EC00-154 Precision Agriculture: Soil Sampling for Precision Agriculture

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Precision AGRICULTURE

Soil Sampling for Precision Agriculture

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RESOURCES

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As various aspects of precision agriculture are implemented in Nebraska, some of the most frequent questions asked by producers, fertilizer dealers and crop consultants relate to soil sampling. *Should I soil sample this field on a grid? What grid spacing should I use? How often should I sample? Can I use a yield map to tell where to soil sample?* All of these are good questions, but often we do not have definitive answers. Site-specific management research conducted in recent years in Nebraska, however, provides some direction on how to implement a soil sampling program for precision agriculture.

Basic Sampling Principles

Historically, the objectives of soil sampling have been to determine the average nutrient status of a field and to provide some measure of nutrient variability in a field. Soil sampling for precision agriculture has these same objectives with some modifications. Instead of a field, producers are interested in areas within fields. They also are interested in relating trends in soil fertilizer levels to other field properties that are predictable or easily measured. Knowledge of factors influencing soil nutrient levels including soil type, topography, cropping history, manure application, fertilizer application and leveling for irrigation will help the producer determine the most effective sampling approach.

The basic principles of soil sampling still apply to precision sampling. An adequate number of samples should be collected to accurately characterize nutrient levels. The samples should be collected to the proper depth for non-mobile and mobile nutrients. Samples should be handled and stored to minimize contamination and degradation.

Grid Sampling

When variable rate fertilizer application was first practiced 8-10 years ago, application maps were most often derived from grid soil samples collected at average densities of one sample for every three to four acres. In research studies conducted in Nebraska, fields have been grid sampled at much higher densities (up to 42 samples per acre) to approximate the true spatial variability of a number of soil nutrient levels. Sampling at high densities allows the evaluation of lower sampling densities on nutrient maps. In some cases, fewer samples can result in inaccurate maps.

Figure 1 shows how a tenfold range in sampling density at a research site in Lincoln County resulted in significantly different patterns. In this case, the coarser sampling grid missed a systematic pattern in soil

Consider grid sampling if:

- Previous management — such as confined livestock, heavy manure application, or aggressive leveling for irrigation — has significantly altered soil nutrient level.
- Small fields with different cropping histories have been merged into one.
- An accurate base map of soil organic matter is desired.

Consider directed sampling if:

- Yield maps, remotely sensed images, or other sources of spatial information are available and show consistency from one layer to another.
- You have experience farming the field that you feel would provide direction on where to delineate management zones.
- There is limited or no history of livestock or manure influence on the field.

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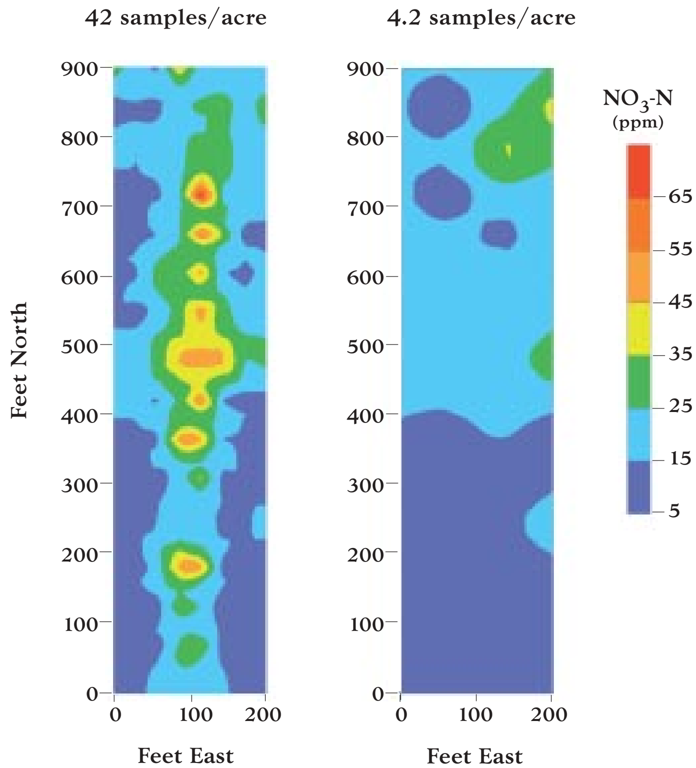

Figure 1. Soil residual nitrate-N. West Central Research and Extension Center, North Platte, 1994.

nitrate, probably related to livestock fencing. The average recommended nitrogen rate for the field at the higher grid density was 148 lb N/acre. The average recommended nitrogen rate was 162 lb N/acre at the lower grid density; 45 percent of the field received a different nitrogen recommendation with the coarser grid. The coarse grid was denser than most commercial grid sampling practiced by fertilizer dealers and crop consultants.

In other situations, accurate maps can be generated at much lower sampling densities. At a site in Buffalo County, a grid density of 14 samples per acre was compared to a density of one sample per 3.7 acres. The coarse grid is similar to that used commercially. In this case, the nitrogen rate maps were not greatly different — 17.6 percent of the field received a different nitrogen recommendation with the coarser grid, and the average nitrogen rate was the same for both grids — 158 lb N/acre.

The optimum grid density depends on the site, and to some extent what nutrient is being assessed — soil organic matter, nitrate, phosphorus, zinc, etc. It helps to know the spatial variability of the field in order to know the optimum grid density — which, after all, is the reason for grid sampling. This also raises the basic question of why we would choose to grid soil sample. Is there a better way to obtain the desired information?

Directed Sampling

Directed soil sampling is in many ways simply an extension of how soil samples were often collected in the past. For example, if a field contains significant areas of more than one soil series, the University of Nebraska recommendation was to collect samples from each soil series. Also, if parts of the field had different preceding crops, different fertilization histories, eroded areas, or an old farmstead location, these areas were to be sampled separately. In these situations, the producer is using his knowledge of spatial factors to direct where samples are taken to determine if they have different fertilizer needs. The new tools of yield maps, aerial photographs and remotely sensed images simply provide more information about variability in the field and where soil sampling can help interpret variability.

In *Figure 2*, three sources of spatial information are provided for a field in Clay County: the soil survey *(2a)*, a bare soil photo *(2b)*, and a yield map *(2c)*. In this case, the soil survey provides little spatial information — the study area is located on one soil series (Crete silt loam). The aerial photo shows areas that vary in soil color. In Nebraska, much of the variation in the color of bare soil is related to soil organic matter content. The yield map shows an area of higher yield that is consistent with darker soil on the aerial photo. Soil samples from the field indicate that areas which are darkest on the aerial photo, and have the highest yield, are highest in soil organic matter (3.1 percent) and that soil organic matter is lowest in the lighter, lower yield areas (1.9 percent). This information can be used in making recommendations for variable rate fertilizer or herbicide applications.

Recommendations

Producers interested in soil sampling for precision agriculture should first consider how they will use information from soil sampling. Some variable rate fertilizer application equipment is controlled by software based on grid samples. In these situations, the field will need to be grid sampled or there must be some way of generating grid information from directed samples. Check with your custom applicator to insure that the information you collect will be compatible with the variable rate equipment requirements.

Grid Sampling

Density. A well-done nutrient map derived from a grid sample can be a valuable resource for many years. Consequently, the density should be adequate to provide confidence in the accuracy of the maps developed from the data. We suggest analyzing one sample per acre, which is composited from five cores collected in a tight radius about the sample point *(Figure 3)*. This density will result in a map that will be good for many years — 10 to 20 years for soil organic matter and cation exchange capacity; five to ten years for pH; and four to five years for phosphorus, potassium and zinc. On fields in which variability is expected to be low, a sampling density of two to two-and-one-half acres per sample may be acceptable. Grid sampling at densities coarser than one sample for every 2.5 acres is not recommended, if the goal is to develop a resource of nutrient maps that can be used with confidence over several years.

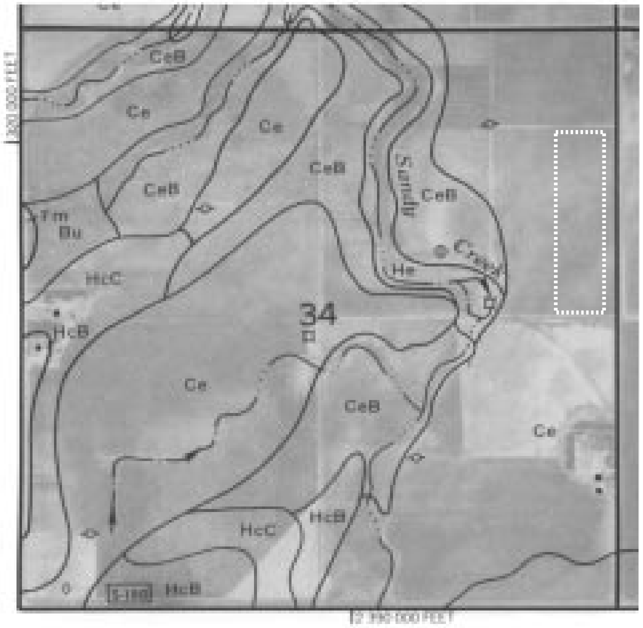

Figure 2a. Soil survey map with study area outlined, Clay County site.

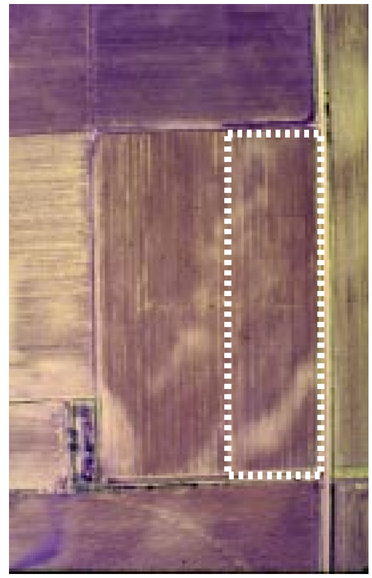

Figure 2b. Bare soil aerial photograph with study area outlined, Clay County site.

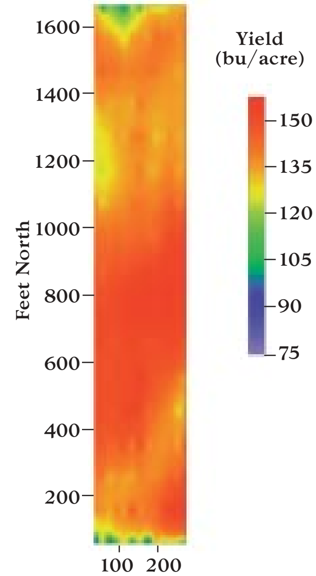

Figure 2c. Yield map, 1995, Clay County site.

Sampling Pattern and Depth. An offset grid pattern is recommended *(Figure 3)*. This will provide more information at a lower cost than a regular grid pattern. Individual cores should be collected in a radius of 8-10 feet of the grid point, to a depth of 8 inches. The grid point should represent the central position of a composited sample. Collect samples within the 8-10 foot radius randomly, in order to avoid systematic patterns such as starter or preplant bands. Conduct a general fertility analysis on the samples, including soil organic matter, pH, phosphorus, potassium and other nutrients of interest.

Frequency. As already mentioned, a nutrient map derived from a grid-sampled field can last a long time. If variable rate application of fertilizer or lime occurs, this will have the potential to change nutrient levels or soil pH over time. Soil phosphorus levels will not change drastically with single variable rate applications. We suggest that grid samples be collected every five years for phosphorus. Lime application according to recommendations should amend soil pH for 8-10 years. Even if variable rate lime application has occurred according to a grid-sampled map of pH, it should not be necessary to grid sample for soil pH for 8-10 years after application.

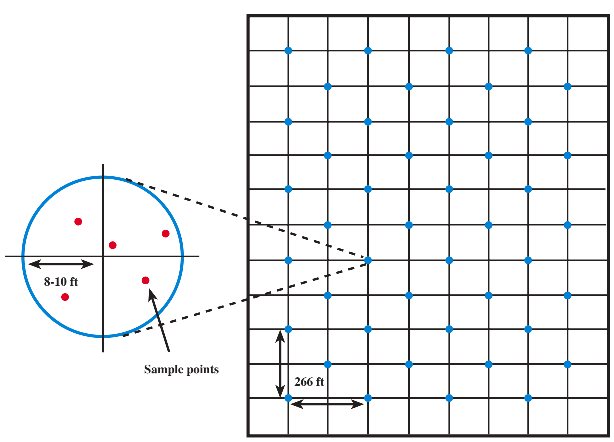

Figure 3. Suggested grid sampling pattern and density. Blue markers are grid intersections to sample; red markers represent soil cores collected about the grid point for compositing into one sample for analysis. This example represents an area of 44 acres with a total of 44 soil samples, each composited from five cores.

Residual Nitrate Sampling. Grid sampling for nitrate-N is not recommended because annual fluctuations in nitrate levels would require annual grid sampling, which is not cost effective for most crops with current fertilizer prices. Instead, residual nitrate sampling (to a depth of 3 feet) should be done on a directed sampling basis.

Directed Sampling

Consider Multiple Data Layers. Patterns which show consistency from one data layer to another, such as multiple years of yield maps, or a yield map and an aerial photo, are more likely related to soils than other sources of variability. In many cases, a soil series map or topography map can be a good base upon which to overlay yield maps and other sources of spatial information. Your experience gained from tillage, cultivation, harvest and field scouting can also serve as effective data layers.

Minimize Subdivision. After deriving information from multiple data layers, including your experience, subdivide the field into management zones. Look for general categories when subdividing and avoid creating many subdivisions. Generally, four to six subdivisions should be adequate. Excessive subdivision may create small areas which are not really manageable. Management zones need not be contiguous. Samples collected from more than one area of a field may fall into the same range of yield, soil color, etc. and thus the same zone *(Figure 4)*.

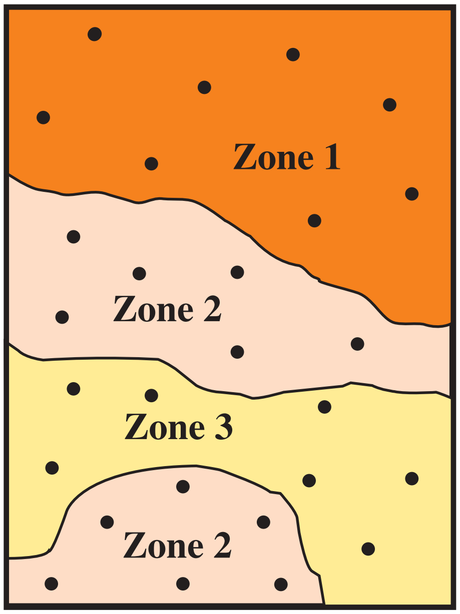

Figure 4. Example of directed sampling pattern for a field with three zones; Zone 2 is comprised of two areas that are similar but not contiguous.

Soil Fertility Isn't Everything. As you look for consistent patterns in fields, remember that soil fertility will not be the only factor influencing patterns in yield maps, remotely sensed images, and other sources of spatial information. Soil factors other than fertility, such as compaction, topsoil depth, and texture will influence patterns. Other sources of stress, such as disease, weeds and insects may significantly influence yield and other patterns. Consider scouting fields for these factors during the growing season according to categories derived from spatial data.

Accurately Sample Each Zone. Soil samples should be collected from each zone according to current recommendations (NebGuide G91-1000, *Guidelines for Soil Sampling*). For general fertility recommendations, collect 10-15 cores to a depth of 8 inches from within the zone, then composite samples into one to send to the lab for analysis *(Figure 4)*. In this example, cores from the two areas of Zone 2 can be combined into one sample to send to the lab. Samples can be georeferenced with a GPS receiver for repeatability if desired. This will allow you to collect samples in the future from basically the same locations, even though you are compositing the cores for analysis.

Residual Nitrate Sampling. Collect six to eight cores to a depth of 3 feet for residual nitrate from each zone, compositing the samples into one to send to the lab for nitrate analysis. For convenience, consider collecting a deep sample for residual nitrate at every other location that you collect surface samples, particularly if georeferencing sample locations.

Choosing a Method

Both grid and directed soil sampling are valid options for precision soil sampling — each has advantages and disadvantages. Unless the grid is dense enough, grid sampling may miss patterns and boundaries that are evident from looking at soil surveys or yield maps. Grid sampling is very expensive — both to collect and to analyze the samples. Directed sampling uses other sources of spatial information to make informed decisions on where to sample, however, there may be patterns in soil fertility which are not detectable except with grid sampling. *Figure 5* is an example of such a situation. This is a map of soil phosphorus from the same field in Clay County as in *Figure 2.* The pattern of soil phosphorus is strongly influenced by the location of a farmstead with confined livestock in the northern portion of the field at some time in the past — 40 or more years ago. Without knowing the farmstead's location to direct sampling, a directed sampling approach would not be likely to detect this area of high soil phosphorus. Other sources of spatial information (the county soil survey, yield map, aerial photograph) give no indication of high soil phosphorus or the past presence of a farmstead. This field also is an example of the benefits of precision sampling over traditional sampling methods. The average Bray-1 P test is 15.1 ppm — just slightly over the critical level of 15 ppm at which phosphorus fertilization is recommended by the University of Nebraska for corn. Traditional sampling procedures might suggest that this field does not need phosphorus fertilizer; however, precision sampling shows that most of the field actually tests well below 15 ppm and phosphorus fertilization should significantly increase yield potential.

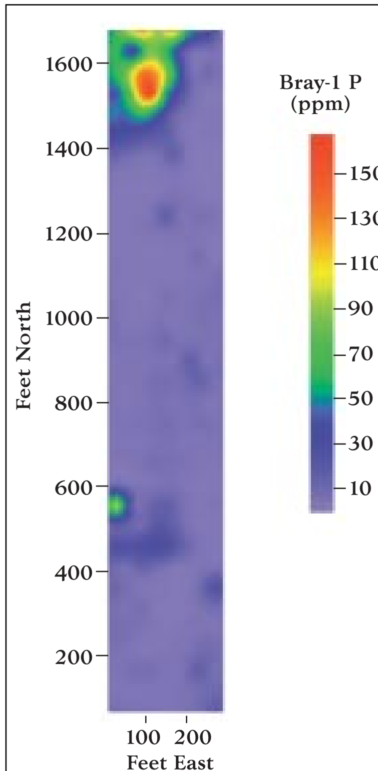

Figure 5. Soil phosphorus concentration, Clay County site.

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