Using site-specific strategies to balance agronomic and environmental goals of wheat production in the inland Pacific Northwest

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Dave Brown, Washington State University

Site-Specific Climate-Friendly Farming Project

- Erin Brooks: Remote Sensing
- Kate Painter: Economics
- Kate Reardon: Microbiology
- Jan Eitel: Hydrology
- Lee Vierling: Soil Sensing & Mapping
- Dave Brown: Simulation Modeling
- Claudia Stockle: Cropping Systems
- Jeff Smith: Biogeochemistry
- Dave Huggins: Palouse

USDA NIFA
Outline

1. Challenges to nutrient management
   • Pacific NW as a case study
   • Spatial and temporal variability in climate and topography
2. Adoption of precision ag technology in the region
3. Application of technology for site-specific nutrient management
4. Evaluation of site-specific nutrient management
Challenges to nutrient management in the wheat belt of the Pacific NW

https://www.palousebrand.com/
Challenges: The climate gradient
Challenges: Landscape variability
Challenges: Legacy of erosion

Fence post buried under 2.5 ft of soil
Challenges: Presence of clay layers
Reliance on soil water storage

In low rainfall zones of eastern Washington, every inch of additional water stored in the soil produces from 5 to 7 bushels of grain per acre. (Leggettt, 1959; Schillinger et al., 2009)
What are these patterns telling us?

Soil water recharge (%)

-120 -80
-80 -40
-40 -0
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
100 - 120
120 - 140
140 - 150

May 9th

July 15th
How can we improve nitrogen management in this landscape?

Profits not maximized unless fertilizer recommendations are tailored to site-specific N requirements (Fiez et al, 1994)
Adoption of Precision Agriculture

2012 Precision Ag Survey on the Palouse
REACCH (Wulfforst et al., 2014)
900 surveys sent, 46% response rate

- Most growers have GPS guidance
- Over half growers do not have a yield monitor
Comparison to adoption in Nebraska

Precision Agriculture Technology Usage

![Bar chart showing adoption rates of various precision agriculture technologies.](chart.png)

- Automatic Section Control
- Variable Rate Technology
- Autosteer
- Prescription Maps
- Yield Maps (if Yes to Yield Monitor)
- Yield Monitor
- Soil Sampling
- Chlorophyll/Greenness Sensors
- Satellite/Aerial Imagery
- GPS Guidance Systems
- Cell Phone With Internet Access
- Computer With Access to High-Speed Internet

Precision Agriculture in the Palouse

1. Application of technology

2. Site-specific nutrient management

3. Evaluation
Monitoring yield variability
Creating a Rx Fertilizer Map using relative yields

<table>
<thead>
<tr>
<th>Year</th>
<th>Field Average Yield (bu/ac)</th>
<th>Good June rains</th>
<th>Drought year</th>
<th>Wire worms</th>
<th>Wet spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>110</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>93</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>105</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>85.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Std. dev.</td>
<td>22.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do I use the average?
Creating a Rx Fertilizer Map

Temporal stability of these zones?
Linking underlying soil processes and crop performance to yield variability spatially and temporally

Daily resolution from time lapse camera
Soil mapping

Predictors:
- Elevation
- Aspect
- Insolation
- Slope
- Topographic wetness index
- Electrical conductivity

Drivers:
- SOM, BD, depth to clay
Detecting variability in crop performance
Remote Sensing – NDVI (RapidEye Satellite)

Troy Magney

Colfax, WA
Detecting variability in crop performance

Crop drying patterns correlate well with both soil and topographic variability.

Soil ECa Map
4/21/2012

July 27
NDVI

Colfax, WA
Detecting variability in crop performance

Crop drying patterns correlate well with both soil and topographic variability.
Hydrology driving crop performance

PLANT AVAILABLE WATER
VARIABLE SOIL PROPERTIES
2013 SPRING WHEAT
5/19-5/25

R = 0.51

NDVI 7/9/13

Caley Gasch  Matt Yourek  Troy Magney
Are we meeting our agronomic and environmental goals?
“Monitoring the ‘N balance’ is essential [for fine tuned management] because it is a metric that addresses the need to provide sufficient N to meet crop N demand while preventing a large excess or deficit.”
What can growers can do?

\[ N \text{ balance index} = \frac{N_g}{N_f} = \frac{N \text{ in grain (protein)}}{N \text{ fertilizer applied}} \]
Post-Harvest Evaluation

Most readily available measurements:
- Grain weight (yield monitor)
- Applied N (fertilizer) (Rx or as-applied map)
- N biomass (from remote sensing)

Variable success:
- Grain N (protein) (protein sensor)

Expensive:
- Pre-plant soil N (soil sampling)
- Post harvest soil N (soil sampling)
- Mineralizable N (estimate from SOM)
Remote Sensing to calculate N balances

Above ground crop N at harvest correlated with NDRE at peak greenness.

Troy Magney

Mapping wheat nitrogen uptake from RapidEye vegetation indices

Troy S. Magney¹,² · Jan U. H. Eitel²,³ · Lee A. Vierling²,³
## Site-specific productivity goals

### Nitrogen use efficiencies at maximum yield

<table>
<thead>
<tr>
<th>Factor</th>
<th>Components</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen use efficiency</td>
<td>Grain yield/N supply</td>
<td>35 lb/lb</td>
</tr>
<tr>
<td>N uptake efficiency</td>
<td>Crop N/N supply</td>
<td>0.5 lb/lb</td>
</tr>
<tr>
<td>N utilization efficiency</td>
<td>Grain yield/Crop N</td>
<td>50 lb/lb</td>
</tr>
</tbody>
</table>

Setting goals

Cassman also says, “If growers also provide data on a short list of management practices ... possible to identify the combination of practices that give the highest yields and greatest factor productivity without the need for traditional replicated field studies.”

4Rs: 2-43% increase in fertilizer recovery by crops

Multi-year management: 13-42% increase in total fertilizer recovery

## Evaluation Table

<table>
<thead>
<tr>
<th>Zone</th>
<th>Fertilizer Rate</th>
<th>Protein Goal</th>
<th>Yield Goal</th>
<th>Efficiency Goal</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Consider boosting fertilizer rates, ran out of fertilizer during grain filling</td>
</tr>
<tr>
<td>2</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Cut fertilizer rates, may check to see if nitrogen fertilizer is still in soil or whether it was lost to leaching</td>
</tr>
<tr>
<td>3</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Good!</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Consider boosting fertilizer rates, used all the fertilizer that was available, maybe unrealistic yield goal</td>
</tr>
<tr>
<td>5</td>
<td>Low</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Likely a timing issue where you lost excess N to leaching: More spring application or consider legume rotation</td>
</tr>
<tr>
<td>6</td>
<td>Low</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Likely over-application of N or very poor soil</td>
</tr>
<tr>
<td>7</td>
<td>Low</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Likely the crop stressed, drought year</td>
</tr>
<tr>
<td>8</td>
<td>Low</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Under-applied, fertilizer skip?</td>
</tr>
</tbody>
</table>

**Performance Class Analysis**

Brooks (2016); Brown (2015); Brown et al. (2014); Huggins et al. (2010)
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Reasons for not using Precision Ag Technology

- Equipment is too expensive: 62.0%
- Not cost-effective for operation: 59.9%
- Do not want to invest in new capital: 25.7%
- Difficult to operate and maintain: 24.1%
- Equipment lacks reliability: 17.1%
- Lack of cost-share programs: 12.8%
Summary

• Hydrology drives crop performance
• Use of remote sensing to estimate crop N uptake
• Evaluation is an iterative process for meeting agronomic and environmental goals
Thank you

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