Improving Potassium Acquisition and Utilization by Crop Plants

By Philip J. White

Dr. White recently highlighted some overlooked factors that influence K uptake by plants. There is considerable genetic variation between K efficiency factors among crop species.

Potassium is required for proper growth to support high yields. The nutrient is essential to the activity of many enzymes in plants including those for energy metabolism, protein synthesis and solute transport. It contributes significantly to cell turgor, especially in rapidly expanding cells, and acts as a counter cation for anion accumulation and transport processes. To fulfill its biochemical roles, K concentrations of 100 to 150 millimoles/L (3,900 to 5,900 ppm) must be present in metabolically active tissues.

Plants acquire dissolved K from the rhizosphere solution. In many agricultural soils, the K supply is insufficient to sustain the rapid growth of young plants and K fertilizers are required to maximize production.

Many definitions of "nutrient use efficiency" are found in the literature. Efficient plants have mechanisms that allow them to (1) gain more access to soil K (KUpE) or (2) utilize it more effectively for metabolic processes (KUtE). This article uses these two measures of K efficiency:

Plant K uptake efficiency (KUpE): The ratio of plant K content per unit of K fertilizer supplied. This measures the ability of plants to acquire K from the soil.

Abbreviations and Notes: K = potassium; ppm = parts per million.

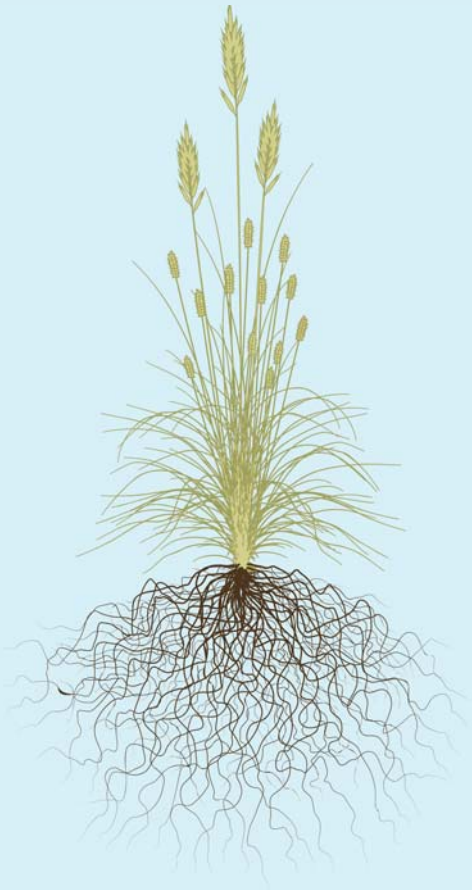
Plant K utilization efficiency (KUtE): The ratio of crop yield per unit plant K content. This parameter indicates the ability of a plant to use K for vegetative and reproductive growth.

Improvements in K efficiency can be achieved through improved management practices or by cultivating crop genotypes that acquire and/or utilize K more effectively. Some plant traits required to improve K efficiency are identified below to highlight recent insights to the genetics of KUpE and KUtE in crop plants.

Potassium acquisition is determined by its delivery to the root surface and then the speed of K uptake by roots. The primary focus is often on the K-supplying power of the soil, but considerable genetic variation exists between and within crop species in both K uptake efficiency (KUpE) and K utilization efficiency (KUtE). Future research may result in crops that use K fertilizer more efficiently. BC

This information was summarized from White, P.J. 2013. Improving potassium acquisition and utilization by crop plants. J. Plant Nutr. Soil Sci. 176:305-316.

Dr. White is with the James Hutton Institute, Invergowrie, Dundee, Scotland; e-mail philip.white@hutton.ac.uk.



Potential mechanisms for improving potassium efficiency by plants

Potassium Utilization Efficiency (KUtE)

Increasing photosynthesis
Accelerating canopy development
Increasing canopy longevity
Increasing harvest index
Tolerating lower tissue K concentrations
Replacing K in non-essential functions
Partitioning K to metabolic cell compartments
Redistributing K from senescent to developing tissues
Redistributing K from root to shoot

Potassium Acquisition Efficiency (KUpE)

Increasing early root vigor
Increasing root biomass or root/shoot ratio
Increasing root surface area (lateral rooting, root hairs)
Increasing root length density
Improving root architecture for soil foraging
Increasing exudation of organic compounds
Increasing K uptake capacity of root cells
Increasing affinity for K of transport proteins
Increasing water uptake through transpiration