Soil Sampling Guidelines

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Soil testing is an integral part of a soil fertility management program. Effective soil testing provides information on the fertility status of soils within a field that can be used for making fertilizer or lime application recommendations, monitoring changes in soil fertility over time and even identifying and targeting low fertility soils within larger fields. Informative soil sampling can improve on-farm nutrient efficiency, leading to increased return on investment for fertilizer and lime application and decreased risk of off-site nutrient movement.

Regardless of the goal, reliable soil testing starts with proper soil sampling. In this article, we will outline the basic principles of agronomic soil sampling, covering the basic principles of soil sample collection and providing guidelines for establishing an effective soil sampling and testing program.

Sample Collection and Handling

Proper soil sample collection relies on three principles:

1. Organization: having an orderly system for soil sample collection and handling simplifies sample collection and minimizes the chance of human errors such as mislabeling or misplacing soil samples.
2. Consistency: collecting each sample in a uniform manner between years and within the course of a sampling event will greatly improve the quality and reliability of your results. This means taking samples in the same manner for each sample.
3. Simplicity: following simple procedures will help ensure sample collection is consistent and easily organized.

Samples and subsamples

Soils can be highly variable, even over short distances. Because of this variability, it is often insufficient to collect soil at just one location. Instead, it is preferable to collect so-called *composite samples*. Composite samples are a mixture of individual samples, or *subsamples,* generally collected from multiple locations and mixed together to form a single composite sample. By combining multiple subsamples into a single composite sample, we can minimize the effects of soil variability by averaging the soil properties over larger areas. Composite samples are less sensitive to unusually high or low soil test values that might occur due to concentrated fertilizer applications (e.g. banded applications) or natural soil variation.

Sample collection

Before collecting soil samples, you will need to gather certain materials and tools:

- A soil probe
- A clean plastic bucket
- A trowel
- Permanent markers
- Sample bags. Many soil testing laboratories will provide wax-lined sample bags. In lieu of laboratory-provided bags, consider using paper bags or zip-top bags.
- Clipboard and paper or field notebook
- GPS-enabled smartphone or handheld gps unit (optional)

To collect a composite sample use the following procedure:

1. Before arriving to the field, determine the number and approximate location of soil samples. (See the Sampling locations and strategies section for details.)
2. Once the appropriate materials have been collected, travel to the first sampling location. If you'd like, you may record the location with a GPS or GPS application on your smartphone. This information can be useful later for tracking where samples have been collected. You may find it helpful to return to the same sampling locations in subsequent sampling events.
3. At the sample location, remove any crop residue from the soil surface.
4. Insert the soil probe to the desired depth. (See Table 1 for details on sample depths.) Take care to ensure the probe is inserted vertically into the soil and not tilted to the side. Remove the probe and transfer the soil core from the probe into a bucket (Fig. 1).

Figure 1. Collecting a soil sample with a soil probe. Insert the probe vertically into the soil and remove the soil core.

5. Move to a new location and repeat Steps 3 and 4. The distance between locations where you collect subsamples will vary depending on the sampling strategies you are employing. (See the Sampling locations and strategies section for more info.) As a general guideline, the larger the area of land you are sampling, the more distance you need between sampling locations. As a rough guideline, sampling locations should be separated by a minimum of 20-30 feet. If employing a zone-based or grid-based soil sampling program, it is often worthwhile to select the location of soil samples prior to arriving in the field for sampling. These preidentified points can be loaded onto a GPS-enabled device and the GPS can be used to direct you to the sampling location.
6. Continue this process of sample collection at new locations until you have collected a sufficient number of samples. Typically, a composite sample should be comprised of between 10 and 20 subsamples. The more subsamples you add into a composite, the more reliable a sample becomes.

7. Using the trowel, thoroughly mix the soil in the bucket until you have a homogeneous mixture.
8. Place 1-2 cups of the mixture into a sample bag. Using permanent marker, label the bag with a unique name. Names should contain identifiers to the field and sample number. For example, "Smith-Field1-1" is a good label that identifies the farm (Smith Farm), field (Field 1) and the sample number (1).

Table 1. Sample depth guidelines

Tillage System	Sample depth
Conservation tillage (Less than 50% of crop residue incorporation)	Take separate samples: • 0-4 inches for pH/liming recommendations • 0-8 inches for fertility analysis
Conventional tillage (Greater than 50% of crop residue incorporation)	0-8 inches for pH/liming recommendations and fertility analysis

Sample Handling

After collecting a composite sample, it is important to properly store samples to prevent contamination. Typically, most laboratories prefer to prepare samples in their lab. This means that you can often send samples directly to the laboratory without doing any processing yourself. Some laboratories require samples to be submitted in specific sample bags or containers. Check with your chosen laboratory for specific information on its requirements for handling and packaging samples.

If you are not sending samples directly to the laboratory, consider storing samples in the refrigerator or freezer to minimize the chance of mold forming in the sample bag.

If the soil is excessively wet or you cannot store samples in a refrigerator/freezer, allow the samples to air dry slightly by spreading the soil in a thin layer on a flat surface like a table. You can put down some paper such as used newspaper to protect the surface from getting dirty. Never dry a sample in an oven or microwave; excessive heat can damage the sample and alter laboratory results.

Soil testing laboratories

Soil testing is available for a nominal fee through several specialized laboratories. Each laboratory will have specific instructions for how to ship and label samples. To ensure the laboratory provides accurate and timely results, be careful to follow any laboratory-specific instructions. For details on laboratory-specific instructions, contact your chosen soil testing service.

While most commercial laboratories provide quality, reliable testing services, there can be differences in methodology and results between laboratories. For this reason, it is often desirable to use the same soil-testing laboratory every year. This will ensure that any observed change in soil-test results from year to year are attributable to true changes in soil fertility status and not due to deviations in testing practices between different laboratories.

Sampling locations and strategies

Determining where to take soil samples depends largely on the management strategy you employ on your farm. These management strategies can be broken down into two types: whole-field and spatially explicit (Fig. 2). In a whole-field management the field is managed as one unit. When fertilizer is applied in a whole-field approach, one fertilizer rate is applied uniformly across the entire field. Whole-field management is simple to implement and does not require any special equipment or data handling.

In spatially explicit management, the field is broken into smaller sections, and each section is managed individually. Spatially explicit management can identify areas of the field with specific fertilizer of liming needs and provides a map of a field's nutrient and liming requirements. Spatially explicit management is an essential part of precision agriculture. In spatially explicit management, variable-rate technology can be used to alter fertilizer and lime applications so that each zone receives a targeted, zone-specific fertilizer or lime application.

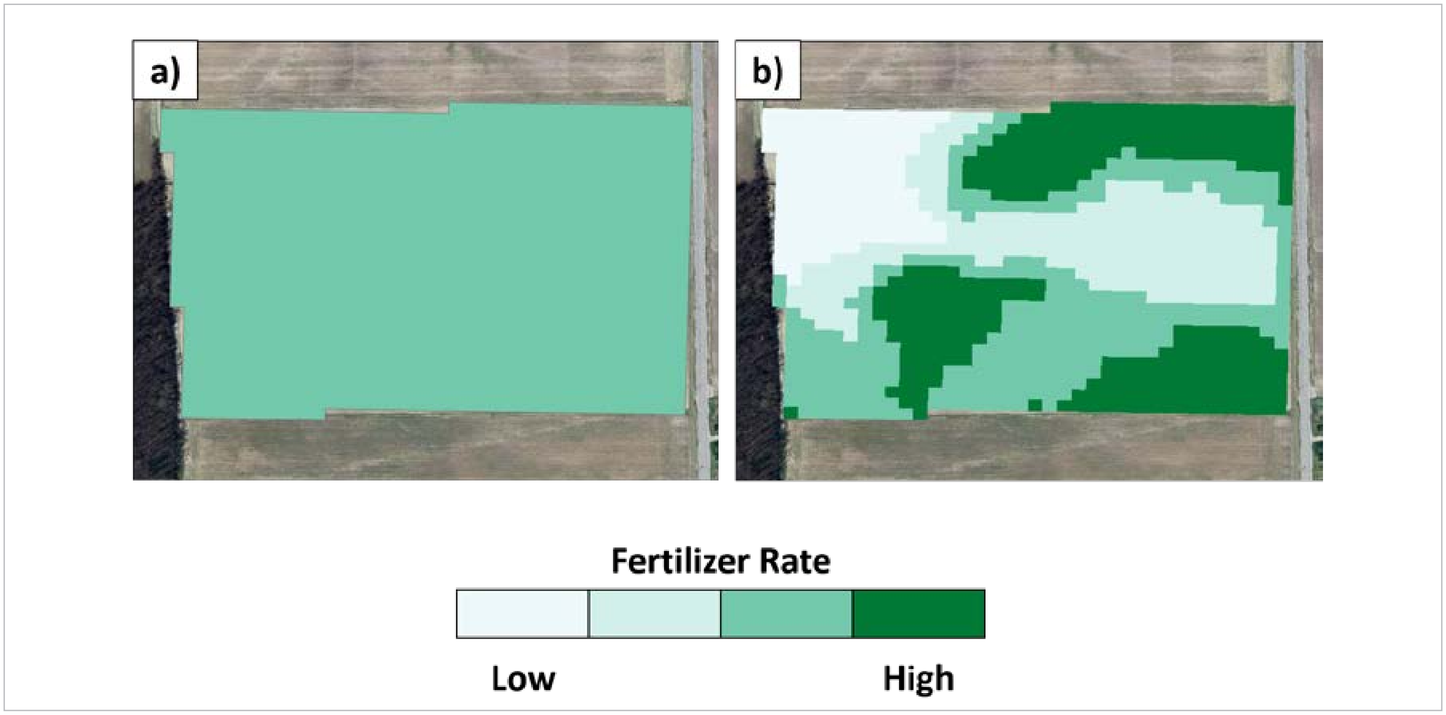

Figure 2. Whole-field management (Fig. 2a) and spatially explicit management (Fig. 2b).

Ultimately, the decision between whole-field and spatially explicit management will depend on the specific goals and constraints of each operation. Whole-field management is simple to implement but risks over- or under-fertilizing some areas of the field. Under application of fertilizer and lime can lead to poor yield while overapplication leads to wasted material and can cause environmental damage. Conversely, spatially explicit management can be more difficult to implement but the spatial information can be used to minimize the risk of over- and under-application of fertilizer and lime.

Soil sampling for whole-field management

The goal of soil sampling for whole-field management is to get a sample representative of the typical soil in the field. To do this, subsamples are distributed across large areas to ensure the entire field is represented. To achieve this, collect composite samples in a zig-zag pattern (Fig. 3). Each composite sample should consist of 10 to 20 subsamples spread evenly across a field. Collect at least one composite per 20 acres.

Figure 3. An example of zig-zag sampling pattern for whole field sampling. Subsamples are collected by traveling in a zig-zag pattern collecting subsamples at each locations indicated by black dots. Background lines represent the various soil types in the field. Ideally, zig-zag sampling samples each soil type equally.

Soil sampling for spatially explicit management

There are two main methods for soil sampling in spatially explicit management — zone-based sampling and grid sampling. With each method, soil samples are collected from predefined areas in a field. By correlating the soil test results with the area of the field where samples were collected, you can generate a map of soil fertility patterns in the field. With both methods, the smaller the predefined region (i.e., zone or grid cell), the more detailed the resulting map. Each method is described in more detail below.

Zone-based sampling

In zone-based strategies, the goal is to collect samples that represent the average soil within each zone. Zones are typically developed based on unique soil types or from patterns in yield maps. The key aspect of each zone is that zones represent areas of homogeneous or uniform soil conditions. Typically, the more variable the soil, the smaller the zones need to be in order to accurately map soil fertility patterns. In most cases, zones are between 2 and 10 acres in size.

For zone sampling, collect a composite sample from each zone (Fig 4). Larger zones require more samples than smaller zones. As a rule of thumb, collect two subsamples per acre in a zone. Regardless of zone size, a *minimum* of five subsamples per zone should be collected. Subsamples should be located randomly within a zone.

The real value of zone-based sampling is that zone-based data can be used to create a map of soil fertility and pH within a field. This map can show areas of particularly high or low fertility and can be used to develop precision, variable-rate fertilizer and lime applications. Because zone-based samples are ultimately used to generate a map, it is especially important that samples be labeled with the correct zone and that the location of each sample or zone is recorded. This will ensure that laboratory results from each soil sample can be correctly correlated with the appropriate location in the field.

Grid sampling

Many producers and farm service provides implement soil sampling on a grid-based system. In a grid system, soil samples are taken at locations spaced in a uniform pattern. Typical grid sizes range from 1 to 5 acres, with smaller grids (i.e., 2.5 acres or less) providing the best results. For a one-acre grid cell, collect at least five subsamples. For grid cells between 2.5 and 5 acres, collect between 8 and 10 subsamples.

Grids are attractive because they are easy to implement and provide improved spatial information over whole-field soil sampling. However, grid-sampling does not utilize or account for underlying variation in management zones or soil types. Subsequently, grid sampling has several disadvantages when compared to zone-based sampling.

The first disadvantage of grid sampling is an increased risk of bias. For example, if a majority of grid samples lie on a particular soil type, the grid sample may underrepresent the true variability in a field (Fig. 5).

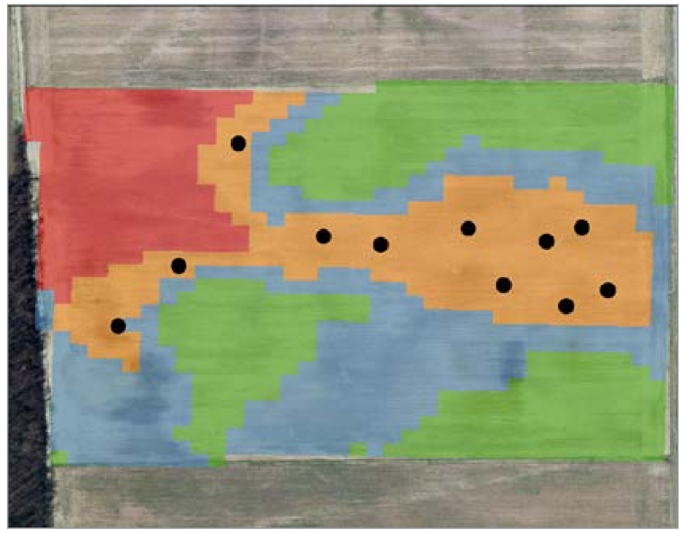

Figure 4. An example of zone-based soil sampling. In this example, different management zones are represented by different colors. Subsamples are collected and composited for each zone. Subsamples are collected for the orange-colored zone at each location denoted by black dots. Each of these samples will be mixed into a single composite sample.

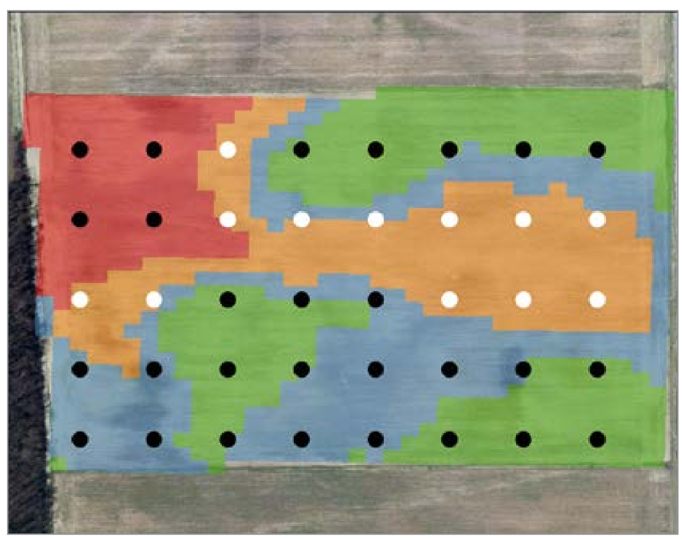

Figure 5. An example of grid-based soil sampling with sampling points (dots) located on an evenly distributed grid. This system can lead to bias. In this example, the orange zone is sampled in 30% of the grid points (white points) but the orange zone only represents 22% of the total field. In this case, the resulting soil sample is highly biased to the soil conditions represented by the orange zone.

Grid sampling can also be inefficient. Because grids do not target areas of known variation in a field, more samples are needed to cover the complete range of soil types and variability. While grid sampling is preferred to whole-field sampling, it is inferior to the more informative zone-based sampling.

Areas to avoid

Regardless of soil sampling strategy, when collecting samples in the field or identifying soil-sampling locations, there are several areas you may wish to avoid. These problem areas (Table 2) are areas in the field where, due to some disturbance of natural variation, the soil may not be representative of the rest of the soil in a field or zone. If your soil sampling point lies within or near one of these problem areas, consider relocating the sample point to a new location. If problem areas occupy substantial portions of a field (i.e. larger than 5-10 acres) consider sampling each problem area as a unique zone.

Table 2. Areas to avoid when collecting soil samples

Examples of Problem Areas
• End-rows or areas of heavy equipment traffic
• Wet spots or depressions
• Highly eroded areas
• Locations of former farmsteads or animal enclosures
• Locations within 100 ft. of roads
• Areas where lime is stored before application

Sample timing

The most convenient time to collect soil samples is when there is no standing crop in the field (i.e. in the spring prior to planting or in the fall after harvest). Both sample collection times can be useful for a given management program. When selecting a sample collection time consider the following points:

- Schedule soil sampling and testing prior to application of fertilizers or lime
- Collect samples early enough to provide the laboratory sufficient time to return the data
- Keep sample collection timing consistent to avoid year-to-year variability. For example, if implementing a spring sampling one year, do not adopt fall sampling for the next year of sampling.

In most soils, try to sample fields once every four years. This should provide sufficient data on changes in soil fertility. An exception to this guideline is for sandy soils or highly managed soils (e.g., irrigated fields, silage or hayfields, etc.). In these circumstances, soil fertility can change rapidly and these fields should be sampled once every two years.

Conclusions

Soil sampling and testing can be highly informative. Information from a well-conducted soil-sampling event can be useful in monitoring changes in soil fertility, developing fertilizer recommendations, and improving on-farm nutrient efficiency. Regardless of the particular soil-sampling program you employ, soil sampling using a consistent, well-conducted, and organized approach will lead to the most usable and informative soil test results.

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November 2018