The Evaluation of Spatial Response to Potassium in Soybeans

Sam Akin[1], Brain Arnall[1]

[1]Department of Plant and Soil Science, Oklahoma State University, Stillwater, OK, United States

A paper from the Proceedings of the
16th International Conference on Precision Agriculture
21-24 July 2024
Manhattan, Kansas, United States

Abstract.

In agriculture, the nutrients that are in the largest in demand are nitrogen (N), phosphorus (P), and potassium (K), as product demands increases so does demand for nutrients requiring fertilization. In the case of potassium, most soils have potassium levels that exceeds the requirements of the crop. However, not all potassium present within the soils are readily available to the crop. This can lead producers to apply potassium to their soils even though soil tests may indicate adequate levels. This leading to a lowering of potassium use efficiency (KUE), with the worlds KUE being estimated to be 19% in (Dhillon et al., 2019)we have great room for improvement. This backed up in Reed et al.(2022) where it is noted that our recommendations for K (potassium) could be considered accurate on the average, but these recommendations were not accurate enough to predict in-site responsiveness within a location. While potassium has been studied immensely in the past and still today, there are many questions to be answered still, questions such as what soil characteristic is causing a response to k application in one area and not another. To improve our K recommendations as well as the world's KUE we first need to identify and understand the drivers of response to K. In this study, field length K strips were applied to on farm soybean fields in both north central Oklahoma as well as in eastern Oklahoma bring the total number of K strips to be

eleven. K strips were established by applying a 16 foot field length strip of K fertilizer at a rate of sufficiency once the crop was established in an effort to apply with the already established soybean rows. In-season measurements captured using a fixed wing sentera drone, capturing both RGB imagery as well as NDVI. Once crop reached maturity the decision was made to drop the north central locations due to lack of response, leaving us with five K strips to be harvested. The crop was then harvested with an 8xp Kincaid small plot harvester and response to K was determined by the difference in yields between plots that were applied and those that were not.

Keywords.
Soybeans, Potassium, spatial response, spatial variability.

Introduction

Soybean (*Glycine max* [L.] Merr.) production accounts for approximately 82.7 million acres in the United States, making it not only an important crop for the producers of the US but also for the world. Soybeans provide a vital option for rotation as well as supplementing the following crops nitrogen needs. Soybeans themselves have a high requirement for nitrogen, but this is largely taken care of by the plant through its relation with nitrogen fixing bacteria. Second to nitrogen, potassium is the second highest in demand nutrient. Potassium is also the cation in the highest in abundance within plant cells, it is highly mobile over short distances (cell to cell) as well as being highly mobile long distance through xylem and phloem pathways(Oosterhuis et al., 2014). Potassium plays a vital role in many areas within the plant all of which can cause a reduction in yield. One such role of potassium is in its ability to regulate water within the plant as well as the plants ability to tolerate drought stress (Bahrami-Rad & Hajiboland, 2017). This is done through the plants ability ot control its stoma and potassium helps the plant open and close said stomata (Hawkesford et al., 2012).

The amount of potassium within the soil exceeds the demands of crops, however not all potassium is created equally. Potassium exists in four soil pools; these being fixed, non-exchangeable, exchangeable and solution K, but not all of these are readily available to the crop. While many labs across the country run soil tests to help producers access their nutrient needs; potassium concentrations will vary through both time and space, (Reed et al., 2022) found that on average these soil test were adequate on average, they were not accurate enough to predict response within a given location. This study examines ways to predict response to potassium fertilizer within a given locations.

Materials and Methods

Experimental design and location

This study was established on producer soybean fields in two areas in Oklahoma. The first being in the north central part of Oklahoma located just outside of Ponca City Oklahoma with the second being in eastern Oklahoma located outside of Fort Gibson Oklahoma. These studies consisted of strip trails of potassium applied at a rate of 250 lbs of K to the acre to ensure sufficient nutrient levels.

Each area of the study had approximately six field length K rich strips on several producer fields resulting in eleven strip trials in total. However, due to lack of response to K application the north central experimental locations were dropped resulting five final strips to be harvested and further analized.

Data collection

Throughout the growing season aerial imagery was captured using a Sentera fixed wing drone, with which both RGB and NDVI imagery was collected. This imagery was used as a tool to help determine crop response. Once the crop had reach maturity yield data was collected using a Kincaid 8xp small plot combine outfitted with a harvest master unit collecting plot weight and moisture. Yield data was collected every fifty feet along the strip resulting a total of 150 plots total for this years studies. Following harvest of the crop soil samples were taken in two fashions. Firstly every plot was composite soil sampled 0-6in and then the plots were deep cored twice using a Veris soil probe. This veris probe also included a penetrometer sensor to measure elctroconductivity (EC) and resistance to depth through the profile giving a vertical look of every plot. Similar to the penetrometer a veris soil sled was also used to collect EC and resistance, but instead of a vertical image this implement gives a horizontal view. Lastly a topsoil mapper made by geoporspectors was also used.

Summary

Soybean production is not only significant to the united stated but the world as a whole, with its high demand for potassium it is critical to manage potassium correctly to optimize and maintain yields. Currently fertilizer recommendation work well on average but as the technology used by producers advances and the capability to become more precise with their fertilizers applications, fertilizer recommendation need to improve as well. By honing in on the drivers of response to potassium applications we can improve our recommendations to accommodate a producers ability

to use precision technology.

References

Bahrami-Rad, S., & Hajiboland, R. (2017). Effect of potassium application in drought-stressed tobacco (*Nicotiana rustica* L.) plants: Comparison of root with foliar application. *Annals of Agricultural Sciences*, *62*(2), 121–130. https://doi.org/10.1016/j.aoas.2017.08.001

Dhillon, J. S., Eickhoff, E. M., Mullen, R. W., & Raun, W. R. (2019). World Potassium Use Efficiency in Cereal Crops. *Agronomy Journal*, *111*(2), 889–896. https://doi.org/10.2134/agronj2018.07.0462

Hawkesford, M., Horst, W., Kichey, T., Lambers, H., Schjoerring, J., Møller, I. S., & White, P. (2012). Chapter 6—Functions of Macronutrients. In P. Marschner (Ed.), *Marschner's Mineral Nutrition of Higher Plants (Third Edition)* (pp. 135–189). Academic Press. https://doi.org/10.1016/B978-0-12-384905-2.00006-6

Oosterhuis, D. M., Loka, D. A., Kawakami, E. M., & Pettigrew, W. T. (2014). Chapter Three—The Physiology of Potassium in Crop Production. In D. L. Sparks (Ed.), *Advances in Agronomy* (Vol. 126, pp. 203–233). Academic Press. https://doi.org/10.1016/B978-0-12-800132-5.00003-1

Reed, V., Souza, J. L. B., Lofton, J., & Arnall, B. (2022). On farm evaluation of preplant soil test P and K in double-crop soybeans. *Agrosystems, Geosciences & Environment*, *5*(4), e20307. https://doi.org/10.1002/agg2.20307