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P and K Reserves Growing Thinner

Do we know enough about optimum soil test levels and nutrient needs at high yield levels is the question being asked.

In the past year, the Potash & Phosphate Institute completed a comprehensive evaluation of P and K levels in North American soils, as well as the rate at which these nutrients are removed from the soil by U.S. crops. Data in its soil test summary were provided by 34 public and 31 private laboratories and consisted of 2.5 million soil samples collected for the 2001 crop year.

The purpose of this article is to highlight some of the more important findings.

Current P status

The median soil test P level for North America is 28 ppm Bray P1 equivalent, indicating that 50 percent of soil samples are less than this amount. Soil test P levels show a skewed frequency distribution with a broad peak running from 5 to 30 ppm and accounting for over 50 percent of the samples. Another 24 percent test greater than 50 ppm.

The lowest median P levels are found in the Northern Great Plains while the highest occur in the Northeast. Regional cumulative frequency distributions show a marked trend of increasing P levels west to east across North America. Nearly 80 percent test below 20 ppm in the Northern Great Plains, while only about 10 percent test below 20 ppm in the Northeast.

Across all of North America, 47 percent of the samples are medium or below in P. (The traditional protocol for the summary is to use the laboratory's definition of medium; therefore, it is not numerically consistent across North America.) As expected, considerable variation exists among states and provinces (Figure 1). The northern Great Plains has the highest frequency of medium or below P tests, with values in the 60 to 90 percent range, while a few states in the Northeast are below 20 percent.

Historical trends

Soil test levels in the Great Plains have been quite stable since the summaries were initiated: 70 to 80 percent medium or below in the north (Alberta, Saskatchewan, Manitoba, South Dakota, and North Dakota) and 50 to 65 percent in the south (Kansas, Nebraska, and Oklahoma). These data indicate that P nutrition remains an important yield -limiting factor in much of the Great Plains.

In 1975, slightly over 50 percent of the samples in the summary were medium or below in the six leading Corn Belt states (Iowa, Illinois, Indiana, Minnesota, Nebraska, and Ohio). As farmers built soil test levels, percent medium or below declined to approximately 40 percent in 1989. Since then, the trend has reversed and these six states are again approaching 50 percent medium or below, similar to the 1975 level.

In contrast to the stable or currently declining soil test P trends in the Great Plains and Corn Belt states are the currently increasing trends in states with large manure supplies relative to crop P demand (North Carolina, Michigan, Wisconsin, Pennsylvania, and Arkansas). Of the five, Arkansas has experienced the most dramatic increase in P test levels with percent medium or below dropping from nearly 90 percent in 1975 to 40 percent today. Over that quarter century, poultry and hog numbers nearly doubled, plus commercial phosphate use increased approximately 40 percent as well. However, 40 percent of Arkansas samples still test medium or below and would be expected to give first-year response to P.

P removal

Historical trends show P removal in the U.S. has been less than inputs over a period extending from 1960 to 2000. In fact, in the late 1960s and early 1970s,

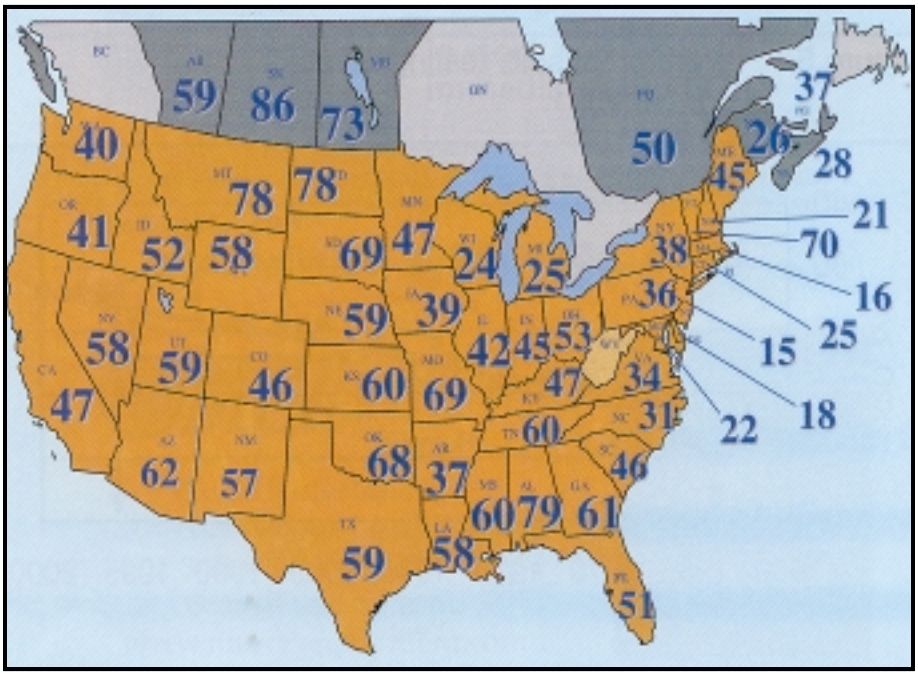

Figure 1. Percent of soils testing medium or below in P in 2001.

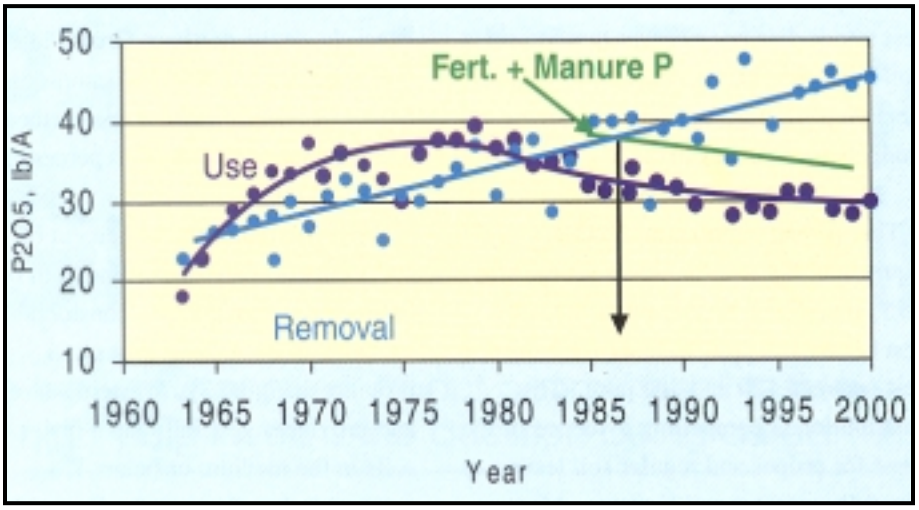

Figure 2. Average P use on corn and soybeans relative to crop removal in the U.S.

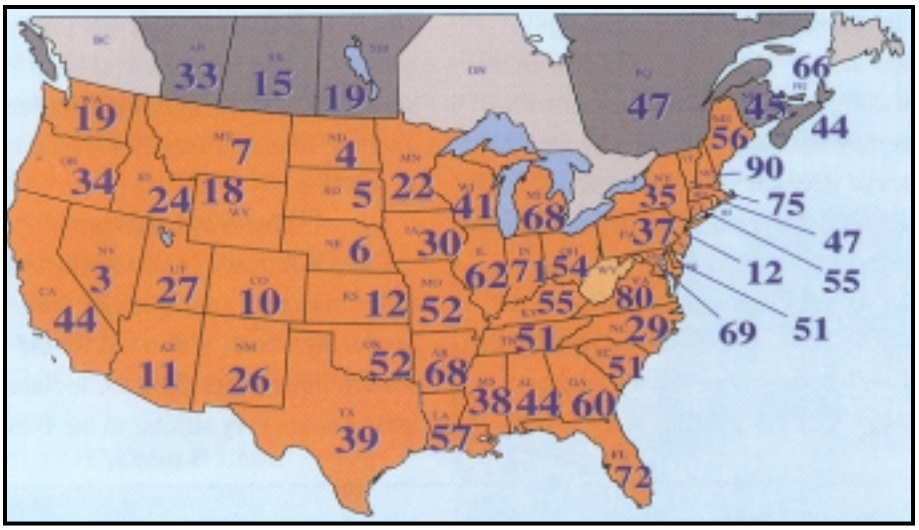

Figure 3. Percent of soils testing medium or below in K in 2001.

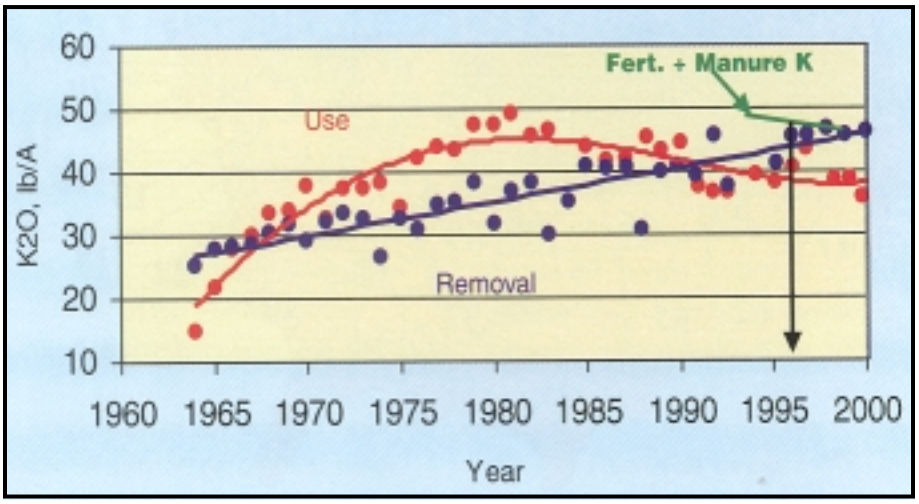

Figure 4. Average K use on corn and soybeans relative to crop removal in the U.S.

P removal by 22 commonly grown crops was only 60 percent of P inputs (fertilizer + recoverable manure). This resulted in build-up of soil test P in many regions of the U.S., especially the Corn Belt. Since 1970, the removal-to-use ratio has trended consistently higher and is now over 0.90 for the U.S. as a whole. If only manure applied to corn, soybeans, wheat, and cotton is considered in the estimate of P inputs instead of total recoverable manure, P removal in the U.S. exceeded use by approximately 20 percent in the year 2000.

Since much of the U.S. corn crop is grown is rotation with soybeans, average use of P on corn and soybeans is a meaningful expression and is graphed in Figure 2. The USDA-ERS estimate of manure P applied to corn and soybeans is included. The analysis indicates that P removal has been exceeding use since the late 1980s, with the deficit growing each year. In 2000, the average deficit was over 10 lbs/A of P_2O_5. This is corroborated by the independent estimate of soil test trends discussed earlier that indicates soil test P levels in the Corn Belt started declining shortly after corn/soybean P budgets became negative.

Current K status

The median ammonium acetate equivalent K level for North America is 155 ppm. Over 50 percent of the soils test below 160 ppm K, and over a third test between 120 and 200 ppm. This distribution is compelling evidence of the need for proper and regular soil testing to carefully monitor soil K status. Many soils test near or below what most calibration research indicates is a critical level for crop response. This is especially true in the North central region where nearly 70 percent fall between 80 and 200 ppm. This frequency distribution may also help explain why we often observe interactions between K and other growth factors such as variety or hybrid, tillage, and weather.

As with P, clear regional differences exist. In contrast to P, the highest median **K** levels occur in the Great Plains and western states while the lowest levels occur in the eastern

regions. For example, in the northern Great Plains less than 20 percent of the samples are below 160 ppm, while in the northeast and southeast more than 70 percent are below 160 ppm.

For North America, 43 percent of soil samples analyzed test medium or below in K. Once again, considerable variation exists among states and provinces (Figure 3). Western states and provinces generally have fewer soils in the medium or below K categories than those in the East. The higher K levels of the West reflect the less weathered status of western soils. However, in states such as California, where 44 percent of soils test medium or below in K, crop removal over several decades with limited nutrient addition has significantly reduced soil **K** levels.

Historical trends

Historical trends in soil test K levels differ markedly among major corn producing states. The trend for the eastern three states (Illinois, Indiana, and Ohio) is very similar to the P trend observed for these states. Percent medium and below in K reached a low point in 1989 and has been steadily increasing ever since. Currently, over 60 percent of samples test medium or below in K. This is in striking contrast to Iowa and Minnesota, where percent medium and below has been steadily declining in linear fashion from 1968 to 2001, suggesting a steady build-up of low and medium testing soils into the high or very high categories. In 2001, only 26 percent of the samples from these two states tested medium or lower in K, which in this case means below 120 ppm. In some respects, this observation appears in conflict with recent field observations from this region of an increase in frequency of K deficiency symptoms in corn and soybeans. However, many soils from the region test between 120 ppm and 200 ppm where K availability problems have been observed. For Minnesota and Iowa, 53 percent of samples test below 160 ppm, and 78 percent test below 200 ppm. Furthermore, ongoing studies by Iowa State University suggest that the existing soil test procedure and associated interpretation may overestimate the K-supplying capacity of some soils. Percent medium or below in Nebraska has been stable throughout the summary period at 5 to 10 percent.

Percent of soils testing medium or below in K may be trending upwards slightly in the northern Great Plains (Alberta, Saskatchewan, Manitoba, South Dakota, and North Dakota) and downwards slightly in Idaho, Oregon, and Washington, although very little change in any direction has occurred in these two regions for the last several summaries. Although variable, an upward trend has occurred in California, increasing from 20 percent in 1986 to approximately 45 percent in 2001. A slow decline in soil test K levels would be expected in much of the West as crops continue to remove K that is not replaced by fertilization.

K removal

Potassium budgets of eastern Corn Belt states have removal-to-use ratios that run higher than P, close to 1.0 when recoverable manure K is considered. In spite of this, some of these states such as Illinois and Indiana appear to be showing trends of declining soil test levels. This should not be surprising since these budgets are calculated at a statewide level and can mask significant nutrient distribution problems. In addition, no account was made for soil erosion losses or potential loss of plant-available K to unavailable forms in the soil.

When the USDA-ERS estimate of manure applied to corn and soybeans is included, K removal by these crops exceeds use in the vicinity of 1997 (Figure 4). Considering 50 to 70 percent of the soil samples from the leading corn states (Iowa, Minnesota, Illinois, Indiana, Ohio—Nebraska is excluded) are less than 160 ppm in soil K, it would seem that continued mining of soil K would be detrimental to crop yields and profitability of the region.

Question

It is plain to see that crop removal of P and K is increasing because yields are increasing. Do we know enough about optimum soil test levels and nutrient needs at high yield levels in the cultural systems and fields of today?

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