Chapter 4

Chemistry of Potassium in Soils

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Potassium is a major component of the earth’s crust, soils, and plants. In the earth’s crust, K is the seventh most abundant element. The lithosphere contains an average of about 25.9 g K kg\(^{-1}\) (Hurlbut and Klein, 1977). In the soil, the common range of K content is 0.4 to 30 g K kg\(^{-1}\) (Jackson, 1964; Helmke, 2000). Of the major and secondary nutrient elements, K is generally the most abundant in the soil (Rich, 1968a; Sparks and Huang, 1985).

Relative abundance and some chemical characteristics of K and certain elements common in the earth’s crust are given in Table 4–1. Among the mineral cations essential for plants, K is the largest in size. Therefore, the number of oxygen ions coordinating K in mineral structures is high. Consequently, the strength of each K–O bond is relatively weak. Potassium has a lower polarizability than NH\(_4\)^+, Rb\(^+\), Cs\(^+\), and Ba\(^{2+}\). By contrast, K, relative to Ca\(^{2+}\), Mg\(^{2+}\), Li\(^+\), and Na\(^+\) ions, has a higher polarizability. Ions with higher polarizability would be preferentially selected in ion exchange reactions. Compared with Li\(^+\), Na\(^+\), Mg\(^{2+}\), and Ca\(^{2+}\), K\(^+\) has a lower hydration energy (Helfferich, 1962) and thus would cause little swelling in the interlayer space.

The role of K in soils is prodigious; of the many plant nutrient–soil mineral relationships, those involving K are of major significance (Sparks, 2000b). Potassium plays a very important role in enzyme catalysis, photosynthesis and respiration, assimilation and transport, protein and oil metabolism, legume dinitrogen fixation, disease reduction, and interactions with other nutrients and with crop varieties or hybrids (Munson, 1985). Therefore, K is vital in sustaining plant growth, yield formation and crop quality. Furthermore, K is essential in human and animal nutrition and is closely related to certain medical and health aspects. The availability of soil K to plants is related to the nature of soil K reserves, the chemistry of the structural configurations and surface properties of soil components involved, and the dynamics and equilibria of K in soil environments. The objective of this chapter is to integrate the current knowledge and discuss future prospects on this subject.

FORMS OF SOIL POTASSIUM

Forms of soil K include solution, exchangeable, fixed, and structural K, as shown in Fig. 4–1. Solution and exchangeable K generally account for relatively