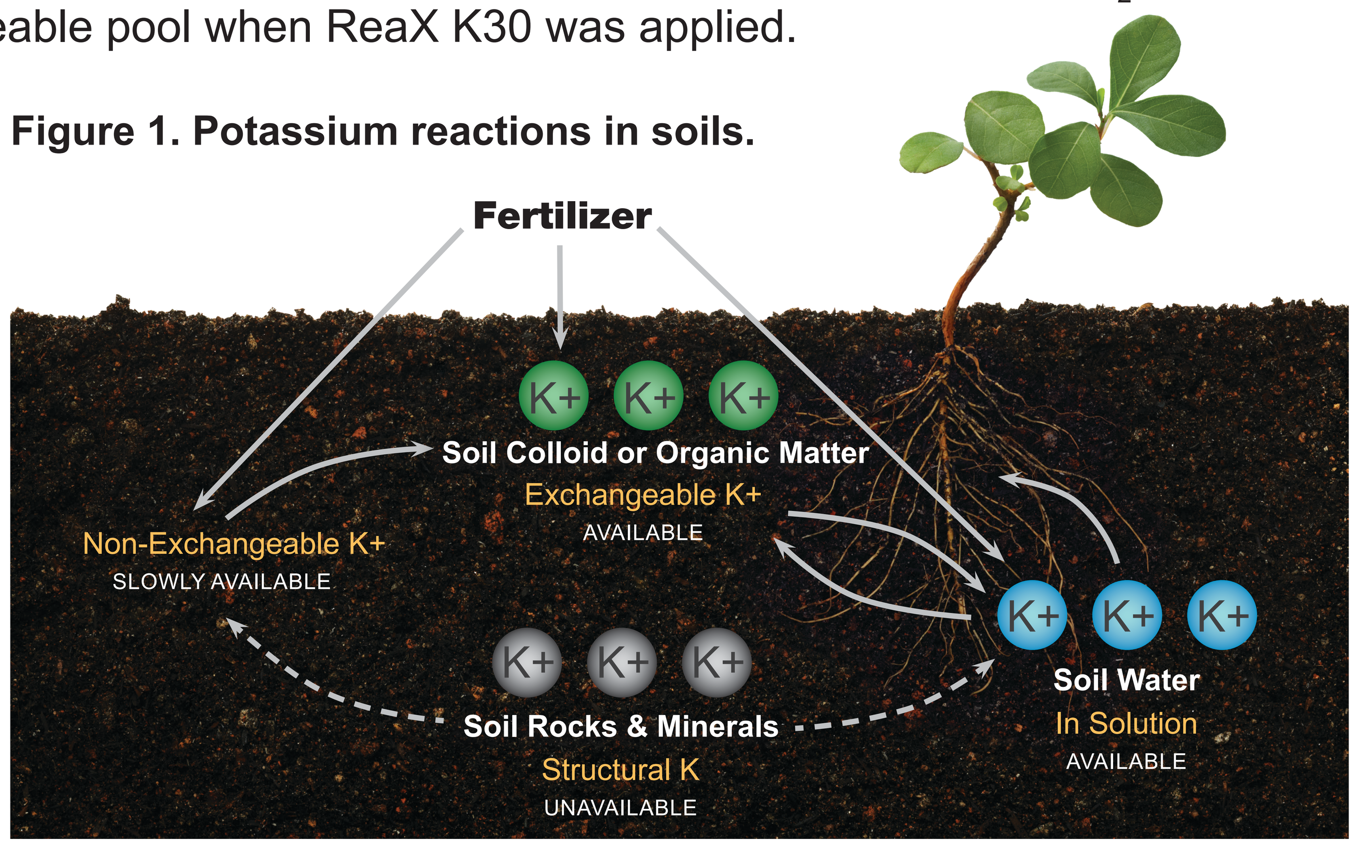
Improving Plant Available K in Soils Using ReaX K30

Authors: Leticia Sonon and John Breen

Abstract

Potassium (K) is a nutrient vital to crop production. When K fertilizer is applied to soil, it is subjected to three possible fates as shown in Fig. 1: dissolved in solution, adsorbed on exchangeable sites, or fixed by clay minerals. Dissolved K and exchangeable K are both plant available, but fixed K is not. ReaX K30 (0-0-30) is a proprietary Actagro-Nutrien liquid fertilizer with 3.5% Actagro Reacted Carbon Technology formulated to improve the availability of soil-applied K to crops. Four separate laboratory incubation studies examined the availability of K using ReaX K30 and KCl (0-0-60) applied at various rates in high K-fixing California soils. Results consistently showed more available K from ReaX K30 compared to KCl. Potassium availability was 15.4% to 53.2% higher using ReaX K30 compared to KCl across all rates. Using KCl applied at 200 mg K_2O/kg, about 85% of K was fixed and consequently unavailable for plant use. In contrast, in the same experiment, >200 mg K_2O/kg soil was released from the non-exchangeable pool when ReaX K30 was applied.

Figure 1. Potassium reactions in soils.



Materials and Methods

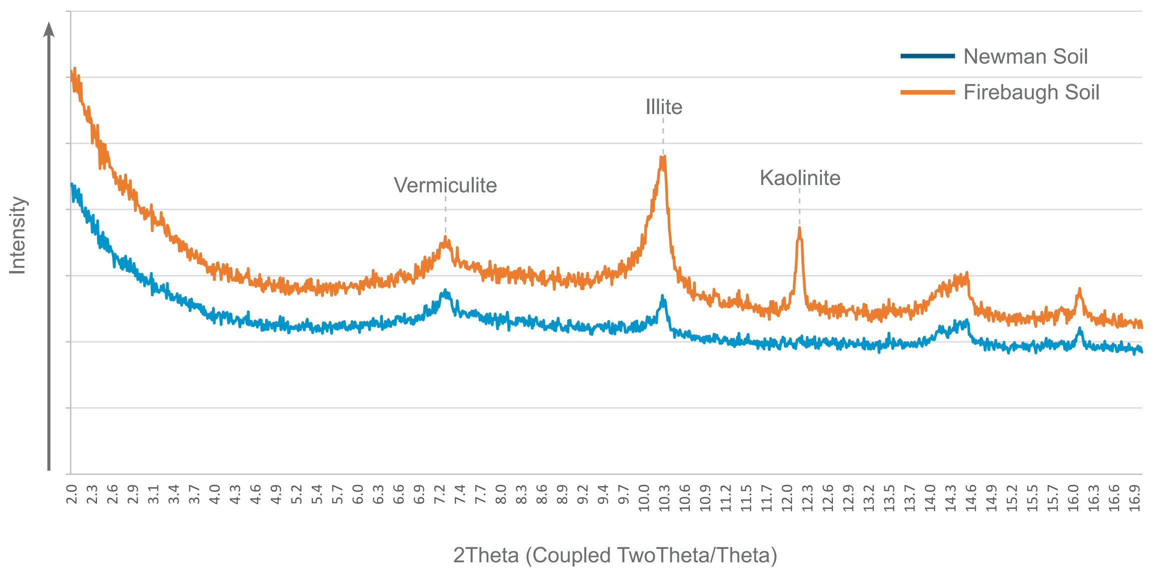
Soils and Mineralogical Analysis

Two CA soils with different mineralogies were used: Deldota clay from Newman, CA classified as Fine, smectitic, thermic, Vertic Haploxeroll, and Bolfar soil Firebaugh, CA classified as Fine-loamy, mixed, superactive, calcareous, thermic Cumulic Endoaquolls. Properties of these soils are shown in Table 1. Inorganic fractions were identified and semi-quantified using X-ray diffraction analysis (Fig. 2). In this analysis, the <0.002 mm fraction was separated using sedimentation and mounted on glass slides after saturation with different exchangeable cations. The slides are placed in a diffractometer, which impinges x-rays on the sample over a range of angles of incident radiation. Diffraction patterns obtained were used to identify phyllosilicate (clay) minerals such as kaolinite, vermiculite, illite and others present in the sample and estimate their abundance. Firebaugh soil has kaolinite and higher illite content than Newman. Both soils have approximately the same vermiculite abundance.

Table 1. Chemical properties of soils used in this study.

Soil	pH	CEC (cmol/kg)	SOM (%)
Newman	7.1	17.2	3.1
Firebaugh	6.4	16.5	2.8

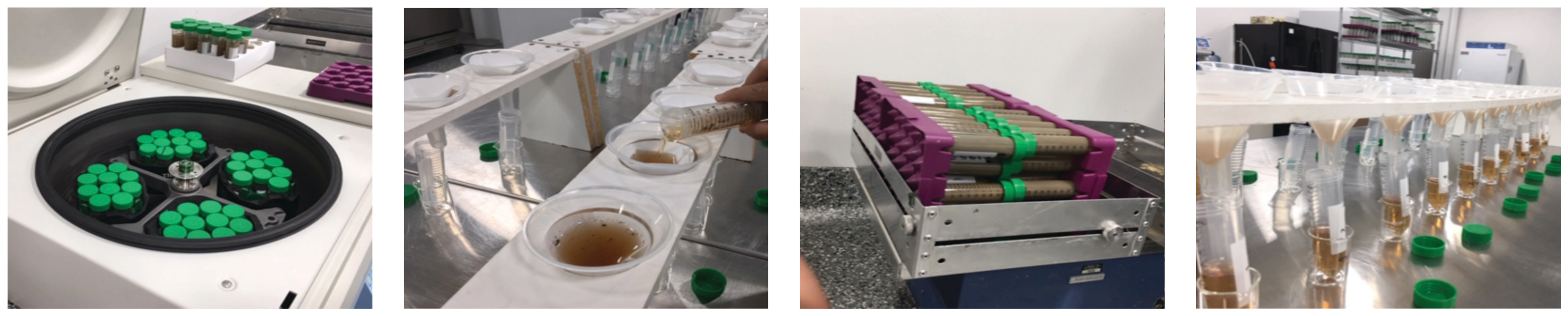
Figure 2. X-ray diffractograms of soil samples collected from Newman and Firebaugh, CA. The intensities of the peaks are proportional to mineral abundance.



Incubation Methods

- Four laboratory incubation studies were conducted: 1) Effects of ReaX K30 and KCl applied at 50, 100, 150, 200, and 300 mg K_2O kg-1 on K availability in Newman soil (2018); 2) Incubation study of K availability in Newman soil applied with either ReaX K30 or KCl at rates of 50, 100, 150, and 200 mg K_2O kg-1 (2019); 3) Effects of K source (ReaX K30 and KCl) applied at 50 and 200 mg K_2O kg^{-1} on available and non-exchangeable K (2020).
- Soil moisture was maintained at 60% water holding capacity (WHC) and soils were incubated at 25°C.
- After each timing, soils were added with 1 M NH_4OAc and shaken (Fig. 3).
- Filtrates were analyzed for K for the exchangeable fraction.
- Non-exchangeable K was determined by Na-tetraphenylboron method by the University of GA Analytical Laboratory.
- Extracts for available K were analyzed by ICP-OES at the University of Georgia Analytical Laboratory and at the Biola Innovation Center Laboratory.

Figure 3. Steps involved in soil extraction.



Results and Discussion

Data from various experiments and times (2018, 2019, 2020) were consistently showing higher available K with ReaX K30 compared to KCl. For the purposes of this poster, the various times are represented by selected data highlighting the difference in exchangeable K concentration as influenced by K source. Data are also normalized against KCl to force its results to 100 units in each case.

Figure 4 shows the normalized exchangeable K data in various experiments. In Newman soil, ReaX K30 was superior to KCl in enhancing K availability. On average, exchangeable K was 50% and 53% higher using ReaX K30 compared to KCl for 2018 and 2019 studies, respectively. In 2020, similar study was conducted on another CA soil, Firebaugh, that has a higher content of illite than Newman soil as shown in Fig, 2. Presence of illite is an indication that the Firebaugh soil has higher K fixation capacity than Newman. This was clearly illustrated in 2020 data where K availability was lower in Firebaugh soil compared to that of Newman in 2018 and 2019. Regardless, ReaX K30 remained better than KCl in terms of K availability. At low rate of application (50 mg K_2O kg^{-1}), ReaX K30was 24% better than KCl. At high rate (200 mg K_2O kg^{-1}), ReaX K30 was 15% better than KCl (Fig. 4).

Figure 5 shows the concentration of non-exchangeable K in Firebaugh soil after a 3-d incubation period. At low application rate (50 mg K_2O kg^{-1}), the applied K using KCl was fixed or became part of the non-exchangeable pool. With ReaX K30, the concentration of non-exchangeable K decreased indicating that some K were released. At high application rate (200 mg K_2O kg^{-1}), similar observation was obtained. Essentially, all of the K (~88%) applied using KCl was fixed into the non-exchangeable pool. In contrast, in the same experiment, >200 mg K_2O kg^{-1} soil was released from the non-exchangeable pool when ReaX K30 was applied. In both rates, ReaX K30 triggered the release of non-exchangeable K.

Figure 4. Effects of ReaX K30 and KCl on exchangeable K concentrations

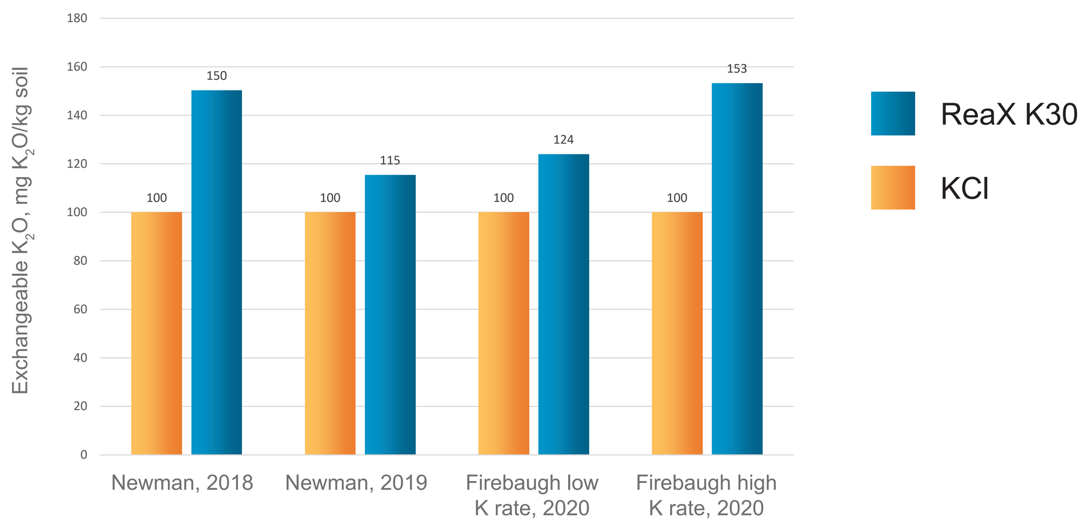
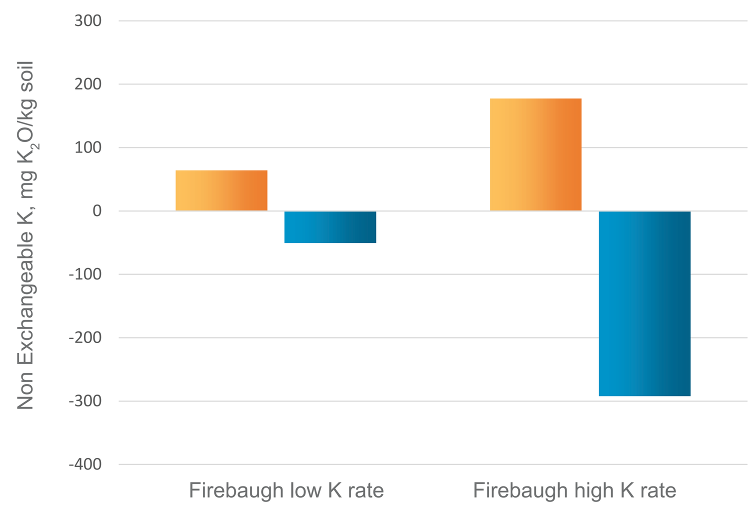


Figure 5. Effects of ReaX K30 and KCl on non-exchangeable K concentrations



Summary and Conclusions

Laboratory incubation of CA soils indicated that concentration of exchangeable K is higher using ReaX K30 compared to KCl as K source. Similarly, ReaX K30 enhanced the release of K from non-exchangeable pool. The exact mechanism of release of K from non-exchangeable sites with ReaX K30 application is currently investigated by our laboratory. However, our hypothesis suggests two possible reactions that we are currently investigating:

a). The organic matter in ReaX K30 acted as complexing agents that solubilized trivalent cation like aluminum in the clay structure. Removal of tetrahedral aluminum from only exposed frayed edges would weaken the clay structure. If the Al dissolution extends far enough, or occurs along the basal plane, expansion may occur across the entire layer exposing fixed K and make it prone to displacement by other cations such as Mg and Ca. Such reaction leads to release of non-exchangeable K.

b). Microbially-mediated dissolution and release of K from non-exchangeable pool. The Actagro Reacted Carbon Technology present in ReaX K30 could have supported more active biological activity and production of microbial metabolites that enhance dissolution of K-containing minerals such as mica-type clay minerals including illites.

actagro | Nutrien Feeding the Future