IMPACT OF POTASSIUM FERTILIZER APPLICATION RATE AND METHOD ON COTTON LINT YIELD AND QUALITY

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INTRODUCTION

The increased yield potential of modern cotton varieties has pushed lint yields to three to four bales acre^{-1} and possibly 5 under subsurface drip irrigation, and as a result greater demands are being placed on cotton root systems to take up sufficient water and nutrients, with potassium (K) uptake being of particular concern. Potassium plays a major role in several critical plant processes, including photosynthesis, activation of protein enzymes, disease and drought resistance, and cotton fiber development and maturity. As K demands have increased, deep-profile soil sampling has indicated decreasing levels of plant available K in the soil of some production areas. Even though K levels are decreasing, most Texas soils are considered close to or greater than the critical level of K (150 ppm), and as a result, K is not included in nutrient management plans. Possibly a consequence of this, K deficiency symptoms in cotton have become more prevalent and severe over the past decade. Insufficient plant K during cotton's reproductive stage may decrease lint yields and fiber quality and subsequently decrease grower profits.

The first objective of this project was to quantify the soil extractable K concentrations, surface and with depth, from several major cotton production regions in the Cotton Belt experiencing K deficiencies. The second objective was to evaluate the impact of application methods and rates of K on cotton yield, quality, and return on investment. Based on these findings, soil K recommendations will be re-evaluated and modified as appropriate to optimize yields.

MATERIALS AND METHODS

This study was conducted at the AG-CARES farm in Lamesa, Dawson County, TX (32.766492°, -101.946370°) and was one of 13 locations to carry out this study. In season rainfall totaled 12.4 inches. Through subsurface drip irrigation, three irrigation levels were implemented: high (10.36"), medium (8.65"), and low (4.28"). Prior to initiating the study, soil cores were collected at depth (0-6, 6-12, and 12-24 inches) and plant available macronutrient concentrations were determined.

Treatments were arranged in a randomized complete block design and replicated four times within the three irrigation levels. Plots were 4 rows (40" spacing) by 40 ft in length. Treatments were a combination of application method (broadcast and knife injected) and K application rate and included the following: 1) broadcast, 0 lb/acre; 2) broadcast, 40 lb/acre; 3) broadcast, 80 lb/acre; 4) broadcast, 120 lb/acre; 5) broadcast, 160 lb/acre; 6) injected, 0 lb/acre; 7) injected, 40 lb/acre; 8) injected, 80 lb/acre; 9) injected, 120 lb/acre; and, 10) injected, 160 lb/acre.

Potassium fertilizer was applied pre plant on 25 April 2015 in either liquid or dry formulations. Liquid fertilizer in the form of 0-0-15 was applied with a four row side-dress applicator with four injection knives, one per row, mounted behind coulters. The knives were set 2-4" off the center of the bed and placed to inject 6" below the soil surface. The second form of potassium was granular muriate of potash (0-0-60), which was broadcast applied. After application a rolling cultivator was used across all plots to incorporate the granular fertilizer and close any trenches left open by injection knives.

Cotton (Deltapine 1321) was planted 11 May 2015, but due to hail damage was replanted on 2 June 2015. Plots were harvested 4 November 2015 using a JD 7445 with an onboard weigh system. Data collected included soil macronutrient concentrations, in-season plant measurements (stand counts, total nodes, boll distribution, and vigor ratings), K content of leaf tissue, and lint yield and quality.

RESULTS AND DISCUSSION

Soil Nutrient Characterization

Soil at the AG-CARES farm is classified as an Amarillo fine sandy loam with an alkaline pH (7.8 – 8.0). Regardless of soil depth, K concentrations are above the critical range of K (150 mg/kg) and considered sufficient for cotton production. Potassium concentrations decrease by nearly 1.5 times from the surface six inches to the 12-24 inch depth.

Table 1. Soil pH and electrical conductivity (EC) and plant available nutrient concentrations at depths of 0-6, 6-12, and 12-24 inches.

Soil Depth	pH	EC	NO_3^--N	P	K	Ca	Mg	S	Na
(inches)		(µS/cm)	---------------------------------(ppm)-------------------------						
0-6	7.8	163	8.4	33	392	1311	280	5.1	8
6-12	7.8	148	8.5	15	294	1287	291	5.0	10
12-24	8.0	194	9.1	9	252	2198	413	8.5	38

Leaf Tissue K

Under high irrigation, leaf tissue K was greater in plots receiving the greatest rate of K, 160 lb/acre (Fig. 1). However, differences between rates only existed using the knife injected application method. Leaf tissue K was greater with 160 lb/acre injected K (1.81% K) compared to the control (1.67% K) and the 40 lb/acre (1.69% K) and 120 lb/acre (1.70% K) injected K treatments. Treatment differences did not exist under low irrigation.

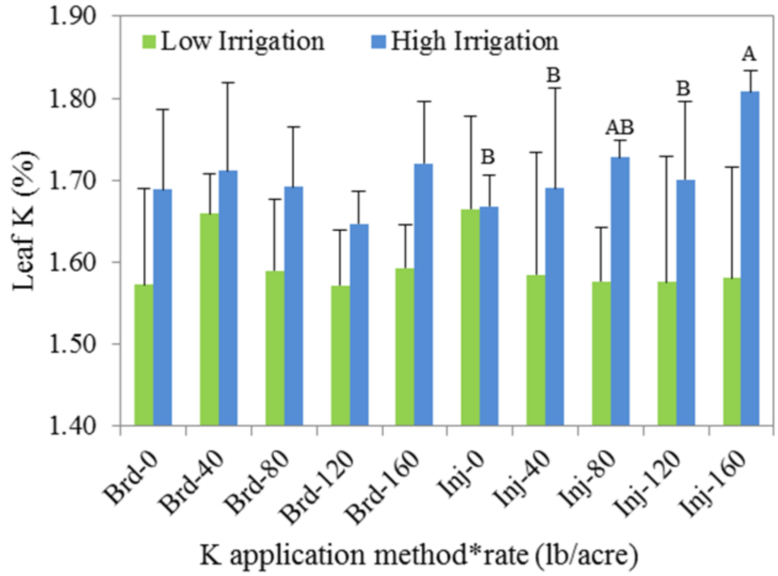

Figure 1. Leaf K content as affected by irrigation and K application rate. Bars represent standard deviation of the sample mean. Mean values followed by the same letter within application method and irrigation level are not significantly different at P < 0.05.

Pearson's correlation coefficients were calculated between leaf tissue K, and leaf tissue P, Ca, Mg, and Na. Significant negative relationships existed between leaf tissue K and leaf tissue Mg and Na (Table 2). In plants K and Na are similar, but the degree to which one monovalent cation can substitute for the other is unclear. Potassium is widely used by plants whereas Na can quickly reach toxic levels. The increasing leaf tissue K with the subsequent decrease of leaf tissue Mg and Na (Fig. 4) may partially explain the observed yield response to increasing K application rates in K sufficient soil. By increasing K availability with injected fertilizer applications, competition for plant uptake with Mg and Na may be reduced.

Table 2. Pearson correlation coefficients determined for leaf tissue K with leaf tissue concentrations of phosphorus (P), calcium (Ca), magnesium (Mg), and sodium (Na).

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0

	K	P	Ca	Mg	Na
K	1	-0.2824	-0.23916	**-0.6709**	**-0.7987**
		0.3279	0.4102	**0.0086**	**0.0006**

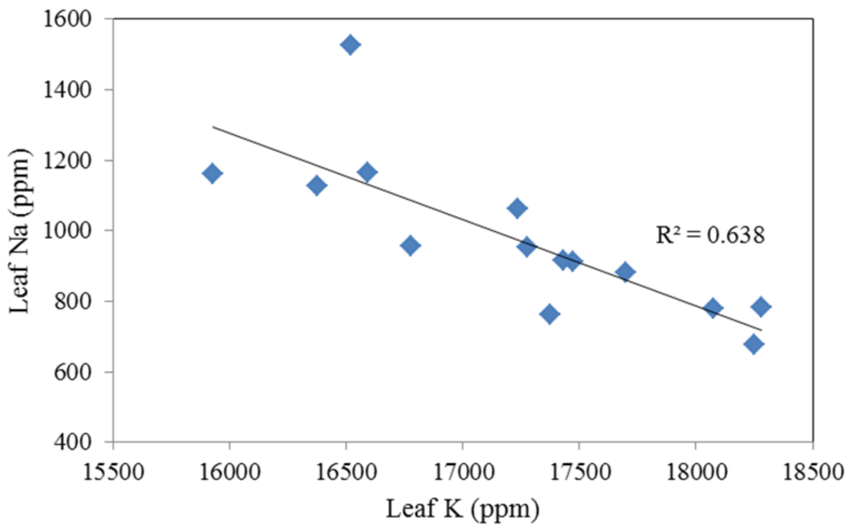

Fig. 2. Regression of leaf tissue Na and K.

Cotton Lint Yield and Fiber Quality

Lint yield was different among irrigation levels particularly between the low level which received 4.28” of irrigation and the medium and high levels receiving 8.65” and 10.36”, respectively (Fig. 3). Lint yield averaged 1072 lb/acre under the low irrigation level with treatment yields ranging from 977 lb/acre at the low K application rate (40 lb/A broadcast) to 1145 lb/acre at the high K application rate (160 lb/acre injected). Under high irrigation, lint yield averaged 1733 lb/acre with treatment yields ranging from 1640 lb at the low K application rate (40 lb/acre broadcast) to 1868 lb at the high K application rate (160 lb/acre injected).

Differences in lint yield between K application rates existed only when fertilizer was knife injected under the high and medium irrigation levels but not the low level (Fig. 3). Under high irrigation lint yield was greater for the high rate of knife injected K compared to the control (0 lb/acre) and 40 lb/acre application rate. Lint yield increased by nearly 200 lb when 160 lb/acre K was knife injected compared to the control. Under medium irrigation the highest rate of injected K (160 lb/acre) resulted in greater lint yield than the 0 lb/acre, 40 lb/acre, and 80 lb/acre injected K treatments.

Potassium fertilizer treatments did not significantly affect fiber quality within any of the irrigation levels; however, the higher irrigation level generally improved fiber quality compared to the lower irrigation level (Tables 5 and 6).

CONCLUSION

Most Texas soil is considered to be close to or above the critical range of K for cotton production; however, the frequency and severity of K deficiency symptoms in cotton on these highly productive soils in the Cotton Belt has been increasing over the past decade. The increased yield potential of most new varieties has placed a substantial demand on the plant’s root system to take up sufficient K to meet the physiological needs of the plant. The soil must be able to replenish available K in order to keep pace with the demands of the plant. The inability of a soil to do so may be a possible explanation for the yield response to increasing rates of knife injected K fertilizer. It is also possible that current ammonium based extraction solutions may be overestimating plant available K in soils containing certain 2:1 clay minerals. Cotton has been reported to be more sensitive to low K availability compared to most other major field crops, and for this reason may be a warning of K deficiencies to come in other row crops especially is areas where K is being depleted and not replaced. Additional research is needed to better understand K availability, release kinetics, and plant demands.

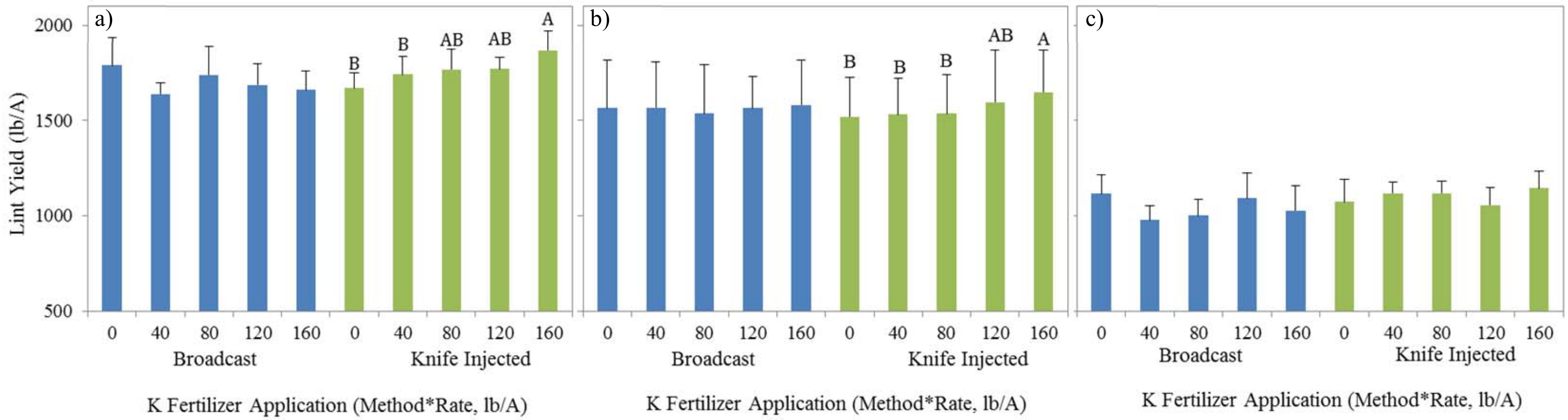

Figure 3. Lint yield (lb/A) affected by application method, rate, and irrigation level [a) high irrigation; b) medium irrigation; c) low irrigation]. Bars represent standard deviation of the sample mean. Mean values followed by the same letter within application method and irrigation level are not significantly different at $P < 0.05$.

Table 3. Fiber quality measurements of cotton receiving high irrigation.

Treatment	MIC	Length	Unif.	Strength	Elong.	Rd	+b	Area %	SFC%	Trash Cnt
Brd-0	3.79	1.14	80.78	30.75	8.15	74.85	8.13	0.90	9.38	41.5
Brd-40	3.89	1.12	81.38	30.58	8.33	74.73	7.93	0.75	9.33	48.3
Brd-80	3.81	1.13	80.80	30.28	8.35	74.63	7.88	0.91	9.35	53.0
Brd-120	3.72	1.12	80.98	30.75	8.43	74.90	7.93	0.98	9.50	55.5
Brd-160	3.66	1.13	80.48	30.38	8.30	75.68	8.03	0.67	9.45	46.0
Inj-0	3.84	1.13	81.15	30.28	8.10	74.45	8.08	0.91	9.30	50.5
Inj-40	3.93	1.12	80.63	30.13	8.23	73.98	8.00	1.19	9.70	55.3
Inj-80	3.88	1.12	81.08	30.53	8.28	74.28	8.10	0.84	9.48	51.3
Inj-120	3.81	1.13	81.18	30.63	8.18	74.50	8.10	0.80	9.25	52.0
Inj-160	3.86	1.12	80.83	30.20	8.40	74.18	8.08	0.92	9.60	51.0

Table 4. Fiber quality measurements of cotton receiving low irrigation

Treatment	MIC	Length	Unif.	Strength	Elong.	Rd	+b	Area %	SFC%	Trash Cnt
Brd-0	4.62	1.07	80.78	28.90	8.10	74.05	7.90	0.64	9.60	34.8
Brd-40	4.62	1.06	81.03	29.18	7.95	73.65	7.98	0.47	9.38	35.3
Brd-80	4.77	1.06	80.58	29.20	8.20	73.90	8.00	0.49	9.75	35.0
Brd-120	4.66	1.07	80.63	29.13	8.08	73.95	7.80	0.57	9.33	41.3
Brd-160	4.66	1.05	80.53	28.48	7.95	73.83	8.13	0.65	9.85	39.8
Inj-0	4.52	1.07	80.60	28.80	8.08	73.90	7.90	0.79	9.60	38.3
Inj-40	4.54	1.08	81.18	29.25	8.08	74.68	8.25	0.38	9.43	30.8
Inj-80	4.65	1.07	80.33	29.13	8.20	74.38	8.03	0.49	9.65	39.0
Inj-120	4.61	1.06	80.30	28.78	8.20	74.23	7.98	0.42	9.78	31.8
Inj-160	4.49	1.08	80.83	29.83	8.10	74.43	7.95	0.37	9.48	31.3