Can Organic Farms Benefit from Precision Agriculture?

Soils and Crops Conference 2020

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Department of Land Resources and Environmental Sciences
• Advisor: Bruce Maxwell
Outline

- Research Problem/Question
- Methods & Preliminary Results
  - A Manitoba Example of On Field Precision Experimentation
- Challenges
- Future
Research Problem

- Feeding a growing population while maintaining ecosystem services

Solutions?
- Organic Agriculture
  - No synthetic fertilizer, no chemicals
  - Low yield
- Precision Agriculture
  - Reams of unused data
Research Question

- Can we improve yields (and the farmer’s bottom line) using PA?
- Apply On Farm Precision Experimentation (OFPE) to answer this question
On Farm Precision Experimentation

**Active Data Acquisition**
- On the Ground
  - soil sample
  - biomass crop
  - biomass weeds

**Passive Data Acquisition**
- Remote sensing
  - NDVI
  - Elevation
- Weather data
- As applied map
- Yield monitor data
- Economic data

**Analysis**
- Linear
- Non-linear
- Bayesian updating
- Random forest

**Optimized Net Return $**

**Input**
- prescription map

**Prescription Map**

**New information built back into the model**
OFPE - introduction

Key point of our approach:

Experiments are intended to inform management on the field where conducted, not other fields.
Applying On Field Precision Experimentation

- Precision seeding experiment
  - Winter wheat

- Precision seeding experiment
  - Spring wheat

- Pea green manure followed by wheat

- Precision nitrogen experiment
  - Blood meal on wheat

- Casey Bailey
- Bob Quinn (Goodman)
- Ole Norgaard
- Ty O’Connor
- Loewen
On Field Precision Experimentation

Design → On the ground
Remote sensing → Weather
As applied → Yield
Economic data → Analysis → MNR $
Variable Rate Spring Wheat, May 15 2019

Field size: 71 hectares (175 acres)
Farmer: Sasha Loewen
Location: South East Manitoba
Field elevation levels

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Location: South East Manitoba
NDVI from Sentinel 8 from oat crop 2017

Field size: 71 hectares (175 acres)
Farmer: Sasha Loewen
Location: South East Manitoba
Weather data from nearby weather stations

**Steinbach**

- **Air Temperature**: -0.5°C
- **Relative Humidity**: 99.9%
- **Barometric Pressure**: 1,005hPa

**Precipitation**
- Last Hour: 0.2mm
- 24 Hours: 2.9mm

**Soil Temperature**
- 6°C
- 8°C
- 10°C
- 11°C

**Soil Moisture (VMC)**
- 61%
- 51%
- 46%
- 54%

**Wind Speed and Direction**
- Average: 42km/h N
- Max: 55km/h

**Yesterday’s Summary**

- **Air Temperature (Min/Avg/Max)**: 4°C | 5°C | 6°C
- **Precipitation**: 13.5mm
- **Evaportranspiration**: 0.1mm
- **Wind Speed (Avg/Max)**: 31 km/h | 55 km/h
- **Avg Soil Temp**: 5°C (2°C to 10°C)
- **Avg Soil Moisture**: 60% | 51% | 46% | 54%

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**On Field Precision Experimentation**

- Design
- Remote sensing
- Weather
- As applied
- Yield
- Economic data

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**Analysis**

- MNR $
As applied spring wheat seed rates, May 2019

<table>
<thead>
<tr>
<th>Lbs/Ac</th>
<th>Kg/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>135</td>
<td>150</td>
</tr>
<tr>
<td>180</td>
<td>200</td>
</tr>
<tr>
<td>225</td>
<td>250</td>
</tr>
</tbody>
</table>

Field size: 71 hectares (175 acres)
Farmer: Sasha Loewen
Location: South East Manitoba
Combine monitor yield results - SE Manitoba field - wheat harvested Aug 15, 2019
field average: 3.01 tonnes/hectare (44.8 bushels/acre)

Field size: 71 hectares (175 acres)
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Location: South East Manitoba
On Field Precision Experimentation

Design → On the ground → Remote sensing → Weather → As applied → Yield → Economic data → Analysis → MNR $
**On Field Precision Experimentation**

**Analysis**

**Weather**

**Remote sensing**

**Design**

**MNR $**

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**Yield as a function of three seeding rates and field elevation**

- **H**: 225 lbs/ac
- **M**: 180 lbs/ac
- **L**: 135 lbs/ac

**Line equations:**

- Low rate yield = \(-342.2 + 0.456\) elevation, \(p\)-value < 0.0001
- Med rate yield = \(108.5 - 0.074\) elevation, \(p\)-value < 0.0001
- High rate yield = \(374.5 - 0.388\) elevation, \(p\)-value < 0.0001

**Tukey multiple comparisons of means**

<table>
<thead>
<tr>
<th>Diff</th>
<th>(p)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>med-low</td>
<td>0.0000</td>
</tr>
<tr>
<td>high-low</td>
<td>0.0000</td>
</tr>
<tr>
<td>high-med</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

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**Legend:**

- Cyan: High rate yield
- Yellow: Med rate yield
- Red: Low rate yield
On Field Precision Experimentation

On the ground
Remote sensing
Weather
As applied
Yield
Economic data

Design → Analysis → MNR $ → Design

MLR:
Seed Rate * Elevation + NDVI = Yield

Optimize seeding rate for max net yield
On Field Precision Experimentation

- Design
- On the ground
- Remote sensing
- Weather
- As applied
- Yield
- Economic data

Analysis → MNR $
Cost and benefit of OFPE from Manitoba test site in net return per acre

Base price = $14.50/bu

Application type
- Experiment
- Uniform Rate
- Variable Rate

Lbs/Am  Kg/h
135  150
180  200
225  250

High  Med  Low
Cost and benefit of OFPE from Manitoba test site in net return per acre

Base price = $14.50/bu

On Field Precision Experimentation

- On the ground
  - Remote sensing
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Analysis → MNR $
Cost and benefit of OFPE from Manitoba test site in net return per acre
Unique Organic Challenges

- Fertility
  - Green manure plowdowns
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- Weeds
  - Map perennials
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- Fertility
  - Green manure plowdowns
- Weeds
  - Map perennials
- Organic farmers skeptical of tech
  - Is PA worth it?
Conclusion and Moving Forward

- Other inputs (manure?)
- Integrate satellite data, NDVI, Soil Moisture Active Passive (SMAP), Enhanced Vegetation Index (EVI)
- Develop complete program that can integrate weather, variable prices, to make predictions for ideal seed rates (build from conventional model)
Thank you!

Advisor – Bruce Maxwell
Lab mates – Hannah Duff, Paul Hegedus, Tommy Bass, Braedon Lineman, Lexi Emeny, Madison Boone
Farmers: Bob Quinn, Ole Norgaard, Casey Bailey, Ty OConnor, Roy Loewen
Funding: Western SARE, Montana Academy of Sciences

Questions?
Estimated weed densities, June 15, 2019

Field size: 71 hectares (175 acres)
Farmer: Sasha Loewen
Location: South East Manitoba
• Farmer driven as far as possible
• Experiments field scale
• Conventional machinery
• Analysis provides insight to treatment effect and causes of variation

(adapted from Cook et al., 2018)