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Potassium in Missouri Soils

Daryl D. Buchholz and J.R. Brown
Department of Agronomy

Missouri soils may contain from 10,000 to 50,000 pounds per acre of total potassium in the surface plow layer. While this appears to be a very large amount, only 0.1 to 2 percent of this total potassium is readily available for plant uptake (Table 1).

Table 1
Total and exchangeable potassium in some Missouri soils (Mo. Bulletin 264 (1929))

Soil	Potassium content (pounds per acre)	
	Total	Exchangeable
Putnam	29,840	200
Wabash	30,275	300
Lebanon	24,100	125

Potassium is taken up by plants as the potassium ion, K^+. Potassium is commonly called **potash**. This term referred to the fertilizer value of wood ashes. The ashes came from the wood fires used to heat hanging pots of liquid; therefore, **pot ash**.

In the fertilizer trade, potash refers to the chemical expression K_2O. In the description of a fertilizer grade such as 6-24-12, the 6 = percent nitrogen, 24 = percent available phosphoric acid, P_2O_5, and 12 represents the percentage of potassium, K_2O, on a weight basis. Researchers now know K_2O is not the effective potassium compound in chemical fertilizers. However, as a carryover from the way chemists expressed analytical results at the turn of the century, the fertilizer industry still uses the expression to designate the true compound.

Always keep in mind, plants use potassium in ionic form (K^+).

Potassium and plant nutrition

Potassium is referred to as the third major plant nutrient. Nitrogen and phosphorus are the other two major nutrients and historically were deficient in many Missouri soils.

Potassium is an important plant nutrient for several reasons. Potassium:

- Increases drought resistance of plants by regulating the opening of stomata in the leaves, which in turn regulates gas exchange between the plant and the atmosphere (carbon dioxide, water vapor).
- Is associated with stronger stalks and stems, thus reduces lodging.
- Assists in more than 60 enzyme systems affecting metabolism.
- Assists in photosynthesis and conversion of sugars to starches and cellulose.
- Aids in translocation of food within a plant.
- Increases protein, starch, and oil content of plants.

Has been associated with resistance to diseases.

With all this activity, potassium has not been shown to be a part of the plant's organic structure. Instead, it acts as a policeman in the plant, keeping traffic ways operating efficiently. More specifically, washing dried plant leaves will remove most of the potassium, while leaving essentially all of the nitrogen and phosphorus behind in the leaf's structure.

Plant leaves, when functioning properly, will contain about 2 percent or more potassium. Thus, when hay and silage are removed from a field, large amounts of potassium are also removed. However, when stover and straw are left in the field after grain harvest, much of the potassium in the plant is returned to the soil.

Potassium availability in soils

The soil's "native" potassium is the result of the parent materials from which it formed. Primary minerals such as muscovite, biotite, and many feldspars contain high amounts of potassium. As these minerals weather, they form clays. If leaching is not excessive during the weathering, the clays will be high in potassium. With further weathering, these clays will give up their potassium. It either may be used by plants growing on these soils or may be gradually leached from the soils. Extreme weathering results in soils low in potassium content.

In Missouri, soils vary considerably in potassium content (Figure 1). Soils of northwest Missouri are still high in available potassium due to formation from wind blown silts (loess) containing high amounts of potassium minerals. In addition, little leaching has taken place over thousands of years of their formation. Eastern Missouri soils are generally lower in potassium because of greater weathering and removal of potassium.

Soils of the Ozarks region are generally low in available potassium because these soils are much older and more intensively weathered than soils in northern and west central Missouri. Soils in the eastern Bootheel region are relatively high in potassium because many of these soils are the result of recent depositing of the river materials (alluvium) brought down from northern U.S. soils rich in potassium.

Generally, as rainfall and average annual temperatures increase, weathering of soils increases, resulting in lower potassium contents. This has certainly been the case within Missouri.

Potassium in soils can be divided into three general categories: **relatively unavailable** forms, **slowly available** forms, and **readily available** forms. The **relatively unavailable** forms include soil minerals such as micas and feldspars. For potassium in soil minerals to become available, mineral weathering must take place. This takes too long to supply adequate potassium to growing plants in a given season.

The **slowly available** forms of potassium are the potassium ions that have been "trapped" between layers of clay particles. Clays such as illite, common to soils in northern Missouri, have large amounts of potassium trapped between clay particles. Plants cannot use much of this slowly available potassium in a single growing season. However, this supply of potassium is very important in the soil's ability to supply potassium over longer periods of time.

The **readily available** potassium is that potassium held by the negative charged clay or organic matter particle. It is known as **exchangeable** potassium. Small quantities of potassium ions are also in soil water available for uptake. Exchangeable potassium and soil solution potassium are most important for growing healthy, high yielding crops. Most soil tests attempt to measure the readily available potassium.

Generally, 90 to 98 percent of the total potassium in soils is in the **relatively unavailable** form, 1 to 10 percent in the **slowly available** form, and 0.1 to 2 percent in the **readily available** form (Table 2). Unlike nitrogen and phosphorus, the organic matter in soils contains very little potassium but can hold potassium by cation exchange. Therefore, plant available potassium comes mainly from readily available forms or fertilizers. Smaller amounts are released from the slowly available forms.

Table 2
Major forms of soil postassium

Portion of total potassium	Form of potassium	Availability
90 to 98 percent	Potassium containing minerals (Micas, Feldspars, etc.)	Relatively unavailable
1 to 10 percent	Clay minerals (Illitic types)	Slowly available "Trapped K+" or "Non-exchangeable K+"
0.1 to 2 percent	Exchangeable K+ and Soil solution K+	Readily available

Fertilizing with potassium

Soils in southern and eastern Missouri are most often medium to low in available potassium. For these soils, recommended rates of potassium fertilizer are often greater than crop removal rates expected. This gradually builds available soil potassium. In some soils, especially in eastern Missouri, applying high rates of potassium fertilizer has not increased the available soil level of potassium. These soils may be trapping fertilizer potassium, which takes the readily available potassium and converts it to a less available form (Table 2). As a general rule, this reversion explains why it takes 4 to 5 pounds of potash to raise the potassium soil test 1 pound. This requirement can, however, vary greatly depending on soil type and the actual starting potassium soil test level.

Crop response to potassium fertilization on soils low in available potassium has been noted on nearly every crop grown in Missouri. Figure 2 shows response of soybeans to potassium fertilization on a sandy, very low potassium (48 pounds K per acre) soil in Mississippi County. The soil was also infected with soybean cyst nematode. Note that the greatest response came from potassium fertilization with or without the use of nematicide. Clearly, potassium was very limiting.

Alfalfa is also a big user of potassium and responds well to potassium fertilizer (Figure 3). These data are three year averages of a potassium rate study conducted in Howell County on a silt loam soil medium in potassium (160 pounds K per acre) initially. This soil has a very limited storehouse of potassium due to the types of clay it contains. The clay minerals have largely been weathered to forms low in slowly available potassium. Therefore, when growing a crop like alfalfa on these soils, the available potassium content of the soil drops rapidly.

Factors other than just crop response can influence the need for potassium fertilization. Stalk strength or standability of a crop can also be affected by inadequate potassium. Studies in southeast Kansas on medium to low available potassium claypan soils, similar to claypan soils of southwest Missouri, showed greatly reduced lodging and yield improvement on grain sorghum (Table 3). Though recommendations for potassium are largely based on yield improvement, additional factors such as risk of yield loss from lodging should be considered.

Table 3
Potassium effects on grain sorghum stalk strength and yield. Southeast Kansas

K_2O rate per acre	Allen County, KS		Cherokee County, KS	
	Lodging	Yield per acre	Stalk deterioration*	Yield per acre
0 pounds	88 percent	95 bushels	22 percent	52 bushels
40 pounds	71 percent	105 bushels	20 percent	61 bushels
80 pounds	45 percent	108 bushels	26 percent	72 bushels
160 pounds	16percent	107 bushels	16 percent	76 bushels
320 pounds	2percent	106 bushels	4 percent	83 bushels

***Based on percent of stalk showing deterioration at the base one month after harvest.**
Taken from *Better Crops with Plant Food.* Number 3-1974, pp. 22-26.

Building up the available potassium level in soils gives flexibility in fertilizer management. When soils test high in potassium, you can apply fertilizer potassium every two or three years to maintain the high potassium status. But if your cash flow is tight, you can skip potassium applications for a year or so without fear of large yield reductions.

Table 4 shows potassium fertilizer requirements to increase soil tests from the current level to a medium to high level in about eight years. These requirements are for alfalfa, row crops, and small grains and are affected slightly by the cation exchange capacity of the soil. Generally, as the cation exchange capacity of a soil increases, the level of available potassium required to reach maximum yield potential also increases slightly. With each unit increase in cation exchange, the optimum available potassium level increases by five pounds. Table 5 shows potassium buildup requirements for forages other than alfalfa.

Table 4
Building up soil exchangeable potassium to an adequate level for alfalfa, row crops, and small grains

This table shows the annual build up recommendations that should increase the soil test to the high range in eight years.

Potassium soil test level per acre	Soil cation exchange capacity (meq per 100 grams)			
	5	10	15	20
	Potassium fertilizer rate (pounds K_2O per acre)			
50 pounds	81	88	95	107
75 pounds	66	73	80	87
100 pounds	53	61	68	74
125 pounds	42	50	57	63
150 pounds	32	39	46	53
175 pounds	23	30	37	44
200 pounds	14	22	29	35
225 pounds	6	14	21	27
250 pounds		6	13	20
275 pounds			6	12
300 pounds				5

Table 5
Building up exchangeable potassium to an adequate level for all forage crops other than alfalfa

This table shows the annual build up recommendations that should increase the soil test to the high range in eight years.

Potassium soil test per acre	Soil cation exchange capacity (meq per 100 grams)			
	5	10	15	20
	Potassium fertilizer rate (pounds K_2O per acre)			
50 pounds	62	70	78	85
75 pounds	47	55	63	70
100 pounds	34	42	50	58
125 pounds	23	31	39	47
150 pounds	13	21	29	36

175 pounds	4	12	20	27
200 pounds		3	11	19
225 pounds			3	10
250 pounds				3

Understanding the potassium soil test is very important. Interpretation levels for available potassium were low to extremely high and are shown in Table 6.

Table 6
Potassium soil test levels and ratings for a desired level of potassium (silt loam soil with a cation exchange capacity of 16 meq per 100 grams

Soil test rating	Probability of response	Alfalfa, row crops and small grains	All other forages
		Soil exchangeable potassium per acre	
Very low	80 to 100 percent	0 to 90 pounds	0 to 70 pounds
Low	50 to 80 percent	90 to 150 pounds	70 to 120 pounds
Medium	20 to 50 percent	150 to 300 pounds	120 to 240 pounds
High	5 to 20 percent	300 to 450 pounds	240 to 360 pounds
Very high	0 to 5 percent	450 to 600 pounds	360 to 480 pounds
Extremely high		600+ pounds	480+ pounds

MU expresses its soil test results for potassium in pounds per acre. Some commercial soil testing laboratories express results in parts per million (ppm). Don't let this confuse you. To convert from ppm to pounds per acre, simply multiply ppm by 2. An example — 100 ppm K is exactly the same as 200 pounds K per acre. Always be sure to understand how soil test results are expressed before trying to interpret those results.

In addition to buildup, fertilizer recommendations also call for maintenance (putting on what the crop takes off) when soil tests are in the medium range or lower. Crop removal values for some selected crops at an average yield level are shown in Table 7. High test levels may call for a small amount of potassium to keep fertility high but little response is expected. When a University soil analysis calls for no potassium to be applied, you can be sure years of research have told us that response is very unlikely and not profitable.

Table 7
Potassium removal by selected Missouri crops

Crop	Yield per acre	Potassium fertilizer equivalent removal per acre
Alfalfa hay	4 tons	180 pounds
Red clover/Grass hay	3 tons	115 pounds
Fescue hay	3 tons	100 pounds
Corn (grain)	120 bushels	35 pounds
Corn (silage)	20 tons	180 pounds
Sorghum (grain)	6,000 pounds	35 pounds
Soybeans	45 bushels	65 pounds
Wheat	50 bushels	15 pounds

Efficient use of potassium

To get the best use of potassium, you must first determine the need through soil analysis. Your local MU Extension center has information on the MU Soil and Plant Testing Laboratory and can help you with any questions. Most fertilizer dealers also offer soil testing services. Be certain you understand the results of the tests made and get proper recommendations for Missouri conditions. Improper sampling, interpretations or recommendations can cost you money and time. The added cost can be either applying more potassium than is necessary or losing yield by not applying adequate potassium.

There is some interest in band applying potassium either close to the seed or with a tillage implement to improve uptake efficiency. Band placement close to the seed often will nearly double the efficiency of uptake as compared to broadcasting potassium on soils testing low to very low in potassium. Take care when applying potassium close to the seed to prevent possible salt damage to seedlings. Limit rates of nitrogen plus potassium to about 80 pounds per acre in a band at least 2 inches from the seed for crops planted in 30 inch rows. The **per acre rate** can increase as rows are narrowed provided the band remains at least 2 inches from the row. In direct contact, about 15 pounds of nitrogen plus potash is a maximum.

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