Fertility management in sorghum

Dorivar Ruiz Diaz

Soil Fertility and Nutrient Management

In-depth Sorghum Schools
2014
Overview

- Basic components of a good soil fertility program for grain sorghum
  - Soil sampling and testing
  - Nitrogen management
  - Phosphorus fertilization
  - Secondary and micronutrients
The first step in fertility management is soil testing

- In Kansas the greatest potential return to fertilizer dollars in sorghum is from N and P.
- Sulfur becoming an issue on some soils.
- Fe and zinc are the micronutrient most likely to be deficient in Kansas for sorghum.
- N, P, Zn, (and K) have reliable soil tests to measure nutrient availability and predict fertilizer needs.
Where to take samples

- Sampling areas should be easily defined and treatable with equipment available
- Soil sampling should try to capture known differences in nutrient levels
- These differences can be due to past management, natural soil variability, topography or removal with yield.
- Consider the potential benefits and cost when deciding how and where to sample
Using yield monitor data to look back, 4 Years of P Removal

L. Haag, 2014
Combine layers of information

• Soils and topography
• Past management
• Yield monitor data
• Grid soil samples
• Manure applications
Proper soil sampling

• Consistency in depth of sample.
  ✓ 0-6” for immobile nutrients
  ✓ 0-24” for mobile (N, Cl, S).
  ✓ 0-3” only for pH evaluation in No-till systems

• Appropriate number of subsamples (12-20 subsamples).

• Proper care of collected samples.

• Attention to details.
### P soil test levels after six years broadcasting P on no-till

<table>
<thead>
<tr>
<th>160</th>
<th>68</th>
<th>78</th>
<th>94</th>
<th>106</th>
<th>54</th>
<th>69</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>13</td>
<td>14</td>
<td>21</td>
<td>10</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>12</td>
<td>9</td>
<td>7</td>
<td>10</td>
<td>12</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>7</td>
<td>5</td>
<td>9</td>
</tr>
</tbody>
</table>

Sorghum/Soybean/Wheat rotation, 80 lbs P$_2$O$_5$ applied broadcast to corn and wheat
When to take soil samples

- P, K, and Zn, anytime, but always the same time of the year. pH, avoid dry conditions.
- Focus on times when soil conditions are good, long enough before planting to use the information.
- Be consistent.
- Late fall, winter and early spring-November through March are good.
Nitrogen
Considerations for N fertilization

- Tillage and residue cover would influence denitrification, immobilization and ammonia volatilization.
- Climate, rainfall-irrigation during key periods, and soil moisture.
- Soil types, texture, drainage.
- N management /application practices.
- Right rate, place, time, source-products (4Rs).
Nitrogen placement in NT

Grain yield (bu/acre)

Control  Broadcast  Dribble  Knifed

63  110  119  130

UAN nitrogen application method

90 lbs  No-till Sorghum, Lamond, KSU
## Typical carbon and nitrogen content of organic materials

<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>
Foliar nitrogen application

• Derived from methylene ureas and triazone.

• Provide flexibility for foliar application later in the season.

• Slow release N source and may be in combination with other nutrients.

• As effective as traditional N sources on a pound basis (consider total N need).
## Nitrogen application time

<table>
<thead>
<tr>
<th>Time and source</th>
<th>Yield (bu/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Early Pre-Plant</strong></td>
<td></td>
</tr>
<tr>
<td>– Urea</td>
<td>80</td>
</tr>
<tr>
<td>– Urea + Agrotain + DCD</td>
<td>88</td>
</tr>
<tr>
<td>– ESN blend</td>
<td>87</td>
</tr>
<tr>
<td><strong>At Planting</strong></td>
<td></td>
</tr>
<tr>
<td>– Urea</td>
<td>93</td>
</tr>
<tr>
<td>– Urea + Agrotain + DCD</td>
<td>95</td>
</tr>
<tr>
<td>– ESN blend</td>
<td>92</td>
</tr>
</tbody>
</table>

Mengel, 2009
Pre-plant vs side-dress nitrogen applications

Grain yield (bu/acre)

Manhattan 06, 07, 08

- Preplant - Sidedress
- 90-0: 124
- 60-30: 127
- 30-60: 134
- 0-90: 135

Hutchinson 06, 07, 08

- Preplant - Sidedress
- 90-0: 73
- 60-30: 78
- 30-60: 77
- 0-90: 74

Urea N 90 lbs/acre. Mengel 2010
Pre-plant vs side-dress nitrogen applications

• Early pre-plant N application can increase the risk of N loses.
• Side-dress application will require irrigation or rainfall to move N in the root zone.
• Split application can improve efficiency, and a good option for eastern KS.
Nitrogen source and products

NITROGEN FERTILIZER ADDITIVES, WHICH ONES WORK?
R. Jay Goos, Department of Soil Science, School of Natural Resource Sciences
North Dakota State University, Fargo, ND 58108; rj.goos@ndsu.edu

Abstract
Nitrogen fertilizer additives were evaluated in a series of studies. Nutrisphere had no effect on urea hydrolysis in a 2-year study. Nutrisphere had no effect on nitrification in a study with urea granules. Nutrisphere had no effect on nitrate leaching in a study with urea granules. Nutrisphere had no effect on nitrate leaching in a study with urea (CaTS) in the reduction of ammonia volatilization (UAN). In a sixth study with granular urea, Nutrisphere, OAC+, NZone, StayN, and NStay had no effect. In an eight- to nine studies Nutrisphere had no effect on nitrogen loss or the conversion of urea to ammonium. The combination of urea and ammonium showed that nitrapyrin was active as a nitrification inhibitor and that the degree of nitrification was influenced by the nitrapyrin slow release technology.

Use of Nitrogen Management Products and Practices to Enhance Yield and Nitrogen Uptake in No-till Grain Sorghum
A.R. Asebedo and D.B. Mengel

Summary
Ammonia volatilization, denitrification, immobilization, and leaching are common nitrogen (N) loss mechanisms grain sorghum producers face in Kansas. These N loss mechanisms cause a reduction in N availability and yield and increase costs for Kansas farmers.
N products: Response to surface applied N in no-till

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (bu/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No N</td>
<td>91 f</td>
</tr>
<tr>
<td>UAN on surface</td>
<td>132 e</td>
</tr>
<tr>
<td>Urea on surface</td>
<td>149 c</td>
</tr>
<tr>
<td>Urea + Agrotain</td>
<td>163 b</td>
</tr>
<tr>
<td>Urea + Super-U</td>
<td>168 a</td>
</tr>
<tr>
<td>Urea/ESN blend</td>
<td>169 a</td>
</tr>
</tbody>
</table>

Weber and Mengel, 2009
Urease inhibitors with surface applied urea

No-till

Sorghum yield (bu/acre)

Nitrogen rate (lbs/acre)

Lamond, 1998
Urease inhibitors with surface applied urea

Conventional tillage

Sorghum yield (bu/acre)

Nitrogen rate (lbs/acre)

- Urea
- Urea + Agrotain

Lamond, 1998
Urease inhibitors

• Rain or irrigation shortly after application (1-3 days).
  – No response to the inhibitor use.

• No rain after application for at least 5 days.
  – Response to inhibitor use.
Nitrogen application rate

Yield goal to estimate the total amount of soil and fertilizer nitrogen needed

\[ N_{rec} = (YG \times 1.6) - (SOM \times 20) - PCA - Manure - Tillage - Profile N \]

Previous crop adjustments (PCA):

- Soybean = -40 lbs
- Fallow = -20 lbs (without profile N)
- Alfalfa = -0 to 120 lbs (<1 to >5 plants/ft²)
- Red clover = -40 lbs (good stand)
### Average residual soil nitrate levels

<table>
<thead>
<tr>
<th>Previous crop</th>
<th>Number of samples</th>
<th>Average Profile NO3 lb/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>1</td>
<td>63</td>
</tr>
<tr>
<td>Corn</td>
<td>1</td>
<td>49</td>
</tr>
<tr>
<td>Fallow</td>
<td>12</td>
<td>134</td>
</tr>
<tr>
<td>Sorghum</td>
<td>5</td>
<td>39</td>
</tr>
<tr>
<td>Soybeans</td>
<td>27</td>
<td>115</td>
</tr>
<tr>
<td>Wheat</td>
<td>9</td>
<td>47</td>
</tr>
</tbody>
</table>

Spring before summer crop, range: 9-150

From a set of 44 samples. Soil testing lab. K-State, 2008
Sensors for N management in sorghum
## Sensor based vs soil test based N recommendations

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Belleville</td>
<td>96</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>Manhattan</td>
<td>155</td>
<td>60</td>
<td>33</td>
<td>33</td>
<td>27</td>
<td>0</td>
</tr>
<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>
<td>109</td>
<td>130</td>
<td>98</td>
<td>105</td>
<td>25</td>
<td>-7</td>
</tr>
<tr>
<td>Partridge</td>
<td>70</td>
<td>40</td>
<td>15</td>
<td>20</td>
<td>20</td>
<td>-5</td>
</tr>
<tr>
<td>Tribune</td>
<td>79</td>
<td>54</td>
<td>0</td>
<td>0</td>
<td>54</td>
<td>0</td>
</tr>
<tr>
<td>Manhattan</td>
<td>128</td>
<td>77</td>
<td>45</td>
<td>45</td>
<td>32</td>
<td>0</td>
</tr>
<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>

Mengel, 2008
# K-State sorghum N rate calculator

## Farmer Inputs

<table>
<thead>
<tr>
<th>Input</th>
<th>Value</th>
</tr>
</thead>
<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>

## Outputs

<table>
<thead>
<tr>
<th>Output</th>
<th>Value</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

http://hollandscientific.com/

http://www.trimble.com
RapidSCAN on UAVs

http://hollandscientific.com/
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

## Nutrient removal

<table>
<thead>
<tr>
<th>Crop</th>
<th>Unit</th>
<th>$P_2O_5$ (lb)</th>
<th>$K_2O$ (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>bushel</td>
<td>0.33</td>
<td>0.26</td>
</tr>
<tr>
<td>Grain Sorghum</td>
<td>bushel</td>
<td>0.40</td>
<td>0.26</td>
</tr>
<tr>
<td>Wheat</td>
<td>bushel</td>
<td>0.50</td>
<td>0.30</td>
</tr>
<tr>
<td>Sunflowers</td>
<td>pound</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Oats</td>
<td>bushel</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>Soybeans</td>
<td>bushel</td>
<td>0.80</td>
<td>1.40</td>
</tr>
</tbody>
</table>
Critical soil test P level
Fertilizer placement and tillage for grain sorghum, SE Kansas

Claypan soils, often with excessive moisture in the spring

Average of 3 years, Ottawa, KS

Janssen, 2010
Phosphorus and N starter fertilizer

- Nitrogen (lbs/acre) + 30 lbs P₂O₅
  - Dry matter at V-6 (lbs/acre)
    - 0 700
    - 10 800
    - 20 900
    - 30 1000
    - 40 1100
    - 50 1200
  - Sorghum grain yield (bu/acre)
    - 0 80
    - 10 90
    - 20 100
    - 30 110
    - 40 120
    - 50 130

Liquid surface dribble  Gordon, 2001
Band P fertilizer placement

- 2 X 2 Starter Band Single Side
- Band Below Seed
- Pop-up Seed Contact
- Dribble Row Band Surface Band
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:
  - Coarse stream on the soil surface beside or above the closed seed furrow. Best for higher rates.
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
Soil test P and application method

Common generalized depiction of broadcast vs. band
Keys to P management

• Soil Test regularly, every 2-4 years

• Use a Build and Maintain P Management System or be willing to fertilize each crop each year

• 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 – not agronomics.
Secondary and micronutrients for sorghum

• The most common issues in KS are iron, zinc and sulfur.
• Research have shown response to chloride
• Zn, S, and Cl have good soil tests.
What conditions favor response to chloride fertilizer?

- Soil Cl level less than 30 lb/acre to 24” soil depth.
- Plant Cl concentration less than 0.4 percent.
- Foliar or root fungal disease pressure.
- Response more frequent in central KS.
- Test irrigation water for Cl.
What conditions favor response to chloride fertilizer?

2012-2013, average of 5 locations

Flag leaf Cl concentration

Grain yield

2012-2013, average of 5 locations
Sorghum and soil pH?

Average soil pH

Grain yield (bu/acre)

Average - 5 years

Average soil pH

K. W. Kelley, 2008 SE KS
Sorghum iron chlorosis

Ruiz Diaz, 2013
Sorghum iron chlorosis

Grain yield (bu/acre)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>60</td>
</tr>
<tr>
<td>Fe w/seed</td>
<td>64</td>
</tr>
<tr>
<td>Zn w/seed</td>
<td>62</td>
</tr>
<tr>
<td>Manure 15 t/a</td>
<td>64</td>
</tr>
</tbody>
</table>

Ruiz Diaz, 2013
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).
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 and other considerations such as crop removal and experience.
Questions?

Dorivar Ruiz Diaz

ruizdiaz@ksu.edu
785-532-6183

www.agronomy.ksu.edu/extension/SoilFertility