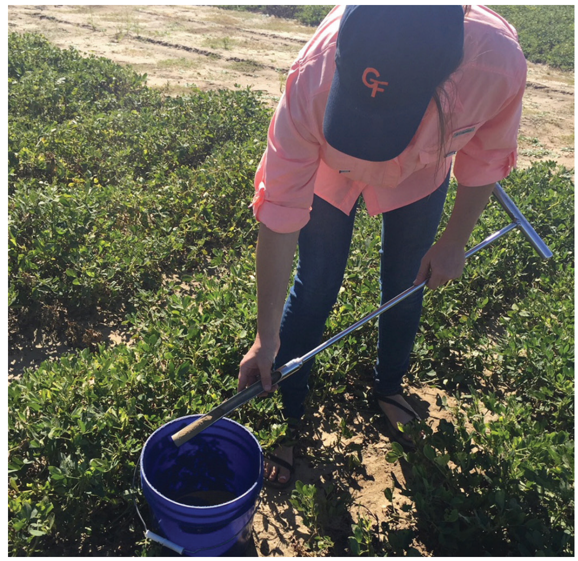
Interpreting Soil Test Reports from Commercial Labs

► **Most Alabama soils are naturally low in plant-available nutrients and must be fertilized to maintain crop production. Soil testing is critical to improve soil fertility for production of row-crops, specialty crops, and forages.**

Producers increasingly rely on commercial soil testing laboratories to provide nutrient recommendations for crops. To make best-management decisions for maintaining soil fertility, it is important to understand the basics of soil testing and reporting, whether you use a public or a commercial soil testing laboratory.



Soil Test Methods

All soil testing laboratories rely on extractants to determine the concentration of plant-available nutrients in soils. Extractants are chemicals developed to mimic substances that plant roots release to extract nutrients from the soil. All soil testing laboratories should use extractants that were developed for the soil types and climates of their routinely submitted samples. For example, the Auburn University Soil, Forage, and Water Testing Laboratory typically uses a Mehlich-1 extraction, which was developed for acidic soils of the Coastal Plain, Piedmont Plateau, and Tennessee Valley. Auburn uses a different extractant, Mississippi extract, for acid or alkaline clay soils of the Blackbelt region.

Commercial laboratories may test soil samples from varying regions of the United States, and as a result, they could use different extractants. Table 1 lists some commonly used soil test methods in the United States. Before submitting samples to a soil testing laboratory, check to ensure that it uses extractants that are acceptable for the soil types being submitted.

Interpretation of Nutrient Recommendations

Decades of research has been used to correlate soil-extractable nutrients with increases in yield to develop fertilizer recommendations for Alabama crops. In Alabama, this research has been based on the correlation between yield and Mehlich-1-extractable or Mississippi-extractable nutrients, respective of soil type. Soil test reports from the Auburn University Soil, Forage, and Water Testing Laboratory use formulas to calculate the recommended phosphorus (P) and potassium (K) to the nearest 10 pounds.

Table 1. Common Soil Test Extractant Use in the United States

Extractant	Additional Names	Soil Suitability	Appropriate for Testing
Mehlich-1*	Dilute Double Acid	Acid, weakly buffered soils	P, K, Ca, Mg
Mehlich-3		Acid to neutral soils	P, K, Ca, Mg, Zn, Mn
Mississippi*	Lancaster	Acid or alkaline clays	P, K, Ca, Mg
Bray P1	Weak Bray	Highly buffered, acid soils	P
Olsen	Sodium bicarbonate	Alkaline, calcareous soils	P
Morgan		Acidic soils	P, K, Ca, Mg
Ammonium Acetate	NH_4OAc	All soil types	K, Ca, Mg, Na (not P)
DTPA		All soil types	Zn, Cu, Mn, Fe
Hot water		All soil types	B

*Indicates method used by the Auburn University Soil, Forage, and Water Testing Laboratory

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There is no guarantee that fertilizer recommendations from commercial laboratories are based on local research; however, it is possible to generate fertilizer recommendations based on Auburn University research from other soil testing laboratory reports if the appropriate soil extractant is used. Formulas to calculate fertilizer recommendations for more than 100 crops commonly grown in Alabama can be found in the Alabama Agricultural Experiment Station publication "Nutrient Recommendations for Alabama Crops."

In certain cases, it is possible to convert between soil test methods to estimate nutrient recommendations based on Auburn University research. A few guidelines for Alabama soils are as follow:

- Mehlich-3 typically extracts between 1.2 to 1.5 times more phosphorus (P) from the soil than Mehlich-1.
- Mehlich-1, Mehlich-3, and ammonium acetate will extract similar amounts of potassium (K), calcium (Ca), and magnesium (Mg).
- If Mehlich-1 is used on calcareous or alkaline soils (Blackbelt soils), it will remove very little P and result in higher P recommendations compared to the Mississippi extract.
- Mehlich-3 is the only extract that does a good job of extracting some micronutrients but may not be reliable in predicting deficiencies.
- None of the extracts in table 1 are useful for estimating sulfate sulfur in soils.

Units for Reporting Extractable Nutrients

The most common unit for reporting extractable nutrients on soil test reports is in pounds per acre. Occasionally, laboratories may report extractable nutrients in parts per million (ppm). If nutrients are reported in ppm, they should be converted to pounds per acre in order to use Auburn University Soil, Forage, and Water Testing Laboratory fertilizer recommendations. To convert ppm to pounds per acre, simply multiply the value in ppm by two.

Pounds per acre	=	ppm x 2

Common Values Reported by Commercial Laboratories

Cation Exchange Capacity (CEC)

Cation exchange capacity (CEC) is a measurement of a soil's capacity to retain nutrients. Soil testing laboratories may report CEC on soil test reports expressed as milliequivalents per 100 grams of soil (meq/100g) or centimoles per kilogram (cmol/kg). Determination of the actual CEC of soil is an expensive, time-consuming process. Consequently, most soil test labs actually measure estimated cation exchange capacity (ECEC). The ECEC is simply the sum of extractable K, Ca, and Mg with an adjustment for exchangeable acidity.

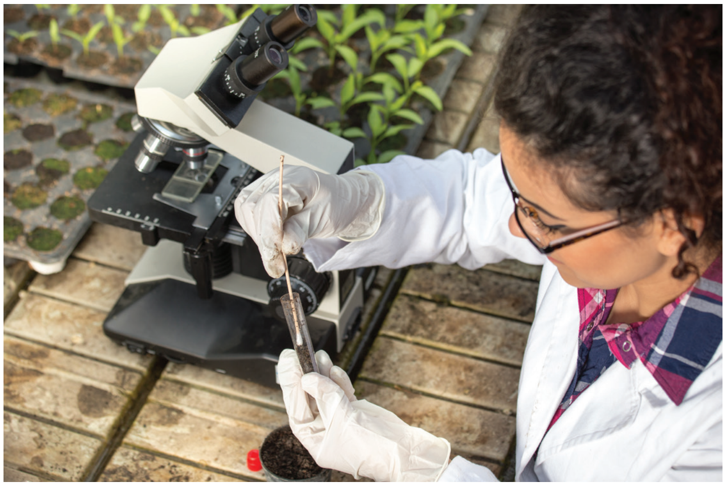
The amount of fertilizer required for maximum plant growth is dependent on CEC. Auburn University soil test recommendations use ECEC to categorize soils into the appropriate soil grouping for nutrient recommendations. Table 2 shows the groupings that the Auburn University laboratory uses. **If using extractable-nutrient concentrations from a commercial laboratory to calculate Auburn University nutrient recommendations, CEC values should be used to determine the appropriate formulas to use.**

Percent Base Saturation

Base saturation is the percentage of the CEC occupied by the cation form of calcium (Ca^{2+}), magnesium (Mg^{2+}),

Table 2. Soil Groups Used by the Auburn University Soil, Forage, and Water Testing Laboratory to Determine Appropriate Fertilizer Recommendation Formulas

Soil Group	Estimated CEC (cmol kg^{-1})	Average Soil Texture	Extract Used
1	<4.6	Sandy soils	Mehlich-1
2	4.6-9.0	Loams	Mehlich-1
3	>9.0	Clayey or high organic matter	Mehlich-1
4	>9.0	Clays of the Blackbelt	Mississippi



and potassium (K^{+}) as opposed to acidic cations of hydrogen (H^{+}) and aluminum (Al^{3+}). Base saturation is affected by pH, and at extremely low soil pH (and base saturation), aluminum toxicity can occur.

Some commercial laboratories may report the percentage of CEC occupied by each basic cation. Labs may even recommend basing fertilizer applications on percent base saturation. This is based off the idea that an ideal ratio of basic cations exists in soils. Research from Alabama and throughout the Southeast shows that calculating percent base saturation ratios is **not** an effective method for making fertilizer recommendations for Alabama soils. Using base saturation to manage soil fertility can result in significant and costly overapplication of nutrients to the soil. The Auburn University lab does not report percent base saturation on routine soil tests, because fertilizing according to lime, K, Mg, and Ca recommendations has proven to be a much more effective method for maintaining soil fertility.

Buffer pH

Lime recommendations made by soil testing labs are based on two separate soil tests, soil pH and buffer pH. Buffer pH is used to measure the soil's resistance to changes in pH, which affects how much lime is required to increase soil pH to a target pH. Soils that are high in organic matter and clay content require more lime to raise pH than sandy, low organic matter soils require. For example, a sandy soil at pH 5.0 may require only 1 ton of ground limestone to raise the pH to 6.5, while a clay soil at the same pH may require 4 tons of ground limestone.

Each soil testing lab has its own buffer solution and tables or formulas used for calculating lime requirements. The Auburn University lab measures buffer pH using a modified Adams-Evans buffer solution. Find tables for Auburn University lime recommendations in the Alabama Agricultural Experiment Station publication "Nutrient Recommendations for Alabama Crops." These table can be used to determine lime requirements based on soil test results from other labs **only if** Adams-Evans buffer solution was used to determine buffer pH. Other soil testing labs may use different buffer solutions to assess buffer pH. If this is the case, the lab that ran the samples should be contacted for additional information on lime requirements.

Agricultural Limestone Recommendations.

The effectiveness of a liming material is expressed as relative neutralizing value (RNV) or effective calcium carbonate equivalent (ECCE). Soil testing labs make varying assumptions regarding RNV when reporting lime recommendations. Alabama has a state lime law that specifies that lime cannot be sold as agricultural limestone unless (1) the material has at least a 90% calcium carbonate equivalent, (2) at least 90% of the material passes through a 10-mesh sieve, and (3) at least 50% of the material passes through a 60-mesh sieve. This equates to a 63% RNV. For this reason, the Auburn University lab assumes that a lime is 63% effective when making lime recommendations. Other labs may assume that the liming material is 80% effective or 100% effective. Depending on the assumed RNV, recommendations by soil testing labs may result in overapplication if a high-quality limestone is used or underapplication if a very poor quality ground limestone or by-product is used. To adjust lime recommendations based on the actual RNV, see table 3.

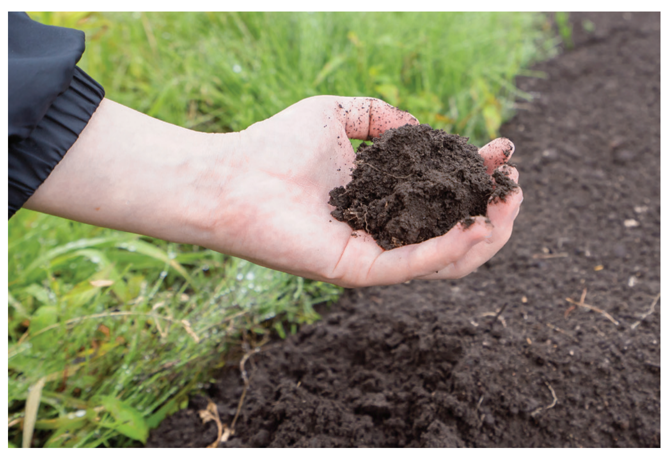


Table.3. Lime Recommendations Based on RNV

$$\text{Adjusted lime recommendation}\left(\frac{\text{tons}}{\text{acre}}\right) = \text{Lime recommendation}\left(\frac{\text{tons}}{\text{acres}}\right) \times \frac{\text{Assumed RNV (\%)}}{\text{Actual RNV (\%)}}$$

Example. Consider a soil test report from the Auburn University Soil, Forage, and Water Testing Laboratory that recommends 2 tons of lime per acre based on a 63% RNV. A producer wants to adjust his lime application based on a liming material with a guaranteed analysis of 90% RNV. His adjusted lime application rate will be 1.4 tons per acre.

$$\text{Adjusted lime recommendation}\left(\frac{\text{tons}}{\text{acre}}\right) = 2\left(\frac{\text{tons}}{\text{acres}}\right) \times \frac{63\ (\%)}{90\ (\%)}$$

Soil Organic Matter

Soil organic matter (SOM) is an important component of soil comprised of carbon-containing compounds from dead and living plant and animal materials. Organic matter performs many functions that support soil heath, such as increasing CEC and soil water-holding capacity. It also improves soil structure and decreases risk of soil compaction. Most agricultural soils in Alabama are depleted in SOM and contain less than 1% SOM. Increasing SOM concentration is important for improving overall soil heath. Values for SOM concentration are most useful to assess whether management practices have a positive or negative impact on soil health. To assess impact of management practices on SOM and soil health, it is best to compare soil samples (1) from the same area over time or (2) for areas with a similar soil type and different management practices. The Auburn University lab does not determine SOM on routine samples, but this analysis can be requested for any soil sample.

Soil Micronutrient Levels

Eight essential micronutrients are required for crop production. Although micronutrients are essential, they are needed in much smaller quantities than macronutrients such as N, P, and K. Micronutrients are typically abundant in mineral soils of Alabama, and in most instances, Alabama soils can supply plant micronutrient requirements as long as pH is maintained according to soil test recommendations.

Field experiments with micronutrients including boron (B), zinc (Zn), manganese (Mn), copper (Cu), iron (Fe), and molybdenum (Mo) have been conducted by Auburn University for decades. However, soil-extractable micronutrients typically do not correlate well with plant response. Recommendations based on needs of specific crops are often more practical than reliance on a soil analysis. For example, the Auburn University lab recommends applying 0.3 to 0.5 pound of B per acre to peanuts regardless of soil-extractable B concentrations. Plant tissue testing has proven to be a much more reliable method for detecting micronutrient deficiencies than soil testing. Many private labs will report values for micronutrients and recommend application in spite of extensive research indicating that soil testing is not the best way to evaluate micronutrient deficiencies.

In some cases, overapplication of micronutrients (e.g., Zn, Cu) could lead to toxicity. Soil testing for extractable Zn and Cu may be more valuable for avoiding toxic buildup than for predicting deficiencies. For questions regarding micronutrient toxicity, consult with your local Extension agent.

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