UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

Managing Seasonal Fluctuations of Soil Tests

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Understanding the seasonal fluctuations of soil test measurements during the year can aid in the understanding and in interpretation of soil test results that vary from year to year or samples taken within the same year.

Many factors can cause soil results to vary from year to year, with seasonal fluctuations being one of them. Seasonal fluctuations are mainly controlled by the uptake and release patterns of nutrients by the crop and by environmental conditions. If soil samples are taken from a field the same way and the same time each year and the results are higher or lower than expected, seasonal fluctuations can sometimes explain these results.

A spring soil sample gives a more accurate picture of what will be available to the plant that year. However, a fall soil sample offers many advantages to the producer such as sampling during good weather, allowing time for planning of the coming crops, and giving lime time to react prior to spring planting. Understanding the seasonal fluctuations of soil tests will allow a producer to take fall soil samples that better represent the fertility in the soil and obtain a more efficient lime and fertilizer recommendation.

Of the commonly reported soil test measurements, phosphorus (P), potassium (K), and pH are the most affected by seasonal fluctuations. Thus, these are the ones that will be examined in this publication.

Field Study

In order to monitor fluctuations in soil P, K, and pH over a season as influenced by Kentucky growing conditions, a corn trial was established in 2004 at Princeton, Kentucky. The trial area was 16 feet by 17.5 feet on a Pembroke soil with 32 sampling sites. Sampling consisted of collecting four cores to a depth of 6 inches from two positions: 1) directly in the row or 2) between the rows. Each sampling position was replicated four times. Fertilizer (50-60-60 pounds per acre of N, $P_2 0_5$, and $K_2 0$, respectively) was applied March 18, 2004, and corn was planted on April 6. Additional nitrogen (100 lb/ac) was broadcast on May 20. Each site was sampled every two weeks beginning on May 6 through October 2004. In early September (2004), 200 bushels of corn per acre were harvested, and stalks were shredded. Later soil samples were taken December 13, 2004, and January 27 and March 3, 2005. The rainfall in 2004 was ideal for a record corn crop, with the only dry period coming in September and early October.

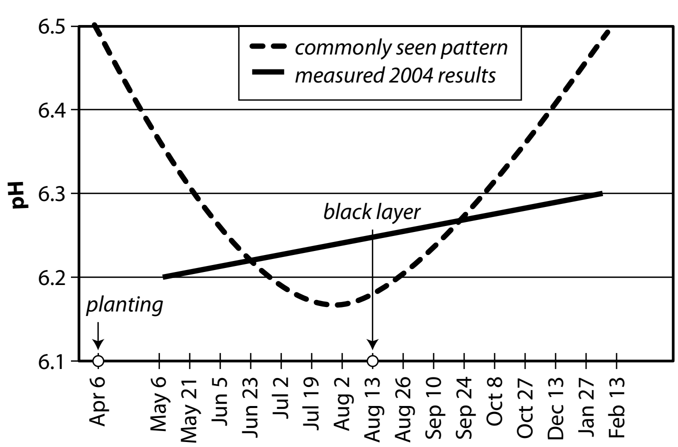
pH

Seasonal fluctuations in pH are not unusual. They are affected by fertilizer rate, time of fertilizer application, organic matter, and root and bacterial activity as well as soil moisture. The pH is usually lower during the summer and early fall and then increases as the soil moisture increases. The reduction in soil pH during this time is generally attributed to soil drying, root and bacteria activity, and nitrification of nitrogen fertilizers. Nitrogen fertilizers containing ammonium are changed to nitrate (nitrified); this process releases acidity (hydrogen ions). The roots and bacteria in the soil produce carbon dioxide that temporarily lowers the pH during the height of their activity. The salts in the soil (natural and added as fertilizers) can concentrate near the soil surface as the soil dries and displace hydrogen ions (acidity) from the cation exchange complex into the soil solution that also lowers the pH. This process is reversed as the soil moisture increases.

All of these factors work together to lower the pH during the growing season. The pH drop is commonly 0.2 to 0.3 of a pH unit (Figure 1), but can be as high as 0.5 of a pH unit or more during very dry periods and can persist as long as these very dry conditions last. Some years it may be late in the fall before the soils are sufficiently moistened to achieve a stabilized pH.

Factors that work to raise the pH during this time are applied agricultural lime that is dissolving and ample rain to keep the soil moist. These factors can reduce or prevent seasonal fluctuations in soil pH. Figure 1 shows an increasing soil pH throughout the growing season of 2004 as a result of a very moist summer and a lime application two years before the study. There was little change in pH during this season and no differences between samples collected in the row compared to the row middles.

Figure 1. Effect of time of cropping year on soil pH in a corn trial, 2004.



Soil tests of pH that are lower than anticipated, based on previous tests of a field during a dry fall, may be due in part to this temporary effect. Wells and Thomas examined soil pH from two tobacco fields in 1999 during a dry summer and early fall. When the soluble salts were removed, the soil pH was raised from 5.96 to 6.66 for one field and from 5.82 to 6.75 in the other field.

A spring sample gives the most accurate answer but is not always practical.

Potassium (K)

Seasonal fluctuations in soil test K are seen almost yearly and can be large. As the crop grows and matures, uptake lowers the soil-available K. Large amounts of K are taken up by the plant, about 160 lb/ac of K_20 in a 150 bu/ac corn crop. For corn, wheat, and grain sorghum, most of the K is in the vegetation with only about 25 to 30% in the grain. Once the grain is harvested, the K in the residue is washed back into the soil. The net effect is that soil test K drops until the crop reaches physiological maturity and then increases slowly as the K is leached from the residue. However, soybean grain contains about 60% of the total K taken up by the crop, so removal is higher, and the soil test K does not rebound to the same extent as other grains.

For crops where the entire plant is harvested such as tobacco, hay, and silage, K removal is highest since everything taken up by the plant is removed from the field. In these cases, the K soil test can drop rapidly in the field with little recovery later in the season.

Figure 2 shows these effects on a K soil test. As the corn grew, the soil test K decreased. Early in the season, it decreased more rapidly in the row where the roots were more concentrated. This difference disappeared as the roots moved into the row middles later in the season. The soil test K began an upward trend at physiological maturity as the plant began to die. The soil near the row increased faster than the row middles as rains moved the K from the dead tissue into the soil. After the crop was harvested and stalks were mowed, this difference became smaller due to more even distribution of the residue and the K leaching.

Soil sampling in the fall for grain crops often results in a lower K soil test than a winter or spring sampling. The difference can be as much as 50 to 100 lb per acre and will be greatest if sampling is done immediately after harvest in a dry fall with little rain to leach the K from the plants. This should be kept in mind when making potassium fertilizer recommendations from fall samples. It should also be kept in mind during fall sampling that there are significant differences between sampling in the row and between the rows. A spring sample is a more accurate measurement of what the plant will see during the season. To better represent this with a fall sampling, samples should be taken beside the row, or at the very least, equal numbers of cores should be collected from each position.

The soil test K for the January and March 2005 samples was higher than the May 2004 samples (Figure 2). This was probably due to the exceptionally good crop in 2004 that removed large amounts of K from the lower profile and deposited it to the surface after harvest by the previously described residue leaching.

Phosphorus (P)

Seasonal fluctuations of soil tests for P are smaller than for pH and K. The quantity of crop P uptake is much lower than K, with most of the P ending up in the harvest grain. The smaller amounts left in the residue are not easily leached from the plant and require microbial decomposition for release (a much slower process). The soil is also a great buffer for P. Fertilizer P is converted to chemical compounds in the soil that greatly reduce its solubility, and it also stabilizes the soil test P and prevents rapid fluctuations.

Figure 3 characterizes soil test P changes during the 2004 growing season with corn grown for grain. The soil test P began a decline in May as the 60 lb/ac of P_20_5 fertilizer began to react with the soil (converting into more unavailable forms) and as the corn began to remove P from the soil. There was no difference between the soil test P measured in the row as compared to between the row until close to black layer formation. At this time,

Figure 2. Effect of time of cropping year on potassium soil tests in a corn trial, 2004.

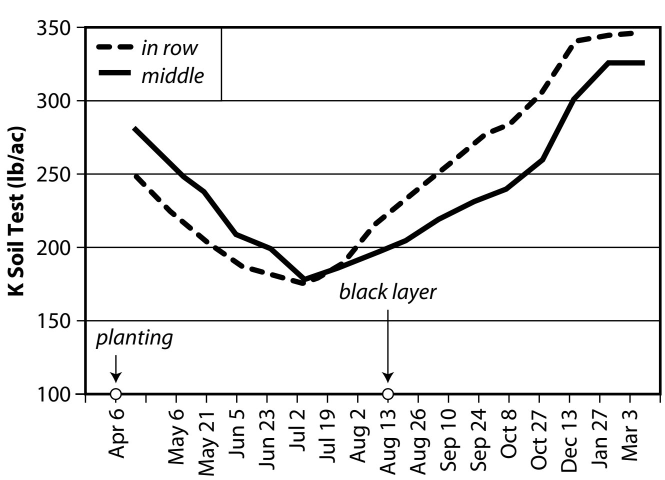
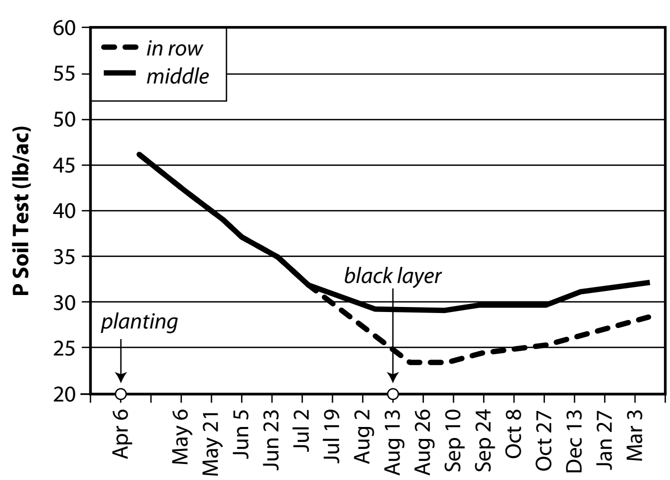


Figure 3. Effect of time of cropping year on phosphorus soil tests in a corn trial, 2004.



P measured in the row continued to decline, while P measured between the rows did not. Following harvest, both sampling positions began to gradually increase. The differences between soil test P measured in the two positions are small enough not to present a problem for fall soil sampling.

Conclusion

Fall soil sampling is a popular practice. It offers the advantages of sampling during good weather, allows time for planning for the coming crops, and gives lime time to react with the soil prior to spring planting. However, it is not without some disadvantages. Because of seasonal test results fluctuations, the pH and soil test K measurements tend to be at their lowest. The amount of rainfall and crop uptake will affect this.

Soil test results should be compared to previous tests to help determine if seasonal fluctuations are great enough in a year to make adjustments in the fertilizer and lime recommendations. When soil sampling in the fall, sampling beside the row may be a more accurate representation of real soil test K but would have little or no effect on the P and pH. At the very least, samples should be taken in equal numbers from both the row and row middle positions to help reduce the seasonal effects.

References

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Issued 5-2006