Understanding Wheat Growth and Development

Shawn P. Conley
Soybean and Wheat Specialist
University of Wisconsin, Madison

Cereal Grain Development Stages

- Feekes Scale
  - Eleven development stages
  - New leaves counted > 50% unfolded
  - Detailed heading & ripening

- Zadoks Scale
  - Ten development stages
  - New leaves counted > 50% unfolded
  - Two or more codes possible

- Haun Scale
  - Not commonly used

Positioning Wheat Plant for Growth Staging

- Find the first leaf
  - Lowest leaf with blunt tip
  - May have senesced
  - Sheath encloses all other leaves
  - Opposite of coleoptilar tiller

Count the Leaves on the Main Stem

- Opposite leaf arrangement
  - Feekes and Zadoks Scale
    - Youngest leaf is ½ the length of the one below
  - Left side: odd number of leaves
  - Right side: even number of leaves
  - Count dead or missing leaves

Count the Tillers

- Each tiller has its own sheath – prophyll
- Be aware of 2° or 3° tillers
- Tillers > 5th leaf will not produce heads and therefore, do not need to be counted

Four-leaf Wheat Plant with Two Tillers
Count the Nodes

- Nodes can easily be seen or felt on the stem above the ground level

Has the Flag Leaf Emerged?

- Occurs when ≥ three nodes are present above the soil surface
- To confirm:
  - Split the leaf sheath above the highest node and search for additional leaves

Has Head Emergence and Flowering Occurred?

- Heading begins when the first awns appear
- Examine Florets
  - Flowering begins in the middle of the head
  - Generally 3-4 days following head emergence
  - Lasts ~7 days
  - Sensitive to stress

Determine Grain Development Stage

- Grain Development
  - Watery Ripe
  - Milk
  - Soft Dough
  - Hard Dough
    - Physiological maturity:
      - Glumes and peduncle are no longer green
    - Water concentration:
      - 40-45%
  - Kernel Hard
  - Harvest Ripe

Pseudo-stem Erection (Hollow stem)

Has Boot Stage Begun?

- Zadoks:
  - Follows emergence of the flag leaf collar and continues until heading
- Feekes and Haun:
  - Follows flat leaf extension and continues until heading
Components of Wheat Yield

- Tiller and head number
  - Nitrogen availability
  - Tillering
  - Feekes 6.0

- Head size
  - Maximum spikelet number
  - Winter wheat
  - Mid-to-late tillering
  - Feekes stage 2-3

- Kernel number per spikelet
  - Late jointing
  - Feekes 5-6

- Kernel size
  - Feekes 8
  - Keys to increase kernel size
    - Healthy flag leaf
    - Water
    - Nutrients

What about fall applied N?

- 3 year study at Arlington on fall applied urea on winter wheat.
- Risk of over winter nitrate loss of fall applied urea to winter wheat or residual soil nitrate appears minimal on this soil type (well drained Plano silt loam) unless above normal temperatures and precipitation occur resulting in minimal frost depth and greater leaching potential.
- The addition of a nitrification inhibitor did not result in reduced over winter soil nitrate losses when above normal temperature and precipitation occurred, however.

Spring N Demand for Winter Wheat

- N fertilizer has two important functions:
  - Manipulate population
    - Effective population is tillers, not plants
  - Supply nutritional needs of crop for production of protein

What is the right time for N?

- Early spring if the crop looks thin < 70 tillers ft$^2$
- If the crop looks good, wait until near jointing
  - Increase yield
  - Increase fertilizer efficiency
  - Avoid growth that is too lush (disease, lodging, water stress)
  - Allow better diagnosis of the right amount of N

What about fall applied N?

- This research was not conducted on poorly or somewhat poorly drained soils and the results might differ in that there could be denitrification losses in the spring under warm wet conditions on poorly or somewhat poorly drained soils.
- The nutrient management regulations do have some restrictions on the application of fall N. These restrictions apply to soils with high permeability, soils with <20” to bedrock or soil with <12” to apparent water table, or within 1000’ of a municipal well.
- On these soils the regulation soil no fall N except for the establishment of fall seeded crops and the N application rate is limited at 30 lb N/a.
N Recommendations for Wheat

<table>
<thead>
<tr>
<th>Crop</th>
<th>&lt; 2.0</th>
<th>2.0 – 9.9</th>
<th>10.0 – 20.0</th>
<th>&gt; 20.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small grain silage</td>
<td>60</td>
<td>40</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Small grain silage, Alfalfa underside</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Small grain and legume silage</td>
<td>25</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Small grain and legume silage u/a</td>
<td>15</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wheat for grain</td>
<td>90</td>
<td>70</td>
<td>40</td>
<td>0</td>
</tr>
</tbody>
</table>

Response of N timing on WW Yield in 2008

<table>
<thead>
<tr>
<th>P25R47</th>
<th>Grain yield (bu per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N rate</td>
<td>Arlington</td>
</tr>
<tr>
<td>0</td>
<td>82.1</td>
</tr>
<tr>
<td>30</td>
<td>92.4</td>
</tr>
<tr>
<td>60</td>
<td>90.5</td>
</tr>
<tr>
<td>90</td>
<td>89.2</td>
</tr>
<tr>
<td>120</td>
<td>87.8</td>
</tr>
<tr>
<td>30+30</td>
<td>86.5</td>
</tr>
<tr>
<td>45+45</td>
<td>85.4</td>
</tr>
<tr>
<td>60+60</td>
<td>86.7</td>
</tr>
</tbody>
</table>

LSD: 0.10 2.7 3.5

Optimum Economic Wheat Nitrogen Rate and Timing

Objective:
To compare the routine N management practices of several wheat growers with our research based recommendations

- 6 grower fields were identified
- Large plots are used
- 2 N treatments – PPNT determined and a grower selected rate
- Fall PPNT soil samples were taken
- Adjusted recommendations have come back from 0 to 70 lbs/a

Winter Wheat P, K, and S Removal

- Sulfur for wheat mainly limited to sandy soils
  (0.25 pounds per bushel: 20 pounds for 80 bu)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Unit</th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat grain</td>
<td>bu</td>
<td>1.5</td>
<td>0.6</td>
<td>0.34</td>
<td>0.1</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>ton</td>
<td>14</td>
<td>3.3</td>
<td>24</td>
<td>2.8</td>
</tr>
</tbody>
</table>
Nozzle types

- Streamer bar once popular is loosing ground
- Tank mixing herbicides and nitrogen is a tricky compromise

Impact of Rotation on Wheat Yield

<table>
<thead>
<tr>
<th>Year (bu/a)</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-W-W</td>
<td>61.1</td>
<td>61.4</td>
<td>68.2</td>
<td>66.1</td>
</tr>
<tr>
<td>C-S-W</td>
<td>60.8</td>
<td>61.1</td>
<td>68.2</td>
<td>66.1</td>
</tr>
<tr>
<td>S-C-W</td>
<td>66.0</td>
<td>62.9</td>
<td>74.0</td>
<td>71.8</td>
</tr>
<tr>
<td>S-C(silage)-W</td>
<td>62.5</td>
<td>62.0</td>
<td>69.9</td>
<td>68.1</td>
</tr>
</tbody>
</table>

Adding a third crop does not increase corn grain yield, but does improve soybean grain yield ...
Effect of % Winterkill and Spring N on Wheat Yield

![Sub-crown internode]

Effect of Spring N on Wheat Yield Components

<table>
<thead>
<tr>
<th>Seeding rate</th>
<th>% WK N rate</th>
<th>Grain Yield</th>
<th>Lodging (1-5)</th>
<th>1000 KWT</th>
<th>Tillers sq ft</th>
<th>Heads SM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.75</td>
<td>0</td>
<td>87.8</td>
<td>2.1</td>
<td>41.3</td>
<td>182</td>
<td>710</td>
</tr>
<tr>
<td>1.50</td>
<td>15</td>
<td>79.6</td>
<td>2.1</td>
<td>41.5</td>
<td>150</td>
<td>640</td>
</tr>
<tr>
<td>1.25</td>
<td>30</td>
<td>79.4</td>
<td>1.6</td>
<td>40.9</td>
<td>112</td>
<td>576</td>
</tr>
<tr>
<td>1.00</td>
<td>45</td>
<td>74.0</td>
<td>1.5</td>
<td>40.5</td>
<td>95</td>
<td>623</td>
</tr>
<tr>
<td>0.75</td>
<td>60</td>
<td>73.4</td>
<td>1.3</td>
<td>41.0</td>
<td>95</td>
<td>533</td>
</tr>
<tr>
<td>LSD (0.10)</td>
<td></td>
<td>5.9</td>
<td>0.3</td>
<td>NS</td>
<td>16.9</td>
<td>60.8</td>
</tr>
</tbody>
</table>

LSD (0.10) 5.9 0.3 NS 16.9 60.8 0 68.4 1.0 42.4 124 572 30 77.2 1.3 42.4 127 630 60 82.0 1.7 40.6 128 580 90 82.1 2.2 40.3 135 679 120 84.7 2.3 39.4 120 622 LSD (0.10) 3.1 0.2 0.8 NS 53.0

Weed Management in Winter Wheat

Chilton: Hopewell: 9/24/07 Research sponsored by the WFRP

Grain yield (bu per acre)
Table 5-3. Crop rotation, resistance, and herbicide effectiveness on weeds that should be controlled in small grains.

Table 5-4. Survival and ending restrictions for herbicides registered for use in small grains.

Table 5-5. Special notes and precautions for herbicides registered for use in small grains.