Nitrogen Management Tools - Needs, Promises and Pitfalls

Paul Gangwish – *Not Today*

John Shanahan – Agronomist (PG Farms)

“Perspective of an irrigated grower in Nebraska”
PG Farms Enterprise

• South Farm
  – Corn, soybean, seed production
  – 6000 acres of cropland
  – Center pivot irrigation
  – Annual precip: 26.3 inches
  – Tillage: No-Till
  – Average corn yield: 210-250 bu/acre

• North Farm
  – Corn, soybean, forages, and livestock
  – 6000 acres of cropland
  – Center pivot irrigation
  – Annual precip: 25.2 inches
  – Tillage: No-Till
  – Average corn yield: 240-270 bu/acre
South Farm

- Soil Resources
  - Soil types: silt loams
  - Terrain: level to rolling
  - pH: 6-8
  - O.M.: **1.5-2.5%**
  - CEC: **15-20 meq/100g**

North Farm

- Soil Resources
  - Soil types: sandy loams
  - Terrain: level to rolling
  - pH: 6-8
  - O.M.: **0.5-1.5%**
  - CEC: **5-15 meq/100g**
Exactrix Applicator (24 rows, 15” intervals)

Anhydrous ammonia
10 – 34 – 0
Ammonium thiosulfate
Moving Day
36-Row Planter  (Precision Planting)
Nitrogen Management Challenge

<table>
<thead>
<tr>
<th>Seasonal Nitrogen Uptake, %</th>
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<tbody>
<tr>
<td>May</td>
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<tr>
<td>June</td>
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<tr>
<td>July</td>
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<tr>
<td>Aug</td>
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<td>Sept</td>
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- **Early Growth**
  - 0%

- **Rapid Growth**
  - 40% of requirement after silking
  - 70-80% of requirement after V8 - 10

- **Maturing**

- **Late Loss**
Nitrogen Management Plan

South Farm

- Applied N (lbs/acre)
  - Preplant N: 90 lbs/acre
  - Pivot N: 170 lbs/acre
  - 3 applications of 30 lbs/acre @ V10, V14 & VT

North Farm

- Applied N (lbs/acre)
  - Planter Applied N: 50 lbs/acre
  - Pivot N: 180 lbs/acre
  - 6 applications of 30 lbs/acre @ V3, V5, V8, V14, VT, R1/R2
Decision Tools Currently Used

John Deere

Farmshots (Landsat & Rapid Eye)

Climate Fieldview - Planting

Climate Fieldview - Weather
Imagery from Farmshots

South Farm

North Farm
Evaluation of N Management Plan With Imagery

100 lbs N/acre
Preplant Applied Ammonia
Imagery Time Series

Bare Soil

NDVI – June 19

NDVI – June 23

NDVI – June 28

NDVI – July 12

Red Edge – July 12

Source: Farmshots

High

Low
Dilemma – Silking Time

**Situation**

~40% of N yet to be taken up by crop
Imagery does not show diagonal strip with extra N
Plants don’t show any signs of N deficiency

**However:**

Yield goal = 240 bu/acre
N recommendation = 230 lb/acre
Total N applied before silking = 170 lb/acre
Planned N = two applications of 30 lbN/acre each
Cost of 30 lb N = ~$15/acre  (~4 bu corn/acre)

$80,000 Decision  
(5,500 acres)
July 21, 2016

“North Farm”

July 26-30

4” of rain

nitrate leaching?

Springview, NE
Experiences / Needs

Implement and seed company software communications are not seamless

How are N recommendations made by service providers?

Imagery or NDVI map is helpful, but is only a pretty picture and provides no information as to how much N might be needed

Need a quick way to assess luxury consumption in corn
Nitrogen Management Tools - - - Needs

- Sunlight
- CO₂
- Water
- Temperature
- Soils
- Nutrients

Jim Schepers
Nitrogen Management

Considerations

Vendors

Populated by Vendors
DuPont Pioneer “EncircaSM Yield”
Monsanto Climate Corp “Nitrogen Advisor”
Adapt-N
WinField “R7 Tool”
Western Ag
Farmer’s Edge
ServiTech
Beck’s Hybrid “FARM Server”
Yield 360 Center
SATSHOTS

Commercial Management Products

- genetics
- software
- resch/advisory
- consulting
- consulting
- genetics
- tools/devices
- imagery
Goal
  Climate
  Soil

**Water Processes**

**Models** (crop, water, nutrients & climate)

**Hybrid Selection**
  Yield Maps
  Tissue Testing
  Remote Sensing
  Previous Crop
  Residual N
  Field Level vs. Spatial Nutrients

**Cultural Practice Tools**
  In-Season Advice
  Marketing (sales & purchases)
  Multiple Product Sales
  Web Site

Considerations
**Goals**

Conveniently-deliver decision support services that help growers *increase profitability*, *production stability*, and *sustainability*

Solution to help *maximizing inputs* while *optimizing yield*

*Profit maximization*, *risk mitigation*, and *scalable environmental benefits*

*Maximize yield profitability*

*Optimize profitability* using multiple nutrient response (N, P, K, S) curves, crop prices, and fertilizer costs

*Sustainable production* of *high yielding* and *high quality* crops
Goals

*Optimize producer profitability* by routine field inspections, by recommending and helping incorporate appropriate technologies for fertility, varieties, irrigation, tillage, weed/insect management, federal/insurance programs, etc;

Offer a simple, secure, web based program to monitor variables and collect and analyze data to *increase productivity*

*Measure and supply the right amount of N* when the crop is ready to use it

*Deliver “Crop-Health Imagery”* analysis and notifications that facilitate *real-time management* and actionable variable rate application maps of fields
Climate

Farm Weather Data
DTN network

Class-A Weather Station
Provides long-term records
Typical Network Weather Station

10 - State Network

“Mesonet” Stations

High Plains Regional Climate Center, Lincoln, NE (www.hprcc.unl.edu)
Simulated Precipitation Map - Example

Map based on radar data that was calibrated using rainfall records
Encirca Weather Network
Soils

**SSURGO data base** (mean *Soil Survey Geographical*)

*Generated and maintained by USDA - NRCS*

See: [websoilsurvey.sc.egov.usda.gov](http://websoilsurvey.sc.egov.usda.gov)

**Search**

- Area of Interest
  - Import AOI

**Quick Navigation**

- Address
- State and County
- Soil Survey Area

- Latitude and Longitude
- PLSS (Section, Township, Range)

**SSURGO** Automatically linked to some service providers
Water Processes

“Infiltration”
Some commercial services use models to estimate water infiltration, percolation and N losses. 

needs SSURGO soil **PLUS** climate data

most use the tipping-bucket rain gauge approach, **IF ANY**

“Hydrology”
Some commercial services use models to route water across the landscape and to the edge of the field.
Tipping Bucket Rain Gauge

- Funnel
- Reed switch
- Magnet
- Small bucket
- Drain hole
- Weather station rain counter
Tipping Bucket Rain Gauge

Diagram showing key components:
- Magnet
- Reed Switch
- Pivot
- Calibration Screw
- Drain Hole
- Lock Nut
Sample of Soil Profile Variability
Samples of Soil Development
Earthworm holes and channels

See root distribution
Tracer Dye

See vertical flow until water reached impeding layer

See vertical flow through dense layer via cracks and root channels
Tracer
Dye
Models

N recommendations *(yield goal, some residual N)*
Mineralization *(OM & climate)*
N losses *(nitrate leaching or denitrification)*
Crop growth

“Then a MIRACLE occurs”

“I think you should be more explicit here in step two.”
“Weather”

Timeliness

N

P

K

S
Tissue Testing

Only a few use tissue testing

- In-season nutrients
- Stalk nitrate test

“You can’t work on a solution until a problem has been identified”
Where Does **Tissue Testing** Fit?

*Seasonal N Uptake - %*

- **Stalk Nitrate Test**
- **Concentrations and Balance**
  - $N : K$
  - $N : S$
  - Etc.

Tissue Testing for adequacy

*Timeline*
- May
- June
- July
- Aug
- Sept
Remote Sensing

Satellite
3 or 4 – band aircraft
Drones ?? ??
Crop canopy sensors

Indices
• NDVI
• NDRE
• Thermal
• others

“A picture is worth 1000 words!” or MORE
Productivity (yield) is proportional to:

Chlorophyll Content \times \text{Incoming Radiation}

Assumes nutrients and water are adequate.
Remember

Canopy sensors and imagery respond to:
“living biomass” and “chlorophyll content”

Treatments / N-rates

Sensors and images can not quantify excess N
AND
Soil background reduces sensitivity
Where Does Remote Sensing Fit?

Imagery or sensor readings to assess N adequacy

Seasonal N Uptake - %-

Sufficiency Index

100%

70%

Relative comparison

May | June | July | Aug | Sept
Remote Sensing

[B G R]

Near Infrared [NIR]
John Niemeyer Field  (July 27, 2015)

**Color (R G B)**

- corn
- woodland
- grass

**Color Infrared**
John Niemeyer Field  (July 27, 2015)

Color Infrared

Stretched Color Infrared

over Color Image

NDVI

low

high
Management Zones

“Real-Time” Algorithm

NDVI

low

high

N Rate
very low
medium
high

cut-back

Image Processing
Courtesy: Cornerstone Mapping

N Rate Map
Courtesy: Holland Scientific
NDVI map

Row Direction?

Tell-Tale - - - - - - - -

Cultural Practices?
Irrigated Corn - 2012

Yield Map

264 bu/acre

NDVI Map

Wheel Track

110 bu/acre

Color IR Image

NDVI Map

Grain-fill (R2)

Best

Average

Worst
Low water application rate in corners when swing-span is extended

Nozzle problem near pivot track

Cultural practice difference (hybrid, previous crop, ?)
Thermal Infrared  *(canopy temperature)*

Water amount and distribution problems
**Field Strip**

12 rows @ 30”

- - 30 ft - -

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Need 4 to 5 pixels (cells) within the width of the target being managed

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**LANDSAT 8**

“free”

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15 meter (~50 ft)

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5 meter (~15 ft)

---

2 meter

---

1 meter

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**Spatial Resolution**
Problems with Spatial Resolution

• Yield maps

  ~250 cells/ac (12 rows @ 4 mph and 1 Hz logging)

- - Wedge-shaped cells - -

• Imagery

  ~1.6 million pixels/ac @ 2 in
  43,560 pixels/ac @ 1 ft
  10,890 pixels/ac @ 2 ft
  4,840 pixels/ac @ 3 ft
  1,210 pixels/ac @ 6 ft
  194 pixels/ac @ 15 ft

Inches to many feet

Cell and pixel shapes are different

Re-sampling
Drone-Based Imagery

Resolution Over-Kill

2” spatial resolution is common

1.6 million pixels / A
256 million pixels / 160 A

Yield map has ~40,000 cells / 160 A
Programs that consider the previous crop in terms of legume credits also credit for manure and other non-fertilizer sources of nutrients.

**Preplant soil sampling** (mostly field level, but some spatial)
- Conventional extraction with wet chemistry analysis
- Ion exchange extraction with wet chemistry analysis

**In-season soil sampling** for side-dress N recommendation
- Conventional extraction with wet chemistry analysis
- Rapid “in-field” procedure for extraction of nitrate in moist soil with *nitrate electrode* analysis
Plant Root Simulator

Anion PRS Probe

- adsorbs: $\text{NO}_3^-$, $\text{H}_2\text{PO}_4^-$, $\text{SO}_4^{2-}$, micros, etc.
- Anion Resin Quaternary R-$\text{NH}_4^+$

Cation PRS Probe

- adsorbs: $\text{NH}_4^+$, $\text{K}^+$, $\text{Ca}^{2+}$, $\text{Mg}^{2+}$, etc.
- Cation Resin sulfonic acid R-$\text{SO}_3^-$
Where Does **Soil Testing** Fit?

- Preplant soil testing
- In-season soil nitrate analysis
- Previous Yield Maps
Yield 360 Center - Rapid-Nitrate Test

Moist soil sample
Add distilled water
Mix well
Nitrate electrode analysis
Sub-field (spatial) recommendations for plant population and variable rate fertilizer recommendations are sometimes offered.

Generally not emphasized but considered by some services.
Hybrid Selection

YES - - - - - - - Only Relative Maturity - - - - - - - NO

Yield Maps

Most consider yield maps

Regional Yield Information

Some integrate regional yields into recommendations
In-Season Advice

Primary service offered by some, others limited

Marketing
(sales & purchases)

Some through Agronomists and Consultants

Multiple Product Sales

Usually not a part of the service, but some offer tailored products

Web Sites
Information and Technology Transfer

Specially Trained Agents

Demonstrations Field Days Conferences Dealers

Web Sites Advertising

Encirca  Climate Corp  Western Ag  Farmers Edge  ServiTech  Crop Quest  Independents

Winfield  Climate Corp  Adapt-N  Beck’s Seed  Yield 360

SATSHOT  Farmshots  Mavrx  FarmLogs  senseFly
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<td><strong>Pioneer</strong> – support services, profitability, stability, sustainability</td>
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<td>SSURGO soil data base; long-term and real-time climate plus DTN; LIDAR topography; model crop growth and water percolation; regional yield data; residual N; spatial N recommendations: <em>(no remote sensing or tissue testing)</em></td>
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<td><strong>Climate Corp</strong> – maximize inputs while optimizing yield</td>
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<tr>
<td>SSURGO soil data base; long-term and real-time climate; model residual N, crop growth and hydrology; field-level N recommendations: <em>(no remote sensing or tissue testing)</em></td>
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<td><strong>Adapt-N</strong> – maximize profits, risk mitigation, environmental benefits</td>
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<tr>
<td>SSURGO soil data base; organic matter; long-term and real-time climate; in-season residual N; model mineralization, N losses, crop growth and water processes; field, zone or spatial N recommendations: <em>(no remote sensing or tissue testing)</em></td>
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<td><strong>WinField</strong> – maximize yield profitability</td>
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<td>real-time climate and future predictions; model precipitation, N inputs, N losses, and yield potential; spatial N recommendations; <em>Answer Plots</em>; satellite imagery; tissue testing:</td>
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Summary

Western Ag – optimize profitability using root interaction functions for N, P, K, & S, fertilizer prices and crop prices

Effective and long-term precipitation; heat units and ET; soil texture, compaction, pH, and EC; residual N and 24-hr mineralization; import yield maps and imagery; field or spatial recommendations: *(no remote sensing or tissue testing)*

*( - - interactive multi-nutrient software - - )*

Farmers Edge – sustainable production of high yield and high quality crops

Real-time farm-specific meteorology; management zone soil data; integrate crop and soil processes; field-level recommendations: *(no tissue testing)*

ServiTech – optimize producer profitability *(recommends appropriate technologies)*

On-line and commercial weather; zone or grid soil sampling; weekly soil cores for water management; field and spatial recommendations; weekly scouting: *(no remote sensing or tissue testing)*
Summary

Beck’s Hybrid – increase profitability using web-based program to monitor variables and analyze data

SSURGO soil types; Davis weather stations for real-time weather; 4-band NDVI imagery; management zone recommendations; yield map analysis: (no tissue testing)

Yield 360 Center – measure and supply the right amount of N when the crop is ready to use it

Anhydrous ammonia metering system; pre-plant base N with in-season rapid nitrate test; Y-Drop liquid N nozzle system; field or spatial N recommendations: (no remote sensing or tissue testing)

Sat Shots – deliver imagery that facilitates spatial analysis and variable-rate applications in fields

Provide access to current and historic satellite and aircraft imagery from various sources having different spatial resolutions and spectral characteristics, including analysis as requested: (no tissue testing)
Mathematics can be Interesting, but Common-Sense is Powerful

Four brothers were traveling to a field day. One of the brothers owned the car and was driving. The car developed a problem and had to be repaired. The brothers had agreed to split the repair expenses four ways. After the repairs, one brother asked the driver how much the others owed. The total bill was $28 (the math follows).

4 cannot be divided into 2, but it can be divided into 8 with a quotient of 2 and remainder of 20.

4 can be divided into 20 with a quotient of 5 and remainder of 0

The driver said that each brother owed him $25.

One of the older brothers told the youngest brother to check the mathematics because he had graduated from high school. The young brother wrote down 25 four times.

He counts down the right row (5, 10, 15, 20) and then went to the top of the left column and continues counting (22, 24, 26, 28).

He announces that each brother owes the driver $25.
Precision Agriculture is about *innovation* and *thinking outside the box*

How would you connect these nine points with *four continuous lines*?

Think outside the box!
Thank You

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