A2521

Understanding Plant Nutrients

Soil and Applied Potassium

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Soils commonly contain over 20,000 parts per million (ppm) of total potassium (K). Nearly all of this is a structural component of soil minerals and is unavailable to plants. Plants can use only the exchangeable potassium on the surface of soil particles and potassium dissolved in the soil water. This often amounts to less than 100 ppm.

Large quantities of potassium are removed with harvests of such plants as alfalfa, certain vegetables, other forages, and corn silage. Grain and seed harvests remove much less potassium. Most Wisconsin soils need relatively large quantities of applied potassium because of removal by crops and because Wisconsin soils have little native exchangeable potassium.

POTASSIUM REACTIONS IN SOILS

Forms of Soil Potassium

The three forms of soil potassium are unavailable, slowly available or fixed, and readily available or exchangeable potassium.

Unavailable soil potassium is contained within the crystalline structure of micas, feldspars, and clay minerals. Plants cannot use the potassium in these insoluble forms. Over long periods, these minerals weather or break down, releasing their potassium as the available potassium ion (K^+). This process is far too slow to supply the full potassium needs of field crops. However, trees and long-term perennials obtain a substantial portion of potassium from the weathering of minerals containing potassium.

Slowly available potassium is trapped between the layers or plates of certain kinds of clay minerals. This is sometimes called fixed potassium. Plants cannot use much of the slowly available potassium during a single growing season. However, the supply of fixed potassium largely determines the soil's ability to supply potassium over extended periods of time. The red soils of eastern Wisconsin are examples of soils that contain significant amounts of slowly available potassium.

Readily available potassium is that which is dissolved in soil water or held on the surface of clay particles. Dissolved potassium levels in the soil water are usually 5–10 ppm. Plants absorb dissolved potassium readily, and as soon as the concentration of potassium in the soil solution drops, more is released into the solution from the exchangeable forms. Most soil tests for available potassium measure the readily available forms but not the unavailable and slowly available forms.

Movement of Soil Potassium

Since clay and organic matter particles hold potassium ions in an exchangeable or available form, potassium does not leach from silty or clayey soils. Some leaching may take place in very sandy soils because sandy soils do not contain enough clay to hold the potassium.

Organic matter particles hold most positively charged nutrients tightly. Potassium is an exception because the attraction between potassium ions and organic matter particles is relatively weak. Consequently, some potassium leaches from organic soils (peats and mucks). Loss of potassium by leaching is one reason sandy and organic soils often test relatively low in available potassium, especially when tested in the spring. These soils require precise annual potassium applications, since it is not possible to build up high potassium reserves.

Table 1. Fertilizer sources of potassium.

NAME OF FERTILIZER	CHEMICAL FORMULA	FERTILIZER ANALYSIS EQUIVALENT N-P_2O_5-K_2O	SALT INDEX
		%	
Potassium chloride (muriate of potash)	KCl	0-0-60 to 0-0-62	116
Potassium magnesium sulfate	K_2SO_4•2$MgSO_4$	0-0-22	43
Potassium nitrate	KNO_3	13-0-44	74
Potassium sulfate	K_2SO_4	0-0-50	46

Table 2. Potassium plant-analysis interpretations for common Wisconsin field crops.

			INTERPRETATION				
CROP	**PART SAMPLED**	**TIME OF SAMPLING**	**DEFICIENT**	**LOW**	**SUFFICIENT**	**HIGH**	**EXCESSIVE**
			%				
Alfalfa	Top 6 inches	Bud	<1.8	1.8–2.4	2.5–3.8	3.9–4.5	>4.5
Corn	Earleaf	Silking	<1.3	1.3–1.7	1.8–2.3	2.4–2.9	>2.9
Oat	Top leaves	Boot stage	<1.3	1.3–1.5	1.6–2.5	2.6–3.0	>3.0
Soybean	First trifoliate	Early flower	<1.3	1.3–1.7	1.8–2.5	2.6–4.5	>4.5

FERTILIZER SOURCES OF POTASSIUM

The most common potassium fertilizer for use on field crops is potassium chloride, or muriate of potash. Both red- and white-colored potash are often available. (See Table 1 for the primary fertilizer sources of potassium.) These materials are equivalent as sources of potassium. The red color is due to iron impurities that have no effect on the availability of potassium or other nutrients. Most of the U.S. supply of potassium chloride is mined from vast underground deposits in Saskatchewan, although some is also mined in the western U.S. This is the least expensive source of potassium and is as effective as the other materials for most cropping situations, except where very high rates are to be used, where the burning quality of tobacco is important, or where the solids content of potatoes are of primary concern. When high rates of potassium are needed or when soil salinity is a problem, potassium fertilizer applications should be split or materials with a lower salt index, such as potassium sulfate (K_2S0_4) or potassium magnesium sulfate ($K_2SO_4 \bullet 2Mg\ SO_4$), should be used.

DIAGNOSTIC TECHNIQUES

Deficiency Symptoms

On corn, soybean, and other field crops, potassium deficiency appears as a yellowing or scorching of the margins of older leaves. In alfalfa, the deficiency appears as whitish-grey spots along the outer margin of the recently matured and older leaflets. As the deficiency becomes more severe, the affected area increases and the leaves or leaflets may become completely yellow and/or drop off. Because potassium is a very mobile element within the plant, deficiency appears on the older leaves first.

Soil Analysis

Available potassium is estimated by measuring the solution and exchangeable potassium. Extension publication A3030, *Optimum Soil Test Levels for Wisconsin*, provides an interpretation of the exchangeable or available potassium test for Wisconsin soils. In general, available potassium should be 60–120 ppm for most field crops and somewhat higher for potato and some vegetable crops, including cabbage, carrot, melons, and tomato. Recommendations for potassium fertilizer vary with crop species, yield goal, and soil type. If soil tests are below optimum levels, the amount of potash recommended will permit a gradual buildup (over 5–8 years) of the available supply. If soil potassium is high, the amount recommended will be less than the amount removed in the harvested portion of the crop, allowing some decrease in the soil test. For excessively high tests, elimination of part or possibly all of the potassium fertilizer allows the soil test to drop to the optimum range.

Plant Analysis

Critical concentrations of potassium for economically important crops are fairly well known. Like nitrogen, the amount of potassium in the plant decreases as it matures; it is therefore important to know the plant's stage of growth to properly interpret the results of potassium analysis. Also, the potassium concentration usually decreases from top to bottom of the plant, so the portion of the plant sampled affects the interpretation as well. Interpretations of potassium levels in the leaf tissue of several major Wisconsin field crops are given in Table 2. See Extension publication A2289, *Sampling for Plant Analysis: A Diagnostic Tool*, for additional information.

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