Potassium Management
Potassium

• Absorbed by plant as K+ ion

• Unique nutrient - not a part of any plant compound - exists in plant sap

• Functions in plant
  – Activation of > 60 different enzymes
  – Role in photosynthesis and metabolism
  – Conversion of N to protein (high levels required for high protein crops)
  – Reduces plant disease
Nutrient Deficiency Symptoms

- **Alfalfa** - slow growth, white or yellowish spots around tips of older leaflets.
- **Corn** - slow growth, lower leaf tips and margins turn brown and fire, chaffy ears; plants die prematurely from stalk rot and leaf diseases.
- **Small Grains** - Slow growth, delayed maturity, shriveled grain, tendency to lodge.
- **Soybeans** - leaves turn yellow and later brown on the tips and edges; base of the leaf usually remains green; seeds are shriveled.
- **Cotton** - yellow spots between veins, browning of leaf margins, premature dropping of leaves.
K Deficiency Symptoms in Alfalfa

- Slow growth
- White or yellowish spots around tips of older leaflets
- Reduced winter hardiness
K Deficiency Symptoms in Corn

• Slow growth

• Lower leaf tips and margins turn brown and fire

• Chaffy ears

• Plants die prematurely from stalk rot and disease.
K Deficiency Symptoms in Soybean

• Leaves turn yellow and later brown on the tips edges

• Base of leaf usually remains green

• Shrived seeds
Potassium Uptake

- Rapidly taken up in plants
  - Corn
    - Uptake soon completed after silking
    - Moved from leaves and stalks as plant matures
  - Soybean
    - Larger percentage of K is moved to grain by soybeans compared to cereal crops
    - More K removed per pound of soybeans harvested in comparison to these crops
Corn Nutrient Uptake And Dry Matter Accumulation

- Potassium
- Nitrogen
- Phosphorus
- Dry Matter

% of Total Uptake

V6 | Tassel | Maturity
Forms of Soil Potassium

Unavailable 90-98% of Total

Soil Rocks and Minerals

Trapped K⁺

Soil Colloid

Slowly Available

Readily Available (1-2% of Total)

Soil Colloid (Exchangeable)

Soil Water
Readily Available K

- Exchangeable plus solution forms
- Soil tests extract these forms
- K absorbed by plants in solution phase
- Equilibrium replenishes K$^+$ ions in the soil water from exchangeable or slowly available forms
Unavailable K

- Mica, feldspar and clay minerals contain 90% to 98%
- Decompose releasing $K^+$ ions
- Great Plains rich in K compared to eastern states with precipitation >30 inches
Factors Affecting K Uptake By Plants

- **Poor Soil Aeration**
  - Oxygen required for root uptake
  - Ridge-till/No-till
  - Compaction

- **Soil Moisture**
  - Very dry
  - Very wet

- **Soil Temperature**
  - Cold
K Uptake By Plants Affected By Soil Moisture
POTASH REDUCED SORGHUM
LODGING HARVEST STRESS

% LODGED

95 BU 105 108 (KS) 107
0 40 80 160 320

K₂O RATE - LB/A

16% 71% 45% 106 2%
Tillage Induced K Deficiency

- K availability can be less in reduced till systems (no-till, ridge till)
Potassium Stratification: Ridge-Till

- 24 consecutive years in ridge-till.
- Localized high concentrations of K in inter-rows of ridges.

Gordon, KSU
Starter fertilizer effects on ridge-tilled corn, 2002-2003

<table>
<thead>
<tr>
<th>Treatments N-P2O5-K2O-S</th>
<th>V6 Dry Weight lb/acre</th>
<th>Days to Mid-Silk</th>
<th>Grain Yield bu/acre</th>
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<tbody>
<tr>
<td>0-0-0-0-0</td>
<td>208</td>
<td>82</td>
<td>161</td>
</tr>
<tr>
<td>30-15-5-5</td>
<td>312</td>
<td>76</td>
<td>189</td>
</tr>
<tr>
<td>30-15-15-5</td>
<td>395</td>
<td>72</td>
<td>198</td>
</tr>
<tr>
<td>30-15-25-5</td>
<td>398</td>
<td>72</td>
<td>197</td>
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<tr>
<td>30-15-0</td>
<td>290</td>
<td>76</td>
<td>185</td>
</tr>
<tr>
<td>30-15-15-0</td>
<td>398</td>
<td>72</td>
<td>198</td>
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</table>

Soil Test K=150 ppm
Atchison County, Kansas
June 2004

Average K Test = 153 ppm
Minimum K Test = 112 ppm
Maximum K Test = 229 ppm
## Potassium Application Effects On Corn Yield

<table>
<thead>
<tr>
<th>K$_2$O Rate</th>
<th>Croplan 599</th>
<th>Croplan 678</th>
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</thead>
<tbody>
<tr>
<td>Lbs/A</td>
<td>Yield</td>
<td>Test Weight</td>
</tr>
<tr>
<td>0</td>
<td>125</td>
<td>56</td>
</tr>
<tr>
<td>40</td>
<td>170</td>
<td>59</td>
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<tr>
<td>80</td>
<td>189</td>
<td>58</td>
</tr>
<tr>
<td>120</td>
<td>179</td>
<td>59</td>
</tr>
</tbody>
</table>

| Sig. Level  | 0.01        | 0.01        | NS    | 0.25        |

Atchison County, Kansas  
June 2004

Average K Test = 153 ppm  
Minimum K Test = 112 ppm  
Maximum K Test = 229 ppm
## Good and Bad Field Areas Yield/Soil Test Comparison

**Atchison Co., 2004**

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Soil Test Exch. K</th>
<th>Corn Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
<td>Bad</td>
</tr>
<tr>
<td>1</td>
<td>162</td>
<td>139</td>
</tr>
<tr>
<td>2</td>
<td>169</td>
<td>119</td>
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<tr>
<td>3</td>
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<td>4</td>
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<td>147</td>
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<td>5</td>
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<td>6</td>
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<td>7</td>
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<td>128</td>
<td>118</td>
</tr>
<tr>
<td>12</td>
<td>130</td>
<td>113</td>
</tr>
</tbody>
</table>
Corn Response To Potassium Soil Test
Atchison Co., KS - 2004

$R^2 = 0.3517$

Yield (Bu/A)

Exch. K Soil Test (ppm)

'Bad' Points
Effect Of Surface Applied Potash On Corn  
Stu Duncan, 2005

<table>
<thead>
<tr>
<th>K Rate</th>
<th>Corn Yield</th>
<th>Test Wt.</th>
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</thead>
<tbody>
<tr>
<td>Lb K20/A</td>
<td>Bu/A</td>
<td>Lb/Bu</td>
</tr>
<tr>
<td>0</td>
<td>101.9</td>
<td>56.9</td>
</tr>
<tr>
<td>80</td>
<td>112.3</td>
<td>58.0</td>
</tr>
<tr>
<td>p &gt; f</td>
<td>0.156</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Crop Removal

- K removal similar to N but > P
- More K in legumes than grasses
- Highest with forage/silage
- Easily leached from crop residue
## Potassium Removal By Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Unit</th>
<th>K2O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>lbs/ton</td>
<td>60.00</td>
</tr>
<tr>
<td>Red clover</td>
<td>lbs/ton</td>
<td>50.00</td>
</tr>
<tr>
<td>Bermudagrass</td>
<td>lbs/ton</td>
<td>40.00</td>
</tr>
<tr>
<td>Bromegrass</td>
<td>lbs/ton</td>
<td>40.00</td>
</tr>
<tr>
<td>Fescue, tall</td>
<td>lbs/ton</td>
<td>40.00</td>
</tr>
<tr>
<td>Corn</td>
<td>lbs/bu</td>
<td>0.26</td>
</tr>
<tr>
<td>Corn silage</td>
<td>lbs/ton</td>
<td>8.70</td>
</tr>
<tr>
<td>Grain sorghum</td>
<td>lbs/bu</td>
<td>0.26</td>
</tr>
<tr>
<td>Sorghum silage</td>
<td>lbs/ton</td>
<td>8.70</td>
</tr>
<tr>
<td>Wheat</td>
<td>lbs/bu</td>
<td>0.30</td>
</tr>
<tr>
<td>Sunflowers</td>
<td>lbs/cwt</td>
<td>0.60</td>
</tr>
<tr>
<td>Oats</td>
<td>lbs/bu</td>
<td>0.20</td>
</tr>
<tr>
<td>Soybeans</td>
<td>lbs/bu</td>
<td>1.40</td>
</tr>
<tr>
<td>Native grass</td>
<td>lbs/ton</td>
<td>30.00</td>
</tr>
</tbody>
</table>
Potassium Uptake Curve - Corn
Fertilizer Sources of Potassium

• Reported as K$_2$O or percent potassium oxide

• Found in salt beds beneath the earth’s surface

• Potash deposits occur in Canada, former Soviet Union and U.S. in states of NM and Utah

• Mining and solution mining
K Mining

- KCl exists in beds below the surface
  - Carlsbad, NM, 600’
K Mining

- K is granulated into different sizes for dry spreading or making liquids
  - White soluble is most suited for liquid grades
Potassium Chloride (KCl)

- Most commonly used source, sometimes called muriate of potassium
- Analysis range from 60% to 63% and 45% to 46% chloride
- Color ranges from deep red to pink to white
- Red potash made by grinding ore, suspended in water and skimmed off, iron adheres giving a red color
- White potash made by dissolving under a not brine under pressure, iron is removed
- White best source for making clear fertilizer solutions because colorless when dissolved
Potassium-Magnesium Sulfate
$K_2SO_4-2MgSO_4$

- K-Mag or Sulfate of Potash-Magnesia
- 22% $K_2O$, 11% Mg, 22% S
Other Sources

- **Potassium Sulfate (K$_2$SO$_4$)**
  - Contains 50% K$_2$O and 18% S
  - Special Uses
    - Tobacco
    - Sulfur source
  - Expensive

- **Potassium Nitrate (KNO$_3$)**
  - Saltpeter
  - 44% K$_2$O, 13% N
  - Expensive
Application of K Fertilizer

- Incorporate for most crops
- Topdressing effective on perennials
- Broadcast - when large amounts of K required
  - Unless soil has high fixing capacity
- Banding - ridge-till or no-till; soils with low subsoil K
- Starter - K is a salt so care must be taken when applied near seed
Seed Placed Fertilizer

• Effect of Row Spacing
  – Higher rate of N + K₂O can be applied on a per acre basis as the row spacing narrows.

• Crop Species Tolerance
  – Small Grains > Corn > Grain Sorghum
  – Soybeans, field beans and sunflowers are sensitive and pop-up should not be used

• Soil Type and Environment
  – Maximum limit of salt should be reduced about 1/3 for dry soil and sandy-textured soil conditions
  – Slow growing conditions such as cool weather increase the contact time of salt and seed
Salt and Free Ammonia Levels of Different Fertilizer Products

- Salt Index of fertilizers is largely determined by N and K$_2$O.
- Phosphate contributes very little
- Boron is highly toxic
- Ammonium thiosulfate (12-0-0-26S) may cause problems
- Free ammonia
  - Urea
  - UAN
- All liquid and dry fertilizers including “premium grade” clear liquids are comparable in their ability to cause salt damage
Salt Index - N + K$_2$O

Suggested Maximum Rates of Fertilizer to be Applied Directly With Seed

(Corn and Small Grains)

<table>
<thead>
<tr>
<th>Row Spacing in Inches</th>
<th>Pounds N +K$_2$O* (No urea or UAN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medium to Fine Textured Soils</td>
</tr>
<tr>
<td>40</td>
<td>6</td>
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<td>30</td>
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<td>12</td>
<td>20</td>
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<tr>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>6-8</td>
<td>30</td>
</tr>
</tbody>
</table>

Reduce salt rates 30% for grain sorghum.
No seed-placed fertilizer is recommended for soybeans, sunflowers, field beans, or sugar beets.
Potassium Management
## Potassium Application Effects On Corn Yield

<table>
<thead>
<tr>
<th>K$_2$O Rate</th>
<th>Hybrid A</th>
<th>Hybrid B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lbs/A</td>
<td>Yield</td>
<td>Test Weight</td>
</tr>
<tr>
<td>0</td>
<td>125</td>
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**Sig. Level**

- Hybrid A: 0.01
- Hybrid B: 0.25
- NS

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Atchison County, Kansas
June 2004

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### Potassium Comparisons - Atchison Co., 2004

<table>
<thead>
<tr>
<th>Field Location</th>
<th>Bad' Area</th>
<th>Good' Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yield</td>
<td>K ppm</td>
</tr>
<tr>
<td>1</td>
<td>80</td>
<td>139</td>
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<td>12</td>
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</tr>
</tbody>
</table>
Corn Response To Potassium
Atchison Co., KS - 2004

\[ y = -6 \times 10^{-5}x^2 + 0.022x - 1.3573 \]

\[ R^2 = 0.3015 \]
Slowly Available K

- $K^+$ ions are trapped or fixed between clay layers so become unavailable to plant roots
- Equilibrium with available forms of $K$ and slowly escape
- Provides a reservoir of $K$ which continually resupplies available form
Fixation of K⁺