KANSAS SOYBEAN COMMISSION FINAL QUARTERLY REPORT OF PROGRESS

Principal Investigators: Dorivar Ruiz Diaz, Agronomy
Daniel Sweeney, Southeast Ag. Res. Center
Su Duncan, North East Area
Ignacio Ciampitti, Agronomy

Project Participants: Diego Charbonnier - Graduate Student, KSU Dept. of Agronomy

Title: "Assessment of soil potassium bioavailability and improving diagnostics tools for K management on soybean in Kansas"

Final Progress Report: April 15 2021

Introduction

Potassium deficiency has been increasing in Kansas over the past decade. Many Kansas soils are naturally high in K, and traditionally we have not focused on K as a needed nutrient in those regions of the state. However, continued withdrawal of K from soils through continuous cropping, including high K removal by crops such as soybeans, has reduced the native levels of K to the point where deficiency symptoms are becoming common, particularly in the older, more highly weathered soils of eastern Kansas.

Soil testing has been used for many years for K management; however, soil test K typically don't show the same level of reliability of other commonly used soil test methods in Kansas (e.g., soil test P). New research during the recent 3-5 years showed a clear effect from soil and plant factors on K bioavailability and uptake during the growing season. Factors such as soil clay types, level of oxidation-reduction and soil moisture can affect K release to the roots. Furthermore, the rate of plant K uptake during the growing season is typically greater for current highly productive systems and current critical values should be evaluated. In addition, soybeans removed about 44% of the total K take up by the crop in seeds at harvest, increasing the pressure of K availability.

Newly proposed soil test methods for K such as moist-soil testing are showing improved predictability in soybean response in other regions of the US. However, other recent research is also showing a significant effect from clay types, and the best test methods and critical values would likely require adjustments based on soil types. In Kansas, we have contrasting clay types including clay with slight, moderate and high swelling potential, which can affect K release from clay minerals, however, our current recommendation does not consider clay types in the recommendation.

In addition to the concern about lower soil K levels causing K deficiency, the use of reduced tillage systems, such as no-till, has raised a second concern: K stratification and positional unavailability. In these production systems, rows are planted in the same general area each year, concentrating the available K near the soil surface, where dense, dry soils can reduce K uptake. These factors, together with the limited root zone available in the claypan soils in southeastern Kansas, has led to a widespread problem of K deficiency, especially early in the growing season.

The questions then become: What is the optimum/critical soil test K level in no-till or strip-till, and is it different from conventional tilled systems? Are current critical values need adjustment based on clay types, and yield potential/plant uptake rate? And can the impact of K stratification be overcome by increased applications of broadcast potash? Can the crop respond to K application even if the soil test analysis shows a high K content and the plant does not show an early-season evidence of K deficiency, asymptomatic response?

The overall objective of this project is to improve potassium management for soybean production in Kansas, increasing yields with improved diagnostic tools and fertilization strategies based on soil types in the main soybean producing regions in Kansas. Specific objectives include:

- Determine the impact of K deficiencies on soybeans yields for different soil types in Kansas.
- Evaluate current soil test interpretations for K fertilization in soybean, including the evaluation of new soil test methods and the effect of soil clay types on critical levels for soybean.
- Assess plant K levels during the growing season and determine possible yield limitations related to the high rate of K uptake in high yielding systems.

Field Sites: Accomplishments April 2021:

Studies were established at 4 locations during 2020 for a total of 10 locations in 2019-2020 with focus on K deficient soils, but also including a location with traditionally high K level. Soybean growth was generally at optimum condition for most locations, and visual response to K fertilization, as well as P for locations with low soil test P. Soil samples were collected from each individual plots before treatment application, and sent for analysis including chemical, physical and biological tests. Soybean plan tissue was also collected at all locations and preliminary results are currently under statistical analysis.

Methods for soil test K are currently under analysis, including traditional K test, analysis on moist samples, and in-season ion-exchange resin as indicator K supply during the growing season. Clay analysis is also ongoing for current field study locations, and additional samples will be collected to across soybean producing regions to evaluate the predominant clay species and correlation to K supply.

Evaluation of Soybean Response to In-Season Potassium Fertilization

One component of the project evaluated the effect of in-season K for deficient soils. Field experiments were conducted at three locations throughout eastern Kansas during 2020. For this evaluation, we focused on three deficient soil K conditions sites (STK< 93 ppm ammonium acetate). Low STK sites (**Table 1**) were located at the East Central Experimental Field (Ottawa, KS), Southeast Research-Extension Center (Parsons, KS), and in a producer field (near Wetmore, KS) under a conventional tillage crop system. The experiments were a randomized complete block design, and three treatments were selected to evaluate K application timing. Treatments included a control (0 lbs K_2O acre^{-1}), 50 lbs K_2O acre^{-1} pre-plant incorporated, and 50 lbs K_2O acre^{-1} in-season broadcasted at the V4 growth stage. The fertilizer source was potassium chloride (KCl). Aboveground plant samples were collected at V4, R2, R4, and R6 stages in order to measure plant K uptake. The samples were dried at 140°F, ground to pass through a 2 mm screen, weighed and digested by nitric-perchloric acid digestion. Total K concentration was determined by inductively coupled plasma (ICP) spectrometry. Soil samples were taken at pre-plant (one per replicate), air-dried at 104 °F, and ground to pass through a 2 mm screen. All samples were analyzed for soil pH (soil:water; 1:1), Organic Matter (OM) (loss on ignition method), extractable P and K (Mehlich-3), exchangeable cations (1 M NH_4OAc pH 7.0, Flame Atomic Absorption) including the field-moist analysis for K, and Cation Exchange Capacity (CEC) (displacement method). Grain was harvested from the center rows (37-ft length) with a plot combine. Yield was corrected at 13% moisture. Statistical analysis (ANOVA) was performed using the GLIMMIX procedure in SAS 9.4.

Results

Potassium fertilization increased yield at all the locations in this study (soil-test K less than 93 ppm). Based on Kansas State University recommendations, these locations had soil K levels that were below the critical level of 130 ppm (**Table 1**), and yield response to K fertilization was expected. Across three locations, the late K fertilization had higher plant K uptake at R4 and R6 growth stages (**Figure 1**). Also, K uptake rate between R2 and R4 was greater than pre-plant when the same KCl rate was broadcasted at V4. However, K uptake rate in late reproductive stages (R4-R6) was not only similar in K fertilized plots but also in those that did not receive K fertilizer. Comparing fertilized treatments, post-emergence K applications had higher plant K concentration at R6 ($p<0.05$) (**Figure 3**), but these higher values did not produce more yield. Also, broadcasting KCl at V4 resulted in a higher plant K/Mg ratio late in the season (**Figure 4**). On the contrary, the pre-plant application produced a slightly higher yield compared to the in-season, but not statistically significant (**Figure 2**). It is important to mention that all treatments had the same plant biomass (data not shown). Similar soybean yield between pre-plant and side-dress applications were reported by Slaton and Roberts (2020) under irrigation conditions. Preliminary results of this study suggest that in-season applications using dry K fertilizers could be used when pre-plant fertilization was not done. Nevertheless, for a dry growing season, soybean response might be limited.

Table 1. Selected soil properties for 0-6” samples

County	pH	OM	P_{M3}	K_{M3}	K_{AA}	$K_{AA\text{-}fm}$	Ca	Mg	Na	K sat.	CEC
		%	----------------------------ppm----------------------------							%	(meq/100g)
Franklin	5.7	3.4	14	102	94	57	2399	322	29	3.1	20.9
Nemaha	6.1	2.4	8	79	60	39	1466	200	11	3.3	14.4
Labette	6.6	2.6	3	46	34	16	1916	171	35	1.5	14.7

M3: Mehlich-3 soil test , AA: Ammonium acetate soil test , fm: field-moist sample

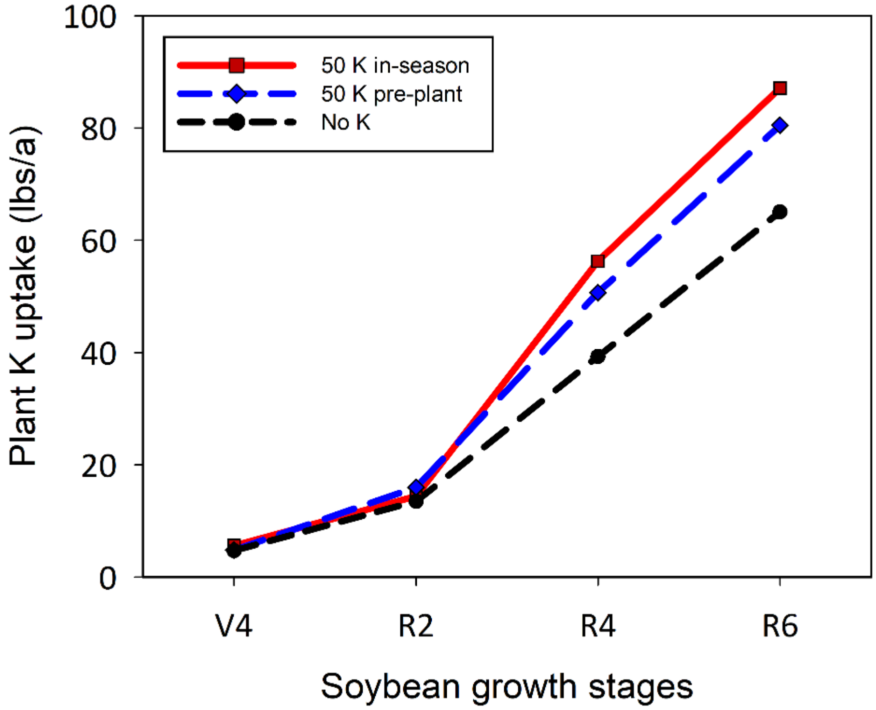

Figure 1. Cumulative plant K uptake as affected by treatment across locations.

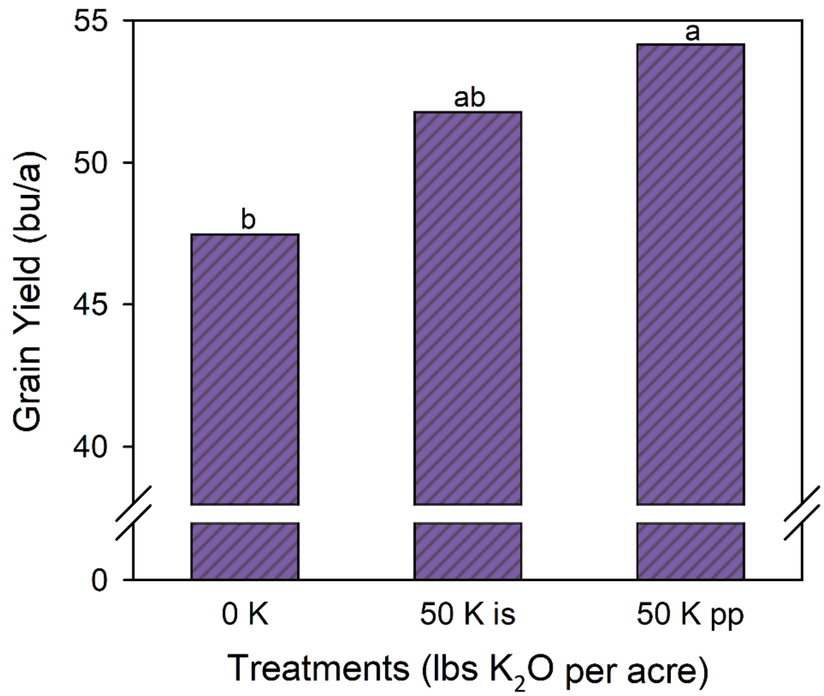

Figure 2. Yield response to K fertilization across locations. Means followed by the same letter are not significantly different at $p<0.05$.

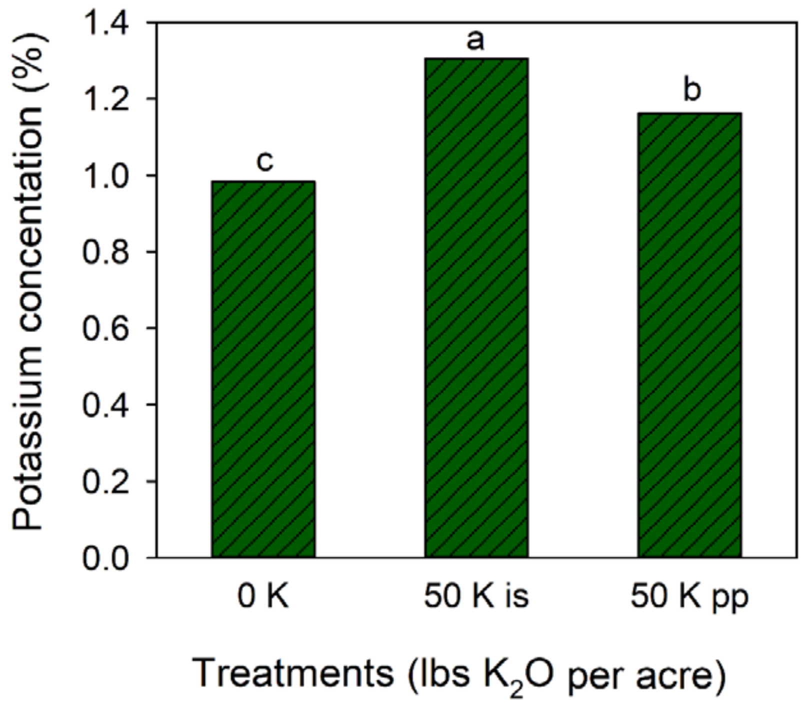

Figure 3. Plant K concentration at R6 growth stage as affected by treatment across locations. Means followed by the same letter are not significantly different at $p<0.05$.

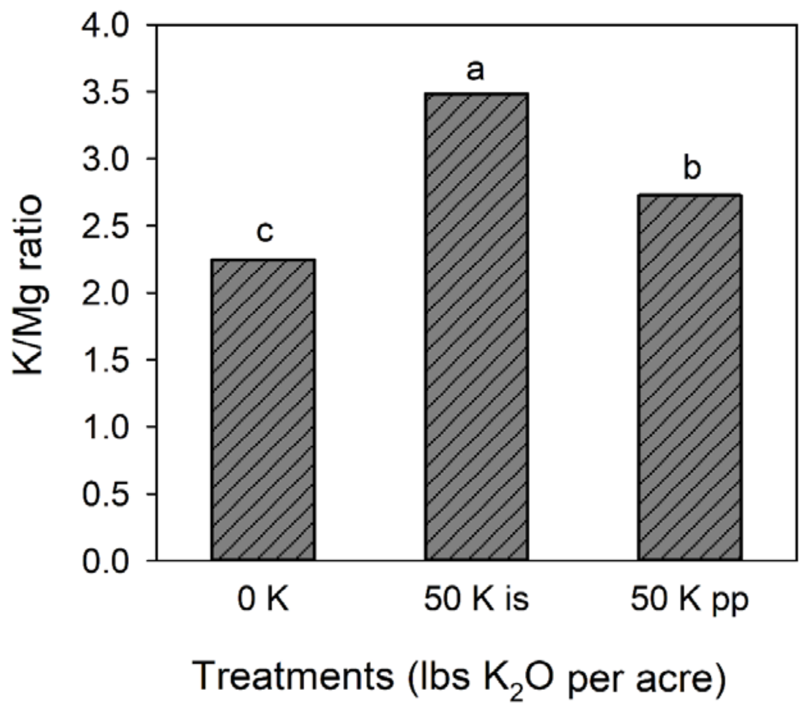

Figure 4. K/Mg ratio at R6 growth stage as affected by treatment across locations. Means followed by the same letter are not significantly different at $p<0.05$.