

# POTASSIUM

Potassium is the last of what might be called the “big three” soil nutrients – nitrogen, phosphorus, and potassium. These three primary nutrients are, by far, the nutrients most commonly limiting for crop production. Potassium has long been referred to as “potash.” A few hundred years ago, potassium fertilizers were commonly obtained by extracting wood ashes – hence the name “potash.” In fact, much of the forest in eastern United States was cut, burned, and the potash was sold to England. Today, potash usually refers to the oxide form  $K_2O$ . By law, fertilizer analyses guarantees are still in terms of the  $K_2O$  equivalent.

## Functions of Potassium in Plants

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A unique aspect of K is that it is not a part of any structural component of plants and as a soluble ion in the plant sap, it is required to activate at least 60 plant enzymes. As a result, potassium in new crop residues is very soluble and is readily washed from the residue and returned to the soil

Potassium plays an essential role in photosynthesis and metabolism of plants. It is important in carbohydrate breakdown which furnishes energy for plant growth. Potassium also increases drought resistance in plants and aid in reducing plant water loss.

Potassium aids in the conversion of N into proteins in the plant. Grasses need K to balance high rates of N fertilizer. If K is lacking, some N will remain as non-protein nitrogen. Crops with high protein levels, such as alfalfa and soybeans, tend to have higher potassium requirements.

Other roles of potassium in plants include assisting plant enzyme systems, reducing respiration, translocation of food within the plant and increasing the starch and oil content of crops.

Potassium is also important in helping the plant fight diseases. When potassium is deficient, fertilization can reduce the severity of several crop diseases, including;

- Corn and Sorghum stalk rot. K strengthens stalks against invading organisms and reduces lodging. However, stalk rot can result from several factors other than K deficiency.
- Corn Leaf blight. Symptoms often occur in K deficient fields.
- Soybean Molds and Mildews. K reduces shrunken, moldy seeds.
- Potato Black Spot and Stem End Rot.
- Grass Leaf spot and Dollar spot. K thickens leaf cuticles. K can improve the quality of lawns, even on soils with high K soil tests.
- Root disease in small grains may be due in part to chloride in KCl.

## Potassium Deficiency Symptoms

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Potassium deficiencies are not easy to detect visually. Moderate deficiencies produce only a reduction in growth. Only with severe deficiencies do classical potassium deficiencies appear.

Typical deficiency symptoms includes spotting, streaking or curling of leaves, starting with the lower portion of plant. Lower leaves appear scorched or burned at margins and tips. In corn, grains, and grasses, burning starts at tip of leaf and proceeds down the edge, usually leaving the midrib green. Potassium moves readily in the plant; thus leaf symptoms appear in older leaves first. Dead areas fall out leaving ragged edges.

*Alfalfa:* Slow growth, white or yellowish spots around tips of older leaflets.

*Corn:* Slow growth, lower leaf tips and margins

turn brown and fire, chaffy ears; plants die prematurely from stalk rot and leaf diseases.

**Small Grains:** Slow growth, delayed maturity, shriveled grain, tendency to lodge.

**Soybeans:** Leaves turn yellow and later brown on the tips and edges. The base of the leaf usually remains green. Seeds are shriveled.

**Cotton:** Yellow spots between veins, browning of leaf margins, premature dropping of leaves.



Removal of K can be very high in forage or silage crops where the entire plant is harvested. With these crops, relatively high rates of potassium fertilizer are required to replace the potassium removed - providing soil tests indicate a need. If only grain is harvested, much less K is removed by the crop.

## Potassium Removal By Crops

Crop	Unit	K <sub>2</sub> O
Alfalfa	lbs/ton	60.00
Red clover	lbs/ton	50.00
Bermudagrass	lbs/ton	40.00
Bromegrass	lbs/ton	40.00
Fescue, tall	lbs/ton	40.00
Corn	lbs/bu	0.26
Corn silage	lbs/ton	8.70
Grain sorghum	lbs/bu	0.26
Sorghum silage	lbs/ton	8.70
Wheat	lbs/bu	0.30
Sunflowers	lbs/cwt	0.60
Oats	lbs/bu	0.20
Soybeans	lbs/bu	1.40
Native grass	lbs/ton	30.00

## Potassium Uptake By Crops

Plants utilize potassium as the positive charged K<sup>+</sup> cation. Potassium is required in large amounts by crops and is taken up much faster than dry matter is accumulated by crops. For corn, K uptake is completed soon after silking. Similar potassium accumulation relationships are true for other crops as well.

Potassium is moved from the leaves and stalks into the grain as the plant matures. A larger percentage of K is moved to the grain by soybeans than by cereal crops, such as wheat, sorghum, or corn. Thus, more K is removed per bushel of soybeans harvested than with cereal crops.

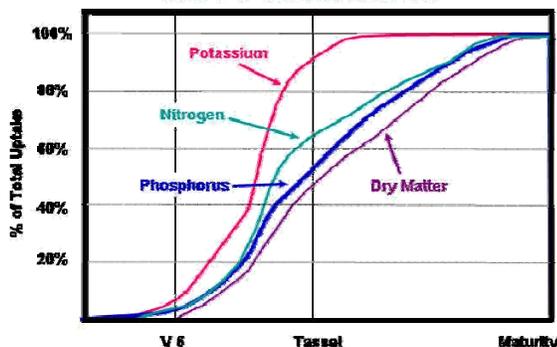
## Forms of Soil Potassium

Soils commonly contain many thousands of pounds of total potassium. However, most potassium exists in structural components of soil minerals and is not available to plants. Only a few hundred pounds of potassium per acre exist in forms potentially available to plants.

The characteristic behavior of plant nutrients in the soil are similar in some respects, yet vary greatly depending on the kind of soil minerals involved, the solubility of these soil minerals and the mobility of nutrient forms in soils. Potassium is unlike phosphorus in that most mineral soils contain large amounts of potassium, but like phosphorus, much of the total potassium is in soil minerals that are only very slowly become potentially available to plants.

Unlike nitrogen and phosphorus, only a very small amount of potassium is associated with soil organic matter. Potassium does not enter into organic plant combinations like nitrogen,

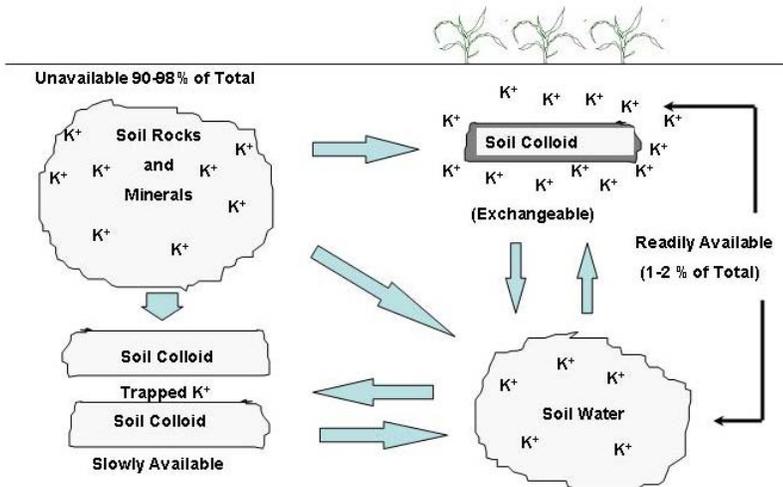
**Corn Nutrient Uptake And Dry Matter Accumulation**



phosphorus and sulfur, but remains active in plant tissues. In fact, even washing dry plant leaves removes significant amounts of potassium.

Various forms of potassium that occur in soils can be classified on the basis of potential availability to plants in three broad general groups: 1. unavailable, 2. slowly available, and 3. readily available. Most potassium is in the unavailable form, therefore, the others are more significant from the standpoint of crop production. These forms interchange as shown in the diagram below:

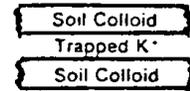
## Forms of Soil Potassium



Unavailable K is contained in micas, feldspars and clay minerals. Plants cannot use potassium in these crystalline, insoluble forms. Over long time periods these minerals weather and their potassium is released as the available potassium ( $K^+$ ) ion. This process is far too slow to take care of the potassium needs of field crops. However, trees and long-term perennials obtain a substantial portion of the potassium they require from the weathering of minerals containing potassium.

It should be noted that most of the soils in the Great Plains and western U.S. have been subjected to much less precipitation and weathering than in the more humid eastern states. As a result, soil minerals in these western soils are rich in K compared to states with annual precipitation of greater than about 30" annually.

Slowly Available K is trapped between the layers of "plates" of certain kinds of clay particles. This is



sometimes called "fixed" potassium. Plants cannot use much of the slowly available potassium during a single growing season. However, the soil's ability to supply potassium over a longer period of time is related closely to its supply of fixed potassium. Fortunately, some of the trapped ions are in equilibrium with available forms of K and slowly escape. Thus, even though this "fixed" potassium is not immediately available, it does provide an important reservoir of potassium that continually replenishes the 'readily available' pool.

Readily Available K is held on the surface of clay and other soil colloids and dissolved in soil solution. Plants easily absorb potassium in this form although there is relatively little potassium dissolved in soil water at any one time. Because of this, the potassium soil test is an index value related to the soils ability to resupply solution  $K^+$  from the CEC after crop uptake. Soil tests for available potassium are intended to extract only  $K^+$  ions in soil solution and on exchange sites.

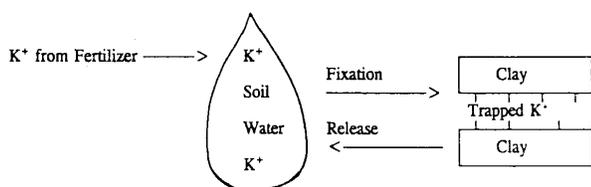
Potassium is a nutrient that plants absorb in amounts far in excess of their requirements if readily if available. While this is also true for some other nutrients, potassium is outstanding in this respect. Therefore, excess amounts applied infrequently result in 'luxury consumption' of applied potassium fertilizers.

In soils where the amount of slowly available K is low, it is possible to draw down the level of readily available K after a few years of cropping. However, in soils with a large reservoir of slowly available K, such as for many Kansas soils, it takes much longer.

Irrigation water can be an important source of K in some areas. In the Great Plains, 10 to 60 lb of  $K_2O$  per acre foot of water are common.

Since  $K^+$  ions are held in an exchangeable form by negatively charged clay particles, potassium does not move readily in most soils. When potassium fertilizers are applied to medium- or fine-textured soils, it takes many years for  $K^+$  ions to move over an inch or two by natural processes. In these soils, potassium is considered an immobile nutrient. In very sandy soils,  $K^+$  is somewhat mobile and can move downward in the soil. However, little applied potassium ever leaches out of the rooting zone. Although organic matter particles have a high cation exchange capacity for most cations, attraction for  $K^+$  is weak. As a result, leaching of potassium from organic or peat soils may result in low exchangeable potassium levels.

As potassium is removed from exchangeable or solution phases, a shift of potassium from slowly available forms to readily available forms occurs. On the other hand, if the  $K^+$  ion concentration of the soil solution and exchange complex is increased by adding potassium fertilizer, the reverse is true. Some of the applied potassium may become trapped (fixed) between the "plates" of the clay particles. Some of the fixed potassium is then slowly available over time. This process may explain why additions of potassium fertilizer do not result in rapid increases in potassium soil test values in some soils.



## Factors Affecting K Uptake by Plants

Since K is relatively immobile in soils, any condition that restricts root growth can decrease root contact and absorption of potassium. Factors restricting K uptake include:

**Poor Soil Aeration.** Poor soil aeration affects plant uptake of potassium more than uptake of most other nutrients. Minimum tillage systems, such as ridge till or no till, often accentuate potassium deficiency problems, presumably due to less aeration in these untilled soils. Another possible explanation

with ridge till is that roots follow old root channels that are K depleted from previous crops. Compaction can also reduce K uptake by restricting aeration and root growth.

**Soil Moisture.** Potassium deficiency symptoms in crops are frequently associated with dry soil conditions. Subsequent rain or irrigation often reduces or eliminates development of potassium deficiency symptoms. Extremely wet soils can also reduce root growth, aeration, and K uptake by plants.

**Soil Temperature.** Cool temperatures decrease the metabolic processes of the plant which affects the uptake of potassium by plants. Also, cold soils slow the release of potassium to the soil solution.

**Crop Varieties/Hybrids.** Some corn varieties in particular are more prone to potassium deficiency. Apparently the root systems of these corn hybrids are less efficient in absorbing potassium, particular in ridge till or no-till fields.

## Fertilizer Sources of Potassium

Potassium is found combined with other elements in salt beds beneath the earth's surface and in brines of lakes. The most important potash deposits occur in Canada, the U.S.S.R., New Mexico, and Utah in the U.S. The Saskatchewan deposit is 3,000 feet deep on the northern edge and 7,000 feet deep at the North Dakota border. While more than 80% of the potash used in the U.S. comes from Canadian deposits, much of the potash fertilizer used in Kansas is comes from mines in New Mexico.

New Mexico potash ore is mined directly with mining equipment while Canadian potash (potassium chloride) utilizes solution mining where a hot brine solution is pumped into the potash bed. The potash salt is dissolved and brought to the surface as a brine and dried. As a result, most New Mexico potash is reddish colored and contains 60%  $K_2O$  equivalent while Canadian potash is white and contains 62%  $K_2O$ .

White soluble material is used for fluid fertilizers and contains 62%  $K_2O$  equivalent

Common potassium fertilizers include:

Potassium Chloride (KCl) accounts for approximately 95% of all potassium fertilizers used. Potassium chloride (also referred to as muriate of potash) is the least expensive source of potassium used today. Analysis is normally 60% or 62%  $K_2O$  equivalent and about 45% chloride. The color ranges from deep red to pink to white, but color has no effect on its value to crops. The small amount of iron (~0.05%) in red potash does not make it any less desirable as a fertilizer material.

Potassium-Magnesium Sulfate ( $K_2SO_4 \cdot 2MgSO_4$ ) is commonly referred to as K-Mag, and contains 22%  $K_2O$ , 11% Mg and 22% S. It is an excellent source when magnesium or sulfur in addition to potassium is required.

Potassium chloride is marketed in several particle sizes but granular material is best suited for direct application and dry blending because it most closely matches size grades of other dry fertilizers and contains a uniform particle size.

Potassium Sulfate ( $K_2SO_4$ ), or sulfate of potash, contains 50%  $K_2O$  equivalent and 18% sulfur. It is preferred for chloride-sensitive crops such as tobacco which will not burn properly if excess chloride is present. Potassium sulfate is not very common in agriculture because of its relatively high cost.

Potassium Nitrate ( $KNO_3$ ), or saltpeter, contains 44%  $K_2O$  and 13% N. While an excellent source of potassium and nitrogen, it is relatively costly to produce and not commonly used

## Application of K Fertilizers

As an immobile nutrient, potassium needs to be placed in the root zone by incorporation or banding for most crops. However, topdressing is effective on perennial crops such as alfalfa and pastures since these crops develop a massive root system near the soil surface.

Potassium fertilizers can be broadcast and incorporated, preplant deep banded or applied near the seed in a band. Broadcasting is preferred when relatively large amounts of potassium are required. Banding near the row concentrates the fertilizer where the young plant can obtain it for early growth. Banding potassium is often recommended for ridge till or no-till crops in soils where subsoil potassium levels are low. Care must be taken not to apply potassium where it will be in contact with the seed or emergence problems may

## Potassium Summary

In eastern Kansas, especially the southeast counties, good responses have been obtained from applications, both broadcast and banded, of potassium on alfalfa, soybeans, wheat, corn, and grain sorghums. Grasses have been less responsive. In the western half of Kansas soil tests generally show high levels of potassium and responses to applied potash fertilizers have been infrequent except on sandy soils. Where heavy cropping is taking place under irrigation potassium should be tried occasionally to see if soil reserves have been depleted. This is especially true in the sandy soil areas.

Potassium soil test values over the past decade or so have decreased in the northeast part of the state as well. As a result, potassium deficiencies for row crops has become more common. This is especially true for reduced tillage systems and is more severe in dry growing seasons.

