Soil-sampling and testing is one of the most important operations in crop production. Traditionally, soil samples are collected throughout the field to get an "average" representation of soil characteristics. Recommendations for fertilizer and lime application rates are based on this collective field representation and used to develop a soil fertilization and liming schedule. This procedure leads to positive yield gains only if the high and low yielding areas in the field are close to the average. However, experience has shown that a lot of Georgia fields, even small fields, have high and low-yielding areas that are significantly different from the average yield. As a result, a uniform application rate can leave parts of the field with too little or too much fertilizer and lime.

High- and low-yielding areas of the field can be separated into smaller areas and managed independently. Soil samples can then be taken from each smaller area to determine if the soil properties are contributing to the differences in yield and if variable rates of fertilizer and lime may be economically beneficial. Sampling smaller areas will require more soil samples than normally collected for individual fields. If the field does have significant variability in soil properties, the producer may want to consider a variable application rate or addition of soil amendments.

While site-specific soil sampling can improve field management, it must be accompanied by conscientious collection and analysis of data. The new technologies that have elevated precision agriculture into the forefront of farm management cannot offset poor data collection and soils testing techniques. Inaccurate data on soil properties will inevitably lead to improper management decisions.

This bulletin addresses three primary factors that can affect the precision management of soil fertility: 1) collecting proper soil sample cores and the consequences of improper soil sampling, 2) breaking the field into smaller management areas, and 3) differences in test results and recommended application rates between soil-test laboratories. A step-by-step procedure is then presented on how to use variable yield goals to develop field maps showing variable application rates of fertilizers and lime.

In making recommendations for accurate spatial soil-testing, this bulletin refers to a study that was conducted on a 27 ha (67 acre) field in Tift County, Georgia. The field was managed on a 3-year rotation of center-pivot irrigated cotton-cotton-peanuts. Soil samples were collected prior to planting the second year of cotton in the rotation. Samples were collected at two soil sample depths (7.5 cm [3 in] and 15 cm [6 in]) and were sent to two soil test laboratories for analysis of phosphorous, potassium and pH and to obtain recommendations for phosphate, potash and lime application rates. A yield goal of two bales per acre on irrigated cotton was used to calculate soil requirements from both labs.

Developing Soil-Sampling Areas Within the Field

Before a precision sampling program can begin, a field must be divided into a grid or management zones. A field grid is a uniform pattern of squares, rectangles or other shapes that divide the field. Typical grid areas range from 0.4 to 2 hectares (1 to 5 acres), depending on the size of the field and the number of samples taken. Management zones use plant and soil properties to divide the field into zones that have relatively consistent topography and soil properties. Zone size and shape are dependent on the amount of variability within a field.

Management zones or field grids cannot be created without an accurate field boundary. There are a couple of methods for creating a field boundary. One method is to
Figure 1. (A) Aerial photograph of 27 ha (67 ac) field six weeks after planting cotton. (B) management zones of field; and (C) 0.8 ha (2 ac) field grids.
to determine fertilizer and lime application rates. It is more difficult to develop the zones, but they usually require less soil sampling than field grids and can more accurately represent the variability in the field. Figure 2 illustrates the example field with variable rates of lime prescribed for each zone based on the soil sample test results and the producer’s yield goal. In this case, one yield goal was used for the entire field.

**Collecting Soil Sample Cores**

Accurate representation of the soil characteristics is extremely important to determining the recommended application rates. Recommendations for soil sampling depth are provided in the Soil Test Handbook for Georgia (Plank, 1989) Recommended practices are also available in UGA Leaflet No. 99:

www.ces.uga.edu/pubcd/L99.htm

Follow these practices and guidelines for each of the soil samples collected for precision soil management. In our study, it was shown that an inaccurate soil depth significantly changed the measured soil properties (Rains et al., 2001). The exact inaccuracies were dependent on which soil properties were analyzed. Phosphorous, phosphate and lime recommendations were the most affected by the depth of sample (test results of a 15 cm [6 in] soil sample core were statistically different from a 7.5 cm [3 in] sample).

Although this study was a unique case for one field, it is expected that sample depth will affect the soil-test results and recommendations for fertilizer and lime in all fields. The level it affects a field will depend on the soil types, topography, tillage practices, crops planted and water availability. It is difficult to determine how accurately the sampling must be to avoid altering the soil test results. In some cases, the soils may be homogeneous over a fairly large depth, while in other cases, soil stratification could largely affect results. A recommendation to sample within ±1 inch of the desired sample depth is recommended here to reduce inaccuracies in desired application rate recommendations.

A GPS receiver and portable computer (laptop or handheld) loaded with one of the software packages listed earlier can provide a method for navigating to soil sample sites. Take samples in management zones from two to three locations within that zone and mixed into one sample.

**Soil Test Laboratory Choice**

Lab-to-lab variability can affect soil-test sample results as well as the recommended application rates.

When comparing soil samples that were split and sent to two separate laboratories, results between the labs were significantly different for pH, phosphorous and potassium levels in the soil, even though both laboratories used the same soil test procedures (mehlich-1 test for P and K, and pH meter) and analytical equipment (Rains et al., 2001). Recommended application rates from the two laboratories were also different. One laboratory used the University of Georgia crop-response functions and the other used “in-house” developed functions to make application recommendations. Consequently, it is best to remain with one lab for soil analyses and application rate recommendations. This is especially true when the producer is monitoring year-to-year changes in soil characteristics and yield responses. If two laboratories are used, find out from each laboratory what basis was used to make application rate recommendations before making any management decisions. If they do not use the same crop response functions and soil testing procedures, the two lab results and amendment recommendations are not comparable.

Some laboratories will create application maps if they are given a computer file with the field boundary, management zones or grids and the location of the soil sample points. The laboratory will create application rate recommendations in each zone based on the soil test...
results and the producer’s prescribed yield goals. They then create an application map in a computer file for use by the sprayer/spreader truck with a variable rate controller (Figure 2, page 3). Consult the soil test laboratory before investing in software packages to ensure compatibility with data formats. Also, if the producer plans on creating his/her own application maps, consult with the company that will be applying the variable rate materials to make sure the software package creates application maps compatible with the variable-rate equipment.

Yield Goals

Results from variable rate studies indicate that some soils will not respond to higher rates of fertilizer or lime. Consequently, a constant yield goal for a field can be as self-defeating as a constant application of fertilizer and lime. Areas requiring a high fertilizer rate because of poor soil nutrient levels and a high yield goal may not show a response and cost much more in fertilizer. It is recommended that when looking at a particular management zone, determine a reasonable yield goal for that area and then get fertilizer recommendations based on that yield goal for that zone.

Precision Farming
Soil-Sampling Recommendations

A checklist of required tools for soil-sampling and creating application maps includes:

- GPS receiver with differential correction
- Software to store GPS data points (where samples were taken), create management zones or field grids, and create application map for variable rate sprayer/spreader
- Soil sampling equipment (core sampler, soil sampling bags, etc.)
- Laptop computer or handheld computer to run software and navigate in the field with the GPS

Using these tools, the following is a step-by-step summary of the process for creating a variable rate application map:

1. Develop management zones for taking soil samples and creating variable rate application maps. Utilize aerial photos, yield maps, field history and any other pertinent data known about the field to create zones within the field. If using an agricultural supplier to variable-rate apply fertilizer and lime, make sure their equipment and software can handle maps created from management zones.

2. Take soil samples in each zone using the soil sampling tools listed above. Always take soil samples at the recommended depth within each zone so soil test results are accurate. Follow the guidelines in the Soil Test Handbook for Georgia appropriate for the particular crop, irrigation, etc.

3. Take samples to a laboratory for analysis. If the field is divided into zones, consider setting different yield goals for each zone that are reasonable, and get recommended application rates tailored to each zone’s yield goal. Use the same lab each year for sample analysis and recommendations.

4. Create an application map for the field using the recommendations from the soil test lab in each management zone. Application maps can be created with several software packages and are provided as a service from some soil test labs and agricultural consultants.

References