Cation Exchange Resins as Indicator of In-Season Potassium Supply for Soybean in Kansas

D.A. Charbonnier, M.J.A. Coelho, and D.A. Ruiz Diaz

Summary

The use of ion-exchange resins to measure soil nutrient availability has potential applications for fertilizer recommendations. The objective of this study was to evaluate the relationship between potassium (K) adsorption by cation exchange resins (CER) and K uptake by soybean in field conditions. The study was conducted at two locations in Kansas during 2019. Two treatments were selected to evaluate the CER. Treatments included a check (0 lb K_2O/a) and a high K rate with 150 lb K_2O/a applied pre-plant and incorporated. The Plant Root Simulator (PRS, Western Ag Innovations, Saskatchewan, Canada) was used as an indicator of in-season K supply to soybean. In addition, whole plant samples were collected at V4, R2, R4, and R6 stages to measure plant K uptake. Soil moisture content was calculated based on soil samples collected at the beginning and end of each burial period. The CER was able to adsorb more K (measured as cumulative adsorption) when K fertilizer (150 lb K_2O/a) was applied. Data showed a positive relation between CER values and soil moisture content. Preliminary results from this study suggest that CER can be used as an indicator of K supply, particularly in soils with low soil test K levels.

Introduction

Some soil test methods used to estimate K availability (e.g. 1 M NH_4OAc) are not always good indicators of K uptake by plants. Since the 1950s, synthetic ion exchange resins have been used for assessing the bioavailable fraction of soil nutrients (Qian and Schoenau, 2002). Compared to soil test methods, ion exchange resins can be used to measure nutrient supply rates during specific adsorption periods. Therefore, soil processes, such as nutrient release and transport, can be considered. In CER, membranes are negatively charged in order to adsorb positively-charged ions, like K^+. Exchange membranes were adequate to assess immediate nutrient supply rate by selecting short burial periods (1 hour) (Qian et al., 1996). Also, long periods are used to capture nutrients released from mineral and non-exchangeable forms (Cooperband and Logan, 1994). This technology has potential applications in numerous areas (including agronomic research) because of its ability to simulate plant root activity in undisturbed conditions. However, there are still limitations such as the unfamiliarity of units used to express results (Qian and Schoenau, 2002), and lack of calibration studies related to crop response. Commonly, K management is based on pre-plant soil sampling to assess nutrient supply for the entire season. Finding an indicator that considers the kinetics of

K release from the soil could be useful to improve future management. The objective of this study was to evaluate whether K adsorbed by CER could be used as an indicator of in-season K supply to soybean in field conditions.

Procedures

Field experiments were conducted at two locations in eastern Kansas during 2019 (Table 1). Sites were located at Ashland Bottoms (Manhattan, KS) and Ottawa, KS, under a conventional tillage system. Treatments included a control (check) with no K application and one with an application of 150 lb K_2O/a (high K rate). Both treatments had an application of 80 lb P_2O_5/a. 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 PRS as an indicator of the 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. The Ottawa location had six burial periods and Ashland 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. 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. 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 v. 9.4 (Cary Inst. Inc., Cary, NC).

Results

Plant K uptake measured at reproductive stages (R2, R4, and R6) was increased by K fertilization in both locations (Figure 1). Location 2 had significantly higher plant K uptake measured at R2, R4, and R6 stages when 150 lb K_2O/a was applied (Figure 2). 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 an indicator of K supply to soybean in field conditions. 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 at location 1 (Figure 3). 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 (Figure 4). Preliminary results from this study suggest that CER can be used as an indicator of K supply, particularly in low K soils.

References

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Table 1. Selected soil properties for 0–6 inch samples

Location	County	Soil texture	pH	OM	P-M	K-M	K	Ca	Mg	Na	CEC
				%	ppm						meq/100 g
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

OM = organic matter. P-M = Mehlich-3 P. K-M = Mehlich-3 K. K = potassium. Ca = calcium. Mg = magnesium. Na = sodium. CEC = cation exchange capacity.

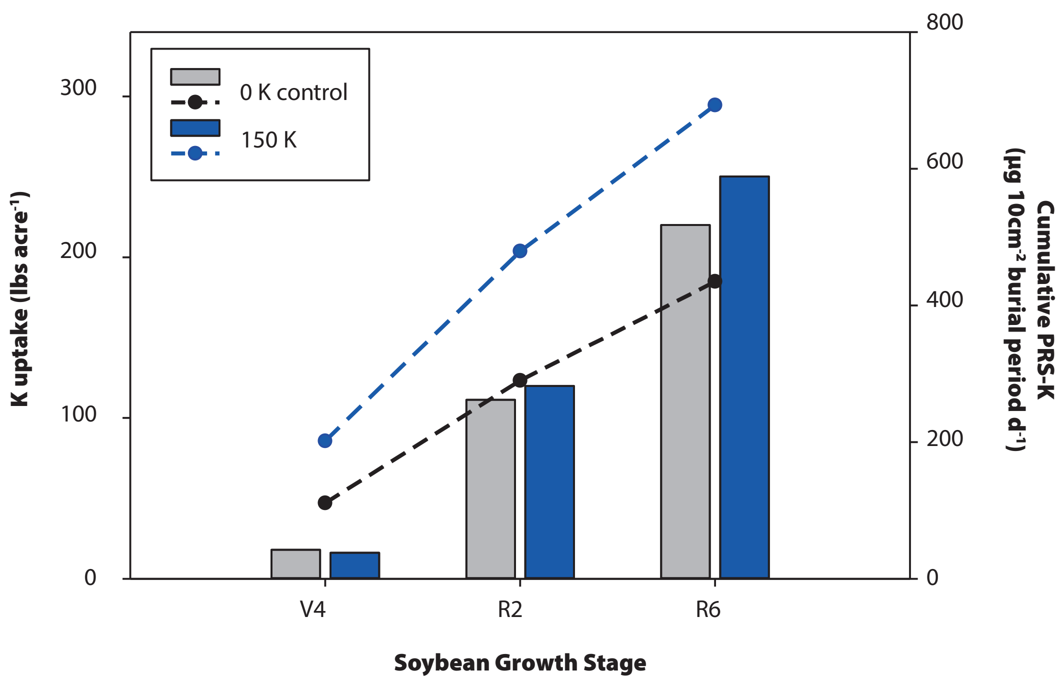

Figure 1. Soybean plant potassium (K) uptake (bars) and cumulative PRS K adsorption as affected by two levels of K application at Location 1 (Riley County).

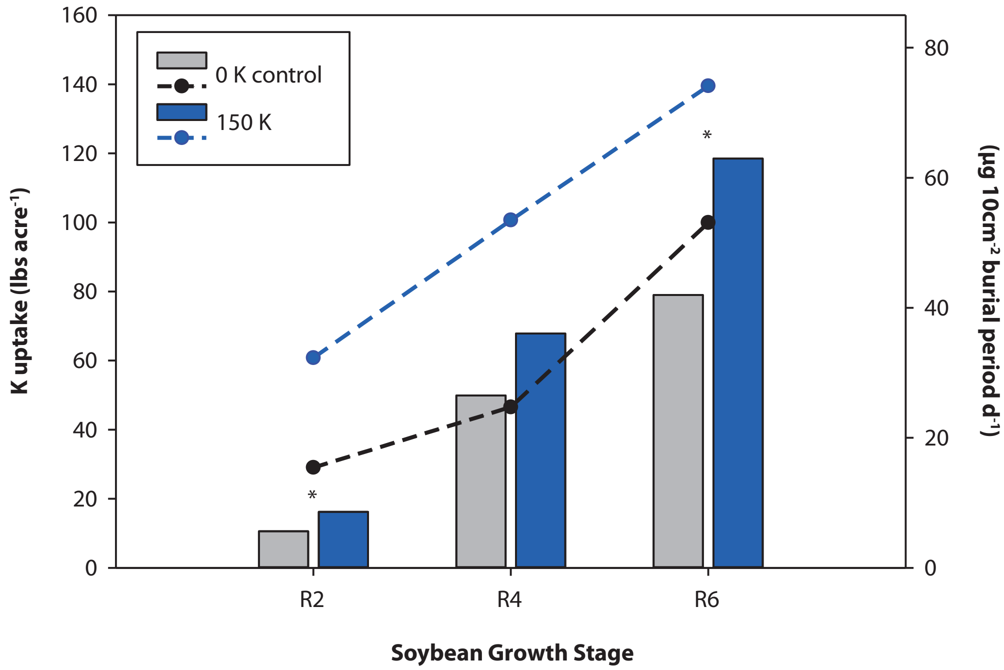

Figure 2. Soybean plant potassium (K) uptake (bars) and cumulative Plant Root Simulator (PRS, Western Ag Innovations, Saskatchewan, Canada) K adsorption as affected by two levels of K application at Location 2 (Franklin County). Pairwise comparisons of K fertilizer application rate within each stage are indicated by "*" when statistically significant at the $P < 0.05$.

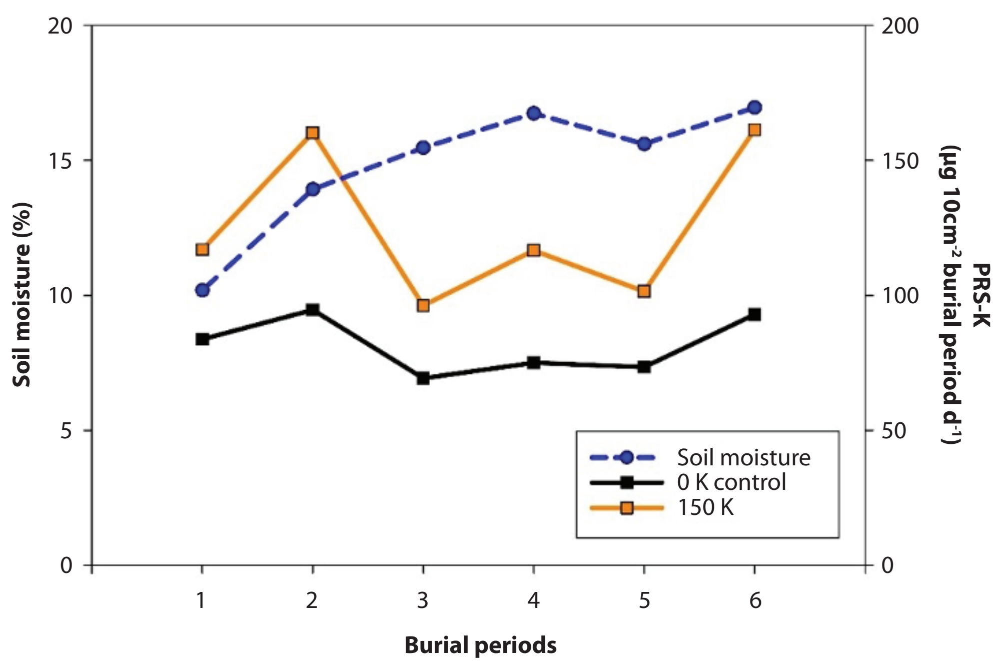

Figure 3. Plant Root Simulator (PRS, Western Ag Innovations, Saskatchewan, Canada) potassium (K) adsorption as affected by two levels of K application compared to soil moisture content at Location 1 (Riley County).

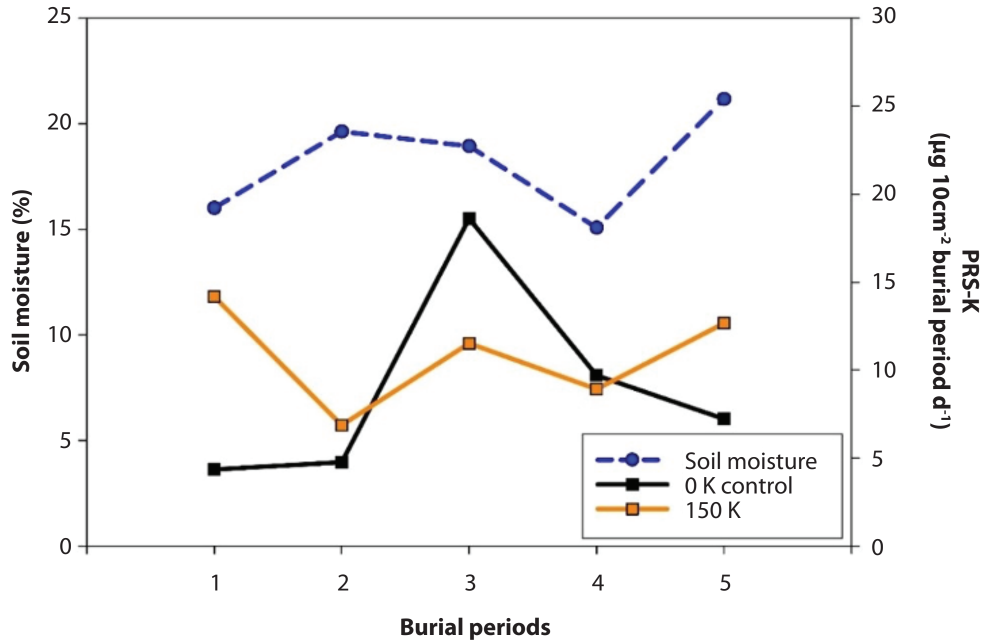

Figure 4. Plant Root Simulator (PRS, Western Ag Innovations, Saskatchewan, Canada) potassium (K) adsorption as affected by two levels of K application compared to soil moisture content at Location 2 (Franklin County).