Nitrogen Diagnostic Tools in Corn Production

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Evaluating Plant-Available N

- Soil N mineralization / Soil supply
  - Indirect procedures (crop rotation)
  - Plant vegetation
    - Yield, N uptake, tissue N, plant sensing
  - Laboratory microbial incubation
  - Total soil N analysis
  - Chemical extraction
    - Water, strong acids or bases, neutral salts
      - Analyze for C, N, distillable \( \text{NH}_3 \), UV adsorption
- Soil inorganic \( \text{NO}_3^- \)-N (PPNT/PSNT)
Sidedress Soil Nitrate Test
In-Season Test

- Presidedress Nitrate Test (PSNT)
- Late Spring Nitrate Test (LSNT)
  - Take a 0- to 12-inch soil sample when corn is 6 to 12 inches tall
  - Analyze for nitrate-N
  - Determine sidedress N rate
Sidedress Soil Nitrate Test

- Measures
  - Residual soil nitrate
  - Spring mineralized nitrate
    - Soil organic matter or manure organic N
  - Applied nitrate or nitrified ammonium (LSNT)
  - Nitrate present (top foot) at sampling
  - Not ammonium-N

- Sampling banded N difficult (LSNT)
- Best at indicating excess N situations
ISU Soil Test-Based N Recommendations For CC and SC

- Set soil nitrate-N critical value
  - 25 ppm NO$_3$-N

- If rainfall > 20% above normal between April 1 and sampling time
  - 3 to 5 ppm lower

- (Critical level minus soil test) \( \times 8 = \) lb N/acre needed

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Samples From Corn Zero-N Plots

Relative Yield of No-N Control (Relative to AONR)

B = 7.2%

A = 2.2%

Sawyer and Barker, 1999-2015

CC
SC

n = 138
Samples From Corn Zero-N Plots

Mean 10.7 lb N/acre per LSNT ppm increase

Sawyer and Barker, 1999-2015
Poultry Manure - 18 Field Trial Sites

-20
0
20
40
60
80
100
0 10 20 30 40 50 60
Soil Nitrate-N (ppm)
Corn Yield Increase (bu/acre)
No Manure
Low Manure Rate
High Manure Rate

Ruiz-Diaz et al.
Corn Stalk Nitrate Test
End-Of-Season Test

- Weather conditions can impact stalk nitrate concentration
  - Drought – result in high concentration
    - Poor ear development (small N sink)
  - High rainfall (N losses) – result in low concentration

- Insect/disease damage

- Stalk nitrate concentrations will vary from low to high between years in relation to late-season corn N use, corn productivity, optimal need, and soil N supply
Corn Stalk Nitrate Test

- Consistently low or high? Evaluate for several years
  - Usually in low range: Increase N rate
  - Usually in excess range: Decrease N rate

- Best at indicating excess N situations
- Does not indicate optimal N rate
- Does not indicate how much to change N rate
Corn Stalk Nitrate Test
CROP 3154

Sample stalk: 6 to 14 inch segment above ground
1 to 3 weeks after black layer
Fifteen 8-inch segments per sample
Corn Yield Increase to Fertilizer N and Liquid Swine Manure Rate
SC and CC, 2000 - 2003

Woli et al.

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Ruiz-Diaz et al. (poultry manure)
Stalk Nitrate at Maturity vs. Applied N Rate Difference from Economic N Response

Sawyer and Barker, ISU
Corn Plant N Stress In-Season Sensing
Aerial Photo
Aerial Sensed Image
Multi-spectral reflectance
Equipment Mounted Sensor
Active Canopy Sensors
  GreenSeeker
  OptRx
  CropSpec
Hand-Held Sensors
  Minolta 502 SPAD Meter
  Phone Apps
Seeing Field Variability in N Deficiency

No N applied in this part of field

N applied in this part of field
2003 LTN Five-Site Average
C-S

Differential from Optimum N Rate (lb N/acre)

N Deficient
N Adequate to Excess

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Corn Nitrogen Uptake and Composition

PMR 1009; Abendroth et al., 2011
Minolta model SPAD 502

- Read 30 plants per area
  - Prior to VT: sample most recently developed leaf with color exposed
  - After VT: sample ear leaf
  - Sample ½ distance from leaf tip to collar
  - Sample ½ distance between leaf edge and midrib

- Read area of interest and well fertilized reference area
- Calculate relative sufficiency index (relative greenness)
Leaf Greenness Chlorophyll Meter

❖ Does indicate N deficiency
   ➢ Relative index < 95% (Nebraska) or <97% (Iowa) indicates N deficiency
     • Need for comparative reference area that is well fertilized

❖ Does not indicate excess available N
   ➢ Maximum leaf greenness not affected by luxury N consumption

❖ Can indicate rate of supplemental N required
Figure 1. Relative SPAD chlorophyll meter (RCM) value versus N rate difference from economic optimum rate, R1 corn growth stage.

\[ RCM = 0.97 + 0.000614 \times ND - 0.000004897 \times ND^2 \]

RCM = 0.99 for ND > 63 \[ R^2 = 0.73^{***} \]
## Active Sensor Wavelengths

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Visible, nm</th>
<th>NIR, nm</th>
<th>Other, nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minolta SPAD Meter</td>
<td>650 (red)</td>
<td>940</td>
<td></td>
</tr>
<tr>
<td>GreenSeeker 506</td>
<td>560 (green)</td>
<td>774</td>
<td></td>
</tr>
<tr>
<td>GreenSeeker 505</td>
<td>656 (red)</td>
<td>774</td>
<td></td>
</tr>
<tr>
<td>Crop Circle ACS-210</td>
<td>590 (amber)</td>
<td>880</td>
<td></td>
</tr>
<tr>
<td>RapidScan CS-45</td>
<td>670 (red)</td>
<td>780</td>
<td>730 (red edge)</td>
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<tr>
<td>Crop Circle ACS-470</td>
<td>various</td>
<td>various</td>
<td>various</td>
</tr>
<tr>
<td>CropSpec</td>
<td>800-810</td>
<td>730-740 (red edge)</td>
<td>730-740 (red edge)</td>
</tr>
</tbody>
</table>
Sensor Index Calculations

❖ Most common active canopy sensor indices
  ➢ Normalized Difference Vegetative Index (NDVI)
    • \((\text{NIR} - \text{VIS}) \div (\text{NIR} + \text{VIS})\)
  ➢ Chlorophyll index (CHL)
    • \((\text{NIR} \div \text{VIS}) - 1\)

❖ Relative values
  ➢ Sensor reading normalized to highest N rate
Why Use Relative Index Values?

- Various canopy characteristics influence sensor readings and index values
  - Leaf chlorophyll
  - Whole plant biomass
  - Canopy temperature
  - Canopy moisture content
  - Hybrid
  - Plant density (population)
  - Other nutrient deficiencies

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Reference Corn?

What’s this?

What’s this?
Why Use Relative Index Values?

Barker and Sawyer, ISU
Active Sensor Calibration at Mid-Vegetative

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Barker and Sawyer, ISU
Within 30 lb N/acre of EONR?
Corn Plant and Canopy Sensing

- Uses corn plant as indicator of N adequacy or deficiency
- Corn plant able to integrate across time
- Provides instantaneous feedback
- With active canopy sensors
  - Electronic integration of sensing and N rate application on-the-go
    • Requires recommended operation
  - Sub-field/continuous N rate adjustment
Corn Plant and Canopy Sensing

Considerations

- Sensors cannot detect excess N
- Corn must be N deficient to express N stress
- Detecting small N deficiency difficult
- Must have an “adequate or N-Rich” in-field references (create relative N stress value)
  - Sensors “see” any plant stresses

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Spring Precipitation as a Tool for Decisions About Additional Nitrogen Application (Main Iowa)

Ames-Lewis-Kanawha-Nashua-Sutherland (SC and CC)

Overall Correct: 76%
Correct: 58%
Incorrect: 14%
Total at 15.5 Inches
Correct: 18%

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Spring Precipitation as Tool for Decisions About Additional Nitrogen Application (Southeast Iowa)

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