Fine Tuning Nitrogen Recommendations across the U.S. Cotton Belt: A Multi-Faceted Approach

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Why do we need to **RE-evaluate** cotton nitrogen use?

- 2017 - 373,409 metric tons of nitrogen (N) were applied to cotton

- 43% nitrogen use efficiency (NUE) in cotton (Bronson, 2008)
  - >200,000 metric tons of N were lost to the environment that year

- How do we use the 4R’s of nutrient management to increase NUE in cotton production

- Do the N recommendations for each cotton growing state change and are they up to date?
## Current State Recommendations for Nitrogen in Cotton

<table>
<thead>
<tr>
<th>State</th>
<th>Extension Nitrogen Recommendations</th>
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<tbody>
<tr>
<td>Alabama</td>
<td>101 ± 34 kg N ha⁻¹ in split application for all soils</td>
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<tr>
<td>Florida</td>
<td>67 kg N ha⁻¹ in split applications</td>
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<tr>
<td>Georgia</td>
<td>67 to 118 kg N ha⁻¹ in split applications based on realistic yield goals of 842 to 1,684 kg lint ha⁻¹.</td>
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<td>Mississippi:</td>
<td>56 to 67 kg N bale⁻¹ on “light-textured soils”; 67-78 kg N bale⁻¹ on “medium textured soils”; split applications if over 112 kg N ha⁻¹ applied.</td>
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<td>North Carolina</td>
<td>56 to 78 kg N ha⁻¹ in split applications</td>
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<td>South Carolina</td>
<td>78 ± 34 kg N ha⁻¹ in split applications</td>
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<tr>
<td>Virginia</td>
<td>Yield goal based: 56 kg N per bale of expected yield (Available soil N will contribute 22-34 kg N ha⁻¹)</td>
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<tr>
<td>Tennessee</td>
<td>34 to 67 kg N ha⁻¹ on bottom soils; 67 to 90 kg N ha⁻¹ on upland soils</td>
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<tr>
<td>Texas</td>
<td>50 kg N bale⁻¹</td>
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2019 Proposal to 4R Fund for Updating Cotton N Requirements

1. Quantify the agronomic response to varying N rates and placement strategies of contemporary cotton varieties adapted to major production regions.
   ◦ 4 locations from 2019 - 2021

2. Determine the impact of EEF’s on N transformations and NUE in cotton production systems. More specifically:
   a. Measure gaseous losses of N species and other greenhouse gases from common N fertilizers, and leaching losses of N applied at varying N application rates and placements with and without enhanced efficiency N fertilizer additives or products
      ◦ VA and TX using Gasmet 4040 to monitor gas flux from 2019-2022
   b. Quantify the effectiveness of current N stabilizers and slow/controlled release N products on N transformations/species in representative soil types from the U.S. Cotton Belt using controlled laboratory environments.
      ◦ A horizon soils from each N placement x application rate trials are sent to Dr. Frame’s laboratory for ammonia volatilization

3. Measure the impact of various cover crops and cropping rotations on N cycling and availability in different regional production systems, and evaluate the responsiveness of cotton to applied N at those locations.
   ◦ 4 locations from 2019 - 2022

4. Develop a comprehensive management guide that informs regional management practices, thus reducing off target movement of N and maximizing the NUE of cotton systems.
Nitrogen Placement and Application Rate Trials

Nitrogen placement determines nutrient acquisition by roots and potential losses to the environment.

- **Broadcast (Dry)**
- **Surface Band (Fluid)**
- **Injection (Fluid)**

Applied at six rates: 0, 45, 90, 135, 180, and 225 kg N ha\(^{-1}\)

How does cotton respond to different placement methods across US Cotton Belt?

How does the optimal N rate change based on placement method?
Three Year Nitrogen Rate/Placement Study in Virginia/North Carolina (2016 – 2018)

**Broadcast**
- Optimal N Rate: >180 kg N ha\(^{-1}\)
- Max Relative Yield: 94% ≈1,600 kg ha\(^{-1}\)

**Surface Banded/Dribbled**
- Optimal N Rate: 128 kg N ha\(^{-1}\)
- Max Relative Yield: 90% ≈1,550 kg ha\(^{-1}\)

**Injection**
- Optimal N Rate: 133 kg N ha\(^{-1}\)
- Max Relative Yield: 95% ≈1,610 kg ha\(^{-1}\)

Join point not shown
2019 Nitrogen Application and Placement Study
Virginia Location

Relative Yield = 0.65 + 0.003(Nrate) - 8.43e^{-6}(Nrate)^2

$R^2 = 0.55$
Enhanced Efficiency Fertilizer Studies

- Virginia was the only location in 2019 in order to solidify sampling protocols for future years of the study
  - Static green house gas chambers did not work
    - No consistent flux due to time from sampling to analysis and variability in crimping of vials
    - Gasmet provided a quick, consistent sampling of GHG emissions
      - Methane, nitrous oxide, ammonia, carbon dioxide simultaneously measured

Agronomic Efficiency = \frac{\text{kg lint}}{\text{kg N applied}}
Ammonia Volatilization in Laboratory Trials
(Fine Sandy Loam from Virginia)

Nitrogen Placement

- Unfertilized Soil
- Surface Broadcast Urea
- Subsurface Banded Urea
- Surface Broadcast UAN32
- Surface Banded UAN32
- Subsurface Banded

Enhanced Efficiency Formulations

- Urea + NBPT
- Urea + Nitrapyrin
- ESN
- UAN + NBPT
- UAN + Nitrapyrin
- UAN + NBPT + Nitrapyrin

Percent N Lost as Ammonia (of applied N)

Time After N Application (hours)
Two Year Average Cotton Yields Following Different Cover Crops 2017-2018

- **Fallow**: $y = 55.1 + 0.002N$, $R^2 = 0.99$
- **Rye**: $y = 52.8 + 0.002N$, $R^2 = 0.99$
- **Legume Mix (LM)**: $y = 74.5 + 0.003N - 0.00001N^2$, $R^2 = 0.89$
- **Rye + Legume Mix (LMR)**: $y = 66.1 + 0.0001N$, $R^2 = 0.99$

**Quadratic Plateau**: 110 kg N ha$^{-1}$ to reach 93% relative yield
Expected Outcomes for N Management in Cotton

- Optimize the N application rates in each production region of the US Cotton Belt.
  - 134 kg N ha\(^{-1}\) in Southeast?
  - 67 kg N ha\(^{-1}\) in Mid-South?
  - Do early, mid-, and late maturing varieties respond differently to N placement and rate?

- Develop N management strategies that maximize NUE across the different regions of the US Cotton Belt
  - Using EEF’s versus placement in VA or TN?

- How can we incorporate legume cover crops in the different regions to reduce the need for inorganic cotton fertilizers?
  - In Virginia there is promising evidence that 0 kg N ha\(^{-1}\) behind crimson clover and hairy vetch can achieve the same lint yields as 134 kg N ha\(^{-1}\) following cereal rye.

- Development of a comprehensive guide to N management in cotton for the US Cotton Belt.
Thank You!
Questions?

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