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POTASSIUM MINERALOGY OF KENTUCKY SOILS

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Feldspars and mica minerals are the two primary natural sources of potassium for most agricultural soils in Kentucky. Potassium feldspars are common mineral constituents of loess deposits in western Kentucky. Mica minerals, although dominant in shales, are also found in variable quantities in siltstone, sandstone and limestone parent materials of soils in the other regions of Kentucky. Because most of the soils in the western Coalfields and western Pennyroyal, and to a lesser extent in eastern Pennyroyal and Bluegrass, are covered by a loess cap of variable thickness, their surface mineralogy has been influenced by the feldspar-rich mineralogy of the loess mantle.

This mineral distribution is reflected in Table 1 which shows a gradually decreasing feldspar influence and an increasing mica influence on the surface and subsoil mineralogy of soils from west to east across Kentucky. Although as much as 50% of the feldspars may be Na- or Ca- rather than K-feldspars, K reserves of soils developed in thick loess and of soils with thick loess caps are primarily associated with K feldspar distributions, while K-reserves of soils with thin or no loess mantle depend primarily on mica.

While feldspars are concentrated primarily in the coarse silt fraction, significant amounts of mica minerals are also found in the clay fraction of many Bluegrass and eastern Pennyroyal soils. This is important because clay-size micas release K more readily than the coarser-sized silt particles even though larger amounts of K may be released by edge-weathering of coarse mica particles than from layer-weathering of clay-size mica. Another important component of K reserves is the interstratified mica/vermiculite or illite/vermiculite minerals. Clay fractions of Bluegrass, eastern Pennyroyal and some western Coalfield soils formed in shale or interbedded shale/limestone materials have from 10 to 30% interstratified components, containing 1 to 7% K in their structure. The vermiculite phase of these components, however, is responsible for the high K-fixing capacity exhibited by some outer Bluegrass soils (Eden, Shrouts).

Although K-feldspars contain more K (14%) than mica (6.6 to 9.8%), K is released much more readily from mica minerals than from feldspars, especially under low pH conditions. This is due to the different crystal structure and the higher atomic bonding energy with which K is held in the feldspar structure. Complete dissolution is necessary for K release from feldspars while a stripping process removes K from the interlayer of micas. The latter is a transformation rather than a dissolution process and usually converts the K-stripped mica into vermiculite. This is a reversible process, however, and can cause soils containing vermiculite to fix significant amounts of K added by fertilization. Apparently, this is the reason why crops grown on some low K-testing Bluegrass soils (Eden, Nicholson) sometimes show K deficiency following high rates of K-fertilizer applications.

Effect of K Minerals on Soil K Availability

The presence of large natural K reserves from K-feldspar or mica sources in a soil does not necessarily guarantee an ample supply of K for plant growth. In fact, many K-demanding crops growing in K-feldspar-or mica-rich soils show K deficiencies if not fertilized properly. This is because the rate of K uptake by the plant is usually greater than the rate of K release from the weathering of feldspar or mica minerals. The amount of K available for plant use is determined not only by mineral K-reserves but also by factors such as the amount of K in solution, other soluble and exchangeable ions, soil moisture, and the mineralogical composition of the soil. Generally, the ability of a particular soil to supply plant available K is a function of (1) K in solution (2) exchangeable K (3) fixed but potentially useful K and (4) mineral K reserve. Unfortunately there is no reliable laboratory method for assessing the K status of a soil in all four forms during the growing season. This is because all these forms are in a dynamic reversible equilibrium with each other, unique to specific sets of soil conditions. Therefore, any soil test value reflects only a temporary evaluation of this equilibrium.

Although table 1 shows that surface soils of the Bluegrass and the Purchase region are somewhat higher in exchangeable K than other regional soils, it is unclear, whether this is a natural or fertilizer application-induced relationship. The fact that subsoil horizons of these regions also contain the highest natural K-reserves in the form of micas or feldspars, and slightly higher exchangeable K levels suggests that they have a naturally greater K supply status. Still, this naturally occurring K constitutes only 0.5 to 6% of the cation exchange capacity of these soils and needs to be supplemented by significant amounts of fertilizer K to meet the needs of high K-demanding crops (tobacco, alfalfa, hay, silage). This appears to be more critical in certain Bluegrass soils where the greater presence of K-fixing minerals (vermiculite, montmorillonite, interstratified illite/vermiculite/montmorillonite) may limit availability of fertilizer K to plants.


Extension Soils Specialist

Table 1. Soil feldspar, mica and exchangeable K⁺ content ^{1/} of surface and subsoil horizons in regional agricultural soils of Kentucky

Physiographic region	Feldspars ^{7/}		%	Mica ^{8/}		Exchangeable K ^{9/}	
	Ap	Bt		Ap	Bt	Ap	Bt
Purchase ^{2/}	22±3	25±2		7±3	10±3	312±156	234±256
Western Coalfields ^{3/}	15±4	10±3		6±3	7±3	195±78	195±78
Western Pennyroyal ^{4/}	10±2	6±2		7±3	10±2	234±78	195±78
Eastern Pennyroyal ^{5/}	6±3	3±2		8±2	12±3	273±156	195±78
Bluegrass ^{6/}	5±2	3±2		16±3	20±5	468±234	234±156

^{1/} Percent of whole soil

^{2/} Average of 24 pedons (6 Memphis, 5 Loring, 6 Grenada and 7 Calloway soils).

^{3/} Average of 9 pedons (4 Zanesville and 5 Frondorf soils).

^{4/} Average of 21 pedons (9 Crider, 8 Baxter and 4 Pembroke soils).

^{5/} Average of 12 pedons (4 Frederick, 4 Mountview and 4 Vertrees soils).

^{6/} Average of 25 pedons (9 Maury, 10 Lowell and 6 Eden soils).

^{7/} Includes K-, Na-, and Ca feldspars.

^{8/} Includes muscovite, biotite, and illite.

^{9/} Extractable by NH₄OAC pH7.

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