FFF Review

Effective Potassium Management

Proper fertility vital with this relatively immobile nutrient.

Like phosphorus, potassium is relatively immobile in the soil. It is also just as vital to proper plant growth. Agronomic crops contain about the same amount of K as N, but more K than P. And in many high-yielding crops, K exceeds N content.

Multi-roles

Unlike N and P, potassium does not form organic compounds in the plant. Its primary function seems to he tied to plant metabolism. It is involved in several plant processes.

Potassium is vital to photosynthesis. When K is deficient, photosynthesis declines and the plant's respiration increases. These two conditions—reduced photosynthesis and increased respiration— lower the plant's carbohydrate supply. K also:

- promotes protein synthesis
- is important in the breakdown of carbohydrates, a process that provides energy for plant growth
- helps control ionic balance
- promotes translocation of heavy metals such as iron
- helps control lodging in corn
- promotes fruit formation
- improves winter hardiness
- is involved in the activation of more than 60 enzyme systems that regulate rates of major plant growth reactions.

Another important role of K in plant growth is its influence on water-use efficiency. The process of opening and closing of plant leaf pores, called stomates, is regulated by K concentration in cells that surround the stomates. A shortage of K causes the stomates to open only partially and to be slower in closing. This increases stress from drought. Table 1 shows how adequate K improves yields of corn under three levels of rainfall. Figure 1 shows the difference between no K and K (120 lbs/A) on yields of corn over a four-year period.

Potassium has a great impact on crop quality, including: 1) increased kernel weight and kernels per ear in corn, 2) improved oil and protein content in soybeans, 3) better milling and baking quality in wheat, and 4) improved stand and longevity in forages.

One problem in forage production is poor fertilizer management, particularly with regard to N and K balance. Growers use N because they know it increases yield, adds green color, and improves protein content. Potassium is less showy and often neglected.

The importance of K in disease suppression cannot be overstated. The USDA Yearbook of Agriculture states: "More plant diseases have been retarded by the use of potassium fertilizer than any other substance.'' When K helps a plant resist disease, it doesn't do it as a direct agent of control but by *strengthening* the natural resistance mechanisms of the plant. It is the key element in reducing:

- leaf blight and stalk rot in corn
- wilt and damping off in cotton
- black spot and stem end rot in potatoes
- wildfire in tobacco
- leafspot and dollarspot in grasses.

Virginia research on soybeans has shown the benefits of K. The incidence of moldy beans has been reduced by as much as 6 bu/A. Yields have increased by as much as 9 bu/A. And substantial savings have been realized through reductions in dockage for poor quality.

Spotting symptoms

Scorching. Firing along the leaf margins is one of the most common K hunger signs. Firing first appears on older leaves in most plants, especially grasses. Newer leaves will show hunger signs first on some plants—especially in high-yielding cotton in mid to late season. Corn will scorch on the outer edge of the leaf, while the midrib remains green. Scorching on soybeans begins on the outer edge of the leaf—the edges becoming broken and ragged as the leaf dies. On fruit trees, scorching develops along edges of leaves, which become ragged.

Stunting. Potassium deficient plants grow slowly. Stalks are weak, lodging is

Table 1. Response of corn to K under three levels of rainfall.

Rainfall level	Rainfall during growing season (inches)	Yield: Low K (bu/A)	Yield: High K (bu/A)
Low (Indiana)	7.1	91	130
Medium (Indiana)	17.7	148	156
High (Indiana)	25.7	92	140
Low (Ohio)	9.0	122	164
Medium (Ohio)	19.9	151	173

common. Seed and fruit are small and shriveled.

Unfilled, chaffy ears are a sign of potassium deficiency in corn.

White/yellowish dots around outer edges of leaves are an indication of K hunger in alfalfa. Leaf then turns yellow and tissue dies.

Yellowish green leaves that curl upward in fruit tree crops could mean a shortage of K.

Crinkled upper leaves that are usually smaller and a darker green than normal are signs of K starvation in potatoes.

Other signs of K deficiency in small fruit are premature dropping and poor storage capability.

Availability in soil

Although most soils contain thousands of pounds of K— often 20,000 lbs/A or more— just a small percent is available to plants over the growing season, probably less than two percent. Soil K exists in three forms:

Unavailable K. Unavailable K is found in minerals (rocks). The K is released as soil minerals are weathered, but so slowly as to be unavailable to growing plants in a particular crop year. The weathering process is so slow, in fact, it could take hundreds of years to add significant amounts of available K to the soil. Generally, soils in the eastern parts of the U.S. are more highly weathered than those in the Midwest and West. Less weathered soils are richer in K than those that have undergone more extensive weathering.

Slowly available K. Slowly available K is "fixed" or trapped between layers of certain soil clays. Such clays shrink and swell during dry and wet soil conditions. Potassium ions (K+) can be trapped between these clay layers, becoming unavailable or only slowly released. Highly weathered soils don't contain many such clays. Sandy soils contain lower reservoirs of slowly available K than do those containing greater amounts of clay.

Available soil K. Readily available potassium is made up of K found in the soil solution, plus K held in exchangeable form by soil organic matter and clays. Most soils contain 10 lbs/A or less of solution K. This will supply a growing crop barely a day or two. But, as the crop removes solution K, some of the exchangeable potassium (K+ cation) moves into solution. It is replaced on the soil colloid (negatively charged) by some other cation. This movement continues until a new equilibrium is established. So, through the cation exchange process, K is continuously available for plant growth *if* the soil contains enough K at the beginning of the growing season to supply the crop's needs.

Slow mover

It is crucial to maintain adequate K fertility levels in the soil because soil K does not move much except in sandy or organic soils. Unlike N and some other nutrients, K tends to remain where fertilization puts it. When K does move, it is usually by diffusion on slow, short trips through water films surrounding soil particles. Dry conditions slow this movement. High soil K levels speed it up.

Adding to the problem are crop roots. Crop roots usually contact less than three percent of the soil in which they grow. So the soil must be well supplied with K to ensure that plant needs at every stage of growth are met until harvest. Total root mass of corn occupies less than one percent of the soil volume. This means corn roots contact less than one percent of the available nutrients in the soil.

As mentioned earlier, plant roots can take up either soluble K or exchangeable K for use in meeting their needs. Question is: How does K act when it is applied in the soil? In other words, what form does K take when it is applied to the soil and dissolved in the soil solution?

The K in fertilizer (commercial fertilizers, organic matter, crop residues, cover crops, etc.) takes on the ionic form (K+) when it dissolves. Thus, K from all sources is the same. Once the K ionizes to the K+ form, it makes no difference what the original source was.

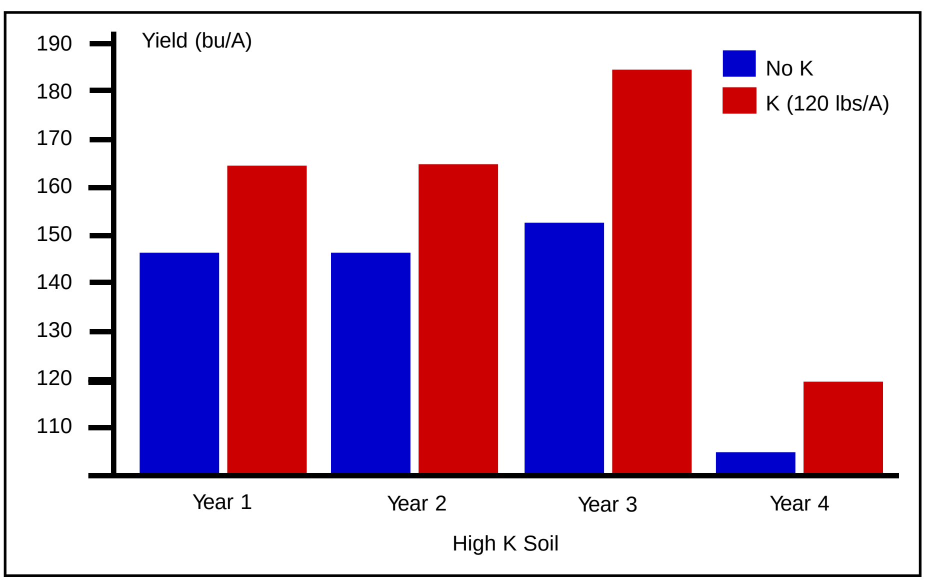

Figure 1. Yield differences between K (120 lbs/A) and no K on Illinois corn yields over four-year period.

What affects K uptake

Soil aeration. Uptake of K is affected more by poor aeration than most other nutrients. Minimum tillage and compaction limit K uptake.

Low soil test. As level of soil test K drops, root uptake decreases.

Fixation. Soils that trap K and hold it in unavailable form reduce the amounts available for plant uptake.

CEC. In general, soils with high CECs have greater storage capacity and supplying power for K.

Soil temperature. Low soil temperature reduces the availability and uptake of K by plant roots. Its effect can be partially offset by increasing soil K levels.

Soil moisture. Both drought stress and excess moisture reduce plant uptake of K.

Soil itself. Soil's overall characteristics determine how efficiently crops uptake K. Included are parent material from which soil was formed, amounts and types of clay materials soil contains, vegetation under which soil was formed, topography, drainage, depth, etc.

Applying K

Methods of applying K are many fold:

- surface broadcast without incorporation
- broadcast and disk
- broadcast and plow down
- direct seed placement
- banding, including various combinations of distances below and to the side of the seed
- deep placement or knifed
- surface strips
- fertigation.