DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Agriculture and Natural Resources

FSA2118

Understanding the Numbers on Your Soil Test Report

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A routine soil test provides an index describing the availability of nutrients for plant uptake. Routine soil tests measure only a portion of the total pool of nutrients in the soil. Soils have large amounts of most plant-essential nutrients, but only a small fraction (often less than 1%) are in a form that can be taken up by plants. The release of native soil nutrients and the "tie-up" of nutrients added from manures, fertilizers, compost and plant residues involve complex soil chemical, microbiological and physical processes.

In January 2006, a number of changes were implemented in the University of Arkansas soil testing and fertilizer recommendations program. The information presented in this fact sheet will help the reader understand the numbers in the soil test report.

Fertilization Philosophy

Due to variations in soil properties from one geographic region to another, soil testing laboratories may use different extractant solutions. Soil testing labs use these solutions to extract plant-available nutrients from soil and apply different philosophies to interpret the results and estimate the amount of nutrients required to optimize plant growth and yield potential. The University of Arkansas uses the Mehlich-3 soil test method and recommends fertilizer rates that optimize plant growth and yield and replace the macronutrients removed by the harvested portion of a crop. For some soils, additional fertilizer will be recommended to build or maintain the soil levels near a "Medium" range for P (phosphorus) and K (potassium). The amount of P and K needed to raise the soil test level to "Medium" may not be economically or agronomically practical in a single application or growing season, particularly for soils with very low nutrient levels. Therefore, the University of Arkansas' recommendations normally use an eight-year period to build nutrient-deficient soils to the "Medium" level. The recommendations assume that, on average, 15 lb P_2O_5/acre are required to raise the soil-test P level by 1 ppm (2 lb/acre), and 8 lb K_2O/acre are needed to raise the soil-test K level by 1 ppm. Fertilizer and lime recommendations are also based on crop rotations, soil texture, plant variety and yield goal when appropriate.

Nutrient Availability Index

The concentrations of soil nutrients appear in the ***Nutrient Availability Index*** section of the University of Arkansas soil test report and are reported with units of ppm (parts per million) and pounds per acre (lb/acre). One part per million equals approximately 2 pounds per acre (when the sample is taken from the top 6 inches). In addition to reporting the concentration of each nutrient, there is also an availability index or soil test level associated with the P (phosphorus), K (potassium) and Zn (zinc) concentrations. This level is related to the expected crop yield that would be produced without additional fertilization. A nominal fertilizer rate may be recommended for selected

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crops on soils with “Optimum” soil nutrient levels to compensate for nutrients removed by the harvested portion of the crop. Variables other than fertilization (e.g., water stress, insects, hardpans, etc.) can also affect yield potential, even if plants are properly fertilized. Table 1 shows the general interpretation of soil-nutrient concentrations and levels for most agronomic crops. Because plant species often have different nutrient requirements, the defined soil-nutrient concentrations that accompany the soil test levels are general in nature.

The interpretations provided in Table 1 apply only to routine tests conducted by the University of Arkansas soil testing laboratory and should not be used to interpret information provided by other laboratories. Contact your county Extension office for additional information or other publications.

Phosphorus (P) and Potassium (K)

Phosphorus and potassium are two of the three macronutrients (the other being nitrogen) required by plants for optimum growth. They are required in larger amounts compared to the micronutrients (e.g., zinc, iron, boron, etc.). Yield response to P fertilization is not likely when the soil P is ≥36 ppm (72 lb/acre) for row and forage crops, above 25 ppm (50 lb/acre) for fruit crops and above 75 ppm (150 lb/acre) for vegetable production. Responses to potassium fertilization are not likely when the soil tests above 175 ppm (350 lb/acre) for vegetables, row and forage crops and above 90 ppm (180 lb/acre) for fruit crops.

Calcium (Ca) and Magnesium (Mg)

Most sandy soils have calcium concentrations below 400 to 500 parts per million (800 to 1,000 lb/acre), while clayey soils usually test above 2,500 ppm. Normally, the higher the calcium level, the greater the soil clay content. Recent limestone applications may result in higher calcium levels. If the soil pH is maintained in the recommended range for the crop grown, calcium deficiency is very unlikely. In general, the higher the clay content, the more lime will be required to raise soil pH to the desired level.

Limited information is available on the crop response to magnesium fertilization in Arkansas, but if the soil tests below 31 ppm (62 lb/acre), the soil test report will suggest an application of magnesium. Most soils low in magnesium are often acidic and low in calcium.

Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn) and Boron (B)

The extractable levels of these micronutrients are printed on the soil test report; however, with the exception of zinc, their levels do not currently affect the fertilizer recommendations. Soil-test zinc levels below 4 ppm (8 lb/acre) coupled with pH above 6.0 may trigger a zinc fertilizer recommendation. Plant tissue and soil analyses should be used together to assess the need for application of the other micro-nutrients. A very high level of any micronutrient does not necessarily indicate that a plant nutrient toxicity will develop. For example, soil-test iron values above

TABLE 1. Interpretation of soil-nutrient concentration ranges and soil test levels of surface soil samples for most row crops and forages. The interpretation for vegetable crops and other plants may vary.

Soil Test Level	Expected Yield Potential†	Mehlich-3 Nutrient Concentrations								
		P	K [Most Crops]	K [Turf Codes]	Ca‡	Mg‡	SO_4-S‡	Mn‡	Cu‡	Zn
		mg/kg (or ppm)								
Very Low§	<65%	<16	<61	<21						<1.6
Low§	65 - 85%	16 - 25	61 - 90	21 - 40	≤400	≤30	≤10	<40	<1.0	1.6 - 3.0
Medium§	85 - 95%	26 - 35	91 - 130	41 - 60						3.1 - 4.0
Optimum	100%	36 - 50	131 - 175	61 - 100						4.0 - 8.0
Above Optimum (High)	100%	>50	>175	>100						>8.0

†Expected yield potential without fertilization.
‡Recommendations are not provided for these nutrients. The listed values represent general guidelines for interpretation.
§The soil test levels of “Very Low,” “Low” and “Medium” are considered “Sub-Optimum” levels.

200 ppm (400 lb/acre) and zinc values above 40 ppm (80 lb/acre) are sometimes observed, but rarely are these concentrations toxic to plants. In contrast, manganese levels exceeding 200 ppm (400 lb/acre), coupled with a soil pH below 5.2, may result in manganese toxicity. This particular problem is easily corrected by applying recommended rates of lime to the soil. Soil-test Mn values <40 ppm (80 lb/acre) are considered low. Although Mn fertilizer is not currently recommended for agronomic crops in Arkansas, manganese deficiencies are sometimes observed on soil with pH >6.5 and soil-test Mn concentrations below 20 ppm (40 lb/acre) and may require application of Mn fertilizer.

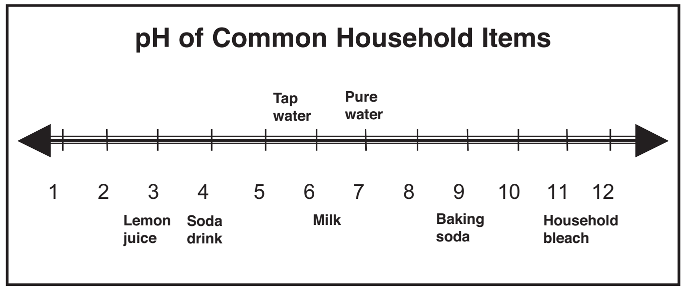
Nitrate-Nitrogen (NO_3-N) and Sulfate-Sulfur (SO_4-S)

Nitrogen is normally the most limiting nutrient for optimum plant growth. Soil tests that estimate soil N availability are not currently used because soil N exists in many forms which may change with time and influence plant availability. Soil nitrogen (N) and sulfur (S) are measured in nitrate-nitrogen (NO_3-N) and sulfate-sulfur (SO_4-S) forms. For most crops grown in Arkansas, nitrogen fertilizer recommendations are developed from research trials and are based on previous crop, soil texture, yield goal and sometimes cultivar. Analysis for soil nitrate-N, however, is done routinely only for a few selected crops, and it is used to refine their N-fertilizer recommendations. Soil samples can be analyzed for nitrate-N if requested for other crops, but fertilizer-N recommendations, particularly for lawns and forages, are not adjusted.

Sulfate-sulfur and nitrate-nitrogen can leach in sandy soils and typically accumulate above the dense or clayey soil horizons. For this reason, positive crop responses to sulfur fertilization are not common in clayey soils. As organic matter decomposes, sulfur and nitrogen are released into the soil solution. As a consequence of these complex reactions, the concentrations of these nutrients may vary considerably with time, environmental conditions and soil depth. Recommendations for sulfur fertilization are based on cropping history and, to some extent, on soil test level, especially for corn, cotton, wheat and forages.

pH or Soil Reaction

The soil reaction, or pH, is a measure of the acidity or alkalinity of the soil. A pH of 7.0 is neutral. Soil pH values below 7.0 are acid, while those above 7.0 are basic or alkaline. Each whole unit (e.g., 1.0) change in pH represents a ten-fold difference in acidity or alkalinity. For example, a pH of 5.2 is 10 times more acidic than a pH of 6.2. For most vegetable and row crops, a pH of 5.8 to 6.5 is optimal. A pH range of 5.5 to 5.8 is desirable for roses, turfgrasses, fruits and nuts. Certain shrubs and blueberries thrive in soils with a pH below 5.5. Most plants suffer visually when soil pH is below 4.8. Lime is recommended to neutralize soil acidity, with clayey soils requiring more lime than soils having a sandy or silty texture. Elemental sulfur (S) or aluminum sulfate (Al_2SO_4) is recommended to acidify the soil (lower the soil pH) for acid-loving plants. Soil pH values (measured in water) may vary by 1.0 pH unit or more during a growing season. In general, soil pH values are highest in the cool, wet winter months and lowest during the hot, dry summer months.



pH of Common Household Items

Salt Content (also referred to as electrical conductivity, or EC)

The electrical conductivity of a soil is used to measure the potential risk of salt injury to plants, and it is currently measured with a 1:2 soil:water mixture. This measurement includes all soluble salts, not just sodium chloride that most people are familiar with. Electrical conductivity readings can vary dramatically within fields and across time and are greatly affected by environmental conditions (e.g., rainfall). For this reason, soil EC is no longer measured on all routine soil samples, but is available (free of charge) by request. Measurement of soil EC can be useful when diagnosing crop growth problems, but has limited use in Arkansas for predicting fields that will experience salinity injury due to salt accumulation from hot, dry conditions, over-fertilization or salts deposited by irrigation water. Electrical conductivity values for soil samples collected during the winter months are commonly <100 μmhos/cm and are considered normal. Depending on the salt sensitivity of the plant species (rice, roses and strawberries are more sensitive than cotton or bermudagrass), salt injury symptoms may occur when EC values are >500 μmhos/cm.

Estimated Cation Exchange Capacity (ECEC)

Cation exchange capacity (CEC) refers to the ability of negatively charged soil particles to attract and retain positively charged ions [calcium (Ca^{++}), magnesium (Mg^{++}), potassium (K^+), sodium (Na^+), ammonium (NH_4^+), aluminum (Al^{+++}) and hydrogen (H^+)]. Cation exchange capacity is expressed in units of centimoles per kilogram (cmol/kg). Soil CEC on the University of Arkansas soil test report is termed "estimated cation exchange capacity," or ECEC, because this property is calculated (rather than determined analytically) by summing the basic cation (Ca, Mg, Na and K) charges and estimating the acidic cation charges from soil pH. Soil ECEC is also an indication of soil texture and organic matter content. Generally, in Arkansas, sandy-textured soils have an ECEC <9 cmol/kg, loamy soils have an ECEC of 9 to 20 cmol/kg and clayey soils have an ECEC above 20 cmol/kg. Soil clay content, clay type and organic matter content influence the soil CEC. In general ECEC increases as the soil clay and/or organic matter content increase.

Organic Matter (O.M.)

Organic matter is no longer a routine test, but can be determined for a fee. Check with your county Extension office to determine the current fee. Soil organic matter content in Arkansas soils typically ranges from 0.5% to 5.0%. Soil organic matter contents <0.5% are low, and values >2.0% are desirable.

Estimated Soil Texture

The soil textural class designation for submitted soil samples was previously provided by the client. However, inconsistent and erroneous textural class designations often resulted in lime and nitrogen fertilizer recommendations that were not appropriate for the intended crop and soil properties. Therefore, the laboratory now estimates the soil textural class based on soil pH and soil-test calcium. While the relationship works well in most cases, continuous animal manure applications, recent liming and long-term application of alkaline well water can dramatically increase soil calcium and may lead to an erroneous estimate of soil textural class. Texture influences the recommended N and lime rates. Therefore, if the estimated soil texture is not correct, contact the county Extension agent.

Percent Base Saturation (% Base Saturation)

Base saturation represents the percentage of soil cation exchange sites occupied by the basic ions Ca, Mg, Na and K. The difference between this number and 100 is the percentage of cation exchange sites occupied by acidic cations: Al and H. Under most conditions, a relatively high base saturation (>60%) is desirable. Soil pH increases as percent base saturation increases, with base saturations of 70% to 80% representing soils having pH >6.0.

Sodium (Na) is not an essential element for plant growth, but is important for diagnosing problem soils that may contain high amounts of Na. In soils with high soil sodium levels, irrigation water may also be high in sodium or the soil may contain natural deposits of this element. Soil-test concentrations are not given, but are expressed as exchangeable Na percentage on the ECEC. When the estimated exchangeable sodium exceeds 15%, the soil is considered "sodic," but crop production problems may occur at lower levels. Exchangeable sodium percentages <5% usually cause few production problems.

Fertilizer and Lime Recommendations

The amount of fertilizer and lime recommended may be given in pounds per acre (lb/acre), pounds per 1,000 square feet (lb/1000 ft^2) or pounds per 100 feet of row (lb/100 ft row), depending on the crop selected. The ***Crop Notes*** section in the soil test report includes instructions on how and when to apply the recommended fertilizer. The notes apply only to the respective crop code (e.g., Crop 1 Notes apply only to Crop 1). Precautionary notes or recommendations for other nutrients may also appear in this section. The user is encouraged to obtain publication ***FSA2153, The Soil Test Report***, for further information.

Printed by University of Arkansas Cooperative Extension Service Printing Services.

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FSA2118-PD-1-12RV