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Input and Management Based Soybean Production Systems with Yield Enhancers and Protectors

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Graduate Students
USB 2.0 Locations in 2012-2014

<table>
<thead>
<tr>
<th>Color</th>
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<tbody>
<tr>
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<tr>
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5 Studies

- USB 1 - “SOYA”: Systematic Optimization of Yield-Enhancing Applications
  - The updated “Kitchen Sink”
  - Examines individual crop inputs and ‘systems’ of inputs
- USB 2 – Variety X Management (SOYA)
  - Examines variety interactions with management
- USB 3 – Population X Management
  - Examines population interactions with management
5 Studies

• USB 4 – Row spacing x Management
  – Examines row spacing interactions with management
    • Kansas and Minnesota only

• USB 5 – Management effects on seed quality
  – Management effects on main seed quality traits
  – Management effects on secondary traits such as isoflavones and fatty acids
    • Michigan only
USB 1 “SOYA”: Systematic Optimization of Yield-Enhancing Applications

• **Seed Treatments (ST):**
  - Untreated control (UTC)
  - Fungicide seed treatment (Fung ST) ➔ *Acceleron®* (45ml/100 lb)
  - Fung ST + Insecticide ST + Nematicide & Biological ST ➔ *Acceleron™ IX-409* (w/ Imidacloprid) (118ml/100 lb) + *Poncho®/VOTiVO® (P/V)* (59ml/100 lb)
  - Fung ST + Insecticide ST + Nematicide & Biological ST + LCO ST + LCO (at V4-V6) ➔ *Acceleron™ IX-409* (w/ Imidacloprid) (118ml/100 lb) + *P/V®* (59ml/100 lb) + *Optimize®* (83ml/100 lb) + *Ratchet™* (4oz/a)
USB 1 “SOYA”: Systematic Optimization of Yield-Enhancing Applications

• FOLIAR OR OTHER TREATMENTS:
  – Nitrogen ➔ Urea (75 lb/a) w/ Agrotaín (3 qt/ton) + ESN® (75 lb/a) @ V4
  – Defoliant ➔ Cobra® (12 fl oz/a) @ V4
  – Foliar fertilizer ➔ Task Force®2 (64 fl oz/a) @ R1
  – Antioxidant ➔ Bio-Forge® (16 fl oz/a) @ R3
  – Foliar fungicide ➔ Headline® (6 fl oz/a) @ R3
  – Foliar insecticide ➔ Warrior II® (1.92 fl oz/a) @ R3

• F and I - Priaxor and Endigo in 2013 and 2014
USB 1 “SOYA”: Systematic Optimization of Yield-Enhancing Applications

• COMBINATION TREATMENTS:
  – SOYA Complete
  – SOYA plus Defoliant @ V4
  – SOYA without Nitrogen
  – SOYA without Foliar fungicide
  – SOYA without Foliar fungicide & insecticide
Summary

• 60 total site years of data
  – 28 showed significant treatment effects
    • 2012- 5 locations
    • 2013- 11 locations
    • 2014- 12 locations
  – North: 15 out of 21 responsive site-years
  – Central: 5 out of 18 responsive site-years
  – South: 8 out of 22 responsive site-years
Red bars indicate statistically greater than UTC at $p \leq 0.05$.
High-Yield Environments (>75.9 Bu/A)

*Red bars indicate statistically greater than UTC at \( p \leq 0.05 \)

ARcol13, ARcol14, ARnew14, ILurb14, INwla14, KYlex13, WIjan13, WIjan14
Low-Yield Environments (<48.5 Bu/A)

*Red bars indicate statistically greater than UTC at p ≤ 0.05

ARnew12, ILurb12, IAhum13, KSros13, MIela12, MIela14
* Red bars indicate statistically greater than UTC at p ≤ 0.05

KYlex, KYhod, KSross, KSman, KSsca, ARnew, ARcol,
*Red bars indicate statistically greater than UTC at $p \leq 0.05$.

IAfar, IAhum, ILmon, ILurb, INwan, INwla
North (MI, MN, WI)

* Red bars indicate statistically greater than UTC at $p \leq 0.05$

MIela, MIbre, MNstp, MNwan, MNIku, MNIkd, WIarl, WIjan
Conclusions

• Seed treatment and early season products show little value in increasing soybean yield
• Benefit from foliar insecticide and fungicide were greatest in the north
• There did not appear to be a yield level x management interaction
  – Higher yielding environments may not see additional benefit from intensive management
USB 2: Variety x management interactions

• Objectives:
  – Determine if cultivar selection interacts with input level
    • Does cultivar selection dictate which inputs to use?
  – Quantify input effects on yield components
Treatments

• 6 cultivars
  – High-yield potential suitable for each location
• 3 input levels:
  1. Standard practice (UTC)
     • University recommendations for fertilizer and weed control
     • No other external inputs
  2. SOYA complete
     • “complete” seed treatment
     • Ratchet® + nitrogen fertilizer @ V4
     • Foliar fertilizer @ R1
     • BioForge®, foliar fungicide, foliar insecticide @ R3
  3. SOYA minus foliar fungicide
Statistical Analyses

• Examined each site-year
  – Determine frequency of significant cultivar and input differences and their interaction
  
  *Cultivar treated as fixed effect

• Regional scale
  – North (MI, MN, WI)
  – Central (IA, IL, IN)
  – South (AR, KS, KY)

  *Cultivar and location treated as random effects
Preliminary Yield Results

• Site-year analysis
  – Only 3 of 53 (5.7%) site-years had a cultivar by input level interaction
  – Cultivar differences were observed in 37 of 53 (69.8%) site-years
  – Input differences were observed in 34 of 53 (64.2%) site-years
2012-2014 Yield

Southern Region
(Arkansas, Kansas, Kentucky)

Columns with the same letter are not statistically different at $P \leq 0.05$
Columns with the same letter are not statistically different at $P \leq 0.05$.
2012-2014 Yield

Northern Region
(Michigan, Minnesota, Wisconsin)

Columns with the same letter are not statistically different at $P \leq 0.05$.
2012-2014 Yield

Across all locations

![Bar chart showing yield comparison across different input levels.]

- **Standard practice** (C): 62 bu acre⁻¹
- **SOYA complete** (A): 65.7 bu acre⁻¹ (+3.7 bu)
- **SOYA minus foliar fungicide** (B): 64.5 bu acre⁻¹ (+2.5 bu)

Columns with the same letter are not statistically different at P ≤ 0.05.

Source: United Soybean Board
2012-2013 Yield Components

Across all locations

Seeds m\(^{-2}\)

<table>
<thead>
<tr>
<th>Input level</th>
<th>Standard practice</th>
<th>SOYA complete</th>
<th>SOYA minus foliar fungicide</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>+2.2%</td>
<td>+1.6%</td>
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Seed mass (grams/100 seeds)

<table>
<thead>
<tr>
<th>Input level</th>
<th>Standard practice</th>
<th>SOYA complete</th>
<th>SOYA minus foliar fungicide</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td>B</td>
</tr>
<tr>
<td>C</td>
<td>+2.8%</td>
<td>+1.9%</td>
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Columns with the same letter are not statistically different at \( P \leq 0.05 \)
Preliminary Conclusions

• Significant cultivar x input interaction was not common.
  – Suggests cultivar selection does not dictate which input level should be used

• Input effects were slightly different by region

• Yield component measurements indicated increased yield across all site-years was due to increased seed number and size.

• Although high input levels increased yield, grower ROI would likely be negative given today’s commodity prices.
USB 3: Population x management interactions

• Objective:

  – Is there an interaction between soybean population and management
    • Do high-input systems require higher plant populations to maximize yield?
    -or-
    • Can high-input systems compensate for a low plant population?
Justification

• Increased soybean prices have emphasized growers’ attention to soybean management decisions

• High market prices have generated many discussions about inputs, variety selection, seeding rates, and the interactions of these management practices

Annual Soybean Sale Price ($ bu⁻¹)

$US Dollar bu⁻¹


USDA-NASS, 2014
Yield Promotion vs. Yield Protection

Greater benefit from high-input system with increasing population

High-input system provides protection from yield loss at lower plant populations
-or-
Higher plants stands cover for crop health issues without additional inputs
Research Methods

• Conducted during 2012 -2014 growing seasons
• Nine States: Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, and Wisconsin
• Minimum of two locations per state
• Randomized Complete Block with 4 reps
• Six target seeding rates: 123500, 197600, 271700, 345800, 419900, and 494000 plants ha$^{-1}$
• Two management regimes: Univ. recommendations (UTC) vs. High-input system (SOYA)
Analysis

- Harvest plant populations were used for analysis
- Yield was standardized as a % of the maximum for each environment
  - 56 Environments total
- The “yield environment” variable was determined by comparison of location the mean to the grand mean (High>1 Std. Dev, Average±1 Std. Dev., Low<1 Std. Dev.)
- Mixed analysis was conducted to determine the effects of yield environment, population and management
  - SAS V9.3 (P<0.05)
Results

• No interaction between population and management was revealed

• The equation $y = \alpha(1-\exp^{-\beta x})$ was used to develop best-fit non-linear regression curves for population and management
  – (Edwards and Purcell, 2005)
2012-2014 Average Yield Env. (43 Envs.)

UTC: \( \%\text{Max} = 0.7916(1-e^{-0.000059x}) \) \( R^2 = 0.98 \)

SOYA: \( \%\text{Max} = 0.8524(1-e^{-0.000059x}) \) \( R^2 = 0.98 \)

- 95% - 50775 ppa
- 99% - 78053 ppa
2012-2014 High Yield Env. (8 Envs.)

\[ \%\text{Max} = 0.8644(1-e^{-0.000062x}) \quad R^2 = 0.99 \]

- 95% - 48318 ppa
- 99% - 74276 ppa
2012-2014 Low Yield Env. (5 Envs.)

% of Max Yield vs. Harvest Plant Population (PPA)
%Max = 0.7365(1-e^{-0.000034x})

R² = 0.95

95% - 88110 ppa

99% - 135446 ppa
2012-2014 Management Responsive Environments (17 Envs.)

UTC: %Max=0.7696(1-e^{-0.000056x}) \ R^2 = 0.99

SOYA: %Max=0.8695(1-e^{-0.000060x}) \ R^2 = 0.99

95% - 49930 & 53495 ppa
99% - 76753 & 82235 pph
Conclusions

• No interaction between population and management
  – Separate analysis of seventeen management responsive sites confirmed no interaction between population and management

• High yield environments achieved maximum yields at only slightly lower plant stands in comparison to average yield environments
  – 99% of Maximum at 74K compared with 78K (High and Average)

• Yield response to population was very small (non-existent) in low yielding environments indicating the presence of other yield limiting factors
USB 4: Row Spacing x Management Interaction

• Objectives:
  – Evaluate the interaction between management systems and row spacing
    • Do high input systems have a greater affect in a particular row spacing?
    • In wide rows, can input systems overcome yield advantage from narrow rows?
Locations

Kansas
3.4 and
4.0/4.1 MG

Minnesota
2.4 MG
Treatments

• **3 row spacings**
  – Narrow (7.5 or 10 inches)
  – Medium (15 or 20 inches)
  – Wide (30 inches)

• **4 input systems:**
  1. Untreated control (UTC)
     • University recommendations for fertilizer and weed control
     • No other external inputs
  2. Seed treatment plus foliar fungicide (STFF)
     • Fungicide, insecticide, and nematicide seed treatment
     • Foliar fungicide @ R3
  3. SOYA
     • “complete” seed treatment
     • Ratchet®, nitrogen fertilizer @ V4
     • Foliar fertilizer @ R1
     • BioForge®, foliar fungicide, foliar insecticide @ R3
  4. SOYA minus foliar fungicide (SOYA – FF)
Statistical Analyses

• Main focus looked at each state separately
  – Row spacing and input system treated as fixed effect
  – Location and year treated as random

• Also examined number of site-year responses
Preliminary Yield Results

- Site-year analysis of yield responses
  - 14 site-years (Waseca, MN 2014 – complete loss)
  - No site-years showed a row spacing by input system interaction
  - Row spacing effect on yield observed in 5 of 14 (35.7%) site-years
  - Input system effect on yield observed in 5 of 14 (35.7%) site-years
2012-2014 Row Spacing

Columns with the same letter are not statistically different at $P \leq 0.05$
Columns with the same letter are not statistically different at $P \leq 0.05$
Overall

2012-2014 Row Spacing

Columns with the same letter are not statistically different at $P \leq 0.05$
2012-2014 Input System

Columns with the same letter are not statistically different at $P \leq 0.05$
Columns with the same letter are not statistically different at $P \leq 0.05$. 

**2012-2014 Input System**

**Input System**

- UTC
- STFF
- SOYA
- SOYA - FF

**Yield (bu ac$^{-1}$)**

- C: +2.3 bu
- B: +5.1 bu
- A: +4.3 bu
- AB: +5.1 bu

**Minnesota**
Overall

2012-2014 Input System

Yield (bu ac⁻¹)

In the image, the bar chart shows the yield comparison across different input systems over the 2012-2014 period. The bars are labeled as follows:

- UTC
- STFF
- SOYA
- SOYA - FF

The bars are color-coded and labeled with percentage increases in yield:

- UTC: C, +1.9 bu
- STFF: B, +4.5 bu
- SOYA: A, +3.2 bu
- SOYA - FF: AB

Columns with the same letter are not statistically different at $P \leq 0.05$. This indicates that the differences in yield among these treatments are not statistically significant at the 0.05 level.
Preliminary Yield Conclusions

• No row spacing by input system interactions were found
  – Row spacing and input system effect on yield did not depend upon the other factor

• Use of high input systems increased yield.
  – Slightly greater response in Minnesota

• Preliminary economic analysis shows a negative ROI for all input systems given today’s commodity prices
In Summary

USB 1 “SOYA”: What worked

• Across 3 years, we saw a much stronger response to inputs in the North
• The full compliment of inputs tended to provide the greatest yields
• Where there were insects, a prophylactic insecticide application worked
  – However, even in these locations, insecticide was not REQUIRED to increase yields – although it appears that it was - by far - the most potent force
Study #1 “SOYA”: What didn’t

• Seed treatments of all sorts
  – although combo products did increase yields in a small number of site-years

• Foliar fungicide
  – Similarly, there were indications that it may be second most important product after foliar insecticides

• Bioforge – Cobra - Foliar fertilizers - Nitrogen
Study #1 “SOYA”: What we don’t know

• We only have estimates of insect populations – and
• We didn’t include additional insecticide treatments – so
• We do not know what insects were affected nor do we know how they were affected
• We do not know what yield gains would have been achieved with properly timed treatments
Take-home

• This summary still represents ‘preliminary data,’ so there can’t be true ‘take homes’ But… if there were...

  – Yields were more responsive to inputs in the North
  – A whole lot of treatments did very little for us.
  – A prophylactic insecticide application was better than doing nothing when insects were present
Take-home

• This research represents an evaluation of true ‘Input-based Soybean Management”. We were not attempting to identify best management practices, only products that provide value to producers in the absence of an “Active Soybean Management” based approach.

• Most products will have a better chance of success if managed more intensively – on a field by field basis
Acknowledgements

• United Soybean Board
  – Project funding and student fellowship
• Field and lab crews at collaborating universities
  – Data Collection and field management

Thank you for your attention!