Foundations for Understanding and Managing Brown Stem Rot (BSR) and Sudden Death Syndrome (SDS) in Soybean

DECEMBER 2015

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Brown Stem Rot (BSR)

- Common & damaging in many areas of the North Central U.S. and Canada
  - Can be a hidden disease that is easily missed
  - First identified in central IL in 1940’s

Caused by a soilborne fungus: *Cadophora gregata*
Significance of BSR

- BSR can be a significant disease (*when conditions are favorable*)
- BSR can cause yield losses exceeding 30%
- Yield losses in the 10 – 15% range is more common
- Can decrease yields by reducing seed size and number

- Has been said that BSR may be:
  “the most undermanaged soybean disease in Minnesota”.
- Could this be true in fields that you work with?
Effects of BSR on Yield (Iowa Study- 1960’s)

Soybeans grown on infested vs. noninfested soils in IA

- Yield 11% lower in infested sites
- Seed number 10.4% lower
- Matured 2 days earlier

![Table 2. Mean agronomic performance of soybean varieties grown on C. gregatum infested and noninfested soils at Cresco](image)

- **C. gregatum** infested and noninfested soils at Cresco
- **Grant**
  - Infested: 15.2 cwt/acre, Maturity: 9-19, Height: 28, Lodging: 1.7, Seed size: 17.0
  - Noninfested: 15.8 cwt/acre, Maturity: 9-20, Height: 28, Lodging: 1.6, Seed size: 16.4
- **Chippewa**
  - Noninfested: 16.2 cwt/acre, Maturity: 9-26, Height: 30, Lodging: 1.6, Seed size: 14.6
- **Blackhawk**
  - Infested: 15.1 cwt/acre, Maturity: 9-30, Height: 32, Lodging: 1.5, Seed size: 15.6
  - Noninfested: 17.5 cwt/acre, Maturity: 10-1, Height: 31, Lodging: 1.8, Seed size: 15.6
- **Mean**
  - Infested: 14.9 cwt/acre, Maturity: 9-24, Height: 31, Lodging: 1.6, Seed size: 15.8
  - Noninfested: 16.5 cwt/acre, Maturity: 9-26, Height: 30, Lodging: 1.7, Seed size: 15.5

Published September, 1966

Influence of Brown Stem Rot on Agronomic Performance of Soybeans

C. R. Weber, J. M. Dunlevy, and W. R. Fehr
10 soybean cv. grown in rotated vs. continuous soybean areas

- BSR much higher incidence in rotated areas (~1% vs. 74%)
- Seed number accounted for 73% of yield difference
- Yield 13% higher in rotated sites

<table>
<thead>
<tr>
<th>Character</th>
<th>Mean, all cultivars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
</tr>
<tr>
<td>Stand, plants/30 cm</td>
<td>11.5</td>
</tr>
<tr>
<td>Date mature</td>
<td>9/14</td>
</tr>
<tr>
<td>Lodging score&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.1</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>85</td>
</tr>
<tr>
<td>Brown stem rot (% of plants)</td>
<td>1.4</td>
</tr>
<tr>
<td>Yield (q/ha)</td>
<td>19.2</td>
</tr>
<tr>
<td>Seed quality score&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.1</td>
</tr>
<tr>
<td>Seed size (g/100)</td>
<td>15.1</td>
</tr>
</tbody>
</table>

Brown Stem Rot

• Common in many years, but often unrecognized due to somewhat ‘hidden’ symptoms
• Research activity over past 20+ years in IA, IL, MN, and WI – but currently low activity
• Still important (‘Peking example’), but not as ‘splashy’ as many other diseases such as SDS
Where does BSR occur?

- BSR is common in the major North Central U.S. states and Canada. Also reported to a lesser extent in some southern/southeastern states.
- This disease is most significant in the northern Midwest.
- BSR has also been reported in Argentina, Brazil, Egypt, Japan, Mexico, and Yugoslavia.
BSR Survey In Northern IA Counties (1977)
Tachibana and Booth, Plant Dis. Rptr. 63:539-541

• 290 fields sampled in 31 counties
• BSR found in 274 (94%) of the fields
• Average incidence per field was 38%
### Percent of fields that tested positive for BSR in the Midwest

<table>
<thead>
<tr>
<th>State</th>
<th>Positive for BSR pathogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td>73%</td>
</tr>
<tr>
<td>Iowa</td>
<td>72%</td>
</tr>
<tr>
<td>Minnesota</td>
<td>68%</td>
</tr>
<tr>
<td>Missouri</td>
<td>28%</td>
</tr>
</tbody>
</table>

Random survey in 1995-1996 from 95-385 samples per state.

Could BSR Be a More Common Yield-Reducing Problem In Many Fields Than Is Known?
BSR: Stem Browning but No Foliar Symptoms
Conditions Favoring BSR

- Cool temperatures (60-80°F) during reproductive growth stages
  
  *Note: temp > 85°F can suppress symptoms*
- Wet soil at flowering (R1) to full seed (R6) followed by dry soil (R6 and beyond)
- Continuous soybean crops and short rotations
- Susceptible soybean varieties
- Field history of BSR
- Slow decay of soybean residue on soil surface
- Soybean cyst nematode
- Soil pH <6.8 may favor BSR
Brown Stem Rot - Symptoms

- Symptoms usually develop after pods form
- Vary depending on type of pathogen, environment, and soybean variety
- Become more severe as plants mature
- Premature defoliation and lodging can develop
Symptoms of BSR

Often the only symptoms are the internal stem symptoms.

Leaf Symptoms Often Don’t Develop
Diagnosis of BSR

• **Stem Symptoms**
  Similar: BSR, Stem Canker, Pod and Stem Blight

• **Leaf Symptoms**
  Similar: BSR, SDS, sometimes white mold

• **Laboratory**
  Symptoms and DNA test or isolation of pathogen
Internal Stem Symptoms on Soybean

- BSR

- Stem Canker

- Pod and Stem Blight (*Phomopsis longicollia*)
What Causes Brown Stem Rot?

- Soilborne fungus, survives in soybean residue
- *Cadophora gregata* (previously *Phialophora gregata*)
- Host range: soybean, mung & adzuki bean
- Grows slowly
- Produce toxins (gregatins) that damage leaves
- Two types of the BSR Pathogen – A and B
- In the *Ascomycete* (*Helotiales*) group of fungi
Two Main Types of the BSR Pathogen

- Type A and type B (also named type M)
- Both types occur in the Midwest, but B is more common.
- Differentiated by symptoms and by genotype (IGS)

- Type A produces internal stem browning & leaf chlorosis+necrosis
- Type B typically produces only stem browning (sometime mild foliar symptoms)
- Type B is detected in resistant soybean var. more frequently than type A

Because type B typically causes mild or no foliar symptoms. Disease not readily detected until stems are split to detect symptoms.
Distribution of Types A and B of *Cadophora gregata* in the North Central Region

Genotype B (or M) was reported to be predominant in Iowa and Minnesota, and A was predominant in Illinois and Ohio (Harrington et al., 2003. Phytopathology 93:901-912.

More recently, genotypes A and B were also detected across the northcentral region (Malvick, D.K. and Grunden, E. 2008. Can. J. Plant Path. 30:581-587).

Symbols indicate where infection by either genotype A (●), genotype B (▲), or both A and B (■) were detected.
Why Might BSR be Less Apparent in Some Fields Than in the Past?

✓ Obvious potential reasons: less favorable weather for BSR, more resistant varieties, longer rotations between soybean, etc.

☐ Another is that the BSR pathogen can change over time:
  • In a central MN field, type B became predominant
  • In a Wisconsin study, type B became more common than A following planting of resistant soybean lines

❖ UPSHOT: Type B (causes no or mild foliar symptoms) may have become the more common type of the BSR pathogen in many fields
How Does Each Pathogen Type Influence Plant Growth and Yield?
Effects of BSR on Yield

Microplot study in IA with susceptible soybean, type B of pathogen)  
(Tabor, Tylka, and Bronson, 2007)

- Yield reduction with BSR averaged 14% across two year field study
Summary From Inoculation Studies

- Types A and B can reduce yield & growth with and without leaf symptoms
- Yield in multiple field studies was significantly reduced >11% in by types A and B
- In greenhouse studies, the number of pods per plant was reduced up to 40% and fresh biomass of plants was reduced up to 41% with types A & B.
- The % of plants with symptoms varied widely among experiments and replications.
How does BSR infect and damage plants?

- Infection occurs early in the season
- Then disease has long latent period
- Pathogen infects the vascular system and pith
- Pathogen affects leaf size and physiology of plant
- Pod number, seed number, and seed size are reduced
Disease Cycle Of *C. gregata*

- **Seedlings infected in spring**
- **Latent Infection (asymptomatic) until August**
- **Pathogenic infection (symptomatic)**
- **Infected soybeans harvested**
  - Infected debris may remain on soil surface or in the soil
  - *C. gregata* survives on residue

Pathogenic infection can occur if infected debris remains on the soil surface or in the soil.
Plants Respond to BSR with Changes in Vessel Numbers & Size

Resistant variety
- Vessel number in infected plants was 20% more compared to the control
- Vessel size similar in infected and healthy plants

Susceptible variety
- No differences in vessel number between infected/noninfected plants
- Had reduced vessel size compared to the ‘R’ cultivar

Impulliti and Malvick, PLoSOne 2014
Management of BSR

- Rotate crops - out of soybean (for example: at least 2 years out of soybean with corn or small grains as rotational crops)
- Plant soybean varieties resistant to BSR
- Manage soybean cyst nematode (Note: SCN can interact with BSR to increase severity of BSR)
- Delayed planting can reduce BSR (may also reduce yield potential)
- Take steps to increase decay of soybean residue (some tillage may help)
BSR Management with Rotation: Effect of Tillage System

✓ In a Wisconsin study, the pathogen survived well in residue on the surface for over 30 months
✓ But the BSR pathogen could not be detected in buried residue after 11-17 months

❖ THUS, longer rotations away from soybean may be needed in no-till to reduce risk of BSR

The Effect of Soybean Planting Interval (Rotation) on Brown Stem Rot (BSR) Severity and Soybean Yield


<table>
<thead>
<tr>
<th>Rotation</th>
<th>% stem length w/ BSR symptoms</th>
<th>Yield (bushels/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-S-C-S-C-S-S-S</td>
<td>55.25 a</td>
<td>54.89 c</td>
</tr>
<tr>
<td>S-C-S-C-S-C-S-S</td>
<td>41.88 b</td>
<td>62.64 b</td>
</tr>
<tr>
<td>C-S-C-C-S-C-S-S</td>
<td>20.94 c</td>
<td>62.05 b</td>
</tr>
<tr>
<td>C-C-C-C-C-C-S</td>
<td>6.13 d</td>
<td>67.85 a</td>
</tr>
<tr>
<td>LSD (p = 0.05)</td>
<td>9.35</td>
<td>2.15</td>
</tr>
</tbody>
</table>

*
Sudden Death Syndrome (SDS) May Appear Similar to BSR

- SDS causes leaf symptoms similar to BSR
- But SDS causes root rot and pith does not become brown
Symptoms
BSR vs Sudden Death Syndrome (SDS)

No browning of pith in stems
<table>
<thead>
<tr>
<th></th>
<th><strong>BSR</strong></th>
<th><strong>SDS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Caused by soilborne fungal pathogen</td>
<td>• Caused by soilborne fungal pathogen</td>
</tr>
<tr>
<td></td>
<td>• Infects roots early in summer</td>
<td>• Infects roots early in summer</td>
</tr>
<tr>
<td></td>
<td>• Produces toxin that damages leaves</td>
<td>• Produces toxin that damages leaves</td>
</tr>
<tr>
<td></td>
<td>• Causes interveinal chlorosis</td>
<td>• Causes interveinal chlorosis</td>
</tr>
<tr>
<td></td>
<td>• Most symptoms appear in Aug.</td>
<td>• Most symptoms appear in Aug.</td>
</tr>
<tr>
<td></td>
<td>• Increased by SCN</td>
<td>• Increased by SCN</td>
</tr>
</tbody>
</table>
# BSR and SDS: Differences

<table>
<thead>
<tr>
<th>BSR</th>
<th>SDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Widespread in Midwest</td>
<td>• Spreading in Midwest</td>
</tr>
<tr>
<td>• Doesn’t cause root rot</td>
<td>• Causes root rot</td>
</tr>
<tr>
<td>• Pathogen has narrow host range</td>
<td>• Pathogen has wide host range</td>
</tr>
<tr>
<td>• Relatively short survival in soil</td>
<td>• Survives long in soil</td>
</tr>
<tr>
<td>• Rotation effective for mgmt.</td>
<td>• Rotation NOT effective for mgmt.</td>
</tr>
<tr>
<td>• Favored by wet then dry soil</td>
<td>• Favored by wet soil throughout summer</td>
</tr>
<tr>
<td>• Common yield loss – 10 to 15%</td>
<td>• Yield loss up to 30-50%</td>
</tr>
<tr>
<td>• Resistance – single genes</td>
<td>• Resistance is complex, many minor genes</td>
</tr>
</tbody>
</table>
BSR and SDS Can Infect the Same Plant

- Based on a survey with 65 plants from different fields in MN with SDS, 17% also were infected with BSR
- BSR may be interacting with SDS frequently in MN fields
- Effects of interaction on plant growth/yield not well understood
Confirmed Distribution of SDS in Minnesota
~ 38 counties with confirmed SDS –
SDS Can Damage More than Soybean: Pinto Bean and Alfalfa Also Susceptible

Research results and photos from Tammy Kolander, Former Graduate Student, Univ. of Minnesota

Top photos – pinto bean, bottom photos - alfalfa
Importance of SDS

- Soybean yield losses from SDS: 5% to >50%
- Losses depend on when plants are infected, weather, SCN, soybean variety.
- Early infections can result in pod abortion.
- SDS often is often severe in well-managed soybean fields with a high yield potential
Impact of SDS on Yield (In a Field with Low SCN)

Effect of SDS on Yield (bu/ac) of an SDS-Susceptible Variety
Malvick data from Waseca, MN 2010 (based on 6 reps for each)

Seed wt/200 seeds: 32.5 g 30.5 g

Plots without SDS 65.5
Plots with SDS 45.3
SDS Risk Factors

- Presence of SDS pathogen & field history of SDS
- Wet and cool soil 2-3 weeks after planting
- Compacted soil, poor drainage
- High SCN populations
- Susceptible soybean varieties
- Periodic heavy rain through mid-July followed by normal or greater rainfall through mid August
Summary and Conclusions

- SDS is a complex disease determined by the interaction of many environmental/biological factors.
- Analyses of climate patterns in IA suggest that no single actor determines development of SDS.
- SDS outbreaks can be severe even when soil temperatures are above average at planting.

- Climatic factor that was consistently associated with epidemics of SDS was rainfall in June.
- WE HAVE SEEN A SIMILAR PATTERN IN MINNESOTA
### Association between SDS and Rainfall in Iowa

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Precipitation (cm)</th>
<th># days with precipitation</th>
<th>SDS incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Apr</td>
<td>May</td>
<td>Jun</td>
</tr>
<tr>
<td>1993</td>
<td>7.9</td>
<td>15.7</td>
<td>27.6</td>
</tr>
<tr>
<td>1998</td>
<td>10.3</td>
<td>11.4</td>
<td>20.3</td>
</tr>
<tr>
<td>2001</td>
<td>8.4</td>
<td>23.3</td>
<td>7.6</td>
</tr>
<tr>
<td>2004</td>
<td>4.9</td>
<td>15.2</td>
<td>9.9</td>
</tr>
<tr>
<td>2005</td>
<td>8.1</td>
<td>8.8</td>
<td>10.8</td>
</tr>
<tr>
<td>2007</td>
<td>14.8</td>
<td>15.7</td>
<td>8.4</td>
</tr>
<tr>
<td>2008</td>
<td>12.8</td>
<td>17.4</td>
<td>24.9</td>
</tr>
<tr>
<td>2010</td>
<td>10.7</td>
<td>16.0</td>
<td>32.3</td>
</tr>
<tr>
<td>2011</td>
<td>8.6</td>
<td>14.1</td>
<td>20.8</td>
</tr>
</tbody>
</table>

Mean SDS yr: 10.4  15.1  26.3  19.5  14.7  13  13  15  13  10  –
Mean non-SDS yr: 8.9  15.4  11.5  8.9  12.2  10  12  10  9   10  –

Weather in Waseca MN: High and Low SDS Years

<table>
<thead>
<tr>
<th>Weather</th>
<th>High SDS-2010</th>
<th>Low SDS-2013</th>
<th>Moderate SDS-2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>June rain (inches)</td>
<td>9.6</td>
<td>6.7</td>
<td>7.6</td>
</tr>
<tr>
<td>July rain</td>
<td>6.6</td>
<td>5.3</td>
<td>7.4</td>
</tr>
<tr>
<td>August rain</td>
<td>2.4</td>
<td>2.1</td>
<td>6.0</td>
</tr>
<tr>
<td>June air temp (mean)</td>
<td>67.0</td>
<td>67.3</td>
<td>68.3</td>
</tr>
<tr>
<td>July air temp (mean)</td>
<td>72.5</td>
<td>72.5</td>
<td>70.6</td>
</tr>
<tr>
<td>August air temp (mean)</td>
<td>73.0</td>
<td>69.6</td>
<td>67.7</td>
</tr>
</tbody>
</table>
Scouting for SDS

- **When**: begin looking first week of August
- **Where**: often but not always appears first in low, poorly-drained, or compacted areas
- **What to look for**: yellow, diffuse spots on leaves that usually appear first in mid-canopy
Management of SDS

✓ Be sure disease is properly diagnosed
  • Crop Rotation – not consistent effect known
  • Tillage – not effective/no consistent effect
✓ Resistant Varieties – EFFECTIVE
✓ Fungicides – now an option (a few seed treatments)
Yield Advantage of Moderately Resistant vs. Moderately Susceptible Varieties Under SDS Pressure in a Field Study

Yield (bu/ac) for Moderately Susceptible and Moderately Resistant Varieties in Plots with SDS (based on 6 replicated plots) (Malvick et al)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Yield (bu/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderately Resistant (MR)</td>
<td>56.3</td>
</tr>
<tr>
<td>Moderately Susceptible (MS)</td>
<td>44.8</td>
</tr>
</tbody>
</table>

DX Score = 41.4 for MR and 84.0 for MS.
Seed Treatments Available with Labeled SDS Activity

- Heads-Up® from Plant Protectants, Inc. (available for a few years)
- ILeVO® from Bayer Crop Science (labelled in Dec. 2014)
- Mertect 340-F from Syngenta (labelled for SDS in January 2015)
Key Points: BSR and SDS

• Take time to look for and diagnose BSR and SDS
• BSR remains an important and widespread disease in Midwest
• Symptoms often not visible on leaves, especially with type B
• BSR reduces pod number, leaf area, and yield with/without external symptoms
• BSR-resistant var. produced more and larger vessels and restricted pathogen
• Manage BSR with crop rotation and resistance

• SDS also now widespread and likely continues to spread
• Favored by wet soil throughout the summer, especially in June?
• Manage SDS with resistant varieties and selected seed treatments
Acknowledgements and Thanks

• Ann Impullitti
• Crystal Floyd
• Eric Grunden
• Many undergraduate research assistants

Sources of Research Funding:
• North Central Soybean Research Program
• Minnesota Soybean Research and Promotion Council
• University of Minnesota Agricultural Experiment Station
Questions or Comments?

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