Potassium Availability at the Soil-Root Interface and Factors Influencing Potassium Uptake

STANLEY A. BARBER
Purdue University
West Lafayette, Indiana

Potassium absorbed by the plant moves through the soil-root interface, so that physical, chemical, and biological processes occurring in this zone may affect K⁺ flux and influence K⁺ availability to the plant. Since K⁺ flux to the root is a dynamic process, thermodynamic equilibrium of K⁺ with the soil rarely occurs in this interface zone. Hence, evaluation of K⁺ available to the plant with models based on kinetic parameters should give more realistic results than those based solely on thermodynamic equilibrium calculations.

In this chapter, I approach K⁺ availability by considering the reactions that occur in the soil-root interface zone when plant roots grow in the soil. Uptake of K⁺ will depend on the K⁺ uptake kinetics of the plant root, the size and morphology of the root system and its rate of growth, and the K⁺ supply characteristics of the soil. Objective mechanistic mathematical models that describe the processes involved have been developed. I discuss the factors influencing K⁺ uptake and K⁺ flux at the soil-root interface both from experimental data and on the basis of predictions of verified mathematical models. Recent research developments in this area allow us to analyze the effects of various soil and plant root factors in K⁺ flux at the soil-root interface.

I. MECHANISMS OF POTASSIUM SUPPLY TO PLANT ROOTS IN SOIL

When plant roots are grown in stirred nutrient solution, the motion of the solution replenishes K at the root surface when K⁺ is removed by root absorption. The properties of the root-solution interface are maintained at near equilibrium levels by stirring. However, when plants are grown in soil, very little of the plants' K requirement is in the soil at the soil-root interface. After K⁺ at the root surface is removed, K is replenished to this site by K⁺ movement to the root by mass flow and diffusion through the soil. Plant roots absorb water and cause a convective flow of water (the soil solution) toward the root. Since soil solution contains dissolved K⁺, this K⁺ is carried to the root by mass flow. If K supplied by mass flow plus that intercepted initially (in soil at the root surface) are not sufficient to supply the plant requirement, K concentration in the soil and soil solution at the root surface will be reduced by K⁺ uptake. This will create a K concentration gradient radiating perpendicular to the root axis. Potassium will diffuse toward the root along this gradi-