Nitrogen Use Efficiency in South Carolina Corn

David B. Wallace
My Family

- Cindi, my wife and teacher
- Meghan, sophomore at Francis Marion University
- Raina, freshman at Columbia College
My Work

- Southern States Cooperative, Alcolu, South Carolina
- Complex manager
- 28+ years experience
- CCA/CPAG
- Primarily crop input supplier
My History

- From a family of farmers
- Father retired clergy
- Georgia native
- Graduated UGA with B.S. in agronomy ‘81
- Gold Kist then SSC
Found This Program

- Surfing the internet
- Baby sister did it at UGA
- Wife was doing it at Winthrop University
- Wanted to be better at what I love - agronomy
- Enrolled three years ago
Thanks to All Involved

- Committee
- My family
- Course instructors
- Classmates
- Staff at Iowa State
- Southern States management
2008 South Carolina Corn

- 26th in nation
- 355,000 acres
- Well below Iowa
- 315,000 acres for grain harvest
- 20,475,000 bushels valued at $92 million
Strong Local Demand

- Vibrant poultry industry
- 8th in Nation
- No ethanol plants in-state yet
- Beef, dairy, and pork industry also in-state consumers
- We use more than we grow
- Strong basis
South Carolina Fertilizer

- 444,190 tons in 2008
- Dry - urea, ammonium sulfate, ammonium nitrate
South Carolina Fertilizer

- Liquid – UAN32, 25-S
- Anhydrous ammonia

-- Very little applied in state
Poultry Litter

- Large integrated industry
- Broilers, turkeys, layers
- Proximity to corn acreage
- Typical 2 tons per acre
- Perceived escape from escalating input cost
NUE Defined

• Nitrogen Use Efficiency
• For this work indicates percentage of applied recovered from harvested portion of the crop
• World cereal grains 33%
• Raun et al. (2002) improved NUE in wheat >15%
Why Improve NUE

- Financial returns for corn producers
- Current value 150 units = 69 dollars
- Environmental benefits related to detrimental effects of excess nitrogen
- Energy conservation- nitrogen manufacture is an energy intense process--Haber-Bosch
Many Ways To Improve NUE

- Crop rotation
- Forage utilization
- $\text{NH}_4$ vs. $\text{NO}_3$
- Application timing or placement
- Hybrid or cultivar selection
- Conservation tillage
- Irrigation
- Precision ag and application resolution
Crop Rotation

- Corn-soybean rotations exhibit improved NUE over continuous corn
- Utilizes residual nitrogen from previous crop
- Legumes particularly important
- Widely practiced by South Carolina growers
Forage Utilization
NH₄ Vs. NO₃

- Utilization of nitrate nitrogen may require more energy than ammonium nitrogen
- Nitrate sources vulnerable to leaching
- Ammonium sources can be held on soil exchange sites
- Additives may retard conversion to nitrates
- South Carolina growers do this
Application Timing and Placement
Hybrid or Cultivar Selection
Conservation Tillage
Irrigation

• Maximum fertilizer use efficiency in corn has been shown with light, frequent applications timed to crop usage needs via irrigation applications

• South Carolina growers with center pivot irrigation utilize irrigation events to spoon-feed the corn crop
Goal

Using advanced technology to accurately place spatially within a corn field more refined amounts of N in concert with the corn plant needs.
Roberts (2009) Listed Two Primary Reasons for Poor NUE

- Poor synchrony between soil supply and crop demand
- Uniform application rates without regard for spatial variability
## Cooperator Info

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<th>County</th>
<th>Plant Date</th>
<th>Pop.</th>
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Soil Electrical Conductivity

- Veris Technologies
  Salina, Kansas
- Deep and shallow measurements
- Used to classify soil management zones
- South Carolina soils are inherently variable
NDVI Sensors

- N-Tech Industries Greenseeker
- Calculated values of crop reflectance
- \texttt{NIR-Red/NIR+Red}
- Instant non-destructive assessment of plant biomass and nitrogen status
Sensors Shown to Perform Well

- Little influence to temperature changes
- Active sensor not affected by sunlight intensity
- Sensor height above canopy
- Dirt and foreign material accumulation
Plot Schematic X 3 Replications

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Yield Yield Yield Yield Yield Yield Yield Yield

NO3

NO3
Plot Nitrogen Applicator

Developed by Dr. Ahmad Khalilian at Edisto Station
Dantzler NDVI Values

NDVI

N rate lb/ac

V5 NS
V8 NS
V10 NS
Whetsell NDVI Values

N Rate lb/ac

NDVI

V5 Sig
V8 NS
V10 NS
Gamble NDVI Values

![Gamble NDVI Values Chart]

- **NDVI**
- **N rate lb/ac**

Legend:
- **V5 NS**
- **V10 NS**
L&S NDVI Values

N rate lb/ac

NDVI

V5 NS
V8 NS
V10 NS
Riverdale NDVI Values

![Bar chart showing NDVI values for different N rates (lb/ac)].
Residual Soil Nitrate

NO₃⁻ PPM

Dantzler  Whetsell  Gamble  Gibbcrest  Riverdale

O N  160N
2008 Conclusions

- Dry hot weather severely hampered results
- Dryland plots non-conclusive
- Irrigated plot at Gibbcrest hampered by fall panicum
- Riverdale plots show significant results
- Trends in NDVI, yield, and nitrate results
- Further study needed to establish applicable algorithm
2008 Observations

- South Carolina corn growers do not set out to fail
- Therefore algorithm should be based on normal years
- Based on soil management zones and plant stress indicators
- Lower preplant N rates
- Delay in season N application to V8-V10
- High clearance sensor-GPS-computer-rate controller equipped
- Change in grower mindset from insurance rates to new philosophy
Nitrogen Fertility for Corn

Dr. Pawel Wiatrak
INSEY - In Season Estimated Yield = NDVI / number of days from planting to sensing (GDD>0).
The INSEY index estimates the plant biomass produced per day when growth is possible.
Applying High N Rates in Reference Strips

Reference High N Rich strip is used to calculate the Response Index (RI).
RI = NDVI N Rich strip / NDVI with no added N.
Corn Grain Potentials With and Without Nitrogen Application

The Response Index (RI) = NDVI N Rich strip / NDVI with no added N.

The predicted yield with added nitrogen $Y_{PN} = YP_0 \times RI$, where the $YP_0$ is the predicted yield without nitrogen.
Corn Grain Potentials With and Without Nitrogen Application

YP_{MAX} - Maximum potential yield (no yield increase expected with additional N).

N application rate = (YPN – YP0) * N in corn grain / N use efficiency
Example – Calculate N Rate

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<tbody>
<tr>
<td>NDVI - Non-N limiting</td>
<td>0.86</td>
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<tr>
<td>Grower Check</td>
<td>0.62</td>
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<tr>
<td>Response index (RI)</td>
<td>1.39</td>
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<tr>
<td>INSEY (NDVI/# of days from planting to sensing)</td>
<td>0.0075</td>
</tr>
<tr>
<td>Predicted yield potential (YP0)</td>
<td>93.59</td>
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<tr>
<td>Grain N uptake without additional N (YP0 * % grain N)</td>
<td>65.51</td>
</tr>
<tr>
<td>Grain N uptake with additional N (YPN) (YP0 * RI * % grain N)</td>
<td>91.06</td>
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<tr>
<td>N recommendation (lb/acre)</td>
<td>51.10</td>
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</table>
Algorithm Vs. Soil Electric Conductivity (EC)
Corn Grain Potentials Under Different Soil Zones

INSEY - In Season Estimated Yield = NDVI / number of days from planting to sensing (GDD>0).
Corn Yields Across Soil Zones

- **2007**
  - Soil Zone 1: c
  - Soil Zone 2: a
  - Soil Zone 3: ab
  - Soil Zone 4: b

- **2008**
  - Soil Zone 1: b
  - Soil Zone 2: b
  - Soil Zone 3: a
  - Soil Zone 4: ab
Thanks!
References


References


References


