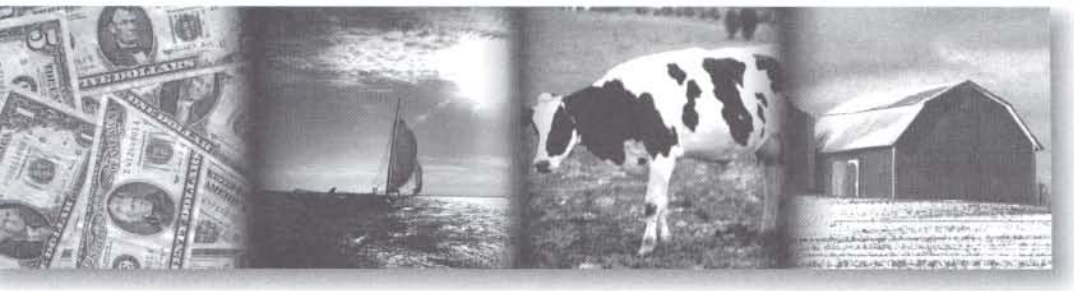

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NUTRIENT MANAGER

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Focus On Potassium

Credit: Dr. Lester Vough, Department of Natural Resouce Sciences and Landscape Architecture, University of Maryland.

Potassium is the seventh most abundant element on the earth's crust. The amount of potassium in a typical 6-inch plow layer of agricultural soils ranges from 2 to 30 tons per acre, far exceeding the needs of any crop.

Yet potassium is the third most likely nutrient, after nitrogen and phosphorus, to limit plant growth and productivity. Producers test their soil for potassium and regularly apply potassium in the form of commercial fertilizer or organic sources to their crops. When potassium is so abundant in nature, why do plants still need more?

This *Nutrient Manager* will examine the third nutrient in the nitrogen-phosphorus-potassium triad.

How Potassium Helps Crops

Potassium activates over 80 enzymes vital for plant processes, including protein and starch production and photosynthesis. An adequate supply of potassium increases yield and improves crop quality, as it strengthens stems, thus preventing lodging—stem weakness and breakage—in grains; advances timely maturity; and increases the size of tubers and grains. Generally, plants require five to ten times as much potassium as they do phosphorus, and about the same amount of potassium as they do nitrogen.

Potassium is also important in helping crops adapt to environmental stress. Potassium promotes tolerance to insect damage and resistance to fungal disease and winter damage. Because it regulates the water balance in plant tissue, potassium helps to prevent crops from drying out in times of drought.

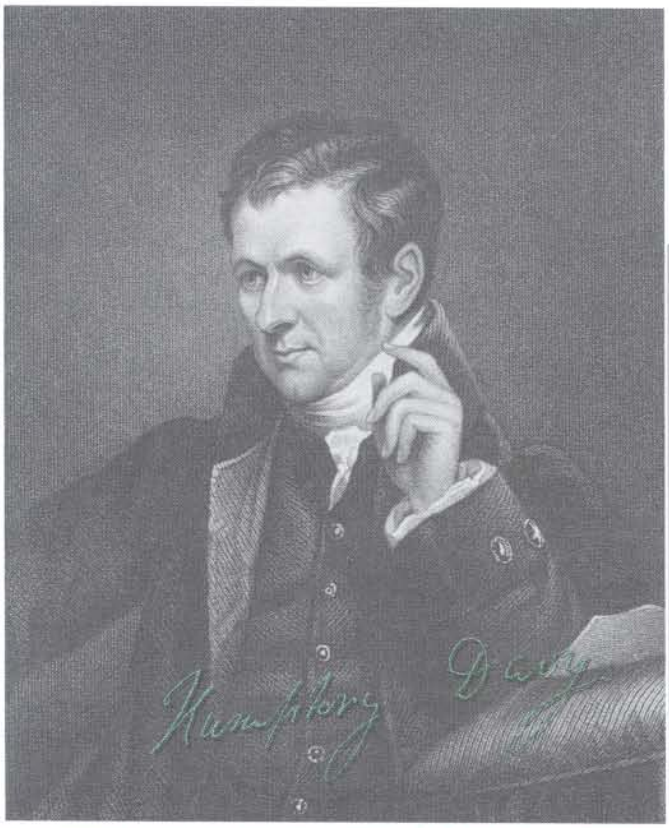
In a plant, potassium makes up 1 to 4 percent of dry plant matter. It's mobile, moving to where it's most needed in the plant. So deficiency symptoms—edges and tips of leaves yellowing and dying, creating a scorched appearance—appear first on older leaves.

Traditionally, potassium has been called "potash," after pot ash—the remains of a cook fire that is rich in this element. In 1806, British Sir Humphry Davy sent an electric current through pot ash and decomposed it into little silvery globules of potassium. He "danced around and was delirious with joy" at his discovery, according to his brother John. Later, he used the same method of passing current through chemical compounds to separate phosphorus, magnesium, calcium, strontium, and barium.

The Potassium Cycle

See Figure 1 for a graphical representation of the potassium cycle.

Primary minerals such as mica or feldspar contain *structural* potassium, which is potassium held inside the minerals. Over time, the minerals release potassium into the soil solution as they weather or disintegrate. Structural potassium is released from the minerals very slowly.



Sir Humphry Davy used an early electrical battery to decompose potash into potassium. Credit: E. F. Smith Collection, Rare Book and Manuscript Library, University of Pennsylvania

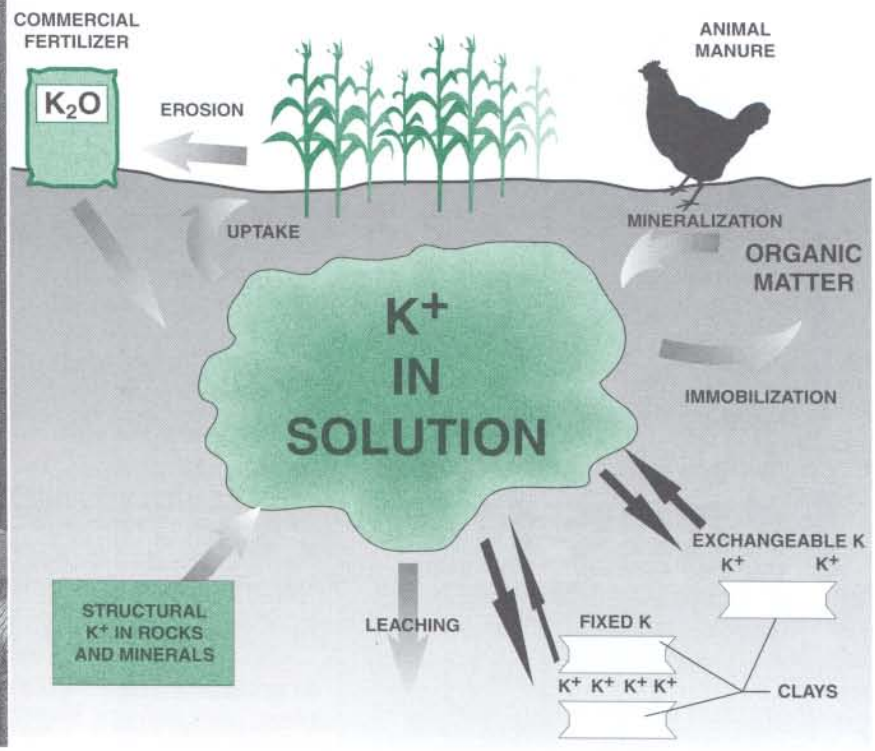


Figure 1. The sources of potassium and its forms in the soil.

Soil clays can attract potassium from the soil solution, adsorbing or holding them on the clay surface. This adsorbed potassium is called *exchangeable* potassium, which can move into the soil solution if potassium in the solution is depleted.

Potassium in the soil solution (*soluble* potassium) is readily available, and plant roots can immediately take it up. Certain clays such as illite or vermiculite can trap, or "fix," potassium between clay particles. This *fixed* potassium is unavailable for plant uptake and is re-released into the soil solution slowly.

Because much of the potassium in soils is either held in slowly available or very slowly available forms sequestered inside minerals and between clay particles, many soils lack adequate plant-available potassium for optimum agricultural production. See Figure 2 for details.

Plants and animals living in the soil take up potassium to meet their nutritional needs. This potassium is later re-released into the soil solution when they die and their bodies decompose, or mineralize.

How is potassium lost from the field?

Crops remove large quantities of soluble potassium from the soil solution. If excess potassium exists in the soil, "luxury consumption" is possible—the plant equivalent of a person gorging at a banquet. Under any condition, crops take up large quantities of potassium, so crop harvest removes large amounts of potassium. See Table 1 for potassium crop removal amounts.

Potassium losses from the field occur via leaching and erosion. Potassium in the soil solution can be lost from the soil due to leaching. Among sandy acid soils, the annual potassium leaching loss may be as high as 20 to 45 pounds per acre. In addition, potassium in plant residue easily leaches, because potassium stays soluble and is not incorporated into plant cells. Exchangeable, fixed, and structural potassium can be lost due to soil erosion.

Low potassium levels are most prevalent in agricultural soils in areas with weathered soils and high precipitation such as the southeast U.S.

Table 1. Potassium Removal.

Crop	Amount harvested per acre	Potassium removed, in lbs/A
Alfalfa hay	8 t	400
Orchardgrass hay	5 t	260
Soybeans	50 bu	40
Corn grain	150 bu	25
Corn silage	25 t	170
Wheat	80 bu	20

Potassium Fixation in Maryland's Soils

In some soils of the Middletown Valley area of Maryland's Frederick County (Myersville, Highfield, Fauquier, and Catoctin soils), potassium fixation may occur. These soils contain substantial amounts of the clay mineral vermiculite (which has a large capacity to fix potassium) in the subsoil. If the soil has not

Dr. Lester Vough demonstrating differences in forage under two fertilization regimes.

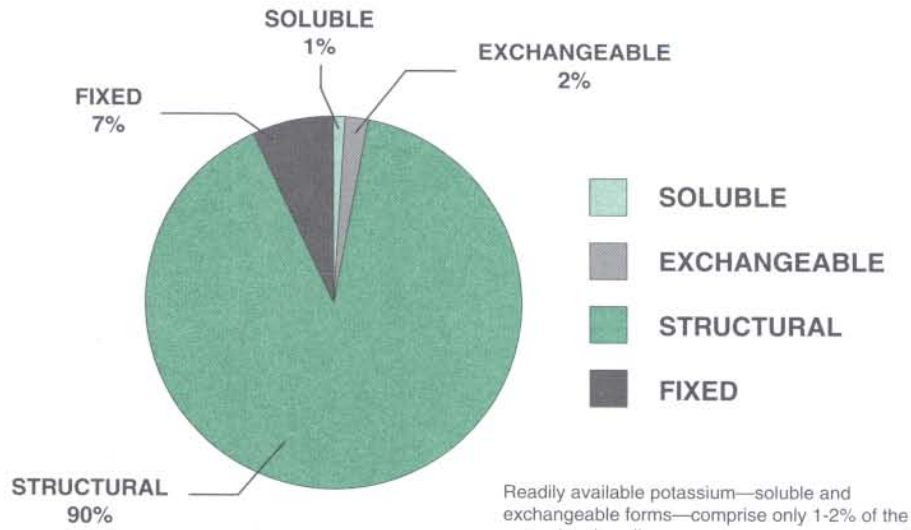


Figure 2. Total potassium in the soil.

eroded, potassium fixation in topsoil should not be extensive because vermiculite is not usually found in the plow layer. But in exposed subsoil, vermiculite can fix large amounts of potassium, reducing the amount of soluble potassium available to plants.

A Crop with a High Potassium Requirement

Alfalfa has the highest potassium requirement of common Maryland crops. University of Maryland forage specialist Lester Vough has spent years researching the effect of potassium on alfalfa's root expansion, longevity, and speed of regrowth.

"Our first project," says Dr. Vough, "was to look at levels of phosphorus, potassium, and sulfur in alfalfa. We found that even on soils testing high in potassium, we still had a yield response when 400 pounds of K_2O an acre were applied."

"On closer examination, we found that potassium increases the size and depth of legume roots and makes the root system more extensive, so plants can obtain more nutrients and water over a larger area. The extensive root system also prevents winterkill caused by heaving and gives the plant a larger capacity for storing sugars, water, and soluble proteins. And the deep roots stay in contact with moist soil for a longer time during drought." He also found that insect and weed controls were less necessary when potassium is added.

In his research, Dr. Vough learned just how large the potassium requirement is. Typically, producers topdress alfalfa with 100 to 200 pounds of potash per acre annually, depending on soil test results. But because each cutting of alfalfa removes a great deal of potassium—65 pounds per ton—the traditional potassium application only allowed 3 to 4 ton yields per acre. When he fertilized for the 65 pounds per ton removal rate—at over 400 pounds K_2O per acre—he was able to harvest alfalfa five times each year and harvest yields of 8 to 10 tons per acre.

For more information on Dr. Vough's current research, contact him through his e-mail: lv14@umail.umd.edu.

Potassium and Grass Tetany

Grass tetany is a complex disorder of ruminants (cattle, sheep, and other animals) involving an inadequate level of magnesium in the diet. The first indication of grass tetany—the discovery of dead cattle—follows low blood serum magnesium (Mg) levels, or hypomagnesemia, which results from grazing on grasses that supply insufficient magnesium. This disorder is most prevalent in situations of intensively managed pastures and highly productive animals. Among the multiple plant, animal, and climatic factors that contribute to grass tetany are agronomic factors such as potassium fertilizer practices and soil properties.

Potassium, or K_2O?

Potassium is called "potash" by much of the agricultural community. "Potash"—potassium oxide or K_2O—is simply a traditional expression, not an accurate description of the form of potassium that plants actually use. Neither is it the form of potassium present in commercial fertilizer. Plants use potassium as an ion (K^+), and many soil test laboratories present it that way. Use these simple equations in converting the units:

$K \times 1.2 = K_2O$ $K_2O \times .83 = K$

Table 2. Potash in Commercial Fertilizer

Fertilizer	Potash (% by weight)	Of Additional Benefit
Potassium-magnesium-sulfate	22	11% magnesium, 22% sulfur
Muriate of potash	60	
Potassium sulfate	50	18% sulfur
Potassium nitrate	44	13% nitrogen

The potential for tetany appears greater under Maryland's highly weathered acid soils and long, mild winters. Under certain conditions—including the onset of spring—high concentrations of potassium interfere with magnesium uptake by pasture grasses, especially when magnesium levels are low in the soil and potassium levels are excessive.

If grass tetany has been a problem in your area, you may need to consider fertilizing pastureland. Look at the calcium index and magnesium index on your soil test, and maintain magnesium at the "Optimum" level. Dr. Vough recommends application of dolomitic lime to pastureland to adjust pH and supply adequate magnesium.

Potassium BMPs

- Test fields for potassium at least every 3 years. If the test detects a potassium deficiency, follow the recommendations of the Soil Testing Laboratory. See Table 2 for options in adding potassium using commercial fertilizer.
- Some crops may be sensitive to chloride, so an alternative to muriate of potash—potassium choride, or KCl—may be needed. Contact your county Extension educator for recommendations.
- Retain plant residue on the soil after harvest as a way to return potassium to the soil while adding the benefits of organic matter.
- Minimize soil erosion. Contact your Soil Conservation District for advice and for a soil conservation plan.

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