Challenges in Accounting for Variability and Developing Variable Rate Prescriptions

Jeff Schoenau PAg

Dept. of Soil Science

UNIVERSITY OF SASKATCHEWAN
College of Agriculture and Bioresources
Developing a Good Variable Rate Prescription:

A Soil Scientist’s Perspective

- Understanding Variability in Soils
- Formulating a VR Fertilization Plan: Approaches, Requirements, Challenges
Scales of Soil Variability

Regional

Kilometers

Farm & Field

Macro

Meters

Micro

Centimeters
For farm and field, it can all seem **rather random** at first glance!

The goal

**Converting random variation into systematic variability**: variability we understand!

1) Soil properties, crop yields are different in different places for a reason (s)

2) Group according to source and nature of variation

3) Creation of separate management units or zones within the field.
Developing / Delineating Management Zones

Many Approaches (SMA Variable Rate Treatments Fact Sheet)

- Yield maps
- Protein maps
- Aerial/Satellite Imagery
- Digitized soil maps, EC (Veris, EM38)
- Topography

www.planthealthimaging.com
www.farmersedge.ca
www.sksis.usask.ca
www.veris.com
Commercial fertilizer

Variable rate manure

U of S Beef Cattle Research Feedlot

Constant rate manure

C1 (Old BCR 1)

C3 (Old BCR 3)
NDVI Map of NE 21-34-3-Wof 3rd at BCRTU courtesy Echelon™
Sources of Variation in Soil Nutrient Availability Across Fields:

1) Topography
2) Past Management
3) Parent Material
Soil Test N
(0-6” depth, lb N/acre)

Soil Test K
(0-6” depth, lb K/acre)
Microscale variability (variation in available nutrient over just a few cm) in soils can be huge! (B. Weiseth MSc project fall 2014)
### Soil Test P Values in Fall after Harvest

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>10 cm</th>
<th>5 cm</th>
<th>Seed-row</th>
<th>5 cm</th>
<th>10 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cm</td>
<td>13.4</td>
<td>12.8</td>
<td>9.8</td>
<td>11.2</td>
<td>17.4</td>
</tr>
<tr>
<td>4 cm</td>
<td>5.7</td>
<td>5.9</td>
<td>4.3</td>
<td>4.1</td>
<td>4.6</td>
</tr>
<tr>
<td>7 cm</td>
<td>1.4</td>
<td>1.5</td>
<td>1.6</td>
<td>1.4</td>
<td>1.7</td>
</tr>
<tr>
<td>10 cm</td>
<td>1.4</td>
<td>1.3</td>
<td>1.5</td>
<td>1.4</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Unfertilized Control

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>10 cm</th>
<th>5 cm</th>
<th>Seed-row</th>
<th>5 cm</th>
<th>10 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cm</td>
<td>5.3</td>
<td>8.5</td>
<td>20.7</td>
<td>12.8</td>
<td>9.6</td>
</tr>
<tr>
<td>4 cm</td>
<td>3.4</td>
<td>6.5</td>
<td>13.0</td>
<td>9.2</td>
<td>5.6</td>
</tr>
<tr>
<td>7 cm</td>
<td>1.6</td>
<td>2.1</td>
<td>2.0</td>
<td>3.0</td>
<td>2.2</td>
</tr>
<tr>
<td>10 cm</td>
<td>1.1</td>
<td>1.6</td>
<td>2.4</td>
<td>2.7</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Seed Placed 20 lbs $P_2O_5$/acre
How to account for micro and macroscale variability in a management unit?
(Hu, Schoenau and Si, 2014. J. Precision Agric.)

- **Microscale:** sample across seed-rows.
  - 30-60cm width for CV<10%
  - ~30cm for avail P, ~60cm for N

- **Macroscale:** take lots of samples!
  - 40 to 80 cores for nutrient CV<10%
  - 40 in VR field, 80 in CR
• Variable rate fertilization, direct seeding helps to smooth out, reduce the macroscale variability.
Putting It All Together: *Formulating the Prescription*

- This is the challenging part!
- How to vary rate of application among management units?
- Which gets more, which gets less?
- How much more? How much less (if any)?
Back to the Basics

NEED TO CONSIDER ALL FACTORS THAT INFLUENCE CROP RESPONSE TO ADDED FERTILIZER
Crop response to added fertilizer nutrient at a particular location in the field depends on:

1) **Capacity of soil** to supply that particular nutrient over growing season, and relative balance of other nutrients.

2) **Relative supply of physical factors** that act as limitations on crop growth and fertilizer response: water, soil conditions

3) **Biological limitations** imposed by weeds, disease, insects

**NEED GOOD INFORMATION ON ALL THESE FACTORS!**

**Soil Properties, Crop Yield, Quality**: Direct measures, remote sensing
Topsoil thickness = fertility, productivity
The Challenge

As yet unknown variations in soil moisture, weather, pests and their effects on soil capacity, yield potential and fertilizer response are magnified within different regions of the field.

Dry-Normal year: low spots very productive
Wet year: low spots flooded out!
Fertilizing to “normal” conditions often doesn’t mean much in Saskatchewan! More extremes than normal
We need good forecasting tools!

Robust prescriptions are developed with several sources of information, have local knowledge incorporated, are flexible, and are tested, validated.

http://bestpaperz.com

And record keeping
Nutrient Rates:
Where to put more?
Where to put less?
N rates have been going up

- Benefits achieved: e.g. record yields in 2013
- Is the allocation of the N among fields on the farm the best that it can be?
  
Probably not!
Tendency to pick one fertilizer blend, one rate, and apply same rate across all acres for a crop on the farm.

Gains can be made by recognizing differing fertility, production potentials on different fields, adjusting rate accordingly.
• Accounting for the differences in nutrient supplying power among fields is the first step in precision nutrient management.

• Soil “building”: e.g. application of manure, P, K, micronutrients to eroded portions within fields.
Guidelines for Developing Sound Variable Rate Fertilization Prescriptions

• Assemble management areas based on key soil and crop indicators of productivity, fertilizer response.

• Understand and address all limitations that may exist within and among management zones.

• Recognize that there is no one simple formula, one size does not fit all.
  – Time, patience and effort required to make it work for prairie cropping systems. A single year of evaluation is not enough.
Precision fertilization, variable rate tech will provide benefit

• Going to take some time and effort by everyone to figure it all out!