Fungicide Performance against White Rot and Other Considerations in Disease Management

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University of California Coop. Ext., Fresno
White Rot of Garlic (and other Alliums)

*Sclerotium cepivorum*
Central San Joaquin Valley

More than 13,000 acres with Sclerotium cepivorum
Management

- Sanitation
- Material to cause sclerotia to germinate
- Fungicide
Management

• Sanitation
Sanitation

- Use disease-free planting material.
- Document of infested fields.
- Clean all equipment after harvesting infected garlic.
- Clean equipment prior to movement from infested fields.
- Spot treatment of infested area to reduce inoculum concentration.
Management

• Sanitation
• Material to cause sclerotia to germinate
• Fungicide
Many of the treatments to be discussed are not currently labeled uses

- Carefully read the current product label before writing any pesticide recommendation.

• Evaluation of at-planting applications combined with fungicides applied through the drip irrigation system

• Chemical/biological control agent efficacy comparison
Application Details

• At planting application
  – CO$_2$-pressurized backpack sprayer
  – 25 gallons of water per acre
  – 30 psi.

• All drip applied materials were pumped into drip line over 45 minutes.
Drip Injection System
Cultural Details

- Location: *S. cepivorum* infested field in Fresno Co.
- Irrigated with sprinklers until February

<table>
<thead>
<tr>
<th>Trial year</th>
<th>Plant date</th>
<th>Variety</th>
<th>Depth of drip tape</th>
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<tbody>
<tr>
<td>2007-08</td>
<td>20 Nov</td>
<td>CA Late</td>
<td>1 inch</td>
</tr>
<tr>
<td>2008-09</td>
<td>23 Oct</td>
<td>CA Early</td>
<td>3 inch</td>
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</table>
Soil Temperatures at Fresno Co. White Rot Trial

2008

Optimum temperature for infection: 60-65°F
Temp range: 50-75°F
Soil Temperatures, Fresno Co. white rot trial, 2008

Temperature (°F)

Sensor depth
- 3 inch
- 6 inch
- 9 inch

Date
- 1/17
- 1/27
- 2/6
- 2/16
- 2/26
- 3/8
- 3/18
- 3/28
- 4/7
- 4/17
Monitoring

- OnSet temperature recorder was used to monitor soil temperatures.
- Fifty garlic cloves were collected from buffers (untreated) on 7 Feb and surface sterilized and incubated in moist chambers at 72°F.
Garlic Clove Collection and Incubation

- 2008: *S. cepivorum* grew from 2/50 cloves
- 2009: *S. cepivorum* grew from 1/50 cloves
Monitoring

• OnSet temperature recorder was used to monitor soil temperatures.

• Fifty garlic cloves were collected from buffers (untreated) on 7 Feb and surface sterilized and incubated in moist chambers at 72°F.

• Above ground symptoms were rated (0-10 scale) on 23 Apr and 14 May 2008; 9 May 2009.
Monitoring

- OnSet temperature recorder was used to monitor soil temperatures.
- Fifty garlic cloves were collected from buffers (untreated) on 7 and 14 Feb and surface sterilized and incubated in moist chambers at 72°F.
- Above ground symptoms were rated (0-10 scale) on 23 Apr and 14 May.
- Twenty-five ft of each plot was harvested mechanically and weighed.
2007-08 At Planting Treatments

1  Folicur 20.5 fl oz
2  Cannonball 8.0 oz
3  Contans 4 lbs/a
4  Cannonball 8.0 oz + Botran 5F 102 oz
5  Untreated control
### 2007-08 Drip Applied Treatments

<table>
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<th>15 Feb</th>
<th>7 Mar</th>
<th>27 Mar</th>
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<tr>
<td>1</td>
<td>Cannonball 8.0 oz</td>
<td>Folicur 20.5 fl oz</td>
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<td>2</td>
<td>Cannonball 8.0 oz</td>
<td>Folicur 20.5 fl oz</td>
<td>Endura 6.8 oz</td>
</tr>
<tr>
<td>3</td>
<td>Folicur 20.5 fl oz</td>
<td>Cannonball 8.0 oz</td>
<td>Endura 6.8 oz</td>
</tr>
<tr>
<td>4</td>
<td>Untreated control</td>
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## Five Replication Split-Plot Experimental Design

<table>
<thead>
<tr>
<th></th>
<th>REP 1</th>
<th>REP 2</th>
<th>REP 3</th>
<th>REP 4</th>
<th>REP 5</th>
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<tr>
<td>Drip 1</td>
<td>IF 5</td>
<td>IF 5</td>
<td>IF 5</td>
<td>IF 5</td>
<td>IF 2</td>
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<tr>
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<tr>
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<th>Drip 3</th>
<th>Drip 4</th>
<th>Drip 5</th>
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<tr>
<td>10'</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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### Contiguous Block Labels:

- 10'
**At planting/in-furrow treatment applied in sub-plots**

<table>
<thead>
<tr>
<th></th>
<th>REP 1</th>
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<th>REP 3</th>
<th>REP 4</th>
<th>REP 5</th>
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<td>Drip 4</td>
<td>Drip 1</td>
<td>Drip 3</td>
<td>Drip 2</td>
</tr>
</tbody>
</table>

- **At planting**
  - REP 1: IF 5
  - REP 2: IF 2
  - REP 3: IF 4
  - REP 4: IF 3
  - REP 5: IF 4

**IF 5**

- **At planting**
  - REP 1: IF 3
  - REP 2: IF 2
  - REP 3: IF 1
  - REP 4: IF 3
  - REP 5: IF 1

**IF 4**

- **At planting**
  - REP 1: IF 1
  - REP 2: IF 4
  - REP 3: IF 3
  - REP 4: IF 4
  - REP 5: IF 2

**IF 3**

- **At planting**
  - REP 1: IF 4
  - REP 2: IF 5
  - REP 3: IF 2
  - REP 4: IF 5
  - REP 5: IF 3

- **At planting**
  - REP 1: IF 1
  - REP 2: IF 5
  - REP 3: IF 4
  - REP 4: IF 3

**IF 2**

- **At planting**
  - REP 1: IF 5
  - REP 2: IF 3
  - REP 3: IF 5
  - REP 4: IF 1
  - REP 5: IF 1

- **At planting**
  - REP 1: IF 2
  - REP 2: IF 4

- **At planting**
  - REP 1: IF 3
  - REP 2: IF 1

- **At planting**
  - REP 1: IF 5

- **At planting**
  - REP 1: 3

**IF 1**

- **At planting**
  - REP 1: IF 4
  - REP 2: IF 3
  - REP 3: IF 4
  - REP 4: IF 4
  - REP 5: IF 5

- **At planting**
  - REP 1: IF 5
  - REP 2: IF 4

- **At planting**
  - REP 1: IF 3

- **At planting**
  - REP 1: IF 4

- **At planting**
  - REP 1: 4

- **At planting**
  - REP 1: 5

**If 3**

- **At planting**
  - REP 1: IF 5
  - REP 2: IF 5
  - REP 3: IF 5

- **At planting**
  - REP 1: IF 1

- **At planting**
  - REP 1: IF 1

- **At planting**
  - REP 1: IF 5

- **At planting**
  - REP 1: 5

**If 2**

- **At planting**
  - REP 1: IF 5

- **At planting**
  - REP 1: IF 4

- **At planting**
  - REP 1: IF 4

- **At planting**
  - REP 1: IF 4

- **At planting**
  - REP 1: 2

**If 1**

- **At planting**
  - REP 1: IF 5

- **At planting**
  - REP 1: IF 4

- **At planting**
  - REP 1: IF 1

- **At planting**
  - REP 1: IF 4

- **At planting**
  - REP 1: 1

|       | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|-------|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 10'   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
### Five Replication Split-Plot Experimental Design

| -10' | Drip 4 | Drip 2 | Drip 1 | Drip 3 | Drip 4 | Drip 2 | Drip 1 | Drip 3 | Drip 4 | Drip 2 | Drip 1 | Drip 3 | Drip 4 | Drip 2 | Drip 1 | Drip 3 | Drip 4 | Drip 1 | Drip 3 | Drip 4 | Drip 2 | Drip 1 | Drip 3 | Drip 4 | Drip 2 | Drip 1 | Drip 3 | Drip 4 | Drip 2 | Drip 1 | Drip 3 | Drip 4 |
|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|      | IF 5   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   | IF 4   | IF 5   |
|      | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   | IF 2   | IF 1   |
|      | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   | IF 1   | IF 4   |
|      | IF 3   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   | IF 5   | IF 1   |
|      | IF 4   | IF 2   | IF 3   | IF 4   | IF 2   | IF 3   | IF 4   | IF 2   | IF 3   | IF 4   | IF 2   | IF 3   | IF 4   | IF 2   | IF 3   | IF 4   | IF 2   | IF 3   | IF 4   | IF 2   | IF 3   | IF 4   | IF 2   | IF 3   | IF 4   | IF 2   | IF 3   | IF 4   | IF 2   | IF 3   | IF 4   | IF 2   | IF 3   | IF 4   |
|      | IF 5   | IF 3   | IF 2   | IF 5   | IF 3   | IF 2   | IF 5   | IF 3   | IF 2   | IF 5   | IF 3   | IF 2   | IF 5   | IF 3   | IF 2   | IF 5   | IF 3   | IF 2   | IF 5   | IF 3   | IF 2   | IF 5   | IF 3   | IF 2   | IF 5   | IF 3   | IF 2   | IF 5   | IF 3   | IF 2   | IF 5   | IF 3   | IF 2   | IF 5   |

**Application in buried drip irrigation system**

10'
2007-08 Programs Trial: In furrow
Above-ground symptom severity, 14 May

Cannonball 8.0 oz + Botran 5F 3.2 qts
Folicur 20.5 oz
Cannonball 8.0 oz
Untreated control
Contans 4 lbs

P=0.05
2007-08 Programs Trial: In furrow fresh weights (tons/acre)

- Cannonball 8.0 oz + Botran 5F 3.2 qts
- Folicur 20.5 oz
- Cannonball 8.0 oz
- Untreated control
- Contans 4 lbs

P=0.05
# 2007-08 Programs Trial: drip applied treatments

<table>
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<tr>
<th>Date of application and materials applied</th>
<th>Severity (0-10)</th>
<th>Weights (tons/acre)</th>
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<tbody>
<tr>
<td></td>
<td>23 Apr</td>
<td>14 May</td>
</tr>
<tr>
<td>15 Feb Cannonball 8.0oz, Folicur 20.5 oz</td>
<td>2.52</td>
<td>3.00</td>
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<td>15 Feb Cannonball 8.0oz, Folicur 20.5 oz, Endura 6.8 oz</td>
<td>2.40</td>
<td>3.28</td>
</tr>
<tr>
<td>15 Feb Folicur 20.5 oz, Cannonball 8.0oz, Endura 6.8 oz</td>
<td>2.24</td>
<td>3.00</td>
</tr>
<tr>
<td>Untreated control</td>
<td>2.40</td>
<td>3.28</td>
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<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
2007-08 At Planting Efficacy Trial

1. Moncut (flutolanil: Gowan) 2.86 lbs
2. Endura 6.8 oz
3. Folicur 20.5 fl oz fp/a with WatermaxxII (soil adjuvant: Western Farm Service) 2 qts
4. Cannonball 50WP 8.0 oz fp/a with WatermaxxII 2 qts
5. Contans (Coniothyrium minitans) 2 lbs
6. Contans 4 lbs
7. Contans 8 lbs
8. Glomes intrardices (Reforestation Technologies International) 30.0 lbs
9. Cannonball 50WP (fludioxonil: Syngenta) 4.0 oz
10. Cannonball 50WP (fludioxonil: Syngenta) 8.0 oz
11. Folicur (tebuconizole: Bayer) 20.5 fl oz
12. Untreated control
2007-08 Efficacy Comparison
Above-ground symptom severity, 23 Apr

- Endura 6.8 oz
- Folicur 20.5 oz
- Cannonball 8.0 oz + Watermaxx II 2 qts
- Folicur 20.5 oz + Watermaxx II 2 qts
- Cannonball 4.0 oz
- Moncut 2.86 lbs
- Glomes intrardices 30.0 lbs
- Contans 4 lbs
- Contans 2 lbs
- Contans 8 lbs
- Untreated control
2008-09 At Planting Treatments

1. Folicur 20.5 fl oz
2. Cannonball 8.0 oz
3. Endura 6.8 oz
4. Contans 4 lbs/a
5. Untreated control
## 2008-09 Drip Applied Treatments

<table>
<thead>
<tr>
<th>Application dates</th>
<th>20 Feb</th>
<th>11 Mar</th>
<th>31 Mar</th>
<th>22 Apr</th>
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<tbody>
<tr>
<td>1</td>
<td>Folicur 20.5 fl oz</td>
<td>Cannonball 8.0 oz</td>
<td>Endura 6.8 oz</td>
<td>Botran 3 qt</td>
</tr>
<tr>
<td>2</td>
<td>Cannonball 8.0 oz</td>
<td>Folicur 20.5 fl oz</td>
<td>Endura 6.8 oz</td>
<td>Botran 3 qt</td>
</tr>
<tr>
<td>3</td>
<td>Cannonball 8.0 oz</td>
<td>Endura 6.8 oz</td>
<td>Botran 3 qt</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Untreated control</td>
<td></td>
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</tbody>
</table>
2008-09 Programs Trial: In furrow
Above-ground symptom severity, 14 May

P=0.05
2007-08 Programs Trial: In furrow
fresh weights (tons/acre)

Folicur 20.5 fl oz
Cannonball 8.0 oz
Endura 6.8 oz
Contans 4 lb
Untreated Control

P=0.05
### 2008-09 Programs Trial: drip applied treatments

<table>
<thead>
<tr>
<th>Date of application and materials applied</th>
<th>Disease severity (0-10)</th>
<th>Weights (tons/acre)</th>
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<tr>
<td></td>
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<td>Fresh wt</td>
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<tr>
<td>20 Feb Folicur 20.5 fl oz</td>
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<tr>
<td>11 Mar Cannonball 8.0 oz</td>
<td>0.44</td>
<td>5.36</td>
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<tr>
<td>31 Mar Endura 6.8 oz</td>
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<td>22 Apr Botran 3 qt</td>
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<td>9 May</td>
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<tr>
<td>Untreated control</td>
<td>0.44</td>
<td>4.10</td>
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<tr>
<td>LSD$_{0.05}$</td>
<td>NS</td>
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2007-08 At Planting Efficacy Trial

1. Gem 2.5 oz
2. Moncut (flutolanil: Gowan) 2.86 lbs
3. Endura 6.8 oz with Watermaxx II 2 qts
4. Contans 4 lbs
5. Contans 8 lbs
6. Endura 6.8 oz
7. Tebuzol 20.5 fl oz
8. Tebuzol 20.5 fl oz + Topsin M 40 fl oz
9. Cannonball 50WP 8.0 oz
10. Folicur 20.5 fl oz
11. Folicur 20.5 fl oz + Botran 102 fl oz
12. Untreated control
2008-09 Efficacy Comparison
Above-ground symptom severity, 9 May

- Folicur 20.5 oz
- Tebuzol 20.5 oz + TopsinM
- Cannonball 8.0 oz
- Tebuzol 20.5 oz
- Endura 6.8 oz
- Endura 6.8 oz + WatermaxxII 2 qts
- Moncut 2.86 lbs
- Gem 2.54 oz
- Folicur 20.5 oz + Botran 102 fl oz
- Untreated control
- Contans 4 lbs
- Contans 8 lbs

Legend:
- □ Folicur 20.5 oz
- ■ Tebuzol 20.5 oz + TopsinM
- □ Cannonball 8.0 oz
- ■ Tebuzol 20.5 oz
- □ Endura 6.8 oz
- ■ Endura 6.8 oz + WatermaxxII 2 qts
- □ Moncut 2.86 lbs
- □ Gem 2.54 oz
- ■ Folicur 20.5 oz + Botran 102 fl oz
- ■ Untreated control
- □ Contans 4 lbs
- □ Contans 8 lbs
2008-09 Efficacy Comparison
Yield (tons/acre), 19 Aug Harvest

- Tebuzol 20.5 oz+TopsinM
- Cannonball 8.0 oz
- Moncut 2.86 lbs
- Gem 2.54 oz
- Tebuzol 20.5 oz
- Contans 4 lbs
- Endura 6.8 oz+WatermaxxII 2 qts
- Folicur 20.5 oz
- Untreated control
- Folicur 20.5 oz+Botran 102 fl oz
- Contans 8 lbs
- Endura 6.8 oz
Summary

- Endura, Folicur (tebuconizole), and Cannonball applied at planting were effective.
- Drip applied fungicides in Spring have not shown promise.
- Under the conditions of these study, biological control agents were not effective against white rot.
- The use of soil adjuvant (Watermaxx II) has not improved efficacy under these conditions.
Acknowledgements

- CGORAB
- Larry Schwankl – UC, Kearney Ag Center
- James Gerik – USDA, Parlier
- Kurt Hembree – UCCE, Fresno
- Richard Molinar – UCCE, Fresno
- Con Agra
- Sentient Dehydrated Flavors
- Advan
- BASF
- Bayer
- Gowan
- Syngenta
- Western Farm Service
- Western Forestation Technologies
Fresno Co. white rot trial report

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