11.0 ef</td>
<td>0 d</td>
<td>103 ab</td>
<td>22.1 ab</td>
</tr>
<tr>
<td>Non-treated control</td>
<td>83.3 a</td>
<td>86.5 a</td>
<td>72.8 a</td>
<td>80.0 a</td>
<td>3.4 c</td>
<td>22.29 a</td>
</tr>
<tr>
<td><strong>P value</strong></td>
<td><strong>&lt;0.0001</strong></td>
<td><strong>&lt;0.0001</strong></td>
<td><strong>&lt;0.0001</strong></td>
<td><strong>&lt;0.0001</strong></td>
<td><strong>&lt;0.0001</strong></td>
<td></td>
</tr>
</tbody>
</table>
Summary

1. Distiller`s dry yeast had potential to enhance ASD effect using C source such as rice bran
2. Proper C sources or C sources combination candidates:
   - Paper mulch
   - Peanut hull (& yeast)
   - Coffee ground & yeast
   - Brewer`s spent grain & yeast
Information from greenhouse trial

- The yeast application had significance effect for ASD on the suppression of weeds.
- The yeast application significantly enhanced the weed suppression effect for treatments using brewer`s spent grain, coffee ground and rice bran as carbon source.
- Yeast had non significant effect on ASD treatments using paper mulch as carbon source and had inconsistent effect on treatments using peanut shell as carbon source.
- Brewer`s spent grain, coffee ground and peanut shell, and those carbon sources with yeast had comparable results on weed controlling as rice bran, or even better than rice bran, which indicate those three carbon sources would be proper carbon sources for ASD.
Basing on cost and localization consideration, brewer`s spent grain with yeast would be recommended choice for further field trial, because:

1. brewer`s spent grain could get from local brewery for free;
2. there are over 100 craft breweries in Virginia with an increasing trend recent 6 years;
3. brewer`s spent grain as a main waste from brewery, could be provided regardless of season;
4. brewer`s spent grain with yeast had better effect compared to coffee ground, and consistent yeast effect compared to peanut shell.
Treatments, Small-Scale Field Trial

1. Fumigant (Pic-Clor-80, 290lbs/acre)
2. Brewer’s Spent Grain 6 ton/acre + Yeast
3. Brewer’s Spent Grain 3 ton/acre soil + Yeast
4. Brewer’s Spent Grain 6 ton/acre soil No Yeast
5. Brewer’s Spent Grain 3 ton/acre soil No Yeast
6. Non-treated + Yeast
7. Non-treated No Yeast

* Yeast application rate: 9.1 lbs/acre, cost $72.8/acre
Brewer’s spent grain could get for free
Distillers Active Dry Yeast

- A specially selected strain of *Saccharomyces Cerevisae* designed for distillers use in grain mash fermentations for ethanol.
- DADY will produce maximum alcohol yields under controlled temperatures (around 90 F).
- It has been the choice of many producers in North America for over 20 years.
- It has been used for the manufacture of light spirit and Whiskeys. It is also used on corn mash and syrup fermentations.
- Cost $8 /lb
Timeline

- ASD C source apply: Aug 14 2018
- Fumigant applied: Aug 17 2018
- ASD-irrigation: Aug 24 2018
- Post-ASD break: Sep 17 2018
- Strawberry plugs transplanting: Oct 3 2018
- Weed count: Nov 2018-Mar 2019
- Harvest: Apr 2019-June 2019
Bacterial endophyte study- *Bacillus velezensis*

Bacillus species are ubiquitous and of great economic importance
- Ability to colonize plants
- Produce spores, biofilms and antibiotics
- Induce synthesis of plant hormones

Dr. Chuansheng Mei
Chuansheng.Mei@ialr.org
The Institute of Advanced Learning and Research
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marketable yield (g/plant)</th>
<th>Total Yield (g/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. <em>velezensis</em> IALR 619</td>
<td>270 (+12%)</td>
<td>343 (+11%)</td>
</tr>
<tr>
<td>B. <em>velezensis</em> IALR 585</td>
<td>231</td>
<td>300</td>
</tr>
<tr>
<td>B. <em>velezensis</em> IALR 308</td>
<td>220</td>
<td>298</td>
</tr>
<tr>
<td>3 B. sp. Combo</td>
<td>206</td>
<td>300</td>
</tr>
<tr>
<td>Untreated</td>
<td>241</td>
<td>310</td>
</tr>
</tbody>
</table>
## Aaron’s Creek Farms

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marketable yield (g/plant)</th>
<th>Total Yield (g/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. sp. 619</td>
<td>336 (+15%)</td>
<td>355 (+17%)</td>
</tr>
<tr>
<td>B. sp. 585</td>
<td>264</td>
<td>264</td>
</tr>
<tr>
<td>B. sp. 308</td>
<td>280</td>
<td>294</td>
</tr>
<tr>
<td>3 B. sp. Combo</td>
<td>210</td>
<td>223</td>
</tr>
<tr>
<td>Untreated</td>
<td>293</td>
<td>303</td>
</tr>
</tbody>
</table>
## Greenbrier Farms

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marketable yield (g/plant)</th>
<th>Total Yield (g/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. sp. 619</td>
<td>104 (+8 %)</td>
<td>170 (+15%)</td>
</tr>
<tr>
<td>B. sp. 585</td>
<td>105</td>
<td>170</td>
</tr>
<tr>
<td>B. sp. 308</td>
<td>132</td>
<td>195</td>
</tr>
<tr>
<td>3 B. sp. Combo</td>
<td>126</td>
<td>206</td>
</tr>
<tr>
<td>Untreated</td>
<td>96</td>
<td>148</td>
</tr>
</tbody>
</table>
Acknowledgements

Danyang Liu
Dr. Charles Johnson
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Spencer Irby

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Dr. Scott Lowman

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Philip Morris International.
Small Fruit

This page focuses on crop production and marketing aspects pertaining to small fruits (strawberry, blueberry, blackberry, raspberry, and other exotic berries). Information on cultivar recommendations, cultural practices including pruning, training, and trellising, plant and soil sanitation practices, and pest management can be found here.

Featured Publications

- 2014 Southeast Regional Strawberry Integrated Management Guide
- 2014 Southeast Regional Cranberries Integrated Management Guide
- Breeding and Production Physiology at UC Davis, Department of Plant Sciences

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