SEEDCOTTON YIELD RESPONSE TO POTASSIUM FERTILIZER APPLICATION RATE IN MISSISSIIPPI DELTA REGION OF ARKANSAS

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Abstract

Potassium plays a pivotal role in biochemistry of cotton development. Despite significant improvements in producing high cotton yield, cotton K fertility recommendations have changed very little during the last three decades. Replicated field research was conducted at four locations in 2015 and 2017 to evaluate seedcotton yield response to K fertilizer application rate under current production practices in the Mississippi River Delta region of Arkansas (MRDR). Mehlich-3 extractable soil test K in the 0-to 15-cm depth at two sites was Optimum and Medium and at the other sites was Low. Potassium fertilizer application did not significantly ($P>0.1$) influence the seed cotton yield at the sites rated Medium or Optimum in K. Potassium fertilizer application rate significantly ($P<0.1$) influenced seedcotton yield at the two sites rated Low in soil test K. At the two responsive sites, the seedcotton yield of plant that did receive any K and plants that received any K were 1594-1660 and 1789-2491 kg ha^{-1} respectively. These results suggest that under the conditions of this research soil-test K was capable of identifying the soils where K fertilizer application will increase the seedcotton yield potential. Additional research will be conducted to test the reproducibility of these results under the diverse soil and cotton production systems of MRDR to ensure that the soil testing is a reliable tool for applying the right rate of K fertilizer.

Introduction

Cotton (*Gossypium hirsutumn* L.) is a major row crop in Arkansas and Southeast United States. In 2014 more than 132,000 ha of land were planted to cotton in Arkansas. Almost 99% of the Arkansas cotton is produced in the Mississippi River Delta region (MRDR) of eastern Arkansas. Potassium (K) is one of the most important nutrients for growth and development of the cotton plant because it is required for many plant biochemical reactions including regulation of the stomatal opening and closing, maintaining leaf turgor pressure, carbohydrate transport, and leaf photosynthesis (Bendarez and Oosterhuis, 1999). Therefore, potassium deficiency will limit producers profit by negatively impacting the cotton yield and/or lint quality. The predominant surface horizon soil texture in the region is silt loam while clay and sandy loams are not uncommon. Many of the agricultural soils in this region have been farmed for more than a century therefore, supplemental K fertilization is required to produce agronomically and economically optimum cotton yields.

Advances in plant breeding, pest control, irrigation, and other production practices have continuously increased cotton yield potential during the last 40 years. From 1976 to 2015 the average seedcotton yield in Arkansas increased from 670 to 1235 kg ha^{-1} largely because of the introduction of fast-fruiting cultivars, improvements in pest management, and irrigation. Modern cotton cultivars produce higher yields and develop their boll load over a shorter period compared with obsolete cotton cultivars (Decamberatto and Jones, 2005). These facts indicate that modern cotton cultivars may require more K to produce optimum yields as compared with obsolete lower yielding ones. Soil test-based K fertility recommendation is the most cost effective tool to apply the right rate of K fertilizer. Thus, modern cotton cultivars response, to K fertilizer application rates should be periodically evaluated to ensure that K deficiency is not limiting cotton yield potential. The objective of this research was to evaluate the effect of K application rate on seedcotton yield under current production practices in representative agricultural soils of the MRDR.

Materials and Methods

Four replicated field experiments were conducted to measure the effect of K fertilizer application rate on seedcotton yield in soils typically used for cotton production in MRDR. The tests were located at the University of Arkansas System Division of Agriculture (UASDA) research stations in Desha, Lee, Mississippi, and Poinsett Counties in 2014 or 2017. At each location, prior to application of any soil amendments, plot boundaries were established and a composite soil sample consisting of six soil cores was collected from the 0-to 15-cm soil depth of each replication.

Soil samples were oven dried at 65°C, crushed, extracted with Mehlich-3 solution and the elemental concentrations in the extract were measured by inductively coupled plasma atomic emission spectroscopy. Soil pH was measured in a 1:2 (weight: volume) soil-water mixture extraction.

The experimental design was a randomized complete block with five replications of each treatment and five rates of K: 0, 28.2, 56.4, 84.7, 112.9, and 141.1 kg K ha^{-1} at Poinsett County, and: 0, 35.2, 70.4, 105.6, and 141.1 kg K ha^{-1} at Lee, Mississippi, and Desha Counties. Each individual plot was 12-m long and 3.86-m wide allowing for four rows of cotton with 96.5-cm wide row spacing. Cotton was fertilized with a total of 102-120 kg N ha^{-1} year^{-1}, the first 22 kg ha^{-1} N was applied as ammonium sulfate, preplant or within one week after planting, and the balance of N was applied as urea at First Square and incorporated with irrigation. All the other nutrients were applied as prescribed by UASDA recommendations for irrigated cotton production. Cotton was irrigated as needed and the standard pest management practices were followed. Selected agronomic information is presented in Table 1.

Table 1. Selected agronomic information for four K fertilizer rate trials conducted in Desha, Lee, Mississippi, and Poinsett Counties in Mississippi River Delta region of Arkansas in 2014 or 2017.

Study site (County)	Year	Soil Series	Cotton Cultivar	Planted	Harvested
Desha	2017	Hebert silt loam	Delta Pine 1646	25-April	12-October
Lee	2017	Convent silt loam	Stoneville 4949	19-May	19-October
Mississippi	2017	Sharkey-Steel Complex	Stoneville 4946	15-May	13-November
Poinsett	2014	Dundee silt loam	Delta Pine 0912	23-May	12-November

Each year the two center rows of each plot were harvested with a plot spindle picker equipped with electronic weight recording instruments that measured seedcotton yield. Analysis of variance (ANOVA) was performed by site-year, using the PROC MIX procedure of SAS and a treatment effect was declared significant when $P < 0.1$. Significant treatment means were separated by the Duncan-Waller MSD test.

Results and Discussion

Soil pH ranged 5.6-7.1, three of the soils were mapped as silt loams and one was a clay (Tables 1-2). Mehlich-3 extractable P was 27-58 mg kg^{-1} (Medium –Above Optimum). According to the current UASDA interpretation of Mehlich-3 extractable K, soil test K was Optimum (131-175 mg kg^{-1}) in Desha County, Low in Lee and Poinsett Counties (61-90 mg kg^{-1}), and Medium (91-130 mg kg^{-1}) in Mississippi County. Other soil chemical properties of typical to those used for cotton production in MRDR. Current UASDA guidelines for irrigated cotton production suggest application of 87, 55, and 37 kg K ha^{-1} for soils rated Low, Medium, and Optimum in K respectively to support optimum cotton yield and prevent excessive soil K depletion (Espinoza et al., 2006).

Table 2. Selected chemical property means of soil samples taken from the 0-to 15-cm depths before fertilizer-K application for the four cotton K fertilizer rate trials conducted in Desha, Lee, Mississippi, and Poinsett Counties in the Mississippi River Delta region of Arkansas in 2014 or 2017.

		Mehlich-3-extractable nutrients						
Site ID	Soil pH[a]	P	K	SD K[a]	Ca	Mg	Cu	Zn
		($mg\ kg^{-1}$)						
Desha	5.6	58	156	±14	982	163	1.3	3.0
Lee	6.5	27	84	±8	1210	291	2.0	1.2
Mississippi	7.1	39	130	±21	1758	340	2.9	3.6
Poinsett	6.7	49	82	±3	1262	207	1.6	3.6

[a] SD, Standard deviation of Mehlich-3 extractable soil-test K in the 0-to 15-cm depth.

Potassium fertilizer application rate did not significantly influence the seedcotton yield at Desha and Mississippi Counties, the two sites with Optimum and Medium Mehlich-3 extractable K levels (P>0.1, Table 3). At these sites the numerical seed cotton yields of the plants that did not receive any K fertilizer and those that received any K fertilizer were 3437-4003 and 3155-4115 kg ha^{-1} respectively. These results support the current UASDA K fertilizer recommendation where 37 and 55 kg K ha^{-1} is recommended to soils tested Medium and Optimum to prevent excessive plant available soil K depletion. Potassium fertilizer application significantly influenced seed cotton yield at Lee and Poinsett County, the two sites with Low Mehlich-3 extractable K (P<0.1, Table 3). Seed cotton yield of the cotton that did not receive any K was 1594-1660 kg ha^{-1}. Seedcotton yield of plants fertilized with any K was 2025-2491 and 1789-2409 in Lee and Poinsett Counties respectively. At the two K responsive sites the application of 105.6 to 141.1 kg K ha^{-1} produced the numerically maximal seedcotton yields of 2491 and 2409 kg ha^{-1}. The results from the two K responsive sites suggests that current UASDA soil-test based guidelines for the irrigated cotton K fertilization are able to identify the soils that will respond positively to K fertilization. The information from these studies will be added to a database that describes the seedcotton response to K fertilization under the modern cultural practices for producing high cotton yields in Arkansas.

Table 5. Seedcotton yield response to K-fertilization application rate for four trials conducted in Desha, Lee, Mississippi, and Poinsett Counties in the Mississippi River Delta region of Arkansas in 2015 or 2017.

K-rate	Desha	Lee	Mississippi	K-rate	Poinsett
kg K ha^{-1}	Seedcotton yield (kg ha^{-1})			kg K ha^{-1}	Seedcotton yield (kg ha^{-1})
0	4003	1594	3437	0	1669
35.2	4089	2025	3185	28.2	1789
70.4	3797	2294	3155	56.4	1884
105.6	3755	2399	3190	84.7	2192
141.1	4115	2491	3305	112.9	2409
				141.1	2361
P value	0.6474	<.0001	0.4953		0.0024
MSD 0.10[a]	NS[b]	188	NS		297

[a] MSD, Least significant difference at P=0.10.
[b] NS, not significant (P>0.10).

Summary

Four replicated K fertilizer application rate trials were conducted to evaluate the response of high yielding modern cotton cultivars in typical soils used for cotton production in 2015 or 2017. Potassium fertilizer application rate did not significantly influence the seedcotton yield at two sites where the Mehlich-3 extractable soil test K was Medium or Optimum (above 91 mg K kg^{-1} soil). Potassium fertilizer application significantly increased the seedcotton yield at two sites rated Low in Mehlich-3 extractable soil test K. The results suggest that under the conditions of this research the current UASDA soil test-based K fertility recommendation for irrigated cotton was able to identify the need for supplemental K fertilization to support optimum yield of modern cotton cultivars and prevent excessive depletion of plant available soil K. Additional research with a wider range of soils is needed to test the reproducibility of these results under the diverse cotton production systems in the MRDR. The data will be assembled to produce a robust database that will be used to evaluate, and if needed, revise the current irrigated cotton soil test based K fertility recommendations in Arkansas.

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