Optimizing Field Sampling
Potato Remote Sensing Conference
University of Wisconsin – Madison
11/14/2017
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BLACK GOLD FARMS HISTORY
• Black Gold Farms started in 1928 – Forest River, ND
• Business Started with Potatoes and Registered Black Angus Cattle
• Headquarters – Grand Forks, ND
• Fourth Generation Farm
• 1986: First Year
• 11 Farms in 11 States
Our History with Remote Sensing

2014  2015  2016  2017

Yield in Potatoes

Yield potential  Soil type  Field characteristics
                Bulk rate  Variety  Drainage
                Vine type  Temp  Environment
Base soil fertility  Rainfall  Seed
Soil temps  Air temps  Dormancy
Diseases  Field loss  Seed cutting
Insect pests  Harvest loss  Seed handling
Mechanical loss  Poor timing  Accuracy
Poor timing  Tissue sampling  Rate
Quality rejects  Storage loss  Placement

Black Gold FARMS
Yield Sampling

• Accurate yield sampling is important
  – Provides estimates to sales and customers
  – Provides information for storage managers to store the best potatoes
• Accurate yield sampling is difficult
  – How/where/when to sample
  – Labor-intensive
  – Potatoes are heavy.....

Yield Sampling Difficulty

• Extrapolating a large volume from a small sample
• Variation complicates estimation
  – Between potato plants
  – Between competitors (weeds)
  – Non-uniform fertility
  – Non-uniform pest control
• Objective: Make informed decisions on where to sample
Current Method

“Improved” Method

2015 Drone Use

Forest River, ND
Hovet Field
August 2015
Trial Purpose

- Identify practical applications of drone use using spectral imagery (RGB, NDVI and NIR).
- Flight was conducted on the Hovet field south of Grand Forks, ND on 08/17/15.
- Flight data was reviewed and yield and QC samples were taken on 08/28/15.
  – Correlate yield and/or other characteristics to data received from the drone flight.

Spectral – NDVI (Near Infrared)

Colors correlate to NDVI values (red = low and green = high)

The breakdown of % area of the field for each color:

- Red = 10.8%
- Orange 1 = 23.4%
- Orange 2 = 25.2%
- Yellow = 25.5%
- Green = 16.1%
Sampling

We sampled locations in red, green and orange 2 locations.

Data collected included:

Number of Tubers
Estimated Yield
Number of Plants
Number of Stems
Vine Rating
% Incidence of Growth Cracks
Scab Rating

Visual

Green  Orange  Red

No readily discernible differences in some areas, though some “green” sample locations were greener/healthier than others but some red areas were actually quite healthy looking.
Results

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>P-Value</th>
<th>Sign. @ 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tubers (Number)</td>
<td>Green 45.6</td>
<td>0.731</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Orange 42.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red 41.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield (cwt/a)</td>
<td>Green 378.4</td>
<td>0.074</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Orange 306.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red 249.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants (Number)</td>
<td>Green 6.6</td>
<td>0.385</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Orange 7.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red 6.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stems (Number)</td>
<td>Green 29.8</td>
<td>0.603</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Orange 30.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red 27.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vine Rating (0-10)</td>
<td>Green 5.0</td>
<td>0.231</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Orange 4.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red 3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth Crack (%)</td>
<td>Green 19.3%</td>
<td>0.026</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Orange 14.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red 5.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scab Rating (0-10)</td>
<td>Green 3.8</td>
<td>0.648</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Orange 3.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red 4.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We found significant correlation in two measured metrics: estimated yield and occurrence of growth cracks.

Yield was positively correlated with NDVI and % growth cracks was negatively correlated with NDVI.

Based on test dig to NDVI estimate difference, there is a potential 30 cwt/a difference in yield estimates or 4,440 cwt of potatoes

Key Learning: Good information, very slow delivery
We were not successful in trialing in 2016. Dickeya!
Despite a clear trend, we lacked significant differences between the values.

2017 Satellite Yield Results

P = 0.147

2017 Drone Work    ND, MI, IN

Aker

Mavrx
2017 Drone Yield Results

Despite messy data, we had significant differences between the values.

Yield Sampling Recap

<table>
<thead>
<tr>
<th>Year</th>
<th>Type</th>
<th>Yield Diff?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>Drone</td>
<td>Significant</td>
</tr>
<tr>
<td>2016</td>
<td>Satellite</td>
<td>Not Significant</td>
</tr>
<tr>
<td>2017</td>
<td>Satellite</td>
<td>Not Significant</td>
</tr>
<tr>
<td>2017</td>
<td>Drone</td>
<td>Significant</td>
</tr>
</tbody>
</table>

Could the type of imagery technology influence our yield estimation?

A problem of scale??
Lessons regarding practical use of imagery

1. Data handling → Information
   • Goal is information
   • Private use of drones is costly
   • Lots of low cost commercial options

2. Scale is likely important for certain circumstances
   • Early season evaluation
   • Potato may require more data to make inferences
Lessons regarding practical use of imagery

3. Timing and number of imagery events is critical depending on what you want to accomplish
   • Early season evaluation of stands?
   • Mid season evaluation of fertility?
   • Late season evaluation of yield?

Lessons regarding practical use of imagery

4. NDVI may not be the best means of yield estimation
   • NDVI is the most common
   • Thermal?
   • Certain wavelengths?
Lessons regarding practical use of imagery

5. Variation is a shared enemy
   - For any attempt to evaluate yield, variation will reduce success
   - But yield differences are created by variation
   - ????

6. Vet your Imagery Company
   - Most Ag start-ups fail in the first two years
   - A lot of venture capital
Final Thought

Linkedin Post