

Site-Specific Nutrient Management

For Nutrient Management Planning To Improve Crop Production, Environmental Quality, and Economic Return

Presentation Script: Potassium - Chapter 4

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... and justice for all

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Potassium Management

Slide 1.

This module will go through the most important concepts of potassium management in agricultural systems for profitable crop production. Since it is impossible to cover specific scenarios for all regions of the U.S., general concepts regarding potassium management will be presented. Even though these principles apply for most regions, viewers are encouraged to review locally developed potassium use guidelines.

Slide 2.

Potassium is abundant in most soils, but the majority of it is not readily available to plants. Plants require potassium for photosynthesis; synthesis of energy exchange compounds like ATP, many carbohydrates and proteins; translocation of sugars; and nitrogen fixation in legumes. Adequate potassium supply strengthens plant stalks and stems, thus helping reduce lodging, and also increases resistance to several diseases through a variety of mechanisms. Typical potassium-deficiency symptoms develop first in the older leaves and may consist of yellow or white spots on the leaf edges, as in alfalfa, for example, chlorosis and necrosis of the leaf edges, as in corn and soybean, or chlorosis of leaf tips, like in wheat.

Slide 3.

When compared with other macronutrients, total plant uptake of potassium is generally second only to nitrogen, and in some crops such as sugar beets and potatoes potassium uptake exceeds nitrogen uptake. Annual potassium removal from fields depends greatly on the portion of the plant removed from the field, crop, and yield level. Removal can range from 50 to 500 pounds of potassium oxide per acre. This table shows an example of guidelines concerning potassium removed per unit of yield for several crops.

Slide 4.

The primary goal of soil testing for potassium is to estimate the supply of potassium available to a crop. Solution and exchangeable potassium are the most important forms for plant growth, but the estimate of exchangeable potassium is far more important than the solution potassium fraction. The soil test potassium methods used in the U.S. measure solution potassium and most of the exchangeable potassium. The most widely used methods extract potassium with the ammonium acetate and the Mehlich-3 methods, but a few states use the Bray-P1, Morgan, or

Mehlich-1. Extracted potassium is then quantified using atomic absorption or inductively coupled plasma (ICP), which both provide similar results. Only the top six to eight inches of soil is generally tested for potassium because the surface soil is the most significant source of potassium for most plants. However, in a few states a shallower sampling depth is recommended for pastures and no-till.

Slide 5.

Soil test potassium levels can change significantly during the year as a result of crop uptake, soil moisture and rainfall, and the rate of potassium cycling between crop residues and the soil. This seasonal variation also happens for other nutrients, but it occurs at a greater extent for potassium. High temporal variability in soil-test potassium from harvest of one crop to planting of the next is often associated with the following conditions: a slow equilibration between exchangeable and less-exchangeable soil potassium pools, the effect of precipitation on potassium recycling from residues, and the effects of soil wetting and drying on the equilibration that occurs between soil potassium pools. For these reasons, variation in soil-test potassium over time should be a factor when considering the timing of soil sample collection and when interpreting test results.

Consistency in the time of the year when soil samples are collected is recommended.

Slide 6.

The figure shows how soil test potassium changes as a result of crop uptake and soil moisture for a corn and soybean rotation. Soil-test potassium is lowest near crop maturity, it increases after harvest, and the increase tends to follow increasing soil moisture.

Slide 7.

This figure shows how rapidly potassium recycling occurs, which is faster and of greater magnitude than with phosphorus. This recycling affects soil test potassium level. It is a reason that soil test potassium levels are usually highest a few weeks or months after crop harvest, instead of at or immediately after harvest, and before uptake by the following crop becomes substantial.

Slide 8.

The relationship between soil test potassium and crop yield response has been a subject of significant research. As shown in this conceptual figure, soil test levels are categorized into low, medium (or optimum), or high, and sometimes also into 'very low' and 'very high' categories.

At soil test potassium levels below the 'critical level or range' which is usually medium or

optimum, the probability that a yield increase will result from fertilizer addition is high. Above the critical level, small or no yield responses to potassium fertilization would generally be expected.

Slide 9.

The suggested approach in much of the U.S, concerning potassium recommendations, is to apply potassium if soil test is in the very low or low categories, and over time these applications will usually increase soil test potassium to adequate levels. Suitable potassium rates depend on several factors such as the soil-test potassium category, consideration of potassium removal with harvest, and crop/fertilizer price ratios. The amount of potassium and time needed to reach the optimum soil test level may vary significantly. Once the desirable soil-test potassium level is reached, this level can be maintained by applications based on crop removal. Overall, the general objective is to apply potassium to reach and maintain soil-test values at the optimum category, where the probability of large crop responses is low.

Slide 10.

This figure provides an example of the long-term relationships between potassium removed with harvest and soil test potassium for several typical Iowa soils in a corn-soybean rotation. Data in this figure shows the commonly found high temporal variability of soil test potassium, which is much more than for phosphorus, but shows a linear relationship between potassium removal and soil test potassium over the long term.

Slide 11.

Potassium fertilizer is available commercially mainly as potassium chloride, potassium sulfate, and potassium nitrate. The potassium is water soluble for these products. These sources, especially potassium nitrate, have the potential for inhibiting plant growth due to salt effects if applied in excess and close proximity or with the seed. The salt can disrupt root cells and limits water uptake. Potassium chloride is often referred to as muriate of potash and it accounts for over 95% of all potassium fertilizer sold in the U.S. because it is the most economic potassium source. Potassium sulfate is primarily used where chloride toxicity or sulfur deficiency is a problem. Potassium nitrate also supplies nitrogen, but is expensive and is generally only used for high-value fruits and vegetables.

Potassium in organic sources, manures and sewage sludge, occurs predominantly as soluble inorganic potassium ion, and it is readily available for crop uptake. In animal manures, the

potassium concentration ranges between 0.2 and 2% of dry matter, therefore large application rates are required to meet crop needs.

Slide 12.

There are many ways of applying potassium to crops and most considerations, except for the additional potential of salt effects, are similar to those for phosphorus fertilizers. Band applications concentrate nutrients at or near the root zone, which is important for young plants with limited root systems, particularly in cold and/or compacted soils. However, the starter effect from potassium is much less than for nitrogen and phosphorus, and too much potassium fertilizer close to the seed can reduce seed germination and injure roots due to high salt concentrations. Banded potassium should be placed beside and below the seed level to reduce potential damage, or use very low rates if potassium is applied to the seed furrow. Banded potassium applications can be more effective than broadcast application in soils with a strong capacity to retain added potassium in forms with low plant availability. This can occur in soils with very high clay content or soils with significant levels of vermiculite in the clay fraction. Research with corn has shown that deep banding of potassium can be more effective than other placement methods, especially for ridge-till and sometimes for no-tillage and strip-tillage. Otherwise, and in most regions, broadcasting potassium fertilizer before planting is a convenient and low-cost way for applying high amounts of potassium fertilizer. With the exception of soils with very high potassium retention capacity, the timing of potassium application before planting has little or no impact on potassium use efficiency by crops.

Slide 13.

Dense soil sampling in many fields has shown very large within-field spatial variability of soil test potassium, crop yield levels, and crop response to potassium fertilization. Precision agriculture technologies available to producers or custom fertilizer applicators facilitate application of fertilizer and manure at rates adequate for different parts of a field based on soil test potassium and estimated potassium removal. Grid or zone soil sampling methods, combined with variable rate application of fertilizer or manure, may not always increase crop yield or increase profits compared with traditional uniform rate application because the average fertilization effect on yield and amount of potassium applied depends on the overall level and distribution of soil test potassium values. Also, soil testing seldom is performed on an annual basis, there is always a certain degree of sampling error, especially in fields with high small-

scale variability, and research has shown that short-term relationships between potassium removal and soil test potassium are very variable. Therefore, even with annual soil sampling and variable-rate application, use of this technology faces challenges for potassium management. However, variable-rate application of potassium fertilizer minimizes or avoids potassium application to high-testing areas within fields, reduces soil test potassium variability, and as a consequence, improves potassium use efficiency. Variable rate application of potassium fertilizer is now common in the Great Plains and Corn Belt.

Slide 14.

The figure shows an example of the variation in corn yield response to potassium fertilization for field areas 10 to 25 acres in size that had different soil test potassium values. As expected, the lower the soil potassium test level, the greater the crop yield increase to applied potassium.

Slide 15.

Sample soil as frequently and densely as possible, and use appropriately calibrated soil-test methods based on research for each state or region. Consider yield levels and crop removal between and within fields to help maintain optimum soil-test potassium levels in conjunction with soil testing and account for crop available potassium applied with manures and other organic sources when deciding on potassium application requirements. Fertilize potassium deficient soils using economically sound agronomic guidelines. In general, soils testing ‘high’ or “very high” will not respond economically to additional potassium and should not receive fertilizer except for a small amount of starter fertilizer in certain specific conditions. Divide large, non-uniform fields into smaller fertility management units based upon yield potential, soil tests, and relevant soil properties. Refer to local research and guidelines concerning potassium placement methods to optimize potassium use efficiency and the profitability of nutrient application. Increased potassium crop use efficiency and economic return can be achieved with the right rate, placement, timing, and source that is appropriate for each situation.

Slide 16.

Effective potassium management requires an understanding of potassium reactions in the soil and an awareness of how soil and climatic conditions can affect levels of crop-available potassium. Soils have large amounts of potassium, but most of it is not crop available and the concentration of readily available forms is small and highly affected by crop uptake and many soil and climatic conditions. There is more temporal variability of soil test potassium and

uncertainty with soil testing than for phosphorus, but soil sampling and testing for potassium is still a useful diagnostic tool. The goal of sound potassium management in most regions of the U.S. should be to keep the soil test potassium level at optimal ranges for maximum economic crop yield and utilize application methods that optimize potassium use efficiency and profitability. Substantial within-field variability of soil test potassium and potassium removal with harvest in most agricultural areas justifies the use of appropriate soil sampling methods and variable-rate application technology to increase potassium use efficiency.