Proximal Sensing For Early Detection of Nitrogen Deficiency in Corn

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Precision management

- Precision agronomists
- developing techniques
- to quantify spatial variability in soil properties and crop canopies
- to practice precision management
• Changes in soils across landscape and within fields is documented globally

• Traditional or uniform nutrient applications results in under and over application of nutrients in many parts of the field
How to address spatial variability?

- Soil sensing
- Crop canopy sensing
Soil sensing

- **Management Zones:**
  A sub-region of a field that expresses a homogeneous combination of yield limiting factors
Management Zones are delineated on farm fields by classifying the field into different sections or zones.

Based on the research conducted in Colorado*

* CSU, USDA-ARS, Centennial Ag Inc.
• Management Zones: A sub-region of a field that expresses a homogeneous combination of yield limiting factors

• In Colorado, we have developed four techniques of delineating management zones

Soil sensing

50 ha irrigated Maize field with Management Zones
Mean grain yield across MZs

In 9 out of 10 site years we can separate low from high zone but NOT low from medium or medium from high zones based on grain yield.

Soil sensing...
Again we could separate low from high zone but NOT low from medium or medium from high zones for most years.
Precision Nutrient Management Across Soil Zones...

- has shown to enhance:
  
  (i) overall grain yield of the field,
  
  (ii) nutrient use efficiency,
  
  (iii) net $ returns to farmers and
  
  (iv) reduces overall nutrient losses from the field.

- What’s the problem?
\[ N \text{ Rate (kg ha}^{-1}\text{)} = (135.3 \times \frac{\text{NDVI}_{\text{Ref}}}{\text{NDVI}_{\text{Target}}}^2) - (134.8 \times \frac{\text{NDVI}_{\text{Ref}}}{\text{NDVI}_{\text{Target}}}) + 1 \]
Soil Sensing + Crop Sensing

Soil sensing efforts must be coupled with crop sensing to make better and most efficient nutrient management decisions.
Previous work with Crop Sensors:

Holland Scientific Crop Circle:

**Amber** NDVI
- Visible waveband = 590 nm
- Near infrared = 880 nm

NTech Industries GreenSeeker:

**Red** NDVI
- Red visible waveband = 660 nm
- Near infrared = 770 nm

Visible ~ 400 to 700nm (G, B, R)
Near infrared ranges ~ 750nm to 1400nm
Amber and Red NDVI correlation with nitrogen application rates across site years.

<table>
<thead>
<tr>
<th>Corn Growth Stage</th>
<th>Site Year 1</th>
<th>Site Year 2</th>
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<tbody>
<tr>
<td></td>
<td>Amber NDVI</td>
<td>Red NDVI</td>
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<tr>
<td>V14</td>
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<tr>
<td>V12</td>
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<td>V8</td>
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<td>V6</td>
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Mulitplex Fluorescence Sensor
Soil background noise

Fluorescence intensity relative to plant fluorescence

Height of sensor (cm)

Fluorescence intensity relative to plant fluorescence

Soil background noise

Fluorescence intensity relative to plant fluorescence
Mulitplex Fluorescence Sensor

6 UV LEDs – fluorescence induction
3 RGB LEDs - fluorescence induction
1 sensor measuring yellow fluorescence
1 sensor measuring red fluorescence
1 sensor measuring far-red fluorescence
What is fluorescence

Photon hits an electron
Electron raises from one level of energy
Returns to its fundamental state: emitting a photon
Chlorophyll fluorescence

Light

Chl α

Chl α *

400
600
800

Wavelength

Normalized fluorescence intensity

Heat
Photosynthesis
Fluorescence

Müller et al., 2001
N Rate

- 0 kg/ha
- 135 kg/ha
- 270 kg/ha

Relative fluorescence intensity vs. Wavelength (nm)

Adapted from McMurtrey III et al. 1994
Effect of nitrogen rates on dry weight

Nitrogen rate (kg/ha) vs. Dry weight (g)
Crop Sensors (ver 1.01)
Currently it is not feasible to differentiate the nutrient deficiency of “iron” versus “nitrogen” in a corn field using sensing technology, either one gives a lower NDVI value.
We need a suite of sensors that could identify the unique signature(s) for various nutrient deficiencies in crop species.
Summary

- Fluorescence based sensor has potential to detect early nitrogen deficiency in corn
- Soil background noise is minimal
- Can it differentiate between N and K deficiency?
- Or deficiency of nutrients vs pest/disease infestations?
11th International Conference on Precision Agriculture

- Hyatt Regency, downtown, Indianapolis
- July 15-18th, 2012
THANK YOU

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