The Inevitability of Soybean Cyst Nematode

Mario Tenuta
NSERC Senior Industrial Research Chair

“Cutting Through the BS”
Soils and Crops
Saskatoon, Saskatchewan
March 11, 2020
### 2015 Soybean Disease Losses U.S. and Ontario

<table>
<thead>
<tr>
<th>Disease/Pathogen</th>
<th>2015 Estimated Yield Losses for U.S. (thousands of bushels)</th>
<th>2015 Estimated Yield Losses for Ontario (thousands of bushels)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Root Rot and Seedling Blights</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean cyst nematode</td>
<td>109,288</td>
<td>3,696</td>
</tr>
<tr>
<td>Seedling diseases (caused by species of <em>Fusarium</em>, <em>Pythium</em>, or <em>Rhizoctonia</em>)</td>
<td>62,948</td>
<td>2,957</td>
</tr>
<tr>
<td>Root-knot nematode</td>
<td>12,366</td>
<td>0</td>
</tr>
<tr>
<td>Reniform nematode</td>
<td>4,438</td>
<td>0</td>
</tr>
<tr>
<td>Other nematodes (lesion, Columbia lance, sting, stubby root)</td>
<td>1,465</td>
<td>148</td>
</tr>
<tr>
<td><strong>Leaf and Aboveground Diseases</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Septoria brown spot</td>
<td>26,868</td>
<td>37</td>
</tr>
<tr>
<td>Frogeye leaf spot</td>
<td>17,662</td>
<td>15</td>
</tr>
<tr>
<td>Cercospora leaf blight</td>
<td>12,840</td>
<td>0</td>
</tr>
<tr>
<td>Downy mildew</td>
<td>4,383</td>
<td>7</td>
</tr>
<tr>
<td>Bacterial diseases (bacterial blight and bacterial pustule)</td>
<td>2,774</td>
<td>4</td>
</tr>
<tr>
<td>*<em>Virus Diseases (AMV, BPMV, SbDV, SMV, SVN, TRSV, TSV)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virus Diseases (AMV, BPMV, SbDV, SMV, SVN, TRSV, TSV)*</td>
<td>2,602</td>
<td>74</td>
</tr>
<tr>
<td><strong>Other leaf and aboveground diseases (Phylllosticta leaf spot, target spot)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other leaf and aboveground diseases (Phylllosticta leaf spot, target spot)</td>
<td>2,427</td>
<td>0</td>
</tr>
<tr>
<td>Purple seed stain</td>
<td>1,594</td>
<td>15</td>
</tr>
<tr>
<td>Rhizoctonia aerial blight</td>
<td>652</td>
<td>0</td>
</tr>
<tr>
<td>Soybean rust</td>
<td>157</td>
<td>0</td>
</tr>
</tbody>
</table>

*AMV = alfalfa mosaic virus, BPMV = bean pod mottle virus, SbDV = soybean dwarf virus, SMV = soybean mosaic virus, TRSV = tobacco ringspot virus, TSV = tobacco streak virus.
Soybean Cyst Nematode (SCN)

- Is a nematode (round worm) that parasitizes roots of soybean
- Like people, not all nematodes are bad, but SCN is bad

Source: Swiss Federal Research Station for Agroecology and Agriculture
Source: Kris Lambert Univ. Illinois
The Life of a SCN Female

Soil

Root

Source: Swiss Federal Research Station for Agroecology and Agriculture

Source: Sandra Sardanelli Univ. Maryland
Female Settles Down to Feed and Produce Eggs

Mature female with eggs breaks through the root surface but remains attached to the root; male leaves root.

Source: Greg Tylka, Iowa State Univ.

Source: Edward McGawley, Louisiana State University
Female Becomes Cyst Eventually
Rupturing and Releasing Eggs

Source: Edward McGawley, Louisiana State University

Soil

Eggs released in soil, develop into juveniles

Source: Edward McGawley, Louisiana State University
White, lemon-shaped cysts on roots
SCN is Spreading to all Soybean Areas of Canada and U.S.

- Japan in 1880
- North Carolina in 1954
- Moved rapidly from there through much of soy growing area of the U.S.
- Minnesota in 1978
- Ontario in 1987
- North Dakota in 2003
The Quick March North
SCN in Manitoba?

- Canadian Food Inspection Agency (CFIA) has done some survey work of random fields
- CFIA found in survey of potato soil in 2010 what seemed to be a lot of SCN in one field
- CFIA has removed SCN as a Regulated Pest in Canada and thus will not survey fields any longer
SCN Survey of Manitoba 2012-2015

- 76 soybean fields sampled
- > 5500 soil samples
- 487 composite samples for processing
- Priority fields based on
  - Proximity to water courses from U.S. that flood
  - Number of soybean years
  - History of dry beans
  - Sampled prone areas of fields
35 fields sampled Oct/Nov 2012

13 fields sampled July/Aug 2013
Collecting Soil Samples

1 foot samples
Juveniles and Cysts

Circumfenestrate

Bifenestrate
Results 2012/13

- 37 composite samples from 22 fields had cysts
- Total of 60 cysts recovered
- 26 cysts were not damaged
- 23 cysts had circumfenestrate vulval cone structures – *Cactodera, Punctodera, Betulodera*
- 3 cysts were bifenestrate – *Heterodera*
Results

- 15 circumfenestrate cysts had eggs or juveniles
- 1 bifenestrate cyst had eggs and juveniles
- ITS sequencing, species-specific PCR
- Circumfenestrate cysts ITS matched *Cactodera*
- Bifenestrate cyst ambiguous – *Heterodera* by morphology, not SCN by species primer sets, *Cactodera* by ITS sequencing
Results 2014/15

- 28 fields sampled
- 205 composite samples analyzed
- 32 samples had cysts, but only a few each
- Most cysts were round and not lemon shaped
- Cone top patterns circumfenestrate
- 6 cysts yielded DNA for analysis, failed to be SCN
Species Specific PCR for SCN in 2015

3 cysts yielding quality DNA but not positive for SCN.

Positive control SCN yielding good DNA and giving band for SCN.
Manitoba 2017/2018 SCN Survey

- Fall 2017, 30 soybean fields soil sampled
- Samples have been extracted and being analyzed now for cysts

PhD student: Nazanin Ghavami
Results 2018

- 30 commercial soybean fields were sampled
- A total of 90 composite soil samples were obtained
- Overall, 17 of the composite samples from 7 fields had nematode cysts
- One to a few cysts were recovered from each of these 17 composite samples
- In total, 42 cysts were recovered and 30 of the cysts from seven fields were brown and lemon-shaped as expected of SCN
Results 2018

- Cyst numbers were 1, 2, 4, and 14 kg\(^{-1}\) soil for each of the fields
- PCR of 7-12 lemon-shaped cysts for the CoxIII gene & SCAR gene regions were SCN
- DNA sequencing of 18s and ITS genes also confirmed cysts were SCN
- Morphology of cysts and nematode juveniles also consistent with being SCN
- In 2019, soy grown on field in Norfolk Treherne
• In 2019, soy grown on field in Norfolk Treherne
• Visited the field twice and on second visit found SCN on roots of soy

Results 2019
Map Summary
On-going

- SCN positive fields resampled in 2020
- Lots of soil brought to lab
- Soy grown in soil to show reproduction on roots
- Build population to determine HG type of SCN population here
Damage Patches in Fields

Source: American Phytopathology Society

Source: Albert Tenuta OMAFRA
Can be Confused with Drown Outs
Can be Confused with Iron Chlorosis

Source: Jay Goos North Dakota State University
Effects of SCN on Soybean

What does it do?

• Takes away nutrients
• Water update disrupted
• Interferes with nodulation
• Damages roots (holes)

Field symptoms?

• Yellowed plants
  – Resembles Iron Chlorosis
• Stunted plants
  – Uneven height
• Early maturity
• Reduction of yield
• Fewer pods
• Damage shows earlier on sands
Avoid Host Plants in Fields

<table>
<thead>
<tr>
<th>Crop Plants</th>
<th>Weed Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adzuki Bean</td>
<td>American Vetch</td>
</tr>
<tr>
<td>Alsike Clover</td>
<td>Carolina Vetch</td>
</tr>
<tr>
<td>Bird’s-foot Trefoil</td>
<td>Common Chickweed</td>
</tr>
<tr>
<td>Common Vetch</td>
<td>Common Mullein</td>
</tr>
<tr>
<td>Cowpea/Black-eyed Pea</td>
<td>Field Pennycress</td>
</tr>
<tr>
<td>Crimson Clover</td>
<td>Hemp Sesbania</td>
</tr>
<tr>
<td>Crownvetch</td>
<td>Henbit</td>
</tr>
<tr>
<td><strong>Pinto, Navy, Cranberry, Black, Kidney, Great Northern, Snap Bean</strong></td>
<td>Hop Clovers</td>
</tr>
<tr>
<td>Hairy Vetch</td>
<td>Milk Vetch</td>
</tr>
<tr>
<td>Lespedezas</td>
<td>Mouse-ear Chickweed</td>
</tr>
<tr>
<td>Lima Bean</td>
<td>Pokeweed</td>
</tr>
<tr>
<td>Lupines</td>
<td>Purple Deadnettle</td>
</tr>
<tr>
<td>Mung Bean</td>
<td>Purslane</td>
</tr>
<tr>
<td><strong>Pea</strong></td>
<td>Shepherd’s Purse</td>
</tr>
<tr>
<td><strong>Soybean</strong></td>
<td>Wild Mustard</td>
</tr>
<tr>
<td>Sweet Clover</td>
<td>Winged Pigweed</td>
</tr>
<tr>
<td></td>
<td>Wood Vetch</td>
</tr>
</tbody>
</table>
Risk Areas in Fields

- Headlands
- Depressions
- Fences
- Entrance ways
- Sloughs
Prevent Soil Movement Between Fields

• Purchase clean used equipment
• Wash implements and tires between fields
• Don’t drive pickups between fields
• Clean footwear

Source: Greg Tylka Iowa State Univ.
Source: Sandra Sardanelli Univ. Maryland
Prevent Birds From Landing on Fields
Use Resistant Soy Varieties

Source: Albert Tenuta OMAFRA
## Resistant Varieties

### Manitoba Seed Guide

<table>
<thead>
<tr>
<th>Manitoba Maturity Zone</th>
<th>Company Maturity Group</th>
<th>Variety</th>
<th>Type</th>
<th>Average DTM +/− Check</th>
<th>Yield % Check</th>
<th>Site Years Tested</th>
<th>Hilum Colour</th>
<th>IDC Rating (1−5)</th>
<th>Group</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>000.8</td>
<td>LS TRI8XT</td>
<td>R2X</td>
<td>−10</td>
<td>86</td>
<td>2</td>
<td>BL</td>
<td>1.9</td>
<td>ST</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>000.5</td>
<td>NocomaR2</td>
<td>R2Y</td>
<td>−9</td>
<td>94</td>
<td>12</td>
<td>BL</td>
<td>2.0</td>
<td>ST</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.9</td>
<td>S0009-M2</td>
<td>R2Y</td>
<td>−9</td>
<td>89</td>
<td>12</td>
<td>IY</td>
<td>2.0</td>
<td>ST</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.7</td>
<td>TH89004 R2X</td>
<td>R2X</td>
<td>−8</td>
<td>94</td>
<td>2</td>
<td>BR</td>
<td>1.8</td>
<td>ST</td>
<td>1c</td>
</tr>
<tr>
<td></td>
<td>000.7</td>
<td>PS 00078 XRN</td>
<td>R2X</td>
<td>−7</td>
<td>95</td>
<td>8</td>
<td>BL</td>
<td>1.9</td>
<td>ST</td>
<td>yes 1c</td>
</tr>
<tr>
<td></td>
<td>000.2</td>
<td>Devo R2X</td>
<td>R2X</td>
<td>−6</td>
<td>94</td>
<td>8</td>
<td>BR</td>
<td>1.8</td>
<td>ST</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.9</td>
<td>RX000918</td>
<td>R2X</td>
<td>−6</td>
<td>103</td>
<td>2</td>
<td>BL</td>
<td>1.7</td>
<td>T</td>
<td>yes 1c</td>
</tr>
<tr>
<td></td>
<td>001.1</td>
<td>P001A48X</td>
<td>R2X</td>
<td>−5</td>
<td>99</td>
<td>2</td>
<td>TN</td>
<td>1.7</td>
<td>T</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>001.1</td>
<td>PV 11s001 RR2</td>
<td>R2Y</td>
<td>−5</td>
<td>90</td>
<td>12</td>
<td>Y</td>
<td>1.9</td>
<td>ST</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.7</td>
<td>Karpo R2</td>
<td>R2Y</td>
<td>−5</td>
<td>104</td>
<td>2</td>
<td>GR</td>
<td>2.2</td>
<td>ST</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.2</td>
<td>RX00218</td>
<td>R2X</td>
<td>−5</td>
<td>89</td>
<td>8</td>
<td>BR</td>
<td>1.9</td>
<td>ST</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.2</td>
<td>Notus R2</td>
<td>R2Y</td>
<td>−5</td>
<td>103</td>
<td>8</td>
<td>BL</td>
<td>1.6</td>
<td>T</td>
<td>1c</td>
</tr>
<tr>
<td></td>
<td>000.3</td>
<td>P003A97X</td>
<td>R2Y</td>
<td>−5</td>
<td>99</td>
<td>2</td>
<td>GR</td>
<td>1.9</td>
<td>ST</td>
<td>yes 1k</td>
</tr>
<tr>
<td></td>
<td>000.1</td>
<td>Torro R2</td>
<td>R2Y</td>
<td>−5</td>
<td>100</td>
<td>12</td>
<td>BL</td>
<td>2.2</td>
<td>ST</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.2</td>
<td>NSC Raders RR2X</td>
<td>R2X</td>
<td>−4</td>
<td>97</td>
<td>2</td>
<td>BL</td>
<td>1.9</td>
<td>ST</td>
<td>yes 1c</td>
</tr>
<tr>
<td></td>
<td>000.9</td>
<td>PV 15s0009 R2X</td>
<td>R2X</td>
<td>−4</td>
<td>99</td>
<td>8</td>
<td>BL</td>
<td>2.0</td>
<td>ST</td>
<td>yes 1c</td>
</tr>
<tr>
<td></td>
<td>000.4</td>
<td>NSC Culross RR2X</td>
<td>R2X</td>
<td>−3</td>
<td>98</td>
<td>2</td>
<td>BL</td>
<td>1.7</td>
<td>T</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.1</td>
<td>LS 001XT</td>
<td>R2X</td>
<td>−3</td>
<td>105</td>
<td>8</td>
<td>BL</td>
<td>1.7</td>
<td>T</td>
<td>yes 1k</td>
</tr>
<tr>
<td></td>
<td>000.5</td>
<td>Lono R2</td>
<td>R2Y</td>
<td>−3</td>
<td>107</td>
<td>8</td>
<td>Y</td>
<td>2.0</td>
<td>ST</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.3</td>
<td>Dinero R2X</td>
<td>R2X</td>
<td>−2</td>
<td>97</td>
<td>8</td>
<td>IY</td>
<td>1.7</td>
<td>T</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.4</td>
<td>TH 32004R2Y</td>
<td>R2Y</td>
<td>−2</td>
<td>102</td>
<td>2</td>
<td>BL</td>
<td>1.7</td>
<td>T</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.1</td>
<td>Prince R2X</td>
<td>R2X</td>
<td>−2</td>
<td>94</td>
<td>8</td>
<td>BL</td>
<td>1.7</td>
<td>T</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.6</td>
<td>S006-M4X</td>
<td>R2X</td>
<td>−2</td>
<td>98</td>
<td>8</td>
<td>IY</td>
<td>1.9</td>
<td>ST</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>000.5</td>
<td>S007-Y4</td>
<td>R2Y</td>
<td>−2</td>
<td>103</td>
<td>12</td>
<td>IY</td>
<td>2.0</td>
<td>ST</td>
<td>−</td>
</tr>
</tbody>
</table>
SCN Emerging Issue for Dry Beans

• 2016 stunted patches in dark-red kidney bean field

• Roots infested with SCN females

• Soybean last grown in 2010

DISEASE NOTES

First Report of the Soybean Cyst Nematode Heterodera glycines Infecting Dry Bean (Phaseolus vulgaris L.) in a Commercial Field in Minnesota

G. P. Yan, A. Plaisance, I. Chowdhury, R. Baidoo, A. Upadhaya, J. Pasche, S. Markell, and B. Nelson, North Dakota State University, Department of Plant Pathology, Fargo 58108-6050; and S. Chen, University of Minnesota, Department of Plant Pathology, St. Paul 55108.
Sudden Death Syndrome

- First reported 1971 in Arkansas
- Disease complex of SCN with *Fusarium virguliforme*
- Occurs after first flowering
- In Minnesota and South Dakota

Scout for SCN

- Fields more than 3 years of soybean
- Get out of the truck and walk
- 30-45 days after emergence, gently lift roots with spade, dunk in bucket of water for clay, look for females using a hand lens
- Up to 21-28 before ready for harvest
- Collect soil samples and SCN test (Agvise or Soil Ecology Lab U Manitoba)
Dig It

Gently obtain roots

Checking Roots

Look for small white lemon-shaped cysts

THANK YOU

- Nazanin Ghavami
- MB Agriculture, WGRF, MPSG, AAFC
- Dennis Lange
- Les Mitchell, Anastasia Kubinec
- Dr. Mehrdad Madani, Terri Fairman
- Albert Tenuta, Tom Welacky
Soybean Cyst Nematode

Warning signs:

• Areas of stunted plants, and poor canopy
• Areas of chlorotic growth
• Areas where weed control is sub optimum
• White females (i.e. cysts) on roots
Soil Sampling for SCN

- Every third soybean crop year
- Sampling in fall following crop harvest and before soil freezes
- Following soybean harvest, sample directly within harvested rows before tillage
- Following other crops, sample after fall tillage, if you till
- Sample top eight inches
- Use a soil push probe or small diameter soil auger
- Take 15 cores for a sample from every 20 acres
- Sample specifically for trouble soybean area
More on Soil Sampling

• Put cores into a bucket
• Mix the cores and place into a ziplock freezer bag
• Label both sides of bag with marker for name, legal, date, field sample number
• Keep bag out of sun
• Place in refrigerator
• Drop off samples to Agvise as you would do for soil fertility testing
• SCN is not a regulated pest, so call Mario if samples come back positive
SCN in Minnesota (2009)
SCN Survey in North Dakota

SCN Survey 2013 - 2017

Eggs/100cc

0 12.5 25 50 Miles

0 50 - 200 201 - 2000 2001 - 10000 10001 - 20000 20000 +
SCN and Manitoba

• Cysts with quality for morphological and molecular analysis belonged to genera *Punctodera* and *Cactodera*

• Likely not of economic concern but on weeds

• But!!! Most of Manitoba’s +1,000,000 acres of soybean acres is relatively new to production, thus over next 5-10 years likely establishment of SCN in Manitoba