

# AgPhD<sup>®</sup>



# SOIL

# FERTILITY

# MANUAL



**2026**  
▲ UPDATE



## TABLE OF CONTENTS

Ag PhD Upcoming Events	3
Cation Exchange Capacity (CEC)	27
Fertilizer Analysis	16
How to Read a Soil Test	19
Lime	23
Manure	39
Micronutrients	46
Nitrogen	32
Nutrient Needs by Crop	33
Organic Matter	30
pH	20
Phosphorus	35
Potassium	42
Secondary Nutrients	44



THANKS FOR  
*Joining us!*



Join us!

2026 AgPhD

# WINTER WORKSHOPS

WITH BRIAN & DARREN HEFTY

**PLEASE JOIN US IN JANUARY AND FEBRUARY AT OUR AG PHD WINTER WORKSHOPS.**



▶ **THEY'RE FREE.** ▶ **THEY'RE EDUCATIONAL AND FUN.** ▶ **THEY ARE EXACTLY WHAT YOU NEED HEADING INTO 2026.**

This winter is the perfect time to improve your farm. When you attend our events, Darren and Brian will give you the information and tools you need to be more successful this coming planting season.

**THE SCHEDULE IS AS FOLLOWS:**



**JAN 13** **NATURALS WORKSHOP**  
10am - 3pm | Baltic, SD  
TUESDAY | JANUARY 13



**JAN 14** **SOYBEAN WORKSHOP**  
10am - 3pm | Baltic, SD  
WEDNESDAY | JANUARY 14



**AGRONOMY WORKSHOP**  
Various Locations:  
JAN 21 JAN 27 JAN 28 JAN 29 FEB 12

**JAN 21** WEDNESDAY, JANUARY 21, 2026  
NEAR HILLSBORO, ND - 9AM TO 2PM CENTRAL

**JAN 27** TUESDAY, JANUARY 27, 2026  
IN BETHLEHEM, PA - 9AM - 2PM EASTERN

**JAN 28** WEDNESDAY, JANUARY 28, 2026  
IN TERRE HAUTE, IN - 10AM - 3PM EASTERN

**JAN 29** THURSDAY, JANUARY 29, 2026  
IN UTICA, IL - 9AM - 2PM CENTRAL

**FEB 12** THURSDAY, FEBRUARY 12, 2026  
IN YORK, NE - 10AM - 3PM CENTRAL



**FEB 17** **SOILS CLINIC**  
10am - 3pm | Baltic, SD  
TUESDAY | FEBRUARY 17



**FEB 18** **CORN WORKSHOP**  
10am - 3pm | Baltic, SD  
WEDNESDAY | FEBRUARY 18



NEAL KINSEY'S  
**MAR 10-12** **SOILS & FERTILITY SEMINAR**  
Ag PhD Event Center  
Hillsboro, ND  
TUES - THURS | MARCH 10-12

DAY 1	DAY 2	DAY 3
11 AM - 5 PM	8 AM - 5 PM	8 AM - 3 PM

**YES, THREE DAYS REALLY SEEMS LIKE A LOT, BUT YOU WILL DEFINITELY WANT TO ATTEND!** Learn in-depth soil and fertility training with Neal Kinsey, one of the world's leading soil fertility experts. If you spend one day at our Soils Clinic and three days with Neal and his group, you will be a fertility expert compared to other farmers.

**REGISTER FOR THE AG PHD WORKSHOPS HERE!**



**IN-PERSON AND LIVESTREAM REGISTRATION AVAILABLE. GO TO AGPHD.COM FOR MORE INFORMATION.**

**ALL EVENTS AT BALTIC, SD WILL BE HELD AT: THE MORTON CENTER | 47669 252ND ST | BALTIC, SD 57003**

Join us! **AgPhD**

**JUN  
27**

# SCOUTING & SCHOLARSHIPS

**9:30am - 3pm**  
AG PHD FIELD DAY SITE | BALTIC, SD



**DON'T MISS YOUR CHANCE AT  
\$50,000 + IN COLLEGE SCHOLARSHIPS!**

*In-field breakout sessions will provide hands-on education, including the following topics:*

- ▶ How to pull a soil sample.
- ▶ Using root pits to understand soil health, compaction, crop root growth and development, and more.
- ▶ How to pull plant tissue tests and interpret the data to improve crop health.
- ▶ Soil and crop health benefits of drainage tile.
- ▶ The impact of using natural soil microbes in production agriculture.
- ▶ Fertilizer use and recommendations
- ▶ Pesticide safety
- ▶ Carbon credits
- ▶ Saving for retirement

*We will also provide a guide to effective field scouting, including:*

- ▶ Staging crops, plant growth and development.
- ▶ How to determine planting depth.
- ▶ What you can learn by digging up plant roots.
- ▶ Weed, insect, and disease identification.
- ▶ How to compare and evaluate seed variety performance.



## PLUS...

**WE WILL BE AWARDING 100 + COLLEGE SCHOLARSHIPS TO ATTENDEES**

*that will be enrolled in any post-secondary school in the fall.*

100+ COLLEGE  
**SCHOLARSHIPS**  
TO BE AWARDED JUNE 27!

**GO TO [AGPHD.COM](http://AGPHD.COM)  
TO REGISTER FOR THIS EVENT!**



*This event is geared toward high school and college students, as well as any farmers under 30 years old, but anyone with a desire to learn more about agronomy is welcome to attend.*

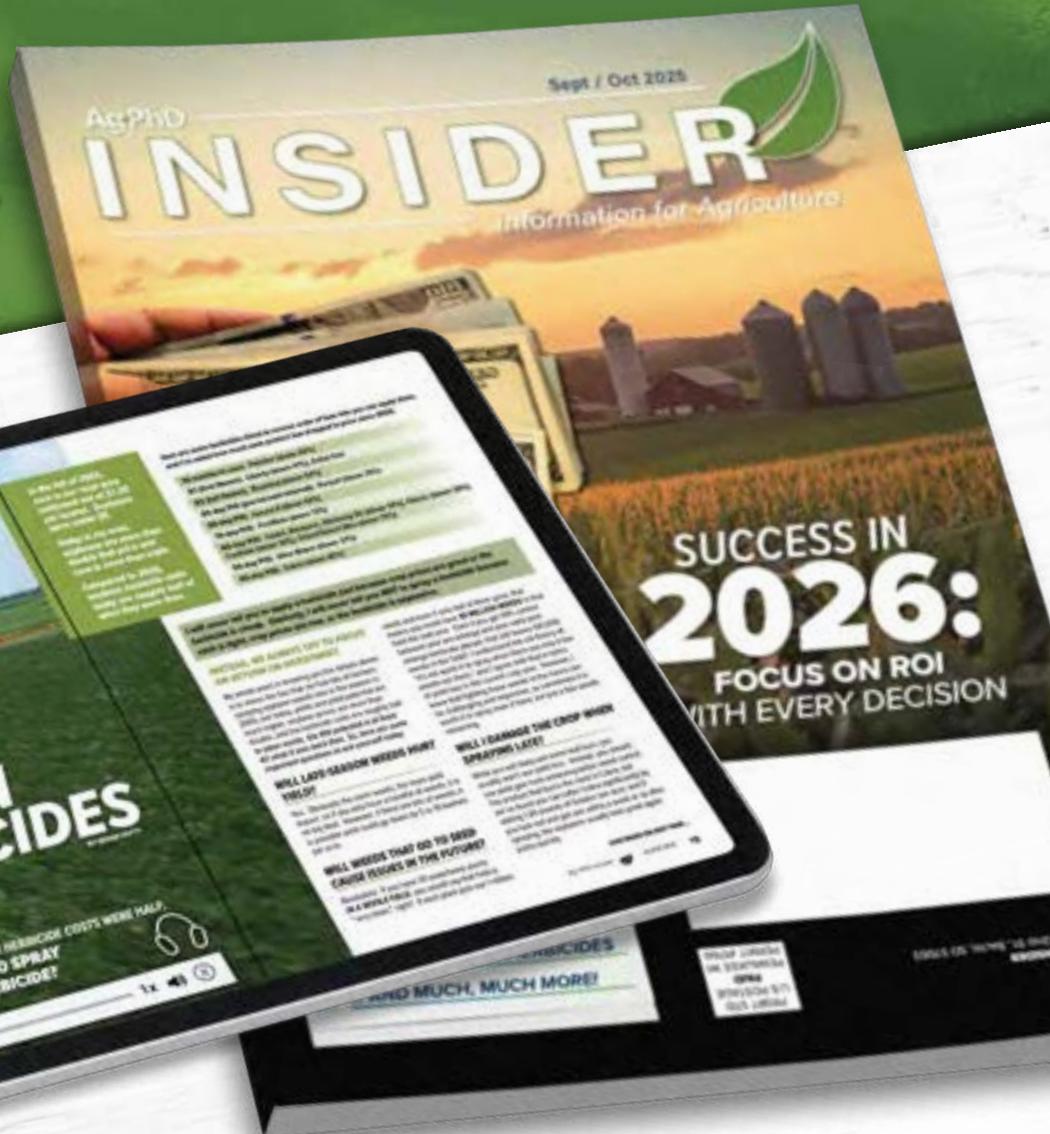
AgPhD

# INSIDER

Information for Agriculture

THE INSIDER IS NOW AVAILABLE WITH A DIGITAL SUBSCRIPTION.

**NEVER MISS AN ISSUE.**



TAP ICON FOR **AUDIO VERSION**

**ANOTHER COOL FEATURE...**

OUR MAGAZINE HAS AN **AUDIO** VERSION OF EACH ARTICLE.



**THE AG PHD INSIDER ONLINE!**



# MOBILE APPS DOWNLOAD

Ag PhD apps for iPhone® are available and can be downloaded from the **APP STORE**.  
Android devices can download via **GOOGLE PLAY**.

**Ag PhD has released numerous free apps on both iOS and Android platforms to help you make more well-informed decisions on the farm:**

- ▶ **Fertilizer Removal** - A fertilizer application reference that calculates fertility based on desired crop yield.
- ▶ **Ag PhD Field Guide** - Helps to identify problem weeds and insects.
- ▶ **Corn Disease Guide** - In-depth photos and descriptions of corn diseases and disorders with information sourced via APS Press.
- ▶ **Soybean Disease Guide** - In-depth photos and descriptions of soybean diseases and disorders with information sourced via APS.
- ▶ **Ag PhD Spray Tips Guide** - Tool for proper nozzle selection based on chemical and application method.
- ▶ **Modes of Action** - A reference of multiple products sortable by chemical family, complete with labels and MSDS information.
- ▶ **Harvest Loss Calculator** - Aids in determining location and amount of harvest loss in bushels and pounds per acre.
- ▶ **Planting Population Calculator** - Helps calculate population and stand counts.
- ▶ **Drainage Tile Calculator** - Contains numerous calculations to aid in pipe selection, as well as tile design and installation.
- ▶ **Crop Nutrient Deficiencies** - A visual guide to nutrient deficiencies in a variety of crops.
- ▶ **GDU Calculator** - Calculates corn and wheat GDUs based on U.S. ZIP code of fields.

AgPhD

DOWNLOAD

TODAY ▶▶▶



iOS



Android



# TV & RADIO SCHEDULE



## NATIONAL COVERAGE

**Dish Network**  
Ch. 231\*, RFD-TV  
TUES 7:00 pm & 11:00 pm  
SAT 1:00 pm



## DIRECTV

Ch. 345\*, RFD-TV  
TUES 7:00 pm & 11:00 pm  
SAT 1:00 pm



\*All RFD Times Central

## REGIONAL CHANNELS

### SOUTH DAKOTA

KELO (CBS)	Sioux Falls	SAT	4:30 a.m.
KSFY (ABC)	Sioux Falls	SUN	5:30 a.m.
KTTW/ODLT (FOX)	Sioux Falls	SUN	10:00 p.m.
KDLT (NBC)	Sioux Falls	SAT	6:00 a.m.
KCPO	Sioux Falls	SAT	12:00 p.m.
KHME-2 (METV)	Rapid City	SAT	5:00 p.m.
KQME-2 (METV)	Lead	SAT	5:00 p.m.

### NORTH DAKOTA

WDAY (ABC)	Fargo	SUN	5:30 a.m.
KVLY (NBC)	Fargo	SUN	9:00 a.m.
KCPM	Grand Forks	SAT	12:00 p.m.
WDAZ (ABC)	Grand Forks	SUN	5:30 a.m.
KXMA (CBS)	Dickinson	SAT & SUN	6:30 a.m.
KXMB (CBS)	Bismarck	SAT & SUN	6:30 a.m.
KXMC (CBS)	Minot	SAT & SUN	6:30 a.m.
KXMD (CBS)	Williston	SAT & SUN	6:30 a.m.

### MINNESOTA

KAAL (ABC)	Austin	SUN	9:30 a.m.
KEYC (CBS)	Mankato	SUN	7:00 a.m.
KMNF (NBC)	Mankato	SUN	10:30 a.m.
KOOL	Alexandria	SAT	5:00 a.m.

### IOWA

KYOU (FOX)	Ottumwa	SAT	6:00 a.m.
KYOU.2 (NBC)	Ottumwa	SUN	6:00 a.m.
KIMT (CBS)	Mason City	SUN	7:00 a.m.
NIMT 3.2 (CBS)	Mason City	SAT	10:30 a.m.
KCAU (ABC)	Sioux City	SUN	9:30 a.m.
KLJB (FOX)	Quad Cities	SAT	6:30 a.m.

### NEBRASKA

KLKN (ABC)	Lincoln	SUN	6:30 a.m.
KNEN (NCN)	Norfolk	SAT & SUN	7:30 a.m.
KMJF (NCN)	Columbus	SAT & SUN	7:30 a.m.
KWBE (NCN)	Beatrice	SAT & SUN	7:30 a.m.
KMLF (NCN)	Grand Island	SAT & SUN	7:30 a.m.

### MONTANA

KHBB (ABC)	Helena	SUN	10:00 a.m.
KFBB (ABC)	Great Falls	SUN	10:00 a.m.
KULR (NBC)	Billings	SAT	5:30 a.m.

### WASHINGTON

KFFX (FOX)	Tri-Cities	SUN	7:30 a.m.
KCYU (FOX)	Yakima	SUN	7:30 a.m.

### IDAHO

KLEW (CBS)	Lewiston	MON	6:00 a.m.
KMVT (CBS)	Twin Falls	SAT	6:00 a.m.
KSVT (FOX)	Twin Falls	SAT	6:00 a.m.

### KANSAS

KWCH (CBS)	Wichita	SAT	5:30 a.m.
KBSL (CBS)	Goodland	SAT	5:30 a.m.
KBSD (CBS)	Dodge City	SAT	5:30 a.m.
KBSH (CBS)	Hays	SAT	5:30 a.m.

### KENTUCKY

WDKA (FOX)	Paducah	SUN	6:30 a.m.
------------	---------	-----	-----------

### MISSOURI

KBSI (FOX)	Cape Girardeau	SAT	8:00 a.m.
------------	----------------	-----	-----------

### ILLINOIS

WICD (ABC)	Champaign	SUN	6:30 a.m.
WICS (ABC)	Springfield	SUN	6:30 a.m.



## Ag PhD RADIO

Live Every Weekday  
2 pm to 3 pm Central



Exclusively on **Rural Radio | SiriusXM 147** Call Ag PhD Radio at **844-44-AGPHD!**

@AgPhDMedia | @brianhefty | @darrenhefty

Acre**s**TV



OPEN A DOOR TO THE  
**WORLD OF AG.**

LEADERS IN THE FIELD PROVIDING  
**ACRES OF  
INFORMATION.**

**Welcome to AcresTV**, your premier streaming  
platform for all things **agriculture!**

With a regular release schedule and exclusive content  
featuring entertainment, equipment, ag information, and  
highlights of rural life, AcresTV brings you straight to the  
heart of farming in America.

**IT'S FREE**  
**STREAM**  
**Anywhere. Anytime.**

android

androidtv

Apple iPad

Apple iPhone

Apple tv

chromecast

fireTV

Roku

Samsung  
SMARTTV

# Sign Up Now!

## 7143+

## Videos

### CONTENT PROVIDERS:

- 360 Yield Center
- Advanced Drainage Systems, Inc.
- Adventures of Farmer King
- Ag Bull Media
- Ag on Wheels | Michelle Martin
- Ag PhD
- AgrisAcademy
- AgroLiquid
- AgroTech
- AMAZONE
- ATI ProMedia
- BASF
- Bayer
- Brandi Buzzard | Buzzard's Beat
- C & B Operations
- Chronicles of Kayla
- Corn Warriors
- Corteva
- Damian Mason
- Dairy Heirs
- Dirt Poor | Grayce & Gavin
- Drago
- Dura Products
- Enduraplas
- ETS Soil Warrior
- Farm Rescue
- Fendt
- Field Trips with Tara Beaver Coronado
- FMC
- Griggs Farms
- Hefty Seed Company
- LEMKEN
- Let's Get Nuts | Randy the Farmer
- Live To Farm
- Market Journal
- Meredith Bernard | This Farm Wife
- Midwest Laboratories
- Morton Buildings
- NewLeaf Symbiotics
- Nufarm
- People of Ag
- Praxidyn
- Precision Labs
- Quest for the Canola Crown
- Redox
- Renovo Seed
- Rural Radio Network TV
- Shark Farmer
- Sound Agriculture
- Successful Farming
- Terraplex
- TEVA
- The Auto Channel
- The Dinner Bell | Janelle
- The Podfather
- Tony Reed | Off the Pavement
- Top Crop
- Trace Genomics
- #UprootTheStigma
- VRAFY
- WDAY Weather & Ag in Focus
- XtremeAg

Download the  
AcresTV app on your  
favorite device.

**START WATCHING!**



**SIGN UP NOW!**

## WATCHACRESTV.COM

AgPhD Store



AgPhD Store

# CHECK OUT OUR Latest Merchandise



\$25

**PUZZLE**

AGRICULTURE'S GREATEST EVENT  
11"x17" 150 PIECES



\$25

**METAL SIGN**

AGRICULTURE'S GREATEST EVENT  
11"x17"

**FREE SHIPPING\*** with Code: **WINTER26**

THROUGH MARCH 1, 2026 SOME RESTRICTIONS APPLY.



SHOP ONLINE ▶▶▶

AGPHDSTORE.COM

AgPhD Store



AgPhD Store

\$200



G6 SOIL PROBE

\$40



SWEATSHIRTS  
FARMERS  
MAKE THE WORLD GROW

\$15



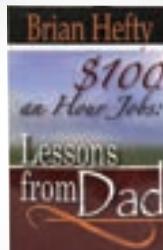
TUMBLERS  
SUPPORT  
LOCAL FARMERS

\$20-30



HATS  
AG PHD

\$10



BOOK  
LESSONS FROM DAD  
BY BRIAN HEFTY

\$20



T-SHIRTS  
FAITH. FREEDOM. FARMING.

\$10



ONESIES  
FUTURE FARMER

\$8



RAIN GAUGE

\$20

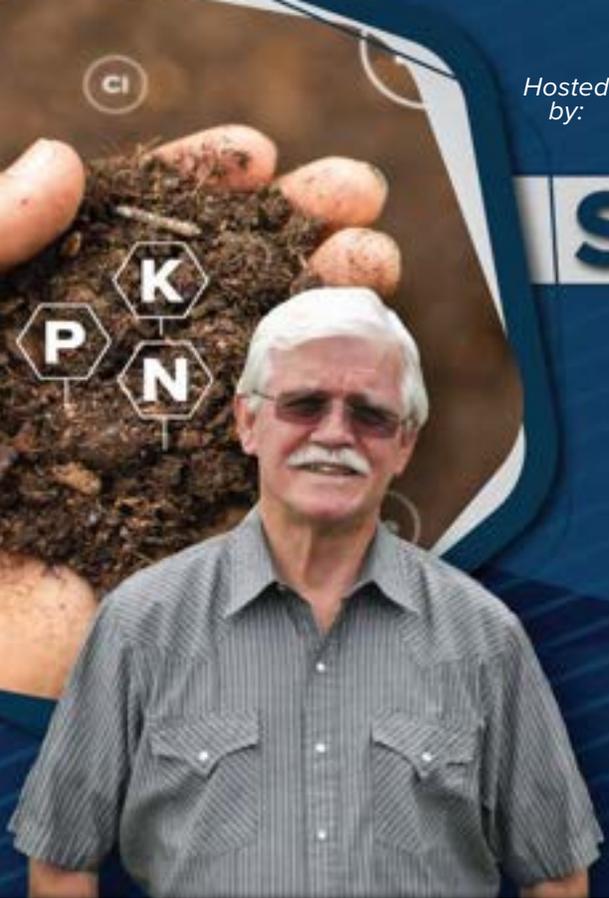


DVD  
FIELD TILE DVD

SHOP ONLINE ▶▶▶

AGPHDSTORE.COM

FREE SHIPPING  
CODE: WINTER26



Hosted  
by:

**AgPhD**

*Join us!*

**NEAL KINSEY'S**

# SOIL & FERTILITY SEMINAR

**GET MORE FROM YOUR FERTILIZER DOLLARS WITH  
A LEADING SOIL FERTILITY EXPERT**

**MAR  
10-12**

**TUESDAY - THURSDAY**

**DAY 1**

**DAY 2**

**DAY 3**

11 AM - 5 PM

8 AM - 5 PM

8 AM - 3 PM

**AG PHD EVENT CENTER**

16209 Highway 200A SE | Hillsboro, ND

**IN-PERSON AND LIVESTREAM REGISTRATION AVAILABLE.  
GO TO [AGPHD.COM](http://AGPHD.COM) FOR MORE INFORMATION.**

PLEASE RSVP



IF YOU HAVE QUESTIONS, PLEASE CALL **(605) 529-5413**  
OR EMAIL **[EVENTS@AGPHD.COM](mailto:EVENTS@AGPHD.COM)**

TO PRE-REGISTER, **SCAN OR CODE**  
OR GO TO **[WWW.AGPHD.COM](http://WWW.AGPHD.COM)**

Agris Academy LLC

## 2026 WINTER WORKSHOP MERCHANDISING AND FUTURES RISK MANAGEMENT FEBRUARY 19<sup>TH</sup> 9AM-3PM



### Workshop will!

- Teach real merchant skills your buyers use
- Provide tricks of the trade that will create immediate value
- Share the best practices of professional risk managers

### Workshop will not

- Discuss current market factors
- Encourage any particular trading strategies
- Make predictions or advise on market direction

**AGRIS ACADEMY IS AN EDUCATION AND CONSULTING COMPANY NOT A  
BROKER OR ADVISOR. IF YOU WANT TO LEARN REAL SKILLS THAT BECOME A  
PERMANENT ASSET TO YOUR FARM OR BUSINESS PLAN ON ATTENDING !!**

### Attend in Person

The workshop will be held at the Morton Center in Baltic SD, RSVP at [AgrisAcademy.com](http://AgrisAcademy.com) so we can plan for food and seating. Attending in person also gives you the chance to speak directly with Jeff and Mike

### Attend on Line

Sign up at [AgrisAcademy.com](http://AgrisAcademy.com) to receive your live stream log in codes. Recordings will be available through April 30<sup>th</sup>.

**SIGN UP TODAY AT  
[AGRISACADEMY.COM](http://AGRISACADEMY.COM)  
TO RESERVE YOUR SPOT**

# ACQUIRED AG LAND IN THE LAST 20 YEARS?

You may qualify for a \$1,700 per acre average tax deduction



## JOIN US TO FIND OUT HOW FARMLAND OWNERS IN SOUTH DAKOTA AND NORTH DAKOTA ARE RECEIVING THOUSANDS IN TAX DEDUCTIONS.

Reserve your seat for a free educational presentation explaining how these deductions work, what qualifies, and how landowners are using them today.

*A hot lunch is included.*

### WHEN AND WHERE

**Tuesday**

**February 24, 2026**

**10:30 AM**

*Baltic, SD*

**HEFTY SEED COMPANY**

47504 252nd St., Baltic, SD 57003

**Wednesday**

**February 25, 2026**

**10:30 AM**

*Aberdeen, SD*

**HEFTY SEED COMPANY**

38352 US-12, Aberdeen, SD 57401

**Thursday**

**February 26, 2026**

**10:30 AM**

*Hillsboro, ND*

**HEFTY SEED COMPANY**

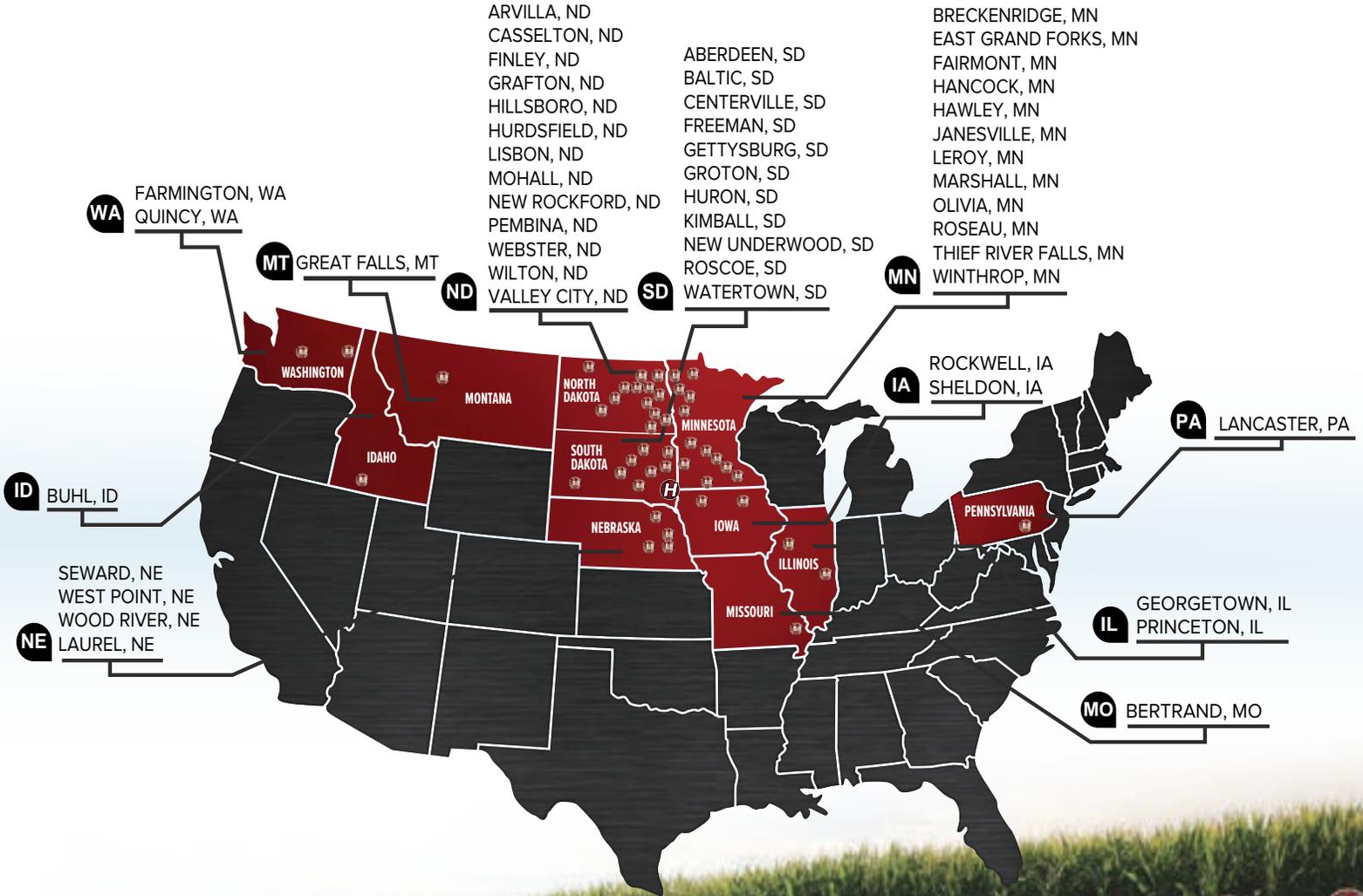
110 6th St SW, Hillsboro, ND 58045



**FREE TO ATTEND: RSVP Encouraged**  
Call or Text: 605-605-2354 or scan the QR code



# HEFTY SEED COMPANY



**SERVING FARMERS SINCE 1969.**

# SAVE FERTILIZER & **SAVE MONEY**

2 WAYS WITH VRAFY

1

## **QUIT OVERFERTILIZING**

In fields you do **NOT** soil test, get a variable rate fertility prescription for any equipment brand so you can put back exactly what you've removed for fertilizer, based on your yield map. No more blanket rate application, which basically underfertilizes half the field and overfertilizes the other half.

2

## **MATCH SOIL TESTS TO YIELD**

See which fertility products are making you money and which ones are not. VRAFY can do this for you in a matter of minutes this fall.



**VRAFY**

BE PRECISE IN YOUR APPLICATIONS.  
**GET VRAFY TODAY!**

Visit [VRAFY.com](http://VRAFY.com) or Call 507.800.0898 to learn more.



## How Can I Cut Expenses?

- Is cutting expenses the goal or is earning more net income the goal?
- If you know how to read a soil test, you will be able to identify where you can cut and where you can't
- If you take more soil tests (smaller grids or zones), you'll be able to find areas in fields that need less or more fertility
- For years you have probably heard about the 3 R's that can help you cut fertilizer expenses, but how do you put these into practice?
  1. Right place
  2. Right time
  3. Right rate

## Broadcast vs Band

- Many people say you can cut rates when banding versus broadcasting, but the crop is still going to remove the same amount of fertilizer from your soil if it yields 200 bushels/acre in a broadcast field versus a banded field. If you apply less fertility than what the crop is removing and the organic matter is releasing, you will be depleting your soil.
- Why does banding allow your crop to be more efficient at removing applied fertilizer in year one?
  - Crop roots can find the fertilizer easier
  - There will be less tie-up, at least in the short-term
- Broadcasting fertilizer is usually faster & easier, and it is safer to the crop because if you get too much salt too close to the seed or young seedling, it can cause significant injury

Nutrient	Uptake form	Mobility in Plant	Mobility in Soil
Nitrogen	NO <sub>3</sub> <sup>-</sup> , NH <sub>4</sub> <sup>+</sup>	Mobile	Mobile as NO <sub>3</sub> <sup>-</sup> , immobile as NH <sub>4</sub> <sup>+</sup>
Phosphorus	HPO <sub>4</sub> <sup>2-</sup> , H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>	Somewhat mobile	Immobile
Potassium	K <sup>+</sup>	Very mobile	Somewhat mobile
Calcium	Ca <sup>2+</sup>	Immobile	Somewhat mobile
Magnesium	Mg <sup>2+</sup>	Somewhat mobile	Somewhat mobile
Sulfur	SO <sub>4</sub> <sup>-</sup>	Immobile	Very mobile
Boron	H <sub>3</sub> BO <sub>3</sub> , BO <sub>3</sub> <sup>-</sup>	Immobile	Very mobile
Copper	Cu <sup>2+</sup>	Immobile	Immobile
Iron	Fe <sup>2+</sup> , Fe <sup>3+</sup>	Immobile	Immobile
Manganese	Mn <sup>2+</sup>	Immobile	Somewhat mobile
Zinc	Zn <sup>2+</sup>	Immobile	Immobile
Molybdenum	MoO <sub>4</sub> <sup>-</sup>	Immobile	Somewhat mobile
Chloride	Cl <sup>-</sup>	Mobile	Mobile
Cobalt	Co <sup>2+</sup>	Immobile	Somewhat mobile
Nickel	Ni <sup>2+</sup>	Mobile	Somewhat mobile

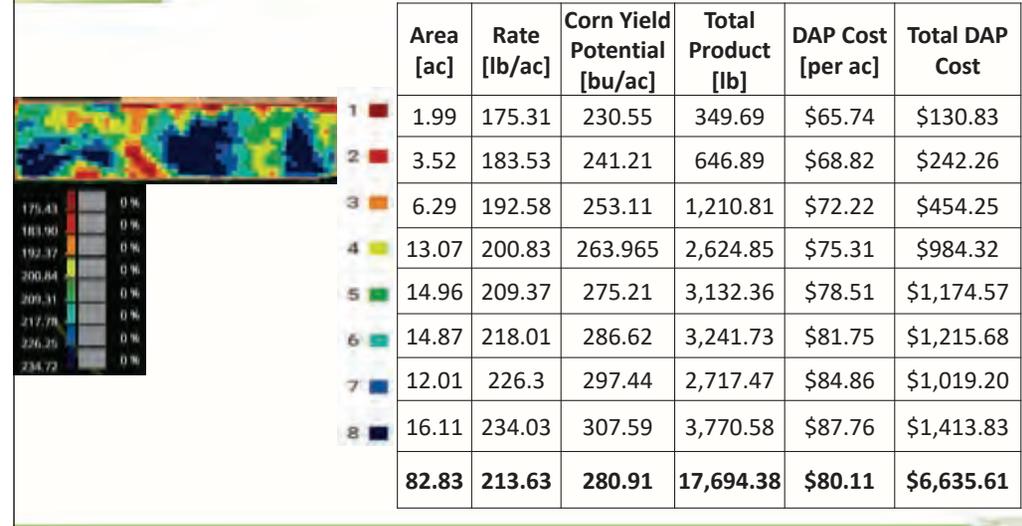
## Analysis for Common Fertilizers

- Urea: 46-0-0, 46% Nitrogen
- DAP: 18-46-0, 46% Phosphate so it is 20% Phosphorus
- MAP: 11-52-0, 52% Phosphate so it is 22.6% Phosphorus
- Potash: 0-0-60, 60% is K<sub>2</sub>O so Potash is 50% actual Potassium
- Magnesium Sulfate: 10% Magnesium, 13% Sulfur
- Elemental Sulfur: 90% Sulfur for the product we use
- Boron 15%: 15% Boron, 13% Calcium, 7% Sodium, 4% Sulfur
- Copper Sulfate: 25.2% Copper, 14% Sulfur
- Iron Sulfate: 20.5% Iron, 12% Sulfur
- Manganese Sulfate: 32% Manganese, 19% Sulfur
- Zinc Sulfate: 35.5% Zinc, 17.5% Sulfur
- Cobalt Sulfate: 38% Cobalt, 20% Sulfur
- Sodium Molybdate: 46% Molybdenum, 20% Sodium

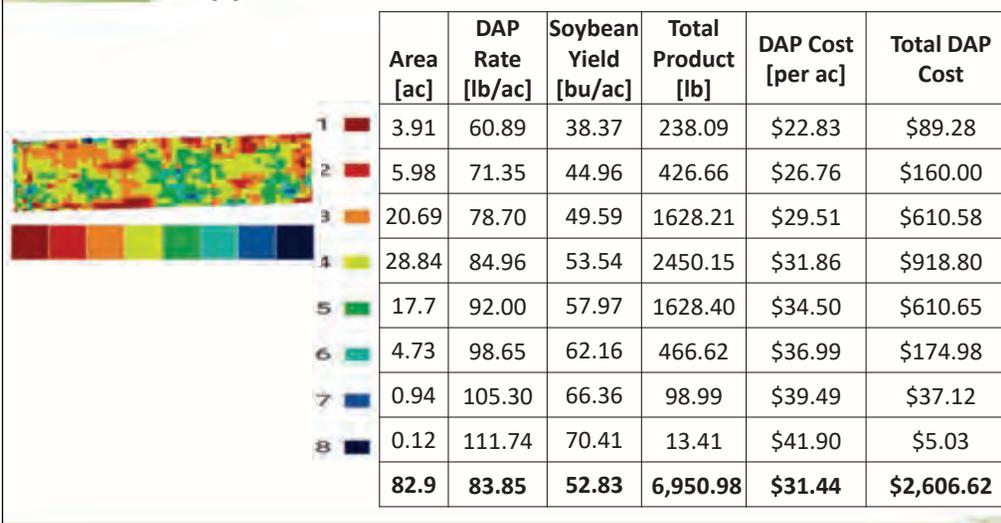
## AgPhD Fertilizer Application Strategies

1. Fertilize to yield goal – Old way was blanket rate & field average. New way is variable rate using a potential yield map, applying what the crop will remove.
2. Fertilize based on nutrient removal – Old way was blanket rate & applying what you removed based on field average yield. New way is variable rate with VRAFY and apply 100% (or any percentage) of what you removed over the past year or the past 2 years.
3. Fertilize to fix problems – Old way was blanket rate to get up to certain minimum levels of specific nutrients. New way is variable rate to get each grid or zone above minimum individual nutrient levels or nutrient ratios.
  - Using VRAFY, you can quickly run all 3 scenarios and look at cost

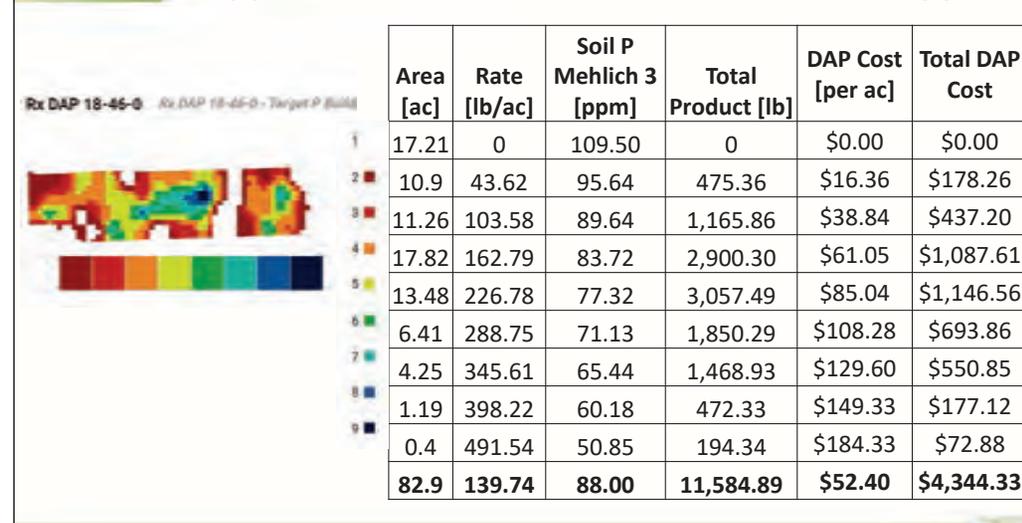
## AgPhD P Application based on This Year's Yield Goal



## AgPhD P Application based on Last Year's Nutrient Removal



## AgPhD P Application to Fix Problems (build P to 100 ppm)



# Example Soil Test

ORGANIC MATTER L.O.L percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY CEC meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SODIUM Na ppm	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	4.9	61	333	418	1934	19	4.7		6.2	28.1	3.0	12.4	34.4

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		
ppm	lbs/A	depth (in)									
75	135	0-6	135	19	12.8	108	155	1.9	1.0	L	0.5

Can you read this soil test and make your own fertility recommendations?

## Why Is Today Important?

For every 1000 acres of corn/bean ground (500 acres of each), **crop removal** of nutrients per year will cost \$154,000. Over 30 years that's \$4.62 million!!

	Corn @ 250 bu/ac	Soybeans @ 70 bu/ac
N	220# X \$0.60 = \$132	
Phosphate	88# X \$0.65 = \$57	51# X \$0.65 = \$33
K2O Potassium	63# X \$0.35 = \$22	84# X \$0.35 = \$29
Sulfur	20# X \$0.30 = \$6	13# X \$0.30 = \$4
Ca, Mg, Micros	Approx. \$15	Approx. \$10
<b>TOTAL/ACRE</b>	<b>\$232</b>	<b>\$76</b>
<b>TOTAL/500 ACRES</b>	<b>\$116,000</b>	<b>\$38,000</b>

Plus, don't forget that corn & soybean yields are going up about 2 and 0.5 bu/year respectively and inflation on fertilizer will likely be 2% to 3% annually

## Soil Test Basics

- How many pounds are in 6" of soil across 1 acre?
- How do I convert ppm to pounds per acre in a 6" test? ppm X 2      In a 12" test? ppm X 4
- What electrical charge does soil have, + or -?

## Quiz

**Which of the following would NOT be considered a leachable nutrient?**

1. Nitrate nitrogen
2. Ammonium nitrogen
3. Sulfate
4. Boron

## How to Read a Soil Test (Mehlich 3 Midwest Labs)

1. Soil pH – 6.3 to 6.8 (corn, soybeans, wheat)
2. Cation Exchange Capacity – max. N = CEC X 10
3. Organic Matter – Mineralization & other benefits
4. Base Sat. – Na (<1), H (2-10), Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate on soil test, then add (O.M. X 20)
6. Phosphorus – Mehlich 3 is similar to P2 test. To figure pounds, take soil test P X 2.3 X 2 = phosphate pounds, then add (O.M. X 4)
7. Sulfur – Sulfur on soil test, then add (O.M. X 2)
8. Zinc – Phosphorus/10
9. Copper – Phosphorus/30
10. Boron – Calcium/1000
11. Manganese – 50+ ppm
12. Iron – 50+ ppm

**AgPhD** **Relative % Yield at Different pH Levels**

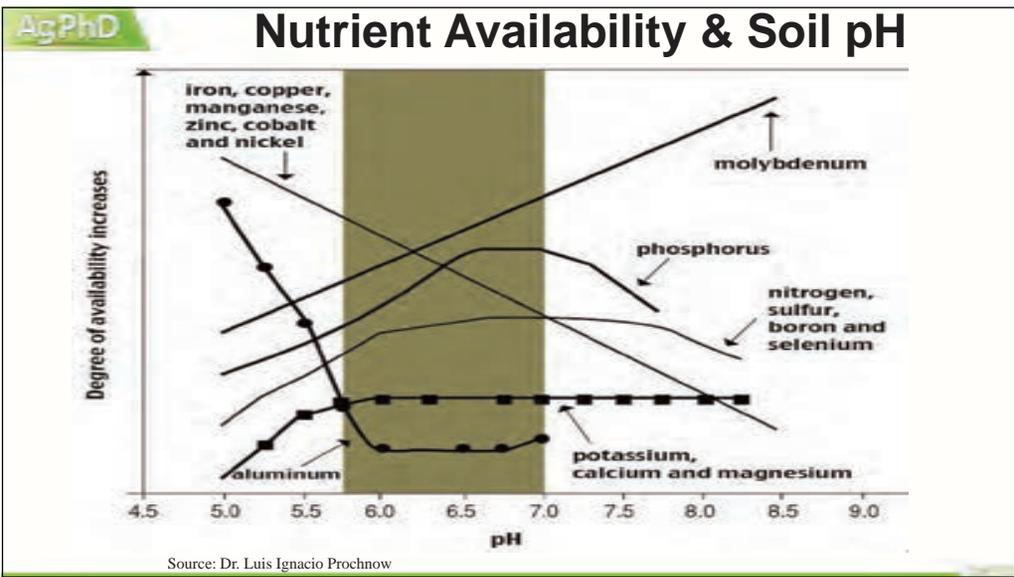
Crop	pH 4.7	pH 5.0	pH 5.7	pH 6.8	pH 7.5
Corn	34%	73%	83%	100%	85%
Soybeans	65%	79%	80%	100%	93%
Wheat	68%	76%	89%	100%	85%
Alfalfa	2%	9%	42%	100%	100%
Barley	0%	23%	80%	95%	100%
Oats	77%	93%	99%	98%	100%

Source: Midwest Labs, Omaha, NE

**AgPhD** **Hefty Farm Soil pH Results 2018-2020**

pH Range	Corn Yield	Sample Points	pH Range	Soybean Yield	Sample Points
4.2-4.6	157.6	31	4.7-5.2	70.9	18
4.7-5.2	166.7	47	5.3-5.7	69.1	62
5.3-5.7	185.2	43	5.8-6.2	69.0	137
5.8-6.2	201.0	104	6.3-6.8	63.6	381
6.3-6.8	210.0	333	6.9-7.3	61.6	575
6.9-7.3	220.5	473	7.4-7.8	67.0	741
7.4-7.8	222.0	552	7.9-8.4	68.6	178
7.9-8.4	207.1	177			

20



**AgPhD** **How to Fix >6.8 Soil pH**

High Soil pH is typically caused by **nutrients out of balance** due to:

1. Poor drainage – fix this with tile
2. Topsoil has disappeared – fix this by building new topsoil (reduce tillage, plant crops with lots of roots, use manure & cover crops & biologicals)
3. Poor irrigation water quality (high pH, high salt, etc.)
4. High Magnesium (Mg raises pH 1.6 to 1 compared to Calcium)
5. Build up of Sodium (Na raises pH 4 to 1 compared to Calcium)

It will likely take many years to get your soil pH down to 6.8 or less. Here are some other things you can do in the meantime:

- Do everything else possible to raise a good crop, including balancing all plant nutrients
- The more healthy roots plants produce, the more organic acids they release which lower soil pH
- Use AMS & especially elemental Sulfur to help nutrient availability

### Soil test data from October, 2014

ORGANIC MATTER	PHOSPHORUS						POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	pH	CATION EXCHANGE CAPACITY	PERCENT BASE SATURATION (COMPUTED)								
	P <sub>1</sub>	P <sub>2</sub>	BICARBONATE P	K	Mg	Ca	Na	SOIL BUFFER	% K	% Mg			% Ca	% H	% Na						
MODIFIED L.O.I.	WEAK BRAY 1:7	STRONG BRAY 1:7	OLSEN							pH	INDEX	C.E.C.									
PERCENT	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	1:1	meq/100g						
3.6	H	23	H	46	H	21	H	171	L	1075	VH	3856	M	71	8.0	29.0	1.5	30.9	66.5	0.0	1.1
3.1	M	20	M	58	H	16	H	176	L	930	VH	3911	H	47	8.3	28.0	1.6	27.7	70.0	0.0	0.7
2.7	M	12	L	53	H	10	L	171	M	480	VH	4279	H	36	8.1	26.0	1.7	15.4	82.3	0.0	0.6

NITRATE-N (FIA)				SULFUR S ICAP	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B	EXCESS LIME RATE	SOLUBLE SALTS 1:1													
Surface	Sub 1	Sub 2		Total	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE												
ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	lbs/A	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	mmhos/cm	RATE					
6	11	0-6							11	20	H	0.8	L	4	VL	29	VH	1.4	H	1.2	M	L	0.5	L
6	11	0-6							11	21	H	0.6	L	3	VL	14	M	1.0	M	1.2	M	M	0.4	L
6	11	0-6							11	21	H	0.5	VL	3	VL	12	M	0.8	L	1.0	M	M	0.3	L



### Potash applied in October, 2014

Application			
Product	Cost		
Addition/Deduction(lbs/A):	-165	Per Acre Min(lbs/A):	None Entered
Percent of Original App:	100%	Per Acre Cap(lbs/A):	None Entered
Minimum Application Rate:	620.0 lbs/A	Min Non-Zero Rate(lbs/A):	None Entered
Maximum Application Rate:	775.0 lbs/A	Est Potash_0-0-60 Cost/Ton:	\$ 260.00
Field Average Rate:	697.92 lbs/A	Est Potash_0-0-60 Total Cost:	\$ 1747.20
Total Applied Acreage:	19.25	Est Potash_0-0-60 Cost/Acre:	\$ 90.76
Total Field Acreage:	19.25	Est App Cost/Acre:	\$ 2.00
Total Field Acreage(lbs):	13435.0	Est Total App Cost:	\$ 38.50
Total Field Acreage(tons):	6.72	Est Combined Cost:	\$ 1785.70

21

### Soil test data from November, 2015

ORGANIC MATTER	PHOSPHORUS						POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	pH	CATION EXCHANGE CAPACITY	PERCENT BASE SATURATION (COMPUTED)								
	P <sub>1</sub>	P <sub>2</sub>	BICARBONATE P	K	Mg	Ca	Na	SOIL BUFFER	% K	% Mg			% Ca	% H	% Na						
MODIFIED L.O.I.	WEAK BRAY 1:7	STRONG BRAY 1:7	OLSEN							pH	INDEX	C.E.C.									
PERCENT	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	1:1	meq/100g						
3.0	M	51	VH	82	VH	49	VH	259	VH	692	VH	2947	H	52	7.5	21.4	3.1	26.9	68.9	0.0	1.1
4.1	H	46	VH	84	VH	45	VH	361	VH	779	VH	3713	H	52	7.3	26.2	3.5	24.8	70.8	0.0	0.9
2.8	M	39	VH	86	VH	42	VH	245	H	860	VH	3339	H	48	7.7	24.7	2.5	29	67.7	0.0	0.8
3.4	M	60	VH	98	VH			362	VH	552	VH	2654	M	48	6.0	22.4	4.1	20.5	59.3	15.3	0.9
4.0	M	70	VH	113	VH			380	VH	404	VH	2413	M	22	5.7	20.9	4.7	16.1	57.7	21.0	0.5
3.4	H	34	VH	91	VH	26	VH	293	VH	483	VH	3274	H	32	7.0	21.3	3.5	18.9	76.9	0.0	0.7
3.8	H	39	VH	102	VH	30	VH	405	VH	575	VH	3593	H	38	7.8	24	4.3	20.0	75.0	0.0	0.7

NITRATE-N (FIA)				SULFUR S ICAP	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B	EXCESS LIME RATE	SOLUBLE SALTS 1:1													
Surface	Sub 1	Sub 2		Total	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE												
ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	lbs/A	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	mmhos/cm	RATE					
26	47	0-6							47	43	VH	3.5	H	4	VL	19	H	1.0	M	1.3	H	L	0.7	L
20	36	0-6							36	34	VH	4.2	H	5	L	27	VH	1.6	H	1.3	H	L	0.8	L
25	45	0-6							45	39	VH	3.3	H	4	VL	15	M	1.0	M	1.6	H	L	0.7	L
32	58	0-6							58	32	VH	6.4	VH	13	H	35	VH	1.3	H	1.1	M	L	0.6	L
11	20	0-6							20	24	H	5.5	H	20	H	58	VH	1.7	H	0.8	M	L	0.4	L
18	32	0-6							32	27	VH	3.7	H	7	L	25	VH	1.1	M	1.2	M	L	0.6	L
24	43	0-6							43	40	VH	3.6	H	5	L	17	H	1.4	H	1.6	H	L	0.7	L



### Soil test data from September, 2021

LAB NUMBER	SURFACE	DEPTH	ORGANIC MATTER	SAMPLE IDENTIFICATION	MEHLICH III ICP						pH	SOIL BUFFER	CATION EXCHANGE CAPACITY	PERCENT BASE SATURATION (COMPUTED)			
					P	S	Mg	Ca	Na	meq/100g				% K	% Mg	% Ca	% H
46555	15	27	0-6	EARL MID1	2.8	69	379	456	4199	38	7.5	25.9	3.8	14.7	80.9	0.0	0.6
46556	40	72	0-6	EARL MID2	3.3	65	332	803	4421	28	7.5	28.1	3.0	17.9	78.7	0.0	0.4
46557	33	59	0-6	EARL MID3	3.0	66	347	740	5166	33	7.8	33.0	2.7	18.7	78.2	0.0	0.4
46558	37	67	0-6	EARL MID4	3.9	70	390	800	3667	26	7.2	24.4	4.1	20.5	74.9	0.0	0.5
46559	19	34	0-6	EARL MID6	4.4	59	388	832	3400	26	6.6	24.7	4.0	21.3	68.8	5.4	0.5
46560	20	36	0-6	EARL MID6	4.7	84	349	844	3430	31	7.0	23.5	3.8	22.8	72.8	0.0	0.6
46561	25	45	0-6	EARL MID7	3.4	100	314	588	2792	31	7.2	19.8	4.1	24.7	70.6	0.0	0.7
46562	29	52	0-6	EARL MID6	4.1	48	432	587	4902	33	7.9	30.7	3.6	15.9	80.0	0.0	0.5
46563	29	52	0-6	EARL MID9	3.8	65	347	616	4151	29	7.7	26.9	3.3	19.1	77.1	0.0	0.5
46564	28	61	0-6	EARL MID10	3.1	81	413	558	4871	36	7.8	30.2	3.5	15.4	80.6	0.0	0.5

AgPhD **Poor Drainage Soil Test**

ORGANIC MATTER	PHOSPHORUS						POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	pH	CATION EXCHANGING CAPACITY	PERCENT BASE SATURATION (COMPUTED)									
	P <sub>1</sub>	P <sub>2</sub>	BICARBONATE P		K	Mg	Ca	Na	SOIL	BUFFER	% K		% Mg	% Ca	% H	% Na						
MODIFIED L.O.I.	WEAK BRAY 1:7	STRONG BRAY 1:7	OLSEN								pH INDEX	C.E.C.										
PERCENT	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	1:1	meq/100g									
5.1	M	2	VL	42	M	10	L	490	VH	1450	VH	2500	H	35	L	8.1	29.4	4.0	23.0	60.0	0.0	0.4

NITRATE-N (FIA)				SULFUR S ICAP	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B	EXCESS LIME RATE	SOLUBLE SALTS 1:1																		
Surface	Sub 1	Sub 2	Total		ppm	RATE	ppm	RATE	ppm		RATE	ppm	RATE																
ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	ppm	lbs/A	depth IN						
105	200	0-6													200	VH	4	H	20	H	60	VH	1.9	VH	2.2	VH	L	2.3	H

AgPhD **Quiz**

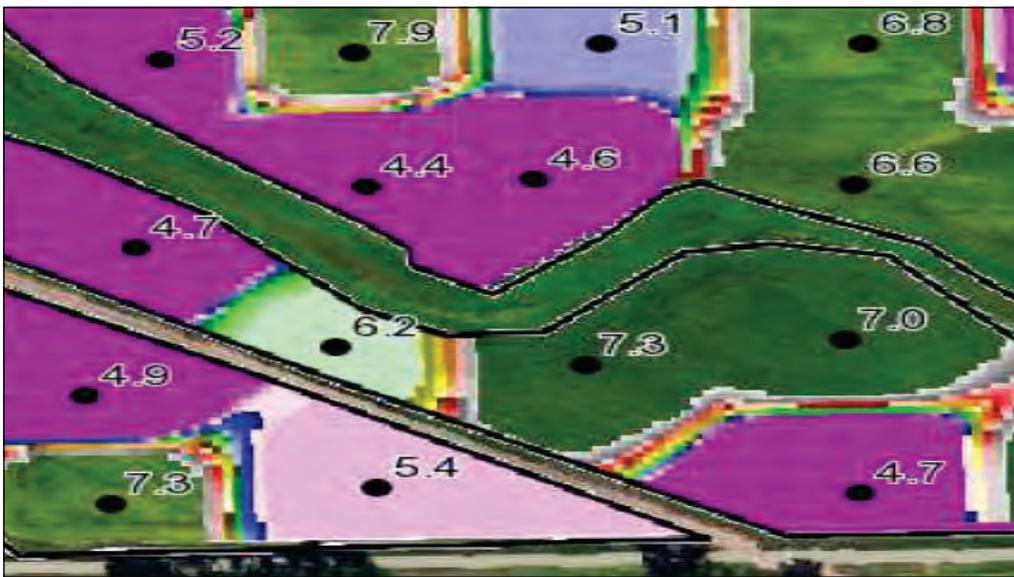
**If you have high pH soil, what is the most likely cause?**

1. Soil is naturally high in pH and there is nothing you can do to fix it
2. There is an excess of sulfur in your soil
3. Nutrients are out of balance

22

AgPhD **How to Fix <6.3 Soil pH**

1. Use a calcitic lime (high Ca) if you don't need more Mg
2. Use a dolomitic lime (high Mg) if you need more Mg
3. Do not exceed 2400# actual calcium per year
4. If you have extreme drought when sampling, soil pH may show slightly lower than normal (0.1 to 0.5)
5. Always be conservative when liming to avoid applying too much. Lime breaks down slowly, sometimes 3 to 5 years, so give your lime time before re-applying.
6. Look at WHY your pH got low in the first place. Do you have compaction? Do you need to build organic matter? Are you over-applying N?



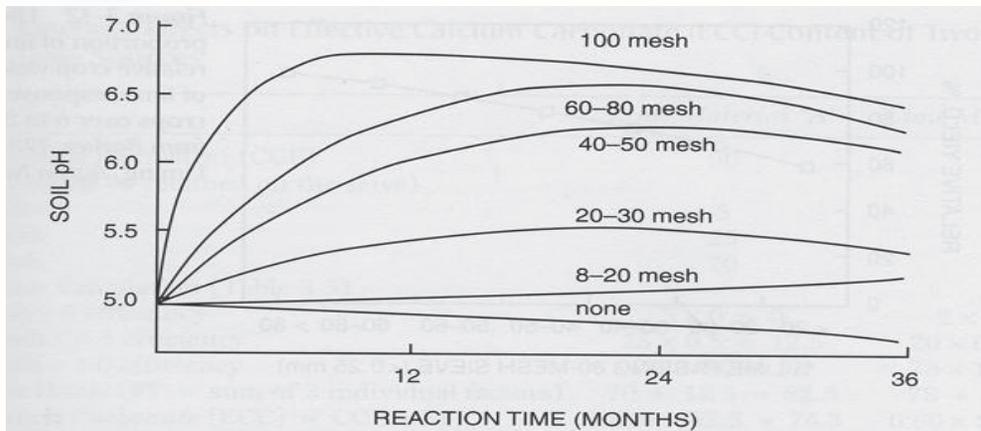
## Lime

- “85% of all nitrate Nitrogen converts to nitric acid before it leaches, stripping calcium out” Neal Kinsey
- Too much lime ties up micronutrients like iron, increases moisture loss, overinflates CEC, causes deficiencies of Mg & K to be overstated on soil test, and soil is easily pulverized to excess (fluffy)
- Dandelions - indicator of compaction and/or low calcium
- Cocklebur likes low calcium and low zinc

## Lime

- Grading lime comes down to 5 things:
  1. Fineness – will it pass through 4, 8, or 60 mesh screen (each state uses different screen sizes)
  2. Calcium Carbonate Equivalent (CCE) – Purity
  3. Moisture
  4. Heavy metals (lead, cadmium, mercury, nickel, arsenic, etc.) – we want none or very low levels
  5. Cost
- ECCE (Effective Calcium Carbonate Equivalent) is based on fineness, purity, and moisture. The higher the number the better.

## Lime Fineness



Havlin et al., 2005

## Resulting Reaction from Lime

- $\text{CaCO}_3 + \text{H}_2 = \text{Ca}^{++} + \text{CO}_2 + \text{H}_2\text{O}$
- Lime is Calcium Carbonate (Tums)
- Acid soils have excess Hydrogen
- Lime produces three products in soil:
  1. Free Calcium
  2. Carbon Dioxide – plants breathe this in
  3. Water

AgPhD Nutrients in 6 Tons of Water Treatment Lime			
	Analysis	Pounds/Acre	ppm in 6" Soil
Moisture	50.92%		
Nitrogen	0.04%	4.80	2.40
Boron	21 ppm	0.25	0.13
Sulfur	0.14%	16.80	8.40
Sodium	0.02%	2.40	1.20
Iron	3720 ppm	44.64	22.32
Manganese	1520 ppm	18.24	9.12
Zinc	33 ppm	0.40	0.20
Calcium	17.6%	2112	1056
Magnesium	1.07%	128.40	64.20

AgPhD Nutrients in 6 Tons of Sugarbeet Lime			
	Analysis	Pounds/Acre	ppm in 6" Soil
Moisture	32.33%		
Available Phosphate (P <sub>2</sub> O <sub>5</sub> )	0.59%	70.8	35.4
Total Phosphate (P <sub>2</sub> O <sub>5</sub> )	0.86%	103.2	51.6
Soluble K <sub>2</sub> O Potassium	0.12%	14.4	7.2
Total K <sub>2</sub> O Potassium	0.25%	30	15
Calcium	21.55%	2586	1293
Iron	0.16%	19.2	9.6
Magnesium	1.21%	145.2	72.6
Manganese	0.02%	2.4	1.2
Sulfur	0.42%	50.4	25.2

24

AgPhD Nutrients in 6 Tons of Egg Shells			
	Analysis	Pounds/Acre	ppm in 6" Soil
Moisture	21.4%		
ECCE (Effective Calcium Carbonate Equivalent)	68.5		
Sieve Analysis (60 mesh)	100%		
Calcium	30.8%	3696	1848
Magnesium	0.27%	32.4	16.2
Phosphorus (total)	0.09%	10.8	5.4
Total Phosphate (P <sub>2</sub> O <sub>5</sub> )	0.21%	25.2	12.6
Potassium (total)	0.07%	8.4	4.2
Total K <sub>2</sub> O Potassium	0.08%	9.6	4.8

### AgPhD What Is Buffer pH or Buffer Index?

ORGANIC MATTER L.O.L percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
4.9	61	333	418	1934	19	4.7	6.2	28.1	3.0	12.4	34.4	49.9	0.3

NITRATE-N (FIA)			MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm	
SURFACE		Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm			
ppm	lbs/A								depth (in)		
75	135	0-6	135	19	12.8	108	155	1.9	1.0	L	0.5

Buffer Index is NOT a direct representation of how low or high your soil pH is

### What is Buffer pH?

- Buffer pH (or Buffer Index) tells you how easily you can raise your soil pH. It has a lot to do with CEC.
- If your soil pH is below 7.0, you have an acid soil. The pH can be raised by adding lime, but how much lime do you need? That's what the buffer pH helps you figure out.
- The closer the number is to 7.0, the easier it is to raise the pH.

### Lime Recommendation Example

Soil Type	C.E.C.	Hydrogen (Meq/100g)	Soil pH	Buffer Index	Lime Rate (Tons/A)
Sand	6	1.8	5.6	6.8	1
Silt	14	4.2	5.6	6.6	2
Clay	24	7.5	5.6	6.2	4

This illustration shows that even when the Hydrogen percentage in the base saturation & the soil pH on one test may be equal to that on another test, the buffer index and therefore the lime recommendation may vary dramatically due to CEC. In other words, the heavier your soil, the more binding sites there are. With more binding sites comes more Hydrogen held in the soil, which means it requires more lime to remove that Hydrogen.

Source: Midwest Labs

### Tons of Lime to Raise Soil pH

Below is information for each of the Lime Charts on the next slides

- The left column is Buffer Index (or Buffer pH) on your soil test
- The top row is ECCE (Effective Calcium Carbonate Equivalent) of your lime source
- The numbers in the table are approximate Tons Per Acre of Lime that must be applied to reach the pH level mentioned on the slide
- According to Neal Kinsey, do not exceed 2400 pounds of Actual Calcium (not lime) applied per year
- Depending on heat, moisture, tillage, and other factors, lime may take several years to fully change your soil pH so if you have applied enough lime to raise pH to a certain level, do not expect to see that level on your soil test for 2-3 years. If lime is applied again during the breakdown period, soil pH may exceed your target level.

### Tons of Lime to Raise Soil pH to 6.9

	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%
6.9	4.7	3.8	3.2	2.7	2.4	2.1	1.9	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.1
6.8	6.8	5.4	4.5	3.9	3.4	3.0	2.7	2.5	2.3	2.1	1.9	1.8	1.7	1.6	1.5
6.7	8.9	7.1	5.9	5.1	4.4	3.9	3.5	3.2	3.0	2.7	2.5	2.4	2.2	2.1	2.0
6.6	10.9	8.7	7.3	6.2	5.5	4.9	4.4	4.0	3.6	3.4	3.1	2.9	2.7	2.6	2.4
6.5	13.0	10.4	8.7	7.4	6.5	5.8	5.2	4.7	4.3	4.0	3.7	3.5	3.3	3.1	2.9
6.4	15.1	12.1	10.0	8.6	7.5	6.7	6.0	5.5	5.0	4.6	4.3	4.0	3.8	3.5	3.3
6.3	17.1	13.7	11.4	9.8	8.6	7.6	6.9	6.2	5.7	5.3	4.9	4.6	4.3	4.0	3.8
6.2	19.2	15.4	12.8	11.0	9.6	8.5	7.7	7.0	6.4	5.9	5.5	5.1	4.8	4.5	4.3
6.1	21.3	17.0	14.2	12.1	10.6	9.4	8.5	7.7	7.1	6.5	6.1	5.7	5.3	5.0	4.7
6	23.3	18.7	15.6	13.3	11.7	10.4	9.3	8.5	7.8	7.2	6.7	6.2	5.8	5.5	5.2
5.9	25.4	20.3	16.9	14.5	12.7	11.3	10.2	9.2	8.5	7.8	7.3	6.8	6.3	6.0	5.6
5.8	27.5	22.0	18.3	15.7	13.7	12.2	11.0	10.0	9.2	8.4	7.8	7.3	6.9	6.5	6.1
5.7	29.5	23.6	19.7	16.9	14.8	13.1	11.8	10.7	9.8	9.1	8.4	7.9	7.4	6.9	6.6
5.6	31.6	25.3	21.1	18.0	15.8	14.0	12.6	11.5	10.5	9.7	9.0	8.4	7.9	7.4	7.0
5.5	33.7	26.9	22.4	19.2	16.8	15.0	13.5	12.2	11.2	10.4	9.6	9.0	8.4	7.9	7.5

AgPhD		Tons of Lime to Raise Soil pH to 6.8														
	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	
6.9	2.7	2.2	1.8	1.6	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	
6.8	4.7	3.8	3.1	2.7	2.4	2.1	1.9	1.7	1.6	1.4	1.3	1.3	1.2	1.1	1.0	
6.7	6.7	5.3	4.4	3.8	3.3	3.0	2.7	2.4	2.2	2.1	1.9	1.8	1.7	1.6	1.5	
6.6	8.6	6.9	5.8	4.9	4.3	3.8	3.5	3.1	2.9	2.7	2.5	2.3	2.2	2.0	1.9	
6.5	10.6	8.5	7.1	6.1	5.3	4.7	4.2	3.9	3.5	3.3	3.0	2.8	2.6	2.5	2.4	
6.4	12.6	10.1	8.4	7.2	6.3	5.6	5.0	4.6	4.2	3.9	3.6	3.4	3.1	3.0	2.8	
6.3	14.5	11.6	9.7	8.3	7.3	6.5	5.8	5.3	4.8	4.5	4.2	3.9	3.6	3.4	3.2	
6.2	16.5	13.2	11.0	9.4	8.2	7.3	6.6	6.0	5.5	5.1	4.7	4.4	4.1	3.9	3.7	
6.1	18.5	14.8	12.3	10.5	9.2	8.2	7.4	6.7	6.2	5.7	5.3	4.9	4.6	4.3	4.1	
6	20.4	16.3	13.6	11.7	10.2	9.1	8.2	7.4	6.8	6.3	5.8	5.4	5.1	4.8	4.5	
5.9	22.4	17.9	14.9	12.8	11.2	10.0	9.0	8.1	7.5	6.9	6.4	6.0	5.6	5.3	5.0	
5.8	24.4	19.5	16.2	13.9	12.2	10.8	9.7	8.9	8.1	7.5	7.0	6.5	6.1	5.7	5.4	
5.7	26.3	21.1	17.5	15.0	13.2	11.7	10.5	9.6	8.8	8.1	7.5	7.0	6.6	6.2	5.8	
5.6	28.3	22.6	18.9	16.2	14.1	12.6	11.3	10.3	9.4	8.7	8.1	7.5	7.1	6.7	6.3	
5.5	30.2	24.2	20.2	17.3	15.1	13.4	12.1	11.0	10.1	9.3	8.6	8.1	7.6	7.1	6.7	

AgPhD		Tons of Lime to Raise Soil pH to 6.3														
	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	
6.7	1.0	0.8	0.7	0.6	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	
6.6	2.7	2.2	1.8	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	
6.5	4.4	3.5	2.9	2.5	2.2	1.9	1.7	1.6	1.5	1.3	1.2	1.2	1.1	1.0	1.0	
6.4	6.1	4.8	4.0	3.5	3.0	2.7	2.4	2.2	2.0	1.9	1.7	1.6	1.5	1.4	1.3	
6.3	7.7	6.2	5.2	4.4	3.9	3.4	3.1	2.8	2.6	2.4	2.2	2.1	1.9	1.8	1.7	
6.2	9.4	7.5	6.3	5.4	4.7	4.2	3.8	3.4	3.1	2.9	2.7	2.5	2.4	2.2	2.1	
6.1	11.1	8.9	7.4	6.3	5.5	4.9	4.4	4.0	3.7	3.4	3.2	3.0	2.8	2.6	2.5	
6	12.8	10.2	8.5	7.3	6.4	5.7	5.1	4.6	4.3	3.9	3.7	3.4	3.2	3.0	2.8	
5.9	14.5	11.6	9.6	8.3	7.2	6.4	5.8	5.3	4.8	4.4	4.1	3.9	3.6	3.4	3.2	
5.8	16.1	12.9	10.8	9.2	8.1	7.2	6.5	5.9	5.4	5.0	4.6	4.3	4.0	3.8	3.6	
5.7	17.8	14.3	11.9	10.2	8.9	7.9	7.1	6.5	5.9	5.5	5.1	4.8	4.5	4.2	4.0	
5.6	19.5	15.6	13.0	11.1	9.8	8.7	7.8	7.1	6.5	6.0	5.6	5.2	4.9	4.6	4.3	
5.5	21.2	16.9	14.1	12.1	10.6	9.4	8.5	7.7	7.1	6.5	6.1	5.6	5.3	5.0	4.7	

AgPhD		Tons of Lime to Raise Soil pH to 6.0														
	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	
6.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
6.4	1.9	1.5	1.3	1.1	1.0	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	
6.3	3.4	2.7	2.3	1.9	1.7	1.5	1.4	1.2	1.1	1.0	1.0	0.9	0.8	0.8	0.8	
6.2	4.9	3.9	3.2	2.8	2.4	2.2	1.9	1.8	1.6	1.5	1.4	1.3	1.2	1.1	1.1	
6.1	6.4	5.1	4.2	3.6	3.2	2.8	2.5	2.3	2.1	2.0	1.8	1.7	1.6	1.5	1.4	
6	7.8	6.3	5.2	4.5	3.9	3.5	3.1	2.9	2.6	2.4	2.2	2.1	2.0	1.8	1.7	
5.9	9.3	7.5	6.2	5.3	4.7	4.1	3.7	3.4	3.1	2.9	2.7	2.5	2.3	2.2	2.1	
5.8	10.8	8.6	7.2	6.2	5.4	4.8	4.3	3.9	3.6	3.3	3.1	2.9	2.7	2.5	2.4	
5.7	12.3	9.8	8.2	7.0	6.1	5.5	4.9	4.5	4.1	3.8	3.5	3.3	3.1	2.9	2.7	
5.6	13.8	11.0	9.2	7.9	6.9	6.1	5.5	5.0	4.6	4.2	3.9	3.7	3.4	3.2	3.1	
5.5	15.2	12.2	10.2	8.7	7.6	6.8	6.1	5.5	5.1	4.7	4.4	4.1	3.8	3.6	3.4	

AgPhD		What Is Cation Exchange Capacity (CEC)?														
ORGANIC MATTER L.O.L percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)							
	PHOSPHORUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SODIUM Na ppm	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na			
4.9	61	333	418	1934	19	4.7	6.2	28.1	3.0	12.4	34.4	49.9	0.3			
NITRATE-N (FIA) SURFACE			MEHLICH III ICP					EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm							
ppm	lbs/A	depth (in)	Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm			COPPER Cu ppm	BORON B ppm					
75	135	0-6	135	19	12.8	108	155	1.9	1.0	L	0.5					

CEC tells you how heavy or light your soil is. It's important to have a number, because everyone's interpretation of heavy & light ground is different.

## AgPhD Cation Exchange Capacity (CEC)

- Tells you the holding capacity of your soil
- The 3 components of CEC are:
  1. Type of clay
  2. Amount of clay
  3. **Amount of organic matter** (this is the only factor you can change in CEC)
- > 20 we consider a “heavy” soil
- < 10 we consider a “light” soil
- CEC X 10 = approximate Nitrogen-holding capacity

## AgPhD Calculating CEC\*\*\*

	Atomic Weight	Number of Valences*	Atomic Weight per Valence**
<b>K</b>	39	1	39
<b>Mg</b>	24	2	12
<b>Ca</b>	40	2	20
<b>Na</b>	23	1	23
<b>H</b>	1	1	1

\* Valence = number of charges. Since these are cations, the charges are positive.  
 \*\* Atomic Weight per Valence gets each element in equal terms. For example, 20 ppm Ca can displace 12 ppm Mg.  
 \*\*\* The presence of free lime or calcium carbonate will increase the C.E.C. value obtained. **Actual soil textures by hydrometer will give the most accurate determination.**

27

## AgPhD How to Calculate CEC

<http://www.agphd.com/cec-calculator-excel/>



## AgPhD Inaccurate CEC Reading – 1 Acre Grid – MN

ORGANIC MATTER	MEHLICH III ICP					pH	BUFFER INDEX	CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)						
	PHOSPHORUS P	POTASSIUM K	MAGNESIUM Mg	CALCIUM Ca	SODIUM Na				% K	% Mg	% Ca	% H	% Na		
L.O.I. percent	ppm	ppm	ppm	ppm	ppm	1:1									
4.7	29	161	349	17080	25	7.8	88.8	0.5	3.3	96.1	0.0	0.1			

NITRATE-N (FIA)			MEHLICH III ICP							EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE		Total lbs/A	SULFUR S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B			
ppm	lbs/A	depth (in)	ppm	ppm	ppm	ppm	ppm	ppm			
17	31	0-6	31	953	4.8	142	29	1.8	4.1	H	1.8

## Excess Lime Rate

- A visual rating of free lime present. Soils having high amounts of free lime available will have problems with availability of major and minor elements to the plant. Application of elemental sulfur or acid forming fertilizer can be beneficial in keeping phosphorus and micronutrients in a more available or soluble form. When excess lime is high, banding usually works better than broadcasting for P, K, & most micros, at least in the short-term.
- When the Excess Lime Rate is high, all soil tests can show higher levels of CEC, but the Mehlich 3 test will show a much higher value. If this is the case on your farm, we suggest running a different test than Mehlich 3, at least if you want a more accurate CEC reading. Neal Kinsey, for example, runs a Cation Displacement test when Calcium is above 84% and TEC (Total Exchange Capacity) is above 9.

## Inaccurate CEC Reading – 1 Acre Grid – MN

	PPM off soil test	Atomic Weight per Valence times 10*	PPM / Weight =
<b>K</b>	161	390	0.41
<b>Mg</b>	349	120	2.91
<b>Ca</b>	17080	200	85.40
<b>Na</b>	25	230	0.11
<b>H</b>		10	0

**rounding to the nearest tenth, CEC = 88.8**

## Kinsey Cation Displacement Test Example

	Original Test Results	Cation Displacement Test
Soil pH	7.1	7.1
Nitrogen pounds	127	127
Phosphate pounds	314	314
Calcium pounds / %	17,890 / 90.29%	5223 / 79.39%
Magnesium pounds / %	504 / 4.24%	504 / 12.77%
Potassium pounds / %	140 / 0.36%	140 / 1.09%
Sodium pounds / %	185 / 0.81%	185 / 2.45%

## Tile in 2013, Soil Tests from 2015 & 2021 - MN

ORGANIC MATTER LOI	PHOSPHORUS				POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	pH		CATION EXCHANGE CAPACITY CEC	PERCENT BASE SATURATION (COMPUTED)				
	P ppm	P ppm	P ppm	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm	SOIL pH	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
6.0 VH	2 VL	10 L	6 L	129 VL	503 M	13330 H	45	7.8		71.4	0.5	5.9	93.3	0.0	0.3	
6.9 VH	2 VL	51 H	17 H	220 M	598 VH	5707 VH	14	8.1		34.1	1.7	14.6	83.5	0.0	0.2	

NITRATE-N (FIA)				SULFUR	ZINC	MANGANESE	IRON	COPPER	BORON	EXCESS	SOLUBLE
SURFACE				S	Zn	Mn	Fe	Cu	B	LIME	SALTS
ppm	lbs/A	depth (in)	Total lbs/A	IC AP	ITPA	ITPA	ITPA	ITPA	SORB. ITPA	RATE	mmhos/cm
9	16	0-6	16	5958 VH	1.0 L	3 VL	9 L	1.0 M	4.4 VH	H	2.0 M
11	20	0-6	20	64 VH	2.2 M	8 L	17 H	1.4 H	4.1 VH	H	0.7 L

## Excess Lime Rate

- A visual rating of free lime present. Soils having high amounts of free lime available will have problems with availability of major and minor elements to the plant. Application of elemental sulfur or acid forming fertilizer can be beneficial in keeping phosphorus and micronutrients in a more available or soluble form. When excess lime is high, banding usually works better than broadcasting for P, K, & most micros, at least in the short-term.
- When the Excess Lime Rate is high, all soil tests can show higher levels of CEC, but the Mehlich 3 test will show a much higher value. If this is the case on your farm, we suggest running a different test than Mehlich 3, at least if you want a more accurate CEC reading. Neal Kinsey, for example, runs a Cation Displacement test when Calcium is above 84% and TEC (Total Exchange Capacity) is above 9.

## Inaccurate CEC Reading – 1 Acre Grid – MN

	PPM off soil test	Atomic Weight per Valence times 10*	PPM / Weight =
<b>K</b>	161	390	0.41
<b>Mg</b>	349	120	2.91
<b>Ca</b>	17080	200	85.40
<b>Na</b>	25	230	0.11
<b>H</b>		10	0

rounding to the nearest tenth, CEC = **88.8**

## Kinsey Cation Displacement Test Example

	Original Test Results	Cation Displacement Test
Soil pH	7.1	7.1
Nitrogen pounds	127	127
Phosphate pounds	314	314
Calcium pounds / %	17,890 / 90.29%	5223 / 79.39%
Magnesium pounds / %	504 / 4.24%	504 / 12.77%
Potassium pounds / %	140 / 0.36%	140 / 1.09%
Sodium pounds / %	185 / 0.81%	185 / 2.45%

## Tile in 2013, Soil Tests from 2015 & 2021 - MN

ORGANIC MATTER LOI	PHOSPHORUS				POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	pH		CATION EXCHANGE CAPACITY CEC	PERCENT BASE SATURATION (COMPUTED)				
	P ppm	P ppm	P ppm	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm	SOIL pH	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
6.0 VH	2 VL	10 L	6 L	129 VL	503 M	13330 H	45	7.8		71.4	0.5	5.9	93.3	0.0	0.3	
6.9 VH	2 VL	51 H	17 H	220 M	598 VH	5707 VH	14	8.1		34.1	1.7	14.6	83.5	0.0	0.2	

NITRATE-N (FIA)				SULFUR	ZINC	MANGANESE	IRON	COPPER	BORON	EXCESS	SOLUBLE
SURFACE				S	Zn	Mn	Fe	Cu	B	LIME	SALTS
ppm	lbs/A	depth (in)	Total lbs/A	IC AP	ITPA	ITPA	ITPA	ITPA	SORB. ITPA	RATE	1:1
9	16	0-6	16	5958 VH	1.0 L	3 VL	9 L	1.0 M	4.4 VH	H	2.0 M
11	20	0-6	20	64 VH	2.2 M	8 L	17 H	1.4 H	4.1 VH	H	0.7 L

## Quiz

### What does it mean when a soil has high Excess Lime on the Excess Lime test?

1. When an applicator applies more lime to the soil than what is recommended
2. There is significant Calcium not attached to soil
3. There is lots of free hydrogen in the soil
4. Soil phosphorus will be more available than normal

## Why Is Organic Matter Important?

- It improves soil structure and tilth
- It reduces compaction & increases oxygen levels in soil
- It helps hold soil in place & reduces erosion potential
- It helps filter contaminants as water moves through soil
- It improves microbial activity and soil life
- It allows soils to warm more quickly in the spring
- Organic matter can hold approx. 3 times as many nutrients as clay
- O.M. can hold anions (N, P, S, B, Zn) better than clay

## Organic Matter Facts

Through mineralization every year each one percent of organic matter in the soil releases approximately:

- Nitrogen - 20 to 30 pounds
- Phosphate - 4 to 7 pounds
- Sulfur - 2 to 3 pounds
- Potassium – almost none. K is released from feldspars (rock) and other base soil components.
- Nutrient release will usually be greater in warmer areas or warmer years and less when it is colder
- For every 1% of organic matter increase in soil, the average soil can hold approx. 4% more water

## Mineralization Examples

- If Organic Matter is 1.5%, a soil may release:
  - Nitrogen - 30 to 45 pounds per acre per year
  - Phosphate - 6 to 11 pounds per acre per year
  - Sulfur - 3 to 5 pounds per acre per year
- If Organic Matter is 7%, a soil may release:
  - Nitrogen - 140 to 210 pounds per acre per year
  - Phosphate - 28 to 49 pounds per acre per year
  - Sulfur - 14 to 21 pounds per acre per year
  - Plus it will have approximately 22% more water-holding capacity vs. the 1.5% organic matter soil

## AgPhD Want Carbon Credits? Build Organic Matter!

- Organic matter can be increased over time, but it's a slow process that requires your commitment
- Top 5 ways to increase organic matter:
  1. Reduce tillage to keep roots intact
  2. Plant high residue crops with lots of roots (e.g. corn instead of soybeans)
  3. Use manure and/or compost
  4. Use cover crops
  5. Use biological products like D-Comp, Reverb, & Nutri-Cycle

AgPhD

## Quiz

**Roughly how much Nitrogen can you get out of 5% organic matter soil for free every single year?**

1. 0 pounds
2. 20 pounds
3. 50 pounds
4. 100 pounds

31

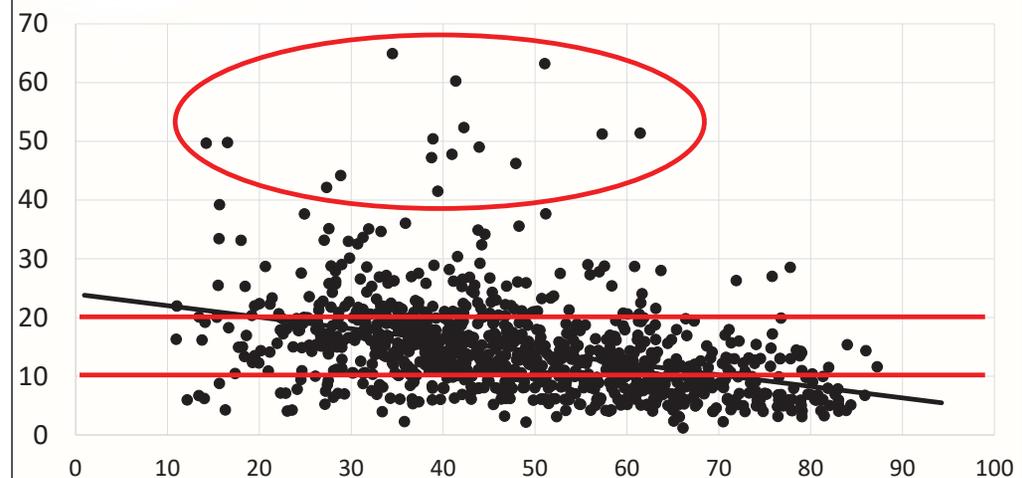
## AgPhD Nitrogen Credit for Soybeans Is a Myth

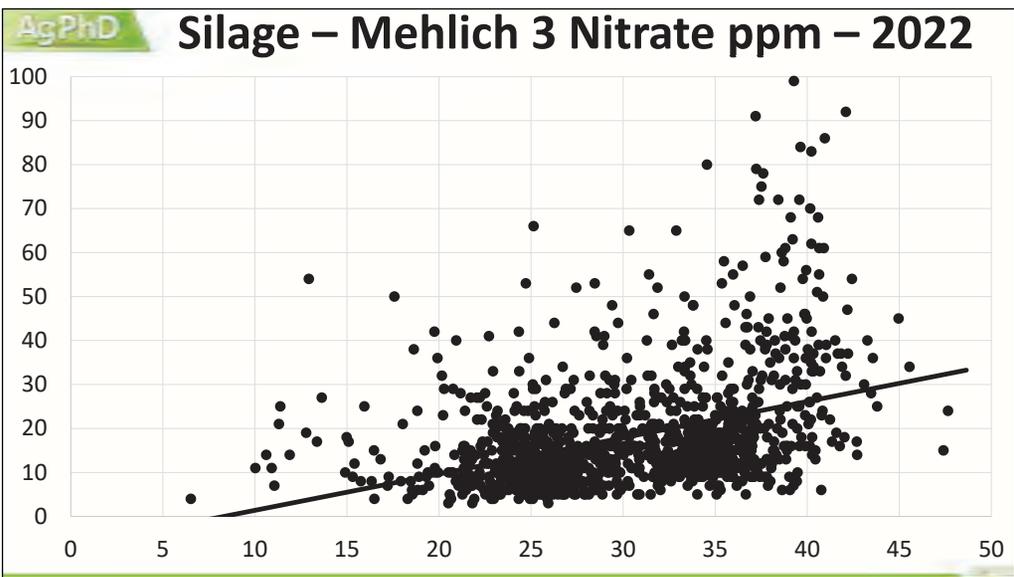
### Nitrate-N Pounds Per Acre - Fall, 2021

	0"- 6"	6"- 24"	Total	Previous Crop
Lowell's W	50	86	<b>136</b>	Soybeans
Siemonsma	18	16	<b>34</b>	Soybeans
Home W	157	49	<b>206</b>	Corn
Nils's West	135	140	<b>275</b>	Corn
Nils's East	162	151	<b>313</b>	Corn
Olaf's	119	111	<b>230</b>	Corn

AgPhD

## Soybeans - Soil Nitrate ppm – Fall, 2021





**AgPhD Nitrogen**

- Nitrate is leachable. Ammonium is not.
- We like to see a 24" test with N rather than just 6"
- We find most farmers are applying adequate N
- Urea breaks down over the course of 30 days. AMS only breaks down in 30 days when pH is above 7.5. AMS breaks down in 60 days when pH is below 7.5.
- Soybeans can produce UP TO 70% of their own Nitrogen needs through rhizobia bacteria under good soil conditions (i.e. neutral pH, good drainage, adequate moisture, moderate temps, etc.)
- Soybeans do NOT get "lazy" when there is lots of soil nitrogen, but they will use soil nitrogen if it is there

32

**AgPhD When Are N Stabilizers More Likely to Pay?**

- When Nitrogen rates are high
- When Nitrogen prices are high
- In lower CEC soils
- When Nitrogen sits on top of the soil more than 2 days
- When Nitrogen is applied far ahead of when it is used
- When soil pH is outside the range of 6.0 to 7.3
- When temperatures are warm
- In wetter years
- When you have environmental concerns

<b>Nitrogen Stabilizer Comparison Chart</b>	Anvol	PinnitMax TG	Trident	N-Serve	Instinct NXTGEN	Centuro
Volatilization	X	X	X			
Leaching			X	X	X	X
Denitrification			X	X	X	X
Urea (dry)	X	X	X	X	X	
28%/UAN (liquid)	X	X	X		X	X
Anhydrous				X		X
Liquid Manure					X	X

AgPhD 300 Bushel Corn Needs:			
	Grain	Stover	Total
Nitrogen	201	135	336
Phosphate	105	48	153
<b>=DAP (18-46-0) equivalent</b>	<b>228</b>	<b>104</b>	<b>332</b>
K <sub>2</sub> O Potassium	75	330	405
Sulfur	24	21	45
Calcium	4	39	43
Magnesium	10	62	72

AgPhD 300 Bushel Corn Needs:			
	Grain	Stover	Total
Copper (Cu)	0.14	0.08	0.22
Manganese (Mn)	0.22	2.25	2.47
Zinc (Zn)	0.32	0.45	0.77
Boron (B)	0.72	0.08	0.80
Iron (Fe)	0.46	0.75	1.21

33

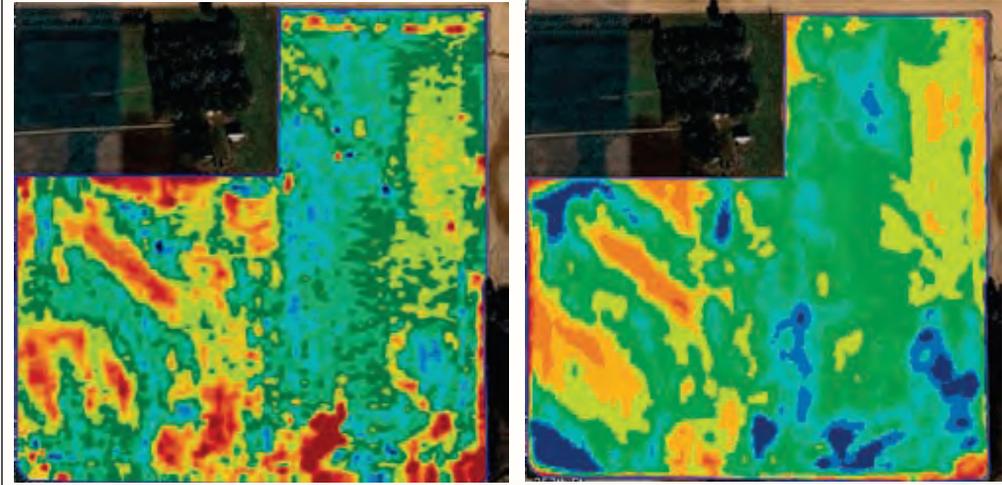
AgPhD 100 Bushel Soybeans Need:			
	Grain	Stover	Total
Nitrogen	325	110	435
Phosphate	73	24	97
K <sub>2</sub> O Potassium	120	100	220
<b>=Potash (0-0-60) equivalent</b>	<b>200</b>	<b>167</b>	<b>367</b>
Sulfur	18	17	35
Calcium	15	80	95
Magnesium (Mg)	15	35	50

AgPhD 100 Bushel Soybeans Need:			
	Grain	Stover	Total
Copper (Cu)	0.10	0.05	0.15
Manganese (Mn)	0.12	0.88	1.00
Zinc (Zn)	0.10	0.52	0.62
Boron (B)	0.12	0.58	0.70
Iron (Fe)	1.00	2.00	3.00

## AgPhD How Much N Do You Really Need?

- Let's say you are shooting for 300-bushel corn. It needs 336 pounds. 1.12 pounds/bushel no matter the yield goal.
- ADD:
  - Carryover N
  - Organic matter mineralization – 20-30#/point
  - Applied N – all forms incl. manure, DAP, etc.
- SUBTRACT:
  - Nitrogen loss – leaching, denitrification, volatilization
  - Nitrogen tie-up in high carbon residue or other loss
- How much of the soil's total N can your plant's roots recover?
- Will you have enough nitrogen every single day for your crop?

## AgPhD Actual Yield (Fall) vs Potential Yield (Spring)



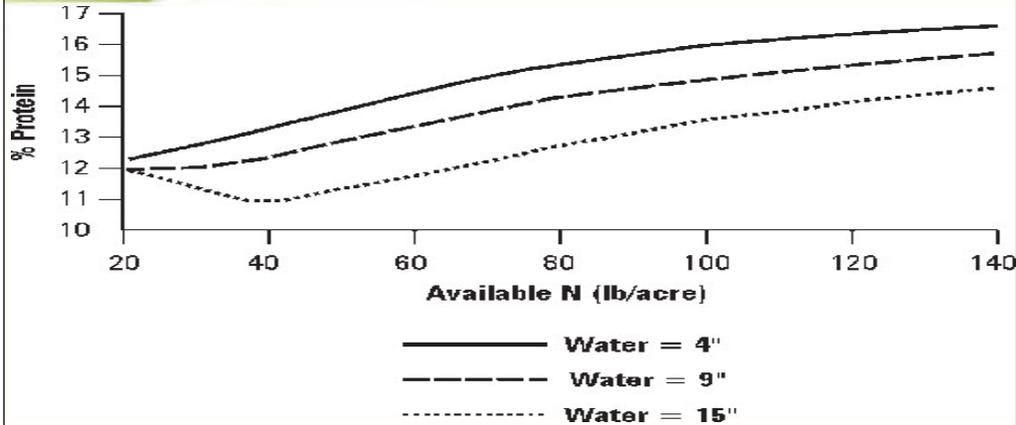
34

## AgPhD Urea Recommendation – Spring 2025 Based on soil test and Potential Yield

Zone	Area (ac)	Rate (lb/ac)	Soil OM 2024-10-18 (%)	Total Product (lb)
1	5.18	196.15	5.3	1,015.35
2	15.39	241.45	4.9	3,715.55
3	14.85	295.92	4.35	4,393.87
4	29.79	363.9	3.48	10,542.04
5	39.83	403.53	3.12	16,072.98
6	15.35	457.34	2.89	77,018.45
7	4.13	513.81	2.52	2,122.87
8	1.54	562.41	2.54	867.20
<b>Avg</b>	<b>126.05</b>	<b>362.93</b>	<b>3.6</b>	<b>45,748.31</b>

\*Organic matter, residual nitrate, and yield potential are all figured into "potential yield" equation

## AgPhD More Nitrogen = More Protein in Wheat



- Note how when water is higher, protein is lower as more of the nitrogen goes toward higher yield due to the ample moisture. Also note how protein continues to increase as available nitrogen increases.
  - Available N is soil N plus fertilizer N. Water is soil water plus May 1 to July 31 precipitation.
- Source: Selles, Agriculture and Agri-Food Canada, Swift Current

## AgPhD Do Biological Nitrogen Replacement Products Work?

Product	Brunswick	York	Avg Yield Gain	N# Added	Cost	Net ROI	Cost/Unit N
N-Hydro	-1.7 bu	15.8 bu	7.05 bu	7.90#	\$5.07	4.9	\$0.64
D-Comp	8.2 bu	14 bu	11.10 bu	12.43#	\$9.12	4.2	\$0.73
Photo-N	9.4 bu	12.7 bu	11.05 bu	12.38#	\$5.46	7.6	\$0.44
Utrisha-N	9.2 bu	13.5 bu	11.35 bu	12.71#	\$14.56	2.3	\$1.15
100% N (80# Br/72# Y)	44.7 bu	42 bu	43.35 bu	76#*	\$53.20	2.5	\$0.70
Proven 40 With WR/BP	16.7 bu	13.4 bu	15.05 bu	16.86#	\$16.50	2.9	\$0.98
Source N	8.9 bu	4.3 bu	6.60 bu	7.39#	\$14.00	1.0	\$1.89
Source N/Nutex EDA	3.4 bu	11.2 bu	7.30 bu	8.18#	\$17.00	0.8	\$2.08
Proven 40 & No WR/BP	8 bu	12.1 bu	10.05 bu	11.26#	\$16.00	1.7	\$1.42

- All trials had 60% N applied first, 120# in Brunswick & 106# in York
- \*Actual additional applied N was 76# average. For all other products we divided yield gain by 1.12#, because to create 1 bushel of corn it takes 1.12# of Nitrogen.
- Corn valued at \$4.25/bushel. Updated with 2026 product costs.

AgPhD

## Don't Kill Your Microbes!

- Zinc - Ammoniated zinc is the worst, but zinc citrate is close behind. Both kill microbes within an hour or so. However, zinc chelate, zinc sulfate, and AgroLiquid zinc are fine.
- Copper – Copper is also bad for microbes and kills them quickly
- Chlorine – Chlorine kills microbes almost instantly. Fortunately, on our farm we use Bio-Prep, that only costs about 5 cents per acre or less, and it turns harmful chlorine into beneficial chloride that is safe for microbial products.
- Calcium, Magnesium, & Iron – While high levels of any of these in water aren't nearly as harmful as the elements listed above, they can all cause minor issues. Water-Rite is the product we use on our farm to tie up these hard-water ions. Cost < \$0.50.

35

AgPhD

## Visual Deficiency Symptoms

- Many people believe their crop is suffering from drought, when in actuality it is suffering from lack of nutrients
- If a crop has ample nutrients it will use less water
- If a crop is short on even 1 nutrient, it will become a waster of water
- N, P, & K (mobile nutrients) **severe** deficiencies show up on older leaves
- Micros/Sulfur (non-mobile) **severe** deficiencies show up on new leaves



N Deficiency K Deficiency



AgPhD

## Phosphorus

- If pH is above 7 look at Olsen P Test (available P)
- If pH is below 7 look at Bray P tests
  - P1 is available P
  - P2 is total P (available + reserve that should be available this year)
- The Mehlich 3 Phosphorus test is similar to the P2 test
- Adding air helps P availability
- MAP (4.5 pH) - can use in any soil pH
- DAP (7.5 pH) - should only use when pH < 7.5 due to seed/seedling damage potential when free ammonia is formed in high pH soils as DAP breaks down

## Soil Test Basics

- How do I convert P to Phosphate (P<sub>2</sub>O<sub>5</sub>)? P X 2.3
- How do I convert K to K<sub>2</sub>O? K X 1.2

## How Can I Raise ppm On a Soil Test?

- Let's say you want to raise your parts per million by 10 in your soil test. If you want your phosphorus level in your 0-6" soil test to go from 40 ppm to 50 ppm using MAP (11-52-0), for example, how would you do that?
- Goal is to raise P ppm by 10
  1. Convert ppm to pounds/acre - 10 X 2 = 20 pounds/acre
  2. Convert P to phosphate - 20 X 2.3 = 46 pounds of phosphate/acre
  3. Convert phosphate to MAP – 46 pounds / 52% = 88 pounds of MAP/acre
- In summary, if you apply 88 pounds of MAP per acre, your phosphorus soil test should go up by 10 ppm assuming no use or loss of phosphorus and no other phosphorus additions

## Pounds (approx.) to Raise Soil Test ppm

	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
<b>DAP</b>	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
<b>MAP</b>	44	88	133	177	221	265	310	354	398	442	487	531	575	619	663

- The top row is the amount of Phosphorus parts per million (ppm) you want the Mehlich 3 soil test to go up
- The numbers in the table are Pounds Per Acre that must be applied to achieve approximately the ppm increase you desire on a Mehlich 3 soil test
- When raising Phosphorus, be mindful of fertility balance in the soil as well. If Phosphorus isn't your yield-limiting factor or if other nutrients aren't in balance, increasing phosphorus may not boost yields. For example, below are recommended Mehlich 3 soil test approximate ratios to consider.
  - Phosphorus to Zinc from 8:1 to 10:1. For example, if Phosphorus=100 ppm then Zinc should be roughly 10 to 12.5 ppm.
  - Phosphorus to Copper at approximately 30:1. For example, if Phosphorus=100 ppm then Copper should be roughly 3.3 ppm.
- Soil test levels may never reach your goals based on many factors including erosion, tillage, tie-up, crop removal, weather, and more

## Quiz

**If you have 10 ppm of available phosphorus in a 6" soil test, how many pounds per acre of available phosphate do you have?**

1. 10 pounds
2. 20 pounds
3. 23 pounds
4. 46 pounds

## Quiz

How much of a “soybean nitrogen credit” can you count on when rotating from soybeans last year to corn this year?

1. 0 pounds
2. 40 pounds
3. Soybean yield in bushels = nitrogen left over
4. 50% of soybean yield in bushels = nitrogen left over

# Saline Soil Test

ORGANIC MATTER		PHOSPHORUS						POTASSIUM		MAGNESIUM		CALCIUM		SODIUM		pH		CATION EXCHANGE CAPACITY	PERCENT BASE SATURATION (COMPUTED)				
		P <sub>1</sub>		P <sub>2</sub>		BICARBONATE P		K		Mg		Ca		Na		SOIL	BUFFER		% K	% Mg	% Ca	% H	% Na
MODIFIED L.O.I.		WEAK BRAY 1:7		STRONG BRAY 1:7		OLSEN										pH	INDEX	C.E.C.					
PERCENT	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	1:1		meq/100g					
3.1	M	50	VH	100	VH	25	VH	550	VH	1467	VH	1585	VL	40	VH	7.8		29.4	5.2	41.6	45.0	0.0	0.4

NITRATE-N (FIA)										SULFUR S		ZINC Zn		MANGANESE Mn		IRON Fe		COPPER Cu		BORON B		EXCESS LIME RATE	SOLUBLE SALTS 1:1	
Surface			Sub 1			Sub 2			Total	ICAP													mmhos/cm	RATE
ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	lbs/A	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE			
60	108	0-6							108	1792	VH	2.2	M	8	L	16	M	2.2	VH	4.2	VH	L	6.5	H

## Fixing Saline Soils

- 1) Run a soil test to see how high your soluble salts, sodium, calcium, and sulfur levels are.
- 2) Add drain tile so salt can flush out of your soil. Usually, following Steps 1 & 2 will solve your problem in time, as salts will leave your soil as you get rainfall.
- 3) If your soil has low calcium less than 75% (base saturation Ca), we would probably recommend gypsum (calcium sulfate) to increase calcium, improve soil porosity, and speed the removal of salts
- 4) You can incorporate high carbon residue (straw or corn stalks) in saline areas to help with drainage and to speed this process along

## Nitrous Oxide

- Nitrous oxide is 300 times more potent than carbon dioxide as a greenhouse gas
- In saline soils, nitrous oxide discharge can be 40 or 50 times more than in non-saline soils!
- Other than fixing saline soils, the best way to reduce nitrous oxide is to simply not let it escape into the atmosphere. This can be done by injecting nitrogen below the soil surface (or having rain move it into the soil soon after application) and having plants use the nitrogen as quickly as possible. Nitrogen stabilizers also help reduce nitrous oxide emissions.

## Manure

- Test it – What do you have in excess? Which nutrients are missing?
- Bury it – this keeps smell down, nutrients where you need them, and reduces the risk for environmental issues with phosphorus
- Some of the benefits of manure often include beneficial microbes, organic matter & organic material, a diverse set of nutrients, and some controlled-release fertility
- You may still be benefiting from where Dad or Grandpa spread manure!
- Use it in moderation – don't overload your soil with nutrients and/or salt

## Manure Salts

- At the bottom of a Midwest Labs' manure test it reads, "Total manure salts should not exceed 500 pounds per acre, less than 500 pounds per acre if annual rainfall is less than 25 inches and/or the soil CEC is less than 12. Salt contributions from commercial fertilizer applications must also be considered."
- If you look at many of the past and present yield champions, their sites were "dumping grounds" for manure. In the short-term, excessive manure rates hurt yield due to high salt levels. Once the salts flush away, many of the nutrients are left, meaning yield potential can then be extremely high.

Liquid Manure Test – Midwest Labs	Analysis	Lbs/1000 gal	1 <sup>st</sup> Year Avail.
Ammonium nitrogen (total)	0.17%	14.4	14
Organic nitrogen	0.18%	15.2	5
Nitrogen (total)	0.35%	29.6	19
Phosphorus (as P2O5)	0.14%	11.8	8
Potassium (as K2O)	0.26%	22	20
Sulfur (total)	0.04%	3.4	1
Calcium (total)	0.15%	12.7	9
Magnesium (total)	0.08%	6.8	5
Sodium (total)	0.10%	8.4	6
Copper (total)	8 ppm	0.07	0.05
Iron (total)	165 ppm	1.39	0.97
Manganese (total)	24 ppm	0.2	0.14
Zinc (total)	24 ppm	0.2	0.14
Moisture	93.90%		
Total solids	6.10%	515	
Total Salts – <b>500/64.2=7788 gal/ac limit</b>	0.76%	64.2	
pH	8.6		

## What Is Base Saturation?

ORGANIC MATTER L.O.L. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS P	POTASSIUM K	MAGNESIUM Mg	CALCIUM Ca	SODIUM Na	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	ppm	ppm	ppm	ppm	ppm								
4.9	61	333	418	1934	19	4.7	6.2	28.1	3.0	12.4	34.4	49.9	0.3

NITRATE-N (FIA)			MEHLICH III ICP							EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		
ppm	lbs/A	depth (in)									
75	135	0-6	135	19	12.8	108	155	1.9	1.0	L	0.5

This is a simple way to determine if some of the most important soil nutrients are in balance!

## Base Saturation – adds up to 100%

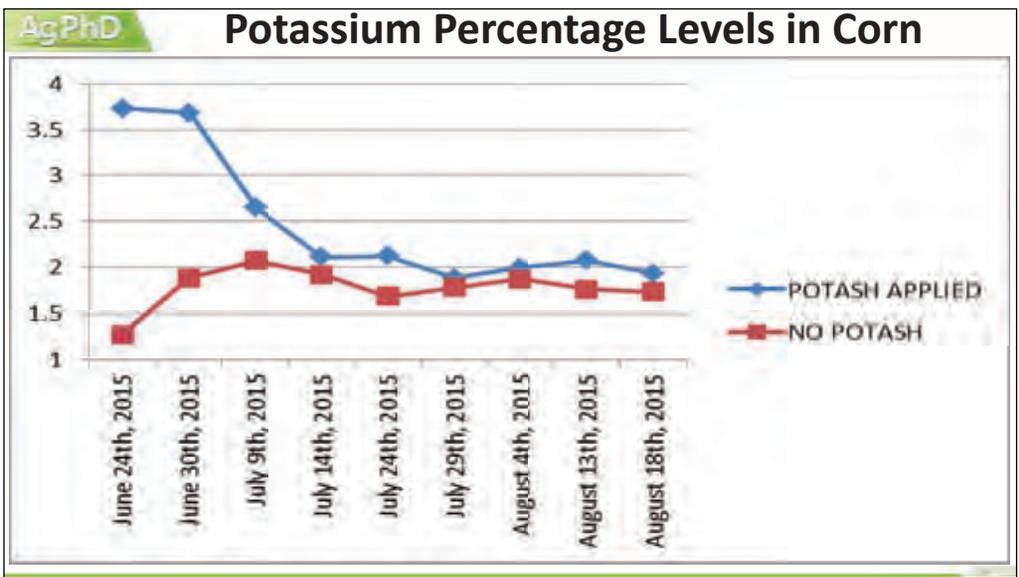
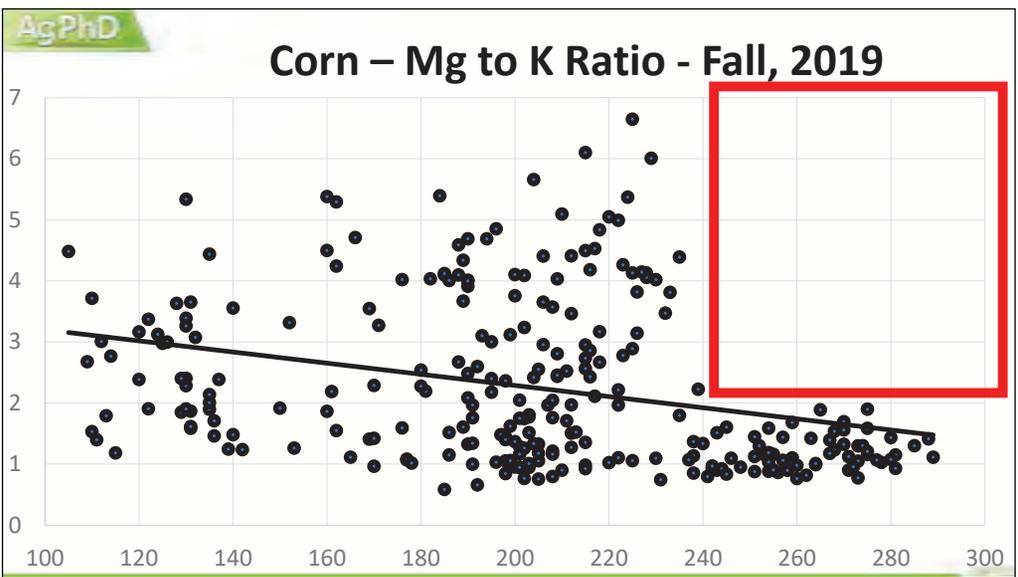
- 1. Sodium (Na) (<1% or 0.5% to 1% for certain crops like barley, brassicas, sugarbeets, pastures, etc.)**
  - if Na is high, improve drainage & decrease manure/high salt applications
  - excess Na raises soil pH 4 to 1 compared to Ca
- 2. Hydrogen (H) (2% to 10%)**
  - if H is high, add lime (calcium carbonate)
- 3. Calcium (Ca) (65% to 80%)**
  - if Calcium level is low, add lime, gypsum, or another calcium source
- 4. Magnesium (Mg) (12% to 14% if CEC > 15, 18% to 20% if CEC < 5)**
  - if Mg level is low, add Mg
  - if Mg is high, improve drainage & add Calcium & Sulfur (if needed)
- 5. Potassium (K) (4% to 8%)**
  - if K level is low, add Potassium
  - for good stalks – K is first, then Manganese (Mn), then Copper (Cu)

# Sodic Soil Test

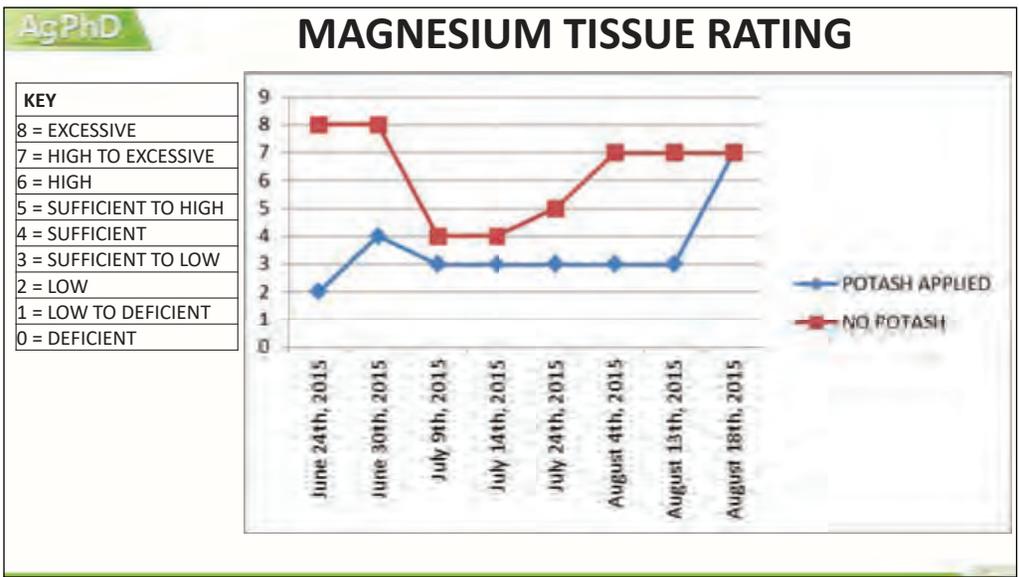
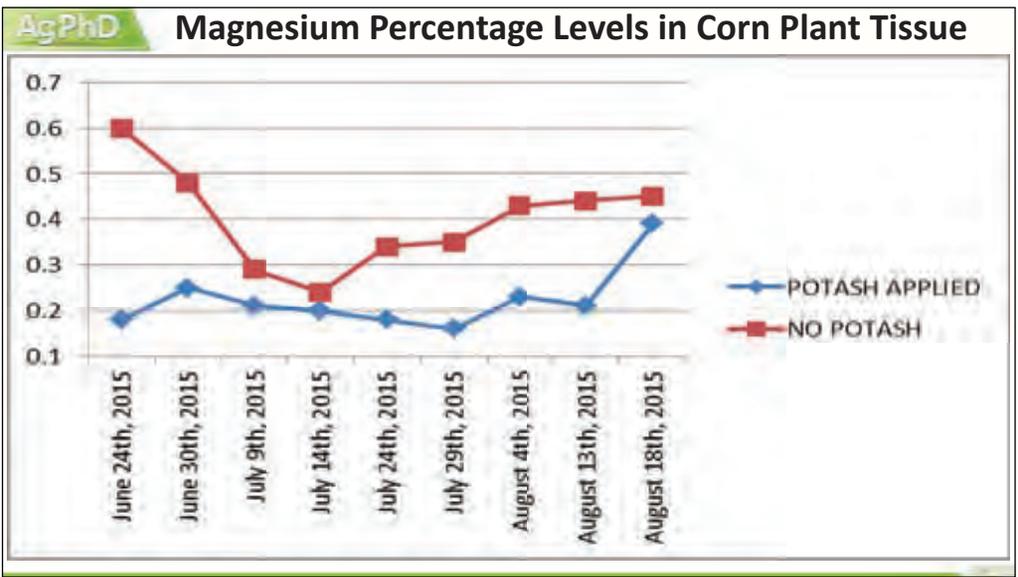
ORGANIC MATTER		PHOSPHORUS						POTASSIUM		MAGNESIUM		CALCIUM		SODIUM		pH		CATION EXCHANGE CAPACITY	PERCENT BASE SATURATION (COMPUTED)				
		P <sub>1</sub>		P <sub>2</sub>		BICARBONATE P		K		Mg		Ca		Na		SOIL	BUFFER		% K	% Mg	% Ca	% H	% Na
MODIFIED L.O.I.		WEAK BRAY 1:7		STRONG BRAY 1:7		OLSEN										pH	INDEX	C.E.C.					
PERCENT	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	1:1		meq/100g					
2.5	L	2	VL	3	VL	68	VH	1215	VH	348	H	2357	L	2078	VH	9.6		26.8	11.6	10.8	43.9	0.	33.7

NITRATE-N (FIA)										SULFUR S ICAP		ZINC Zn		MANGANESE Mn		IRON Fe		COPPER Cu		BORON B		EXCESS LIME RATE	SOLUBLE SALTS 1:1	
Surface			Sub 1			Sub 2			Total														mmhos/cm	RATE
ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	ppm	lbs/A	depth IN	lbs/A	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE	ppm	RATE			
6	11	0-6							11	67	VH	5.5	H	7	L	11	M	1.2	M	4.5	VH	H	1.0	L





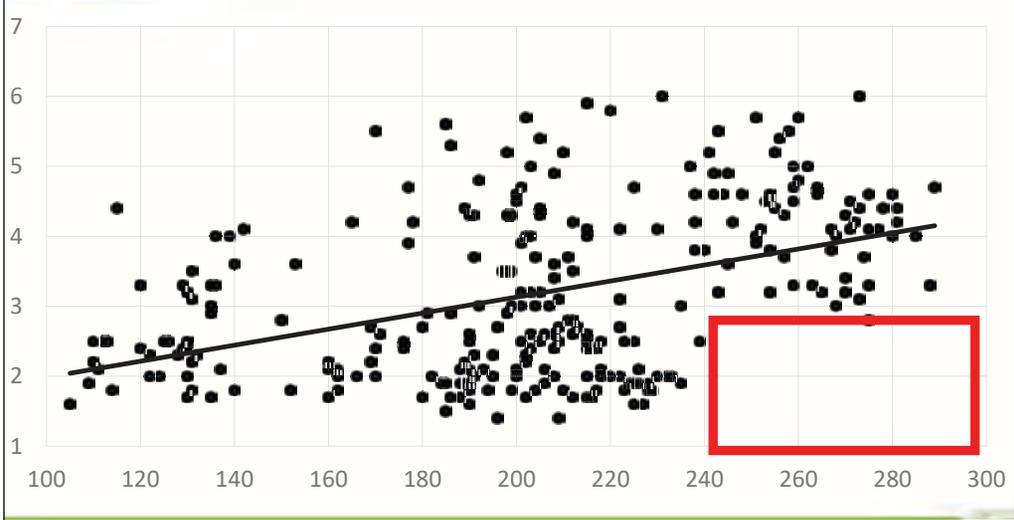
43



**AgPhD** **How to Fix High Magnesium Soils**

1. Improve drainage. Over a long period of time, Magnesium can be flushed out of soil if drainage is good.
2. Add Sulfur IF you don't have excessive Sulfur levels already. Magnesium becomes leachable when combined with sulfate (Epsom salts). Neal Kinsey says it takes 2 pounds of sulfur to drive out 1 pound of magnesium.
3. Add Calcium if your levels are below 75% on a base saturation test. You will make your soil more porous so the magnesium sulfate can leach out. Also, you will change your Calcium/Magnesium ratio so it is more beneficial for nutrient availability and your crops.
4. We have not found high magnesium alone to be super-detrimental to yields. If you have high magnesium, do everything else to raise a great crop and at least start slowly working on fixing your high magnesium issue.

**AgPhD** **Corn – Base Saturation K% - Fall, 2019**



44

**AgPhD** **Potash Required to Raise Base Saturation**

Below is information for the Potash Chart on the next slide

- The left column is Parts Per Million (PPM) on your soil test
- The top row is Percent K on your base saturation test
- The numbers in the table are Pounds Per Acre of Potash that must be applied to reach roughly 4% base saturation K
- If it will take more than 600 pounds (or more than what you want to spend) of Potash to reach 4%, the standard recommendation is to work on a build program over time, applying at least double what crop removal is each year
- If Potassium is not your yield-limiting factor, raising K levels alone will not increase your yield
- In heavy soils in dry regions, Potash may take 2 to 3 years to fully break down in our experience, but Potassium is virtually immobile in those soils, so if there is excess in the soil you may have many years to remove it with your crops before it is lost
- Soil test levels may never reach your goals based on many factors including erosion, tillage, tie-up, crop removal, weather, and more

**AgPhD** **Potash Pounds (approx.) to Reach 4% K**

	1.0%	1.2%	1.4%	1.6%	1.8%	2.0%	2.2%	2.4%	2.6%	2.8%	3.0%	3.2%	3.4%	3.6%	3.8%
100	1200	933	743	600	489	400	327	267	215	171	133	100	71	44	21
125	1500	1167	929	750	611	500	409	333	269	214	167	125	88	56	26
150	1800	1400	1114	900	733	600	491	400	323	257	200	150	106	67	32
175	2100	1633	1300	1050	856	700	573	467	377	300	233	175	124	78	37
200	2400	1867	1486	1200	978	800	655	533	431	343	267	200	141	89	42
225	2700	2100	1671	1350	1100	900	736	600	485	386	300	225	159	100	47
250	3000	2333	1857	1500	1222	1000	818	667	538	429	333	250	176	111	53
275	3300	2567	2043	1650	1344	1100	900	733	592	471	367	275	194	122	58
300	3600	2800	2229	1800	1467	1200	982	800	646	514	400	300	212	133	63
325	3900	3033	2414	1950	1589	1300	1064	867	700	557	433	325	229	144	68
350	4200	3267	2600	2100	1711	1400	1145	933	754	600	467	350	247	156	74
375	4500	3500	2786	2250	1833	1500	1227	1000	808	643	500	375	265	167	79
400	4800	3733	2971	2400	1956	1600	1309	1067	862	686	533	400	282	178	84
425	5100	3967	3157	2550	2078	1700	1391	1133	915	729	567	425	300	189	89
450	5400	4200	3343	2700	2200	1800	1473	1200	969	771	600	450	318	200	95

AgPhD **Lodged Corn**



AgPhD **Lodged Corn Soil Tests – 36,000 population**

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. mg/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SODIUM Na ppm	SOIL pH	BUFFER INDEX 1:1		% N	% Mg	% Ca	% H	% Na
6.0	55	176	1359	6832	69	7.9		46.2	1.0	24.5	73.9	0.0	0.6
4.6	48	148	823	6647	46	7.9		40.7	0.9	16.9	81.7	0.0	0.5

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE		Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm			
ppm	lbs/A								depth (in)		
6	22	0-12	22	138	4.2	102	50	4.3	7.3	H	1.1
4	14	0-12	14	90	3.5	96	45	3.8	5.3	M	0.7

45

AgPhD **Corn Planting Population**

Corn Population	7X Yield	10X Yield	Cost Per Bag	1000	2500	5000
18,000	126	180	\$400	\$5.00	\$12.50	\$25.00
20,000	140	200	\$375	\$4.69	\$11.72	\$23.44
22,000	154	220	\$350	\$4.38	\$10.94	\$21.88
24,000	168	240	\$325	\$4.06	\$10.16	\$20.31
26,000	182	260	\$300	\$3.75	\$9.38	\$18.75
28,000	196	280	\$275	\$3.44	\$8.59	\$17.19
30,000	210	300	\$250	\$3.13	\$7.81	\$15.63
32,000	224	320	\$225	\$2.81	\$7.03	\$14.06
34,000	238	340	\$200	\$2.50	\$6.25	\$12.50
36,000	252	360	\$175	\$2.19	\$5.47	\$10.94
40,000	280	400	\$150	\$1.88	\$4.69	\$9.38

AgPhD **Quiz**

**What is the “most correct” amount of potassium in a soil with a 20 CEC?**

- 150 ppm
- 250 ppm
- Whatever your yield goal calls for
- 4% to 8% base saturation K

## Sulfur (S)

- Adequate Sulfur means better Nitrogen utilization
- Less air pollution means less free Sulfur for farmers
- Sulfur leaches easily in most soils (at about half the rate as nitrate)
- Sulfur is more likely to pay in lighter soils, if organic matter levels are low, or if yield goals are high
- Excess sulfur can reduce phosphorus availability
- Sulfate is available today and is the form plants will use
- Elemental sulfur breaks down slowly over time
- Foxtails thrive in low Sulfur, high Magnesium soils

## Why Does Elemental Sulfur Lower pH?

- Elemental sulfur is converted to sulfuric acid through microbial oxidation. Adding acid to soil lowers pH.
- $2S + 3O_2 + 2H_2O = 2H_2SO_4$
- Bacteria + Sulfur + Oxygen + Water = Sulfuric Acid (aka Hydrogen Sulfate)
- Make sure drainage is fixed first or bacteria can't do their job, and your elemental sulfur may turn to hydrogen sulfide. Then your soil will likely smell like rotten eggs.
- The problem with elemental sulfur is it may not break down immediately in soil. Some elemental sulfur products have been known to take 5 years to fully come available. **If you want quicker results, look for elemental sulfur that has a very small particle size.**
- If a soil has high pH and low sulfur levels, adding elemental sulfur is often a great idea, but keep in mind, high pH is a result of a nutrient imbalance.
- If a soil has high pH and very high sulfur levels, drainage is likely the biggest issue. Fix the drainage first. Once sulfur levels have started to drop, consider adding elemental sulfur if soil pH is not where you want it to be.

## Manganese (Mn)

- You can often reduce the incidence of sclerotinia white mold by having good levels of Manganese
- Manganese is called "the element of life"
- Important for chlorophyll production, lignin building (meaning less lodging), disease prevention, pollen, and kernel weight
- Manganese is not very available when the soil is cold, and it is less available the higher the pH gets above 6.5
- When Sodium base sat. plus Potassium base sat. is greater than 10%, that blocks out Manganese and hurts seed germination
- Be sure to use a Mehlich 3 test (not a DTPA) for manganese. In tens of thousands of points of research, all we can correlate manganese to with a DTPA test is soil pH. Higher pH means less manganese. Lower pH means more manganese in a DTPA test.

## More on Manganese

...from Neal Kinsey

- Deficiency or even just low means shorter corn
- Lime can tie up manganese, but not as quickly as it ties up iron. 600# of calcium (roughly 1 ton of lime) ties up 25# of manganese sulfate (roughly 8# of actual manganese).
- Mn is more deficient in tight, water-logged soils without much air & high pH
- Soybeans are more sensitive than corn to low manganese, and silage corn tonnage is more impacted than corn grain
- Manganese can oxidize iron in the plant when manganese levels are higher than iron levels. The result is IDC.
- Neal said even where soil pH is 8 to 8.4, as long as there has been no lime in the last 3 years and nothing else to raise soil pH, manganese sulfate can build manganese pound for pound

...from Dick Goff

- AMS at 100+#/acre in soybeans has freed up some manganese for plants

## Iron (Fe)

- Important for chlorophyll production, respiration, photosynthesis, and Nitrogen fixation in legumes
- Soil test levels are usually higher in subsoil than topsoil
- Iron is usually the first micronutrient to suffer from reduced availability due to excess liming. If you are going to add lots of lime that doesn't contain iron, you will usually need to add iron to avoid an iron deficiency.
- IDC (Iron Deficiency Chlorosis) can be temporarily helped by adding in-furrow ortho-ortho EDDHA iron to soybeans, but the long-term fix is to lower soil pH. Available ferrous iron turns to ferric in pH above 7.0.
- Neal Kinsey's recommendation is to keep your Iron levels higher than your Manganese levels.

## Boron (B)

- Important for moving sugar, food, and hormones inside plants. It is also important for cell structure. Calcium puts the starch in the leaf, but boron moves it from the leaf to the ear.
- Adequate levels reduce missing seeds by moving seed growth hormones. For example, if your corn ear doesn't fill out all the way to the end, it may be short on Boron.
- Boron leaches, but not as quickly as nitrate or sulfate
- Potassium ties up Boron when Potassium base saturation exceeds 8%
- Boron toxicity doesn't seem to be an issue when you keep the Calcium to Boron ratio greater than 1000:1

## Zinc (Zn)

- Key for moisture absorption
- Important for flower formation, frost protection, assisting plant growth regulators, germination, protein synthesis, and plant vigor
- Animals deficient in zinc require twice as much feed to reach same weight
- Does not move much in soil
- Too much Nitrogen & Phosphorus limits Zinc uptake
- Greater response can be expected when Phosphorus levels are high. We have found the proper P:Zn ratio to be around 8:1 to 10:1 when using a Midwest Labs' Mehlich 3.

## Zinc Sulfate to Raise Soil Test ppm

	1	2	3	4	5	6	7	8	9	10
<b>Pounds/Acre</b>	5.6	11.3	16.9	22.5	28.2	33.8	39.4	45.1	50.7	56.3
<b>Cost/Acre</b>	\$4.65	\$9.38	\$14.03	\$18.68	\$23.41	\$28.05	\$32.70	\$37.43	\$42.08	\$46.73

- The top row is the amount of Zinc parts per million (ppm) you want the Mehlich 3 soil test to go up
- The numbers in the table are what must be applied to achieve approximately the Mehlich 3 soil test ppm increase you desire
- Soil test levels may never reach your goals based on many factors including erosion, tillage, tie-up, crop removal, weather, and more

## Copper (Cu)

- Key to seed coat resiliency, disease control, plant flexibility, and test weight
- Copper is often referred to as the “disease nutrient”, since higher levels in plants commonly lead to fewer disease problems
- Important for lignin building (less lodging) and seed size
- Too much Nitrogen and Phosphorus limits Copper
- Copper as a foliar treatment can serve as a bactericide and fungicide
- According to Neal Kinsey, copper levels over 5 ppm means lower (or no) SDS (sudden death syndrome) in soybeans

## Copper Sulfate to Raise Soil Test ppm

	0.5	1.0	1.5	2.0	2.5	3.0
<b>Pounds/Acre</b>	4	7.9	11.9	15.9	19.8	23.8
<b>Cost/Acre</b>	\$8.64	\$17.06	\$25.70	\$34.34	\$42.77	\$51.41

- The top row is the amount of Copper parts per million (ppm) you want the Mehlich 3 soil test to go up
- The numbers in the table are what must be applied to achieve approximately the Mehlich 3 soil test ppm increase you desire
- Soil test levels may never reach your goals based on many factors including erosion, tillage, tie-up, crop removal, weather, and more

## Greensnap



## How to Reduce Greensnap

No corn on its own is resistant to lodging or greensnap! Below are the top reasons why corn will greensnap.

1. Wind speed & time of day (worst is right before sunrise) in relation to the growth stage of the corn at that point
2. Excessive planting population for the fertility (K, Mn, **COPPER**). Do you have 4% K, 50 Mn, & 3 to 5 Cu on a Mehlich 3 test? Is your nitrogen excessive? **Soil test before deciding on a planting population!**
3. Herbicide injury – don't spray unsafened dicamba past V2
4. Diseases – seed, seedling, & foliar diseases
5. Insect feeding – especially rootworms but also other bugs
6. Poor drainage and/or compaction – stress & small roots mean weak stalks

AgPhD <b>Micronutrient Options</b>	
Nutrient	Purchase Options
Zinc	Zinc sulfate (35.5% zinc – 17% sulfur) dry - \$0.83/lb AgroLiquid 4% zinc - \$19/gal
Manganese	Manganese Sulfate (32% manganese – 19% sulfur) dry - \$0.80/lb AgroLiquid 4% manganese – \$22/gal
Iron	Soygreen – 6% EDDHA iron dry soluble - \$8/lb Iron sulfate (20.5% iron – 12% sulfur) - \$0.60/lb. AgroLiquid 4% iron - \$22/gal
Copper	Copper Sulfate (25% copper – 12% sulfur) dry - \$2.16/lb AgroLiquid 6% copper - \$40/gal
Boron	15% dry boron - \$0.70/pound Borates Plus (21% boron) dry - \$1.71/lb AgroLiquid 5% boron - \$19/gal

- AgPhD **How To Soil Sample**
- Whether you are using grids or zones, we suggest you pick a single GPS point inside each grid or zone where you will sample
  - Drive to the GPS point
  - Pull 2 to 3 samples on each side of your vehicle
  - Keep your probe straight up and down
  - Always go to the same depth. You can pre-determine whether you want 4”, 6”, 8”, 12”, etc. for a depth of samples.
  - Dump your samples from a single grid or zone into a bucket as you sample, then fill your soil sample bag and send it in. There is no need to stir your sample prior to filling the bag, as long as you dump all the soil into the bag.
  - If you don’t sample correctly and consistently, your data could be misleading!

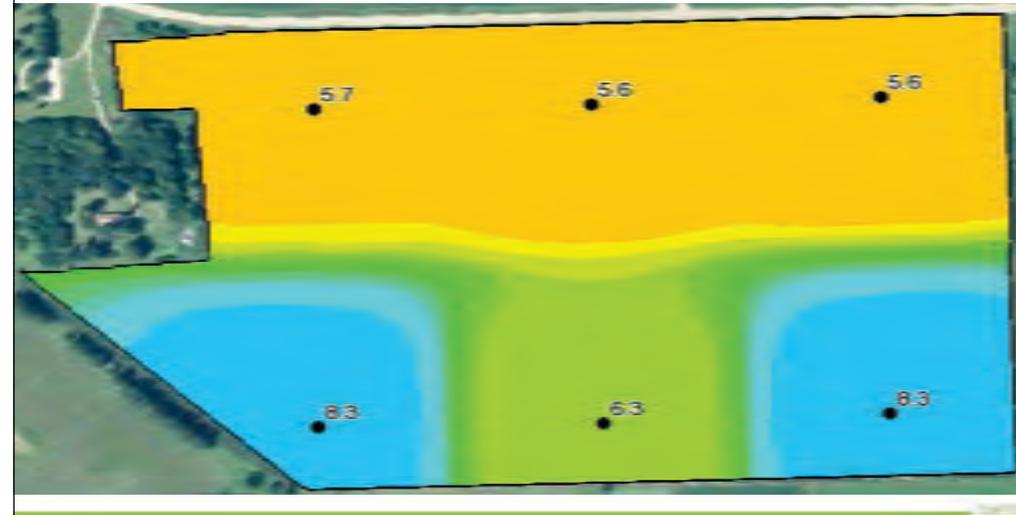
- AgPhD **In-Crop Soil Testing Is Now Possible!**
- In the past, if you wanted good data so you could accurately fertilize in the fall or spring based on soil tests, you had to pull those samples in the fall after harvest
  - Today, you can pull early-season, in-crop soil tests and use those to fertilize with in the future. Here’s how.
    1. Pull soil samples early in the growing season at a GPS location within each grid or zone in a field
    2. Immediately after harvest, have VRAFY take your harvest map and convert it into a nutrient removal map
    3. Take the in-crop soil test data, subtract out the nutrient removal information, and add back estimated organic matter mineralization. These numbers should roughly equal what fall soil test data will show.

- AgPhD **Advantages to In-Crop Soil Testing**
- In the past, by the time you would get soil samples pulled in the fall and get the results back, it would often be 2 to 4 weeks after harvest. With in-crop soil sampling and VRAFY, you can have roughly the same data within a day or two after harvest. This gives you much more time to make fertility decisions and applications in the fall.
  - If you are having soil samples pulled in May or early June vs. October or November, the daylength is longer, the temperatures are warmer, and it is much more likely you either have your own help (high schools and colleges are not in-session) or your soil sampling company has much more time to get sampling done for you at a reasonable cost

## AgPhD Use Small Grids/Zones At Least Once

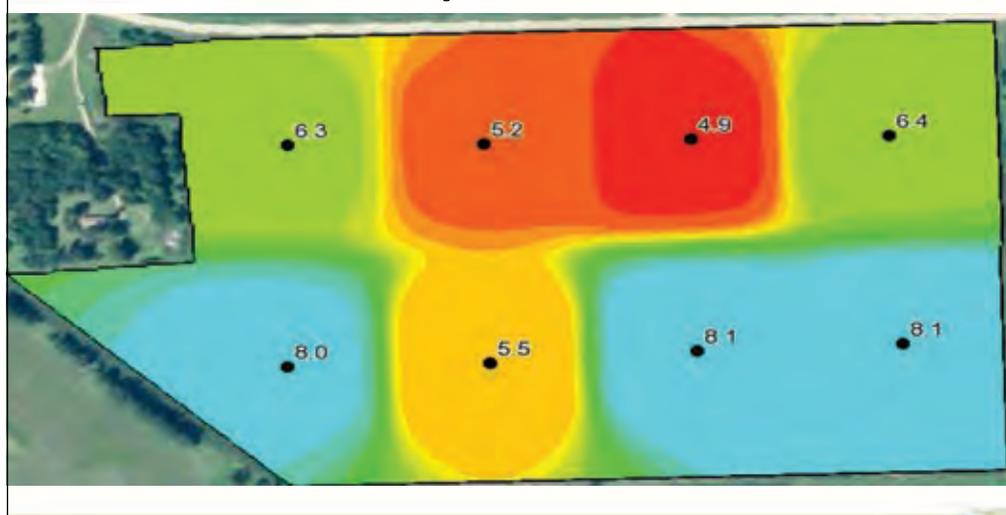
- When you first get going with a good soil sampling program, start by pulling 1-acre (or very small) grids or zones
- The smaller the area, the more you can identify field variances
- The greater accuracy you have, the more you will save on fertilizer both today and in the future. For example, we overlimed and overapplied nitrogen on our farm in big zones. Because of the overliming, we overspent on lime, lost yield, and then we had to invest in elemental sulfur. Because of the excess nitrogen in other areas, we overspent on N and then had to lime to raise our pH back.
- Using small grids or zones, in time you can even-out your fields, meaning you can eventually go to bigger zones or grids if you want to, since fertility and pH will be more even throughout the field.

## AgPhD Soil pH in 10 Acre Grids

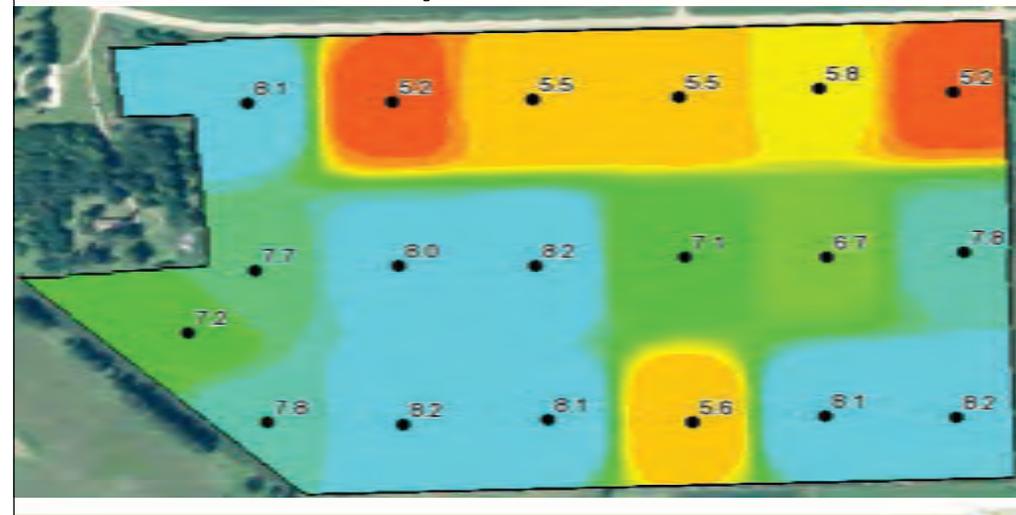


50

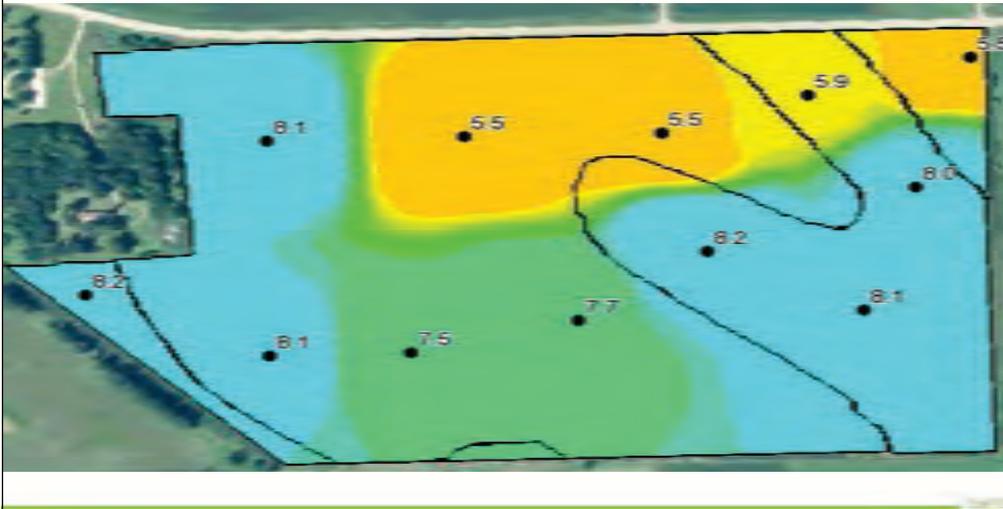
## AgPhD Soil pH in 5 Acre Grids



## AgPhD Soil pH in 2.5 Acre Grids



### Soil pH in Zone Samples



### Example Soil Test

ORGANIC MATTER L.O.L percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SODIUM Na ppm	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
4.9	61	333	418	1934	19	4.7	6.2	28.1	3.0	12.4	34.4	49.9	0.3

NITRATE-N (FIA)			MEHLICH III ICP							EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE		Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm			
ppm	lbs/A								depth (in)		
75	135	0-6	135	19	12.8	108	155	1.9	1.0	L	0.5

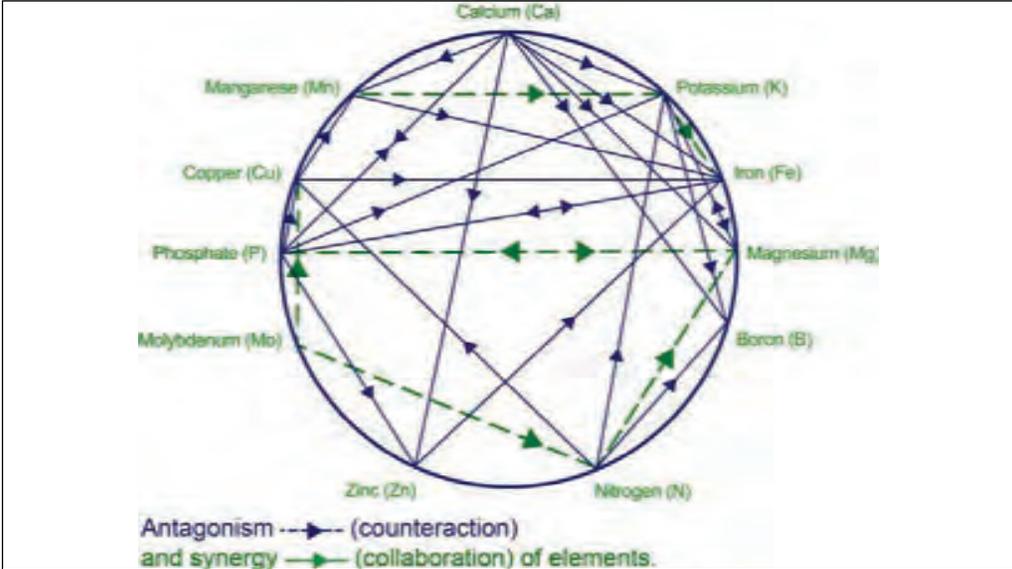
What should YOUR levels be?

### Brian's "Heavy Soil" Fertility Targets - Mehlich 3

- pH adjustment – for every 0.1 above 6.5, add 15# of elemental sulfur. If pH is above 5.9, do not add lime.
- K – 7% – potash or manure
- P – 150 ppm – MAP, DAP, or manure
- Zn – Phosphorus/10 = 15 ppm – Zinc sulfate
- Mn – 100 ppm – Manganese sulfate
- Iron – 150 ppm – Lime, manure, or iron sulfate
- Copper – Phosphorus/30 = 5 ppm – Copper sulfate
- Boron – Calcium/1000 – Dry boron
- Sulfur – 50 ppm – AMS, elemental sulfur, gypsum, or manure
- Moly – 1 ppm – sodium molybdate
- Note: I would like to see these levels after harvest before fertilizing for the next crop

### Brian's "Light Soil" Fertility Targets - Mehlich 3

- pH adjustment – for every 0.1 above 7.0, add 5# of elemental sulfur. If pH is above 5.9, do not add lime.
- K – 7% (maybe more based on crop needs) – potash or manure
- P = 150 – MAP, DAP, or manure
- Zn – Phosphorus/10 = 15 ppm – Zinc sulfate
- Mn – 50 ppm – Manganese sulfate
- Iron – 75 ppm – Lime, manure, or iron sulfate
- Copper – Phosphorus/30 = 5 ppm – Copper sulfate
- Boron – Calcium/1000 – Dry boron
- Sulfur – 30 ppm – AMS, elemental sulfur, gypsum, or manure
- Moly – 1 ppm – sodium molybdate
- Note: spoon-feeding N, S, B, and possibly K is very important



	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Magnesium (Mg)	Sulfur (S)	Calcium (Ca)	Boron (B)	Copper (Cu)	Chlorine (Cl)	Iron (Fe)	Zinc (Zn)	Nickel (Ni)	Manganese (Mn)	Molybdenum (Mo)	Cobalt (Co)	Silicon (Si)	Selenium (Se)	Sodium (Na)	
Nodulation/ Nitrogen Use	+																		
Photosynthesis		+																	
Disease Resistance																			
Abiotic Stress Tolerance																			
Carbohydrate Production																			
Protein Production																			
Oil Production																			
Vegetative Growth																			
Hormone Metabolism																			
Root Growth																			
Energy Transfer																			
Nutrient Uptake																			
Water Usage																			

52

**AgPhD** **How to Read a Soil Test**  
 Spreadsheet You Can Use For Recommendations  
<http://www.agphd.com/fertilizer-calculator-excel/>

# Low CEC Area – 1 Acre Grid – SD

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SODIUM Na ppm	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	2.2	152	212	138	1121	14	6.8			7.4	7.3	15.5	76.4

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIMING RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B		
ppm	lbs/A	depth (in)		ppm	ppm	ppm	ppm	ppm	ppm		
22	40	0-6	40	17	5.6	18	122	2.8	0.6	L	0.1

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High pH Area – 1 Acre Grid

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SODIUM Na ppm	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
3.1	39	173	511	4388	18	8.1		26.7	1.7	15.9	82.1	0.0	0.3

NITRATE-N (FIA) SURFACE				MEHLICH III ICP						EXCESS LIMB RATE	SOLUBLE SALTS 1:1 mmhos/cm
ppm	lbs/A	depth (in)	Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		
11	20	0-6	20	22	8.9	122	80	2.1	1.9	L	0.3

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10), Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High Mg Area – 1 Acre Grid - MN

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meg/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
4.1	22	143	634	2937	28	6.3	6.7	22.7	1.6	23.3	64.7	9.9	0.5

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B		
ppm	lbs/A	depth (in)		ppm	ppm	ppm	ppm	ppm	ppm		
8	14	0-6	14	8	2.8	50	128	2.7	1.3	L	0.3

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High Ca Area – 1 Acre Grid - IA

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SODIUM Na ppm	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
2.9	14	116	481	3899	16	7.8		23.9	1.2	16.8	81.7	0.0	0.3

NITRATE-N (FIA) SURFACE				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
ppm	lbs/A	depth (in)	Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		
11	20	0-6	20	7	0.9	102	73	2.5	1.5	L	0.3

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10), Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High Ca & Mg Area – 1 Acre Grid - MN

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
4.1	26	168	726	3494	26	6.7		24.1	1.8	25.1	72.6	0.0	0.5

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B		
ppm	lbs/A	depth (in)		ppm	ppm	ppm	ppm	ppm	ppm		
10	18	0-6	18	9	3.8	66	104	3.7	1.7	L	0.4

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High Na Area – 1 Acre Grid - IA

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
5.6	200	548	1115	4110	227	7.8		32.2	4.4	28.9	63.6	0.0	3.1

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		
ppm	lbs/A	depth (in)									
73	131	0-6	131	69	7.4	58	138	5.8	2.7	L	1.2

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High K Area (2) – 1 Acre Grid - MN

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
4.6	275	634	471	3505	37	7.1		23.2	7.0	16.9	75.4	0.0	0.7

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		
ppm	lbs/A	depth (in)									
22	40	0-6	40	17	18.1	84	196	4.1	1.6	L	0.5

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High Excess Lime/Ca Area – 1 Ac Grid – MN

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SODIUM Na ppm	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
3.2	14	155	298	8620	16	8.1		46.1	0.9	5.4	93.5	0.0	0.2

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		
ppm	lbs/A	depth (in)									
7	13	0-6	13	8	4.8	97	43	2.3	1.8	H	0.4

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4

7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High Mg Area – 1 Acre Grid – IA

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
5.5	77	383	1037	3764	151	7.5		29.1	3.4	29.7	64.6	0.0	2.3

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B		
ppm	lbs/A	depth (in)		ppm	ppm	ppm	ppm	ppm	ppm		
48	86	0-6	86	17	4.2	46	95	5.2	2.3	L	0.7

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4

7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High K & Mg Area – 1 Acre Grid – MN

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
5.4	496	1111	762	3877	150	7.6		29.2	9.8	21.7	66.3	0.0	2.2

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B		
ppm	lbs/A	depth (in)		ppm	ppm	ppm	ppm	ppm	ppm		
53	95	0-6	95	20	22.5	68	270	6.3	2.8	L	0.7

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4

7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High K Area – 1 Acre Grid – MN

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
4.2	194	667	501	4081	33	7.5		26.4	6.5	15.8	77.2	0.0	0.5

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B		
ppm	lbs/A	depth (in)		ppm	ppm	ppm	ppm	ppm	ppm		
21	38	0-6	38	16	13.4	114	236	4.6	1.9	L	0.5

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High Copper Area – 1 Acre Grid – IA

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm				K	Mg	Ca	H	Na
5.0	183	584	662	3445	90	6.9		24.6	6.1	22.4	69.9	0.0	1.6

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		
ppm	lbs/A	depth (in)									
58	104	0-6	104	25	10.3	75	122	35.0	1.3	L	0.7

- 250-bushel corn grain removal only is 0.12 pounds/year of copper
- 75-bu soybeans grain removal only is 0.08 pounds/year of copper
- If you were in a corn-bean rotation, that's an average of 0.10 pounds of zinc removed each year, meaning 70 pounds (35 ppm X 2 = 70 pounds/acre) could last 700 years before it is completely removed!

# High Zinc Area – 1 Acre Grid – SD

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
4.0	90	476	327	2286	15	6.4	6.8	16.9	7.2	16.1	67.6	8.7	0.4

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B		
ppm	lbs/A	depth (in)		ppm	ppm	ppm	ppm	ppm	ppm		
8	14	0-6	14	23	30.6	72	118	2.0	1.4	L	0.3

- 250-bushel corn grain removal only is 0.27 pounds/year of zinc
- 75-bu soybeans grain removal only is 0.07 pounds/year of zinc
- If you were in a corn-bean rotation, that's an average of 0.17 pounds of zinc removed each year, meaning 61.2 pounds (30.6 ppm X 2 = 61.2) pounds/acre) could last 360 years before it is completely removed!

# High Ca & Mg Area – 1 Acre Grid – IA

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SODIUM Na ppm	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
3.4	25	92	565	2680	16	6.3	6.8	19.5	1.2	24.1	68.7	5.6	0.4

NITRATE-N (FIA) SURFACE				MEHLICH III ICP						EXCESS LIMB RATE	SOLUBLE SALTS 1:1 mmhos/cm
ppm	lbs/A	depth (in)	Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		
10	18	0-6	18	7	1.3	36	86	1.9	0.8	L	0.2

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10), Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High Mg Area – 5 Acre Grid – SD

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
3.6	18	239	2633	3938	679	7.7		45.2	1.4	48.5	43.6	0.0	6.5

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B		
ppm	lbs/A	depth (in)		ppm	ppm	ppm	ppm	ppm	ppm		
5	9	0-6	9	1585	3.2	232	157	4.9	3.4	L	3.3

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# High Mg Area – 1 Acre Grid – SD

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
4.0	9	161	1063	3410	22	7.1		26.4	1.6	33.6	64.4	0.0	0.4

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm
SURFACE			Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		
ppm	lbs/A	depth (in)									
7	13	0-6	13	7	4.0	136	187	3.1	1.2	L	0.2

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# Low Ca Area – 1 Acre Grid – SD

ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
	P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
3.7	28	96	502	1906	16	4.9	6.2	25.4	1.0	16.5	37.5	44.7	0.3

NITRATE-N (FIA)				MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/ cm
SURFACE			Total lbs/A	SULFUR S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		
ppm	lbs/A	depth (in)									
15	27	0-6	27	12	1.2	44	102	0.9	0.2	L	0.2

1. Soil pH – 6.3 to 6.8
2. CEC – max. N = CEC X 10
3. Organic Matter (N=20, P=4, S=2)
4. Base Sat. – Na (<1), H (2-10),  
Ca (65-80), Mg (12-20), K (4-8)
5. Nitrogen – Nitrate plus O.M. X 20
6. P – Mehlich 3=P2, add O.M. X 4
7. S – Sulfur on test plus O.M. X 2
8. Zinc – Phosphorus/10
9. Manganese – 50+ ppm
10. Iron – 50+ ppm
11. Copper – Phosphorus/30
12. Boron – Calcium/1000

# SOIL ANALYSIS REPORT

INFO SHEET: 1757141

LAB NUMBER	SAMPLE IDENTIFICATION	ORGANIC MATTER L.O.I. percent	MEHLICH III ICP					pH		CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED)				
			PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
			P ppm	K ppm	Mg ppm	Ca ppm	Na ppm								
*442*															
24681	Good #1	2.9	63	151	449	2504	19	5.5	6.5	22.2	1.7	16.9	56.4	24.6	0.4
24682	Good #2	2.1	18	129	460	2984	19	7.0		19.2	1.7	20.0	77.9	0.0	0.4
24683	Good #3	5.1	29	154	698	4675	31	6.8		29.7	1.3	19.6	78.6	0.0	0.5
24684	Good #4	2.8	21	169	1125	12674	28	8.0		73.3	0.6	12.8	86.4	0.0	0.2
24685	Poor #1	1.9	17	116	393	7517	22	8.0		41.3	0.7	7.9	91.2	0.0	0.2
24686	Poor #2	1.1	3	74	773	23123	20	8.2		122.3	0.2	5.3	94.4	0.0	0.1
24688	Poor #3	1.8	7	98	600	19025	22	8.2		100.5	0.3	5.0	94.6	0.0	0.1
24689	Poor #4	1.2	2	96	1159	25971	30	8.2		139.9	0.2	6.9	92.8	0.0	0.1

LAB NUMBER	NITRATE-N (FIA)									MEHLICH III ICP						EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm	
	SURFACE			SUBSOIL 1			SUBSOIL 2			Total lbs/A	SULFUR S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu			BORON B
	ppm	lbs/A	depth (in)	ppm	lbs/A	depth (in)	ppm	lbs/A	depth (in)		ppm	ppm	ppm	ppm	ppm			ppm
*442*																		
24681	9	32	0-12							32	13	2.5	90	165	1.4	0.5	L	0.2
24682	5	18	0-12							18	8	1.8	91	119	1.4	0.6	L	0.3
24683	8	29	0-12							29	12	4.8	79	208	2.4	1.2	L	0.3
24684	4	14	0-12							14	19	3.7	89	49	2.2	2.1	M	0.4
24685	4	14	0-12							14	8	1.9	73	45	1.6	0.9	M	0.3
24686	7	25	0-12							25	11	1.4	15	22	1.3	0.5	H	0.3
24688	3	11	0-12							11	9	1.9	16	23	1.1	0.8	H	0.3
24689	3	11	0-12							11	10	1.5	12	18	1.1	0.6	H	0.3

## Upcoming Ag PhD Schedule of Events

- \*Corn Workshop – Wednesday, February 18 at Baltic, SD
- \*Neal Kinsey Seminar – March 10-12 at Hillsboro, ND
- Scouting & Scholarships – Saturday, June 27 at Baltic, SD
- Thursday, July 30 – Ag PhD Field Day – 7 am to 4 pm at Baltic
- **Please pre-register for all our events at [www.agphd.com](http://www.agphd.com)**
- \* Livestream option is available



7

## AcreSTV

- Streaming ag TV platform – think Hulu or Netflix for ag
- Free – no initial cost or monthly fees
- Watch Ag PhD, Shark Farmer, XtremeAg, Tony Reed, Griggs Farms, Corn Warriors, Dirt Poor, Randy the Farmer, Live to Farm, and lots more ag programming for free
- All shows are on demand and available anytime
- Livestream Ag PhD Workshops and other events on AcreSTV
- 3 ways to watch:
  1. Add AcreSTV for free to your Smart TV
  2. Download the Acre TV app to your smartphone or tablet
  3. Go to [watchacrestv.com](http://watchacrestv.com) and start watching for free online

## Darren, Brian, & Ag PhD

- Ag PhD Radio – 2 pm Central each weekday on SiriusXM 147 or podcast the show. We take live phone calls at 844-442-4743 or e-mail us at [radio@agphd.com](mailto:radio@agphd.com).
- Ag PhD TV – Tuesday nights on RFD-TV at 7 pm Central or on demand on AcreSTV
- Ag PhD Insider Magazine – [agphdinsider.com](http://agphdinsider.com)

# Summary

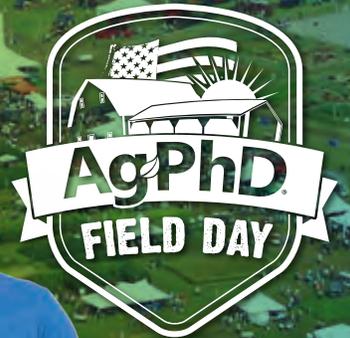
1. Get your soil tested
2. Start with small grids or zones, but you can combine them into larger grids or zones in the future once you even them out
3. Use soil test results to make better fertility decisions
4. There are many unknowns out there, so prove things on your farm on a small scale first before implementing new practices on a large scale, and be sure to match yields to soil test results
5. Don't get overwhelmed and then do nothing different than what you've done before! You can't improve your yields and your profits without making changes.

Save The  
**DATE 2026**

THURSDAY

**JULY 30<sup>th</sup>**

FREE EVENT | BALTIC, SD



THE AG PHD FIELD DAY IS STILL SEVERAL MONTHS AWAY, BUT WE ARE PLANNING FOR OUR  
**BIGGEST AND BEST EVENT EVER!**

**WE WILL HAVE... MORE EQUIPMENT, MORE PLOTS, MORE TENTS, MORE FOOD,  
MORE EDUCATION, AND MORE ENTERTAINMENT THAN ANY FIELD DAY BEFORE.**

## EVENT Highlights



### 1. RESEARCH Plots

Take a guided tour of this Ag PhD Research Station with Darren and Brian so you can see in the field what's performing and what's not.



### 4. 70+ Exhibitors

See the newest technologies and innovations from the best ag companies and industry leaders.



### 2. EDUCATIONAL Sessions

Topics include estate planning, soil testing, Ag Myths, increasing yields and profits, and much more!



### 5. IT'S Free!

There is no charge for parking, entry, food, demos, or educational seminars.



### 3. ALL DAY Entertainment

Vanguard Squadron Air Show, numerous speakers, live polka band, a Kid's Area, and more.

**DON'T MISS  
AGRICULTURE'S  
Greatest  
ONE-DAY EVENT!**



FREE EVENT | BALTIC, SD

**GO TO AGPHD.COM TO REGISTER!**