“Localization and Mapping of Sw-7, a Tomato spotted wilt virus Resistance Gene”

Mikel R. Stevens
John W. Scott, Keri Dockter, Derek O’Neil, and David Price
Tospoviruses

• Thrips are the vectors
• Over 1,000 species are infected
  – Both monocots and dicots
• Over 15 Tospovirus species have been identified
Control of TSWV in Tomato

- Limited success with pesticides
- Limited success with cultural practices

- Success with genetic engineering
  - Using viral genes inserted into the genome
    - Hampered by public acceptance

- Natural resistance
Reports of TSWV Resistance in Cultivated Tomato Lines

- ‘Pearl Harbor’ 1945
- ‘Ray de los Tempranos’ 1949
- ‘Manzana’ 1949
- ‘Anahu’ 1971
- ‘Stevens’ 1986
- ‘Platense’ and ‘Quil-Quil’ 1992

- Sw-5 was identified in ‘Stevens’ and a Peto Seed line

- **Problem** “only Sw-5 has provided broad – long lasting resistance”
Resistance in Related Wild Species

- Samuel et al., 1930
  S. pimpinellifolium
- Wenholz, 1939
  S. peruvianum
- Costa, 1944
  S. habrochaites
- Iizuka et al., 1993
  S. chilense
- Kumar et al., 1993
  S. pennellii

- Sw-5 was derived from S. peruvianum
Reports of Sw-5 “Breaking Down”

• Areas of the world
  – Italy
  – Spain
  – Hawaii
  – Australia
  – And other areas
S. *chilense* Resistance
From LA 1938

- Has been difficult to work with in the greenhouse:
  - Using artificial inoculation conditions
    - Reason – too severe – overwhelming – unknown for sure – ???

- However clear evidence of resistance in field conditions
  - South Africa
  - Hawaii
  - Panhandle of Florida/Southern Georgia

- **This *S. chilense* resistance is resistant to isolated**
  that overcome Sw-5
S. chilense TSWV Resistance

• New sources pedigree
  • S. lycopersicium x S. chilense (LA 1938)

• Initially selected for geminivirus resistance in Florida
  – Jay Scott
CK12 Pedigree

S. lycopersicum x S. chilense (LA 1938)

Interspecific hybrid (F₁)

F₁BC₁

Fla 7482B = 936011 x F₁BC₁S₅ = IE925F-2

F₁

F₂ = CK12

F₃

Tested for TSWV Resistance

Seed from four F₃ lines were sent to the Cape area of South Africa
At Fruit Harvest

% of Plants

Visual Ratings

No disease

Clear disease

1

2

3

4

5

Stevens
At Fruit Harvest

% of Plants

Visual Ratings

No disease
Clear disease

Stevens
Floradade

0 10 20 30 40 50 60 70 80 90

1 2 3 4 5

0 10 20 30 40 50 60 70 80 90

0 10 20 30 40 50 60 70 80 90

No disease
Clear disease
At Fruit Harvest

Visual Ratings

% of Plants

Stevens
F3
Floradade

No disease
Clear disease

1 2 3 4 5

0 10 20 30 40 50 60 70 80 90
At Fruit Harvest

Visual Ratings

% of Plants

- No disease
- Clear disease

Stevens
F3
BC res
Floradade
**CK12 Pedigree**

**L. esculentum x L. chilense (LA 1938)**

- Interspecific hybrid (F₁)
  - $F_{1BC_1}$
  - Fla 7482B = 936011 x $F_{1BC_1}S_5 = IE925F-2$

- Studied in greenhouse

- $F_1$
  - $F_2 = CK12$

- Studied in South Africa

- $F_3$
  - Fla 7482B x $F_4$ CK12 (red)

- Studied in Hawaii

- $F_1$
  - $F_2 = sent to Florida$

- Studied in Florida
Elucidating Sw-7 Inheritance

- Field and greenhouse studies demonstrated a single dominant gene
  - Greenhouse studies used a TSWV isolate that overcomes Sw-5
  - Suggested name “Sw-7”
  - Florida field studies clearly demonstrated that Sw-5 and Sw-7 were not allelic
Breeding for Sw-7 in Florida

• 70+ $F_3$ lines (selected for resistance at $F_2$) were field screened
  – 48 were selected for to use for marker work
Looked at over 200 SSR “like” markers

Focused on chromosome 12

Found a small area on chromosome 12
Progress Towards Locating Sw-7

- Data suggest Sw-7 is between
  - 40 (C2_AT4g16710) and 59 (CT189)
    - ExPEN 2000 map
    - Chromosome 12

- This introgression segregates 100% with Sw-7 resistance
So what do we know about this area?

- There are 46 markers found in the area
- Over half are above 55 cM
- Some not easy to work with
Scrutiny of the Area

• Using the 48 F₃ lines
  – Data suggested Sw-7 was near 50 cM area

• But then when more markers near that area were checked...
  – Things did not add up
HUM...

- So we took another F₂ population segregating for Sw-7
- No deliberate selection pressure
- It’s purpose was to map this region with Sw-7 present
What did we Learn???

Found on the Ohio Tomato Mapping Resource Database Chromosome 12 at 29.9 Mapping Units
What About 48 F₃ Lines From Florida and These Markers?

- Markers with some resistance testing to-date
  - T1263
  - C2At_g42G1120 ***
  - TG360
  - T1045
  - T1736
  - T211**
  - CT-99***
  - SSR20*
  - SL 10953i*

<table>
<thead>
<tr>
<th>Marker</th>
<th>$X^2$</th>
<th>Locus</th>
</tr>
</thead>
<tbody>
<tr>
<td>cLET-8-K4</td>
<td>3.64</td>
<td>41.0</td>
</tr>
<tr>
<td>C2_At5g57970</td>
<td>92.81</td>
<td>43.0</td>
</tr>
<tr>
<td>T1263</td>
<td>2.81</td>
<td>45.0</td>
</tr>
<tr>
<td>C2_At2g42620</td>
<td>145.55</td>
<td>46.0</td>
</tr>
<tr>
<td>C2_At4G11120</td>
<td>2.03</td>
<td>48.0</td>
</tr>
<tr>
<td>TG360</td>
<td>0.47</td>
<td>50.0</td>
</tr>
<tr>
<td>T1045</td>
<td>141.51</td>
<td>51.0</td>
</tr>
<tr>
<td>T1736</td>
<td>30.85</td>
<td>52.0</td>
</tr>
<tr>
<td>T1211</td>
<td>141.51</td>
<td>53.0</td>
</tr>
<tr>
<td>CT-99</td>
<td>1.38</td>
<td>53.5</td>
</tr>
<tr>
<td>SSR20</td>
<td>0.79</td>
<td>58.2</td>
</tr>
<tr>
<td>SL10953i</td>
<td>2.03</td>
<td>5**</td>
</tr>
</tbody>
</table>

The rest have insufficient or unreliable data to even “intimate” relationships to Sw-7
Importance of Field Trials

- Difficult to work with in artificial inoculation trials
- Need to understand “fitness” of resistance
- Determine effectiveness to unusual isolates (strains) of TSWV
  - Examples:
    - Australia
    - Taiwan
    - Italy
    - South Africa
Develop Commercially Ready Lines
Thanks To The Assistance Of:

• Key undergraduates
  – Fred Memmott
  – David Price
  • Outstand Undergraduate Oral Presentation at the National ASHS Meetings (Phoenix, AZ) in 2007
    – Derek O’Neil
    – Keri Dockter

• And Many others