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Nitrogen Fertilizer Recommendation for Florida Cotton[1]

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Abstract

This publication focuses on the evaluation of optimal nitrogen (N) rate for cotton in Florida. Currently, UF/IFAS recommends a rate of 60 lb N/acre for cotton production in Florida. This recommendation dates to the 1980s. However, changes in cultural practices, development of new cultivars, and grower dissatisfaction with existing recommendations indicated a need for reassessment of this rate. Thus, research was conducted to reassess the N requirement for cotton production in Florida and to move towards a yield goal-based N recommendation. The research presented herein indicates that for the combined data of sites in west and north Florida, lint yield is maximized at an application rate of 105 lb N/acre. The yield goal-based analysis shows that 0.09 lb of N is needed for every pound of lint produced, and 43 lb N/acre is required to produce 1 bale (480 lb) of cotton lint per acre. For higher yield targets, N rate can be adjusted accordingly (Table 1). These updated recommendations assist growers in achieving economically viable yields while minimizing risks of both under- and overfertilization. The target audience for this publication includes cotton growers, Extension agents, crop consultants, state and local agencies, researchers, students, and the general public in Florida.

Background of the Nitrogen Rate Study

The United States (U.S.) is a leading exporter of cotton, accounting for 25% of the global cotton trade. In Florida, cotton was grown on 89,000 acres in 2023, producing 53.3 million pounds of lint with a production value of $40.7 million (USDA 2025).

Nitrogen is a key nutrient that plays a vital role in cotton production, influencing both yield and fiber quality. It enhances photosynthetic capacity, facilitates nutrient transport to reproductive organs, and contributes to increased leaf area, boll count, boll weight, and yield (Zhou and Yin 2018). However, cotton's indeterminate growth habit requires a careful approach to N fertilization. Excessive N can lead to overgrowth, delayed boll maturation, increased susceptibility to pests and diseases, reduced N use efficiency, and environmental pollution. Therefore, optimizing N is essential for enhancing yield and fiber quality and minimizing environmental impacts, while promoting both sustainable farming practices and high productivity (Zhang et al. 2017).

Over the last five decades, global cotton yields have increased by 2.5 lb/acre per year to 16.3 lb/acre per year, driven by the development of high-yielding cultivars with improved pest resistance and stress tolerance (Zhang et al. 2019; Conaty and Constable 2020). Between 1960 and 2018, U.S. cotton yields and N fertilizer use increased by 94% and 36%, respectively (USDA-ERS 2023; USDA-NASS 2024). Additionally, the average cotton yield for Florida has increased from 490 lb/acre to 750 lb/acre between 1998 and 2024 (USDA-NASS 2024). The introduction of high-yielding cultivars with enhanced nutrient utilization efficiency has significantly improved lint production. However, concerns about soil nutrient depletion and potential for future yield limitations have emerged (Pabuayon et al. 2020). This underscores the need for continuous evaluation of fertilizer recommendations to address evolving nutrient needs of new cultivars (Singh et al. 2023).

Cotton production is highly influenced by the amount of N fertilizer applied, which is affected by factors such as fertilizer price and energy, transportation, and application costs. Determining an optimum N rate is critical to avoid financial losses due to either excessive or insufficient N use. However, the ideal N rate for cotton varies depending on climate, soil type, and field management practices. In the U.S., state-specific recommendations for cotton production range from 60 lb N/acre to 196 lb N/acre. For example, Georgia recommends 105 lb N/acre to 120 lb N/acre based on soil type and yield goals (Whitaker et al. 2019), while Alabama's recommendation ranges from 60 lb N/acre to 119 lb N/acre, depending on soil texture (Mitchell 2000). A study conducted by Main et al. (2013) across ten sites in the U.S. found an optimum N rate of 100 lb N/acre to 147 lb N/acre. In Florida, UF/IFAS currently recommends 60 lb N/acre for cotton (Mylavarapu et al. 2020), based on guidelines published in 1981 (Whitty et al. 1981). Fertilizer management research in Florida indicates a supplemental application of 30 lb N/acre after leaching rain (a leaching rain occurs when it rains at least 3 inches in 3 days, or 4 inches in 7 days).

Consequently, changes in cultivation practices, cultivar availability, and grower dissatisfaction with existing N rate recommendations highlight the need for updated fertilization guidelines. As lint yield varies across sites, a yield goal-based N recommendation is proposed for site-specific N application. As such, this publication presents a yield goal-based N recommendation for cotton production in Florida.

Experimental Details of the Nitrogen Rate Study

In 2022 and 2023, experiments were conducted by UF/IFAS in north and west Florida, utilizing loamy sand, sand, and sandy loam soil types. Each experiment included six N rates, ranging from 0 lb N/acre to 225 lb N/acre with 45-lb increments (0 lb N/acre, 45 lb N/acre, 90 lb N/acre, 135 lb N/acre, 180 lb N/acre, and 225 lb N/acre), arranged in a randomized complete block design with four replications. Each experimental unit consisted of 8 to 12 rows, spaced at 36 inches. Cotton cultivar DP 2038 (Deltapine®, Bayer Crop Science, Littlefield, TX) was used with the planting dates of May 15 to May 20, except at one site in 2022, which had planting dates during the first week of June. Nitrogen was applied in 2 to 4 splits, starting at first true leaf stage, depending on local practices. Urea (46% N) was used as the N source, with ANVOL™ (Koch Agronomic Services, Wichita, KS) added as a stabilizer to mitigate N volatilization losses. The west Florida sites were rainfed, while north Florida sites were irrigated. Cotton growth was regulated through applications of mepiquat chloride [Mepstar 6X® (Albaugh, LLC, Ankeny, IA) or Compact® (Winfield Solutions, LLC, St. Paul, MN)] in 2 to 3 split doses. Seed cotton yield data were determined by harvesting four middle rows in each plot with a cotton picker. To estimate commercial lint yields, seed cotton yield was multiplied by 38% lint turnout, at which commercial gins generally operate (Mulvaney et al. 2024). This was done to reduce bias observed with higher lint turnout in small, locally operated gins and closely match commercial lint yields. Relative yield for a given N rate was determined by dividing its yield by the yield achieved at maximum yielding N rate (e.g., 135 lb N/acre in these studies).

Figure 1. Aerial view of cotton nitrogen rate study at UF/IFAS WFREC, Jay, FL.
Credit: Joseph Iboyi, UF/IFAS WFREC, Jay, FL.

Lint Yield Response to Different Nitrogen Rates

Combined data analysis from all sites demonstrated a significant increase in lint yield up to 90 lb N/acre, beyond which no significant yield improvements were observed (Figure 2). At 90 lb N/acre, lint yield was 65% and 23% higher compared to 0 lb N/acre and 45 lb N/acre, respectively.

Individual site analyses for north and west Florida exhibited similar trends, with lint yield reaching its maximum at 90 lb N/acre. There were no significant differences in average lint yield between north and west Florida sites, despite west Florida sites being rainfed and north Florida sites being irrigated. This similarity can be attributed to the fact that west Florida receives higher rainfall than north Florida. Additionally, west Florida soil is heavier in texture, with greater water-holding capacity as well as higher organic matter and initial soil N compared to north Florida sites.

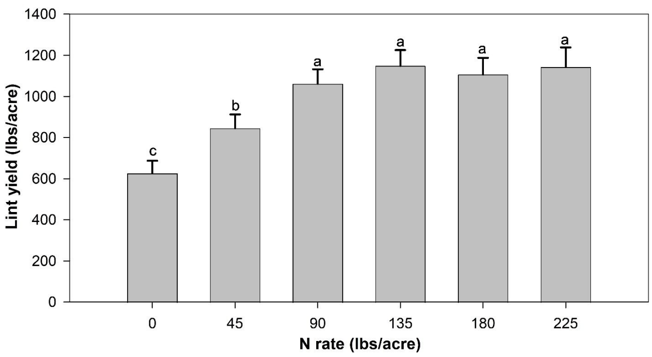

Figure 2. Cotton lint yield at six nitrogen rates for the combined data for all the five site years from west and north Florida. Bars represent mean ± standard error of mean from five sites. Means sharing a common letter are not significantly different by Tukey's test at 95% confidence level.
Credit: Hardeep Singh, Eajaz A. Dar, Ethan Carter, Michael Dukes, and Lakesh Sharma, UF/IFAS.

Nitrogen Use Efficiency of Cotton under Different Nitrogen Rates

According to Dowling (2014), fertilizer nitrogen use efficiency (NUE) between 13 lb lint per lb of N applied and 18 lb lint per lb of N applied indicates efficient utilization of applied N by cotton. NUE below 13 indicates N was not used efficiently, and NUE greater than 18 indicates unavailability of sufficient N to the crop. Based on this range, only the 90 lb N/acre application was close to the efficient range for both west Florida (NUE=12.8) and north Florida (NUE=11.1) sites and for the combined data of all site years (NUE=11.8) (Figure 3). At a low N rate of 45 lb N/acre, there may be insufficient N availability (NUE>18), and at an N rate of ≥135 lb N/acre, there may be inefficient N absorption and utilization (NUE=8.5).

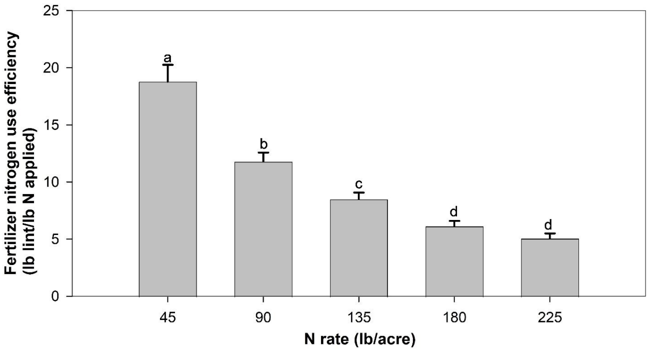

Figure 3. Nitrogen use efficiency at different nitrogen rates for the combined data of all five site years from west and north Florida. Bars represent mean ± standard error of mean from each treatment. Means sharing a common letter are not significantly different by Tukey's test at 95% confidence level. Credit: Hardeep Singh, Eajaz A. Dar, Ethan Carter, Michael Dukes, and Lakesh Sharma, UF/IFAS.

Determining Optimum Nitrogen Rate for Cotton in Florida

Yield response models were employed to determine the best fit model and calculate optimum N rate for cotton. Models were analyzed separately for rainfed and irrigated sites in west and north Florida, as well as combined across all sites. The linear plateau model emerged as the best fit for both individual and combined site data. For west Florida, the optimum N rate was 115 lb N/acre (Figure 4A) (Dar et al. 2025). The relative yield curve (Figure 4B) indicates that with no N application, 63% of maximum yield can be achieved, while 90 lb N/acre results in approximately 90% of maximum yield.

In north Florida, the optimum N rate was 101 lb N/acre (Figure 4C). The relative yield curve (Figure 4D) shows that with no N application, 48% of maximum yield can be achieved, and with 90 lb N/acre, more than 90% of maximum yield can be attained.

Combined data across all sites show an optimum N rate of 105 lb N/acre (Figure 4E). The relative yield curve (Figure 4F) demonstrates that with no N application, 55% of maximum yield is achievable, while 90 lb N/acre can result in more than 90% of maximum yield.

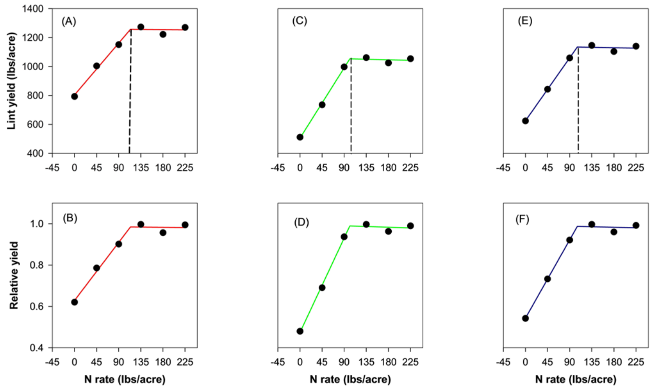

Figure 4. Best fit linear plateau model for determining optimum N rate and relative yield (treatment yield/maximum treatment yield) across six N rates at west Florida (A, B), north Florida (C, D), and combined data from five sites (E, F). Solid lines represent linear plateau fit, and vertical dashed lines indicate the N rate at which the plateau is reached. Credit: Hardeep Singh, Eajaz A. Dar, Ethan Carter, Michael Dukes, and Lakesh Sharma, UF/IFAS.

Yield Goal-Based Nitrogen Recommendation for Cotton in Florida

Yield goal-based N recommendations are particularly important for cotton, where N needs can vary significantly depending on yield potential, soil fertility, and environmental conditions. Unlike a single-rate recommendation, which assumes uniform crop response across diverse production scenarios, a yield goal-based approach tailors N applications to the expected productivity of each field. This strategy improves N use efficiency by aligning nutrient supply with crop demand, helping to avoid under-fertilization in high-yielding situations and reducing the risk of over-application that can lead to excessive vegetative growth, delayed maturity, and environmental losses. For cotton producers in Florida, where weather variability and soil differences are common, yield goal-based N recommendations offer a more adaptive and sustainable framework for maximizing lint yield and quality while protecting natural resources.

Combined analysis of five site years from current research indicates that 0.09 lb of N is required to produce 1 lb of cotton lint. Based on this, a yield goal-based N recommendation can be calculated by multiplying the expected lint yield by 0.09. For example, to produce 1 bale of cotton (equivalent to 480 lb of lint), 43 lb N/acre is needed. The N rate recommendations based on this algorithm for different yield goals are provided in Table 1. For example, to produce 2 bales lint/acre, 86 lb N/acre is required. To produce 3 bales lint/acre, 130 lb N/acre is required. This approach allows producers to adjust N rates according to their realistic yield expectations, improving efficiency, reducing waste, and supporting environmental stewardship.

To calculate a specific fertilizer rate per acre, divide the N rate per acre by the fertilizer's N content. For example, commonly used fertilizers have the following N contents: 0.82 (anhydrous ammonia), 0.46 (urea), 0.34 (ammonium nitrate), 0.21 (ammonium sulfate), and 0.28–0.32 (liquid N fertilizers). Therefore, to apply 105 lb N/acre, one would require 128 lb of anhydrous ammonia/acre or 228 lb of urea/acre.

Key Takeaways from the Nitrogen Rate Study in Cotton

This study found that peak lint yield was recorded at an application of 105 lb N/acre. Yield-goal based analysis shows that 0.09 lb N is required to produce 1 lb of lint. To produce 1 bale, 43 lb N/acre is required. If the yield target is 2 bales per acre, 86 lb N/acre is required. For higher yield targets, N rate can be increased accordingly (Table 1). A supplemental dose of 30 lb N/acre is allowed after a leaching rain.

This information can help farmers make site-specific N decisions. The soil types in Florida's Panhandle (cotton-producing region) vary considerably; soils in west Florida (Escambia County and Santa Rosa County) have more clay content while soils in north Florida (Jackson County) have more sand content. Therefore, these soils have a different yield potential, and applying the same N rate across the region may lead to over- or under-application. Therefore, using a yield goal-based approach (Table 1) for determining the N rate for cotton production is an appropriate method to avoid economic and environmental losses.

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Tables

Table 1. Yield goal-based nitrogen recommendation for cotton in Florida.

Yield Goal (lb lint/acre)	Bales/acre	N Rate (lb/acre)
480	1.0	43
720	1.5	65
960	2.0	86
1200	2.5	108
1440	3.0	130

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