SUPPLEMENTAL FUMIGATION STRATEGIES FOR THE MANAGEMENT OF SOILBORNE DISEASES IN TOMATO PRODUCTION

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Wimauma, FL

September 9, 2015
40th Joint Tomato Conference
Naples, FL
Why do we fumigate?

* Soil Fumigation: Reduce soil levels of
  * Weeds
  * Nematodes
  * Soilborne pathogens to an acceptable level that limits crop losses.

Reduced Plant Vigor and Yield
Since transitioning away from MBr growers have observed: (confirmed by UF investigators)

- **↑** Diseases caused by soilborne pathogens
  - Fusarium wilt
  - Fusarium crown and root rot
  - Southern blight
- **↑** Nematodes
- **↑** Weeds (nutsedge)
- **↓** Crop vigor (lucky to get 3 picks off a crop).
Spring 2013 – Tomato Field with Fusarium Wilt – Manatee Co. FL
Identify weaknesses in current fumigation systems.
Identify weaknesses in current fumigation systems.

<table>
<thead>
<tr>
<th>Fumigant</th>
<th>Vapor pressure (mm Hg)</th>
<th>Boiling point (°C at 1 atm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl bromide (100%)</td>
<td>1,420 (20 °C)</td>
<td>4</td>
</tr>
<tr>
<td>Chloropicrin (100%)</td>
<td>18.3 (20 °C)</td>
<td>112</td>
</tr>
<tr>
<td>1,3-Dichloropropene (98%)</td>
<td>23.0 (20 °C)</td>
<td>107</td>
</tr>
<tr>
<td>Dimethyl disulfide (100%)</td>
<td>28.6 (25 °C)</td>
<td>109</td>
</tr>
<tr>
<td>Metam potassium (54%)</td>
<td>24 (25 °C)</td>
<td>97</td>
</tr>
<tr>
<td>Allyl isothiocyanate (94%)</td>
<td>4 (20 °C)</td>
<td>150</td>
</tr>
<tr>
<td>Water</td>
<td>17.5 (20 °C)</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>23.8 (25 °C)</td>
<td></td>
</tr>
</tbody>
</table>
Identify weaknesses in current fumigation systems.

- Distribution in an untarped column packed w/ sandy loam.
- Pic degrades faster than MBr via microbial degradation
- Pic degradation increases with soil temp.
- Dispersal of MBr in soil is $> 10^3$ greater than Pic (Jury et al. 1997).

Identify weaknesses in current fumigation systems.

Methyl Bromide

Vapor Pressure
1,420 mm Hg

Pic-Clor 60

Vapor Pressure
23 mm Hg
Identify weaknesses in current fumigation systems.

Vapor Pressure
1,420 mm Hg
Methyl Bromide

Vapor Pressure
23 mm Hg
Pic-Clor 60

Physical soil factors:
• Soil moisture
• Soil temperature
• [organic matter]
• Compaction
Trials were established at GCREC as a last attempt to:

• Compare chemical alternatives to MBr
• Evaluate MBr as a crop rescue treatment for situations where the alternatives failed
GCREC Fumigant Trials

- Planned, multi-site studies at GCREC
- 4 separate field sites
  - With varying pest & disease pressure
  - 1 inoculated site
- 4 reps per treatment
- 75 ft single bed plots
- Fall & Spring trials...
- PicClor60 (300 lbs); Trifecta (400 lbs); MBr:Pic (67:33 & 50:50, 350 lbs); FL 3way (Telone II, 122 lbs; Pic, 150 lbs; Kpam, 60 gal)
Soilborne Disease

MBr 67:33 provided consistent control of Fusarium wilt and crown rot under field conditions. Other chloropicrin containing formulations failed...
Identify weaknesses in current fumigation systems.

- Understand effective fumigation zone for soilborne pathogens
  - *Fusarium* spp.
Recovery of total *Fusarium oxysporum* from soil samples

**Type III Tests of Fixed Effects**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
<td>0.9363</td>
</tr>
<tr>
<td>TRT</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Field*TRT</td>
<td>0.2896</td>
</tr>
<tr>
<td>Loc</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Field*Loc</td>
<td>0.7216</td>
</tr>
<tr>
<td>Loc*TRT</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Field<em>Loc</em>TRT</td>
<td>0.4649</td>
</tr>
</tbody>
</table>

Identify weaknesses in current fumigation systems.

Recovery of total *Fusarium oxysporum* from soil samples.
Identify weaknesses in current fumigation systems.

<table>
<thead>
<tr>
<th>loc</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>M3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>M5</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>M8</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>M10</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>E3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>E5</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>E8</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>E10</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>RM2</td>
<td>0.8274</td>
</tr>
<tr>
<td>RM4</td>
<td>0.6577</td>
</tr>
<tr>
<td>T2</td>
<td>0.0105</td>
</tr>
<tr>
<td>T4</td>
<td>0.0537</td>
</tr>
</tbody>
</table>

LS-Means for loc*trtN
With 95% Confidence Limits

Red circles indicate differences in [Fusarium] among fumigants
Florida Fumigant Studies

- Assess MBr at grower sites with specific disease/pest problems.
- Specific grower sites: MBr:Pic 67:33 & 50:50
  - 350 lbs/A.
  - Comparison to grower standard (PicClor60, 300 lbs/trtA)
  - Stripped applications
  - Varying plot dimensions; 3 raised beds (500 – 700ft row lengths)
  - 4 – 6 reps per treatment
Yes, MBr works!!!!

Pic-Clor 60
300 lbs/A

MBr:Pic 67:33
350 lbs/A
Yes, MBr works!!!!
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Disease Incidence</th>
<th>No. Fruit/A</th>
<th>Weight (ton/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBr:Pic 50:50</td>
<td>4.9 a</td>
<td>48,167 a</td>
<td>7.5 a</td>
</tr>
<tr>
<td>MBr:Pic 67:33</td>
<td>5.3 a</td>
<td>48,500 a</td>
<td>7.6 a</td>
</tr>
<tr>
<td>PicClor 60</td>
<td>25.4 b</td>
<td>26,167 b</td>
<td>4.3 b</td>
</tr>
</tbody>
</table>

Yes, MBr works!!!!
Yes, MBr works!!!!
Identify weaknesses in current fumigation systems.

Vapor Pressure
Methyl Bromide
1,420 mm Hg

Vapor Pressure
Pic-Clor 60
23 mm Hg
Identify weaknesses in current fumigation systems.

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23 mm Hg

Pic-Clor 60
Identify weaknesses in current fumigation systems.

Vapor Pressure
1,420 mm Hg

Methyl Bromide

Vapor Pressure
23 mm Hg

Pic-Clor 60

Pic

Pic
Supplemental applications of chloropicrin along bed edges for under-fumigated areas.

* Located at field with a known history of high levels of FOL
* Treatments:
  * 1) Pic-Clor 60 @ 300 lbs/Treated Acre
  * 2) Pic-Clor 60 @ 300 lbs/Treated Acre + Pic 100 @ 200 lbs/Treated Acre (Yetter rig)
* Plot size: 3 beds x 700 ft long; 6 Replications
2 Coulters per bed, placed long bed edge prior to laying mulch; application is > 6” below mulch tuck.
Spring 2014

<table>
<thead>
<tr>
<th>Field Site A</th>
<th>Field Site B</th>
</tr>
</thead>
<tbody>
<tr>
<td>PicClor60</td>
<td>PicClor60</td>
</tr>
<tr>
<td>PicClor60 + 200 Pic</td>
<td></td>
</tr>
</tbody>
</table>

Disease Incidence (%)

$P = 0.0010$  $P = 0.5623$

↓ 77%

Spring 2015

<table>
<thead>
<tr>
<th>Field Site A</th>
<th>Field Site B</th>
</tr>
</thead>
<tbody>
<tr>
<td>PicClor60</td>
<td>PicClor60</td>
</tr>
<tr>
<td>PicClor60 + 200 Pic</td>
<td></td>
</tr>
</tbody>
</table>

Disease Incidence (%)

$P = 0.0050$  $P = 0.0946$

↓ 38%

↓ 26%
Tomato Yield
(field pack out)

Spring 2014 - Field Site A

Yield 1
PicClor60: 15 Tons/A, P = 0.0703 (↑ 36%)
PicClor60 + 200 Pic: 15 Tons/A

Yield 2
PicClor60: 10 Tons/A, P = 0.7356
PicClor60 + 200 Pic: 10 Tons/A

Total Yield
PicClor60: 25 Tons/A, P = 0.1152 (↑ 23%)
PicClor60 + 200 Pic: 25 Tons/A
Tomato Yield
(field pack out)

Spring 2015 - Field Site A

<table>
<thead>
<tr>
<th>Tons/A</th>
<th>Yield 1</th>
<th>Yield 2</th>
<th>Total Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PicClor60</td>
<td>PicClor60 + 200 Pic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P = 0.0031</td>
<td>P = 0.0728</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↑ 19%</td>
<td>↑ 26%</td>
<td></td>
</tr>
</tbody>
</table>

|        | P = 0.0051 |
|        | ↑ 21% |
Tomato Yield
(field pack out)

Spring 2015 - Field Site B

<table>
<thead>
<tr>
<th>Yield</th>
<th>PicClor60</th>
<th>PicClor60 + 200 Pic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield 1</td>
<td>$P = 0.0231$</td>
<td>↑ 35%</td>
</tr>
<tr>
<td>Yield 2</td>
<td>$P = 0.5277$</td>
<td></td>
</tr>
<tr>
<td>Total Yield</td>
<td></td>
<td>↑ 21%</td>
</tr>
</tbody>
</table>

$P = 0.0739$
Supplemental Pic application improved root growth throughout bed and bed edge.
Effect of Supplemental Pic on Root Mass

Supplemental Pic application extended roots to > 1 foot beyond edge of bed.

However, only dead roots could be found along bed edge of grower standard.
Supplemental Chloropicrin Rate Study

* Fall 2014:
  * Standard Pic-Clor 60 @ 300 lbs/A
  * + Pic 100 @ 50, 100 & 150 lbs/A
  * Plot size: 3 beds x 1500 ft long; 6 Replications

* Spring 2015:
  * Standard Pic-Clor 60 @ 300 lbs/A
  * + Pic 100 @ 75, 100, 150 & 200 lbs/A
  * Plot size: 3 beds x 1500 ft long; 6 Replications
On-Farm Rate Study - Fall 2014

Fall 2014 – Fusarium Wilt Incidence

Disease Incidence (%)

Pic-Clor 60
+ 50 lbs Pic 100
+ 100 lbs Pic 100
+ 150 lbs Pic 100

P = 0.0362

81%
On-Farm Rate Study - Fall 2014

Fall 2014 - Yield

Yield tons/A

bc

Pic-Clor 60

+ 50 lbs Pic 100

c

+ 100 lbs Pic 100

ab

+ 150 lbs Pic 100

a
On-Farm Rate Study - Spring 2015

Spring 2015 – Fusarium Wilt Incidence

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Disease Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pic-Clor60 + 75 lbs Pic 100</td>
<td>bc</td>
</tr>
<tr>
<td>Pic-Clor60 + 100 lbs Pic 100</td>
<td>bc</td>
</tr>
<tr>
<td>Pic-Clor60 + 150 lbs Pic 100</td>
<td>b</td>
</tr>
<tr>
<td>Pic-Clor60 + 200 lbs Pic 100</td>
<td>c 40%</td>
</tr>
</tbody>
</table>

*P = 0.0010*
Supplemental Pic 100 adds:
  * $183/A (150 lb/Trt Acre)
  * $246/A (200 lb/Trt Acre)

Repeat grower trials assessing chloropicrin rates and offset of chloropicrin in bed are in progress.

Large-scale demonstration trials – Economics...

Also assessing whether other fumigants could be used to further reduce cost... metam sodium/potassium or AIT?
UF Personnel

**Tyler Jacoby**
Dr. Joe Noling
Dr. Nathan Boyd
Dr. Andrew MacRae
Rebecca Willis
Heather Adkison
Samantha Newman
Julie Seibert

Scott Hughes
Steve Kalb
Mike Sweat
Jose Moreno
Jeb Cofer
Clint Dyer
Billy Triner
Payton Barbon

Scott DiMare
Greg, Paul & Robert Harloff

Research was supported by funds provided by the South Atlantic Area Extension Program for Methyl Bromide Alternatives (Cooperative Agreement 58-6618-8-116) and USDA NIFA MBr Transition Grant 2012-51102-20189

THANK YOU