Root-knot Nematode Resistance in Upland cotton

Peng W. Chee
ICGI Conference
Raleigh, NC, Oct 10, 2012
The most important nematodes of cotton in the U.S.

Southern root-knot (Meloidogyne incognita)

Reniform (Rotylenchulus reniformis)

Columbia Lance (Hoplolaimus columbus)
Disease Cycle and Epidemiology

J2s initiate feeding sites by injection of esophageal gland secretions into root cells, forming "giant-cells".

Nematodes develop into J3, J4 and adult stage. Galling occurs as a response to nematode parasitism.

J2s enter roots and migrate to the area of cell elongation.

Infected juvenile (J2) is attracted to growing roots.

First stage juvenile (J1) molts within egg.

Eggs are exuded into an egg mass on the outside of the female.

Egg Masses

Adult females produce >1000 eggs. Males are unnecessary in most species, but are sometimes encountered.

Heavily galled roots provide minimal resources for the rest of the plant.

Root-knot nematodes disease cycle.

Courtesy V. Brewster
Population distributions and densities of root-knot nematodes in the cotton belt (2009)

Source: National Cotton Council
Tools available for nematode management

- Crop Rotation
- Nematicicides
- Plant-Host Resistance
Tools available for nematode management

- Crop Rotation
- Nematicides
- Plant-Host Resistance
Tools available for nematode management

- Crop Rotation
- Nematicides
- Plant-Host Resistance
Sources of resistance to *M. incognita*

**Auburn 623** – created by crossing Clevevilt 6-3-5 and Wild Mexico
Released to breeders in 1970

Source: Robinson 1999
Sources of resistance to *M. incognita*

**Auburn 623** – created by crossing Clewewilt 6-3-5 and Wild Mexico
Released to breeders in 1970

![Genetic Diagram]

**STILL NO HIGHLY-RESISTANT CULTIVARS!**

Source: Robinson 1999
Development of GA 120R1B3 cotton germplasm line with a high level of resistance to *M. incognita*

Davis et al. 2011

- 2001 – crossed M120 RNR (resistant) with PD94042 (susceptible)
- Three generations of backcrossing into PD94042
- A single-seed descent – lowest galling and eggs count
- Eight generations of self-pollinations and individual plant selection
PHY 367, ST 4288, ST 5458, and DP 174 are moderately resistant and suppressed *M. incognita* levels by 63% to 82% vs. DP 0935 (or 45% to 74% vs. GA 2004230)
PHY 367, ST 4288, ST 5458, and DP 174 are moderately resistant and suppressed *M. incognita* levels by 63% to 82% vs. DP 0935
None of the currently grown commercial cotton cultivars expresses a high level of resistance to root-knot nematodes.
None of the currently grown commercial cotton cultivars expresses a high level of resistance to root-knot nematodes.

Why?
Genetic mapping populations

Pima S6 X M120 RNR

F1 Plant #1
F1 Plant #2

107 F2 progeny
138 F2 progeny

Egg counts

Galling Index

Pop1
Pop2

M-120

F1

Pima-S6

M-120

F1

Pima-S6
QTLs associated with galling - Chr. 11 and 14

PVA = 63%
PVA = 32%
Add = -2.7
Add = -0.48

Shen et al. 2006
Origin of root-knot nematode resistance locus on Chromosome 11

<table>
<thead>
<tr>
<th>Lineage</th>
<th>RNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pima S6</td>
<td></td>
</tr>
<tr>
<td>M-120 RNR</td>
<td></td>
</tr>
<tr>
<td>Auburn 623</td>
<td></td>
</tr>
<tr>
<td>Auburn 634</td>
<td></td>
</tr>
<tr>
<td>Clewilt 6</td>
<td></td>
</tr>
<tr>
<td>Wild Mexican JJ</td>
<td></td>
</tr>
<tr>
<td>Coker 201</td>
<td></td>
</tr>
<tr>
<td>M-92 RNR</td>
<td></td>
</tr>
<tr>
<td>M-240 RNR</td>
<td></td>
</tr>
<tr>
<td>M-249 RNR</td>
<td></td>
</tr>
<tr>
<td>M-272 RNR</td>
<td></td>
</tr>
<tr>
<td>M-315 RNR</td>
<td></td>
</tr>
<tr>
<td>M-331 RNR</td>
<td></td>
</tr>
<tr>
<td>M-725 RNR</td>
<td></td>
</tr>
<tr>
<td>Acala NemX</td>
<td></td>
</tr>
<tr>
<td>LA887</td>
<td></td>
</tr>
</tbody>
</table>
Origin of root-knot nematode resistance locus on Chromosome 14

1 Marker, 2 Pima S-6, 3 M-120 RNR, 4 Auburn 634 RNR, 5 Auburn 623 RNR, 6 Clevewilt 6, 7 Wild Mexican Jack Jones, 8 Coker 201, 9 M-92 RNR, 10 M-240 RNR, 11 M-249 RNR, 12 M-272 RNR, 13 M-315 RNR, 14 M-331 RNR, 15 M-725 RNR, 16 Auburn 56, 17 Acala NemX, 18 LA887.
Reduction in galling and eggs production among F2s carrying Chr 11 and Chr 14 QTLs.
## Epistasis between Chr 11 and Chr14 QTLs (QTL Network)

<table>
<thead>
<tr>
<th>Trait</th>
<th>QTLi</th>
<th>Interval-i</th>
<th>QTLj</th>
<th>Interval-j</th>
<th>AA</th>
<th>p-value</th>
<th>H^2(aa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>logeggs</td>
<td>1-6</td>
<td>UGT0045-CGR5668</td>
<td>2-1</td>
<td>CIR069-CIR316</td>
<td>-0.3007</td>
<td>0.001509</td>
<td>0.0494</td>
</tr>
<tr>
<td>logeggroot</td>
<td>1-5</td>
<td>CIR381-UGT0045</td>
<td>2-1</td>
<td>CIR069-CIR316</td>
<td>-0.3586</td>
<td>0.000016</td>
<td>0.0596</td>
</tr>
</tbody>
</table>
Shen et al. 2010

**Fig 1.** Polymorphisms analysis using AFLP markers.

**Fig 3.** Polymorphisms analysis of SCAR marker P4M12 in mapping parents and individuals.

**RKN resistance QTL**

Shen et al. 2010 TAG
Summary

• The root-knot nematode resistance in the Auburn 623RNR source is conferred by two major genes.

• The resistant allele on Chr. 11 is derived from Clewewilt-6, and the resistance allele on Chr. 14 is originated from Wild Mexican.

• The gene on Chr. 11 appears to mostly affect gall suppression while that on Chr. 14 appears to reduce eggs production but has little effects on root galling.

• the transgressive segregation in Auburn 623RNR source could be due to the stacking of genes from two moderately resistant parents with different mechanisms for resistance.
Acknowledgements

Postdocs/Students
Dr. Guillermo Bacalaere
Nino Brown
Dr. Kedong Da
Aparna Desai
Dr. Yajun He
Dr. Naeem Iqbal
Pawan Kumar
Limei Liu
Dr. Edward Lubbers
Jinesh Patel
Dr. Hamidou Sakhanokho
Dr. Xinlian Shen
Dr. Baohua Wang

Technicians
Kippy Lewis
Jennifer McCurdy
Michael Jing
Jumin Zhuang
Stephen Walker

Collaborators
Dr. Richard Davis
Dr. Lloyd May
Dr. Andrew Paterson
Dr. C. Wayne Smith
Dr. Bob Nichols
Dr. Todd Campbell
Dr. Don Jones
Dr. Robert Wright

Funding source:
Thank you for your attention