SOIL FERTILITY OF SOYBEAN & SOIL INTERACTIONS

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Soybean requires

N, P, K, S, Ca,
Mg, Cu, Fe, Mn,
Zn, B, Cl, Mo, Ni

Liebig's Law of the Minimum

Water is usually limiting

- ND soybeans typically require 17 in moisture.
- Need rain at R1-R6 growth stages

Inoculation

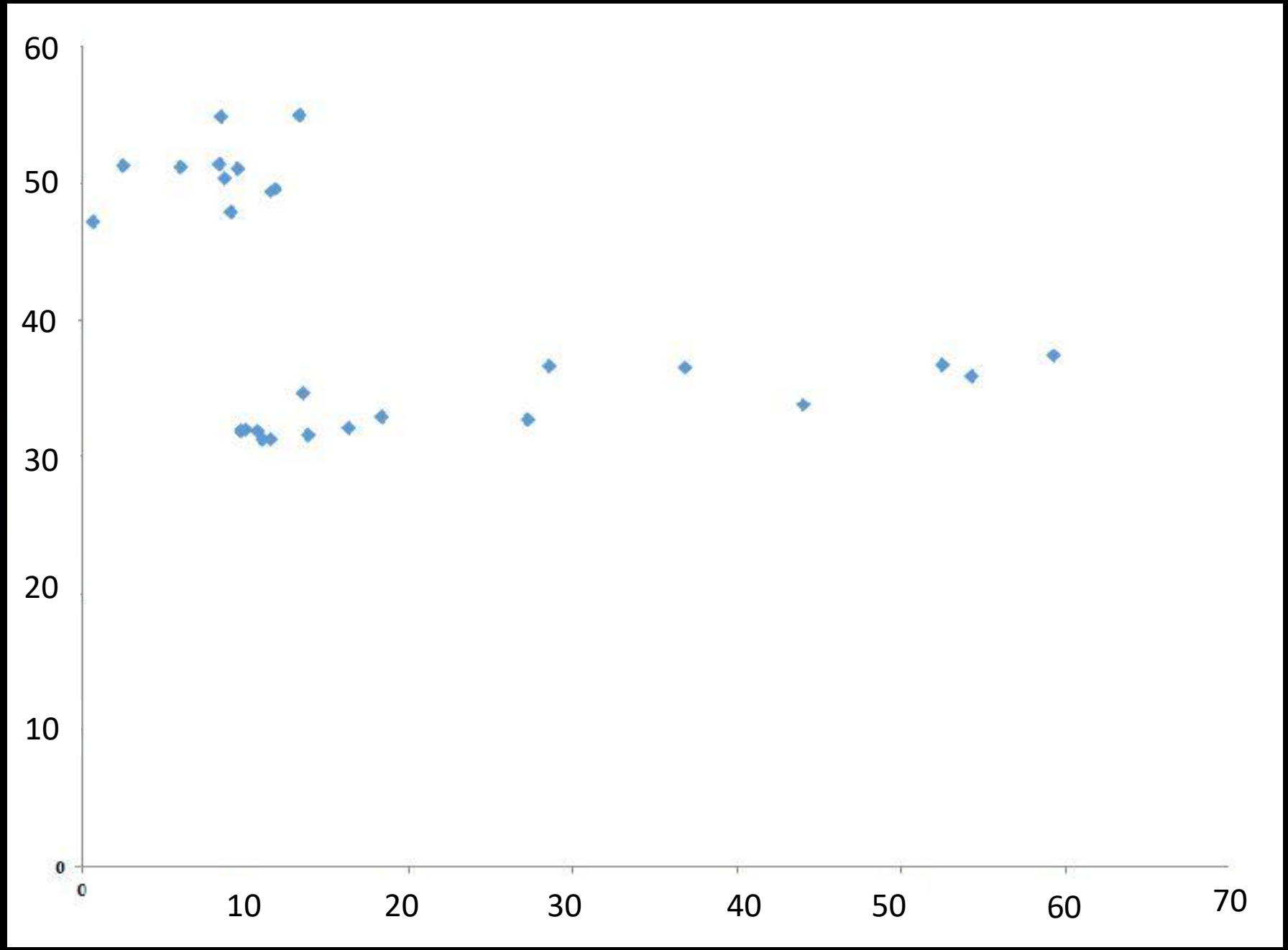
Inoculation

Table 1. Frequency of soybean yield responses, grain yield and protein differences between experiments with or without a soybean history when seed is inoculated with *Bradyrhizobium japonicum* formulations at planting. (Carrington Research Extension Center, 2003-2007b and 2012; Oakes NDSU Experiment Farm, 2007a)

Site year*	Number of treatments	Soybean history	Number of treatments higher than check	Yield without inoculation	Mean yield with inoculation	Grain protein of the check	Mean grain protein inoculated
2003	38	No	38	32.8	38.8	31.5	35.0
2004	23	Yes	0	29.1	28.9	33.5	34.5 (NS)
2005	25	Yes	0	39.6	39.6	33.5	33.8 (NS)
2007a	7	Yes	0	55.9	55.9	35.1	35.1
2007b	11	No	11	46.1	50.7	32.0	34.1
2012	6	Yes	0	56.1	56.1	34.6	34.6

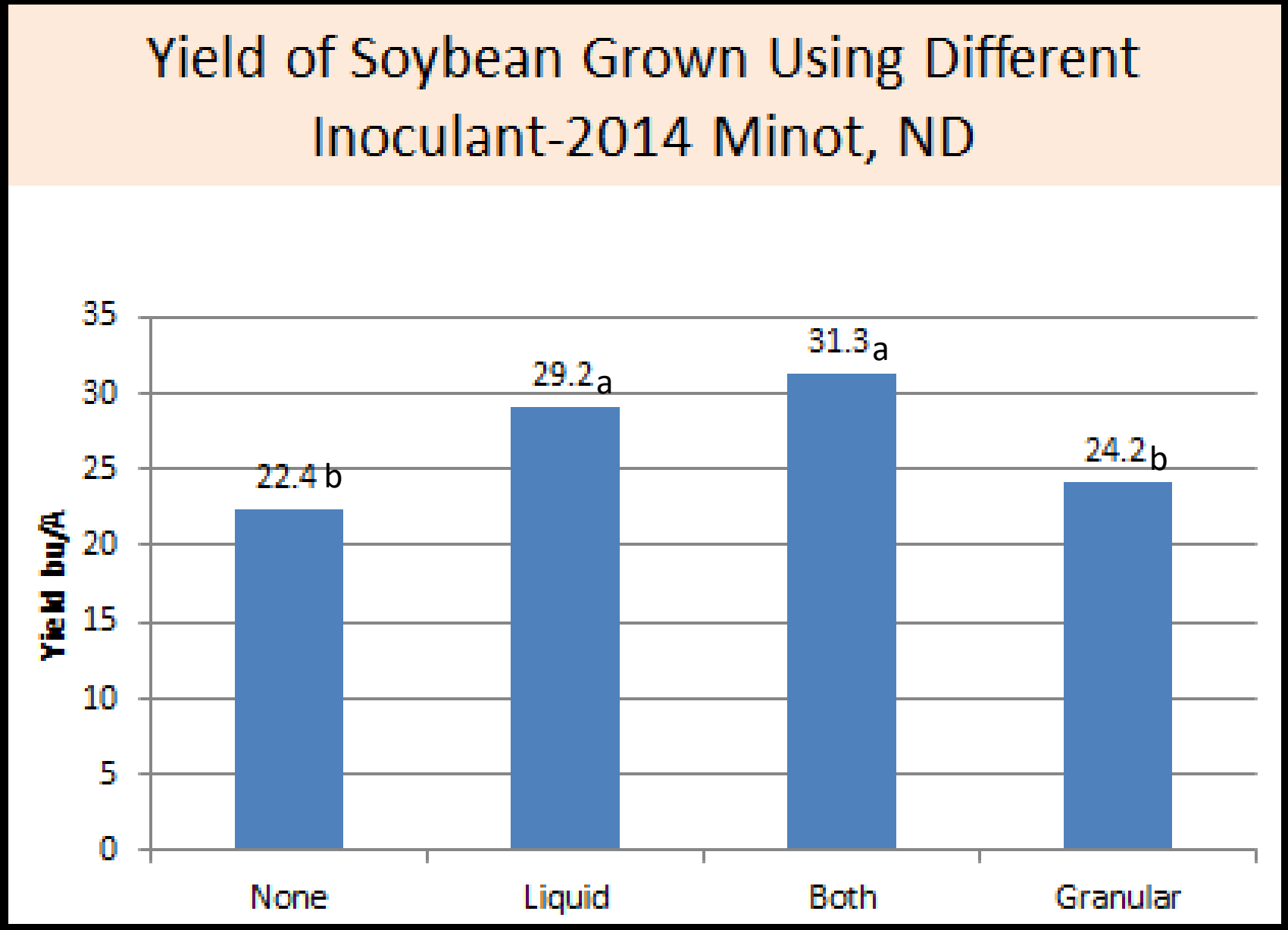
*All site years Carrington except 2007a treatment study at Oakes

Soybean Soil Fertility, Franzen, 2013, NDSU Extension Service



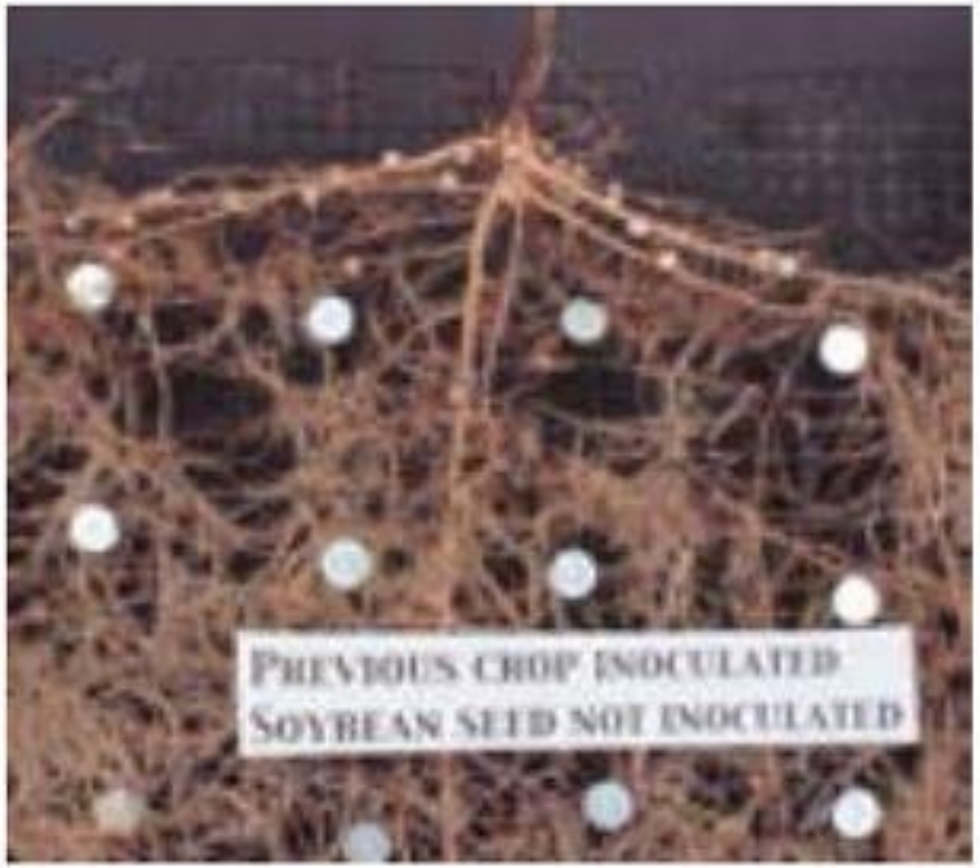
Soybean Soil Fertility, Franzen et al., 2019

Inoculating virgin soybean ground



Forster, 2015

Seed Placed
Inoculation



Previous Wheat Crop
Inoculation

Goos et al., 2000

If soybean had good nodulation, you'll likely not see a response from inoculation

Time since last soybean crop	Bradyrhizobium cells per gram of soil
1 year	19,534
2 years	3,718
3 years	2,464
4 years	2,234

Soybean Soil Fertility, Franzen et al., 2019

Don’t forget the N credit for next year!

Rescue N application only profitable with little or no nodulation. R3 N application

Treatment	Yield (bu/ac)
100 lbs N/ac as urea	34.5a
100 lbs N/ac as UAN	32.9a
50 lbs N/ac as UAN	29.0ab
50 lbs N/ac as urea	25.9bc
Untreated	21.9c
LSD 5%	6.2

Endres, Aberle, and Henson, 2002

Phosphorus rates

Olsen P test, ppm				
Very Low	Low	Medium	High	Very High
0-3	4-7	8-11	12-15	16+
----------lbs P_2O_5/ac----------				
52	26	0	0	0

Soybean Soil Fertility, Franzen et al., 2019

Kalra and Soper, 1968
Bardella, 2016

Soybean prefers broadcast P

P_2O_5/ac	Placement Method	
	Broadcast	2x2in Band
	---Yield (bu/ac)---	
0	35.5	34.3
20	39.6	35.3
40	41.1	36.2
60	44.0	39.1
80	42.4	37.1

Soybean Soil Fertility, Franzen, 2013, NDSU Extension

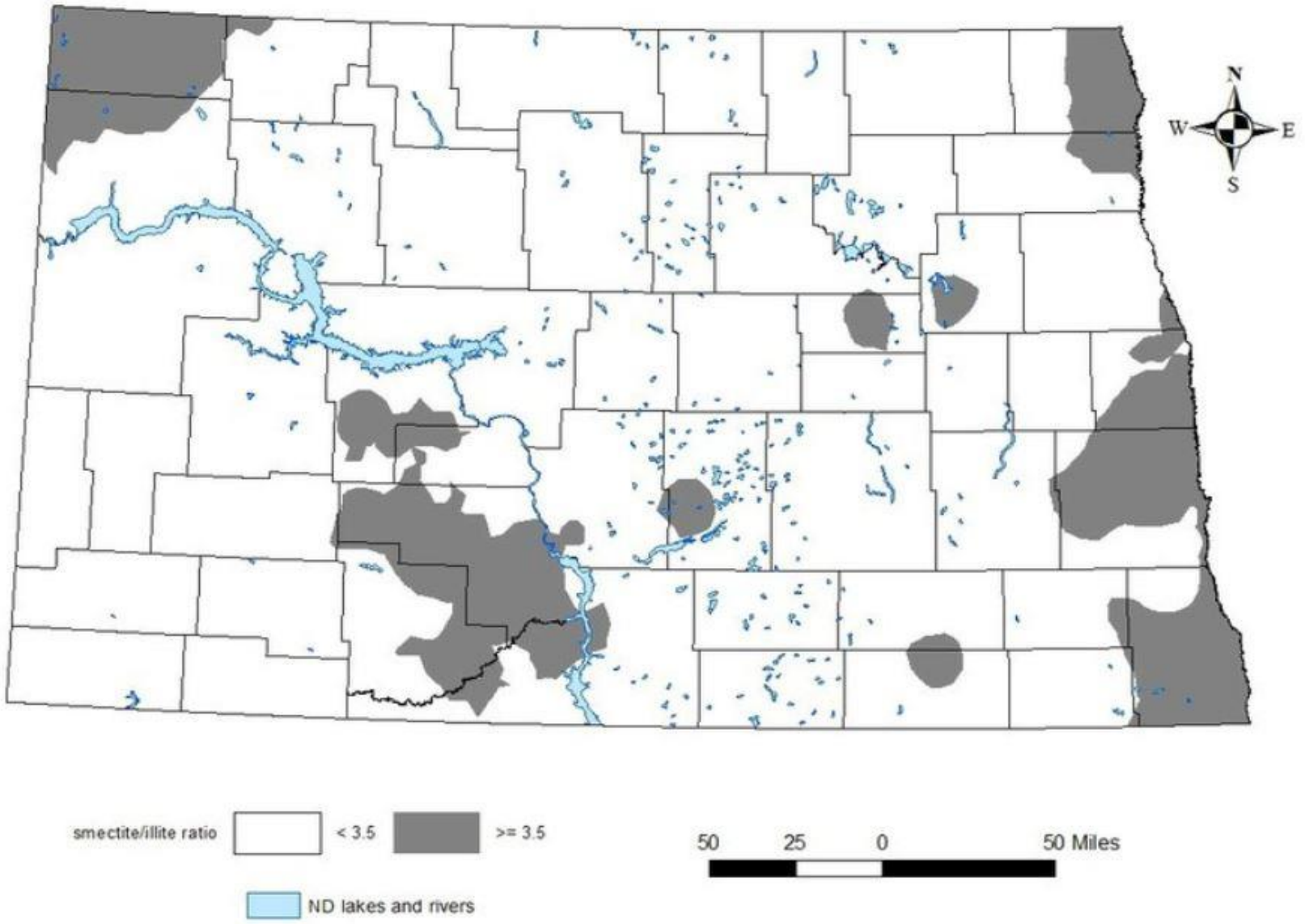

In-furrow liquid P fertilizer

In Furrow P

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

Smectite:Illite Potassium Thresholds



Potassium rates

Ammonium acetate K test, ppm					
VL/VL	L/L	M/M	H/M	VH-H	VH/VH
0-40	41-80	81-120	121-150	151-200	201+
----------lbs K_2O/ac----------					
90/90	60/90	60/60	30**I**/60**S**	0/60	0/0

Soybean Soil Fertility, Franzen et al., 2019

Iron Deficiency Chlorosis

- Don’t worry if pH is under 7
- Test CCE for soybean
- Low risk = CCE < 2.5%
- Moderate risk = 2.5 – 5%
- High risk = >5%

1. Plant tolerant varieties
2. ortho-ortho-EDDHA Fe chelate

Photo courtesy of Sarah Lovas

Figure 5. Effect of a 1.5 percent Fe as ortho-ortho EDDHA added to soil at different rates (left) compared with a 5.5 percent Fe as ortho-ortho EDDHA applied at the same rates (right).

Soybean Soil Fertility, Franzen, 2019, NDSU Extension Service

Photo Courtesy of Goos & Lovas

Companion Crop Oats can Reduce IDC

Soybean Soil Fertility, Franzen, 2019, NDSU Extension Service
Photo Courtesy of J. Lamb University of Minnesota

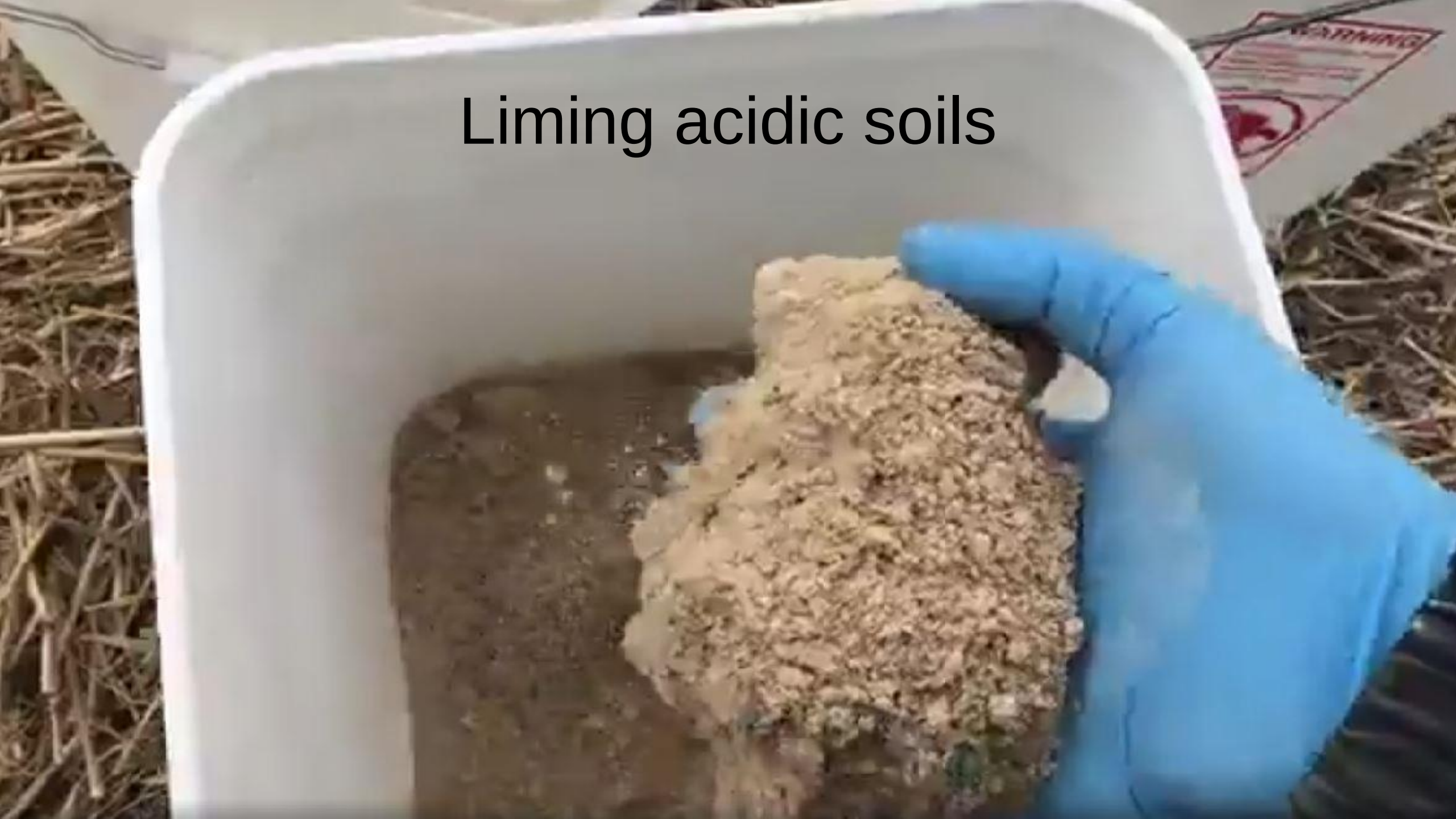
- **Seed oats/barley at 1bu/ac**
- **Spray out Oats at V5 if wet spring, earlier if dry**

Foliar fertilizers

Micro-nutrients

Mallarino et al., 2015
Ahmed and Evans, 1959
Jayakumar et al., 2018

Liming acidic soils



Causes of soil pH

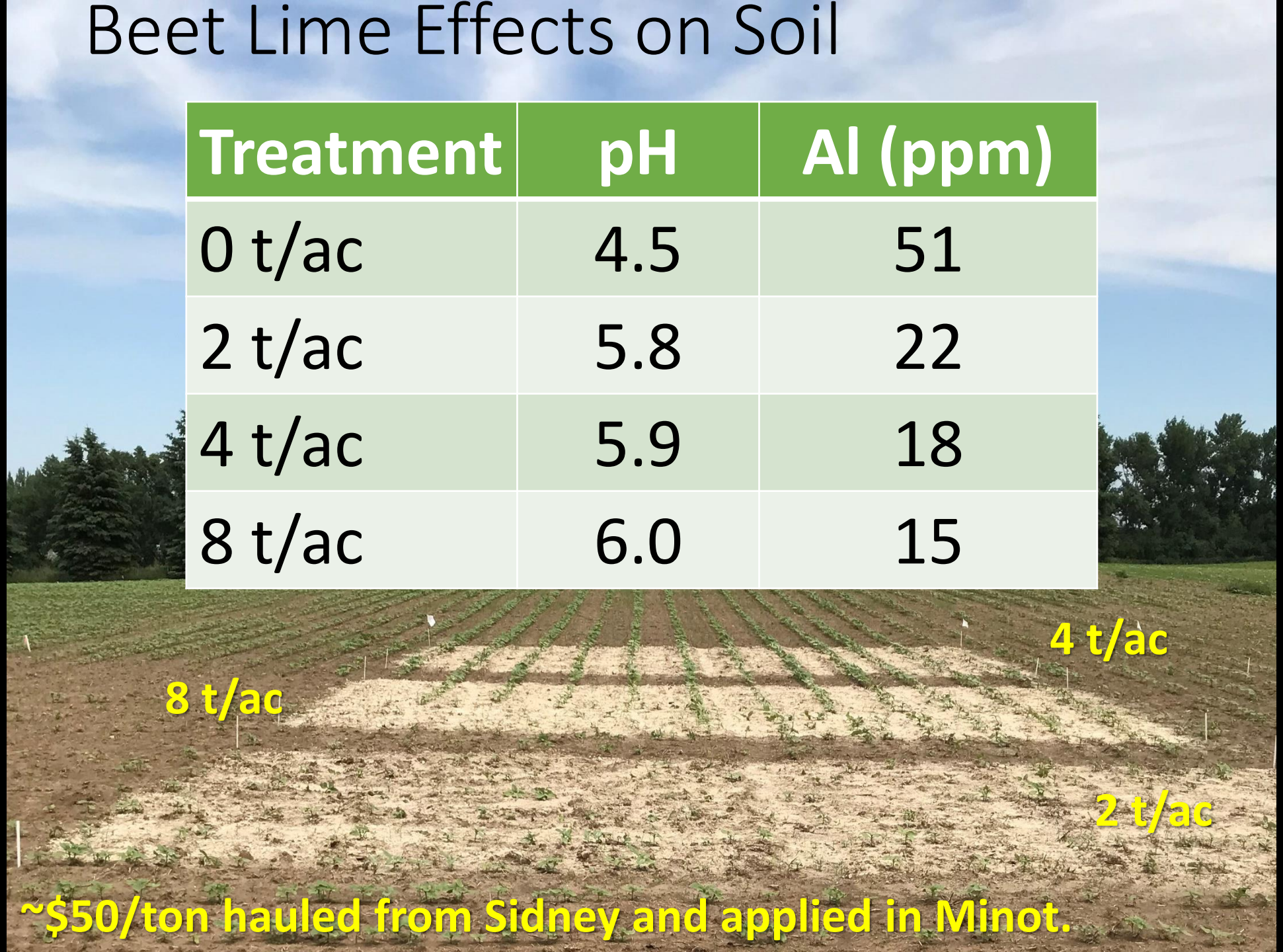
- Parent materials
  - Granite and volcanic ash are acidic
  - Limestone and ocean sediments are alkaline
- Nitrogen fertilizer
  - $CO(NH_2)_2 + 2H_2O + \mathbf{H^+} \blacktriangleright NH_3 + H_2O + \mathbf{H^+} \blacktriangleright NO_2^- \blacktriangleright NO_3^-$
- Over time the soil acidifies and frees up aluminum. Clays are made up of aluminum and silicates.

Strong Acidity & Aluminum Toxicity

- Inhibits microbial activity
- Occurs when pH < 5.5 and Al^{+3} is freed up.
- Al^{+3} is 25 ppm or >
- As Al^{+3} frees up, it splits H_2O and attached to OH^-. This frees up H^+ and acidifies even more.
- Al^{+3} ties up P. Early on it can look like a P deficiency.
- As it worsens, roots are abnormally shaped or amount is reduced.
- Manganese toxicity has now been observed in ND.

Beet Lime Effects on Soil

Treatment	pH	Al (ppm)
0 t/ac	4.5	51
2 t/ac	5.8	22
4 t/ac	5.9	18
8 t/ac	6.0	15



~$50/ton hauled from Sidney and applied in Minot.

Summary

- Inoculate if you've had issues or virgin soybean ground.
- Soybean is efficient at mining P
- K thresholds & P have changed
- Micronutrients rarely benefit
- IDC

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Questions?