Soil Sampling and Analysis

James L. Walworth, Ph.D., Extension Specialist, Department of Soil, Water and Environmental Science, University of Arizona

Soil analysis can provide important information about physical conditions, fertility (nutrient) status, and chemical properties that affect a soil's suitability for growing plants. Four steps associated with soil testing include: 1) soil sample collection, 2) laboratory analysis, 3) interpretation of results, and 4) fertilizer or other management recommendations. We'll look at soil sample collection and analysis.

SOIL SAMPLE COLLECTION

The first step in soil analysis is soil sample collection. It's important to realize that only a tiny portion of a field is actually analyzed in the laboratory. Thus, collecting a representative soil sample is critical for accurate results.

The most common method is composite sampling. Sub-samples are collected from randomly selected locations in the field. The sub-samples are thoroughly mixed to obtain a representative sample and analysis of this sample gives average values for the entire area. Although the actual number of sub-samples depends on field size and uniformity, no less than 5 sub-samples should be taken, and 15 to 25 are preferred. Usually samples are collected to a depth of about 6 to 8 inches or to the effective rooting depth.

Soil samples should be immediately air-dried at room temperature for two to three days and should not be heated or dried in an oven. If samples cannot be dried immediately, they can be refrigerated for several days and taken to a laboratory as soon as possible.

The primary consideration for timing of soil sample collection is convenience. Collect samples early enough to allow for interpretation and soil management adjustments. Status of some soil nutrients can change quickly, whereas others do not. For example, phosphorus levels in soil are unlikely to change rapidly and frequent testing is unnecessary. Nitrogen levels, on the other hand, change very quickly and only very recent tests will reflect current plant-available levels. When making substantial changes to soil fertility levels, it is a good idea to make the change over a period of two to three years, retesting the soil annually. Otherwise, occasional testing (once every few years) is adequate in the absence of any noticeable nutritional deficiencies.

SAMPLE ANALYSIS

A soil test determines the soil's nutrient supplying capacity by mixing soil during the analysis with a very strong extracting solution (often an acid or a combination of acids). The soil reacts with the extracting solution, releasing some of the nutrients. As soil supplies most of the mineral nutrition for higher plants through the plant's root system, the extracted nutrient concentration is evaluated based on research that relates plant utilization to soil nutrient concentrations. This works well for some nutrients, but is less accurate for others. Nutrients supplied from soil organic matter (OM) decomposition (such as nitrogen and sulfur) depend more on the rate of OM decomposition than on extractable levels of these nutrients.

Standard or routine soil tests vary from laboratory to laboratory, but generally include soil texture; electrical conductivity (EC, a measure of soil salinity); soil pH; available phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg); sodium (Na); cation exchange capacity (CEC); and often an analysis of OM content. Most laboratories offer nitrogen (N), sulfur (S), and micronutrient analyses for additional cost.

The methods used to test soils vary depending on soil chemical properties which are affected by geographic region. A listing of local soil test laboratories that use methods suitable for local soils can be found in the University of Arizona publication, "Laboratories Conducting Soil, Plant, Feed or Water Testing" (AZ1111) http://cals.arizona.edu/pubs/garden/az1111.pdf.

STANDARD SOIL TESTS

Soil Texture

Soil texture reflects the amounts of various sized particles (sand, silt, and clay) in the soil. Relative amounts of these particles are used to categorize soil into textural classes. Listed generally from most clayey to most sandy these are clay, silty clay, sandy clay, silty clay loam, clay loam, sandy clay, loam, sandy clay loam, silt, silt loam, sandy loam, loamy sand, and sand. Clayey soils hold more water and nutrients, but are more difficult to till and may absorb water very slowly. Sandier soils accept water quickly, are easy to till, but hold little water and may require frequent irrigation and fertilizer application.

pH

Soil pH is a measure of the acidity or alkalinity of a soil. Arizona soils are generally alkaline (high pH; pH 8.0 to 8.5), and, although pH adjustment is not a common practice, amendments containing sulfur can be used to lower pH levels.

Electrical Conductivity (EC)

Electrical conductivity (EC) of a soil extract is used to estimate the level of soluble salts. This is one of the most useful soil tests for desert southwest soils because salt buildup is one of the leading causes of poor plant growth. Higher EC equates to saltier soil. The acceptable limit depends on the salt tolerance of the plants grown. EC is a very reliable test for soil salinity, and this is a routine test in the arid southwest.

Nitrogen (N)

Nitrogen analyses are not difficult to conduct, but interpreting results can be problematic. This is because plant availability of soil N depends on OM breakdown, which can not be predicted from a soil test. Nitrogen in the nitrate form (NO_3-N) is directly available to plants, however, NO_3-N can be quickly lost from soil. Be aware that nitrate analyses provides a 'snapshot' of available N, but may not indicate N availability later in the growing season.

Phosphorus (P)

Most soil P is tightly bound to soil particles. The P-containing complexes in alkaline soils are very different than those in neutral or acidic soils. The amount of P removed during soil extraction is dependent on the nature of P complexes and on the specific extractant used, so it is critical that P extractants be matched to soil properties. The Olsen or bicarbonate extractant is appropriate for Arizona soils and is a reliable and useful soil test in our state. On a soil test report, the analysis may be reported as PO_4-P.

Potassium (K), Calcium (Ca), Magnesium (Mg), and Sodium (Na)

The four major exchangeable cations in arid-region soils are K, Ca, Mg, and Na. All except Na are essential plant nutrients; however Na is included because it plays an important role in soil physical properties. Sodium levels are expressed as exchangeable sodium percentage (ESP) or sodium adsorption ratio (SAR) which are measures of soil Na content relative to other soil cations. High levels of sodium (reflected in high SAR or ESP values) are associated with instability of soil physical structures, and affected soils may not absorb water or drain adequately due to lack of aggregate structure. Many desert soils contain Ca or Mg minerals (carbonates) that are not available to plants, but which may elevate the levels of these nutrients indicated in a soil analysis. This is not usually a large problem and K, Ca and Mg tests generally provide excellent estimates of plant available levels of these nutrients.

Cation Exchange Capacity (CEC)

Cation exchange capacity is usually estimated by summing the major exchangeable cations (K, Ca, Mg, and Na). This provides a measure of a soil's ability to hold nutrients.

OPTIONAL SOIL TESTS

Sulfur (S)

Measuring total soil S does not provide a good estimate of plant available S because S release from OM can not be predicted. Sulfate (SO_4-S) is a common test and an accurate measure of sulfur availability, although it provides a better estimate of immediately available S than the soil's long-term ability to supply S.

Micronutrients

Micronutrient analyses are optional at most laboratories and are slightly less accurate for predicting plant deficiencies or responses to added nutrients than are analyses of K, Ca, and Mg.

Copper (Cu), Iron (Fe), Manganese (Mn), and Zinc (Zn) - It is difficult to estimate plant-available levels of these micronutrients. The tests are best for identifying extremely high or extremely low levels.

Boron (B) – Boron is very easy to extract from soil and analyses provide a good estimate of plant available B. However, B is easily leached from soil, so plant-available levels can change rapidly. Also, some water supplies contain high levels of B. If soil irrigated with B-rich water is not adequately leached, B can reach plant-toxic levels.

Organic Matter (OM)

The amount of OM in a soil can be easily determined, but these tests do not determine how it will contribute to soil fertility. Although organic matter content is not routinely determined in southwestern soils, typical OM contents are rarely above 1 to 2% in most Arizona soils.

SUMMARY

As part of a soil analysis the laboratory will usually supply some interpretation, which includes an indication of whether individual soil tests are low, medium, or high. The laboratory may also provide fertilizer recommendations based on the analysis, although these recommendations are plant and soil specific.

Routine sampling and analysis can be useful tools for the management of small acreages. Maintaining a record of soil analysis results also can give valuable information on long-term changes in soil properties. Contact your county extension agent for more information.