Fertilizer Use for High Yield Corn

Charles S. Wortmann
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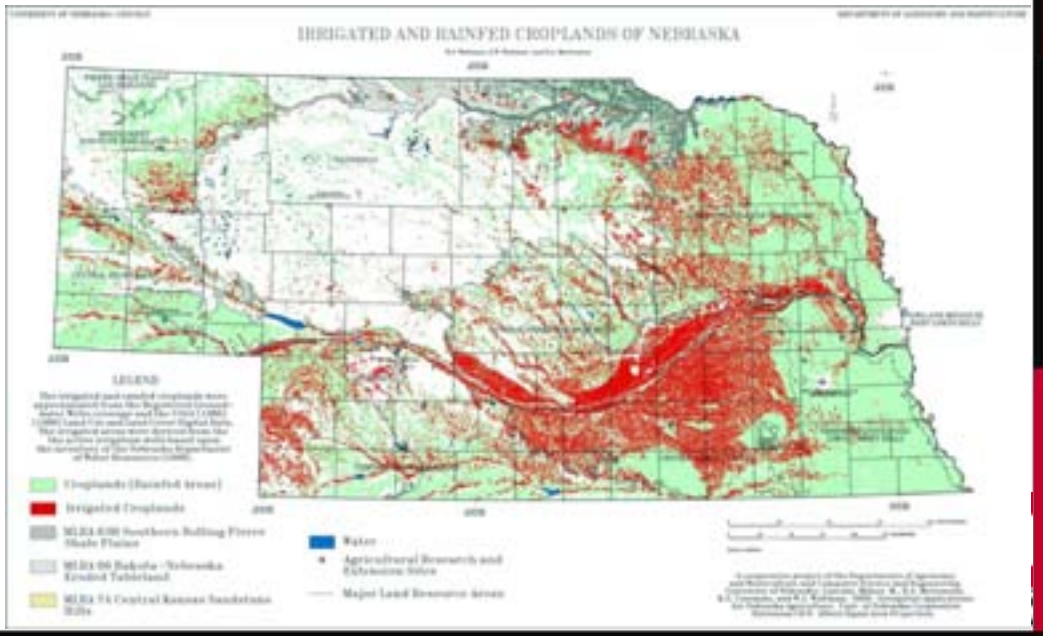
High Yield Corn: Topics

- Economically optimal N rates
- N use efficiency
- P, K, S
- Implications of 2012 drought



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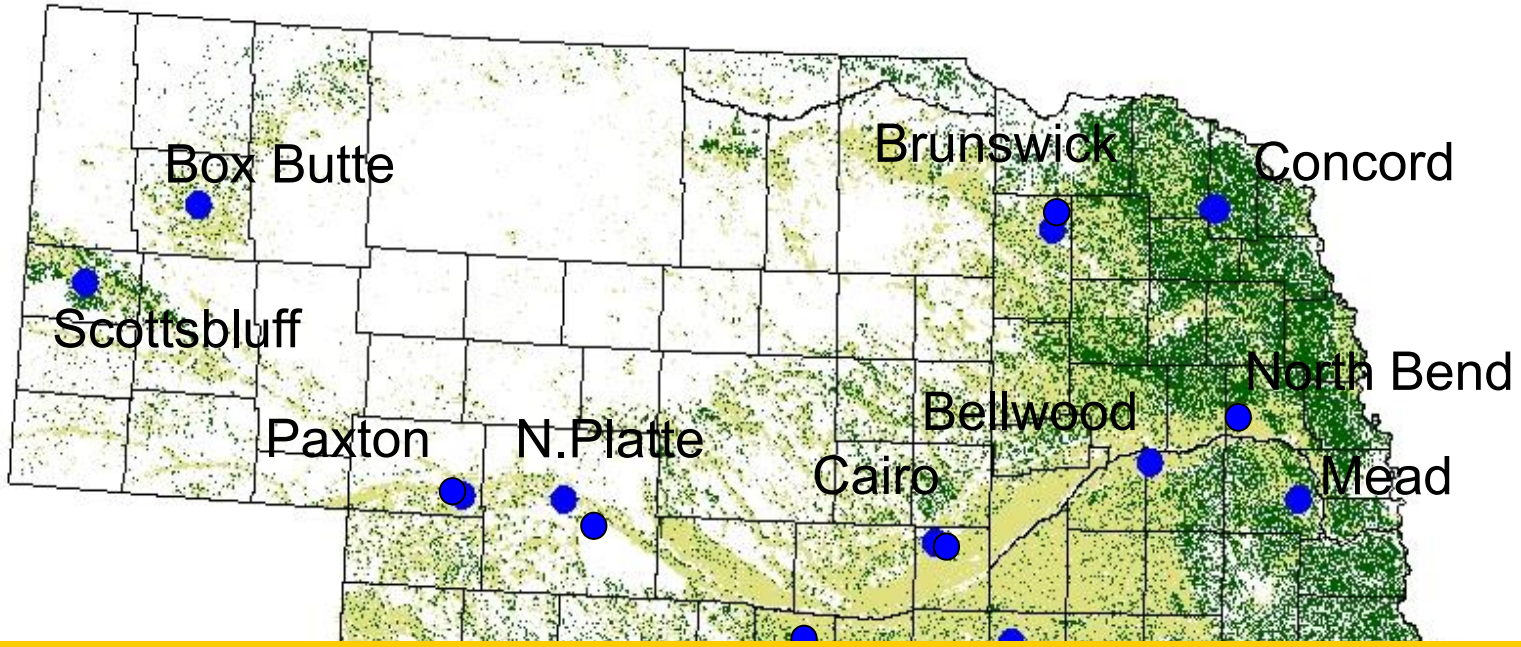


34 site-years (13 on-station, 21 on-farm), all irrigated

corn following soybean	16
corn following corn	13
corn following dry bean	5

No-till: 11, Ridge-till: 9, Conv. Till.: 14

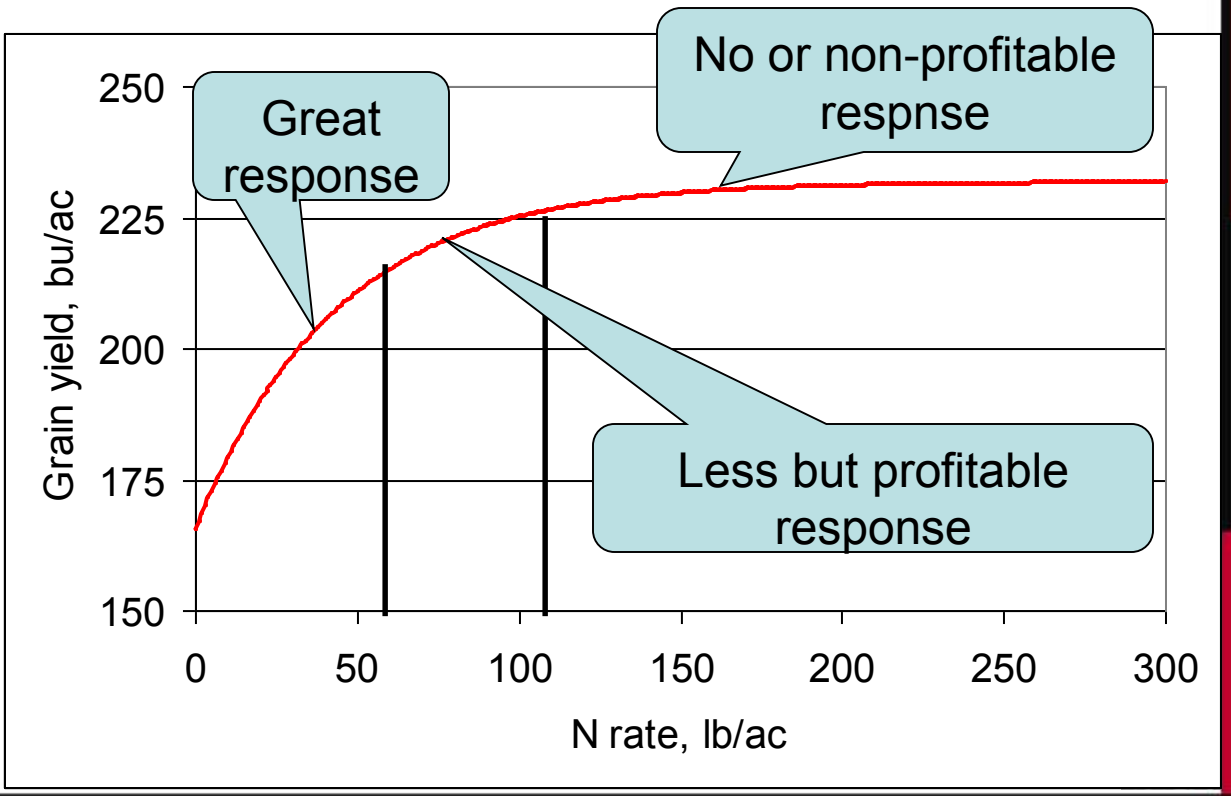
Max. treatment mean = 240 bu/ac

NSFP sites 2002-2004

NSFP Treatments

Treatment		lb N/acre		lb P_2O_5/acre	lb K_2O/acre
		C-C	C-S		
1	$N_0P_1K_1$	0	0	41	43
2	$N_3P_0K_1$	200	150	0	43
3	$N_3P_1K_0$	200	150	41	0
4	$N_1P_1K_1$	100/125	50/75	41	43
5	$N_2P_1K_1$	150/175	100/125	41	43
6	$N_3P_1K_1$	200/225	150/175	41	43
7	$N_4P_1K_1$	300	250	41	43
8	$N_4P_2K_2$	300	250	82	86
9	UNL	75-235	0-175	0-40	0-40
10-12	optional				

Response to applied N is a typically curvilinear-plateau response



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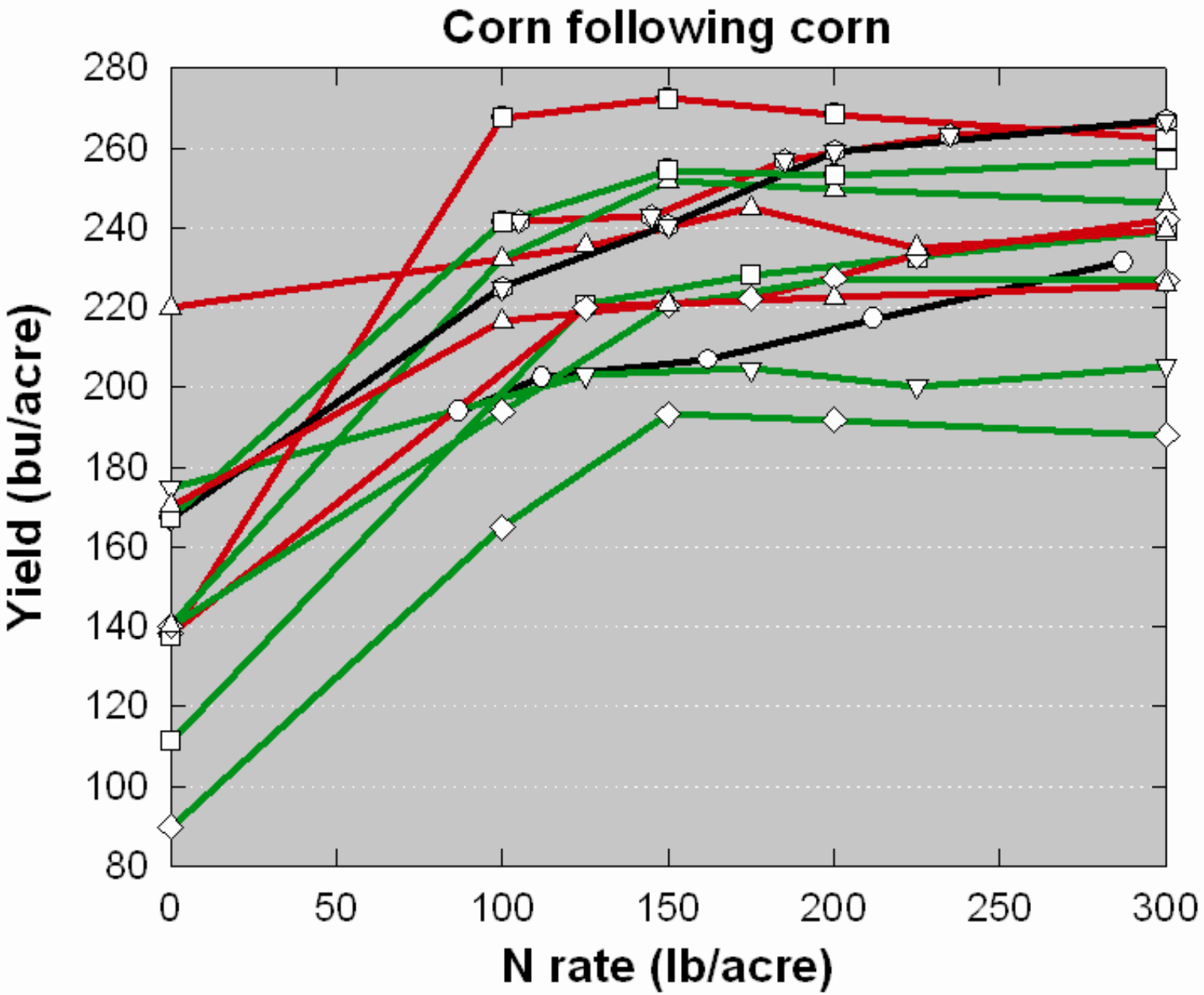

Nebrask
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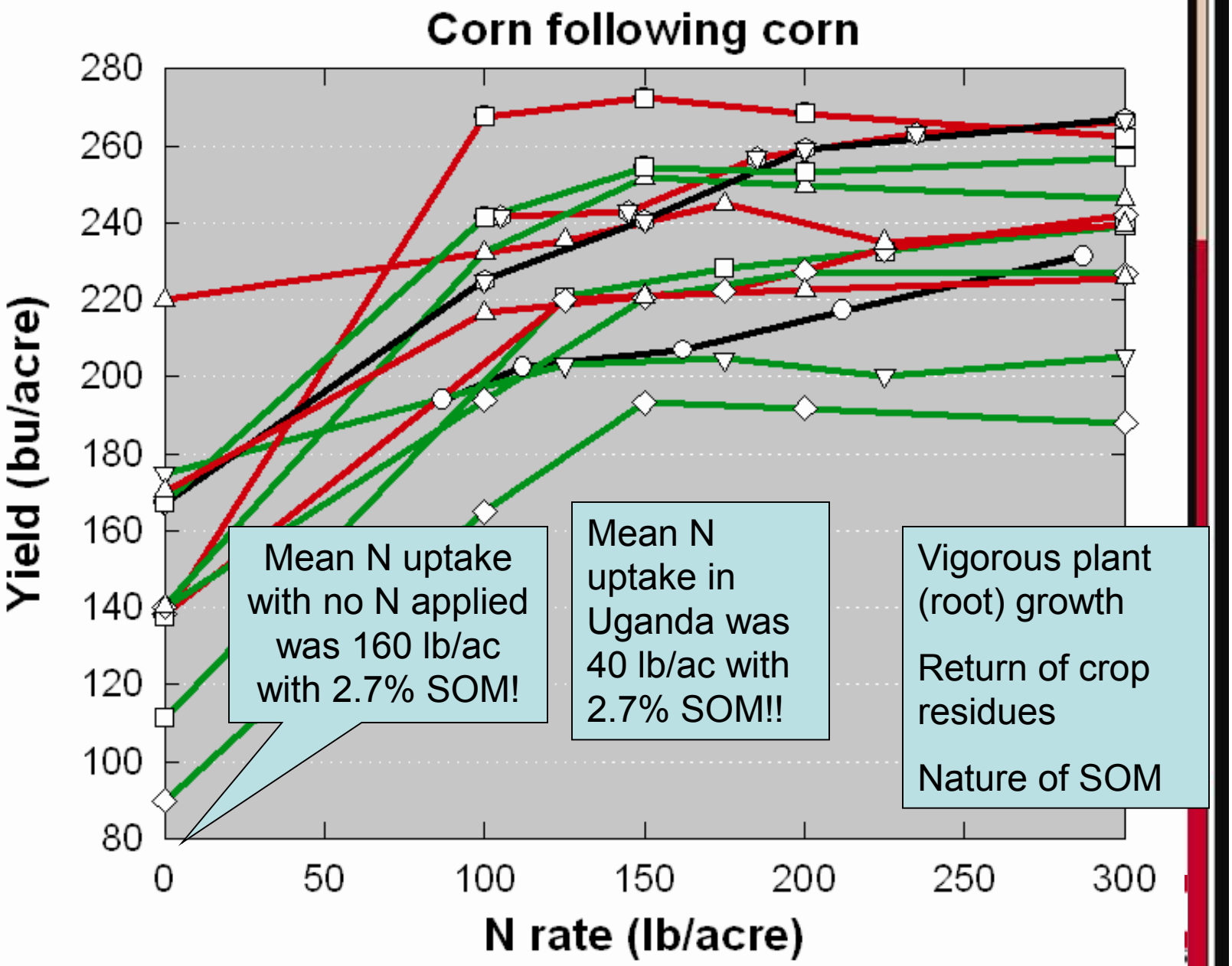

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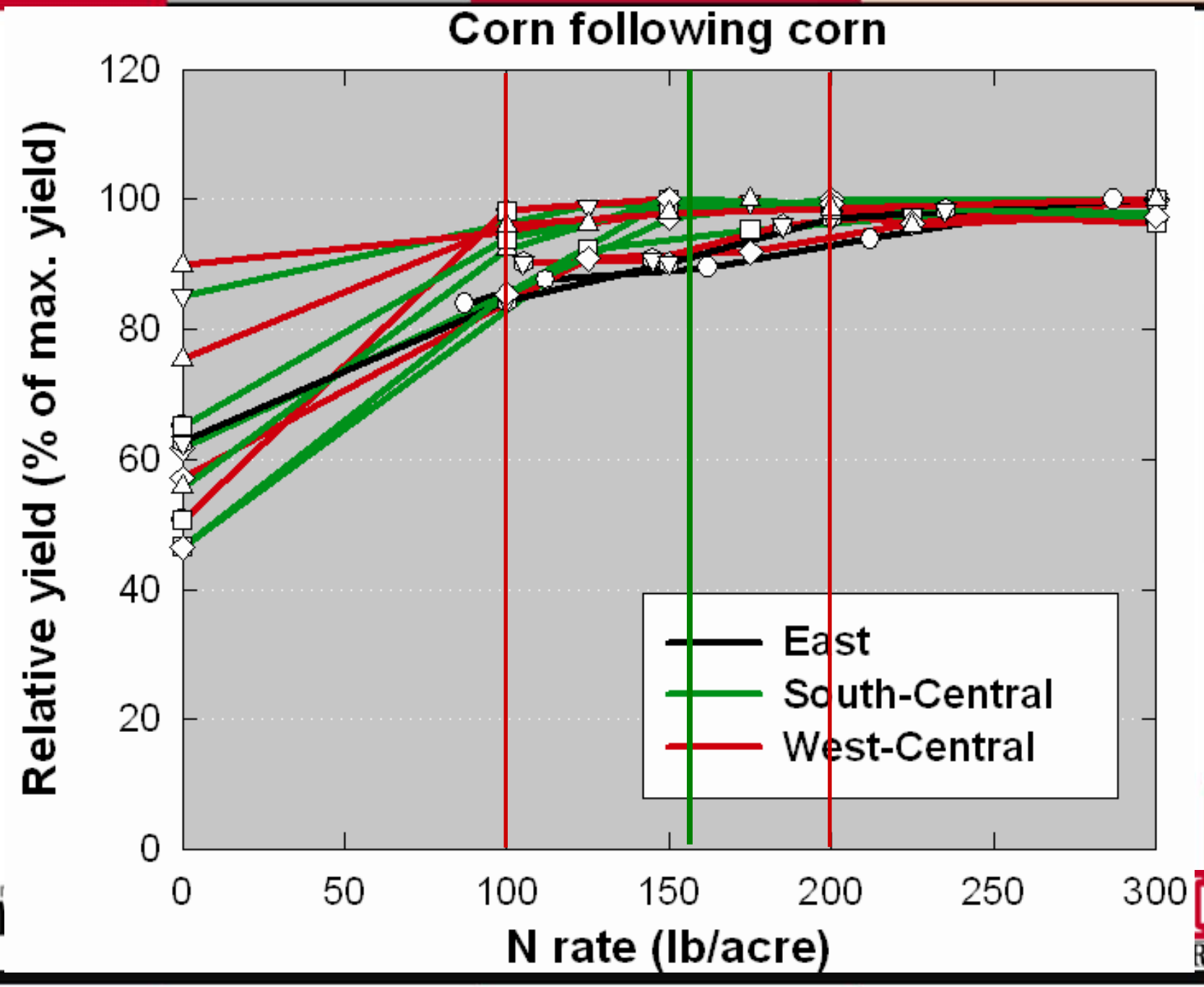
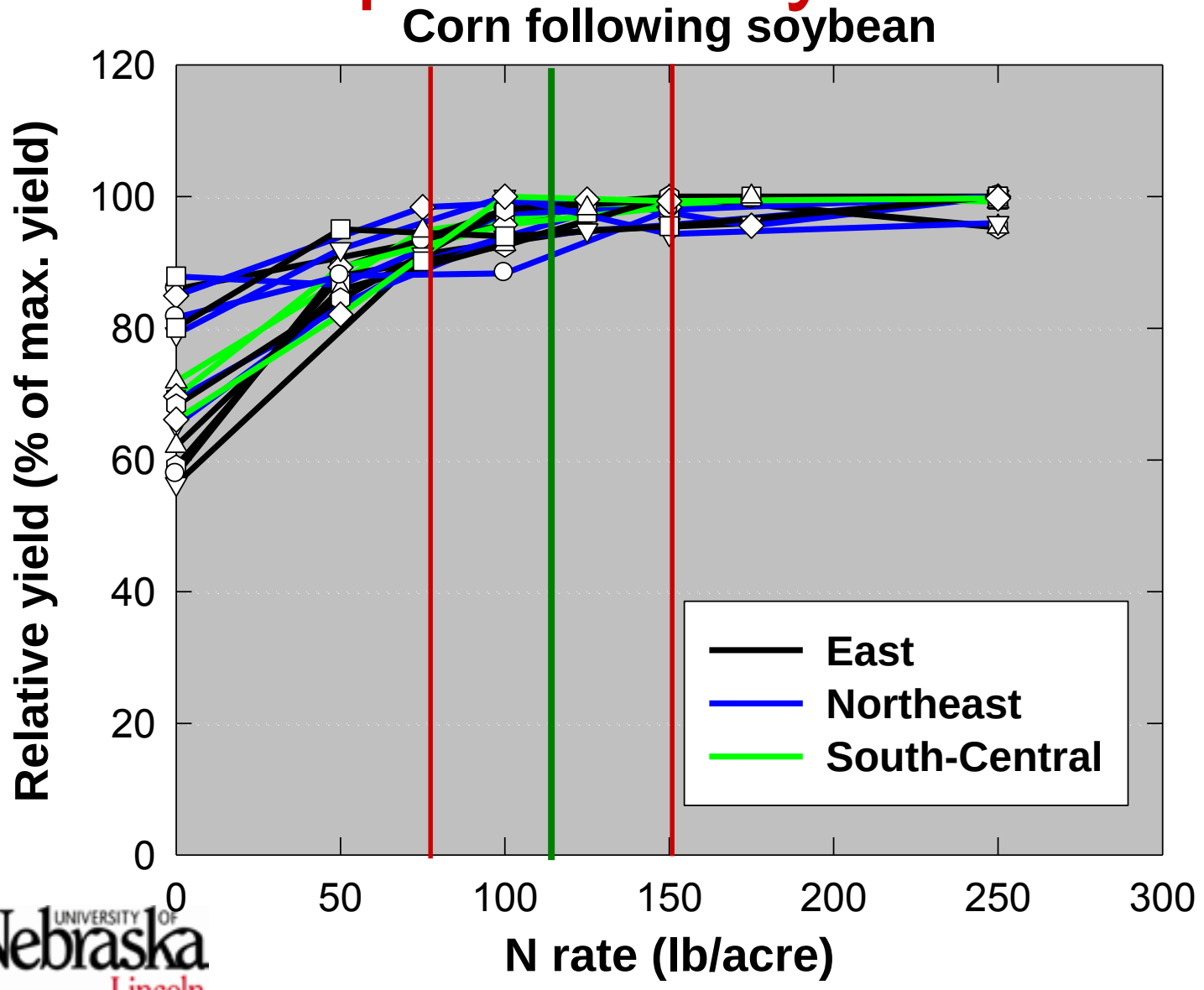

Corn following corn
Relative yield (% of max. yield)
120
100
80
60
40
20
0
0
50
100
150
200
250
300
N rate (lb/acre)
East
South-Central
West-Central

N response: soybean - corn



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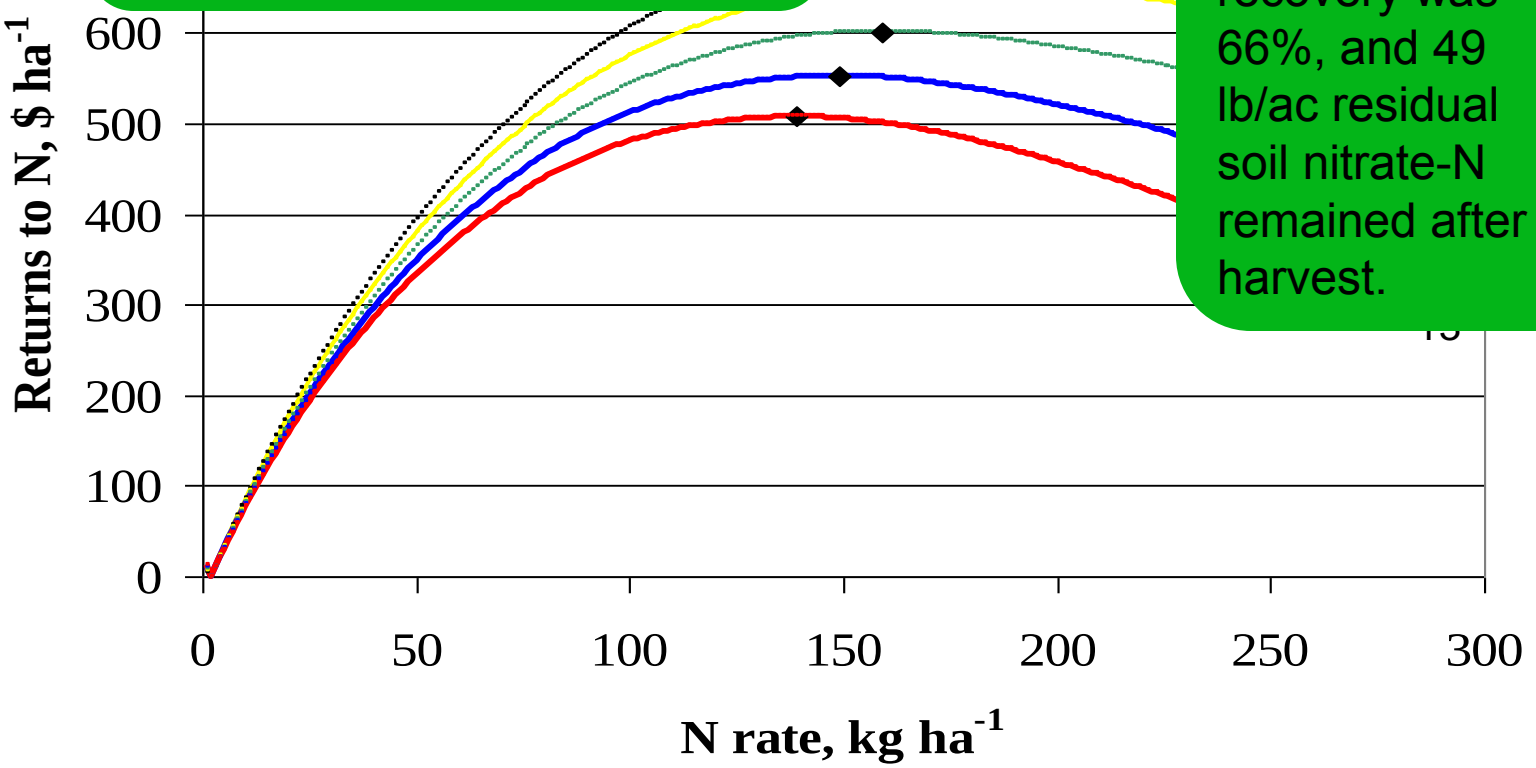
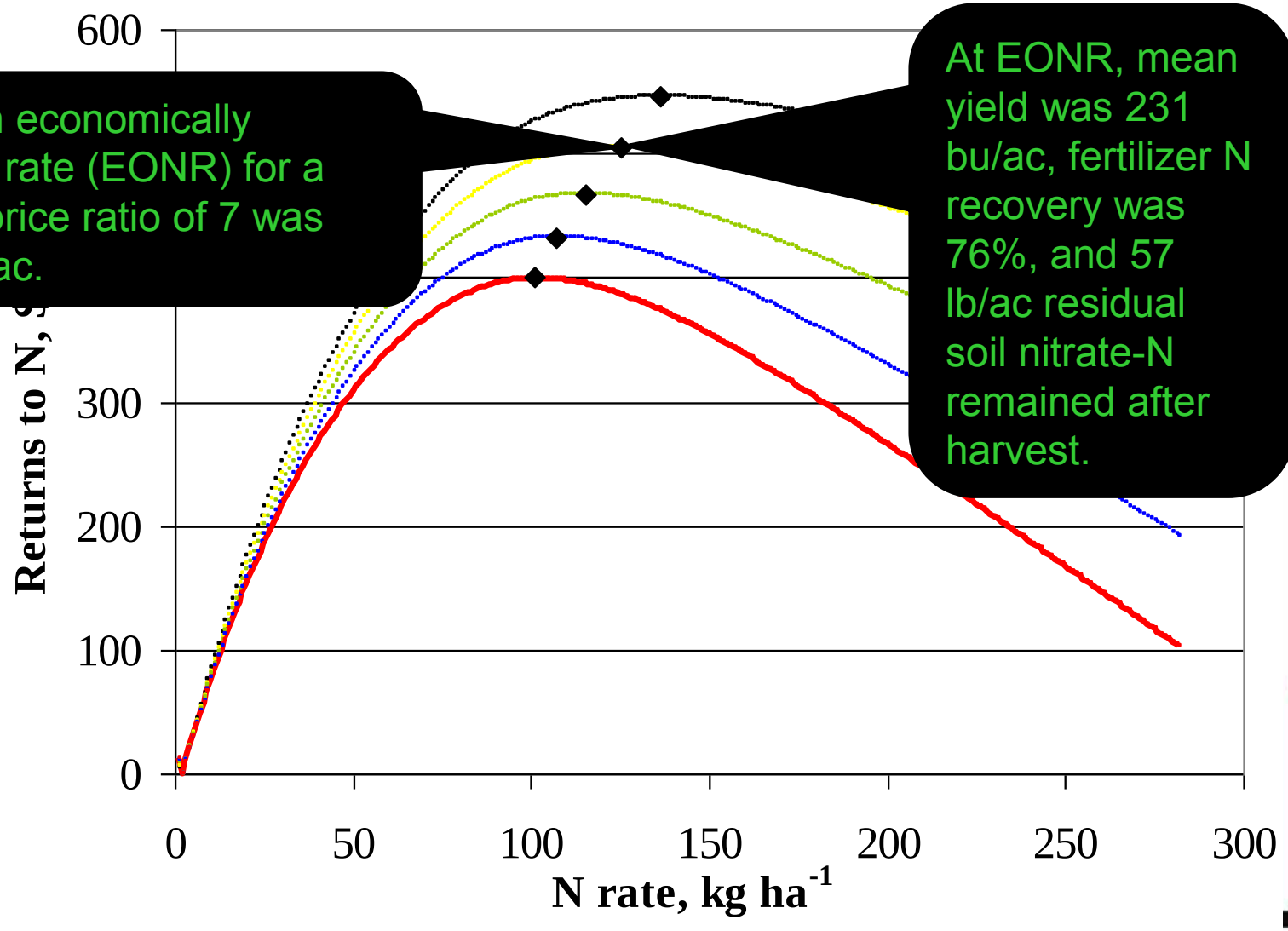
N response at 5 N:grain price ratios for corn following corn

The mean economically optimal N rate (EONR) for a N:maize price ratio of 7 was 158 lb/ac N.

At EONR, mean yield was 237 bu/ac, fertilizer N recovery was 66%, and 49 lb/ac residual soil nitrate-N remained after harvest.



N response at 5 N:grain price ratios for corn following soybean



The mean economically optimal N rate (EONR) for a N:maize price ratio of 7 was 111 lb N /ac.

At EONR, mean yield was 231 bu/ac, fertilizer N recovery was 76%, and 57 lb/ac residual soil nitrate-N remained after harvest.

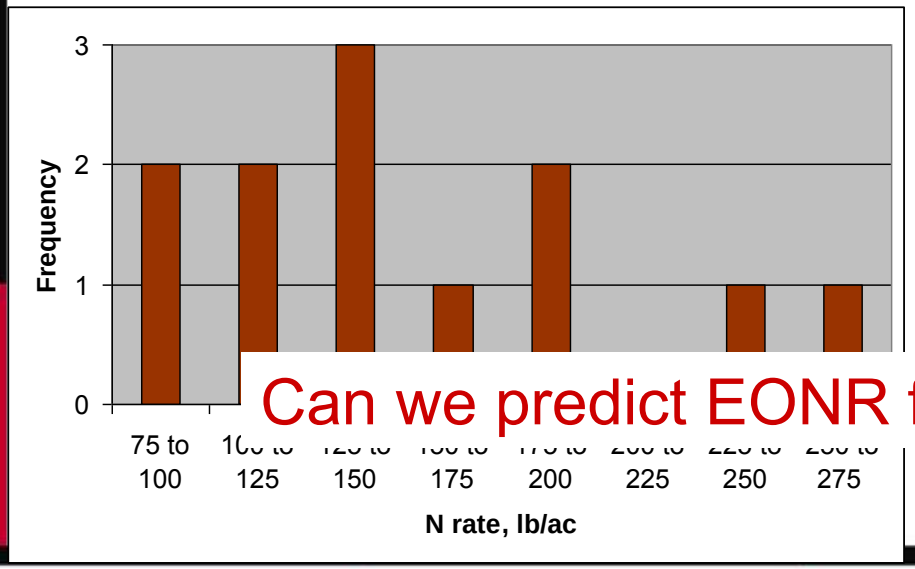
EONR distribution

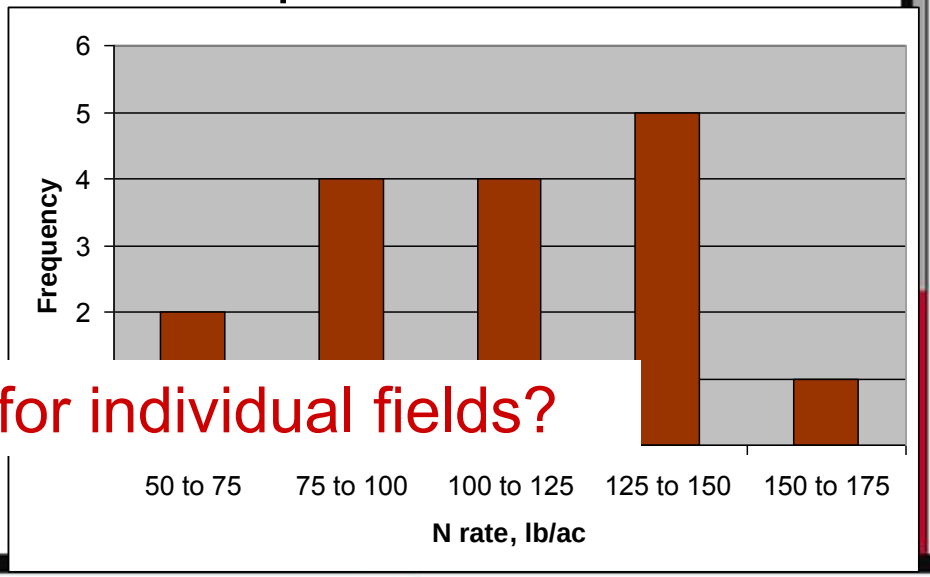
Corn-corn, 12 site-yr

- Mean = 156 lb/ac N
- Minimum = 91
- Maximum = 240
- Low 25% ≤ 114
- Top 25% ≥ 171

Soy-corn, 16 site-yr

- Mean = 111 lb/ac N
- Minimum = 72
- Maximum = 150
- Low 25% ≤ 93
- Top 25% ≥ 128





Can we predict EONR for individual fields?

UNL Nitrogen Corn Recommendation

N Rate (lb/acre) = 35 + (1.2 x EY) – (8 x NO_3-N) – (0.14 x EY x OM).

EY = Expected yield (bu/acre)
NO_3-N = Root zone residual nitrate-N (ppm)
OM = Soil organic matt

Additional credits for le
irrigation water subtrac
Adjustment for fertilizer
Adjustment for time of a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Fertilizer Suggestions for Corn

Charles A. Shapiro, Richard B. Ferguson, Gary W. Hergert, and Charles S. Wortmann, Extension Soils Specialists; Daniel T. Walters, Professor of Agronomy and Horticulture

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depth of 0 - 8 inches every three to five years in the fall. Most Nebraska soils supply adequate amounts of K, sulfur, zinc, and iron, but on some soils the corn crop will benefit from applying

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Corn Nitrogen Rate Calculator

Finding the Maximum Return To N and Most Profitable N Rate

A Regional (Corn Belt) Approach to Nitrogen Rate Guidelines

This web site provides a process to calculate economic return to N application with different nitrogen and corn prices and to find profitable N rates directly from recent N rate research data. The method used follows a newly developed regional approach for determining corn N rate guidelines that is being implemented in several Corn Belt states.

Regional Corn N Rate Publication

Single Price Ratio | Multiple Price Ratios

V. 1.20c

Choose state

- Iowa
- Illinois - North
- Illinois - Central
- Illinois - South
- Minnesota
- Wisconsin – VH/HYP Soils
- Wisconsin – M/LYP Soils
- Wisconsin – Irr. Sands

Choose rotation pattern(s)

- (•) Corn following soybean
- ( ) Corn following corn

☐ Include non-responsive sites

Set corn and nitrogen prices

Anhydrous Ammonia (82% N)	360.80	($/Ton)
Nitrogen price	0.22	($/lb N)
Corn price	2.20	($/bu)

Calculate | Reset

More Info | How to Use

Why the components in Nebraska N equation?

- Yield goal: varies from <50 to >250 bu/ac in NE but maybe 140 to 220 bu/ac in IA
- Residual soil nitrate-N: less likely to be lost in NE to leaching and denitrification compared with IA, especially where rainfall is less
- SOM: varies from 0.5 to >3% in NE but maybe 2.0 to >3% in IA

Prediction with the UNL algorithm

- On average, it was very close
  - Within 5 lb/ac N for S:C
  - About 12 lb/ac over for C:C
- However, much site-year variation in N effect on yield and N uptake
  - predicted and actual EONR not well-related
  - components of algorithm were not well related to yield and N uptake response to N rate
- In-season assessment and application probably needed to approach EONR

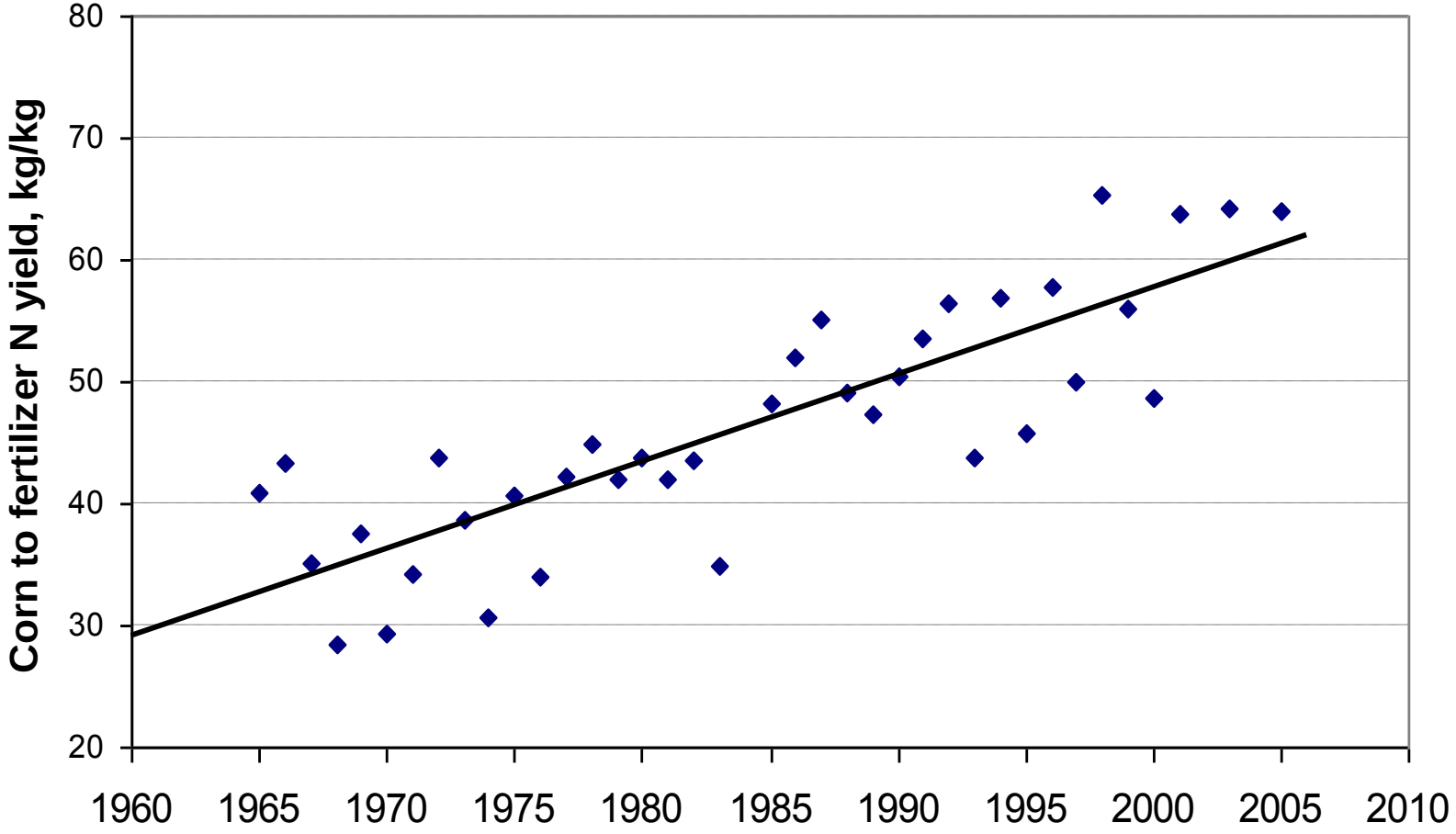
Nitrogen use efficiency:

more bu/lb and less loss;

is high NUE compatible with high yield?

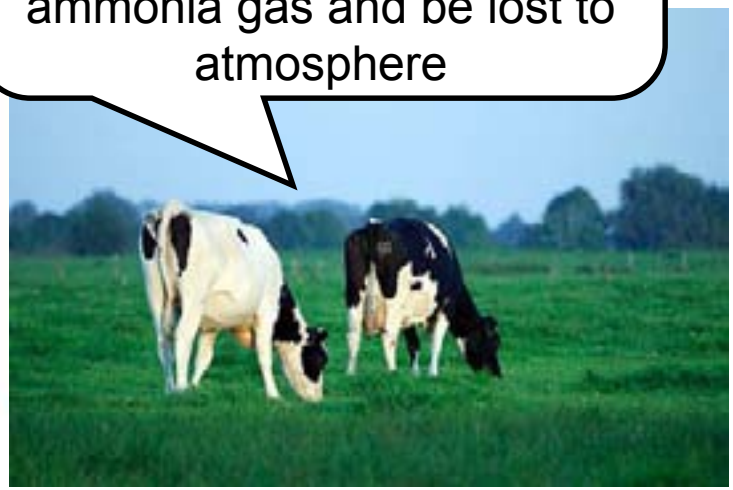
Nitrogen use efficiency

Corn produced per lb applied N has doubled since 1960.



Nitrogen Losses

Volatilization: surface applied manure or fertilizer ammonium N may convert to ammonia gas and be lost to atmosphere



Runoff: causes N loss and water contamination

Denitrification: reduction of nitrate-N to N_2 or nitrous oxide under low O_2 conditions

Leaching of nitrate-N below the rooting zone

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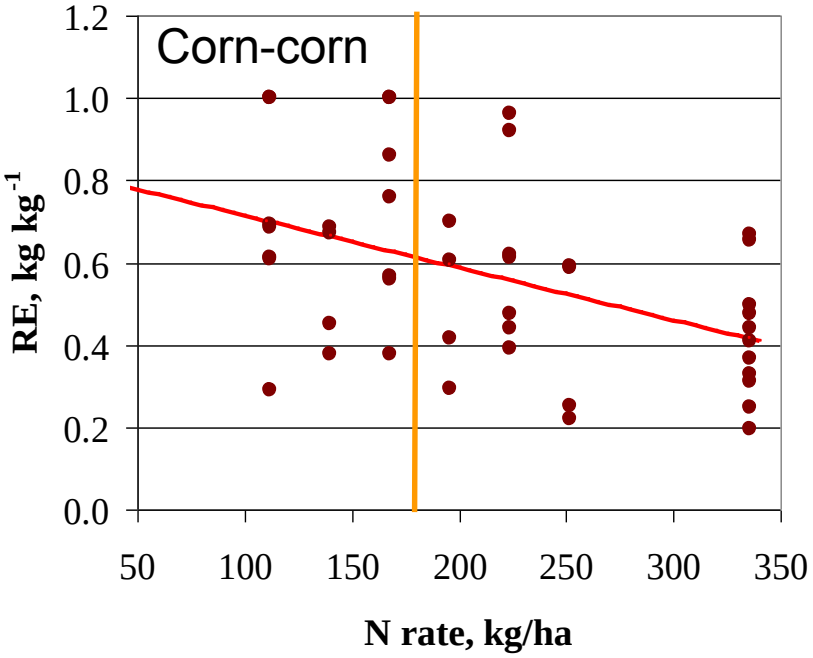
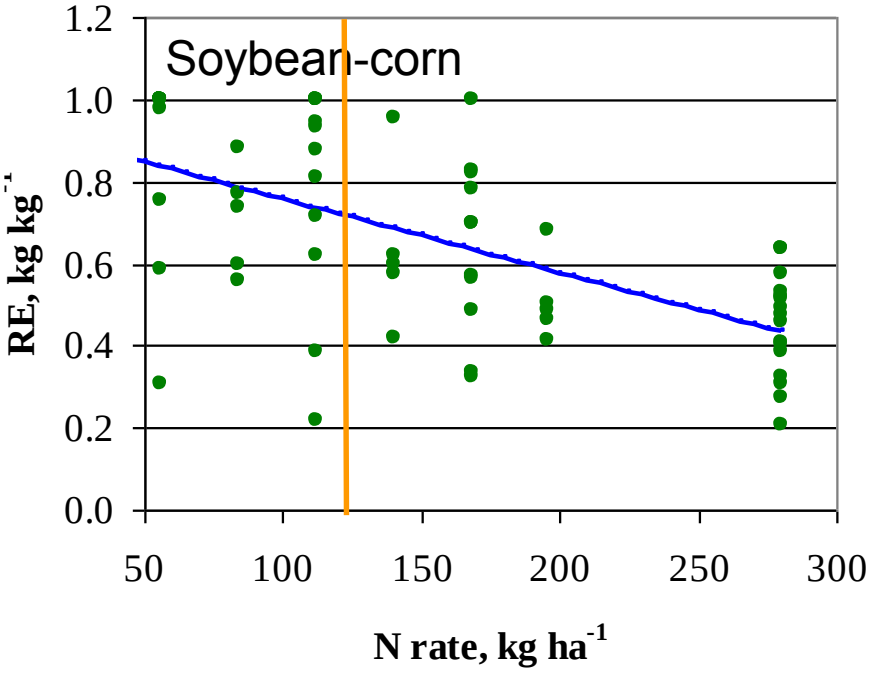
Fertilizer N recovery efficiency

National average is less than 0.4 lb/lb





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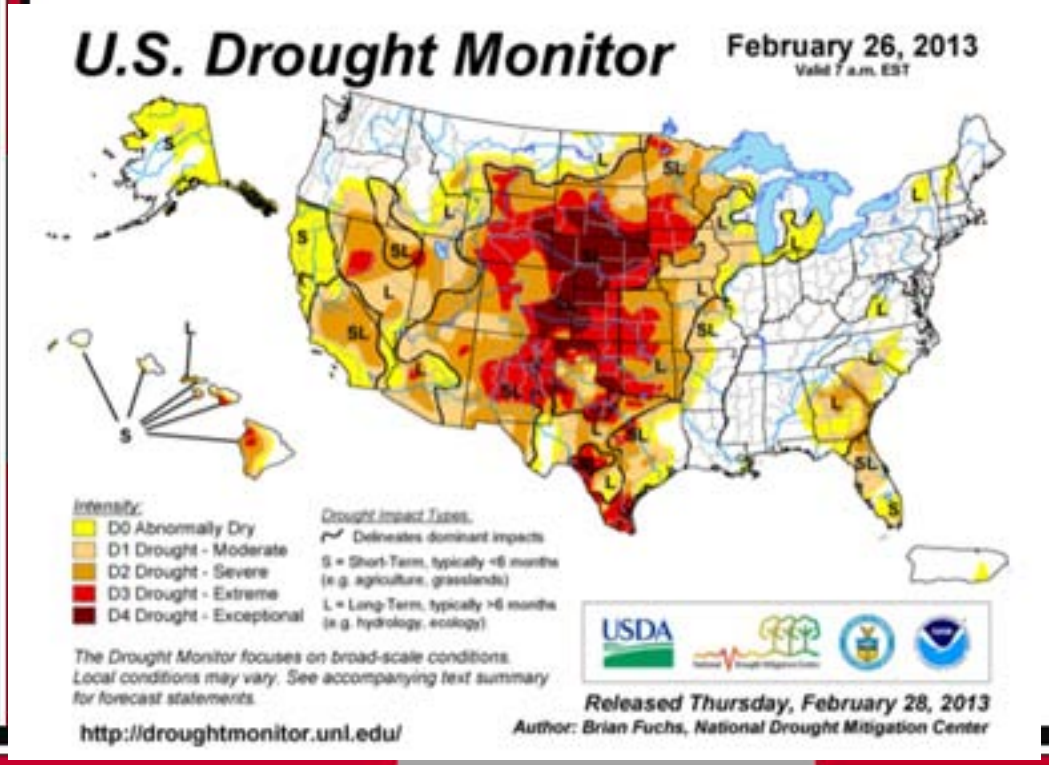
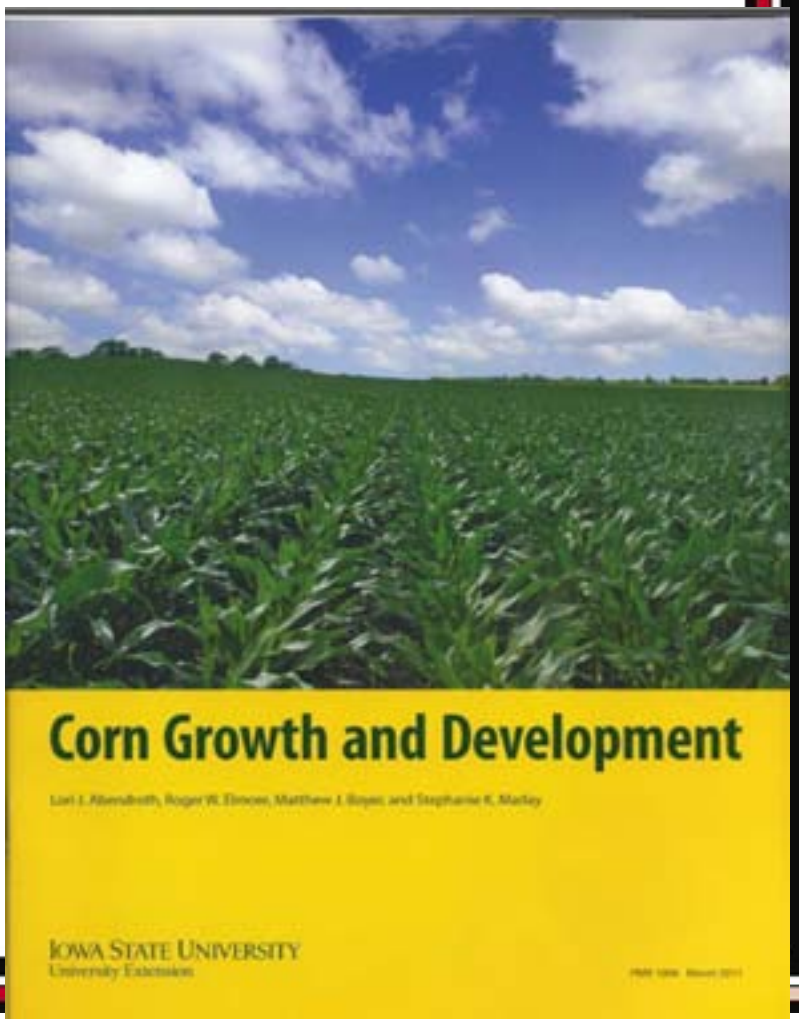
Drought Implications for Nitrogen Management

Charles Wortmann





- What are the implications of the 2012 drought for nitrogen management in 2013?
- Do fertilizer rates need to be adjusted?
- Is the soybean credit still valid?
- How was the release of manure N affected?

N management

- Residual soil nitrate levels
  - often unusually high
    - rainfed and irrigated fields
    - following soybean as well as corn
  - Several contributing factors relating to 2012 weather conditions.

High residual soil nitrate levels

- High soil organic N mineralization because of high temperatures.
- Reduced yield ~ reduced N uptake
- Less leaching and denitrification losses
- Early crop maturity, less robust plants, a warm fall, & more soil N resulted in more decomposition of crop residue, especially soybean leaves, for more N release.

- High residual soil nitrate following soybean and corn.

Taking stock of residual nitrate-N

- Deep sampling, at least to 24” but 0-8” depth especially important for 2013
- UNL algorithm credits 50-60% of nitrate-N found but give more credit if low soil water, especially if
  - used with in-season diagnosis
    - pre-sidedress nitrate test
    - reading the crop canopy reflectance

What is the soybean N credit? Will it be affected?

- Less immobilization of N with soybean compared with corn crop residue
- Mineralizable soil organic N increases with soybean (exudates/nodules) but decreases with corn production

Manure N and S

- Organic N and S release
  - Less in 2012 for very dry fields but
  - Maybe more for irrigated fields because of high temperature and high microbial activity

N suggestions for 2013

- Give the 45 lb credit, even where soybean yields were low.
- Deep sample for nitrate for 2013 N management, including after soybean
- Consider N from manure applied in 2011-12
- Apply less than normal N pre-plant and sidedress or fertigate according to crop need
    - Pre-sidedress soil nitrate test
    - Apply according to canopy greenness
- Consider yield potential

In-season evaluation

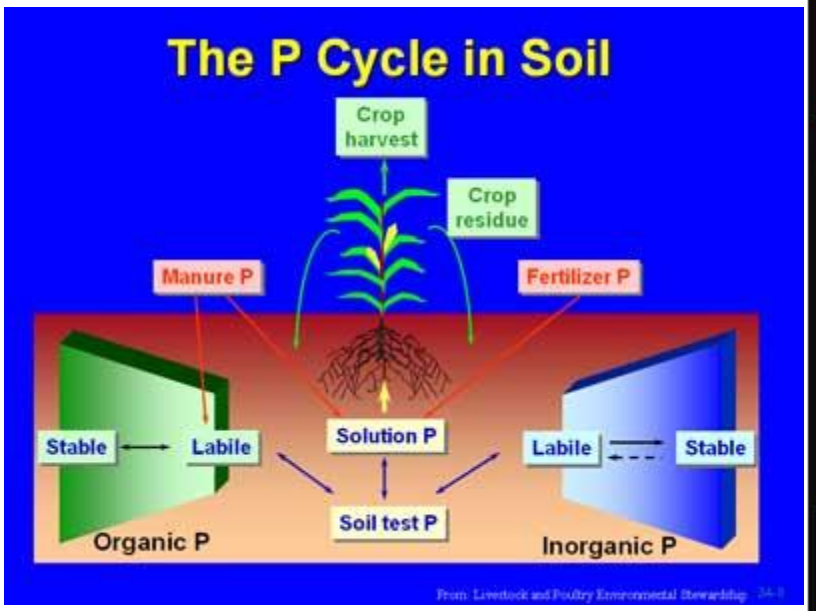
- Pre-sidedress nitrate test (PSNT): Soil NO_3-N in 0-12” soil depth when corn is 12” tall or >1 week before planned sidedressing.
  - Most valuable with manure applied
  - Less valuable with cool spring or leaching conditions
  - 2013!!
- Leaf color, chlorophyll meters, sensors, tissue samples

Phosphorus (P), Potassium (K), Zinc (Zn)

- Where are the applied 2012 nutrients for rainfed fields? How will low 2012 uptake affect 2013 availability?
- Immobile nutrients

P-rainfed fields

- Unused 2012 P was sorbed
  - Still present
  - in equilibrium with solution and non-labile P
- Increased soil test P is expected
  - Soil test important for 2013 management but mis-leading for future years
- Generally less fertilizer P needed in 2013 rainfed



Potassium for rainfed fields

- Less K uptake in 2012
  - 4-8 lb K_2O to raise STK by 1 ppm
    - Affected by soil CEC
- However, little leaching of K from crop residue; STK can be increased by 30-40 ppm by leaching of K from crop residues
  - Less leaching from residues and lower STK?

Drought effect on soil test K

- Some evidence that ratio of exchangeable to less-exchangeable K in soil decreases with drought; therefore, reduce STK
  - Lab results may under-represent STK in 2012

Relatively unavailable K ←→	Slowly available K ←→	Readily available K
90–98 percent of total	1–10 percent of total	0.2-1 percent of total
Non exchangable K	Exchangable K (90 percent of 2 percent)	
	Soil Solution K (10 percent of 2 percent)	

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Potassium for rainfed fields

- High or low STK expected this spring?
- Depends on
  - K uptake
  - K leached from crop residues
  - Drought effects on representiveness of soil K test
- STK important for 2013 management but mis-leading for future years
- Probably reduced fertilizer K needed in 2013

Zinc

- Similar guidelines as for P and K

Drought and soil pH

- Soil test pH likely to be reduced
  - maybe by 0.1 to 0.3 unit
  - but soil pH can be restored to normal with ~2” of rain
  - no clear effect on buffer pH, the value used to determine lime requirement
- More lime applied with more irrigation

Grid sampling

- Delay to a more typical year

U. Missouri suggestion for 2013

Table 1. Estimated impact on next year's fertilizer need (drought nutrient credits) for selected harvest strategies for drought stressed corn or soybean. Assumes fertilizer applied this year was based on 150 B/A yield for corn and 50 B/A yield for soybean. Arrow down means recommended fertilizer rate for next year should decrease by the associated value.

	Corn			Soybean		
Harvest Management	N	Phosphate	Potash	N	Phosphate	Potash
	- - - - lbs/acre - - - -			- - - - lbs/acre - - - -		
No crop harvested	↓□145	↓□50	↓□40	0	↓□40	↓□65
Harvested as grain (40% of yield goal)	↓□70	↓□30	↓□25	0	↓□24	↓□40
Grazed	↓□40	↓□50	↓□40	0	↓□40	↓□65
Chopped and removed[1]	0	↓□15	↑ 60	0	↓□20	↓□25

[1] Assumes most growth stopped at R1 for corn and R3/4 for soybean.

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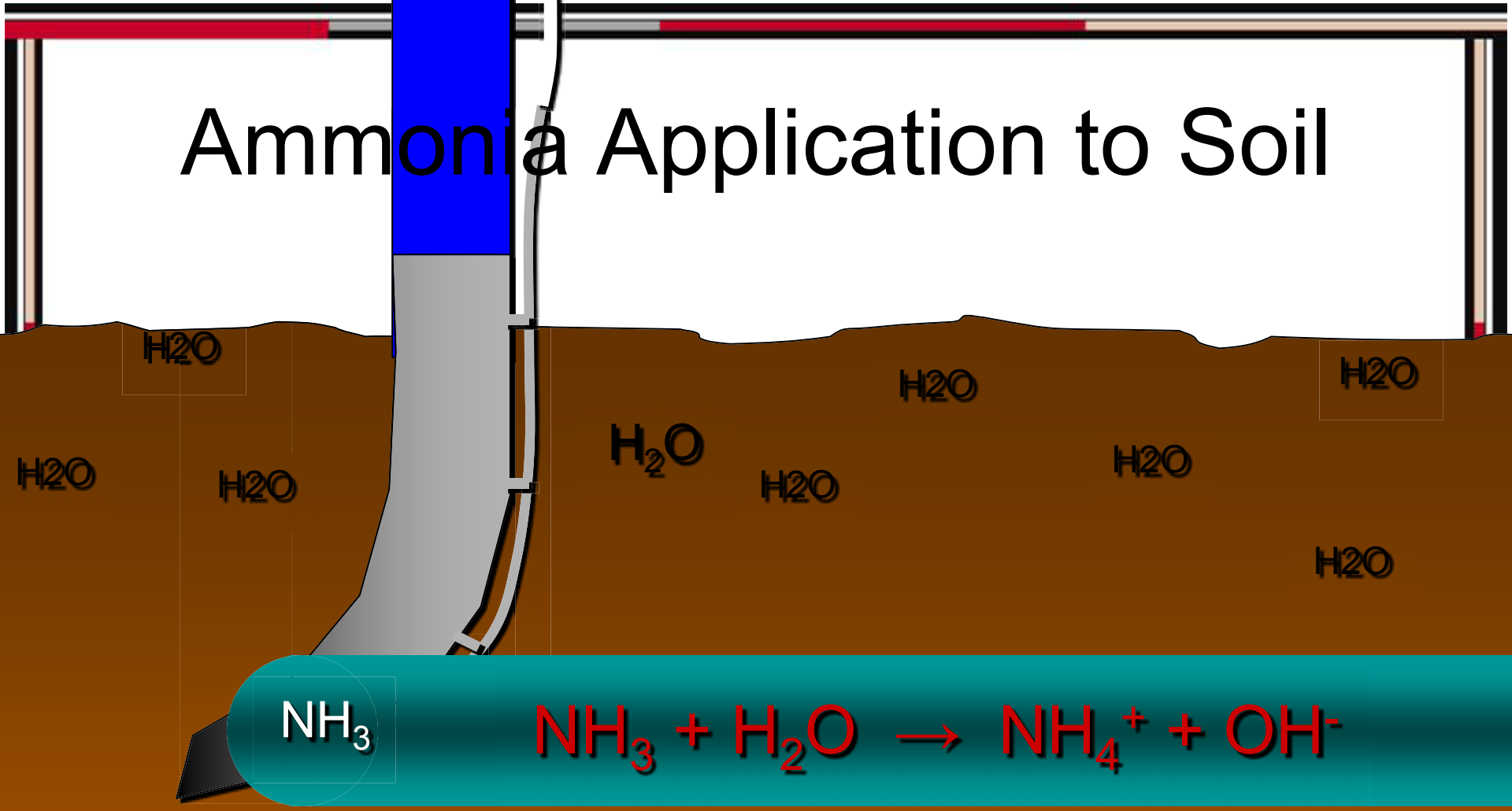
Anhydrous application with dry soil?

- Can you get it into the ground??
- Will the soil close well?
- Is soil water adequate?
  - Soil water needed for NH_3 to convert to NH_4^+ and react with soil

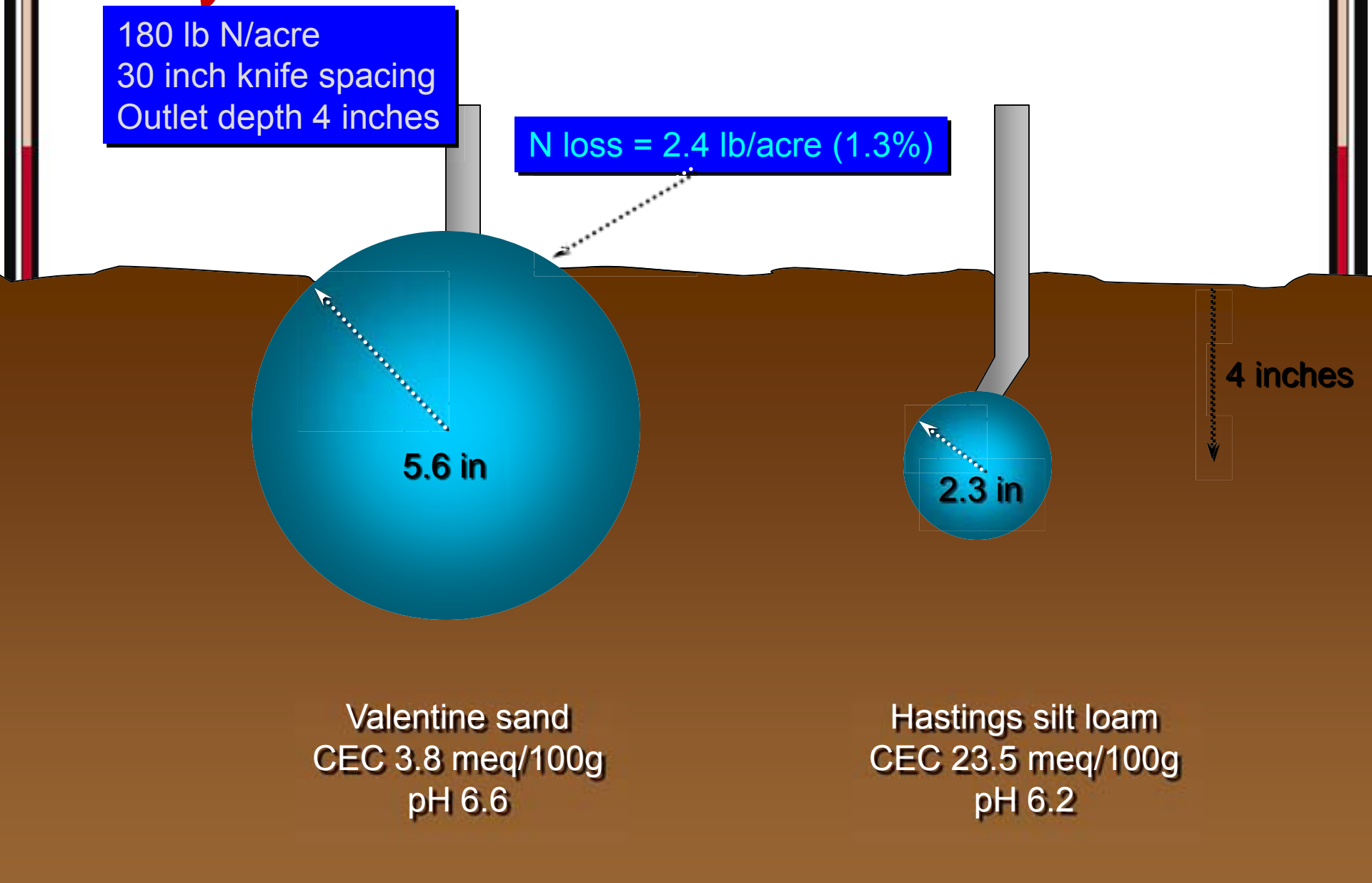
Ammonia Application to Soil



Ammonium (NH_4^+) binds rapidly to cation exchange sites on soil clay particles and soil organic matter.

Hydroxyl anions effectively increase soil pH.

Anhydrous Ammonia Retention Zone



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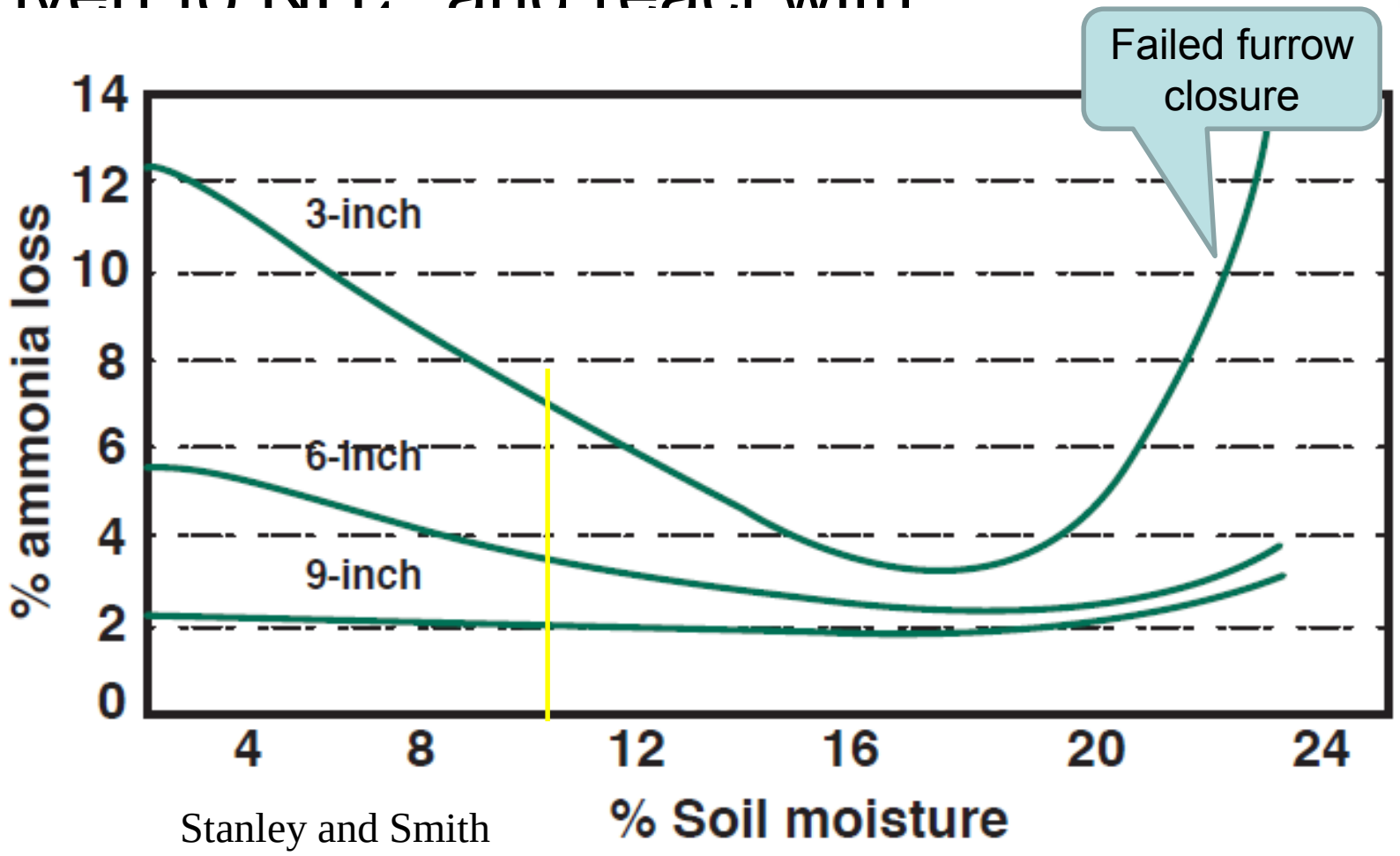
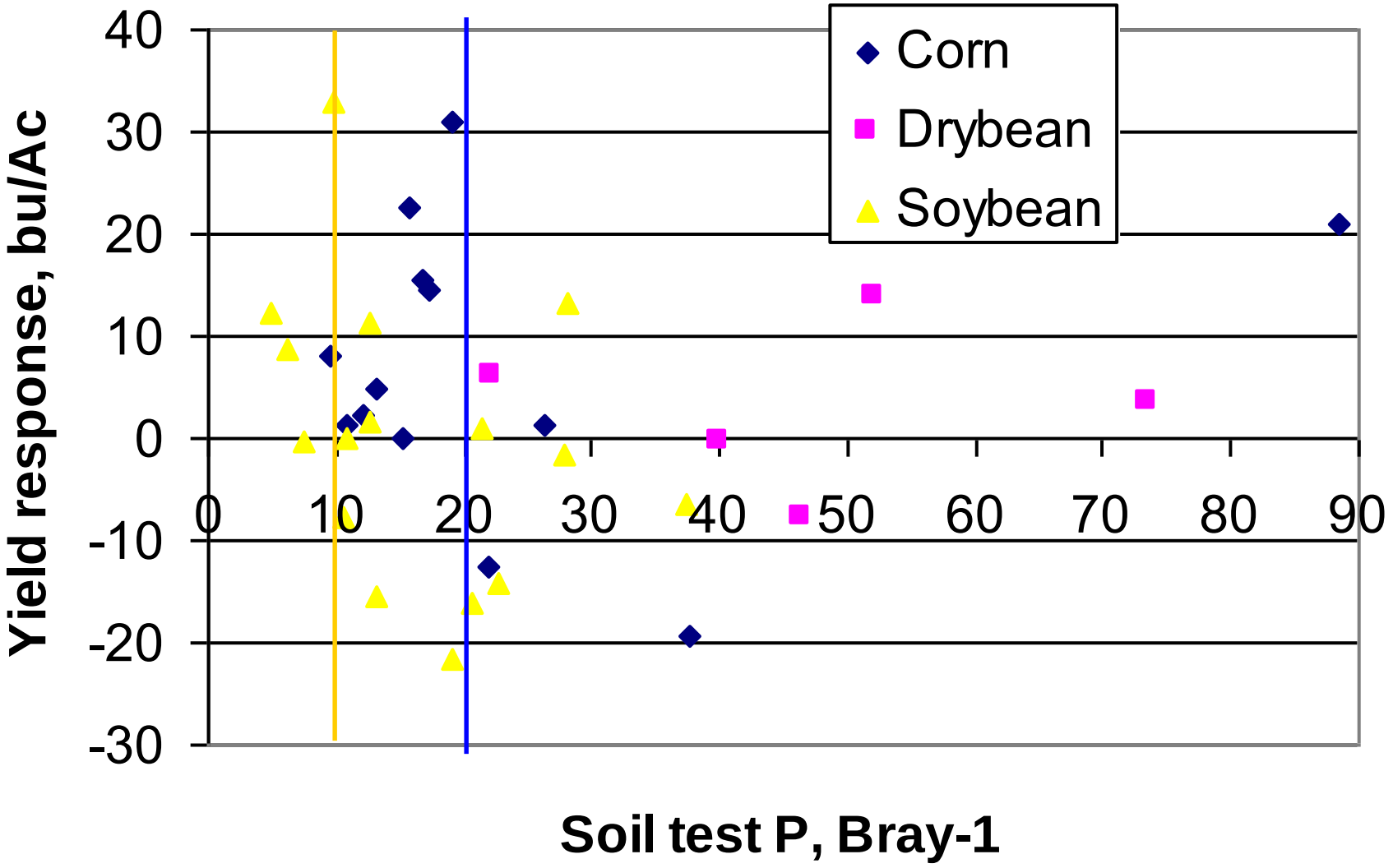


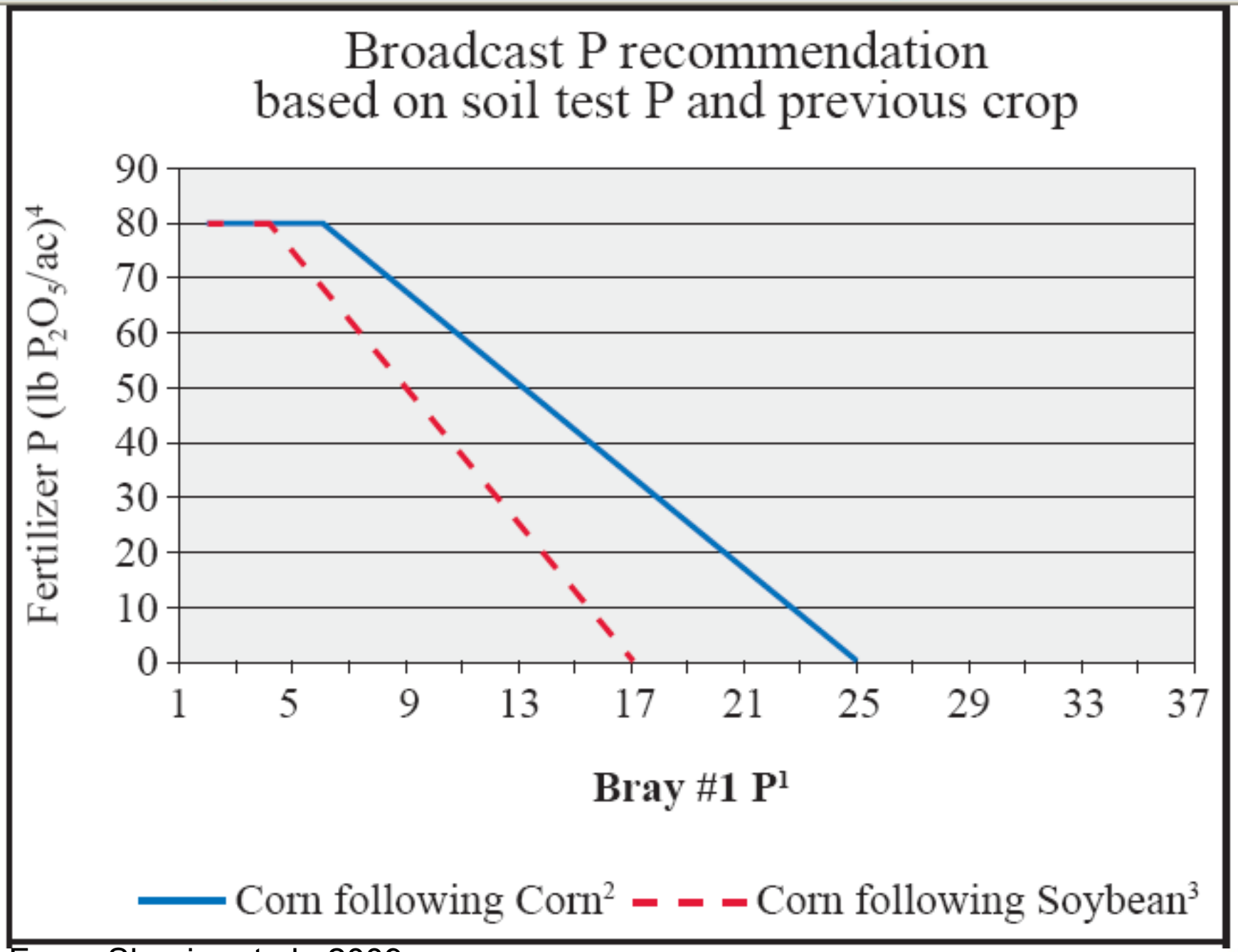
Stanley and Smith

Anhydrous application with dry soil

- Most important is good furrow closure
- Soil water is generally adequate

Response to 40 lb/ac P2O5





From: Shapiro et al., 2009.

Do we need high STP for consistently high yields?

- Nutrient removal will increase
- But high yield crops are expected to have healthy, well-developed roots systems efficient in nutrient uptake
- Slow to warm soils???

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Slow-to-warm soils issue

- MN results show that high STP may be important in cases of slow to warm soils
  - Latitude dependent issue?? Canada, Great Britain, MN
- Study at: SCAL 8-10 yr; HAL >10 yr
- 2011-15 study at 3 locations to compare UNL P recommendations to 25 and 35 mg/kg STP
  - continuous maize
  - tilled and no-till

Reasons to consider maintaining high soil test levels

- Soil test levels vary across field; maintaining higher levels reduces risk of having low level areas
  - Minimize risk with site-specific management
- Applications can be withheld for one or two years in cases of unusually high costs
  - Depends on rental arrangements

K application often results in reduced grain and biomass yield in Nebraska

Previous crop	0 kg/ha K	40 kg/ha K
Soybean	229	222*
Corn	235	232
Drybean	235	225
All	232	226*

Supported by findings of Miany and Olson (Miany, 1980) at UNL-ARDC and by McCallister et al. (1988) across numerous site-years.

Table VI. Potassium fertilizer suggestions.

Potassium Soil Test, ppm K	*Relative Level*	*Amount to Apply Annually (K_2O), lb/ac*		
		Broadcast[1]		**Row[2]**
0 to 40	Very Low (VL)	120	plus	20
41 to 74	Low (L)	80	plus	10
75 to 124	Medium (M)	40	or	10
125 to 150	High (H)	0		0
Greater than 150	Very High (VH)	0		0

From: Shapiro et al., 2009.

Effect of 22 kg/ha sulfur, irrigated corn

5 trials each for sandy and medium/ fine textured soil.

No additional response to 44 kg S/ha.

Texture	0 lb S	20 lb S
Sandy	226.2	232.3
Fine	214.8	214.1

About 100 S application trials conducted for corn, sorghum, soybean since 2000; verify UNL recommend.

S application commonly results in greener crops; cost is not great; on-going verification needed. Environmental and S resource availability issues relatively minor

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Test irrigation water for all nutrients

1965 report: 1141 wells; approx. median/mean lb/ac-ft

- Potassium: 37; Grant Co. 190
- Calcium: 110; Grant Co. 250
- Magnesium: 37; Cheyenne 85
- Lime: 400
- Sulfur: 27; Douglas 500; Keith 300
- Boron: 0.6; Box Butte 0.75
- Chloride: 30; Dixon/Johnson 150

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Crops
Corn, Soybean, Sorghum, Wheat, Oats, more ...

Welcome to the University of Nebraska Department of Agronomy and Horticulture site for fertilizer recommendations. This site will allow you to calculate fertilizer recommendations for all crops produced in Nebraska, either by directly entering crop and soil test information, or by uploading files with test information from analytical laboratories. Please select a crop button to the left to begin.

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Soil Management to Optimize Crop Production in Nebraska

Nutrient Deficiencies

- Key to Nutrient Deficiencies in Soybean -**NEW**
- Key to Nutrient Deficiencies in Wheat and other Small Grains -**NEW**
- Key to Nutrient Deficiencies in Corn and Sorghum

Plant symptoms can be used to differentiate and identify crop nutrient disorders. Symptoms of

Soil Test

Soil Test Nebraska

University of Nebraska Department of Agronomy and Horticulture site for fertilizer recommendations.

Calculate fertilizer recommendations for all crops produced in Nebraska:

1. Directly enter crop and soil test information, or,
2. Upload files with test information from ical laboratories.

http://cropwatch.unl.edu/web/soils/home/

New

Free Slide Rule Offers Quick Calculation for Nitrogen Rates

Click here for more information on how to

Featured Pubs

UNL Publication:

Fertilizer suggestions for

http://cropwatch.unl.edu/web/corn/home

CropWatch: Corn

Nebraska Corn Production, Pest Management, and Research Information

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CROPWATCH

Nebraska Corn

The lastest information on corn production and management practices from the University of Nebraska-Lincoln.

Corn Planting Depth, Date, and Population Information

With these nice spring days, you may be eager to start planting, even in wet soils where planting may be difficult. Remember that many agronomic problems that occur later in the season start with how things were done at planting, particularly the planting depth you use. For more information on problems related to planting depth, click here. You can also check out the April 2, 2010 Market Journal segment on this topic by clicking here.

As corn hybrid genetics and seed treatments continue to improve, producers are often encouraged to consider increasing their plant populations and

Upcoming Events

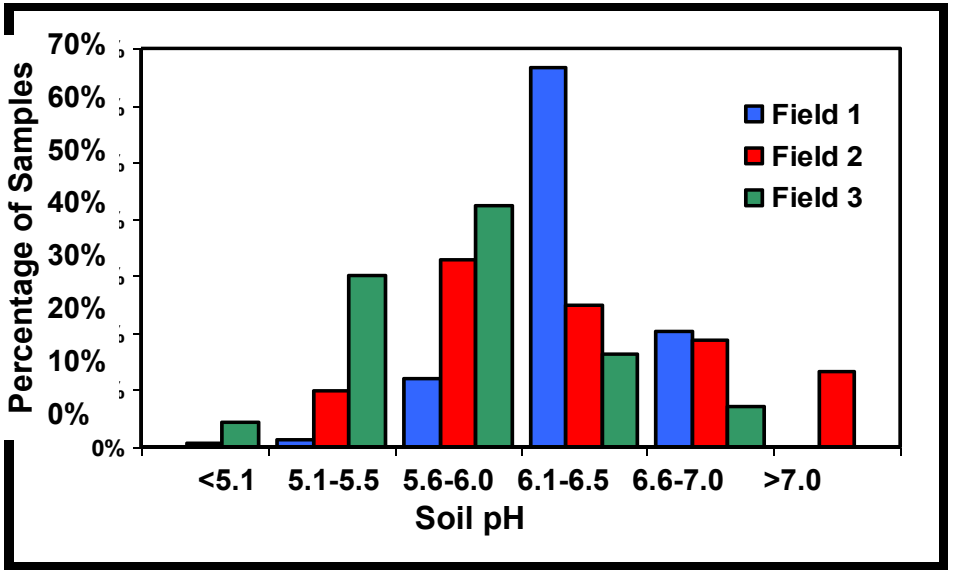
Please check the Crop Watch Calendar for Upcoming Events!

Corn Facts

Corn is an economically important crop to Nebraska resulting in $5.8 billion in 2009 from 8.9 million acres harvested according to USDA National Agricultural Statistics Service.

1. Nebraska ranks 3rd in U.S. corn production
2. Nebraska has 8.5 million irrigated acres
3. Ethanol plants utilized 38% of Nebraska's grain (2007)
4. Nebraska ranks 1st in U.S. popcorn production

Lime use to amend acid soils



Determine the variability in soil pH.
Is variable rate or site-specific application justified?

- management zones
- grid sampling
- on-the-go sensor mapping?

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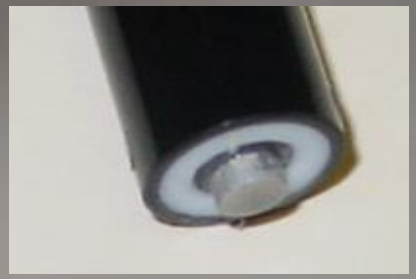
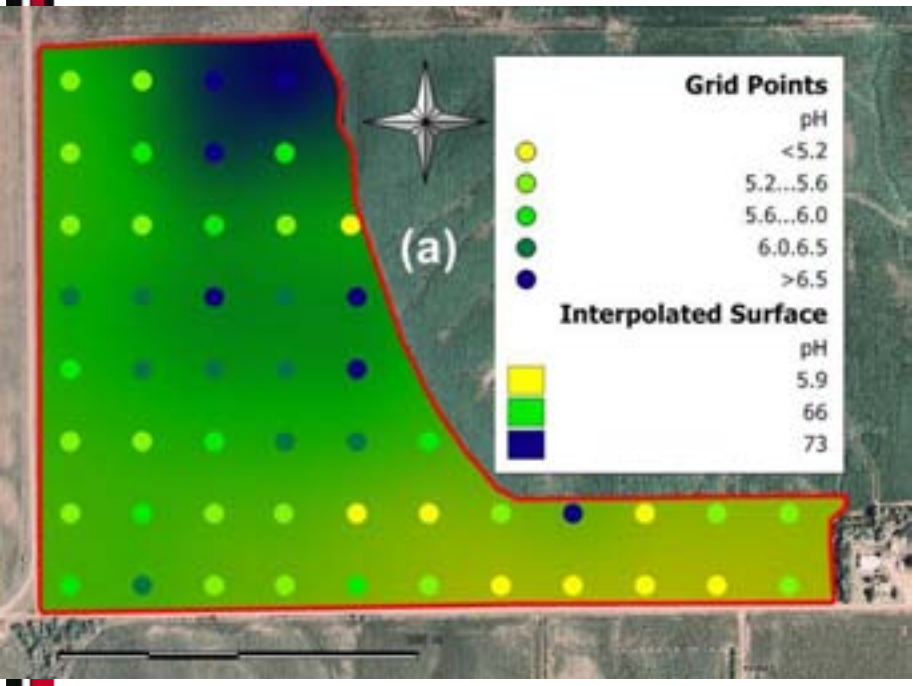
The scoop of soil is brought up to ion specific electrode and pH is read. Scoop is lowered for next sample. Electrode is washed.

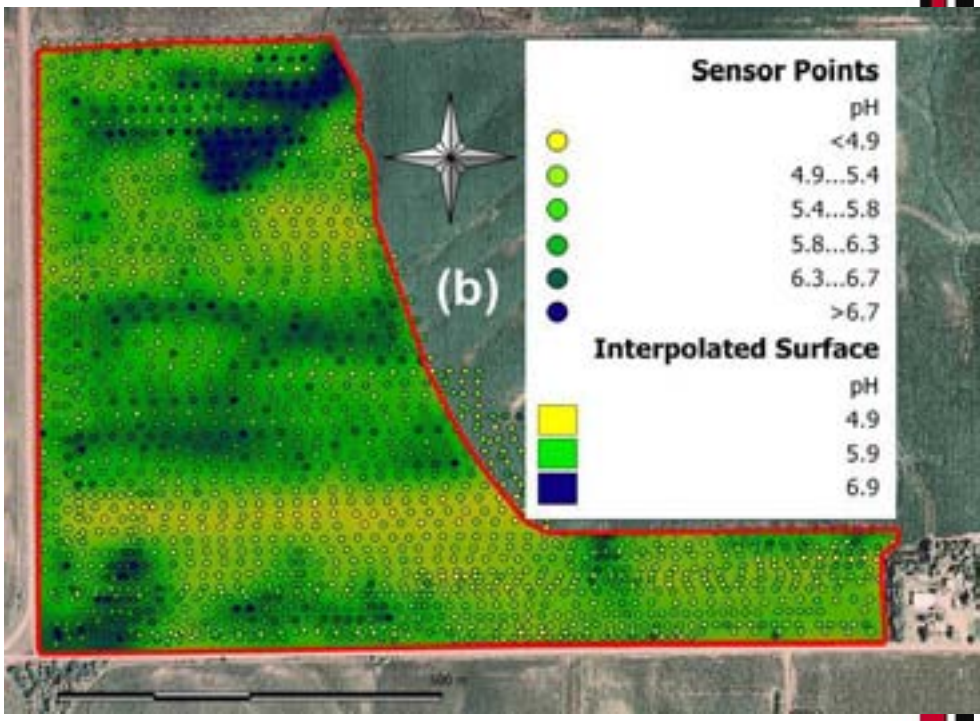


A scoop drops to collect soil sample

Electrical current is sent from coulter through soil to be intercepted by another coulter to measure EC at different depths.

Grid sampling vs sensor mapping of soil pH: MS field





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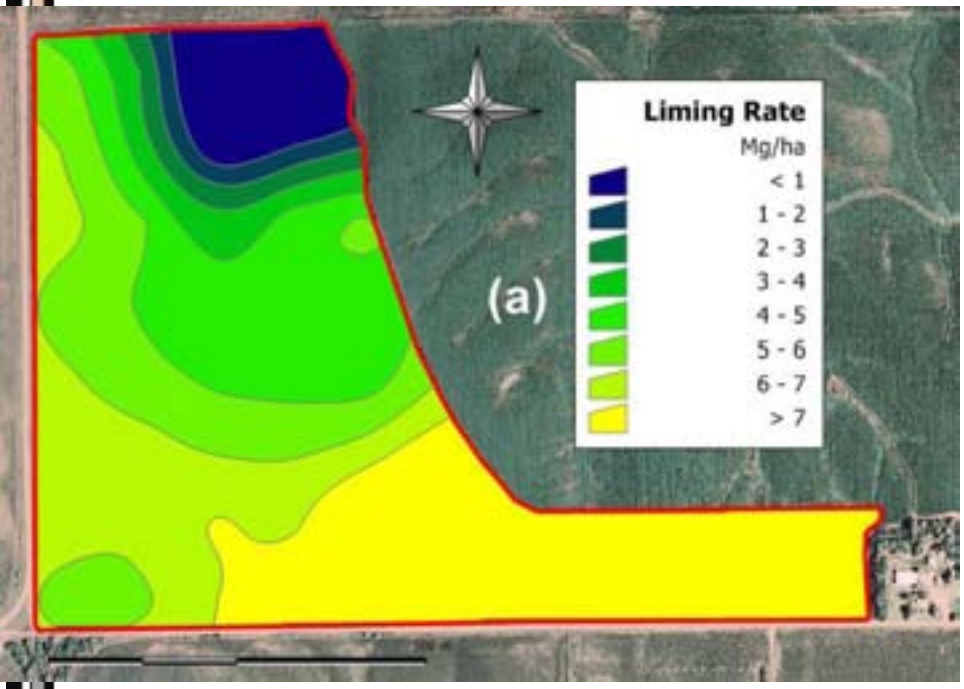
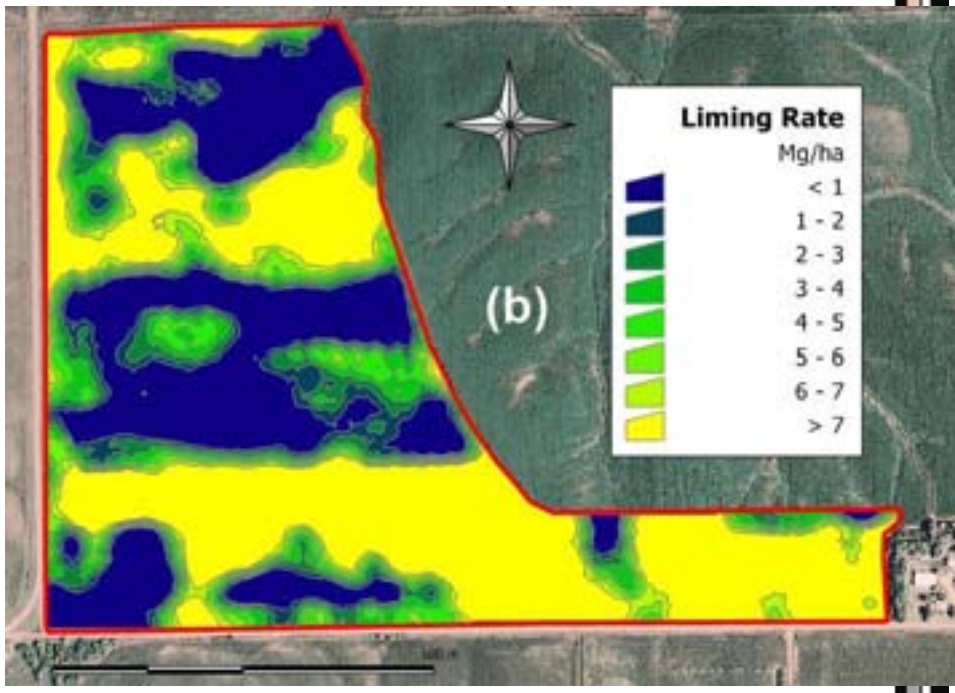
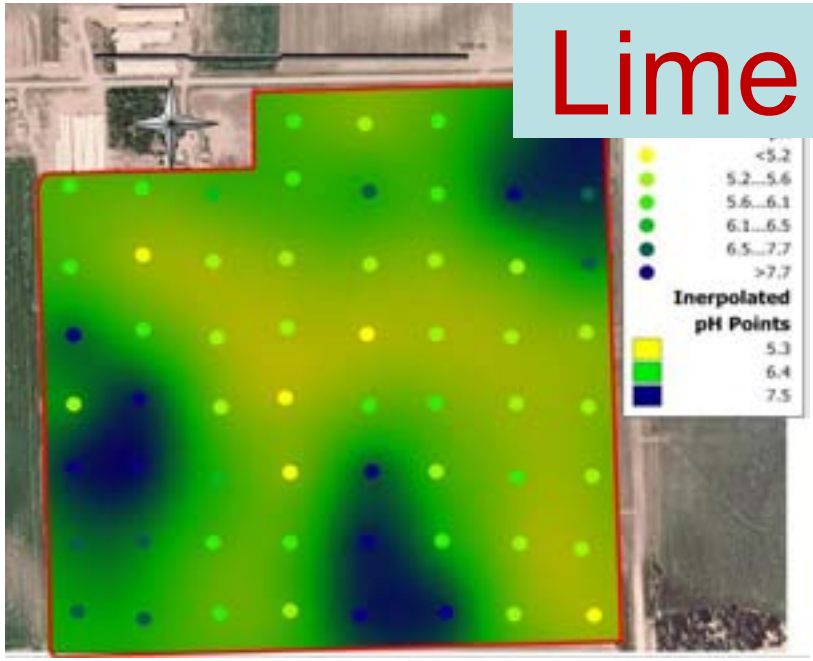
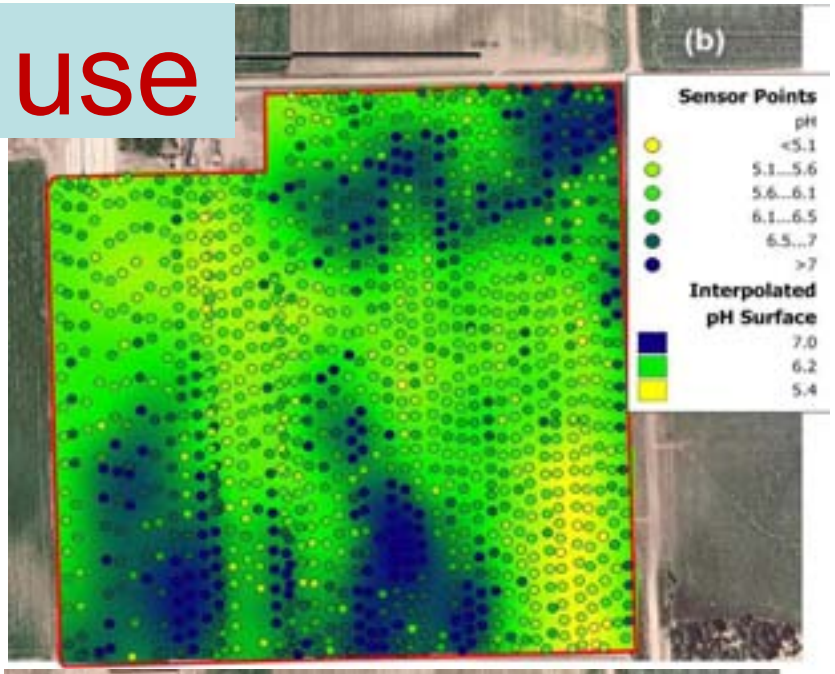
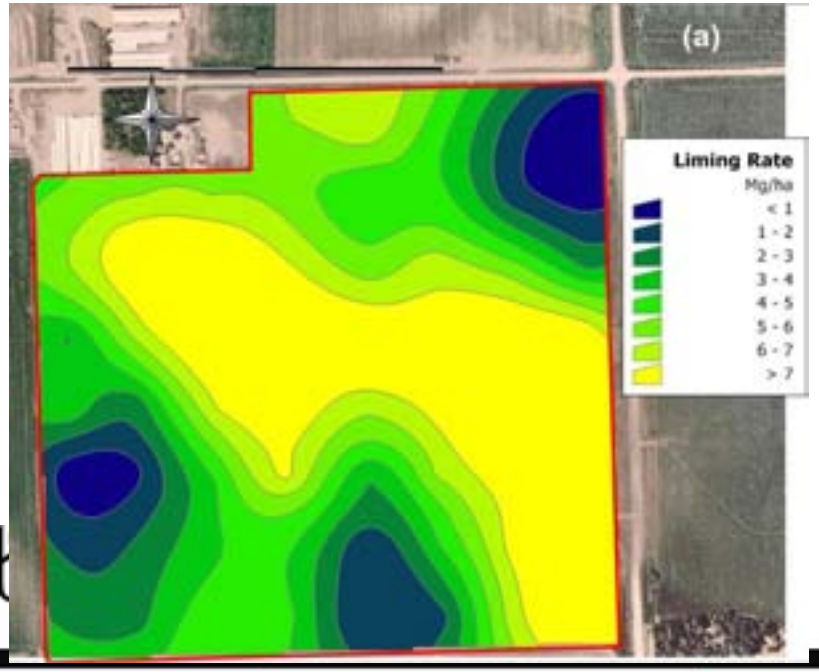

Liming Rate
Mg/ha
< 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
(a)

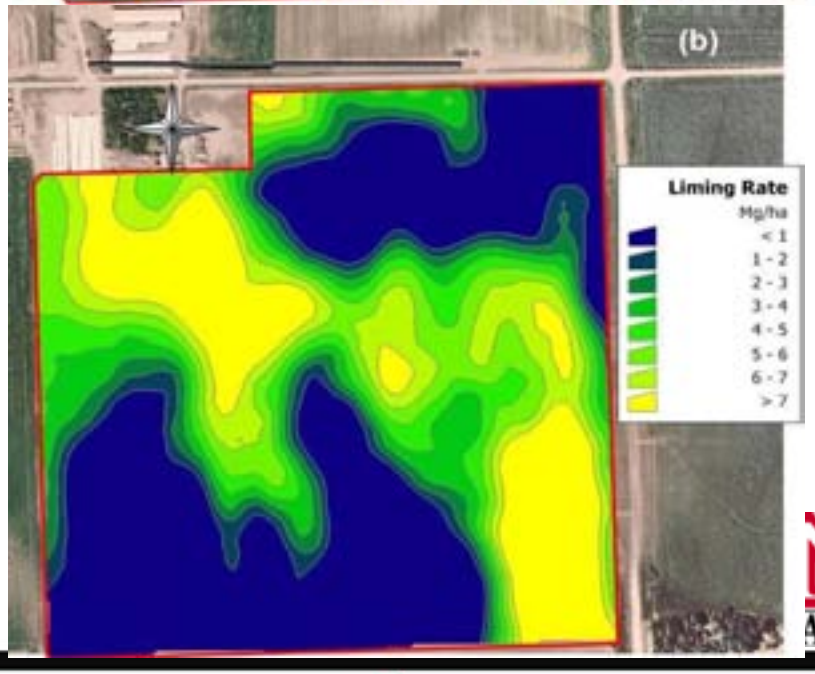

Liming Rate
Mg/ha
< 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
(b)

Lime use


<5.2
5.2...5.6
5.6...6.1
6.1...6.5
6.5...7.7
>7.7
Inerpolated pH Points
5.3
6.4
7.5

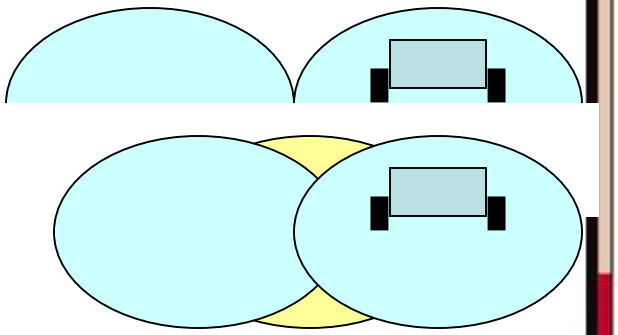

(b)
Sensor Points
pH
<5.1
5.1...5.6
5.6...6.1
6.1...6.5
6.5...7
>7
Interpolated pH Surface
7.0
6.2
5.4

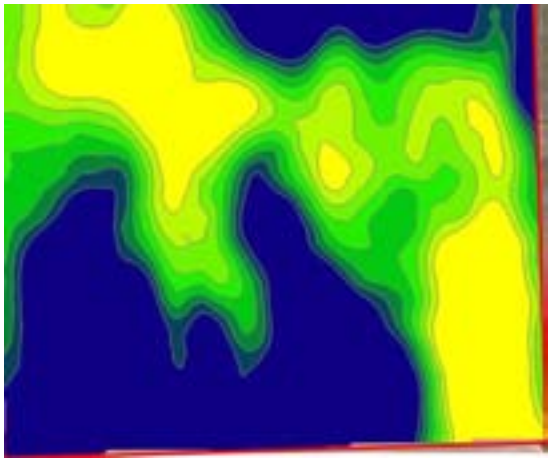

(a)
Liming Rate
Mg/ha
< 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7


(b)
Liming Rate
Mg/ha
< 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7

Control of lime rate

- Lime is broadcast applied; particle size is small
  - Uniformity of application is affected by wind and slope
  - How much overlap of passes is needed?
- Can variable rate applicators respond quickly enough to detailed prescription maps?
- Alternative application
  - Pelletize ag lime, finer particle size
    - More value per ton
  - Adapt dry fertilizer boom air-flow technology for lime





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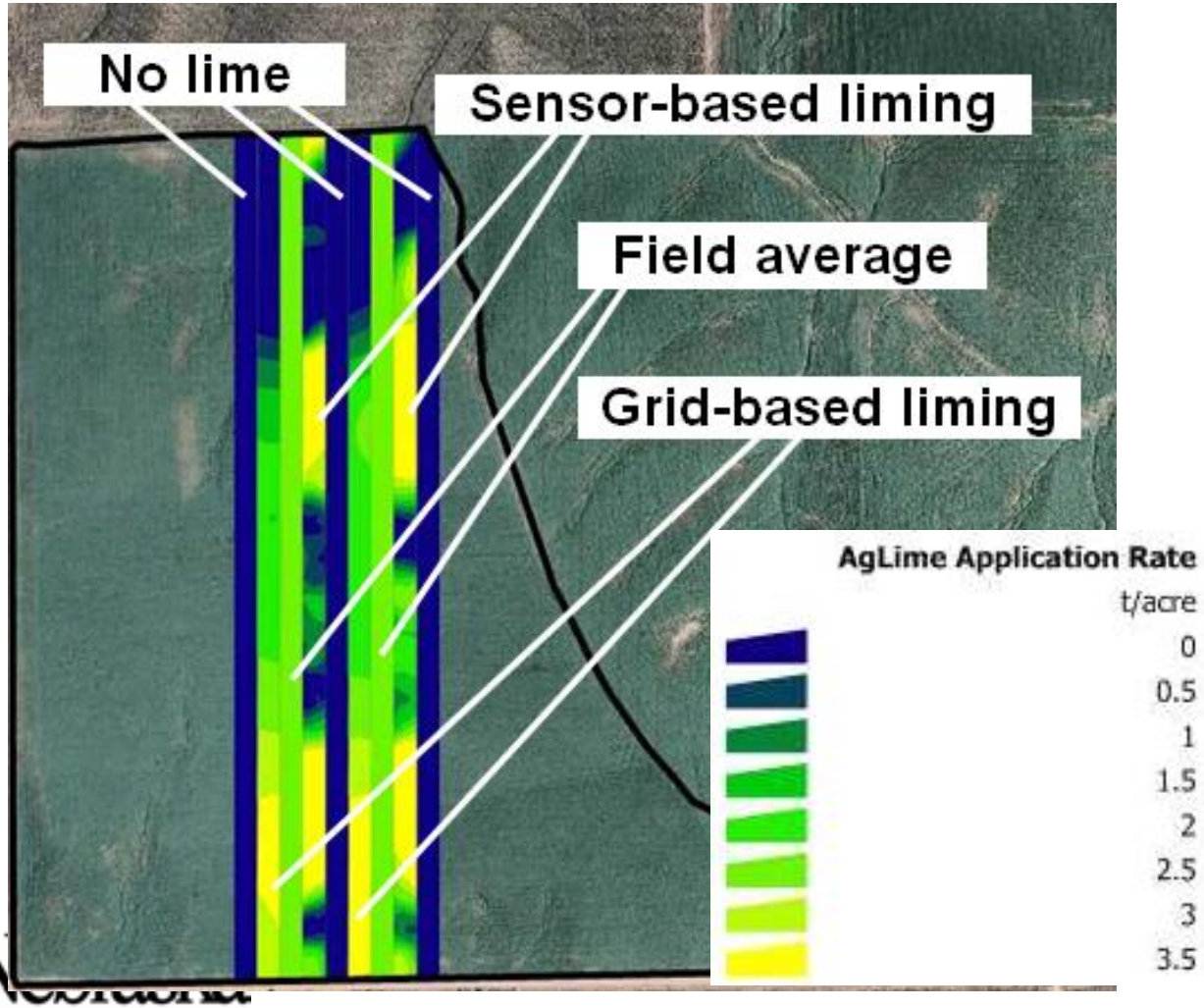
The agronomics and economics of variable rate liming



Trials in Nance, Saunders, and Wayne Counties

4 treatments

2 reps

Lincoln


Thank you!
Questions?