Strategies for Reducing Nitrate Leaching from Irrigated Potato Production

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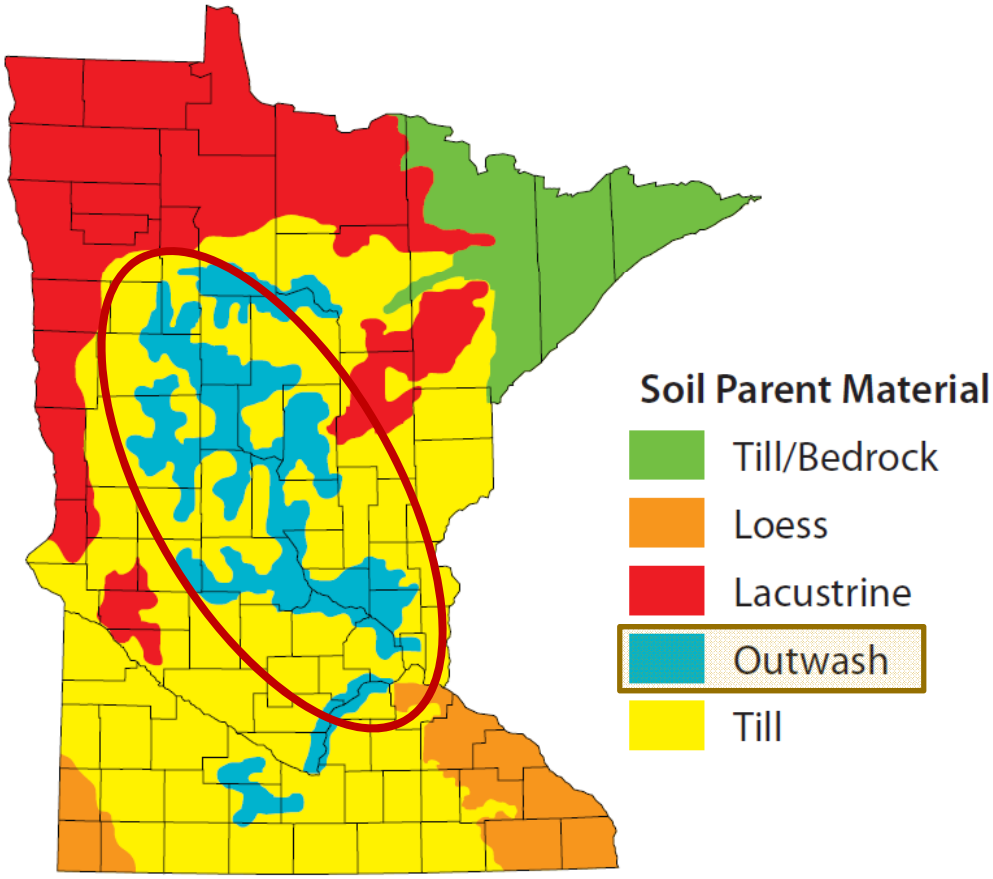
UNIVERSITY OF MINNESOTA
EXTENSION

Topics

- Potato production in Minnesota
- Specific potato production factors contributing to nitrate leaching
- Best management practices identified that reduce nitrate leaching
- Challenges involved - Case study in Perham, MN
- General conclusions and long-term solutions

Background

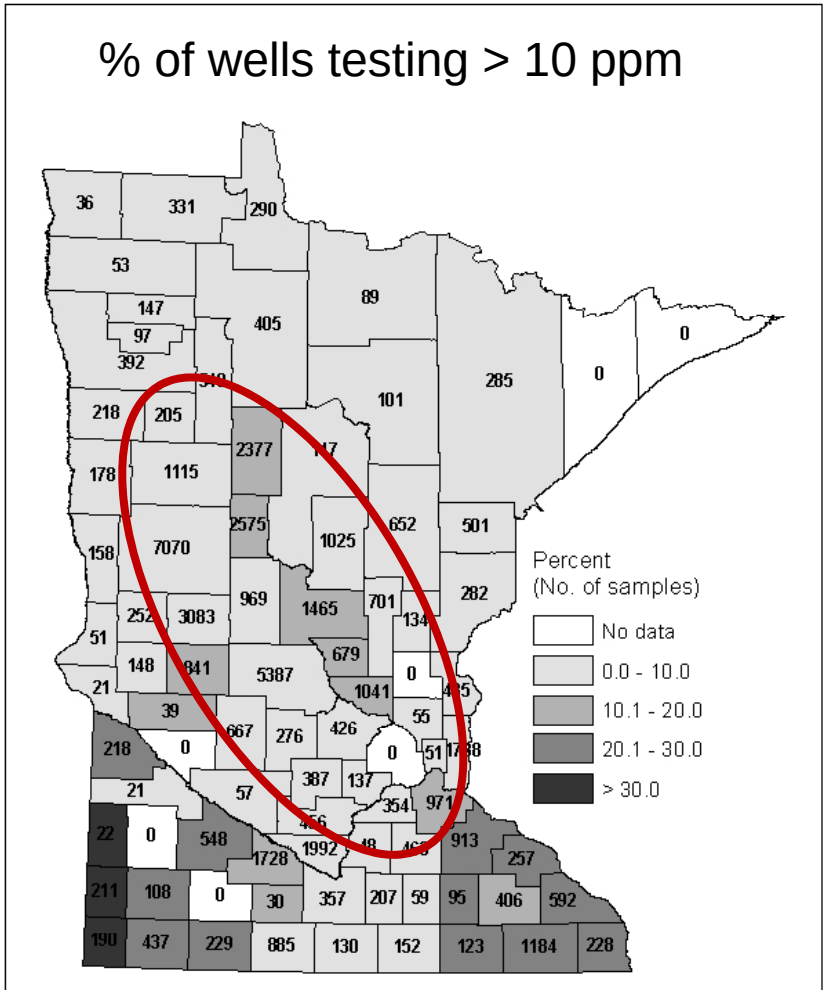


- Irrigated potato production in Minnesota
  - ~50,000 acres mostly on loamy sand soils with low organic matter
  - 70% for processing
    - Russet Burbank
    - 450 – 600 cwt/A
  - 30% fresh market
    - Early harvest reds
    - Some russets/whites
    - 300 – 500 cwt/A
  - $100 million in raw product value
  - Irrigation is essential for optimizing yield and quality

Background

- Potatoes have a relatively shallow root system – most roots in the top 12”
- Sensitive to N and water stress
  - Rates of 160 to 300 lb N/A applied
- Rainfall averages about 12” during the growing season
  - Rainfall after an irrigation is a problem
  - Water holding capacity ~ 1” in the top ft
- All these factors contribute to a high potential for nitrate leaching

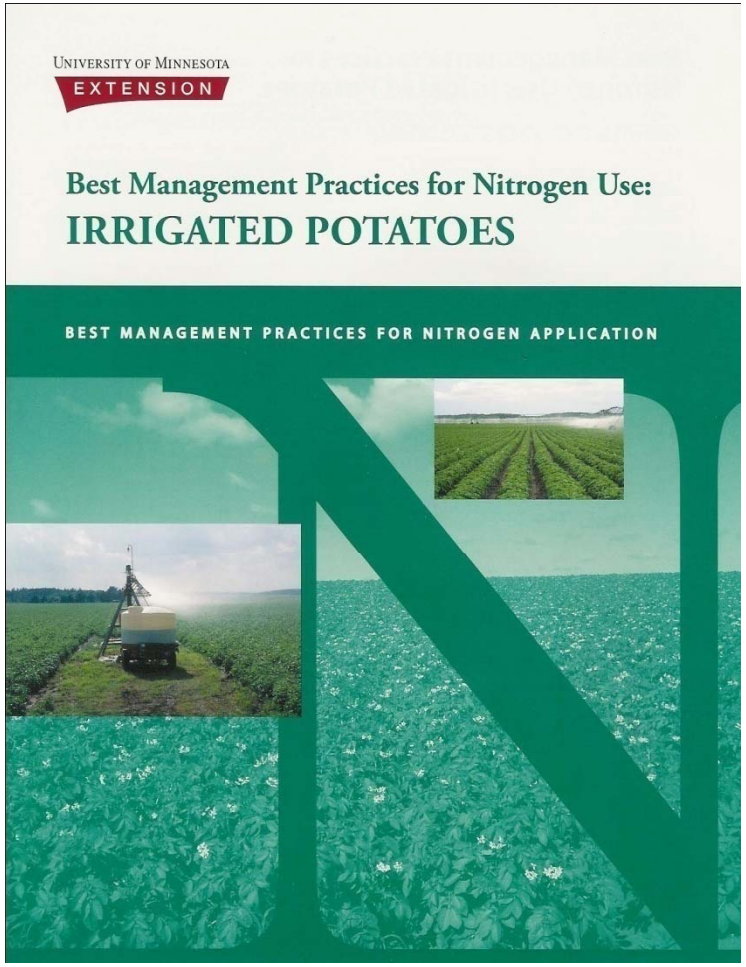
Nitrate Concerns - Statewide Results 1993-2005



Nitrate Testing Clinic Program
(Over 50,000 observations – Data courtesy of Minnesota Department of Agriculture)

- 10 to 20 % of the wells tested in the potato growing regions were above 10 ppm NO_3-N
- Many individuals and municipalities have had to take action to remediate the problem

BMPs to Address Nitrate Concerns



- Response to Groundwater Protection Act – 1989
  - N fertilizer management plan
  - Central tool is adoption of BMPs
    - Voluntary
    - Research-based
    - Focus is on N fertilizers
    - Manure management also considered
  - Published in 2008 for potato

http://www.extension.umn.edu/distribution/cropsystems/DC8559.pdf

Specific N BMPs for Potatoes

- Select a realistic N rate
  - Variety
  - Harvest date (based on market)
  - Yield goal
  - Previous crop/manure
  - Irrigation water nitrate-N

- Time N application to meet N demands of the crop
  - Split applications of soluble N
    - No preplant N and limit the amount of N in the starter
  - Consider use of controlled release N sources

Potato Growth Characteristics

- Five general growth stages
- Each with a different nutrient requirement
- Length of each stage depends on variety/climate

Growth Stage I

- Sprout development
- Seed is the primary source of nutrients
- Occurs within 30 days of planting
- Water and nutrient demand is low

Growth Stage II

- Vegetative growth
- 30-55 days after planting
- Relative water and nutrient demand is low to moderate

Growth Stage III

- Tuber initiation and set
- Tuber formation is sensitive to nutrient supply at this stage
- 50 to 70 days after planting
- Vegetative growth increases rapidly
- Water and nutrient demand is moderate to high

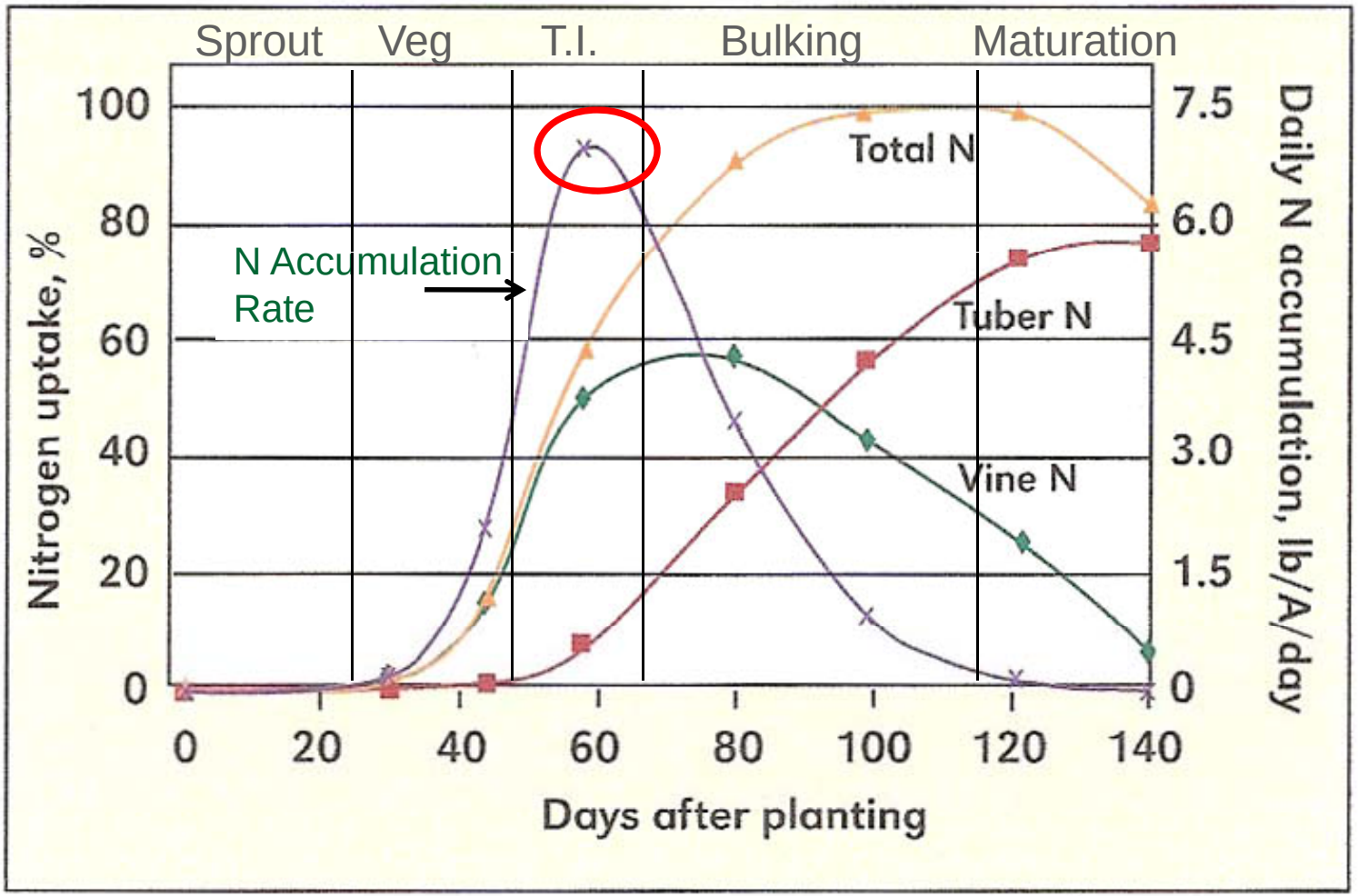
Growth Stage IV

- Tuber bulking
- Vegetative growth slows down
- 60 to 90 days after planting - early
- 70 to 110 days after planting – late
- Water and nutrient demand is moderate to high

Growth Stage V

- Tuber maturation
- Vines begin to die
- Transport of nutrients to tubers
- Water and nutrient demand is low

Potato Seasonal N Accumulation & Daily Accumulation Rate



Russet Burbank – Becker, Minnesota

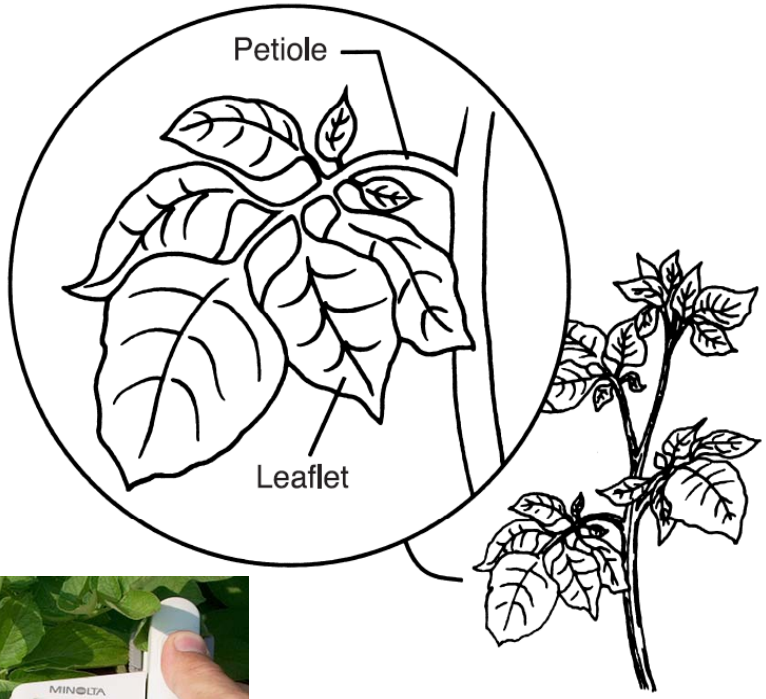
Suggested Nitrogen Timing

Timing of Application	% of Total Nitrogen to Apply	
	Early Maturing Variety	Late Maturing Variety
Preplant/planting	10-40%	10-20%
Emergence	40-60%	20-40%
Final hilling (or tuber initiation)	0-40%	30-60%
Post-hilling	0	0-40%

Total N applied to potatoes typically ranges from 160 to 250 lb N/A

Diagnostic Tools to Help Determine In-season N Applications

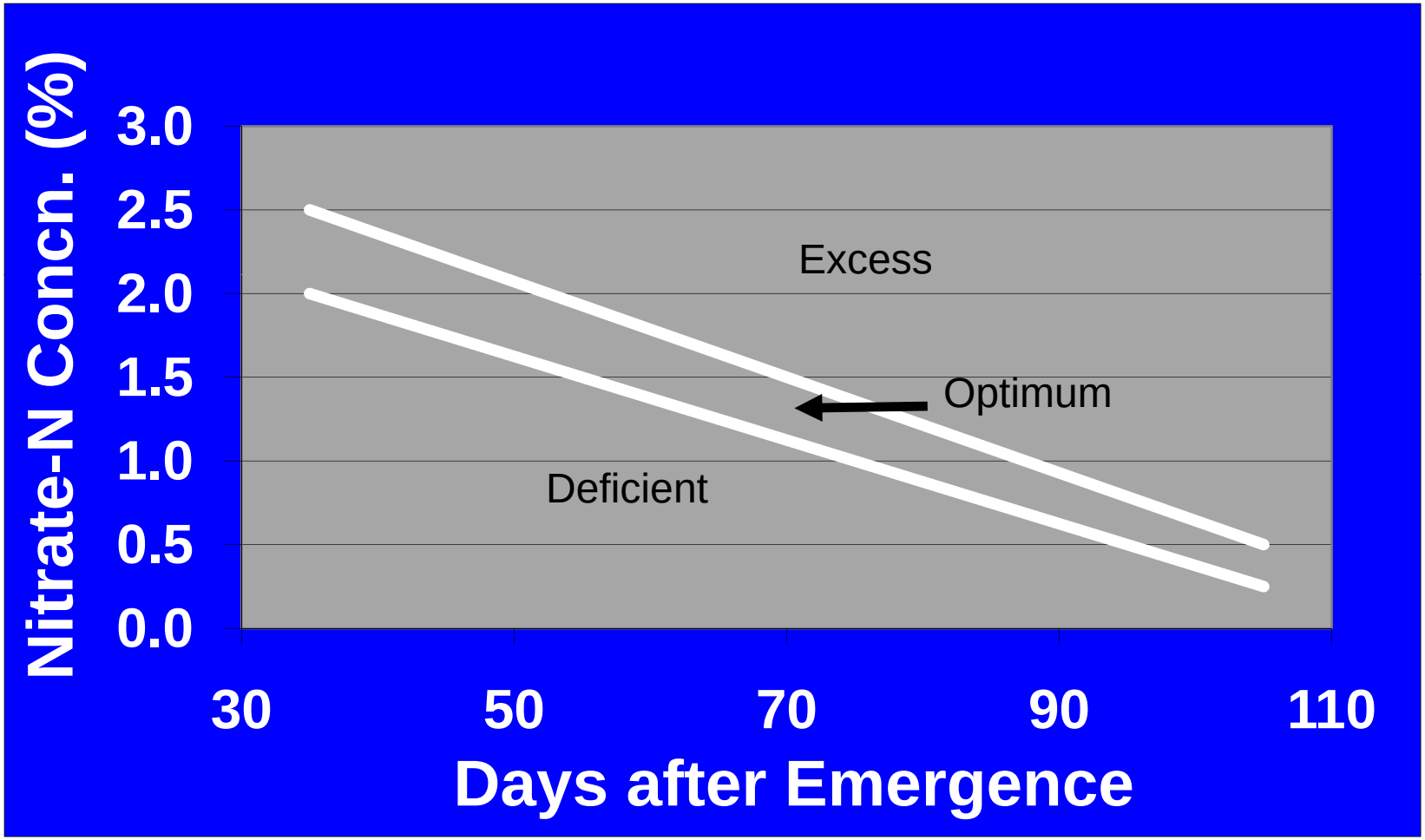
- Petiole nitrate analysis
  - 4th-5th leaf from growing point
  - Works well with indeterminate varieties and when bulking conditions are optimum
  - Apply N when petiole nitrate-N is at or below the optimum range



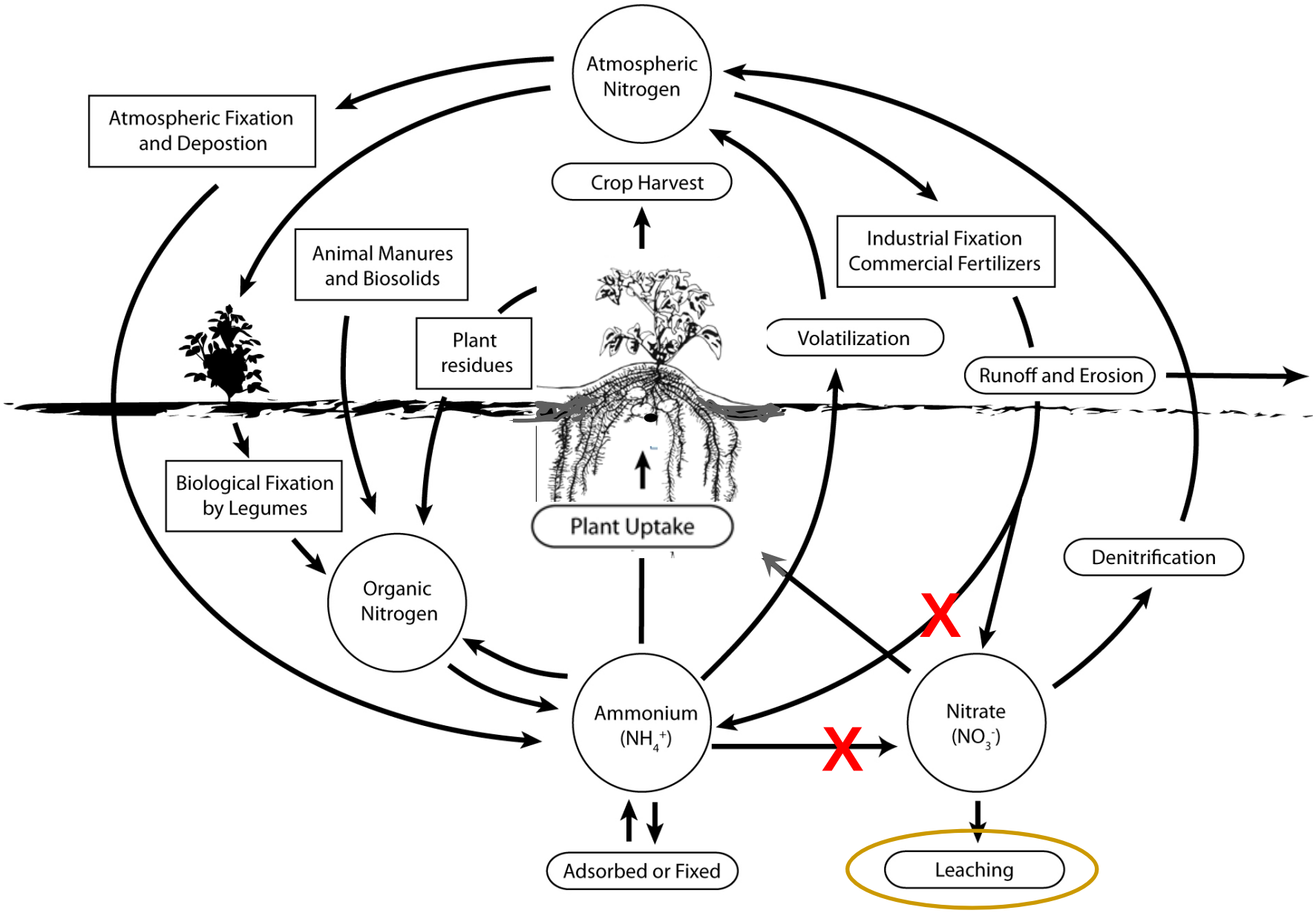
- In-season soil nitrate testing
  - Sample to 1 ft in hill
  - Interpretations not well calibrated
  - Wide fluctuations due to rainfall

- Chlorophyll meter & other reflectance techniques
  - Area of active research

Interpretation of Petiole Nitrate-N Concentrations Through the Growing Season (d.w. basis)



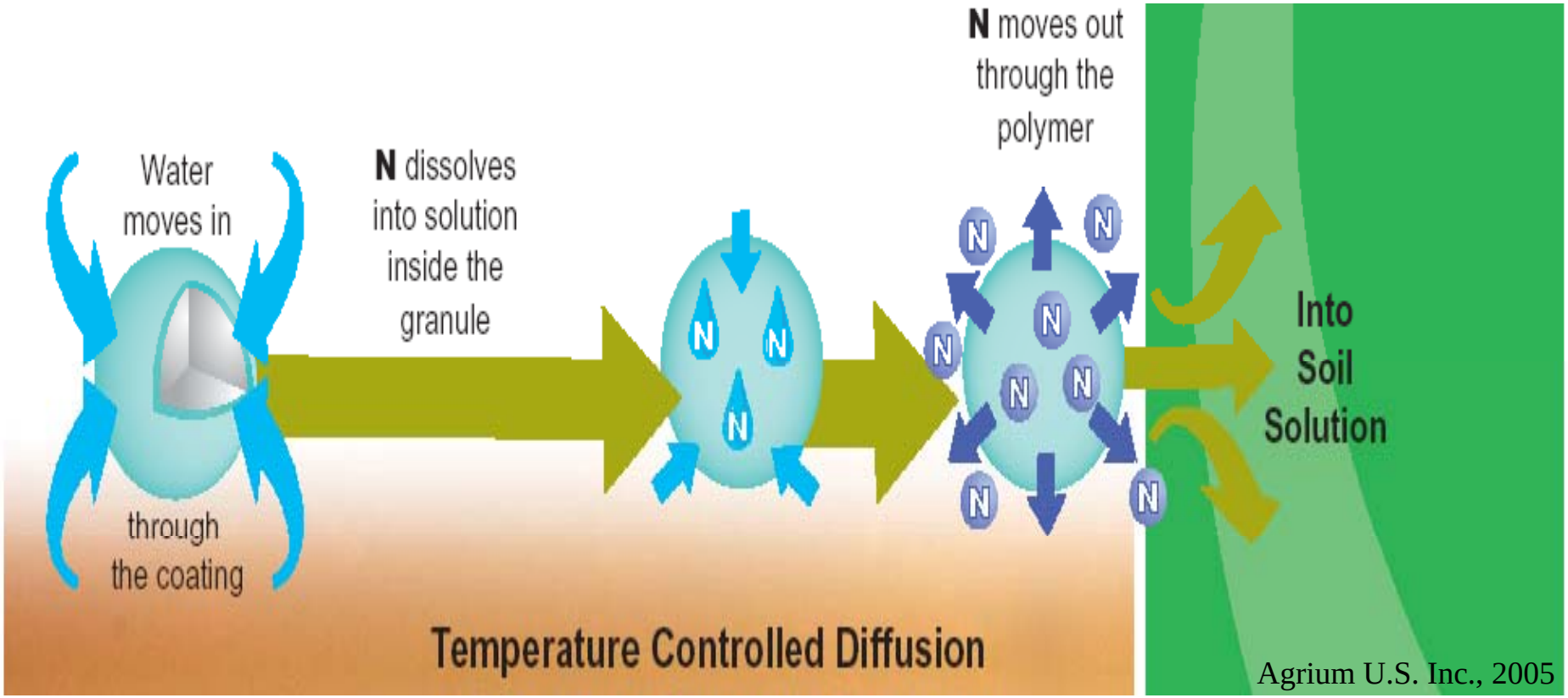
The Nitrogen Cycle



Enhanced Efficiency N Sources

- Controlled release nitrogen
  - Physical or chemical barrier to slow down solubility
    - Sulfur coating around prill
    - Polymer coating around fertilizer prill (usually urea)
  - Example: ESN (manufactured by Agrium, Inc.)
    - “Environmentally Smart Nitrogen”
    - Only economically viable slow release currently available for potato
    - Coated urea - mode of action - lowers solubility
    - Release rate depends on soil moisture and temperature

Polymer Coated Technology

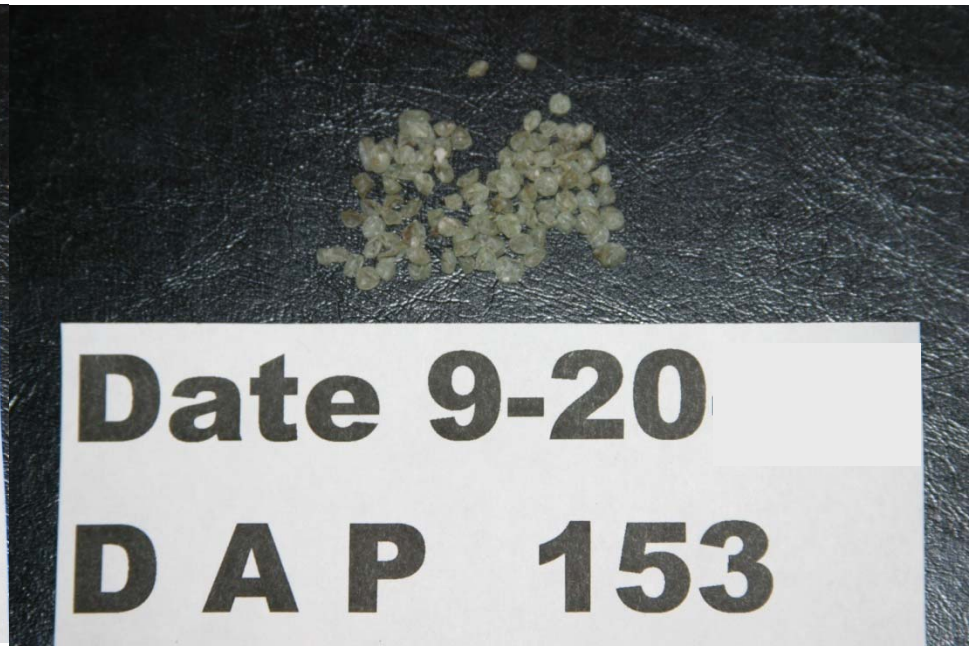


Release rate depends on: coating thickness, temperature, and moisture

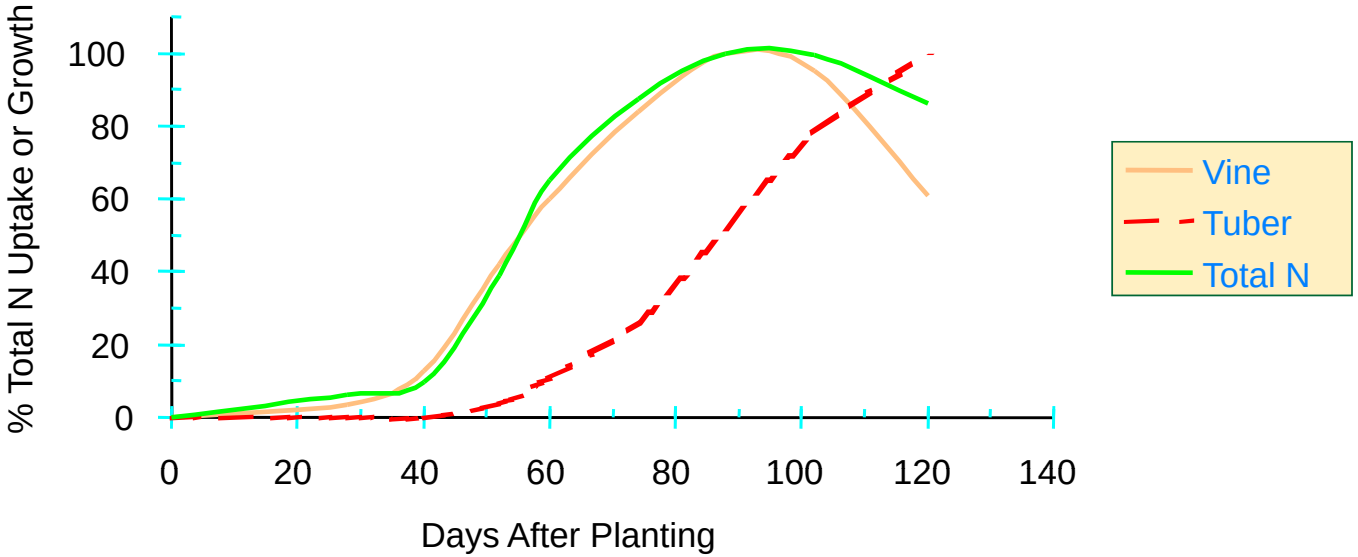
N Release from ESN

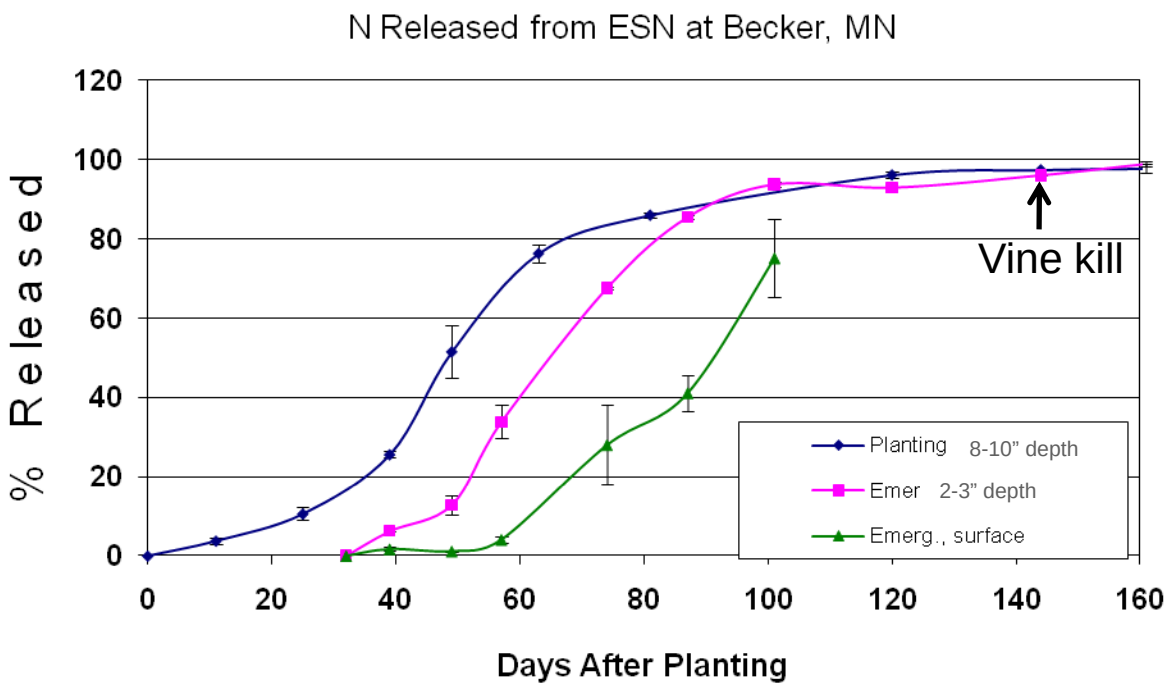
- “Mesh Bag” Method -

Visual assessment of ESN granules through the growing season



Nitrogen Uptake and Growth



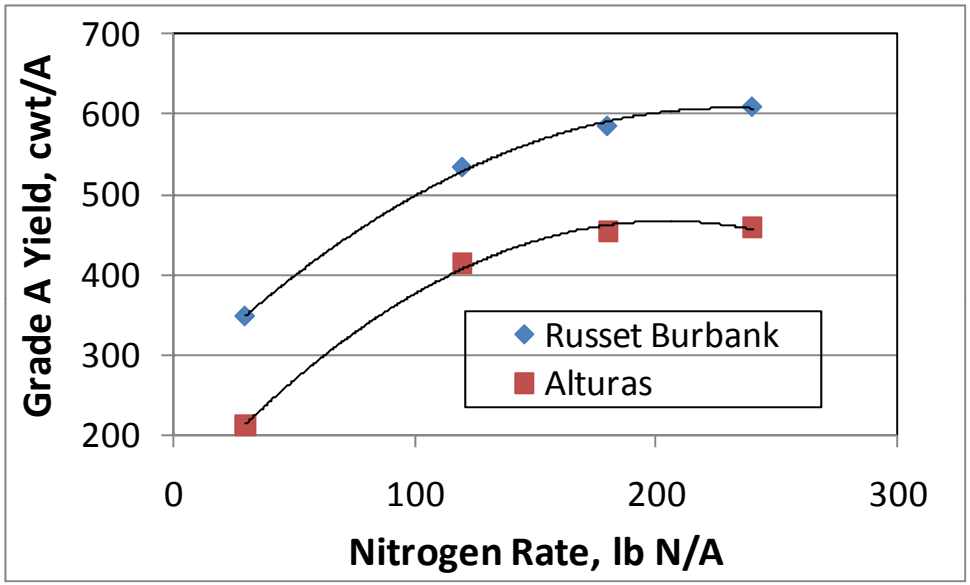


Comments on Polymer-coated Urea

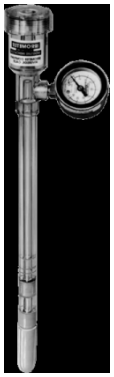
- When used properly leaching is lower during the growing season
- Susceptible to damage during handling and application
- False sense of security – too high rate will result in leaching
  - Growers tend to apply soluble N later in the season when ESN is used
- More research on coating technology is warranted

Other Recommended Practices

- Sound irrigation management
  - "Checkbook" method
  - Water monitoring devices
- Use of cover crops
  - Especially after early harvest potatoes
  - Not effective for long season potatoes



- Use of N efficient varieties/crops
  - Active area of research
- Amendments to increase soil water holding capacity



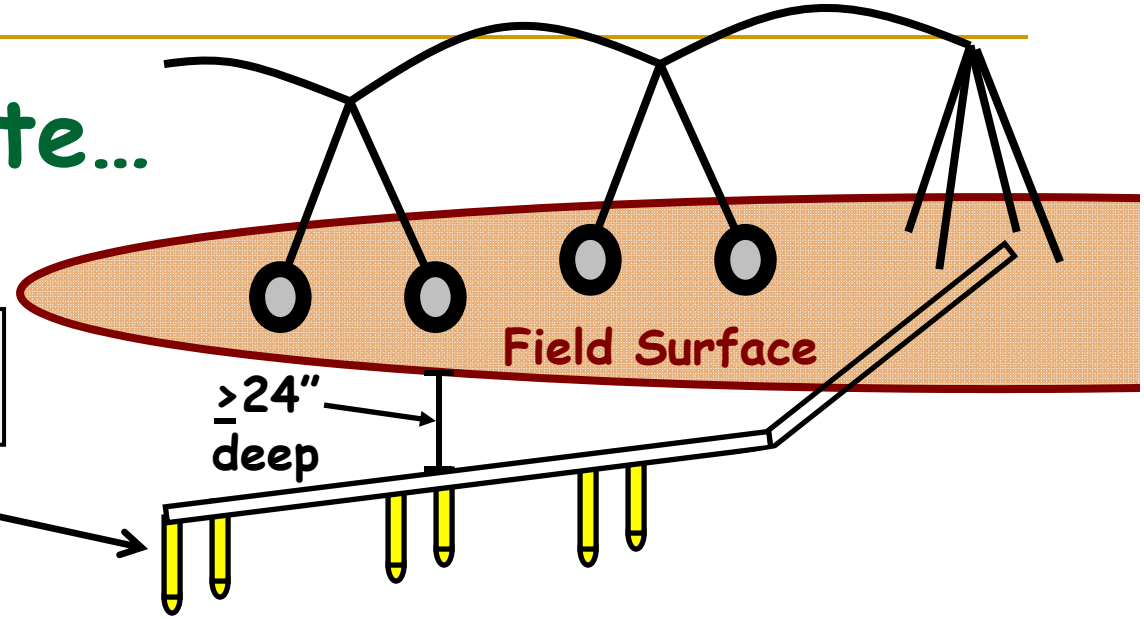
Case Study in Perham, Minnesota

- High density of center pivots with potato in the rotation
- One pivot near the center of town
  - Giloman site
  - Believed to contribute to elevated nitrate in drinking water

In cooperation with MDA

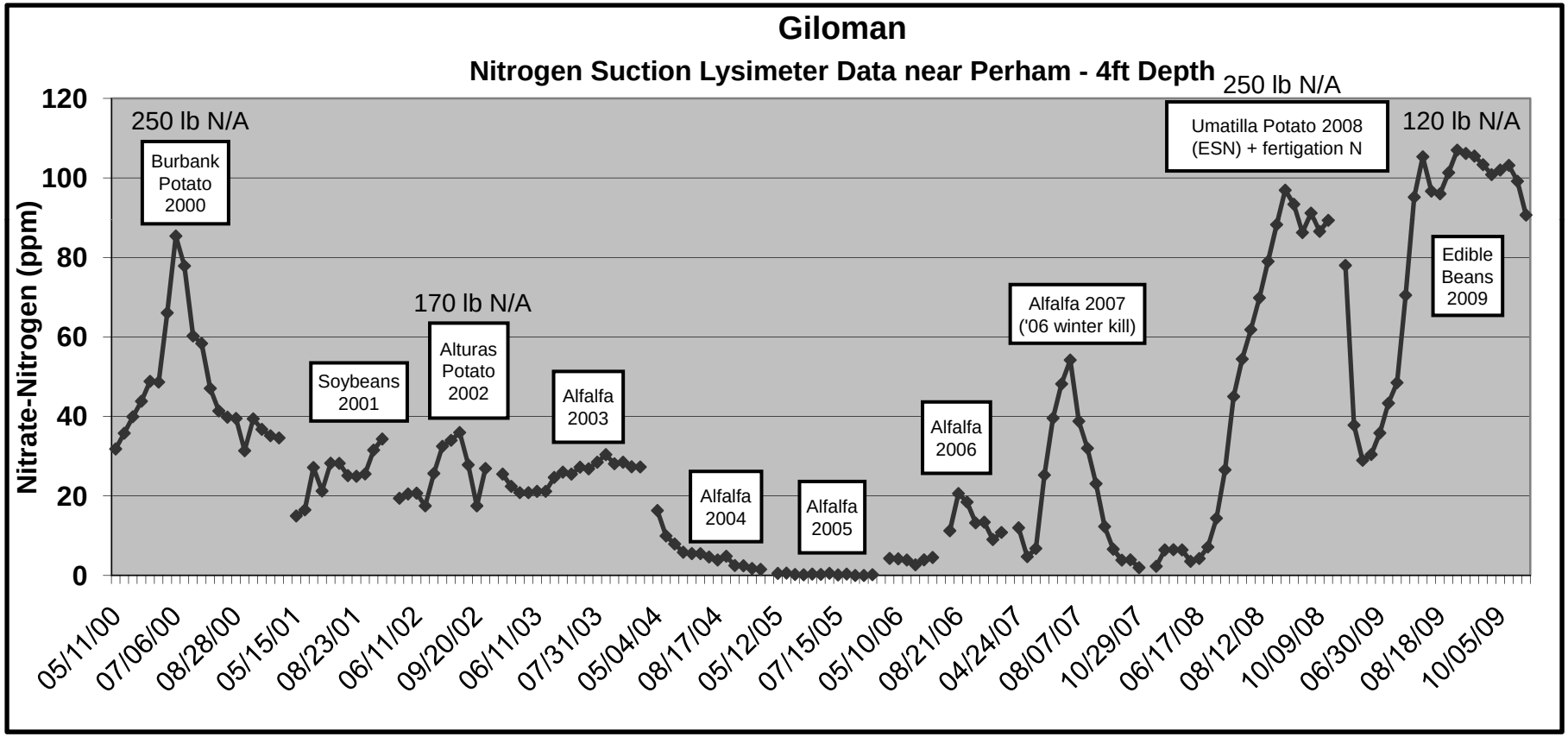
The Giloman Site…

- *Suction lysimeters installed to a 4 ft depth*



- *The approximate area where the lysimeters are located*

Reducing Nitrate Leaching is a Challenge!!



Data – Courtesy of the Minnesota Department of Agriculture

Overall Conclusions

- Growing potatoes on irrigated sandy soils in Minnesota is a leaky system
- BMPs can help in reducing nitrate losses, but in many years leaching will still occur
  - Integrated approach is needed
- Long term solution
  - Grow N efficient varieties with lower N rates
  - Avoid growing potatoes in areas were there are sensitive aquifers