NUTRIENT STRESS EFFECTS ON COTTON PRODUCTIVITY

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Abstract

Optimal nutrient management is critical to enhance the yield and quality of cotton (*Gossypium hirsutum*) production because insufficient or excess nutrients can impair the growth and development of cotton. The study evaluated how cotton responds to early-season, late-season, and reduced nutrient stress effects at various locations and production conditions (dryland and irrigated) in Georgia. The late-nutrient stress was induced by supplying 30-40% of all recommended nutrient rates only at the initial stages of planting, and the early-nutrient stress was induced by making the first fertilizer application at the square stage. The reduced nutrient stress plots received the full recommended nutrient rates that were split applied over the growing season. The standard University of Georgia Agricultural and Environmental Services Laboratories (UGA-AESL) fertilizer recommendations for achieving 1000 lbs/ac (dryland) and 1500 lbs/ac lint yield (irrigated) was included as control. The effects of early-season nutrient stress on cotton lint yield were minimal, but yield loss under the late-season nutrient stress conditions ranged from 21.6% to 45.4% when compared to the reduced nutrient stress. We observed a lint yield reduction of 1.1% to 25.4% in the standard UGA-AESL fertilizer recommendation when compared to the reduced nutrient stress; however, the differences were not statistically significant. Overall, the results showed that adequate nutrient supply throughout the growing season is important to achieving greater yields in cotton.

Introduction

Georgia soils, predominantly Ultisols, are highly weathered and they are characterized as possessing a clay-enriched subsoil with relatively low native fertility or a base saturation of less than 35% in the subsoil (Soil Survey Staff, 2014; Truman et al., 2010). Sand is usually the topsoil layer and kaolinite is the dominant clay mineralogy in the subsoil, but under intensive weathering and poor soil management conditions, some areas in the region have lost the sandy topsoil layer. Both sand and kaolinite clay minerals actually have very low cation exchange capacity, making crop production systems in the state, in general, less resilient. A slight change in soil conditions can adversely impact crop performance. Thus, optimum plant nutrition is, particularly, very critical to sustaining cotton (*Gossypium hirsutum*) production in the state.

Optimal nutrient management in cotton will require an understanding of the growth characteristics of cotton, especially under different nutrient stress levels. Insufficient or excess nutrients, especially nitrogen, can lead to fruit shed in cotton (Wright et al., 2005). Nutrient deficiency causes cotton to slow the formation of photosynthates and stop developing new nodes and squares, thereby entering into premature cutout. Too much plant nutrition, especially nitrogen, can result in rank growth, excessive vegetative growth, which causes cotton plants to be susceptible to boll rot, difficult to defoliate, and more attractive and vulnerable to late-season insects (Ritchie et al., 2007). Thus, the yield of cotton does not always correlate well with biomass accumulation. The objective of the study was to evaluate cotton response to nutrient stress dynamics across different environmental conditions.

Materials and Methods

Study location and field history

The study was established in 2021 at two research and education centers at the University of Georgia (UGA): (a) C. M. Stripling Irrigation Research Park in Camilla, Mitchell County, and (b) Southeast Georgia Research and Education Center in Midville, Burke County. The trial at the Camilla site was under overhead and subsurface drip irrigation systems, and the trial at the Midville site was under dryland and overhead irrigation systems, constituting four environmental conditions. Previous cash crops cultivated on the various fields were corn for the studies in

Camilla and peanuts for the studies in Midville. All the fields were under rye cover crops after the cash crops.

Experimental management

The treatments consisted of inducing early-season nutrient stress, late-season nutrient stress, and reduced nutrient stress conditions. The standard fertilizer recommendations of UGA Agricultural and Environmental Services Laboratories (UGA-AESL) for achieving 1500 lbs/ac lint yield was included as a control, except for the dryland site in Midville, where the control was the standard UGA-AESL fertilizer recommendation for achieving 1000 lbs/ac lint yield.

The level of nutrient stress varied across the study locations. For both study conditions in Camilla, the early-season nutrient stress plots did not receive any nutrient application until the formation of squares where it received 50% of all the nutrient rates, and another 50% of all the nutrient rates was applied between the second and third week of bloom. The late-season nutrient stress plots received only 40% of all the nutrient rates at the early stage of planting. The reduced nutrient stress plots received 30% of all the nutrient rates at the early stage of planting, 30% at the formation of squares, 30% between the second and third week of bloom, and 10% at the sixth week of bloom. For both study conditions in Midville, the early-season nutrient stress treatment was similar to the one described for Camilla. However, the reduced nutrient stress plots received 40% of all the nutrient rates at the early stage of planting, 30% at the formation of squares, and 30% between the second and third week of bloom. Also, the late-season nutrient stress plots received only 30% of all the nutrient rates at the early stage of planting.

Nutrient elements identified as essential for cotton productivity are N, P, K, Ca, Mg, S, Fe, Mn, Zn, B, and Cu (Campbell, 2000). Thus, some rates of all the essential nutrients were included in the full fertilizer rate (Table 1), except for the UGA-AESL nutrient recommendation that did not call for the application of all the nutrient elements of interest. The full fertilizer application rates for the various essential nutrients were based on standard recommendation and specific production conditions at the various study locations. The dryland condition in Midville informed the lower nutrient application rates (Table 1).

At every location, the treatments were arranged in a randomized complete block design with four replications. Cotton was planted on 36-inch row spacing at both locations, but the varieties differed: DP1646 for the studies at Camilla and Stoneville 4550 for the studies in Midville.

Table 1. Full nutrient application rates (lbs/ac) used at the various study locations.

Nutrient elements	Camilla (UGA)	Camilla overhead	Camilla SSDI	Midville dryland (UGA)	Midville dryland	Midville overhead (UGA)	Midville overhead
N	95	105	105	45	70	75	105
P	40	100	70	30	60	70	90
K	90	150	120	30	75	120	125
Mg	0	10	3	0	5	0	5
Ca	0	15	6	0	10	0	20
S	10	12	12	10	10	10	10
B	0.5	1	1	0.5	0.5	0.5	1
Zn	0	1	1	0	1	0	2
Mn	0	3	3	0	2	10	5
Fe	0	2	2	0	2	0	2
Cu	0	0.5	0.5	0	0.5	0	0.5

Results and Discussion

Late-season nutrient stress had more pronounced negative effects on cotton lint yield than the effects of early-season nutrient stress (Figure 1). Compared to the reduced nutrient stress, the late-season nutrient stress led to 21.6% to 45.4% reduction in lint yield across the different environments, whereas the early-season nutrient stress led to 4.7%

to 7.3% reduction in lint yield for the studies in Camilla and even 1.5% to 3.2% increase for the studies in Midville. The effect on the late-season nutrient stress could also be attributed to the rates of nutrient applied. The effects of early-season nutrient stress on lint yield was minimal, likely because the early-season nutrient stress had the same nutrient rate as the reduced nutrient stress and the cotton plants did not require substantial nutrients by the square stage to induce significant yield loss. We observed lint yield reduction of 1.1% to 25.4% in the standard UGA-AESL fertilizer recommendation when compared to the reduced nutrient stress; however, the differences were not statistically significant.

The nutrient stress conditions also significantly affected cotton plant height, number of nodes, number of bolls, boll weight, and the gin turnout within an environmental condition. The trend was not very consistent across the different environmental conditions, but overall, the late-season nutrient stress tended to be lower or equivalent to the reduced nutrient stress condition in all the measured growth parameters at the various environmental conditions. Significant differences were observed for plant height at the two conditions in Camilla but not for that in Midville. Also, significant differences were observed for the number of nodes under the overhead irrigation systems at the two locations, but not under the SSDI system in Camilla and the dryland condition in Midville.

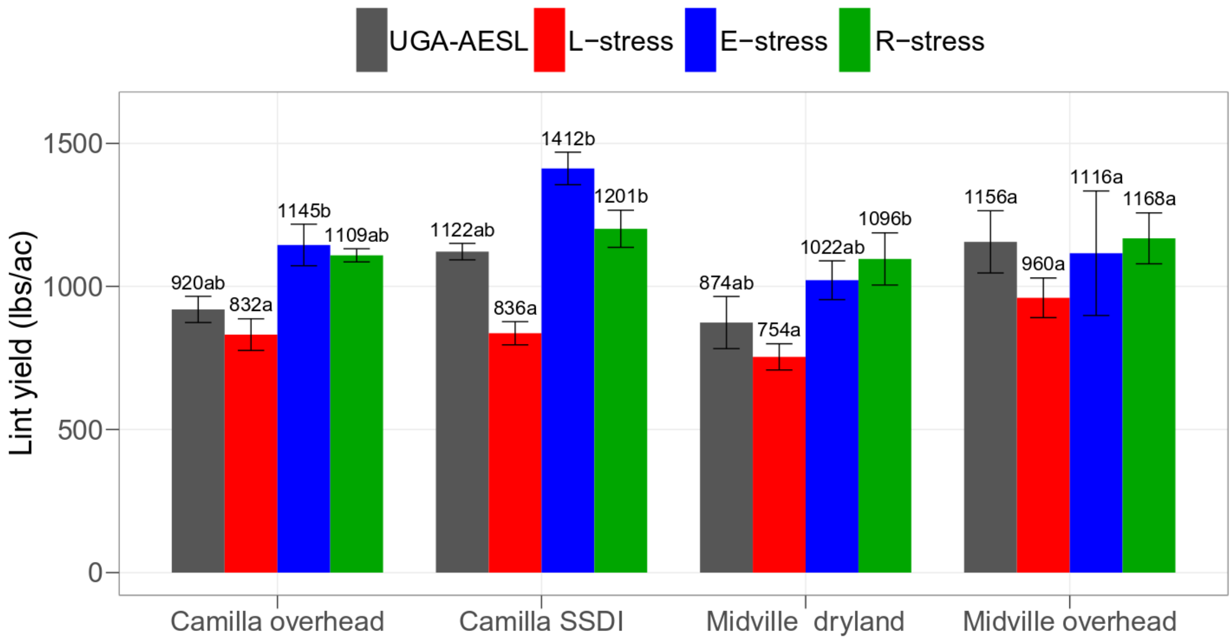

Figure 1: Effects of nutrient stress conditions on cotton lint yield across different environmental conditions in Georgia.

Table 2: Effects of nutrient stress conditions on cotton growth parameters across different environmental conditions in Georgia.

Treatment	Plant height (inches)	Nodes (#/plant)	Good bolls (#/plant)	Total bolls (#/plant)	Boll weight (g/boll)	Gin turnout (%)
			Camilla overhead			
UGA-AESL	36.8ab	17.8a	5.8a	10.6a	3.68a	44.5b
L-stress	33.7a	16.7a	6.3a	9.3a	4.08ab	44.2b
E-stress	38.5ab	21.6b	7.5a	11.7a	4.05ab	42.3a
R-stress	40.9b	20.9b	6.8a	10.7a	4.35b	42.9ab
			Camilla SSDI			
UGA-AESL	44.6b	25.1a	10.0ab	14.4ab	4.75a	43.7a
L-stress	37.1a	25.5a	6.9a	10.5a	4.40a	43.4a

E-stress	49.0b	26.8a	11.8b	18.4b	4.41a	42.2a
R-stress	46.4b	26.6a	12.4b	18.5b	4.39a	42.9a
			Midville dryland			
UGA-AESL	35.1a	20.7a	6.9a	8.7ab	4.59a	42.9a
L-stress	35.5ab	21.4a	7.5a	8.5a	4.31a	42.8a
E-stress	36.7ab	22.4a	9.6a	11.8ab	4.40a	41.3a
R-stress	40.3b	21.4a	10.7a	13.5b	4.47a	41.5a
			Midville overhead			
UGA-AESL	41.0a	19.4ab	10.9a	12.4ab	4.51a	39.8ab
L-stress	38.1a	17.3a	8.3a	9.9a	4.62a	38.5a
E-stress	43.0a	21.2b	11.1a	15.7b	4.89a	39.6ab
R-stress	42.6a	20.5b	11.0a	13.6ab	4.79a	40.4b

Summary

This section whether titled 'Summary' or 'Conclusions' should include (1) the principles, relationships, and generalizations inferred from the results, (2) any exceptions to, or problems with, these principles, relationships and generalizations, (3) agreements or disagreements with previously published work, (4) practical implications of the work, and (5) conclusions drawn. All text in the main body of the paper should be 10 pt Times New Roman font, black font color, single-spaced, and with full justification. Double-space below the title '**Summary**' and the following paragraph. Double-space between sections, and double-space between paragraphs within sections. To enter your text, simply highlight the paragraph here and replace with your material.

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