# Should Soil Health Tests be Used in Generating Fertilizer Recommendations?

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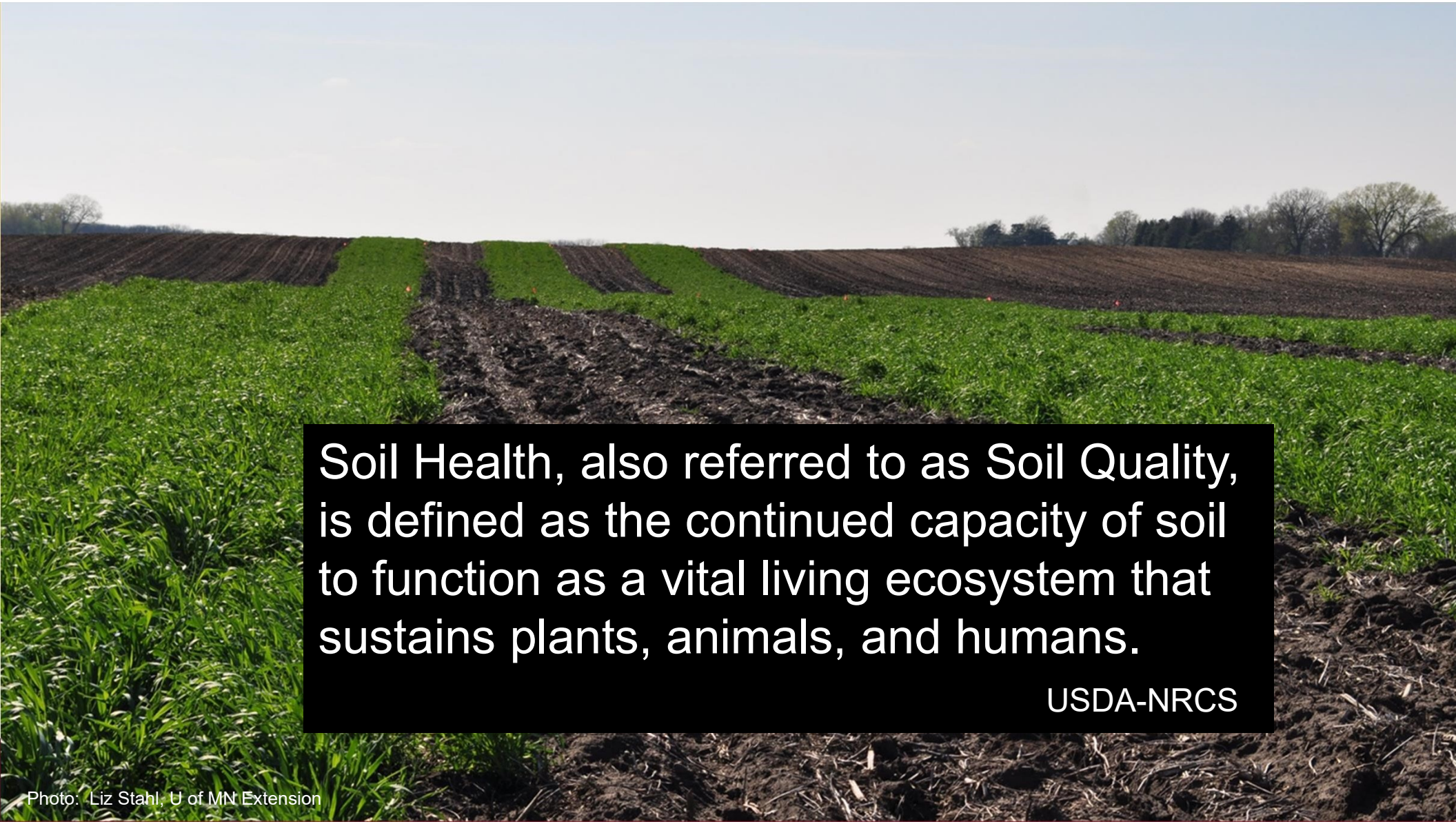


Soil Health, also referred to as Soil Quality, is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.

USDA-NRCS

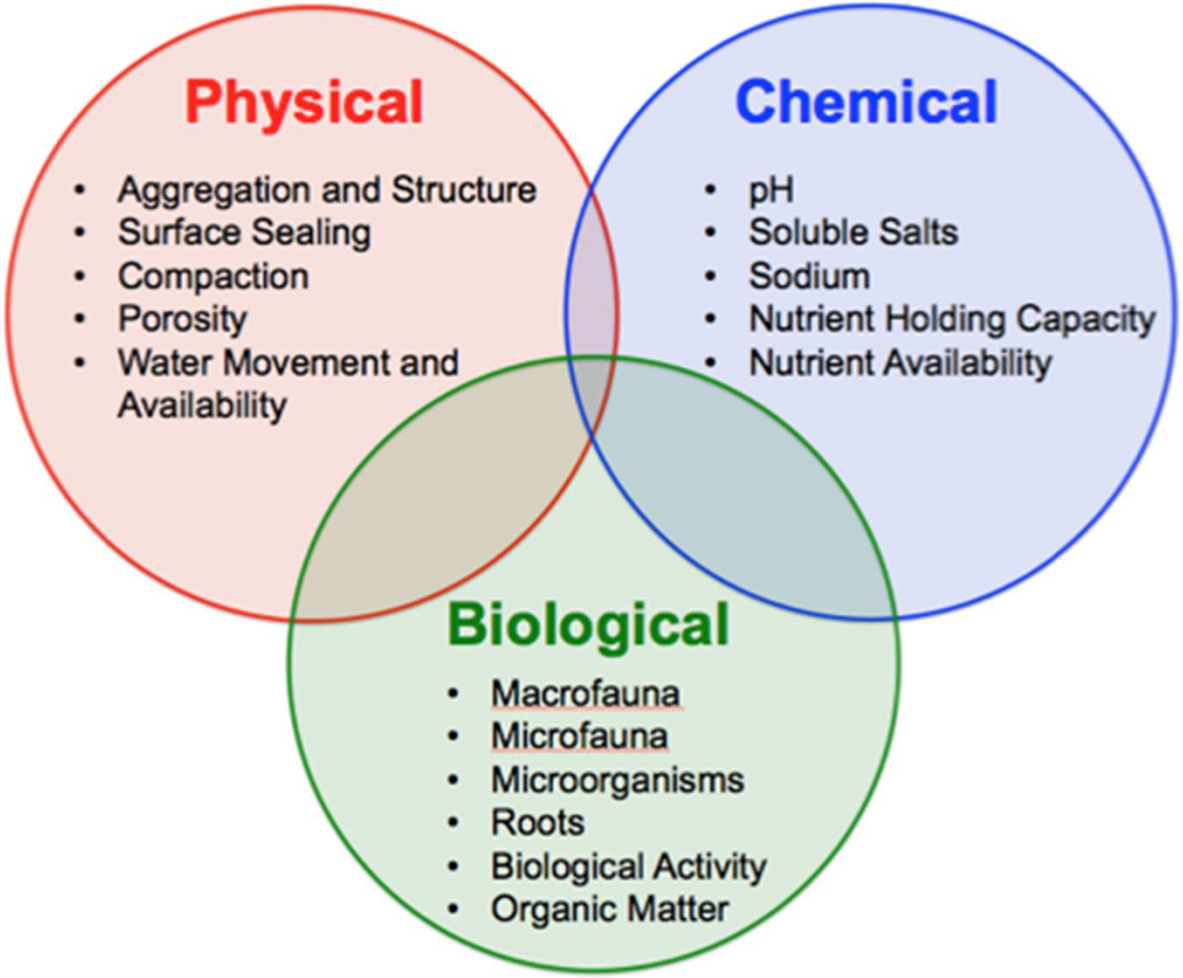
Photo: Liz Stahl, U of MN Extension

# How to Measure Soil Health:

## You can SEE differences …….

Photos: Liz Stahl, U of MN Extension

# Soil Health Indicators We Can Measure




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

*Generally used for agronomic crops


## Extended ($170) *Standard plus*:

- Soluble Salts
- Heavy Metal Screening
- Root Health Bioassay

## Other Options

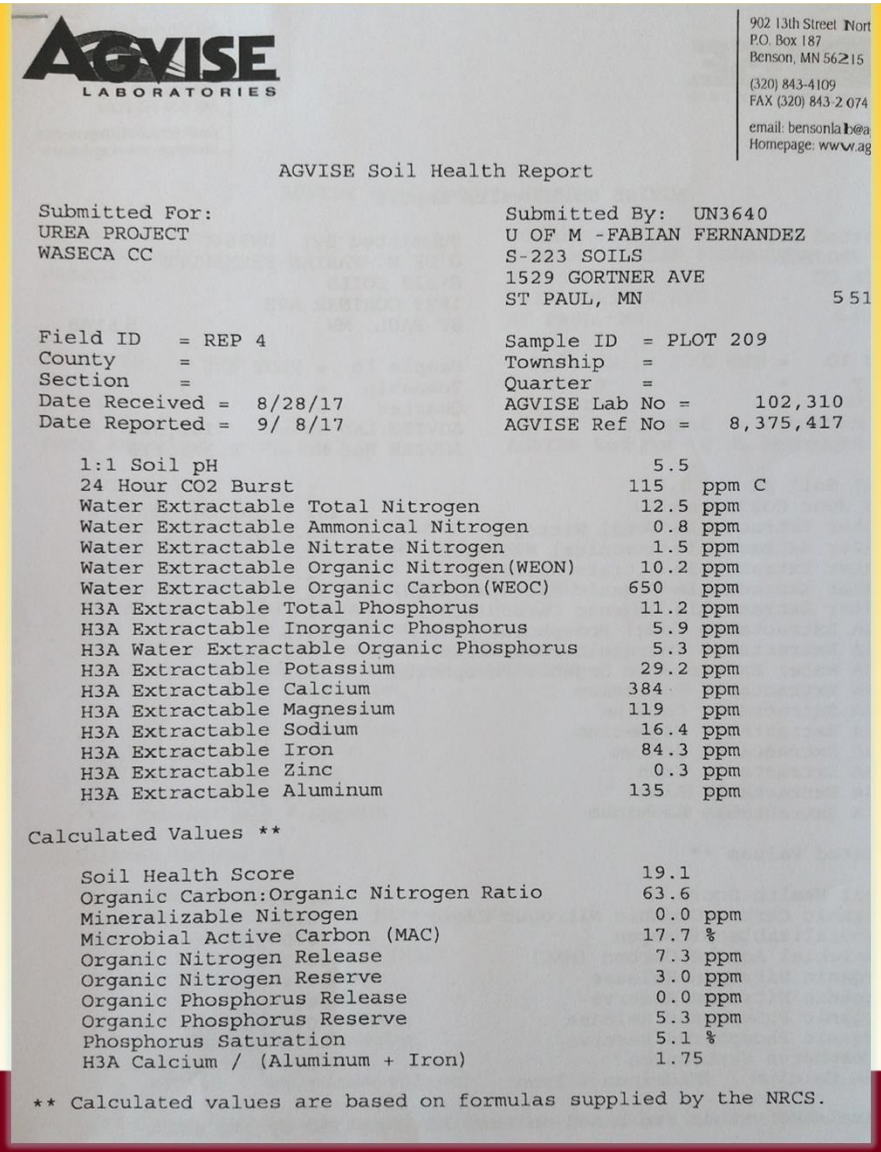
- Hot water soluble Bo
- Potentially mineralizable N

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:
  - Soil Health Score, Organic C:Organic N, Microbial Active C, Organic N & P release, Organic N & P Reserve, P saturation, H3A Ca / (Al+Iron)

Photo: Solvita.com



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AGVISE Soil Health Report

Submitted For:
UREA PROJECT
WASECA CC

Submitted By: UN3640
U OF M -FABIAN FERNANDEZ
S-223 SOILS
1529 GORTNER AVE
ST PAUL, MN 551

Field ID = REP 4
County =
Section =
Date Received = 8/28/17
Date Reported = 9/ 8/17

Sample ID = PLOT 209
Township =
Quarter =
AGVISE Lab No = 102,310
AGVISE Ref No = 8,375,417

| | | |
|---|---|---|
| 1:1 Soil pH | 5.5 | |
| 24 Hour CO2 Burst | 115 | ppm C |
| Water Extractable Total Nitrogen | 12.5 | ppm |
| Water Extractable Ammonical Nitrogen | 0.8 | ppm |
| Water Extractable Nitrate Nitrogen | 1.5 | ppm |
| Water Extractable Organic Nitrogen(WEON) | 10.2 | ppm |
| Water Extractable Organic Carbon(WEOC) | 650 | ppm |
| H3A Extractable Total Phosphorus | 11.2 | ppm |
| H3A Extractable Inorganic Phosphorus | 5.9 | ppm |
| H3A Water Extractable Organic Phosphorus | 5.3 | ppm |
| H3A Extractable Potassium | 29.2 | ppm |
| H3A Extractable Calcium | 384 | ppm |
| H3A Extractable Magnesium | 119 | ppm |
| H3A Extractable Sodium | 16.4 | ppm |
| H3A Extractable Iron | 84.3 | ppm |
| H3A Extractable Zinc | 0.3 | ppm |
| H3A Extractable Aluminum | 135 | ppm |

Calculated Values **

| | | |
|---|---|---|
| Soil Health Score | 19.1 | |
| Organic Carbon:Organic Nitrogen Ratio | 63.6 | |
| Mineralizable Nitrogen | 0.0 | ppm |
| Microbial Active Carbon (MAC) | 17.7 | % |
| Organic Nitrogen Release | 7.3 | ppm |
| Organic Nitrogen Reserve | 3.0 | ppm |
| Organic Phosphorus Release | 0.0 | ppm |
| Organic Phosphorus Reserve | 5.3 | ppm |
| Phosphorus Saturation | 5.1 | % |
| H3A Calcium / (Aluminum + Iron) | 1.75 | |

** Calculated values are based on formulas supplied by the NRCS.

- Farmers have been taking Haney Tests as part of Conservation Stewardship Program
- Should results be used in making fertilizer decisions?

SOLVITA®

# How can crop advisers use Solvita soil testing?

1. The Solvita Lab Tests helps you optimize your fertilizer recommendations.

https://solvita.com/soil/crops/

Successful Farming at AGRICULTURE.COM

## HANEY SOIL TEST CAN HELP PRODUCERS MAXIMIZE FERTILIZER INPUTS

By Bill Spiegel
8/29/2014

dtn The Progressive Farmer

The "Haney Test"
Dan Crummett

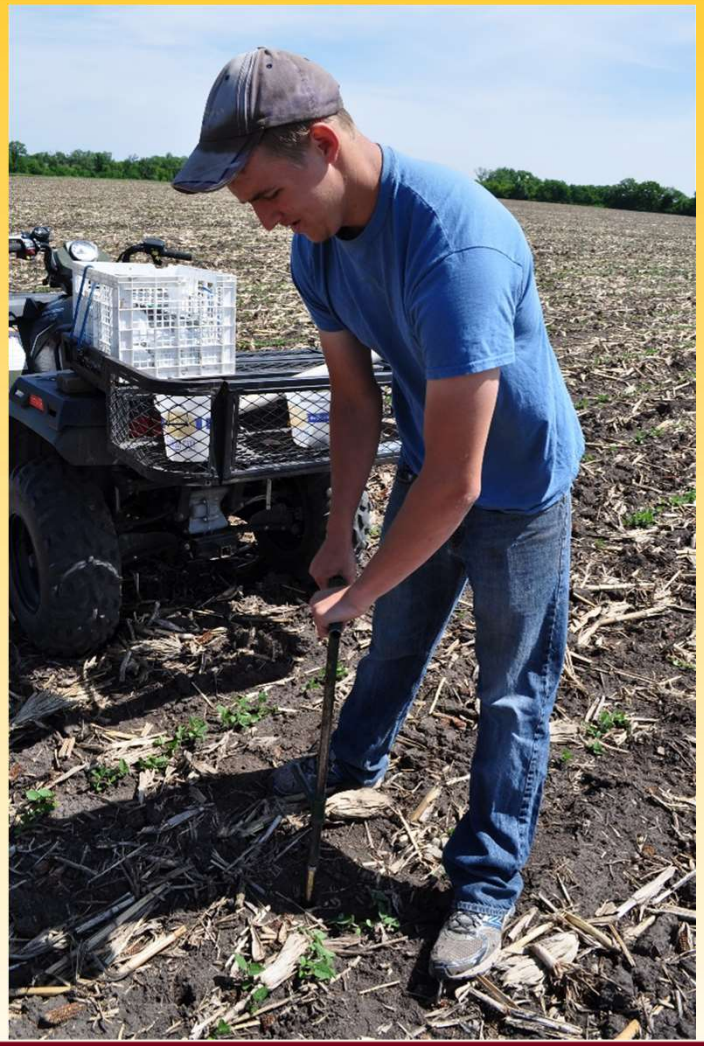
Nov. 2017

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


Photo: Liz Stahl, U of MN Extension

# Correlation

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.

Photo: Liz Stahl, U of MN Extension

# Example for P using Standard Testing Procedures

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

| BRAY-P1 OR OLSEN SOIL TEST P CATEGORY | EXPECTED TIME P FERTILIZER WILL INCREASE CORN GRAIN YIELD | EXPECTED YIELD WITHOUT P FERTILIZER |
|---|---|---|
| | ----------%---------- | |
| Very Low | 87 | 87 |
| Low | 83 | 90 |
| Medium | 27 | 98 |
| High | 13 | 99 |
| Very High | 7 | 99 |

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

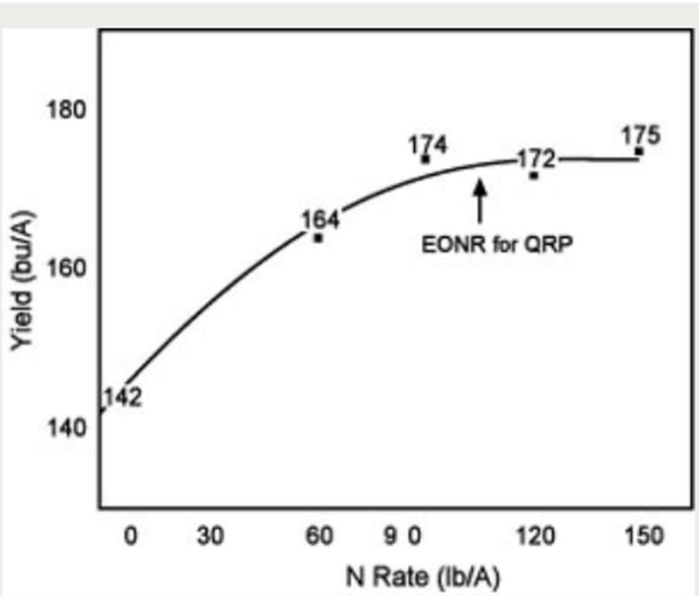



Figure 2. The quadratic response plateau (QRP) model used to find the optimum N rate for an example data set.

- 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

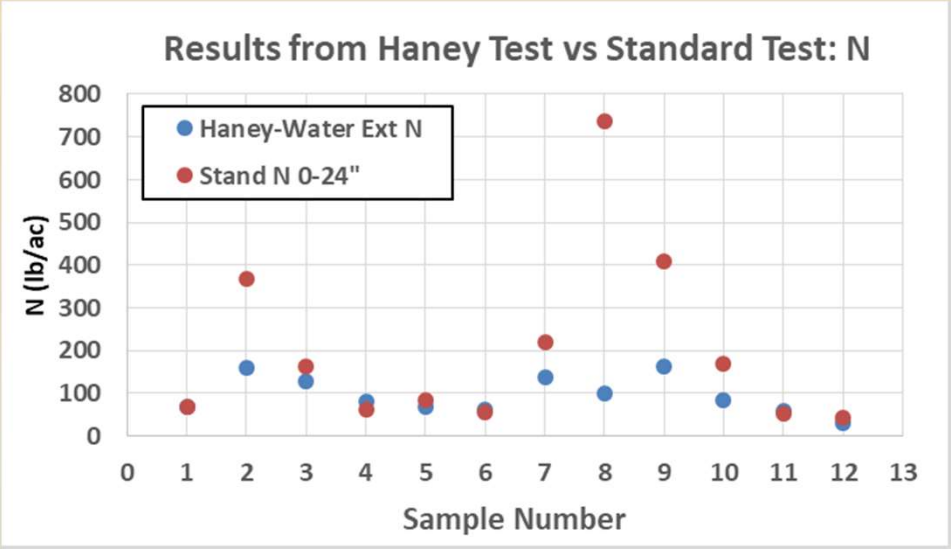
# Haney Test Soil Testing Project (2016 initiated)

- 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


Photo: Liz Stahl, U of MN Extension

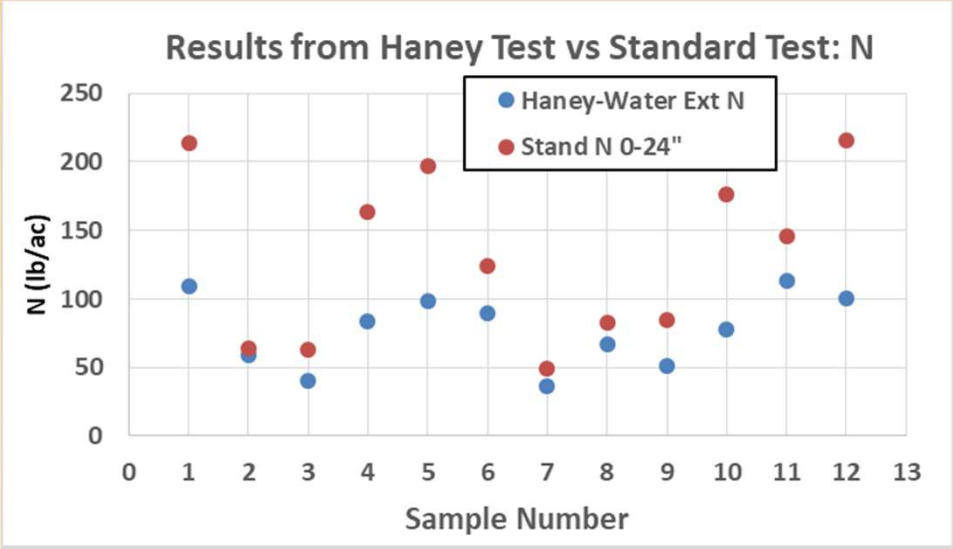
# Comparison Between Standard Soil Test Results & Haney Test Results: N

**2016**




r = 0.5768

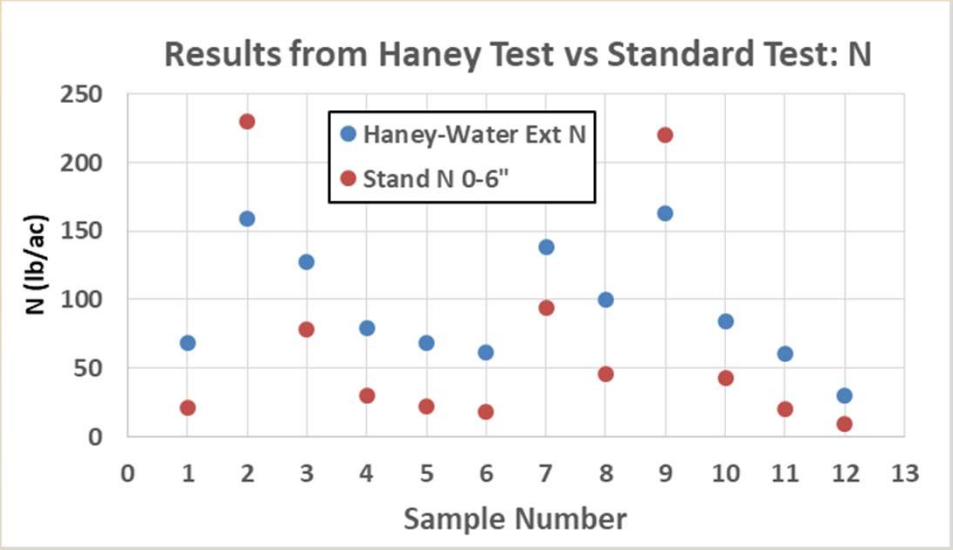
**2017**




r = 0.8663

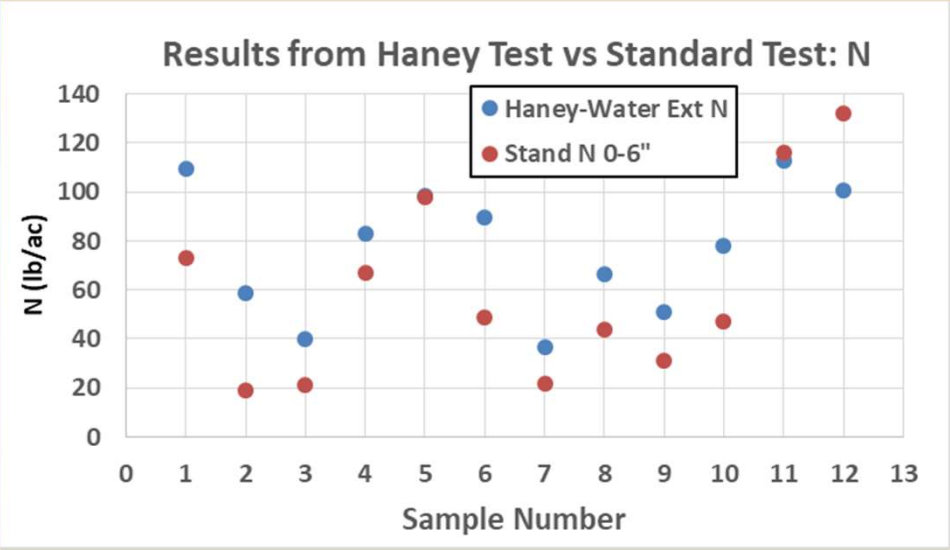
# Comparison Between Standard Soil Test Results & Haney Test Results: N (0-6”)

**2016**



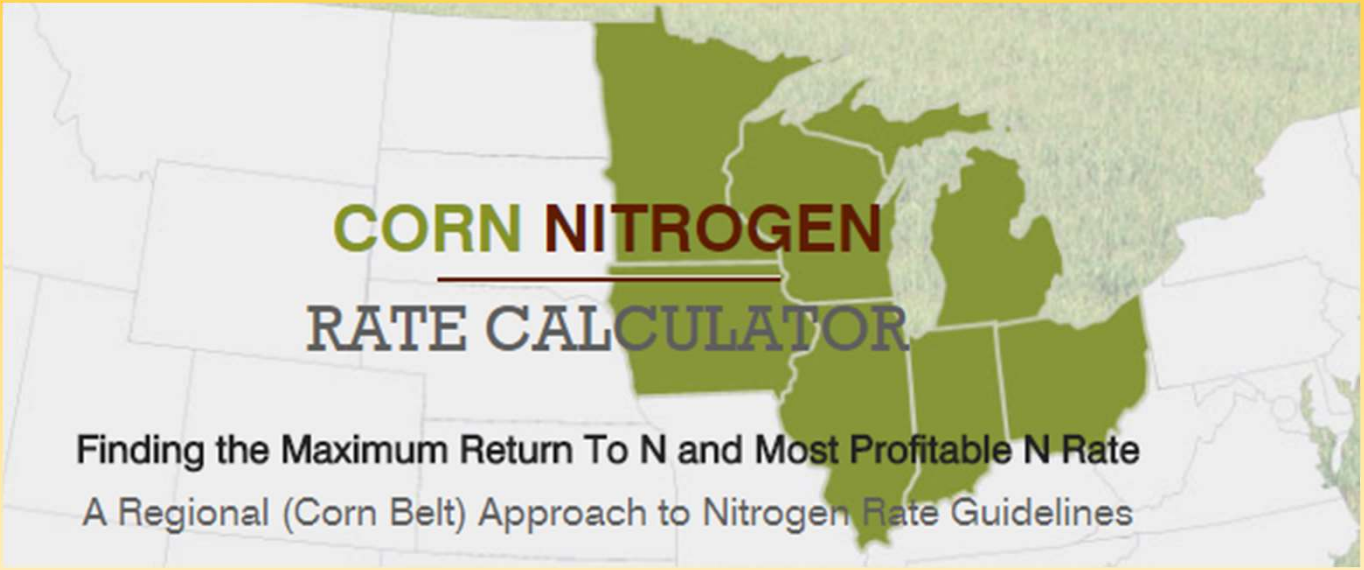

r = 0.9009

**2017**




r = 0.8556

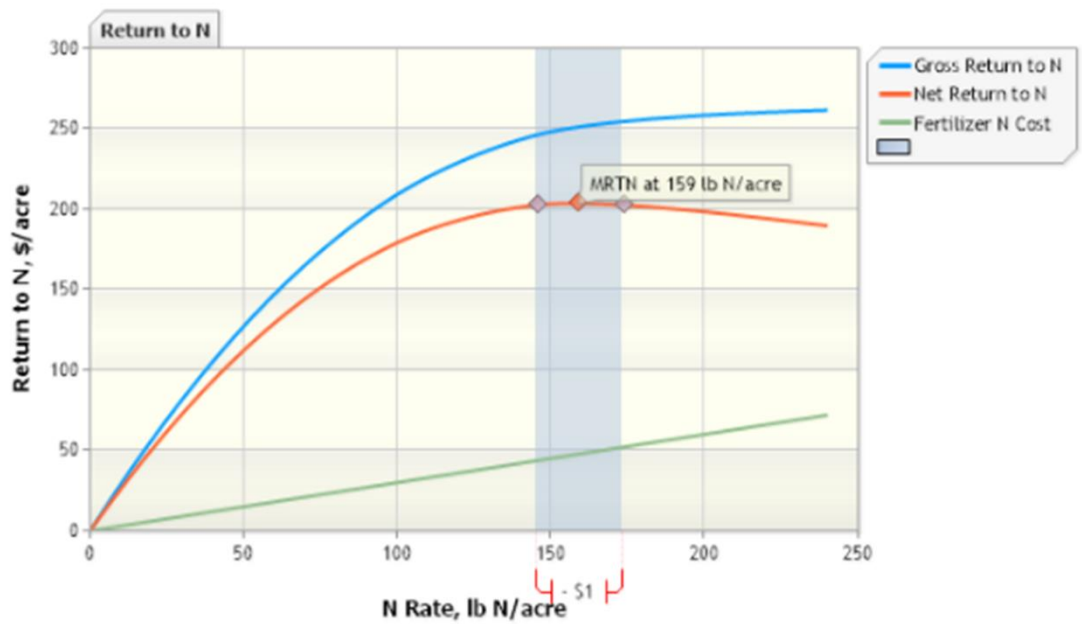
# Fertilizer Guidelines / Recommendations: N




- 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

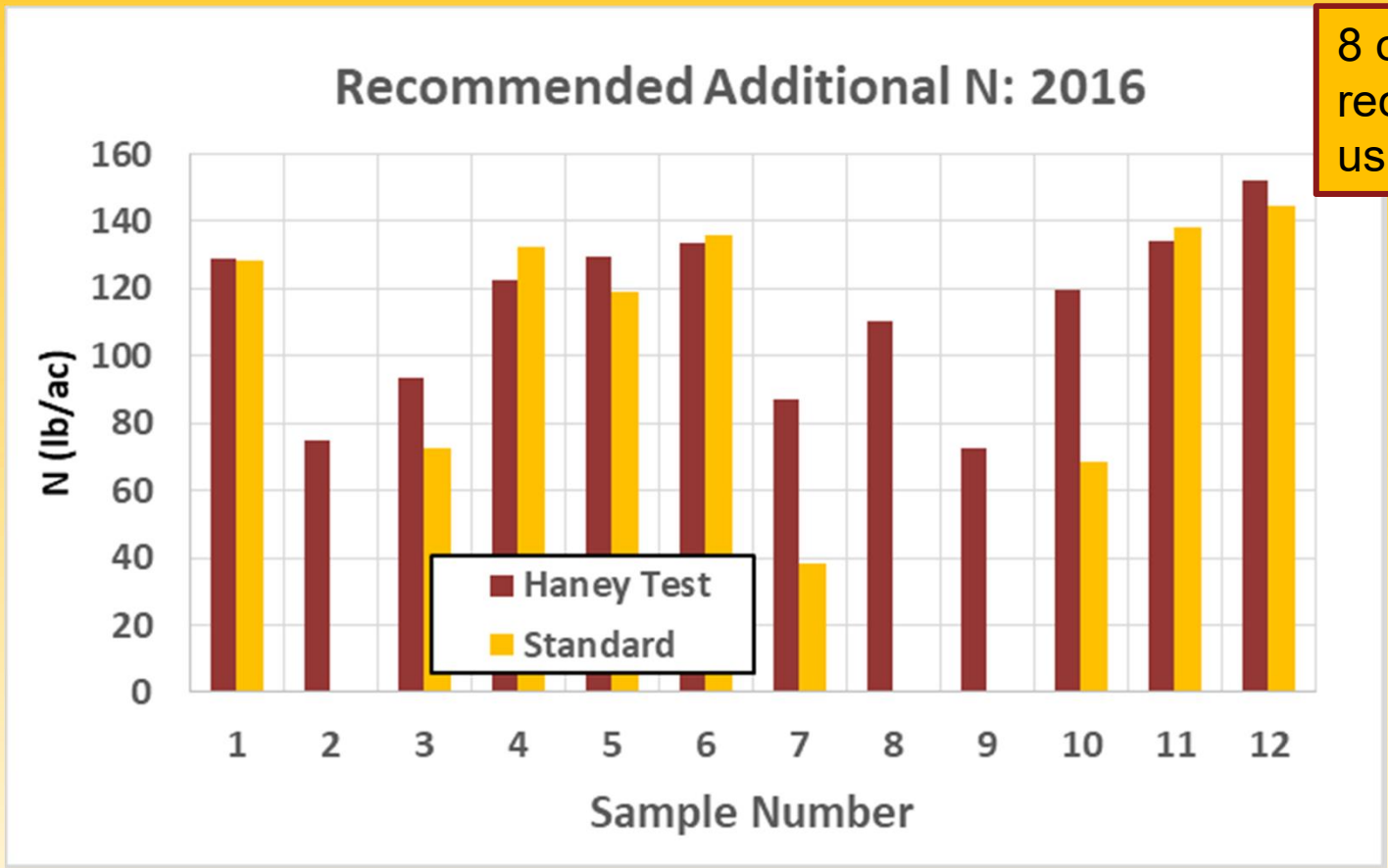
State: Minnesota
Number of sites: 63
Rotation: Corn Following Corn

| | |
|---|---|
| Nitrogen Price ($/lb): | 0.30 |
| Corn Price ($/bu): | 3.00 |
| Price Ratio: | 0.10 |
| MRTN Rate (lb N/acre): | 159 |
| Profitable N Rate Range (lb N/acre): | 145 - 173 |
| Net Return to N at MRTN Rate ($/acre): | $203.45 |
| Percent of Maximum Yield at MRTN Rate: | 98% |
| Anhydrous Ammonia (82% N) at MRTN Rate (lb product/acre): | 193 |
| Anhydrous Ammonia (82% N) Cost at MRTN Rate ($/acre): | $47.70 |



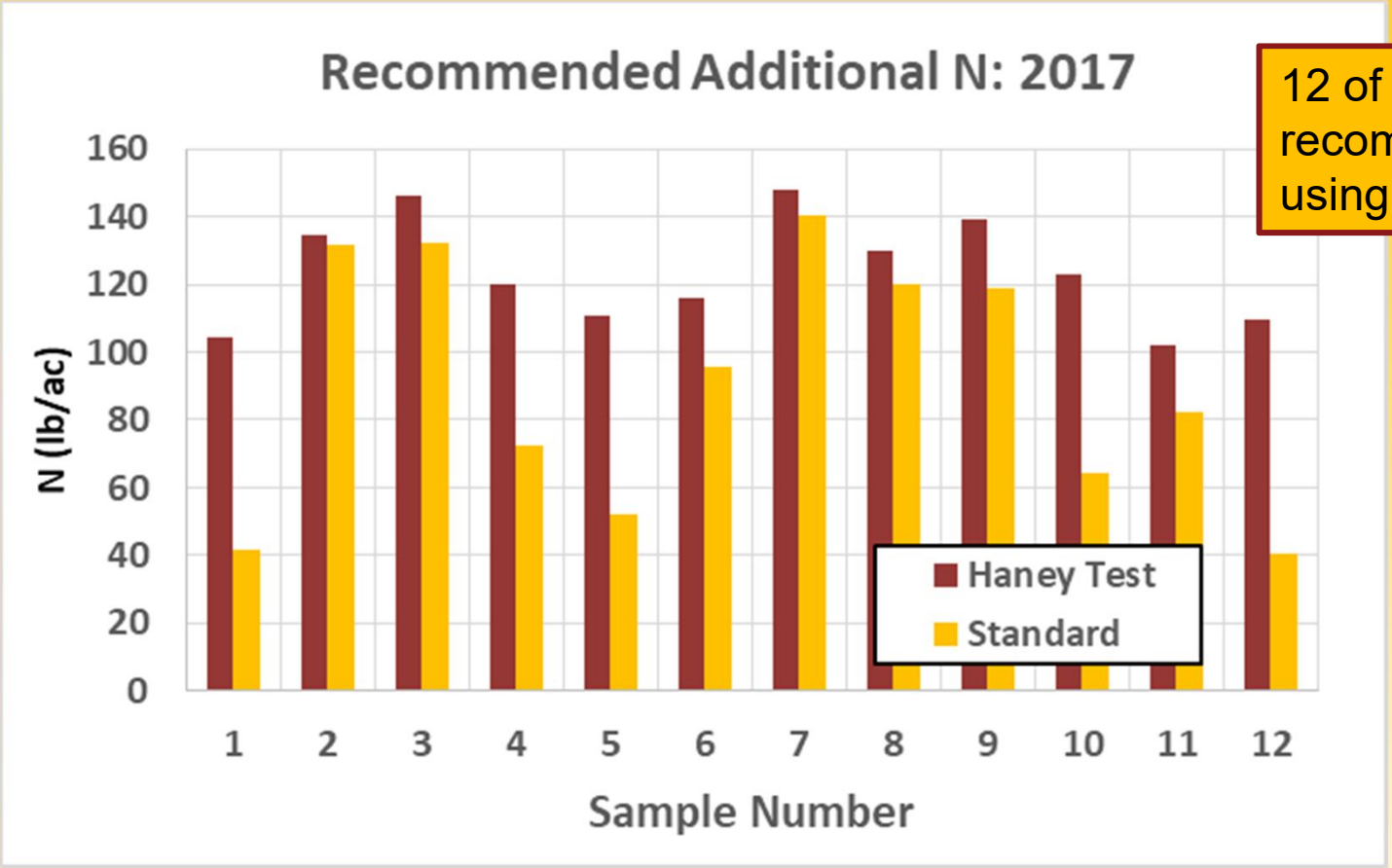

# N Rate Calculator

- 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))




8 of 12 sites > N recommended if using the Haney

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.

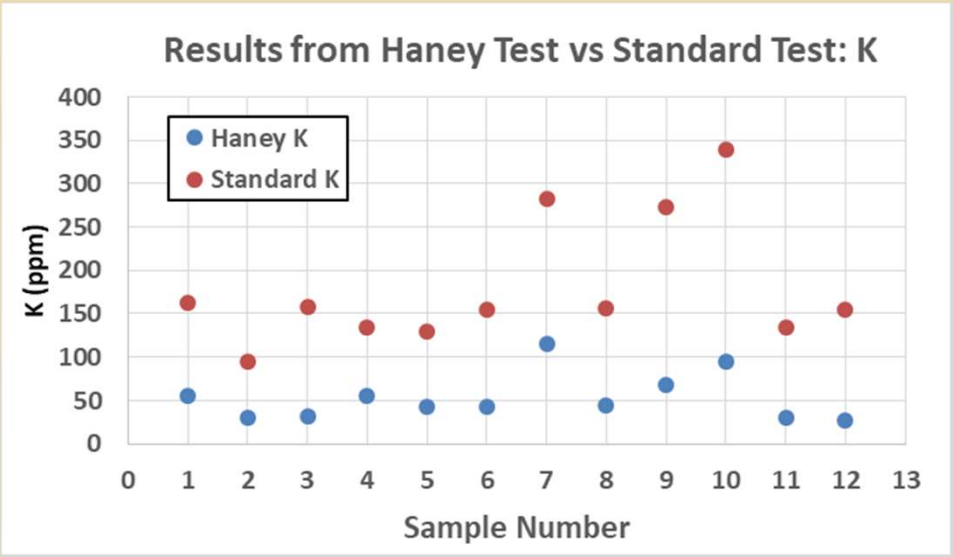



12 of 12 sites > N recommended if using the Haney

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)

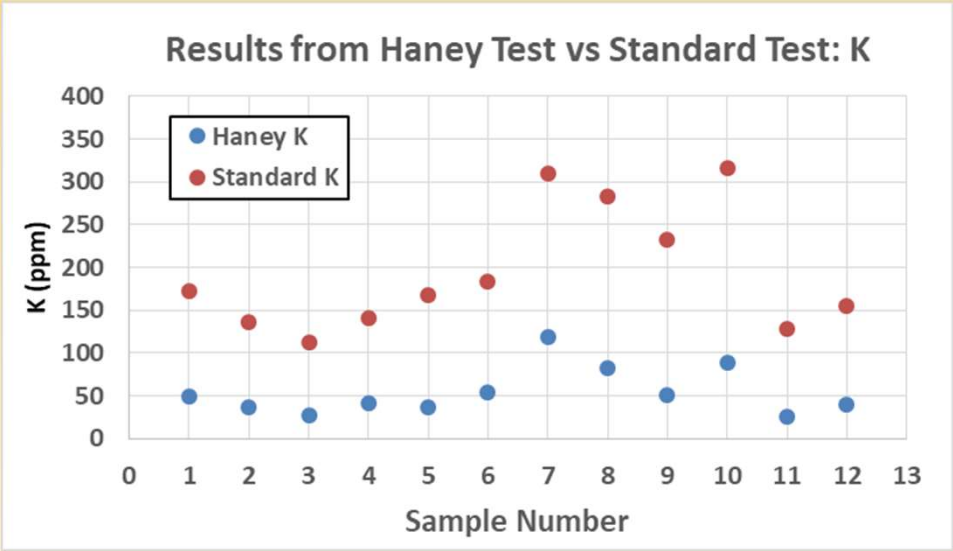
# Comparison Between Standard Soil Test Results & Haney Test Results: K (0-6”)

**2016**




r = 0.8598

**2017**




r = 0.9365

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.* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Soil test K (ppm) | | | | | | | | | |
| | Very Low | | Low | | Medium | | High | | Very High | |
| Expected | 0-40 | | 41-80 | | 81-120 | | 121-160 | | 160+ | |
| Yield | Bdcst | Band | Bdcst | Band | Bdcst | Band | Bdcst | Band | Bdcst | Band |
| bu/acre | ---------- $K_2O$ per acre to apply (lb. per acre) ---------- | | | | | | | | | |
| | | | | | | | | | | |
| 175 - 199 | 185 | 90 | 135 | 70 | 80 | 50 | 25 | 10-15 | 0 | 10-15 |
| 200 - 219 | 210 | 105 | 155 | 80 | 90 | 55 | 30 | 10-15 | 0 | 10-15 |
| 220 -239 | 235 | 120 | 165 | 85 | 100 | 60 | 30 | 10-15 | 0 | 10-15 |
| 240 + | 255 | 130 | 180 | 90 | 110 | 65 | 35 | 15-20 | 0 | 10-15 |

Used Yield Goal of 210 bu/ac

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

# Potassium

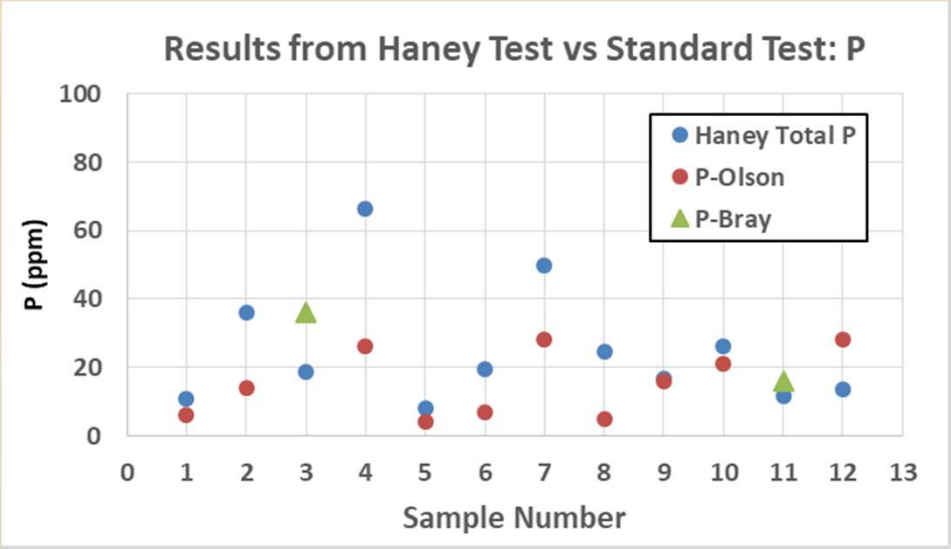
| | 2016 | | | | | 2017 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Resulting Soil Testing Range | | $K_2O$ to Broadcast (lb/acre) | | | Resulting Soil Testing Range | | $K_2O$ to Broadcast (lb/acre) | | |
| Site | Standard Test | Haney Test | Standard Test | Haney Test | Diff | Standard Test | Haney Test | Standard Test | Haney Test | Diff |
| 1 | V High | Low | 0 | **155** | **+155** | V High | Low | 0 | **155** | **+155** |
| 2 | Med | V Low | 90 | **210** | **+120** | High | V Low | 30 | **210** | **+180** |
| 3 | High | V Low | 30 | **210** | **+180** | Med | V Low | 90 | **210** | **+120** |
| 4 | High | Low | 30 | **155** | **+125** | High | Low | 30 | **155** | **+125** |
| 5 | High | Low | 30 | **155** | **+125** | V High | V Low | 0 | **210** | **+210** |
| 6 | High | Low | 30 | **155** | **+125** | V High | Low | 0 | **155** | **+155** |
| 7 | V High | Med | 0 | **90** | **+90** | V High | Med | 0 | **90** | **+90** |
| 8 | High | Low | 30 | **155** | **+125** | V High | Med | 0 | **90** | **+90** |
| 9 | V High | Low | 0 | **155** | **+155** | V High | Low | 0 | **155** | **+155** |
| 10 | V High | Med | 0 | **90** | **+90** | V High | Med | 0 | **90** | **+90** |
| 11 | High | V Low | 30 | **210** | **+180** | High | V Low | 30 | **210** | **+180** |
| 12 | High | V Low | 30 | **210** | **+180** | High | V Low | 30 | **210** | **+180** |

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

Stahl and Fernandez, 2018

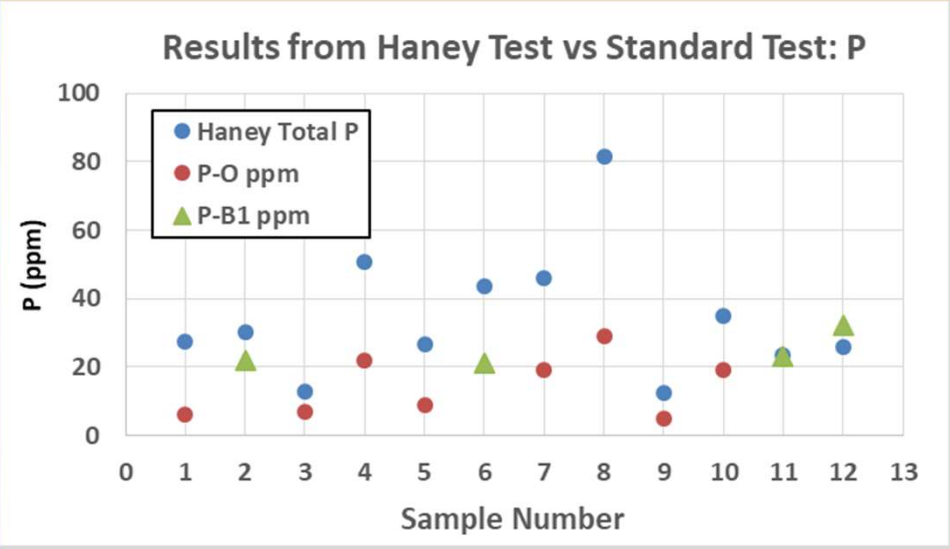
# Comparison Between Standard Soil Test Results & Haney Test Results: P (0-6”)

**2016**




r = 0.4009

**2017**




r = 0.5858

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

# Phosphorus Guidelines in MN

| Table 9. Broadcast (Bdcst) and band phosphate guidelines for corn production in Minnesota.* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Soil test P (ppm) | | | | | | | | | |
| | | Very Low | | Low | | Medium | | High | | Very High | |
| Expected | Bray: | 0-5 | | 6-10 | | 11-15 | | 16-20 | | 21+ | |
| Yield | Olsen: | 0-3 | | 4-7 | | 8-11 | | 12-15 | | 16+ | |
| | | Bdcst | Band | Bdcst | Band | Bdcst | Band | Bdcst | Band | Bdcst | Band |
| bu/acre | | ---------- $P_2O_5$ per acre to apply (lb. per acre) ---------- | | | | | | | | | |
| | | | | | | | | | | | |
| 175 – 199 | | 110 | 55 | 75 | 40 | 45 | 30 | 15 | 10-15 | 0 | 10-15 |
| 200 – 219 | | 130 | 65 | 90 | 45 | 55 | 30 | 20 | 10-15 | 0 | 10-15 |
| 220 – 239 | | 145 | 75 | 100 | 50 | 60 | 30 | 20 | 10-15 | 0 | 10-15 |
| 240 + | | 160 | 80 | 115 | 60 | 70 | 35 | 25 | 10-15 | 0 | 10-15 |

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

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

# Phosphorus

| | 2016 | | | | | 2017 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Resulting Soil Testing Range | | $P_2O_5$ to Broadcast (lb/acre) | | | Resulting Soil Testing Range | | $P_2O_5$ to Broadcast (lb/acre) | | |
| Site | Standard Test | Haney Test | Standard Test | Haney Test | Diff | Standard Test | Haney Test | Standard Test | Haney Test | Diff |
| 1 | Low | Med | **90** | 55 | **-35** | Low | V High | **90** | 0 | **-90** |
| 2 | High | V High | **20** | 0 | **-20** | V High | V High | 0 | 0 | **0** |
| 3 | V High | High | 0 | **20** | **+20** | Low | High | **90** | 20 | **-70** |
| 4 | V High | V High | 0 | 0 | **0** | V High | V High | 0 | 0 | **0** |
| 5 | Low | Med | **90** | 55 | **-35** | Med | V High | **55** | 0 | **-55** |
| 6 | Low | V High | **90** | 0 | **-90** | V High | V High | 0 | 0 | **0** |
| 7 | V High | V High | 0 | 0 | **0** | V High | V High | 0 | 0 | **0** |
| 8 | Low | V High | **90** | 0 | **-90** | V High | V High | 0 | 0 | **0** |
| 9 | V High | V High | 0 | 0 | **0** | Low | High | **90** | 20 | **-70** |
| 10 | V High | V High | 0 | 0 | **0** | V High | V High | 0 | 0 | **0** |
| 11 | High | Med | 20 | **55** | **+35** | V High | V High | 0 | 0 | **0** |
| 12 | V High | High | 0 | **20** | **+20** | V High | V High | 0 | 0 | **0** |

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?

SOIL HEALTH INSTITUTE

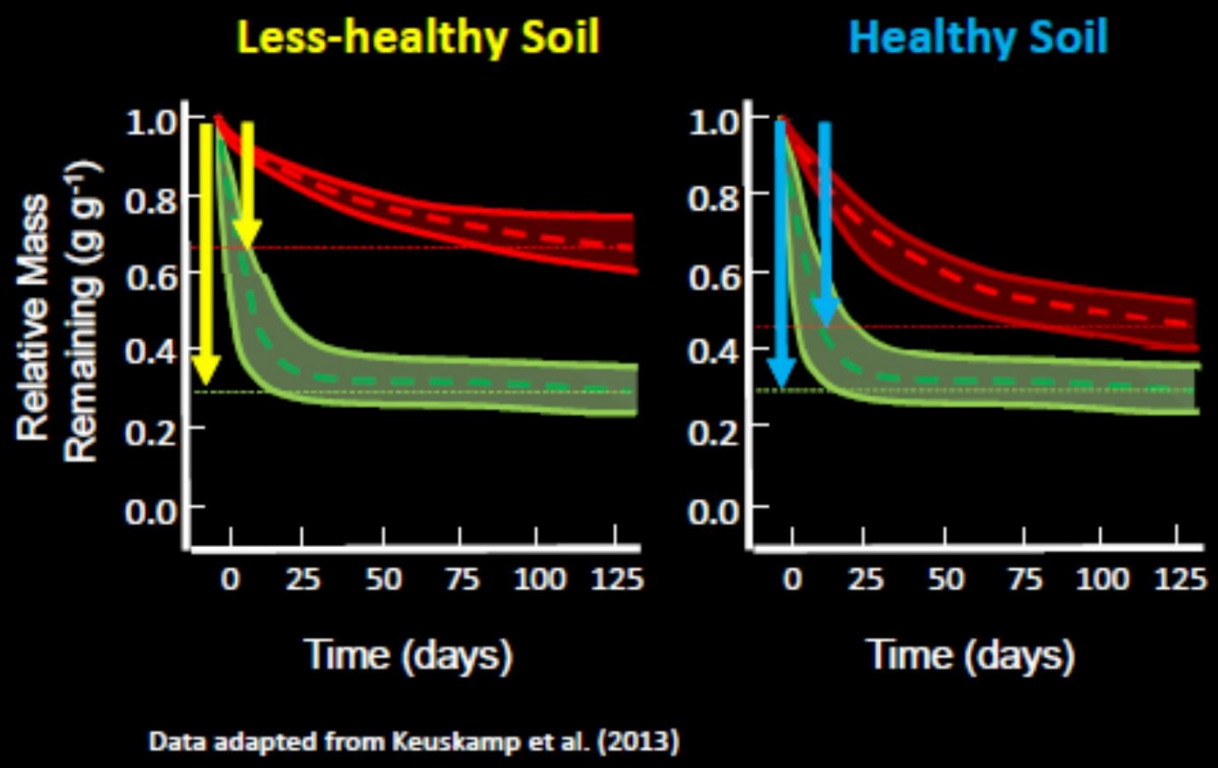
# Tier 1 Soil Health Measures

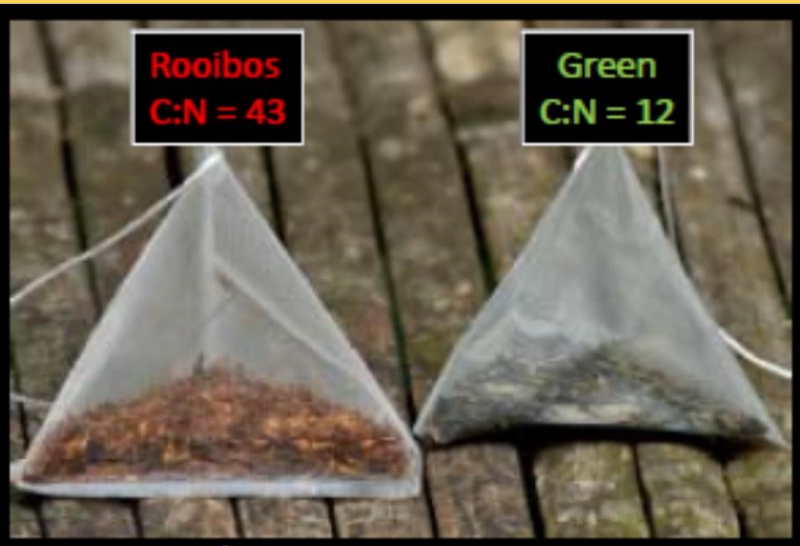
- Organic C
- pH
- Water-stable aggregation
- Crop yield
- Texture
- Penetration resistance
- CEC
- Electrical conductivity
- N, P, K
- C & N mineralization
- Erosion rating
- Base saturation
- Bulk density
- Available water holding capacity
- Infiltration rate
- micronutrients

# Soil Your Undies

http://www.soilcc.ca/soilsweek/2017/Soil-Your-Undies-Protocol.pdf

# Using Tea Bags to Measure Soil Health




~$20 for 60 pyramids



= Rooibos Tea

= Green Tea

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

# Acknowledgements


- Dorian Gatchell, Minnesota Agricultural Services
- AGVISE Soil Testing Laboratories
- MN Agriculture Fertilizer Research and Education Council
- Fabian Fernandez, University of MN Extension
- Daniel Kaiser, University of MN Extension
- Marshall McDaniel, Iowa State University


# GO VIKINGS!!!!!

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