Introduction

- Nitrogen (N) is essential to plant growth, but can be easily lost from the soil by leaching or denitrification with excess rainfall.
- Wet conditions in May and June can delay planned sidedress applications and promote loss of previously applied nitrogen.
- Producers should evaluate how much N remains in the soil and if that will be enough to meet crop needs; if not, a rescue N application may be needed.


- **Soil Tests** – The Pre-Sidedress Nitrate Test (PSNT), a.k.a. the Late Spring Soil Nitrate Test (LSNT), is most common.
- Sampling 12+ inches deep will give a more accurate measure of the remaining nitrate in the root zone after a heavy rain (the critical level may need to be adjusted above 25 ppm).
- **Optical sensors** can help assess N deficiency and the amount of N needed to optimize crop response.
- As the N applicator traverses the field, sensing, rate calculations and N application all occur at once.
- In addition, aerial imagery and chlorophyll meters are also good tools for evaluating the N needs of a growing corn crop.
- To estimate the quantity of N in the nitrate form when rainfall occurred, one must know the following:
  1. When was N applied?  
  2. What fertilizer was used?  
  3. Quantity of N applied?  
  4. Field conditions after application?
- Greater quantities of N fertilizer are converted to nitrate as time goes by and soil temperatures increase.

### Table 1. Amount of nitrogen fertilizer in the nitrate-N form 0, 3 and 6 weeks after application.

<table>
<thead>
<tr>
<th>N Source</th>
<th>Week After Application</th>
<th>% Fertilizer as Nitrate-N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anhydrous ammonia (NH₃)</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Anhydrous ammonia (NH₃)</td>
<td>3</td>
<td>65</td>
</tr>
<tr>
<td>NH₃ with N-Serve</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>NH₃ with N-Serve</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Urea</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>UAN</td>
<td>25</td>
<td>60</td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>50</td>
<td>80</td>
</tr>
</tbody>
</table>

**Table 2. Estimated denitrification losses as influenced by soil temperature and days of saturation.**

<table>
<thead>
<tr>
<th>Soil Temp (°F)</th>
<th>Days Saturated</th>
<th>Nitrate-N Loss (% of total N applied)</th>
</tr>
</thead>
<tbody>
<tr>
<td>55-60</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>75-80</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>95</td>
</tr>
</tbody>
</table>

**Figure 1.** Percent of years with greater than 14 inches of precipitation from April through June. Spring N losses are more common in higher rainfall areas (green on map).**

- The nitrate form of N is more susceptible to loss from rainfall; however, it is not always lost during heavy rains.
- Soil temperature and duration of soil saturation are two key factors affecting denitrification.
- The warmer the soil and the longer it is saturated, the more denitrification losses are increased (Table 2).

### Rescue N Application Methods

- **Equipment availability** and **N source** are the two most important factors to consider, as well as **risk of leaf injury** and the potential for **NH₃ volatilization** from urea application.
- If a high-clearance sprayer is available, banded applications of urea ammonium nitrate (UAN) solution can be made.
  - To reduce leaf burn, weight the hoses to help keep them on the ground.
  - Banding will also help minimize urea hydrolysis and volatilization.
**Urea is the product of choice for broadcasting rescue N**

- Broadcasting ammonium nitrate (NH$_4$NO$_3$) and UAN solution can cause extensive leaf burning and possible yield loss.
- Urea is much safer to broadcast, usually resulting in only minimal crop injury (Figure 3).
- Urea is subject to NH$_3$ volatilization in the presence of urease, a naturally occurring soil and plant enzyme.
- The use of a urease inhibitor (e.g., Agrotain® N stabilizer), can help delay urea hydrolysis and reduce NH$_3$ volatilization.
- Banded applications also will help minimize N loss.
- Late applications of controlled-release urea are not recommended because of the delay between application and the N being released and available to the corn.

**Corn Response to Rescue N Applications**

- Pre-tasseling rescue N applications have proven effective at recovering yield, as these and other research studies show:
  - An Illinois study found that an intentionally flooded plot, with 50 lbs/acre of supplemental N applied after flooding, produced similar yields to the non-flooded plots (Torbert et al., 1993).
  - In an Indiana study, 70 lbs N/acre applied at V13 resulted in an economic yield response (Emmert, 2009).
  - Grain yield of corn receiving N at V15 was not significantly different than the yield of corn receiving 200 lb N/acre at planting in northwestern Indiana in 2010 (Nielsen et al., 2011).
  - Missouri studies have shown that yield can be recovered with N applications as late as tasseling.
- Under severe N deficiency, a positive response was demonstrated to applications of low rates of N (30 to 60 lbs/acre) as late as three weeks after pollination (Thomison, 2010).
- Recent DuPont Pioneer and university research gives new insights into the timing of N uptake:
  - Corn takes up about 37% of its total N requirement during the grain-fill period (R1 to R6). In high yield environments, post-flowering N uptake can range from 85 to 130 lbs N/acre.
  - N for grain development originates from both remobilized N from vegetative tissues and continued N uptake from the soil.
  - Approximately 62% of grain N content is supplied by continued N uptake after flowering.
- This new research underscores the importance of adequate N supply throughout the reproductive period to maximize yield.

**Considerations When Applying Rescue N**

- Corn is more responsive the sooner N is applied. The greater the N deficiency and the longer it goes uncorrected, the greater the potential for yield loss.
- Early-season N stress can result in irreversible yield loss (Binder et al., 2000).
  - Due in part to a reduction in the number of kernel rows per ear, which is generally determined between V5 and V8.
- If prolonged soil saturation and/or ponding lowered corn yield potential, full N rates may no longer be needed.
- Denitrification is greatest in low-lying areas; therefore, a whole-field rescue application may result in unnecessary costs and potential future losses of excess N.

**Management Practices**

- When use of ground equipment is prevented by wet field conditions, aerial application of urea is still an option.
  - Use of a urease inhibitor can help prevent urea hydrolysis and subsequent NH$_3$ volatilization.
  - To avoid severe corn tissue damage, do not use UAN solution, ammonium nitrate or ammonium sulfate.
- Maintain an advance plan in case rescue application is needed. A quick response to N-deficiency stress is often required to minimize yield loss.
  - Could include finding a service provider for high-clearance or aerial applications well ahead of the potential need.
- When N is lost and plants are deficient, rescue applications should be made as soon as possible, preferably by silking.
  - However, because corn takes up and uses N throughout the reproductive period, consider remediating deficiencies with moderate (40 to 80 lbs/acre) amounts of N as late as four weeks post-pollination.