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Where do Enhanced Efficiency Nitrogen Fertilizers and Split N Applications Fit?

Cynthia Grant and Alan Moulin
AAFC - Brandon Research Centre

Nicolas Tremblay
AAFC - St. Jean

cgrant@agr.gc.ca

Canada

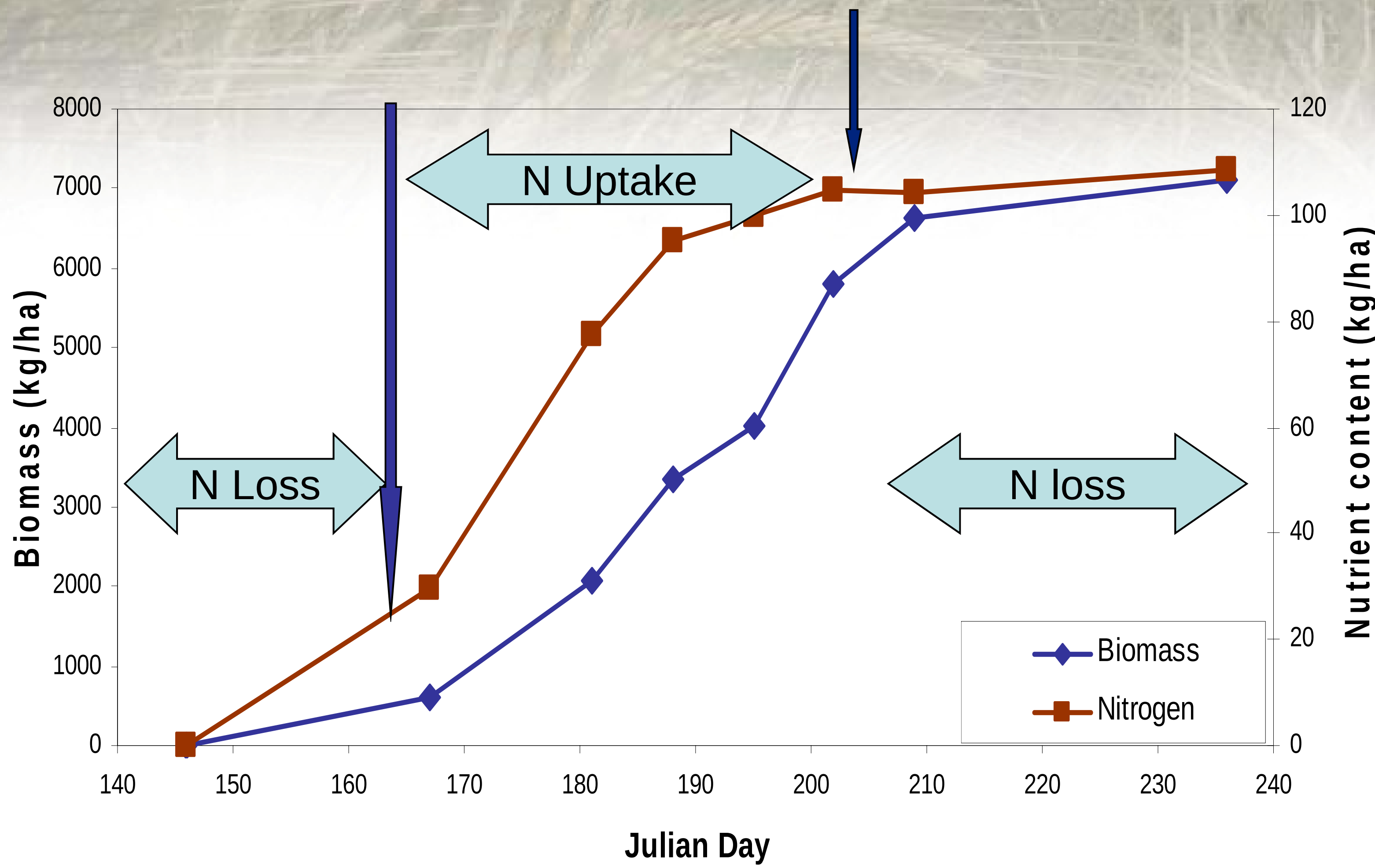
Producers have Adopted Many Fertilizer BMPs

- Rate
- Source
- Timing
- Placement
  - More than 75% of fertilizer in Canada is banded – even higher proportion in the prairies

But:

Fertilizer N use efficiency IN THE YEAR OF APPLICATION is generally less than 50%

Synchrony of N Supply and Uptake Can Improve NUE



Adrian Johnston


How Can We Match N
Supply to Crop
Uptake?

Historically, Split Applications Have Been Used to Match N Supply with Crop Demand

- Minimise inorganic N in solution before crop uptake
- Reduce the risk of N losses and may increase nitrogen use efficiency (NUE)
- Allow rate to be changed if yield potential changes
  - Minimise investment in low-yielding crop
- Potential agronomic benefits
  - Reduced lodging
  - Less disease
  - Improved crop quality

Drawbacks of Split Applications

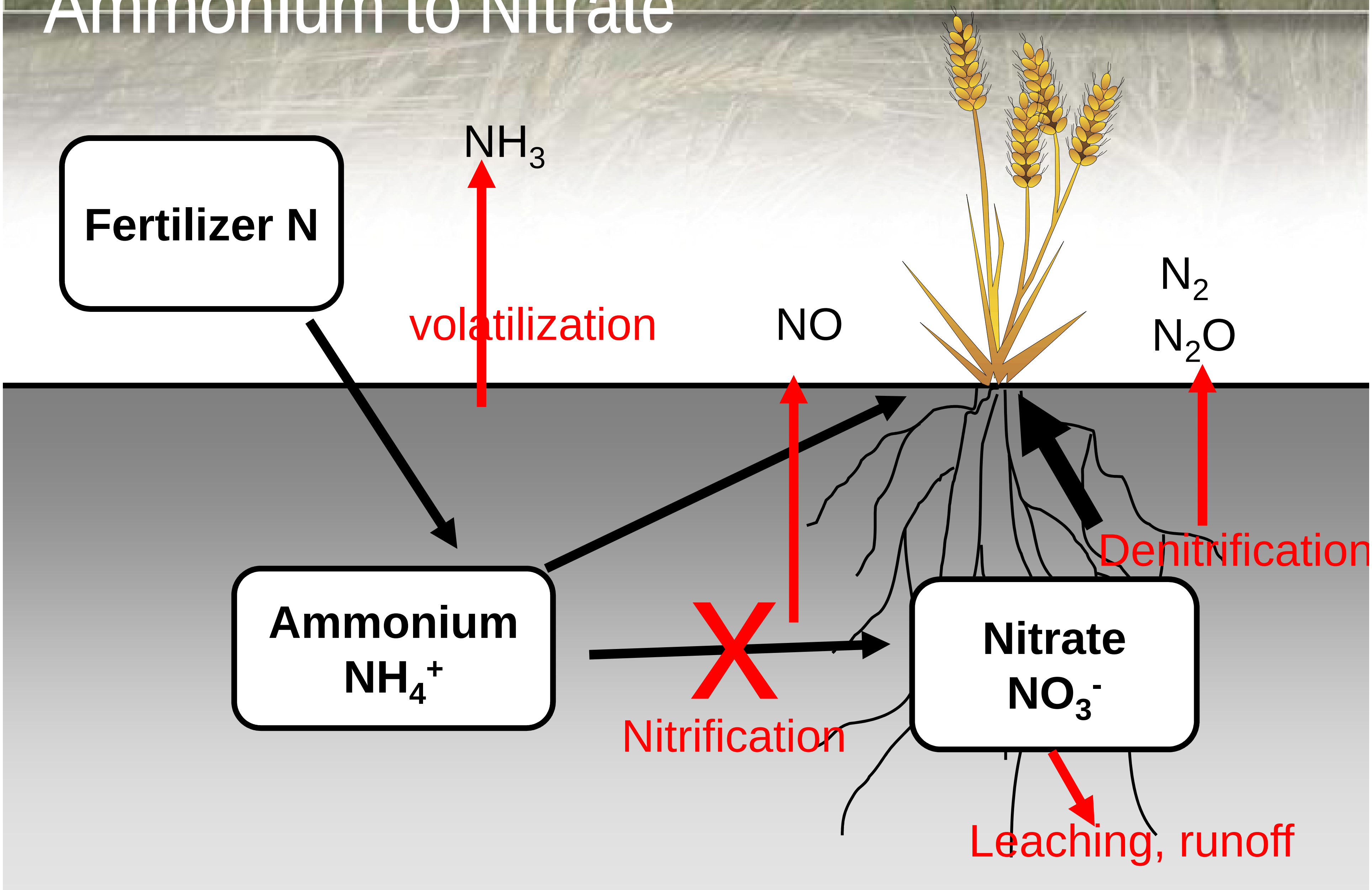
- Surface application may be inefficient
  - Volatilization and immobilization
  - Stranding on soil surface
  - Lack of foliar uptake
- In-soil applications may damage crop
- Multiple passes increase cost, fuel consumption, traffic, and labour
- Often of limited value in short-season low-moisture areas
- Risk of missing window of application

Wet Conditions may Hamper Field Operations

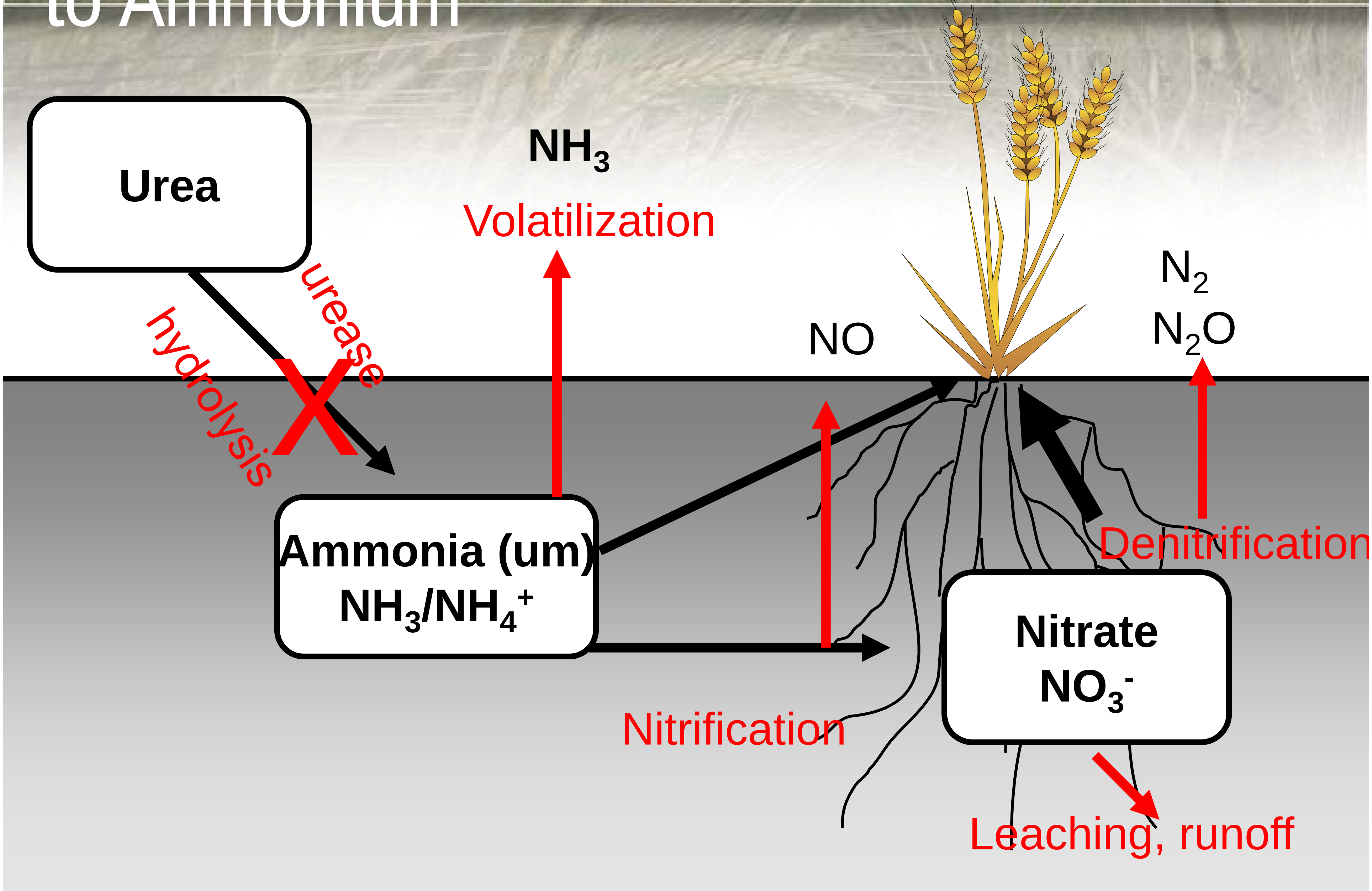
Enhanced Efficiency Fertilizers

- Fertilizers formulated to reduce losses and improve the plant uptake as compared to the "unenhanced" formulation
- Reduce volatilization and immobilization from broadcast fertilizers
  - May be used with split applications
- Reduce losses from in-soil banded applications
- Slow release products can help match uptake with demand

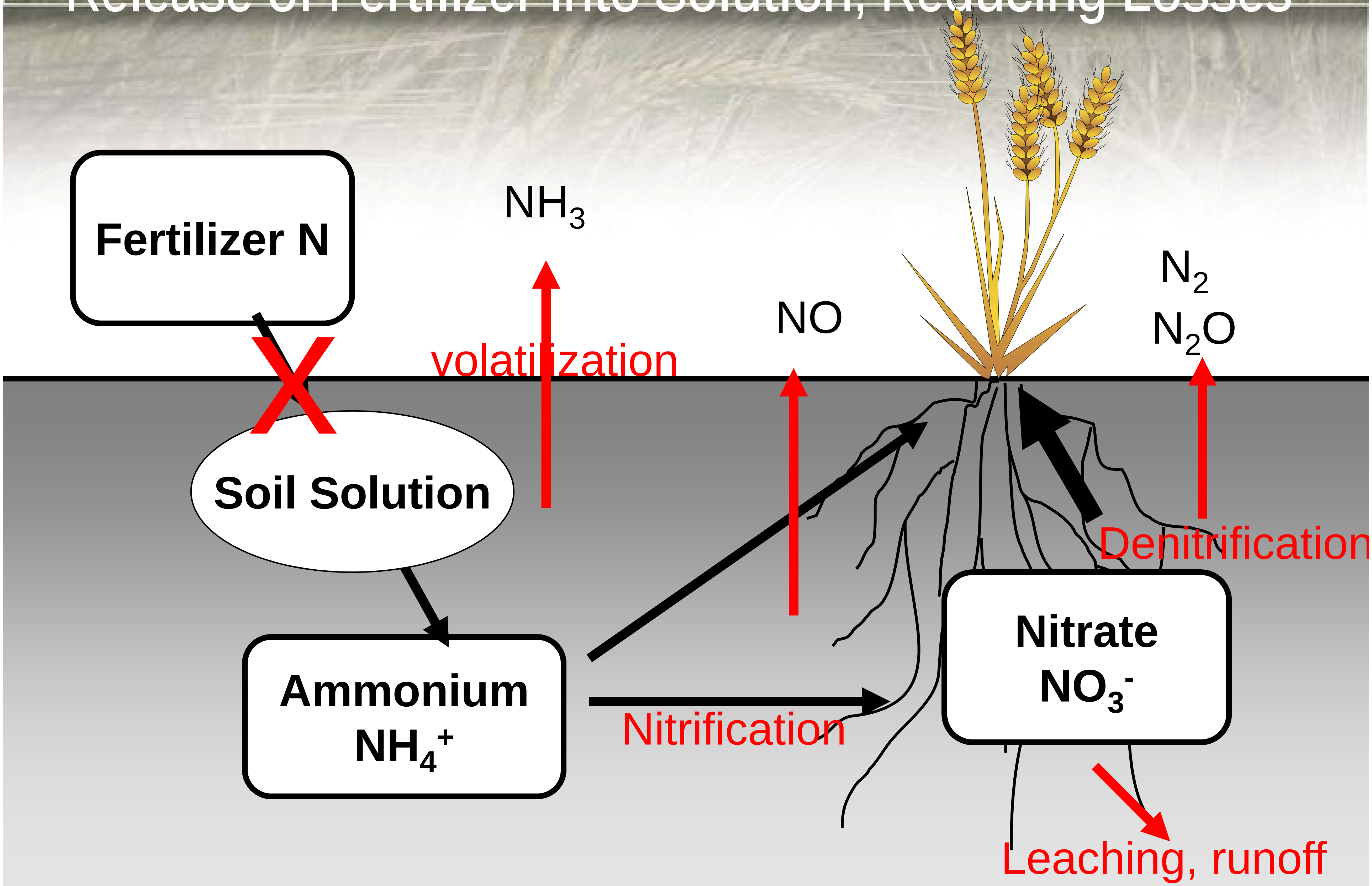
Nitrification Inhibitors Delay Conversion of Ammonium to Nitrate



Urease Inhibitors Delay Conversion of Urea to Ammonium



Slow and Controlled Release Products Delay Release of Fertilizer into Solution, Reducing Losses



Greater Potential for Benefit Under Wet Conditions

- More potential for nitrogen loss
- Greater yield potential and N demand
- Under dry conditions, losses and benefits are both lower

Research Questions

- Is there an economic benefit to more closely matching N supply to crop uptake under prairie conditions?
  - split N applications
  - control release urea (CRU)
  - urease and nitrification inhibitors
- How does microclimate influence optimum N management?
- Should N management strategies be altered with seeding date?
- Can N sufficiency measurements be used to predict the need for in-crop N applications?

Treatments were applied at upper and lower slope positions at two sites

This gave us four different slope by site combinations

At each site-slope combination, two seeding dates were used

This let us test the fertilizer treatments at 8 different environments

Weather stations were located at each site-slope position to monitor soil moisture, temperature and rainfall

Treatments

1. Control – no N
2. Fall banded urea N at 1.0 x recommended rate
3. Fall banded CRU at 1.0 x recommended rate
4. Spring side-banded urea N at 0.5 x recommended rate
5. Spring side-banded urea N at 1.0 x recommended rate
6. Spring side-banded urea N at 1.5 x recommended rate
7. Spring side-banded CRU at 0.5 x recommended rate
8. Spring side-banded CRU at 1.0 x recommended rate
9. Spring side-banded CRU at 1.5 x recommended rate
10. Super U at recommended rate (broadcast before seeding)
11. Agrotain Plus at 1.0 x recommended rate (dribble on seed row))
12. Split N application 1 - 0.5 side-banded at seeding and 0.5 dribble-banded as UAN at early tillering (Feekes stage 2-3) 2” off seed row
13. Split N application 2 - 0.5 side-banded at seeding and 0.5 dribble-banded as UAN at late tillering to early stem extension (Feekes stage 5-6) 2” off seed row

Measurements

1. Soil nutrient content, pH, conductance, soil texture, and organic carbon to 60 cm.
2. Gravimetric soil moisture to 60 cm at seeding
3. Soil moisture and temperature at 7.5 cm depth, using dataloggers.
4. Air temperature and rainfall
5. Date of emergence and plant stand density.
6. Tissue N, and crop assessment with SPAD and GreenSeeker meters immediately prior to fertilization at Feekes 2-3 and 4-6
7. Plant biomass and tissue N at heading
8. Grain yield, straw yield, N concentration, harvest index and N harvest index
9. Soil N content to 60 cm at harvest

The Spad meter and Green Seeker were used to assess N sufficiency

Values were compared to tissue N analysis

Statistics

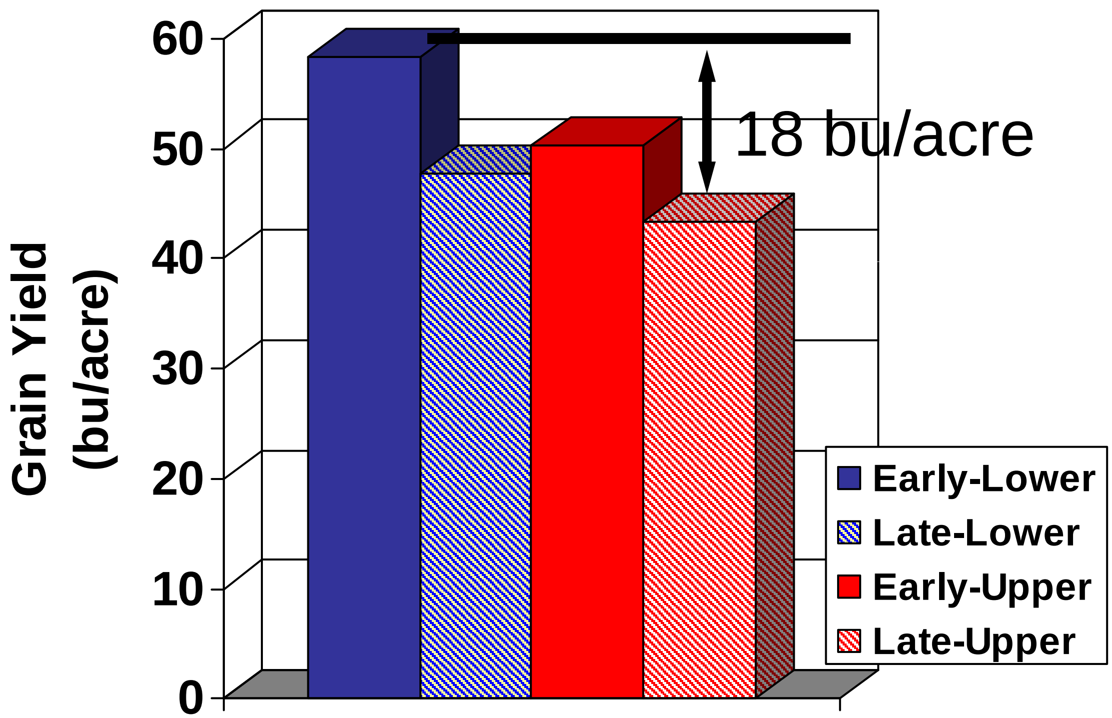
- Split plot factorial experiment with four replicates
  - seeding dates as the main plots
  - fertilizer treatments as the sub-plots,
  - 2 locations x 2 slope positions x 2 seeding dates x 13 treatments x 4 replications
  - 416 plots per year.
- Statistical analysis used contrast analysis under Proc Mixed of SAS

What was the Season Like?

- The 2008 growing season began with relatively dry conditions
- Turned wet and cool relatively early in the season
- June through August were wetter and cooler than average
- Growing conditions were relatively good, with crop yields being high

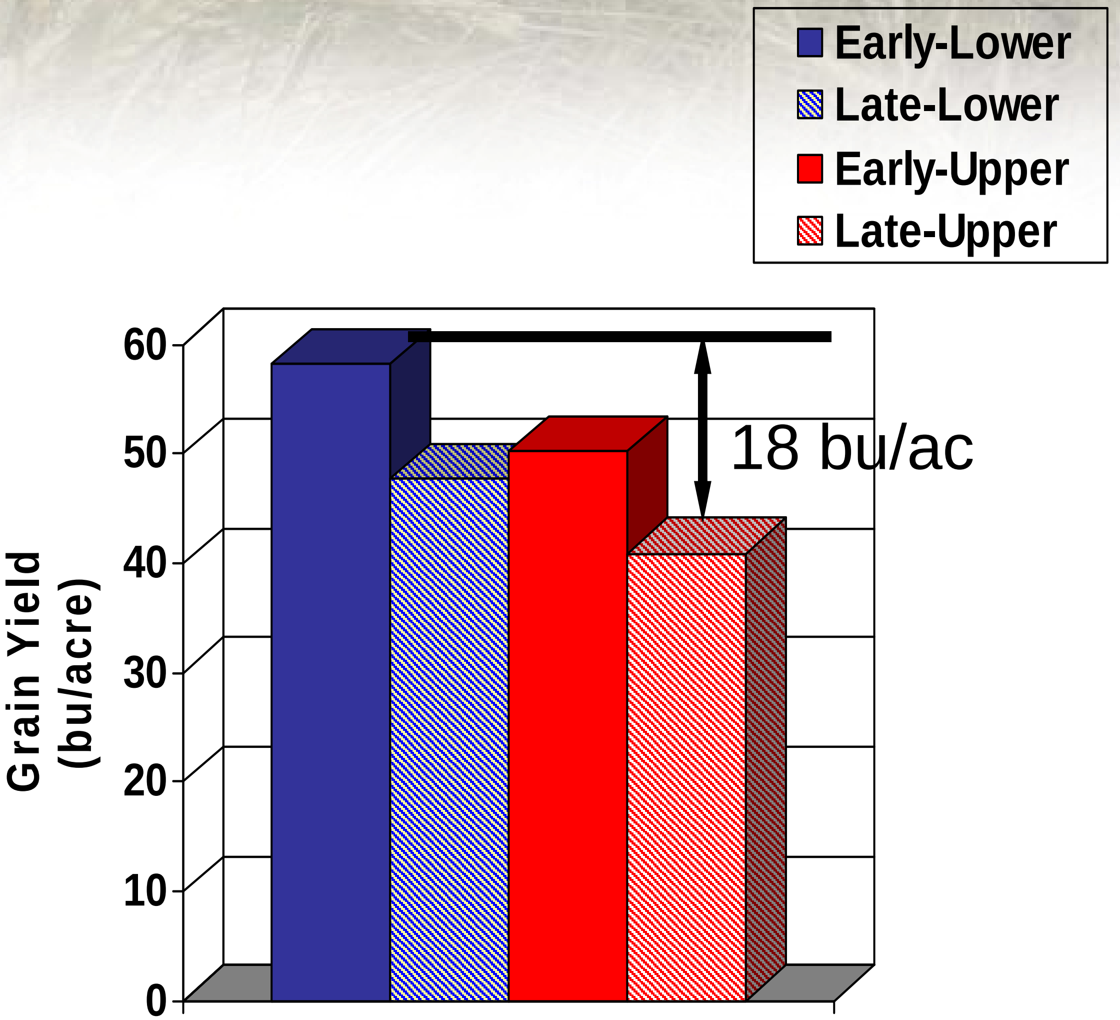
At the Silty Clay site, grain yield was affected by seeding date and slope position

- Higher yield with early seeding date
  - About 10 bu/acre benefit
- Higher yield on lower slope than upper
  - About 7 bu/acre
- Same effects as in 2007

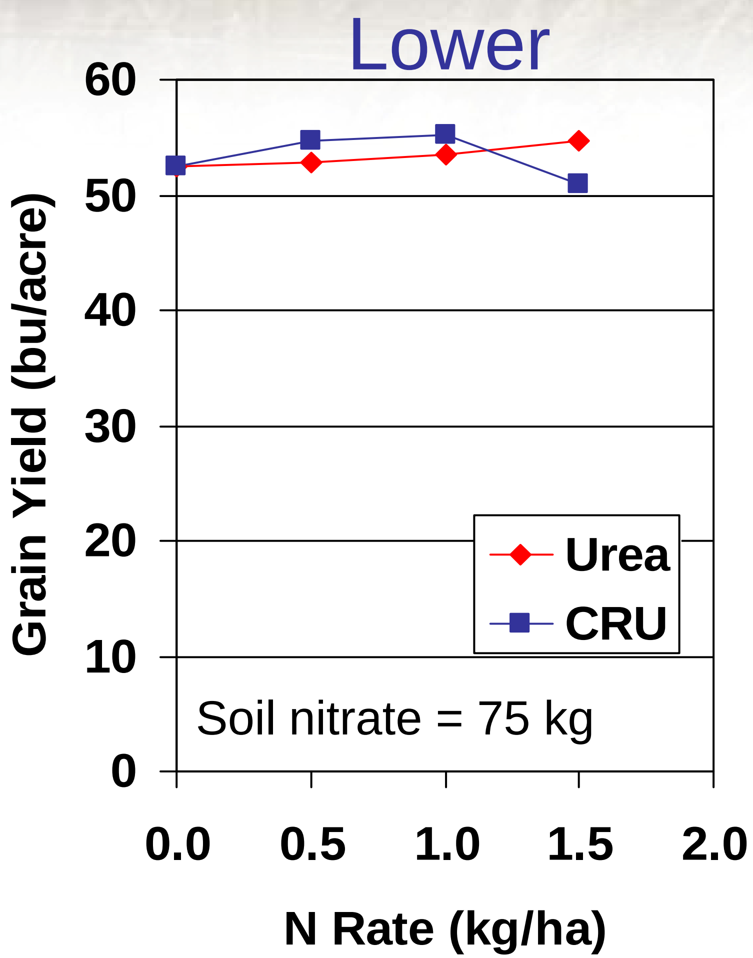


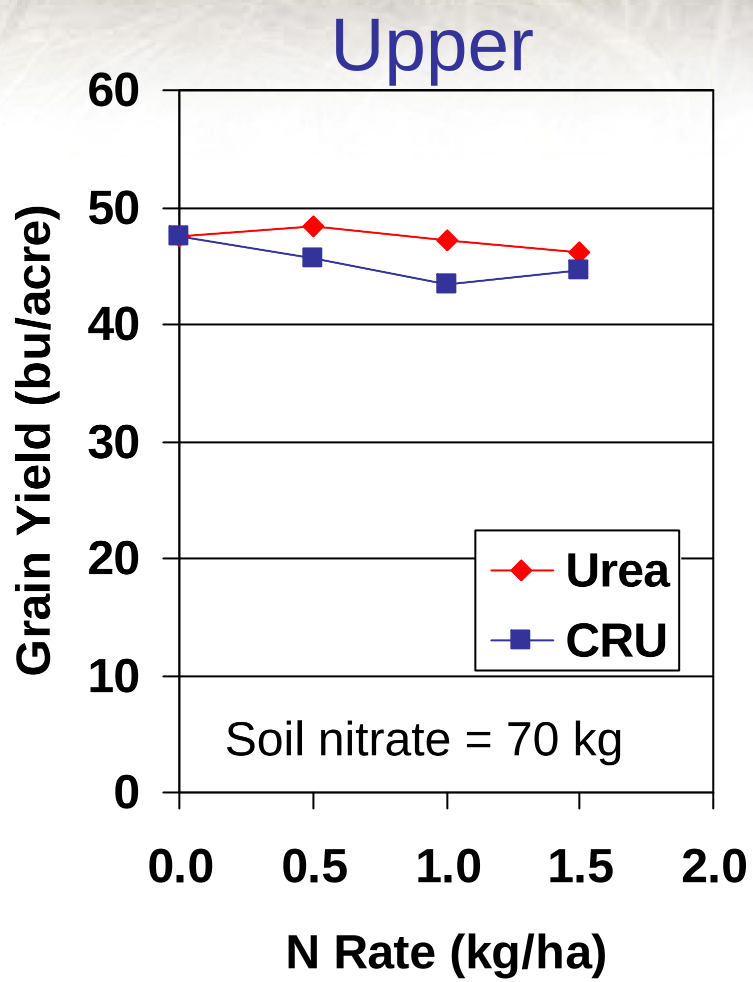
Slope position and seeding date also had an effect at the clay loam site

- Higher yield with early seeding date
  - Averaged 10 bu/acre more
- Higher yield on lower than upper slope positions
  - Extra moisture on lower slope helped
- Yield increased by 18 bu/acre with early seeding and lower slope position



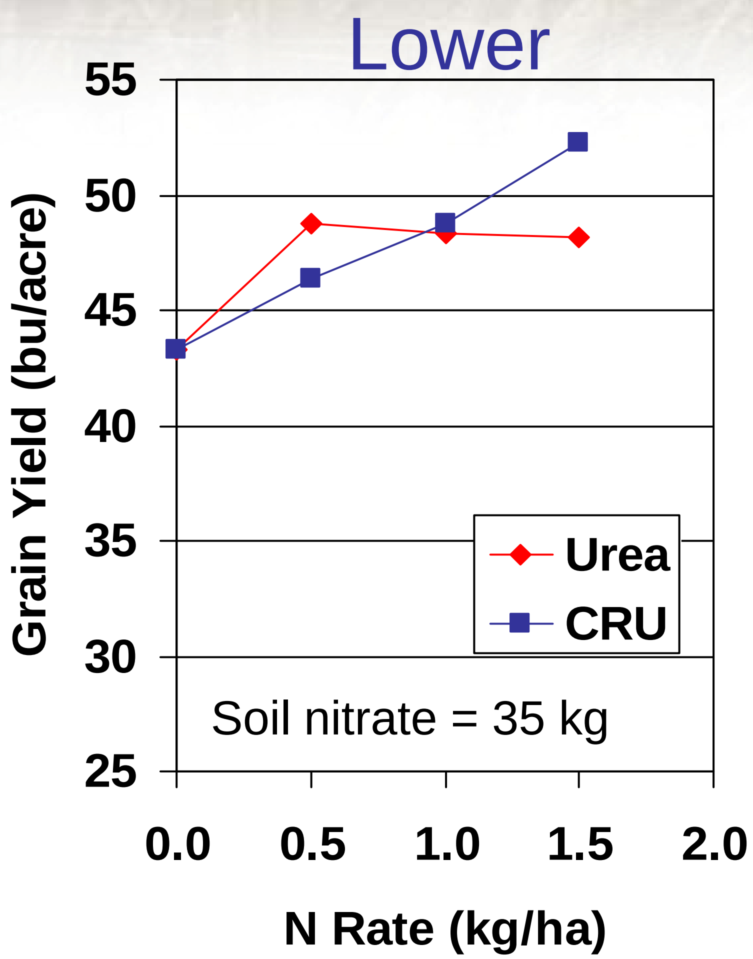
There was no significant effect of N application on grain yield at the Silty Clay site

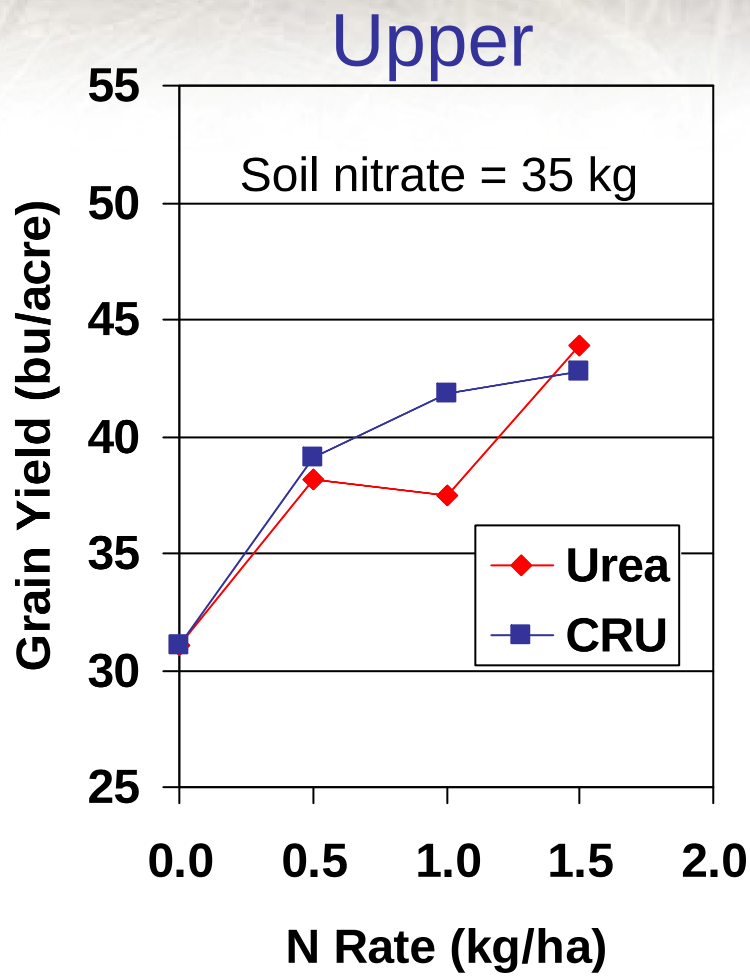




Nitrogen increased grain yield at the Clay Loam site

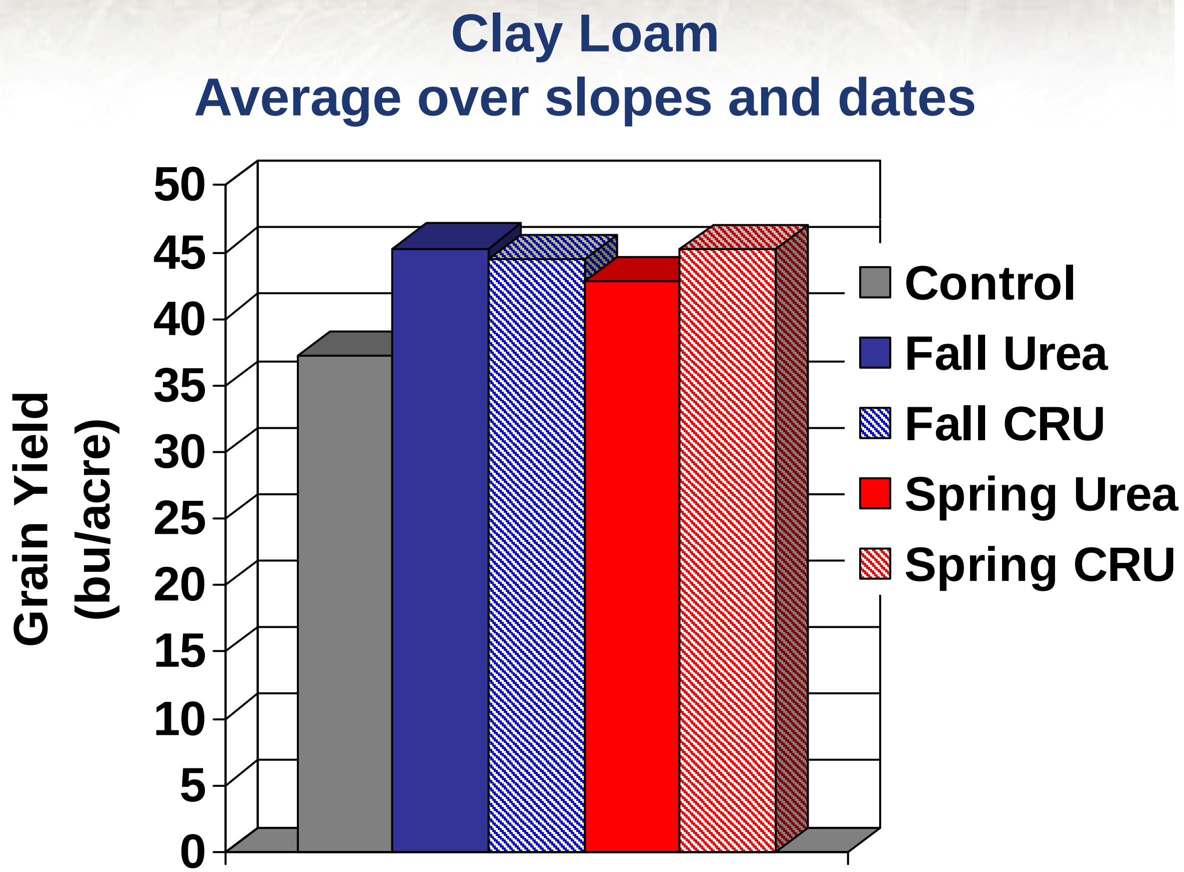
-Yield similar with CRU and urea if spring-banded





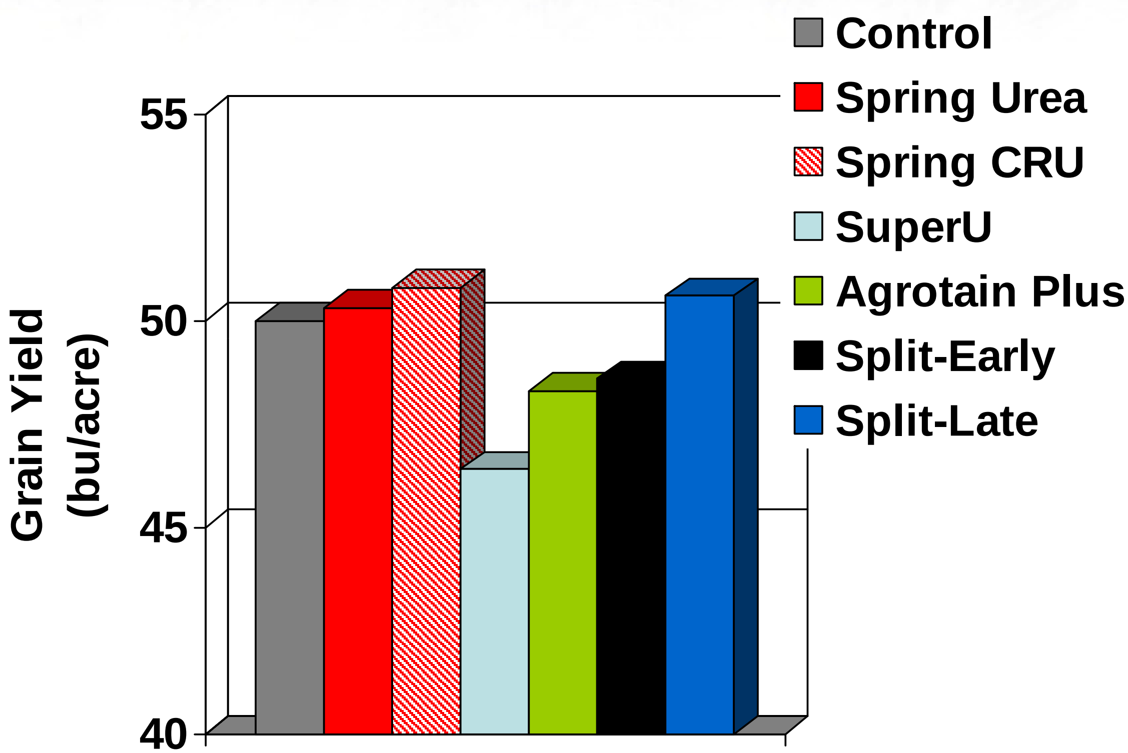
Fall-banded urea performed as well as spring-banded urea at both sites

- Losses from fall-application were low
- No need or benefit from use of CRU



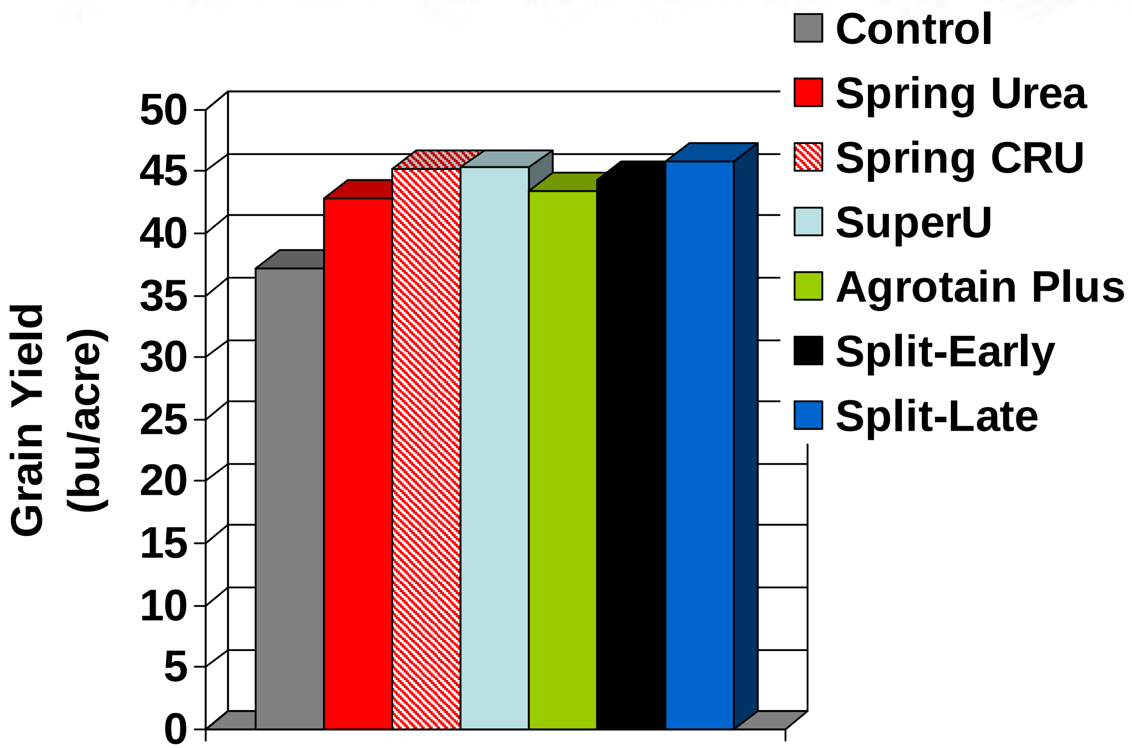
At the Silty Clay site there was no benefit of enhanced efficiency fertilizers

- No response to N application
- SuperU gave slightly lower yields than urea or CRU
  - No logical reason for depression

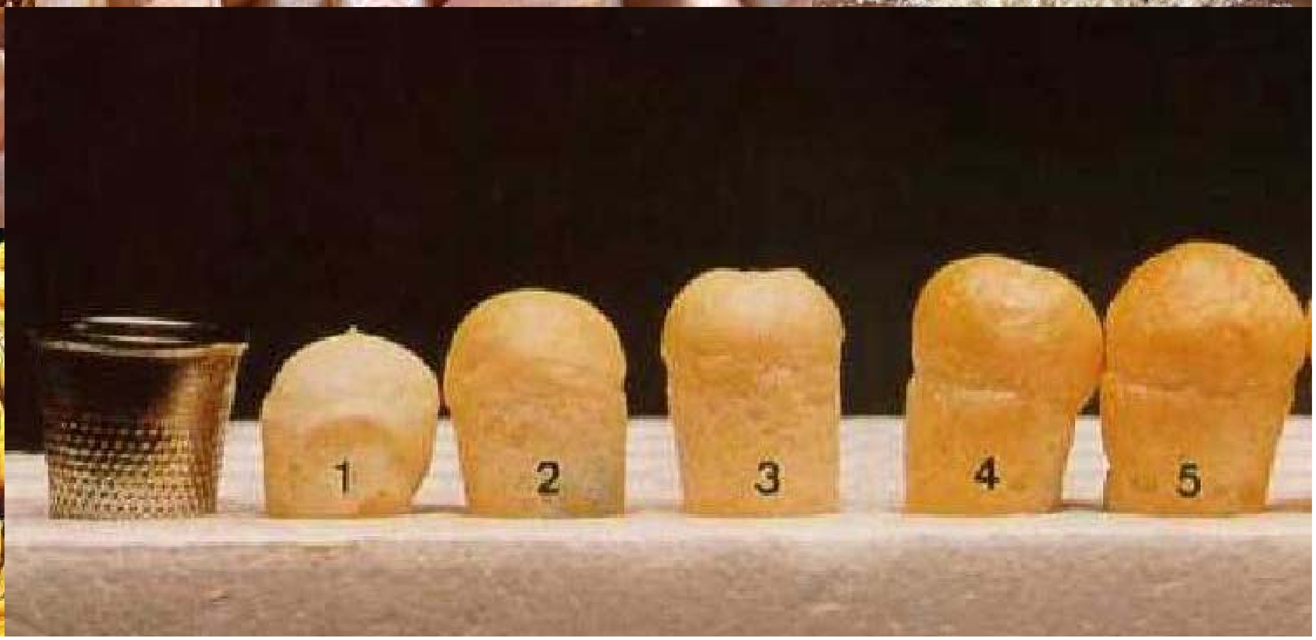


At the Clay Loam site there was no significant benefit of the enhanced efficiency fertilizers

- Consistently about 2 bu/acre higher than urea, numerically
  - Too small a difference to be significant

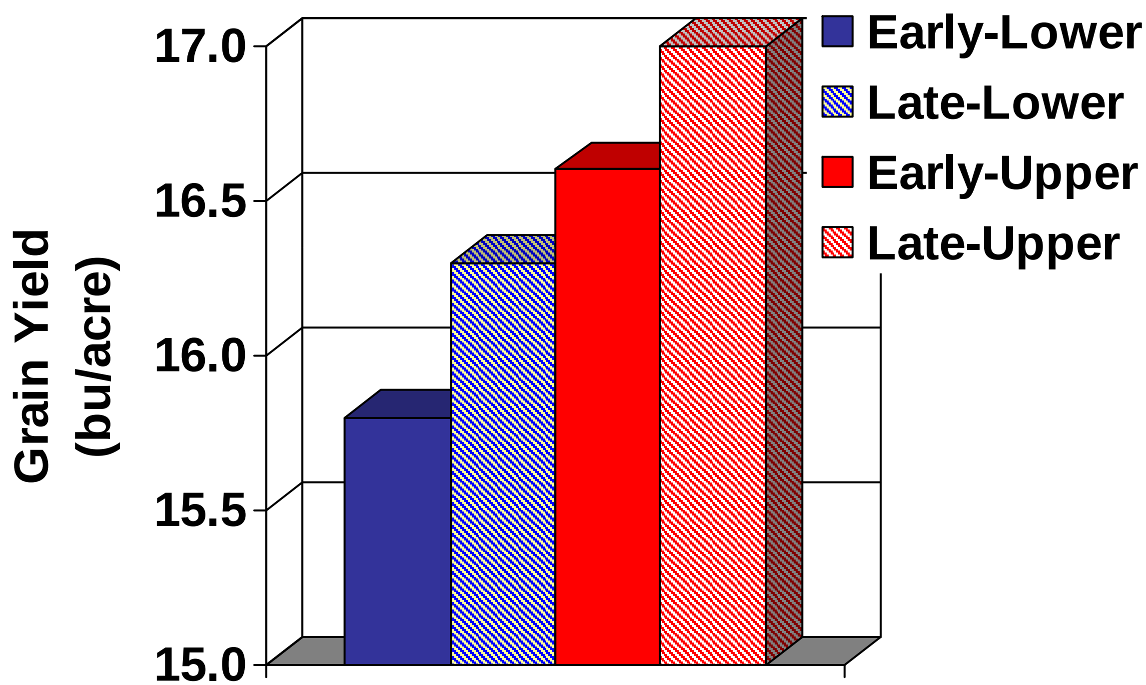


High protein content is needed for good bread and pasta



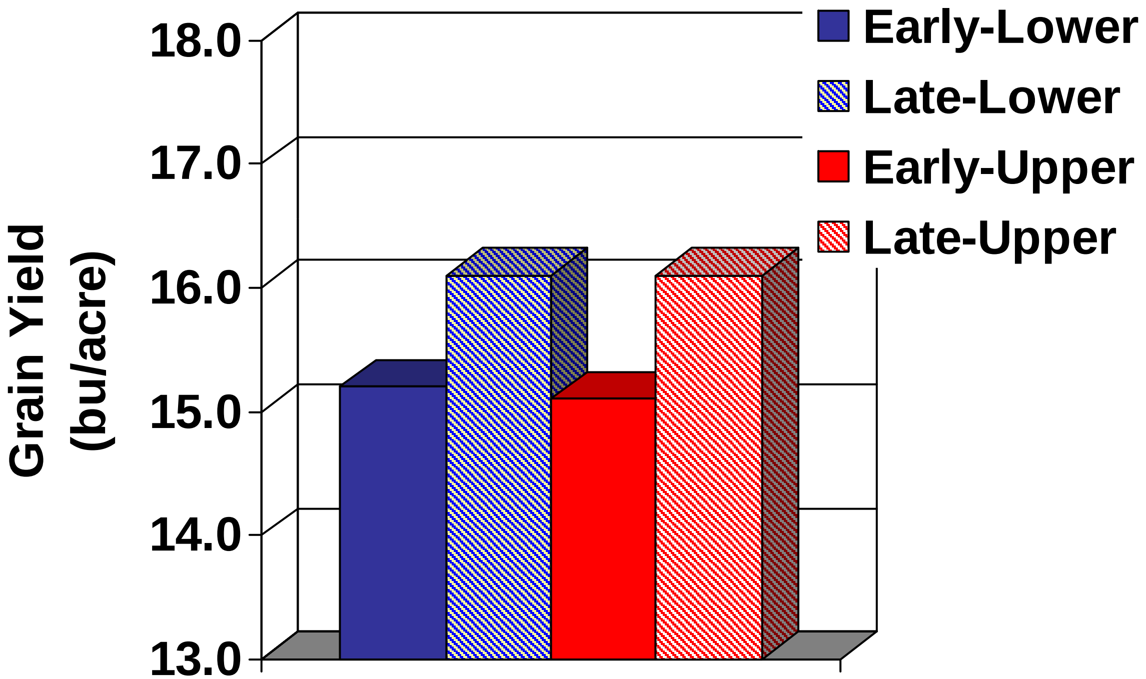
At the Silty Clay site, protein content was affected by seeding date and slope position

- Higher protein with late seeding
  - Greater late season drought stress and lower yield
- Drier upper slope position gives higher protein
- Larger effect of slope with early seeding

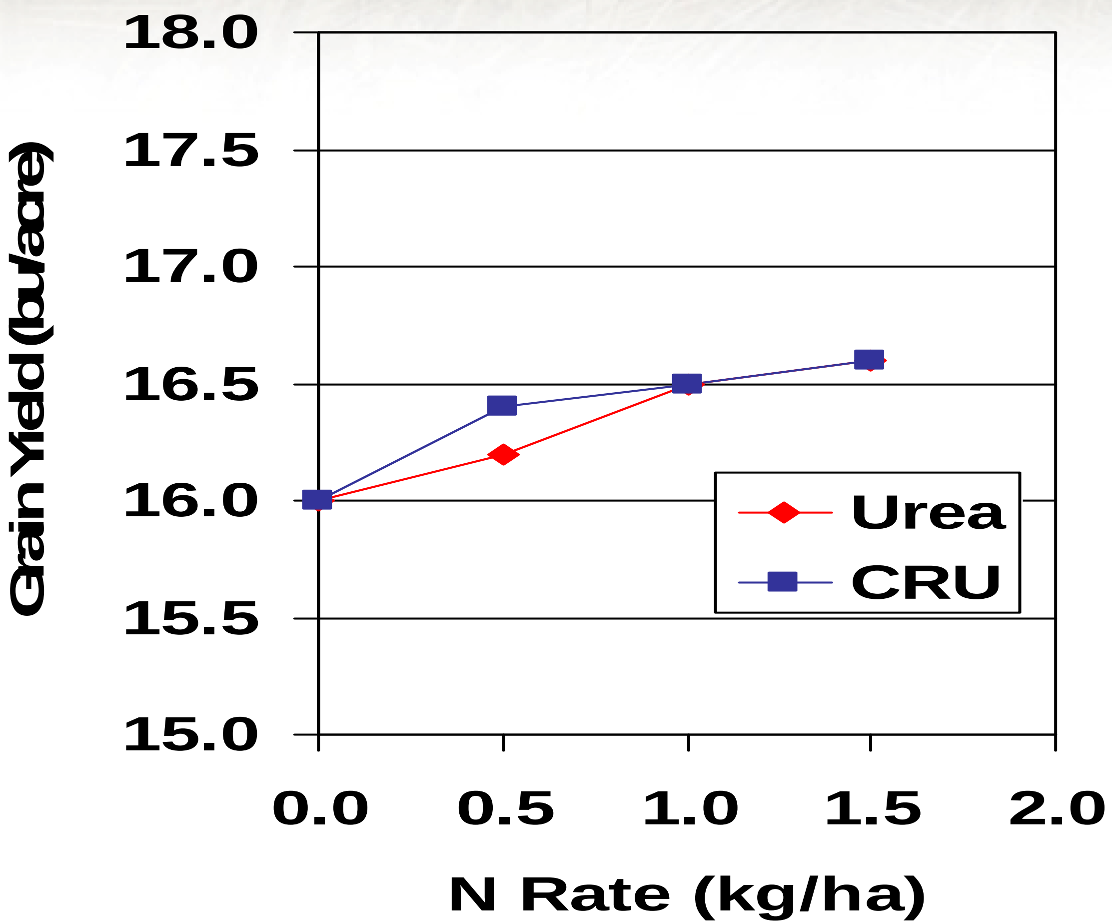


At the Clay Loam site, protein content was affected by seeding date but not slope position

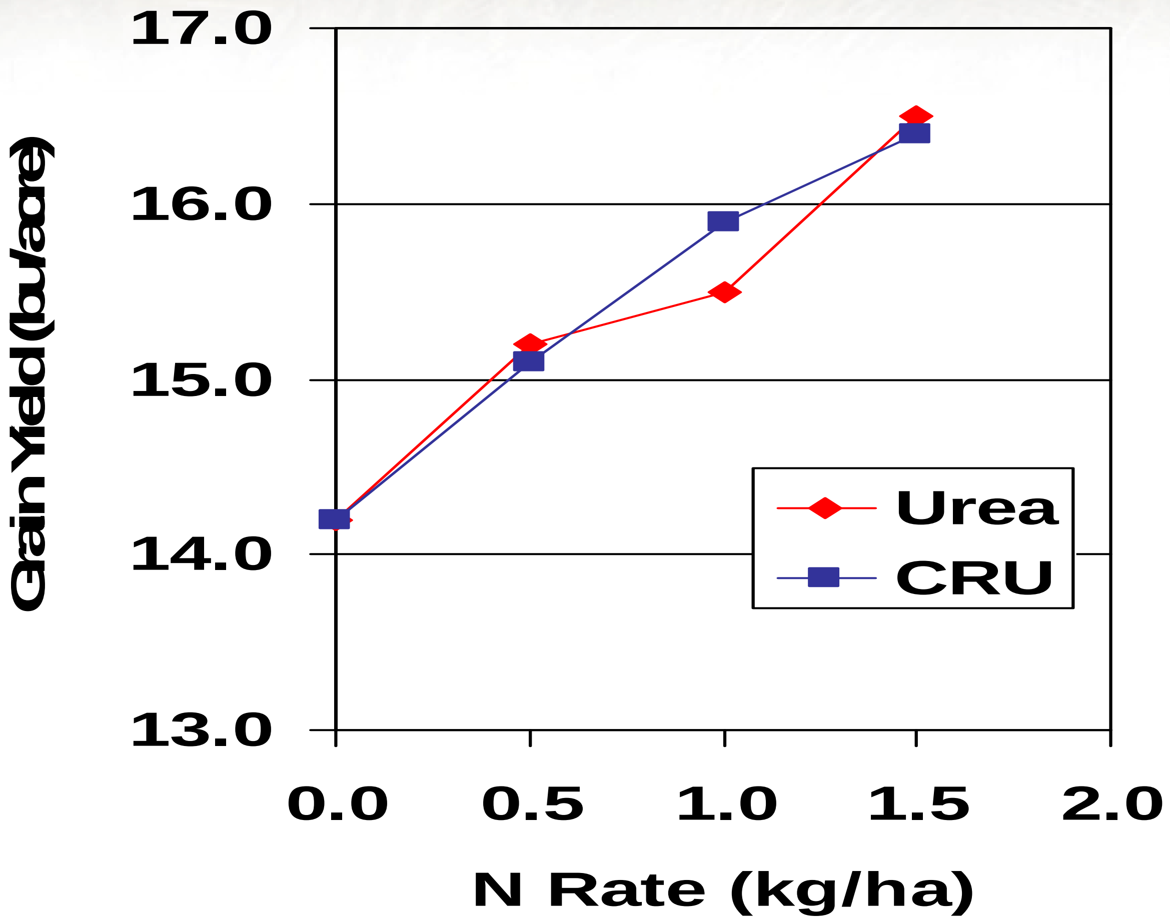
- Higher protein with late seeding
  - Lower yield and more drought stress elevates protein content



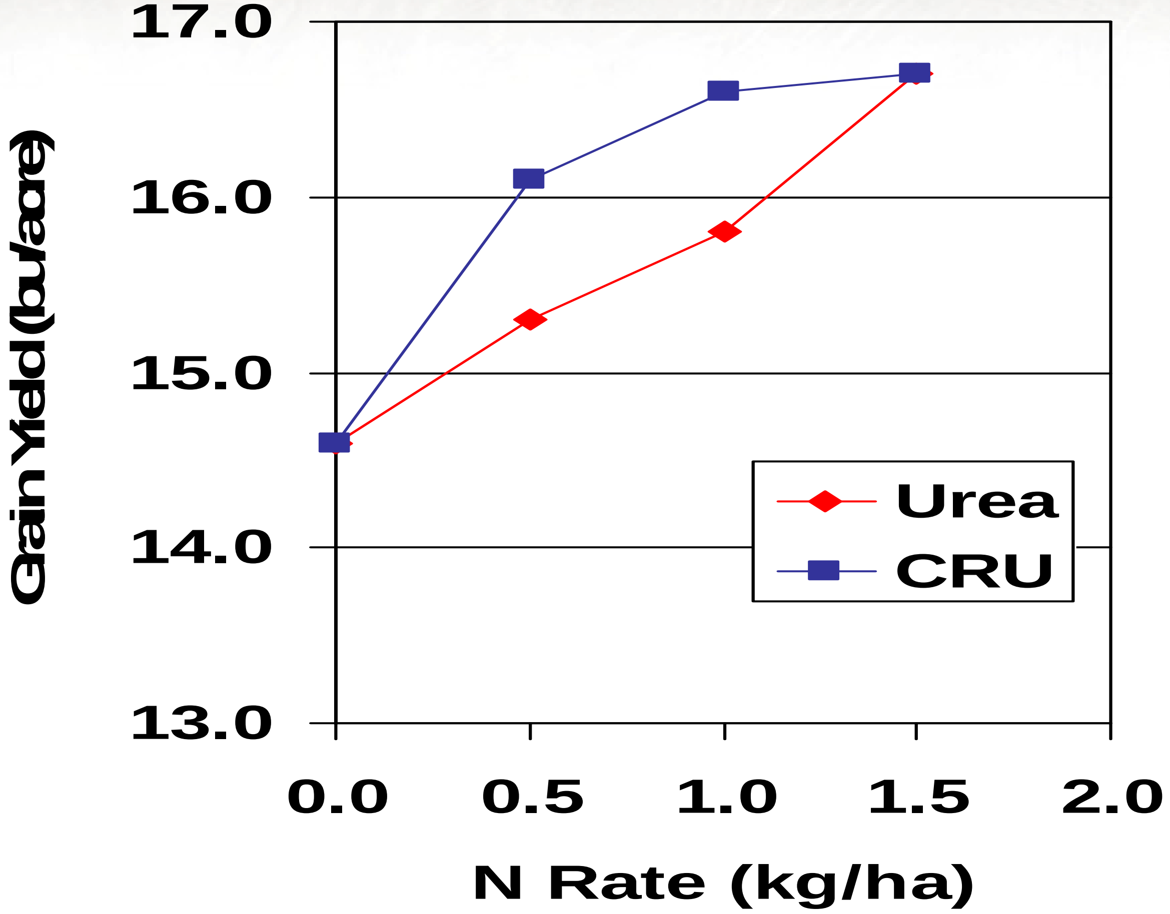
Protein Content at the Silty Clay Site increased with N, with some benefit of CRU at low N rate



Protein Content at the Clay Loam site increased with N

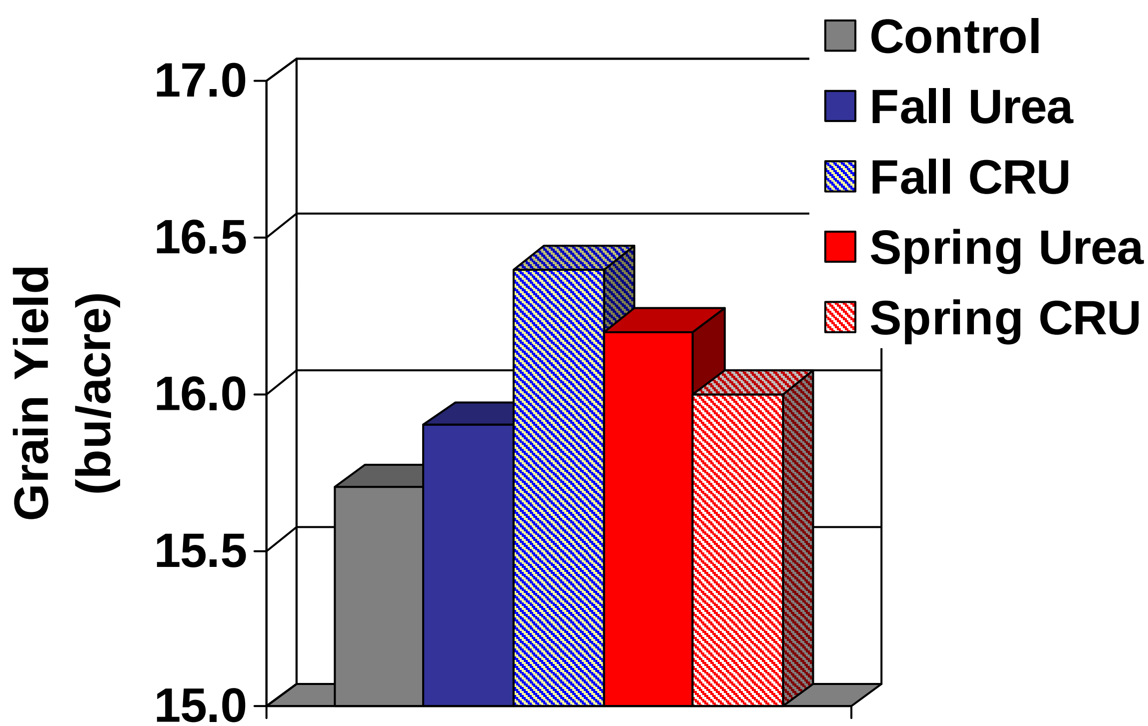


On the lower slope position with late seeding, CRU gave higher protein than urea at low N rates



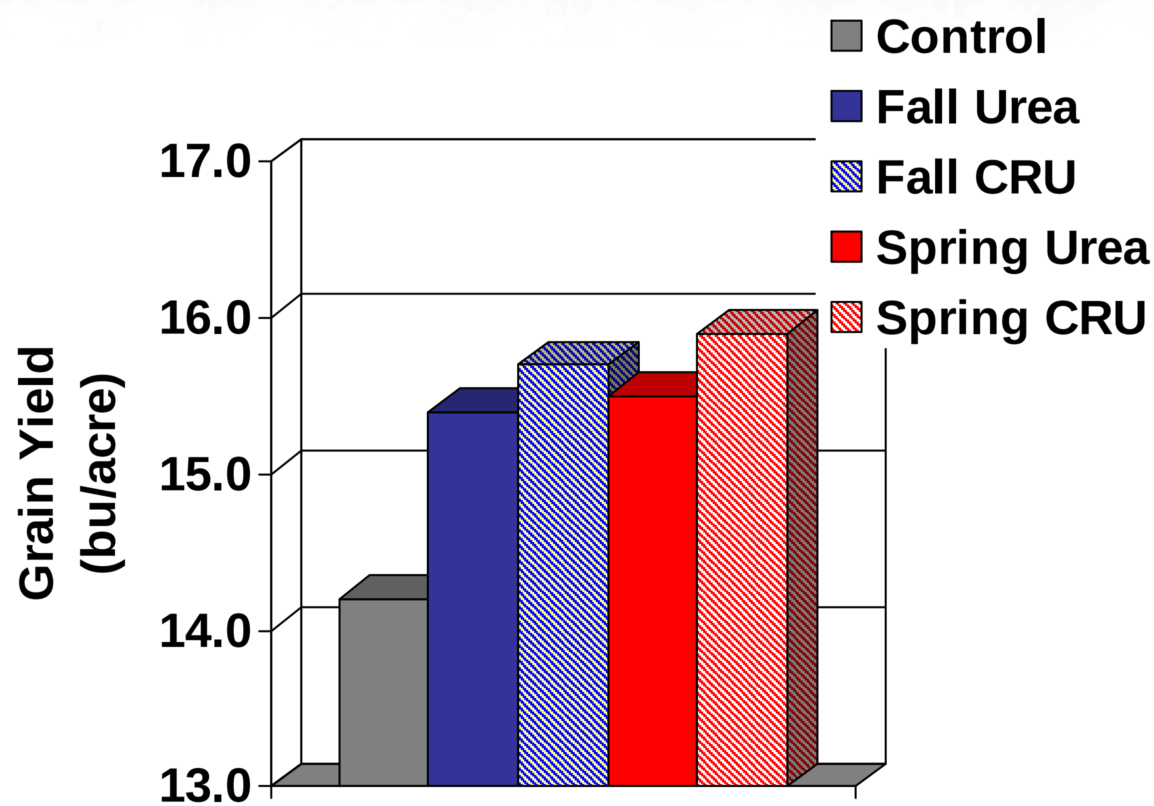
At the Silty Clay site, at the lower slope position

- CRU increased protein content with fall-applied N
  - Later N release reduced losses and increased late N supply



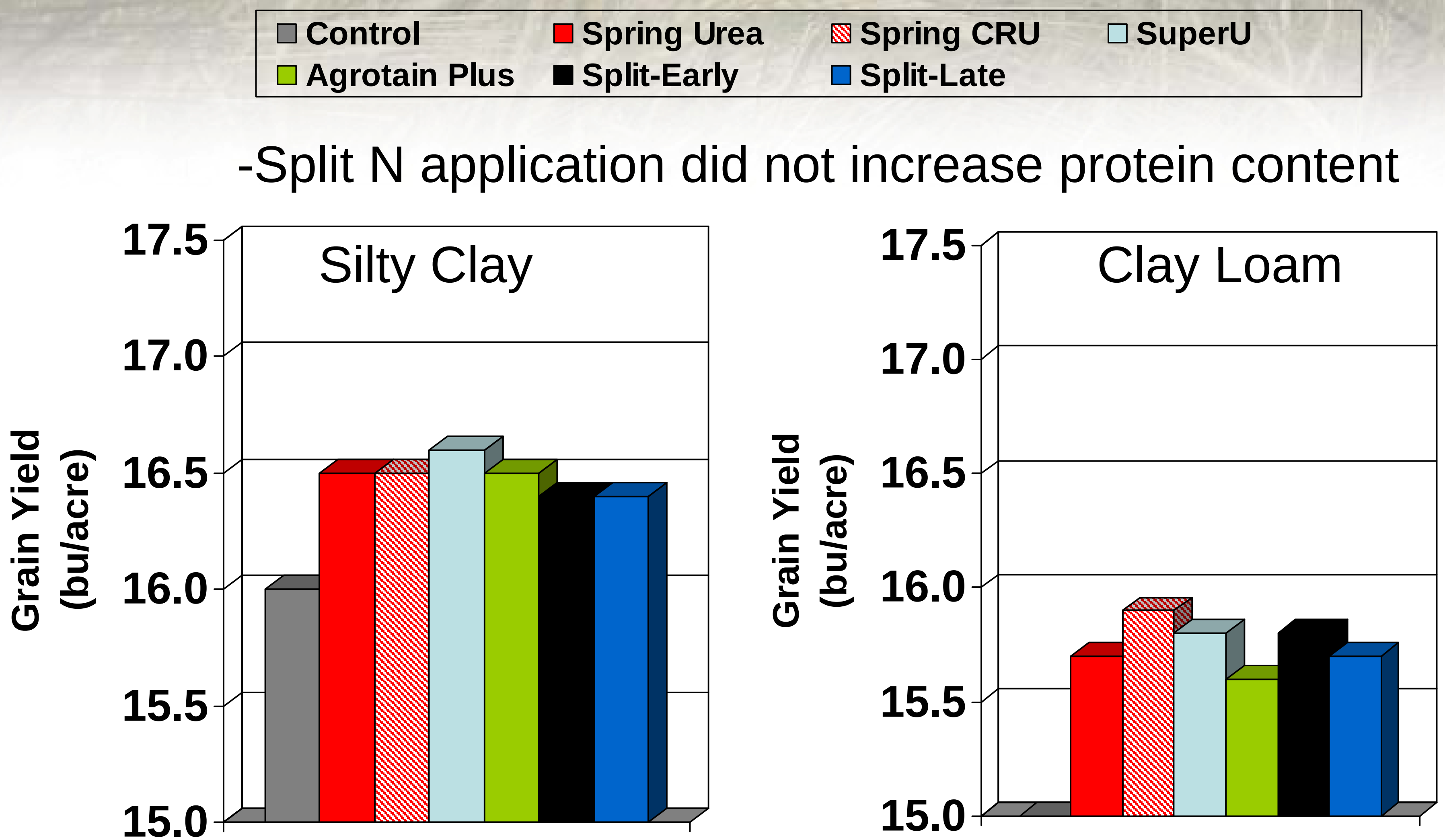
At the Clay Loam site, trend with CRU was not signfiicant

- Tendency to a benefit in protein with fall or spring CRU rather urea
  - CRU reduced losses and increased late N supply



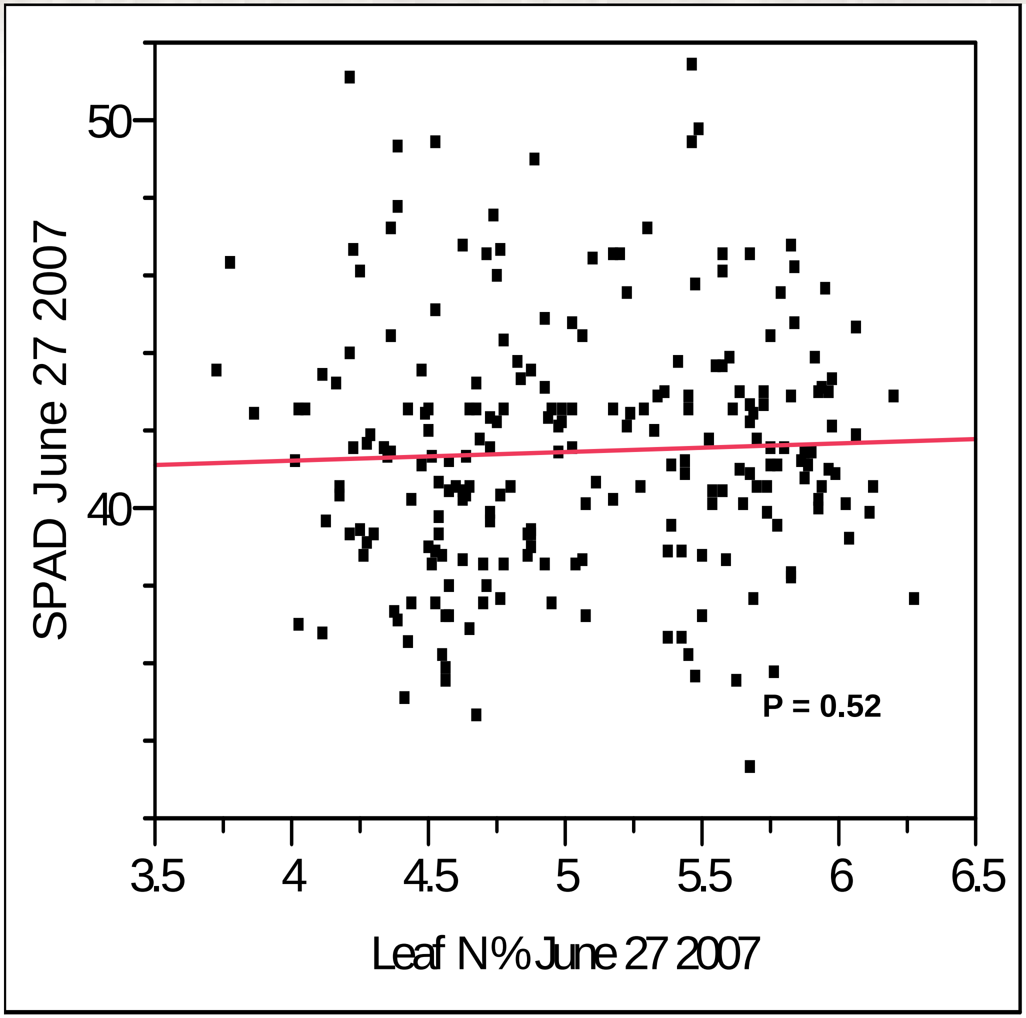
Protein was not affected by source of fertilizer, other than CRU, on either soil

-Split N application did not increase protein content



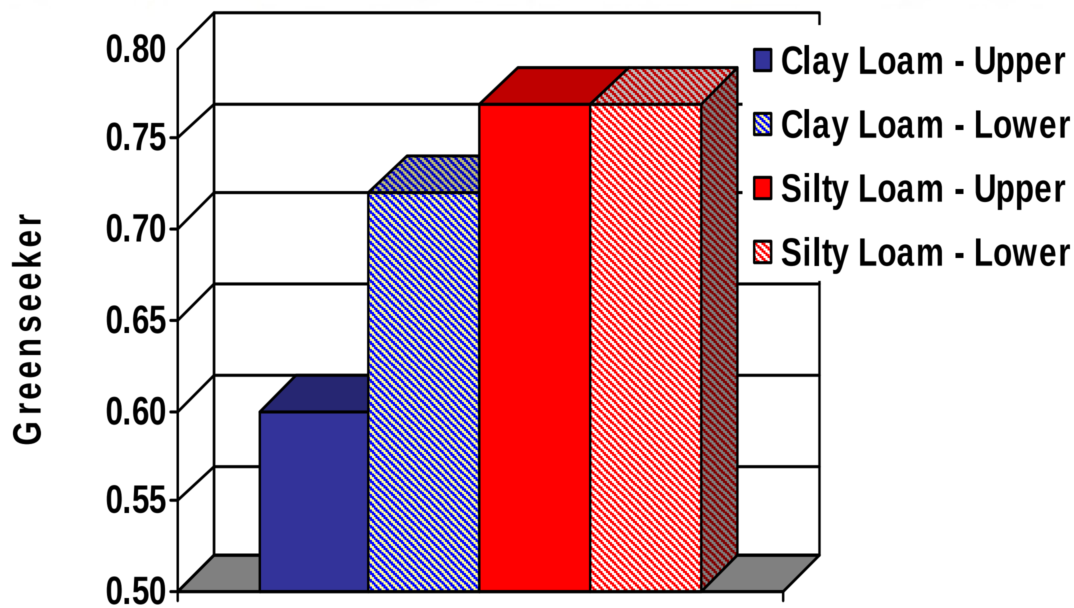
Neither SPAD meter nor Greenseeker were effective at predicting N status in late June

- No relation between tissue N and Spad meter or Greenseeker in late June
- Tissue N was relatively high
- N stress likely not yet a factor

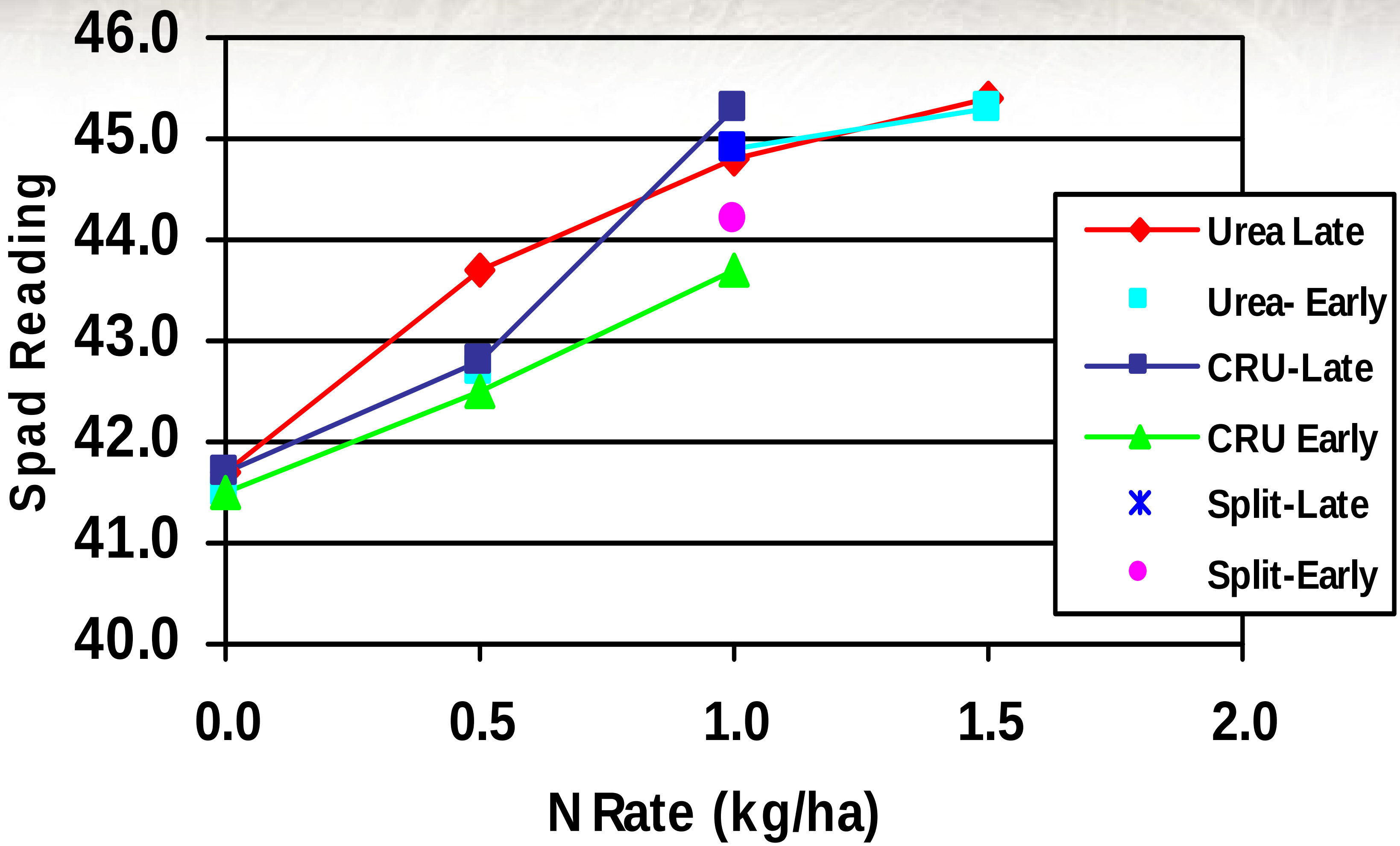


Greenseeker measurements for 2007 season

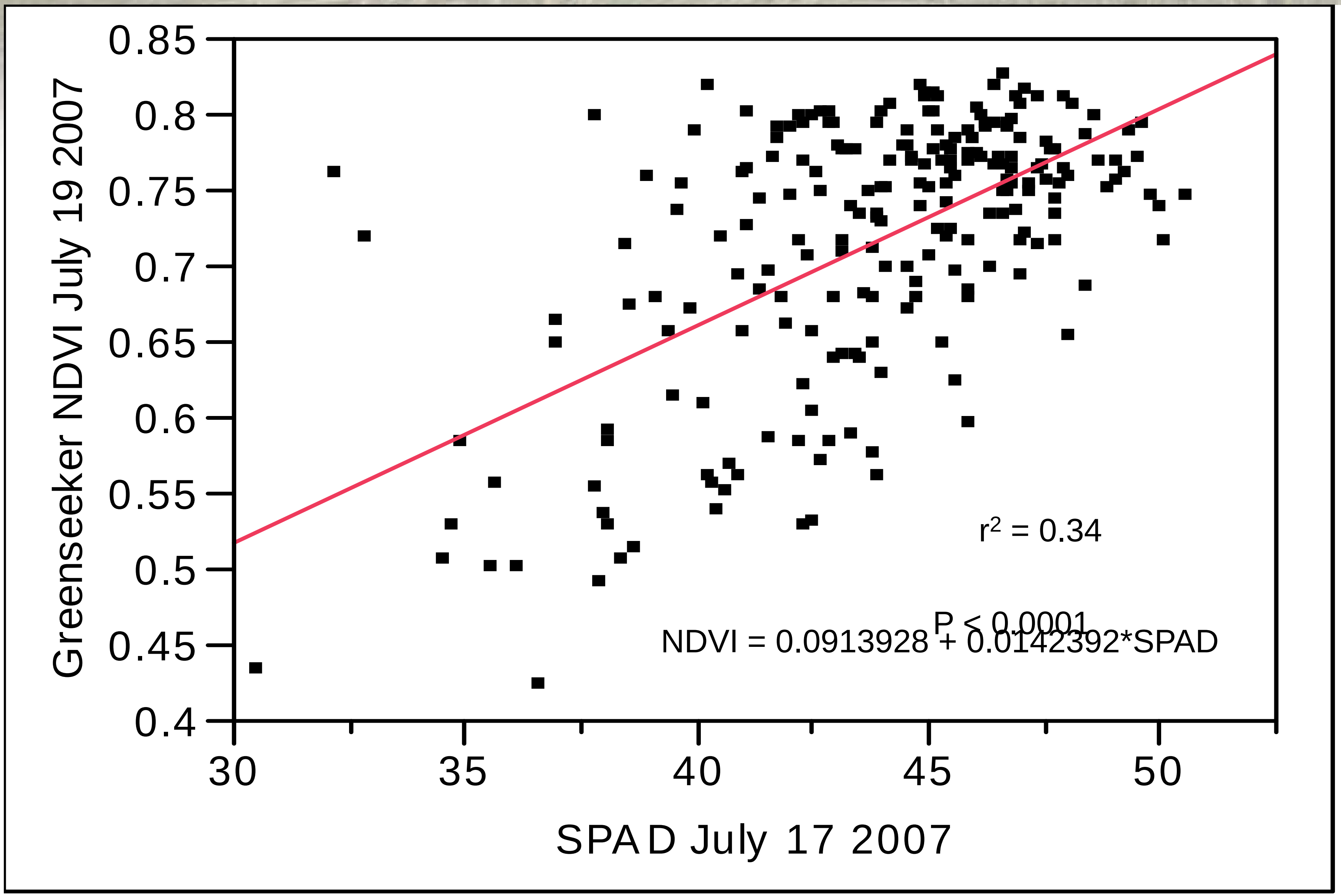
- On July 19, differences occurred in NDVI between sites and between slope positions at the Clay Loam site
- 2008 data is not yet analysed



Spad meter readings in mid-July increased with N Rate and tended to be slightly higher with urea than CRU



In mid-July , the Spad meter and Greenseeker readings were correlated



Summary

- Early seeding and lower slope positions consistently increased crop yields at both sites
  - 18 bu/acre difference
- SiC was not responsive to N fertilizer
  - High N supply from soil led to high yields and protein content
- Clay Loam showed increase with N application
  - Less response than would be predicted from nitrate N test in spite of high yield
  - Higher mineralization over season than in the past?
- With spring application, grain yield did not increase with enhanced efficiency fertilizers as compared to urea
  - Minimal N losses?
  - Low N response?

Summary

- CRU increased protein as compared to urea at lower N rates in some environments
  - Enhanced late season N availability
- SPAD and Greenseeker did not find differences at June 27 date, but found differences at July 19 date
  - N stress may not have been great at June 27
  - Could possibly be used to predict need for late N applications for protein enhancement


Thank you to the Fluid Fertilizer Foundation, Agrium, Agrotain International, Agvise Laboratories and AAFC-MII for their support of this project
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