Understanding & Increasing Soybean Yields

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National Rate of Yield Increase: Corn vs Soybean

Corn:
\[ y = 2.5105x - 4834.6 \]

Soybean:
\[ y = 1.6528x - 3161.5 \]
Current Yield Record

• Kip Cullers, Missouri
  ➢ 2006 – 139.4 bu/ac
  ➢ 2007 – 154.6 bu/ac
  ➢ 2010 – 160.6 bu/ac

• Randy Dowdy, Georgia
  ➢ 2016 – 171.8 bu/ac
Harvesting 100+ Bu/A Soybeans in Arkansas

Perry Galloway
Pioneer® variety
P47T36R

Always follow grain marketing, stewardship practices and pesticide label directions. Varieties with the Glyphosate Tolerant trait (including those designated by the letter “R” in the product number) contain genes that confer tolerance to glyphosate herbicides. Glyphosate herbicides will kill crops that are not tolerant to glyphosate.
What percent of flowers on a soybean plant typically become pods?

A. 25%
B. 35%
C. 45%
D. 75%

Example

Add 1 pod to each main stem node on a plant that has 17 nodes

Each pod contains 3 average size seed (2900 seed per lb)

Final Stand of 120,000 plants/A

+35 Bu/A

Self pollinated
Near 100% fertilization
Higher yield = more flowers
Seed Number Determination

\[
seed \ m^{-2} = \left( \sum_{R1}^{R5} IR \right) \times RUE \times \gamma \times A_g^{-1}
\]

Seed number = Total crop photosynthate R1-R5
Factors Influencing Photosynthesis

- Water balance
- Temperature
- Nutritional status
- Weed, insect, disease pressure
- Light quantity and quality

Sotirios Archontoulis
Figure 4. Daylengths during the growing season for Pittsburg, PA (40.4° N) with example planting, R1, and R6 dates from Parker et al. (2016).
Arkansas Growing Season

Daily Incident Radiation (MJ m⁻²)

12-Apr 2-May 22-May 11-Jun 1-Jul 21-Jul 10-Aug 30-Aug 19-Sep

VE R1 Beg. R5 R7

4.2 RM 5.5 RM
Factors Influencing Photosynthesis

- Water balance
- Temperature
- Nutritional status
- Weed, insect, disease pressure
- Light quantity and quality

• Supplemental sugar?
• *Hula’s $\frac{1}{2}$ lb/ac = 54 seconds of photosynthesis*
Seed Number Determination

\[ \text{seed } m^{-2} = \left( \sum_{R1}^{R5} IR \right) \times RUE \times \gamma \times Ag^{-1} \]

Seed number = Total crop photosynthate R1-R5 × \gamma
Probability of flower abortion

Figure 6: Effect of position within soybean canopy on flower abscission probability. Node 1 is closest to soil surface.

http://ipm.missouri.edu/ipcm/2012/10/Arrested-Development-in-the-Soybean-Field/
Seed Number Determination

\[
\text{seed } m^{-2} = \left( \sum_{R1}^{R5} IR \right) \times \text{RUE} \times \gamma \times A_g^{-1}
\]

Seed number = Total crop photosynthate R1-R5

Allocation to reproductive growth

Photosynthate needed per seed
Probability of pod abortion

Figure 7: Abscission probability of flowers/pods within a raceme. Picture is from Iowa State University.

Seed abortion

http://ipm.missouri.edu/ipcm/2012/10/Arrested-Development-in-the-Soybean-Field/
Seed Weight Determination

- Late season conditions and management influence seed growth rate and fill duration

Seed weight = Seed growth rate x Seed fill duration
Seed Yield Determination

Seed number = Seed yield

Seed weight = Seed growth rate x Seed fill duration

Total crop photosynthate R1-R5

Allocation to reproductive growth

Photosynthate needed per seed

Seed fill duration
Seed Yield Determination

Seed yield = Total crop photosynthate R1-R5 \times Seed fill duration

Management options:
- Earlier planting
- Later maturity
- Narrower rows
- Higher population
- Irrigation/drainage
- Fertility
- Pest control (weeds, insects, diseases)

Weather can trump all
Pause for Questions
Current Yield Record

- Kip Cullers, Missouri Soybean Association
  - 2006 – 139 bu/ac
  - 2007 – 155 bu/ac
  - 2008 – 118 bu/ac
  - 2009 – N/A
  - 2010 – 161 bu/ac
  - 2011 – 109 bu/ac
  - 2012 – N/A
  - 2013 – 115 bu/ac
  - 2014-2018 – N/A

[Current Yield Record](http://agwired.com/2010/10/13/kip-cullers-sets-new-world-record-soybean-yield/)
Research with Kip Cullers

- Establish four “plots” within each variety
  - Radiation use efficiency (RUE)
  - N accumulation rate
  - Rate of harvest index (HI) increase and seed fill duration
- Leaf N during seed fill
- Yield and components
N Accum Rate & RUE

• N accumulation rate (NAR) with a full canopy

• Radiation use efficiency (RUE) during vegetative growth

• Both NAR and RUE are highest ever reported for soybean

<table>
<thead>
<tr>
<th>Variety</th>
<th>NAR</th>
<th>RUE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g N m(^{-2}) d(^{-1})</td>
<td>g MJ(^{-1})</td>
</tr>
<tr>
<td>1</td>
<td>1.88 AB</td>
<td>508 lbs/ac/day</td>
</tr>
<tr>
<td>2</td>
<td>1.66 AB</td>
<td>1.73 A</td>
</tr>
<tr>
<td>3</td>
<td>1.43 B</td>
<td>1.46 B</td>
</tr>
<tr>
<td>4</td>
<td>2.07 A</td>
<td>1.89 A</td>
</tr>
<tr>
<td>5</td>
<td>2.07 A</td>
<td>1.80 A</td>
</tr>
<tr>
<td>6</td>
<td>1.51 B</td>
<td>1.83 A</td>
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</tbody>
</table>

<10% of N was derived from N\(_2\) fixation

Van Roekel and Purcell. 2014. Crop Sci. 54:1189
Kip Cullers’ Management

• Rotates between two contest fields of Newtonia silt loam
• Perennial poultry litter applications
• Fertigation
Picture taken in 2010 from Kip Cullers’ contest field
Where does this nitrogen come from?

**Iowa Field**
- 60 bushels yield, 250 lbs plant N uptake
- Mineralization: 36%
- Fixation: 52%
- Residual N or fertilizers or manure: 11%
- Deposition: 1%

**Cullers Field**
- 120 bushels yield, 650 lbs plant N uptake
- Mineralization: 6%
- Fixation: 7%
- Deposition: 1%
- Residual N or fertilizers or manure: 86%
Supplemental N on Commercial Soybeans

1996-2016 nationwide summary:
<1% of total variability explained by N treatment

### Nutrient Requirements for 80 bu/ac Soybeans

Gaspar & Conley, 2017

#### Total Uptake at Maturity (lbs/ac)

<table>
<thead>
<tr>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
<th>S</th>
<th>Mg</th>
<th>Ca</th>
<th>Fe</th>
<th>B</th>
<th>Cu</th>
<th>Mn</th>
<th>Zn</th>
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<tr>
<td>302</td>
<td>73</td>
<td>200</td>
<td>19</td>
<td>44</td>
<td>83</td>
<td>0.61</td>
<td>0.20</td>
<td>0.09</td>
<td>0.46</td>
<td>0.24</td>
</tr>
</tbody>
</table>

#### Total Removal with Grain (lbs/ac)

<table>
<thead>
<tr>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
<th>S</th>
<th>Mg</th>
<th>Ca</th>
<th>Fe</th>
<th>B</th>
<th>Cu</th>
<th>Mn</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>274</td>
<td>59</td>
<td>98</td>
<td>13</td>
<td>13</td>
<td>11</td>
<td>0.17</td>
<td>0.09</td>
<td>0.09</td>
<td>0.17</td>
<td>0.17</td>
</tr>
</tbody>
</table>

- 80 bu/ac crop removal maintenance would need \(~0-60-100-15(S)~\)
Building A High Yield Fertility Plan

1. pH & Macros (N, P, K)
2. Secondary’s (S, Mg, Ca)
3. Micros (Cu, Mn, Zn, B, Fe)
Iowa Soil Test Potassium

2,002 Fields
6,647 Soil Samples

% of Soil Samples

Potassium

Very Low: 31%
Low: 26%
Optimum: 18%
High: 10%
Very High: 15%

43% of samples optimum or greater
57% of samples below optimum
Nutrient Uptake and Partitioning

**Figure 3.** N and S uptake, partitioning, and remobilization through the growing season for a 66 bu/acre soybean crop.

**Figure 3.** P₂O₅ and K₂O uptake, partitioning, and remobilization through the growing season for a 66 bu/acre soybean crop.
% Leaf Potassium – Early Bloom (R1)

\[ y = -7.6515x^2 + 41.204x + 16.618 \]

\[ R^2 = 0.1228 \]
Cullers’ Management

• Rotates between two contest fields of Newtonia silt loam
• Perennial poultry litter applications
• Fertigation
• Early planting
• Modest plant density ~140,000 plants/ac
• 9 inch twin rows on 30 inch centers

• Indeterminate Pioneer® brand varieties from 4.2 – 5.1 RM
• Frequent (daily) overhead irrigation
• Multiple seed treatments, herbicides, insecticides, fungicides, and others…
Research in Fayetteville

• Establish maximum yield environment
• Plots 30ft x 4 rows, center 20ft for yield, RCBD with 4 replications
• Characterize 12-14 varieties of 4.2 to 5.5 RM from Pioneer, Asgrow and NK
Fayetteville Management

• Soil test + 200 bu yield goal (250 lbs Potash, 250 lbs K-Mag)
• 5 or 7.5 dry tons/ac poultry litter
• N, K, & S fertigation
• Sprinkler irrigation @ 1 in. deficient (26”)
• April planting
• 18 inch rows
• 175,000 seeds/ac
• Deep tillage ≥ 14 in.
• Preventative fungicides
• Strict pest control
Fayetteville Lodging
Cobra + Aim + Crop Oil

129 bu/ac

93 bu/ac

47T36 Cont. 1

47T36 Cobra + Aim + Crop Oil
Pioneer data:
- 8 oz Cobra with crop oil at V3-4
- 4-6 varieties
- No weed pressure or white mold
- Only reduction in plant height & lodging in 2014
Management For Lodging

• Variety Standability
Pioneer® brand soybean varieties
Management For Lodging

- Variety Standability
- Earlier Relative Maturity
- Extremely Early Planting or Late Planting
- Lower populations
- Delay Water & Nutrient Applications
- Sufficient (+supplemental?) Potassium
Yield Components

- Cullers’ 2011-13
  2900 seeds per lb

- Fayetteville 2012-13
  2800 seeds per lb

USA avg. 2012 & 13: 2800 seeds per lb

- Seeds m\(^{-2}\): 3600
- Seeds m\(^{-2}\): 3800

USA avg. 2012 & 13: 1700 seeds m\(^{-2}\)

More PODS
Are soybean yields in Iowa supply (root-soil) or demand (cultivar-climate) limited?

Each point is the mean of 37 weather-years simulations; bars = ± SE

Baseline: SOC = 3%, 40 lbs/ac residual N, PAW = 11 inches at 6 feet depth, root growth 0.4 and 1 inch/day, weather conditions = Ames 1980-2016, RUE = 0.88 g/MJ, maturity = 2.7, row spacing 30 inches, plants/acre = 130 K, planting date = May 5 every year.
Model scenario analysis

Each point is the mean of 37 weather-years simulations; bars = ± SE

Baseline simulation with Ames weather conditions (1980-2016):
planting date = May 5 every year, maturity = 2.7, irrigation = none, RUE = 0.88 g/MJ, row spacing 30 inches, plants = 130,000/acre
Top Ten For High Soybean Yields

1. **Water**, Solar Radiation & Temperature
2. Variety Selection
3. Early Planting Date
4. Narrow Row Spacing (≤ 22 in)
5. Fertility
6. Extended Rotations
7. Foliar Fungicides & Insecticides
8. Fungicide + Insecticide + ILeVO® fungicide seed treatments
9. Weed Management
10. Timely Harvest

ILeVO® is a registered trademark of Bayer.
THANK YOU
ryan.vanroekel@pioneer.com
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**Varieties with the LibertyLink® gene (LL)** are resistant to Liberty® herbicide.

Liberty®, LibertyLink® and the Water Droplet Design are trademarks of Bayer.

**DO NOT APPLY DICAMBA HERBICIDE IN-CROP TO SOYBEANS WITH Roundup Ready 2 Xtend® technology unless you use a dicamba herbicide product that is specifically labeled for that use in the location where you intend to make the application. IT IS A VIOLATION OF FEDERAL AND STATE LAW TO MAKE AN IN-CROP APPLICATION OF ANY DICAMBA HERBICIDE PRODUCT ON SOYBEANS WITH Roundup Ready 2 Xtend® technology, OR ANY OTHER PESTICIDE APPLICATION, UNLESS THE PRODUCT LABELING SPECIFICALLY AUTHORIZES THE USE. Contact the U.S. EPA and your state pesticide regulatory agency with any questions about the approval status of dicamba herbicide products for in-crop use with soybeans with Roundup Ready 2 Xtend® technology.**

**ALWAYS READ AND FOLLOW PESTICIDE LABEL DIRECTIONS.** Soybeans with Roundup Ready 2 Xtend® technology contain genes that confer tolerance to glyphosate and dicamba. Glyphosate herbicides will kill crops that are not tolerant to glyphosate. Dicamba will kill crops that are not tolerant to dicamba.

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