

Aerial View Farm



Imagery Date: Mar 5, 2005

Image © 2009 Aerodata International Surveys
lat 53.273665° lon -93.675276° elev 0 ft

©2009 Google

Eye alt: 3287 ft



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Farmstead



Grain Yield and Grain Protein

I want both....Can I?

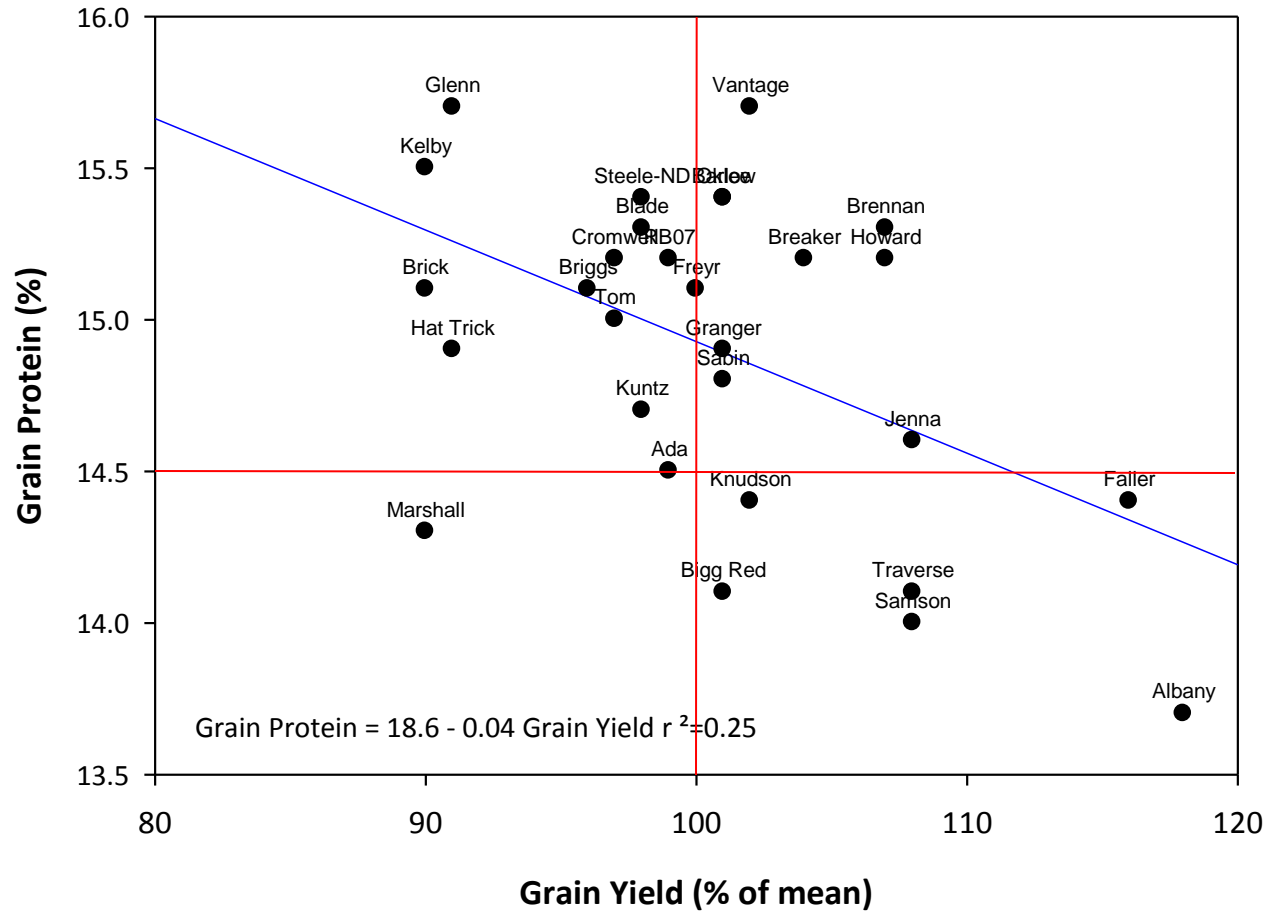
Jochum Wiersma



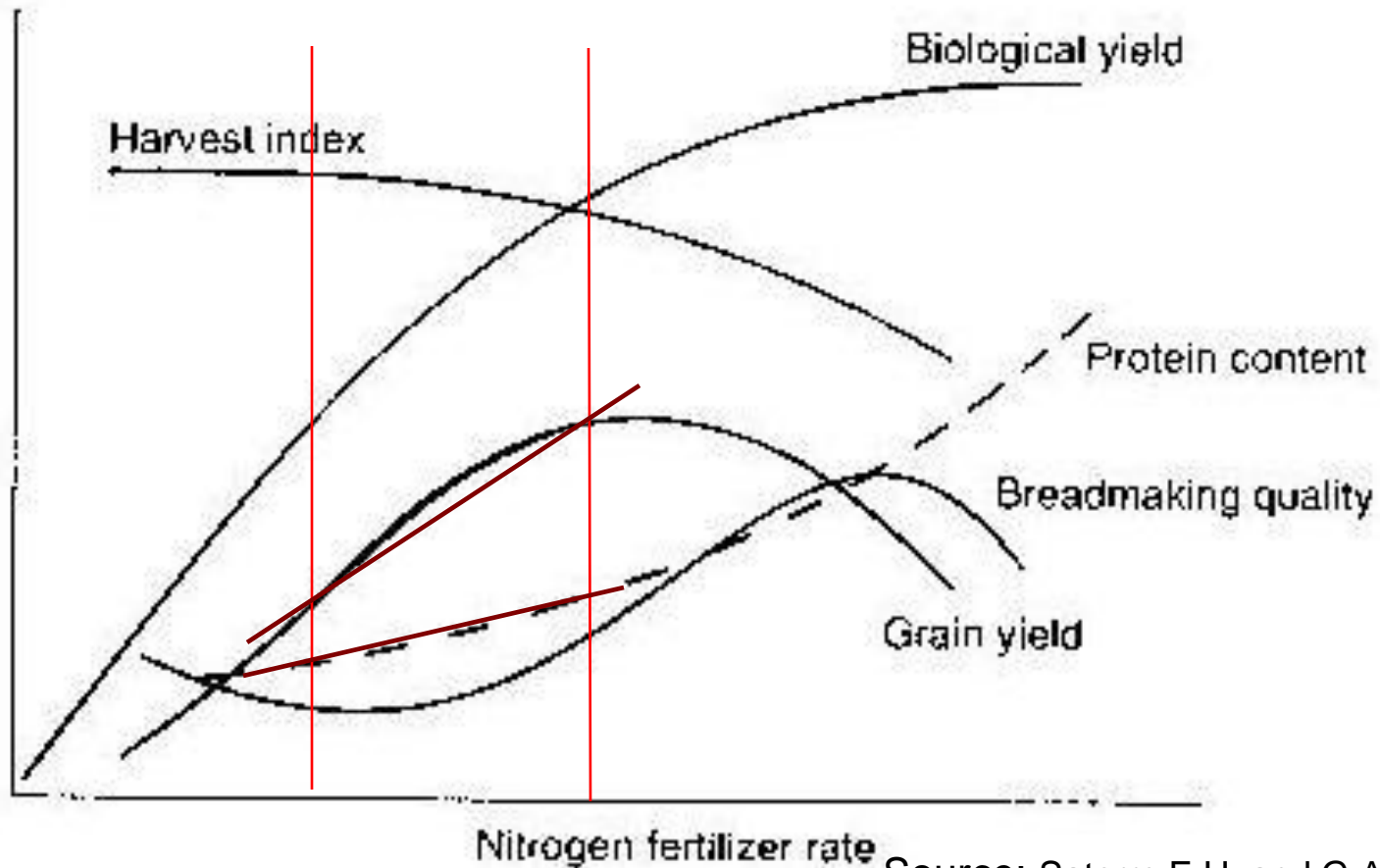
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The Conundrum



Physiology of Grain Fill

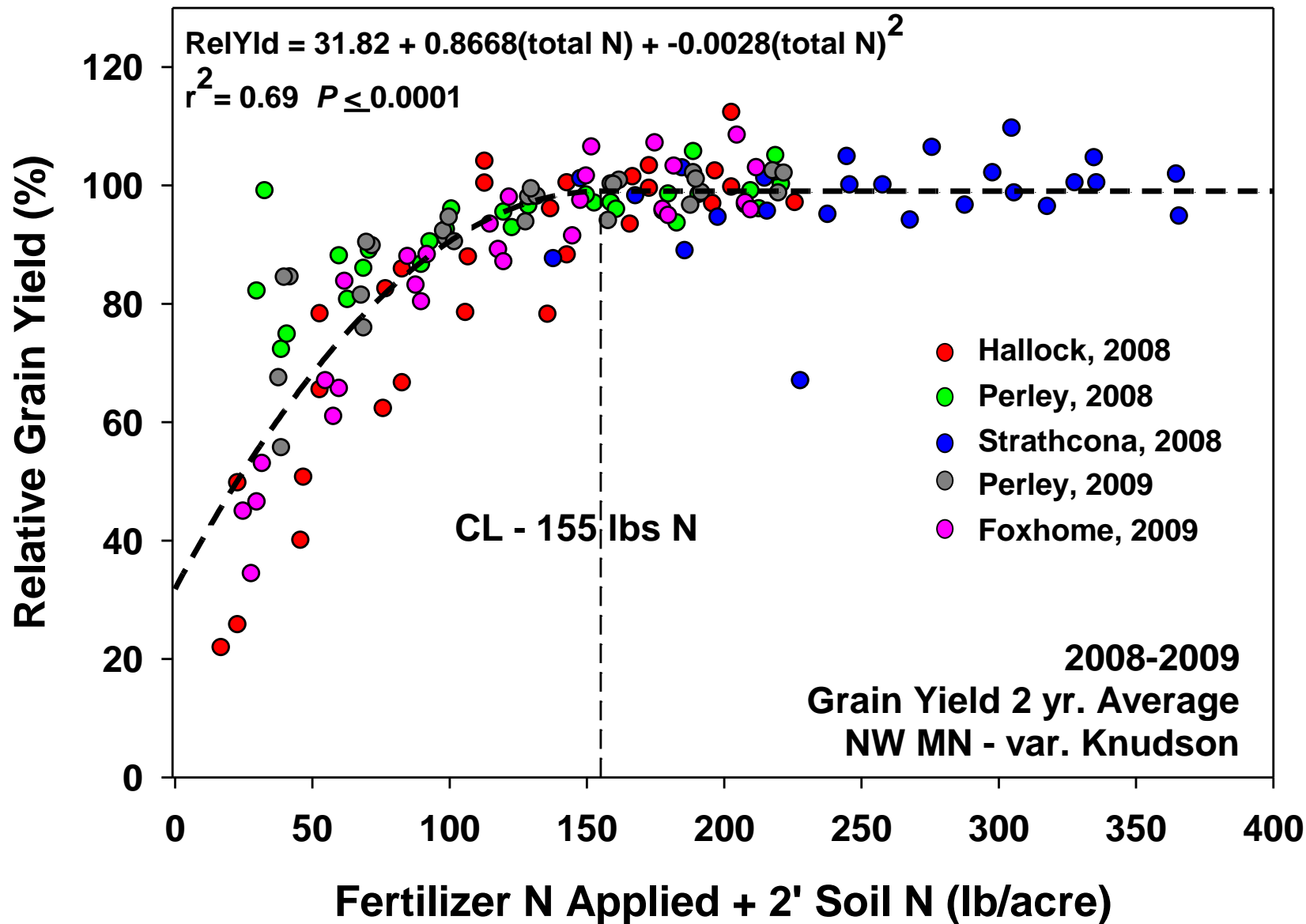


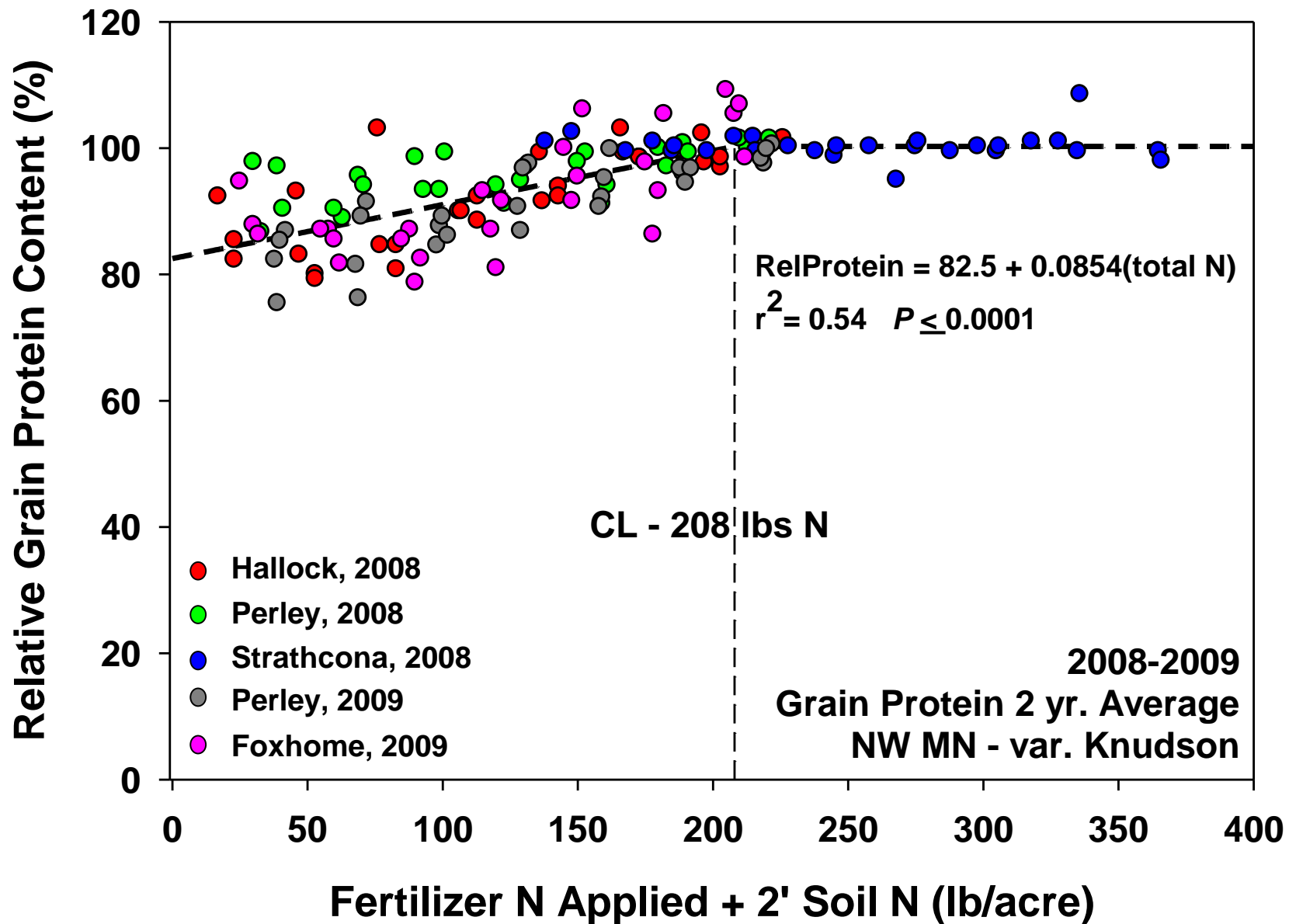
Source: Satorre E.H, and G.A. Slafer 1999.
Wheat Ecology and Physiology of Yield Determination.

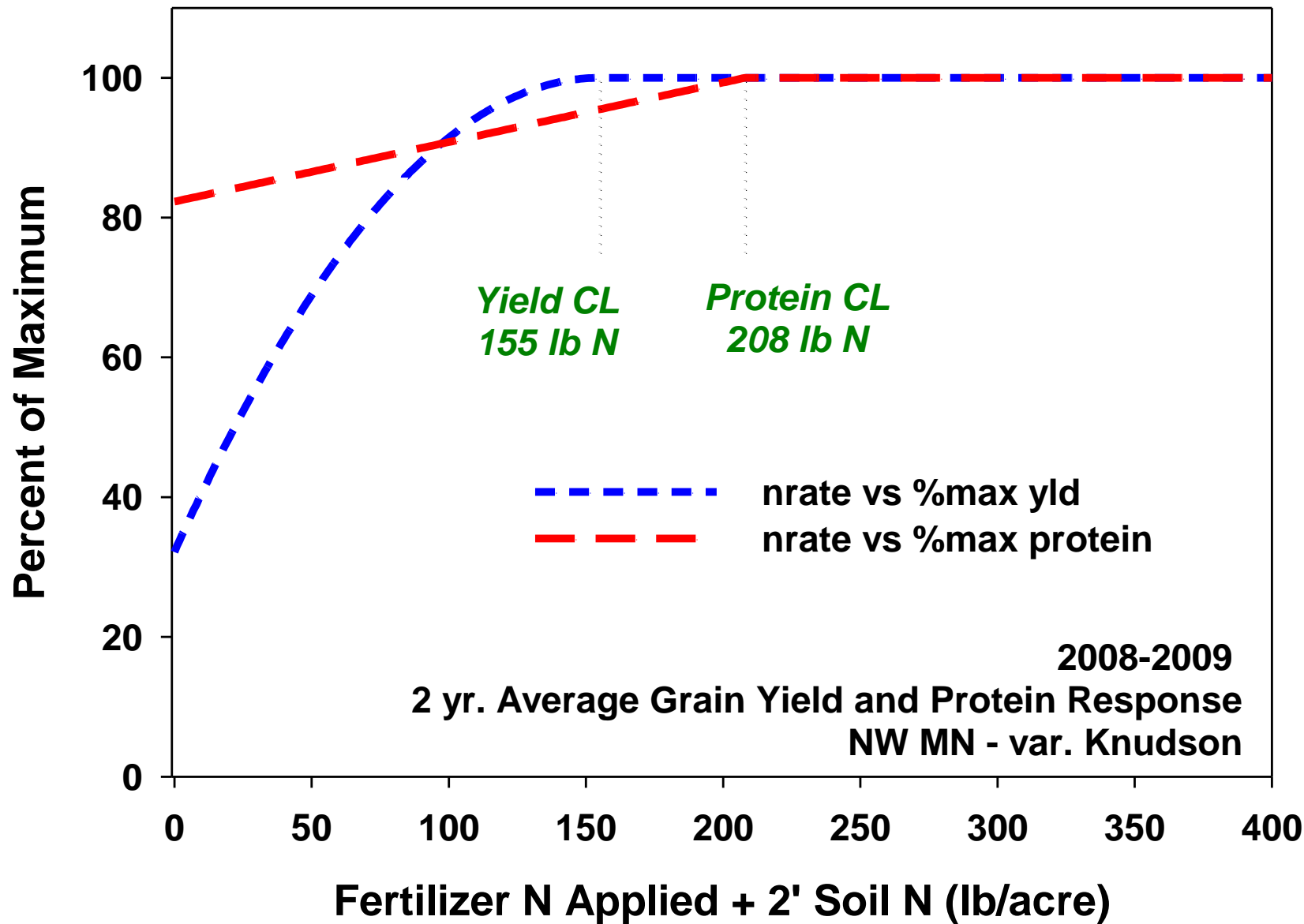


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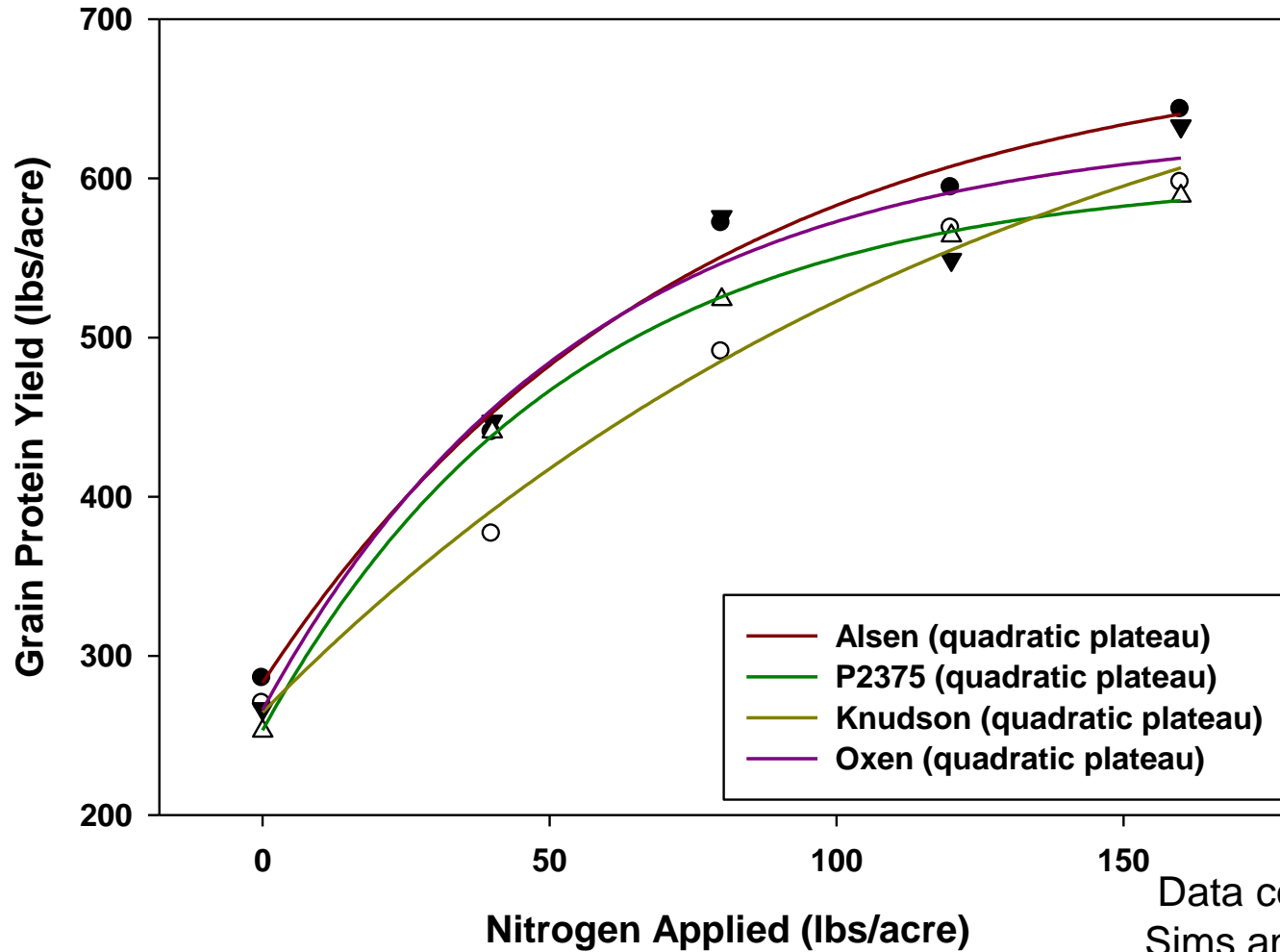
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Grain Protein Yield



Data courtesy of Albert Sims and George Rehm



The Issues

- Increased cost of N fertilizer.
- Low protein HRSW this past season.
- Interest in anything to avoid discounts.



Current Recommendation

- Western Minnesota:
 - Soil nitrate test
 - Equation:

$$N_{\text{Rec}} = 2.5 (\text{YG}) - \text{STN}_{(0-24 \text{ in})} - \text{NPC}$$

YG = yield goal

STN = amount of nitrate-nitrogen

NPC = N credit previous crop



Why not build N in the soil?

- N is mobile:
 - Water and environmental quality concerns.
- Cost prohibitive.
- Excess N will result in lodging.
- Problematic with sugar beets in rotation.



Underlying Issues

- Recommendation is:
 - Based on ‘Crop Usage’ principle.
 - An average (69 year-sites in MN, ND, and SD).
 - Derived from grain yield response curves.
 - Build-in margin of ‘safety’.
- Confounding factors:
 - In-season mineralization.
 - In-season denitrification.
 - Leaching.



Leaching

- Difficult, if not impossible, to predict losses
- Major concern in sandy soils:
 - Adoption of split N applications warranted.
- Limited downward movement in heavier soils:
 - Temporary N deficiencies possible
(largely as a result of the excess water and not lack of available N).



Denitrification

- Denitrification difficult to predict:
 - Only when fields are above field capacity.
 - Speeds up considerably when soil temperatures are above 50°F.



Mineralization

- Difficult to predict:
 - Factors that improve mineralization:
 - Higher temperatures.
 - Availability of water.
 - Availability of nitrogen.



Time to Change?

- NDSU has published new N guidelines for spring wheat modeled after the new corn guidelines:
 - Move away from yield goal formula.
 - Includes nitrogen and wheat prices.
 - Still includes soil nitrate and previous crop credits
 - Allows for adjustments for variety, tillage system, lodging risks.



Initial Assessment

- As nitrogen prices increase, total amount of N applied will decline:
 - Risk of disproportionate decline in grain protein?



Question

- Q: Did we have an opportunity to intervene in our N management in 2009 to improve grain protein?
- My answer to this question:

Maybe..

(assuming the recommended amount of N was applied for the chosen yield goal)



Reasoning

- At the latest decision point (anthesis/early grain fill) no clear warning signs that differences in grain protein were imminent.
- What made the difference:
 - Most likely - A decrease in mineralization
 - Less likely - The result of temporary N-deficiencies caused by excess precipitation.



Split Applications of N

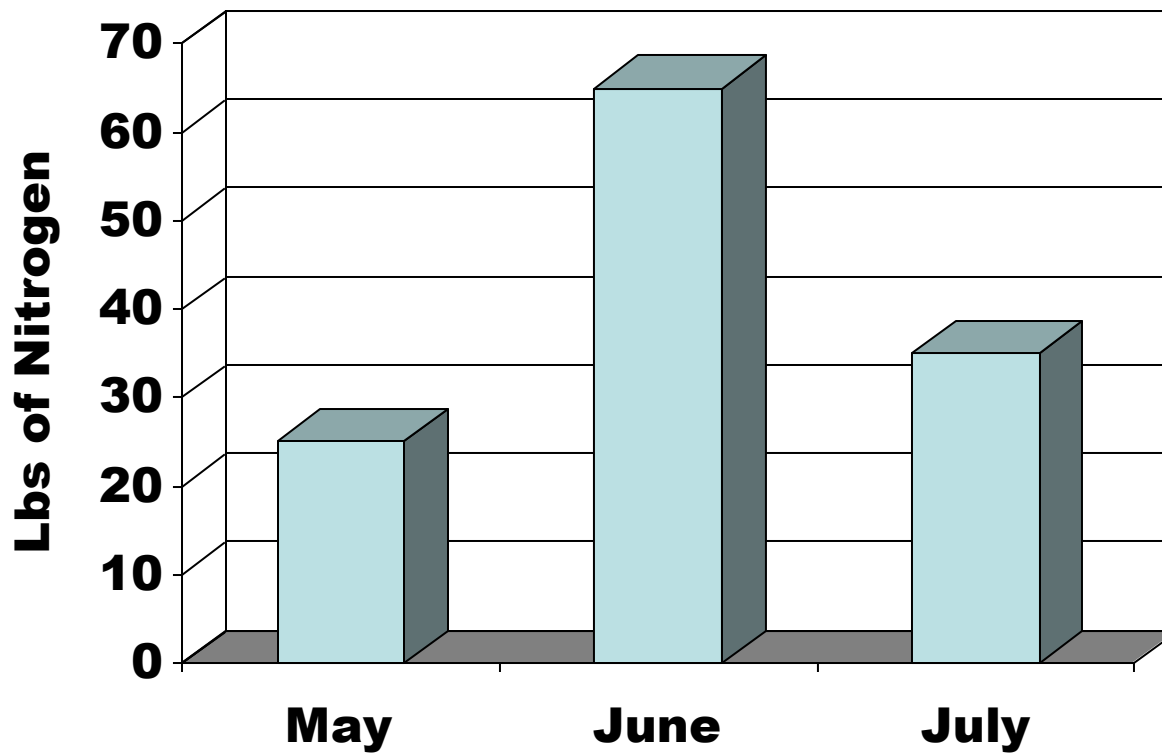
Does it work?



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Typical Nitrogen Uptake Per Acre for a 45 bu/a Hard Red Spring Wheat



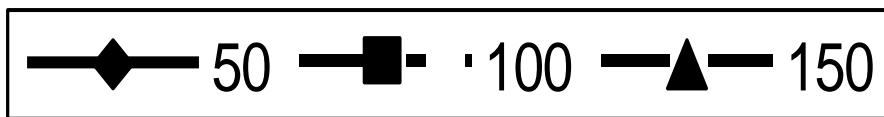
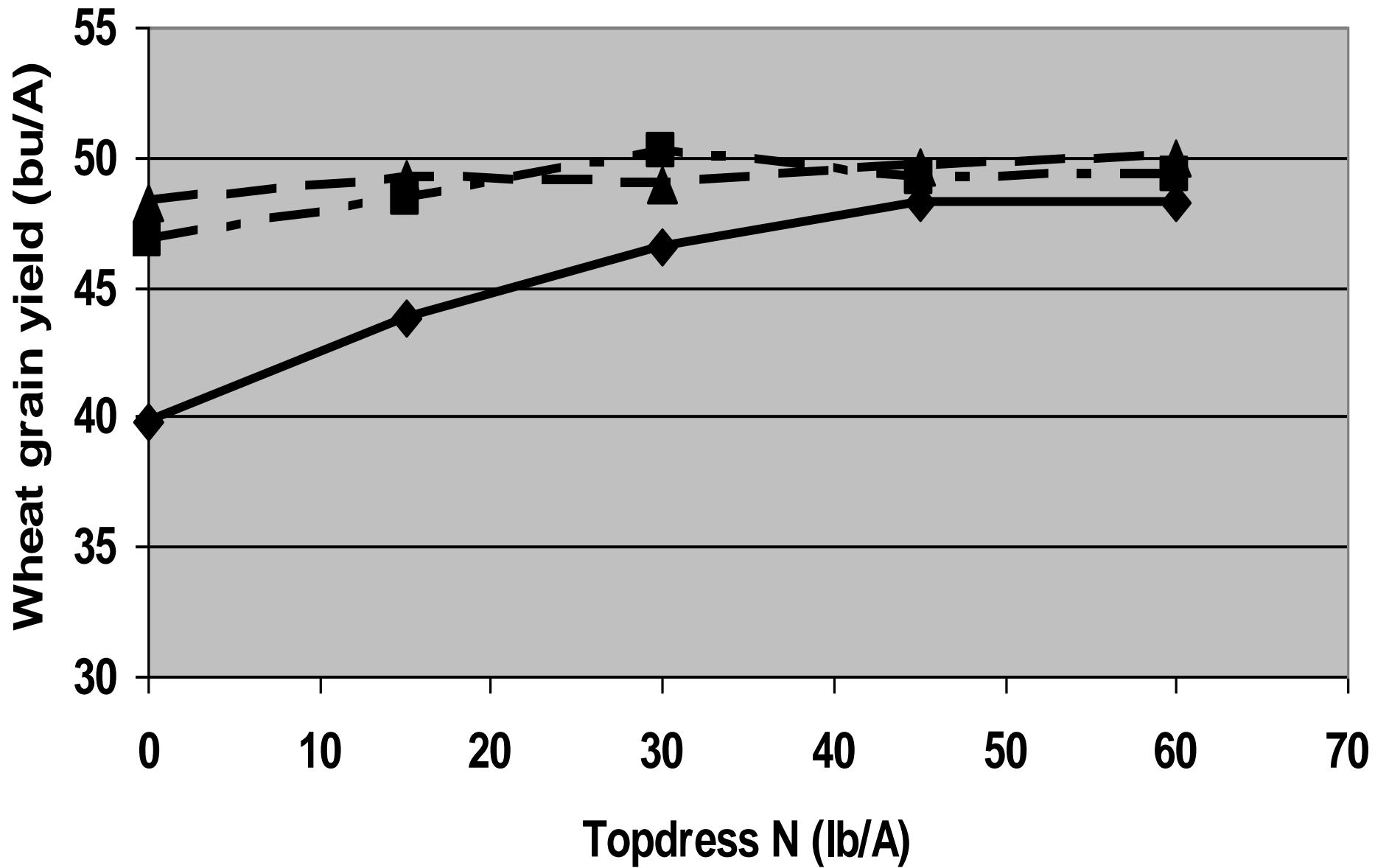
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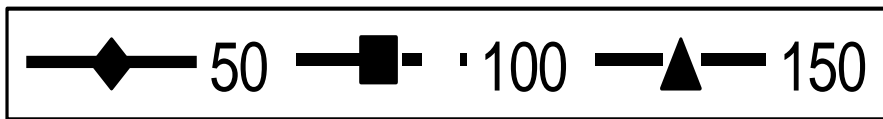
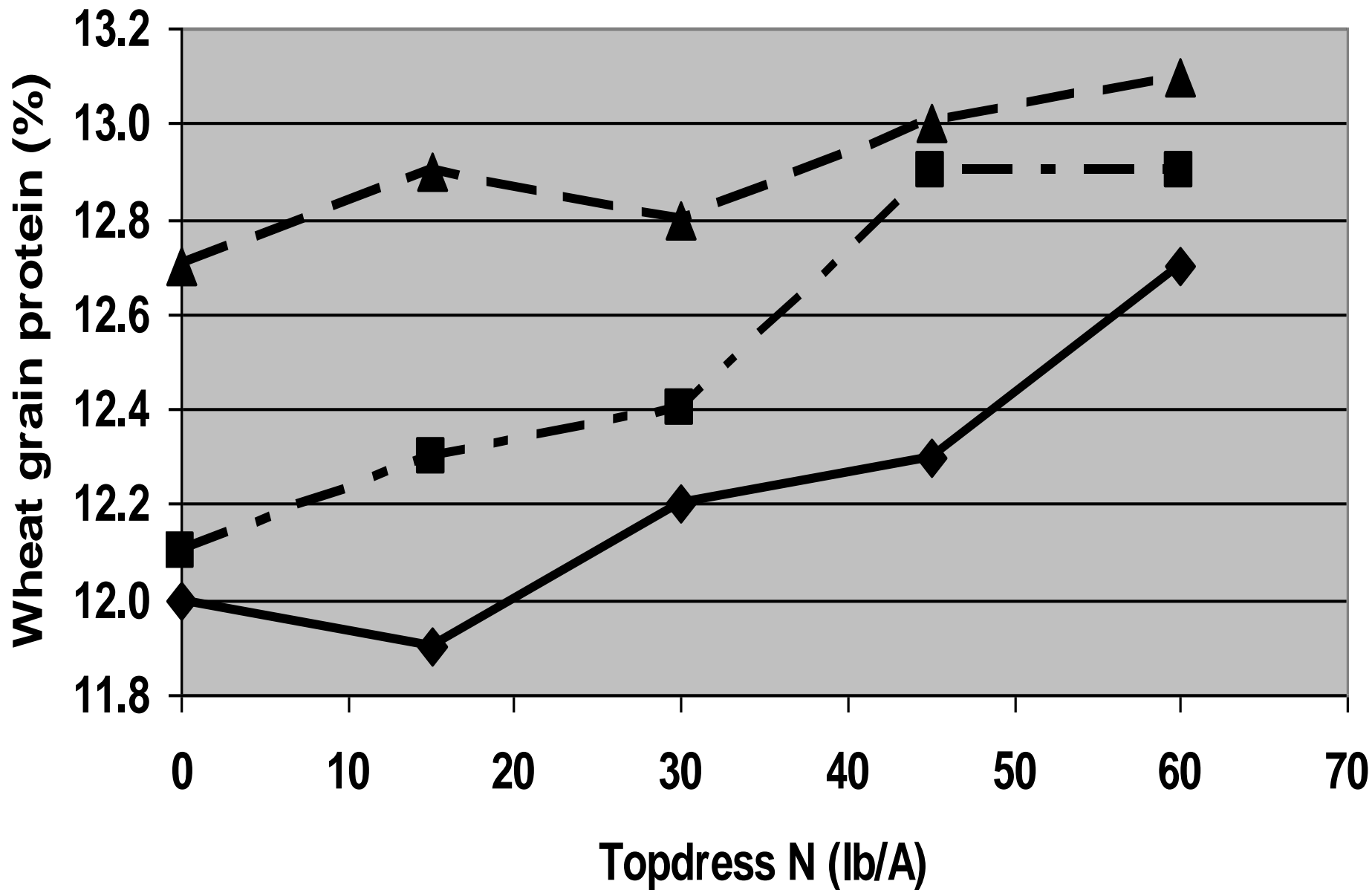
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Rehm & Lamb (early 90's)

- Materials & Methods:
 - Base level fertility equal to 50,100, and 150 lbs/A (urea – 46-0-0).
 - Supplemented at late tillering 0, 15, 30, 45, 60 lbs/A (ammonium nitrate – 33-0-0).
 - 15 site years.







Results

- Adequate pre-plant N sufficed for optimum yield.
- Top-dressed N had no effect on grain yield at pre-plant rates of 100 and 150 lbs/A of available N.
- Grain protein increased by use of top-dressed N with a diminishing return as pre-plant N increased (approx. 150 lbs N/point grain protein for highest pre-plant rate).



Late Season Nitrogen

Can additional N improve grain protein?



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Late Season N

- Late season applications of nitrogen have been standard practice for three plus decades in winter wheat production in England, Denmark, the Netherlands and northern Germany.
- The most common practice is application a dry fertilizer just before heading.



Late Season N

- In our region both NDSU and University of Minnesota have done some work on late applications of nitrogen to enhance grain quality:
 - Greg Endres and Bill Schatz at the Carrington Experiment Station.
 - John Wiersma at the Northwest Research & Outreach Center.



Endres & Schatz. (1994)

- Materials & Methods:
 - Crop planted with 100 lb N/A available.
 - Foliar nitrogen applied with 1:1 solution of water and urea ammonium nitrate (UAN) at 0, 15 and 30 lb N/A right after anthesis (10 gallons/A).
 - Gus, Grandin, Kulm, 2375, Norm, and Krona as spring wheat varieties. Monroe and Renville as durum wheats.



Agronomic Traits

<i>Rate</i>	<i>Leaf Burn</i>	<i>1000 KWT</i>	<i>Test Weight</i>	<i>Grain Yield</i>	<i>Grain Protein</i>
0	0	30.3	58.5	39.5	12.5
15	11.3	30.3	58.1	41.1	13.1
30	21.1	29.8	57.9	39.7	13.7
LSD	5.4	NS	NS	NS	0.6



Leaf Burn

<i>Cultivar</i>	<i>0</i>	<i>15</i>	<i>30</i>
Kulm	0	13.0	30.0
Grandin	0	20.0	28.8
P2375	0	10.8	18.8
Norm	0	8.8	17.5
Monroe	0	9.5	17.5
Renville	0	10.5	20.0



Results

- About 30 lbs N/ percentage point protein.
- Significant leaf burning using UAN with differences between cultivars – use early morning or evening applications to avoid leaf burning.
- No significant differences between cultivars for response to foliar nitrogen.
- No significant responses for grain yield, test weight, and kernel weight to foliar nitrogen.



Wiersma (1993)

- Materials and Methods:
 - Crop planted with 150 lb N/A available;
 - Nitrogen application methods:
 - 30, 60, 90, 120 lb N/A as urea granules at planting.
 - 30, 60, 90, 120 lb N/A as urea solution one week after anthesis applied to soil.
 - 30, 60, 90, 120 lb N/A as urea solution in four applications every four days beginning one week after anthesis applied foliar (22 gallons/A).



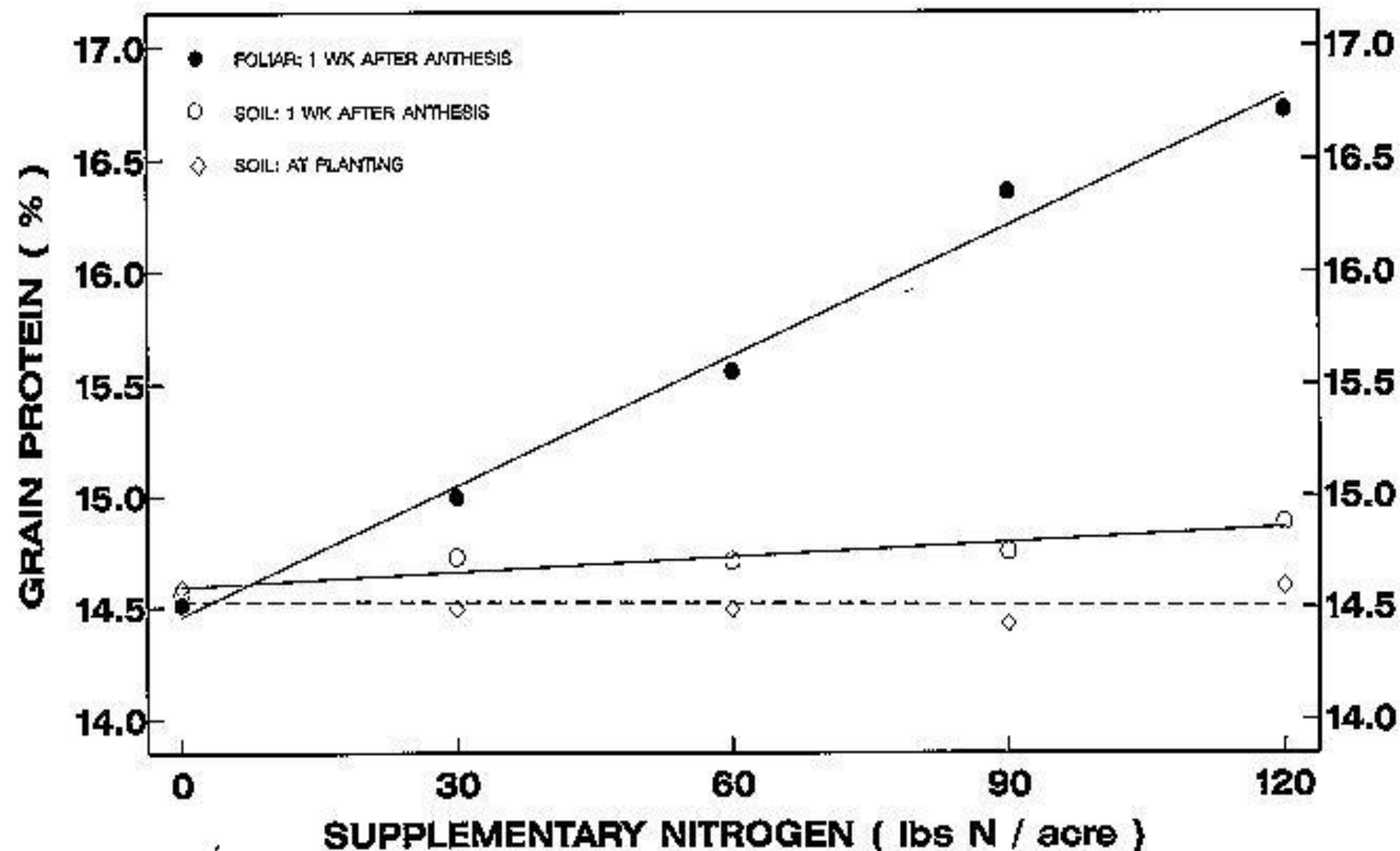


FIG. 1. CHANGES IN GRAIN PROTEIN CONCENTRATION WITH INCREASING N RATE: COMPARISON OF METHODS / TIMING OF N APPLICATION, CROOKSTON, 1993. (N APPLIED IS IN ADDITION TO 150 LBS N FROM SOIL + FALL-APPLIED N).

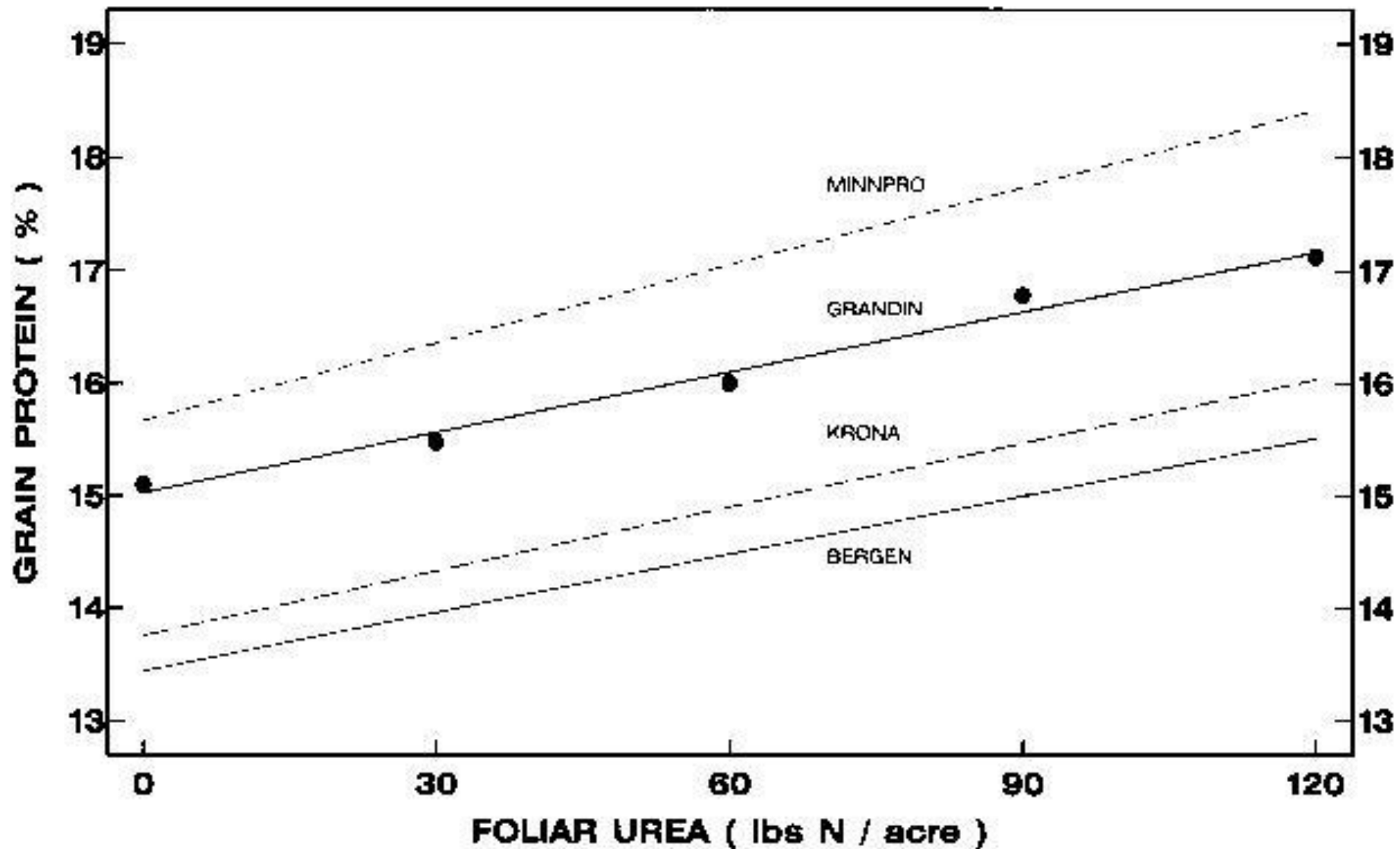
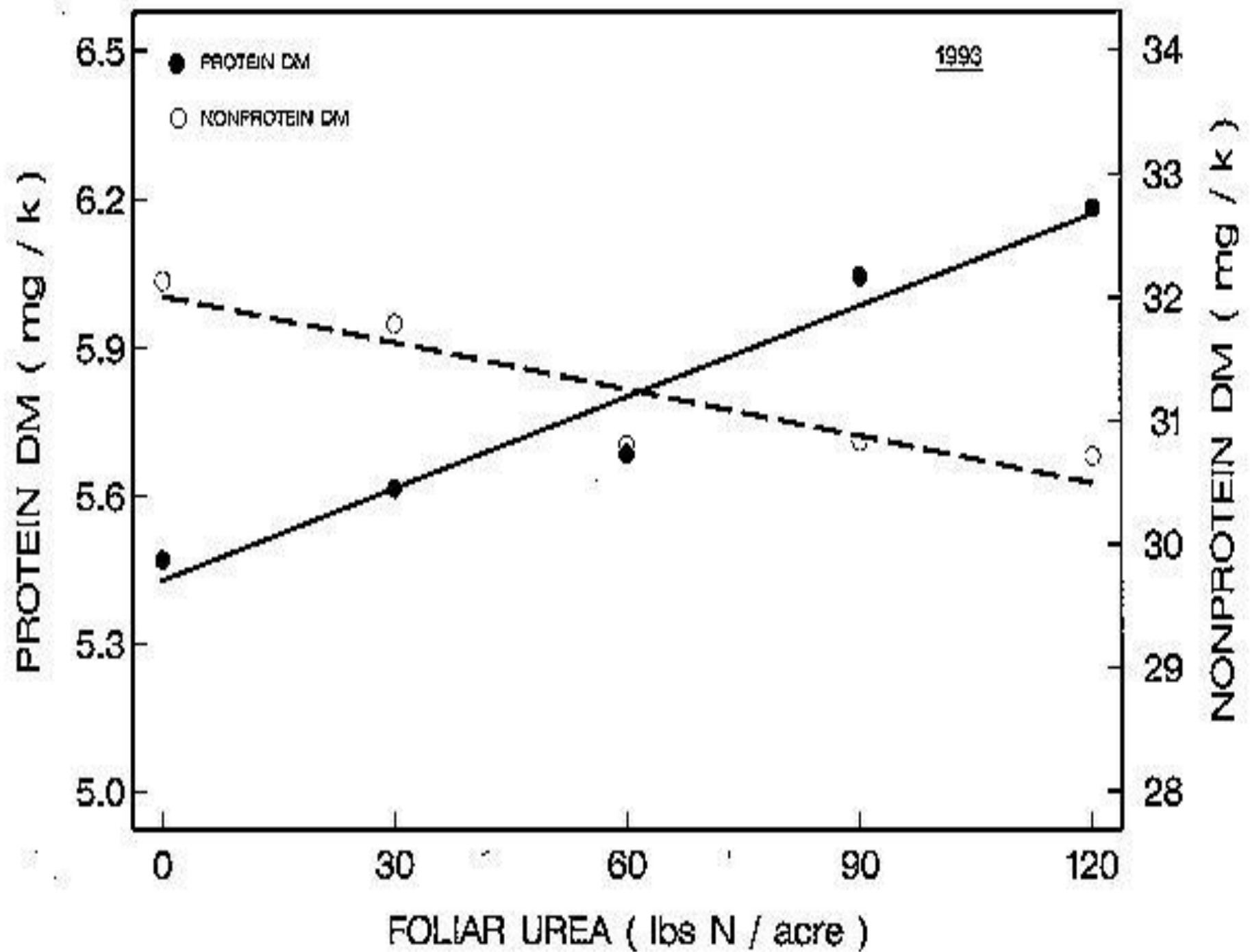


FIG. 3. GRAIN PROTEIN RESPONSES OF FOUR HRSW VARIETIES TO FOLIAR UREA APPLIED SEQUENTIALLY, BEGINNING ABOUT ONE WEEK AFTER ANTHESIS, CROOKSTON, 1993. (N APPLIED IS IN ADDITION TO 160 LBS N FROM SOIL + FALL-APPLIED N).



GRAIN PROTEIN (%)

18.0
17.0
16.0
15.0
14.0
13.0

● GRAIN PROTEIN
○ KERNEL WT

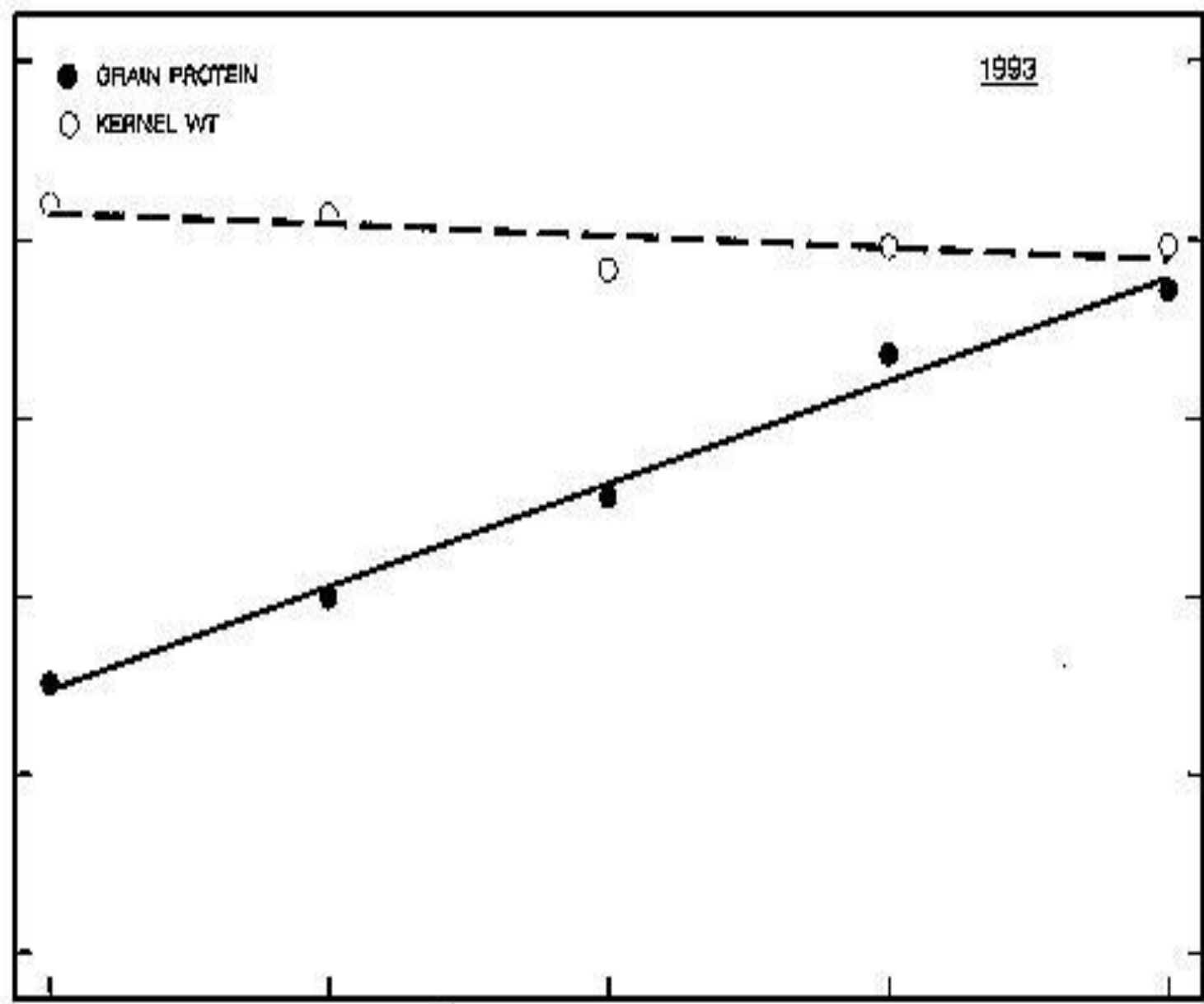
1993

40.0
37.0
34.0
31.0
28.0
25.0

0 30 60 90 120

FOLIAR UREA (lbs N / acre)

KERNEL WEIGHT (mg / k)



Results

- No response in test weight, kernel weight or grain yield to additional nitrogen when applied either at planting or to soil at anthesis.
- About 60 lbs N/ percentage point protein.
- No leaf burning.
- No differences between cultivars.
- Non protein dry matter decreases as protein dry matter increases whilst kernel weight doesn't change.



Conclusions

- Grain yield maximized using current recommendations.
 - Its okay to post apply nitrogen to meet historical yield goals using appropriate precautions.
 - Its okay to apply supplemental nitrogen to meet higher than expected yield.
- Improving grain protein is attainable but cost effectiveness uncertain:
 - Foliar applications most efficient.
 - Applications at heading/grain fill most effective.
- Lack of good predictors makes it difficult to implement.



Jochum Wiersma (2005)

- Materials and Methods:
 - RCB with 3 replication (90ft strips across the field)
 - Treatments:
 - 1) Control.
 - 2) 30 lbs N/A stream bar at GS 59.
 - 3) 30 lbs N/A foliar at GS 59+7d.
 - 4) 15 lbs N/A SB at GS 59 + 15 lbs N/A foliar at GS 59+7d.
 - 5) 15 lbs N/A foliar at GS 59 +7d + 15 lbs N/A foliar at GS 59+12.
 - UAN:water = 1:1 (Ross Farms) or UAN:water = 1:2 (AWG Farms).



Materials & Methods

- Yield:
 - Yield monitors
- Grain Protein:
 - AWG Farms - Zeltec grain protein monitor
 - Ross Farms - 'Stuck in the hopper'



Protein

Trooper

Avg Yield 65.0
Avg Protein 13.8

Yield

Protein Points

- 10.5 - 12
- 12 - 13
- 13 - 14
- 14 - 15
- 15 - 16
- 16 - 18.8

Lo282 05 Wht Pts

- 20.556 - 40.887
- 40.887 - 50.939
- 50.939 - 57.915
- 57.915 - 63.142
- 63.142 - 67.763
- 67.763 - 73.406
- 73.406 - 86.919



Protein

Treatment Avg Pro Min Pro Max Pro St Dev Frequency

30# Foliar 13.30 11.40 15.30 0.70 107.00

15# S / 15# F 13.80 12.40 15.60 0.70 103.00

30# Stream 13.90 12.30 15.30 0.60 79.00

2 x 15# Foliar 13.90 12.50 15.30 0.60 67.00

Check 13.70 12.20 15.10 0.60 36.00

2 x 15# Foliar 13.50 11.90 15.50 0.60 35.00

30# Stream 13.60 12.20 15.10 0.60 103.00

15# S / 15# F 13.90 12.70 15.60 0.60 75.00

30# Foliar 13.80 12.50 15.80 0.60 76.00

Check 14.00 12.90 16.20 0.70 55.00

15# S / 15# F 13.80 13.00 15.50 0.70 36.00

Check 14.00 12.20 15.70 0.70 107.00

30# Foliar 14.00 11.90 16.70 0.90 106.00

30# Stream 14.10 12.80 15.50 0.60 73.00

2 x 15# Foliar 14.40 11.50 16.40 0.90 86.00

Leaf Burn

<i>Treatment</i>	<i>Field</i>						<i>Mean¹</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	
1	3.3 ³	0.7	10.0	0.0	0.0	1.7	2.6
2	10.0	36.7	13.3	25.0	23.3	6.7	19.2
3	3.3	25.0	21.7	36.7	10.0	18.3	19.2
4	5.0	6.7	13.3	13.3	16.7	13.3	11.4
5	3.3	8.3	11.7	23.3	20.0	18.3	14.2
Mean ²	5.0	15.5	14.0	19.7	14.0	11.7	13.3

¹ The LSD (0.05) to compare treatments means averaged across fields is 6.0.

² The LSD (0.05) to compare field means averages across treatments is 6.5.

³ The LSD (0.05) to compare treatments means within and across fields is 14.6.



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Grain Protein

Table 2 The grain protein percentage as a result of the application of late season supplemental N in 6 HRSW fields nearby Crookston, MN in 2005.

<i>Treatment</i>	<i>Field</i>						<i>Mean</i> ¹
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	
1	14.7 ³	15.3	14.0	14.9	13.9	15.5	14.7
2	14.6	15.4	14.4	15.3	13.9	16.3	15.0
3	14.6	15.7	14.4	15.3	13.7	16.2	15.0
4	14.7	15.8	14.7	15.5	13.9	16.4	15.2
5	14.6	15.4	14.4	15.0	13.8	16.5	15.0
Mean ²	14.6	15.5	14.4	15.2	13.8	16.2	15.0

¹ The LSD (0.05) to compare treatments means averaged across fields is 0.2.

² The LSD (0.05) to compare field means averages across treatments is 0.2.

³ The LSD (0.05) to compare treatments means within and across fields is non significant.



Results

- Significant leaf burning:
 - Split foliar applications reduce risk.
 - Time of day and GPA reduce risk (data not shown).
- No effect on grain yield (data not shown):
- Significant increases in grain protein
 - Split application most effective.
 - About 60 lbs N/ percentage point protein.
 - No response in 2 of the 6 fields



Decision Guide

- The utilization index is between 0.47 and 0.93. These ratios are derived from the two small plot studies.
- The premium/discount per fifth point of grain protein is constant.
- The expected total amount of grain protein to be gained from supplemental N is constant and thus the increase in grain protein percentage is smaller as grain yield increases.
- A single application of 30 lbs. N/A is made with an application cost of \$3.00/A.
- No effects on grain yield, test weight, or kernel weight are expected.



Decision Guide

