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Soil Sampling for Variable Rate Fertilizer Application

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BACKGROUND

Variable rate fertilizer application is quickly becoming a major component of crop production and has progressed together with Differential Global Positioning Systems (DGPS) to provide accurate "on-the-go" variation in fertilizer application.

Yet, the concept of site-specific fertilizer application is not new. Historically in Montana, fields were smaller than they are today and small areas within fields were frequently fertilized differently than the major portion in order to address special situations or landscape. Today, computers and guidance systems are quickly replacing techniques like counting rows or looking for atypical areas within a field. In addition, new technology such as yield monitors and advances in aerial or satellite photography has increased the awareness of variability within fields.

Regardless of the methodology used for site-specific fertilizer application, *the* ***rate of fertilizer applied is still highly dependent on the analysis of soil samples***. Soil samples are intended to be representative of a field or a portion of a field. Even though the technology for fertilizer application has changed over the years, the purpose and/or objective for collecting the samples has not. The information generated from the analysis of soil samples should either:

1. provide the information necessary for accurate fertilizer application, or
2. be used as a basis for monitoring changes in soil test values that may take place over time.

As you might have reasoned, these changes are primarily the consequence of manure and, fertilizer use, tillage operations, and cropping history. Various sampling strategies that can be used as a basis for variable rate fertilizer application have evolved. Several factors influence the sampling strategy that will be used. For instance, cause of the variability (natural vs. man-made) is an important consideration in strategy selection. In addition, the strategy used for sampling **immobile** nutrients probably should not be the same as the one used for sampling for the nutrients considered to be **mobile**. Tillage systems also have a major effect on sampling strategy because of differences in fertilizer placement.

One thing to keep in mind, there is no single optimum strategy for collection of soil samples for measurement of all nutrients in all production systems.

GRID VERSUS ZONE SAMPLING

Generally, there are two sampling strategies that can be used for site-specific fertilizer application, grid and zone sampling. Grid sampling uses a systematic approach that divides the field into squares or rectangles of equal size (usually referred to as "grid cells"). Using the grid strategy, there is an assumption that the **variability of soil pH and immobile nutrients within fields cannot be easily identified**. Soil samples are collected from within each of these "cells." The location of each "grid cell" is then geo-referenced using Global Positioning System (GPS) technology. The results of the analysis of soil samples collected with the grid sampling strategy may be used directly for fertilizer (in effect, treating each grid as a small field), or they may be entered into a mapping program that uses geo-statistics to draw fertilizer application boundaries.

In both situations (grid, zone), the results of the soil sampling and analyses are used to define the boundaries of the areas receiving different rates of fertilizer.

Zone sampling uses a more subjective and intuitive approach to divide any field into smaller units. Soil samples collected at random from within each “zone” are bulked together and analyzed to provide an average sample value for each unit. This approach assumes that **variability of soils within a field can be easily identified**. For example, soils with different percentages of organic matter can be distinguished by color and, therefore, can be sampled separately. Information from a yield monitor may be helpful in identifying zones that should be sampled separately. As with the grid system, sampling points are geo-referenced.

So, which one should you use, grid or zone sampling? The following are criteria that would favor the use of “grid” sampling strategies:

- non-mobile nutrients are the primary concern (phosphorus).
- Soil test levels in the field range from very high to very low with substantial acres in both categories
- There is a history of manure use
- Small fields have been merged into large fields; past management may have larger influence on soil test levels than natural variability
- the field history is not known.

The criteria that would favor the use of zone sampling are:

- cost of sampling and analysis; zones may be larger than grid cells thereby lowering sampling costs
- a measure of mobile nutrients is the primary concern (nitrogen, potassium)
- relatively low rates of fertilizer have been applied in recent years
- there is no history of manure application
- history of the field is known and can be used to divide the field into smaller units; a more accurate judgment can be made when all available information is used.

A COMBINATION OF THE GRID AND ZONE SAMPLING

Instead of thinking about either grid or zone sampling, a more logical approach might be a combination of the two strategies. This approach would consist of imposing a grid on zones in a field identified by:

1. observation,
2. a modern soil survey, or
3. information obtained from a yield monitor.

This combined strategy would increase the costs of sampling and analysis relative to the zone approach, but it would have the advantage of providing a measure of the variability within zones, and possibly uncovering variation due to past management that had not been otherwise accounted for.

Regardless of the sampling strategy preferred by the farmer or crop consultant collecting the samples, intensive sampling is an improvement over the more traditional approach of collecting samples at random from a field with subsequent fertilizer recommendations based on this field average. The more soil samples and data obtained the more accurate the variable rate application will be.

ECONOMICS OF GRID SAMPLING STRATEGIES

The economic benefits of grid sampling are not cut and dry. Since any intensive sampling program represents an increased cost over conventional sampling, there must be an offsetting economic advantage from either increased crop yields, or reduced fertilizer costs.

Increases in crop yield would be expected if intensive sampling identifies parts of a field that could respond to higher rates of fertilizer than normal and the added fertilizer increases yield in those areas. Savings from reduced fertilizer application could be realized if non-responsive areas of a field are identified and fertilizer application for those areas is reduced. *The challenge is to identify opportunities for increased net income with sufficient precision, but without excessive cost*.

VARIATIONS IN SOIL TEST VALUES OVER TIME

Research has identified that spatial patterns of soil test variations for phosphorus remained relatively constant throughout the growing season if soil cores were collected from the same locations at each time of sampling.

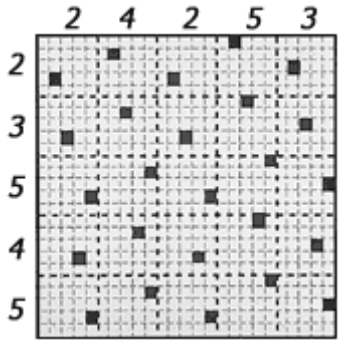
On the other hand, potassium soil test values fluctuate with soil moisture content at time of sampling. Therefore, soil samples should be collected at the same time each year to minimize some variability in soil test values.

SAMPLING STRATEGY FOR GRID CELLS

Regardless of the grid sampling procedure used, the soil sample collected should provide the best representation of the area sampled. A stratified, systematic, unaligned strategy is one type of grid strategy. With this procedure, location of a point to be sampled in each grid cell is pre-determined and each point from which a sample is taken is geo-referenced. If this procedure is followed, soil is collected from one location or point in any grid cell. Frequently,

the sample that represents the point consists of six or more cores taken from an area with a radius of two or three feet (see ILLUSTRATION 1 for an example of this sampling system). Use of this system poses some serious concerns, i.e., that the soil collected from a single point within a cell may not be representative of the true fertility status of the cell.

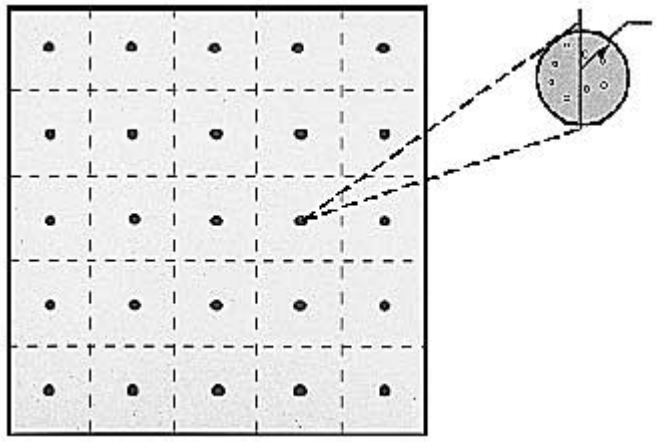
ILLUSTRATION 1.



Use of a non-aligned system allows for flexibility. We know that variability is common within most fields. But even when a non-aligned system is used collection of samples from points that are not typical of the remainder of the cell should be avoided (this is the same caution that has always applied to the collection of soil samples, even those collected at random on a field basis).

A systematic grid cell sampling procedure is another strategy that can be used to collect samples. With this procedure, the field to be sampled is first divided into grid cells that are uniform in size. The soil sample is collected from a point in a grid cell (usually the center). The location of the point of sample collection is the same for all grid cells (see ILLUSTRATION 2 for this sampling procedure).

ILLUSTRATION 2.



Grid cells can also be sampled with a random technique where there is no definite procedure. Several cores are collected from within a grid cell and composited to make one sample. Remember that a larger number of cores provide better representation of the fertility status of the grid cell.

SAMPLING STRATEGY FOR ZONES

In general, mobile nutrients (i.e., ones that are highly water soluble) in soils are dynamic and concentration of any form of that nutrient changes constantly. The rate of change among the various forms is highly dependent on environmental factors. For these nutrients, zone sampling is probably more appropriate because relative levels of a mobile nutrient are frequently related to fixed soil properties.

When considering zone sampling, it's important to point out that it's not easy to determine where to draw the line between one topographic position and another. Past management practices such as fertilization, cropping history, and manure use, can be used to define zones. Topographic maps and aerial photographs can also be used.

The County Soil Survey can be a tool to assist with zone sampling along with other soil property information. An Order 1 Survey (1 to 5,000 scale) shows a better relationship between soils that are mapped and measured soil properties. It should not be the only tool. The County Soil Surveys should be used as a general guide that can be refined by information from other sources (aerial photos, topography maps, yield maps, etc.). Keep in mind that a soil survey is not the same as soil sampling for nutrient management.

The zone sampling approach should also use common sense. If there are obvious visual differences in soils across a landscape, these soils should be sampled separately.

Soil pH is frequently related to topography and landscapes. Soil texture and organic matter will affect the buffering capacity and rate of acidification of soil. This is particularly true in humid climates. Differential erosion will also create patterns of pH variability in various places on the landscape.

Studies in North Dakota have led to the conclusion that permanent or fixed soil properties such as topography, organic matter content, and Electrical Conductivity (EC) maps, are related to the spatial variability of nitrate, sulfate, and chloride in soils. Topography affects the movement of mobile nutrients. Organic matter content is usually higher in depressions than on the higher positions of the landscape. In drier climates, the mobile nutrients tend to accumulate in the depressional areas. With higher rainfall or irrigation the mobile nutrients may be lost through leaching. As a result, nutrient levels may be lower or found at greater soil depths in the depressional areas.

Regardless of the pattern used for the collection of samples, it's still important to collect samples from the same position on the landscape each time that the field is sampled. Depth from which the sample is taken should also remain the same over time.

SUMMARY

Precision in the application of fertilizer is highly dependent on the information derived from the soil samples collected for that purpose. Therefore, from a nutrient management perspective, the sample collected should provide the best representation of the area sampled.

To guide more precise fertilizer applications, existing fields should be divided into smaller fields and sampled accordingly. To generate the information needed to support variable rate fertilizer application, fields are divided into either grid cells or zones. In general, grid cells should be used where recommendations for use of immobile nutrients are the major concern. Zone sampling appears to be most appropriate where application of mobile nutrients is the major concern.

Regardless of the strategy used–grid cell or zone–it is necessary to collect soil from several locations within any defined area. Point sampling does not provide the best predictive information.