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# Soil Testing: Field, Sample and Laboratory Variability

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# Soil Science News & Views

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## SOIL TESTING: FIELD, SAMPLE AND LABORATORY VARIABILITY

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### Introduction

Soil testing has advanced as a science and has become a tool widely used in making fertilizer recommendations. One of the basic components for ensuring reliability of recommendations is calibration of soil test results to determine the proper match of fertilizer recommendations with the soil test level for each nutrient and crop. Generally, calibration has been accomplished on small plot areas and is quite accurate. Even though there is nutrient variability within small areas, the potential for variability is much greater on a field basis. An important factor in making reliable fertilizer recommendations is the assumption that the soil sample itself accurately represents a field. Large variations in fertility levels and pH within a field can result in poor recommendations. Therefore, the nutrient variability within a field is of interest and importance. In some cases, the nutrient variability within a field can be caused by a number of things such as soil erosion and deposition, combining of fields, past history, fertilization and manure application patterns, soil types and other factors. Large variability within a field has been proven to cause variable yields. Soil test records from many fields over a number of years show that the extent of soil test variability is dependent on the field. Because of this, some fields show little change in soil test levels from year to year while other fields show large changes in the nutrient status from year to year. Such large yearly changes can come from a combination of primarily four sources: 1) Variability in the field as described above; 2) How the soil sample is taken (number of cores, depth, time of year, etc.); 3) Quality control within the laboratory (the capability of the lab to reproduce its results); and 4) Fertilizer applied during the year and time of soil sampling relative to fertilizer application and crop growth. We have closely monitored a field for a number of years to evaluate the effect of these factors on making lime and fertilizer recommendations.

### Description of Study

A field in Webster County was identified on which a good record of soil test results from the same testing laboratory over years was available and the results varied significantly from year to year (Table 1). Some of the variability may be attributed to changes in extractants used by the testing laboratory during this period and this may have contributed to the year-to-year variability. However, we feel that most of the variability was due to other factors. The field was 22 acres in size and contained 3 soil types, Grenada, Loring, and Belknap Silt loams. The field had been moldboard plowed for a number of years and had been in a corn and soybean rotation since 1975.

Four people sampled the field individually on the same day (December 3, 1987), and each person sampled the field 3 times to a depth of 8 inches (plow depth). The field was then divided into 12 separate areas based on differences in soil type and topography. Each of these areas was then sampled separately.

All samples were analyzed by the same soil testing laboratory 3 times without the knowledge of the laboratory personnel.

## Results

The soil test history (Table 1) shows a significant amount of variability. Either the soil fertility status in the field changed drastically each year or the variability in the field is high, making it difficult to get a representative sample. Although the yearly field records are not complete for fertilizer application rates and time of soil sampling, we assume that some of the differences are due to nutrient variability and/or how the field was sampled.

***Variability by Area:*** Table 2 shows the variability we found in the field from intensive sampling. Some nutrients varied considerably from area-to-area, with the greatest variation being in P, pH and Mg. One area tested as low as 16 in P and another area as high as 58. The pH was as low as 5.1 in one area and as high as 6.4 in another. Areas with the low values of P and pH would be underlimed and underfertilized based on the field average soil test values. These low areas seemed to occur where moderate to severe erosion had taken place. Although there was some variability in K and Ca, it was not as great as that of pH, P, and Mg. The average soil test for the field was 35 P and 5.9 pH, but there was significant variation above and below this average.

***Effect of Soil Sampling:*** It is likely that such variability could result in different soil test results each time the field was sampled. Table 3 shows that this happened. Even though the same sampler obtained identical results a few times for P and several times for pH, in most cases they were different, and in one case by as much as 80% with P. The K, Ca, and Mg almost always differed although not greatly in most cases. But, as shown by our results (Table 2), it would be possible to pull a sample that would be relatively high in most nutrients, or one that would be relatively low in most nutrients. This shows that nutrient level and pH variability within a field can possibly be a greater cause of year-to-year variability in soil test results than fertilizer and lime use and cropping systems. The differences between years could vary even more if the field were sampled at different times of the year and by different people. It is worth noting that there was a tendency for the samples with the fewest cores to vary the less the chance that one or two cores, very high or low in nutrients, would greatly influence the results.

***Laboratory Variation:*** Variation in the laboratory is usually considered to be small, which was the case in this study. We calculated standard deviation of the test results to help with this determination. The standard deviation gives the range within which 2/3 of the values fall. Based on this, we calculated that there were 6 times more variation in values due to field sampling than from laboratory procedures. We also calculated the average difference that the individual samples varied from the mean of the larger population. Using this method, we found that field sample variation was over 5 times greater than the laboratory variation.

## Summary

A 22-acre field which had a history of large, yearly fluctuations in soil test results was sampled intensively. Areas within the field were found to vary greatly and caused variations in results of composite samples of the entire field. Only a small amount of the variation was found to be due to laboratory procedures.

## Conclusions

1. Great variation in the soil test results from one year to the next is a good indication of large nutrient variations within the field.

2. Subdividing the field for sampling is the best way to minimize variation in results.

3. When subdividing is not possible, making lime and fertilizer recommendations based on an average of the past 3 or 4 years test results is the next best alterative.

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**Table 1. Soil Test History of Overall Field as Taken by Farmer and Tested by University of Kentucky Service Laboratory**

| | | Soil Test Results | | |
|---|---|---|---|---|
| **Year** | **Crop** | **pH** | **P** | **K** |
| 1979 | Soybeans | 5.6 | 25 | 190 |
| 1980 | Corn | 6.2 | 52 | 289 |
| 1981 | Soybeans | - | 75 | 329 |
| 1982 | Corn | 6.7 | 38 | 172 |
| 1983 | Soybeans | 6.7 | 47 | 195 |
| 1986 | Corn | 5.9 | 22 | 194 |

**Table 2. Soil Test Results from 12 Different Topographical Areas in the 22-Acre Field.**

| | | | | Lbs/Acre | | | |
|---|---|---|---|---|---|---|---|
| **Description** | **No. of Areas** | | **pH** | **P** | **K** | **Ca** | **Mg** |
| Ridgetop | 1 | Avg. | 6.1 | 47 | 180 | 2403 | 89 |
| | | Range | - | - | - | - | - |
| Side Slope, 4-5% slope, slight to moderate erosion | 3 | Avg. | 6.1 | 46 | 224 | 2627 | 156 |
| | | Range | 5.9-6.4 | 35-58 | 178-283 | 2497-2770 | 144-171 |
| Side Slope, 4-8% slope, moderate to severe erosion | 2 | Avg. | 5.2 | 19 | 229 | 3027 | 285 |
| | | Range | 5.1-5.4 | 17-20 | 211-247 | 2813-3240 | 275-294 |
| Red Upland Knoll | 2 | Avg. | 5.5 | 27 | 196 | 2772 | 145 |
| | | Range | 5.4-5.6 | 16-37 | 167-224 | 2477-3067 | 117-173 |
| Toe Slope | 2 | Avg. | 6.1 | 36 | 181 | 2703 | 115 |
| | | Range | 6.0-6.1 | 36-36 | 176-186 | 2657-2750 | 109-121 |
| Bottom Area | 2 | Avg. | 6.4 | 42 | 170 | 3158 | 140 |
| | | Range | 6.4-6.4 | 42-42 | 159-181 | 3007-3310 | 126-154 |

**Table 3. Difference in Soil Sampling Results with Four Samplers and Three Different Samples Taken on Same 22-Acre Field at Same Depth on the Same Day**

| | | | | | Lbs/Acre | | | |
|---|---|---|---|---|---|---|---|---|
| **Sampler** | **Sample** | **Cores #/Field** | **pH** | **Buffer pH** | **P** | **K** | **Ca** | **Mg** |
| 1 | 1 | 27 | 6.0 | 6.9 | 41 | 192 | 2837 | 154 |
| | 2 | 32 | 6.0 | 6.8 | 36 | 193 | 2703 | 143 |
| | 3 | 21 | 6.0 | 6.8 | 36 | 173 | 2527 | 126 |
| 2 | 1 | 24 | 5.8 | 6.8 | 38 | 200 | 2903 | 141 |
| | 2 | 21 | 5.8 | 6.8 | 37 | 187 | 2573 | 116 |
| | 3 | 38 | 5.9 | 6.8 | 29 | 184 | 2977 | 133 |
| 3 | 1 | 16 | 5.4 | 6.7 | 24 | 168 | 2660 | 203 |
| | 2 | 16 | 5.8 | 6.9 | 43 | 217 | 2747 | 176 |
| | 3 | 16 | 5.6 | 6.7 | 34 | 173 | 2670 | 163 |
| 4 | 1 | 17 | 6.0 | 6.9 | 33 | 228 | 2840 | 147 |
| | 2 | 24 | 6.0 | 6.9 | 33 | 216 | 3013 | 149 |
| | 3 | 20 | 6.0 | 6.8 | 33 | 237 | 2830 | 170 |
| **Overall Average** | | | 5.9 | 6.8 | 35 | 197 | 2773 | 152 |

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