Tomato Diseases...

Greenhouse/High Tunnel

In the field

Fungicides
The Influence of Cultural Practices on Tomato Diseases in High Tunnels

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Greenhouse vs. High Tunnel

- High Tunnel = greenhouse without heat
- Plants may be grown in ground or in pots/bags
- Tomatoes are by far the most common crop in either structure.
## Most Common Tomato Diseases

<table>
<thead>
<tr>
<th>Field</th>
<th>High Tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Early blight</td>
<td>• Leaf mold</td>
</tr>
<tr>
<td>• Septoria leaf blight</td>
<td>• Gray mold</td>
</tr>
<tr>
<td>• Bacterial spot</td>
<td>• White mold</td>
</tr>
<tr>
<td>• Bacterial canker</td>
<td></td>
</tr>
</tbody>
</table>
Most diseases require leaf wetness and rain for infection and spread.
High tunnels reduce leaf moisture and diseases.
...but high tunnels increase relative humidity.
Relative humidity inside and outside of a high tunnel 8/15/2014

Relative humidity inside and outside of a high tunnel 8/15/2014

Relative Humidity (%)

- RH inside Hightunnel 2
- RH for Knox county

Midnight to Midnight
Another factor which influences diseases in high tunnels…
…tomatoes planted without crop rotation.
The Diseases

- Leaf mold
- Gray mold
- White mold
Leaf mold of tomato

- Affects leaves only
- Survives in crop residue
- Resistant varieties
- Reduce relative humidity
Botrytis Gray mold of tomato

- Affects leaves, stems occasionally fruit
- Survives in crop residue
- Wide host range
- Reduce relative humidity
White mold of tomato

- Stem lesions cause wilt
- Survives soil
- Spread by mushroom spores
- Lower RH, raise temp.
Cultural Controls
Greenhouse Floor Covering

• Without crop rotation, crop residue accumulates in soil
• Plant pathogens may survive in crop residue
• Floor covering reduces crop residue
Tomatoes in high tunnel with floor covering
Greenhouse floor covering

• White woven ground cover
  • Clean and sanitize at the end of each year
  • Re-use several years
  • $0.14/sq ft.; our cost= $340/HT

• Black landscape fabric
  • Under ground cover
  • One year only
  • $0.03/sq. ft.; our cost= $71/HT
Black landscape fabric
White woven ground cover
Keep area around high tunnel clear

• Reduces insect pressure
• Reduces fungal plant pathogens
• Better ventilation
Ventilation to reduce disease pressure

- Ventilate high tunnels at night to replace humid air
  - Cool temperatures may trump need to ventilate
- Prune plants to increase ventilation
  - Especially with indeterminate tomatoes
- Avoid crowding plants
What is correct spacing for determinate tomatoes in a high tunnel?

• Data in literature only for indeterminate tomatoes
• My observation is that HT’s with too many plants have-
  • Poor ventilation
  • More disease
  • Poor quality or smaller fruit
• Tomato trial in 2014 at SWPAC to study
  • 5 spacing's
  • 2 varieties
High Tunnel plant population study

Tomato plant spacing - inches
- 16-Florida weave
- 20-Florida weave
- 20-Spanish trellis
- 24-Florida weave
- 28-Florida weave

Tomato hybrids - determinants
- Mountain Spring
- Red Deuce

Diagram of trellis systems:
- Spanish Trellis
- Florida Weave
Spanish trellis

Florida weave

5 foot centers
Tomato Population Study

- Tomatoes in HT April 7 to September 11
- Fertigated 4X/day (main season)
- 120 gallons per day per high tunnel (420 linear feet)
- Primary fertilizer potassium nitrate KNO3
  - 13.5-0-46.2
- Fruit weight & number collected
- Also took data on disease severity, stink bug damage.
Total tomato yield for both high tunnels all treatments = 143,529 lbs/A
No. of fruit per harvest.

- Mountain Spring
- Red Deuce

Summer 2014

Number of Fruit
Weight per Linear Foot

Variety

Weight (lbs)

Red Deuce
Mountain Spring

P=0.5075
No. Tomatoes/ft

<table>
<thead>
<tr>
<th>Variety</th>
<th>Total Number of fruit</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountain Spring</td>
<td>25</td>
<td>0.0004</td>
</tr>
<tr>
<td>Red Deuce</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>
Total Number of tomatoes

No. tomatoes/ft.

Plant Spacing in inches

- 20 trellis
- 16 weave
- 20 weave
- 24 weave
- 28 weave

P=0.0003
Mean Fruit Weight

Plant spacing in inches

<table>
<thead>
<tr>
<th>Plant spacing in inches</th>
<th>Weight in lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 Weave</td>
<td>0.30</td>
</tr>
<tr>
<td>24 Weave</td>
<td>0.30</td>
</tr>
<tr>
<td>20 Weave</td>
<td>0.29</td>
</tr>
<tr>
<td>16 Weave</td>
<td>0.27</td>
</tr>
<tr>
<td>20 Trellis</td>
<td>0.27</td>
</tr>
</tbody>
</table>

P=0.0396
Disease Severity by Variety

Disease Severity (AUDPC)

Variety

Mountain Spring
Red Deuce

P=0.0001

a

b
Disease Severity by Plant Spacing

Disease Severity (AUDPC)

Plant Spacing in inches

20 weave 16 weave 28 weave 24 weave 20 trellis

P=0.8270
Stink bug damage

• Fruit culled for stink damage as unmarketable
• Data for stink bug damage comes from 8 harvests, mid-July to mid-Sept.
  • 14, 16, 18, 21 Jul; 21 Aug; 5, 8, 11 Sep.
Stink bug damage
Stink bug damage by variety

<table>
<thead>
<tr>
<th>Variety</th>
<th>Stink bug damaged/total no. fruit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountian Spring</td>
<td>0.5</td>
</tr>
<tr>
<td>Red Deuce</td>
<td>1.2</td>
</tr>
</tbody>
</table>

P = 0.0060

Varieties with different letters (a, b) are significantly different.
Stink bug damage by plant population

![Bar chart showing stink bug damage by plant population.](chart.png)

- 24 Weave: 1.2
- 16 Weave: 0.88
- 28 Weave: 0.8
- 20 Weave: 0.78
- 20 Trellis: 0.6

Plant spacing in inches

Stink bug damaged/total no. fruit (%)

P=0.7875
Proportion of zipper scars

Variety

Mountain Spring
Red Deuce

P=0.0021
Proportion of Zipper scars

No. Fruit with sipper scars/total fruit

Plant spacing in inches

<table>
<thead>
<tr>
<th>Plant spacing</th>
<th>No. Fruit with sipper scars/total fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Weave</td>
<td>P=0.4766</td>
</tr>
<tr>
<td>16 Weave</td>
<td></td>
</tr>
<tr>
<td>28 Weave</td>
<td></td>
</tr>
<tr>
<td>24 Weave</td>
<td></td>
</tr>
<tr>
<td>20 Trellis</td>
<td></td>
</tr>
</tbody>
</table>
Red Deuce culls by number

- Total Marketable number: 80.7%
- Total Non-Marketable: 19.3%
  - Zipper scar: 7.3%
  - Catface: 1.1%
  - All insect damage: 3.5%
  - BER: 0.8%
  - Cracked or split: 4.3%
  - Other: 2.2%

Mountain Spring cull by number

- Total Marketable number: 80.7%
- Total Non-Marketable: 19.3%
  - Zipper scar: 9.9%
  - Catface: 2.6%
  - All insect damage: 2.6%
  - BER: 0.3%
  - Cracked or split: 3.2%
  - Other: 2.5%
Tomato High Tunnel Population Experiment

- Leaf mold severity was not affected by in-row spacing.
  - Distance between rows was not considered in exp.
  - Other diseases may be affected by spacing.
- Red Deuce was resistant to leaf mold.
  - Red Deuce not listed as resistant by seed co.
- Weight of tomatoes per plot was not affected by variety or plant population.
- Rows with more closer spacing's had more fruit #.
- Closer spaced plants had smaller fruit.
- Red Deuce had larger fruit; Mt. Spring had more fruit.
Acknowledgements

• Dennis Nowaskie- superintendent, SWPAC
• Larry Sutterer & Michael Russell- maintenance & harvest
• Sara Hoke- Agricultural technician
• Shubin Saha- started HT program at SWPAC
• Rispen Seeds
Septoria leaf blight
<table>
<thead>
<tr>
<th>Tillage</th>
<th>Seedborne</th>
<th>Rotation</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>No</td>
<td>2-3 yrs</td>
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Septoria leaf blight
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<th>Resistance</th>
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<tbody>
<tr>
<td>Critical</td>
<td>No</td>
<td>3-4 yrs</td>
<td>Partial</td>
</tr>
</tbody>
</table>

early blight
bacterial spot
<table>
<thead>
<tr>
<th>Tillage</th>
<th>Seedborne</th>
<th>Rotation</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>Yes</td>
<td>2-3 yrs</td>
<td>No</td>
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</table>

*bacterial spot*
bacterial canker
<table>
<thead>
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<th>Seedborne</th>
<th>Rotation</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>Yes</td>
<td>3-4 yrs</td>
<td>No</td>
</tr>
</tbody>
</table>

bacterial canker
Organic Fungicides

- Organic Materials Review Institute (OMRI.org)
- Fewer resistance issues than conventional fungicides
- Many different MOA
<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Mode of action</th>
<th>Specificity</th>
<th>Residual</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic chemicals</td>
<td>Multiple-sites</td>
<td>Wide range of pathogens.</td>
<td>Residual good.</td>
<td>Examples: copper, sulfur</td>
</tr>
</tbody>
</table>

Examples include:

- Copper hydroxide (e.g., Champ WP); copper oxide (Nordox 75WP)
- Sulfur (e.g., Microthiol Disperss)
<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Mode of action</th>
<th>Specificity</th>
<th>Residual</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen dioxide</td>
<td>Multiple-sites</td>
<td>Wide range</td>
<td>None or little</td>
<td>Oxidate, Zerotol</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>Multiple (cell disruption)</td>
<td>Wide range</td>
<td>Little or none</td>
<td>Potassium bicarbonate is common form. Ex: Milstop</td>
</tr>
<tr>
<td>Active ingredient</td>
<td>Mode of action</td>
<td>Specificity</td>
<td>Residual</td>
<td>Example</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------</td>
<td>----------------------</td>
<td>---------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Microbial</td>
<td>Competition</td>
<td>Usually wide range</td>
<td>Varies per product.</td>
<td>T-22</td>
</tr>
<tr>
<td></td>
<td>Toxin production</td>
<td>Depends on product</td>
<td>Best results w/ early app.</td>
<td>Serenade Max</td>
</tr>
<tr>
<td></td>
<td>Parasitic on pathogen</td>
<td>Very specific</td>
<td></td>
<td>Contans</td>
</tr>
</tbody>
</table>

Some microbial products can have more than one MOA:

- TaegroEco (*Bacillus subtilis var. amyloliquefaciens*)
  - Induces Systemic Acquired Resistance (SAR)
  - produces antibiosis
<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Mode of action</th>
<th>Specificity</th>
<th>Residual</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant extracts</td>
<td>Depends on product</td>
<td>Varies per extract.</td>
<td>Varies.</td>
<td>Example, Neem, Regalia.</td>
</tr>
</tbody>
</table>
Gray mold fungicides-greenhouse
D.M. Ingram Mississippi State

Disease Severity

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Disease Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Control</td>
<td>a</td>
</tr>
<tr>
<td>Regalia</td>
<td>ab</td>
</tr>
<tr>
<td>Oxidate</td>
<td>a</td>
</tr>
<tr>
<td>Actinovate</td>
<td>abc</td>
</tr>
<tr>
<td>Cease + Milstop</td>
<td>c</td>
</tr>
</tbody>
</table>
Gray mold fungicides—greenhouse
D.M. Ingram Mississippi State

Stem Lesions

- Untreated Control
- Regalia
- Actinovate
- Prestop
- Cease + Milstop

The diagram shows the effectiveness of different fungicides on stem lesions. The treatments are labeled as follows:

- untreated control
- Regalia
- Actinovate
- Prestop
- Cease + Milstop

The bars are labeled with lowercase letters (a, ab, b, c) indicating significant differences among the treatments.
Septoria leaf spot of tomato control in field  
M. McGrath Cornell-two studies

<table>
<thead>
<tr>
<th>Product</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Control</td>
<td>*</td>
</tr>
<tr>
<td>Actinovate</td>
<td>*</td>
</tr>
<tr>
<td>Actinovate + Kocide</td>
<td>**</td>
</tr>
<tr>
<td>TaegroECO</td>
<td>*</td>
</tr>
<tr>
<td>TaegroECO + Kocide</td>
<td>**</td>
</tr>
<tr>
<td>Regalia</td>
<td>*</td>
</tr>
<tr>
<td>Conv. Fungicides</td>
<td>***</td>
</tr>
</tbody>
</table>

*, little control
**, significantly more control than *
***, significantly more control than **
Organic Zucchini leaf disease ratings

Powdery mildew

<table>
<thead>
<tr>
<th>Treatment, rate/A&lt;sup&gt;z&lt;/sup&gt;</th>
<th>Disease Severity 27 Aug (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leaf top</td>
<td>Leaf bottom</td>
</tr>
<tr>
<td>Untreated check. . . . . . . . . . .</td>
<td>18.8 a</td>
<td>37.5 a</td>
</tr>
<tr>
<td>Serenade Max 3 lbs. . . . . . . . .</td>
<td>15.0 ab</td>
<td>37.5 a</td>
</tr>
<tr>
<td>Oxidate 90 fl oz. . . . . . . . . .</td>
<td>12.0 ab</td>
<td>30.3 ab</td>
</tr>
<tr>
<td>Milstop 2 lbs. . . . . . . . . . .</td>
<td>5.7 bc</td>
<td>12.0 c</td>
</tr>
<tr>
<td>Champ DP 3 lbs . . . . . . . . . .</td>
<td>2.3 c</td>
<td>18.8 bc</td>
</tr>
<tr>
<td>P-value</td>
<td>0.0125</td>
<td>0.0525</td>
</tr>
</tbody>
</table>

<sup>z</sup> Fungicides were applied approximately weekly from 9 until 31 Aug, except Oxidate which was applied twice weekly.
### Muskmelon Alternaria Leaf Blight ratings

<table>
<thead>
<tr>
<th>Treatment, rate/A$^z$</th>
<th>Disease severity 23 Jul (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternaria leaf blight</td>
<td></td>
</tr>
<tr>
<td>Serenade Max 3 lbs.</td>
<td>2.9 b</td>
</tr>
<tr>
<td>Oxidate 90 fl oz.</td>
<td>4.1 ab</td>
</tr>
<tr>
<td>Untreated check.</td>
<td>7.7 a</td>
</tr>
<tr>
<td>Milstop 2 lbs.</td>
<td>3.5 b</td>
</tr>
<tr>
<td>Champ DP 3 lbs.</td>
<td>2.3 b</td>
</tr>
<tr>
<td>$P$-value</td>
<td>0.0496</td>
</tr>
</tbody>
</table>

$^z$Fungicides were applied approximately weekly from 12 Jun until 29 Jul, except Oxidate which was applied twice weekly.