Non-microbial Fumigants for Control of Nematodes, soil Diseases and Weeds

• IR-4 Training Workshop 2017

George Stallings, PhD
Non-Microbial Fumigants

US EPA major non-microbial fumigant list:

1. Chloropicrin fumigant (chloropicrin)
2. Dazomet* fumigant (2H-1,3,5-Thiadiazine-2-thione, tetrahydro-3,5-dimethyl
3. Dominus biofumigant (allyl isothiocyanate)
4. Methyl bromide* fumigant (methyl bromide)
5. Telone fumigant (1,3-dichloropropene)
6. Vapam or Metam sodium/potassium fumigant (sodium methyldithiocarbamate)
7. Combinations
## Non-Microbial Fumigants

### US EPA label comparison:

<table>
<thead>
<tr>
<th>Product</th>
<th>Buffer zone</th>
<th>FMP Field Mgt Plan</th>
<th># acres applied per day</th>
<th>Efficacy</th>
<th>Restricted Use pesticide</th>
<th>Entry Restricted Period</th>
<th>Film type</th>
<th># applications per season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominus</td>
<td>0-25’</td>
<td>NO</td>
<td>Unlimited</td>
<td>Weeds Diseases Nematodes</td>
<td>NO*</td>
<td>5 days</td>
<td>None</td>
<td>Unlimited</td>
</tr>
<tr>
<td>Metam / K-pam</td>
<td>25-300’+</td>
<td>Yes</td>
<td>Restricted</td>
<td>Weeds Diseases Nematodes</td>
<td>Yes</td>
<td>5 days</td>
<td>Yes, variable by application</td>
<td>Restricted</td>
</tr>
<tr>
<td>Chloropic</td>
<td>25-300’+</td>
<td>Yes</td>
<td>Restricted</td>
<td>Diseases Nematodes</td>
<td>Yes</td>
<td>5 days</td>
<td>Yes, variable by application</td>
<td>1</td>
</tr>
<tr>
<td>Telone / Inline</td>
<td>100’</td>
<td>Yes</td>
<td>Restricted</td>
<td>Nematodes Diseases</td>
<td>Yes</td>
<td>5 days</td>
<td>Yes, variable by application</td>
<td>1</td>
</tr>
<tr>
<td>Methyl Br /CP</td>
<td>25-300’+</td>
<td>Yes</td>
<td>Restricted</td>
<td>Weeds Diseases Nematodes</td>
<td>Yes</td>
<td>5 days</td>
<td>Yes, variable by application</td>
<td>1</td>
</tr>
</tbody>
</table>

* Dominus is a Restricted Use pesticide in Florida only
DOMINUS® bio-fumigant

Key Features

1. Product history ...
   - Isagro testing since 2009 for soil applications.
   - Registered by US EPA in 2013 as a biopesticide.
   - Florida unconditional registration expected late 2016.
   - Submission to CA DPR in 2014 (anticipated registration later 2017).
   - Accepted as a non-ozone depleting alternative to methyl bromide.
   - Tolerance exemption for all crops in the US.
   - Biopesticide with improved environmental footprint vs. conventional products.

2. Product activity ...
   - Broad spectrum soil activity: nematodes, fungal diseases, weed seeds, insects.

3. Product source ...
   - AITC (allyl isothiocyanate) is a naturally occurring plant defense compound provided by ISAGRO-USA in a consistent synthetic formulation.
   - DOMINUS is the synthetic equivalent of oil of mustard found in broccoli, brussel sprouts, mustard seed, wasabi, and horseradish.
DOMINUS® bio-fumigant

Key features:

4. Product formulation:
   - DOMINUS® (96% AITC + adjuvant).
   - The allyl form of the a.i. is immediately available and highly active; no a.i. breakdown process required (i.e. MITC).

5. Product use ...
   - Versatility of use (soil pre-plant & soil crop termination).
   - Broadcast, raised bed shank, drip injection.
   - Crop termination: post harvest application, disease/pest mgt.
   - Fits with conventional equipment and conditions.
   - Proven performance in research & commercial applications.

- Entry Restricted Period: 5 days (buffer zone 24 hrs, when applicable).
- Planting interval: 10 day minimum.
- Entry into the application block during this period is only allowed for appropriately PPE-equipped handlers performing handling tasks.
6. **Product benefits:**

- Lower application volumes per acre (40-50%) compared to conventional “ITC generator products”.
- “xITC” Fungicidal Toxicity to target pests comparison:
  - Allyl ITC >> phenyl ITC > methyl ITC > ethyl ITC
  
- Favorable label conditions/restrictions (i.e. 0-25’ buffer zones, favorable worker safety, etc.).
- More favorable human and environmental toxicity comparison to conventional fumigant standards
- Application via conventional equipment.
- Breaks down rapidly by soil degradation & photolysis via UV light.
- Doesn’t leave a detectable residue in the soil and is not transmitted to plants or food products.
- More favorable human and environmental toxicity comparison to conventional fumigant standards.
- Favorable alternative choice as a stand alone soil fumigant.
DOMINUS® bio-fumigant
Registrations:

- Submit
- Registered
- No Registration
- Pending

Non-microbial fumigants
DOMINUS® bio-fumigant

Application methods:
### DOMINUS® bio-fumigant

**Rates:**

<table>
<thead>
<tr>
<th>Product</th>
<th>Formulated product %</th>
<th>Rate BROADCAST gal/A</th>
<th>Rate CROP TERMINATION gal/A</th>
<th>L/Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominus</td>
<td>96</td>
<td>n/a</td>
<td>8</td>
<td>74.8</td>
</tr>
<tr>
<td>Dominus</td>
<td>96</td>
<td>10</td>
<td>10</td>
<td>93.5</td>
</tr>
<tr>
<td>Dominus</td>
<td>96</td>
<td>15</td>
<td>15</td>
<td>140.3</td>
</tr>
<tr>
<td>Dominus</td>
<td>96</td>
<td>20</td>
<td>20</td>
<td>187.1</td>
</tr>
<tr>
<td>Dominus</td>
<td>96</td>
<td>22</td>
<td>n/a</td>
<td>205.8</td>
</tr>
<tr>
<td>Dominus</td>
<td>96</td>
<td>25</td>
<td>n/a</td>
<td>233.8</td>
</tr>
<tr>
<td>Dominus</td>
<td>96</td>
<td>30</td>
<td>n/a</td>
<td>280.6</td>
</tr>
<tr>
<td>Dominus</td>
<td>96</td>
<td>35</td>
<td>n/a</td>
<td>327.4</td>
</tr>
<tr>
<td>Dominus</td>
<td>96</td>
<td>40</td>
<td>n/a</td>
<td>374.1</td>
</tr>
</tbody>
</table>
**DOMINUS® bio-fumigant**

Crop termination (post crop disease/nematode mgt):

- **Strawberry**
  - Nematodes, soil disease

- **Lettuce**
  - *Fusarium*, *Verticillium*

Non-microbial fumigants
DOMINUS® bio-fumigant
Nematode control:
(Root knot & Sting)

Summary Nematode Control

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Control Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRF135 @15 gpa</td>
<td></td>
</tr>
<tr>
<td>IRF135 @20 gpa</td>
<td></td>
</tr>
<tr>
<td>IRF135 @30 gpa</td>
<td></td>
</tr>
<tr>
<td>IRF135 @40 gpa</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td></td>
</tr>
</tbody>
</table>

Non-microbial fumigants
DOMINUS® bio-fumigant

Soil disease control:
(Verticillium, Fusarium, Phytophthora)

Summary Disease Control

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Disease Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRF135 @15 gpa</td>
<td>20</td>
</tr>
<tr>
<td>IRF135 @20 gpa</td>
<td>60</td>
</tr>
<tr>
<td>IRF135 @30 gpa</td>
<td>100</td>
</tr>
<tr>
<td>IRF135 @40 gpa</td>
<td>100</td>
</tr>
<tr>
<td>Standard</td>
<td>100</td>
</tr>
</tbody>
</table>
DOMINUS® bio-fumigant

Weed control:
(Nutsedge - purple/yellow, Purslane, Grasses)

Summary Weed Control

- IRF135 @15 gpa
- IRF135 @20 gpa
- IRF135 @23 gpa
- IRF135 @30 gpa
- IRF135 @40 gpa
- Standard
Strawberry
California (PAR) - 40 weeks

*Plant diameter*

Non-microbial fumigants
Strawberry
California (PAR) - 40 weeks

Crop vigor

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Crop Vigor (0-10 scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>8.00</td>
</tr>
<tr>
<td>IRF 135 15 gal/a</td>
<td>8.50</td>
</tr>
<tr>
<td>IRF 135 22.5 gal/a</td>
<td>9.00</td>
</tr>
<tr>
<td>IRF 135 30 gal/a</td>
<td>9.50</td>
</tr>
<tr>
<td>IRF 135 - Shank 30 gal/a</td>
<td>10.00</td>
</tr>
<tr>
<td>Methyl Bromide 200 lb/a</td>
<td>7.00</td>
</tr>
<tr>
<td>K-Pam 60 gal/a</td>
<td>9.00</td>
</tr>
<tr>
<td>Inline 28 gal/a</td>
<td>8.00</td>
</tr>
</tbody>
</table>

Non-microbial fumigants
Strawberry
California (PAR) - 40 weeks
Dagger XI nematode (counts #/50g soil)

- Untreated
- IRF 135 15 gal/a
- IRF 135 22.5 gal/a
- IRF 135 30 gal/a
- IRF 135 - Shank 30 gal/a
- Methyl Bromide 300 lb/a
- K-Pam 60 gal/a
- Inline 28 gal/a

Non-microbial fumigants

TREATMENT
Strawberry
California (PAR) - 10 weeks
Ring CX nematode (counts #/50g soil)

Non-microbial fumigants
Strawberry
California (PAR) - 10 weeks
Root knot nematode (counts #/50g soil)
Strawberry
California (PAR) - 40 weeks
Verticillium counts (cfu/g soil)

Non-microbial fumigants

- Untreated
- IRF 135 15 gal/a
- IRF 136 22.5 gal/a
- IRF 136 30 gal/a
- IRF 135 - Shank 30 gal/a
- Methyl Bromide 300 lb/a
- K-Pam 60 gal/a
- Inline 28 gal/a
Strawberry
California (PAR) - 10 weeks

*Fusarium oxysporum* (cfu/g soil)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fusarium Count (CFU/g soil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Check</td>
<td>1200.00</td>
</tr>
<tr>
<td>IRF135-Drip 15 gal/a</td>
<td>0.00</td>
</tr>
<tr>
<td>IRF135-Drip 22.5 gal/a</td>
<td>0.00</td>
</tr>
<tr>
<td>IRF135-Drip 30 gal/a</td>
<td>0.00</td>
</tr>
<tr>
<td>IRF135-Shank 30 gal/a</td>
<td>0.00</td>
</tr>
<tr>
<td>Methyl Bromide-Shank 300 lb/a</td>
<td>0.00</td>
</tr>
<tr>
<td>K-Pam-Drip 60 gal/a</td>
<td>0.00</td>
</tr>
<tr>
<td>Inline-Drip 28 gal/a</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Non-microbial fumigants**
Strawberry
California (PAR) - 40 weeks
Ave # weeds per treatment

- Untreated
- IRF 135 15 gal/a
- IRF 135 22.5 gal/a
- IRF 135 30 gal/a
- IRF 135 - Shank 30 gal/a
- Methyl Bromide 300 lb/a
- K-Pam 60 gal/a
- Inline 28 gal/a

Non-microbial fumigants

TOTAL WEEDS

TREATMENT

1/30/2012
3/7/2012
Strawberry
California (PAR) - 10 weeks
Weeding cost ($/acre)

Non-microbial fumigants

TREATMENT

- Untreated Check
- IRF135-Drip 15 gal/a
- IRF135-Drip 22.5 gal/a
- IRF135-Drip 30 gal/a
- IRF135-Shank 30 gal/a
- Methyl Bromide-Shank 300 lb/a
- K-Pam-Drip 60 gal/a
- Inline-Drip 28 gal/a
Strawberry
California (PAR) - 40 weeks
Yield by seasonal picks

Non-microbial fumigants
Strawberry
California (PAR) - 40 weeks
Cumulative yield by seasonal picks

Non-microbial fumigants
DOMINUS® bio-fumigant

Near-term technical objectives:

• Crop use expansion against existing and new target pests.

• Technical Development
  ➢ Application equipment and techniques to enhance soil distribution
    • Drip tape modifications
    • Shank placement, # nozzles and inter-shank distance
  ➢ Compatibility testing with new and existing fumigants and non-fumigant products.

• Development under review in: Mexico, Canada, Italy, Spain, Turkey, Morocco, Costa Rica, Guatemala, Chile, Argentina, Brazil, New Zealand, Australia, others.
DOMINUS® bio-fumigant

Near-term registration objectives:

- Canadian registration submission supporting trial work in potatoes, ginseng, onion, carrot, strawberry, tobacco. EUP approved for testing in 2017 w/ approval in 2018.
- Complete the California registration process, and obtain the full California registration later in 2017.
- NOP (National Organic Program) submission 2017 w/anticipated approval for specific applications, diseases & nematodes.
- Submission w/TriCal for pre-mix product w/chloropicrin for approval 3Q 2017.
- Open Mexico office (Isagro Mexicana) Nov 2016 w/anticipated registration 2019.
Conclusions:

- DOMINUS commercial introduction continues to grow steadily.
- Acreage increased in key states with expansion for new uses and crops providing positive results for crop yields, disease and pest control.
- Time of application for pre-plant and crop termination uses expanded significantly.
- 2017 focus will continue to support strong and orderly adoption of DOMINUS in target markets.
- Complete the California registration process, and obtain the full California registration later in 2017.
DOMINUS® bio-fumigant
Isagro contact list:

➢ George Stallings, Technical Development Manager, North America
  • 208-841-9850
  • gstellings@isagro-usa.com

➢ Mike Allan, President, N America
  • 415-254-5711
  • mallan@isagro-usa.com
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