LARGE SCALE DEMONSTRATION TRIALING OF METHYL BROMIDE ALTERNATIVES IN FLORIDA STRAWBERRY

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OBJECTIVES:

This USDA ARS South Atlantic Area wide Project was funded to:

Demonstrate and improve the performance and consistency of MBr alternatives in large scale grower field demonstration trials in Florida Strawberries.
~ 0.1 acres (4 reps / trtmt)

Table 1. Proposed treatments for FSGA Fall 2011. One of five experimental objectives (OBS).

<table>
<thead>
<tr>
<th>Fall 2010 Treatment</th>
<th>Spring 2011 Crop Termination Treatment</th>
<th>Fall 2011 Treatment</th>
<th>OBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW PLASTIC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>MBr 50/50 Blockade 1 tape</td>
<td>No treatment</td>
<td>1, 3, 5</td>
</tr>
<tr>
<td>2</td>
<td>MBr 50/50 Blockade 2 tapes</td>
<td>No treatment</td>
<td>1, 3</td>
</tr>
<tr>
<td>3</td>
<td>Telone C35 Blockade 1 tape</td>
<td>Telone EC</td>
<td>1, 2, 4, 5</td>
</tr>
<tr>
<td>4</td>
<td>Telone C35 Blockade 2 tape</td>
<td>Telone EC</td>
<td>1, 2, 4, 5</td>
</tr>
<tr>
<td>5</td>
<td>PicCor 60 Blockade 1 tape</td>
<td>Telone EC</td>
<td>1, 2, 4, 5</td>
</tr>
<tr>
<td>6</td>
<td>PicCor 60 Blockade 2 tape</td>
<td>Telone EC</td>
<td>1, 2, 4, 5</td>
</tr>
</tbody>
</table>

Strawberry Double Cropping (strawberry after strawberry) - OLD PLASTIC

| 7                   | Telone Inline LDPE 1 tape               | Telone EC           | 1, 2, 3 |
| 8                   | Telone Inline LDPE 2 tape               | Telone EC           | 1, 2, 3 |
| 9                   | PicCor 60 EC LDPE 1 tape                | Roundup Herbicide  | 2, 3 |
| 10                  | PicCor 60 EC LDPE 2 tapes               | Roundup Herbicide  | 2, 3 |
| 11                  | Kpam LDPE 1 tape                        | Kpam                | 1, 2, 3 |
| 12                  | Kpam LDPE 2 tapes                       | Kpam                | 1, 2, 3 |
| 13                  | Vapam LDPE 1 tape                       | Vapam               | 1, 2, 3 |
| 14                  | Vapam LDPE 2 tapes                      | Vapam               | 1, 2, 3 |
| 15                  | Check LDPE 1 tape                       | Roundup Herbicide  | 1, 2, 3 |
| 16                  | Check LDPE 2 tapes                      | Roundup Herbicide  | 1, 2, 3 |

1. Long-term impacts / consequences of using Kpam, Vapam, Inline, Telone C35, Check, MBr 50/50
2. Value of crop destruct w/drip fumigant compared to top-down herbicide or simple tillage
3. Value of 2nd drip tape (includes both horticultural and fumigation effects)
4. Value of thermal heating of using black, double cropped plastic mulch
5. Value of new, commercial fumigant product (PaladinPic)
Figure 1. Comparison of shank applied DMDS + PIC (60 gpta), and Telone C35 (40 gpta) or drip applied Telone Inline (42 gpta), with or without spring drip fumigation / crop termination treatment with Telone EC (12 gpa), KPaM (60 gpta), Vapam (75 gpta), and compared with an untreated control and Methyl bromide Chloropicrin 50/50 (320 lb/ta) under VIF Plant Blockade on strawberry yield (cv. Festival) at the Florida Strawberry Growers Association Farm, Dover, FL. 2011-12.

### Spring
- No Treatment: Check-Old Plastic 2 tapes
- Vapam 75 gpta: Vapam-75 gpta - Old Plastic 2 tapes
- Vapam 75 gpta: Vapam-75 gpta - Old Plastic 1 tape
- KPaM 60 gpta: KPaM-60 gpta - Old Plastic 2 tapes
- KPaM 60 gpta: KPaM-60 gpta - Old Plastic 1 tape
- Roundup: Inline-42 gpta - Old Plastic 2 tapes
- Roundup: Inline-42 gpta - Old Plastic 1 tape
- Telone EC 12 gpa: Telone Inline-42 gpta - Old Plastic 2 tapes
- Telone EC 12 gpa: Telone Inline-42 gpta - Old Plastic 1 tape
- No Treatment: DMDS + PIC - 60 gpta - VIF
- Telone EC 12 gpa: Pull August
- Telone C35 - 40 gpta - LDPE
- No Treatment: Telone C35 - 40 gpta - VIF
- Telone EC 12 gpa: Telone C35 - 40 gpta - LDPE
- No Treatment: Mbr 50/50 - 333 lb/ta - VIF - 2 tapes
- No Treatment: Mbr 50/50 - 333 lb/ta - VIF - 1 tape

### Fall

![Graph showing strawberry yield comparison](image)

If you do nothing!
### USDA ARS Areawide Strawberry Project - FSGA 2011-12

**Charcoal Root Rot Plant Mortality**

- *Macrophomina phaseolina*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mortality (Number Plants Killed / 40 feet of row)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated - LDPE - T1</td>
<td>a</td>
</tr>
<tr>
<td>Untreated - LDPE - T2</td>
<td>b</td>
</tr>
<tr>
<td>Inline (42 gpt/a) - no spring crop destruct - LDPE - T1</td>
<td>c</td>
</tr>
<tr>
<td>Inline (42 gpt/a) - spring crop destruct - LDPE - T1</td>
<td>d</td>
</tr>
<tr>
<td>Inline (42 gpt/a) - no spring crop destruct - LDPE - T2</td>
<td>e</td>
</tr>
<tr>
<td>Inline (42 gpt/a) - spring crop destruct - LDPE - T2</td>
<td>f</td>
</tr>
<tr>
<td>Kpam (60 gpt/a) - LDPE - T1</td>
<td>g</td>
</tr>
<tr>
<td>Vapam (75 gpt/a) - LDPE - T1</td>
<td>h</td>
</tr>
<tr>
<td>Telone C35 (40 gpt/a) - LDPE - T1</td>
<td>i</td>
</tr>
<tr>
<td>Telone C35 (40 gpt/a) - LDPE (plastic pulled late) - T1</td>
<td>j</td>
</tr>
<tr>
<td>Vapam (75 gpt/a) - LDPE - T2</td>
<td>k</td>
</tr>
<tr>
<td>DMDS + PIC (60 gpt/a) - PIC - VIF - T1</td>
<td>l</td>
</tr>
<tr>
<td>Kpam (60 gpt/a) - LDPE - T2</td>
<td>m</td>
</tr>
<tr>
<td>Telone C35 (40 gpt/a) - VIF - T1</td>
<td>n</td>
</tr>
<tr>
<td>Methyl Bromide 50/50 (333 lb/ta) - VIF - T2</td>
<td>X: 17.495</td>
</tr>
<tr>
<td>Methyl Bromide 50/50 (333 lb/ta) - VIF - T1</td>
<td>Y: 3.79326</td>
</tr>
</tbody>
</table>

**Figure 4.** Comparison of shank applied DMDS + PIC (60 gpt/a), Telone C35 (40 gpt/a) and drip applied Telone Inline (42 gpt/a), Vapam (75 gpt/a), or KPam (60 gpt/a) with or without spring drip fumigation / crop termination treatment with Vapam (75 gpt/a), KPam (60 gpt/a) or Telone EC (12 gpt/a), and compared with an untreated control and Methyl bromide Chloropicrin 50/50 (320 lb/ta) on Charcoal Root rot induced plant mortality (cv. Festival) at the FSGA Farm, Dover, FL. 2011-12.
How do drip fumigant treatments seem to work when water/gas phase don't reach bed shoulders?

DAILY TEMPERATURE, 8" SOIL DEPTH, WEST SIDE OF BED LOCATION
With and Without a holey plastic covering the raised bed
Double Cropping after a Summer Long Stale Bed

Max vs. Min Soil Temperature Hobo N6b
FSGA June - Aug 2011

Under holey Mulch - West Side of Bed 8" deep

No Mulch Cover - West Side of Bed 8" deep

drenching rain events

Calendar Day
Because nematodes may not be killed by a fumigant which does not reach the shoulder in either water or gas phase, they may just likely die of Heat Stress and or starvation anyway.

Applications may not have to be perfect if beds are allowed to bake in the sun all summer long.
Two Experiments
- 4 shank applied fumigants
- 4 drip fumigation Treatments

Min. plot size 0.16 acres
Each 4 treatments x 4 reps
Top-Down vs Bottom-Up Spring Crop Termination (Paraquat, Telone EC) Summer Heating of Double Crop Stale Beds (w and w/o new plastic)

Figure 1. Comparison of shank applied DMDS + PIC (60 gpta) and Telone C35 (40 gpta), with or without a spring drip fumigation/crop termination treatment with Telone EC (12 gpa), and compared with an untreated control and Methyl bromide Chloropicrin 50/50 (320 lb/ta) under VIF Plant Blockade on strawberry yield (cv. Festival) at the Florida Strawberry Growers Association Farm, Dover, FL 2011-12. Most plastic mulch was removed in April, one treatment was removed in August.

Table 2. Treatments within USDA Large Scale Field Demonstration Plots at Ferris, Florida Pacific, Favorite, and FSGA Farms 2011-2012 strawberry production season.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Double Crop</th>
<th>Spring Crop Termination</th>
<th>Remove Plastic After Spring Crop Termination</th>
<th>Summer Treatment</th>
<th>Plastic Mulch</th>
<th>Fall Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>Paraquat</td>
<td>No</td>
<td>Holey Black Solarization</td>
<td>Old</td>
<td>Telone Inline</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>Telone EC</td>
<td>No</td>
<td>Holey Black Solarization</td>
<td>Old</td>
<td>Telone Inline</td>
</tr>
<tr>
<td>3</td>
<td>Yes</td>
<td>Paraquat</td>
<td>Yes</td>
<td>Holey Black Solarization</td>
<td>New on Old bed</td>
<td>Telone Inline</td>
</tr>
<tr>
<td>4</td>
<td>Yes</td>
<td>Telone EC</td>
<td>Yes</td>
<td>Holey Black Solarization</td>
<td>Old</td>
<td>Telone Inline</td>
</tr>
<tr>
<td>5</td>
<td>No</td>
<td>Paraquat</td>
<td>No</td>
<td>Holey Black Solarization</td>
<td>New on New bed</td>
<td>Telone Inline</td>
</tr>
<tr>
<td>6</td>
<td>No</td>
<td>Telone EC</td>
<td>No</td>
<td>Holey Black Solarization</td>
<td>New on New bed</td>
<td>Telone Inline</td>
</tr>
<tr>
<td>7</td>
<td>No</td>
<td>Paraquat</td>
<td>Yes</td>
<td>Summer Weed Fallow / disked</td>
<td>New on New bed</td>
<td>Telone Inline</td>
</tr>
<tr>
<td>8</td>
<td>No</td>
<td>Telone EC</td>
<td>No</td>
<td>Summer Weed Fallow / disked</td>
<td>New on New bed</td>
<td>Telone Inline</td>
</tr>
</tbody>
</table>

Experimental Objectives:
1) contrast top down vs. bottom up crop termination (Foliar w Paraquat vs. Roots w/ drip Telone EC)
2) Evaluate benefits of summer solarization period for nematode management under black, holey, black plastic
3) Evaluate fall double crop treatments under new plastic with Telone Inline and Telone C35

Unfortunately little to no nematode, disease, weed pressures
Ferris Farms – Floral City, FL  2011-2012

A Double Crop / Fumigant effect!

- **Drip Fumigation**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Strawberry Yield (lb/25 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBr 50/50 (320 lb/ta)</td>
<td>1 tape/bed New Plastic</td>
</tr>
<tr>
<td>MBr 50/50 (320 lb/ta)</td>
<td>2 tape/bed New Plastic</td>
</tr>
<tr>
<td>Inline (35 gal/ta)</td>
<td>1 tape/bed Double Crop</td>
</tr>
<tr>
<td>Inline (35 gal/ta)</td>
<td>2 tape/bed Double Crop</td>
</tr>
</tbody>
</table>

Fumigant  $P \leq 0.001$
Drip Tape  $P \leq 0.821$

* Does not factor possible double crop effect independent of fumigant

Thank you Al Herndon, Dudley Calfee, Ferris Farms
Trimble NDVI ‘GreenSeekers’

Laptop controlling Data Acquisition

Trimble ‘Nomad’
Variable Rate Controller

Maps to indicate where they occur and yield maps to estimate impacts
The Greenseeker® NDVI sensor
Trimble (formerly NTECH Industries, Ukiah, Ca)

- The Greenseeker uses its own light source
- Normalized Difference Vegetation Index (NDVI)
  \[ NDVI = \frac{(NIR - Red)}{(NIR + Red)} \]

Emits light at two wavelengths, measures reflectances, computes and outputs NDVI, a measure of the **amount** and vigor of **green** plant canopy cover in its view.

Healthy plants reflect more NIR

Multi-Sensor Systems

Yield Estimation

Mapping
Ground Truthing Sting efficacy and treatment performance

PLANT SIZE DISTRIBUTIONS enumerated for All Fields and Chemical Treatments by Row and Sprinkler Section

40 - 50 feet row

<table>
<thead>
<tr>
<th>Size</th>
<th>Canopy Diameter</th>
<th>Relative Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>&lt; 8 ”</td>
<td>17%</td>
</tr>
<tr>
<td>Medium</td>
<td>&lt;12 ”</td>
<td>48%</td>
</tr>
<tr>
<td>Large</td>
<td>&gt;12 ”</td>
<td>100%</td>
</tr>
</tbody>
</table>

and Dead = 0 %

RELATIVE YIELD computed as the sum contribution from all plant of different sizes within each sprinkler section.
Differentiating Alternative Treatments

NDVI Mapping / Performance Testing of Nematode Management Tactics

Example of color coded NDVI output distinguishing performance of methyl bromide alternatives with NDVI measurement in a grower field demonstration trial. Spring 2008.

NDVI Legend: Green = large plants, white = medium plants, Red = small/dead plants
Evaluating the Methodology – Berry Yield vs NDVI

Yield and NDVI well Correlated!
Evaluating the Methodology – Relative Yield vs NDVI

Charlie Young West Packinghouse Field
Dover, FL  April 2012

Equation: 2 Parameter, Power

\[ f = a \cdot x^b \]

\[ r^2 = 90.2\% \]

The effect of subsoil delivery of:
Telone II (18 gpa)
Injected 20 inches deep
2 years after application
The effect of subsoil delivery of:
Telone II (18 gpa)
Injected 20 inches deep
2 years after application
Evaluating the Methodology – Treatment Evaluation

Chloropicrin EC
It speaks for itself!

Red implies severely stunted / Dead Plants
White implies less severe levels of stunting

Florida Pacific - Mopra's Lake Horsham Field
March 2012

Relative Yield (0-1)
Evaluating the Methodology – Treatment Evaluation
12 rows / 2 farm locations - new Chitin Product

MBFF Location 2011-2012

SSF Location 2011-2012

Red implies severely stunted / Dead Plants
White implies less severe levels of stunting
Evaluating the Methodology – Relative Yield vs NDVI

Relationships which don’t have to be redefined for each field, We know how to calibrate NDVI with Relative Plant Yield!

Equation: Power, 2 Parameter

\[ f = a \times x^{b} \]

Defining the Mean \( \bar{X} \) Response!
General Conclusions

- Telone Inline ineffective for control of Charcoal Rot
- Summer heating (solarization) of double cropped stale beds effective IPM tool \((15-20\% \text{ increase DD})\)
- Paladin Pic produced yields superior to Mebr Pic 50/50
- Bottoms-up Crop Termination treatment essential for nematode control / high yields
- In years of severe nematode pressure, a 2\(^{nd}\) drip tape per bed essential enhancing efficacy of drip fumigants
- NDVI extremely useful tool providing treatment discrimination between canopy coverage and yield response
Do Strawberry Root Systems Block Cross bed movement of Fumigants?

Large Plants

Small Plants

Gas & Nematode sampling locations

Large

Small

Bed center

Bed Shoulder
Do Strawberry Roots block lateral movement of Drip Applied Fumigants?

Telone EC (12 gpa)

Stickles Experiment 1 - Applied March 27, 2012
Telone EC 18 gpa - 158 minute injection period + 20 min flush
Concentration 1,3-D in irrigation water - 1748 ppm

March 28, 2012

March 30, 2012

March 30, 2012

April 2, 2012

April 2, 2012

April 4, 2012

April 4, 2012

Stickles Experiment 2 - Applied March 28, 2012
Telone EC (12 gpa) Injection Period 178 minutes + 30 minute flush
Concentration 1,3-D irrigation water - 1669 ppm

March 30, 2012

April 2, 2012

April 4, 2012

April 5, 2012

Bed Location

Concentration Isobutylen (ppm)

Large Plants
Small Plants

Bed Location

Concentration Isobutylen (ppm)

Large Plants
Small Plants
Do Strawberry Roots block lateral movement of Drip Applied Fumigants?

Kpam (60 gpa)

Stickles Experiment 1: Kpam 60 gpa - Applied March 27, 2012
158 minute injection period + 20 minute flush
3750 ppm metam potassium in irrigation water

March 28, 2012

March 30, 2012

Stickles - Experiment 2 - Kpam 60 gpa
Applied March 28, 2012
Injection Period 178 minutes
Concentration metam potassium irrigation water - 3366 ppm

March 30, 2012

April 2, 2012

April 4, 2012

April 5, 2012