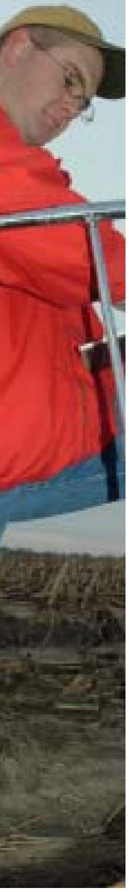

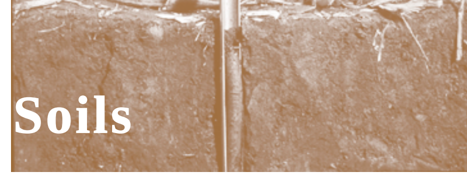

The Fertility of North American Soils

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Food and fiber are fundamental to the survival of all civilizations. Agriculture is the major source of both and agriculture depends on **productive soils** to support the plant life that captures the sun's energy to produce the products that become our food, fiber and, more recently, a growing portion of our fuel. For soils to be productive, they must be fertile. Therefore, the **fertility of our soils** is a critical indicator of the health of our agriculture and of our food, fiber, and fuel production capacity.

Assessing Soil Fertility by Soil Tests

This is a report of the phosphorus (P) and potassium (K) fertility of the soils of North America. These two essential nutrients, along with nitrogen (N), are the most frequently limiting nutrients for crop production in North America and throughout the world. The data used in this report were provided by 70 major North American public and private soil testing laboratories that analyzed 3.4 million soil samples submitted to them by farmers and their advisers for the purpose of determining the amount of plant nutrients to apply prior to the 2005 growing season. As such, this summary is probably the most comprehensive evaluation of the status of soil fertility in North America ever conducted. Additional details of how laboratory data were processed and summarized and complete frequency distributions for soil test levels for each state and province are available in the soil test summary bulletin (Potash & Phosphate Institute, 2005). Regional interpretations of the results are available in a special edition of *Better Crops with Plant Food* (Potash & Phosphate Institute, 2006).

A laboratory soil test is an analytical procedure that extracts a quantity of the nutrient of interest from a soil sample that is correlated with what plant roots obtain from the soil. In-field research has been conducted on the tests used by laboratories to relate the quantity extracted by the soil test to the soil's ability to meet the nutritional needs of the crop. If the soil test indicates the soil will not be able to supply sufficient nutrient for the crop to be grown, a recommendation is given for additional nutrients to be applied in the form of fertilizer or manure.

Critical Soil Test Levels

One way of indicating the soil fertility status for a large region such as a state or province is to determine the percent of soil samples that test below a critical level. In this summary, **the critical level is defined as the level below which a profitable yield response by most major crops in the year of application is expected based on university research**. In other words, if fertilizer or manure is not applied every year a crop is grown, agronomists expect yield and profitability to be reduced. For some universities, this level represents the break between medium and high in their rating while in other cases it is the break between high and very high. It may also represent the lower limit of the optimum or maintenance range.

Phosphorus and potassium critical levels used for this summary are shown in **Figures 1 and 2**. These levels vary across North America due to variation in soil organic matter levels, soil texture, soil mineralogy, climate, major crops planted, and other cultural practices. These differences in turn result in variation in research results on crop response at various soil test levels. Critical levels for specific crops will also vary and may be either below or considerably

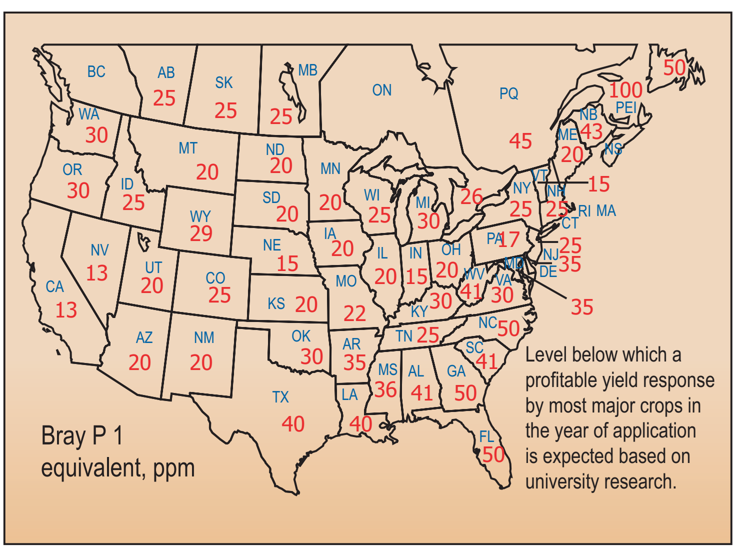


Figure 1. Critical soil phosphorus levels, 2005.

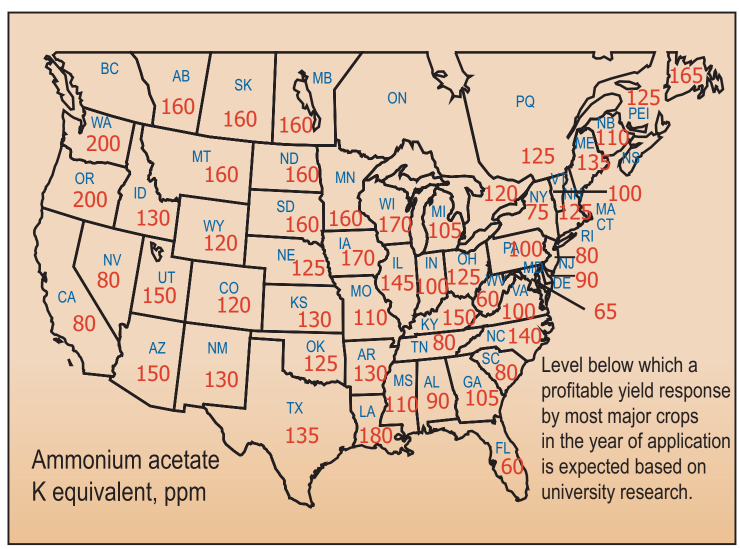


Figure 2. Critical soil potassium levels, 2005.

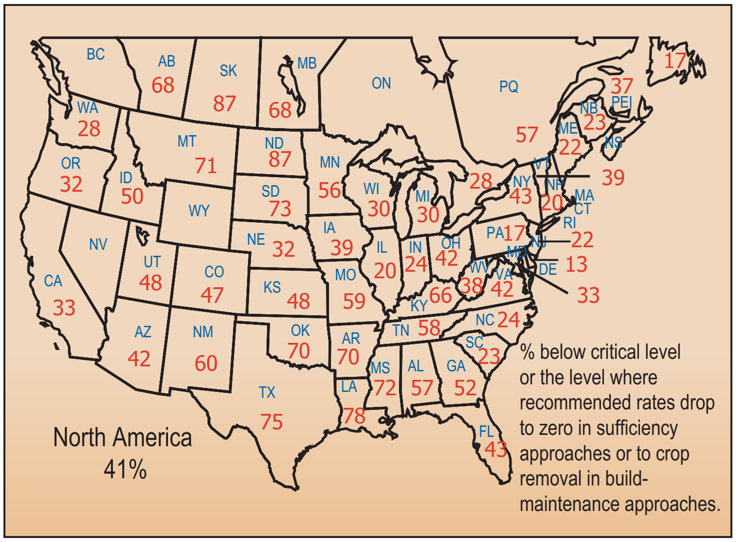


Figure 3. Percent of soil samples requiring annual P fertilization to avoid profit loss in most major crops in 2005.

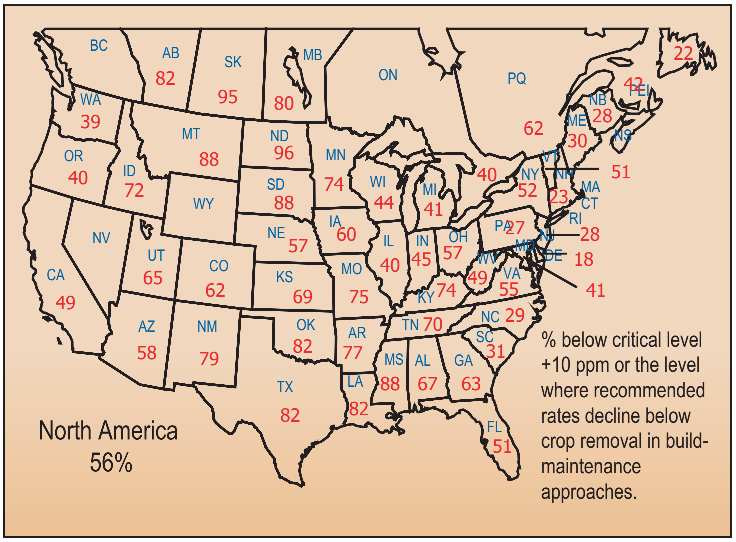


Figure 4. Percent of soil samples requiring a P rate of at least crop removal when following a typical build-maintenance program.

above those presented here. Generally, critical soil P levels increase in North America as you move towards the southeast and south central U.S. Soil K critical levels are generally lower for the eastern states and provinces than for the rest of North America.

When Soils Test above the Critical Level

For a given range above the critical level, fertilizer may or may not be recommended based on philosophical considerations, attitudes about risk, crop quality effects, land tenure, tax considerations, and other factors that are specific to individual farmers, fields or soils. Two widely recognized soil test interpretation approaches or philosophies are employed by those responsible for offering soil testing-based nutrient recommendations (Leikam et al., 2003).

Nutrient sufficiency approach: Since the goal with this approach is to apply just enough fertilizer to maximize profitability in the year of application, no fertilizer is generally recommended if soils test above the critical level.

Build-maintenance approach: The goal of this approach is to minimize the possibility of P and/or K limiting crop growth while providing near maximum yield, high levels of grower flexibility, and good economic returns over the long run. Soil test levels are increased by recommending more nutrients than are removed by crops, until the critical level is reached. Once the critical level is attained, the rate recommended drops to the quantity removed in the harvested portion of crops with the objective of maintaining soil test levels. Maintenance fertilizer is then typically recommended across a range of soil test levels, often extending about 10 ppm above the critical level for P or 25 ppm above the critical level for K. If soil test levels are above these values, the recommendation drops below maintenance amounts.

University laboratories differ in recommendation approaches used for soil test interpretation as do private laboratories and agronomists. In general, sufficiency approaches are more common in western North America, while build-maintenance approaches are more common in the East.

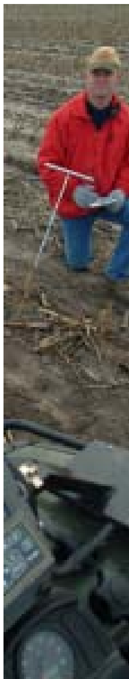
Interpretation of the 2005 Soil Test Summary

With the recent increases in fertilizer costs, sound soil testing along with appropriate interpretation of the results have increased in importance to growers. Therefore, in this summary of soil fertility, two maps are presented for each nutrient. The first map shows the percent of samples that test below the critical level and that require annual fertilization to avoid profit loss. The second map shows the percent of samples requiring a rate of at least crop removal when following a build-maintenance program. A third set of maps is under development that will use the recommendation approach utilized by the university or agency with fertilizer recommendation responsibility for each specific state or province. This article will be updated in the near future to include this third set.

Phosphorus and Potassium Fertility

For North America, 41% of the 3.4 million soil samples collected for the 2005 crop year indicated that P fertilizer should be applied each year to avoid profit loss by most major crops (**Figure 3**). States and provinces varied greatly from a low of 13% in Delaware to a high of 87% in North Dakota and Saskatchewan. Annual P addition tended to be most often needed in the Northern Great Plains and Midsouth and least often in the Mid-Atlantic and Northeast regions. If a typical build-maintenance soil fertility program is being followed, 56% of the samples indicated a P rate of at least crop removal is needed (**Figure 4**). Regional differences in P fertility are due to a combination of historical manure or fertilizer use patterns and differences in indigenous soil properties.

The K fertility of North American soils as a whole



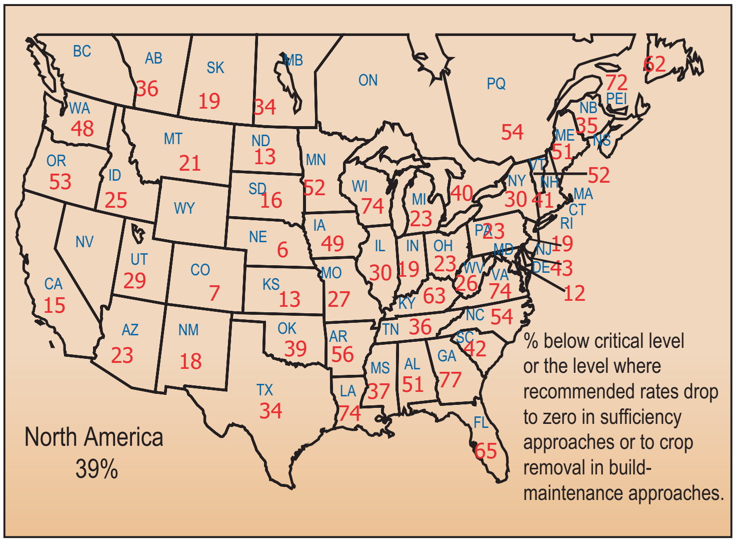


Figure 5. Percent of soil samples requiring annual K fertilization to avoid profit loss in most major crops in 2005.

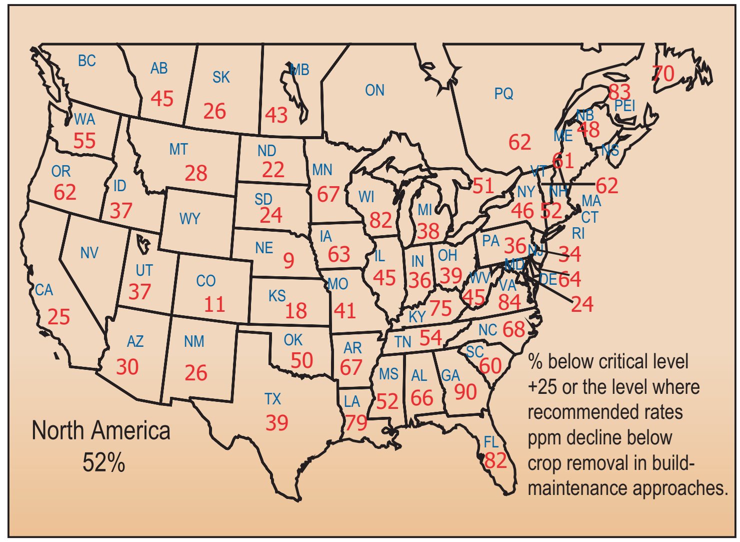
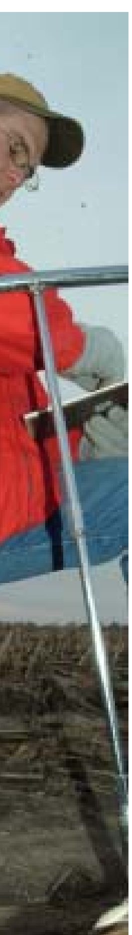


Figure 6. Percent of soil samples requiring a K rate of at least crop removal when following a typical build-maintenance program.



is similar to P, with 39% of the summary samples showing that K fertilizer should be applied each year to avoid profit loss by most major crops (**Figure 5**). If a typical build-maintenance soil fertility program is being followed, 52% of the samples indicated a K rate of at least crop removal is needed (**Figure 6**).

The distribution of the most fertile and least fertile soils for K is much different than for P. Annual K addition was generally most often needed in the Southeast and least often needed in the central Great Plains. Nebraska shows the lowest frequency of annual need at 7%, while Georgia shows the highest frequency of 77%. These regional differences are due primarily to indigenous soil properties. The central Great Plains and much of western North America generally have high K soils due to the prevailing climate and dominance of soils that have developed from high K parent materials. However, crop removal over several decades with limited nutrient addition is significantly reducing soil K levels in this region. On the other hand, the Southeast experiences a more intense weathering environment and has soils developed from parent materials lower in K and with a limited capacity to hold onto plant available K.

Fertility Changes since the Last Summary

A primary function of soil testing is to monitor changes in soil fertility over time to determine if adjustments in management are needed. Comparison of the results of this soil test summary to the previous summary, conducted in 2001, can provide some insights into soil fertility trends across North America. **Figure 7** shows the direction of change in typical P and K levels for individual states or provinces where sufficient data were available to determine if change had occurred. Changes in geographic sample sources due to changes in participating laboratories between the two summaries coupled with low sample volumes in some states or provinces reduces the ability of this summary to detect changes over time. However, some regional trends do seem apparent.

For P, much of North America shows little change. Levels appear to be trending downward in a couple states in the Midsouth and slightly downward in Quebec. It is important to note that these decreases in the Midsouth are occurring where soil P levels are already quite low as indicated in **Figures 3 and 4**. A few eastern states and states in the Pacific Northwest appear to be showing increases in P. However, the volume of samples in the summary from the northwest states was much lower than in the 2001 summary, so the changes could be reflecting changes in laboratory participation and the dominant source of samples within these individual states.

Two trends in K changes are evident (**Figure 7**). Nearly half the states and provinces (46%) west of the Mississippi River indicate decreases in soil K levels. This is not surprising since these states have many high K testing soils, reducing K fertilization. The result is gradual soil test depletion over time as high indigenous levels are depleted by crop removal. Growers in these states need to diligently monitor levels in their fields as more of them continue to drop into ranges where fertilization is needed. The other trend is the increasing K levels in the heart of the Corn Belt. This is a puzzling trend since K application in most of these states is less than crop removal. Research is planned and underway to understand more about the K dynamics in these important soils.

Summary

Critical to appropriate use of this information is recognition that nutrient management should occur on a site-specific basis where the needs of individual fields, and in many cases areas within fields, are recognized. **Therefore, a general soil test summary like this one has no value in on-farm nutrient management.** Its value lies in calling attention to broad nutrient needs and challenges and in motivating educational and action programs.

The key findings of this summary of tests per-

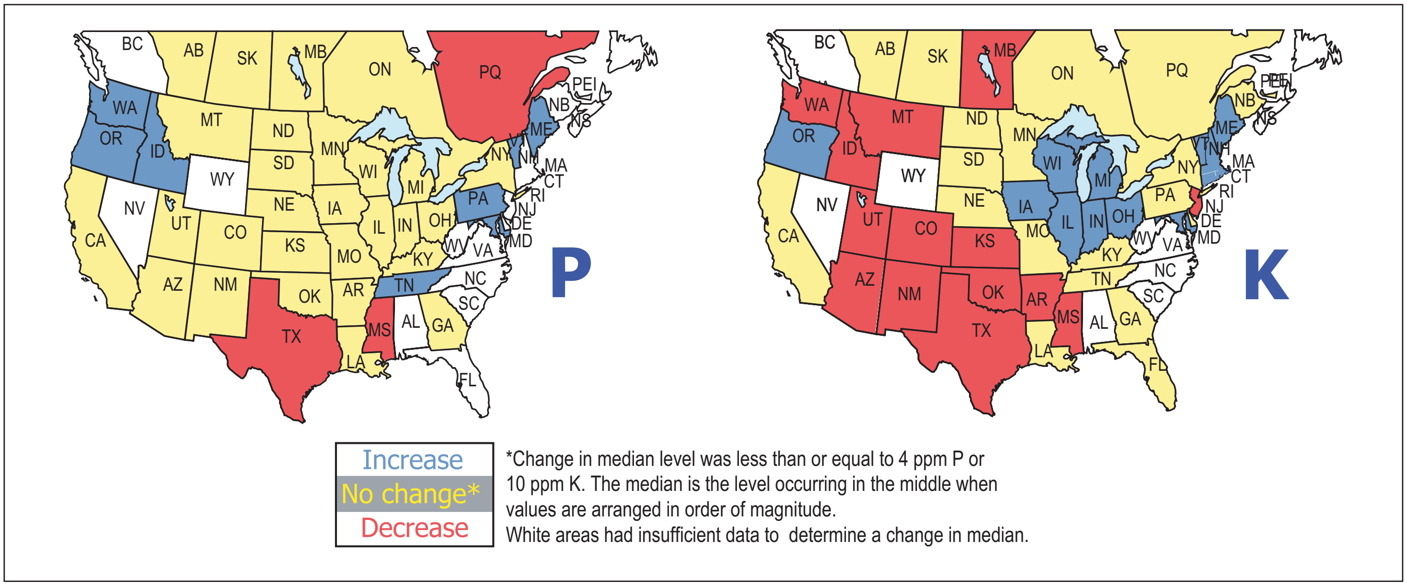
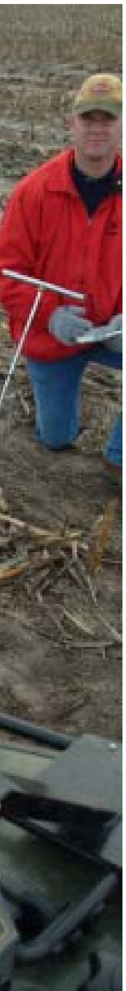
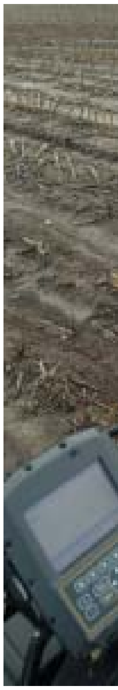


Figure 7. Change in typical soil test levels from 2001 to 2005.





formed on 3.4 million soil samples collected for the 2005 crop year:

- 41% of the P tests and 39% of the K tests indicated that fertilizer should be applied each year to avoid profit loss by most major crops. Little management flexibility exists for these soils.
- For typical build-maintenance recommendation programs, 56% of the P tests and 52% of the K tests indicated a rate of at least crop removal would be needed.
- Much of North America showed little change in soil P since the 2001 summary. There were trends of decreasing P levels in the Midsouth and Quebec and increasing levels in the Pacific Northwest and a few eastern states.
- Since the 2001 summary, soil K levels declined in nearly half the states and provinces west of the Mississippi River. Soil K levels increased in several major Corn Belt states even though more K was removed in crops than was applied.
- The wide-ranging distribution of soil test results in nearly all states and provinces points clearly to the need for soil testing to determine fertility needs of specific fields as a guide to fertilizer and manure application.

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