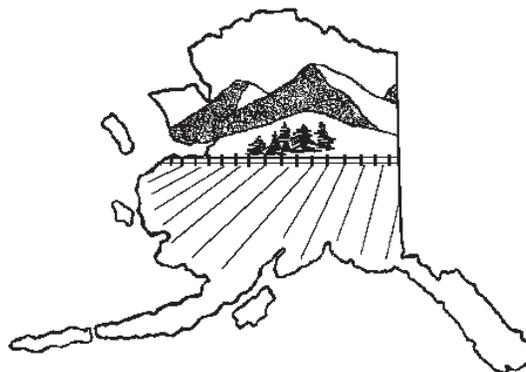


Crop Production and Soil Management Series



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SOIL SAMPLING AND ANALYSIS

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This publication is intended to provide information on techniques of soil sampling and analysis of soil samples. The reader should gain an understanding of the potentials and limitations of soil testing.

Soils are sampled to determine their fertility status and suitability as plant growing mediums. Through field and laboratory research, analytical methods are developed which provide a good estimate of plant-available nutrients through laboratory analyses. Field research determines the optimum soil test levels for various nutrients for specific soil and crop combinations. Optimum fertilizer practices can be determined by knowing the optimum test level of each nutrient for a specific crop and soil, and by knowing how much fertilizer is required to change soil test values.

SOIL SAMPLING

Soil testing begins with soil sampling. A soil analysis is only as good as the sample sent to the laboratory. One should realize how small a portion of a field is actually analyzed in the laboratory. For example, a 1 lb soil sample taken from a 5 acre field represents just 1/10,000,000 of the field, so it is critical that a soil sample be representative of the entire field. Each soil sample submitted for analysis should be a composite of several subsamples; the actual number depends on field size and uniformity. Generally, a larger field or a less uniform field should be more intensively sampled than one that is small and uniform. No less than 5 subsamples should be taken, and 15 to 25 are preferred. Ideally, sampling should be done with a soil probe or auger to the depth of tillage (i.e. sample the portion of the soil worked). A small shovel or trowel can be used if a probe is not available. Each subsample should be approximately equal in size. The subsamples should be placed in a **clean** bucket (preferably made of plastic) and mixed thoroughly. The desired sample amount is then removed from the bucket and the remainder discarded. Approximately two cups of soil are required for analysis.

The area or size of the field sampled is dependent upon management practices. Sample only the smallest unit which can be managed separately. For example, if a field has two distinctly different halves, perhaps one

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half level and the other sloped, then sample the area as two fields, and fertilize each half separately to obtain optimum results. However, if each half of the field will not be fertilized, limed, or planted separately, there is no point in separate sampling. A single, representative sample will be less expensive and just as useful. Sample the smallest management unit.

Soil samples should be air-dried **immediately**. Spread the sample out in a clean, warm, dry area, and let it dry for two to three days (a day or two more may be required if samples are very wet). Bag the sample and send it to a laboratory for analysis. Soil samples can be refrigerated for several days if they cannot be dried immediately. Note: soil samples should not be heated or dried in an oven because soil chemical properties may be altered.

SOIL ANALYSIS

After soil samples are received at a laboratory, a number of tests can be performed. A general understanding of soil testing will help one know how the results can be interpreted and appreciate the accuracy of the analytical results.

Soil supplies most of the mineral nutrition for higher plants through the plant's root system. The root system extracts nutrients from the soil over a long period of time, two to three months for most annual crops, several years for perennial crops. A soil test determines the soil's nutrient supplying capacity by shaking a soil for a few minutes with a very strong extracting solution (usually a strong acid or a combination of acids). The soil reacts with the extracting solution, liberating some of the nutrients. The solution is filtered and analyzed to determine the concentration of each nutrient. The nutrient concentration is then related to field calibration research that indicates the yield level reached with varying soil nutrient concentrations. This method works quite well for some nutrients, but is less accurate for others, particularly those supplied largely from organic matter (OM) decomposition (See CES Publication FGV-00242A, *Soil Fertility Basics*). This is primarily due to the difficulty of estimating or predicting OM breakdown rates.

Standard or routine soil tests vary from laboratory to laboratory, but all include soil pH and available phosphorus (P) and potassium (K). They sometimes also include available calcium (Ca) and magnesium (Mg), lime requirement, and often include an analysis of OM content and soil texture. Some laboratories offer nitrogen (N), sulfur (S), micronutrient, as well as soluble salt analyses.

Organic Matter (OM)

Determining the OM level of a soil can be accomplished by several analytical techniques; all are quite accurate. All of them determine the level of OM, but do not determine the nature of the OM or how it will contribute to soil fertility.

pH and Lime Requirement

Soil pH is the acidity or alkalinity of a soil. Usually it is a standard test and is one of the most useful. The term pH technically only applies to solutions and the analysis can only be made on a solution. Usually a soil sample is mixed with water, allowed to equilibrate for about an hour, and the pH measured. Several factors affect pH measurement. Primary among these is the salt concentration of a soil. A salt is any molecule that, when placed in water, separates into positively and negatively charged components or ions. The salt concentration of a soil may vary with the season or, more importantly, with fertilizer application. The salt concentration of a soil is generally much greater immediately following fertilizer application than before. The result is an apparent pH drop up to one-half a pH unit. (This should not be confused with actual pH reductions caused by ammonium fertilizers. See CES Publication FGV-00349, *Field Crop Fertilizer Recommendations for Alaska—Fertilizer Nutrient Sources and Lime*.)

When samples are taken frequently or at various times of the year it is often noted that pH values tend to increase and decrease, seemingly at random. This leads many to question the validity of soil pH measurements, but the fluctuations are often due to changes in salt levels. It does not usually present a serious problem in the use of the analysis. Some laboratories measure pH in a dilute salt solution to mask salt-induced variations. This method gives lower pH values and the laboratory should provide interpretation guidelines.

Lime requirement (amount of lime required to adjust the soil pH to a desired level) is determined by current soil pH, the buffering capacity of the soil, and the desired pH. The buffering capacity is the ability of a soil to resist pH change in the presence of a liming material. The University of Alaska Fairbanks Soil and Plant Analysis Laboratory uses the SMP (Shoemaker-McLean Pratt, named for the originators of this test) buffer test, which is probably the most widely used in the United States. Some laboratories use different buffer tests, all of which should give acceptable results, although each requires individual interpretation. Some laboratories

base lime requirement determinations on soil texture and OM content. Lime recommendations based on these analyses may be slightly less accurate than those based on chemical buffers.

Nitrogen (N)

Nitrogen is one of the more difficult nutrients to analyze. This is because a major portion of soil N may be contained in the soil OM. Availability of organic N is dependent on OM breakdown, which is difficult to estimate. Without knowing what soil temperature and moisture is going to be in the future, a prediction of N release from OM is no more than a guess. The amount of inorganic N in soils (that which is not contained in OM) is fairly easy to determine. However, it may be quickly converted between N forms, and is easily lost from the rooting zone of the soil. There is no way to relate inorganic N present in a fall sampling to that which may be present in the spring. An accurate determination of the N available to plants at the time of soil sampling can be made, although even this may not provide reliable information concerning an entire growing season. If soil N analysis is to be used for making fertilizer recommendations, it is important that the sampling be done either shortly before planting time or during the growing season.

The University of Alaska Fairbanks Soil and Plant Analysis Laboratory can analyze soil for either total or inorganic N. The total N analysis is not particularly useful for agricultural purposes. Inorganic N analysis provides a measure of N at the time of sampling, but remember, if a soil is over-irrigated or if a heavy rainfall occurs, much of this N can be lost, and a re-evaluation of N status may be required.

Phosphorus (P)

Phosphorus is tightly bound to soil particles in many soils. The amount removed during soil extraction is very dependent on soil type and on the specific extractant used. Most laboratories use only a single type of extractant regardless of the type of soil being analyzed. In Alaska, where there are tremendous differences in the P-fixing capacities of various soils, it is difficult for one extractant to accurately evaluate plant available P in all soils. The extractant currently in use at the University of Alaska Fairbanks Soil and Plant Analysis Laboratory is called Mehlich-3 extractant, and is the best for a wide range of conditions (see AFES Circular 81, *Relating Mehlich-3 extractable P to Morgan and Bray 1 extractable P for Alaska Soils*). However, the optimum P soil test value varies substantially in

Alaskan soils, requiring separate interpretation for each soil type. Phosphorus analysis is one of the most reliable and useful soil tests.

Potassium (K) Calcium (Ca) and Magnesium (Mg)

The analyses for available K, Ca, and Mg are also quite reliable. The Mehlich-3 extractant is used by the University of Alaska Fairbanks Soil and Plant Analysis Laboratory, although other extractants also produce acceptable results. The main difficulty that may be encountered is when Ca or Mg analyses are conducted on soils with undissolved Ca or Mg-containing materials. This may be the case if a coarse liming material has recently been applied, or in very high pH soils. In these situations, the analytical results may indicate a higher level of plant available nutrient than actually exists. This is not usually a problem and K, Ca and Mg tests usually provide excellent estimates of plant available levels of these nutrients.

Sulfur (S)

Sulfur, like N, may be contained primarily in the soil OM. Analysis of inorganic sulfur (SO_4) is relatively easy, yet may indicate little about the soil's ability to supply S to the growing plant. Similarly, soil analysis for total S does not provide information which is directly related to plant-available S. Many laboratories analyze soil for inorganic S or for total S, although interpreting the results is difficult. Generally, if an inorganic S analysis indicates high soil S, then S will be adequate for plant growth. If however, low S is indicated, enough S may still be mineralized from decomposing OM to provide S nutrition for crop plants.

MICRONUTRIENTS

Micronutrient analysis is optional at most laboratories. Analyses of the micronutrients vary considerably in their value in determining soil fertility status.

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

These four elements can be successfully extracted from soils using a chelating agent. The Mehlich-3 extractant (used by the University of Alaska Fairbanks Soil and Plant Analysis Laboratory) contains EDTA (ethylenediaminetetraacetic acid). Many laboratories use the chelator DTPA (diethylenetriamine pentaacetic acid) to extract these micronutrients. Both extractions can provide a good estimate of plant available nutrient levels, although they can not be directly substituted for one another. Because these nutrients are greatly affected by soil pH, their availability should be retested following large

applications of lime. Additionally, Mn availability can change substantially if the soil drainage status is altered. Manganese toxicity can occur in a soil that tests medium for Mn if the soil is allowed to become waterlogged for a prolonged period of time.

Molybdenum (Mo)

Few laboratories conduct soil Mo analysis. Molybdenum is present at very low levels in most soils, much lower than most of the other nutrients, making an accurate determination difficult. Most plants have a low requirement for Mo, and slight differences in soil Mo levels can impact plant performance. Also, seeds may contain enough Mo to supply all the Mo required by a crop. For these reasons soil tests for Mo are of limited use and are seldom conducted.

Boron (B)

The most common method of extracting B from soils is with hot water. The plant availability and level of extractable B in a soil may be influenced by soil pH. Boron may also be leached from the rooting zone. Therefore, extractable soil B provides estimates of plant availability that are less reliable than those of many other nutrients.

Soluble Salts (EC)

Soluble salts are usually measured only in greenhouse media. Salts seldom build up to levels which are damaging to crops in field situations, except in very low rainfall areas. Salt buildup is more likely in confined containers where fertilization levels are often high and watering may be inadequate to flush salts from soils. Soluble salts

analysis is a very simple and reliable test. The electrical conductivity of a soil/water extract is measured and this provides a good measure of soluble salts (See CES Publication FGV-00242, *Soil Fundamentals* - Electrical Conductivity). Test results are dependent on the soil: water ratio used, so results from different laboratories may not be directly comparable. The University of Alaska Fairbanks Soil and Plant Analysis Laboratory, determines soluble salts in a saturated soil paste. This is the most commonly used method.

SOIL SAMPLING FREQUENCY

The frequency with which soil samples should be collected depends on the specific soil test, environmental conditions, and value of the crop. For example, P levels in soil are unlikely to change rapidly and annual testing may be unnecessary. Nitrogen levels change very quickly and frequent tests are required to obtain accurate determinations of plant-available levels. A new soil analysis might be necessary after heavy rains or after a prolonged period of waterlogging if one needs an accurate soil N level estimate.

When trying to make substantial changes in soil fertility level, it is generally a good idea to make the change over a period of two to three years, retesting the soil after each year's fertilizer application. If a crop does not have a high economic value, for example in a recreational home garden, then occasional soil testing (once every 2 to 3 years) may be considered adequate in the absence of any noticeable nutritional problems. In contrast, a commercial producer with crop dependent income should soil test every year to ensure maximum yields.

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