Chapter 2
Soil Sampling

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Chemical analyses of soil samples are a prime source of information on soil fertility. When the soil test procedure is well calibrated with crop nutrient requirements, and where soil samples are properly obtained, the diagnostic soil test result can be a firm foundation on which to base soil fertility management practices.

Other chapters of the **Utah Fertilizer Guide** discuss soil test interpretations. This chapter emphasizes the proper soil sampling technique. A nonrepresentative soil sample is essentially useless, and may even be misleading when seeking the most appropriate soil fertility management for a given soil and crop situation.

Since an appropriate plant sampling technique for tissue analyses depends on crop type, plant sampling is discussed in the respective chapters of the **Utah Fertilizer Guide** which deal with different crops.

The soil sampling techniques described below are based on two contrasting field situations: Fields that are relatively uniform or homogeneous and fields that are relatively nonuniform or heterogeneous.

Soil Sampling Equipment

The basic soil sampling tools include the following:

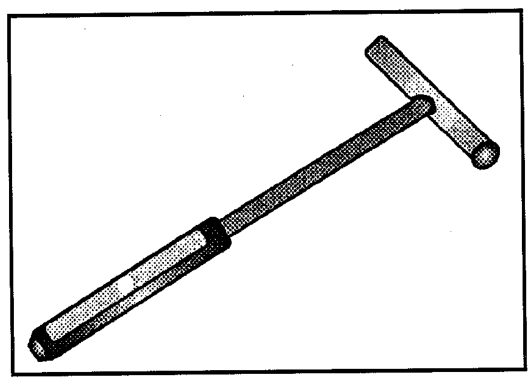

Figure 2.1 Soil sampling probe.

1. A stainless steel soil sampling tube which has a knife edge cutting end and is slotted for easy extraction of the soil core (Fig. 2.1). This tube is used for sampling the plow layer or surface 10 to 12 inches of soil.
2. Plastic buckets for collecting soil cores during the field sampling operation.
3. Soil sample bags or boxes for use in transporting the soil sample to the diagnostic laboratory.
4. For depth soil sampling below the 0-12 inch layer (when testing for nitrates for example), a hydraulic ram mounted on a pickup truck or tractor is very useful for forcing sampling tubes into the subsoil. If this kind of equipment is not available then a specially built hand driven soil sampling tube is usually needed.

Soil Sampling Depth

Most fertility elements are immobile in soil. In Utah the principal elements of concern in this category include phosphorus (P), potassium (K), and zinc (Zn). The appropriate sampling depth for the immobile elements is the plow layer. Applied fertilizer, whether band or broadcast-applied, will be mixed into the plow layer during the plowing operation. It is recommended therefore, that soil samples be taken uniformly to the 10 to 12 inch depth which will be adequate for all routine plowing depths.

The principal mobile fertility element in soil is nitrate-nitrogen (NO_3-N). Diagnostic tests for this element require that the soil sampling procedure represent most or all of the effective root zone. For corn and wheat, for example, the soil sample should be taken to at least 4 feet or to a limiting layer, whichever occurs first. Limiting layers include water table, caliche or other cemented layers, gravel layers, or bedrock. The depth soil samples should be segregated into two or more depths, including the surface (0-12") layer, and at least one sample representing all lower layers. Each foot depth increment below the surface should be maintained separate. Most of the soil fertility information with respect to nitrogen will come from the subsurface samples. The surface sample alone has very little utility for prescribing nitrogen fertilizer needs.

An effective procedure is to run the routine soil test package (i.e. pH, EC, P, K and NO_3-N) on the surface sample. Then for all subsurface samples analyze only for NO_3-N.

Special caution is needed with nitrate soil sampling and analysis. Changes may take place in soil nitrate composition if the sample is stored in a closed (e.g. plastic) bag and held at room temperature for several days. Soil samples to be tested for nitrate should be air-dried immediately, or frozen, or taken to the diagnostic laboratory immediately after the field sampling is complete.

Components of soil salinity and sodicity are also mobile and depth soil sampling is necessary for these kinds of diagnostic tests as well.

When to Soil Sample

Soil sampling can be done any time. However, there are specific advantages of soil sampling in the fall and spring. Fall fertilization has the advantage of incorporation of applied fertilizer with fall plowing. On the other hand, spring soil testing for nitrates will provide a better evaluation of nitrogen availability for the spring crop establishment period. Residual nitrogen from the previous season depends on the amount of snow-melt/rainfall that has occurred between growing seasons.

How Often to Soil Test

Test the soil before crop establishment and subsequently every three years for perennial crops. For annual crops it would be good practice to sample the soil annually or at least biennially. Farm managers should keep complete soil test records for all farm fields, together with fertilizer application records (kinds and amounts) in order to relate changes in soil test results to cropping and fertilizer practices. This will allow for the development of site specific information which can improve the efficiency of the overall farm soil fertility management program.

Sampling Uniform Fields

A uniform field or field portion will have similar characteristics in respect to slope, aspect, soil depth and texture, cropping history, fertilization history, and uniform irrigation for irrigated fields. A uniform field will have uniform appearing crops in terms of presence or absence of deficiency symptoms, and uniform growth and productivity. Thus, for a large field which includes distinctive differences within its perimeters, there will be as many soil samples as there are distinctively different field portions. Clearly identify field differences before beginning soil sample collection in the field.

Soil sampling of uniform fields involves collection of 20 to 30 soil cores, using the slotted soil sampling tube shown in Figure 2.1. The sample is collected by following a zigzag path, taking care to force the path into corners and along edges of the field. Figure 2.2 illustrates the idea. The soil cores are then crushed and thoroughly mixed before reducing the sample size to the appropriate amount for transfer to the laboratory. This is referred to as a composite soil sample.

Crushing and mixing of the collected soil cores, together with reduction in sample size, must be done properly to assure that the final sample represents the original whole sample.

It is recommended that one composite soil sample not represent more than 20 to 30 acres regardless of apparent field uniformity. This is because non-uniformity is usually difficult to assess over broad areas of landscape. Thus a 50 acre field will be divided for sampling purposes into two or three smaller portions.

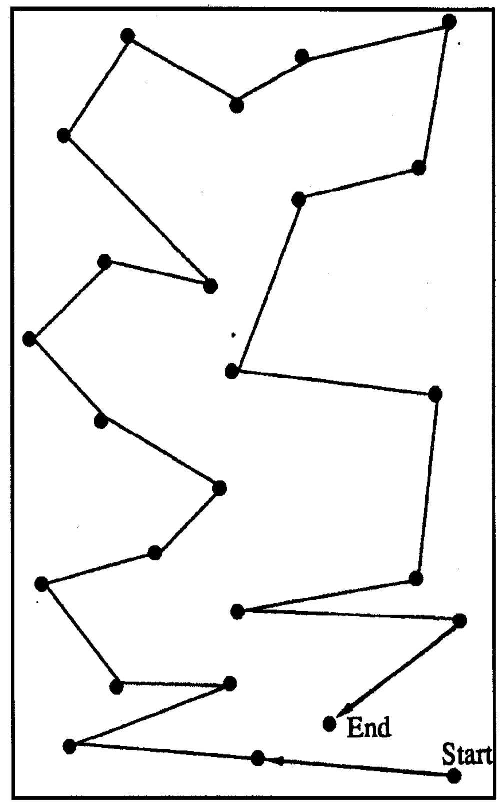

Figure 2.2. General approach used to sample a uniform field. Each dot represents a sampling spot.

Sampling Nonuniform Fields

Extreme field heterogeneity can result from subsoil exposure and also from fertilizer application by any of several injection methods (banded at seeding time, side-dress etc.) without a subsequent plowing or tillage operation, which would tend to mix the fertilizer in the plow layer.

Sampling Fields with Exposed Subsoil

Subsoil is typically very low in fertility, especially in regard to phosphorus. Subsoil exposure results from soil erosion and from land leveling. Eroded fields, hill tops, and side gullies are susceptible to subsoil exposure. In Utah this is seen frequently on summer-fallow wheat land. Leveling or smoothing of irrigated lands is a common practice to facilitate uniform water application by furrow or border methods.

On leveled lands the pattern of subsoil exposure usually depends on the original field contours. Soil is cut and moved from high areas and deposited in low areas, resulting in differing degrees of subsoil exposure in the cut areas. An example of field heterogeneity generated by land leveling is given in Figure 2.3. In this example the average soil test P was

12.6 which, standing alone, would not indicate any P fertility deficiency. But, in the actual case, 13.6% of the field was severely P deficient and 35.6% of the field was moderately deficient. This means that 51.8% of the field would have yielded at less than its potential if no P fertilizer was applied based on the average soil test value. On the other hand, if fertilizer was uniformly applied at any rate, 27.6% of the field would not provide a return on the fertilizer P investment, assuming two or three years for amortization.

Sampling of leveled fields is done by marking the field ends and sides at regular intervals, for example every 100 or 200 feet. Five or six soil cores are then collected from a 3-foot diameter circle centered on the intersection of the field grid lines. This type of sample is referred to as a point sample. Point samples are maintained separately and labeled with the field grid numbers in order to map the soil variability and facilitate the application of the appropriate amounts of fertilizer for each soil test category.

A 100 foot-square grid system would result in an average of 4.4 samples per acre while a 200 foot-square grid would result in an average of 1.1 samples per acre. On casual inspection this may seem to be prohibitive. However, intensive soil sampling may be indispensable in restoring cut lands to their original level of productivity within reasonable time limits.

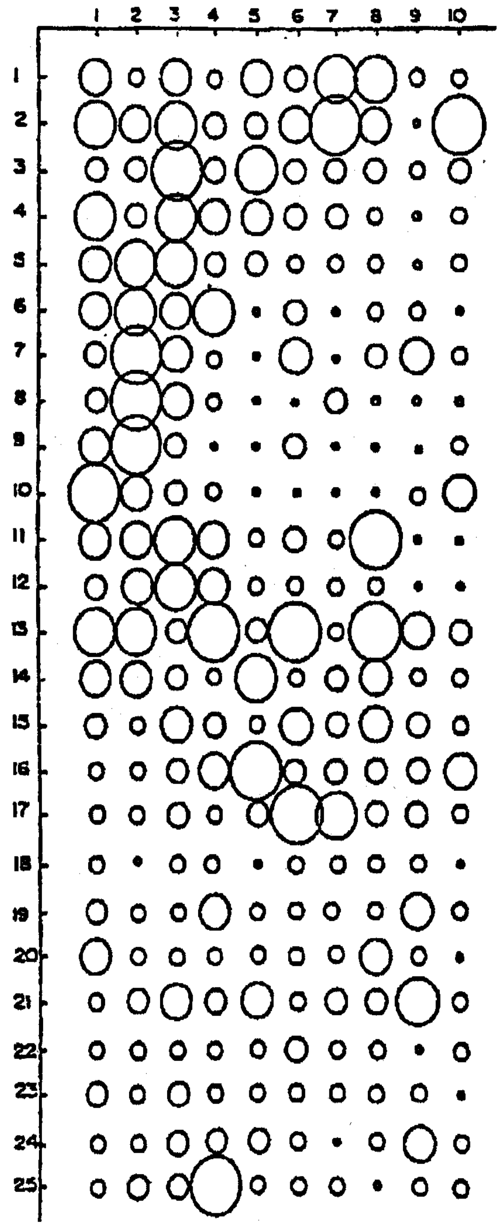

Figure 2.3. Soil test P results obtained from point soil samples taken on a 100 foot square grid on a newly leveled field in Cache County, Utah. Circles from small to large represent the following soil test P ranges: 0-3, 4-7, 8-11, 12-15, 16-19, and 20 respectively.

It is not necessary to apply all the standard soil fertility tests on every sample from an intensively sampled field; usually phosphorus alone will suffice. Further, when large numbers of samples to be treated alike are submitted to the laboratory, lower per sample analytical costs are encountered. Thus, the cost of re-establishing uniform crop growth and yield on leveled fields, expressed in terms of soil analyses, will usually be small compared to the loss of productivity associated with nonuniform soil fertility. Specific details on intensive soil sampling for specific field situations may be obtained from the Soil Plant and Water Analysis Laboratory at Utah State University.

Intensive soil sampling of nonuniform fields need not be repeated once the heterogeneity has been reduced by judicious application of fertilizer. The routine composite soil sample should suffice for future soil fertility diagnostics.

Soil Sampling No-till and Minimum-till Fields

Ordinarily fertilizer is mixed throughout the plow layer at plow time, whether or not the fertilizer was originally applied broadcast or injected (shanked) into the soil. Fertilizer mixing does not occur, however, where no-till or minimum-till is practiced. This is not important to plant use of fertilizer carried over from the previous season, but it does represent a special challenge in regard to obtaining representative soil samples which will accurately assess fertilizer requirements for the current season.

Injection fertilization without subsequent plowing, or other deep tillage operation, results in high soil variability. Narrow fertilizer-enriched bands alternate with wider strips (depending on injector spacing) of soil which has the lower, unfertilized, fertility level. The best soil sampling procedure for these conditions has not been fully developed. It is suggested however, that no-till and minimum-till fields be sampled in a manner similar to that suggested for uniform fields (Figure 2.2) except that the **number of soil cores collected for the composite sample be doubled**. In other words, for otherwise uniform field areas which have been injection fertilized without subsequent plowing, collect at random 40 to 60 soil cores for development of the composite soil sample. It is important that every core be collected at random so as not to bias the soil sample with too much representation in or out of the fertilizer enriched soil band. Also soil core crushing and mixing to form the composite soil sample would obviously be more involved. The suggestions given above for preparing the composite soil sample collected from plowed fields would need to be followed with extra caution.

References

Burt, Charles M., Glen E. Stringham, and David W. James. 1976. Increasing yields on recently graded land through proper phosphate fertilization. Utah Science 37:8-10.

Dow, A. I., and D. W. James. 1972. Intensive soil sampling: Uniformly high soil fertility for uniformly high crop production. Proc. 23rd. An. Northwest Fert. Conf. Boise, Idaho July 18-20.

James, D. W., and A. I. Dow. 1972. Source and degree of soil variation in the field: The problem of sampling for soil tests and estimating soil fertility status. Wash. Ag. Exp. Sta. Bull. 749.

James, D. W. 1977. Diagnostic soil testing for nitrogen availability: The effects of nitrogen fertilizer rate, time, method of application and cropping patterns on residual soil nitrogen. Utah Ag. Exp. Sta. Bull. 497.

Knighton, R. E., and D. W. James. 1983. Soil test phosphorus as a regionalized variable in leveled land. J. Soil Sci. Soc. Am. 49:675-679.

James, D. W. 1985. The economics of soil fertility diagnostic testing. Proc. Pacific NW Fert. Conf. Salt Lake City, Utah. July 16-17.