Managing Soybean Cyst Nematode (SCN) and Iron Deficiency Chlorosis (IDC)

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SCN is considered the most damaging soybean pathogen in North America, #2 in the world

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>soybean cyst nematode</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>sudden death syndrome</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>seedling diseases</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Phytophthora stem &amp; root rot</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>charcoal rot</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Septoria brown spot</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Sclerotinia stem rot</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>brown stem rot</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Fusarium wilt and root rot</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>pod and stem blight</td>
<td>10</td>
<td>19</td>
</tr>
</tbody>
</table>

*108,008,000 bushels yield lost in Midwestern US and Ontario, Canada, in 2014 (most recent published estimates)

Known SCN-Infested Counties – 2017

34 new since 2014:
- Alabama = 1
- Georgia = 3
- Indiana = 1
- Iowa = 1
- Kansas = 3
- Kentucky = 3
- Minnesota = 2
- Missouri = 1
- New York = 1
- N. Carolina = 4
- N. Dakota = 7
- Ohio = 3
- S. Dakota = 1
- Virginia = 2
- Wisconsin = 1
- Quebec = 1

Typical yield loss with severe symptoms – central Iowa

Typical yield loss with no symptoms – central Iowa

- **Resistant**: 50.0 bushels/acre
- **Susceptible**: 44.7 bushels/acre

10% yield loss

5 bushels/acre yield difference

Scouting for SCN

1. Dig roots and look for females. (Dig, don’t pull.)

2. Collect soil samples for testing.
Corn reduces *H. glycines* population densities

- **1st year corn:**
  from 5 – 10% decrease to 45 – 50% decrease

- **2nd year corn:**
  not as effective as 1st year corn at decreasing numbers

- **3rd year corn:**
  even less effective at decreasing numbers
Effects of continuous corn on SCN population densities in Iowa

End-of-season SCN numbers (eggs/100 cc soil)

- Soybeans, 18,000
- 1st year corn, 10,000

Tylka, unpublished
Yield and SCN control
SCN-resistant vs. susceptible soybean varieties
(1,310 eggs/100 cm³ at planting)
Many (>100) other breeding lines with different sources of resistance to SCN identified and released by breeders as well.

These breeding lines are agronomically undesirable due to flat vine growth, black seed coat, late maturity, etc. but they can be used to introduce SCN resistance genes into agronomically acceptable soybean varieties.

Registered germplasm lines that are sources of SCN resistance for breeding

- PI 88788
- PI 548402 (Peking)
- PI 90763
- PI 437654

- PI 209332
- PI 89772
- PI 548318 (Cloud)
Number of SCN-resistant soybean varieties available for Iowa (1991 - 2018)

Very few commercial soybean varieties are described as SCN susceptible these days.

Reproduction of SCN populations on PI 88788

From 1991 to 1999, almost all SCN populations in farmer cooperators’ fields reproduced below 10% on PI 88788

Reproduction of SCN populations in fields has increased on pure PI 88788

Each data point represents the SCN population in a field in which a variety trial field experiment was conducted.

Reproduction should be less than 10%

Additional 2016 and 2017 data provided by G. Tylka, ISU
SCN reproduction on varieties with PI 88788 resistance has increased greatly in the last 15 years.

Each data point represents the MEAN SCN reproduction on all varieties with PI 88788 resistance in a variety trial field experiment.

RF = 2 means SCN egg numbers doubled from spring to fall;  
RF = 4 means SCN egg numbers quadrupled from spring to fall.

Additional 2016 and 2017 data provided by G. Tylka, ISU.
Yield of varieties with PI 88788 resistance has decreased as SCN reproduction on PI 88788 increased.

Each data point represents the MEAN yield of all resistant varieties with PI 88788 in a variety trial field experiment.

R^2 = 0.14294
Y = 59.726 - 0.3798X

14 bushels per acre less

Very few commercial soybean varieties are described as SCN susceptible these days.
The percentage of SCN populations in a state/province with elevated reproduction (>10%) on PI 88788
Prospects for resistance in the future

- Usefulness of traditional PI 88788 SCN resistance will continue to decline
- Many new varieties with non-PI 88788 resistance not very likely in the near future
## Nematode-Protectant Seed Treatments

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Crop(s)</th>
<th>Targeted Nematodes</th>
<th>Active Ingredient</th>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Avicta™ Complete</strong>&lt;br&gt;Syngenta</td>
<td>cotton, corn, soybean</td>
<td>all plant-parasitic nematodes</td>
<td>abamectin</td>
<td>inhibits nematode nerve transmission</td>
</tr>
<tr>
<td><strong>N-Hibit</strong>&lt;br&gt;Plant Health Care, Inc.</td>
<td>all plants</td>
<td>all plant-parasitic nematodes</td>
<td>harpin protein</td>
<td>induced plant defenses</td>
</tr>
<tr>
<td><strong>VOTiVO</strong>&lt;br&gt;BASF</td>
<td>cotton, corn, soybean</td>
<td>all plant-parasitic nematodes</td>
<td><em>Bacillus firmus</em></td>
<td>living barrier of protection on roots</td>
</tr>
<tr>
<td><strong>Clariva™ pn</strong>&lt;br&gt;Syngenta</td>
<td>soybean</td>
<td>SCN</td>
<td><em>Pasteuria nishizawai</em></td>
<td>nematode parasite</td>
</tr>
<tr>
<td><strong>LEVO</strong>&lt;br&gt;BASF</td>
<td>soybean</td>
<td>SCN, root-knot, reniform, lesion</td>
<td>fluopyram</td>
<td>SDHI enzyme inhibitor</td>
</tr>
<tr>
<td><strong>NEMA STRIKE™ TECHNOLOGY</strong>&lt;br&gt;Bayer Crop Science</td>
<td>cotton, corn, soybean</td>
<td>SCN, root-knot, reniform, lesion, others</td>
<td>tioxazafen</td>
<td>mitochondrial translation inhibitor</td>
</tr>
<tr>
<td><strong>AVEO™ EZ</strong>&lt;br&gt;Valent</td>
<td>corn, soybean</td>
<td>SCN, root-knot, reniform, lesion, others</td>
<td><em>Bacillus amyloliquefaciens</em></td>
<td>not stated or known</td>
</tr>
<tr>
<td><strong>NEMASECT</strong>&lt;br&gt;Becks</td>
<td>corn, soybean</td>
<td>all plant-parasitic nematodes</td>
<td>heat-killed <em>Burkholderia rinjenses</em> + fermentation media</td>
<td>not stated or known</td>
</tr>
<tr>
<td><strong>TRUNEMCO</strong>&lt;br&gt;BASF</td>
<td>cotton, corn, soybean</td>
<td>???</td>
<td><em>Bacillus amyloliquefaciens</em> + cis-Jasmone</td>
<td>induced plant defenses and ???</td>
</tr>
</tbody>
</table>
Nematode-protectant seed treatments

- **Effective seed treatments** should slow the continuing loss of effectiveness of PI 88788 SCN resistance
- Unfortunately, across many states, researchers have noted only infrequent examples of significant yield increases.
  - Examples of measured SCN control are even more infrequent - but not non-existent.
  - Understanding (so that we can predict) what environments will provide a positive yield response would be helpful for positioning these products, but this is still elusive.

- **Yield and SCN** effects may be different for new seed treatment products with new modes of action
Integrated management of SCN

Collect soil samples from fields to determine the situation - know your numbers!

Grow nonhost crops (corn, wheat and other small grains, others)

Use nematode-protectant seed treatments

Grow resistant soybean varieties

- Continue using and rotate varieties with PI 88788
- Seek varieties with Peking, other sources of resistance
- Add other types of resistance when available

Cover crops? (usefulness and consistency of results not yet determined)
Iron Deficiency Chlorosis (IDC): an overview

Seth Naeve
naeve002@umn.edu
Iron deficiency is caused by a combination of stresses rather than a simple deficiency of available soil Fe

Soil Chemical Factors
- pH, carbonates and HCO$_3^-$, salinity (electrical conductivity (EC)), available Fe (DTPA-Fe)
- Nitrate
- Water

Biotic factors
- Variety, SCN, root rotting fungi, *Bradyrhizobia*, interplant competition, herbicides
Managing IDC

- Variety Selection
- Rotation
- Companion or cover crops
- Soybean populations
- Iron chelates
- Rescue treatments (do not try these at home, kids)

- Carryover N management
IDC – Summary

- Variety selection is the #1 tool for managing IDC
- Companion crops do not predictably increase yields in IDC prone soils.
- Increased populations tend to lead to greener soybeans early in the season. Yield effects tend to be relatively small.
  - Variable Rate Technology (VRT)
- Iron chelates do work where there is IDC
- Yield responses can be linear beyond common 2 or 3 pound rates
  - This is an ideal use of VRT
The Minnesota Challenge: Interactions between IDC and SCN

Austin Dobbels & Seth Naeve
dobbe045@umn.edu, naeve002@umn.edu
IDC and SCN are major problems in MN

- Hard to manage
- Difficult to research
- Likely acting together in the field
Management issues and solutions

**IDC**
- Susceptible variety
- High soil pH
- Calcium carbonates
- Soil Nitrates
- Wet soil
- Tolerant Variety
- Fe chelates-Soygreen
- Companion Crops
- Calcium carbonates
- Reduce other stress

**SCN**
- Susceptible variety
- Presence of nematodes
- High soil pH
- Hot and dry
- Tolerant Variety
- Nonhost crops
- Seed treatments
- Cover crops?
- Reduce other stress
Challenge accepted!

Teasing apart IDC and SCN

Project Goals:
• Identify in-field treatments that differentially affect IDC and SCN
• Investigate how IDC and SCN stress affects yield losses and SCN reproduction
  – Individually and together
• Quantify stress using remote sensing tools
Field Locations target high pH soils

Average Value

- < 1.1
- 1.1-2.1
- 2.2-3.3
- 3.4-4.4
- 4.5-5.5
- 5.6-6.6
- 6.7-7.7
- >=7.8

Do not meet criteria

Water

Range of Results: 0 - 8.9

What’s your number?
Take the test. Beat the pest.
The SCN Coalition
Funded by the soybean checkoff

2017
Lost from flooding

2018
Field locations target nematode presence

<table>
<thead>
<tr>
<th>Location</th>
<th>SCN Initial (eggs/100CC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jay</td>
<td>422</td>
</tr>
<tr>
<td>Otto</td>
<td>1619</td>
</tr>
<tr>
<td>Kevin</td>
<td>1700</td>
</tr>
<tr>
<td>Palmer</td>
<td>756</td>
</tr>
<tr>
<td>Sunderland</td>
<td>1269</td>
</tr>
<tr>
<td>Kevin18</td>
<td>2160</td>
</tr>
</tbody>
</table>
## Treatments we can introduce

<table>
<thead>
<tr>
<th>IDC</th>
<th>SCN</th>
</tr>
</thead>
</table>
| • **Susceptible variety**  
  • High soil pH  
  • Calcium carbonates  
  • **Soil Nitrates**  
  • Wet soil  
  • **Tolerant Variety**  
  • **Soygreen**  
  • Companion Crops  
  • Calcium carbonates  
  • Reduce other stress  
| • **Susceptible variety**  
  • Presence of nematodes  
  • High soil pH  
  • Hot and dry  
  • **Tolerant Variety**  
  • Nonhost crops  
  • Seed treatments  
  • Cover crops?  
  • Reduce other stress  |
Treatments arranged to study interactions

SCN

Susceptible - PI 88788 - Peking

IDC

i. Nitrogen

ii. No treatment

iii. Soygreen
## Affect of IDC treatments on yield

<table>
<thead>
<tr>
<th>Treatment</th>
<th>IDC Resistant Varieties</th>
<th>IDC Susceptible Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate</td>
<td>45.5 bu/ac</td>
<td>15.7 bu/ac</td>
</tr>
<tr>
<td>Control</td>
<td>57.1 bu/ac</td>
<td>46.8 bu/ac</td>
</tr>
<tr>
<td>Soygreen</td>
<td>66.9 bu/ac</td>
<td>64.8 bu/ac</td>
</tr>
</tbody>
</table>
IDC resistant varieties out-yield susceptible under all treatments (Averaged across locations)
**Affect of SCN treatments on yield**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Soygreen</th>
<th>SCN Susceptible</th>
<th>PI 88788 resistance</th>
<th>Peking resistance</th>
<th>Peking resistance + nematicide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (bu/ac)</td>
<td></td>
<td>65</td>
<td>62.5</td>
<td>67.9</td>
<td>67.9</td>
</tr>
</tbody>
</table>

**Significant yield differences only found in 3/6 locations**
SCN variety impacted yield at 3 of 6 locations

*** = significant at .001

* = significant at .05
<table>
<thead>
<tr>
<th></th>
<th>Jay</th>
<th>Kevin</th>
<th>Otto</th>
<th>Kevin18</th>
<th>Palmer</th>
<th>Sunderland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial counts</td>
<td>421</td>
<td>1,700</td>
<td>1,619</td>
<td>2,169</td>
<td>2,169</td>
<td>1,269</td>
</tr>
<tr>
<td>Peking FI</td>
<td>1.7</td>
<td>3.9</td>
<td>14.8</td>
<td>3.9</td>
<td>.6</td>
<td>2.1</td>
</tr>
<tr>
<td>PI 88788 FI</td>
<td>18.7</td>
<td>6.3</td>
<td>13.6</td>
<td>10.9</td>
<td>8.4</td>
<td>22.7</td>
</tr>
<tr>
<td>HG Type</td>
<td>2</td>
<td>-</td>
<td>1,2</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
</tbody>
</table>

SCN treatment
- Peking
- Peking + Fluopyram
- PI 88788
- SCN susc.

27 bu/ac decrease
Reproduction Factor

\[
RF = \frac{\text{Beginning of season egg counts}}{\text{end of season egg counts}}
\]

RF = Nematodes reproducing
Nematodes are reproducing on susceptible soybean varieties.
Yield data did not show an interaction

**SCN**
**Susceptible - PI 88788 - Peking**

<table>
<thead>
<tr>
<th>IDC</th>
<th>40.8</th>
<th>46.7</th>
<th>40.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Nitrogen</td>
<td>48.3</td>
<td>59.9</td>
<td>53.0</td>
</tr>
<tr>
<td>ii. No treatment</td>
<td>62.1</td>
<td>67.7</td>
<td>67.9</td>
</tr>
<tr>
<td>iii. Soygreen</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IDC**
- i. Nitrogen
- ii. No treatment
- iii. Soygreen
No interaction between IDC and SCN

Yield penalty from IDC are same over levels of SCN

Nematodes reproduce on SCN susceptible plots regardless of IDC stress
In season data collection

**Greenness score**

<table>
<thead>
<tr>
<th>Score: 1</th>
<th>Score: 2</th>
<th>Score: 3</th>
<th>Score: 4</th>
<th>Score: 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Image" /></td>
<td><img src="image2.jpg" alt="Image" /></td>
<td><img src="image3.jpg" alt="Image" /></td>
<td><img src="image4.jpg" alt="Image" /></td>
<td><img src="image5.jpg" alt="Image" /></td>
</tr>
</tbody>
</table>

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IDC treatment impact on visual greenness

![Graph showing IDC application treatment impact](image)

- **Nitrate**
- **None**
- **Soygreen**

**Scores:**
- Score 5
- Score 4
- Score 3
- Score 2
- Score 1

**Visual Score**

**Date:**
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
Visual differences in plots correlate strongly with yield.
One point difference = \(~12 - 15\) bu/ac decrease in yield
NDVI significantly different between IDC treatments
RGB + NDVI imagery
Drone NDVI correlates with yield
• UAV advantages:
  • Faster
  • Can cover a lot more area
  • Spatial variability assessments
  • Can measure more than a single row at a time
  • Can find interesting field patterns
  • Potential applications for variable rate prescriptions
Summary

• The good news is that it appears that we can manage IDC and SCN independently

• Start by identifying the problem
  – IDC will be obvious - but understand that many other issues can cause yellowing in soybean
    • SCN
    • Aphids
    • Other fertility issues
  – Soil sampling for SCN is a required first step.
    • Be certain of very low SCN numbers before planting a susceptible line
    • Medium to high populations (2000-10,000 eggs) require significant action
    • Beyond 10,000 one should consider more corn
Summary

• Manage IDC with genetic tolerance first, then add iron chelates
  – Variable Rate iron chelates if available
• Identify **good** SCN resistant varieties
  – Public Variety Trial reports
  – Seed company advise
  – Evaluate varieties on your own farm
  – It’s nearly impossible to ID varieties that allow low reproduction, on-farm
  – The best that you can do is continually monitor SCN levels
QUESTIONS?
What’s your number?

Take the test. Beat the pest.

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Funded by the soybean checkoff

Thank you!

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