SECTION CONTENTS:

Soil Sampling

Soil sampling and testing provides an *estimate* of the capacity of the soil to supply adequate *nutrients* to meet the needs of growing crops. The test results are compared to standard response data to estimate the need to supply additional nutrients for optimum crop production. Traditionally, the goal of soil sampling was to develop a representative estimate of the average nutrient needs for a field so that the best single rate of application could be determined.

Less than a teaspoonful of soil is actually used for the laboratory analysis. That small amount must represent the entire area for which the recommendation is to be made. For example, in a traditional sampling scheme, one teaspoon or less of soil represents up to 40 acres (that is over 80 million pounds of soil in the top 7 inches). In more intensive sampling, such as used for site-specific management, the sample represents a 1 to 2 ½ acre area of the field , and that teaspoonful represents 2 to 5 million pounds of soil in the acre-furrow-slice. (The "acre-furrow-slice" is approximately 2 million pounds of soil, representing the top 7 inches of the profile, and is the basis of most soil test calibrations.)

With site-specific management being implemented on many farms, there is a growing need to characterize the variability in nutrient needs across the field. Each sample should represent 2 ½ acres or less for best characterization of the variability within the field, to serve as a guide for variable-rate application of crop nutrients. Where field variability is low, larger sample areas are acceptable; where variability is high, more samples are needed to adequately represent the field.

Sampling Procedures

Think about why you are sampling the soil. The goal is to estimate the capacity of the soil to provide adequate amounts of the necessary nutrients to meet the needs of the crop (or crops) to be grown. It should be clearly understood that soil testing does not measure the amount of nutrients in the soil. The test results can only be used in conjunction with a calibration curve that relates the laboratory ananlysis results to a set of crop response data. Without the response (calibration) data, the laboratory results are meaningless. The samples should be collected in such a way as to best meet that goal. The sampling pattern should be set to best characterize the variability within the field.

Depth

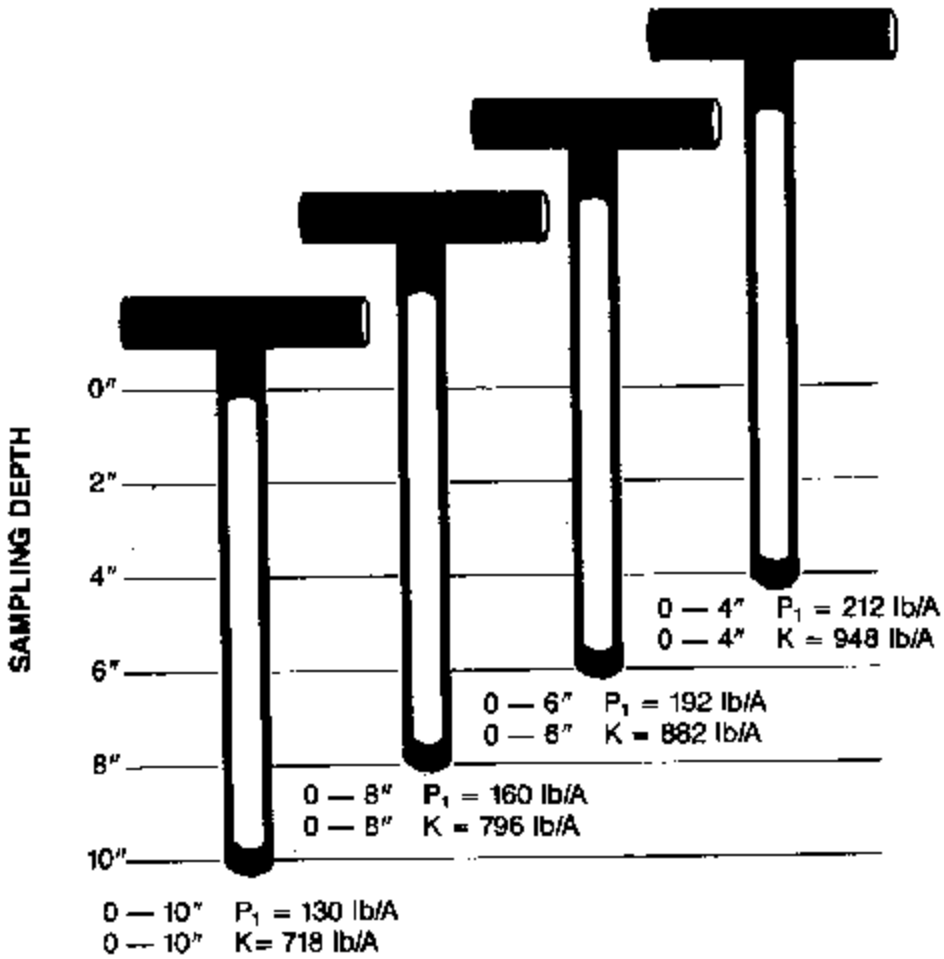

Figure 12.1 Effect of Sampling Depth on P and K Soil Test Results.

Before sampling, check with the laboratory that will conduct the analysis to see what sampling depth is recommended. Sampling depth should be determined to represent the root zone that the plant will draw from, but should also be consistent with the sampling depth used in developing the calibration data set to be used for interpreting the soil tests. Most soil test calibrations are based upon a 6 to 8 inch depth, most commonly 6-2/3 inches. In dry years, when it is difficult to push the probe into the ground, there is a danger of not getting the proper depth. Sampling too shallow will often lead to unusually high soil tests, because of the tendency for nutrients to become concentrated near the surface. Shallow sampling will thus over-estimate the actual soil nutrient status and lead to under-estimating fertilizer rates needed. This problem is even greater in reduced tillage systems.

Uniformity of soil sampling depth is one of the most critical parts of soil testing, yet it is one of the most common sources of error. Figure 12.1 illustrates an extreme example that emphasizes the problem. These sample results represent the difference in soil test P and K results for 4", 6", 8" and 10"sampling depths is Herman Warsaw's high yield field, which produced 370 bu/acre corn yield in 1985. Though the numbers are not as dramatic, similar variation is common in any field, and is even more pronounced in reduced-tillage and no-till fields where stratification of nutrients is common.

Pattern

Whether variable-rate nutrient application is planned or not, sampling the soil in an organized pattern is a good management practice. It helps ensure adequate representation of the entire field. Most agronomists recommend sampling on a pattern so that each sample represents about 2 ½ acres (one hectare) or less. At least one sample per acre is preferred, especially in areas receiving 25" or more of annual rainfall and in irrigated fields.

Sampling Where Banded Fertilizer Has Been Used

Banded fertilizer applications complicate the process of getting representative sampling. Researchers in Colorado and Kansas devised a plan that does a reasonable job in such situations. The recommendation is to take a number of samples between bands equal to 8 times the distance (in feet) between bands. For example, if bands are 30 inches (2 ½ feet), there should be 20 samples (8 x 2 ½ = 20) collected between bands for each sample collected in the band.

Soil Sampling Instruction Sheet

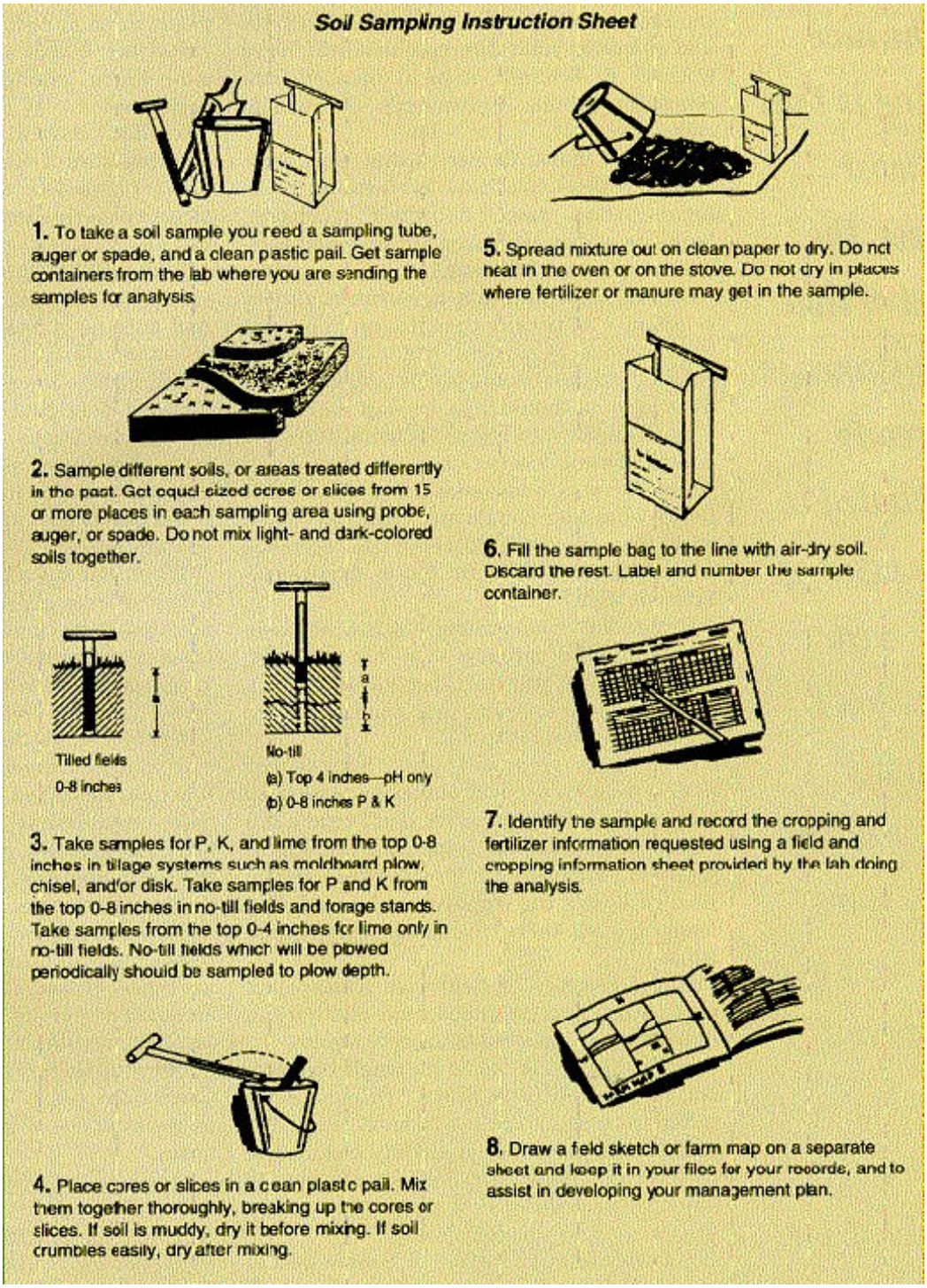

Figure 12.2 Soil Sampling Instruction Sheet (Purdue University) - click on thethumbnail image to see full size image.

Sampling Pattern Options

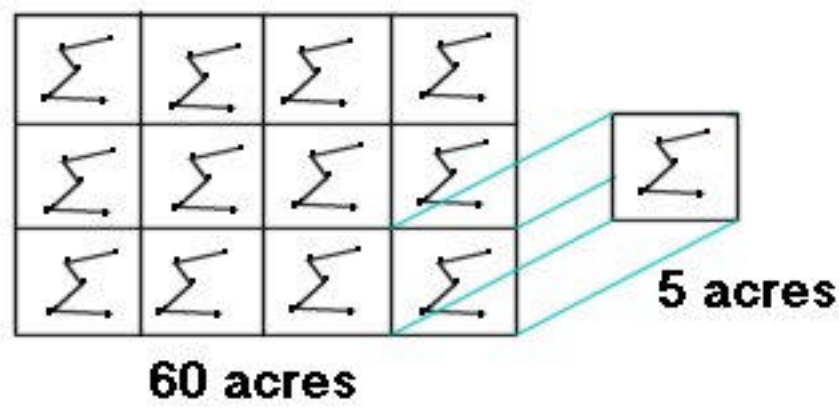

Figure 12.3 Area (Cell) Sampling Technique - Soil Test Values Represent an Area.

The sampling pattern should be selected to best represent the field, accounting for known sources of variability (major soil type changes, past cropping patterns, etc.). A grid pattern is usually the best way to be sure the entire field is represented, but with the possibility of patterns developing from past nutrient applications, cropping effects and other uniform patterns, it is advisable to use a sampling scheme that avoids arranging sampling points in a straight line.

For conventional sampling, a common approach is to divide the field into cells of about 2 ½ to 5 acres, and collect 5 cores in a zig-zag pattern within each cell to make up the sample. (Figure 12.3) This area sampling method provides for fairly complete sampling of the field and a good estimate of the needs for a single uniform application rate to be applied to the entire field.

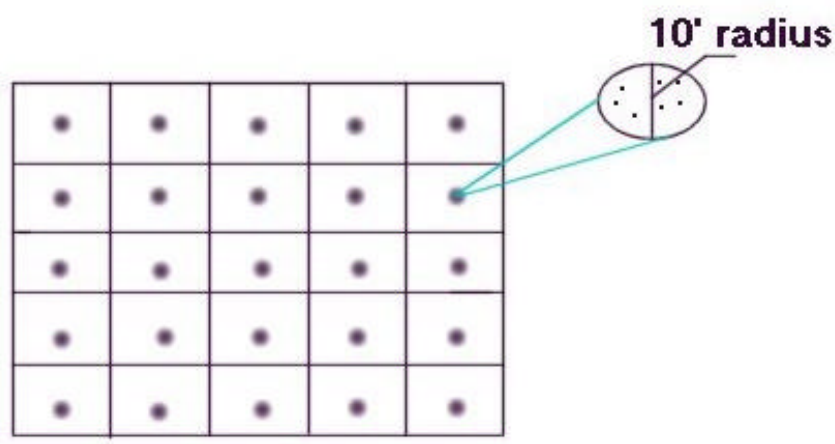

Figure 12.4 Grid Point Sampling Technique - Soil Test Values Represent a Point (Stratified Systematic Square Grid).

To better characterize the field for site-specific management and variable-rate application, point samples can be used to measure the variability across the field. Dividing the field into 2 ½ acre grids and collecting a sample for each cell, the grid lines help ensure a good spatial representation of the field that can be used to develop a nutrient map. Again, 5 cores should be collected, but they should be within a 10-foot radius of the center point for the sample. This provides nutrient information for the point, and the collection of data for all points in the field provides the basis of nutrient variability maps. Several different interpolation schemes are used to estimate the nutrient levels across the field based upon the sample points. The more points, the more accurate the map, but there is a practical and economic limit to the sample density---which appears to be about 2 ½ acres per sample (Figure 12.4).

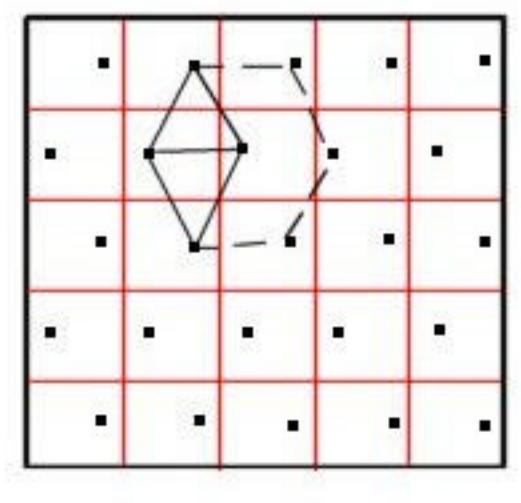

Figure 12.5 Stratified Systematic Sampling Triangle, Diamond, or Hexagon.

To avoid sampling bias caused by patterns in the field due to tillage, crop residue, fertilizer application, and other patterns associated with crop production, a staggered pattern can be used. (Figure 12.5.) It helps avoid the pattern bias, yet provides an organized sampling scheme to represent the entire field. This pattern can be set up by counting rows, using a measuring wheel or using a global positioning satellite (GPS) navigation system. To gain the benefits of grid sampling, yet also the benefits of random sampling, the stratified systematic unaligned sampling pattern (Figure 12.6.) can be used to help avoid the effects of any patterns in the field.

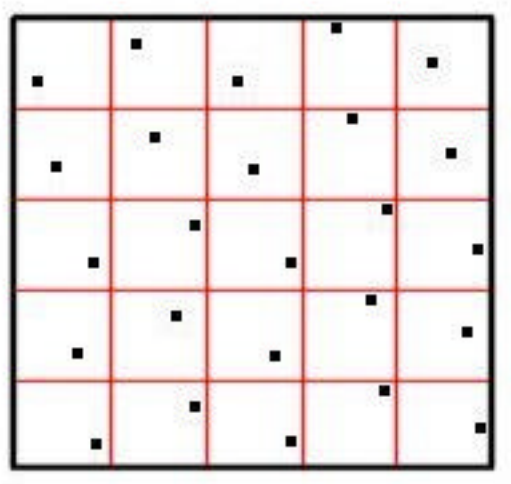

Figure 12.6 Stratified Systematic Unaligned Sampling.

Geo-referencing records. The GPS provides accurate positioning of the sample points, so that accurate geo-referenced maps of nutrient levels can be made with geographic information systems (GIS), and related to other data sets such as yield maps, soil survey, and remote sensing imagery. Even if GPS is unavailable, sample points should be referenced.

Auxiliary Data Layers

Knowledge of specific sources of yield variability can be used to guide the sampling pattern. Additional samples may be taken to represent known wet spots, areas where cattle feedlots had previously been located, etc. Soil Survey maps, yield maps, topographic maps, aerial photographs and management histories are examples of auxiliary data layers that may be helpful in determining the best sampling pattern. If these data layers are in a GIS database, they may be used to help refine the recommendations for the field.

Soil survey maps are useful in determining major limiting factors, such as poor drainage, steep slopes, and erosion. Soil survey data can be used to identify variation in soil organic matter, soil texture and other factors influencing changes in soil water content across the field and over time. This is important information to guide nutrient applications, pesticide rates, and other production inputs.

Sampling by Soil Type

Some agronomists prefer to set sampling patterns to reflect variation in soil types within the field. This plan requires a good soil survey map for the field, which may be obtained from the Natural Resources Conservation Service (NRCS). Digital soil surveys being developed for many counties can be incorporated into the GIS database, making all of the data associated with soil types available as a part of the management tool package.

In this sampling plan, sample points are set to lie within the bounds of the different soil types, with care taken to avoid sampling on the transition between soil types.

Where intensive, site-specific management is planned, it may be helpful to have a special Order 1 Soil Survey prepared for the field. The local NRCS office should be able to help identify a soil scientist who can prepare such as survey. (Specifications for Order 1 Soil Survey, specifically designed for site-specific management systems, have been developed by the Illinois State NRCS office staff.)

As with grid sampling, you will need to choose between area sampling (several cores taken at random points throughout the soil type boundary and mixed together for the sample) or point sampling (several cores collected within a few feet of specific sample points within the boundaries of each soil type). If point sampling is used, the points can be geo-referenced so that they can be related to other data sets or to future soil sampling.

The number of samples should be based on the known variability within the field. The number of cores per sample can also be chosen on that basis. Generally at least 5, and preferably 8, cores per sample should be collected. The cores for each sample should be thoroughly mixed before being sent to the lab for analysis.

Soil Survey

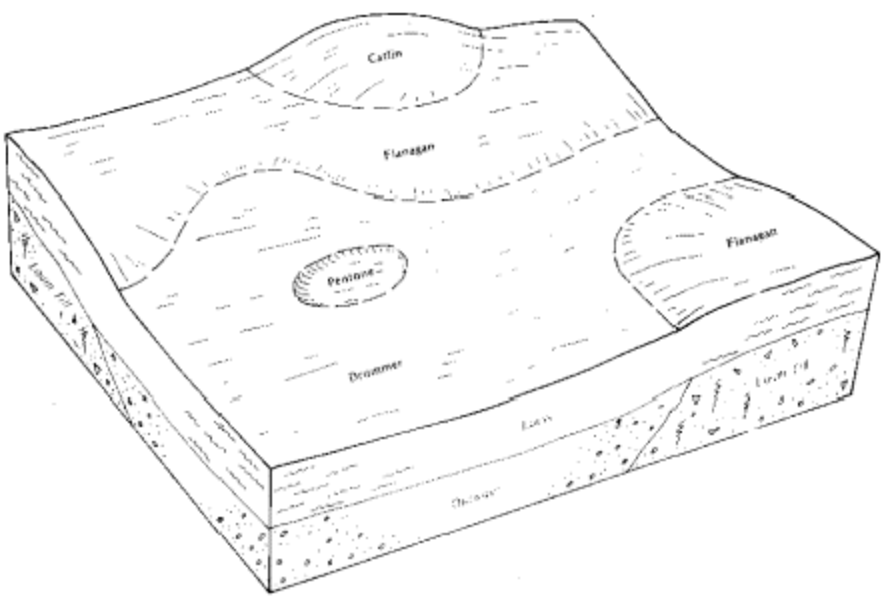

Figure 12.7 Topographic Representation of Soil Map.

Soil surveys are an important tool for nutrient management planning. They provide useful information for interpreting soil test results and predicting response to added nutrients. Most of the natural variability in soil nutrient levels and productivity is due to the characteristics documented in the soil survey. It is an excellent place to start in designing a sampling plan for nutrient management.

These diagrams, from Bob McLeese, Illinois State Soil Scientist for NRCS, illustrate a common problem with following a strict grid approach to sampling. The depressional

area on the topographic map (Figure 12.7) appears on the soil survey map (Figure 12.8) as Peotone-330. If a straight grid is used to establish sampling points (Figure 12.9), none of the points lies in the Peotone area, so it is missed entirely. In fact, of the 64 sample points in this field, up to 40% fall on boundaries between soil types.

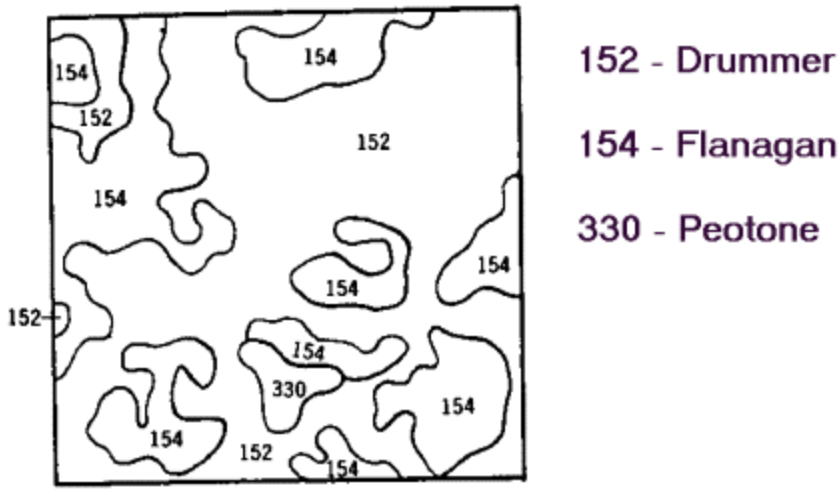

Figure 12.8 Soil Survey.

By using a soil survey map or topographic map to "bias" the sampling and be sure the sample points are well within a given soil type, the influence of soil type and topography can be better taken into consideration when interpreting soil test values. While the relative importance of soil type of the soil test results is influenced by many factors, it is helpful to avoid this "Peotone" problem whenever possible.

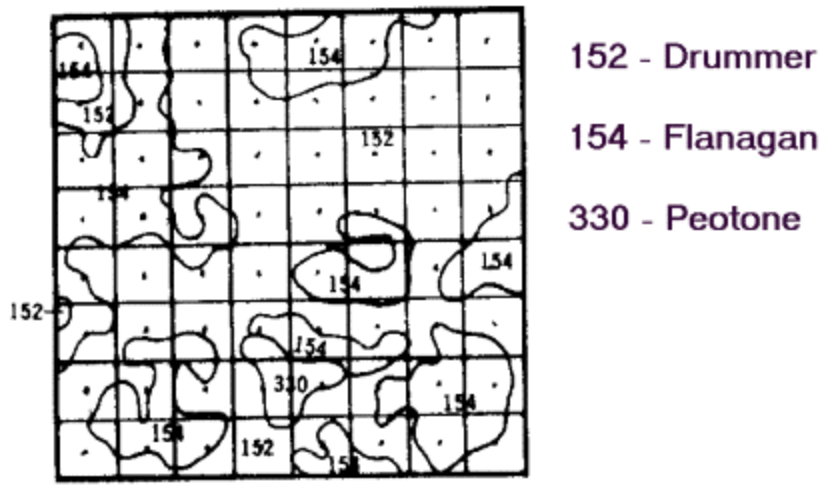

Figure 12.9 Straight Grid Over Soil Survey.

Whether sampling by soil type or by grid, the soil survey should be consulted in designing the sampling pattern to be used.

Smart Sampling or Biased Sampling

It is common sense, and good management, to adjust sampling patterns to help account for known sources of variability, such as topography, previous management patterns, old livestock lots or fence rows. These features can affect soil test levels and should be considered in determining sampling points. Even if a grid sampling pattern is used, it should be adjusted for known sources of nutrient variability. In some cases, you need to avoid these specific features. In other cases, it may be important to collect samples to adequately represent them.

Combinations

Many combinations of these different sampling patterns could be used. For example, grid sampling within soil types is a popular variation that gives some of the benefits of both systems. Select the pattern that will best represent the field. Remember the goal is to best represent the variability within the field. Design a pattern that will best do that. Even if variable-rate application is not planned, having the geo-referenced soil test record can be a valuable management resource. It also helps prepare for future implementation of variable-rate systems.

When?

Choose a time that is convenient and allows adequate time to get results back from the lab and interpretations and recommendations made in time for the application of nutrients. Sampling time is flexible, but it is important to sample at the same time each year if you intend to compare results from one year to the next. A few helpful guidelines:

1. Be sure to note date of sampling in the record system. Some recommendations may require adjustment factors for samples taken at different times of the year.
2. Avoid mid-summer, especially on sandy soils, where wetting and drying cause movement of salts and affect the pH.
3. Sample before seeding or liming on acid soils where perennial forage crops will be planted.
4. Avoid late winter sampling on heavy textured soils. Freezing and thawing tend to release potassium and give unusually high soil test readings.
5. Use October to December sampling for spring fertilizer applications and March to April for fall fertilizer applications. These periods tend to have the lowest testing variability.

Sampling Under Different Tillage Systems

Different tillage systems provide different amounts of mixing and different depths of mixing of nutrients. Often nutrients become stratified----or layered---in the soil profile. This can affect availability of nutrients to the plant, especially if moisture conditions limit root activity at anytime during the growing season. For example, if nutrients accumulate

in the top 3 to 4 inches of the rootzone and the soil dries out in mid-summer, the plant may become undernourished because of positional unavailability of the nutrients. That is, the supply is actually there, but inaccessible to the roots due to lack of moisture.

Moldboard Plow

Where a moldboard plow is used at least once every two or three years, nutrients and pH are uniformly distributed throughout the plow layer. For P, K, and lime recommendations, samples should be taken to the plow depth---usually about 8 inches. Try to avoid collecting samples from the last year's fertilizer band.

Mulch Tillage

Some nutrient and pH stratification can be expected in mulch tillage systems, including chisel, disk and field cultivator systems. Sampling to a depth of about 8 inches with care to avoid old rows and fertilizer bands is recommended. Since muilch tillage also helps maintain moisture, this stratification is not necessarily a problem, and may result in concentrations of nutrients in small zones of varying pH, which may enhance nutrient uptake efficiency.

No-Till

Where continuous no-till is practiced, distinct stratification of pH and nutrients is observed. Samples for routine P and K analysis should be taken to a depth of about 8 inches, again attempting to avoid crop rows and fertilizer bands. Stratification under no-till has not proven to be a problem in most cases. However, under drought stress, long-term no-till fields may become nutrient deficient in the lower part of the old plow layer. Monitoring the 4- to 8-inche depth, especially for K, may be helpful. Deep band placement of K is an effective means of overcoming this weather-related problem. Since lime is relatively immobile, recommendations for continuous no-till fields where lime is surface-applied should be based on a 4-inch sample depth. This also means that the amount of lime applied should be ½that recommended for a conventionally tilled field at the same pH.

Identifying Missed Opportunities Through Intensive Sampling

More intensive sampling can help identify missed fertilizer and crop profit opportunities in high testing fields. Consider a central Illinois field with an average soil test K level of 358 lb/acre. According to the University of Illinois Agronomy Handbook, this soil test is in the range where only maintenance fertilizer application would be needed. Based on a yield goal of 200 bu/acre corn and 60 bu/acre soybeans, the maintenance recommendation would be 134 lb/acre K2O for the 2-year rotation.

Sampling on a 1-acre grid, reveals the spatial variability of the soil test level making up that average. Using the "build up plus maintenance" fertilizer recommendation determined on the basis of the one-acre cells instead of the field average, 47acres show

a need for build up application of K, 30 acres need maintenance only and 13 acres need no K applied. This means that the field-average approach (in this case, maintenance only) would put fertilizer on 13 acres that need none, and would miss the opportunity to supply needed "build up" nutrients on 47 acres.

This field is representative of much of the eastern Midwest, where a long history of fertilizer use has resulted in field average soil test K levels in the adequate range, but where significant areas within the field still need build up applications to reach or maintain optimum productivity. There is no way to determine the total fertilizer market potential represented by these areas unless detailed grid sampling is done. For most fields, that means sampling every 1 to 2 ½acres, either on a uniform grid, or a modified grid that accounts for known sources of variability.

This is just one example of how site-specific management can be used to identify hidden market potential for fertilizer and at the same time uncover hidden profit potential for the farmer…all in areas where most people consider productivity to be optimum and fertilizer markets to be mature. Of course, a true site-specific management system would include other factors, such a yield variability from provious crops, in determioning the recommendations.

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Figure 12.10 K Recs Based on 1-Acre Sampling Grid.

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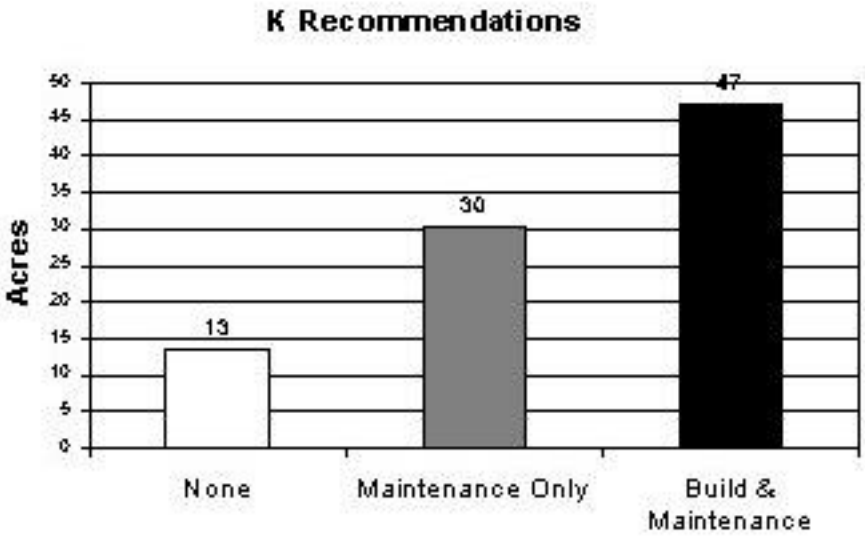

Figure 12.11 K Recommendations Chart.

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Links to other sections of the Efficient Fertilizer Use Manual

History • Mey • Soil • pH • Nitrogen • Phosphorus • Potassium • Secondary • Micronutrients • Fertigation • Fluid-Dry • Testing • Site-Specific • Tillage • Environment • Appendices • Contributors