On-Farm Research
An Educational Tool for Implementing Precision Agriculture Technologies

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Why On-Farm Research and Precision Ag?

• To develop and deliver methods and tools that allow corn and soybean producers to manage within-field variability for production.
On-Farm Research – Helpful Items

• Background
  – Historical aerial photos
  – Yield maps
  – Fertility maps
On-Farm Research – Helpful Items

• Dense data sets obtained on 30 foot transects
  – Soil electrical conductivity
    • Geonics EM38 sensor
    • Veris Technologies 3100 coulter-based sensor
  – Elevation data
    • RTK GPS
On-Farm Research Topics

• Variable rate nitrogen and corn seeding based on management zones
• Nitrogen rate study, replicated strip trial
• Variable rate phosphorus and potash using soil electrical conductivity
• Sensor-based nitrogen studies, replicated strip trials
• Evaluation of proposed changes in University of Missouri fertilizer recommendations in variable rate fertility management of P and K
On-Farm Research – Example 1

• Producer wished to investigate the use of management zones to maximize productivity through variable nitrogen application and corn seeding rates.
On-Farm Research – Example 1

Development of Productivity Zones

- Use of Soil Electrical Conductivity
On-Farm Research – Example 1

Development of Productivity Zones

- Use of Past Years’ Yield Maps
On-Farm Research – Example 1

Development of Productivity Zones

- Use of Soil Electrical Conductivity and Past Years’ Yield Maps
On-Farm Research – Example 1
Development of Productivity Zones
## On-Farm Research – Example 1

**Development of Productivity Zones**

<table>
<thead>
<tr>
<th>Productivity Zone</th>
<th>Soil EC (mS/m)</th>
<th>Nitrogen Rate (lb/acre)</th>
<th>Seeding Rate (seeds/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>45-135</td>
<td>80</td>
<td>22,000</td>
</tr>
<tr>
<td>Medium</td>
<td>28-45</td>
<td>120</td>
<td>28,000</td>
</tr>
<tr>
<td>High</td>
<td>6-28</td>
<td>160</td>
<td>34,000</td>
</tr>
</tbody>
</table>
Corn was planted using a 16-row planter. Planter was equipped with two variable rate drives to control each half of the planter. This allowed the producer to plant one half of the planter with the variable seeding rate and the other half to his usual whole field rate of 28000 seeds/acre.

GPS data was collected on the variable rate side of the planter by mounting the GPS antenna in the middle of that half of the planter.
Results and Discussion – Yield Maps
Results and Discussion – Yield Maps
## Results and Discussion – Yield Summary

<table>
<thead>
<tr>
<th>Productivity Zone</th>
<th>Fixed-rate seeding</th>
<th>Variable-rate seeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>115.1</td>
<td>123.1</td>
</tr>
<tr>
<td>High</td>
<td>144.5</td>
<td>149.5</td>
</tr>
<tr>
<td>Field Average</td>
<td>137.1</td>
<td>143.6</td>
</tr>
</tbody>
</table>

Yield in bu/acre
## Results and Discussion - Economics

|                                | Fixed rate, whole field | Variable rate                       |                |                |
|--------------------------------|-------------------------|-------------------------------------|----------------|
|                                |                         | Whole field | Low productivity zone | High productivity zone |
| N applied, lb                  | 6651                    | 7178       | 1206                      | 4522                      |
| Reduction in N expense, $/acre*| --                      | (4.75)**   | 20.00                    | (20.00)                   |
| Corn seed, bags                | 19.4                    | 20.4       | 4.1                       | 12.0                       |
| Reduction in seed expense, $/acre* | --                  | (4.51)     | 18.75                    | (18.75)                   |
| Yield, bu/acre*                | 137.1                   | 143.6      |                          |                           |
| Yield increase, bu/acre        | --                      | 6.5        | 8.0                       | 5.0                        |
| Grain revenue increase, $/acre* | --                      | 35.75      | 44.00                    | 27.50                      |
| Net benefit, $/acre*           | --                      | 26.49      | 82.75                    | (11.25)                   |

* compared to whole-field fixed rate. Assumes N cost of $0.50/lb, seed cost of $250.00/bag, and corn grain price of $5.50/bu. ** indicates additional cost or reduced revenue
On-Farm Research Study - Example 2

• To evaluate sensor-based nitrogen application in corn production.
  – Strip trial utilizing applicator to collect plot information for developing plot identification
  – Utilizing as-applied data as for plot map
  – Yield monitor data pass number attribute key in analyzing results
Utilizing As-Applied Data for Plot Map
Utilizing As-Applied Data for Yield Data Analysis
Sensor Benefits:

• Make sure enough N is applied
• Avoid unneeded N application
N application to head-high corn

N rate map

June 20, 2007
129 bu/ac
149 bu/ac

High-N reference area

115 N lbs/acre

40 extra lbs of N with the sensors

175 N lbs/acre

175 N lbs/acre
Outcomes from the demos

- 55 side-by-side comparisons
- Sensor outcomes:
  - 2 bu/acre yield increase
  - 14 lb N/acre saved
  - $13/acre at 2009 prices
  - $19/acre at 2008 prices
- Making money with sensors is easier when prices are high
Outcomes from the demos

• Different in different years
• 2004-2007
  – No effect on yield
  – Saved 24 lb N/acre
• 2008 (very wet year)
  – Used 15 lb extra N/acre
  – Made 8 extra bushels
  – Adjusted for wet weather and N loss!
On-Farm Research Study - Example 3

- To evaluate proposed changes in University of Missouri fertilizer recommendations in variable rate fertility management of P and K.
Implementation of Example 3
Plot Layout – 80’ x 300’
Proposed Soil Test K Recommendations

Equation Output: K Rec for Corn

If [Soil K] < (220.00 + (5.000 * [Soil CEC])) Then

RESULT = [Corn Yield Goal] * 0.300 + 75.50 * ((220.00 + (5.000 * [Soil CEC]))^0.500) - (([Soil K] * 1.000)^0.500) / [Build Years]

Else If [Soil K] >= (220.00 + (5.000 * [Soil CEC])) Then

RESULT = [Corn Yield Goal] * 0.300 * (1.000 - (2.000 * ((100.00 * ([Soil K] * 1.000)) / (220.00 + (5.000 * [Soil CEC]))) - 100.00)) / 100.00

Equation Output: K Rec for Corn

If [Soil K] < (150.00 + (4.000 * [Soil CEC])) Then

RESULT = [Corn Yield Goal] * 0.250 + (2.100 * ((150.00 + (4.000 * [Soil CEC])) - [Soil K])) / [Build Years]

Else If [Soil K] >= (150.00 + (4.000 * [Soil CEC])) Then

RESULT = [Corn Yield Goal] * 0.250 * (1.000 - (2.000 * (([Soil K] / (150.00 + (4.000 * [Soil CEC]))) - 1.000)))
Results from soil sampling using a 1-acre grid

Soil Test K

In

lbs/acre
Current status/importance of research area

- 5810 lbs of K₂O
- 1762 lbs of K₂O
Plot Level – Application Map
Analysis Buffer Overlaid on a Yield Map
Utilizing As-Applied Data for Yield Data Analysis
## 2010 Corn Yield Results – Field 1

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rep 1</th>
<th>Rep 2</th>
<th>Rep 3</th>
<th>Rep 4</th>
<th>Rep 5</th>
<th>Treatment Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Fertilizer</td>
<td>163.4</td>
<td>172.3</td>
<td>155.2</td>
<td>188.2</td>
<td>146.2</td>
<td>164.8</td>
</tr>
<tr>
<td>Whole Field</td>
<td>149.2</td>
<td>150.7</td>
<td>142.6</td>
<td>190.8</td>
<td>148.9</td>
<td>156.1</td>
</tr>
<tr>
<td>Current Recommendations</td>
<td>150.8</td>
<td>180.2</td>
<td>153.0</td>
<td>182.3</td>
<td>151.3</td>
<td>163.0</td>
</tr>
<tr>
<td>Proposed Recommendations</td>
<td>156.4</td>
<td>171.7</td>
<td>153.5</td>
<td>194.8</td>
<td>165.4</td>
<td>169.1</td>
</tr>
<tr>
<td>Block Mean</td>
<td>154.9</td>
<td>170.4</td>
<td>150.6</td>
<td>189.2</td>
<td>152.8</td>
<td>163.1</td>
</tr>
</tbody>
</table>

No significant treatment differences (P=0.05) LSD 9.9
### 2010 Corn Yield Results – Field 2

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rep 1</th>
<th>Rep 2</th>
<th>Rep 3</th>
<th>Rep 4</th>
<th>Rep 5</th>
<th>Treatment Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Fertilizer</td>
<td>134.5</td>
<td>126.7</td>
<td>102.8</td>
<td>121.1</td>
<td>92.3</td>
<td>116.8</td>
</tr>
<tr>
<td>Whole Field</td>
<td>171.3</td>
<td>101.4</td>
<td>99.6</td>
<td>110.4</td>
<td>126.3</td>
<td>118.6</td>
</tr>
<tr>
<td>Current Recommendations</td>
<td>145.1</td>
<td>137.2</td>
<td>98.9</td>
<td>139.2</td>
<td>135.0</td>
<td>133.0</td>
</tr>
<tr>
<td>Proposed Recommendations</td>
<td>153.4</td>
<td>106.8</td>
<td>125.1</td>
<td>107.0</td>
<td>134.8</td>
<td>120.9</td>
</tr>
<tr>
<td>Block Mean</td>
<td>150.5</td>
<td>116.6</td>
<td>106.7</td>
<td>116.6</td>
<td>124.3</td>
<td>122.2</td>
</tr>
</tbody>
</table>

No significant treatment differences (P=0.05)

LSD 22.7
# Field 1 – Fertilizer Amounts for Corn

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Pounds of $\text{P}_2\text{O}_5$</th>
<th>Total Pounds of $\text{K}_2\text{O}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Field</td>
<td>3920</td>
<td>6770</td>
</tr>
<tr>
<td>Current Recommendations</td>
<td>3607</td>
<td>5810</td>
</tr>
<tr>
<td>Proposed Recommendations</td>
<td>983</td>
<td>1762</td>
</tr>
</tbody>
</table>
# Field 2 – Fertilizer Amounts for Corn

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Pounds of P₂O₅</th>
<th>Total Pounds of K₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Field</td>
<td>10766</td>
<td>5700</td>
</tr>
<tr>
<td>Current Recommendations</td>
<td>11099</td>
<td>6220</td>
</tr>
<tr>
<td>Proposed Recommendations</td>
<td>4920</td>
<td>2073</td>
</tr>
</tbody>
</table>
## 2012 Silage Yield Results for Field 2

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rep 1</th>
<th>Rep 2</th>
<th>Rep 3</th>
<th>Treatment Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Recommendations</td>
<td>8.5</td>
<td>8.6</td>
<td>9.8</td>
<td>8.95</td>
</tr>
<tr>
<td>No Fertilizer</td>
<td>9.5</td>
<td>5.8</td>
<td>6.7</td>
<td>7.33</td>
</tr>
<tr>
<td>Proposed Recommendations</td>
<td>11.0</td>
<td>12.5</td>
<td>9.75</td>
<td>11.08</td>
</tr>
<tr>
<td>Whole Field</td>
<td>7.2</td>
<td>5.8</td>
<td>9.4</td>
<td>7.47</td>
</tr>
<tr>
<td>Block Mean</td>
<td>9.05</td>
<td>8.18</td>
<td>8.90</td>
<td>8.71</td>
</tr>
</tbody>
</table>

No significant treatment differences (P=0.05)

LSD: 2.89
## Economics of Proposed Changes to Soil Test Equations for VR Management Using 2010 and 2011 Yield Data

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Difference in Crop Value Minus Cost of P and K Fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Recommendations</td>
<td>$644.70</td>
</tr>
<tr>
<td>Proposed Recommendations</td>
<td>$712.77</td>
</tr>
<tr>
<td>No Fertilizer</td>
<td>$732.64</td>
</tr>
<tr>
<td>Whole Field</td>
<td>$631.76</td>
</tr>
</tbody>
</table>

Analysis assumed $\text{P}_2\text{O}_5$ cost of $0.46$/lb, $\text{K}_2\text{O}$ cost of $0.50$/lb, corn price of $5.50$/bu, and soybean price of $14.20
Conclusions

• On-farm research can be used to help understand the complexities of site-specific management.

• Data collected has been useful for educating other producers and precision agriculture service providers on how to utilize sensor-based information for making better management decisions.
Conclusions and Future Work

• Commercial precision agriculture software can assist in automating the process of conducting on-farm research.
• Future products of our work will be a guide and online course on the design and analysis of on-farm research trials utilizing commercial precision agriculture software.
Questions ???

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