EVALUATION OF SOYBEAN RESPONSE TO IN-SEASON POTASSIUM FERTILIZATION

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ABSTRACT

In-season application of potassium (K) fertilizer may offer an alternative to remediate deficiencies developed during the growing season. The objective of this study was to determine soybean (*Glycine max*) response to topdress K application timing under deficient soil conditions. 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). Measurements collected were plant biomass, tissue nutrient concentration at vegetative and reproductive stages (V4, R2, R4, and R6), and grain yield. In addition, K concentration in stover and grain was analyzed. Potassium fertilization increased yield at the three locations evaluated in this study. The pre-plant application produced a slightly higher yield compared to the in-season, but not statistically significant. The late K fertilization had higher K concentration in the plant at R4 ($p<0.10$) and R6 ($p<0.05$) with the same plant biomass than the pre-plant treatment. However, these higher values did not produce more yield. Also, broadcasting KCl at V4 resulted in a higher K/Mg ratio late in the season (R4 and R6). 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.

INTRODUCTION

Potassium (K) deficiency on soybean (*Glycine max*) could be detected in early stages when soil K levels are low. In-season application of K fertilizer may offer an alternative to remediate deficiencies developed during the growing season. Currently there is limited information on how crops respond to post-emergence applications using dry K fertilizers. Foliar application of 11-39 lbs K_2O acre^{-1} at the R3-R4 growth stage increased soybean yield in K-deficient conditions (Nelson et al., 2005). However, neither vegetative (V4) nor reproductive (R1-R2 and R3-R4) foliar applications yielded more than soybean fertilized pre-plant with 151-602 lbs K_2O acre^{-1}. Nelson, Motavalli, Stevens, Dunn, and Meinhardt (2010) showed similar results reporting that low K rates via foliar applications failed to increase yields compared to no K fertilization. Under irrigation conditions, Slaton and Roberts (2020) reported similar soybean yield applying equal rates of potassium chloride (KCl) in-season compared to pre-plant. The authors suggested that fertilizer K applications could be postponed in case other crop management practices need to be timely implemented (e.g. planting in favorable conditions). Despite of reporting similar grain yields regardless of fertilization timing, they recommended a pre-plant application and more K fertilizer in-season if an economic benefit is expected. Nevertheless, for a dry growing season under a rain-fed crop system, soybean response might be limited. The objective of this study was to determine soybean response to topdress K application timing using dry K fertilizer under deficient soil conditions.

MATERIALS AND METHODS

Field experiments were conducted at three locations throughout eastern Kansas during 2019. 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 AND DISCUSSION

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.

REFERENCES

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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

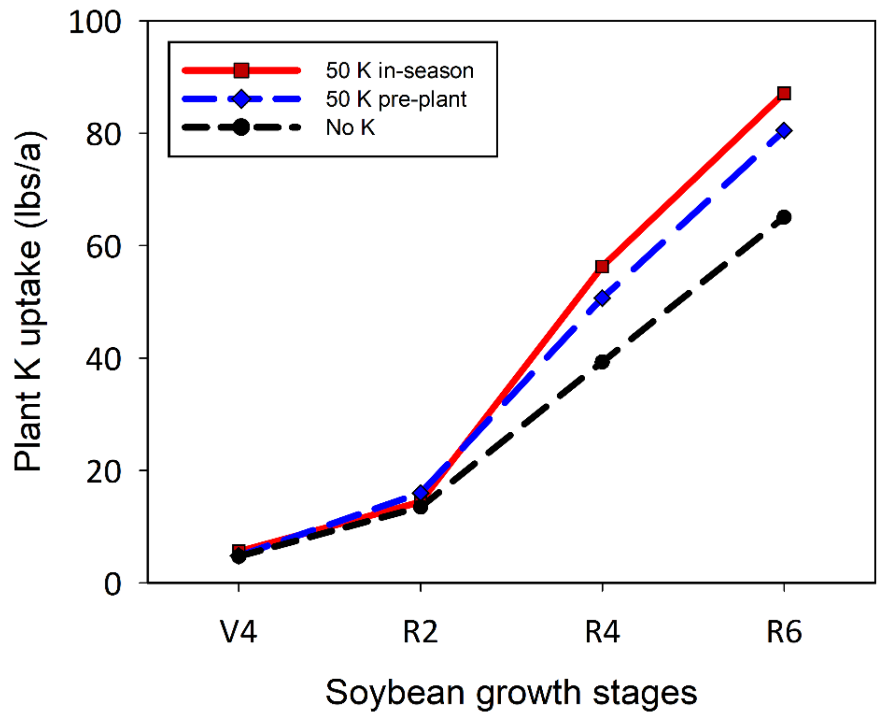

Figure 1. Cumulative plant K uptake as affected by treatment across locations.

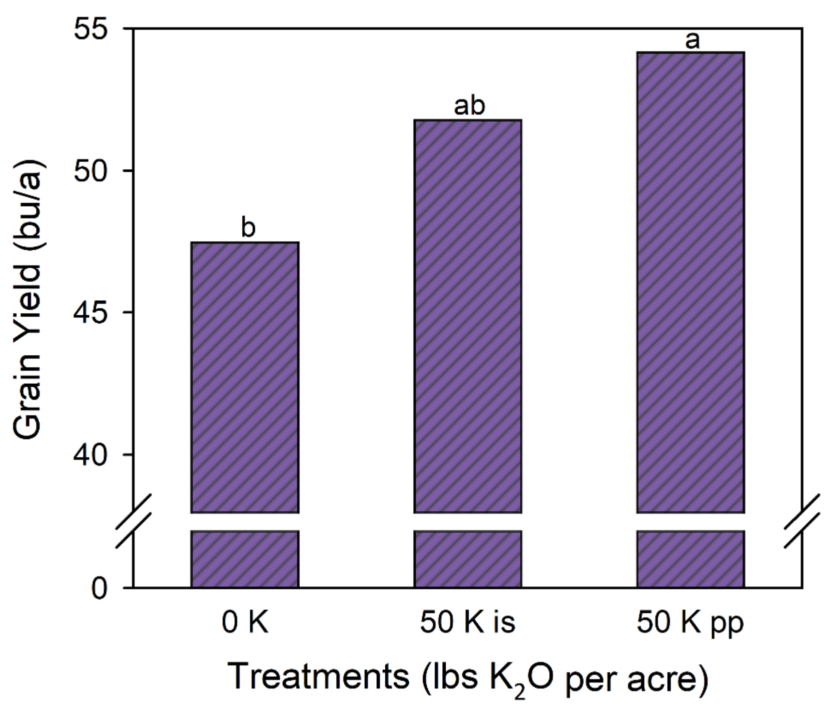

Figure 2. Yield response to K fertilization across locations. Means followed by the same letter are not significantly different at $p<0.05$.

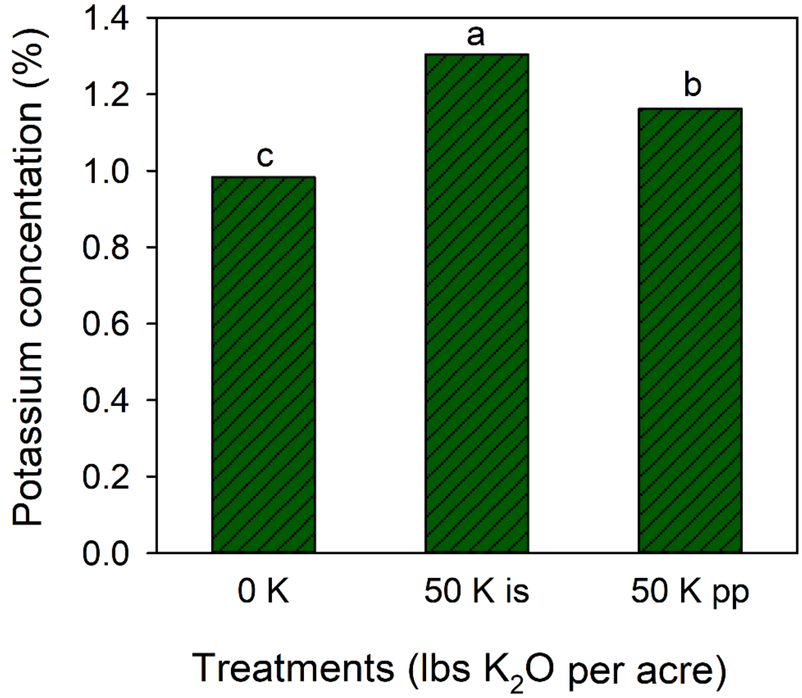

Figure 3. Plant K concentration at R6 growth stage as affected by treatment across locations. Means followed by the same letter are not significantly different at $p<0.05$.

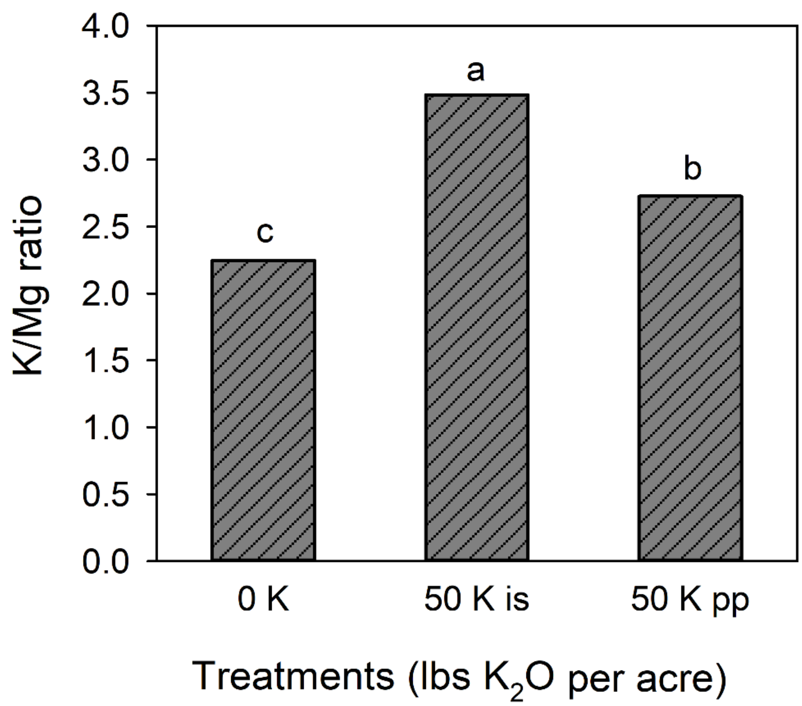

Figure 4. K/Mg ratio at R6 growth stage as affected by treatment across locations. Means followed by the same letter are not significantly different at $p<0.05$.