Module 4: Potassium Management

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Module 4: Potassium Management

Introduction

• Potassium (K) is abundant in most soils, but the vast majority is unavailable to plants.

• Plants require K for:
  - photosynthesis
  - synthesis of ATP (an energy exchange compound)
  - synthesis of many carbohydrates and proteins
  - translocation of sugars
  - nitrogen fixation in legumes
  - strength of plant stalks and stems
  - resistance to several diseases

• K-deficiency symptoms:
  - yellow or white spots on the leaf edges (in alfalfa)
  - chlorosis and necrosis of older leaf edges (in corn and soybean)
  - chlorosis of leaf tips (in wheat)
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## Potassium Amounts in Harvested Portions of Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Unit of Yield</th>
<th>Pounds K₂O per unit of yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>bu</td>
<td>0.3</td>
</tr>
<tr>
<td>Corn silage</td>
<td>bu grain equivalent</td>
<td>1.3</td>
</tr>
<tr>
<td>Soybean</td>
<td>bu</td>
<td>1.5</td>
</tr>
<tr>
<td>Oat and Straw</td>
<td>bu</td>
<td>1.0</td>
</tr>
<tr>
<td>Wheat</td>
<td>bu</td>
<td>0.3</td>
</tr>
<tr>
<td>Sunflower</td>
<td>100lb</td>
<td>0.7</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>ton</td>
<td>40</td>
</tr>
<tr>
<td>Tall fescue</td>
<td>ton</td>
<td>66</td>
</tr>
</tbody>
</table>

Source: Iowa State University Extension publication PM 1688.
Potassium Soil Testing

- The goal is to estimate the supply of K available to a crop.

- Amount of K in solution is very small, therefore, exchangeable K is the most important pool to measure since it should replenish K in solution as plants take up K.

- The soil-test K methods used in the U.S. approximately estimate exchangeable K, and also include the very small amount of K present in the soil solution.

- Most common K extractants:
  - ammonium acetate
  - Mehlich-3
  - some states use the Bray-P1, Morgan, or Mehlich-1

- Extracted K is measured by atomic absorption or ICP (inductively coupled plasma), which give similar results.
Understanding Temporal Potassium Soil-Test Variability

- High temporal variability in soil-test K from harvest of one crop to planting of the next is often associated with slow equilibrium between soil K pools, precipitation, and soil wetting and drying:
  - Variation in soil moisture can make soil K less or more crop available by affecting the equilibrium between exchangeable and non-exchangeable K pools
  - The timing and amount of K recycling from crop residues is affected by rainfall

- The effects of these processes on soil-test K is difficult to predict

- Reasons for soil-test K variation over time need to be considered when deciding the time of soil sampling and when interpreting results.

- Consistency in the time of the year when soil samples are collected is recommended.
Temporal variability of Potassium Soil-Test

Relationship between soil moisture and soil-test K levels over time in a Southern Illinois soil. Adapted from T. Peck (moisture) and S. Ebelhar and E. Varsa (soil-test K), University of Illinois.
Concentration and amount of potassium in soybean plant tissue (except grain) over time for two K application rates (averages across 11 sites). Adapted from R. Oltmans and A.P. Mallarino, Iowa State University).
Potassium Interpretation and Recommendation Concepts

- The interpretation of test results and recommended fertilization rates vary across regions.

General relationship between crop yield response to K addition and soil-test K level interpretation categories (the medium category often is referred to as optimum).
Potassium Interpretation and Recommendation Concepts

- Recommended approach in much of the U.S.:
  - Potassium application if soil test K is in the very low or low categories; applications will increase soil test K to the medium level (often referred to as optimum).
  - Appropriate K rates depend on soil-test K category, consideration of removal with harvest, and crop/fertilizer price ratios.
  - Consideration of the amount and time needed to reach the optimum soil test level, but varies.
  - Maintenance of desirable soil-test K values based on crop removal.
  - The goal often is to increase to and keep soil-test values at the optimum category, where the probability of large crop responses is low.
Soil-test K and cumulative K removal long-term trends for the average of five Iowa sites. Adapted from A.P. Mallarino, Iowa State University.
Potassium Sources

- Potassium chloride (KCl, 0-0-60)
- Potassium sulfate (K$_2$SO$_4$, 0-0-50)
- Potassium nitrate (KNO$_3$, 13-0-44)
- Potassium in manure and biosolids
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Application Method and Timing

• Band applications concentrate nutrients at or near the root zone (important in cold and/or compacted soils).

• The "starter" effect from K is much less than for N and P.

• Banded K should be placed beside and below the seed level to reduce potential damage or by using very low rates if seed placed.

• Band K applications are recommended in soils with strong capacity to retain K.

• Deep banding K can be more effective for ridge-till and sometimes no-till, where K tends to accumulate at or near the soil surface.

• Timing of K application typically has little or no impact on K use efficiency by crops; except in the rare soil with very high K fixing capacity.
Variable Rate Potassium Application

- Dense or zone soil sampling in many fields has shown very large within-field spatial variability of soil-test K, crop yield levels, and crop response to K.

- Precision agriculture technologies and variable-rate application facilitate application of fertilizer and manure at rates adequate for different parts of a field.

- Variable-rate technology:
  - may not always increase crop yield or increase profits; depends on soil-test K values and variation
  - minimizes or avoids K application to high-testing areas within fields
  - reduces soil-test K variability
  - improves K use efficiency
Within-field soil-test K variability and yield response variability from eight representative strip trials conducted in Iowa. Adapted form A. P. Mallarino, Iowa State University.
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Management Practices for Potassium Fertilization

• Sample soil as frequently and densely as economically possible (every 2 to 4 years), and use appropriately calibrated soil-test methods.

• Consider yield levels and crop removal to help maintain optimum soil-test K levels and account for crop available K applied with manures and other organic sources.

• Fertilize K deficient soils using economically sound agronomic guidelines.

• 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 K placement methods to optimize K use efficiency and the profitability.

• Increased K crop use efficiency and economic return can be achieved with the right rate, placement, timing, and source that is appropriate for each situation.
Summary

• Proper management of K is essential to maximize the profitability and efficiency of a non-renewable resource.

• Although there is large temporal variability of soil-test K and uncertainty with soil testing, soil sampling and testing for K is a useful diagnostic tool.

• The goal of sound K management should be to keep the soil-test K level at optimal ranges.

• Substantial within-field variability of soil-test K and K removal with harvest in most agricultural areas justifies the use of precision agriculture technologies.