Strategies for Reducing Nitrate Leaching from Irrigated Potato Production

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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

- 10 to 20% of the wells tested in the potato growing regions were above 10 ppm NO\textsubscript{3}-N
- Many individuals and municipalities have had to take action to remediate the problem

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

[Link](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

<table>
<thead>
<tr>
<th>Timing of Application</th>
<th>% of Total Nitrogen to Apply</th>
<th>Early Maturing Variety</th>
<th>Late Maturing Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preplant/planting</td>
<td>10-40%</td>
<td>10-20%</td>
<td></td>
</tr>
<tr>
<td>Emergence</td>
<td>40-60%</td>
<td>20-40%</td>
<td></td>
</tr>
<tr>
<td>Final hilling (or tuber initiation)</td>
<td>0-40%</td>
<td>30-60%</td>
<td></td>
</tr>
<tr>
<td>Post-hilling</td>
<td>0</td>
<td>0-40%</td>
<td></td>
</tr>
</tbody>
</table>

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
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
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 where there are sensitive aquifers.