Best Predicting Corn N Needs: To Sample or Not to Sample?

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Outline: Best Predicting Corn N Needs

1. Background and Problem

2. Novel soil N testing
   Case Study A: CO$_2$ Burst
   Case Study B: multi-test approach

3. The future of N fertilizer recommendations
   (and role of soil/plant sampling and analysis)

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Predicting crop N needs has never been more important!

Agronomic/Economic Optimum N Rate

Nitrate leaching
N$_2$O Emissions
Corn Yield
Soil Organic Carbon
There are many possible ways farm operators can decide on N fertilizer rate to apply

✓ The “1.2 Rule” (or “yield goal”)

✓ The Nitrogen Rate Calculator (MRTN)

✓ Cornstalk Nitrate Test

✓ Soil testing (e.g. LSNT or PSNT)

✓ Crop/Canopy Sensing

✓ Guessing???
Are growers testing for N recommendations?

30% of US Farmers (25% in Australia)

2,219 Farm Operators Surveyed
(1,296 Responded – 58%)

J. Arbuckle – Professor in Rural Sociology; Hanna Rosman – Graduate Student
Farmers aren’t using extension N recommendations

Percentage of Respondents

Late Spring Nitrate Test
Stalk N Test
Canopy sensors for N deficiency
Test strips
Corn N Rate Calculator (MRTN)

Not Familiar With
Familiar With, But Don't Use
Limited Use
Moderate Use
Heavy Use

Arbuckle & Rosman (2014)_PM 3066
Novel Soil N Testing

Case Study A: CO$_2$ Burst

Case Study B: multi-test approach
Problems with LSNT (or PSNT)

**TYPE A FAILURE**
Tested high, but didn’t apply enough N fertilizer

**TYPE B FAILURE**
Tested low, but over-applied N fertilizer

Bundy et al. 2002
New soil tests and/or technologies are needed to get the ‘whole story’ over the growing season.

Sampling soil extractable NO$_3^-$ once at the beginning of the year (e.g. LSNT) is like seeing a picture (or snapshot) of a movie and expecting to know the whole story!
Instead of looking at a snapshot, we should be at least looking at the movie trailer (or N-supplying power)
We need soil test that measures **N-Supplying Power**

**Soil A**
- No N needed
- +200 lbs N/ac needed

**Soil B**
- 200 lbs N need to make up for N-Supplying Power deficit
- 0 lbs N/ac

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Franzluebbers et al. 2018_SSSAJ
A tale of two soils (under corn)...

"Soil B"
Maize-Soybean (+ synthetic fertilizer)

"Soil A"
Maize-Soybean-Oat/Alfalfa-Alfalfa (+ manure)

Baldwin-Kordick et al. 2020 ASFS
Measuring N-supplying power of soils

1. Measure a biological process
e.g. 14-d aerobic incubation (Keeney and Bremner 1996) or CO₂ Burst (Franzluebbers et al. 2018)

2. Extract an organic form of N, that is mineralized over the growing season
e.g. Illinois Soil Nitrogen Test (Kahn et al. 2001) or Glomalin extraction (Hurißso et al. 2018)

3. Quantify labile or active SOM fraction
e.g. permanganate oxidizable C (Culman et al. 2013)
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How can we measure their activity?

1. **Respiration** (or breathing)

2. **Decomposition**

3. **Abundance**
CO₂ Burst

1. Respiration
   (or breathing)

2. Decomposition

3. Abundance

Case Study A – the Trailer
Case Study A – the Trailer

Microbial biomass – eye of the needle that all organic matter passes through

Soil Organic Matter

CO₂

Plant Available Nutrients

Adapted from Tate Book Cover
Soil

50 ml centrifuge tube

Incubate in the dark at 25-30°C & 50-60% WHC

CO\textsubscript{2}

H\textsubscript{2}O


Both should be related to a soil’s N-supplying Power

NH\textsubscript{4}\textsuperscript{+} + NO\textsubscript{3}\textsuperscript{-}

extracted with salt solution

CO\textsubscript{2} measured on IRGA

Case Study A – the Trailer

T\textsubscript{0d}

T\textsubscript{1-14d}
Greater soil biological activity = Less need for N fertilizer

Combined 3 recent studies that used “CO$_2$ Burst” test

- 79 N-rate trials from Midwest used 1-day CO$_2$ Burst (Yost & Bean)
- 34 N-rate trials from NC and VA used 3-day CO$_2$ Burst (Franzluebbers)

Used maximum-minimum normalization to put on same x-axis

A lot of variability, but shows definite potential.

Franzluebbers 2018, Yost 2018, Bean 2020
Probably need more than just “N supplying power” to accurately predict corn AONR

**NRHY** = Non-Responsive to N and High Yield

**NRLY** = Non-Responsive to N and Low Yield

**RN** = Responds to N

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NRHY = Non-Responsive to N and High Yield
NRLY = Non-Responsive to N and Low Yield
RN = Responds to N
Case Study B – Trailer + Exclusive Cast Interview

- 56 site-years in Midwest
- Used >30 soil tests/measurements
- Had past management, climate, soil, and many other factors

![Diagram of soil layering and exchangeable ions]

Bell et al. 2020 Chapter in *Improving K Recommendations For Ag Crops*

![Diagram of mean-normalized value charts]

McDaniel et al. 2020_AJ

![Legend for N Response Type]

RN: Responds to N
NRHY: No Response, High Yield
NRLY: No Response, Low Yield
A test (TPB5) that measures N stored between layers of micaceous mineral helps
The Future of N Recommendations (and role of soil sampling/analysis)
Remote/Proximal Sensors (Expand Spatial Prediction)

<table>
<thead>
<tr>
<th>Sensor deployment platform</th>
<th>Coverage</th>
<th>Spatial resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Global/National</td>
<td>Low</td>
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<td></td>
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<td>High</td>
</tr>
<tr>
<td></td>
<td>Site</td>
<td>Ultra high</td>
</tr>
</tbody>
</table>

https://www.veristech.com/the-sensors

Talbot et al. 2017
Soil Sensors (Expand Temporal Prediction)

THE WORLD'S FIRST WIRELESS NPK SENSOR

Get the most detailed and quality data available via a single probe with 10 sensors measuring soil moisture, salinity, and pH at various different depths, as well as environment parameters like temperature, light, and humidity.

No wires. Nothing to catch. The sensor is installed and ready to stand up to the wear and tear of your farm.

Pre-Order Your Probes Now

A DETAILED VIEW OF YOUR FARM'S SOIL QUALITY

Manage your soil quality from the top soil to your roots with precise control and strategic recommendations customized to your crops.

Diagnose problem areas and compare soil losses, 20%.

Match fertilizer supply with demand, saving money and increasing yields while improving soil health.

Learn More →

Pre-Order Your Probes Now

THE MOST COMPREHENSIVE SOIL PROBE EVER BUILT

No wires. Nothing to break. Just 26 sensors beaming microclimate and soil data right back to you.

Microclimate

- Air Temperature
- Humidity
- Light

Soil Sensors

- Soil Moisture
- Salinity
- Soil Temperature
- pH

Nitrate
- Potassium
- Phosphorus

Gas Sensors

- Aeration (O₂)
- Respiration (CO₂)
Trade-offs in technology require a nuanced approach

farm operators are not using current recommendation methods

We need...

1. multi-tiered, multi-method approach to increase accuracy/precision AND adoption of N recommendations

2. some selected soil sampling/analyses still needed; esp. use novel approaches that measure N-supplying power!

3. Sensing, modeling, and multivariate/spatial statistics to extrapolate beyond intensively measured fields

4. user-friendly website for farm operators

5. strong Extension programs
A possible system to improve adoption of N fertilizer rate recommendations

1. Greater Profits ($$$)
2. Cleaner Environment

- Intensive soil sampling w/ N rate trials
- On-farm N trials (strip trials) w/ some soil sampling
- Remote or proximal sensing

MODELING

Outward-Facing Recommendations via Website & Extension
Predicting crop N needs has never been more important!

![Graph showing the relationship between N fertilizer application and various crop parameters.](image)

- Agronomic/Economic Optimum N Rate
- Nitrate leaching
- $\text{N}_2\text{O}$ Emissions
- Corn Yield
- Soil Organic Carbon

Relative Units

N Fertilizer (lbs/ac)

0 25 50 100 150 200 250
Questions?

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Case Study B

Having management, climate, and other variables didn’t help out all that much.

### TABLE 5
Comparison between number of observed and predicted site-years that responded to N fertilizer from two methods: management, soils, and climate model (no-soil-test-required) and 14-d aerobic incubation (AEIM) soil test.

<table>
<thead>
<tr>
<th>Observed</th>
<th>Management, soils, and weather model</th>
<th>AEIM</th>
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<tbody>
<tr>
<td></td>
<td>Predicted (n)</td>
<td>Predicted (n)</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>Response</td>
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<tr>
<td>No response</td>
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<td>8</td>
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<tr>
<td>Response</td>
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<tr>
<td>Total % accuracy</td>
<td>82%</td>
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