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SITE-SPECIFIC SOIL SAMPLING

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Introduction

Soil sampling and subsequent testing are used to determine the amount of fertilizer and/or lime to apply to a field and estimate the potential for a crop yield or quality response to those added nutrients. Soil test results are compared to standard crop response data (rate studies) to estimate the amount of a particular nutrient that needs to be applied for optimum crop production. Trends in soil nutrient levels over time also are used to determine if fertilizer rates need to be locally adjusted up or down to account for variations in nutrient removal from crops on that field. Traditionally, the goal of soil sampling was to collect and composite random samples from across a field to develop a representative estimate of the average nutrient requirement for that field so that the best single application rate could be determined. Many fields in Tennessee, however, have a high degree of spatial variability in soil type, topography, drainage, and other factors that can result in field areas that vary significantly in soil fertility.

Managing highly variable fields based on average soil conditions and applying crop fertilizers or lime at a uniform rate oftentimes leads to over-application in some areas of the field and under-application in others. Inadequate or excessive applications of fertilizers or lime can adversely affect crop yields, environmental quality, and/or profitability. Site-specific soil sampling is an effective tool for managing soil fertility variability within a field by allowing the application of the correct fertilizers at the right rate and in the right place, enabling the optimization of crop inputs and maximum profitability. Applying the right rate at the right place also decreases environmental impacts because fertilizer is not being over-applied, which could potentially lead to off-site movement of nutrients.

Site-Specific Soil Sampling

Site-specific soil sampling uses the Global Positioning System (GPS) to georeference soil samples at locations in the field where samples are collected. Geographic Information System (GIS) software is then used to process and analyze the geo-referenced soil data. Site-specific soil sampling is accomplished using either grid sampling or zone management techniques, discussed herein.

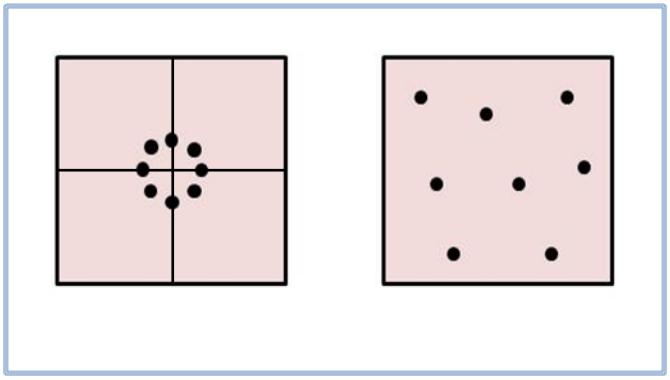
Grid Sampling

Grid sampling uses GIS software to divide the field into squares or rectangles of equal size (usually referred to as grid cells). Grid cells can be of any size and are independent of field shape, size, and variability. Grid size can range from ¼ to 10 acres, although grids of 1 to 2 ½ acres are the most common and practical to manage. The size of the grid depends on the producer's goals and how much they are willing to invest for information. Smaller grid sizes have more upfront cost but provide more detailed information and therefore are better able to characterize fields that have a high degree of variability. The upfront cost may be offset or even reduce overall cost as the probability of over-fertilization is reduced. Larger grid sizes have lower upfront cost especially when sampling large acreages but may not always adequately represent the variability within the field. Larger grid sizes may increase overall cost with a higher probability of over-applying fertilizer where it may not be needed. No one grid size best fits all fields, but a suggested minimum size is one sample per 2 ½ acres if the goal is to develop nutrient prescription maps that can be used with confidence over several years.

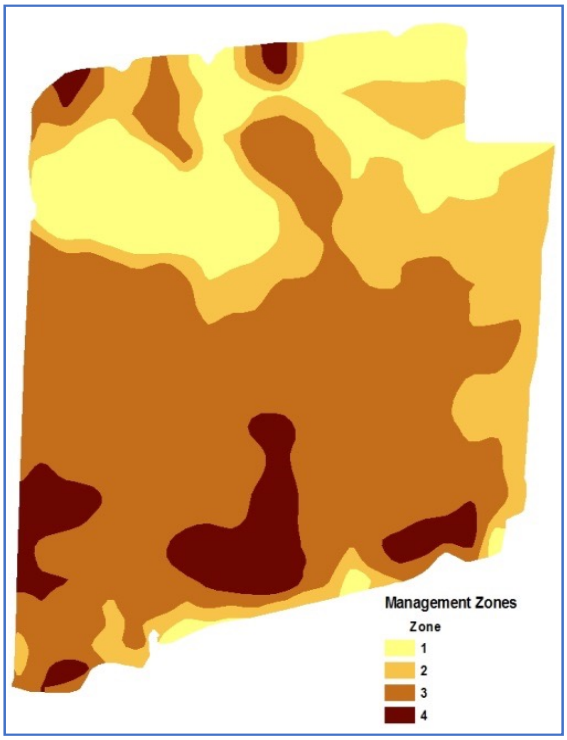
Grid soil sampling map

results in soil test values that are not a true depiction of the grid average. Grid-point sampling gives significantly different values compared to grid-cell sampling where higher soil type variability is present within the field being grid sampled. An overall assessment of UT studies suggests that grid-point sampling may be sufficient to obtain accurate soil test values in fields where soil type variability is minor, but grid-cell sampling is preferred and more likely to give a thorough and accurate representation of grid soil test values, especially when soil type varies greatly within the field to be sampled.

Soil samples can be collected from grids using either one of two methods—grid-point sampling or grid-cell sampling. In grid-point sampling, all soil samples are collected around a georeferenced point, such as the grid center or at grid intersections, and mixed to generate a composite sample for that point. In grid-cell sampling, soil samples are collected randomly throughout the cell and mixed to generate a composite sample for the cell. The samples should not be collected in a straight line because they might unintentionally correspond to spreader patterns of previous lime or fertilizer applications or other equipment applications or effects. Grid-point sampling (versus grid-cell) may result in values that do not accurately represent respective grids due to the small radius from which samples are often collected and



Grid-point *Grid-cell*



Zone management sampling map

Management Zone Sampling

Producers generally know which areas of their fields are high producing and which areas are low producing. It is logical that nutrient needs are different for these areas. Management zone sampling utilizes several layers of spatial information, including multiple years of yield data, soil and topographical maps; remotely sensed images; grower knowledge of the field; and other available forms of spatial data to create areas in the field, or zones, with similar soil properties and crop growth characteristics. Soil samples are collected at random within each zone, and then composited and analyzed to provide an average sample value for each zone. It is important to remember when delineating zones that soil factors other than fertility, such as compaction, water holding capacity, elevation, drainage, and topsoil depth, will influence patterns in yield maps, remotely sensed images, and other layers of spatial data. Other factors, such as weed, disease, and insect pressure, can also influence yield variability within the field. Once zones have been established, fields should be carefully scouted during the growing season to determine if existing zone boundaries are fairly accurate or if these boundaries need to be redefined.

Unlike grid sampling, the number of zones (and their shape and size) will depend on how much measured variability exists in the field. General trends should be used when creating management zones and the number of zones kept to a manageable level. Creating too many zones oftentimes creates small areas in the field that are not practical to manage. Generally, three to six zones are manageable, realistic, and adequate. Management zones do not need to be contiguous – samples may be collected for more than one area of the field which falls in the same zone, such as in the example figure with Zones 1-4 labeled.

Which Sampling Method is Better?

There is often debate over which is the better sampling method—grid sampling or management zone sampling. Some feel that grid sampling gives a very good representation of the variability in soil fertility, while others feel that sampling by management zones (based on soil type, topography, past yield, etc.) is a better approach. What works best for one field may not be the best option for another. If manure has been applied in the past or if there is no knowledge of the past history of the field, grid sampling is a good place to begin. Furthermore, if the field is relatively flat or has only a few soil types, then grid sampling is an excellent approach. Management zone sampling is a better approach if the producer has experience farming the field, yield maps and other sources of spatial data are available, relatively low rates of fertilizer have been applied in recent years, and there is no history of manure application or livestock confinement. Also, since soil characteristics affect the productivity and nutrient holding capacity of the soil, sampling by management zones is usually a better and less costly approach than grid sampling for fields with highly variable topography and multiple soil types. While zone sampling requires information about the field and is more time consuming to establish initially, it requires less intensive sampling and is less expensive to sample than grids. When nutrient or lime needs vary greatly within a field, variable rate application of fertilizers or lime based on site-specific soil sampling provides an economical and environmental improvement over application at a uniform rate across the entire field

Applying fertilizer at the right rate and at the right place promotes sustainable row crop production

Taking Quality Soil Samples

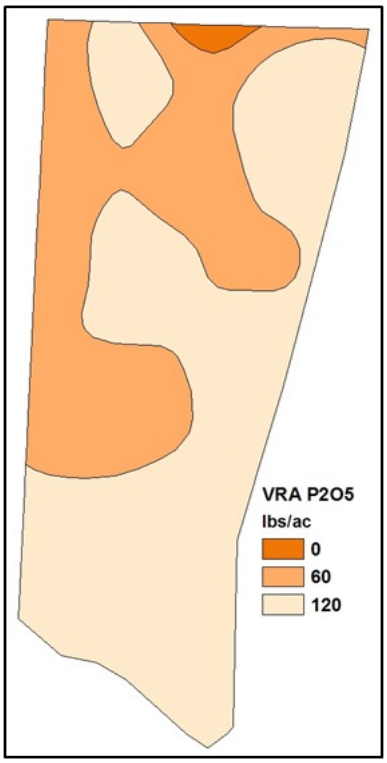
The most important aspect of making proper fertilizer recommendations is collecting a good quality, representative soil sample. Soil test results and fertilizer recommendations are based solely on the few ounces of soil analyzed by the laboratory. If the soil sample is not collected properly, the resulting soil fertility recommendations can be inaccurate and lead to costly over- or under-fertilization. It is recommended that 10-15 soil cores be collected when sampling using either the grid-point or grid-cell method or at least 20 cores for each zone when sampling by management zones. Thoroughly mix the core samples in a plastic bucket and take a well-mixed composite sample and place it in the soil testing laboratory's sample container. For most fields and cropping systems, sampling and testing the soil in each field at least once every three years is recommended. In high value crops and where high rates of acid forming nitrogen fertilizers are frequently used, fields should be sampled at least every two years. The recommended sampling frequency depends upon cropping rotation, soil types, fertilization rates, tillage methods, and weather conditions. For more detailed information on soil sampling see UT Extension Publication PB 1061, "Soil Testing."

Keep Good Records

It is important to keep good records on sample locations and soil test results over time in order to evaluate the effectiveness of fertility programs. For example, if soil test nutrient values have been increasing over time, lower rates of fertilizer may be recommended, or if soil test levels are above optimum, additions of P and K could be omitted for a period of time and soil testing continued to monitor soil test changes. If soil test levels are consistently low or are decreasing even with fertilizer application, then increased fertilizer rates may be required. Due to seasonal variability, long-term trends in soil test values are needed to provide this information.

Using Site-Specific Soil Sampling Data

When site-specific soil sampling maps are created, each grid or zone within the field is automatically assigned a number. When soil test results are returned from the lab, the same naming convention is used, which allows the GIS software to join soil test results to the corresponding sample location in the field. GIS software processes the soil test data using geostatistics to draw fertilizer prescription maps. One of the problems facing producers who want to use site-specific soil sampling is how to make variable rate application maps (often called prescription maps) that can be used in their fertilizer application controllers. This process requires a computer, GIS software, and the skills to use it. Several GIS software packages are available to develop the georeferenced soil test results into variable rate prescription maps. Most fertilizer companies and crop consultants in Tennessee offer site-specific soil sampling services and will provide variable rate prescription maps on a per acre basis.



Variable rate application map

Conclusions

In most cases, applying fertilizer based on site-specific soil sampling using either the grid sampling or zone management approach is an improvement over applying them based on average soil conditions for the field. The decision to use grids or zones should be based on the producer's goals and the amount of variability that exists in individual fields along with field history. In fields that have a large amount of variability, grid sampling might be the best option. However, if there are large areas in a field with a uniform yield history, then zone sampling is more economical. NRCS offers cost-share opportunities through its Environmental Quality Incentives Program (EQIP) for site-specific soil sampling; please consult your local NRCS office for more information.

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