

NITROGEN REQUIREMENTS OF ADAPTED, GENETICALLY-MODIFIED COTTON VARIETIES

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Abstract

Other than lack of water, nitrogen (N) is frequently the greatest limitation to cotton [*Gossypium hirsutum* (L.)] yield and quality. Nitrogen use efficiency (NUE) of modern cotton cultivars should be optimized to prevent crop production and environmental issues associated with excess N, especially with escalating fertilizer costs. The greatest fraction of N in the cotton plant is associated with seed. Studies with genetically-modified (GMO) cotton varieties have demonstrated decreased seed size and weight, which should result in lower N needs. The current Agrilife Extension recommendation for cotton (50 lbs N/bale of lint), however, is based on conventional cultivars, and may result in excess N with GMO varieties. The study site was located at the Texas Agrilife Research Farm in Buleson County, TX near College Station. Four GMO varieties and five N rates in increments of 35 lbs N/acre were used in the study. Seed N/bale ranged from 20 to 23.3 lbs N/acre. Cotton variety ST 4498 B2RF produced the greatest lint and seed yields, the greatest number of seed per acre, and the second greatest lint (g) per seed. Added N increased seed cotton, seed, and lint yields. FM 840 B2RF required the most N per bale of lint among varieties because it had the lowest lint yield and seed yield equivalent to ST 4498 B2RF.

Introduction

Nitrogen is the principal fertilizer input into most cotton management systems. In 2010, approximately 90% of US upland cotton acreage received some form of N fertilizer, totaling 630 million lbs of N applied. Second only to water, N is often the greatest limitation to cotton yield and quality. Excess N can also create problems, such as excessive vegetative growth, harvest delays, insect injury, and nitrate pollution of surface and ground waters (Hutmacher et al. 2004). Nitrogen fertilizer has escalated dramatically in cost, increasing by as much as 130% over the past several years (Haby 2008). With rapidly increasing fertilizer prices, it has become even more important that the NUE of modern cotton cultivars be optimized.

The principal “N sink” in cotton is seed, where N is incorporated into protein and other seed constituents. Research has shown that seed size and weight are decreasing as lint turnout is increasing with GMO cotton varieties. Since the majority of N in cotton is concentrated in the seed as protein, then lower seed weight per unit of lint produced should result in reduced N needs. Therefore, the current AgriLife Extension recommendation of 50 lbs of available N/bale of cotton lint (Hons et al. 2004), which is based on conventional cultivars, would result in excess N application with GMO varieties. The objective of this study was to determine the N requirements of widely grown, genetically-modified cotton varieties in order to modify N recommendations.

Materials and Methods

The location of the study was the Texas AgriLife Research Farm in Burleson County, Texas near College Station. The soil at this site is a Weswood silt loam under a rotation of cotton with corn [*Zea mays* (L.)]. The top 36 inches of this soil is moderately alkaline, with an average pH of 7.97 (Table 1). Electrical conductivity of the profile averaged 0.32 dS m⁻¹ indicating no problems with salinity. Nitrate-N decreased by a factor of 14 from the 0 to 6 inch depth (10.8 ppm NO₃-N) to the 24 to 36 inch depth (0.75 ppm NO₃-N). Nitrate-N totaled approximately 50 lbs available N/acre to a depth of 24 inches. This result is very similar to previously reported results in 2009. All extractable nutrients were in the high to very high category, except for P, which was rated as moderate to low. Most extractable nutrients, except Ca and S, decreased with depth but not to the extent of NO₃-N.

Table 1. Nutrient analysis of soil use is the study.

Depth inches	pH	EC dS/m	NO ₃ -N	P	K	Ca	Mg	S	Na	Fe	Zn	Mn	Cu
-----parts per million-----													
0-6	7.85	0.42	10.8	38	508	9437	430	30	68	11.6	0.8	24.2	1
6-12	7.93	0.42	8	19	366	9790	376	26	82	13.5	0.6	17.2	1.1
12-24	8.03	0.23	3	7	166	9319	239	28	62	8.8	0.2	4.5	0.5
24-36	8.05	0.21	0.75	6	120	10884	214	30	47	7.9	0.2	4.1	0.5

The experiment was designed as a split-plot within a RCB with four treatment replications. Main plots were planted to one of four GM cotton varieties including FM 840 B2RF, PHY 375 WRF, DP 141 B2RF, and ST 4498 B2RF. Each main plot was then divided into five split plots of differing nitrogen regimes (0, 35, 70, 105, and 140 lbs N/A). Nitrogen, as urea (46-0-0), was preplant banded. The study was located under a linear-move irrigation system and irrigated approximately every 10 days. Each plot was four, 40-inch rows wide by 40 ft long. Plots were originally planted at a rate of 49,500 seed/acre on April 4th. Emergence was poor because of excessively dry and windy conditions, and plots were re-planted on April 22nd. The entire 40 ft of the middle two rows of each plot were harvested with a plot picker in early September. Following seed cotton harvest, seed and lint yields (lb/A) were determined by ginning subsamples in a small research gin. Weights per 100 seed and grams of lint per seed were also determined. Subsamples of seed were finely ground and analyzed for total N concentration using a combustion analyzer. Following harvest seed cotton, seed and lint yields (lb/A) were determined, along with seed and lint weights. Analysis of variance was used to identify statistically significant treatment effects and Fishers Protected LSD was used for means separation. Means separation and regression was conducted at P<0.05.

Results and Discussion

Varietal effect on seed yield was significant at P=0.004. Cotton seed yields of FM 840 B2RF and ST 4498 B2RF were statistically equal and greater than the other two varieties (Fig. 1a). ST 4498 B2RF produced significantly greater lint yield (P<0.001) than FM 840 B2RF as well as the other two varieties (Fig. 1b). ST 4498 B2RF and DP 141 B2RF produced the greatest number of seed per acre (Fig. 1c). PHY 375 WRF and ST 4498 B2RF resulted in the greatest and statistically equal lint (g) per seed, whereas DP 141 B2RF produced the least (Fig. 1d).

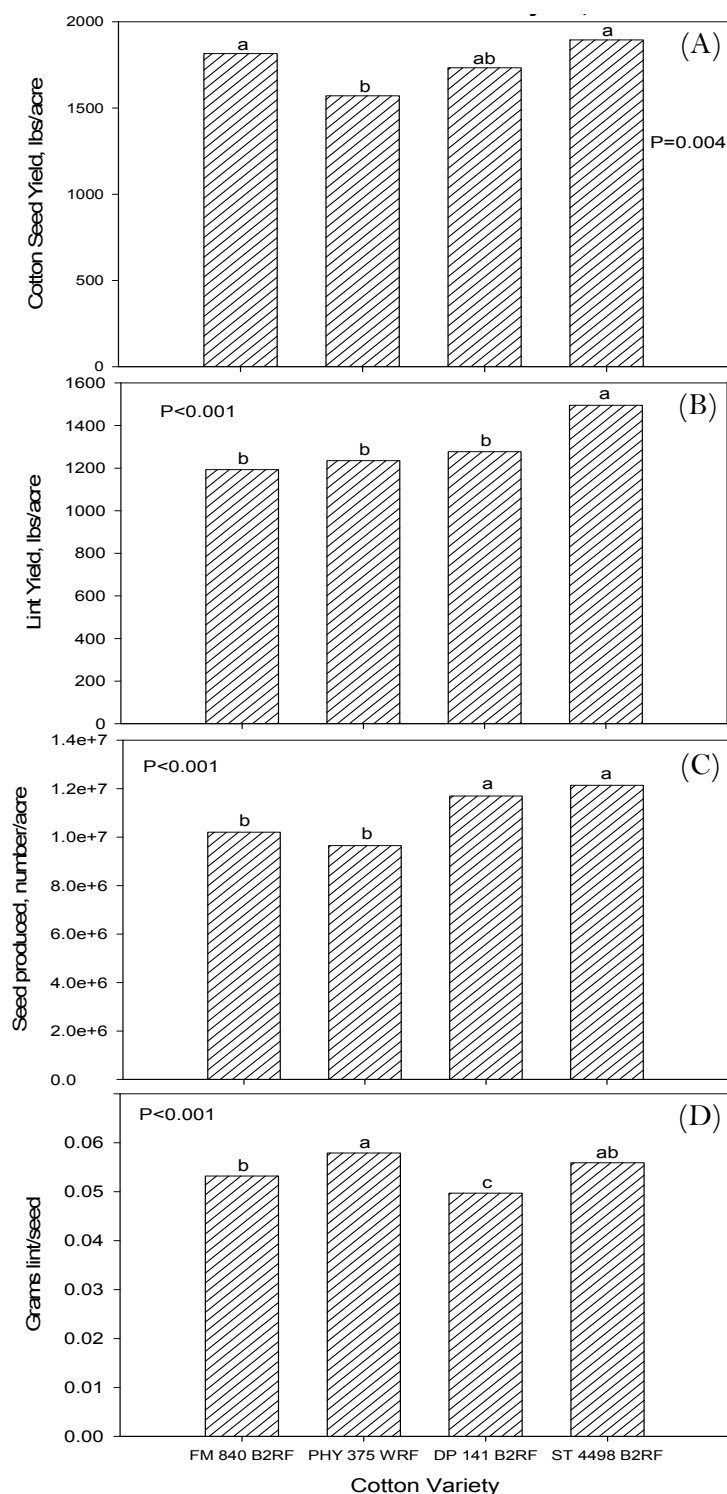


Figure 1. Varietal effect on seed and lint yield of cotton, number of seed produced per acre and grams of lint per seed. Means within in each figure followed by the same letter are not different at $P<0.05$ by LSD.

Varietal effect on lint turnout was significant at $P < 0.001$. PHY 375 WRF and ST 4498 B2RF resulted in the greatest lint turnout, followed by DP 141 B2RF and then FM 840 B2RF (Fig. 2). FM 840 B2RF contained 23.3 lbs seed N per bale of lint, while the other three varieties were very similar and contained only 20.0 lbs seed N per bale of lint (Fig. 3). Estimated total pounds of N required to produce one bale of lint was calculated assuming 57% of cotton plant N is in seed (Tewolde et al., 2007). Based on this value, N required to produce a bale of lint averaged 35 to 41 lbs/acre depending on variety and was highest for FM 840 B2RF.

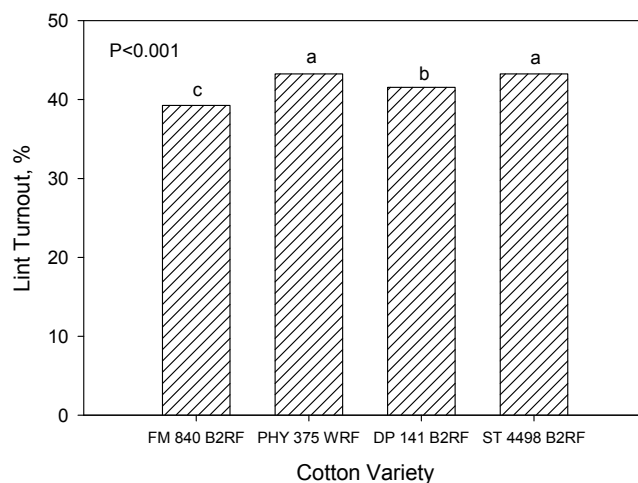


Figure 2. Varietal effect on lint turnout. Means followed by the same letter are not different at $P < 0.05$ by LSD.

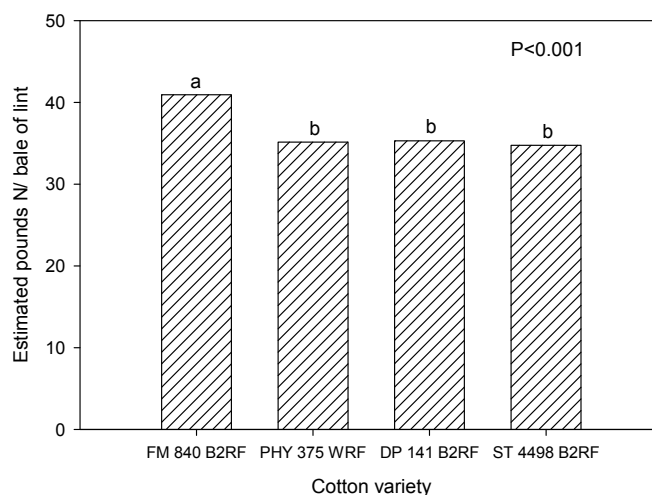


Figure 3. Pounds of seed nitrogen per bale of lint as affected by variety. Means followed by the same letter are not different at $P < 0.05$ by LSD.

Added N increased seed cotton, seed, and lint yields (Fig. 4). Seed cotton and seed yields responded up to highest N rate (140 lbs/acre), while lint responded up to 105 lbs/acre. A greater number of seed per acre was produced with 140 compared to 70 lbs added N/acre or less (Fig. 5). Added N had no effect on weight per seed or lint (g) per seed.

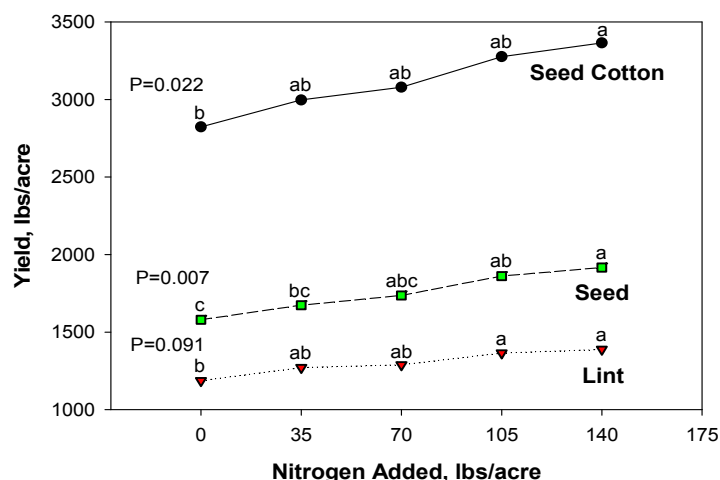


Figure 4. Effect of added nitrogen on seed cotton, seed and lint yield. Means within seed cotton, seed or lint yield followed by the same letter are not different at $P < 0.05$ by LSD; lint significant at $P < 0.10$.

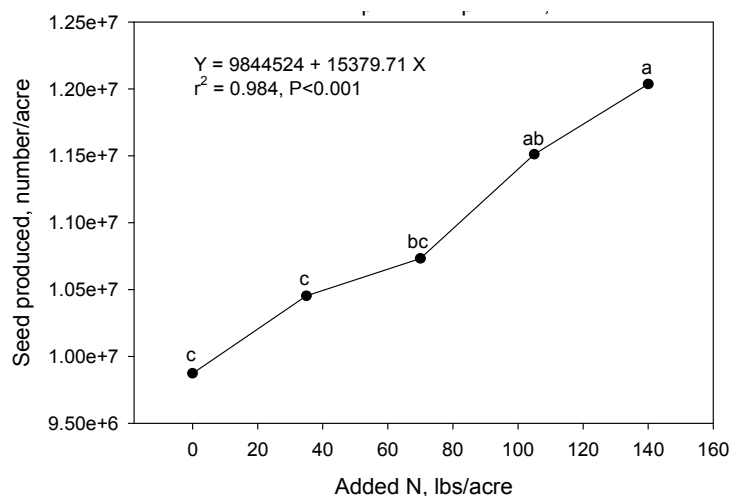


Figure 5. Effect of added nitrogen on number of seed produced per acre. Means followed by the same letter are not different at $P < 0.05$ by LSD.

Conclusions

Seed cotton and seed yields responded up to 140 lbs added N/acre, while lint yield responded up to 105 lbs N/acre. Increasing N addition increased the number of seed produced per acre, but not grams of lint per seed. ST 4498 B2RF produced the most lint because it produced the greatest seed yield, the greatest number of seed per acre, and the second greatest grams of lint per seed, but was not the highest N requiring variety. Seed N per bale ranged from 20.0 to 23.3 lbs N, and averaged 20.8 lbs N/bale. Using this value and assuming 57% of total plant N in seed resulted in an N requirement of 36.5 lbs N/bale of lint when averaged across all varieties.

References

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