South Carolina Soybean Board

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PROJECT NUMBER:	2011969
PROJECT DESCRIPTION:	Evaluating Potassium Fertilizer Recommendations For Irrigated and Dryland Soybean in South Carolina
REPORT DUE DATE:	On or before April 1, 2018
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1.) GOALS AND OBJECTIVES OBTAINED:

April 1st to June 30th:
The goal in the first quarter was to establish and maintain plots and conduct soil sampling to measure baseline soil fertility. All the planned goals for the current quarter were accomplished.

June 31st to September 30th:
The plans for the second quarter were soil sampling at R5 growth stage, plant tissue, roots and nodules sampling at R2 and R5 growth stages. All the goals were achieved.

October 31st to December 30th:
The objectives of the third quarter were to analyze the soil and tissue samples from the second quarter and analyze the results from the nodule numbers, dry weight of roots and nodules.

December 31st to March 30th:
The objectives for the first quarter in year 2018, were to measure the soybean grain yields; analyze and interpret soybean yield and soil data.

2.) ACTIVITIES PERFORMED AND OUTCOMES:

April 1st to June 30th:

Treatments included factorial arrangement of three potassium (K) sources [KCl, K_2SO_4 (0–0–50–18, N–P_2O_5–K_2O–S), and K-Mag (0–0–22–22–11, N–P_2O_5–K_2O–S–Mg)] and five K rates (0, 50, 100, 150, and 200 pounds of soil-applied K_2O ac^{-1}) were arranged in a randomized complete block with three replications. The field was disk-tilled a week before planting. Strip-till soybean was planted in 8 row plots with row spacing 97 cm on May 4, 2017. All plots were 30 ft long and 25 ft wide. Soil samples (6-9 cores/plot) were collected from all plots on May 19, 2017 to 30 inches cm using 1-inch diameter hand-held soil probe and divided into 0–6, 6–12, and 12–18 inches depth increments and sent to Clemson University's Soil Analytical Lab to determine pH and P and K fertility using Mehlich-1 extraction. Concentrations of P and K were determined by inductively coupled plasma atomic emission spectroscopy. Treatments were hand broadcasted on one side of planting row in a band of 10 cm to 15 cm and 5–10 cm away from the planting row on June 6, 2016. As per Clemson University's soil test recommendation, 30 pounds P_2O_5 ac^{-1} was applied as triple superphosphate (44% P_2O_5) over the entire field along with the treatments to ensure adequate P fertility.

June 31st to September 30th:

The same method for soil sampling described above for testing the baseline soil fertility was used for soil sampling at the R5 growth stage (when the soybeans began to produce seeds).
At the R2 growth stage (full bloom), the uppermost matured trifoliate leaves with the petioles were taken from 20 plants per plot and oven dried at 65°C for 72 h to a constant weight. The dried leaves were weighed and grinded. The ground tissue samples were stored and will be sent to Clemson University's Soil Analytical Lab and analyzed for N, P, K, Mg and Mn concentrations.
Furthermore, 10 whole plants with the roots were selected for nodule sampling from each plot. The above-ground and below-ground plant parts were separated. The aboveground plants were oven dried at 65°C for 72 h to a constant weight. The dried leaves were weighed, grinded, and used to calculate plant dry biomass. For the below-ground parts, the nodule numbers, the dry weights of the nodules, and roots were recorded.
Results of pre-treatment soil samples came back and results are shown in Table 1. The pH and CEC at the 0-6 and 6-12 inches depth was same but pH decreased and CEC increased slightly at the lowest depth. There was around 100 lbs/acre of K was available at top two depths but at the third depth, amount of K was found highest.

Table 1: Mean values of selected soil properties measured from samples collected at 0-6, 6-12, and 12-18 inches before application of fertilizer treatments.

Soil depth, Inches	Soil pH	P	K	Ca	Mg	Mn	B	CEC	Base saturation
		lbs/acre						*meq/100g*	%
0-6	6.0	88	101	711	54	15	0.3	3	62
6-12	6.0	74	103	576	47	10	0.3	3	57
12-18	5.7	37	116	550	56	8	0.3	4	49

We are planning in the next quarter to analyze roots, nodule, and in-season soil samples.

October 31st to December 30th:

We got the results for the tissue analysis and the response of the trifoliate K concentration to the various K sources and rates is presented in fig. 1. For all the K sources, there was decrease in trifoliate leaf concentration at 200 lbs K_20/ acre that implies the supply of K at that rate was more than the plants needed.

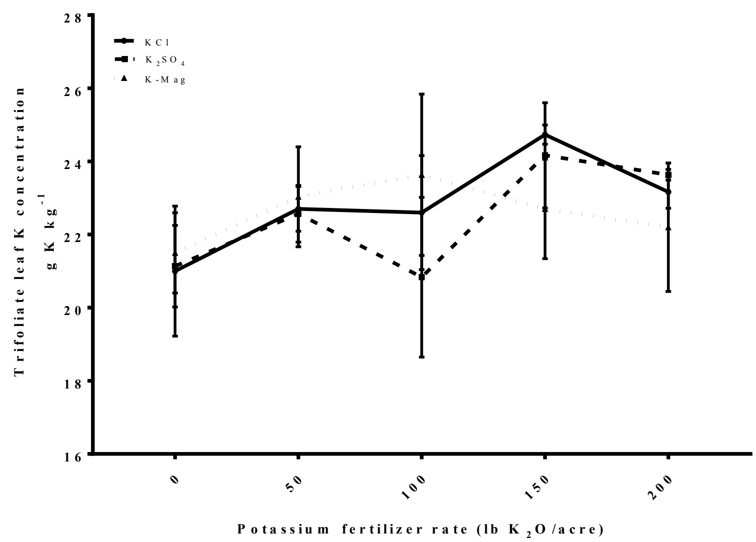


Fig 1: Trifoliate leaf K concentration in response to three K sources (KCl, K_2SO_4 and K-Mag) across five K rates (0 – 200 lbs K_2O/acre). Error bars are one standard error from the mean.

There was decline in the trifoliate leaf Ca: Mg ratio for K-Mag as the K rates increased (0 to 200 lbs K_2O/ acre) as shown in fig 2. The Mg from K-Mag, may have reduced the Ca in the leaf.

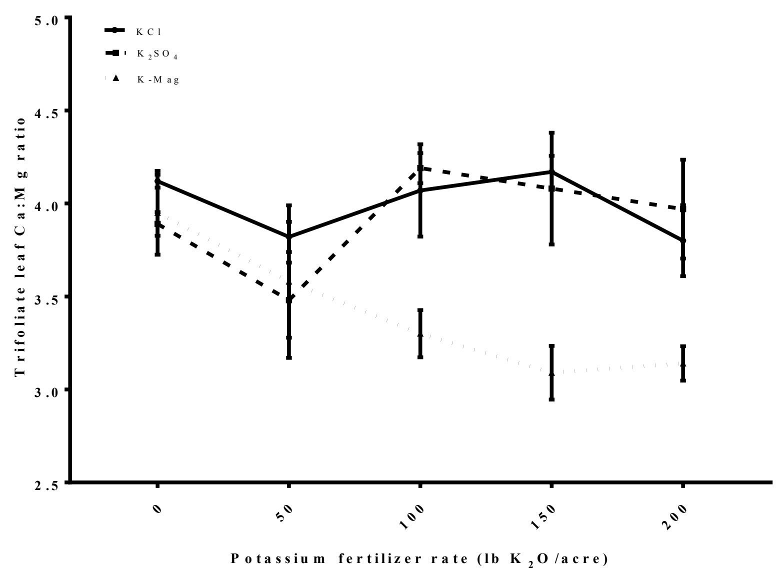
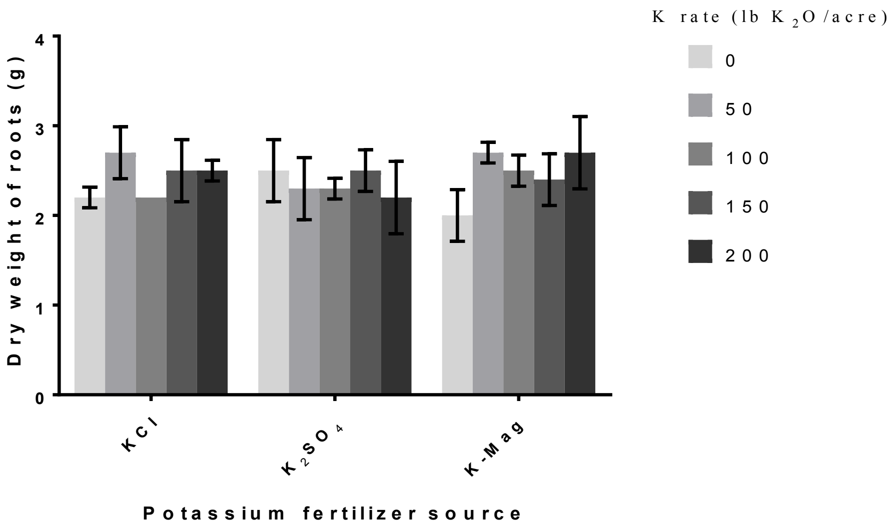


Fig 2: Trifoliate leaf calcium to magnesium ratio as affected by (KCl, K_2SO_4 and K-Mag) across five K rates (0 – 200 lbs K_2O/acre). Error bars are one standard error from the mean.

(a)



(b)

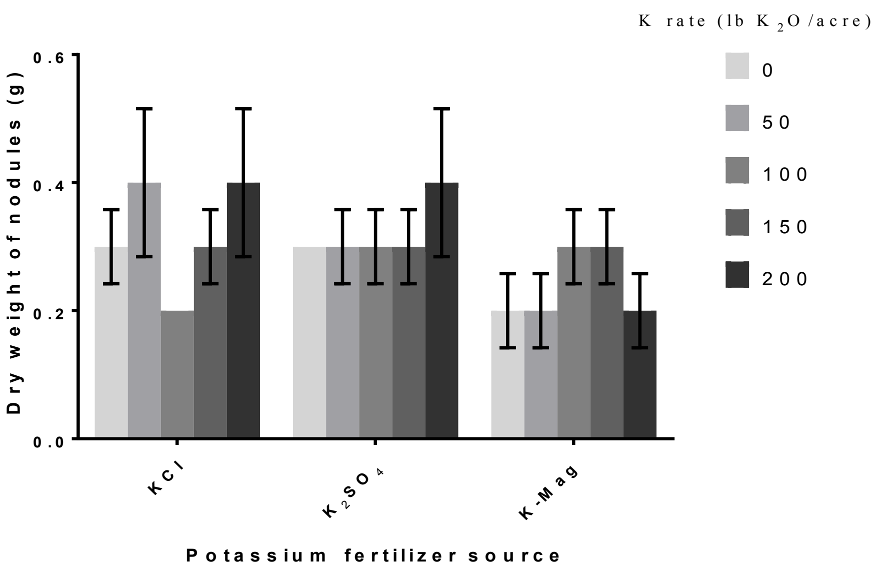


Fig 3: Effect of three K sources (KCl, K_2SO_4 and K-Mag) and five K rates (0 – 200 lbs K_2O/acre) on (a) soybean root growth and (b) nodule dry weight. Error bars are one standard error from the mean.

Potassium rate 50 lbs K_2O/acre increased soybean root weight for KCl and K-Mag. While, no root growth response was observed for K_2SO_4 as K source as shown in fig 3a. On the other hand, nodules dry weight increased as K rates increased (fig 3b).

We would be taking and analyzing seed yields in the next quarter.

December 31st to March 30th:

Figure 4 shows the changes in soil potassium concentration at R5 growth stage. There was a decrease in soil K concentration for unfertilized plots, of averaged 34.8, 16.12 and 9.37 lbs K/acre for 0 - 6, 6 - 12, and 12 -18″ soil depths respectively, showing a reduction in K decrease with increasing soil depth.

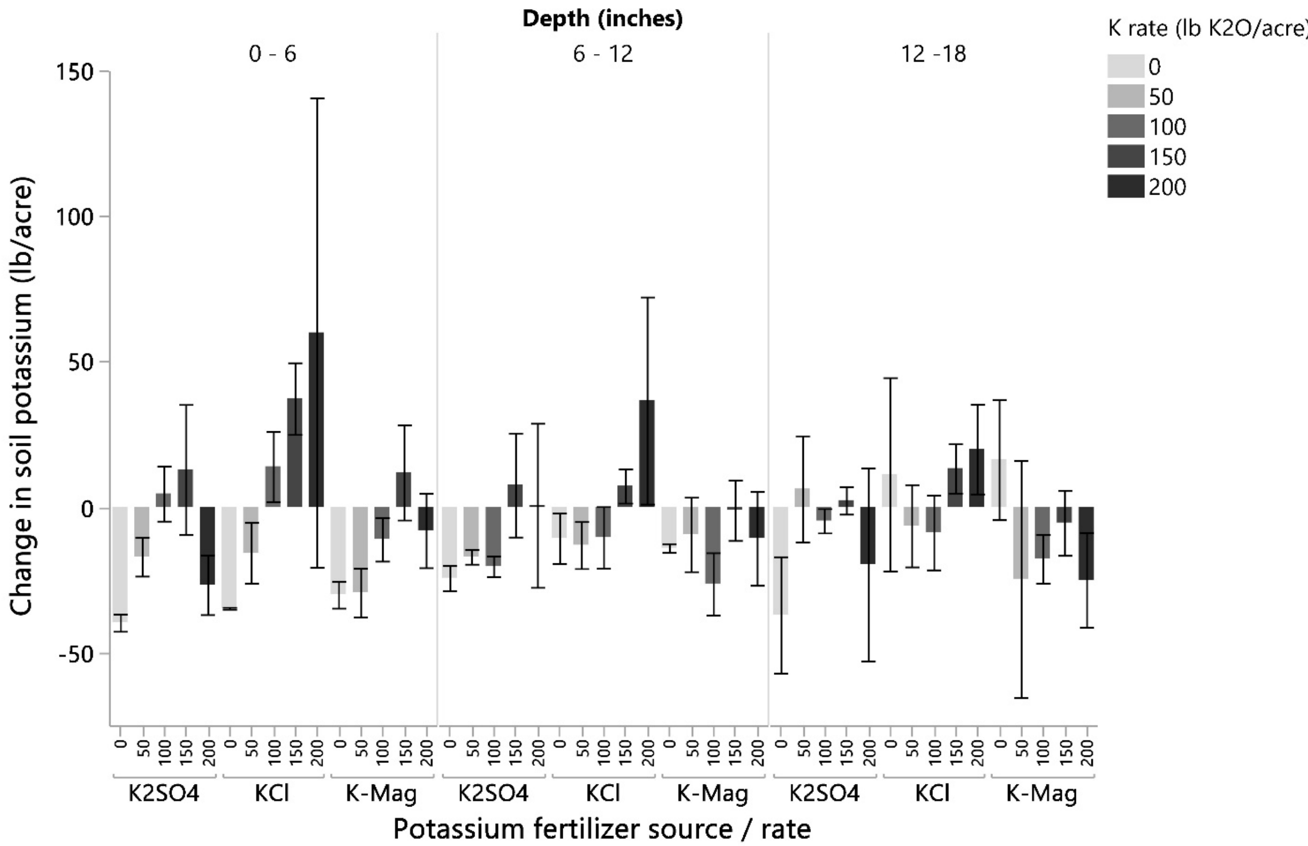


Fig 4: Changes in soil potassium concentration at R5 growth stage, within three soil depths (0-6, 6-12 and 12-18 inches) as influenced by three potassium fertilizer sources KCl, K_2SO_4, and K-Mag application across five K rates (0 – 200 lbs K_2O/acre). Error bars are one standard error from the mean.

At 0-6″ soil depth, increase in soil K concentration was observed at the rate 150 lbs K_2O/acre for all the K fertilizer sources. Unlike K-mag and K_2SO_4, KCl was consistent in increasing soil K concentration at the top soil with increasing rates. The reduction in K concentration observed at the 200 lbs K_2O/acre for K-mag and K_2SO_4 signifies that K leaching occurred at high rates in the presence of K-mag and K_2SO_4 and not in KCl. Increase in soil K concentration in soil depth 6-12″ was only seen at the rates 150 and 200 lbs K_2O/acre. While K increase in 12 -18″ soil depth was not consistent with K fertilizer application rates and sources.

Soil K concentration at 0 -6 and 6 -12 inches depths correlated (r^2 = 0.82 and 0.78) better with soybean yield response to K fertilizer rates compared to soil K at 12 -18 inches depth (r^2 = 0.07).

Table 2: Analysis of variance for soybean seed yield for three potassium sources (KCl, K_2SO_4, and K-Mag) across five potassium rates (0 -200 lb K_2O/acre)

Source of variation	df	Seed yield
Potassium fertilizer sources (S)	2	0.4013
Potassium fertilizer rates (R)	1	0.0972
S x R	2	0.8514

p values are shown

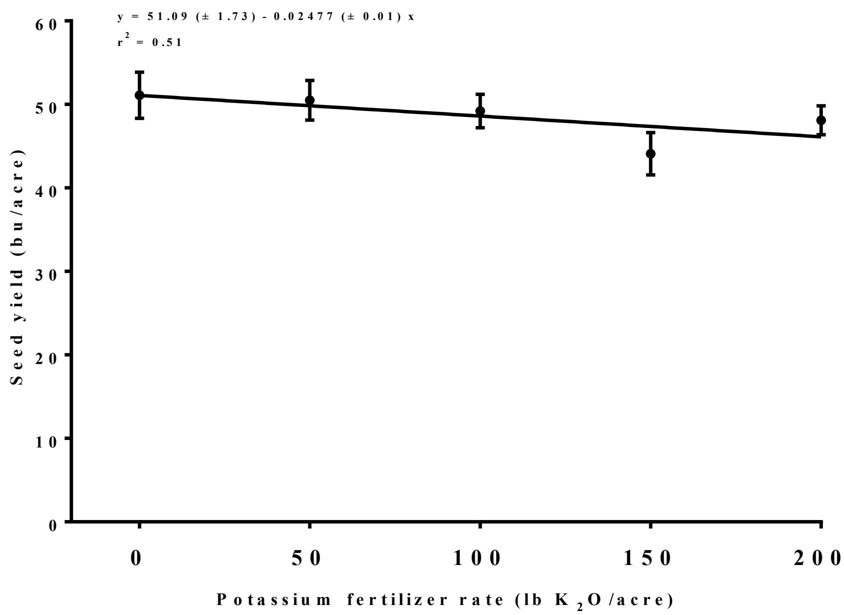


Fig 5: Soybean seed yield response to potassium fertilizer rates (0- 200 lbs K_2O/acre). Error bars are one standard error from the mean.

Soybean seed yields were affected by K fertilizer rates ($P \leq 0.1$) as shown in Table 2. There was a decline in seed yields with increasing K rates (fig 5). The lack of interaction between K source and rate (Table 2) indicates that potassium source had no influence on the declining yield observed with K rates.

Table 3: Analysis of variance for trifoliate leaf nutrient concentrations at R2 growth stage for three potassium sources (KCl, K_2SO_4, and K-Mag) across five potassium rates (0 – 200 lbs K_2O/acre).

Source of variation	df	K	P	Mg	Ca	S	Mn
Potassium fertilizer sources (S)	2	0.5577	0.0668	0.0021	0.1678	0.0014	0.0768
Potassium fertilizer rates (R)	1	0.0399	0.0226	0.3081	0.0155	0.0492	0.0104
S x R	2	0.5118	0.0906	0.7628	0.0309	0.0023	0.2754

p values are given in the table

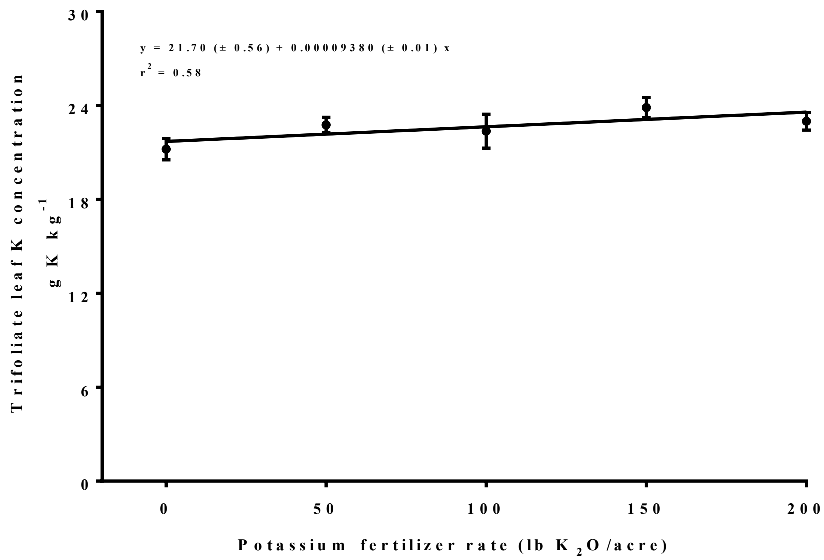


Fig 6: Effect of potassium fertilizer rates (0-200 lbs K_2O/acre) on trifoliate leaf K concentration at R2 growth stage. Error bars are one standard error from the mean.

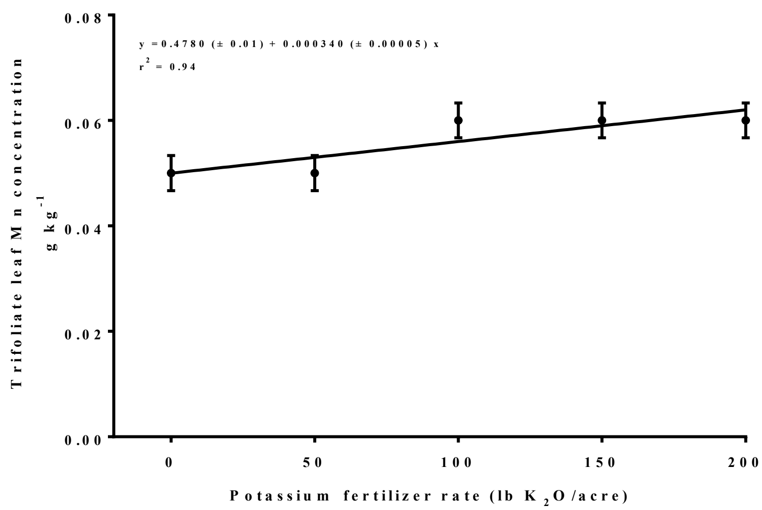


Fig 7: Effect of potassium fertilizer rates (0-200 lbs K_2O/acre) on trifoliate leaf Mn concentration at R2 growth stage. Error bars are one standard error from the mean.

Potassium fertilizer rates had significant ($P \leq 0.05$) effect on trifoliate leaf K and Mn. While the interaction of K fertilizer source and rate had no effect on trifoliate leaf K and Mn. An increase in trifoliate leaf K and Mn concentrations were observed with increasing K rates (Fig. 7 and 8).

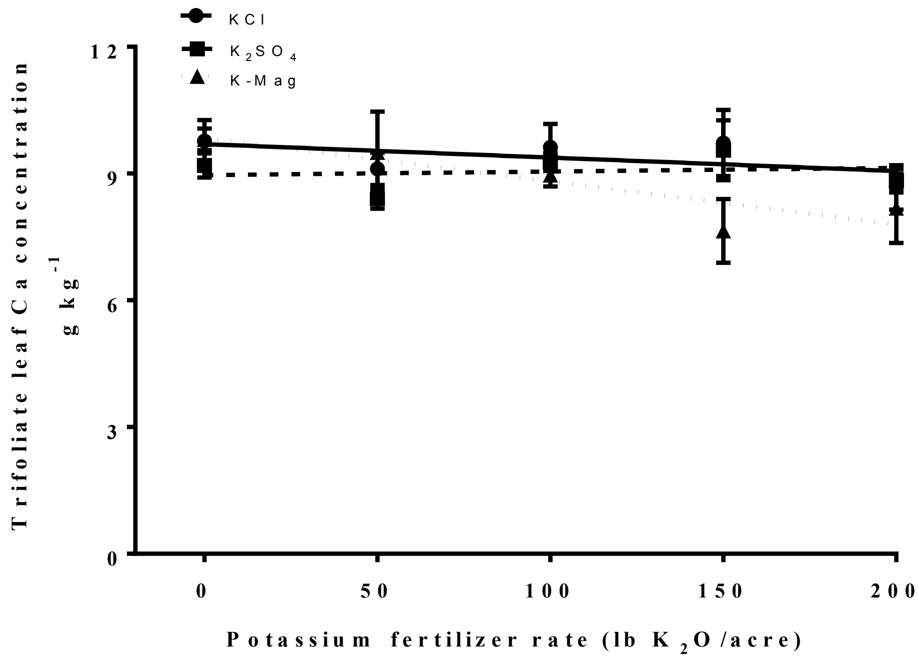


Fig 8: Effect of potassium fertilizer sources (K_2SO_4, KCl, and K-Mag) on trifoliate leaf Ca concentration at R2 growth stage across five potassium application rates (0 – 200 lbs K_2O/acre). Error bars are one standard error from the mean. (K_2SO_4, Y = 8.962 + 0.00086* X, $r^2 = 0.02$; KCl, Y = 9.696 - 0.00318* X, $r^2 = 0.28$; K-Mag, Y = 10.04 - 0.01024* X, $r^2 = 0.60$).

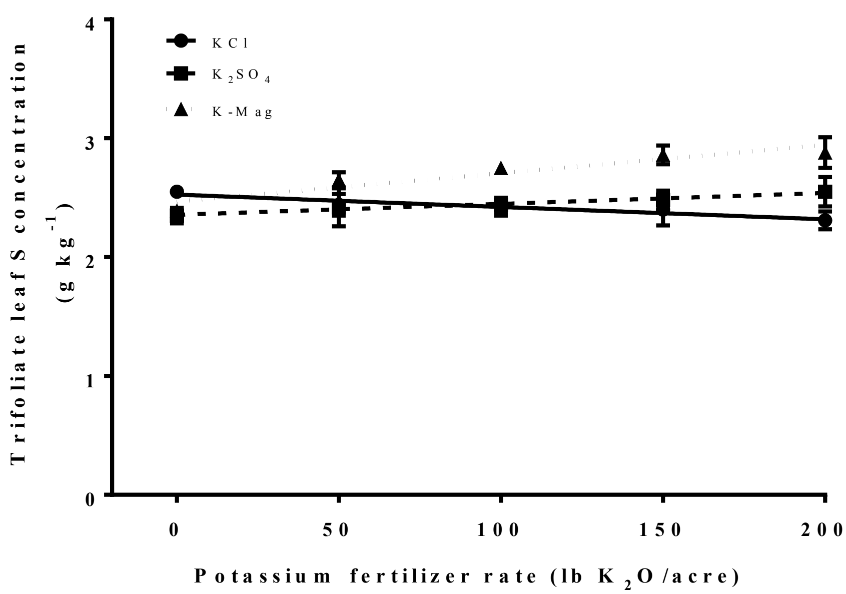


Fig 9: Effect of potassium fertilizer sources (K_2SO_4, KCl, and K-Mag) on trifoliate leaf S concentration at R2 growth stage across five potassium application rates (0 – 200 lbs K_2O/acre). Error bars are one standard error from the mean. (K_2SO_4, Y = 2.356 + 0.00092* X, $r^2 = 0.97$; KCl, Y = 2.526 - 0.00104* X, $r^2 = 0.90$; K-Mag, Y = 2.468 + 0.00238* X, $r^2 = 0.89$).

Trifoliate Ca concentration decreased as K-mag rates increased, the increasing Mg concentration observed with K-mag (figure not shown) may be responsible for the decreasing Ca concentration observed in K-mag, while, the increase in S concentration observed for both K-mag and K_2SO_4 can be attributed to the presence of S present in both fertilizers.

Discussion

This study showed that K rate had significant effect on soybean seed yield and K source and its interaction with K rate were not significant on yield. This implies that seed yield declined with increasing K rates irrespective of the K source applied. The decline in the yield was not associated with chloride and reduced Mg uptake.

Although according to the Clemson University Soil Test Rating System the initial soil K level were within the medium soil K level (89.3 -144 lb K/acre) and the decrease in seed yield with increasing rates showed that the soil test K level was sufficient for optimum soybean yield and further addition of K led to a negative soybean yield response.

However, the data from this study are limited to a one-year study and is important to repeat this experiment for another year to validate the result.

3.) CHALLENGES ENCOUNTERED AND LESSONS LEARNED:

April 1st to June 30th:

As per the original proposal, we were planning to have this trial at dryland as well as irrigated field. But, we received only $9,000 compared to our proposed budget of $17,208. Therefore, it was decided to conduct this study only at the irrigated site at the EDISTO Research and Extension Center at Blackville, SC.

We have budgeted to purchase soil sampling kit to install on four-wheel drive. Some portion of that money has to come from Dr. Farmaha's start-up funds. To use those dollars, we have to get the request approved from NIFA. We have submitted that request three months ago but it is still in pipeline. Once we will get their approval, then we will purchase the soil testing kit and get it mounted on John Deere Gator.

June 31st to September 30th:
There have been no challenges so far in the second quarter.

October 31st to December 30th:
We had no challenges this third quarter.

December 31st to March 30th:
There was no challenge for the first quarter in the year 2018.