IMPROVING RESISTANCE TO FUSARIUM WILT RACE THREE OF TOMATO

Jessica Chitwood-Brown

Tomato Breeders Roundtable Meeting 2018

J. Lee, S.F Hutton, T. G. Lee, and G.E. Vallad

Gulf Coast Research and Education Center, University of Florida
Outline

- Fusarium wilt of tomato
- Available resistance and its challenges
- Improving available resistance
- Novel resistance
- Improved Fol3 resistant cultivars
Tomatoes in Florida

Photo credit: J. Chitwood Brown
Fusarium wilt in tomato

- *Fusarium oxysporum* f. sp. *lycopersici* (*Fol*)
  - Soilborne fungus – colonizes vascular tissue
  - Forms chlamydospores
  - Chlorosis, wilting, stunting, vascular browning, plant death

- Management
  - Fumigation
    - Phase-out of methyl bromide
  - Host resistance is most effective

- Three races

Photo credit: http://plantpath.ifas.ufl.edu/u-scout/Tomato/Pages/Fusarium_wilt.html
Photo credit: J. Chitwood-Brown
Genetic resistance

Race 1
S. pimpinellifolium

Race 2
S. pimpinellifolium

Race 3
S. pennellii
Genetic resistance

- Race 1: *S. pimpinellifolium*
- Race 2: *S. pimpinellifolium*
- Race 3: *S. pennellii*
Genetic resistance

Focusing on race 3 ($Fol_3$) resistance
Genetic resistance

• I-3 cultivars available since the 1990’s
  • Associated with negative traits
  • Increased sensitivity to bacterial spot

Photo credit: Li et al. 2018
Genetic resistance

- *I*-3 cultivars available since the 1990’s
  - Associated with negative traits
  - Increased sensitivity to bacterial spot
Genetic resistance

- I-3 cultivars available since the 1990’s
  - Associated with negative traits
  - Increased sensitivity to bacterial spot
- Reduced fruit size
  - 1999

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**TOMATO PLANTS HETEROZYGOUS FOR FUSARIUM WILT RACE 3 RESISTANCE DEVELOP LARGER FRUIT THAN HOMOZYGOUS RESISTANT PLANTS**

J. W. Scott  
University of Florida  
Gulf Coast Research and Education Center  
Bradenton, FL 34203-9434

Additional index words. Fusarium oxysporum f. sp. lycopersici, hybrid, Lycopersicon esculentum, yield.

The race 2 resistance gene has been mapped to chromosome 11 by morphological (Laterrot, 1976) and DNA markers (Surfati et al., 1989). In 1982 Fusarium wilt race 3 was reported in Florida (Jones et al., 1982) and Australia (Grattidge and O’Brien, 1982). A single dominant resistance gene (I-3) was reported in L. pennelli (Corr.) D’Arcy accessions PI 494773 by McGrath et al. (1987) and in LA 716 by Scott and Jones (1989). The gene from LA 716 conferring race 3 resistance...
Genetic resistance

- 1-3 cultivars available since the 1990’s
  - Associated with negative traits
  - Increased sensitivity to bacterial spot

- Reduced fruit size
  - 1999
  - 2004


**Fla. 7946 Tomato Breeding Line Resistant to *Fusarium oxysporum* f.sp. *lycopersici* Races 1, 2, and 3**

J.W. Scott
Gulf Coast Research and Education Center, 5007 60th Street East, University of Florida, Bradenton, FL 34203

Additional index words: blossom-end rot, cultivar, disease resistance, fruit size, fusarium wilt, *Lycopersicon esculentum*
Genetic resistance

• 1-3 cultivars available since the 1990’s
  • Associated with negative traits
  • Increased sensitivity to bacterial spot

• Reduced fruit size
  • 1999
  • 2004
  • 20+ years of breeding later
Genetic resistance

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• Linkage drag or pleiotropy?
Approach

- Eliminate linkage drag with I-3
- Identify and utilize novel resistance
Approach

- Eliminate linkage drag with I-3
- Identify and utilize novel resistance
Linkage drag

- Linkage drag or pleiotropy?
  - Pleiotropy – *I*-3 itself
  - Linkage drag – linked genes from wild species

Linkage between the *I*-3 gene for resistance to Fusarium wilt race 3 and increased sensitivity to bacterial spot in tomato

Jian Li¹ · Jessica Chitwood¹ · Naama Menda² · Lukas Mueller³ · Samuel F. Hutton¹
Linkage drag

- Linkage drag or pleiotropy?
  - Pleiotropy – I-3 itself
  - Linkage drag – linked genes from wild species

**Abstract**

*Key message*  The negative association between the I-3 gene and increased sensitivity to bacterial spot is due to linkage drag (not pleiotropy) and may be remedied by reducing the introgression size.
Eliminate linkage drag

<table>
<thead>
<tr>
<th>Chromosome 7</th>
<th>SL2.50 Physical Positions (Mb)</th>
<th>R12 RIL</th>
<th>R18 RIL</th>
<th>F1 F2 Cross-over Products</th>
<th>Fla. 8978</th>
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Diagram showing the elimination of linkage drag through genetic crossing over.
Eliminate linkage drag

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- **I-3**

Fla. 8978
Eliminate linkage drag

- Backcrossing this minimal introgression into several elite UF/IFAS breeding lines
- Testing for effect on bacterial spot sensitivity and fruit size

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[Photo credit: J. Chitwood-Brown]
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Photo credit: J. Chitwood-Brown
Eliminate linkage drag

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<th>Average Fruit Size (g)</th>
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<tr>
<td>Fla. 7946</td>
<td>Lg/Lg</td>
<td>5.8 A</td>
<td>132 A</td>
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<tr>
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Linkage with negative effects likely broken.
Approach

Eliminate linkage drag with I-3

Identify and utilize novel resistance
Novel *Fol3* resistance

- *S. pennellii* demonstrated to have high resistance to fusarium wilt
- 42 *S. pennellii* accessions from the Tomato Genetic Resource Center (TGRC)
  - Almost all accessions resistant
- Resistance introgressed into Florida breeding lines via backcrossing
  - Seedling disease assays, selecting for resistance
Novel *Fol3* resistance

- Molecular markers used to select away from known resistance genes
- Spring 2018 - resistance from 26 accessions advanced to BC5F1
- Choosing families for mapping
  - Clear phenotypes
  - Segregation ratios
  - Phylogenetic relationships
#### Novel *Fol3* resistance

<table>
<thead>
<tr>
<th>Resistance from</th>
<th>Healthy</th>
<th>Infected</th>
<th>Ratio</th>
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<tr>
<td>LA750</td>
<td>45</td>
<td>7</td>
<td>6:1</td>
</tr>
<tr>
<td>LA1273</td>
<td>43</td>
<td>12</td>
<td>4:1</td>
</tr>
<tr>
<td>LA1302</td>
<td>33</td>
<td>13</td>
<td>3:1</td>
</tr>
<tr>
<td>LA1303</td>
<td>42</td>
<td>13</td>
<td>3:1</td>
</tr>
<tr>
<td>LA1522</td>
<td>43</td>
<td>13</td>
<td>3:1</td>
</tr>
<tr>
<td>LA1809</td>
<td>37</td>
<td>15</td>
<td>3:1</td>
</tr>
<tr>
<td>LA1911</td>
<td>44</td>
<td>12</td>
<td>4:1</td>
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</table>
Novel *Fol3* resistance

- Phylogenetic relationships
- Different accessions belong to different clusters
- Accessions from different clusters chosen
Novel *Fol3* resistance

- Phylogenetic relationships
- Different accessions belong to different clusters
- Accessions from different clusters chosen

Families with resistance from these 4 accessions are being genotyped for mapping and prepared for *characterization studies*. 

Credit: T.G. Lee
Impacts

Linkage between I-3 and negative traits likely broken

Continued exploration of novel \textit{Fol3} resistance alleles

Combine available and novel genes for more durable resistance
Thank you

• Committee members
  • Dr. Sam Hutton – advisor
  • Dr. Tong Geon Lee
  • Dr. Gary Vallad – plant pathology lab
  • Dr. Vance Whitaker

• Tomato breeding lab
  • Rebecca Wente
  • Dolly, Jose, Judith, Kazuyo, Keri, Nate, Reza, Tim
  • John and Upinder
  • Edgar and Jasmine

• Funding
  • PBGI
  • USDA Tomato CGC
QUESTIONS?
Recombinant inbred lines
## Horsfall-Barratt Scale

<table>
<thead>
<tr>
<th>Score</th>
<th>% Diseased Tissue</th>
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<tbody>
<tr>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>0-3%</td>
</tr>
<tr>
<td>3</td>
<td>3-6%</td>
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<tr>
<td>4</td>
<td>6-12%</td>
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<tr>
<td>5</td>
<td>12-25%</td>
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<td>6</td>
<td>25-50%</td>
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<tr>
<td>7</td>
<td>50-75%</td>
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<tr>
<td>8</td>
<td>75-87%</td>
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<td>87-94%</td>
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<td>11</td>
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