Grain Sorghum Fertility Management
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With Cooperation Of:
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K-State Southwest Research-Extension Center, Tribune

Corn:Nutrient Price Ratio
Lbs of corn to buy one lb of nutrient
Monthly Kansas NASS Price Received and Urea/DAP FOB Gulf
December 1985 – October 2017

Corn:P ---- Corn:N
In Nutrient Management, the Primary Objectives of Soil Testing are:

• Determine the fertility and pH status of an area, field or farm, with the goal of removing fertility as a yield limitation.

• Predict where fertilizer responses will or will not occur:
  – Increase the return on our fertilizer investment
  – Increase the efficiency of fertilizer use
  – Reduce the potential for environmental injury
Consider the accuracy and reliability of individual soil tests

• What constitutes a good soil test
  – Good relationship between soil test level and yield
  – Accurately predicts nutrient needs
  – Simple
  – Inexpensive
  – Precise
  – Reproducible

Useful soil tests in Kansas

• Profile Nitrate-N
• Bray P-1 Extractable P
• Olsen Extractable P
• Mehlich III Extractable P
• Exchangeable K
• DTPA Extractable Zn
• Chloride
• Sulfur/Sulfate
• Soil pH
• Lime Requirement / Buffer pH
• Soil Organic Matter
Phosphorus Soil Test Methods

- Bray P1 roughly equivalent to Mehlich III, use for soil pH < 7.0
- Bray P2 – NOT USEFUL!, Developed for rock phosphate applications in Indiana
- Olsen Bicarbonate – Developed at CSU for high pH soils especially > 7.0
- Mehlich III, equivalent to Bray P1, but valid over a wider range of soil pH

Economics of Soil Testing

Does it pay?
Change in profit if true STN varies from expected STN
STP = 16; OM = 1.6; Expected STN = 40
Corn @ $3.37, Wheat @ $3.39, N @ $0.33, P @ $0.43

Change in profit if true STP varies from expected STP
STN = 40; OM = 1.6; Expected STP = 16
Corn @ $3.37, Wheat @ $3.39, N @ $0.33, P @ $0.43
Data Quality

• The proceeding economics are based on having good data, as good of a representation of “truth” as we can reasonably obtain.
• Good decisions require good data
• Good soil test data comes from good procedures in the field

Number of Cores to Make a Good Sample

• Soils vary across very short distances in nutrient supply due to many factors including:
  – Position on the landscape
  – Past erosion
  – Parent material of the soil
• We also induce variability on the soil
  – Band applications
  – Livestock grazing
• To account for this variation you should take 10-20 cores per sample
EXAMPLE OF THE RELATIONSHIP BETWEEN NUMBER OF SOIL CORES PER COMPOSITE SAMPLE AND ERROR

MEAN SOIL P = 19 ppm

ECONOMICS OF ACCURACY

Profits from soil sampling at different number of points relative to an all-point composite

- $0.00
- $0.50
- $1.00
- $1.50
- $2.00
- $2.50

Number of points in sample

5 10 15 20
Sampling Depths for Mobile Nutrients

• While P and K are relatively immobile in soils and accumulate in the surface few inches, Nitrate-N, Sulfur (S) and Chloride (Cl) are mobile and move through the soil profile.

• We recommend a 24” Profile Soil Sample to test for mobile nutrients such as nitrate-N in the soil. 10-15 cores are still needed to give a high quality sample.

When to Take Soil Samples

• P, K, Zn and pH always the same time.

• Focus on times when soil conditions are good, long enough before planting to really use the information.

• Be consistent.

• Late fall, winter and early spring-November through March are good.
When to Take Soil Samples

• For N, S and Cl
• **Summer crops:** after harvest in the fall, but before the soil warms in the spring.

• **Fall crops:** before planting in the fall.
  – Spring or winter samples to predict topdress N needs don’t work real well.

Grain Sorghum N, P, K, and dry matter accumulation
Nitrogen Management

Nitrogen Uptake

2016 Sorghum U - Dodge City
K-State Grain Sorghum Nrec

- Nrec = YG * 1.6 – (% OM x 20) – Profile - Other

### Fertilizer N Required At Various Yield and Soil Organic Matter Levels Assuming Profile N Test Is Not Used (includes 30 Lb N/A residual default)

<table>
<thead>
<tr>
<th>Soil Organic Matter Content (%)</th>
<th>Yield Goal (Bu/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>14 4 0 0 0 0 0</td>
</tr>
<tr>
<td>80</td>
<td>78 68 58 48 38 28 18</td>
</tr>
<tr>
<td>120</td>
<td>142 132 122 112 102 92 82</td>
</tr>
<tr>
<td>160</td>
<td>206 196 186 176 166 156 146</td>
</tr>
<tr>
<td>200</td>
<td>270 260 250 240 230 220 210</td>
</tr>
</tbody>
</table>

N rec = (Yield Goal x 1.6) – (% SOM x 20) – Profile N – Manure N – Other N Adjustments + Previous Crop Adjustments

Consider your crop rotation, use of cover crops, etc.

<table>
<thead>
<tr>
<th>Source</th>
<th>% Carbon</th>
<th>% Nitrogen</th>
<th>C:N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>40</td>
<td>3.0</td>
<td>13:1</td>
</tr>
<tr>
<td>Soybean Residue</td>
<td>--</td>
<td>--</td>
<td>15:1</td>
</tr>
<tr>
<td>Cornstalks</td>
<td>40</td>
<td>0.7</td>
<td>60:1</td>
</tr>
<tr>
<td>Small grain straw</td>
<td>40</td>
<td>0.5</td>
<td>80:1</td>
</tr>
<tr>
<td>Microorganisms</td>
<td>50</td>
<td>6.2</td>
<td>8:1</td>
</tr>
<tr>
<td>Soil O.M.</td>
<td>52</td>
<td>5.0</td>
<td>10:1</td>
</tr>
<tr>
<td>Grain Sorghum</td>
<td>40</td>
<td>0.5</td>
<td>80:1</td>
</tr>
<tr>
<td>Manure</td>
<td>--</td>
<td>--</td>
<td>&lt;20:1</td>
</tr>
<tr>
<td>Wood Chips</td>
<td>40</td>
<td>0.1</td>
<td>200:1</td>
</tr>
</tbody>
</table>
Corn and Sorghum Trials Established 1961

Fully Irrigated

N rates:
0, 40, 80, 120, 160, and 200 lb/a

P$_2$O$_5$ rates:
0 and 40 lb/a
80 lb/a on corn since 1992
Long-term Sorghum Fertility

1961-2017

Yield, bu/a

N rate, lb/a

0 40 80 120 160 200

0 50 100 150 200

0 P

40 P

Long-term sorghum fertility, Tribune, KS 2017

2016 Sorghum U - Dodge City

Long-term Sorghum Fertility

2008-2017

Yield, bu/a

N rate, lb/a

0 40 80 120 160 200

0 50 100 150 200

0 P

40 P

Long-term sorghum fertility, Tribune, KS 2017

2016 Sorghum U - Dodge City
Long-term Grain Sorghum Fertility

Nitrate-N, ppm

Depth, ft

0 2 4 6 8 10
0 5 10 15 20 25

Long-term sorghum fertility, Tribune, KS 2010

2016 Sorghum U - Dodge City

0 lb P/a

80 N

0 N

120 N

Long-term Grain Sorghum Fertility

Nitrate-N, ppm

Depth, ft

0 2 4 6 8 10
0 5 10 15 20 30 40

Long-term sorghum fertility, Tribune, KS 2010

2016 Sorghum U - Dodge City

40 lb P/a

80 N

0 N

120 N
Long-term Sorghum Fertility

Average of w/ and w/0 K, 0-6" Tribune, KS 2010

After 50 years

Long-term Sorghum Fertility

0-6" without blocks 1 & 2, Tribune, KS 2010

No effect from P
Summary – Grain Sorghum

pH decreased ~ 1.2 unit by N

SOM increased ~ 0.5% by N & P

Soil test P increased with 40 P

NO$_3$ increased by N, particularly when N rates above optimal
Sorghum P Study

Sorhgm P Study, Tribune, KS
2004-2011

Sensors for Nitrogen management in sorghum
Sensor based vs soil test based N recommendations

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Belleville</td>
<td>96</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>0</td>
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<tr>
<td>Manhattan</td>
<td>155</td>
<td>60</td>
<td>33</td>
<td>33</td>
<td>27</td>
<td>0</td>
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<tr>
<td>Partridge</td>
<td>32</td>
<td>42</td>
<td>57</td>
<td>55</td>
<td>-13</td>
<td>2</td>
</tr>
<tr>
<td>Tribune</td>
<td>128</td>
<td>30</td>
<td>24</td>
<td>15</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Manhattan</td>
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<td>40</td>
<td>15</td>
<td>20</td>
<td>20</td>
<td>-5</td>
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<tr>
<td>Tribune</td>
<td>79</td>
<td>54</td>
<td>0</td>
<td>0</td>
<td>54</td>
<td>0</td>
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<tr>
<td>Manhattan</td>
<td>128</td>
<td>77</td>
<td>45</td>
<td>45</td>
<td>32</td>
<td>0</td>
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<tr>
<td>Ottawa</td>
<td>64</td>
<td>56</td>
<td>55</td>
<td>60</td>
<td>-4</td>
<td>-5</td>
</tr>
<tr>
<td>Partridge</td>
<td>123</td>
<td>41</td>
<td>30</td>
<td>15</td>
<td>26</td>
<td>15</td>
</tr>
</tbody>
</table>
K-State sorghum N rate calculator

<table>
<thead>
<tr>
<th>Farmer Inputs</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>NDVI Reference Strip</td>
<td>0.6</td>
</tr>
<tr>
<td>NDVI Farmer Practice</td>
<td>0.55</td>
</tr>
<tr>
<td>Max Yield for Area bu/ac</td>
<td>150</td>
</tr>
<tr>
<td>Days from planting to sensing where avg. temp &gt; 63 F</td>
<td>35</td>
</tr>
<tr>
<td>Grain Price, $/Bu</td>
<td>5.8</td>
</tr>
<tr>
<td>Nitrogen Price, $/lb actual N</td>
<td>0.6</td>
</tr>
<tr>
<td>Application Cost, $/Ac</td>
<td>6</td>
</tr>
<tr>
<td>Expected Nitrogen Efficiency, % Recovery</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outputs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Response Index of Grain Yield</td>
<td>1.44</td>
</tr>
<tr>
<td>Yield Potential of Reference Strip bu/ac</td>
<td>100.1</td>
</tr>
<tr>
<td>Yield Potential without N bu/ac</td>
<td>69.7</td>
</tr>
<tr>
<td>N Rec. lbs N/Ac unadjusted for G:N price ratio</td>
<td>57.8</td>
</tr>
<tr>
<td>N rec. lbs N/Ac adjusted for G:N price ratio</td>
<td>63.5</td>
</tr>
<tr>
<td>Gross Return (no Nitrogen) $/ac</td>
<td>404.35</td>
</tr>
<tr>
<td>Gross Return (using N Rec) $/ac</td>
<td>554.21</td>
</tr>
</tbody>
</table>

Handheld versions- low cost


2016 Sorghum U - Dodge City
Nitrogen – management factors

- Timing – as close to utilization as possible
- Rate – determine accurate application rates
- Placement – apply below the soil surface if possible
- Fertilizer source – AA, UAN, Urea
- Specialty fertilizers and additives
  - ESN
  - Agrotain – urease inhibitor
  - N-Serve – nitrification inhibitor
  - Super U – urease and nitrification inhibitor

Phosphorus Management
Phosphorus Uptake

DAYS AFTER EMERGENCE

PHOSPHOROUS UPTAKE (% of total)

LEAVES
STALK
HEAD
HALF BLOOM

P Example

Phosphorus Management Model for Kansas Crop Production and Manure Management

Relative Yield (%)

100%
80%
60%
40%
20%
0%

Phosphorus (P2O5) Recommendation (lb/a)

Soil Test P (ppm)

0 20 40 60 80 100

0 10 20 30 40 50 60 70 80

Soil Test P (ppm)

P2O5 Recommendation (lb/a)
Soil test P and application method

Common generalized depiction of broadcast vs. band

Phosphorus removal values

<table>
<thead>
<tr>
<th>Crop</th>
<th>Unit</th>
<th>P\textsubscript{2}O\textsubscript{5} (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>bushel</td>
<td>0.33</td>
</tr>
<tr>
<td>Grain Sorghum</td>
<td>bushel</td>
<td>0.40</td>
</tr>
<tr>
<td>Wheat</td>
<td>bushel</td>
<td>0.50</td>
</tr>
<tr>
<td>Sunflowers</td>
<td>pound</td>
<td>0.02</td>
</tr>
<tr>
<td>Oats</td>
<td>bushel</td>
<td>0.25</td>
</tr>
<tr>
<td>Soybeans</td>
<td>bushel</td>
<td>0.80</td>
</tr>
</tbody>
</table>
Crop Removal – the next step

- Calculate crop removal
- Depending on over/under applications after crop removal, soil test levels will change.
- 18 lbs P$_2$O$_5$ is required to change STP one ppm.

- One cycle of a W-S-F rotation (using field averages)
  - Wheat yield = 60 bu/a, Sorghum yield = 110 bu/ac
  - STP = 22 ppm, P$_2$O$_5$ applied during seeding = 30 lb/a
  - Wheat Removal = 60 * .50 = 30 lbs P$_2$O$_5$ removed
  - Sorghum Removal = 110 * .40 = 44 lbs P$_2$O$_5$ removed
  - Total Crop Removal = 30+44 = 74 lbs P$_2$O$_5$ removed
  - STP change = [30-74]/18 = 2.4 ppm drop
  - Final STP = 22 – 2.4 = 19.6 ppm
- Just perform this process at every point in the field

Crop Removal – the next step

- Perform crop removal and STP calculations at a site-specific scale for the field
- Potential Decision Rules
  - Land ownership/tenancy makes a difference
  - Decisions based on STP
    - IF STP > 30 then apply 0 or very minimal amount (intentional mining)
    - IF STP is >20 and <30 then apply removal rates
    - IF STP is <20 then apply removal + build (build rate?)
- VRT apply P to meet management goals
Keys to P management

- Soil Test regularly, every 2-4 years
- Use P placement to enhance availability at low ST (<20ppm). For low application rates (maintenance), band application is preferred.
- Consider crop removal in the rotation, removal sound be replaced or ST levels will drop.
- Choice of fertilizer product depends on preference and equipment.

Phosphorus and N starter fertilizer

Liquid surface dribble  Gordon, 2001
Pop-up and surface dribble

- Adapted to economically adapting planters
- Most commonly utilizes fluid fertilizers
- Pop-up:
  - Limited to low rates because of potential germination/stand establishment issues
- Surface dribble:
  - Refers to ‘dribbling’ liquid fertilizer in a coarse stream on the soil surface beside or above the closed seed furrow at planting time

In-furrow starter: Reduce injury

- Limit to 10 lb N + K₂O/ acre
- Avoid high salt carriers
- No urea, UAN
- Use caution on sandy or dry soils
Micros

Secondary and micronutrients for sorghum

- The most common issues in Kansas are iron, zinc and sulfur.
- Research have shown response to chloride in low testing soils.
- Zn, S, and Cl have good reliable soil tests that translate well into anticipated yield response.
Sorghum iron chlorosis

- Manure application show some benefit.
- In furrow chelated Fe fertilizer also contribute with yield increase.
- Previous studies evaluating foliar Fe application show limited response.
- Hybrid selection can help (limited information on iron chlorosis ratings).

Field Studies

- Three locations: KSU SWREC in Garden City and Tribune, and a producer’s field near Garden City

  - Treatments:
    - Four chelate rates (0, 3, 6 and 6 lb split)
    - Five sorghum hybrids (Pioneer 86G32, 87P06, 85Y40; Golden Acres 5613, and Sorghum Partners NK5418)
Producer’s field (60-days after planting)

NK5418-Check

87P06-Check

86G32-Check

85Y40-check

A. Obour, 2015

Chelate application reduced IDC in susceptible hybrids

NK5418-Check

NK5418- 6lb split

Pictures at 60-days after planting

A. Obour, 2015
Iron chelate application and grain sorghum hybrid effects on IDC in grain sorghum

Grain yield of sorghum hybrids at SWREC and a producer’s field in Garden City, KS
Sorghum grain yield as affected by iron chelate application (two-dryland locations in Garden City, KS)

Results - Tribune under irrigation

NK5418-Check  87P06-check
86G32-check  85Y40-Check
Grain yield of sorghum hybrids (Tribune)

![Graph showing grain yield of different sorghum hybrids]

Chelate effects (Tribune)

![Images showing comparison of sorghum fields]

85Y40-check  85Y40-3 lb product
Chelate effects (Tribune)

A. Obour, 2015

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87P06-Check 87P06-3 lb product

Chelate by hybrid effect on grain yield (Tribune)

A. Obour, 2015

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Chelate effect on yield-average across hybrids

![Graph showing the effect of chelate application on sorghum grain yield.](Image)

A. Obour, 2015

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Chloride for sorghum

![Graph showing the chloride levels in early tissue and flag leaf tissue.](Image)

Ruiz Diaz, 2014. 8 sites

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Chloride for sorghum

5 of 8 sites had profile soil test Cl < 6 ppm

Chloride for sorghum – profile soil test

<table>
<thead>
<tr>
<th>Category</th>
<th>Soil chloride</th>
<th>Cl recommended</th>
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</thead>
<tbody>
<tr>
<td>Low</td>
<td>&lt; 30</td>
<td>&lt; 4</td>
</tr>
<tr>
<td>Medium</td>
<td>30-45</td>
<td>4-5</td>
</tr>
<tr>
<td>High</td>
<td>&gt; 45</td>
<td>&gt; 6</td>
</tr>
</tbody>
</table>

Ruiz Diaz, 2014. 8 sites

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Summary

• Nitrogen and P are generally the most limiting nutrients.
• Iron, Cl and S in some cases for sorghum.
• Fertility requirements are best determined by soil testing, estimated crop removal and experience.

Cover Your Acres Conference
January 16th and 17, Oberlin

<table>
<thead>
<tr>
<th>A Historical Look at Climate Variability</th>
<th>Profitability Opportunities &amp; Pitfalls</th>
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<tbody>
<tr>
<td>Making the Right Crop Insurance Choices</td>
<td>Smart Spending of Your Fertility Dollar</td>
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<tr>
<td>Maximizing Your Rangeland</td>
<td>Soil Health &amp; Profitability in Dryland Cropping</td>
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<tr>
<td>Moisture Probes: Measurement to Management</td>
<td>Surviving &amp; Thriving in Tough Times</td>
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<tr>
<td>NWKS Agronomy Research Update</td>
<td>Weed Management Strategies</td>
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Questions?
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www.northwest.ksu.edu/agronomy