Should Soil Health Tests be Used in Generating Fertilizer Recommendations?

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Soil Health, also referred to as Soil Quality, is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.

USDA-NRCS
How to Measure Soil Health:
You can SEE differences ……..

Photos: Liz Stahl, U of MN Extension
Soil Health Indicators We Can Measure

Physical
- Aggregation and Structure
- Surface Sealing
- Compaction
- Porosity
- Water Movement and Availability

Chemical
- pH
- Soluble Salts
- Sodium
- Nutrient Holding Capacity
- Nutrient Availability

Biological
- Macrofauna
- Microfauna
- Microorganisms
- Roots
- Biological Activity
- Organic Matter

Source: NDSU https://www.ndsu.edu/soilhealth/?page_id=37
Basic Package ($60)*:
- Soil pH, OM, Modified Morgan Extractable P, K, and micronutrients
- Wet Aggregate Stability
- Soil Respiration (4 days)
- Surface (0-6”) & Sub-Surface (6-18”) Hardness Interpretation

Standard ($110) Basic plus:
- Soil Texture, Active Carbon, Autoclave-citrate extractable protein test, Available water capacity

Extended ($170) Standard plus:
- Soluble Salts
- Heavy Metal Screening
- Root Health Bioassay

Other Options
- Hot water soluble Bo
- Potentially mineralizable N

*Generally used for agronomic crops

Source: http://soilhealth.cals.cornell.edu/testing-services/comprehensive-soil-health-assessment/
The Haney Test (~$70/test)

- Solvita 24-Hour CO2 Burst, also pH
- Water Extractable:
  - Total N (Ammonical N, Nitrate N, Organic N) and Organic C
- H3A Extractable:
  - Total P (Inorganic & Organic P), K, Ca, Mg, Na, Fe, Zn, and Al
- Calculated Values:
Farmers have been taking Haney Tests as part of Conservation Stewardship Program.

Should results be used in making fertilizer decisions?
Haney says the importance is increased precision of the new test and its ability to save significant amounts on fertilizer inputs. (See “Haney Test vs. Traditional” below.)

“Essentially, the research behind the test shows traditional soil-testing methods have been missing nearly half of the nitrogen in the sample for more than 70 years,” Haney says. That translates into a lot of wasted dollars for fertilizer.
Basics of Soil Testing

• A relative measurement of nutrient sufficiency for plants.
• Measures the amount of a nutrient that is proportional to the amount actually available for plants.
• Different tests / extractants measure different amounts of a nutrient.
• Also…

Adapted from: https://www.agronomy.org/files/.../07-comparing-p-soil-test-methods-mallarino.ppt
Photo: Liz Stahl, U of MN Extension
The amount measured of a nutrient has no meaning by itself.

Correlation and Calibration give results meaning.
A soil test is considered “correlated” when lower yield and plant growth can be predicted at lower soil test values, and higher yield and plant growth can be predicted at higher soil test values.
Example for P using Standard Testing Procedures

Table 8. Corn grain yield response to applied P fertilizer based on soil test category.

<table>
<thead>
<tr>
<th>Bray-P1 or Olsen Soil Test P Category</th>
<th>Expected Time P Fertilizer Will Increase Corn Grain Yield</th>
<th>Expected Yield Without P Fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>Low</td>
<td>83</td>
<td>90</td>
</tr>
<tr>
<td>Medium</td>
<td>27</td>
<td>98</td>
</tr>
<tr>
<td>High</td>
<td>13</td>
<td>99</td>
</tr>
<tr>
<td>Very High</td>
<td>7</td>
<td>99</td>
</tr>
</tbody>
</table>

Source: Fertilizing Corn in Minnesota, U of MN Extension AG-FO-3790-D
Calibration

The process of determining how much fertilizer is needed to meet nutrient needs of the crop at different soil test levels.

Photo: Liz Stahl, U of MN Extension
Example for N

- Typical calibration trials
  - Small plot, replicated trials
  - Test a range of fertilizer rates
  - Determine economic optimal fertilizer rate

- Little to no correlation or calibration work has been done with the Haney Test in Minnesota, or across the Midwest.

Source: Validating N rates for corn on farm fields in southern Minnesota, U of MN Extension, WW-07936 2003
Haney Test Soil Testing Project (2016 initiated)

- Objectives include:
  - Compare results between methods
  - Determine impact on fertilizer recommendations
  - Also a pilot study

- 12 on-farm sites over 3 years
  - Sites selected for a range in common soil types & productivity
  - Sites georeferenced
  - Haney @ 0-6 inch, Standard @ 0-6 inch and 6-24 for nitrate-N
  - Samples taken in the spring, split & taken to same lab for analysis
Comparison Between Standard Soil Test Results & Haney Test Results: N

2016

Results from Haney Test vs Standard Test: N

Sample Number

0 1 2 3 4 5 6 7 8 9 10 11 12 13

N (lb/ac)

Haney-Water Ext N
Stand N 0-24”

r = 0.5768

2017

Results from Haney Test vs Standard Test: N

Sample Number

0 1 2 3 4 5 6 7 8 9 10 11 12 13

N (lb/ac)

Haney-Water Ext N
Stand N 0-24”

r = 0.8663

Stahl and Fernandez, 2018
Comparison Between Standard Soil Test Results & Haney Test Results: N (0-6")

2016

$r = 0.9009$

2017

$r = 0.8556$

Stahl and Fernandez, 2018
Fertilizer Guidelines / Recommendations: N

- MRTN calculated for 6 states (IL, IA, MI, MN, OH, and WI)
  - Uses ratio: N fertilizer price ($/lb) / Corn grain price ($/bu)
  - Yield Goal is NOT used, although other states may use it

http://cnrc.agron.iastate.edu/
N Rate Calculator

- N as anhydrous @ $491/Ton
  (DTN AgFAX 12/17/17)
- Corn @ $3.00/bu
  (NASS Nov. 2017)
- Used 170 #N for N needs
  (in range of 145 – 173)
- Standard calculation:
  N application needs = (170) – (.60 x STN (0-24in))
Assumptions: Based on Fertilizing Corn in Minnesota (AG-FO-3790-D) for Corn/Corn, with an N Price / Crop Price ratio of .10 (N Rate Calculator @ http://cnrc.agron.iastate.edu/), with N as anhydrous @ $491/Ton (DTN AgFAX 12/17/17) & Corn @ $3.00/bu (NASS Nov. 2017) = total N need of 170#/ac.
Assumptions: Based on Fertilizing Corn in Minnesota (AG-FO-3790-D) for Corn/Corn, with an N Price / Crop Price ratio of .10 (from the N Rate Calculator @ http://cnrc.agron.iastate.edu/) using N as anhydrous @ $491/Ton (DTN AgFAX 12/17/17) & Corn @ $3.00/bu (NASS Nov. 2017)

Stahl and Fernandez, 2018
Comparison Between Standard Soil Test Results & Haney Test Results: K (0-6”)

2016

\[ r = 0.8598 \]

Results from Haney Test vs Standard Test: K

2017

\[ r = 0.9365 \]

Results from Haney Test vs Standard Test: K

Standard test for K: Ammonium acetate, the Haney Test uses H3A extract
Stahl and Fernandez, 2018
## Potassium Guidelines in MN

### Table 10. Broadcast (Bdcst) and band potash guidelines for corn production in Minnesota.*

<table>
<thead>
<tr>
<th>Expected Yield (bu/acre)</th>
<th>Very Low (0-40)</th>
<th>Low (41-80)</th>
<th>Medium (81-120)</th>
<th>High (121-160)</th>
<th>Very High (160+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>175 - 199</td>
<td>185</td>
<td>135</td>
<td>80</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>200 - 219</td>
<td>210</td>
<td>155</td>
<td>90</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>220 - 239</td>
<td>235</td>
<td>165</td>
<td>100</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>240+</td>
<td>255</td>
<td>180</td>
<td>110</td>
<td>35</td>
<td>0</td>
</tr>
</tbody>
</table>

*K2O per acre to apply (lb. per acre)*

*Source: Fertilizing Corn in Minnesota, AG-FO-3790-D (REVISED 2016)*

Used Yield Goal of 210 bu/ac
### Potassium

<table>
<thead>
<tr>
<th>Site</th>
<th>Resulting Soil Testing Range</th>
<th>K\textsubscript{2}O to Broadcast (lb/acre)</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard Test</td>
<td>Haney Test</td>
<td>Standard Test</td>
</tr>
<tr>
<td>1</td>
<td>V High</td>
<td>Low</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Med</td>
<td>V Low</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>High</td>
<td>V Low</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
<td>Low</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>High</td>
<td>Low</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>High</td>
<td>Low</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>V High</td>
<td>Med</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>High</td>
<td>Low</td>
<td>30</td>
</tr>
<tr>
<td>9</td>
<td>V High</td>
<td>Low</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>V High</td>
<td>Med</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>High</td>
<td>V Low</td>
<td>30</td>
</tr>
<tr>
<td>12</td>
<td>High</td>
<td>V Low</td>
<td>30</td>
</tr>
</tbody>
</table>

Using U of MN Fertilizer Guidelines @ 210 bu/ac corn yield goal
Comparison Between Standard Soil Test Results & Haney Test Results: P (0-6”)

Standard test for P: Bray (pH <7.4 (0.025 M HCl; 0.03 M NH₄F) or Olsen pH≥ 7.4 (0.5 M NaHCO₃). The Haney Test uses H3A extract.

Stahl and Fernandez, 2018

2016

\[ r = 0.4009 \]

2017

\[ r = 0.5858 \]
Phosphorus Guidelines in MN

In general, use the Olsen test if the soil pH is 7.4 or greater
Used Yield Goal of 210 bu/ac

**Table 9. Broadcast (Bdcst) and band phosphate guidelines for corn production in Minnesota.**

<table>
<thead>
<tr>
<th>Expected Yield</th>
<th>Bray: 0-5</th>
<th>Olsen: 0-3</th>
<th>Soil test P (ppm)</th>
<th>Bdcst</th>
<th>Band</th>
<th>Bdcst</th>
<th>Band</th>
<th>Bdcst</th>
<th>Band</th>
<th>Bdcst</th>
<th>Band</th>
<th>Bdcst</th>
<th>Band</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Low</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Very High</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>175 – 199</td>
<td>110</td>
<td>55</td>
<td>75</td>
<td>40</td>
<td>45</td>
<td>30</td>
<td>15</td>
<td>10-15</td>
<td>0</td>
<td>10-15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 – 219</td>
<td>130</td>
<td>65</td>
<td>90</td>
<td>45</td>
<td>55</td>
<td>30</td>
<td>20</td>
<td>10-15</td>
<td>0</td>
<td>10-15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>220 – 239</td>
<td>145</td>
<td>75</td>
<td>100</td>
<td>50</td>
<td>60</td>
<td>30</td>
<td>20</td>
<td>10-15</td>
<td>0</td>
<td>10-15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>240 +</td>
<td>160</td>
<td>80</td>
<td>115</td>
<td>60</td>
<td>70</td>
<td>35</td>
<td>25</td>
<td>10-15</td>
<td>0</td>
<td>10-15</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Fertilizing Corn in Minnesota, AG-FO-3790-D (REVISED 2016)
### Phosphorus

#### 2016

<table>
<thead>
<tr>
<th>Site</th>
<th>Resulting Soil Testing Range</th>
<th>( P_{2}O_{5} ) to Broadcast (lb/acre)</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low Med</td>
<td>90 55</td>
<td>-35</td>
</tr>
<tr>
<td>2</td>
<td>High V High</td>
<td>20 0</td>
<td>-20</td>
</tr>
<tr>
<td>3</td>
<td>V High High</td>
<td>0 20</td>
<td>+20</td>
</tr>
<tr>
<td>4</td>
<td>V High V High</td>
<td>0 0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Low Med</td>
<td>90 55</td>
<td>-35</td>
</tr>
<tr>
<td>6</td>
<td>Low V High</td>
<td>90 0</td>
<td>-90</td>
</tr>
<tr>
<td>7</td>
<td>V High V High</td>
<td>0 20</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Low V High</td>
<td>90 0</td>
<td>-90</td>
</tr>
<tr>
<td>9</td>
<td>V High V High</td>
<td>0 0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>V High V High</td>
<td>0 0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>High Med</td>
<td>20 55</td>
<td>+35</td>
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<td>12</td>
<td>V High High</td>
<td>0 20</td>
<td>+20</td>
</tr>
</tbody>
</table>

### 2017

<table>
<thead>
<tr>
<th>Site</th>
<th>Resulting Soil Testing Range</th>
<th>( P_{2}O_{5} ) to Broadcast (lb/acre)</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low V High</td>
<td>90 0</td>
<td>-90</td>
</tr>
<tr>
<td>2</td>
<td>V High V High</td>
<td>0 0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Low High</td>
<td>90 20</td>
<td>-70</td>
</tr>
<tr>
<td>4</td>
<td>V High V High</td>
<td>0 0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Med V High</td>
<td>55 0</td>
<td>-55</td>
</tr>
<tr>
<td>6</td>
<td>V High V High</td>
<td>0 0</td>
<td>0</td>
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<tr>
<td>7</td>
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<td>0 0</td>
<td>0</td>
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<td>90 20</td>
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<td>V High V High</td>
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<tr>
<td>11</td>
<td>V High V High</td>
<td>0 0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>V High V High</td>
<td>0 0</td>
<td>0</td>
</tr>
</tbody>
</table>

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Using U of MN Fertilizer Guidelines @ 210 bu/ac corn yield goal

Stahl and Fernandez, 2018
Key Points: Fertilizer Recommendations

• Use results from tests that have been correlated & calibrated in your state
  – Otherwise you risk over or under application of nutrients

• How were the recommendations listed on soil test generated?
  – What does the lab’s “University” recommendations mean
    • Are they really from your state’s University or somewhere else?
    – What are the rates being compared against if there is a “savings”

• On-farm trials, report good yields with less N
  – What was their starting point??
Concerns / Questions Raised with the Haney Test & other Soil Health Tests

- Repeatability
- Cost
- Not able to detect fine differences in long-term cropping systems
- Lack of correlation & calibration research
- Does a “healthy soil” result in higher yields?
- What do the results mean
  - How can the information be applied?
Tier 1 Soil Health Measures

- Organic C
- pH
- Water-stable aggregation
- Crop yield
- Texture
- Penetration resistance
- CEC
- Electrical conductivity
- N, P, K
- C & N mineralization
- Erosion rating
- Base saturation
- Bulk density
- Available water holding capacity
- Infiltration rate
- Micronutrients
Soil Your Undies

Using Tea Bags to Measure Soil Health

Source: M. McDaniel, Iowa State University, ICM Conference 2017
Soil Health Testing: Wish List

- Soil health tests should be robust
- Results repeatable
- Results correlate to yield response
- Be able to measure differences among long-term management systems (cover crops, reduced tillage, etc.)
- Inexpensive and easy to use
- Sound basis in science in what is being measured and why
- Have sound correlation and calibration research behind them to give clear direction in interpretation

Photo: Liz Stahl, U of MN Extension
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GO VIKINGS!!!!!