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: September 2020

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 September 2020:

Studies were established at 4 locations during 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 with potential for good yields, and visual response to K fertilization. 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 al 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.

In season soil moisture and temperature was monitored at all locations during 2020, as well as the evaluation of in-season soil K (**Figure 1, Table 1**). These results will be evaluated in the context soybean K uptake and availability for the growing season.

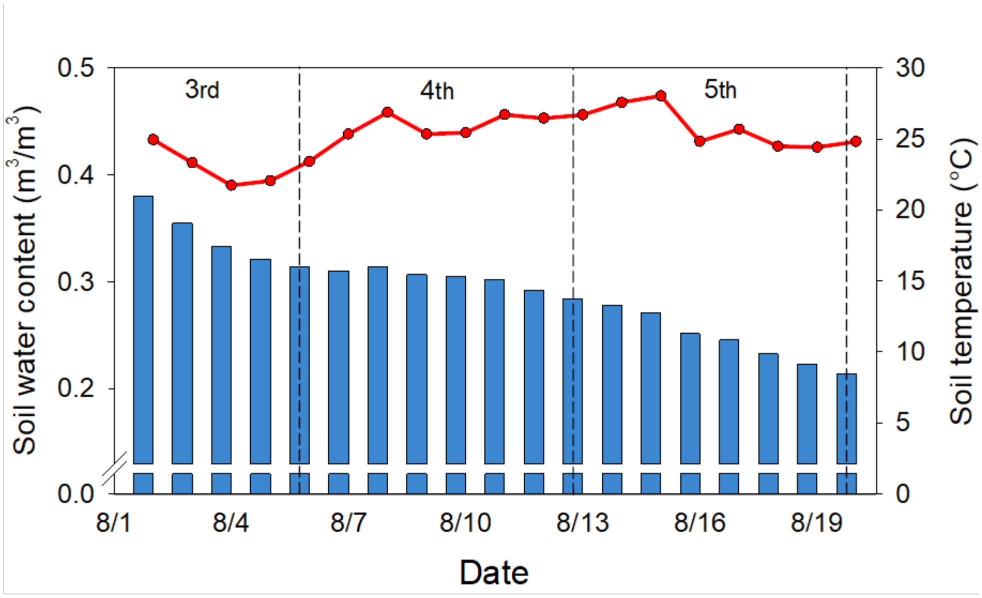

Figure 1. Soil moisture and temperature at Ottawa, KS during the 2020 growing season.

Period	Water cont. (m3/m3)	Temp (°C)	CER K (ppm)
3	0.341	23.1	0.81
4	0.302	26.1	0.68
5	0.245	25.7	0.64

Table 1. Changes in soil potassium during the growing season at Ottawa KS as affected by soil moisture and temperature.

Evaluation of resin test (ion exchange resin) under field conditions (preliminary results or 2019 data)

Field experiments were conducted at two locations throughout eastern Kansas during 2019 (**Table 1**). Sites were located at Ashland Bottoms Research Farm (Manhattan, KS) and East Central Experimental Field (Ottawa, KS) under a conventional tillage crop system. The experiments were a randomized complete block design and two treatments and two replicates were selected to evaluate the CER. Treatments included a control (check) with no K application and one with application of 150 lbs K_2O acre^{-1} (high K rate). Both treatments had an application of 80 lbs P_2O_5 acre^{-1}. The fertilizer applications were a surface broadcast at pre-plant using triple superphosphate (TSP) and potassium chloride (KCl) as a P and K sources, respectively. For this study, we used a commercial CER (Plant Root Simulator® (PRS®, Western Ag Innovations, Saskatchewan, Canada) as an indicator of in-season K supply to soybean. This product consists of an exchange resin membrane held in a plastic frame that is inserted into the soil to measure *in situ* ion supply. Variables such as number, length, and time between burial periods were defined in order to cover most of the soybean growing season (V4 to R7). Ottawa location had six burial periods compared to Ashland that had seven. Burial length consisted of 7 days with a time between burials of 15 days. A total of 4 probes were distributed within the plot to obtain a composite sample. The CERs were inserted vertically into the soil (facing plant row), between 2-4 inches soil depth at a distance of 3 inches from the soybean row during all the sampling season. For every new burial period, the CERs were buried 5 inches apart from the previous period (parallel to the row) to avoid sampling the same portion of soil. 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 of the extractant 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:deionized 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), and Cation Exchange Capacity (CEC) (displacement method). Soil samples were taken at the beginning and end of each burial period to calculate soil moisture content (air-dried at 104 °F). Statistical analysis (ANOVA) was performed using the GLIMMIX procedure in SAS 9.4.

Results and Discussion

Plant K uptake measured at reproductive stages (R2, R4, and R6) was increased by K fertilization in both locations. However, differences were not statistically significant ($p < 0.05$) at location 1 (**Fig. 4**). This result was likely due to its high soil K levels. Based on Kansas State University recommendations, this location had soil K levels that was above the critical level of 130 ppm, and no K fertilizer was needed (**Table 2**). In contrast, location 2 had significantly higher plant K uptake measured at R2 ($p < 0.05$), R4 ($p < 0.10$), and R6 ($p < 0.05$) stages when 150 lbs K_2O acre^{-1} was applied (**Fig. 5**). At the R6 stage, fertilized plots had 50% more K uptake and 40% more K adsorption (cumulative) by CER compared to the control. This observation suggests the potential use of CER as indicator of K supply to soybean in field conditions, but further research is needed to confirm these findings. In both locations, CER were able to adsorb more K (measured as cumulative adsorption) at high K rate. The amount of K that was adsorbed by the CER was influenced by soil moisture content, particularly in location 1 (**Fig. 6**). A similar trend was observed between these two variables. Plots without K fertilization were less affected and minor fluctuations were measured compared to those with high K rate. However, data from location 2 did not show a clear pattern (**Fig. 7**). Preliminary results from this study suggest that CER can be used as an indicator of K supply particularly in low K soils.

Table 2. Selected soil properties for 0-6” samples

Location	County	Soil texture	pH	OM	P-M	K-M	K	Ca	Mg	Na	CEC
				%	-----------------		ppm		----------------------		(meq/100g)
1	Riley	silt loam	7.7	3.2	55	350	324	2749	117	11	14.6
2	Franklin	sandy clay loam	5.7	3.4	14	102	94	2399	322	29	20.9

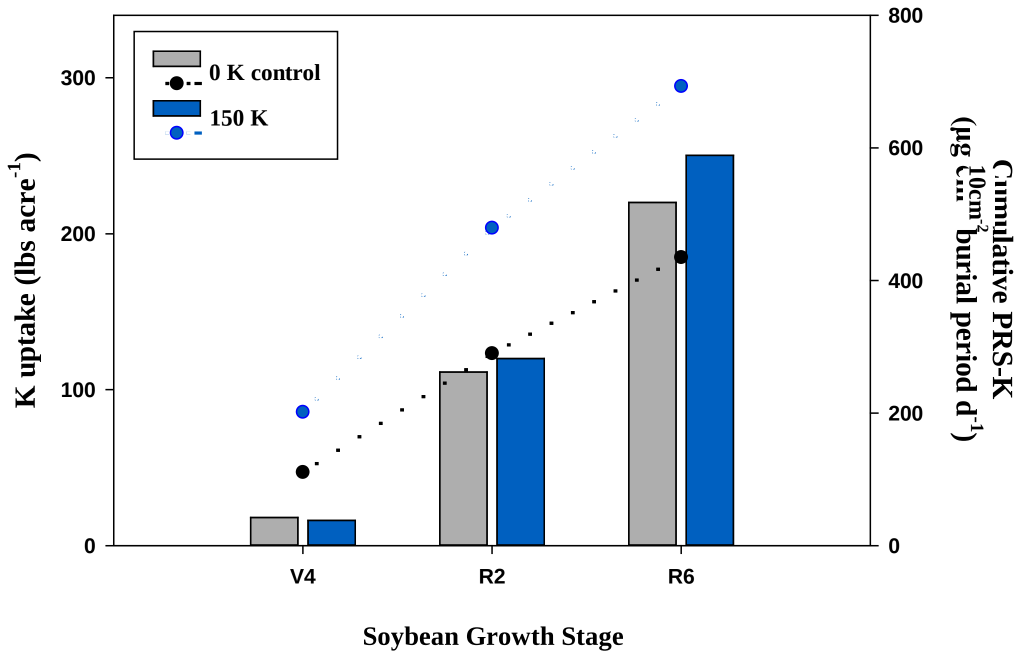

Figure 4. Soybean plant K uptake (represented by bars) and cumulative PRS K adsorption as affected by two levels of K application at Location 1. Pairwise comparisons of K fertilizer application rate within each stage are indicated by "*" when statistically significant at the p<0.05.

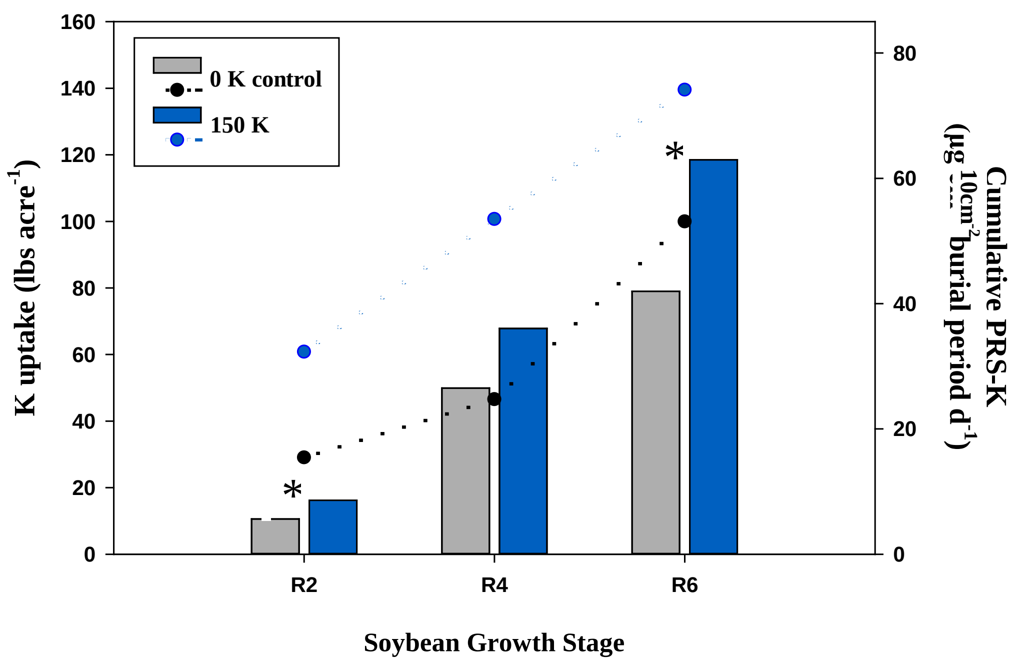

Figure 5. Soybean plant K uptake (represented by bars) and cumulative PRS K adsorption as affected by two levels of K application at Location 2. Pairwise comparisons of K fertilizer application rate within each stage are indicated by "*" when statistically significant at the p<0.05.

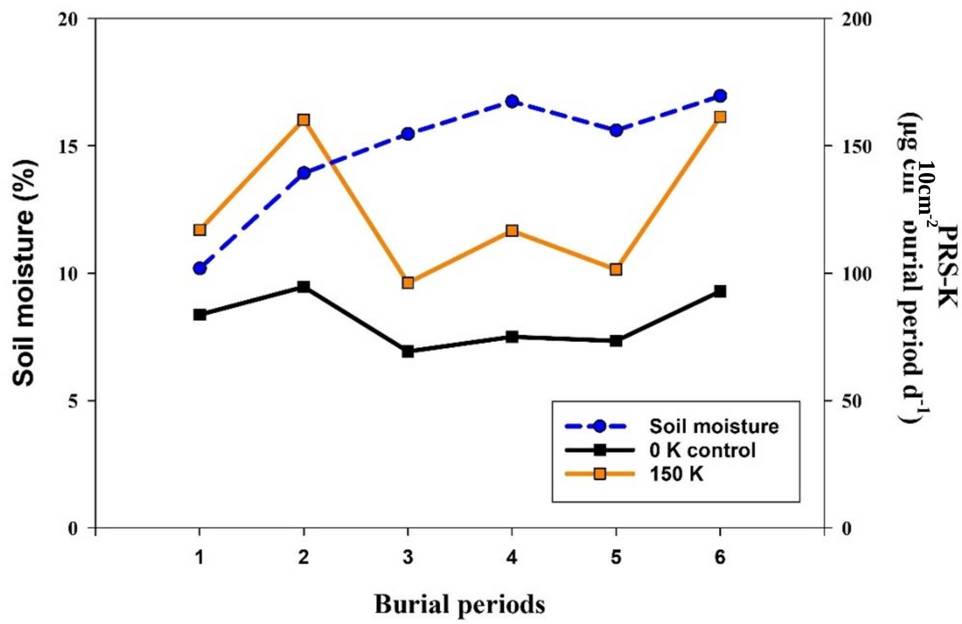

Figure 6. PRS K adsorption as affected by two levels of K application compared to soil moisture content at Location 1.

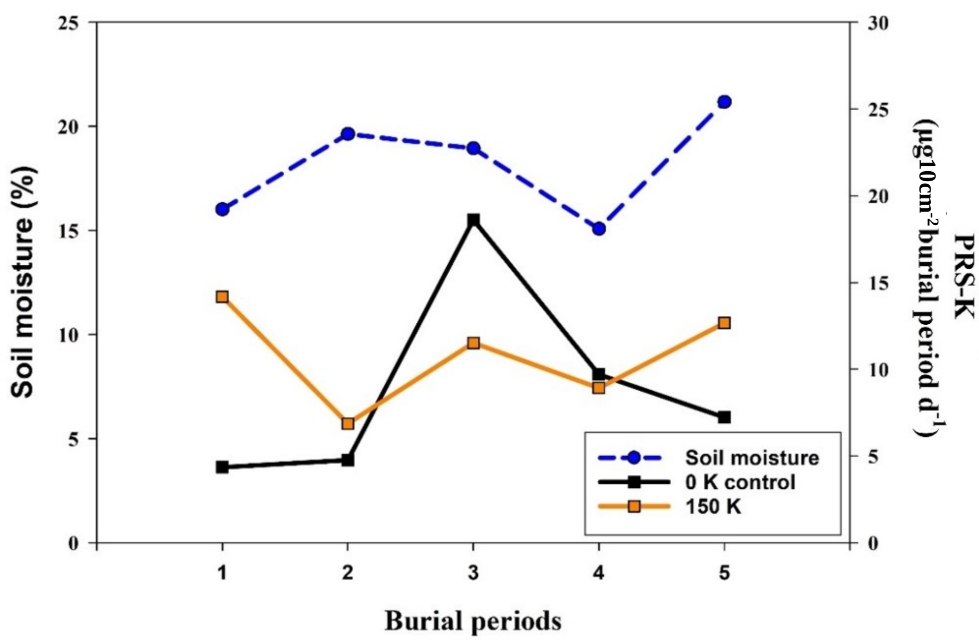

Figure 7. PRS K adsorption as affected by two levels of K application compared to soil moisture content at Location 2.

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