Molecular Markers and Mapping of Root-knot Nematode Resistance in Cotton

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USDA-ARS, WICS, Res Unit, Shafter
Outline

1. Background

2. Markers & Mapping of RKN R genes in *G. hirsutum*  
   Acala NemX and Auburn 634 sources

3. Transgressive segregation for enhanced resistance

4. Mapping TS genes in *G. barbadense*

5. Search for gene origins in *Gossypium*
Root-knot Nematodes are one of the Most Economically Important Pests in Cotton

- Occur in every cotton-producing area in United States.
Parental Reaction to Root-knot Nematode

NemX  Pima S-7  SJ-2
Fusarium wilt of Cotton

Vascular disease caused by the soilborne Fungus Pathogen: *Fusarium oxysporum* f. s.p. *vasinfectum* (FOV)
FOV R4 + RKN

NemX
F$_{2:7}$ RIL Galling Index

The graph shows the galling index plotted against plant number. The data points are labeled as SJ-2 and NemX. The graph indicates a trend where the galling index increases with plant number.
AFLP marker and RIL F_{2:7} (NemX x SJ-2)

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4/128 EcoR1/Mse1

P1P2
CAPS marker (NlaIII) RIL7 (NemX x SJ-2)
Cotton Linkage map


284 primers
SSR: CIR 316

Marker

SJ-2
NemX
F₁ (NXS)

F₂

NemX x F₁

SJ-2 x F₁
Localization of NemX R gene

Published data:
- Nguyen et al. (2004) TAG
- Rong et al. (2004) Genetics
- http://cottondb.tamu.edu
- Frelichowski, Ulloa (2006) MGG
- Unpubl. data Mauricio Ulloa

F₂ (Pima S-7 x NemX)

Chr.11

BNL1231
BNL1066
CIR003
BNL836a
BNL3649
BNL1408
BNL3592
BNL4094
BNL1681a

CIR316a*

rkn1
Other RKN resistance mapping studies in Auburn 634 sources

1. Shen, Davis, May, Chee et al. TAG, 2006
   - 2 QTL Chr. 11 and Chr. 7 (F₂ with M120)

   - 2 SSRs, Chr. 11 and 14 (NIL from A634)

   - Major gene in A634 (Mi2) on Chr. 11 (F₂ with A634)
Localization of A634 R gene

Nui et al Crop Sci 2007

Chr.11

ST 474 x A 634 F₂
## Cotton germplasm: Marker Screening

| Marker         | PimaS-2 | PimaS-3 | PimaS-4 | PimaS-7 | Coker100 | Coker307-6 | Wild Mexico | Cleveilt 6 | Auburn 623 | Auburn 634 | Auburn56 | M-75 | M-78 | M-120 | M-188 | M-315 | TX 110 | Acala442 | Tanguis | LARN 4-4 | LA RN 1032 | NemX | SJ-2 | Marker |
|----------------|---------|---------|---------|---------|----------|------------|-------------|------------|------------|------------|-----------|--------|------|-------|-------|-------|-------|--------|---------|--------|---------|----------|------|------|--------|

SSR: CIR 316
Root-knot Nematode Resistance Sources

Wild Mexico
  Jack Jones

Clevevilt 6

Auburn 623  X  Auburn 56  X  Tanguis

Auburn 634

M -lines
  M-75, M-78, M-120, M188, M-315

AXTE, FBCX-2

LA RN 4-4
LA RN 1032

Acala NemX
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<th>SJ-2</th>
<th>NemX</th>
<th>Pima S-7</th>
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F₁ and Parent Resistance phenotypes for NemX, Pima S-7, SJ-2
F₂ (Pima S-7 x NemX) 179 plants

![Bar chart showing the number of plants with different egg counts per gram root for NemX and Pima S-7.]
Galling response of plants from 64 F$_{2:3}$ families of Pima S-7 x NemX

Extreme phenotypes of transgressive segregants outside parent range
**BC$_1$F$_1$ (NemX x F$_1$)**

(90 plants)

**BC$_1$F$_1$ (Pima S-7 x F$_1$)**

(114 plants)
Testcross NemX x F₁ (PimaS-7 x SJ-2)

All plants Het for \textit{rkn1}; \frac{1}{2} have PS7 factor

\[
R^2 = 0.6316
\]
Marker screening P x N with SSR for TS gene RKN2 from Pima S-7

**RKN2 SSR marker**

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<th>F₁ (N×SJ-2)</th>
<th>F₁ (P×SJ-2)</th>
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Markers 167 and 165 are highlighted.
Linkage groups and Joint-group representing Chr 11 showing the distance and position relationships between SSR markers and the nematode resistance genes $rkn1^*$ and $RKN2^{**}$.

Pop 1
Chromosome 11
F2 interspecific
(Pima S-7 x NemX) LOD = 4.0

Pop 2
Chromosome 11
F2 intraspecific
(NemX x SJ-2)
LOD = 6.0

Joint-LG
Chromosome 11
Cotton marker/R gene origin
Screening A and D genome donors

*RKN2* SSR marker – MUCS-088
Current working map of Chr 11, with BAC-end derived SSRs in the CIR316/BNL1231 region.
Summary

• Chromosome 11 important RKN R gene region: \textit{rkn1}, A634 source, \textit{RKN2}

• Excellent markers linked to \textit{rkn1} and \textit{RKN2} for MAS (SSR, CAPs, SNP)

• Transgressive segregation for enhanced resistance phenotypes

• Marker screening of diverse germplasm - test for unique R genes and origins

• Saturation mapping tied to physical mapping
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Jim Starr (Texas A&M)

Richard Davis and Peng Chee
(U. Georgia)
Johnnie Jenkins (USDA, MS)

Funding: Cotton Incorporated

UC Discovery Grant Program
Linkage groups representing Chr 11 showing the distance and position relationships between SSR markers and the nematode resistance genes

- Wang et al: Rkn1-NemX
- Shen et al: M120-Au 634
- Nui et al: Au 634