A common crop rotation in the Mid-Atlantic USA is corn or cotton followed by winter wheat then soybean. Soybean is planted immediately after the wheat harvest in June; hence three crops are grown in two years. Due to late development of the soybean crop, there is a higher probability of foliar diseases. Although the most effective and economical method for soybean disease management is genetic resistance, agronomically-acceptable and broad-spectrum disease resistant soybean cultivars are not generally available. In response, soybean farmers manage late-season diseases with fungicides but the yield response to foliar fungicides is inconsistent. Furthermore, field observations and on-farm non-replicated experiments indicated that cultivars respond differently to fungicides. Therefore, experiments were conducted to evaluate the response and specific interaction between soybean cultivars and foliar fungicide application in a wheat-soybean double-crop system. Field experiments were conducted at four locations in Virginia during 2012. Two experiments were conducted at each location: one containing maturity group IV cultivars and one containing maturity group V cultivars. The experimental design was a randomized complete block in a strip-plot arrangement. Vertical plots included 10 cultivars with varying levels of disease resistance. Horizontal plots included an untreated control and foliar fungicide application (2:1 premix of pyraclostrobin and fluxapyroxad) at development stages R3 (beginning pod), R5 (beginning seed), or R3 + R5. Disease incidence was assessed and NDVI measurements were obtained weekly beginning at the R2 (full flower) stage and through R7 (physiological maturity). Beginning at R6 (full-seed), percent defoliation was measured weekly until R8. Yield and yield components were measured. Results will be presented at the conference.
INTERACTION OF FOLIAR FUNGICIDES WITH CULTIVAR IN DOUBLE-CROPPED SOYBEAN

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Tidewater Agricultural Research & Extension Center
Suffolk, VA, USA

2013 World Soybean Research Conference
February 17-22, 2013
Durban, South Africa
Presentation Outline

- Introduction
- Objectives
- Materials & Methods
- Results & Discussion
- Conclusion
- Acknowledgements
- Questions/Comments
Soybeans 2011
Yield Per Harvested Acre by County for Selected States

Bushels Per Acre
- Not Estimated
- ≤ 15
- 15 - 19.9
- 20 - 29.9
- 30 - 39.9
- 40 - 49.9
- 50 - 59.9
- 60 - 69

U.S. Department of Agriculture, National Agricultural Statistics Service

USDA Agriculture

[Map showing soybean yield per acre by county for selected states, with a red circle highlighting a specific area.]
Virginia versus U.S. Soybean Yield

Seed Yield (kg ha⁻¹)

- U.S.
- Virginia

y = 21.717x - 40839
R² = 0.3701

y = 36.254x - 70515
R² = 0.2553

(Holshouser, 2013)
Virginia Soybean Yields (VT OVT)

Seed Yield (kg ha$^{-1}$)

$y = 29.225x - 55707 \quad R^2 = 0.0772$

$y = 10.263x - 17485 \quad R^2 = 0.0086$

$y = 48.187x - 93929 \quad R^2 = 0.1615$

(Holshouser, 2013)
Virginia Soybean Disease Incidence

• Total yield reduction of 7.15%
  – (Phipps and Telenko, 2011)

• Nematodes: 5% yield loss
  – Soybean cyst, southern and northern root-knot, sting, and stubby root

• **Cercospora blight**: 0.5% yield loss
  – Most prevalent foliar disease

• Leaf spot diseases: 0.4% yield loss
  – Brown spot, frogeye leaf spot, and anthracnose

• Pod and stem blight: 0.1% yield loss

• No yield loss due to Soybean Rust to date
2011 Variety Response to Strobilurin Fungicide

Soybean Yield Response (Bu/A)
Objectives

- Evaluate the response and specific interaction between soybean MGIV and V cultivars and foliar fungicide application in a wheat-soybean double-crop production system
MGIV & MGV Studies Locations (3)

- Eastern Shore Agricultural Research & Extension Center (ESAREC)
  - Painter, VA
  - Soil: Bojac sandy loam
  - Latitude/Longitude: 37°35'9.82"N, 75°49'29.58"W

- Tidewater Agricultural Research & Extension Center (TAREC)
  - Suffolk, VA
  - Soil: Dragston fine sandy loam
  - Latitude/Longitude: 36°40'56.20"N, 76°45'55.76"W

- Virginia Crop Improvement Foundation Seed Farm
  - Mt. Holly, VA
  - Soil: State fine sandy loam
  - Latitude/Longitude: 38° 5'0.16"N, 76°42'39.49"W
Materials & Methods: MGIV & V Studies

• Factors (2)
  – Foliar Fungicide Application Timing (4)
    • Untreated
    • R3 (beginning pod)
    • R5 (beginning seed)
    • Both R3+R5
      – Priaxor® (2:1 pre-mix of a.i. pyraclostrobin and Xemium, BASF Corporation, Research Triangle Park, NC)
  – Soybean cultivar (10)
MGIV Cultivars

- Asgrow
  - AG4632
  - AG4732
- Pioneer
  - 94Y22
  - 94Y70
- Progeny
  - P4811RY
- Public VA
  - V04-1022
- Southern States
  - SS-4711R2
  - SS-4700R2
- USG
  - 74A79R
  - 74B81R

MGV Cultivars

- Asgrow
  - AG5332
  - AG5632
- NK
  - S51-J3
  - S56-G6
- Pioneer
  - 95Y40
  - 95Y60
- Progeny
  - P5610RY
  - P5655RY
- Southern States
  - SS-5112NR2
  - SS-5510NR2
Materials & Methods: MGIV & V Studies

• Experimental design
  – Strip plot, RCBD
    • Vertical plots = soybean cultivars
    • Horizontal plots = foliar fungicide application timings
  – 4 replications
  – 40 treatment combinations rep$^{-1}$
  – 160 plots study$^{-1}$
# Studies Experimental Design

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<table>
<thead>
<tr>
<th>Untreated</th>
<th>R3</th>
<th>R5</th>
<th>R3+R5</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Materials & Methods: MGIV & V Studies

• Plot size
  – 5 rows
  – 38 cm row width
  – 5.2 m length

• Planting
  – Planted no-till into wheat stubble after wheat harvest
  – Plot planter
  – Seeding rate: 592,800 seed ha$^{-1}$
Materials & Methods: MGIV & V Studies

• Canopy reflectance with NDVI (GreenSeeker)
  – R3 & R5
Materials & Methods: MGIV & V Studies

• Foliar Fungicide Application Timing
  – Priaxor® (2:1 pre-mix of a.i. pyraclostrobin and Xemium)
  – Rate: 292 mL ha$^{-1}$ + Induce® non-ionic surfactant at 460 mL ha$^{-1}$ (0.25% v/v)
  – At least 141 L ha$^{-1}$ water volume
Materials & Methods: MGIV & V Studies

• Disease incidence
  – At each application timing
  – Sampled untreated plots from all 4 reps
  – Total of 10 leaves plot\(^{-1}\)
    • 5 leaves from upper canopy
    • 5 leaves from lower canopy
  – Leaf Incubation = ID specific disease presence in canopy

• Disease ratings
  – Weekly after R6
  – Cercospora Leaf Blight
    • % Stem area
    • % Leaf area
Materials & Methods: MGIV & V Studies

• % Defoliation
  – R6-R8
  – Weekly ratings
  – Canopy reflectance with NDVI

• % Yellowing
  – R6-R8
  – Weekly ratings
Materials & Methods: MGIV & V Studies

• Harvest
  – Seed yield
    • Middle 3 rows of plot with small plot research combine
  – Subsample
    • 100 seed weight
    • Seed quality ratings
Materials & Methods: MGIV & V Studies

• Statistical Analysis
  – Proc Mixed (SAS, 2008)
  – Cultivar and fungicide application considered fixed
  – Replicate considered random
  – P < 0.05 used for mean separation
MGIV & V Disease Incidence at Suffolk, VA

- Disease at all 3 locations
- Lower plant canopy

% Leaf Area Infected

Disease

MGIV 8/17/2012  MGV 8/21/2012  MGIV 8/30/2012  MGV 9/6/2012
Seed Yield MGIV Results

<table>
<thead>
<tr>
<th>Source</th>
<th>Mt. Holly</th>
<th>Painter</th>
<th>Suffolk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivar (CV)</td>
<td>0.4626†</td>
<td>0.0038</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Fung. app timing (FT)</td>
<td>0.4708</td>
<td>0.0209</td>
<td>&lt;.0001</td>
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<tr>
<td>CV*FT</td>
<td>0.8023</td>
<td>0.9717</td>
<td>0.1919</td>
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</table>

† P = 0.05 level of significance. A P value of < 0.05 indicated significant effect or interaction.
MGIV Painter Seed Yield: Cultivar
(P=0.0038) (LSD=780)

Seed Yield (kg ha⁻¹)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Seed Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pioneer 94Y70</td>
<td>5216 a</td>
</tr>
<tr>
<td>USG 74B81R</td>
<td>5170 ab</td>
</tr>
<tr>
<td>Asgrow AG4632</td>
<td>4982 abc</td>
</tr>
<tr>
<td>Asgrow AG4732</td>
<td>4823 abc</td>
</tr>
<tr>
<td>USG 74A79R</td>
<td>4800 abc</td>
</tr>
<tr>
<td>SS-4700R2</td>
<td>4424 bcd</td>
</tr>
<tr>
<td>SS-4711R2</td>
<td>4356 cd</td>
</tr>
<tr>
<td>Pioneer 94Y22</td>
<td>4295 cd</td>
</tr>
<tr>
<td>Progeny P4811RY</td>
<td>3965 d</td>
</tr>
<tr>
<td>VA V04-1022</td>
<td>3888 d</td>
</tr>
</tbody>
</table>
MGIV Painter Seed Yield: Fung. App. Timing

(P=0.0209) (LSD=493)

Seed Yield (Kg ha\(^{-1}\))

Fungicide Application Timing

- R3: 4816
- R5: 4787
- R3+R5: 4644
- Untreated: 4120
MGIV Suffolk Seed Yield: Cultivar
(P<.0001) (LSD=268)
MGIV Suffolk Seed Yield: Fung. App. Timing
(P<.0001) (LSD=169)

Seed Yield (kg ha⁻¹)

<table>
<thead>
<tr>
<th>Fungicide Application Timing</th>
<th>Seed Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>R3</td>
<td>4959</td>
</tr>
<tr>
<td>R3+R5</td>
<td>4951</td>
</tr>
<tr>
<td>R5</td>
<td>4900</td>
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<tr>
<td>Untreated</td>
<td>4525</td>
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</tbody>
</table>

Values followed by the same letter are not significantly different.
# Seed Yield MGV Results

<table>
<thead>
<tr>
<th>Source</th>
<th>Seed Yield</th>
<th>Mt. Holly</th>
<th>Painter</th>
<th>Suffolk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pr &gt; F</td>
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<tr>
<td>Cultivar (CV)</td>
<td>0.3694†</td>
<td>0.1925</td>
<td>0.0004</td>
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<td>Fung. app timing (FT)</td>
<td>0.7426</td>
<td>&lt;.0001</td>
<td>0.0427</td>
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<tr>
<td>CV*FT</td>
<td>0.9990</td>
<td>0.8624</td>
<td>0.9117</td>
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† P = 0.05 level of significance. A P value of < 0.05 indicated significant effect or interaction.
MGV Painter Seed Yield: Fung. App. Timing
(P<.0001)(LSD=389)

<table>
<thead>
<tr>
<th>Fungicide Application Timing</th>
<th>Seed Yield (kg ha⁻¹)</th>
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<tbody>
<tr>
<td>R3+R5</td>
<td>4880</td>
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<tr>
<td>R3</td>
<td>4835</td>
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<tr>
<td>R5</td>
<td>4718</td>
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<tr>
<td>Untreated</td>
<td>4028</td>
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</table>
MGV Defoliation Ratings Painter, VA 2012

% Defoliation plot$^{-1}$

Fungicide Application Timing

- 10/4/12 %DEF
- 10/10/12 %DEF
- 10/17/12 %DEF
- 10/24/12 %DEF
- 11/1/12 %DEF

R3, R3+R5, R5, Untreated, Painter Mean
MGV Suffolk Seed Yield: Cultivar
(P=0.0004)(LSD=312)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Seed Yield (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asgrow AG5632</td>
<td>5062 a</td>
</tr>
<tr>
<td>NK S56-G6</td>
<td>4996 a</td>
</tr>
<tr>
<td>Pioneer 95Y60</td>
<td>4848 ab</td>
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<td>Pioneer 95Y40</td>
<td>4805 abc</td>
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<tr>
<td>Progeny P5610RY</td>
<td>4683 bcd</td>
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<td>Progeny P5655RY</td>
<td>4666 bcd</td>
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<td>NKS51-J3</td>
<td>4603 bcd</td>
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<tr>
<td>Asgrow AG5332</td>
<td>4509 cd</td>
</tr>
<tr>
<td>SS-512NR2</td>
<td>4475 d</td>
</tr>
<tr>
<td>SS-5510NR2</td>
<td>4438 d</td>
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</tbody>
</table>
MGV Suffolk Seed Yield: Fung. App. Timing

(P=0.0427)(LSD=197)

Seed Yield (kg ha\(^{-1}\))

<table>
<thead>
<tr>
<th>Fungicide Application Timing</th>
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<tr>
<td>R3</td>
<td>4802 a</td>
</tr>
<tr>
<td>R3+R5</td>
<td>4781 a</td>
</tr>
<tr>
<td>R5</td>
<td>4709 ab</td>
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<tr>
<td>Untreated</td>
<td>4542 b</td>
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The bars indicate seed yield differences across the fungicide application timings, with varying letters denoting significant differences at P=0.0427 (LSD=197).
Conclusion: Mt. Holly

- Disease incidence: CB & DM present at R5 (MGIV) and R5.5 (MGV)

- % Defoliation:
  - MGIV = Untreated > all other treatments
  - MGV = Mixed results, R3+R5 = lowest amount

- No seed yield significance

- Drought conditions limited soybean growth & development & masked any cultivar or fungicide application effects on seed yield
Conclusion: Painter

- Disease incidence: CB levels elevated in both MGIV & V late season (MGIV = R5.5; MGV = 4.25)

- MGIV
  - CB ratings: Untreated (36%) > R3≈R5 (19%) > R3+R5 (13%)
  - % Defoliation: Untreated > all treatments (slightly)
  - Cultivar differences in seed yield
  - Fungicide application (all 3 timings) increased seed yield compared to untreated; untreated decreased yield by 11%

- MGV
  - CB ratings: Untreated (21%) > R3 (16%) > R5 (14%) > R3+R5 (13%)
  - % Defoliation: Untreated > R3+R5 (lowest)
  - Fungicide application (all 3 timings) increased seed yield compared to untreated; untreated decreased yield by 15%
Conclusion: Suffolk

- Disease incidence: initial CB infection high for MGIV (R3.5); MGV peaked high CB incidence at R5

- MGIV
  - CB ratings: Untreated (55%) > R3≈R5 (24%) > R3+R5 (18%)
  - % Defoliation: Untreated > than all other treatments
  - Cultivar differences in seed yield
  - Fungicide application (all 3 timings) increased seed yield compared to untreated; untreated decreased yield by 8%

- MGV
  - CB ratings: Untreated (62%) > R5 (39%) > R3 (32%) > R3+R5 (26%)
  - % Defoliation: Untreated > R5 > R3≈R3+R5
  - Cultivar differences in seed yield
  - Untreated decreased seed yield by 5% compared to R3 and R3+R5
Summary

• CB Ratings (MGIV & V): Suffolk > Painter > Mt. Holly

• MGIV % Defoliation:
  – Untreated = highest defoliation (all 3 locations)

• MGV % Defoliation:
  – Untreated = highest defoliation (all 3 locations), BUT....
  – Painter: R3+R5 = limited defoliation
  – Suffolk: R3 & R3+R5 = similarly limited defoliation

• Seed Yield:
  – Mt. Holly = Drought conditions masked cultivar/fungicide application
  – MGIV Painter & Suffolk, cultivar differences; untreated decreased yield
  – MGV Painter = Fungicide effect on yield greater compared to Suffolk
  – MGV Suffolk = Cultivar differences, lower fungicide yield effect compared to Painter
Future Research Initiatives

• Field scouting importance
  – Growth stages?
  – Disease severity?
  – Weather patterns?
  – Application cost?
  – Soybean market value?

• Next step
  – Correlate seed yield with disease ratings/NDVI data/% defoliation
  – Analyze and summarize 100 seed weight
  – Repeat studies in 2013 growing season
Acknowledgements

• Professors:
  – Dr. D. Holshouser
  – Dr. M. Reiter
  – Dr. W. Thomason
  – Dr. A. Herbert
  – Dr. P. Phipps
  – Dr. H. Frame

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  – Tommy Custis
  – Bruce Beahm
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