The 4Rs and Potassium

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Introduction – Are we meeting crop K needs?

Using the 4R nutrient stewardship approach of selecting the right source at the right rate at the right time and in the right place is just as important when dealing with a nutrient supply challenges as it is for reducing risk of nutrient loss. Potassium (K) behavior in the soil is different from nitrogen (N) or phosphorus (P). While some of the same factors influence your 4R decisions, right source, right rate, right time, and right place; the variability of the soil's ability to supply and store K is quite dynamic. Availability of K in the soil is dependent on the percent and type of clay present, cation exchange capacity (CEC, meq/100 g), organic matter (OM) content, soil moisture level, and soil temperature.

Plants require K in similar quantities to N. In the plant, K activates enzymes, is involved in protein synthesis, photosynthesis, water regulation, stomatal movement, and phloem transport. Potassium nutrition levels are related to dehydration and wilting responses as well as response to disease and pest pressure. In general, when crops are grown in soils with insufficient K they produce less than optimum yields, and they do not use water or N efficiently (Mikkelsen and Roberts, 2017).

In N and P management, beyond production, we are more often than not talking about concerns with cropping system loss to water and air. With K, the focus is on supply and availability. In 2015, the International Plant Nutrition Institute (IPNI) summarized soil test results from private and public soil testing laboratories in the United States and Canada to provide an indicator resource on the nutrient supplying capacity or fertility of soils in North America (IPNI, 2015). The percentage of samples that tested below the critical level, the soil test level above which the soil can supply adequate quantities of K to support optimum yield, ranged from 8 to 79 percent (Figure 1). The highest percentages of K soil tests below the critical level were found in the Southeast, with Georgia having the most K deficient soil test results (IPNI, 2015; Figure 1). In a second project, soil samples were collected between the fall of 2015 and the spring of 2016 in the Corn Belt, soils testing below the critical level ranged from 2 percent in Nebraska to 56 percent in Iowa (Schulte and Heggenstaller, 2017). Potassium deficiency was most frequently observed in Michigan where 55 percent of samples tested below the critical level for K (Schulte and Heggenstaller, 2017). The use of commercial K fertilizer has declined in the recent past, while crop removal has increased, resulting in mining of soil K reserves (Singh et al., 2017).

The K situation in Ohio

In Ohio, two additional soil test surveys have been conducted (Brooker et al., 2017 and Schulte and Heggenstaller, 2017). Schulte and Heggenstaller (2017) reported that 25 percent of the samples taken in Ohio were below the critical level. For the study by Brooker et al. (2017), soil samples were collected for three consecutive years from soybean fields and combined with yield data. The study reported 22.6 percent of samples were below the critical level, 34.9 percent of samples were at a maintenance level, and 43.5 percent of samples were above a level where there is no agronomic reason to apply K on the sampled fields. Overall, 57.5 percent of the soils test results indicated supplemental K application. Additionally, observed soybean yield was reduced by 4 bu/acre when soil test K was below the critical level (Booker et al., 2017).

Source

When K is supplied from commercial sources, it is highly soluble and rapidly dissolved when adequate soil moisture is present. Once commercial K fertilizers dissolve in the soil, the K available for plant nutrition is identical across sources (Mikkelsen and Roberts, 2017). The nutrient accompanying the K in the source will change solubility, pH, salt index, and conditions for most appropriate use (Mikkelsen and Roberts, 2017). Potassium chloride (KCl) is the most widely used K fertilizer, due to its lower cost and higher K concentrations relative to other sources (Mikkelsen and Roberts, 2017). However, high concentrations of salt from chloride-based fertilizers can burn crops if rates, soil chloride levels, and placement of the fertilizer are not considered. The sensitivity of crops to chloride is variable across species and among varieties within a species (Mikkelsen and Roberts, 2017). Be sure to consider crop sensitivity to chloride, soil moisture conditions, and soil chloride levels when selecting a K source.

Rate

The availability of K in the soil is largely determined by the mineralogical composition: sand, silt, and clay content of the soil (Singh et al., 2017). Additionally, soil OM content can play a role in K soil cycling. The influence of charge on soil K availability has resulted in recommendations based on soil tests results like CEC, in the Tri-Sate Fertilizer Recommendations (Vitosh et al, 1995). In other areas, classification of soil types into soil management group based on sand, silt, and clay make-up are used to account for differences in K availability (Ketterings et al., 2008). Soils can be tested for CEC by a laboratory. Information on the mineral make up or management group for a soil can be found using tools like the Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov), which allows users to define a map area and then reports the soil types in the area.

Time

Uptake of K can be improved with application timing. In high CEC soils (20 to 30 meq/100 g), a single application can work well because of the soil's capacity to hold K and cycle it into a plant available form. For soils with low CEC (5 to 10 meq/100 g), split applications can improve the use of K and decrease the potential of loss via leaching (Bell et al., 2017). Split applications of K, including foliar application, are most beneficial when the crop has a consistent demand for K through the growing season. Crops like cotton and soybeans take up smaller amounts of K throughout the whole season, where corn has a high demand early in the growing season before dry matter growth takes off (Bell et al., 2017). Soil moisture influences how and if K will be moved by diffusion to a root for plant uptake. In flooded systems, the lack of oxygen in the soil will increase K cycling (Bell et al., 2017).

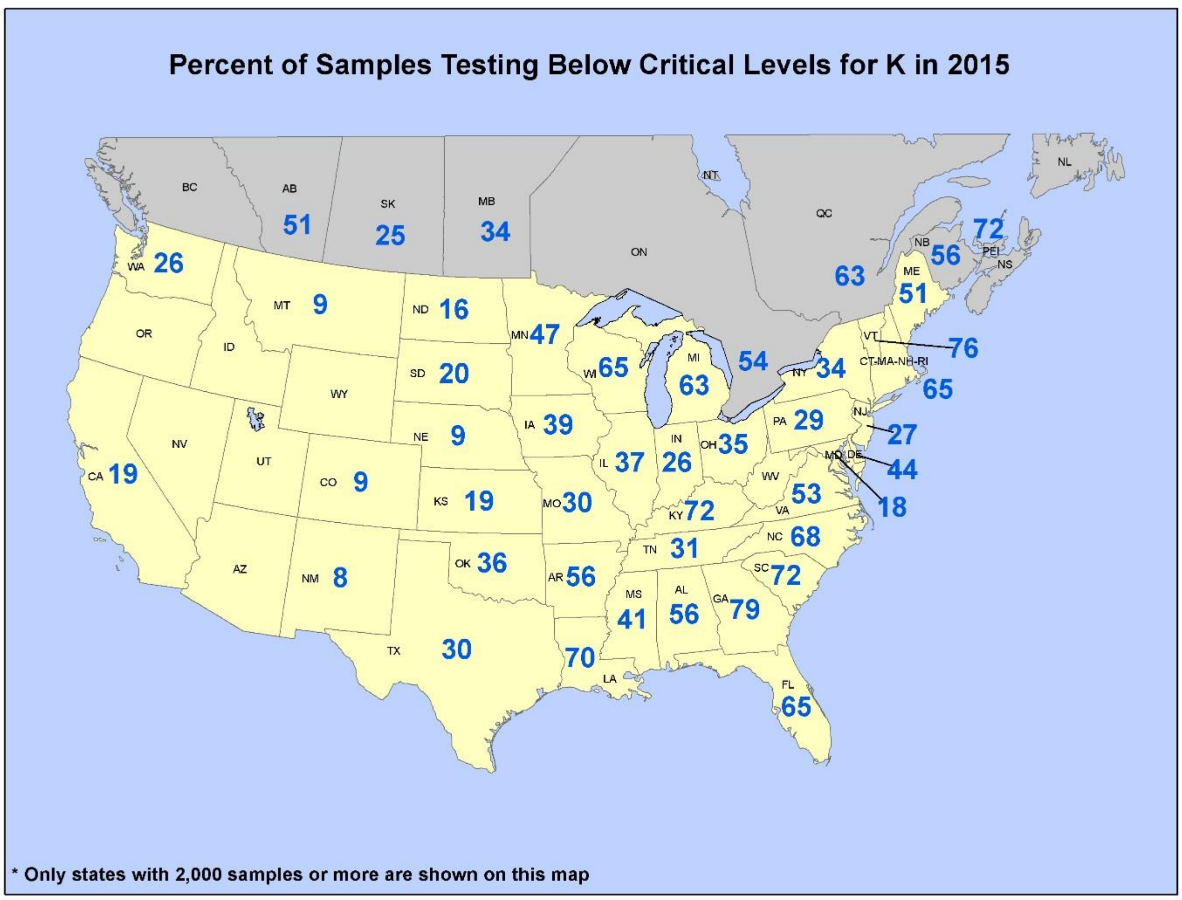
Place

Soil K available for plant uptake moves as water moves and as roots create the osmotic pressure to move water through the soil. This relationship makes considering how and where water moves an important piece of information when deciding where to place fertilizer. In high CEC soils, applications that are not incorporated can lead to stratification of K in the soil, limited movement of K, and low K uptake because the roots never connect with the applied K (Bell et al., 2017). Light incorporation, banding, or starter placement in high CEC soils will improve the ability of the roots to reach the applied K (Bell et al., 2017 and Vyn, 2017). However, when placing K in bands or as a starter, it is important to place the fertilizer far enough away that high salt concentrations won't negatively impact germination or the seedling (Bell et al., 2017). Surface application of K with no incorporation can be more effective in meeting crop needs in low CEC soils, because higher drainage rates and lower capacity to adsorb K can aid in the movement of K to lower parts of the soil profile (Bell et al., 2017). Foliar application of K is most often used to supplement soil applications on crops with a steady demand for K through the season, when K is stratified in the top layers of the soil, or when fertilizing deep rooted plants (Bell et al., 2017).

Conclusions

Recent surveys of soil test K levels indicate that concerns with under supplying K to growing crops should guide many 4R nutrient stewardship decisions. An important part of making 4R decisions for K applications is the difference in how K behaves in the soil compared to N and P. The low mobility and the difference in mobility based on the soil mineral make up, organic matter content, and CEC affect how we implement 4R practices to meet the need of the crop, taking care not to apply nutrients from a source that could damage the crop, at a rate under what the crop needs, at a time when the crop needs K, and in a place the soil-water and roots cannot reach them.

Figure 1. Results from the 2015 International Plant Institute Soil Test Levels in North America Summary Report. Available at http://soiltest.ipni.net/.



References

Bell, M. J., A. P. Mallarino, P. Moody, M. Thompson, and S. Murrell. 2017. Soil Characteristics and Cultural Practices that Influence Potassium Recovery Efficiency and Placement Decisions. Proceedings of Frontiers of Potassium Science Conference. 25-27. January 2017. Rome, Italy.

Brooker, A.P., L.E. Lindsey, S.W. Culman, S.K Subburayalu, and P.R. Thomison. 2017. Low soil phosphorus and potassium limit soybean grain yield in Ohio. Crop Forage Turfgrass Manage. Vol. 3.

International Plant Nutrition Institute (IPNI). 2015. Soil Test Levels in North America. Int. Plant Nutrition Inst. http://soiltest.ipni.net/

Ketterings, Q., P. Ristow, and B. Aldrich. 2008. Potassium Guidelines for Corn. Cornell Univ. Coop. Ext. Agronomy Fact Sheet Series. Fact Sheet 40. http://nmsp.cals.cornell.edu/publications/factsheets/factsheet40.pdf

Mikkelsen, R. L. and T. L. Roberts. 2017. Selecting the Proper Source of Potassium Fertilizer. Proceedings of Frontiers of Potassium Science Conference. 25-27. January 2017. Rome, Italy.

Schulte, M. and A. Heggenstaller. 2017. Soil test phosphorus and potassium levels in the corn belt. Agronomy Sciences Research Summary. Dupont-Pioneer.

Vitosh, M.L., J.W. Johnson, and D.B. Mengle. 1995. Tri-state fertilizer recommendations for corn, soybeans, wheat, and alfalfa. Ext. Bull. E-2567. Ohio State Univ. Ext. Ser. Columbus.

Vyn, T. 2017. Potassium Placement Considerations for Plant Nutrient Balance Optimization in Modern Maize Hybrids. Proceedings of Frontiers of Potassium Science Conference. 25-27. January 2017. Rome, Italy.

CEU Questions

1. Plant require K in levels similar to:
    - **a. N**
    - b. P
    - c. S
    - d. Zn
2. Which state has the greatest number of soils testing below the critical level for K, based on the IPNI, 2015 data?
    - a. New York
    - b. California
    - **c. Georgia**
    - d. Michigan
3. Soil test K fertilizer recommendation ranges are based on:
    - a. pH or OM
    - **b. CEC or soil management group**
    - c. Soil management group or OM
    - d. Soil test Zn or CEC
4. Which crops have a steady need for K through the growing season?
    - **a. Cotton and soybeans**
    - b. Soybeans and corn

c. Corn and rice
d. Cotton and corn

5. When applying K fertilizer as a starter placement of the fertilizer need to take into account
    a. Leaching potential
    b. Potential for burn damage to the seed or seedling
    c. Runoff potential
    d. Plant rooting depth