Precision Ag and Weather Impact on WI Soybeans

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University of Wisconsin, Madison
2014 WI Soybean Yield Contest Winners

<table>
<thead>
<tr>
<th>Division</th>
<th>Rank</th>
<th>Contestant</th>
<th>County</th>
<th>Brand</th>
<th>Variety</th>
<th>Yield (bu/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Jerry Koser</td>
<td>Barron</td>
<td>DuPont Pioneer</td>
<td>91M10</td>
<td>54.72</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>Paul Graf</td>
<td>Door</td>
<td>DuPont Pioneer</td>
<td>90Y90</td>
<td>38.45</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Steven Stetzer</td>
<td>Jackson</td>
<td>NK Brand</td>
<td>17G8</td>
<td>81.78</td>
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<tr>
<td>2</td>
<td>2</td>
<td>Steve Kloos</td>
<td>Marathon</td>
<td>Pioneer</td>
<td>91Y90</td>
<td>60.60</td>
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<tr>
<td>3</td>
<td>1</td>
<td>Ron Ellis</td>
<td>Walworth</td>
<td>Jung</td>
<td>1250RR2</td>
<td>73.80</td>
</tr>
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<td>3</td>
<td>2</td>
<td>Travis Van De Hey</td>
<td>Outagamie</td>
<td>DuPont Pioneer</td>
<td>P22T69R</td>
<td>63.32</td>
</tr>
<tr>
<td>3</td>
<td>Recognized</td>
<td>UW-Gaspar, Marburger, Smidt</td>
<td>Columbia</td>
<td>Pioneer</td>
<td>P28T33R</td>
<td>89.58</td>
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<tr>
<td>4</td>
<td>1</td>
<td>Kevin Bahr</td>
<td>Lafayette</td>
<td>Channel</td>
<td>2402R2 Brand</td>
<td>84.99</td>
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<tr>
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<td>2</td>
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## Winners Management Practices

Average Planting dates

<table>
<thead>
<tr>
<th>Division</th>
<th>Date</th>
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<tbody>
<tr>
<td>All Divisions</td>
<td>17-May</td>
</tr>
<tr>
<td>Division 1</td>
<td>29-May</td>
</tr>
<tr>
<td>Division 2</td>
<td>12-May</td>
</tr>
<tr>
<td>Division 3</td>
<td>18-May</td>
</tr>
<tr>
<td>Division 4</td>
<td>9-May</td>
</tr>
</tbody>
</table>

Avg. Seeding rate (seeds/acre) 156,000

<table>
<thead>
<tr>
<th>Practice</th>
<th>% using this practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inoculant</td>
<td>22</td>
</tr>
<tr>
<td>Seed fungicide</td>
<td>55</td>
</tr>
<tr>
<td>Seed insecticide</td>
<td>55</td>
</tr>
<tr>
<td>Foliar fungicide</td>
<td>78</td>
</tr>
<tr>
<td>Foliar insecticide</td>
<td>44</td>
</tr>
<tr>
<td>Row spacing &lt; 30&quot;</td>
<td>44</td>
</tr>
<tr>
<td>Conventional tillage</td>
<td>33</td>
</tr>
<tr>
<td>Previous crop corn</td>
<td>89</td>
</tr>
</tbody>
</table>

Data provided by contestants
Second Year Soybean Recommendations

1. Don’t do it!
2. Do not plant the same variety you planted in that field last year.
3. Pick a variety with high disease ratings
4. If you have scn... choose a different source of resistance if possible
5. Use a fungicide seed treatment (go with the high rate of a.i.)
6. Use a preemergence herbicide
7. Do not skimp on potassium
   – Soybean is a high demand user of K
   – Fertility deficiencies often exacerbate disease incidence and severity
8. Plant early – Always a good idea to maximize yield
Climate-induced reduction in US-wide soybean yields underpinned by region- and in-season specific responses

Introduction

• Global annual temperatures have increased by 0.4 °C since 1980 with several regions exhibiting even greater increases.

• Climate change already appears to affect crop yields, and these effects are expected to continue.

• Crop management strategies, such as new cultivars and hybrids, altered maturity groups, changes in planting dates, use of cover crops, and enhanced crop residue management may be able to be used to adapt to future climate to mitigate potential negative impacts on crop yields.
The United States is one of the largest soybean exporters in the world and approximately 80% of the total planted hectares are annually located in the upper Midwest.

Most of the production in this region is not irrigated and therefore, soybean production systems in this area are highly affected by in-season weather conditions.

Several studies have focused on the effects of in-season weather trends on crop yields in several countries, however none have accounted for the annual genetic by management yield gains.
Objective

• The objective of this study was to quantify the historical regional and national monthly-specific climate effects on U.S. soybean yields
Materials and Methods

- Soybean yield from non-irrigated cultivar performance trials conducted at sites within each of twelve states for periods ranging from 18 to 80 years (depending on the state) were assembled for this study.

- ~80% US soybean production
Materials and Methods

- Advantages of using measured multi-location and multi-year cultivar performance trial data over county yield estimates include:
  - knowing the identity of cultivars,
  - documentation of agronomic practices,
  - statistically valid replicated trials, and
  - availability of weather data for each trial site.
Materials and Methods cont.

• These multiple-site trials conducted each year can be considered to be representative of the state-wide soybean yield performance. Therefore, using state-wide yield data, we generalized the site-specific weather effects on soybean yield to state-wide yield estimates.

• Factors affecting soybean yield:
  - in-season weather conditions
  - agronomic management
  - genetics
Agronomic management yield de-trending

• The contributions of agronomic management practices to soybean grain yield are not constant through time.

• In the locations of this study, researchers were changing agronomic management approximately every 3-8 years.

• We estimated the effect of agronomic management during the time series at each location by subtracting the average yield before the change from the average yield after the change. The yield difference (positive or negative) was attributed to the management practice change.
Genetic yield gain de-trending

- Achieved by using recently published estimates of annual genetic yield improvement in U.S. soybean production systems (Rincker, K. et al. Genetic improvement of US soybean in maturity groups II, III, and IV. Crop Sci. 54, 1419 (2014)).

- After trend removal, yields were assumed to vary from year to year as a result of yearly weather anomalies, with trends over years driven by climate change.
Materials and Methods cont.

- It is difficult to isolate and remove all possible non-weather factors that might affect crop yield, such as atmospheric CO$_2$.

- We calculated first year differences (year-to-year changes) for the de-trended soybean yields and weather variables (May-September month-specific cumulative precipitation and average temperature) to minimize the impact of other long-term factors.
Calculations:

1) **Total yield** change potential (state- and nation-wide) for 1 unit change in month-specific precipitation (mm) and/or temperature (°C).


3) Estimated (state- and nation-wide) 20-yr climate-soybean-related monetary impacts. The monetary values were adjusted for inflation and are reported as 2013 U.S. dollars.
## Results

### Soybean yield change potential for 1 unit change in month-specific weather conditions

<table>
<thead>
<tr>
<th>State</th>
<th>Precipitation May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>Temperature May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
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<tbody>
<tr>
<td></td>
<td>kg ha(^{-1}) mm(^{-1})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>kg ha(^{-1}) C(^{-1})</td>
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<tr>
<td>N. Dakota</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-3.1</td>
<td>117</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>S. Dakota</td>
<td>-</td>
<td>7.8</td>
<td>8.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>7.1</td>
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<td>-118.2</td>
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<tr>
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<td>15.7</td>
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</tr>
<tr>
<td>Ohio</td>
<td>6.2</td>
<td>-8.4</td>
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<td>-</td>
<td>-7</td>
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<td>8.4</td>
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<td>Mississippi</td>
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<tr>
<td>USA kg ha(^{-1}) (adjusted for state-hectares)</td>
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<td>3.6</td>
<td>0.6</td>
<td>-19.6</td>
<td>17.2</td>
<td>-29.3</td>
<td>-45.7</td>
<td>14.5</td>
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</table>
Effect of individual historical month-specific climate on **soybean yield trend**

<table>
<thead>
<tr>
<th>State</th>
<th>Precipitation</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May</td>
<td>June</td>
</tr>
<tr>
<td>N. Dakota</td>
<td>-</td>
<td>-</td>
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<tr>
<td>S. Dakota</td>
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<td>6.1</td>
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<td>Minnesota</td>
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<td>5.8</td>
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<tr>
<td>Wisconsin</td>
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<td>0.6</td>
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<tr>
<td>Iowa</td>
<td>-4.3</td>
<td>-</td>
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<tr>
<td>Illinois</td>
<td>-</td>
<td>-0.6</td>
</tr>
<tr>
<td>Indiana</td>
<td>-</td>
<td>-2.9</td>
</tr>
<tr>
<td>Ohio</td>
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<td>12.1</td>
</tr>
<tr>
<td>Missouri</td>
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<tr>
<td>Arkansas</td>
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</tr>
<tr>
<td>Kentucky</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mississippi</td>
<td>-1.9</td>
<td>-</td>
</tr>
<tr>
<td>USA kg ha(^{-1})</td>
<td>-1.2</td>
<td>1.7</td>
</tr>
<tr>
<td>% effect on USA average yield</td>
<td>-5.5</td>
<td>7.7</td>
</tr>
</tbody>
</table>
Results cont.

Effect of historical climate anomalies on U.S. soybean yield trend (1994-2013)
Results cont.

Estimated state-wide **climate-soybean-related monetary impacts**

-0.32 B
0.95 B
0.58 B
0.77 B
-2.54 B
-0.53 B
-1.3 B
-5.0 B
-2.9 B
-1.3 B
0.94 B
-0.4 B
Conclusions

• The recent climactic warming appeared to favor soybeans in northern states, but suppressed yields in the central Midwest. These results are in agreement with previous studies that showed that soybean yields before 1982 were favored by cooler and wetter years in the Midwest, whereas the Northern Great Plains were favored by hotter years after 1982.

• The results of this study suggest that the development of regional adaptation strategies to mitigate climate change is imperative due to the spatial impact on soybean yield variability and the impact of month-specific temperature and precipitation variability (driven by climate change).
Conclusions cont.

- Biotechnology and classical breeding can be used to develop crops that not only survive increased water saturation during establishment but also increased heat stress tolerance during the reproductive stages of the plants that usually occur in July-August.

- Climatologists must strive to develop accurate region-based predictive early-, mid-, and late-season weather projections.

- Using these projections, plant scientists must develop region-specific adaptation practices that target sensitive regions.
Conclusions cont.

For example:

• In locations that yield is being suppressed due to warming trends, the use of cover crops could assist in mitigating excessive soil warming and water evaporation.

• Planting dates or soybean maturity groups could be adjusted to avoid the sensitive reproductive development stages of the crop that currently occur in August.

• Combination of row spacing and seeding rate could be altered to allow for adequate light interception to minimize in-season water loss due to evaporation or mitigate excessive soil temperatures.
Conclusions cont.

- The results of our study suggest that long-term economic returns are sensitive to regional climatic trends.

- These trends will impact trade policy, consumer food prices and national food security.

- Failure to acknowledge and develop region based strategies to mitigate climate change impacts would greatly weaken the competitive ability of US soybean farmers and subsequently impact food security for US consumers.
Can soybean growers benefit from precision ag data?

Ethan R. Smidt and Shawn P. Conley
Introduction

- Growers are collecting multiple layers of data each year
- GPS and equipment advances have allowed for variable rate technology (VRT)
- Many growers are unsure which data layer(s) to use when creating these prescriptions
Objectives

1. Find key parameters influencing soybean yield
2. Use those parameters to make accurate seeding rate prescriptions
Materials and Methods

- Created prescriptions with high, medium, and low seeding rates running across soil types
- Rates were confirmed by as-planted data and stand counts
- Data layers also collected from soil samples, yield monitors, and soil surveys
Materials and Methods (continued)

- We had a wide range of locations/conditions/soils
- Multiple varieties
- 15”, 20”, and 30” rows
Materials and Methods (continued)

• Soybean yield data was “cleaned” to discard outliers and incorrect data points

• Data analysis:
  – random forest model
  – cross-validation tests
  – decision tree models
2013 Pooled Results

- Soil type was the most important variable in 2013 across Wisconsin

- Cross-validation indicated soil phosphorus (ppm), soil organic matter (%), soil water storage capacity from 0-39in (in), elevation (ft), and soil pH were also important in predicting yield
Decision Tree from Top 6 Parameters

Key:
- Average Yield (bu/ac)
- Percent of total dataset
- Number of data points
- Separation of most important parameter to this specific node of data

Decision Tree – Full Model (2013)
Soil Independent Decision Tree (2013)
Results (continued)

Maly - Seed Yield x Elevation

K1 - Seed Yield x Elevation

Avg. Estimated Volume (Dry) (bu/ac)

Elevation

COOL BEAN
University of Wisconsin-Madison | UW Extension
WWW.COOLBEAN.INFO
Results (continued)

Soybean Yield x Elevation x Seeding Rate

- 120000 sds/ac
- 160000 sds/ac
- 200000 sds/ac
Results (continued)

Yield x Elevation x Seeding Rate

Yield (bu/ac)

Elevation (ft)

- 955.00 - 960.00 ft
- 965.00 - 970.00 ft
- 975.00 - 980.00 ft
- 985.00 - 990.00 ft
- 995.00 - 1,000.00 ft
- 1,005.00 - 1,010.00 ft
- 1,015.00 - 1,020.00 ft
- 1,025.00 - 1,030.00 ft
- 1,035.00 - 1,040.00 ft

Seeding Rates:
- 120000 sds/ac
- 160000 sds/ac
- 200000 sds/ac
Results (continued)
Results (continued)
SatShot Data Example

NDVI Satellite Image – June 30
Yield x Plant Population (2013)
Combined Results

Most important variables – 2013 Pooled Data

- Soil.Type
- Soil.P1
- Soil.OM
- WS.0.39
- Elevation
- Soil.pH
- Soil.K
- WS.0.59
- SlopePercent
- HZ1.Depth
- Seeding.Rate

Node Purity (measure of importance)

Most important variables – 2014 Pooled Data

- Soil.Type
- Soil.P1
- Elevation
- Soil.OM
- Soil.K
- WS.0.59
- WS.0.39
- Soil.pH
- HZ1.Depth
- Seeding.Rate
- SlopePercent

Node Purity (measure of importance)
Single Field Analyses

- Very different story
- Local knowledge is still very important
- All other variables (including soil type) ranked 6.00 or lower

<table>
<thead>
<tr>
<th>2013 Variable Rankings</th>
<th>2014 Variable Rankings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Elevation (1.73)</td>
<td>1. Elevation (2.00)</td>
</tr>
<tr>
<td>2. Soil Potassium (3.18)</td>
<td>2. Soil pH (3.09)</td>
</tr>
<tr>
<td>4. Soil pH (3.91)</td>
<td>4. Soil Organic Matter (3.36)</td>
</tr>
<tr>
<td>5. Soil Phosphorus (4.09)</td>
<td>5. Soil Phosphorus (3.82)</td>
</tr>
</tbody>
</table>
Preliminary Conclusions

• Soil type was the most important variable in both 2013 and 2014 across Wisconsin

• Individual fields had very different results with elevation as the most important on average

• Seeding rate was not a statistically significant variable in either year
What else are we learning?

• NDVI can be a good late-season yield predictor

• Low yielding areas may respond to higher seeding rates (more work needed)

• Precision farming data can be useful to soybean growers
Can soybean growers benefit from precision ag data?