SOIL HEALTH INSTITUTE
Enriching Soil, Enhancing Life

Standard Operating Procedure

Soil Health Sampling

Scope

This document outlines the collection of soil for measuring: 1) soil organic carbon, total nitrogen, potential carbon mineralization, and texture; 2) aggregate stability; 3) bulk density. The procedures outlined here are intended to serve as general guidance and you may need to make slight deviations from this procedure to suit your project. When in doubt about deviations from these procedures, consult a professional soil sampler or certified crop advisor for guidance.

Regardless of your final sampling procedure there are several general factors to consider prior to soil health sampling:

- Separate samples should be collected whenever there is a difference in soil type or management because inherent properties and management influence the soil's capacity to function and may impact soil health measurements.
- Soil biological activity and subsequently soil health measurements are sensitive to moisture and temperature and so a *priority in soil health sampling is for sample collection to occur at similar times each year.* It is best to be "similar" regarding the cropping cycle which tends to consider climatological variation, rather than a specific day of the year. We recommend sampling prior to field activities at the beginning of the cropping cycle to minimize the chances that changes in soil measurements are impacted by field operations. For most row-crops in temperate climates, this preferred sample period is in spring prior to planting or preplant field operations (e.g. seedbed preparation, pre-plant fertilizer application, planting, etc.). A second preferred window is about 3 to 4 weeks after planting.
- As with any scientific procedure, consistency is key. If your operations deviate from this procedure, ensure that that deviation is done as consistently as possible to minimize random error in your sampling results. For example, if soil samples can only be collected to 10-cm depth in one area (for example due to shallow bedrock), it is best practice to collect all samples for a project to the same depth to ensure consistent results.

Equipment

Field notebook
Push probe, approximately 2.54 cm (1 in) diameter[1]
Soil knife
Sharpshooter shovel
19 L (5 gal) plastic bucket (2 per sample)[2]
8-mm sieve
3.8 L (1 gal) zip-lock bag (2 per sample)
Preprinted sample labels or permanent marking pen
Wire brush

50 mL conical tube[3]
Slide hammer[4]
2" or 3" diameter sampling cup that connects to a slide hammer[4]
Sleeves (typically 15 cm) for easy removal of the soil from the sampling cup[4]

[1] In cases where soils are difficult to get into the push probe because they are too sandy, clayey, wet, or compact we advise advised to using a bucket auger (for sandy soils) or a Dutch auger for other situations instead of a push probe
[2]Do not use galvanized metal buckets. The zinc-based galvanization can interfere with some chemical analysis
[3]Equipment only needed if sampling for aggregate stability
[4]Equipment only needed if sampling for bulk density

Definitions

- Sample: For the purposes of this report the term *sample* will refer to a unit of soil that is shipped to the lab labeled with a unique identification. In most cases, a sample will be a composite of subsamples collected around an identified sampling location and homogenized into a single body.
- Subsample: an individual specimen of soil that is mixed with other individual specimens to create one blended sample.
- Composite sample: a sample that consists of several subsamples.
- Point sample: a sample that is intended to represent a single location in space. A point sample may be either a single specimen sample, or more commonly, a composite sample. If the point sample is a composite, the subsamples should be taken from a small radius (i.e. < 5 meters). A point sample has only one sample location (latitude/longitude/depth coordinate) and is assumed to represent soil properties at that unique location.
- Sample location: a single spatial coordinate for a soil sample, which may be in latitude/longitude, easting/northing, etc. and depth.
- Sample zone: an area of soil (soil map polygon, farm field, management zone, etc.) whose mean characteristics are represented by one composite sample. In some cases, the topographic position, drainage class, or distance from irrigation valves are cause to create a separate sample zone in the field. The locations of the subsamples within the zone can be determined using a grid or randomly with a zig zag pattern across the area. A sample zone will typically have a polygon boundary, and the samples within the boundary can each have a sample location recorded if desired.

Point- vs. zone-sampling

The choice of sampling type has implications not only for how sampling is conducted but also how the results of sampling can be used (Figure 1).

Zone-sampling is used when you want to know the average soil property within a given area (e.g. a field or management zone). The benefit of zone-sampling is that the area represented by the sample can be large and therefore a small number of samples can describe large management units (e.g. field or farms). The major drawback of zone-sampling is that it lacks the spatial specificity of point-sampling, and should not be used where spatial specificity is integral to subsequent analysis (e.g. spatial interpolation).

Point-sampling is used to represent the properties of soil at a singular location in space. Often the location of that point is used in subsequent analysis. Examples of when point sampling may be used include 1) when the sampling results will be used for spatial interpolation, 2) when you plan to compare sampling results to other environmental factors (e.g. slope or elevation of the field), 3) when you want to observe the change in soil properties over time and plan to resample soils at the same location, or 4) if you want to quantify the variability of properties within a given area. The major drawback to point-sampling is that due to the small spatial footprint of point samples, results generated from point-sampling are not generalizable to large areas. For example, to characterize a single field with point samples, you would need to collect tens of point samples whereas the same area could be characterized with only a few zones.

In general, point-sampling generates very specific information at the expense of spatial coverage whereas zone-sampling generates information for large spatial coverages at the expense of spatial specificity. If you are unsure which sampling type is appropriate for your project, please consult with a soil sampling professional for guidance prior to sampling.

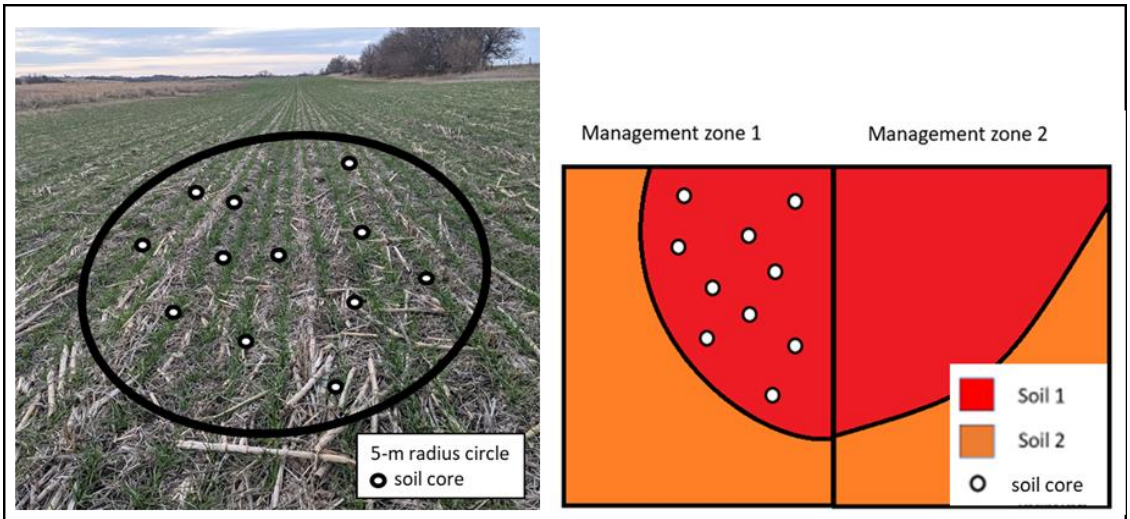

Figure 1. Diagram of a composite of soil cores for a point sample (left and a composite of soil cores for zone sampling .

Procedure

The decision on the type of sampling (point- vs zone-) and the locations of point samples or sample zones should be made prior to sampling. However, it may be necessary to adjust the locations of point samples or sample zones if conditions in the field are different than prior information (e.g., plat or soil maps, field boundaries, etc.) indicated.

The subsampling locations and number can be determined in the field and adjusted as needed depending on what equipment works best. The procedures outlined in this document detail the equipment used in most typical row-crop soils; however, deviation from recommended equipment is sometimes beneficial to suit soil conditions at the time of sampling. For example, in very loose (e.g., sandy) or firm (e.g., clayey) soils, push probes may be difficult to use and therefore sand or Dutch augers may be needed. If augers are used instead of push probes, the number of subsamples needed may be adjusted accordingly. For example, a 1-inch/2.5-cm diameter push probe collects ~125 g of soil in a 15-cm deep sampling. A 2-inch diameter auger will ~500 g of soil for the same 15-cm depth. Fewer subsamples are need when using augers to achieve the same final composite sample mass.

Measurement depth

This document outlines the soil sampling procedures for soil health testing. Generally, most changes in soil health occur in the upper 15 cm of soil. Therefore, the procedures outlined in this document focus on sampling the soil from 0-15 cm.

If you are also sampling soils to quantify soil carbon stocks, you will need to soil testing data from 0-30 cm depth to qualify for most voluntary soil carbon markets. To collect a 0 to 30 cm sample for carbon to stock measurements you will have to make the following modifications to the following procedures:

- In Part 1, “Sampling for soil organic carbon concentration, total nitrogen, potential carbon mineralization, and texture”, you will need to collect an addition composite sample from 15 to 30 cm. The best way to do this in practice is to insert the push probe to 30 cm (see Part 1, step 3) instead of 15 cm. After collecting a 30-cm core, separate the 0 to 15- and 15 to 30-cm sections into separate buckets and follow steps 4 to 8 for each depth interval (i.e., 0-15 and 15-30) separately. Note: for the 15-30 cm section, you will only need laboratory analysis for soil organic carbon concentration, not the other assays from Part 1.
- In Part 3, “Sampling for bulk density”, you will need to follow the procedure outlined in steps 13 to 15 which details collecting a bulk density sample for 15 to 30 cm.

Part 1) Sampling for soil organic carbon concentration, total nitrogen, potential carbon mineralization, and texture

The primary aim of sampling for soil organic carbon concentration, total nitrogen, potential carbon mineralization, and texture is to collect a soil sample that is representative of the area you are sampling. These properties can change over very small distances (e.g., 1-2 meters) and therefore composite samples, consisting of multiple cores, are needed to prevent small-scale local variation in soil properties from skewing results.

The following steps outline the basic procedure for collecting a composite sample. This procedure is very similar to the sampling procedures used for standard soil fertility analysis:

1. Pre-label a gallon zip-lock bag for each sample.
2. Mark dates, name (i.e., unique sample identifier) and any other pertinent information about sample in field notebook.
3. Collect 10 to 15 soil cores (sub samples) using a push probe to a depth of 15 cm. The set of soil cores should cover the representative area you are sampling and avoid borders, turn rows, wheel tracks, and other abnormalities. Place all soil in the probe into bucket.
    a. If collecting a zone sample, the 10 to 15 cores should be distributed at random locations across the sampling zone.
    b. If collecting a point sample, the 10 to 15 cores should be taken from random locations within a 5-meter radius circle center on the sampling point (Figure 1).
4. Place cores in 5-gal bucket and gently break up by hand.
5. Pass broken up cores through 8 mm sieve and gently homogenize the soil.
6. Pour approximately one liter (4 cups) of homogenized soil into corresponding labeled zip-lock bag[5]. Gently squeeze air out of the bag and seal.
7. Seal the bag of soil within a second gallon bag.
8. Tap out excess soil from the 5-gallon bucket and clean the 8 mm sieve with a wire brush in between sampling zones.

[5]Typically, 1000 g of fresh soil are needed for soil organic carbon concentration, total nitrogen, potential carbon mineralization, and texture analysis combined. If you are unsure of the sample volume or mass needed for analysis, contact your chosen laboratory to confirm minimum or maximum sample volume or mass prior to sampling.

Part 2) Sampling for wet aggregate stability

The aim of sampling for wet aggregate stability is to collect intact soil aggregates (clods) for analysis. To that aim, it is important to limit the amount of disturbance of soil aggregates while sampling. Overly aggressive sample handling can result in biased measurements as result of disruption of the soil fabric. Additionally, because the aim of this procedure is to limit soil disturbance, sampling for aggregate stability should not be done using a push probe that may cause excessive disruption of the soil fabric. We also recommend pulling soil aggregates from 0 to 6 cm of the soil surface.

The following section outlines the procedure for collecting samples for aggregate stability analysis. Note: due to the labor-intensive nature of sampling for aggregate stability, fewer composite samples are used compared to the procedure outlined in Part 1:

1. Pre-label a 50 mL conical tube for each sample.
2. At one of the locations where soil cores were collected using the push probe (as outlined in Part 1), insert a sharpshooter shovel, perpendicular to the ground, approximately 15 cm deep and pull back out.

3. Turn 90 degrees and insert the sharpshooter perpendicular to the ground, making the cut meets the corner of the previous cut. Repeat the process two more times, resulting in a "square."
4. Place sharpshooter approximately 2 cm back from one edge and push at angle to remove the plug from the ground. If the plug does not come out cleanly, use a soil knife to remove excess soil, resulting in edges perpendicular to the ground.
5. Use the soil knife to remove 6 cm deep slices from three sides of each plug, avoiding the edge used to extract the plug from the ground. Aim for uniform knife slices, approximately 2 cm thick.
6. Place knife slices in 5-gal bucket and gently break up by hand.
7. Select aggregates between 3 to 12 mm in diameter, with preference given to aggregates on the larger end, and gently place in 50 mL conical tube.
8. Continue selecting aggregates until 1/3 of the tube is filled, taking care not to compress the aggregates.
9. Repeat steps 2 to 8 two more times at different locations until the tube is full.

Part 3) Sampling for bulk density

The aim of bulk density sampling is to collect all the soil from a known volume. There are several important considerations for bulk density sampling:

- Care should be taken to minimize compaction of the soil during sample collection. Compaction can occur if the sample cup is driven too far into the soil, if the soil is too wet, or if the sample cup is not driven into the soil at a consistent angle. Larger diameter sampling cups (e.g., 3 inches in diameter) are less susceptible to compaction and mistakes. When in doubt about the presence of compaction in a given sample, it is best practice to retake a new sample.
- Avoid loss of soil material during sampling. Because the aim is to collect all the soil mass within a known volume, loss of soil mass can create negative bias in bulk density measurements. Samples are most susceptible to soil loss while removing the soil sleeve from the soil sampler. Be very careful while handling soil sleeves to minimize soil loss.
- Due to the labor-intensive nature of bulk density sampling, we do not recommend composite sampling for bulk density. However, because you will not be using a composite sample, extra care needs to be taken when choosing a sampling point. Avoid areas where the soil may be compacted due to field operations (e.g., tire tracks, planter rows), erosion, or animal/human traffic.
- Rock fragments can interfere with bulk density sampling and quantification. Any rock fragments greater the 2 mm in diameter, referred to as coarse fragments, can impact bulk density measurements in several ways. First, coarse fragments can interfere with the sampling cup as it is driven into the ground causing compaction. As stated earlier, it is best practice to retake new samples when samples become compacted. Second, when coarse-fragment volume is greater than 2% of the total sample volume, you will likely need to measure the volume of coarse fragments and adjust your bulk density calculations. If you suspect there is 2% or greater coarse fragment volume in your sample, make a note of the presence of coarse fragments and

communicate with your laboratory staff to ensure that the coarse fragment volume is measured.

The following procedure outlines collection of a bulk density sample:

1. Pre-label a gallon zip-lock bag for each sample by depth.
2. Mark dates, name, and any other pertinent information about sample in field notebook.
3. Make sure that the sampling cup is clearly marked on the outside with a permanent marking pen at the depth 15 cm **above the lip on the inside**.
4. Insert a sleeve into the sampling cup and attach to the slide hammer
5. Remove any loose vegetation or residue from the surface. The aim here is to keep surface residue out of the sample and prevent this residue from interfering with sample collection. Take care not to disturb the soil surface while removing vegetation and avoid pulling out plant roots that may disturb the soil.
6. Pound the slide hammer into the ground up to the marked line.
7. Use the sharpshooter to dig a hole around the sampling cup. The goal here is to expose the sampling cup so it can be removed without disturbing the sample.
8. Gently lever the sampling cup out of the ground. In dry and sandy soils, it may be necessary to cover the bottom of the sampling cup as you remove it.
9. Unscrew the sampling cup and remove the sleeve filled with soil. It may be necessary to use the soil knife to smooth the top or bottom surface
10. Pour soil into corresponding labeled zip-lock bag. Gently squeeze air out of the bag and seal.
11. Seal the bag of soil within a second gallon bag.
12. Clean the sampling cup and sleeve with a wire brush or rag.
13. If you are collecting a sample from 15 to 30 cm-depth, continue to step 14 and 15.
14. Use the sharpshooter and/or soil knife, expand the hole from step 6 and create a level surface at 15 cm deep. The goal here is expose a flat area, adjacent to the location the previous sample was collected. You will collect your next 15 to 30-cm sample by driving the sampling cup into this surface.
15. Repeat steps 3-12 to collect a sample from 15 to 30 cm, this time using the level surface exposed in the previous step.

NOTE

- Measures are listed in both metric and US Customary due to sampling equipment availability
- Do not sample saturated soils
- Carbon stock calculations require both SOC and bulk density to a depth of 30 cm. If soil health measurements are being made as well, you can use the SOC from the 0-to 15 cm soil health sample and just measure bulk density on the 0 to 15 sample. Because the spatial variation of SOC is greater than bulk density, it is preferable to use a sample with more subsamples for SOC (a composite sample).

This SOP was developed by SHI, for SHI communication. For any specific questions, contact Dr. Liz Rieke erieke@soilhealthinstitute.org.