Recalibration of Soil Potassium Test for Corn in North Dakota, U.S.A. and Effect of Sampling Time

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Introduction

- Current potassium (K) fertilizer recommendations for corn in North Dakota developed in late 1970s and early 1980s, when soil test K (STK) levels well above 200 ppm were nearly ubiquitous (Dahke et al., 1982). Potassium deficiencies were seldom observed due to high native K fertility and low K removal in spring wheat-dominated production systems.
- The recent change to intensive corn and soybean production systems, particularly in eastern North Dakota, without maintenance K fertilization has resulted in more low STK values being reported. In 2010, 17% of soil samples had STK levels below 150 ppm critical level (Fixen et al., 2010).
- The standard soil K test method using NH₄OAc has come under scrutiny:
  - Soil sample drying often increases NH₄OAc-extractable K from its field-moist level, and NH₄OAc-extractable K from dried soil correlates poorly with yield response to K fertilization (Barboglu et al. and Mallarrino, 2012).
  - Soil test K levels change throughout the year, often highest in spring and lowest in late summer (Franzen, 2011).
- Yield response to K fertilization may be inconsistent on low and high soil test K soils (Rakkar et al., 2015).

Materials and Methods

- LOCATION
  - Southeastern North Dakota
    - 2015: Thirteen sites
    - 2016: Six sites

 experimentation design
- Randomized complete block design with split-plot in time arrangement
- Four replications (3 sites x 12 plots)
- Plot treatments
  - Fertilizer grade potassium chloride (0-0-60 K₂O), broadcast
    - Rates: 0, 34, 67, 101, 135, and 168 kg K₂O ha⁻¹
  - Shallow incorporation (5-cm), except for no-till sites
  - Non-fertilized fallow treatment to assess soil K change without plant uptake
- Soil samples collected from non-fertilized check and fallow plots from 0-15 cm
- Biweekly until grain harvest

SOIL ANALYSIS
- 1.0 M NH₄OAc (pH 7), 2 g soil with 20 mL NH₄OAc, shaken for 5 minutes
- Air-dried soil ground to pass 2-mm sieve
- Field-moist soil passed through 2-mm sieve, moisture content determined
- Sodium tetraphenylboron (Cox et al., 1999), 5-minute and 168-hour extractions
- Ion-exchange resin capsule (UNIBEST, Inc., Walla Walla, Washington, U.S.A., 30-g air-dry equivalent mass of field-moist soil and 30 mL deionized water
- Incubated with resin capsule for 168 hours at constant 20 °C
- Mineralogical analysis and clay speciation (ACT Laboratories, Ancaster, Canada)

Results: Soil Test Methods and Yield Response

- Table 1. Frequency of yield response prediction by dry soil K test.

<table>
<thead>
<tr>
<th>Soil K test class (mg kg⁻¹)</th>
<th>Number of sites in soil test class</th>
<th>Number of sites with significant yield response</th>
<th>Probability of significant yield response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (L)</td>
<td>6</td>
<td>3</td>
<td>0.50</td>
</tr>
<tr>
<td>Medium (M)</td>
<td>6</td>
<td>2</td>
<td>0.33</td>
</tr>
<tr>
<td>High (H)</td>
<td>6</td>
<td>3</td>
<td>0.50</td>
</tr>
<tr>
<td>Very high (VH)</td>
<td>6</td>
<td>5</td>
<td>0.83</td>
</tr>
</tbody>
</table>

- Fig. 1. (a) Relationship between the ratio of air-dry soil K (DK) and field-moist soil K (MK) regressed against the field-moist soil K (MK). (b) Average DK/MK ratio of a site related to smectite-to-smectite ratio of its clay fraction.

- Fig. 2. Relative grain yield of unfertilized treatment to maximum yield compared with NH₄OAc-extractable K from air-dry soil (DK), field-moist soil (MK), K saturation of estimated cation exchange capacity (ECEC), tetraphenylboron-extractable K (TBK) for 5-minute and 168-hour extractions, and ion-exchange resin extractable K.

- Fig. 3. Orthogonally-rotated principal factor solution of air-dry soil NH₄OAc-extractable K (DK) and mineral components related to relative yield response to K fertilization. Axis-position of variable represents factor loading score on common factor. Proportion of common variance for each factor shown in parentheses. Mineral components expressed as fraction of whole soil.

Summary and Discussion

- Only six of 14 sites with STK below the current 150 mg kg⁻¹ DK critical level had significant yield responses to K fertilization (Table 1). One site above the critical level (201 mg kg⁻¹ DK) responded to fertilization. The standard testing method using dry soil and current critical level predicted less than half of yield responses.
- Sample drying increased NH₄OAc-extractable K by 1.26 on average (range: 0.8–2.4) from its field-moist condition. Relative amount of K released upon drying was greater for low STK soils (Fig. 1a). Potassium release was greater in smectite-rich soils (Fig. 1b).
- The NH₄OAc extraction on dry soil had the best predictive relationship with relative yield response (Fig. 2), in spite of predicting less than half of significant responses (Table 1). Field-moist soil K and 5K saturation were inferior predictors of yield response. Non-exchangeable K methods (i.e., sodium tetraphenylboron and ion-exchange resin) were not significant related to yield.
- Yield response was positively albeit minimally associated with DK, K-bearing minerals, and clay species (Fig. 3). No mineralogical component exhibited a distinct relationship with yield response, suggesting that the mineralogical controls on plant-available K are multifaceted.
- Soil K levels were highest in spring and lowest in late summer, following crop uptake or water use.
- Sinusoidal modeling of STK and sampling time significant (P < 0.01) for: DK: 10 sites MK: 15 sites

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References


justification and objectives
- This research is important to corn producers in North Dakota because low STK levels are more common and the yield potential of modern corn hybrids is higher, posing increased risk for potential K deficiencies. The standard NH₄OAc soil testing method may not accurately assess plant-available K and seasonal variation in soil K makes soil test interpretation difficult. Therefore, a better understanding of (1) the K requirements for modern corn hybrids, (2) the methods for assessing plant-available K, and (3) the role of soil sampling date on soil K is needed for profitable K management in modern corn production systems.
- The objectives of this field study are to:
  1. Evaluate corn yield response to K fertilization
  2. Identify an accurate plant-available K testing method
  3. Assess seasonal soil K variation for soil test interpretation