Overwinter Soil Nitrate Changes and Implications

Montana Agri-business Association Convention

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Background

• Nitrogen fertilizer guidelines are based on spring soil samples for nitrate in Montana
• BUT, most sampling in MT occurs from late summer to late fall

Based on 35 ‘clicker’ responses at MABA 2010 Convention, when asked when crop advisers do most of their soil sampling:
• Previous research suggested that nitrate changes could be substantial (up to 33 lb N/ac) from late summer to early spring (Miller et al. 2006)
• Study undertaken to see how nitrate changes vary with previous crop, soil, climate, year and location across Montana
• Ideally develop a regression equation so a crop adviser who samples in Fall could adjust N rates
• Funding provided by Fertilizer Check-off
Methods

Soil samples collected:

<table>
<thead>
<tr>
<th>3 Sampling Times</th>
<th>Aug/Early Sep, mid Nov, early Apr*</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Locations</td>
<td>Each Ag Res Center, plus Post Farm</td>
</tr>
<tr>
<td>4 Previous Crops</td>
<td>A. legume, cool season oilseed, sm grain, fallow</td>
</tr>
<tr>
<td>3 Seasons</td>
<td>07-08, 08-09, 09-10</td>
</tr>
<tr>
<td>2 Depths</td>
<td>0 to 6, 6 to 24 in.</td>
</tr>
<tr>
<td>2 Replicates</td>
<td>For each previous crop</td>
</tr>
</tbody>
</table>

* at the Post Farm, samples were also collected monthly between late summer and mid November
Sampling Sites

☆ Sampling Locations
▲ Agrimet Weather Stations
• NCDC Weather Stations

Map by Sara Copeland
Sources:
http://www.wrcc.dri.edu/inventory/inventact.html
http://nris.mt.gov/gis/
## Methods

### Analyses:

<table>
<thead>
<tr>
<th>August Analyses</th>
<th>November and April Analyses both depths</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 6 in.</td>
<td>6 to 24 in.</td>
</tr>
<tr>
<td>Nitrate-N</td>
<td>Nitrate-N</td>
</tr>
<tr>
<td>Soil texture</td>
<td>Soil texture</td>
</tr>
<tr>
<td>Soil water content</td>
<td>Soil water content</td>
</tr>
<tr>
<td>O.M.</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
</tr>
<tr>
<td>Electrical conductivity</td>
<td></td>
</tr>
<tr>
<td>Olsen P</td>
<td></td>
</tr>
<tr>
<td>Exchangeable K</td>
<td></td>
</tr>
<tr>
<td>Nitrate-N</td>
<td></td>
</tr>
<tr>
<td>Soil water content</td>
<td></td>
</tr>
</tbody>
</table>
Modeling Methods

Added monthly precipitation and average air temperature for each site-year to database. Developed regression models for the nitrate changes based on full data set.

Form:

\[ \text{Nitrate change} = a + b_1 \times x_1 + \ldots + b_n \times x_n \]

Where

- \( a \) is the intercept
- \( b \)'s are coefficients (slopes)
- \( x \)'s are values of each variable (O.M., pH, precip etc)
Changes in soil nitrate-N from **August to April** in top 2 feet of soil by *previous crop*

Average = 18 lb N/ac

Jones unpubl data.

Averaged over 8 sites and 3 years. **Previous crop effect was significant.**
Changes in soil nitrate-N from **November to April** in top 2 feet of soil by *previous crop*

Average = 5 lb N/acre

<table>
<thead>
<tr>
<th>Previous Crop</th>
<th>Nitrate Difference Nov. to Apr. (lb N/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A legume</td>
<td>8</td>
</tr>
<tr>
<td>Fallow</td>
<td>-4</td>
</tr>
<tr>
<td>Oilseed</td>
<td>10</td>
</tr>
<tr>
<td>SmGrain</td>
<td>2</td>
</tr>
</tbody>
</table>

Jones unpubl data.

Averaged over 8 sites and 3 years. **Previous crop effect was not significant.**
Why was previous crop statistically important for Aug to Apr nitrate changes, but not for Nov to Apr nitrate changes?
Changes in soil nitrate-N from August to April in top 2 feet of soil by previous crop

Jones unpubl data.

Averaged over 8 sites and 3 years. Location effect was not significant.
Changes in soil nitrate-N from **November to April** in top 2 feet of soil by *location*

Jones unpubl data.

Averaged over 8 sites and 3 years. *Location effect was not significant.*
Questions so far?
Year to Year variability in August to April nitrate change

Year had a significant effect on nitrate change
Average Temperature (September to March) by Year (averaged over location)
Total Precipitation (September to March) by Year (averaged over location)

![Bar chart showing total precipitation (in inches) for the years 2007-08, 2008-09, and 2009-10. The years 2007-08 and 2009-10 have similar precipitation levels, while 2008-09 has significantly higher precipitation.](image-url)
Year to Year variability in August to April nitrate change

<table>
<thead>
<tr>
<th>Year</th>
<th>Nitrate Difference Aug. to Apr. (lb N/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-08</td>
<td>13</td>
</tr>
<tr>
<td>2008-09</td>
<td>25</td>
</tr>
<tr>
<td>2009-10</td>
<td>15</td>
</tr>
</tbody>
</table>
Monthly nitrate-N changes at Agronomy Post Farm

**2007-8**

**2008-9**

**NOTE:**
- Average October and April nitrate almost identical
- Nitrate increased ~30 lb N/ac from October to April
Precipitation at the Post Farm

Message: Higher precipitation in Sep and Oct 07/08 appeared to kick start N mineralization
Monthly nitrate-N changes at Agronomy Post Farm

**2007-8**

NOTE: Average October and April nitrate almost identical

**2008-9**

NOTE: Nitrate increased ~ 30 lb N/ac from October to April
Questions so far?
August to April Model Findings

- Initial nitrate-N level, soil depth, Olsen P, previous crop, and year were all found to be important

  Specifically, *higher* Aug nitrate related to *lower* nitrate changes (more there to lose, offsetting N mineralization)

  *Lower* soil depth related to *lower* nitrate changes

  *Higher* Olsen P related to *lower* nitrate changes (?)

- Climate, texture, water content, pH etc were found to NOT be important (!)
1. Unfortunately, model not accurate enough to have confidence in using it.

2. Large range in nitrate changes suggests Aug sampling may be too early.
November to April Model Findings

• Initial nitrate-N level, soil depth, surface pH, precipitation, and year were all important

  Again, *higher* Aug nitrate related to *lower* nitrate changes, and *lower* soil depth related to *lower* nitrate changes

  *Higher* pH related to *higher* nitrate changes

  *Higher Aug to Feb* precipitation related to *lower* nitrate changes (suggesting leaching offset mineralization OR precip speeded up mineralization before November?)

• Temperature, texture, water content, Olsen P etc were found to not be important
As a crop adviser what could you do with this information?

- Sample later in fall if practical
- On coarser soils with high nitrate levels, consider increasing recommended N rate to account for nitrate loss.
- Consider an N ‘credit’ if sample Sep or earlier, especially after a broadleaf crop.
- Use adjusted soil nitrate levels in MSU’s economic N rate calculator for small grains on fallow to maximize grower’s bottom line.
IF credited 10 lb N/ac for Aug to Apr nitrate change AND used this model:
Recommended available N rate = \[
\frac{(170 \text{ lb N} - 10 \text{ lb N})}{50 \text{ bu}} = 3.2 \text{ lb N/bu}
\]
Summary

- Nitrate levels increased on average by 18 lb N/ac from Aug to Apr, and were highly variable
- Nitrate changes after mid November are much smaller (~5 lb N/ac), but also highly variable
- High nitrate levels on shallow coarse soils can be lost, resulting in under-fertilization
- Sampling later in Fall will better represent spring nitrate levels
For more information

- Soil fertility website: http://landresources.montana.edu/soilfertility
- Overwinter nitrate change study report: go to Reports on above site
- Small grains nitrogen economic calculator: go to Fertilizer Information and then Fertilizer Economics on above site
Questions?