Sampling and Managing Spatial Variability – Why Not This Fall?

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BY SYSTEMATICALLY MANAGING soil fertility as one of the main sources of yield variability in the field, we can enhance the productivity of the land. From the operator's perspective this means the land can be managed for higher yields with less risk because a major yield limitation has been eliminated. The landowner can benefit from the increased productive capacity through an increased share of the higher yields or from charging a higher cash rent, as well as by increases in land value.

Sources of Yield Variation

The overall purpose for soil sampling is to provide a means of estimating the soil's ability to provide adequate nutrition to the crops to be grown. That ability will vary within the field as a result of a variety of natural and man-made forces. Natural soil differences and man's activities, such as past production practices, are important sources of within-field variability. The soil itself is one of the most basic sources of field variability in nutrients and other factors affecting yield. Changes in soil texture and structure, organic matter content, mineral makeup, and rooting depth provide the basic limits of the system. Production practices for the current year and effects of previous years' practices are man-made impacts on the system, which may be more important than the natural soil variability. Previous crops, tillage systems, and manure applications are important man-made forces. Changes in soil organic matter, pH, compaction, and erosion are usually more long-term, accumulative effects, but all have an impact on the spatial variability of soil nutrients. As these factors vary across the field, yield potential and conditions affecting nutrient management will also vary. Site-specific management technologies available today provide the first opportunity to document and manage these sources of variability.

Interaction with Weather and Management

Weather has a profound effect on responses to applied nutrients and thus can influence the interpretation of soil test results. Sampling in the fall is generally recommended, because the cumulative impact of weather patterns for the season has been experienced, and nutrient levels tend to be at their lowest, providing a good basis for determining nutrient needs for the coming season. Matching soil test results with yield monitor maps can provide some insight into within-field variability in nutrient needs. Areas with highest yields often have lower soil test levels, because nutrient removal rates are higher. Likewise, areas with low yields tend to have high soil tests, because removal rates are lower and fertilizer applications over the years have built up soil tests. Such inverse correlations between yield and soil tests make site-specific nutrient management more challenging.

Sampling Patterns

There are many different philosophies on selecting the best sampling pattern for a field. Unfortunately there is no one "best" system that fits all fields. Where little is known about the field from historical records or current measurements, a uniform grid sampling approach is often the best choice. As more information is available, it should be used to help design a soil sampling pattern for the field. Which pattern is best for a field depends on the type of decision to be made.

Sampling Intensity

Sampling intensity varies widely, depending on traditional recommendations, cropping systems, inherent nutrient variability across the field, and perceived economic value of soil testing. In Illinois, for example, standard recommendations for sampling on a 2.5-acre pattern have been in place for many years, so intensive grid sampling is easier to "sell" to farmers and dealers. In the Great Plains, traditional patterns are more commonly in the range of one sample for 20 to 40 acres. Getting these farmers to accept the expense of intensive grid sampling is a greater challenge. Their perception is that their soil nutrient levels are more uniform and need for fertilizer is generally lower, so intensive sampling is not justified. Where intensive grid sampling has been used, the variability sometimes verifies that perception, but sometimes proves that there is value in more intensive sampling. Local experience is a good guide to sorting out which approach is best for a given field. Again, the answer is site-specific. In most cases, we find that more intensive sampling is justified where site-specific fertilizer application is possible and where yield monitor data are available to help interpret the results. For example, in Illinois that may mean moving from 2.5-acre sample patterns to 1-acre patterns. In South Dakota, it may mean sampling on a 10-acre pattern instead of a 40-acre pattern.

Dr. Don Bullock, University of Illinois Agronomist, developed a detailed comparison of sampling intensities, based on an intensive sampling of a 640-acre farm in central Illinois. Using more than one million data points to characterize the variability in phosphorus (P) soil test, he sampled the data set at different sampling intensities to determine the soil test levels and P recommendations for the field (see **Figure 1**). Using the field-average P test for determining P fertilizer needs, 38 percent of the field did not receive adequate fertilizer to meet crop needs. When a 110-foot grid was used to collect samples and generate recommendations, only 2.5 percent of the area needing P fertilizer was missed. On a 330-foot grid, 9 percent of the area needing fertilizer was missed, still much better than the field average recommendation. So even the coarser (2.5-acre) site-specific system is a better choice than the field-average system for ensuring crop nutrient supplies are adequate. Economics of the costs of sampling and the potential for improving profits with adequate nutrients will dictate which intensity will best fit a given field. It should be noted that the farm used in this study is relatively uniform, so more variable fields would show greater advantage to more intensive sampling and use of variable-rate fertilizer application.

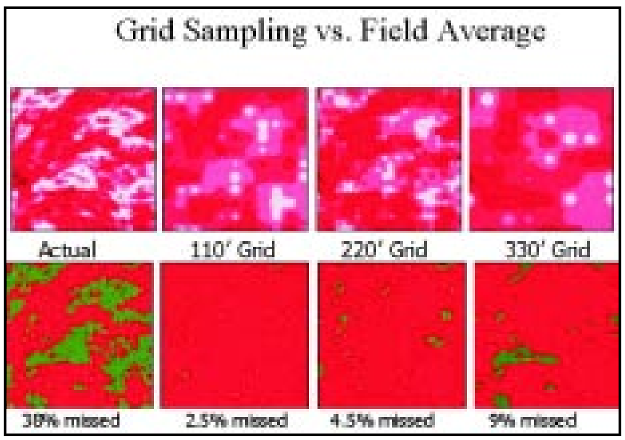

Figure 1. Comparison of sampling intensities for soil test P.

Lance Murrell, agronomist with The Andersons/Erny's Fertilizer Company in north central Indiana, finds sampling by management zones based on soil types is a better approach for his customers than grid sampling. Zones are generally no larger than 5 to 8 acres and are defined along soil type boundaries. Where soil types in a field cover larger areas, they are subdivided on a grid basis. He has the benefit of access to good soil survey maps and a long history of intensive soil sampling and yield information on these fields. The extra information makes it possible to define management zones and take advantage of known sources of variability to refine the nutrient management plan. This is an example of how an experienced agronomist working with the right kind of data sets can help sharpen the management plan for a field. The key is to be able to act on the information and manage more intensively where more intensive data and experience are available.

Implementation of management zones can be done on the basis of any of several factors, depending on the variable to be managed. It would be reasonable to manage different nutrients on different zone patterns for example. **Table 1** lists examples of different characteristics on which precision farming management zones could be based.

Being able to interpret and act on the results is a key part of deciding which sampling pattern is most appropriate.

Interpretation

The data bases used to define management zones may also be helpful in interpreting the results obtained from site-specific management. Often this stage of the process draws more heavily on the "intuitive/historical" components. The experience and knowledge accumulated by the farmer and the farmer's advisers are impossible to document or quantify, but are extremely important in the final management decisions to be made.

Table 1. Types of site characteristics on which precision farming management zones can be based.

Type of site characteristic	Examples
Quantitative, stable	Elevation/topography, soil organic matter, pH or calcium carbonate ($CaCO_3$) , soil electrical conductivity (E.C.), high intensity soil survey maps, surface curvature and hydrological properties
Quantitative, dynamic	Yield monitor data, weed density and distribution, crop canopy appearance or temperature, soil moisture or salinity, soil or plant nitrogen (N) status
Qualitative, stable	Soil color, first order Natural Resources Conservation Service (NRCS) soil survey maps (1:15,800 scale), immobile nutrients [e.g. P and potassium (K)], soil pathogen or pest patterns, depth to subsoil, soil aeration/drainage status
Intuitive/historical	Grower knowledge of field characteristics, overall yield patterns and historical practices, soil tilth and quality, past crop rotations, old field boundaries, land leveling and drainage patterns, subsoil characteristics

Action

All the planning and technology employed in defining management zones and interpreting information collected have little value until action is taken. A farmer who is not in a position to use variable-rate application of fertilizer, for example, cannot experience the full benefit from the information and technology that went into determining the nutrient variability across the field. If resources are limited, it is important to carry some of the management factors through to action if any return on the technology investment is to be realized.

Soil sampling involves a lot more that just collecting samples. The thought processes and information that go into defining the sampling pattern have a profound impact on the returns. It is not a last-minute process. Beyond the technology of site-specific management, the decisions relative to considering part of the fertilizer applied as a capital investment may adjust the decision process or what and when to apply and will definitely impact the economic analysis of the decision. On a long-term basis, maintenance of soil nutrient level…and buildup to improve productivity where possible…is a critical investment and a critical management decision. Site-specific management may be much more important when considered for the long term than if it is evaluated on the basis of a single cropping season.

Putting these plans together and acting on them take time. When the spring rush is on, best-laid plans often get pushed aside. It is often wise to put the plan in place and prepare to take action on these long-term, site-specific plans in the fall when there may be more time available. Implementing a site-specific sampling plan to manage spatial nutrient variability is a good activity for the fall season. Fall sampling usually ensures that you are at the low point of the nutrient cycle, better reflecting the potential limitations of soil nutrient supplies.

Buildup as a Capital Investment

Fertilizer costs are usually budgeted as an annual expense or at most amortized over the two to four years of a crop rotation. This serves to discourage application rates above those needed to replace nutrients removed by the harvested crop. Yet most fields have areas that would benefit from additional amounts to build soil test levels and thus productive capacity of the field. A more appropriate budget would be to charge the fertilizer applied to replace crop removal (maintenance application) to the crop grown each year and budget a separate charge for additional amounts (buildup application) as a capital investment. Buildup fertilizer adds to the productive capacity of the soil for years to come, just as new tile drainage system or irrigation system increases productivity. These investments are not expected to be paid from one season's crop, but they allow the farmer to manage at a higher level and therefore provide an opportunity to increase profit.

If soil test levels are high, the buildup category will be relatively small, and budgeting as a capital expense may not be a major issue. But when soil tests are low, the buildup portion of the fertilizer recommendation can be large enough to have major impact on production costs if charged against one crop season.

When buildup fertilizer application is treated as a capital investment, the question of who pays for it must be addressed. The argument could be made that the buildup fertilizer increases the value of the land and should be charged to the landowner. But it also increases the value of the land to the operator and increases potential income. One of the more common problems of short-term cash rent is that there is limited incentive for the operator to pay for build up fertilizer applications. Unless there is a provision in the lease to maintain or build fertility levels, there is a tendency for the operator to deplete soil reserves.

21st Century Nutrient Management… a New Look

Managing soil nutrients is no longer a simple process. Site-specific technologies facilitate more accurate accounting of inputs and production. It is important to define management zones carefully, to interpret data systematically to reach decisions, and to act on those interpretations to take advantage of the improved information. Economics of site-specific nutrient management also may need to be assessed in a different way from field-average systems. Site-specific systems often uncover missed opportunities to build productivity of the field and enhance profit potentials far into the future...enhancements that perhaps should be considered a capital investment. ■

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