3 Soil Sampling and Analysis

3.1 Principles of Soil Sampling

Soil sampling and analysis is the only way to determine the available nutrient status of a field and to receive field-specific fertilizer recommendations. To be fully effective, an on-farm soil testing program should properly sample and test every field every year. In order to use manure as a fertilizer, soil sampling principles should be incorporated into sustainable manure management practices.

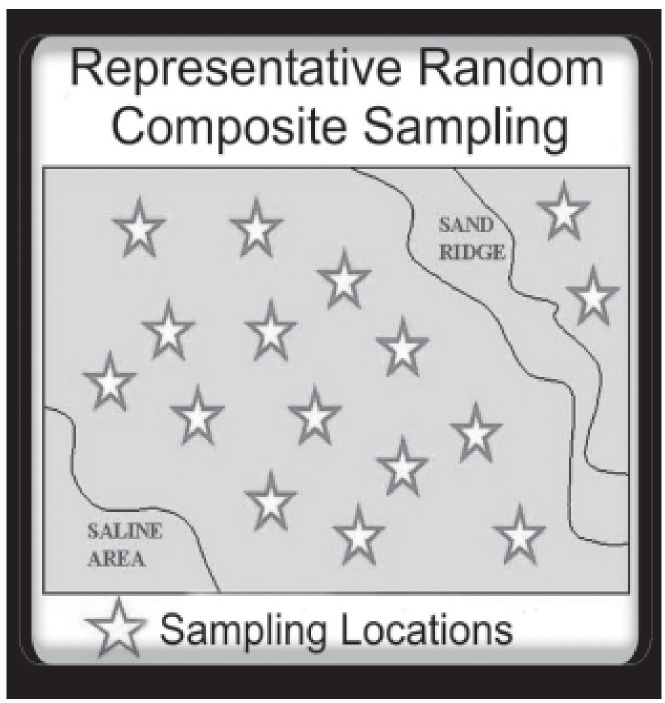
There are a variety of ways to take a soil sample. Before deciding on a soil sampling strategy, the objective(s) of the sampling program must be considered (e.g. improved crop response, identification of micronutrient deficiencies and problem areas, or monitoring of soil nutrient levels). A good sampling strategy will provide information that can be used to support or adjust manure application practices, given the site characteristics and application equipment.

Although most manure management programs are based on "Representative Random Composite Sampling", details on all of the popular soil sampling strategies are provided.

Whichever method of soil sampling is employed, all fields should be sampled at the 0 to 15 cm and 15 to 60 cm depths (0 to 6 and 6 to 24 inch), and the composite samples for each depth should be kept separate for analysis.

3.2 Representative Random Composite Soil Sampling

Representative random composite soil sampling (commonly referred to as Traditional Composite Sampling) is the most common soil sampling strategy. It involves taking random core samples throughout a field, bulking and thoroughly mixing them, and submitting a single, representative sub-sample to the soil-testing laboratory for analysis.



Before sampling, evaluate the field to determine representative areas for sampling. Level fields are relatively easy to sample. For hilly fields with knolls, slopes or depressions, take samples from mid-slope positions to get "average" results.

Avoid sampling obvious sources of unusual variability, such as saline areas, eroded knolls, old manure piles, burn piles, haystacks, corals, fencerows or old farmstead sites, headlands, areas within 15 metres (50 feet) of field borders and shelterbelts, or areas within 45 metres (150 feet) of built-up roads.

A composite soil sample should include at least 15 to 20 sample sites per field, with a minimum of one sampling site for every 3 – 4 hectares (8 to 10 acres). Sample at 0 to 15 cm and 15 to 60 cm depths (0 to 6 and 6 to 24 inch), and separate the samples according to depth.

Features

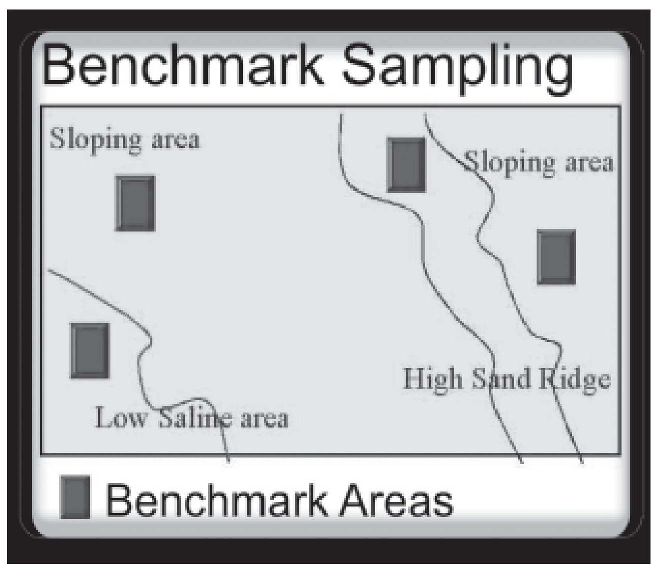
- Reduced analytical costs as single sub-samples are submitted as "representative" of an area.
- Supportive data for agricultural fertility programs.
- Level fields are relatively easy to sample.

Limitations

- Does not provide any indication of field variability. Small areas of very high nutrient levels that are probed and included in composite samples may artificially raise the "average" reported value, resulting in much of the field being under-fertilized. This frequently occurs in sulphur sampling, but may occur with other nutrients as well.
- Minimizes the potential for site-specific soil management and does not support variable-rate fertilizer application as whole fields are represented by a single composite sample. University, government and industry soil-sampling guidelines have indicated for some time that major areas within fields having distinctly different soil properties (such as texture) should be sampled and fertilized separately because of differences in nutrient requirements. This was rarely done in the past, since farmers had limited options for variable rate fertilization.

3.3 Site-Specific Soil Sampling

Site-specific soil management focuses on managing the variability that occurs within fields. Understanding the pattern of variability allows the field to be divided into relatively uniform units, which can be managed individually.



More detailed soil sampling strategies have been developed to support site-specific management techniques. These techniques often incorporate Global Positioning System (GPS) technology so that soil sampling locations can be geo-referenced and these areas can be revisited in the future for fertilizer application, scouting or re-sampling.

3.3.1 Benchmark Soil Sampling

The basic principle of benchmark sampling is continued sampling at the same location from year to year. A benchmark is an area of approximately 1/10 ha or 30 by 30 metres (1/4 acre or 100 by 100 feet) that is chosen as being typical of the field or a dominant soil type within the field. In this benchmark area, 15 to 20 samples are randomly collected and mixed together as a composite. This technique assumes that the benchmark area is less variable than the entire field, because it is much smaller. By using the same benchmark location and method year after year, sampling error should be minimized, provided the benchmark is representative of the field or management unit. It is treated as a reference area on which all fertilizer recommendations for that field are based. More than one benchmark site per field may be chosen if complex soil types or variable landscapes occur, or if variable-rate fertilization is an option.

The critical part of this method is the selection of the benchmark site. Representative sites can be selected by close observation of the crop (particularly during early growth stages when fertility differences are most evident), past grower experience, yield maps, soil surveys and remotely sensed images.

Features

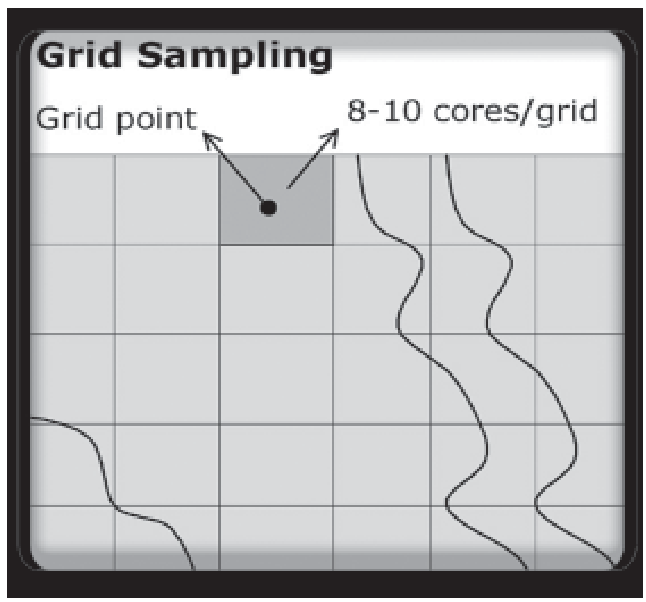
- Less expensive and time-consuming than grid soil sampling (see 3.3.2).
- Year-to-year variations better reflect actual nutrient changes.
- May provide information for variable-rate application when different benchmark sites are selected to represent different areas of the field.

Limitations

- Does not provide a full indication of field variability, but assumes that the rest of the field will respond similarly to the benchmark area.

3.3.2 Grid Soil Sampling

The grid sampling system uses a systematic method to reveal fertility patterns and assumes fertility patterns do not vary within a field.



The first step in grid sampling is to divide the field into small cells called grids. The second step is to identify a sample location within the grid. The point at the centre of the grid cell is usually referred to as the grid point. From this centre point, approximately 10 sample cores would be collected in a 3 to 6 metre (10 to 20 foot) radius to form a composite sample. Generally, as sampling intensity increases, the identification of fertility patterns becomes more accurate. Some jurisdictions recommend a sampling density of one sample per half hectare (1 acre) in order to obtain representative soil N, P, K and pH data. Less intensive sampling may still provide useful information on the magnitude of field variability, but may be too inaccurate for variable-rate management.

Features

- Grid sampling is well integrated into commercial GPS-based soil sampling and nutrient-mapping GIS programs.

Limitations

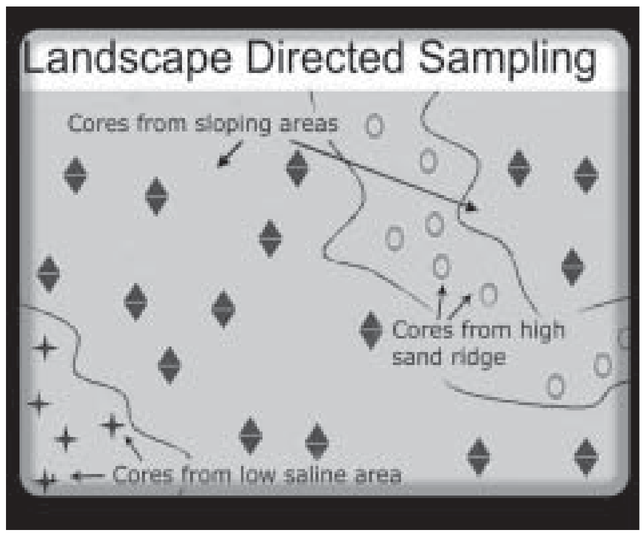
- Grid point sampling may result in bias because of the regular row and column sample alignment. Other regularly spaced patterns, such as tillage, drainage tiles and ditches, or fertilizer spreading may cause a repeating pattern that, if aligned with the sample rows, will seriously bias results. Modifications to the

sampling pattern, such as staggering of sample points or random placement within the grid, may be used to overcome this problem.
- The intensive grid sampling required to effectively reveal fertility patterns can be quite expensive, especially for the lower-value grain and oilseed crops grown on the Prairies.
- There is no soil-landscape rationale for grid size. In fields with complex landscapes, there is a risk of missing some soil units with a large grid size, and commercial grid spacing is often too large.

A field may be suitable for grid sampling if the field history is unknown or its natural fertility patterns have been masked because:
- The field has a history of manure application.
- Smaller fields have been merged into a larger one.
- High rates of fertilizers or lime have recently been used.

3.3.3 Landscape-Directed Soil Sampling

Landscape-directed sampling is based on spatial patterns defined using some prior knowledge or observation of a field, and assumes that fertility patterns exist for logical reasons. Patterns in soil and crop variation can often be observed by reviewing the management history and consulting soil survey information, detailed elevation mapping, aerial photographs, satellite imagery, yield monitor maps, and the land owner. This type of variation is called “systematic variation” because it follows a system or pattern and is predictable and manageable if that pattern is understood. The recent use of yield monitors has shown that yield variation is often related to topography, although this variation may be due more to differences in drainage or available water and weed pressure than to nutrient variation.



Soil development and productivity are largely a function of water flow, which is in turn controlled by landscape properties such as slope gradient and length, slope curvature and relative elevation. The combination of these factors determines the location of soil types in the landscape and their inherent productivity. Nutrient levels, particularly for the mobile nutrients, N and S, have shown consistent relationships with landscape or topography in recent studies. Soil/moisture relationships largely control N availability in the landscape through processes of denitrification, leaching, mineralization of organic matter and crop uptake. Elevation measurements may be used to initially develop topographical management zones, but it is actually landscape features or slope position that influences nutrient relationships.

This system requires the identification of areas (polygons) with similar soil and hydrological conditions. Properly identified, there will be less variability within each polygon than among polygons.

Research has not firmly established the required sampling density or pattern for landscape sampling. If landscape units were totally homogeneous, one sample would characterize the entire unit, but in reality these units are not homogeneous. Options are to take several point cores per landscape unit or to take a composite sample of 10 to 20 cores for each area. Within a field, various management zones, based on topographic variation, can generally be delineated with the aid of elevation maps, yield maps or remotely sensed images. Boundaries may be adjusted with further data and experience with the system.

Features

- Potentially fewer soil samples required than intensive grid sampling.
- Nutrient distribution and management-unit boundary delineation are often superior to grid sampling, especially for N.

Limitations

- Requires previous knowledge of crop performance within the field and an ability to discern slight topographic and soil changes within the field.
- Crop growth and yield relationships with topography may be completely reversed in years of extreme wetness versus years of extreme dryness.
- For fields with subtle changes in topography, a digital elevation map may be needed to select sample sites. Such elevation mapping is available as a commercial service.
- Past management, such as heavy fertilization or manure application, may mask the landscape-nutrient relationships and reduce the usefulness of this method.

Research and field experience suggests a field may be suitable for landscape-directed soil sampling if:

- Remote sensing or yield mapping reveals some relationship between crop growth and landscape properties.
- The field does not have a history of manure application.
- Relatively low rates of nutrients have been applied.

3.4 Soil Analysis

It is recommended that the soil-testing laboratory be consulted regarding specific requirements for sample size and shipping, turn-around times, analytical options, costs and any additional instructions they may have. As well, some labs provide bags, labels and submission forms for soil samples.

Although a variety of analytical packages are available, a package that includes nitrate-N, exchangeable K and available P should be selected. There are a number of analytical methods for determining P, including Modified-Kelowna, Olsen (sodium bicarbonate) or Mehlich-lll. These analytical methods can yield considerably different results. The soil-testing laboratory will calculate the crop nutrient recommendations for the region based on the analytical method used.

In areas where salinity or sodicity is a concern, electrical conductivity (EC) and sodium adsorption ratio (SAR) should be considered. Electrical conductivity is used as an indicator of salt accumulation in the soil (i.e. salinity). Sodium adsorption ratio is a measure of sodium (Na^+) in relation to calcium (Ca^{2+}) and magnesium (Mg^{2+}) in soil. For the purpose of manure management planning, it is also useful to have an estimate of the amount of potentially mineralizable N in soils that have received solid manure applications. Some labs offer a test intended to determine potentially mineralizable N.

3.4.1 Depth of Sampling

The type of information that is required from the soil analysis will determine the depth of soil sampling:

- At a minimum, nitrate-N analysis should be conducted on both the 0 to 15 cm (0-6 inch), 15 to 30 cm (6-12 inch), 30 to 60 cm (12-24 inch) depth samples because nitrate is a mobile nutrient in soil water.
- If the fields have received heavy or unknown N applications or if the soil is susceptible to leaching, nitrate-N analysis should be conducted on deeper samples (greater than 60 cm or 24 inches) to determine if leaching is occurring.
- At a minimum, P and K analysis should be conducted on the 0 to 15 cm (0 to 6 inch) depth sample.
- Sulphur and salinity analysis should be conducted on the 0 to 15 (0-6 inch), 15 to 30 cm (6-12 inch), and 30 to 60 cm (12-24 inch) depth samples, if this information is required.
- pH, organic matter or micronutrient analysis should be conducted on the 0 to 15 cm (0 to 6 inches) depth sample, if this information is required.