Accomplishments of a 10-Year Initiative to Develop Host Plant Resistance to Root-Knot and Reniform Nematodes in Cotton 2003 - 2013
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Nematode Management

**Rotation** – Driven by Crop Prices

**Nematicides** – Aldicarb Unavailable

**Resistant Cultivars**

Root Knot – before 2014 partial resistance

Reniform - none
Cotton Incorporated
Host Plant Resistance Initiative
Situation: 2003

- Root-Knot Nematode
  - Germplasm
  - ‘Shepard Source’
  - Variety – LA 887

- Reniform
  - ZERO
Cotton Incorporated Sponsored Meeting
“Breeding Cotton for Resistance to Nematodes”
August 20, 2003 – Austin Texas

Objectives
1. Identify, characterize, and locate genes to develop germplasm with host plant resistance against root-knot (Meloidogyne incognita) and reniform (Rotylenchulus reniformis) nematodes.
2. Identify the technologies needed to conduct efficient breeding programs and provide them.
3. Address the task of transferring germplasm and necessary breeding technologies to commercial planting seed companies.
# Genetics of Root-Knot Nematode Resistance

<table>
<thead>
<tr>
<th>Population</th>
<th>Genes/QTL</th>
<th>Markers</th>
<th>Researcher</th>
</tr>
</thead>
<tbody>
<tr>
<td>NemX x SJ-2</td>
<td>rkn-1 – ch. 11</td>
<td>CIR-316</td>
<td>Roberts</td>
</tr>
<tr>
<td></td>
<td>(recessive)</td>
<td>BNL 1066</td>
<td>Roberts</td>
</tr>
<tr>
<td>M 125 x S-6</td>
<td>Mi-A03 – ch. 11</td>
<td>CIR-316</td>
<td>Chee</td>
</tr>
<tr>
<td></td>
<td>(dominant)</td>
<td>CIR-069</td>
<td>Chee</td>
</tr>
<tr>
<td>M 240 x STV 213</td>
<td>QTL – ch. 11</td>
<td>CIR-316</td>
<td>Jenkins</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BNL 1231</td>
<td>Jenkins</td>
</tr>
<tr>
<td>M 240 x STV 213</td>
<td>QTL ch 14</td>
<td>BNL 3545</td>
<td>Jenkins</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BNL 3661</td>
<td>Jenkins</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BNL 3664</td>
<td>Jenkins</td>
</tr>
</tbody>
</table>
Extreme phenotypes of transgressive segregants outside parent range in RIL TM1 x Pima 3-79
Segregants from the Population TM-1 x Pima 3-79

TM-1 Sus.

Pima 3-79 Sus.

RIL Progeny Highly Res.

RIL progeny Highly Sus.
Comparison of lines with/without combinations of 2 to 4 QTLs showed reduction > 50% in both Galling Index (GI) and Egg production.

- C03 x C04 x C11 x C19  GI 1.7
- TM1 x P3-79 x P3-79 x TM1
<table>
<thead>
<tr>
<th>Chromosome (interval)</th>
<th>LOD</th>
<th>Add</th>
<th>Dom</th>
<th>d/a*</th>
<th>PV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chr. 11 (CIR069-CIR316)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pop1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galling index</td>
<td>9.69</td>
<td>2.463</td>
<td>-2.521</td>
<td>1.02</td>
<td>52.6</td>
</tr>
<tr>
<td>Galling index [log (x + 1)]</td>
<td>9.68</td>
<td>0.221</td>
<td>-0.269</td>
<td>1.20</td>
<td>34.4</td>
</tr>
<tr>
<td>Eggs [log (x + 1)]</td>
<td>3.32</td>
<td>0.391</td>
<td>-0.376</td>
<td>0.96</td>
<td>11.0</td>
</tr>
<tr>
<td>Eggs/g of root</td>
<td>2.55</td>
<td>2.105</td>
<td>-1.539</td>
<td>0.73</td>
<td>12.9</td>
</tr>
<tr>
<td>Eggs/g of root [log (x + 1)]</td>
<td>3.76</td>
<td>0.432</td>
<td>-0.353</td>
<td>0.82</td>
<td>15.84</td>
</tr>
<tr>
<td>Pop2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galling index</td>
<td>9.61</td>
<td>2.734</td>
<td>-2.831</td>
<td>1.04</td>
<td>65.6</td>
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<tr>
<td>Galling index [log (x + 1)]</td>
<td>7.21</td>
<td>0.148</td>
<td>-0.184</td>
<td>1.24</td>
<td>31.7</td>
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<tr>
<td>Eggs</td>
<td>7.35</td>
<td>16.729</td>
<td>-21.862</td>
<td>1.31</td>
<td>23.3</td>
</tr>
<tr>
<td>Eggs [log (x + 1)]</td>
<td>7.70</td>
<td>0.461</td>
<td>-0.655</td>
<td>1.42</td>
<td>33.8</td>
</tr>
<tr>
<td>Eggs/g of root</td>
<td>6.47</td>
<td>1.152</td>
<td>-1.800</td>
<td>1.56</td>
<td>18.9</td>
</tr>
<tr>
<td>Eggs/g of root [log (x + 1)]</td>
<td>7.04</td>
<td>0.505</td>
<td>-0.545</td>
<td>1.08</td>
<td>25.4</td>
</tr>
<tr>
<td>Combined</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galling index</td>
<td>19.21</td>
<td>2.677</td>
<td>-2.896</td>
<td>-1.08</td>
<td>63.7</td>
</tr>
<tr>
<td>Galling index [log (x + 1)]</td>
<td>8.51</td>
<td>0.193</td>
<td>-0.208</td>
<td>-1.08</td>
<td>35.8</td>
</tr>
<tr>
<td>Eggs</td>
<td>4.98</td>
<td>1.354</td>
<td>-14.346</td>
<td>-1.06</td>
<td>8.9</td>
</tr>
<tr>
<td>Eggs [log (x + 1)]</td>
<td>7.76</td>
<td>0.280</td>
<td>-0.434</td>
<td>-1.54</td>
<td>14.4</td>
</tr>
<tr>
<td>Eggs/g of root</td>
<td>7.23</td>
<td>1.859</td>
<td>-2.155</td>
<td>-1.16</td>
<td>16.1</td>
</tr>
<tr>
<td>Eggs/g of root [log (x + 1)]</td>
<td>7.98</td>
<td>0.273</td>
<td>-0.444</td>
<td>-1.63</td>
<td>15.0</td>
</tr>
</tbody>
</table>

* Indicates dominant gene action when the absolute d/a ratio is greater than 1
Identifying the Resistance-Gene Rich Region of Chromosome 11
Dr. Jim Starr showed that five primitive race stocks from Mexico had good to excellent, heritable root-knot nematode resistance.

Markers associated with the resistance in other lines were not associated in the newly evaluated lines.

Reniform Nematode Resistance
(2003)

Gossypium hirsutum (AADD) – none
G. barbadense (AADD) - primitive
G. arboreum (A) – little known
G. armorianum (D) - little known
G. longicalyx – virtual immunity
Triple Species Hybrids

Gossypium hirsutum x G. longicalyx x G. armorianum
AD x F = (FAD)^2 x D = FADD

G. hirsutum x G. herbaceum x G. longicalyx
AD x A (AAD)^2 x F = AADF

Robinson et al. 2007. Crop Sci. 47: 1865-1877
Belle Mina, July 14, 2011 (58 days after planting)

plot 301 - BARBREN-713

plot 302 - LONREN 21-4

Cotton Incorporated
MARKERS ON INTROGRESSION SEGMENTS FROM G. longicalyx

- Fzg\textsuperscript{Ion} (green)
- CIR 316_191
- BNL 1231\_null
- BNL 3279_114
- BNL 1066_156
- BNL 836_215

LONREN Lines

→ Recombination Sites
Triple Species Hybrids

Gossypium arboreum x (G. hirsutum x G. aridum)²

Romano et al. 2009. TAG 120: 139-150

Reniform Nematode Resistance from GB 713


2010. Gutierrez et al. conclude that resistance in GB 713 is due to 3 QTLs.

2012. Release Notice for Barbren (1 line)
Yields

- Lowest Yield Reduction: 2% for M713 Ren3
- Highest Yield Reduction: 93% LONREN 21-4
- Yield Reduction for BAR 41: 9%

Highest yield: 1748 lbs/acre LONREN-1 on the no RN field
Lowest yield: 102 lbs/acre LONREN 21-4 on the with RN field
# Cotton Resistance to Nematodes

## Situation at start of 2014

<table>
<thead>
<tr>
<th>Nematode Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Root Knot</strong></td>
<td>High Level Resistance is at least a two-gene system – ch. 11 + chs. 7, 14, 21 – possibly others; resistance is epistastic. Delta &amp; Pineland and Phytogen launch resistant cultivars in 2014.</td>
</tr>
<tr>
<td><strong>Reniform</strong></td>
<td>Public releases with moderate resistance from <em>G. hirsutum</em> MT2468. Public releases with high-level resistance from <em>G. barbadense</em> – Barbren and M713. Numerous markers publically available for both.</td>
</tr>
</tbody>
</table>
What has been accomplished?

Enabling Technology – Genes Identified, Inheritance Characterized, Published Markers, Germplasm Releases.

Information in Public Domain

Incentive for Development

Grower Awareness of Research Progress