The Science Behind N and P Fertilizer Timing and Placement

Advanced Crop Advisors Workshop, Feb 7-8, 2023

Dave Franzen

Professor Soil Science

Extension Soil Specialist

North Dakota State University

More N and P fertilizers are applied to regional fields than all other fertilizers combined.

2009- 430,000 tons N
145,000 tons P_2O_5
14,000 tons K_2O
7,000 tons S

N and P were typically 30-40% of many crop input costs in 2022 (NDSU Crop Budgets)

Fertilizers are used to increase crop profitability.

Timing and placement are important for greatest return.

Nitrogen

Timing-

Fall

Preplant

At Planting

Topdress-sidedress

Nitrification inhibitors

Placement-

Surface

Under surface

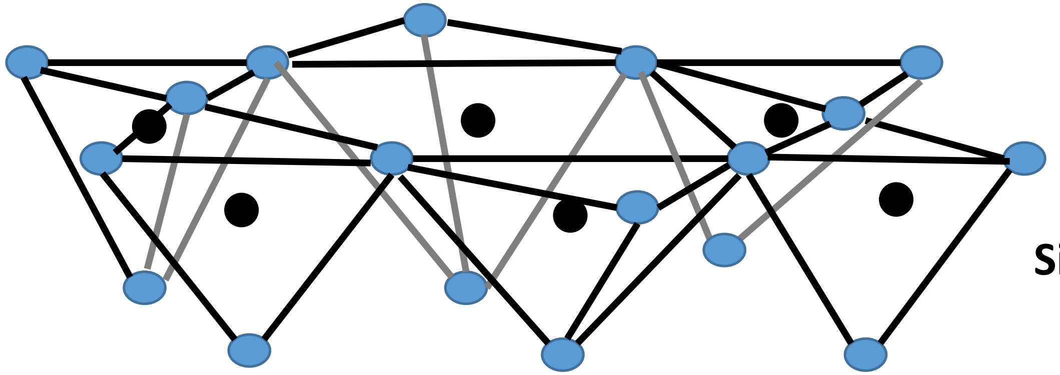
Urease inhibitors

Basis of application timing for N is
<u>risk of loss</u>

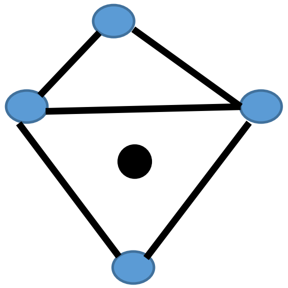
nitrate, nitrous oxide/N_2 gas and ammonia

Clay chemistry short version:

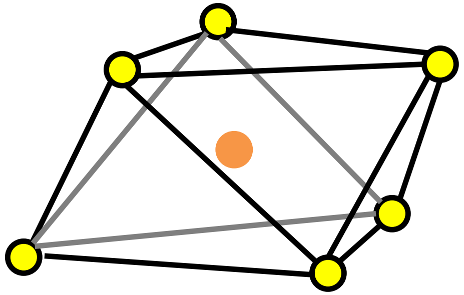
The silicon oxide sheet layer-



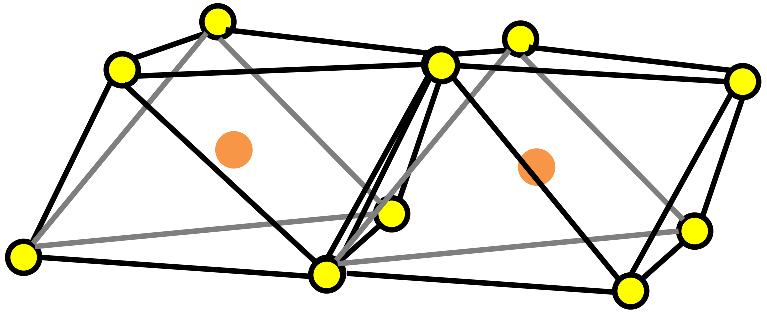
SiO_4 in a sheet



The SiO_4 building block

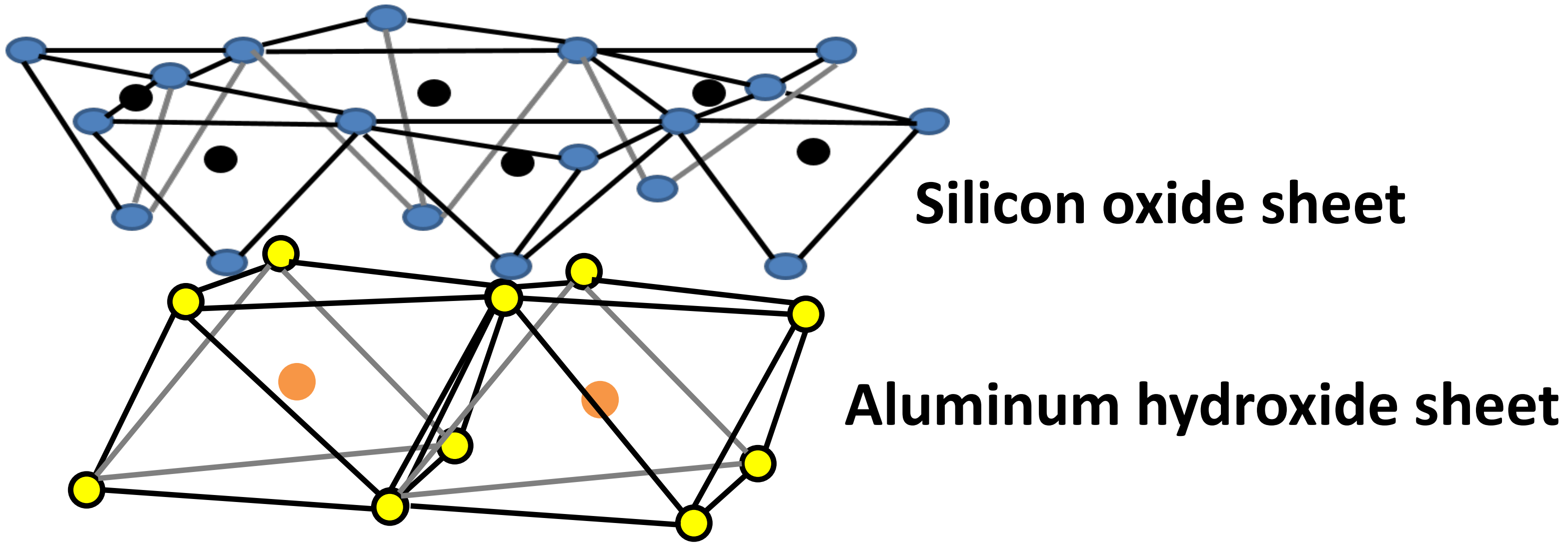


Aluminum hydroxide building block



Aluminum hydroxide sheet

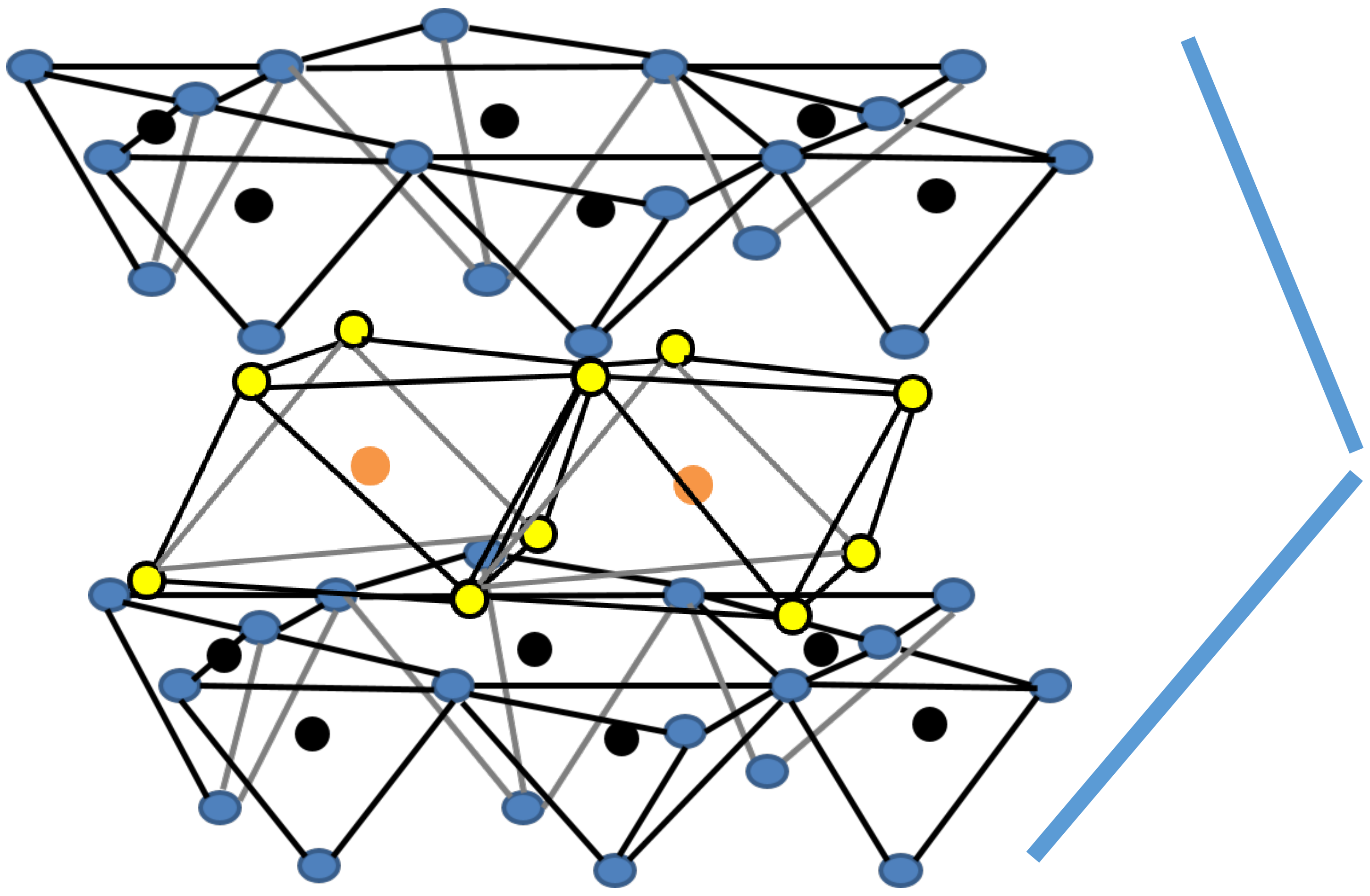
A 1:1 silicon oxide sheet bound to an aluminum hydroxide sheet.



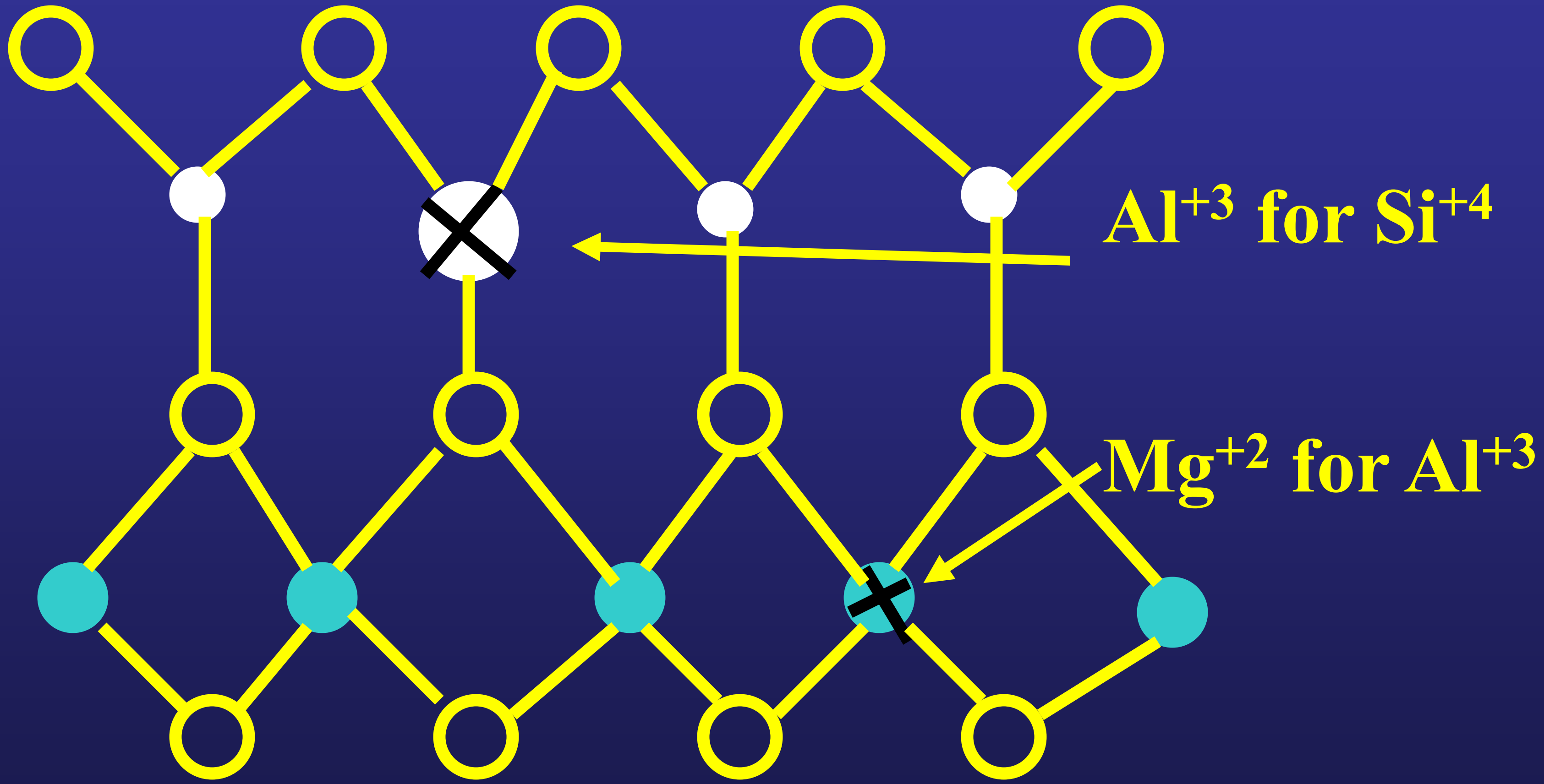
Bound by partial charge from $O^{-\rho}$ and $OH^{+\rho}$

A 2:1 clay-

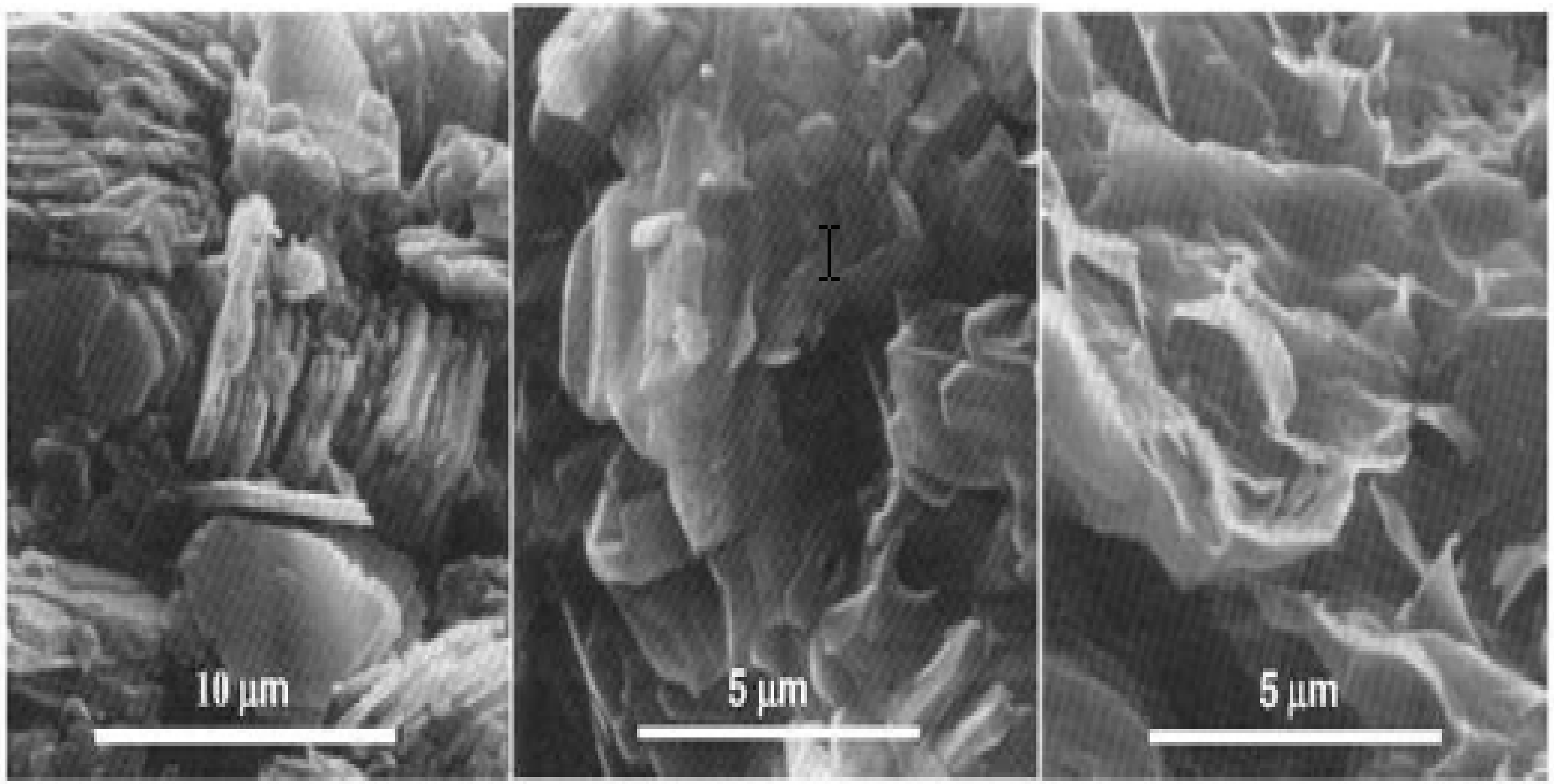
Sheet of Aluminum hydroxide with 2 sheets of Silicon oxide- one above, one beneath.



Substitution during initial mineral formation results in net negative charge.



CATION EXCHANGE



Micrographs of kaolinite (1:1 clay) left
Illite (limited shrinking 2:1 clay) center
and Smectite (high shrink/swell 2:1 clay) right

Organic matter has a pH dependent charge

Example

COOH side chain

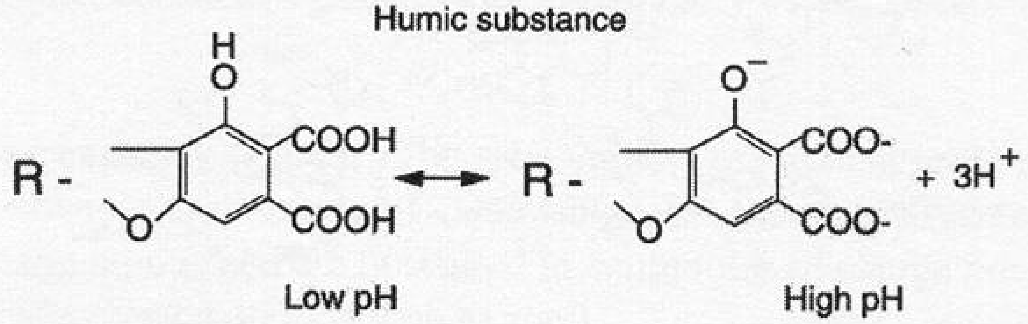
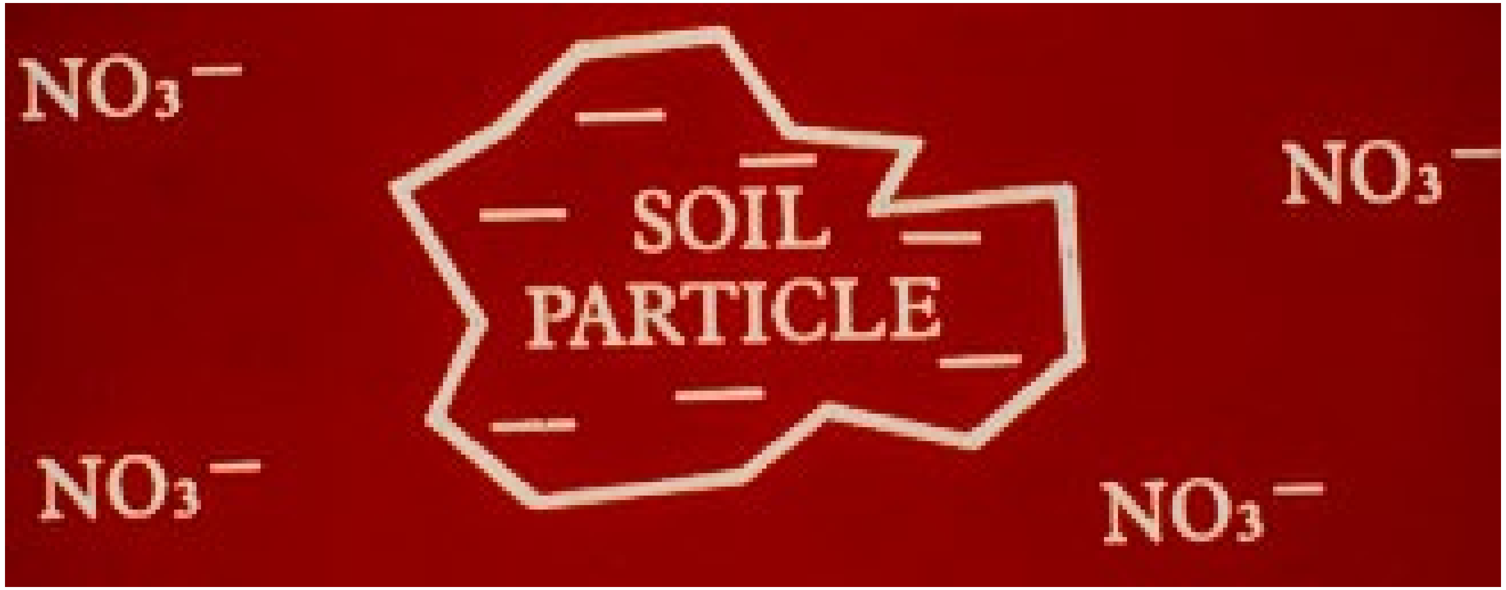


Fig. 6.10. Disassociation of functional groups of humic substances at high pH (Hassett and Banwart, 1992). Reproduced with permission from Prentice-Hall, New Jersey.

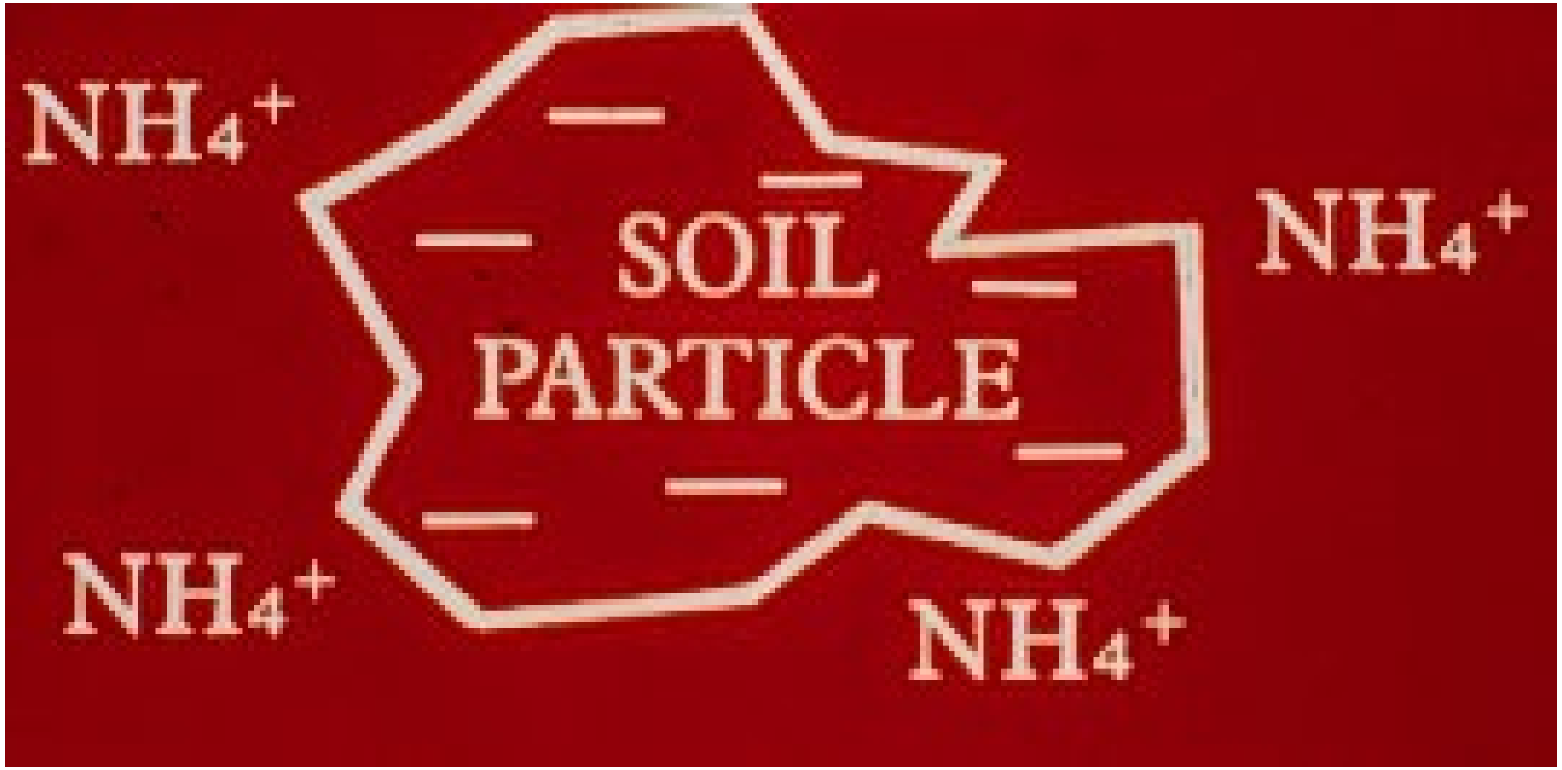
When soil solution is acidic, organic matter has less negative charge

When pH is higher, COOH $\longrightarrow$ COO^-

Most anions are not held by soil (NO_3^-, Cl^-, SO_4^{-2})



Cations (NH_4^+, K^+, Ca^{+2}, Mg^{+2}) are held by soil



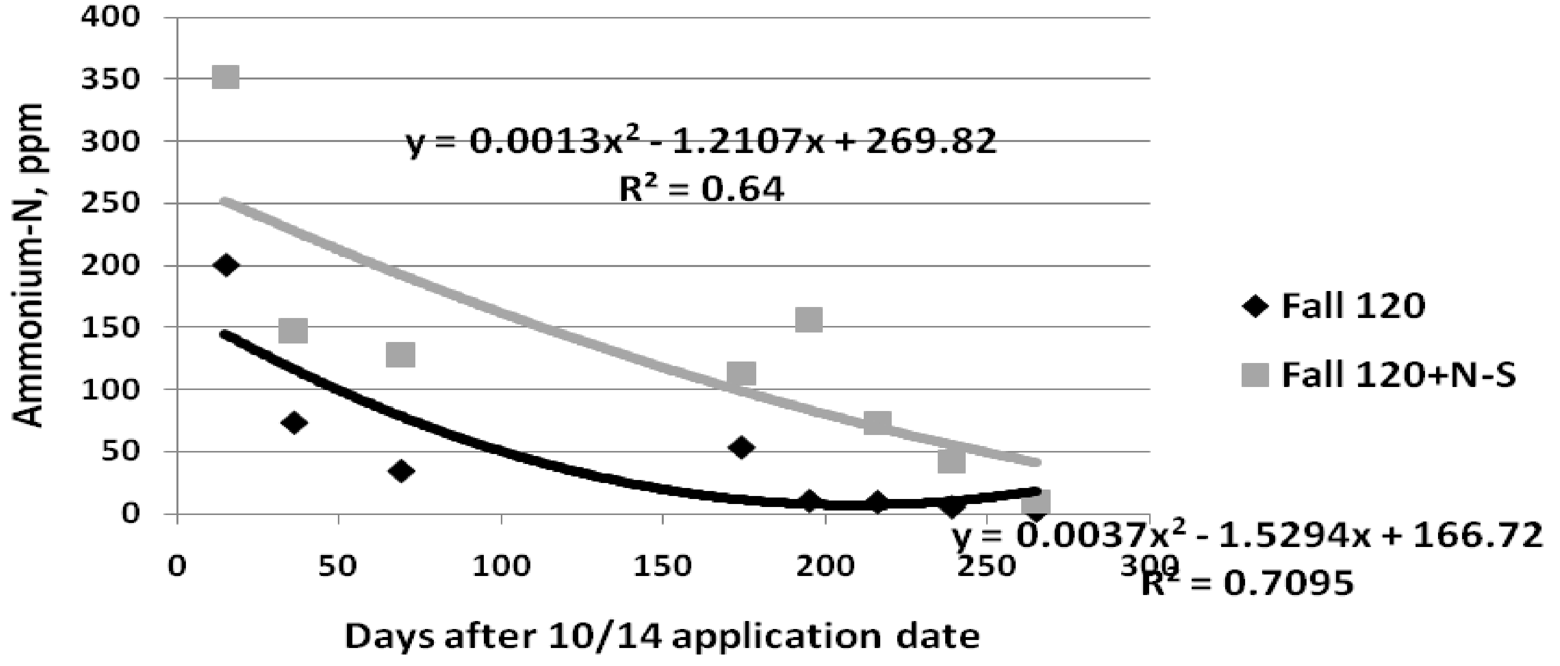
Fall N success is dependent on the ability of ammonium-N to <u>remain</u> on clay/organic matter surfaces, and <u>not convert to nitrate</u> in time for snow-melt/spring rains.

$$NH_4^+ + H_2O \xrightarrow{\textit{Nitrosomonas}} NO_2^{-1} + 3H^+ + 2e^{-1}$$

$$NO_2^{-1} + H_2O \xrightarrow{\textit{Nitrobacter}} NO_3^{-1} + 2H^+ + 2e^{-1}$$

Strategy for retaining greatest N as ammonium is three-fold:

-Use of ammonium-based fertilizers
-Timing as late as possible to minimize warm soil temperature
-Use of a nitrification inhibitor with proven rate of success.

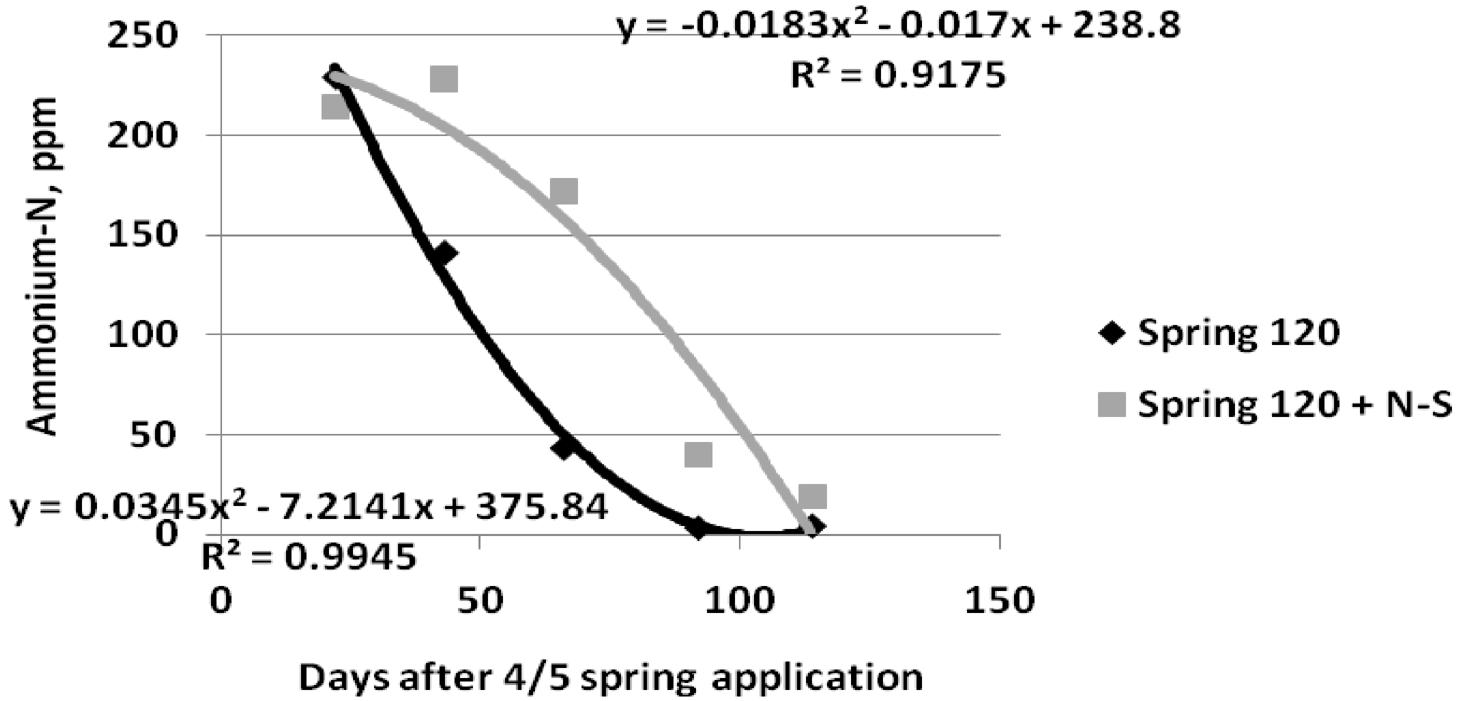


Fall N, Touchton et al., 1978
N-Serve 24, Illinois

	%W/O	%W
100 days is January 22	20	60
150 days is March 13	5	50
200 days is May 2	0	30

Spring N, Touchton et al., 1978
N-Serve 24, Illinois

	%W/O	%W
50 days is May 25	20	80
100 days is July 14	0	20



Minnesota

Average +15 bushels/ acre corn fall NH_3 + N-Serve compared with NH_3 alone

Spring NH_3 +27 bushels/acre compared to fall NH_3 alone

(Randall et al., 2008).

North Dakota

Goos and Johnson, Agronomy Journal 1999

Very snowy winter (100^{+} inches snow, 1996-97)

N uptake efficiency without nitrapyrin was 24%
with nitrapyrin was 50%

Goos, NH_3 application 10/3, both sites.

Soil sampling Buffalo, Gardena poorly drained 10/24 fall, May 14, spring

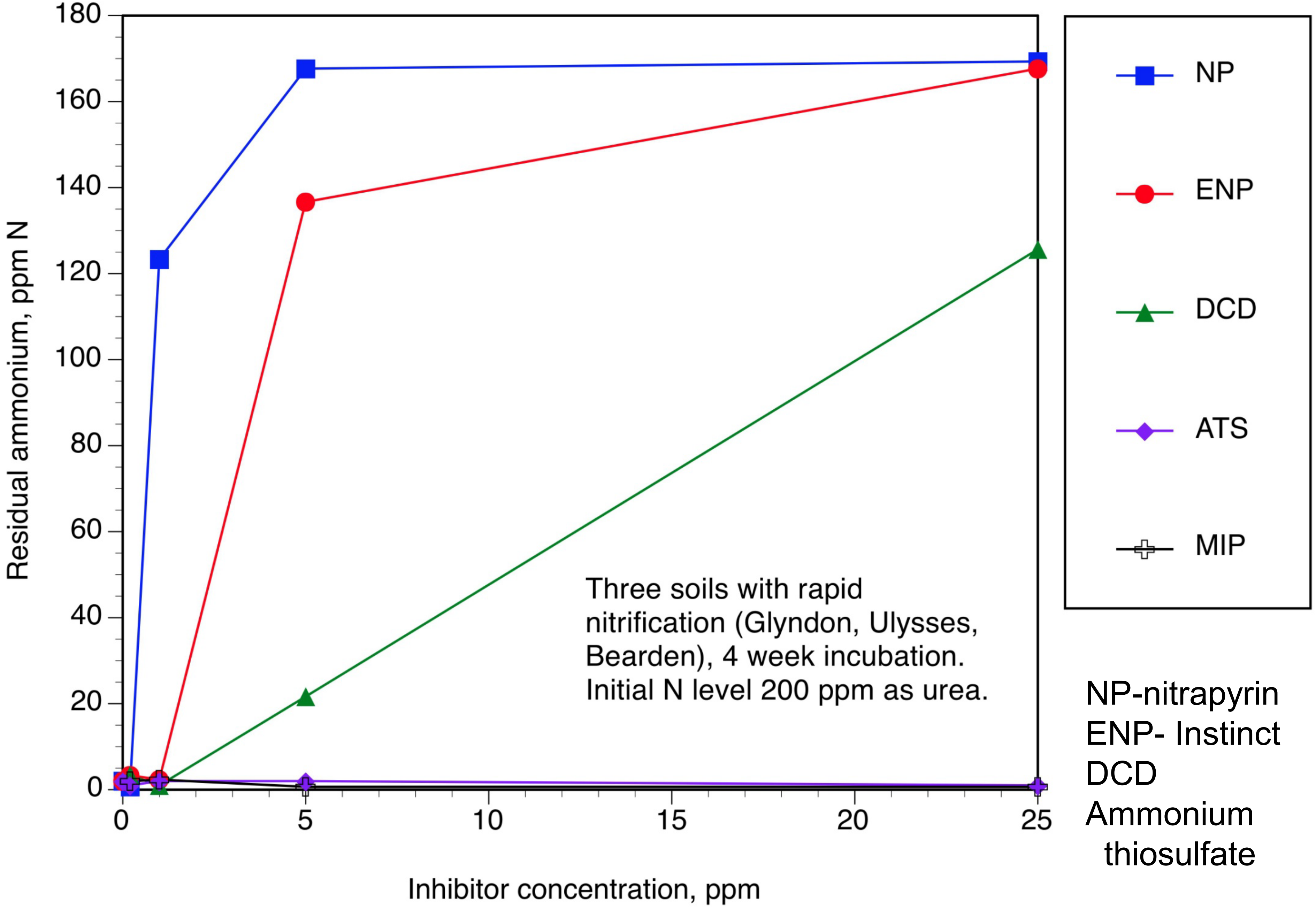
Treatment	Fall NH4	Fall NO3	Fall Total	Spring NH4	Spring NO3	Spring total
Lbs N/acre + additive	---------------------------------- ppm	---				
0	3	1	4	2	2	4
75	32	21	53	0	9	9
75 + 0.5 lb nitrapyrin	63	16	**79**	19	12	**31**
75 + 1.5 lb nitrapyrin	68	10	78	32	9	41
LSD 0.1	10	6	14	11	3	11

Soil sampling Fargo soil, poorly drained 10/23 fall, May 12, spring

Treatment	Fall NH4	Fall NO3	Fall Total	Spring NH4	Spring NO3	Spring total
Lbs N/acre + additive	---------------------------------- ppm	---				
0	0	6	6	3	0	3
75	54	41	95	2	5	7
75 + 0.5 lb nitrapyrin	80	32	**112**	9	13	**22**
75 + 1.5 lb nitrapyrin	88	24	112	26	11	37
LSD 0.1	23	7	14	7	3	11

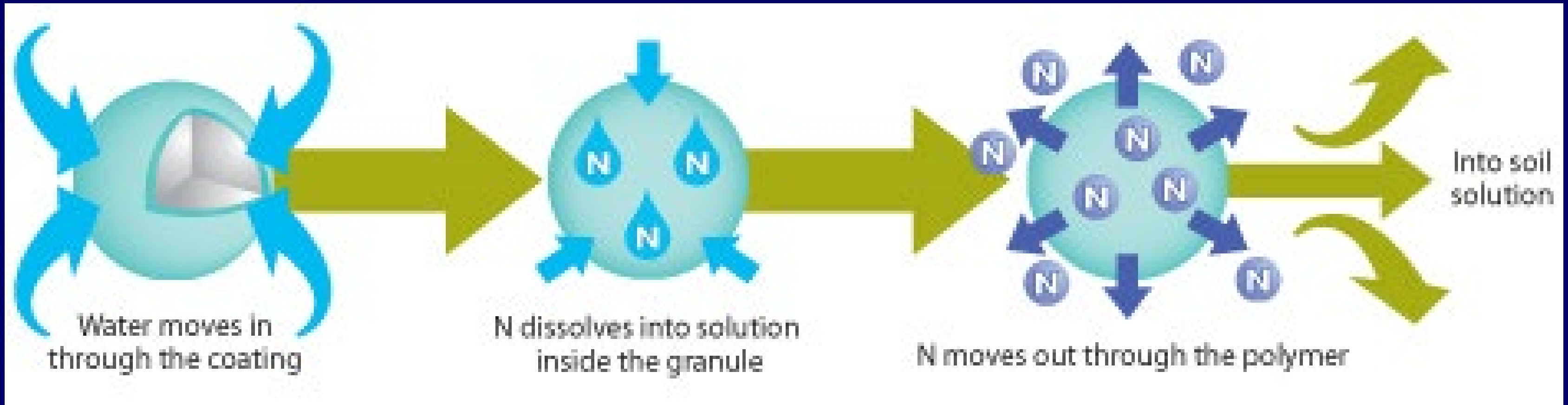
Spring wheat yield, 1997, Buffalo, ND after very wet winter/spring

Treatment	Spring wheat yield, bu/a	Apparent N use Efficiency, %
0	23.5	
75	37.0	24
75 + 0.5 lb/a nitrapyrin	45.0	50
75 + 1.5 lb/a nitrapyrin	46.0	50
LSD 0.1	4.2	9

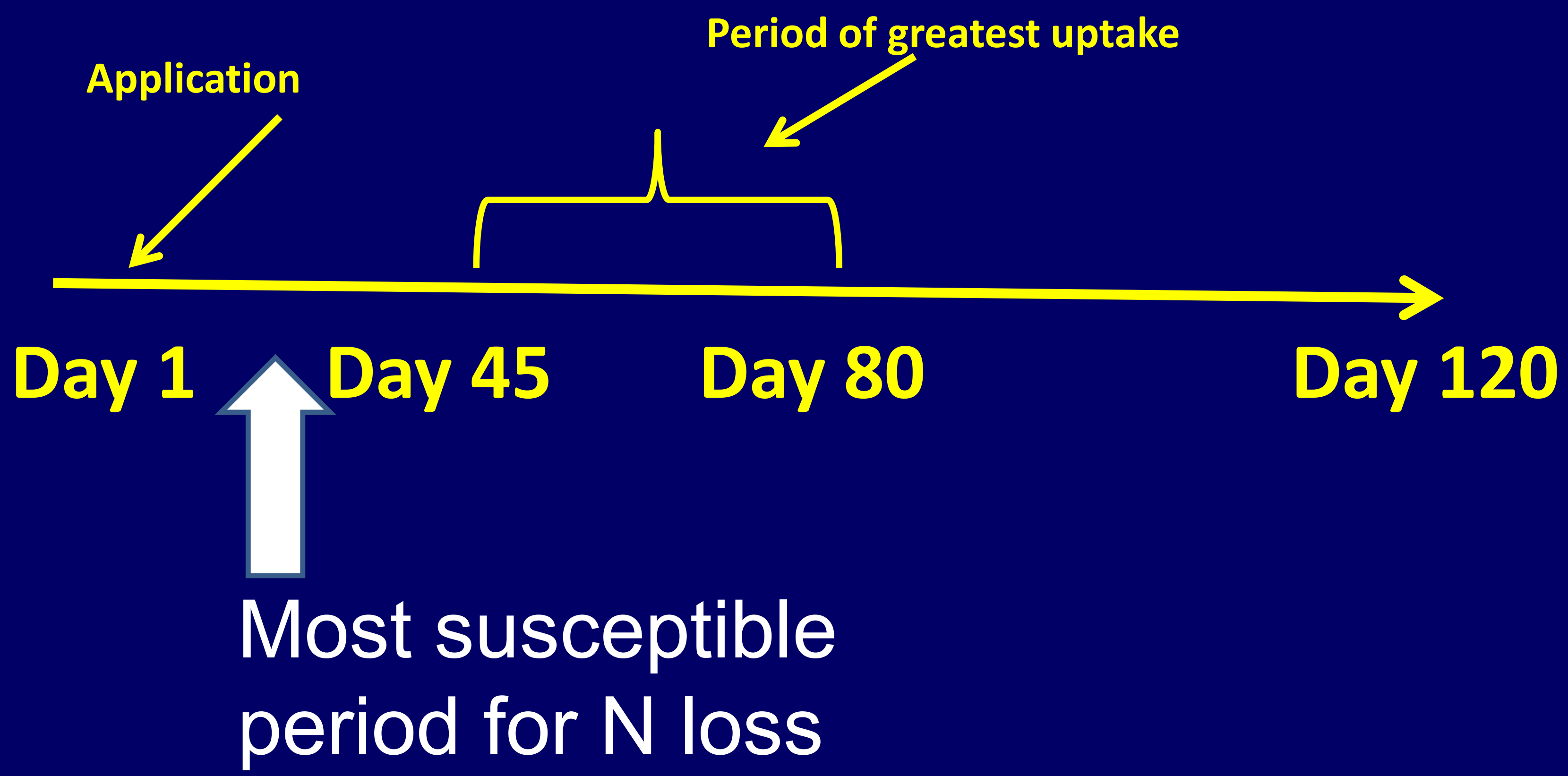


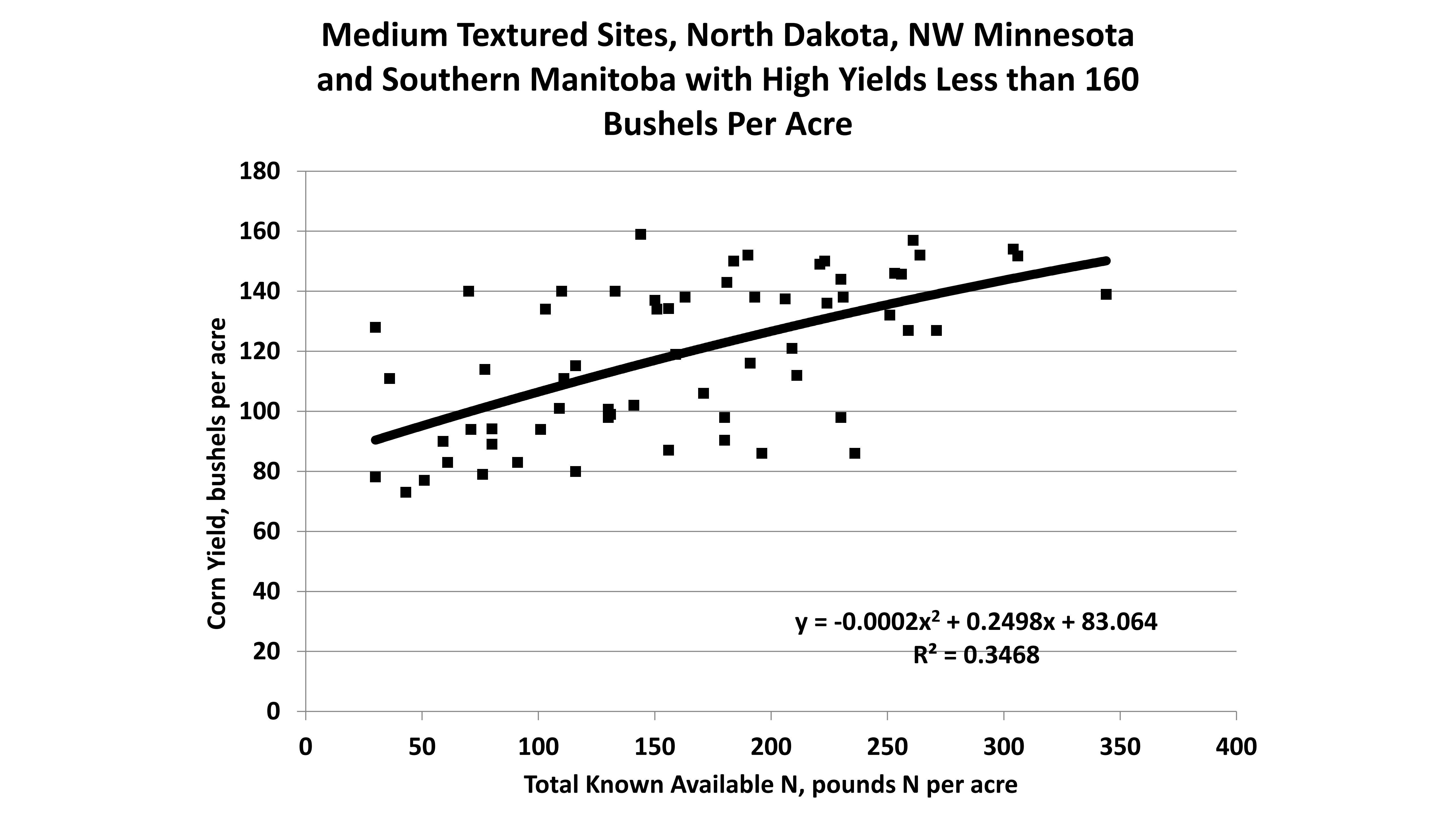
NP-nitrapyrin
ENP- Instinct
DCD
Ammonium thiosulfate

How ESN works (Agrium website)



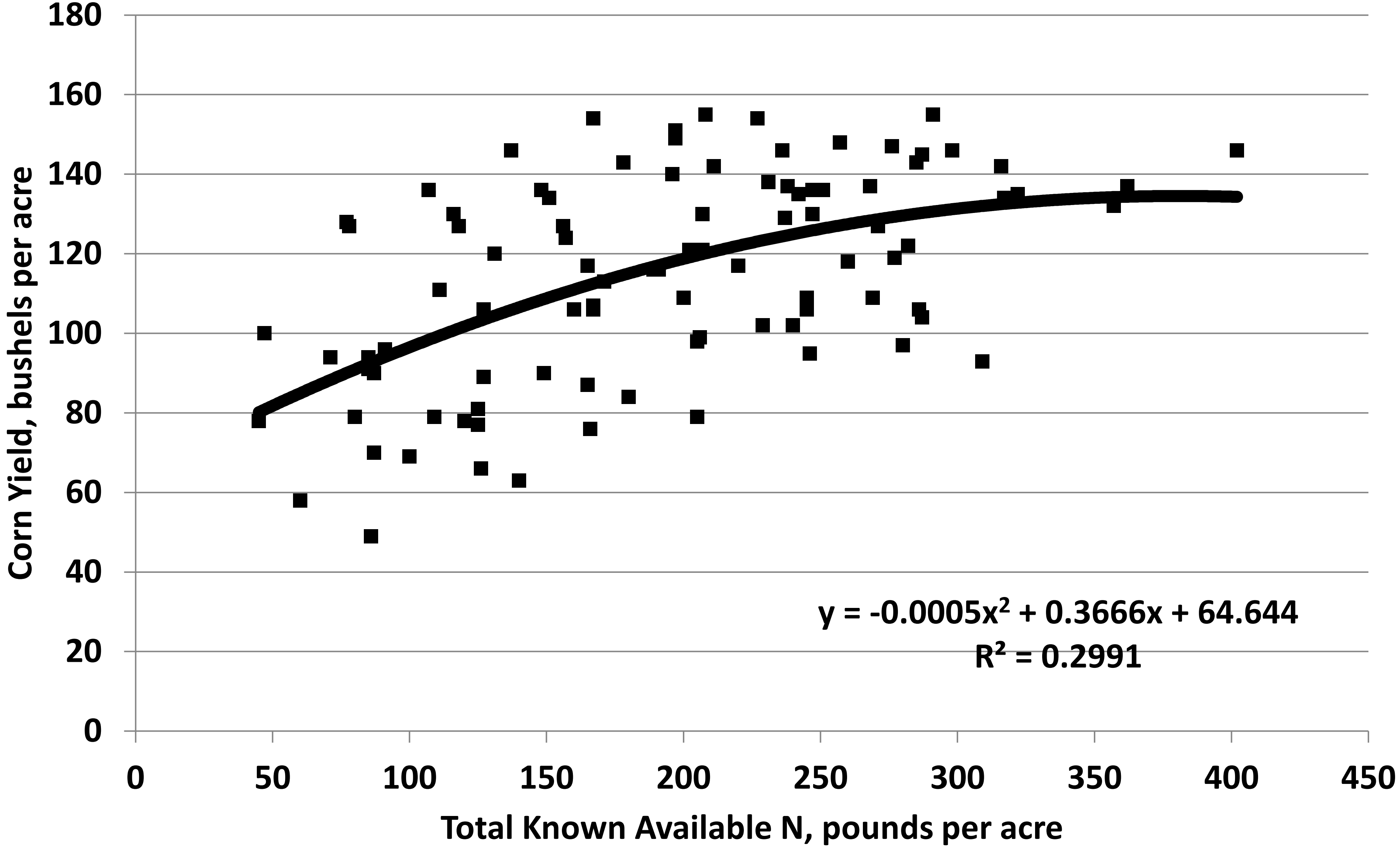
Corn N timeline





Medium Textured Sites, North Dakota, NW Minnesota and Southern Manitoba with High Yields Less than 160 Bushels Per Acre
Corn Yield, bushels per acre
Total Known Available N, pounds N per acre
0
20
40
60
80
100
120
140
160
180
0
50
100
150
200
250
300
350
400
y = -0.0002x2 + 0.2498x + 83.064
R2 = 0.3468

High Clay Sites Yielding Under 160 bushels per acre, North Dakota, NW Minnesota, and Southern Manitoba, 2001-2013



Amenia

2014

TREATMENT	YIELD
Check	70.9
40 pp	108.5
80 pp	131.3
120 pp	152.9
160 pp	152.1
200 pp	168.3*
240 pp	152.6
280 pp	167.2*
40 pp 40 sd	136.2
40 pp 80 sd	147.0
40 pp 120 sd	156.1
40 pp 160 sd	150.5
40 pp 200 sd	169.4*
40 pp 240 sd	157.8
80 pp 80 sd	165.7*
80 pp 160 sd	176*
LSD 5%	24.5

Amenia 2015

Treatment	Yield, bushels per acre	
Check	81	
40 pp	118	
80 pp	142	
120 pp	160	
160 pp	161	
200 pp	180*	
240 pp	159	
280 pp	178*	
40/40	153	
40/80	177*	
40/120	178*	
40/160	175*	
40/200	165	
40/240	177*	
80/80	161	
80/160	183*	
LSD	31	

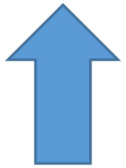
Corn yield following soybeans as affected by time/method of N application for two tillage systems at Waseca, 2001-2003.

Nitrogen treatment				Tillage system	
Time	Source	Rate	N-Serve	SFC[1/]	ST[1/]
		lb N/A		- Yield (bu/A) -	
--	--	0	--	122	111
Fall	AA	100	Yes	167	161
Spr.	AA	100	No	165	168
Spr.	Urea	100	"	167	166
Spr.	UAN	100	"	161	--
Plant[2/] + SD[1/]	"	20 + 80	"	--	170
Plant[2/] + SD[1/]	"	40 + 60	"	174	163
Plant[3/] + SD[1/]	"	40 + 60	"	172	174

1/ SFC = spring field cult., ST = strip-till, SD = sidedress at V3 to V4 stage.
2/ Dribbled 2 inches from the row at planting
3/ Broadcast pre-emergence with herbicide (weed and feed)

From Randall, 2008

<u>Surface urea application-</u>

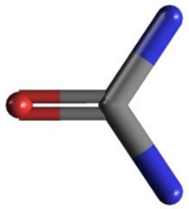
Risk of NH_3 loss 

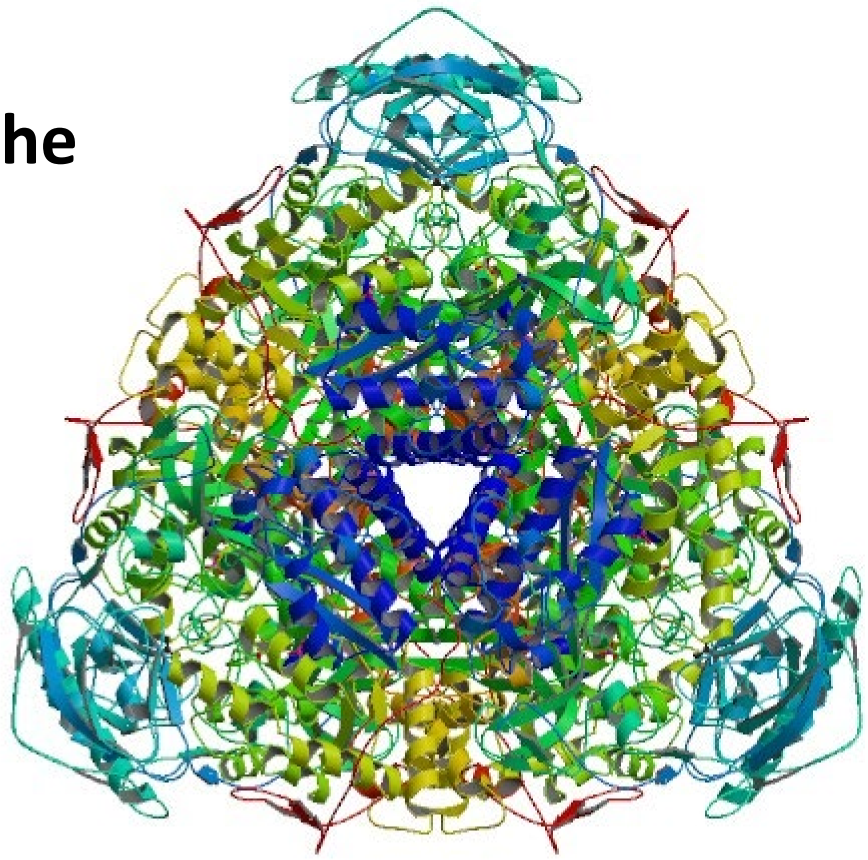
Mediated by urease enzyme

Risk increases as pH increases

as residue increases

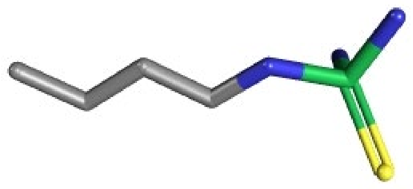
Urea is acted on in the 'keyhole' structure of the <u>urease enzyme</u>

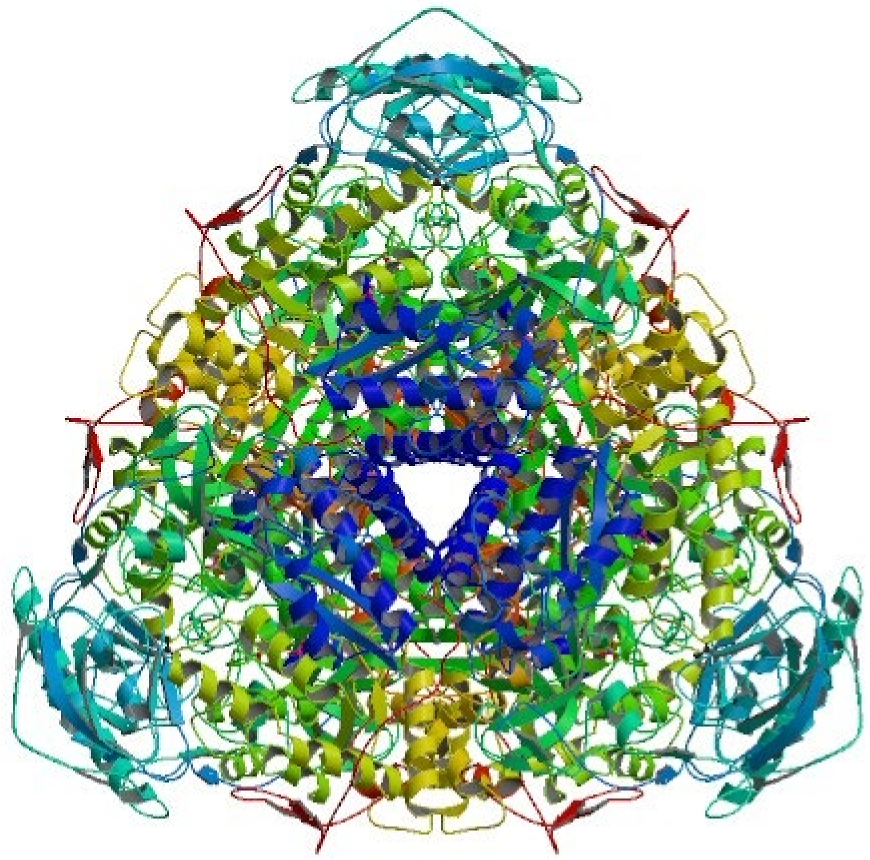




N-(N-Butyl)thiophosphoric triamide (NBPT)

Has same tri-atom configuration as urea





NPPT has same tri-atom structure, but tail has an additional C group.

NBPT (Agrotain and siblings)
and
NPPT (Limus)

are the only chemistries known to inhibit urease activity for days (usually about 10)
(Agrotain Ultra- 26.7% NBPT, use rate 3 qt/t of urea AU density is 8.9 lb/gal [1.8 lb NBPT/Ton urea])

Ammonium thiosulfate has measureable short-term activity, but NBPT is much better.

Ammonia volatilization from surface and incorporated urea at various depths-

Rochette et al., 2014, J. Env. Q.

Period-hours	Surface (% loss)	1 inch (% loss)	2 inch (% loss)	3 inch (% loss)
0- 1 week	2.2	18.4	2.6	0.0
1-2 weeks	29.5	15.2	3.2	0.1
2-3 weeks	15.2	3.8	1.8	0.5
3-4 weeks	3.4	1.0	1.0	0.0
Total	50.3	38.4	8.6	0.4

Slightly acid silt loam soil

Yield for side-dressed no-till corn in Hardin County, KY. (From Schwab and Murdock, 2009)

Treatment	Yield, bushels per acre
Check (50 lb N/acre preplant N only)	117 d*
Urea	158 c
Urea + Agrotain	201 b
SuperU	201 b
UAN	150 c
UAN + Agrotain	179 bc
UAN + Agrotain Plus	175 bc
Ammonium nitrate	239 a

Placement of anhydrous ammonia- Apply at angle to row, even in fall, or between intended rows with DGPS

Spring wheat after fall
(early November) shallow
(about 3 inches) application
in high pH soil near St. Thomas

Asymbiotic N-fixing organisms

Organisms, usually a species of bacteria, that have the ability to fix atmospheric N (N_2), transforming it into NH_3, which is immediately attached to a 'carbon-skeleton', safening it.

The fixation requires energy, which when conducted in soil comes from organic matter.

Asymbiotic N-fixing organisms

Evidence for asymbiotic N-fixing organisms finds that these organisms were active 1.5 billion years ago- some of the oldest organisms found in the fossil record.

(Boyd & Peters, 2013, Frontiers in Microbiology)

Compared with about 59 million years ago for symbiotic N-fixers (Sprent and James 2007, Plant Physiology)

Asymbiotic N-fixing organisms

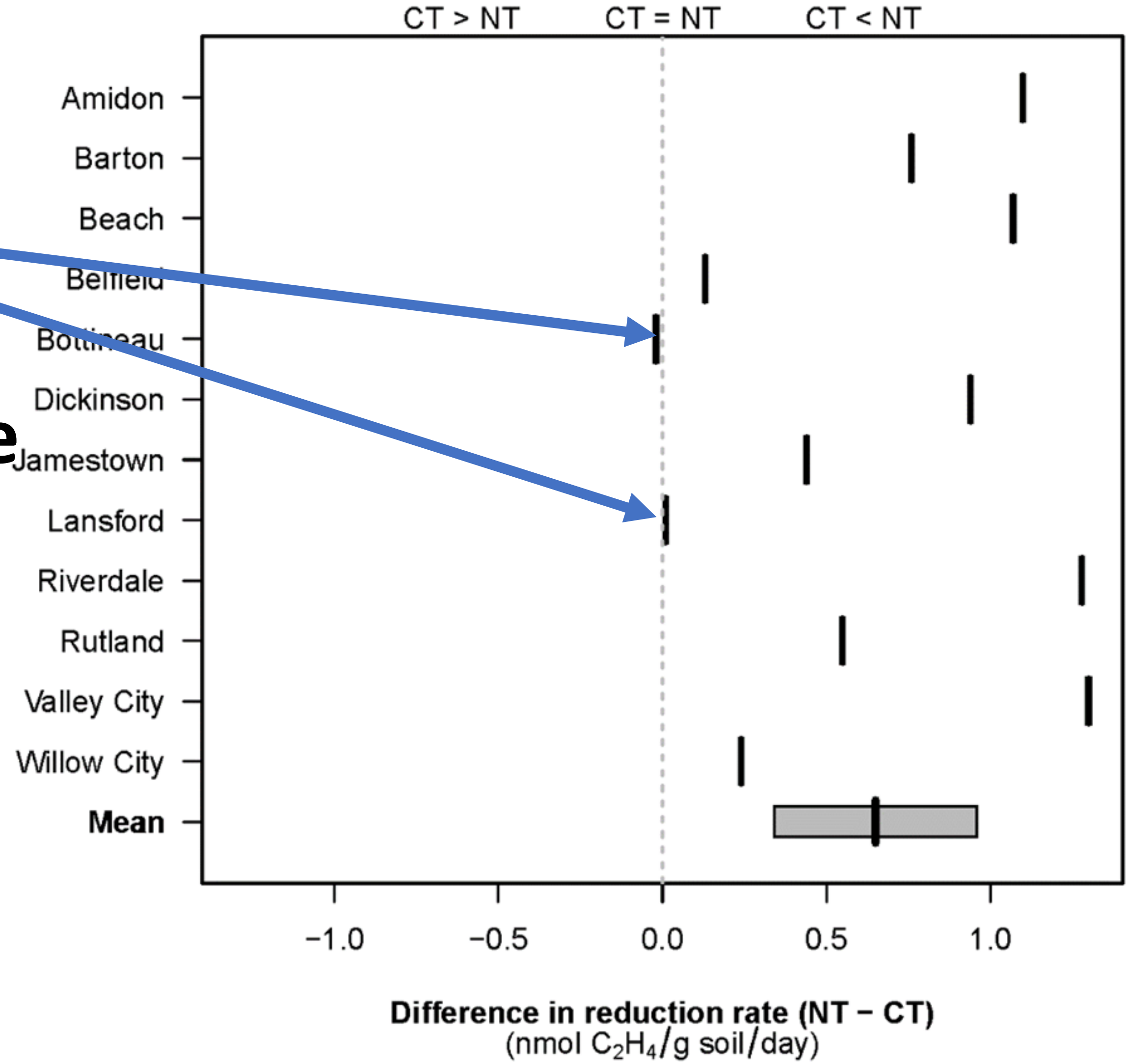
N-fixation is an energy-expensive process.
The enzyme that serves as 'fixation facilitator' in bacteria is *nitrogenase.*
To convert 1 N_2 to 1 NH_3 requires 16 ATP molecules (produced during photosynthesis) and 8 electrons.

Energy limits N fixation.
(Smercina et al., 2019, Applied Environmental Microbiology)

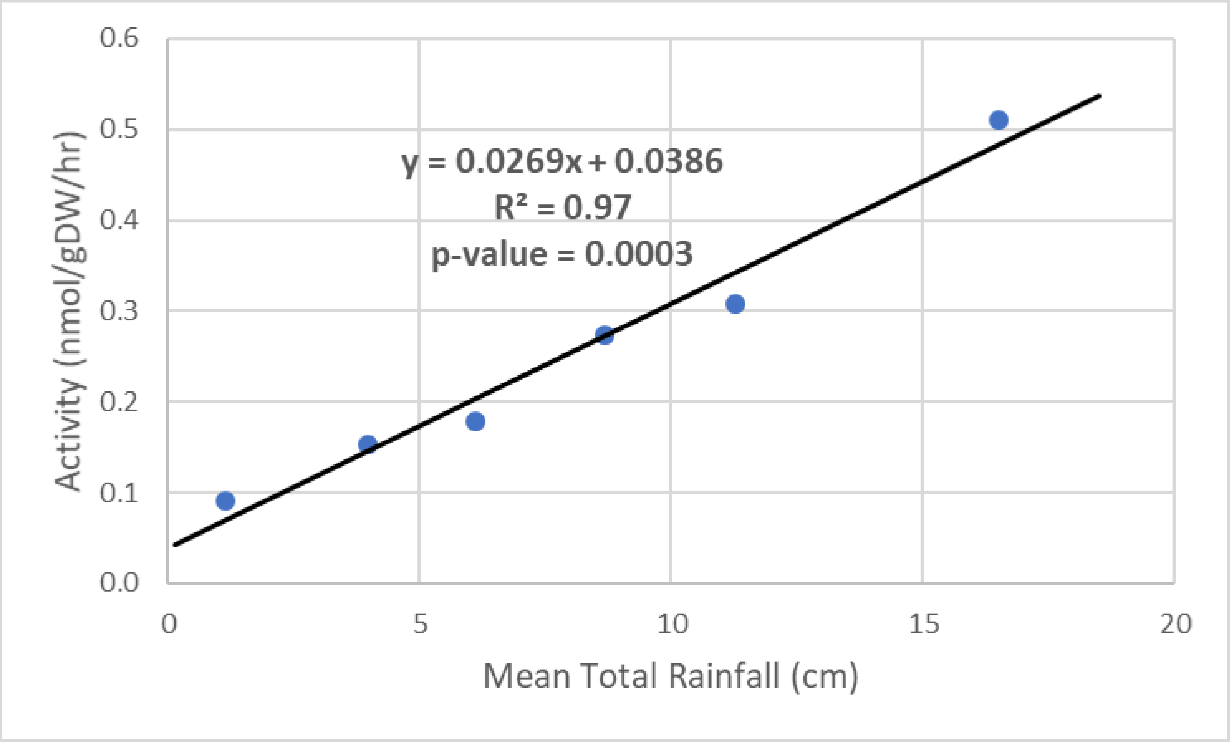
For comparison, production of 1 peptide bond in protein synthesis requires only 5 ATP (still considered 'high energy requirement')

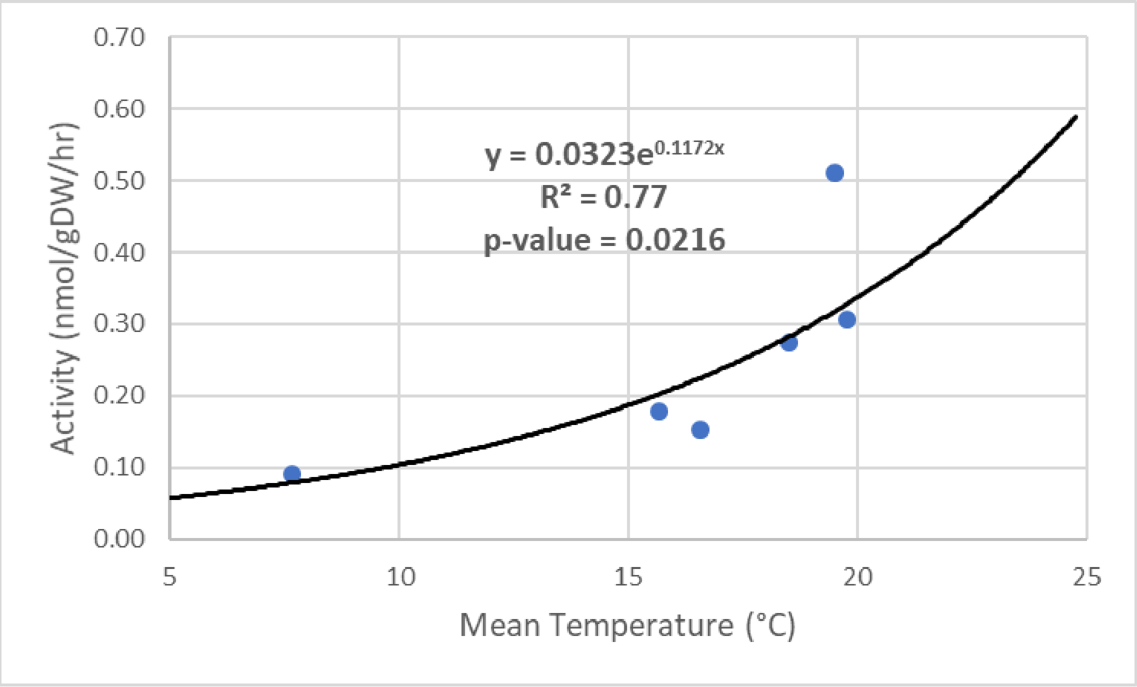
Took paired no-till/conventional till across state.

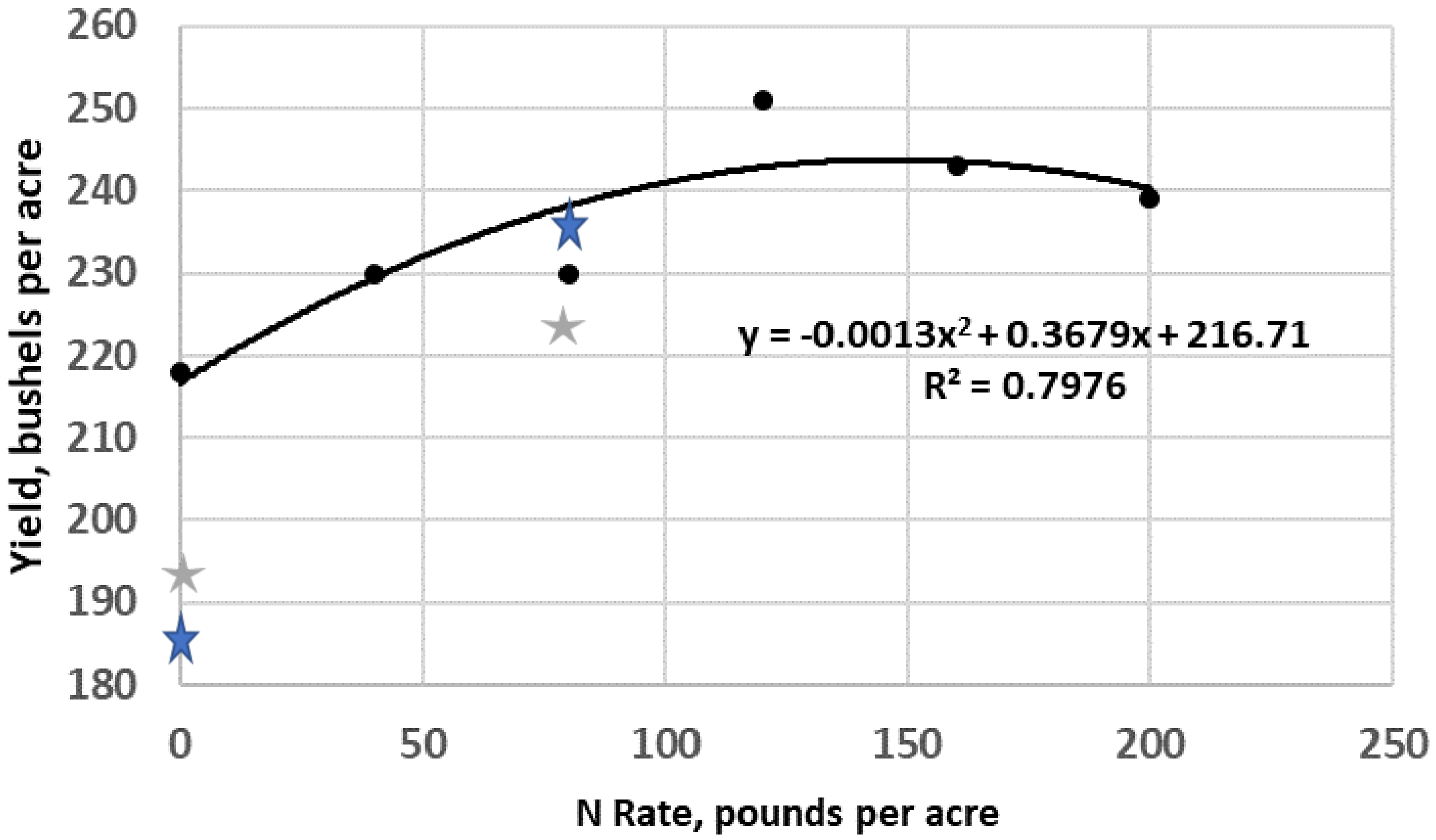
Turns out the 'conventional till' site across the fence was one-pass shallow tillage, so the same tillage category



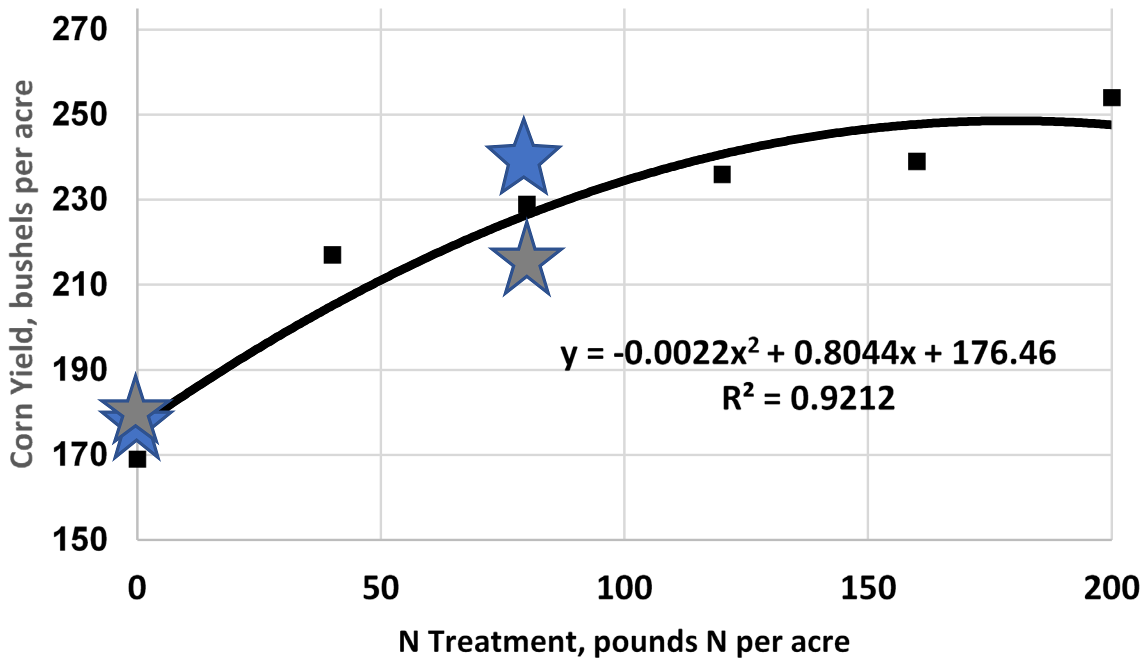
In 2020 and 2021, 6 sites in eastern North Dakota were sampled each month for asymbiotic N fixing activity. Change in activity was related to rainfall within 30 days before sampling and mean air temperature.



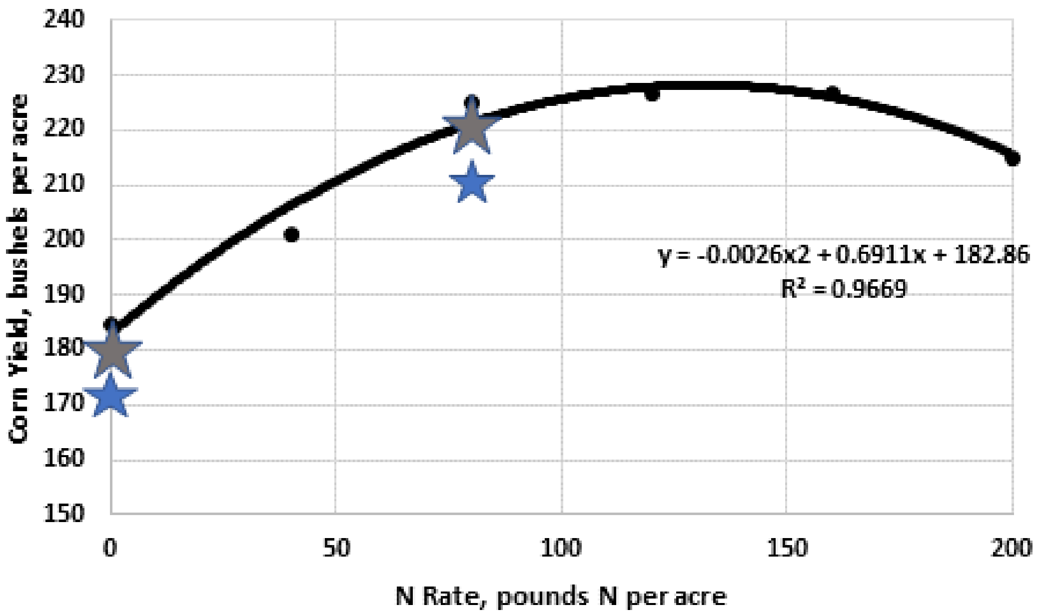




Absaraka response of corn to N treatment and N rate with additives.
Blue stars indicate treatments (0 and 80 lb N/acre) with Utrisha post-applied V6.
Gray stars indicate treatments (0 and 80 lb N/acre) with Envita in furrow at planting.



Prosper response of corn to N treatment and N rate with additives.
Blue stars indicate treatments (0 and 80 lb N/acre) with Utrisha post-applied V6.
Gray stars indicate treatments (0 and 80 lb N/acre) with Envita in furrow at planting.



<u>Carrington</u> response of corn to N treatment and N rate with additives.
Blue stars indicate treatments (0 and 80 lb N/acre) with Utrisha post-applied V6.
Gray stars indicate treatments (0 and 80 lb N/acre) with Envita in furrow at planting.

Summary of results from 10 states.

No means no difference between same N rate with or without additive

Yes means a yield increase present at least 1 N rate

State	Envita IF†	Envita F	Utrisha	ProveN	ProveN 40 IF	ProveN 40 ST	MAZ‡ ST	MAZ F
	Number of site years included in evaluations							
ND	4 No	1 No	4 No	--------	--------------	--------------	1 No	1 No
MN	1 No	---------	--------	3 No/1 Yes	---------------	---------------	----------	-------
IL	2 No	--------	--------	4 No	5 No	2 No	----------	-------
IN	1 No	----------	--------	----------	-------------	--------------	----------	-------
MO	2 No / 1 Yes		3 No	2 No	1 No	-------------	---------	-------
KS	---------	---------	--------	1 No	-------------	-------------	----------	------
MI	1 No	---------	1 No	-----------	1 No	------------	----------	-------
KY	-----------	--------	2 No	----------	------------	------------	---------	-------
NE	-----------	---------	--------	5 No	6 No	-------------	----------	--------
OH			1 No					
Total	11 No/1 Yes	1 No	11 No	15 No/1 Yes	13 No	2 No	1 No	1 No

Total corn experiments 53.

51 no benefit to yield over N rate alone.

2 benefits with N rate benefits 12-20 lbs N/a

Sugarbeet- 2 experiments with Bio-Red/Bio-Mate

no benefit to yield/sugar yield

Canola- 2 Envita foliar experiments (Minot) no benefits

Spring wheat with Envita foliar (2) and MicroAZ seed treatment (1) and foliar (1) no benefits.

General comments about additives

Growers need to understand that since about 2008, the burden of research falls on the user.

Companies are good at ‘development’, meaning marketing, but research is sparse and results from University researchers may be controlled by the restrictions of signed confidentiality agreements.

Growers should be skeptical about new products

Try them on replicated strips on the farm.

Refer to L. Thompson, 2022 from
Proceedings of the North Central Extension-Industry Soil Fertility Conference
for ideas regarding on-farm testing and data analysis.

PROMOTING ADOPTION OF PRECISION NITROGEN MANAGEMENT TECHNOLOGIES THROUGH ON-FARM RESEARCH

L.J. Thompson, L.A. Puntel, T. Mieno, J. Iqbal, B. Maharjan, J. Luck, S. Norquest, J. G. C. P. Pinto, C. Uwineza
University of Nebraska – Lincoln, Lincoln, NE
laura.thompson@unl.edu 402-245-2224

ABSTRACT

The Nebraska On-Farm Research Network helps farmers evaluate products and practices that impact the productivity, profitability, and sustainability of their operations. There are many technologies that have potential to increase nitrogen use efficiency (NUE) on corn and winter wheat but typically these technologies have low adoption. Concurrently, farmers have technologies such as GPS, yield monitors, and variable-rate application equipment on their farmers that enables them to easily conduct on-farm research to evaluate new technologies and products. Participating farmers evaluated commercially available nitrogen (N) management technologies across Nebraska and their impact on yield, profit, and NUE. We enabled farmer's hands-on experience with technologies that are relevant for their operation and promoted technology adoption. We also collected field data to validate and improve the technology tested. 40 trials are established each year in the three-year project. We utilized an innovative experimental design combining traditional strip trials with small N plots where all treatments are established with variable-rate fertilizer equipment on-the-go. An automated data processing tool was developed for data processing, analysis, and reporting. 98% of the experiments were successfully established in the first year of the study and 90% were analyzed using the automatic process. To measure impact, grower incremental changes in N management strategy and technology adoption were documented.

INTRODUCTION

Nitrogen (N) is critical for attaining higher crop yields; however, risks of environmental losses necessitate more precise fertilizer management. Predicting the economic optimum N rate (EONR) remains challenging due to spatial and temporal

Phosphorus (P) application/placement

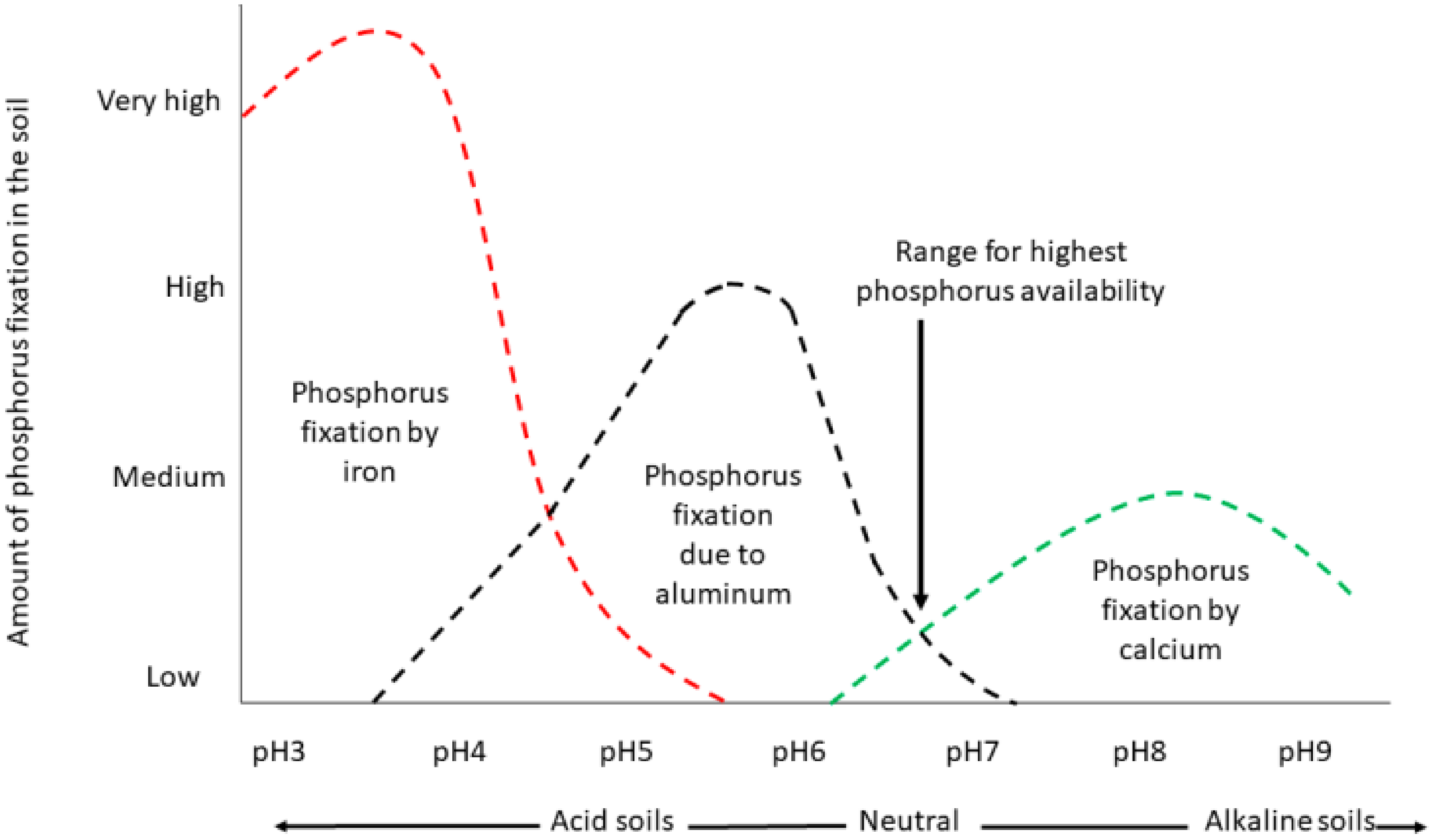
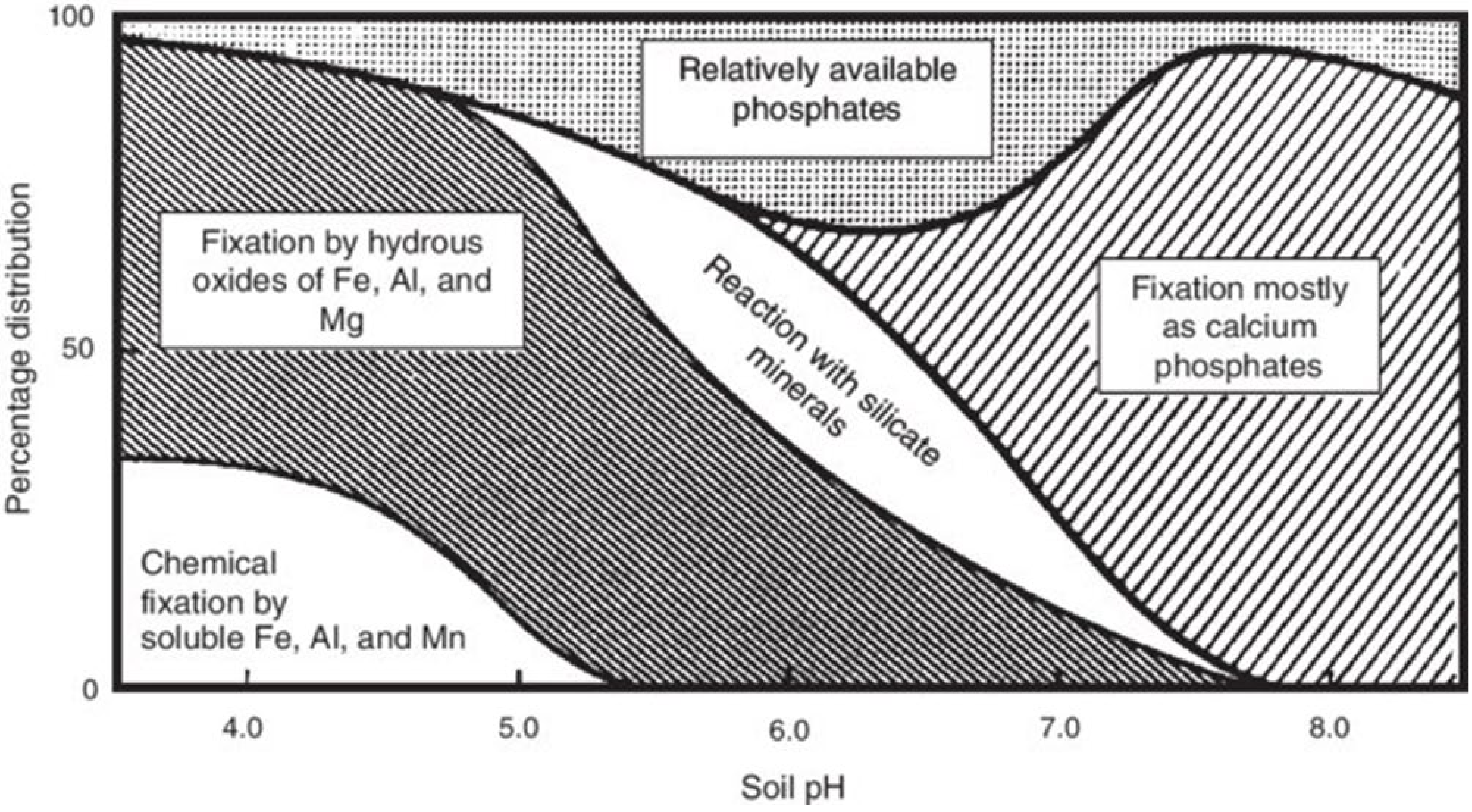


Figure 1. General qualitative representation of soil phosphorus availability as impacted by pH. Redrawn from Price [1].

Taken from Penn and Camberato, 2019, Agriculture 2019 pg 120.



From Brady 1974

$$aA(s) \rightleftharpoons cC(aq) + dD(aq) \qquad K_{sp} = [C]^c[D]^d$$

$$Ca^{2+}{}_{(aq)} + 2H_2PO_4^-{}_{(aq)} + H_2O \leftrightarrow Ca(H_2PO_4)_2{\cdot}H_2O_{(s)} \text{ (mono-calcium phosphate) Log K} = 1.15,$$

$$Ca^{2+}{}_{(aq)} + H_2PO_4^-{}_{(aq)} + 2H_2O \leftrightarrow CaHPO_4{\cdot}2H_2O_{(s)} \text{ (brushite)} + H^+ \text{ Log K} = -0.63,$$

$$Ca^{2+}{}_{(aq)} + H_2PO_4^-{}_{(aq)} \leftrightarrow CaHPO_{4(s)} \text{ (monetite)} + H^+ \text{ Log K} = -0.30,$$

$$5Ca^{2+}{}_{(aq)} + 3H_2PO_4^-{}_{(aq)} + H_2O \leftrightarrow Ca_5(PO_4)_3OH_{(s)} \text{ (hydroxyapatite)} + 7H^+ \text{ Log K} = -14.46.$$

$$Al^{3+} + H_2PO_4^-{}_{(aq)} + 2H_2O \leftrightarrow AlPO_4 \cdot 2H_2O_{(s)} \text{ (variscite)} + 2H^+ \text{ Log K} = 2.50,$$

$$Fe^{3+} + H_2PO_4^-{}_{(aq)} + 2H_2O \leftrightarrow FePO_4 \cdot 2H_2O_{(s)} \text{ (strengite)} + 2H^+ \text{ Log K} = 6.85.$$

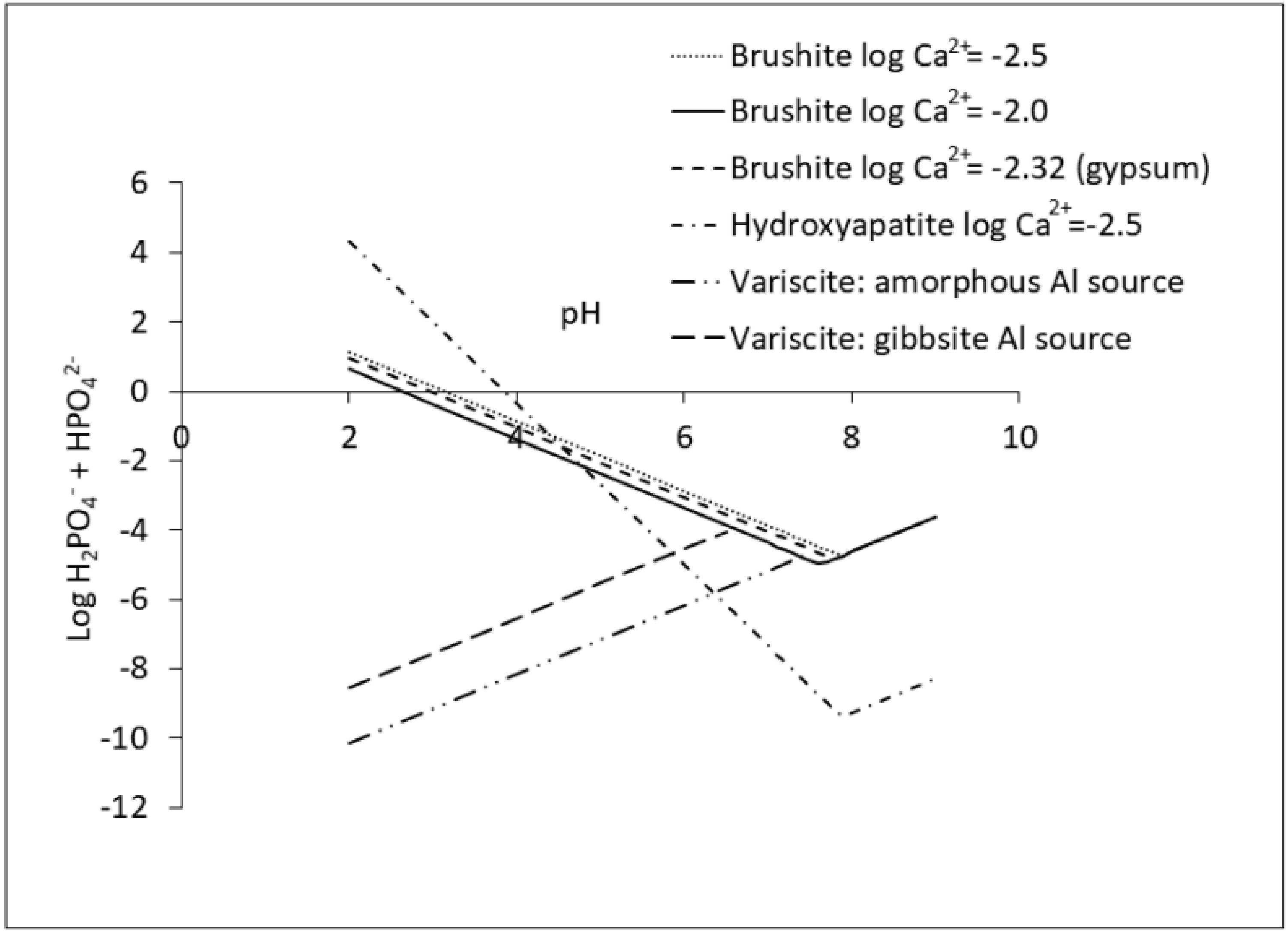
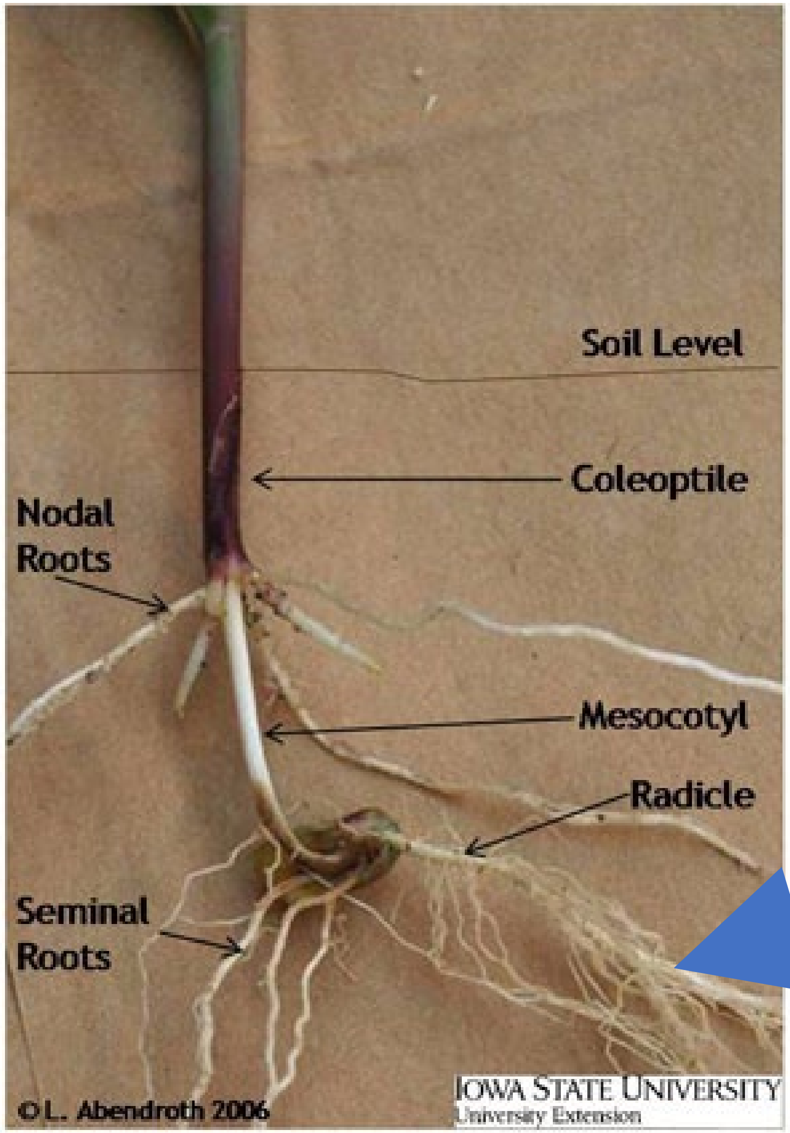


Figure 2. Solubility diagram for Al (variscite) and Ca (brushite and hydroxyapatite) phosphate minerals calculated with thermodynamic constants from Lindsay [47] and using different sources or concentrations of Ca^{2+} and Al^{3+}.


Soil Level
Coleoptile
Nodal Roots
Mesocotyl
Radicle
Seminal Roots
©L. Abendroth 2006
IOWA STATE UNIVERSITY
University Extension


BAND PLACEMENT=
SAFETY + EFFICIENCY
2"
2"

Seed-placed or 2X2 starter application is highly encouraged for corn

‘We are north of Dekalb’

Site, Illinois studies	Yield with starter	Yield without starter
Ashton (west of Dekalb)	142	122
Oblong (S of Dekalb 200 miles)	196	187
Ashton 1994	191	177
Oblong	136	136
Gridley (75 miles S of Dekalb)	142	128
Pana (S Central, IL) 1994	151	136
Pana, 1993	185 NS	171
Ashton 1995	108	95
Gridley 1995	117	111
Oblong 1995	134	116
Pana, 1995	81	77

Ritchie et al., IFCA 1996 Proceedings frec.ifca/1996/report8

Southern Illinois, corn yield increase ~ 20% of time

5-10 bu/acre

Central Illinois, corn yield increase ~ 50% of time

10-15 bu/acre

Northern Illinois, corn yield increase ~ 80% of time

15-20 bu/acre

We are N of Dekalb!

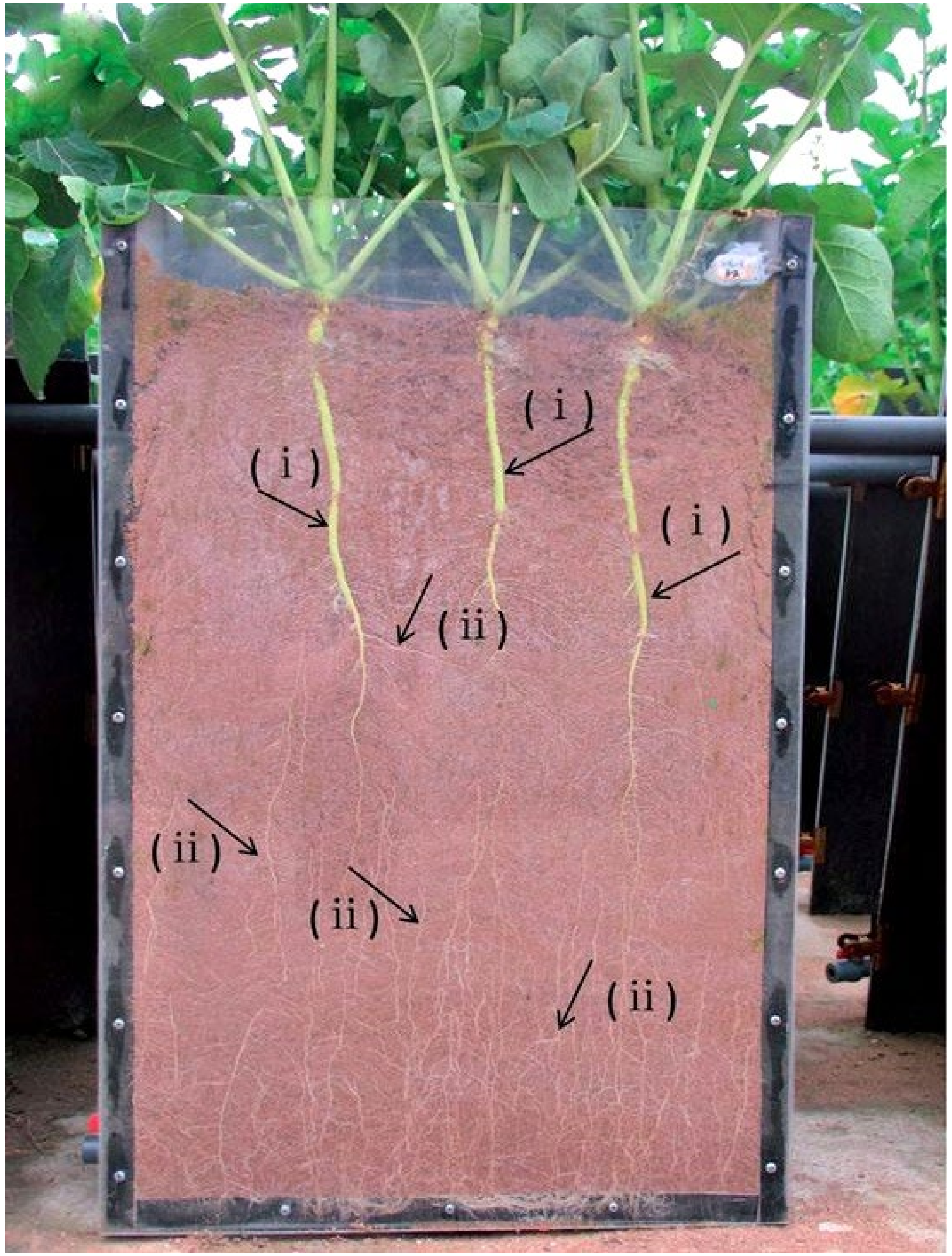
Corn yield with in-furrow 10-34-0, Carrington, 2007.

*Conventional tillage
5 ppm (L) P (Olsen)

Rate	Yield
Gal/ac	Bu/ac
0	101
2	121
4	125
6	150
8	156
10	153

No difference in plant stand among fertilizer rates

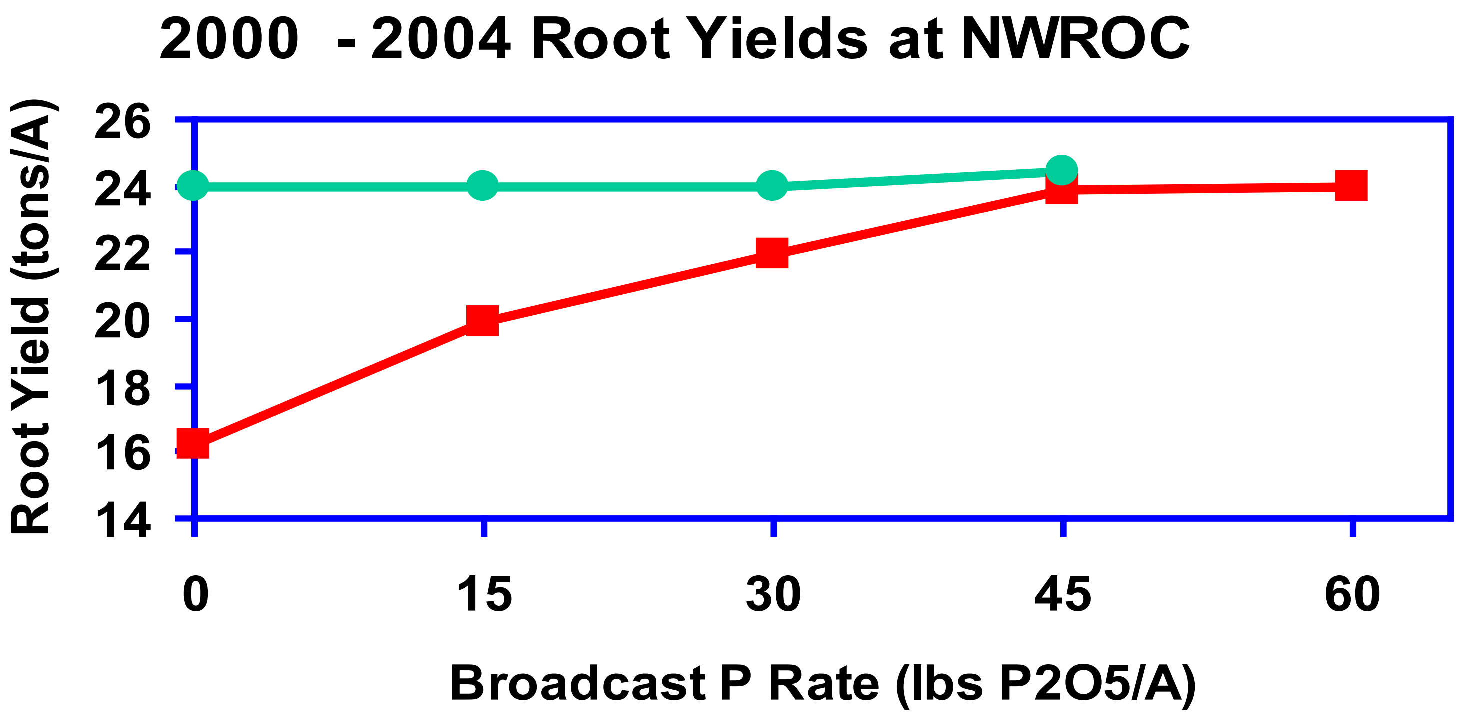
P. Hendrickson



Root systems of wheat (above)
and oil-seed rape (right)
(rape root image from
Pan et al., 2016, Annals of Botany)

According to Goos, spring wheat nearly always increases in yield with starter vs broadcast

Starter Fertilizer (Banded Phosphorus) on Sugar Beet
Compare 3 gal 10-34-0 rate to broadcast P



U of MN, 2000 – 2004, Dr. Sims

20 lb/acre P_2O_5 resulted in about 6 bushels per acre spring wheat yield increase regardless of soil test P.
(Goos/Johnson 2001)

Starter P for wheat was at least twice as efficient in yield increase as broadcast P (Bailey, Canada).

In canola, about 30 lb P_2O_5/acre resulted in yields similar to those with about 3 times the rate broadcast.
(Bailey & Grant, 1990)

Table 1. Maximum nitrogen fertilizer rates with small-grain seed at planting based on planter spacing, planter type and seedbed utilization.

		Planter Spacing							
		— 6 Inch —		— 7.5 Inch —		— 10 Inch —		— 12 Inch —	
Planter Type	Seed Spread	SU	lb N/Ac	SU	lb N/Ac	SU	lb N/Ac	SU lb	N/Ac
	(inches)	%		%		%		%	
Double disc	1	17	20-30	13	19-28	10	17-23	8	15-20
Hoe	2	33	32-44	27	27-38	20	23-31	17	20-27
	3	50	44-58	40	37-48	30	30-40	25	26-34
Air seeder	4	66	56-72	53	46-58	40	37-48	33	32-42
	5	83	68-86	68	56-68	50	44-57	44	38-49
	6	100	80-100	80	66-79	60	51-55	50	44-56
	7			94	76-90	70	58-74	58	50-64
	8					80	66-83	67	56-71
	9					90	73-92	75	62-78
	10					100	80-100	83	68-86
	11							92	74-93
	12							100	80-100

SU = Seedbed utilized

Table 3. Maximum rates of seed-placed N + K_2O for canola and mustard.

Soil Texture	Disc or Knife (1-inch spread) Row Spacing			Spoon or Hoe (2-inch Spread) Row Spacing			Sweep (4- to 5-inch Spread) Row Spacing		
	6 in.	9 in.	12 in.	6 in.	9 in.	12 in.	6 in.	9 in.	12 in.
	- - - - - - - - - - - - - - - - lbs N + K_2O / A - - - - - - - - - - - - - - - -								
Light	5	0	0	20	15	10	30	20	15
Medium	10	5	5	25	20	15	35	25	20
Heavy	15	10	5	35	25	20	45	30	25

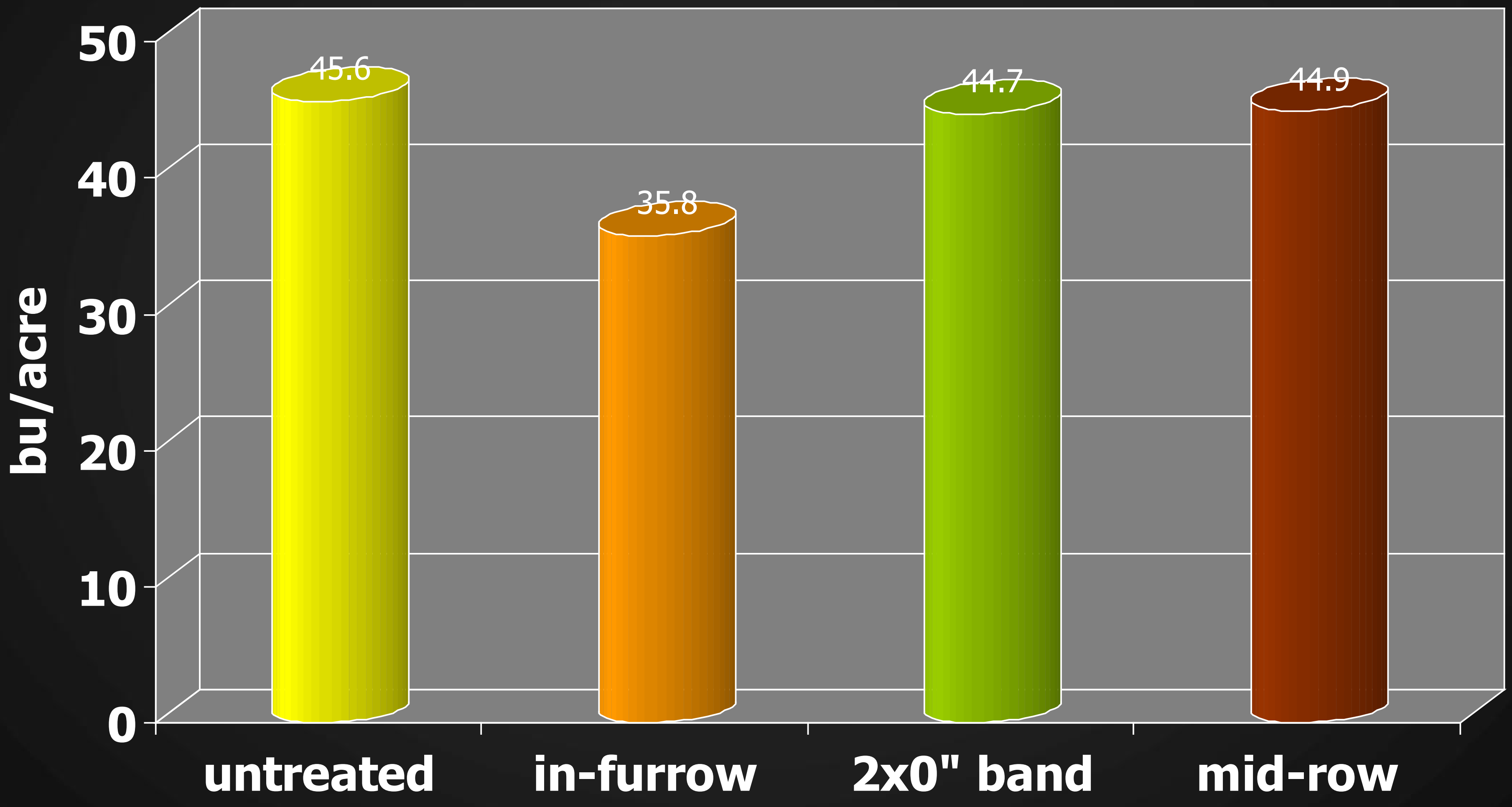
Risk of germination loss is similar for
‘low-salt’ (white-phosphorus based)
and ‘high-salt’ (10-34-0 based)
starter fertilizer liquid formulations

The N source in low-salt formulations
is urea, which is as harmful to seed as salt.

CREC In Furrow Soybean

Application Method	Stand 1,000 plants/ac	Yield bu/ac
Check	**187.5a**	**32.8a**
2x2 4gal/ac	**188.6a**	**33.5a**
In furrow 4 gal/ac	**133.2b**	**24.5b**
In Furrow 8 gal/ac	**120.6b**	**18.9c**
LSD 5%	**16.5**	**4.3**
Endres and Hendrickson, 2008		

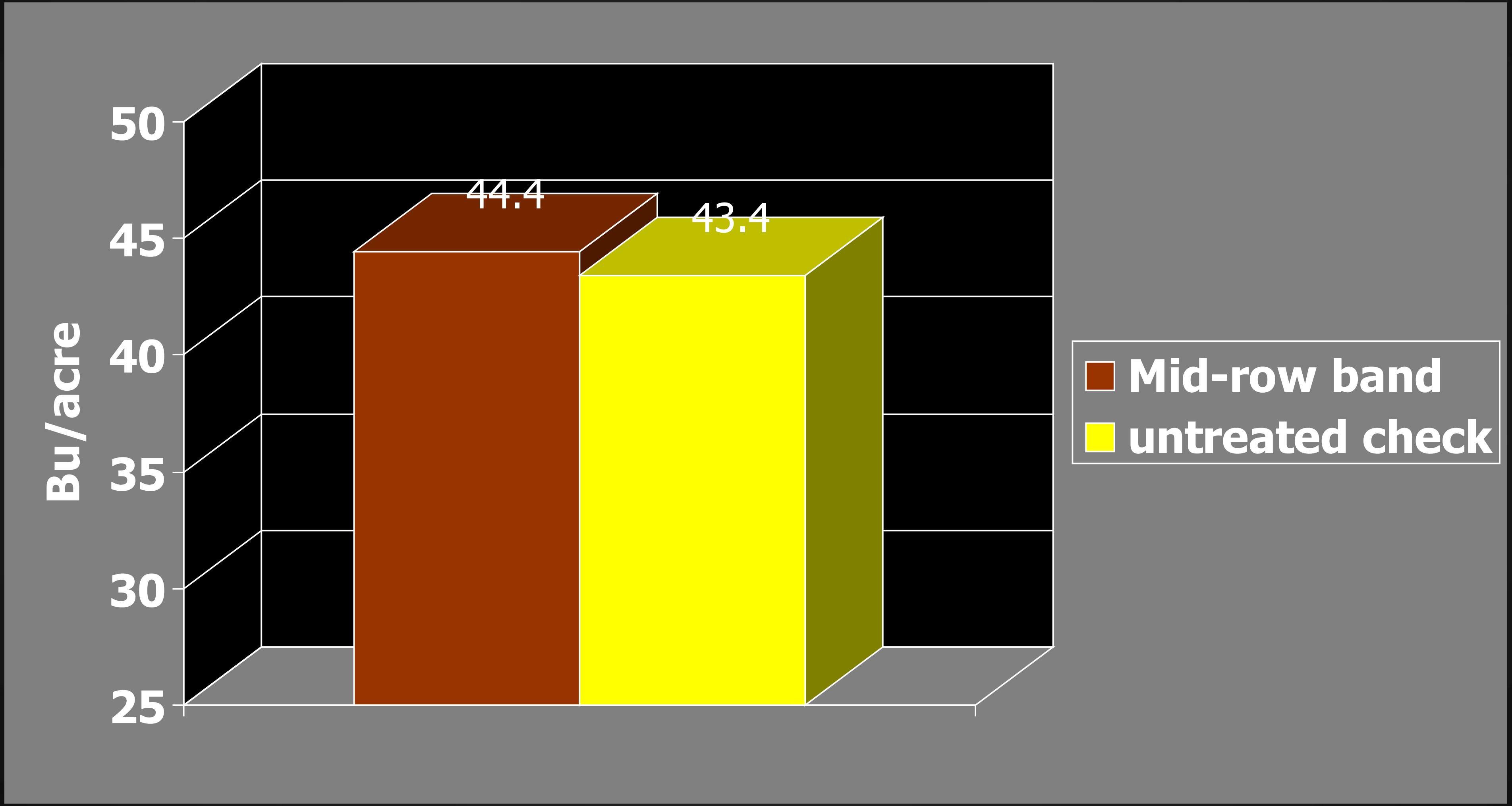
Soybean yield among fertilizer placement methods, Carrington, 2009-10*.



*Strip till; 30-inch rows; 4 or 6 gal/A 10-34-0 during planting.
Statistically significant (LSD=0.05): 2009 and 2010.

Endres and Hendrickson

Soybean yield with MID-ROW P placement, Carrington, 3 site-yr (2009-11)*.

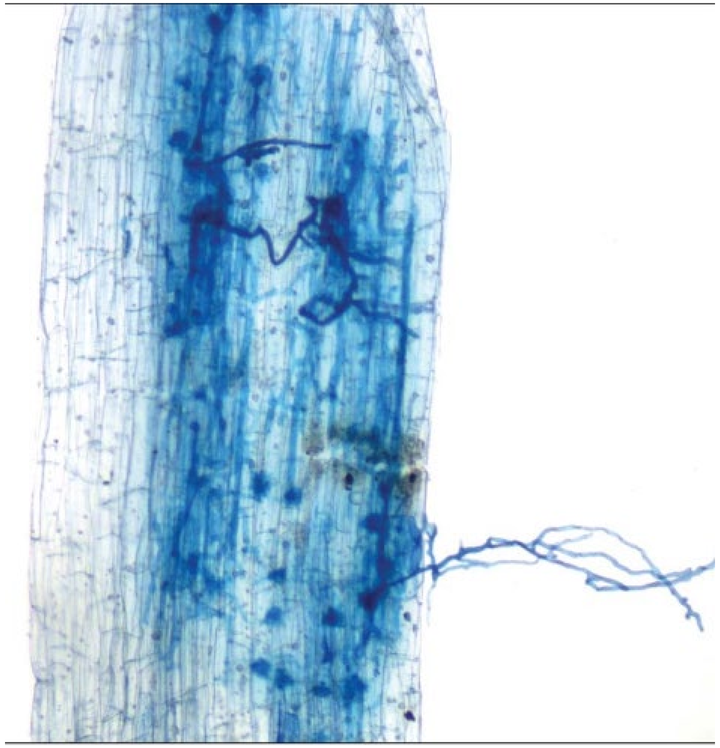


*2009-10: 30-inch rows, med P soil, 4 or 6 gpa 10-34-0; 2011: 22-inch rows, med soil P, 10 gpa 6-24-6

G. Endres and P. Hendrickson

Mycorrhiza aids greatly in acquiring P

Crops in Amaranthaceae (sugar beet)
and Brassicaceae
(canola, mustard, radish, turnip)
do not support mycorrhiza



Planting corn after requires starter,
and perhaps greater rate than normal

Flax should not be planted after these crops

Sunflower and Flax

Sunflower and flax do not require supplemental P fertilizer regardless of soil test. No yield increases have been seen in regional P rate trials with either crop. Sunflower work in ND was conducted 2014-15 on 30+ sites.

Soil P values were as low as 2 ppm.

Yes Virginia, buckwheat can provide P to a subsequent crop.

NDSU work (Teboh and Franzen) found that fractionation of soil P pools after buckwheat reduced the Ca-P pool and increased inorganic P pool (more available).

Crop advantage to banded P at planting-

Benefit-

Corn Small Grains Canola Potato Sugarbeet

No Benefit-

Soybean Lentil Field Pea Chickpea

Might it pay to increase soil test P?

Corn yield as affected by soil P test and P placement

Treatment		P Test	
Rate low/high	Placement	Low	VH
lbs P_2O_5/acre		- - - - bu/A - - - -	
0	--	148	193
50/40	Deep-band[1/]	166	186
50/40	Pop-up	166	194
50/40	Broadcast	167	190
50/40	DB + Pop-up	172	189

[1/] 6-7” below soil surface under row.

From Randall, University of Minnesota

Randall's findings on placement to corn and differences between L and VH soil test P

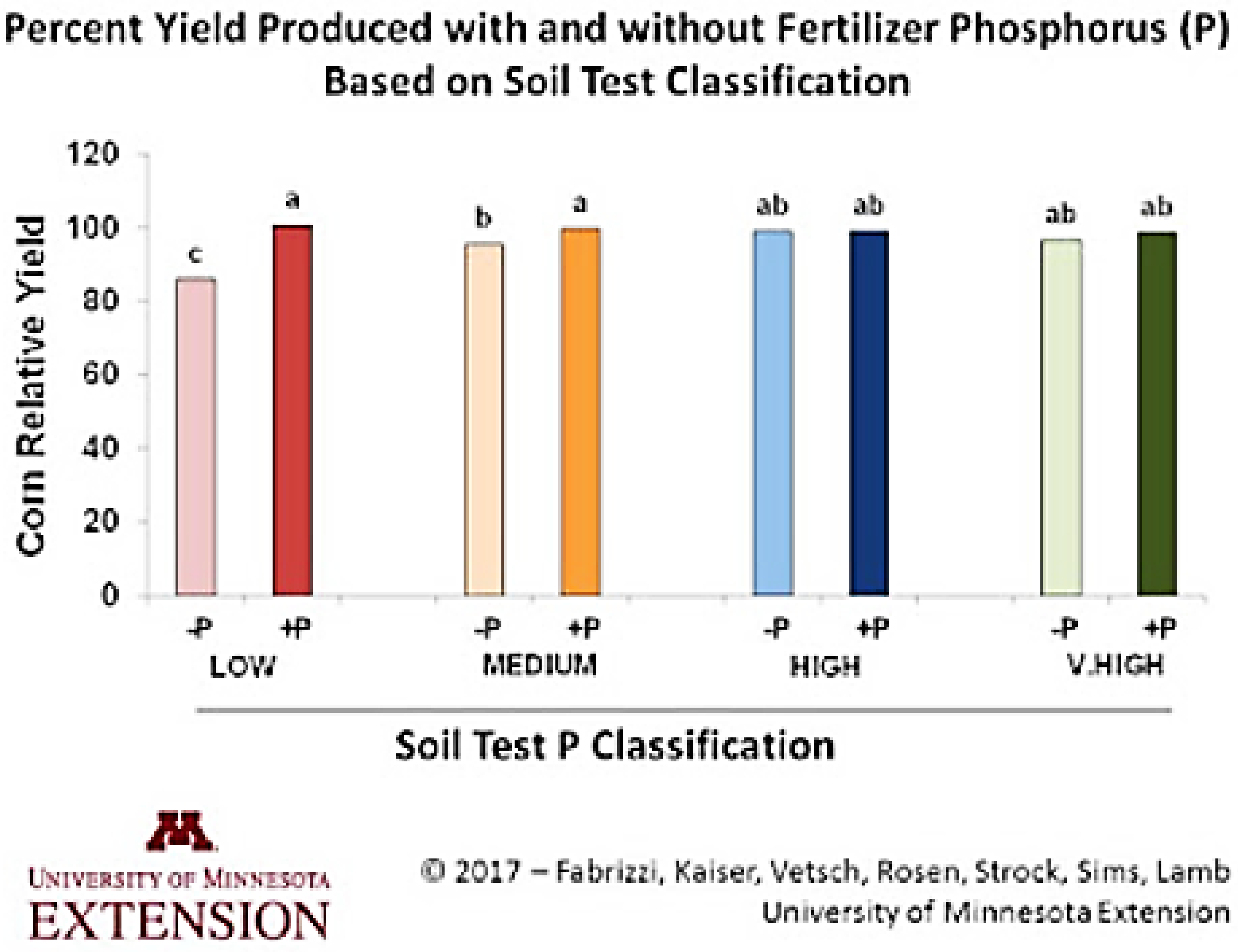
3 sites averaging 25 ppm Bray P (VH)

were compared to

3 sites averaging 7 ppm Bray (L)

Economic penalty for Low P was $140-175 /acre/ year

University of MN corn, fertilized with 150% of U of MN recommended P rates



Let's figure a soil in a corn soybean spring wheat sugarbeet rotation.

-Starting soil test 5 ppm Olsen.

-Goal is 15 ppm Olsen.

--Glyndon soil - ~ 5% by weight $CaCO_3$ in surface 6 inches

-Cost of buildup P is 50 cents /lb P_2O_5

Estimated increase in P test is

1 ppm per 80 lb P_2O_5 applied over needed rate

Extra rate required- 10 ppm X 80 = 800 lb P_2O_5

800 lb P_2O_5 X 50 cents/lb P_2O_5 = $400/acre

Return from higher P test?

Corn- once achieved, perhaps 20 bu/acre/year
Soybeans, ND, perhaps 5 bu/acre/year
Sugarbeet, perhaps 5% increase/acre/year
Spring wheat, perhaps 10% increase/acre/year

Corn ($6/bu) $120/a/yr benefit
Soybean ($10/bu) $50/a/yr benefit
Sugarbeet ~ $40/a/yr benefit
Spring wheat ($6/bu) $30-75/a/yr benefit

If applied over a 4-year period, requires extra $100/acre per year input.

If crop fails (too much water, drought, other)

The application may strain a budget.

Crop insurance will help with a ‘floor of funding’, but will not consider your extra input.

Buildup Maintenance-

Why the different strategies?

Buildup/Maintenance makes sense when risk of crop failure is low

Sufficiency/Response-based makes sense when crop failure is frequent (North Dakota, NW MN, NE SD)

Sufficiency Approach

- Short-term returns are most important consideration

- Frequent soil testing for P is important, as is the economics of the application, requiring accurate calibration of rate, and efficient application methods.

- Beneficial for soil that limit P availability due to tie-up

Buildup/Maintenance-based P Management

- Long-term productivity is most important
- Once ‘H’ is reached, the fields are less sensitive to errors in soil sampling
- Soil sampling may be conducted less often
- May not be suitable for soils with fixation chemistry
- Attaining H is probably not reasonable for short-tenure land

- Provides opportunity for rate reduction once attained when P fertilizer costs are high relative to crop price

So what might you do?

If fields are not likely to fail, and you are in a corn/bean rotation, or they dominate your rotation building soil test may result in long-term benefits.

If the soil tends to tie-up P (pH less then 5.8, greater than 7) buildup may not be a great choice, because more P is required to build each soil test increment.

North Dakota Crop Nitrogen Recommendation Calculators

SUNFLOWER | SPRING WHEAT & DURUM | CORN | ABOUT

Sunflower Nitrogen Calculator

closest sunflower price ($/lb)

0.36

closest nitrogen cost ($/lb)

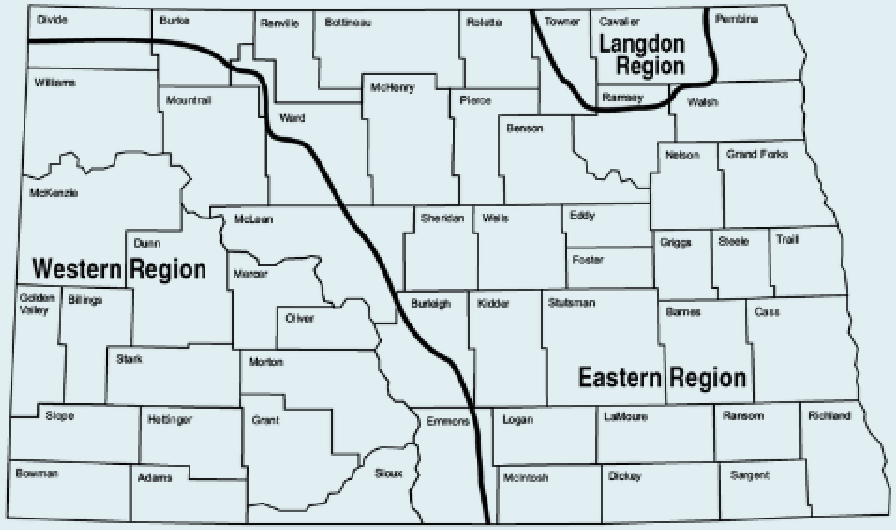
0.6

percent organic matter in soil (%)

0

2-ft depth soil test nitrate-N (lbs/acre)

0

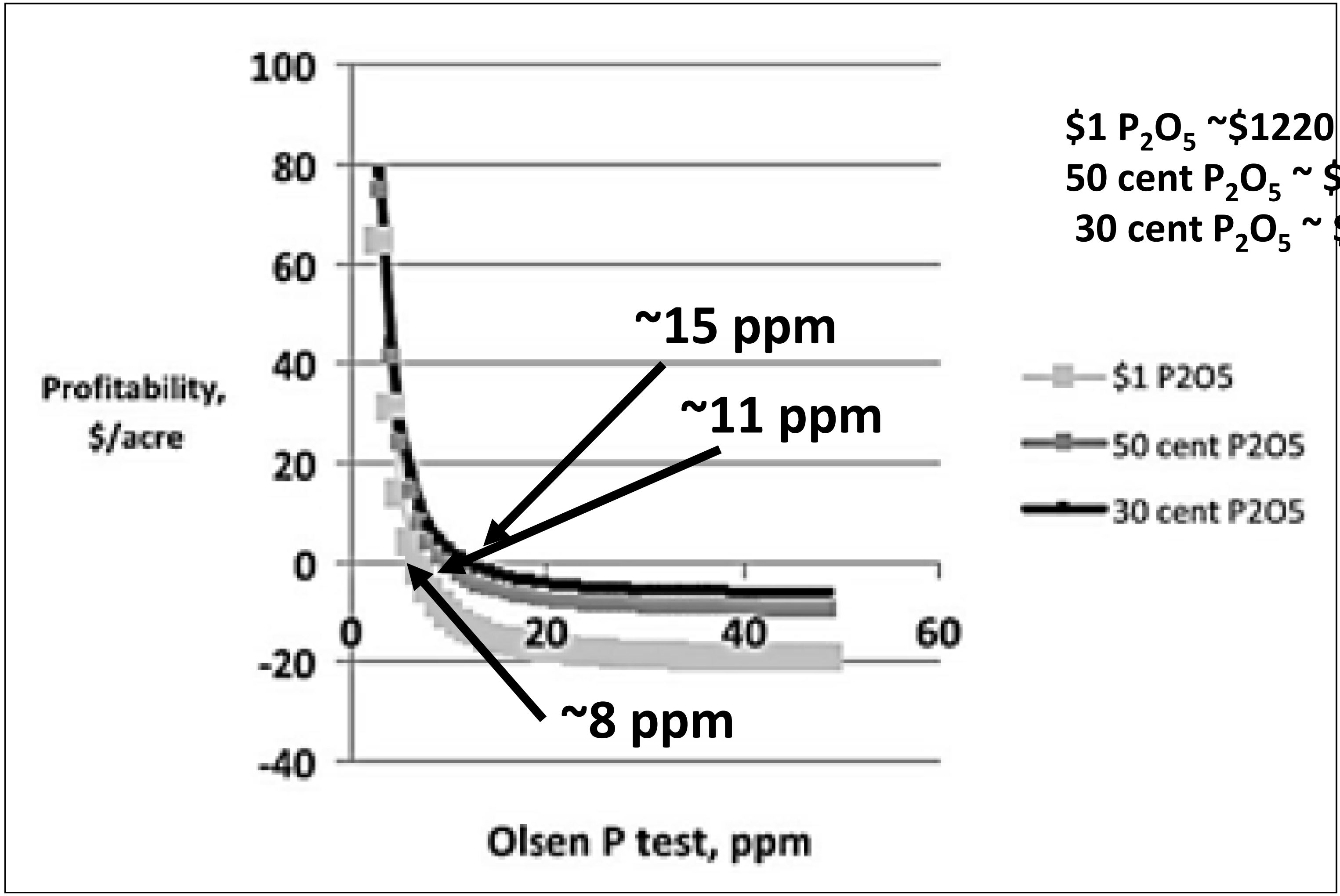


region in North Dakota

- (●) Western Region
- ( ) Eastern Region
- ( ) Langdon Region

tillage type

- (●) conventional tillage
- ( ) minimal no-till
- ( ) long-term no-till



$1 P_2O_5 ~$1220 MAP
50 cent P_2O_5 ~ $610 MAP
30 cent P_2O_5 ~ $365 MAP

Presently P_2O_5 about $800-900?

Figure 4. Profitability of using P for $6/bushel wheat at 30 cent/pound of P_2O_5, 50 cent/pound P2O5, and $1/pound P_2O_5. From Halvorson (1978).

Summary of Main points-

Nitrogen

Strategy should be to minimize leaching, ammonia and denitrification losses

Use of the N calculator for your state incorporates return into rate strategy

Placement decision might require a urease inhibitor or distance from intended seed.

Summary of Main points-

Phosphorus

- P fertilizer will always tie up in any soil.
- P available does not decrease always with greater pH
- Starter P is very efficiently used in some crops, not all
- Strategy for Sufficiency and Buildup/Maintenance requires consideration of frequency of crop failure, P cost, ability of soil to strongly fix P, and general economic condition of farmer and land tenure status

Dave Franzen

701-799-2565

david.franzen@ndsu.edu