MISSISSIPPI STATE UNIVERSITY EXTENSION

Soil Acidity, Phosphorus, and Potassium Nutrient Levels: Key to Forage Nutrient Management Planning

Mississippi has almost 300 different soil types, and they all provide, to some degree, a reservoir of nutrients required by forage crops and livestock. Although soil nutrients can be present in the soil at different soil depths, they are not necessarily at optimum levels or always in available form for plant uptake. Plant-available soil nutrient levels are impacted by many factors such as acidity, soil texture, soil structure, mineral composition, and soil moisture. The most efficient method to assess soil nutrient levels for optimum production is to take a representative sample of the area in question for a soil nutrient analysis. This information can help you avoid a miscalculated application that could impact the environment (e.g., phosphorus runoff) and ensure that suitable levels of nutrients are provided for maximum crop potential.

Applications based on soil sample recommendations can help maintain the nutrient-supplying capacity of the soil. Good nutrient estimates depend on collecting a representative soil sample for every 10–15 acres; collect at least 20–25 soil cores to a minimum soil depth of 6 inches. Soil analysis is recommended every 2–3 years for pastureland and every year or every other year for hayland. It is also best to sample fields at the same time of year each time you sample. For more information on how to collect a soil sample, please consult MSU Extension Service Publication 3858 Soil Testing for the Farmer. Highly variable soil fertility levels across a field can make it difficult to collect a representative soil sample. When sampling a paddock or field, avoid sampling in areas that are unrepresentative of the field, such as in winter feeding areas, under shade trees, close to water sources, in areas with fresh manure piles and urine spots, and in bottomland areas with high moisture content.

Forage and livestock producers should develop a nutrient management plan that can keep the stand healthy and productive. A soil sample estimates the plant-available concentrations of the major nutrients such as phosphorus (P) and potassium (K) in the soil. Measuring available soil nitrogen (N) can be useful in forage systems, but it is more complex than other nutrients and could be more expensive to analyze.

Soil Acidity

Soil acidity is measured as pH (concentration of hydrogen ions), and plant tolerance can range from 4.5 to 6.8 in most forage crops across the state. Average soil pH in forage systems across Mississippi ranges from 5.2 to 6.0. Soil pH can be impacted by several factors, including vegetation (grasses versus legumes), soil parent material, topography, climate, soil organisms, temperature, rainfall, and soil mineral weathering. Remember that, while some grasses may sustain productivity at a pH of 5.8, legumes will need an optimum pH range of 6.0–6.8 to be productive and persistent.

Acidity can reduce root growth, which then reduces nutrient uptake. Soil acidity can lead to toxic levels of certain elements such as aluminum, iron, manganese, and zinc. Organic matter decomposition by soil organisms is slower in acidic soils. Soil acidity has also long been known to decrease symbiotic nitrogen fixation in legumes, which negatively affects growth and yield, especially in plants that depend exclusively on symbiosis to acquire nitrogen during the growing season.

Lime application is the most effective treatment for neutralizing soil acidity. Lime can be applied at any time during the growing season, but it is recommended to apply at least 6 months before green-up to allow an effective treatment. Different types of lime are commercially available, and each type of lime amendment has its benefits and drawbacks, such as effectiveness, price, purity, and neutralizing value (NV). For more information on NV, please consult MSU Extension Publication 3762 Agricultural Limestone's Neutralizing Value.

Phosphorus

Phosphorus is very stable in the soil and changes very little with soil depth as compared to nitrogen and potassium. The amount of phosphorus in soil is generally low, and it is often a limiting factor for plant growth. Several factors impact phosphorus mineralization and availability, including pH, rainfall, temperature, moisture, and aeration (oxygen level). A soil pH that is less than 5.5 could limit phosphorus availability by 30 percent or more. Phosphorus release from organic matter (such as poultry litter) will occur more quickly in warm, humid climates than in cool, dry climates. A soil pH above 6.0 is ideal to increase phosphorus availability for plant uptake. Adequate soil phosphorus levels can encourage the formation of a vigorous root system, stimulate shoot growth, and promote efficient water use by forage crops.

Phosphorus deficiency occurs in low-input managed grasslands and may affect the ability to produce legumes, particularly white clover, to obtain an input of nitrogen that is sufficient to ensure a productive system. The first symptom of phosphorus deficiency is usually purple leaves. The symptoms appear first in the tips of the leaves and progress until the entire leaf turns purple. Symptoms are usually observed in the lower leaves because phosphorus is usually mobilized from the younger leaves. Table 1 lists phosphorus sufficiency levels for forage production in Mississippi.

Table 1. Soil phosphorus levels for all forage crops based on Mississippi State University soil testing (Lancaster soil test method).

Level	Range (lb P/ac)
Very low (VL)	0–18
Low (L)	19–36
Medium (M)	37–72
High (H)	73–144
Very high (VH)	144+

Note: Sufficiency levels can vary depending on the soil extraction method. Source: Oldham, 2012.

Potassium

Potassium is the second-most important nutrient in forage production (after nitrogen) and is required in large amounts for growth and reproduction. Factors that can affect potassium uptake by plants are soil moisture, aeration, temperature, cation exchange capacity, and tillage system. An increase in soil moisture tends to increase potassium availability and, therefore, enhance plant root uptake. Good soil aeration is needed for root respiration and potassium uptake. Compaction and water saturation (very wet soils) can decrease oxygen levels and subsequently decrease potassium uptake.

Potassium uptake is usually reduced at low soil temperatures. An optimum soil temperature of 60–80°F can increase microbial activity and increase potassium uptake. Cation exchange capacity (CEC) is a measure of the soil's ability to hold positively charged ions such as potassium. The CEC of soils varies according to the amount of clay, type of clay, soil pH, and amount of organic matter. *Soils with a higher* clay fraction tend to *have a higher CEC*, while sandy soils tend to have a lower CEC and are more likely to develop potassium deficiencies.

Potassium sufficiency levels for forage production in Mississippi based on CEC are provided in Tables 2, 3, and 4. Some studies have indicated that soil availability of potassium in no-till systems can be reduced, although the exact cause of this reduction is not yet known. However, there are speculations that this reduction could be related to root growth restriction resulting in unexplored potassium reserves within the soil. In pastures with potassium-deficient soils, grasses are more efficient at securing their potassium needs than associated clovers. Potassium deficiency in forage crops (especially legumes) can impact stand persistence, reduce plant survival under drought or very cold conditions, and reduce insect and disease resistance. Typical symptoms of potassium deficiency in forage crops include brown leaf scorching, curling leaf tips, yellowing (chlorosis) between leaf veins, and purple spots under leaves.

Developing a good nutrient management program depends on taking a representative soil sample as well as selecting a reputable soil testing laboratory. Sometimes, producers take a representative soil sample, split it, and send it to different laboratories. The results and recommendations obtained from the laboratories might be different, and this can cause confusion and frustration for the producer. The results might differ because soil analysis methods and extractants used usually vary from lab to lab. Protocols or techniques also vary by lab and can result in different recommendations. Other factors that can affect soil nutrient interpretation include soil sampling depth and amount of organic matter. Soil with greater organic matter can have higher microbial activity and increase plant available nutrients.

Also, different soil testing labs have different philosophies when it comes to fertilizer recommendations (maintenance versus build-up). MSU recommendations are a hybrid of maintenance in low and medium indices and build-up in very low indices. This is a reason that MSU's soil test recommendations have a 3-year recommendation approach. Consult with your laboratory about soil analysis methods, and make sure that samples were collected and submitted within the same sampling period (spring, summer, or fall) that they were recommended.

Table 2. Soil potassium levels for forage crops group 1 based on MSU soil testing (Lancaster soil test method) and soil cation exchange capacity.

Level	Range (lb/ac) CEC ≤ 7	Range (lb/ac) CEC 7–14	Range (lb/ac) CEC 14–25	Range (lb/ac) CEC 25+
Very low (VL)	0–40	0–50	0–60	0–70
Low (L)	41–80	51–110	61–130	71–150
Medium (M)	81–120	111–160	131–180	151–200
High (H)	121–210	161–280	181–315	201–350
Very high (VH)	201+	280+	315+	350+

Annual grasses (wheat, oats, barley, ryegrass); perennial cool-season grasses (tall fescue or orchardgrass); cool-season annual clovers (arrowleaf, ball, berseem, balansa, crimson, persian) with annual ryegrass; perennial or mixed warm-season grass pasture (bahiagrass, bermudagrass, dallisgrass). Note: Sufficiency levels can vary depending on soil extraction method. Source: Oldham, 2021.

Table 3. Soil potassium levels for forage crops group 2 based on MSU soil testing (Lancaster soil test method) and soil cation exchange capacity.

Level	Range (lb/ac) CEC ≤ 7	Range (lb/ac) CEC 7–14	Range (lb/ac) CEC 14–25	Range (lb/ac) CEC 25+
Very low (VL)	0–50	0–60	0–70	0–80
Low (L)	51–110	61–140	71–160	81–180
Medium (M)	111–160	141–190	161–210	181–240
High (H)	161–280	191–335	211–370	241–420
Very high (VH)	280+	335+	370+	420+

Lespedeza (annual and sericea); perennial mixed grass hay (bahiagrass, bermudagrass, dallisgrass); forage legumes [annuals (clovers: arrowleaf, ball, berseem, balansa, and crimson; and other: caley peas and vetch) and perennial clovers (red and white)]; perennial cool-season grass (tall fescue or orchardgrass) with clovers (white, red, subterranean). Note: Sufficiency levels can vary depending on soil extraction method. Source: Oldham, 2021.

Table 4. Soil potassium levels for forage crops group 3 based on MSU soil testing (Lancaster soil test method) and soil cation exchange capacity.

Level	Range (lb/ac) CEC ≤ 7	Range (lb/ac) CEC 7–14	Range (lb/ac) CEC 14–25	Range (lb/ac) CEC 25+
Very low (VL)	0–70	0–90	0–120	0–150
Low (L)	71–150	91–100	121–240	151–260
Medium (M)	151–200	191–240	241–290	261–320
High (H)	201–350	241–420	291–510	321–560
Very high (VH)	350+	420+	510+	560+

Alfalfa; hybrid bermudagrass. Note: Sufficiency levels can vary depending on soil extraction method. Source: Oldham, 2021.

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