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Furrow-irrigated cotton yield and fiber quality response to potassium fertilization

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Abstract

Potassium (K) deficiency is a common yield-limiting factor in cotton (*Gossypium hirsutum* L.) production, requiring effective management to minimize yield losses and maintain fiber quality. We evaluated how K availability influences cotton lint yield and fiber quality. Ten fertilizer-K rate (0–187 kg K ha⁻¹) trials were conducted on silt loam soils with soil-test K (STK) ranging from very low to above optimum during the 2023 and 2024 growing seasons. Cotton was planted in raised beds and furrow-irrigated, and lint yield, turnout, and fiber quality (i.e., fiber length, micronaire, uniformity, strength, and elongation) were measured at maturity. Cotton lint yield was positively affected by fertilizer-K rates ($p \leq 0.10$) at $STK \leq 114$ mg K kg⁻¹. Yields were maximized at responsive sites with applications of 56 kg K ha⁻¹ in long-term trials and 37, 75, or 112 kg K ha⁻¹ in single-site-year trials, showing yield increases of 20%, 53%, 47%, and 70% compared to the no-K control, respectively. Lint turnout and fiber quality were affected by K availability. Overall, at yield-maximizing fertilizer-K rates, lint turnout was 2.4% greater across cultivars in relation to the control. Similarly, fiber elongation increased by 0.35%. At sites with Very Low STK, as little as 37 kg K ha⁻¹ increased lint uniformity and strength up to 0.67% and 1.84 g tex⁻¹. Micronaire increased on average by 0.50, with greatest values occurring with 112 kg K ha⁻¹ application. These findings suggest adequate K management is key to maximizing both cotton yield potential and fiber quality.

Plain Language Summary

Effective potassium (K) management is important for cotton production and crucial to maximize yield and maintain fiber quality. Over the past decade, K deficiency has become more common across the US Cotton Belt. Modern high-yielding cotton

Abbreviations: Bt, *Bacillus thuringiensis*; LMCRS, Lon Mann Cotton Research Station; PRC, potash rate calculator; RRS, Rohwer Research Station; SAREC, Milo J. Shult Agricultural Research and Extension Center; STK, soil-test K.

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cultivars have great nutrient demand, and current fertilizer-K recommendations may no longer meet the crop's K requirement. Ten field trials were established to evaluate how furrow-irrigated cotton yield and fiber quality respond to K fertilization on soils with different K availability in Arkansas. Our results showed that K fertilization increased cotton yields by up to 70% in K-deficient soils. Similarly, fiber quality improved with K fertilization, especially traits like lint turnout, fiber elongation, uniformity, and strength. However, in soils with optimum K availability, no response was observed. Our findings emphasize that adequate K management is key to maximizing both cotton yield potential and fiber quality.

1 | INTRODUCTION

Successful cotton (*Gossypium hirsutum* L.) production relies on efficient nutrient management to enhance fiber quality and maximize yield, with potassium (K) being a nutrient required in significant quantities for optimal crop development (Kerby & Adams, 1985; Oosterhuis et al., 2013); especially in soils with low cation exchange capacity or high K fixation (Oosterhuis, 2002; Rosolem & Mikkelsen, 1991). Research conducted several decades ago examined various aspects of cotton production, including yield response, fiber quality, fertilizer application techniques, and soil test outcomes to enhance K supply for optimal cotton growth (Bennett et al., 1965; Cope, 1970, 1981; Cope & Rouse, 1973; Evans et al., 1970). These studies were fundamental in defining “sufficient levels” of available K in the soil, supporting the development of fertilizer-K recommendations to ensure adequate K availability for cotton. However, K deficiency symptoms in cotton across the United States Cotton Belt, an area extending from Virginia to California (Coker et al., 2009), have reportedly increased in recent decades, indicating that K deficiency remains persistent and challenges crop yield potential (Lewis et al., 2021; Oosterhuis et al., 2013). The trend toward increasing K deficiency has coincided with average modern cotton lint yields exceeding 950 kg ha⁻¹ in recent years (United States Department of Agriculture, National Agricultural Statistics Service, 2025) and led producers to use significantly larger amounts of fertilizer-K than in previous years (Oosterhuis et al., 2013) with hopes that increased K input would be translated to increased crop yield.

A summary of soil-test K (STK) results from the University of Arkansas System Division of Agriculture Marianna Soil Test Laboratory from 2012 to 2023, where cotton was the previous crop, indicates an increase in cotton acreage with below-optimum Mehlich-3 extractable-K (i.e., <131 mg K kg⁻¹; DeLong et al., 2025). In soils with suboptimal K availability, K may be a major yield-limiting factor, and a positive yield response to K fertilization is expected. Nutrient supply

and balance are challenging in cotton due to its indeterminate growth habit and complex physiology of growing a perennial plant as an annual crop (Constable & Bange, 2015; Constable & Hearn, 1981; Lawton et al., 2023; Pabuayon et al., 2021). Furthermore, cotton K deficiency can still occur even when STK values are considered adequate, due to limited uptake during peak flowering demand (Cope, 1981; Gerik et al., 1987; Kusi et al., 2021; Yang et al., 2012).

Potassium deficiencies in cotton occur more frequently and intensely than in most other agronomic crops (Coker et al., 2009; Cope, 1981), leading to disturbances in essential biochemical and physiological processes. Potassium is crucial for enzyme activation (Blevins, 1985; Hu et al., 2018), maintaining cell turgor (Szczerba et al., 2009), regulating stomatal opening and closing (Dong et al., 2004), and plant photosynthesis (Rawat et al., 2022; Steven, 1985). These processes directly affect fiber development and lint yield (DeLanghe, 1986; Denton et al., 2023; Heitholt, 1993). Bennett et al. (1965) found that sufficient K nutrition significantly enhances fiber length and micronaire index in irrigated cotton. Potassium nutrition may be even more important in rainfed conditions; Davis et al. (2024) reported a significant interaction between K fertilization and irrigation, with fiber micronaire and elongation increasing more under rainfed than irrigated conditions. Additionally, K uptake per unit of lint increases with higher K application rates. These studies demonstrate how K deficiency can lead to reduced cotton lint yields and inferior fiber quality. Adequate K availability can increase cotton productivity by enhancing overall boll development and improving lint turnout and fiber quality properties (Cassman et al., 1990; Muthusamy & Jayabalan, 2011; Oosterhuis et al., 2013).

Efficient use of fertilizer-K is crucial to prevent yield losses in cotton (Kerby & Adams, 1985). Research in the southern United States highlighted the importance of K nutrition for adequate cotton production by documenting a 95% cotton yield decrease over a decade without K fertilization (Mitchell et al., 2011). Furthermore, modern high-yielding cotton cultivars with the *Bacillus thuringiensis* (Bt) trait

introduced in the mid-90s require more fertilizer-K than conventional cultivars to achieve high yields and maintain fiber quality (Shahzad et al., 2019; Wang et al., 2022; Z. Zhang et al., 2007). Z. Zhang et al. (2007) reported that Bt cotton is more susceptible to K deficiency than conventional cultivars, likely due to reduced K^+ absorption under stress and limited assimilate translocation to roots, which may partially explain why K deficiency in cotton has reportedly increased in recent decades.

Research on cotton fiber quality response to K fertilization using modern cultivars across the United States is limited compared to studies focusing on cotton yield. The University of Arkansas Division of Agriculture soil scientists acknowledged the importance of adequate K fertilization programs many years ago by establishing multiple cotton K fertilization trials. Recently, the information from these studies was combined to develop an economic meta-analysis and define profit-maximizing K rates for cotton producers. This information allowed the development of a novel decision support tool, the potash rate calculator (PRC; Oliver et al., 2022). The PRC determines the recommended fertilizer-K rates based on the field's STK level, while the yield potential of a field, crop price, and fertilizer cost are used to estimate the profitability of the recommended rate. However, while the PRC support tool provides guidance on selecting accurate fertilizer-K rates for cotton, a summation of the analyzed cotton dataset shows that more information on cotton response to K fertilization is needed, especially to better understand the effect of K fertilization on fiber quality.

Fertilizer-K is required to meet plant K demands and maximize yield potential on soils with low cation exchange capacity or high K fixation (Oosterhuis, 2002; Rosolem & Mikkelsen, 1991). In a recent study across the US Cotton Belt, Lewis et al. (2021) reported a 25% yield response to broadcast application of K on soils with Very Low STK ($<60 \text{ mg K kg}^{-1}$; Mehlich-3 extractable K) compared to the no-K control. Likewise, research by Oliver et al. (2022) showed that cotton cultivated in soils with Low STK is more responsive to K fertilization than soils with greater K availability. Their research indicates minor to no yield responses to K fertilization on soils with STK between 120 and 177 mg K kg^{-1} (Mehlich-3 extractable K). Conversely, Kusi et al. (2021) observed that fertilizer-K application in soils with Mehlich-3 extractable $K > 125 \text{ mg K kg}^{-1}$ may positively affect cotton lint yield and fiber quality. Luo et al. (2016) suggested that environmental factors like rainfall or growing degree day units likely impact fiber quality more than K availability. These diverse observations highlight the need to better understand the magnitude and frequency of cotton yield and fiber quality response to K fertilization and revise current fertilizer-K recommendations to ensure return on investment with fertilizer-K applications. The objectives of the current study are to determine if (i) there is a greater fertilizer-K rate requirement and yield increase to K fertilization on soils with lower Mehlich-3 extractable K

Core Ideas

- Furrow-irrigated cotton responded positively to K fertilization on K-deficient soils.
- The 112 kg K ha^{-1} application increased lint yield up to 70% on soils with Very Low or Low K availability.
- Cotton lint turnout increased by up to 2.4% with K fertilization across cultivars.

due to insufficient K availability for optimum cotton growth, fiber development, and overall yield potential; (ii) cotton lint turnout will improve with adequate K availability (soil or fertilization), as increased K supply supports fiber development, particularly fiber length and elongation; and (iii) provide updated information to the PRC (Oliver et al., 2022). The objectives were investigated in furrow-irrigated cotton trials with different K availability in Arkansas.

2 | MATERIALS AND METHODS

Field trials were established at the University of Arkansas System Division of Agriculture properties in 2023 and 2024 to investigate the response of cotton lint yield and fiber quality to K fertilization. In 2023, research was conducted in Marianna, AR (sites 1, 4, 5, 7, and 8), at the Lon Mann Cotton Research Station (LMCRS); in Fayetteville, AR (site 2), at the Milo J. Shult Agricultural Research and Extension Center (SAREC); and in Rohwer, AR (sites 3, 6, 9, and 10), at the Rohwer Research Station (RRS) on soils with Very Low ($<61 \text{ mg K kg}^{-1}$), Medium ($91\text{--}130 \text{ mg K kg}^{-1}$), and Optimum ($131\text{--}175 \text{ mg K kg}^{-1}$) STK, respectively. During the 2024 growing season, two field trials were conducted at LMCRS and one additional trial at RRS on soils with Very Low and Low ($61\text{--}90 \text{ mg K kg}^{-1}$) STK. The site location, soil series, and agronomic information for each trial are presented in Table 1. Plots were four rows wide (91 or 97 cm) and 12 m long for the 2023 trials and 15 m long for the 2024 trials, respectively. Each trial used a randomized complete block design with four replicates. High-yielding traits characterize the cultivars selected for this study and represent the cotton acreage of Arkansas and the Mid-South United States.

Data were also collected in the 2024 growing season from two long-term trials established in 2017 at LMCRS and RRS to examine the effects of cover crop (winter fallow or cover crop) and fertilizer-K rate (0, 56, 112, and 168 kg K ha^{-1}) on cotton yield response in a corn (*Zea mays* L.)–cotton–soybean [*Glycine max* (L.) Merr.] rotation (Smartt et al., 2024). A brief narrative of the field and crop management in the long-term trial is presented in the following text. In the first year,

TABLE 1 Site-year location, soil series, and agronomic information for K fertilization trials conducted at the University of Arkansas System Division of Agriculture’s properties during the 2023 and 2024 growing seasons.

Site	Year	Trial ID	Location	GPS coordinates	Soil series ^a	Soil-test K category	Cultivar ^b	Previous crop	Row width (cm)	Planting date
1	2023	LMCRS-G14A	Marianna	34.7297, -90.7363	Convent	Very Low	DP 2020 B3XF	Corn	97	May 17
2	2023	SAREC-15	Fayetteville	36.0957, -94.1787	Captina	Medium	DP 2020 B3XF	Fallow	91	May 8
3	2023	RRS-3B	Rohwer	33.7998, -91.2720	Sharkey and Desha	Optimum	DP 2020 B3XF	Soybean	97	May 16
4	2024	LMCRS-G14C	Marianna	34.7292, -90.7336	Convent	Very Low	NG 3195 B3XF	Soybean	97	May 21
5	2024	LMCRS-G15D	Marianna	34.7236, -90.7355	Convent	Low	PHY 411 W3FE	Corn	97	May 21
6	2024	RRS-1DS	Rohwer	34.7276, -90.7595	Herbert	Very Low	PHY 411 W3FE	Corn	97	May 29
7	2024	LMCRS-IBNf ^c	Marianna	34.7298, -90.7594	Calloway	Very Low–Optimum	NG 3195 B3XF	Corn	97	May 21
8	2024	LMCRS-IBNcc ^d	Marianna	34.7298, -90.7594	Calloway	Very Low–Optimum	NG 3195 B3XF	Corn	97	May 21
9	2024	RRS-1DNI ^e	Rohwer	33.8088, -91.2704	Herbert	Low–Above Optimum	PHY 411 W3FE	Corn	97	May 21
10	2024	RRS-1DNcc ^d	Rohwer	33.8088, -91.2704	Herbert	Very Low–Optimum	PHY 411 W3FE	Corn	97	May 21

Abbreviations: LMCRS, Lon Mann Cotton Research Station; RRS, Rohwer Research Station; SAREC, Milo J. Shult Agricultural Research and Extension Center.

^aPredominant soil series: Convent silt loam (45.2%; Coarse-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquepts; Captina silt loam (100%; Fine-silty, siliceous, active, mesic Typic Fragiudults); Calloway (54%; Fine-silty, mixed, active, thermic Aquic Fraglossudalfs); Herbert (59% silt loam, fine-silty, mixed, superactive, mesic Udollic Epiaqualfs); Sharkey and Desha silt loam (61.5%; Very-fine, smectitic, thermic Chromic Epiaquepts [Sharkey] and Vertic Hapludolls [Desha]) (Soil Survey Staff, 2024).

^bDP, Deltapine (Bayer Crop Science—St. Louis, Missouri); NG, NexGen (Americot—Lubbock, Texas); PHY, PhytoGen (Corteva Agriscience—Indianapolis, Indiana).

^cLong-term trial with winter fallow.

^dLong-term trial with cereal rye (*Secale cereale* L.) and hairy vetch (*Vicia villosa* Roth.) mix as winter cover crop.

corn was planted without fertilizer-K, followed by a cereal rye (*Secale cereale* L.) winter cover crop planted in the fall of 2017. Fertilizer treatment applications were initiated in the spring of 2018, followed by cotton in the 2018 growing season, soybean in 2019, and then maintaining the 3-year corn–cotton–soybean rotation throughout the duration of the trial. Following the corn harvest in fall 2023, cover crop treatments were established by drill seeding a 50:50 mix of cereal rye and hairy vetch (*Vicia villosa* Roth) at 40 kg seed ha⁻¹ in half of the plots, with 15-cm row spacing, in early November. Cotton was planted after cover crop termination in the spring of 2024. Plots were four rows (97-cm row spacing) wide and extended the length of each field, approximately 67 m at RRS and 79 m at LMCRS. The experimental design of each trial consisted of three replicates, a randomized complete block with a split-plot treatment structure where cover crop (with or without) was the main plot factor and fertilizer rate was the subplot factor. This study will not assess the interaction between cover crop and fertilizer-K rates; therefore, the main effect of K fertilization will be evaluated separately for winter fallow and cover crop treatments, totaling two site years per location (four sites in total; Table 1).

Composite soil samples (six to eight individual cores) were collected from each replicate at the 0- to 15-cm depth before planting and applying the fertilizer-K rate treatments in all the trials, except in long-term trials where two composite soil samples were collected from each plot to track the long-term effects of crop and nutrient management on soil test values. After sampling, the soil was oven-dried at 55°C for 48 h, ground in a mechanical grinder (Dynacrush soil crusher, Custom Laboratory) to pass through a sieve with 2-mm openings, and stored at room temperature for subsequent chemical analyses. Oven-dried soil samples were analyzed for pH (1:2 v/v soil/water mixture; Sikora & Kissel, 2014), Mehlich-3 extractable nutrients (H. Zhang et al., 2014), and soil organic matter by weight loss on ignition (Combs & Nathan, 2015). The nutrient concentrations of Mehlich-3 extracts were determined using inductively coupled plasma optical emission spectrophotometry (Spectro Arcos, Spectro Arcos model 160). Selected soil chemical characteristics from each location are shown in Table 2.

Fertilizer-K treatment rates were 0, 37, 75, 112, 150, and 187 kg K ha⁻¹ at single-site year trials (sites 1–6), and 0, 56, 112, and 168 kg K ha⁻¹ at long-term trials (sites 7–10) as muriate of potash (500 g K kg⁻¹). This wide range of fertilizer-K rates, applied to various STK values, enabled data collection on diverse soil K availabilities to assess the effect of K nutrition on cotton yield and fiber development. Treatments were broadcast applied and incorporated into the raised bed before planting for single-site-year trials and broadcast on the soil surface for long-term trials. Additionally, phosphorus (P), nitrogen (N), sulfur (S), and boron (B) were applied across the entire trial area to provide adequate nutrient availability for

plant development (Table 3). All crop management practices (e.g., irrigation, pest, and weed control) closely followed the University of Arkansas Cooperative Extension Service recommendations. Irrigation timing was scheduled according to the Arkansas Irrigation Scheduler, set for a 5-cm soil profile water level deficit.

2.1 | Cotton yield and fiber quality

At maturity, the two center rows of each plot were harvested with a spindle-type picker or handpicked (SAREC-15 only) for yield measurement. Before harvesting, a subsample of 15 cotton bolls (representing the bottom, middle, and top of the plant across five different plants) was collected from the two middle rows in all trials except RRS-3B. The subsamples were processed through a laboratory cotton saw gin to determine the weight and lint percentage. The lint yield was calculated by multiplying each trial's average fiber percentage (lint turnout obtained from raw cotton after ginning) per treatment by the corresponding total seed cotton yield of the treatment plots. For RRS-3B, the lint turnout was calculated by averaging the results from the other trials conducted in the same year using the same cultivar. Lint samples were submitted for High Volume Instrument (two mix, two colors, four lengths, and four strengths) analysis and included measurements of fiber length, micronaire, uniformity, strength, and elongation at the Fiber and Biopolymer Research Institute in the Department of Plant and Soil Science at Texas Tech University.

2.2 | Statistical analysis

Single-site-year trials were a randomized complete block design with four replicates. Long-term trials were a randomized complete block design with three replicates. Analysis of variance (ANOVA) was performed by location to evaluate the effect of fertilizer-K rate on cotton lint yield, relative yield (calculated by dividing the yield in each plot by the highest yielding treatment in each replicate and multiplying by 100; Pearce et al., 2022), lint turnout, and fiber quality parameters using the PROC GLIMMIX procedure of SAS v. 9.4 (SAS Institute Inc., 2013) with a gamma distribution and log transformation of data. Replicate was considered a random effect and fertilizer-K rates as a fixed effect in the ANOVA model, and differences being interpreted as significant at $\alpha = 0.10$. Regression analysis was performed using the REG procedure in SAS to evaluate the relationship between fertilizer-K rate and treatment mean values of cotton lint yield. The graphical results were displayed using SigmaPlot 15.0 (Systat Software, Inc., 2022). The studentized residual (>2.5) and Cook's D (>0.16) statistics were reviewed to identify potential outliers and influential data. When

TABLE 2 Mean soil pH, Mehlich-3 extractable nutrients, and soil organic matter (SOM) in the 0- to 15-cm depth prior to fertilizer-K treatment application and planting of cotton K response trials during the 2023 and 2024 growing seasons.

Site ^a	pH ^b	Mehlich-3 extractable nutrients ^d										SOM ^e (g kg ⁻¹)
		P (mg kg ⁻¹)	K ^c (mg kg ⁻¹)	Ca (mg kg ⁻¹)	Mg (mg kg ⁻¹)	S (mg kg ⁻¹)	Fe (mg kg ⁻¹)	Mn (mg kg ⁻¹)	Zn (mg kg ⁻¹)	Cu (mg kg ⁻¹)	B (mg kg ⁻¹)	
1	7.8	31	53 (4.4)	1357	306	7.3	315	217	2.5	2.0	0.5	16
2	5.8	80	114 (17.4)	501	32	7.9	153	145	7.3	0.9	0.2	13
3	6.1	71	173 (19.8)	1346	215	12.9	310	151	6.1	1.8	0.7	20
4	6.5	15	47 (3.1)	931	218	3.8	125	117	1.7	0.9	0.8	24
5	6.6	49	85 (10)	1516	408	4.5	149	116	2.4	1.3	0.8	21
6	6.5	17	56 (6.9)	679	120	4.7	154	87	2.6	0.7	0.9	18
7	7.4	38	^{-f}	1147	315	5.3	171	125	4.1	1.2	0.4	15
8	7.1	34	^{-f}	1196	294	5.7	169	120	3.5	1.2	0.4	18
9	6.5	38	^{-f}	725	115	4.9	217	101	3.0	0.7	0.7	14
10	6.5	38	^{-f}	765	109	5.2	247	108	3.1	0.7	0.8	16

^aTrial location and agronomic information are presented in Table 1.

^bSoil pH measured in a 1:2 (weight:volume) soil–water mixture (Sikora & Kissel, 2014).

^cMean (± standard deviation). Soil test K categories are Very Low (<61 ppm); Low (61–90 ppm); Medium (91–130 ppm); Optimum (131–175 ppm).

^dH. Zhang et al. (2014).

^eSOM, soil organic matter as determined by loss on ignition (Combs & Nathan, 2015).

^fSoil-test K values as affected by annual fertilizer-K rate treatments are shown in Table 3. Other soil chemical properties are presented for the no-K control.

TABLE 3 Fertilizer rate information and application method for cotton K response trials during the 2023 and 2024 growing seasons.

Site ^a	K rate treatments ^b (kg ha ⁻¹)	K Application method ^c	Nutrient rate applied across the trial area			
			P ^d (kg ha ⁻¹)	N (kg ha ⁻¹)	S ^e (kg ha ⁻¹)	B ^f (kg ha ⁻¹)
1	0, 37, 75, 112, 150, 187	Incorporated	34	34 ^e + 90 ^g	38	0.6
2	0, 37, 75, 112, 150, 187	Incorporated	34	34 ^e + 90 ^g	38	0.6
3	0, 37, 75, 112, 150, 187	Incorporated	34	34 ^e + 90 ^g	38	0.6
4	0, 37, 75, 112, 150, 187	Incorporated	44	34 ^e + 90 ^g	38	0.6
5	0, 37, 75, 112, 150, 187	Incorporated	44	30 ^h + 90 ^g	—	0.3
6	0, 37, 75, 112, 150, 187	Incorporated	34	30 ^h + 140 ⁱ	—	0.3
7	0, 56, 112, 168	Broadcast	23	103 ^g	—	0.3
8	0, 56, 112, 168	Broadcast	23	103 ^g	—	0.3
9	0, 56, 112, 168	Broadcast	23	135 ⁱ	—	0.3
10	0, 56, 112, 168	Broadcast	23	135 ⁱ	—	0.3

^aTrial location and agronomic information are presented in Table 1.

^bApplied as muriate of potash (500 g K kg⁻¹).

^cPhosphorus and potassium were broadcast applied and incorporated into the raised bed before planting, or broadcast on the soil surface for long-term trials (sites 7–10).

^dApplied as triple superphosphate (201 g P kg⁻¹).

^eApplied as ammonium sulfate (210 g N kg⁻¹; 240 g S kg⁻¹) preplant incorporated.

^fFoliar application of Solubor (U.S. Borax Inc.) between first square and first flower.

^gApplied as urea (460 g N kg⁻¹), broadcast on the soil surface between first square and first flower.

^hApplied as urea preplant incorporated.

ⁱApplied as urea ammonium nitrate (320 g N kg⁻¹), incorporated, between first square and first flower.

necessary, outlying or influential observations were omitted, and the model was refitted.

3 | RESULTS

3.1 | Cotton lint yield response to potassium fertilization

Cotton lint yield was significantly ($p \leq 0.10$) affected by fertilizer-K rate in five out of six single-site-year trials (Figure 1). For these sites, a strong quadratic relationship was observed between fertilizer-K rate and cotton yield, with R^2 values ranging from 0.81 to 0.95, indicating that fertilizer-K rate explained a high proportion of the yield variability. Overall, on responsive sites with Very Low or Low STK, near maximum cotton lint yield was observed with the application of 75 kg K ha⁻¹ or 112 kg K ha⁻¹, an average yield increase of 45% and 69% compared to the no-K control, respectively. Likewise, a 20% increase in yield was observed in the Medium STK site, with a fertilizer rate of 37 kg K ha⁻¹ producing near maximum yield. Cotton lint yield in the no-K control treatment ranged from 370 to 1500 kg lint ha⁻¹, with an overall mean of 1087 kg lint ha⁻¹, whereas the maximum yields in plots with K fertilization ranged from 1065 to 1869 kg lint ha⁻¹, with an overall mean of 1548 kg lint ha⁻¹. No significant yield response to K fertilization was observed in the Optimum (site 3) STK site, but there was a numerical trend of 32% yield increase with the application of 37 kg K ha⁻¹ in relationship to the no-K control.

In the long-term trials, the continuous application of fertilizer-K rate treatments to the same plots significantly ($p \leq 0.10$) affected STK (Table 4). Overall, STK increased as fertilizer-K rate increased at all sites. These changes in soil K availability associated with fertilizer-K rate resulted in positive cotton lint yield responses (Figure 2). A significant yield increase from K fertilization was observed at LMCRS (sites 7 and 8), regardless of winter cover crop treatment. Lint yield increased from 592 (site 7) and 1595 (site 8) kg lint ha⁻¹ at the no-K control to an average of 1380 and 1848 kg lint ha⁻¹ for fertilized treatments, respectively. In contrast, at the RRS location, only site 9 (winter fallow) responded to K fertilization, with an overall 43% greater yield from the application of 56 kg K ha⁻¹ year⁻¹. No significant yield response occurred at site 10 (winter cover crop), but a numerical increase was also observed for the 56 kg K ha⁻¹ year⁻¹ in comparison to the no-K control. These findings highlight the importance of adequate K supply to maintain crop yield while enhancing soil K availability over time.

3.2 | Cotton lint turnout and fiber quality

Potassium fertilization positively affected cotton lint turnout and quality in both single-site-year and long-term trials (Tables 5 and 6). Overall, lint turnout was positively affected by K availability in five out of nine trials where lint quality was measured and was positively correlated with relative yield ($r = 0.35$, $p < 0.001$), with an overall lint increase ranging from 1.35% to 4.15% compared to the no-K control.

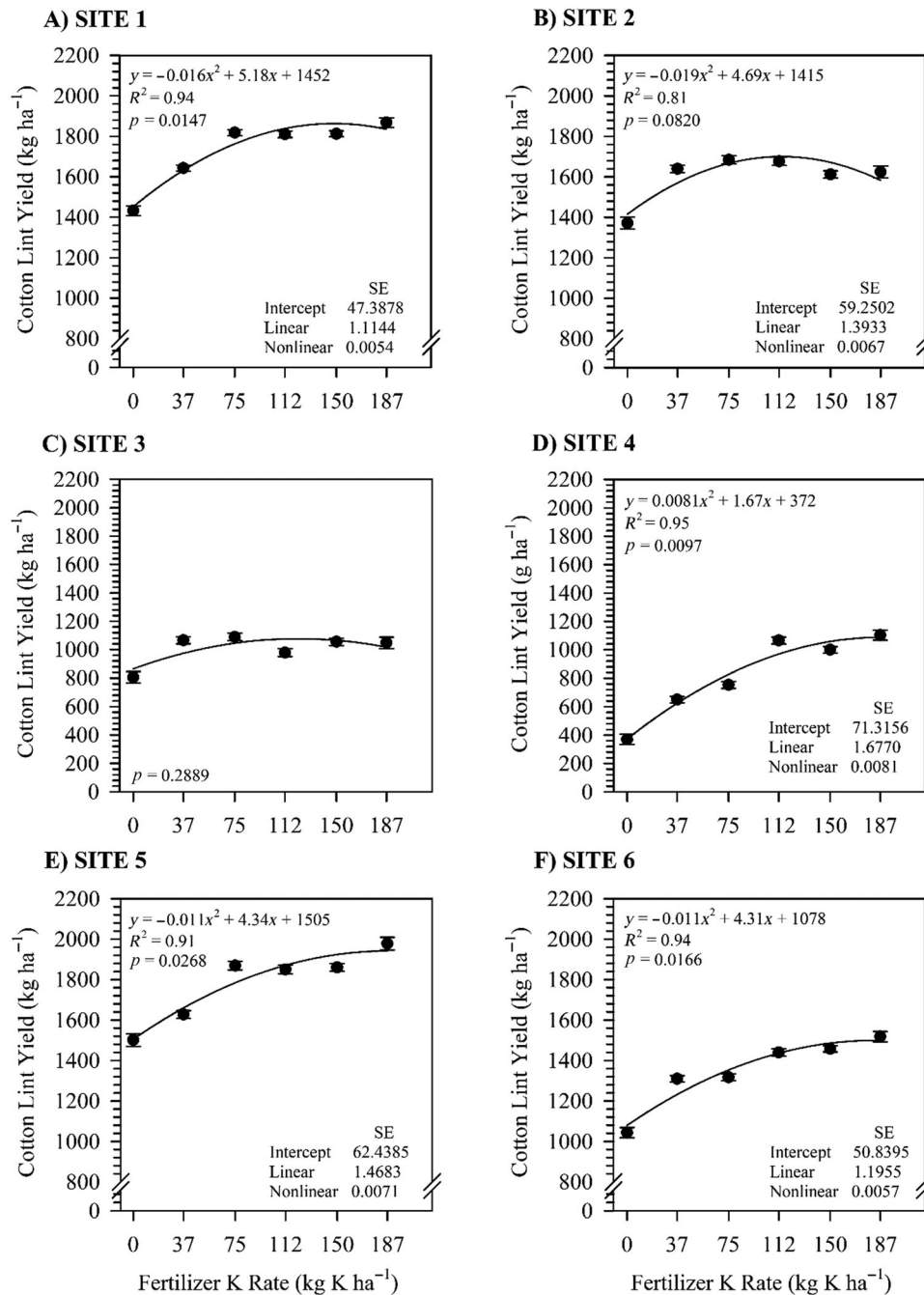


FIGURE 1 Cotton lint yield response to K fertilization in single-site-year trials conducted during the 2023 and 2024 growing seasons at Lon Mann Cotton Research Station (LMCRS), near Marianna, AR (sites 1, 4, and 5), Milo J. Shult Agricultural Research and Extension Center (SAREC), near Fayetteville, AR (site 2), and Rohwer Research Station (RRS), near Rohwer, AR (sites 3 and 6).

Likewise, K availability also significantly affected fiber quality parameters, including micronaire, uniformity, strength, elongation, and length in at least one experimental trial (Tables 5 and 6). Overall, fiber elongation was the most responsive trait to fertilizer-K application across multiple trials conducted in our study, with an overall increase ranging from 0.29 to 0.41 percentage points within yield-maximizing K rate treatments compared to the no-K control. Additionally, strength and micronaire showed significant responses to K fertilization in three of the long-term trials, as well as single-

site-year trials with Very Low STK. Across responsive sites (i.e., sites 1, 4, 6, 7, 8, and 10), fiber strength had an average increase of 1.84 and 1.75 g tex⁻¹ with either the 37 or 75 kg K ha⁻¹ application compared to the no-K control. Meanwhile, in sites 4, 6, 7, 8, and 9, micronaire increased on average by 0.50 with the 112 kg K ha⁻¹ application compared to the no-K control. Fiber length and uniformity were affected by fertilizer-K rate in three out of the nine trials. Fiber length was affected by K fertilization only in the long-term trials, where the no-K control had the greatest fiber lengths; a similar trend was

TABLE 4 Mean Mehlich-3 extractable K in the 0- to 15-cm depth as affected by annual fertilizer-K application in long-term trials during the 2024 growing season.

K rate (kg K ha ⁻¹)	Sites ^a (mg K kg ⁻¹)			
	7	8	9	10
0	57 (7)c	67 (15)d	66 (6)d	57 (12)b
56	98 (30)b	88 (6)c	109 (16)c	75 (24)b
112	135 (14)a	124 (8)b	147 (18)b	120 (5)a
168	174 (11)a	168 (11)a	181 (32)a	139 (8)a
CV (%)	15.6	9.4	16.0	14.6
<i>p</i> -value	<i>0.0003</i>	<i>0.0003</i>	<i>0.0001</i>	<i>0.0018</i>

Note: Means ($\pm$ standard deviation) followed by the same lowercase letter are not different at the 0.10 probability level. *p*-values in italics indicate statistical significance at the 0.10 probability level.

Abbreviation: CV, coefficient of variation.

^aTrial location and agronomic information are presented in Table 1.

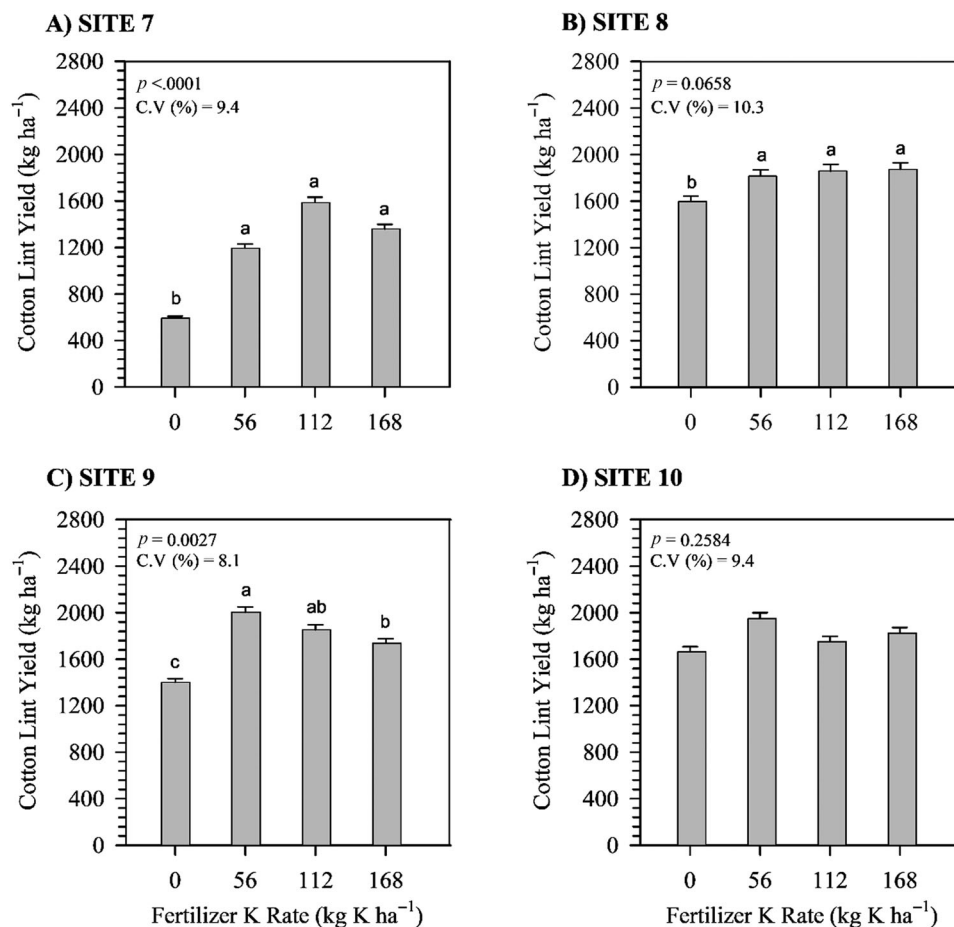


FIGURE 2 Cotton lint yield response to K fertilization in long-term field trials during the 2024 growing season at the Lon Mann Cotton Research Station (LMCRS), near Marianna, AR (sites 7 and 8), and the Rohwer Research Station (RRS), near Rohwer, AR (sites 9 and 10). Crop yield response is related to long-term fertilizer-K rates applied to the same plots (since 2018); Mehlich-3 extractable K values for each fertilizer-K rate treatment are presented in Table 3. Sites 7 and 9 were fallow, while sites 8 and 10 had a winter cover crop (50:50 mix of cereal rye and hairy vetch). Means followed by the same lowercase letter are not different at the 0.10 probability level.

TABLE 5 Mean cotton lint yield and fiber quality in K fertilization trials carried out on soils with different soil K availabilities in Arkansas during the 2023 and 2024 growing seasons.

Site ^a	K rate (kg K ha ⁻¹)	RY ^b (%)	Lint quality parameters					Length (mm)
			Turnout ^c	Uniformity	Elongation	Micronaire (–)	Strength (g tex ⁻¹)	
1	0	73c	38.6c	83.0c	5.03d	4.50	29.5b	1.23
	37	84b	39.7bc	83.8ab	5.23c	4.70	31.6a	1.22
	75	93a	40.0ab	83.8ab	5.40bc	4.62	31.0a	1.22
	112	94a	39.4c	84.3a	5.38bc	4.67	30.9a	1.24
	150	93a	40.2a	84.0ab	5.50ab	4.68	30.7a	1.22
	187	96a	40.1ab	83.4bc	5.68a	4.49	30.7a	1.20
CV (%)		7.3	1.2	0.6	3.4	7.7	2.4	1.5
p-value		<i>0.0004</i>	<i>0.0029</i>	<i>0.0650</i>	<i>0.0008</i>	0.9191	<i>0.0288</i>	0.1135
2	0	76	42.9	81.2	5.88b	4.29	30.2	1.16
	37	90	44.0	82.5	6.23a	4.30	30.0	1.16
	75	92	42.9	82.5	6.20a	4.38	30.4	1.19
	112	91	43.6	80.9	6.35a	4.39	30.0	1.17
	150	87	43.9	80.9	6.13ab	4.58	30.6	1.14
	187	89	43.5	80.9	6.37a	4.29	28.5	1.20
CV (%)		15.2	1.9	1.8	3.7	6.9	3.9	3.5
p-value		0.5005	0.2760	0.2185	<i>0.0735</i>	0.7379	0.2050	0.3224
4	0	31c	38.6c	82.1b	5.40c	3.76d	28.0c	1.14
	37	54b	42.7b	82.6ab	5.55b	4.32bc	28.9bc	1.15
	75	61b	43.1b	82.9a	5.53b	4.23c	29.8ab	1.15
	112	91a	46.4a	83.0a	5.78a	4.51ab	29.9ab	1.14
	150	85a	46.2a	83.1a	5.78a	4.67a	29.8ab	1.15
	187	93a	45.0ab	83.1a	5.67a	4.72a	30.2a	1.15
CV (%)		12.9	4.7	0.7	1.5	5.0	3.3	2.3
p-value		<i><0.0001</i>	<i>0.0002</i>	<i>0.0945</i>	<i><0.0001</i>	<i><0.0001</i>	<i>0.0409</i>	0.8538
5	0	76c	48.0	82.4	6.70	4.83	30.1	1.08
	37	81c	50.6	82.3	6.80	4.84	30.6	1.09
	75	94ab	51.7	82.6	6.55	4.90	30.1	1.09
	112	92b	49.4	82.4	6.75	5.00	30.4	1.08
	150	92ab	48.7	82.6	6.83	5.05	30.4	1.09
	187	99a	49.1	82.5	6.78	5.20	30.5	1.07
CV (%)		5.3	6.0	0.7	4.0	6.6	3.2	1.7
p-value		<i>0.0001</i>	0.5391	0.9846	0.7403	0.4334	0.9512	0.5862
6	0	67c	42.9	82.7	6.10c	4.86b	29.8c	1.10
	37	92ab	44.0	82.5	6.25bc	4.80b	31.4a	1.13
	75	89ab	44.7	82.3	6.58a	5.16a	30.6b	1.10
	112	97a	43.7	83.0	6.30bc	5.12a	31.1ab	1.11
	150	86b	43.7	83.2	6.45ab	5.00ab	31.2ab	1.11
	187	92ab	44.7	82.9	6.40ab	5.13a	30.8ab	1.10
CV (%)		10.6	0.2	0.6	3.4	3.8	2.1	1.6
p-value		<i>0.0016</i>	0.2284	0.1915	<i>0.0746</i>	<i>0.0657</i>	<i>0.0362</i>	0.3543

Note: p-values in italics indicate statistical significance at the 0.10 probability level.

Abbreviation: CV, coefficient of variation.

^aTrial location and agronomic information are presented in Table 1. Site 3 was not included in the fiber quality analysis.

^bRelative lint yield was calculated by dividing the yield in each plot by the highest yielding treatment in each replicate and multiplying by 100 (Pearce et al., 2022).

^cLint turnout is presented as the percentage of fiber obtained from raw cotton after ginning.

TABLE 6 Mean cotton lint yield and fiber quality in long-term K fertilization trials carried out in Arkansas during the 2023 and 2024 growing seasons.

Site ^a	K rate (kg K ha ⁻¹)	Lint quality parameters						
		RY ^b (%)	Turnout ^c (%)	Uniformity (%)	Elongation (%)	Micronaire (–)	Strength (g tex ⁻¹)	Length (mm)
7	0	33b	43.2b	83.2	5.53	4.54b	30.8b	1.17
	56	81a	46.3a	84.3	5.93	4.95a	30.3b	1.15
	112	89a	46.4a	83.9	6.27	4.95a	30.3b	1.15
	168	84a	44.3b	84.2	6.27	5.07a	31.7a	1.13
	CV (%)	17.5	2.2	0.6	14.8	4.5	1.7	1.2
<i>p</i> -value		<i>0.0002</i>	<i>0.0297</i>	0.1165	0.7480	<i>0.0637</i>	<i>0.0825</i>	0.1641
8	0	84b	44.6b	83.4	5.90b	4.75b	29.8ab	1.18a
	56	96a	45.4ab	84.0	6.10ab	5.07a	31.4a	1.18a
	112	98a	45.5ab	83.2	6.30a	4.98a	30.6bc	1.15b
	168	99a	46.2a	84.0	6.33a	5.14a	31.1c	1.15b
	CV (%)	6.4	1.4	0.5	2.8	2.6	2.6	1.7
<i>p</i> -value		<i>0.0849</i>	<i>0.0940</i>	0.1285	<i>0.0527</i>	<i>0.0287</i>	<i>0.0219</i>	<i>0.0030</i>
9	0	78	44.3	82.7	6.37b	5.33b	31.1	1.12a
	56	98	45.8	82.5	6.73a	5.30b	31.1	1.13a
	112	92	47.5	82.3	6.77a	5.47a	30.0	1.09b
	168	86	46.6	83.0	6.67a	5.30b	30.1	1.09b
	CV (%)	14.0	2.9	0.7	1.7	2.4	2.7	1.7
<i>p</i> -value		0.2653	0.1445	0.6988	<i>0.0008</i>	<i>0.0764</i>	0.2953	<i>0.0454</i>
10	0	83	46.5b	83.0a	6.47b	5.27	30.4a	1.11a
	56	97	47.8a	81.9c	6.93a	5.26	29.3b	1.09b
	112	87	46.3b	82.2bc	6.90a	5.13	29.8ab	1.12a
	168	91	47.0ab	82.8ab	6.97a	5.30	30.6a	1.11a
	CV (%)	10.5	1.3	0.6	1.9	1.4	1.8	1.0
<i>p</i> -value		0.3254	<i>0.0735</i>	<i>0.0585</i>	<i>0.0022</i>	0.1600	<i>0.0848</i>	<i>0.0260</i>

Note: *p*-values in italics indicate statistical significance at the 0.10 probability level.

Abbreviation: CV, coefficient of variation.

^aTrial location and agronomic information are presented in Table 1.

^bRelative lint yield was calculated by dividing the yield in each plot by the highest-yielding treatment in each replicate and multiplying by 100 (Pearce et al., 2022).

^cLint turnout is presented as the percentage of fiber obtained from raw cotton after ginning.

observed for fiber uniformity at site 10. However, fiber uniformity was positively affected by increasing fertilizer-K rate in two single-site-year trials (sites 1 and 4, with Very Low STK) and increased on average 0.67% with the application of 37 kg K ha⁻¹ compared to the no-K control.

4 | DISCUSSION

4.1 | Cotton lint yield response to potassium fertilization

Cotton lint yield increased significantly with fertilizer-K application, particularly in soils with Low or Very Low Mehlich-3 extractable K (Figures 1 and 2). The majority of

single-site-years had Very Low or Low STK (four out of six), reflecting the STK level distribution of Arkansas cotton acreage (DeLong et al., 2024, 2025). In Arkansas, the “build and maintain” fertilization philosophy is the basis for soil-test-based fertilizer-K recommendations for cotton. Hence, fertilizer-K rates are recommended to provide sufficient K to meet the crops’ needs and maintain and build up soil-K levels over time (Hochmuth et al., 2014). However, regardless of the fertilization philosophy, growers and crop consultants continuously report K deficiency symptoms in cotton, which has led producers to the most intuitive response: increase fertilizer-K rates with the hope of increasing yield.

The overarching questions we aimed to answer are: *How do cotton yield responses and yield-maximizing fertilizer-K rates*

from this study align with current recommendations? Also, is there a need to increase fertilizer-K rates to maximize yield for modern, high-yielding cotton cultivars? Current fertilizer-K rate recommendations for cotton in Arkansas suggest a preplant K application of 130 and 88 kg K ha⁻¹ on soils with Very Low and Low STK, respectively (Robertson et al., 2022). Our results showed that fertilizer-K rates of 56 (long-term trials), 75 (sites with Low STK), and 112 kg K ha⁻¹ (sites with Very Low STK) produced near-maximal cotton lint yields (Figures 1 and 2). These results align with current recommendations that aim to maximize crop yield, provide additional K to build STK, and replenish nutrient removal or loss to maintain optimal STK values. Although higher fertilizer-K rates led to further yield increases, these improvements were generally small and not statistically significant. Similar results were reported by Lewis et al. (2021) in rainfed and irrigated cotton trials across the United States Cotton Belt, where soils with Low STK responded positively to broadcast K fertilization, resulting in an overall 40% yield increase from the application of 112 kg K ha⁻¹ in relation to the no-K control. In the same study, trials in Arkansas on silt loam soils with STK ranging from 158 to 174 mg K ha⁻¹ did not respond to K fertilization. Surprisingly, site 10 with Very Low STK did not significantly respond to K fertilization; only a numerical increase was observed at the lowest fertilizer-K rate. This lack of significant yield response may be associated with the contribution of K cycled by cover crops. In the spring of 2024, winter cover crops produced ~12.3 metric tons of biomass in the no-K control at RRS and accumulated 201 kg K ha⁻¹ (data not shown); this K can be released to the soil throughout the growing season and contribute to cotton K nutrition, but is not captured by soil testing. Oliver et al. (2022) reported that positive economic returns are expected from K applications in soils with Mehlich-3 STK < 120 mg K kg⁻¹. However, for STK values near this threshold, further increases in fertilizer-K rates did not result in a yield increase large enough to generate a return on investment (i.e., offset the cost of fertilizer and application, considering 10-year average crop and fertilizer prices). Therefore, results from 10 sites with modern, high-yielding cotton cultivars suggest that increasing fertilizer-K rates beyond current fertilizer-K recommendations did not consistently lead to further yield improvements.

Our results reinforce the importance of adequate K fertilization, as maximizing cotton yield without adding fertilizer-K was unachievable on soils with sub-optimum K availability. At the Optimum STK site, only a numerical yield increase was observed with the lowest fertilizer-K rate, suggesting that K fertilization in soils with Optimum STK maintains soil test values (Table 4), may increase plant vigor, but without an agronomic yield response. Other studies have reported cotton yield increases from K fertilization in soils with Mehlich-3 extractable K values greater than the 120 mg K kg⁻¹ threshold suggested by Oliver et al. (2022). Kusi et al. (2021) reported

a 16% cotton yield increase with a 75 kg K ha⁻¹ preplant application in Amarillo fine sandy loam (fine-loamy, mixed, superactive, thermic Aridic Paleustalf) with 292 mg K kg⁻¹ Mehlich-3 extractable K, using a surface drip irrigation production system. Kommineni and Bhandari (2024) reported a 25% yield increase with a 50 kg K ha⁻¹ application in sandy clay loam soil (fine, mixed, active, thermic Typic Paleudult) with 370 mg K kg⁻¹ Mehlich-3 extractable K in a dryland cotton production system. However, these studies (Kommineni & Bhandari, 2024; Kusi et al., 2021) were performed on soils with low cation exchange capacity and greater K loss potential (Öborn et al., 2005), or in a drip irrigation system that concentrates the plant root system in the moist soil layer and limits the K absorption from the bulk soil, which may help explain the positive yield response to K fertilization on soil with greater STK. Furthermore, the yield response to K fertilization in dryland systems with high STK may be attributed to K fixation dynamics for soils in a semi-arid climate (Simonsson et al., 2009). Although the amount of K extracted with Mehlich-3 is inconsistently affected by soil moisture due to soil-specific mineralogical interactions (Martins et al., 2015), dry field conditions can increase K fixation (Barbagelata & Mallarino, 2013) and limit K solubilization and plant uptake (Sardans & Peñuelas, 2015), which may lead to an overestimation of soil K availability and a weak correlation between STK and crop yield response. In contrast, in furrow-irrigated systems, consistent soil moisture facilitates K solubility, diffusion, and plant uptake, reducing the likelihood of a yield response at similar STK values. These features reinforce the need for continuous research to fine-tune nutrient management for specific regions, soils, or production systems, as generalized recommendations may lead to overuse or underuse of fertilizers, affecting overall nutrient use efficiency, farming profitability, and/or the environment.

Crop management factors such as planting date, cultivar, and environmental conditions can potentially affect crop yield response to fertilization. For instance, the timing and availability of soil moisture can influence the lint yield response to K fertilization, as K uptake is directly related to water availability (Denton et al., 2023; Mullins & Burmester, 1990). Additionally, it is important to note that in Arkansas, cotton is most commonly grown on raised beds and furrow-irrigated, where fertilizer-K is typically applied preplant and incorporated into the bed. This system concentrates fertilizer-K into the bed, enhancing K availability for plant roots. Therefore, furrow-irrigated cotton may respond differently to K fertilization than dryland systems and other management systems (Drescher et al., 2021). Our results are supported by research in soybean (Mallarino et al., 1991; Popp et al., 2020; Slaton et al., 2010), corn (Drescher et al., 2021; Mallarino et al., 1991; Oliver et al., 2022), and rice (*Oryza sativa* L.; Gruener et al., 2022; Popp et al., 2021; Slaton et al., 2009) that suggests economic benefits from K fertilization primarily occur

when STK levels are Very Low or Low for Arkansas silt loam soils.

The differences in soil texture and mineral composition that affect soil K availability, as well as the contrasting yield responses to K fertilization in dryland and furrow-irrigated systems, underscore the need for continuous research to fine-tune K management strategies and optimize cotton production. The complex dynamics of soil K combined with the plant's strategy of retaining K in vegetative tissues without directly enhancing yield (i.e., luxury consumption) further increase the challenge of understanding and predicting yield response frequency and magnitude solely based on fertilizer-K rates or STK (Lewis et al., 2021). Long-term fertility research has also indicated that cotton yield is more affected by K deficiency compared to corn and soybean (Mitchell et al., 2005), highlighting the importance of adequate K management to maintain soil productivity over time.

4.2 | Cotton lint turnout and fiber quality parameters

Cotton lint turnout and quality parameters were significantly affected by K fertilization across different STK values (Tables 5 and 6). Potassium fertilization increased lint turnout by 1.35% to 4.15% compared to the no-K control, indicating the importance of adequate K nutrition for fiber development. These results align with the findings of Gormus (2002), who reported that the absence of K fertilization resulted in a K deficiency leading to a reduction in lint turnout. Although many other studies have reported the impact of K fertilization on lint quality, the impact of K fertilization on each specific fiber parameter remains inconsistent (Davis et al., 2024; Gormus, 2002; Hussain et al., 2021; Kommineni & Bhandari, 2024; Kusi et al., 2021; Pervez et al., 2005). For instance, a study by Tariq et al. (2018) found no clear association between fiber quality and K fertilization. In our study, this pattern of no consistent response was only observed for fiber length, where long-term trials showed a negative effect of K fertilization (Table 6), and uniformity demonstrated inconsistent behavior across sites (e.g., positively affected by K fertilization in sites 1 and 4, and negatively affected by K fertilization on site 10). Research by Davis et al. (2024) also reported that fiber quality parameters responded positively to K fertilization, although no significant response was observed for fiber length. A lack of fiber length response to K fertilization is expected, as this trait exhibits high heritability and varies among cultivars (Bourland et al., 2025; Percy et al., 2006). For the majority of fiber quality parameters, there was a positive relationship between K availability and fiber quality.

Selecting the right cultivar is crucial for cotton lint quality (Hu et al., 2018; Kusi et al., 2021), as cotton cultivars may respond differently to fertilization (McClanahan et al., 2020),

differ in dry matter partitioning from vegetative to reproductive growth stages compared to older cultivars (Bridge et al., 1971; Coker et al., 2009), and vary in yield potential, maturity, and growth habits (Rochester & Constable, 2015; Virk et al., 2023). Although cultivar traits associated with fiber quality were not statistically compared in our study, it is worth noting that fiber elongation was the most consistently responsive trait to K fertilization across all field trials, highlighting its sensitivity to K availability. Kusi et al. (2021) reported that fiber elongation increased by 0.50% with the application of 150 kg K ha⁻¹ compared to the no-K control. Additionally, variations in rainfall and prevailing environmental conditions play a crucial role in determining cotton fiber quality (Darawsheh et al., 2022; Iqbal et al., 2021), which may help explain the diverse responses in fiber quality reported in the literature.

Field studies by Kommineni and Bhandari (2024), Hussain et al. (2021), Davis et al. (2024), and Bennett et al. (1965) observed responses in at least one of the following fiber quality parameters: length, strength, uniformity, or micronaire. Similarly, the cotton in certain site-years of our study exhibited significant differences in fiber strength, micronaire, and uniformity with increased K availability. Kommineni and Bhandari (2024) reported a 3% increase in fiber uniformity with the application of 50 kg K ha⁻¹ in relation to the no-K control on soil with 370 mg K kg⁻¹ Mehlich-3 extractable K. Compared to the results of our study, uniformity increased by only 0.67% (with the yield-maximizing fertilizer-K application of 37 kg K ha⁻¹). Davis et al. (2024) reported significant two-way interaction differences in fiber quality micronaire as a result of K fertilization and irrigation. Likewise, Bennett et al. (1965) reported that the fiber micronaire index of irrigated cotton increased with K fertilization, which aligns with our findings in furrow-irrigated systems using modern cultivars. The positive impact of K nutrition on some fiber quality metrics reinforces the importance of adequate K fertilization. Cotton with superior fiber quality can provide a market advantage for growers as fiber quality directly influences market value by raising the price for premiums (particularly length, strength, and micronaire are closely tied to processor preferences), whereas lower fiber quality leads to discounts (Bradow & Davidonis, 2000). For instance, considering the mean value of \$1.75 kg⁻¹ of fiber for the 2023 and 2024 growing seasons (United States Department of Agriculture, 2024) and the marketing quality generated by the 2024 Upland Loan Calculator (Cotton Incorporated, 2024), the yield-maximizing treatments of sites 1, 4, and 6 (i.e., sites with consistent responses of length, strength, and/or micronaire to K fertilization) would have an average 1.3% increased marketing value with adequate K fertilization compared to the no-K control. For the maximum yields of 1818, 1065, and 1440 kg lint ha⁻¹ observed in sites 1, 4, and 6, respectively (Figure 1), the marked advantage associated with fiber quality alone would result in \$43, \$66, and \$29 increased revenue per

hectare, which illustrates the economic benefit of optimal K management for both cotton yield potential and fiber quality.

Breeding programs are consistently working to address the negative relationship between agronomic performance and fiber quality (Campbell, 2021; Constable et al., 2015). The overall yield and fiber quality results observed in this study suggest that soil K availability and fertilization influence cotton performance, and both should be carefully considered in K management decisions. Additionally, the overall response of lint quality to K fertilization was more frequent in long-term trials than in single-site-year trials. This may be due to more intense K depletion in control plots (no-K applied) throughout the years, resulting in more severe and consistent K deficiency than in the single-year treatment trials, thereby suggesting that K management decisions may have a greater impact on fiber development over time.

5 | CONCLUSIONS

Our goal was to investigate cotton yield and fiber quality responses to K fertilization on soils with different K availability and determine if fertilizer-K rate recommendations need to be adjusted for furrow-irrigated cotton production in Arkansas. Results across 10 field trials (six short-term and four long-term experiments) encompassing three locations and three modern, high-yielding cotton cultivars showed that cotton lint yield was greatly influenced by K availability, with significant yield increases occurring in soils with Very Low, Low, and Medium STK (≤ 130 mg K kg⁻¹). Maximizing cotton yields without adding fertilizer-K was unachievable in K-deficient soils. As expected, K fertilization in soil with Optimum STK (131–175 mg K kg⁻¹) or above did not significantly increase cotton lint yield. The novel aspect of our research is providing robust evidence that the fertilizer-K rates required to maximize cotton yield in K-deficient Arkansas soils align with current soil-test-based fertilizer-K rate recommendations using a “build and maintain” fertilization philosophy, and suggest no need to increase fertilizer-K rates for optimal furrow-irrigated cotton production in Arkansas. Additionally, we show evidence that lint turnout and quality are positively affected by K fertilization, with fiber elongation and strength being more strongly related to K availability than other lint quality parameters.

Overall, our findings show that lint yield and fiber quality are greatly impacted by K availability and that fertilizer-K rates above current recommendations did not increase yield or fiber quality. These results underscore the need for strong educational programs to demonstrate the importance of soil testing and adequate K management for optimal cotton production, lint quality, and farm profitability. Research needs to further investigate fertilizer-K rate calibration for cotton

and tools to diagnose in-season K deficiencies, and determine whether in-season K fertilization can correct K-deficient cotton, increase K use efficiency, and maintain optimal cotton yield potential. These efforts should include objectives documenting how K availability and K fertilization timing affect fiber development and quality in diverse modern cotton cultivars.

AUTHOR CONTRIBUTIONS

Maria Paula R. Prado: Data curation; formal analysis; investigation; methodology; writing—original draft; writing—review and editing. **Gerson L. Drescher:** Conceptualization; data curation; funding acquisition; investigation; methodology; project administration; resources; supervision; visualization; writing—original draft; writing—review and editing. **Trenton L. Roberts:** Conceptualization; funding acquisition; investigation; methodology; resources; visualization; writing—review and editing. **Nathan A. Slaton:** Conceptualization; funding acquisition; investigation; methodology; resources; visualization; writing—review and editing. **Alden D. Smartt:** Data curation; investigation; methodology; visualization; writing—review and editing. **Fred M. Bourland:** Investigation; methodology; resources; visualization; writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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