PLANT NUTRITION TODAY

2018 ISSUE 3, NO. 3

THE CONCEPT OF "MINIMAL" EXCHANGEABLE POTASSIUM

When the quantity of potassium (K) applied is less than the quantity removed by crop harvest, soil fertility declines. The exchangeable K concentration also declines, but it drops only so far. It eventually evens out at a lower level. A new equilibrium is created, which keeps the exchangeable K concentration fairly constant. This lower equilibrium is termed "minimal" exchangeable K. It serves as one measure of the K supplying power of a soil.

In 1969, Drs. Tabatabai and Hanway, both working at Iowa State University at the time, introduced the minimal exchangeable K concept. Scientists still publish research using their concept, confirming its lasting significance.

Their work was conducted in the greenhouse. They grew ryegrass in a measured amount of soil in pots. They repeatedly cut the ryegrass, each time allowing it to regrow, only to be cut again. They analyzed the stems and leaves at each cutting and calculated how much K had been removed from the soil. Their calculations showed fertility was definitely declining, but was the exchangeable K test a sensitive measure of that decline?

The exchangeable K test they used was the ammonium acetate extractant. The ammonium in that extractant trades places, or exchanges, with K at soil mineral surfaces and on organic matter. The ammonium displaces K into the extracting solution where it can be measured. Scientists generally agree that exchangeable K is readily available to plants.

Exchangeable K does not represent all of the K that is plant-available. It is only a portion. In the soil, plants access additional K that does not readily exchange with ammonium. This K is termed "non-exchangeable K" (**Figure 1**). During the season, plants access both exchangeable K and non-exchangeable K. Therefore, soil fertility and exchangeable K are not the same. Soil fertility includes all of the exchangeable K, but it also includes an additional portion of non-exchangeable K that plants use.

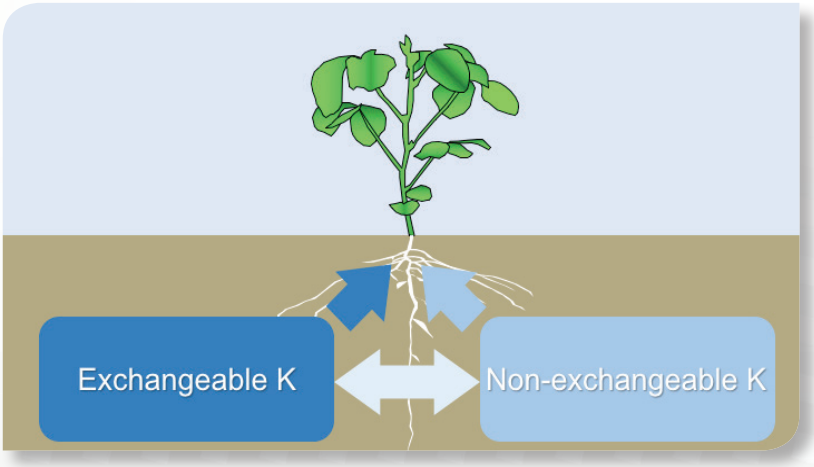

Figure 1. Plants take up K from exchangeable and non-exchangeable fractions in soils. These fractions are in equilibrium with each other (denoted by the double-headed arrow).

Exchangeable K is defined as the K in soil that is exchangeable with ammonium in the ammonium acetate extractant. Non-exchangeable K is the K in soil that is not exchangeable with ammonium in the extractant.

Dr. T. Scott Murrell
Director, North American Program
smurrell@ipni.net

IPNI

PLANT NUTRITION TODAY is a monthly publication of compiled scientific information developed by the International Plant Nutrition Institute (IPNI). Website: http://www.ipni.net/pnt

"… soil (K) fertility and exchangeable K are not the same. Soil fertility includes all of the exchangeable K, but it also includes an additional portion of non-exchangeable K that plants use."

In their experiment, Tabatabai and Hanway examined how exchangeable K changed with successive cuttings of ryegrass (**Figure 2**). They noticed that after the first two to three cuttings, exchangeable K dropped rapidly, but its drop then slowed substantially. By the last few cuttings, exchangeable K had essentially stabilized, reaching a minimal concentration.

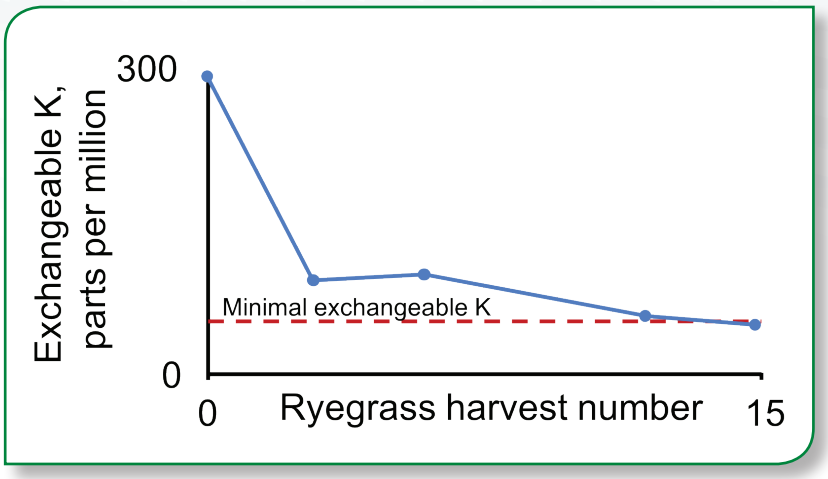

Figure 2. *Change in exchangeable K with successive cuttings of ryegrass. Adapted from Tabatabai, M.A. and J.J. Hanway. 1969.*

They hypothesized that two processes were at work. First, when exchangeable K was higher, a greater proportion of ryegrass uptake came from exchangeable K, causing its rapid depletion. As fertility continued to decline, ryegrass relied more heavily on non-exchangeable K. Second, as ryegrass depleted exchangeable K, some non-exchangeable K transformed to exchangeable K, maintaining a minimal concentration. This minimal concentration represented a chemical equilibrium between exchangeable and non-exchangeable K, denoted by the double-headed arrow in **Figure 1**.

Tabatabai and Hanway tested several soils in their study. They observed that soils maintaining a higher minimal exchangeable K provided more K to ryegrass when summed over all cuttings. They concluded that a soil able to maintain a higher concentration of minimal exchangeable K had a greater K supplying power.

Minimal exchangeable K represents the lower limit of the sensitivity of exchangeable K to changes in soil fertility. When minimal exchangeable K is reached, exchangeable K no longer responds to further reductions in fertility. Exchangeable K is most sensitive to changes in fertility at higher concentrations, when the crop depends more on exchangeable K for its nutrition.

References

Tabatabai, M.A. and J.J. Hanway. 1969. Soil Sci. Soc. Am. J. 33:105-109.

IPNI International Plant Nutrition Institute

5550 Triangle Parkway, Suite 300, Peachtree Corners, GA 30092-6515 U.S.A.
Phone: 770-447-0335 | Fax: 770-448-0439 | www.ipni.net