Potassium in Mississippi Soils

MISSISSIPPI STATE UNIVERSITY EXTENSION

Potassium (K) is absorbed in large amounts by plants. Potassium uptake by crops under good growing conditions is high, often equal to nitrogen (N) uptake. Potassium is used in photosynthesis, sugar transport, water and nutrient movement, protein synthesis, and starch formation by plants. Adequate potassium in plants increases disease resistance, water stress tolerance, winter hardiness, tolerance to plant pests, and uptake efficiency of other nutrients.

Potassium mobility is often related to soil texture: movement is greatest in soils with more sand content. The buildup of potassium in soils is related to soil texture, with the greatest accumulation generally in clay soils, followed by loam and coarse-textured sands.

Although soils provide a great deal of potassium through natural processes, fertilization with potassium may be necessary to maximize plant growth. The total amount of potassium in soil ranges from 5 to 25 tons per acre. While this seems like a lot of potassium, only a small amount is plant-available at a particular point in time. Most potassium is in the structural component of the soil. Sandy-textured soils have much less potassium than fine-textured, clay soils. Where levels of soluble potassium in the soil are high, plants may take up more potassium than needed in a "luxury consumption" that does not increase yields.

Potassium in Soils

There are three forms of potassium "pools" in the soil: unavailable, slowly available or "fixed," and readily available.

Unavailable potassium is within soil minerals such as feldspars and micas. Over extremely long periods, these minerals will break down and potassium will be released. However, this process is much too slow to provide full potassium needs of growing plants.

Slowly available or "fixed" potassium is trapped between layers of clay minerals. This type of soil potassium is not measured by soil-testing procedures, but, over time, it will become plant-available. However, it is possible for potassium measured in the soil-testing process to become "fixed" in the slowly unavailable pool to plants during the growing season.

How much potassium is "fixed" varies with the particular types of clay present in a soil. Many Mississippi soils are dominated by clays with large shrink-swell capacities (i.e., cracks form in dry seasons). These soils can fix large amounts of potassium upon drying but release substantial amounts when rewetted.

Sandy, low-organic-matter soils have little capacity to hold or retain potassium. These soils should be managed to minimize potassium loss. Readily available potassium is the pool measured by soil-testing procedures. This is potassium present in the soil solution and potassium easily removed from soil clay edges. Potassium in the soil readily and regularly interchanges between the water in the soil and the clay solids. Note that this potassium is not the same pool within the clay structure.

When plants use the potassium present in the soil solution, more potassium is released from the clay particles to the solution in response to the decrease in concentration. This interchange of potassium in the soil is extremely important to plant nutrition.

Plant Uptake of Potassium

Potassium used by growing crops must be absorbed from the soil. Potassium constitutes 1 to 4 percent of plant dry-matter weight. The quantity removed by plants varies among crops. Cotton contains about 20 pounds of K_2O equivalent potassium per bale harvested, and hybrid bermudagrass hay contains about 50 pounds per ton. Extension Publication 2647 *Nutrient Management Guidelines for Agronomic Crops Grown in Mississippi* contains detailed information about potassium uptake by various crops.

Plant root systems cannot intercept sufficient potassium in the soil or soil water to maintain plant function.

About 90 percent of the potassium needed by plants must move to the root surfaces by diffusion, which is movement from an area of high concentration to one of low concentration within moisture films surrounding soil particles.

Factors affecting potassium diffusion include soil moisture conditions, soil aeration, and soil temperature. Higher soil moisture usually increases potassium movement in the soil. However, when soils are saturated with water, the resulting decrease in root function will decrease potassium uptake. Soil temperature affects all plant functions. Potassium uptake is optimum at temperatures of 60 to 80°F, but uptake is reduced at lower temperatures.

Managing Soil Potassium

Soil-fertility management should follow the four Rs: using the **right fertilizer** at the **right rate** at the **right time** and at the **right place**. Determining the **right rate** begins with a sound soil-testing program. Information on soil testing in Mississippi is available for farmers and homeowners. The common potassium soil-test procedures use a chemical procedure that results in assessing the potassium in soil solution and the potassium on soil solids that exchanges with it. The Mississippi State University Extension Service Soil Testing Laboratory uses an extraction solution and procedure developed for the diverse soils of the state.

Research develops the relationship between potassium soil-test levels and potassium fertilizer requirements. Plant potassium uptake and yield are related to measured quantities of potassium in the soil. These results are integrated into "soil-test K indices"; these are commonly seen on soil-test reports as very high, high, medium, low, or very low. Each category reflects the probability of plant response to potassium application. Crops grown on soils testing with a very high potassium index normally will not respond to potash fertilizer application, but crops on very-low-potassium soils should usually respond.

The potassium indices used by the MSU Extension Soil Testing Laboratory are listed in **Tables 1, 2, and 3**. These indices are categorized by crop and by cation exchange capacity (CEC). The CEC of a soil is a measure of its ability to store the positively charged nutrients that are determined during the soil-testing procedure.

Potassium Fertilization

If the soil-test recommendations associated with that sample's index call for potassium fertilizer to optimize crop production or plant growth, several materials are available. Determining the **right fertilizer** is relatively simple for potassium. Most commercial potassium fertilizer used in the state is potassium chloride, or muriate of potash. Potassium chloride may be pink, red, or white. The color difference is due to iron content of the materials; there is no difference in the amount of plant-available potassium in the material. Potassium-magnesium sulfate is a good potassium source if magnesium is also needed for the crop.

The MSU Extension Service does not recommend potassium fertilization for soils that have high or very high indices, except for cotton in the high index. In these cases, the **right rate** is zero. In most crop-production systems, the **right time** to apply potassium is at or before planting. While potassium may be fall-applied for row-crop production in Mississippi on soils with low loss potential (CEC > 8), potassium is vulnerable to overwinter loss on sandy, low CEC soils.

The **right place** to apply potassium is where it will be useful to the growing plants, which can be a site-specific decision. Detailed information on commercial fertilizer recommendations, options, and management is available for field crops. See Extension Publication 2647 *Nutrient Management Guidelines for Agronomic Crops Grown in Mississippi* and Publication 2500 *Inorganic Fertilizers for Crop Production*.

Potassium Deficiency Symptoms

Plants lacking potassium will have shortened internodes, weak stalks, excessive lodging, and more leaf and stalk disease; they also will be a lighter green when viewed from a distance. Severe deficiency will cause leaf drying along the outer margins. Because potassium is mobile in plants, symptoms begin at the tips of lower leaves and move up the plant as the deficiency persists.

Inner portions of the leaves may have a striped appearance. This often can be confused with deficiency symptoms for sulfur, magnesium, and zinc. Potassium deficiency has been an issue in cotton production during times of high "demand" growth. Guidance is available elsewhere for this situation.

Table 1. Soil-test potassium levels (pounds K per acre) and indices using the Mississippi soil-test extractant for perennial winter grass pasture (fescue or orchard grass); small grains for pasture; peanuts; perennial summer grass pasture (bahia, dallis, or Bermuda); rice; or annual legumes with ryegrass.

Index	CEC < 7	CEC 7–14	CEC 14–25	CEC > 25
Very Low	0–40	0–50	0–60	0–70
Low	41–80	51–110	61–130	71–150
Medium	81–120	111–160	131–180	151–200
High	121–210	161–280	181–315	201–350
Very High	> 210	> 280	> 315	> 350

Table 2. Soil-test potassium levels (pounds K per acre) and indices using the Mississippi soil-test extractant for dryland corn for grain, oats, wheat, barley, summer pastures (bahia, dallis, or Bermuda) with annual legumes (white clover, red clover, lespedeza, arrowleaf clover, ball clover, or subterrean clover); temporary summer grass pastures (millet, sorghum, sudangrass, sorghum-sudangrass hybrids, or johnsongrass); forage legumes; perennial winter grass pasture with clover (white clover, red clover, subterranean clover with fescue or orchardgrass); pasture grass with annual legumes (crimson clover, annual lespedeza, arrowleaf clover, ball clover, or subterrean clover with Bermuda, dallis, or bahiagrass); Johnsongrass hay; mixed grass hay; annual or sericea lespedeza hay; or sunflowers.

Index	CEC < 7	CEC 7–14	CEC 14–25	CEC > 25
Very Low	0–50	0–60	0–70	0–80
Low	51–110	61–140	71–160	81–180
Medium	111–160	141–190	161–210	181–240
High	161–280	191–335	211–370	241–420
Very High	> 280	> 335	> 370	> 420

Table 3. Soil test potassium levels (pounds K per acre) and indices using the Mississippi soil-test extractant for alfalfa; cotton; corn or sorghum for silage; soybeans; sweet potatoes; irrigated corn; or hybrid Bermudagrass hay.

Index	CEC < 7	CEC 7–14	CEC 14–25	CEC > 25
Very Low	0–70	0–80	0–120	0–150
Low	7–150	91–190	121–240	151–260
Medium	151–200	191–240	241–290	261–320
High	201–350	241–420	291–510	321–560
Very High	> 350	> 420	> 510	> 560

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By **Larry Oldham**, PhD, Extension Professor, and **Keri Jones**, PhD, Laboratory Coordinator, Plant and Soil Sciences.

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