Precision AGRICULTURE

Soil Sampling for Precision Agriculture

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RESOURCES

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Producers, fertilizer dealers and crop consultants implementing precision agriculture often ask questions relating to soil sampling. *Will I be able to use fertilizer more profitably on this field with precision sampling? Should I soil sample this field on a grid? What grid spacing should I use? What about directed, or management zone sampling? How often should I sample? Can I use a yield map to tell me where to sample?* Site-specific management research conducted recently in Nebraska and other states provides some direction on how to implement a soil sampling program for precision agriculture.

Basic Sampling Principles

Historically, the objectives of soil sampling were 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 modification. Instead of a field, producers are interested in areas within fields. They are also interested in relating trends in soil fertility 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, leveling for irrigation, and fertilizer management will help you decide on 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. 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 began to be practiced 15 to 20 years ago, application maps were most often derived from grid soil samples, collected at average densities of 3 to 4 acres per sample. Nebraska research grid-sampled fields at much higher densities (up to 42 samples per acre) so as to approximate the true spatial variability of many soil nutrient levels.

Sampling at high densities allows us to remove some data to look at how lower sample density effects map accuracy. In some cases, fewer samples can result in inaccurate maps. *Figure 1* is an example, in which a tenfold range in sampling density at a research site in Lincoln County results in significantly different patterns.

In this case, the coarser sampling grid falsely identified higher soil P levels in the northeastern corner of

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- An accurate base map of soil organic matter is desired.

Consider management zone 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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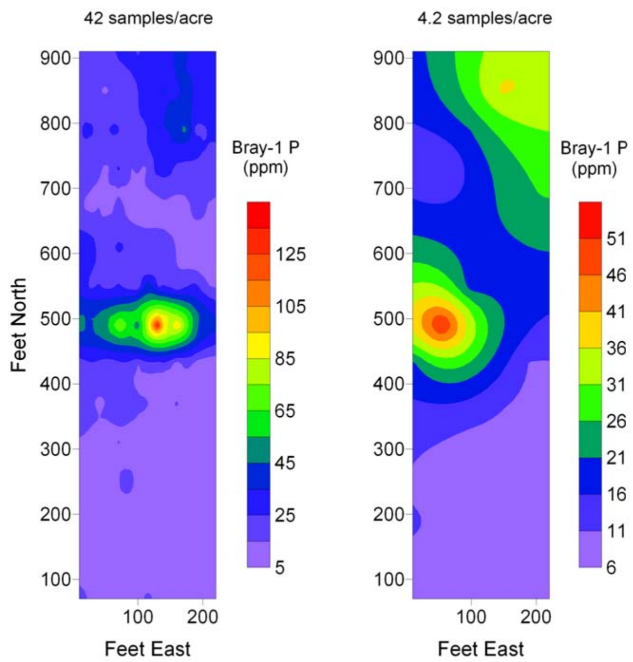

Figure 1. Soil Bray-1 phosphorus, West Central Research & Extension Center, 1994.

the field, and missed areas of high P concentration in the center of the field. The coarse grid was still much denser than practiced commercially — 4.1 samples per acre.

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 3.7 *acres per sample* to calculate recommended N rate. The coarse grid is similar to that used commercially. In this case, N-rate maps were not greatly different — 17.6 percent of the field received a different N recommendation with the coarser grid, and the average N rate was the same for both grids — 158 lb N/acre.

Optimum grid density depends on the site and, to some extent, the nutrient(s) of interest — soil organic matter, nitrate, phosphorus, zinc, etc. Optimal grid density can be influenced by manure application, especially if a farmstead used to be located within or near the field. If other layers of spatial information are available, use that data to direct sampling in order to avoid — or account for — management factors influencing nutrient distribution, such as uneven manure application or land leveling.

Management Zone Sampling

Management zone soil sampling is, in many ways, simply an extension of how we have suggested soil samples be collected in the past. For example, if a field has significant areas of more than one soil series, we recommend collecting samples from each soil series. Also, if parts of the field have different preceding crops, different fertilization histories, areas that are eroded, and/or an old farmstead location, etc., then these areas should be sampled separately.

In these situations, use your knowledge of historical management and spatial factors to direct where to take samples to determine if these areas have different fertilizer needs. The new tools — 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.

Figure 2 gives three sources of spatial information for a study area 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 within 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 consistent with the darker soil in the aerial photo. Soil samples from the field indicate:

(1) that areas which are darkest on the aerial photo, and have the highest yield, are highest in soil organic matter (3.1 percent) and

(2) that soil organic matter is lowest in the lighter, lower yielding areas (1.9 percent).

You can use this information when making recommendations for variable rate fertilizer or herbicide applications.

Recommendations

If you're interested in soil sampling for precision agriculture, first consider how you will use soil sampling information. Some variable rate fertilizer application equipment is controlled by software based on grid samples. In these situations, grid-sample the field or develop some means of generating grid information from directed sampling. Ask your custom applicator to help ensure that the information collected will be compatible with the VRT requirements.

Some fields, relatively uniform in soil properties and historical management, which are not likely to benefit from site-specific management. Ideally, you should first evaluate other spatial information, particularly the county soil survey, before investing in precision sampling. Fields mapped as one soil series, which have uniform cropping history and show little variability in yield, are less likely to benefit from precision sampling.

Grid Sampling

Density. A well-done grid sample-derived nutrient map can be a valuable resource for many years with density adequate to provide confidence in the accuracy of maps developed from the data.

For optimum accuracy, 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 good for many years — 10 to 20 years for soil organic matter and cation exchange capacity; 5 to 10 years for pH; 4 to 5 years for phosphorus, potassium, and zinc.

On fields where larger-scale variability is expected and is less influenced by historical management, a sampling density of 2 to 2.5 acres per sample is acceptable. Grid sampling at densities

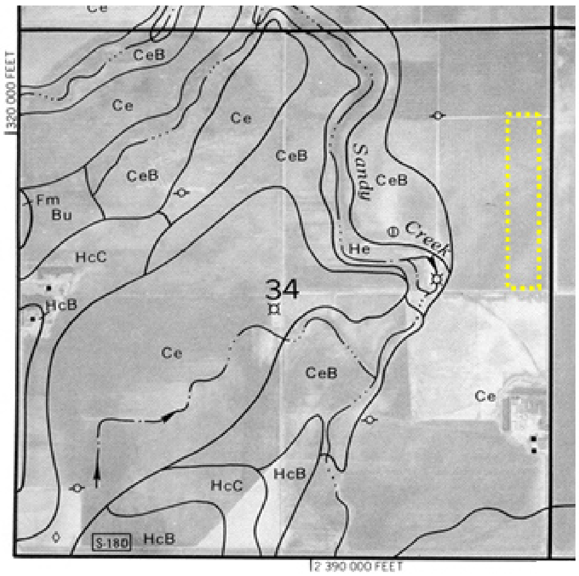

Figure 2a. Soil survey map with study area outlined, Clay County site.

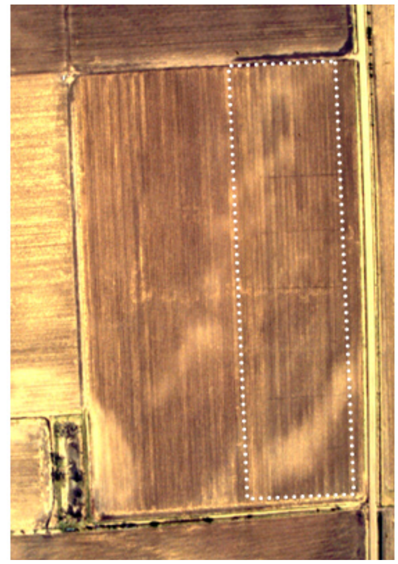

Figure 2b. Bare soil aerial photograph with study area outlined, Clay County site.

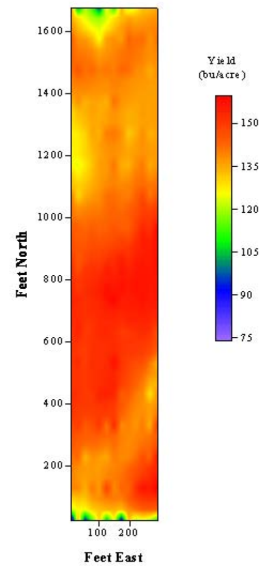

Figure 2c. Yield map, 1995, Clay County site.

coarser than one sample for every 2.5 acres isn't recommended if your goal is developing a resource of nutrient maps you can use with confidence over several years.

Sampling Pattern and Depth. An offset grid pattern is recommended *(Figure 3)*, which will provide more information at a lower cost than a regular grid pattern. Collect individual (4 to 5) cores in a radius of 8 to 10 feet of the grid point, to a depth of 8 inches. The grid point should represent the central position of the composited sample.

Sampling in a tight radius about grid points is preferred to more dispersed sampling within grid cells. Randomly collect samples within the 8 to 10 foot radius. This avoids 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.

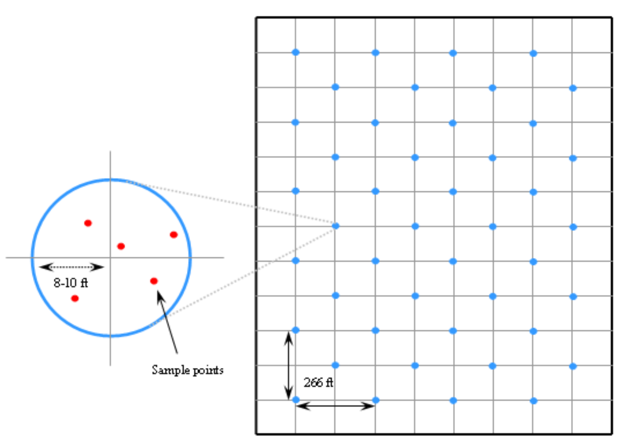

Figure 3. Suggested grid sampling pattern and density. Blue markers are grid intersections to sample; red markers represent soil cores collected about grid point for compositing into one sample for analysis. This example represents an area of 44 acres with a total of 44 soil samples, each composited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

Frequency. As already mentioned, a good grid sample-derived nutrient map can last a long time. Any VRT applications of fertilizer or lime can potentially change patterns of nutrient levels or soil pH over time. Soil phosphorus levels will not change drastically with single VRT applications.

We suggest grid samples be collected every five years for phosphorus. Applying lime according to recommendations should amend soil pH for a period of 8 to 10 years. Thus, even if VRT lime is applied according to a grid-sampled map of pH, it should not be necessary to grid-sample for soil pH for 8 to 10 years.

Residual Nitrate Sampling. Grid sampling for nitrate-N is not recommended. Annual fluctuations in nitrate levels would require annual grid sampling, which is not cost-effective for most crops with current fertilizer prices. Instead, we recommend you do residual nitrate sampling (to a depth of 3 or 4 feet) on a directed sampling basis.

Management Zone Sampling

Consider Multiple Data Layers. Patterns showing 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 for yield map overlay and other sources of spatial information. Experience gained from tillage, cultivation, harvest, and scouting the field can also serve as an effective information layer.

Minimize Subdivision. After you've pulled information from multiple data layers, including your experience, subdivide the field into management zones. Look for general categories when subdividing and don't create lots of subdivisions. Generally, three to six zones should be adequate. Excessive subdivision

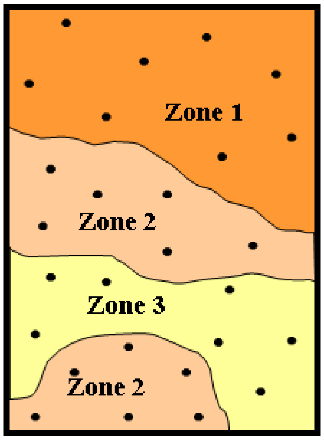

Figure 4. Example of directed sampling pattern for a field with three zones; Zone 2 is comprised of two areas that are similar but not contiguous.

may create small areas which are not really manageable. Management zones need not be contiguous — samples may be collected for more than one area of a field which fall into the same range of yield, soil color, etc. and, thus, the same zone *(Figure 4)*.

Soil Fertility Isn't Everything. As you look for consistent patterns in fields, keep in mind that soil fertility won't be the only factor influencing patterns in yield maps, remotely-sensed images, and other sources of spatial information. Soil factors such as compaction, topsoil depth, slope, landscape position, 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. Collect soil samples from each zone according to current recommendations (NebGuide G1740, *Guidelines for Soil Sampling*). For general fertility recommendations, collect 10 to 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)*.

Figure 4 shows how cores from the two areas of Zone 2 can be composited 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 6 to 8 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 from which you collect surface samples, particularly if georeferencing sample locations.

Choosing a Method

Both grid and management zone 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 evident from looking at soil surveys or yield maps. Grid sampling is very expensive — both to collect and analyze the samples. Management zone sampling uses other sources of spatial information to help you 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 map of soil phosphorus is from the same field in Clay County as in *Figure 2*. The pattern of soil phosphorus is strongly influenced by a farmstead located in the northern part of the field at some time in the past — 50 or more years ago. Without knowing the farmstead's location, in order to direct sampling, a zone sampling approach is unlikely 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.

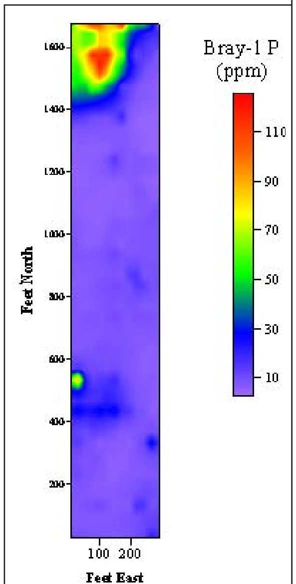

Figure 5. Soil phosphorus concentration, Clay County study site.

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. Traditional sampling procedures suggest that this field needs only low rates of phosphorus fertilizer. However, precision sampling also shows that the majority of the field actually tests well below 15 ppm; phosphorus fertilization should significantly increase yield potential.

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