Soybean Yield Response in High and Low Input Production Systems

Grace Bluck
Ohio Soybean Industry

- Ohio’s soybean industry is valued at $2.6 billion (Ohio Soybean Association, 2013)
- Soybeans are most widely planted crop in Ohio - over 4.8 million acres (NASS, 2014)
Ohio Soybean Yield
(1924 – 2013)

\[ y = 0.345x - 652.44 \]

\[ R^2 = 0.9478 \]

Yield (bu/ac)

Year

Ohio State University Extension

Data from USDA NASS

October 23, 2015

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Soybean Commodity Prices (1996 – 2013)

Data from USDA NASS

\[ y = 1.0973x - 2194.4 \]

\[ R^2 = 0.8919 \]

Price (bu)

Year


Price (bu) vs. Year graph showing the trend from 1995 to 2015.

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Evolving Farm Practices

• Increased no-till systems
• Earlier planting dates
• Higher planting populations
• Interest in high input production
Evolving Farm Practices

- Increased no-till systems
- Earlier planting dates
- Higher planting populations
- Interest in high input production
Inputs

- *Rhizobia* Inoculant
- Gypsum
- Manganese Foliar Fertilizer
- Insecticide
- Fungicide
Inoculant

- Soybean has high nitrogen demand
  - 228 lbs N for 60 bu/ac beans
- *Bradyrhizobium japonicum* bacteria
  - TagTeam LCO
- 60% of Ohio farmers annually inoculate
- Yield advantages vary
Gypsum

• Pelletized gypsum
• S deficiency believed to be increasing
  – Greater S removal from high-yielding crops
  – Reduction in S atmospheric deposition
• Soybean yields have been found to increase by up to 30% when S added to deficient fields

(Agrawal and Mishra, 1994)
Mn Foliar Fertilizer

- Max-In Ultra Manganese
- Plays key role in photosynthesis
- Most common micronutrient deficiency in Ohio soybeans
- Deficiency varies with environmental conditions
  - pH greater than 7, high soil organic matter, and dry soil

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Insecticide

• Pyrethroid - Lambda-cyhalothrin (Warrior®)
• Controls soybean aphid and other insects
• Commonly applied in tank-mixes
• Concerns of resistance
Fungicide

• Strobilurin – Pyraclostrobin (Headline®)

• Effective against wide range of pathogens
  – Ascomycetes, deuteromycetes, basidiomycetes, and oomycetes
## Treatment Design

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Inoculant</th>
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<tbody>
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Objectives

• Determine

1. If an input removed from the enhanced (high-input) production system decreases yield

2. If an input added to the traditional (low-input) production system increases yield
Methods

• Randomized complete block design
  – 6 rows wide with 15 in rows
  – 28 to 30 ft long depending on site
• Omission trial approach
• 4 replications of treatments
Methods

Sixteen site-years

bullet 2013

triangle 2014

Not estimated

<250,000 bu

250,000 – 749,999 bu

750,000 – 1,999,999 bu

2,000,000 – 3,999,999 bu

4,000,000 – 7,999,999 bu

>8,000,000 bu

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(NASS, 2014)
Methods

• Pre-emergence herbicides
• Asgrow 3231 seed
  – Maturity group 3.2
• Acceleron® seed treatment
• Seeding rate
  ~142,000 seeds/ac
Methods

- *Rhizobia* inoculant seed-applied within 60 days before planting
- Gypsum applied by hand at VC (unrolled unifoliate leaves)
  - 2 tons/ac
Methods

• Chemical inputs applied at R3 (beginning pod)
  – Pyraclostrobin fungicide
  – Lambda-cyhalothrin insecticide
  – Mn foliar fertilizer
Methods

Intensive Measurements

- 2013
- 2014

(NASS, 2014)
Methods

• Leaf tissue sampling conducted at R1 (beginning flowering)
  – Manganese
  – Sulfur
Methods

- Disease ratings collected at 2 and 4 weeks after fungicide application
  - Foliar disease measured as percent leaf area affected in bottom, middle, and top third of plant canopy
  - Frogeye and brown spot were most predominant diseases
Methods

Frogeye

Brown Spot

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Methods

• Insect defoliation ratings collected at 2 and 4 weeks after insecticide application
  – Defoliation measured as percent leaf area affected in middle and top third of plant canopy
Methods
Methods

• Harvested at plant maturity
  – Yield adjusted to 13% moisture
Methods

- Statistical analysis performed using Proc Mixed in SAS
- Single degree of freedom contrasts ($\alpha=0.05$)
Methods

• Statistical analysis performed using Proc Mixed in SAS
• Single degree of freedom contrasts ($\alpha=0.05$)
Results – Inoculant

- Omission from enhanced
  - No significant decreases
- Addition to traditional
  - No significant increases

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Results – Inoculant

Omission of Inoculant from Enhanced System

Change in Yield (bu/ac)

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Results – Inoculant

Addition of Inoculant to Traditional System

Change in Yield (bu/ac)

-15 -10 -5 0 5 10 15

N1 N2 N3 C1 C2 S1 S2 NW WE WO

2013 2014

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Discussion – Inoculant

• All fields in corn/soybean rotation
• 1 bu/ac yield increase at $\alpha = 0.30$
• Inoculant cost $\$3.50 - \$5.00$ per acre
  need $\sim 0.5$ bu/ac benefit to justify cost
# Results – Gypsum

- **Omission from enhanced**
  - No significant decreases
- **Addition to traditional**
  - No significant increases

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Results – Gypsum

Omission of Gypsum from Enhanced System

Change in Yield (bu/ac)

α = 0.05

N1      N2       N3      C1      C2      S1       S2      NW     WE     WO

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Results – Gypsum

Addition of Gypsum to Traditional System

Change in Yield (bu/ac)

N1      N2       N3      C1      C2      S1       S2      NW     WE     WO

α = 0.05

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Discussion – Gypsum

• Yield gains would have likely been due to sulfur response
• No S deficiency in tissue samples
• No visual deficiency symptoms
• Soil properties regarding S within OSU Extension recommendations
  – pH
  – Organic matter (Barker et al., 2005)
## Results – Mn foliar fertilizer

- **Omission from enhanced**
  - Decreases at 1 of 16 site-years
- **Addition to traditional**
  - No significant increases

### Inputs Table

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<td>T + Mn</td>
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<td>No</td>
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</table>
Results – Manganese

Omission of Manganese from Enhanced System

α = 0.05

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Results – Manganese

Addition of Manganese to Traditional System

Change in Yield (bu/ac)

N1      N2       N3      C1      C2      S1       S2      NW     WE     WO

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Discussion – Mn foliar fertilizer

• Sandusky site 8 bu Mn response
  – 60% sand content
Discussion – Mn foliar fertilizer

• Cost is ~$9 – $11 per acre
• Mn toxicity
  – 300 ppm
  – Acidic and poorly drained soil
  – Yield losses of 3 bu/ac in Ohio (Diedrick, 2010)
Results – Insecticide

• Omission from enhanced
  – Decreases at 1 of 16 site-years
• Addition to traditional
  – No significant increases

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Results – Insecticide

Omission of Insecticide from Enhanced System

α = 0.05

Change in Yield (bu/ac)

N1      N2       N3      C1      C2      S1       S2      NW     WE     WO

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Results – Insecticide

Addition of Insecticide to Traditional System

Change in Yield (bu/ac)

-15 -10 -5 0 5 10 15

N1 N2 N3 C1 C2 S1 S2 NW WE WO

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Discussion – Insecticide

• Defoliation levels were low

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>% Defoliation</th>
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<tr>
<td>Seedling</td>
<td>Bloom</td>
<td>40</td>
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<tr>
<td>Bloom</td>
<td>Pod Fill</td>
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<td>Pod Fill</td>
<td>Maturity</td>
<td>25</td>
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</tbody>
</table>

• Cost is $3 – 5 per acre
• Concerns of resistance
Results – Fungicide

- Omission from enhanced
  - Decreases at 5 of 16 site-years
- Addition to traditional
  - Increase at 1 of 16 site-years

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Results – Fungicide

Omission of Fungicide from Enhanced System

\( \alpha = 0.05 \)

Change in Yield (bu/ac)

N1      N2       N3      C1      C2      S1       S2      NW     WE     WO

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Results – Fungicide

Addition of Fungicide to Traditional System

Change in Yield (bu/ac)

N1      N2       N3      C1      C2      S1       S2      NW     WE     WO

α = 0.05

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Results – Disease Suppression

• Fungicide reduced
  – Brown leaf spot for 29% of treatment comparisons
  – Frogeye leaf spot for 58% of treatment comparisons
## Results – Disease Suppression
Brown Spot 4 weeks after application

<table>
<thead>
<tr>
<th>Year</th>
<th>Site</th>
<th>Enhanced (E)</th>
<th>E – fungicide</th>
<th>Δ</th>
<th>Traditional (T)</th>
<th>T + fungicide</th>
<th>Δ</th>
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</thead>
<tbody>
<tr>
<td>2013</td>
<td>Clinton</td>
<td>4.7</td>
<td>15.9</td>
<td>+11.2*</td>
<td>12.4</td>
<td>4.5</td>
<td>-7.9*</td>
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<tr>
<td>2013</td>
<td>Delaware</td>
<td>2.5</td>
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<td>2013</td>
<td>Henry</td>
<td>3.9</td>
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<td>4.5</td>
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<td>+2.9*</td>
<td>6.5</td>
<td>3.5</td>
<td>-3.0*</td>
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---

% leaf area affected in bottom third canopy

\[ \alpha = 0.05 \]
## Results – Disease Suppression

**Brown Spot 4 weeks after application**

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α = 0.05
Discussion – Fungicide

• Disease pressure
• Higher than 30 yr. average rainfall in June and July (>10 in)
• Above average yield (>52 bu/ac)
• Tank-mixing?
<table>
<thead>
<tr>
<th>Year</th>
<th>Site</th>
<th>June/July Rainfall</th>
<th>Yield</th>
<th>Predicted Fungicide Response</th>
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<tbody>
<tr>
<td>2013</td>
<td>Clinton</td>
<td>14 inches</td>
<td>71 bu/ac</td>
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<td>40 bu/ac</td>
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<td>38 bu/ac</td>
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<td>2013</td>
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<td>11 inches</td>
<td>58 bu/ac</td>
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<tr>
<td>2013</td>
<td>Mercer</td>
<td>8 inches</td>
<td>58 bu/ac</td>
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<tr>
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<td>14 inches</td>
<td>59 bu/ac</td>
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<td>2013</td>
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<td>64 bu/ac</td>
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<td>54 bu/ac</td>
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<td>Year</td>
<td>Site</td>
<td>June/July Rainfall</td>
<td>Yield</td>
<td>Predicted Fungicide Response</td>
</tr>
<tr>
<td>------</td>
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<td>--------------------</td>
<td>--------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>2013</td>
<td>Clinton</td>
<td>14 inches</td>
<td>71 bu/ac</td>
<td>Yes</td>
</tr>
<tr>
<td>2013</td>
<td>Delaware</td>
<td>9 inches</td>
<td>40 bu/ac</td>
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<td>2013</td>
<td>Erie</td>
<td>15 inches</td>
<td>38 bu/ac</td>
<td>No</td>
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<tr>
<td>2013</td>
<td>Henry</td>
<td>11 inches</td>
<td>58 bu/ac</td>
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<tr>
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<td>Mercer</td>
<td>8 inches</td>
<td>58 bu/ac</td>
<td>No</td>
</tr>
<tr>
<td>2013</td>
<td>Northwest</td>
<td>14 inches</td>
<td>59 bu/ac</td>
<td>Yes</td>
</tr>
<tr>
<td>2013</td>
<td>Preble</td>
<td>11 inches</td>
<td>68 bu/ac</td>
<td>Yes</td>
</tr>
<tr>
<td>2013</td>
<td>Western</td>
<td>10 inches</td>
<td>71 bu/ac</td>
<td>No</td>
</tr>
<tr>
<td>2013</td>
<td>Wooster</td>
<td>14 inches</td>
<td>58 bu/ac</td>
<td>Yes</td>
</tr>
<tr>
<td>2014</td>
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<td>64 bu/ac</td>
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<tr>
<td>2014</td>
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<td>54 bu/ac</td>
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<tr>
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<td>7 inches</td>
<td>48 bu/ac</td>
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<tr>
<td>2014</td>
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<td>2014</td>
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<td>Wooster</td>
<td>11 inches</td>
<td>56 bu/ac</td>
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</table>
Discussion – Fungicide

What is needed to see a return on investment?

- $10/bu - Need yield benefit of 3.5 bu/ac to pay for tank-mix
- $12/bu - Need yield benefit of 3 bu/ac to pay for tank-mix
- $14/bu - Need yield benefit of 2.5 bu/ac to pay for tank-mix
## Discussion – Fungicide

<table>
<thead>
<tr>
<th>Site-Year</th>
<th>Production System</th>
<th>Yield Response</th>
<th>$10/bu</th>
<th>$12/bu</th>
<th>$14/bu</th>
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<tbody>
<tr>
<td>Clinton 2013</td>
<td>Enhanced</td>
<td>-12</td>
<td>Yes</td>
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<tr>
<td>Clinton 2014</td>
<td>Enhanced</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Wayne 2014</td>
<td>Enhanced</td>
<td>-5</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Mercer 2014</td>
<td>Traditional</td>
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</table>
Conclusions

• Limited benefit of inoculant, gypsum, Mn foliar fertilizer, and insecticide
• Inputs can be beneficial under right conditions
Conclusions

• Fungicide response at 6 of 16 site-years
• Reduction in foliar disease
• High rainfall (> 10 inches)
• High yielding systems (> 52 bushels)
Conclusions

• Awareness of field conditions
  – Crop scouting
  – Watching the weather
  – Tissue testing at R1
  – Soil testing
  – Tracking field history

• Staying up-to-date
  – corn.osu.edu

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Thank you!