Forage Management:
Low Lignin Alfalfa
Leaf Loss at Harvest

Dr. Dan Undersander
University of Wisconsin

Cell Wall

Developing cell wall

Mature cell wall
Cellulose

- Consists of D-glucose units
- Is a straight chain polymer: unlike starch, no coiling or branching occurs,
- The molecule adopts an extended and stiff rod-like shape

Pectin – to congeal

- Polymer of sugar acids
- Mainly composed of pectinic acid,
- Is water soluble,
- Is able to form gels in the presence of acid and sugar
- A major component of the middle lamella, where it helps to bind cells together,
Hemicellulose

- Is a polymer of several sugars
- Besides glucose, sugars can include xylose, mannose, galactose, rhamnose, and arabinose.
- Has a random, amorphous, branched structure with little strength.
- Is easily hydrolyzed by dilute acid or base as well as hemicellulase enzymes.

Lignin

- Is a polymer of aromatic alcohols

[Chemical structures of coniferyl alcohol, coumaryl alcohol, and sinapyl alcohol]
Importance of Lignin

- Lignin:
  - is second most abundant organic compound on earth
  - constitutes 30% of non-fossil organic carbon
  - fills spaces in the cell wall
  - is linked to hemicellulose

Importance of Lignin in Alfalfa

- Provides strength to plants
- Allows the plant vascular system to transport water in the plant without leakage.
- Contributing a major fraction of soil organic matter.
Lignin is a polymer of phenyl propane units

Plant lignins can be broadly divided into three classes

1) softwood (gymnosperm) composed principally of coniferyl alcohol units
Plant lignins can be broadly divided into three classes

1) softwood (gymnosperm) composed principally of coniferyl alcohol units
2) hardwood (angiosperm) composed of coniferyl and sinapyl alcohol units.
3) grass or annual plant (graminaceous) lignin composed mainly of p-coumaryl alcohol units.
Plant lignins can be broadly divided into three classes

- Alfalfa is composed principally of coniferyl alcohol units (like softwoods).

Nobel Foundation gene knockouts
-low lignin alfalfa

Alfalfa lignin is composed primarily of G-Lignin

H-Lignin (p-hydroxyphenyl) G-Lignin (guaiacyl) S-Lignin (syringal)
Planted at 5 locations to determine response in harvest system
Yield Curve of Alfalfa

Yield and Quality Curve of Alfalfa
Yield and Quality Curve of Alfalfa

Effect of harvest delay on alfalfa yield, at each of 4 cuttings, Wisconsin 2015
3 vs 4 cutting by Sept 1 effect on alfalfa yield, Arlington, Wisconsin

<table>
<thead>
<tr>
<th></th>
<th>1st cutting</th>
<th>2nd cutting</th>
<th>3rd cutting</th>
<th>4th cutting</th>
<th>Season Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd year 3 cut</td>
<td>2.97</td>
<td>2.43</td>
<td>2.15</td>
<td>----</td>
<td>7.55</td>
</tr>
<tr>
<td>4 cut</td>
<td>1.66</td>
<td>1.48</td>
<td>1.71</td>
<td>1.68</td>
<td>6.53</td>
</tr>
<tr>
<td>3rd year 3 cut</td>
<td>2.32</td>
<td>1.53</td>
<td>1.24</td>
<td>----</td>
<td>5.09</td>
</tr>
<tr>
<td>4 cut</td>
<td>1.31</td>
<td>1.18</td>
<td>0.75</td>
<td>0.83</td>
<td>4.07</td>
</tr>
</tbody>
</table>

Yield of RR/RL alfalfa with grass

Yield, t/a DM

- RR/RL
- RR/RL Orchardgrass
- RR/RL Tall Fescue
### Low lignin alfalfa varieties

<table>
<thead>
<tr>
<th>Type/Company</th>
<th>Lignin Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional/Alforex</td>
<td>7 to 10%</td>
</tr>
<tr>
<td>GM/Forage Genetics</td>
<td>15 to 20%</td>
</tr>
</tbody>
</table>

**Unit reduction** (assuming 7% lignin)

<table>
<thead>
<tr>
<th>Type/Company</th>
<th>Lignin Reduction</th>
<th>Unit reduction (assuming 7% lignin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional/Alforex</td>
<td>7 to 10%</td>
<td>0.5 to 0.7</td>
</tr>
<tr>
<td>GM/Forage Genetics</td>
<td>15 to 20%</td>
<td>1.1 to 1.4</td>
</tr>
</tbody>
</table>
Delay Harvest for Yield

- Forage Yield
- Cutting Interval (Days)
- NDFD (%)
- Various cultivars and growth stages:
  - S4R02 (FD4)
  - LegenDairy (FD3)
  - XHD (FD3)
  - Hi-Gest 360 (FD3)

NDFD - 4 Locations (WA, ID, IA, & WI) 2 yrs

Value of reduced lignin

- Improved forage quality
- Wider harvest window?
- Later harvest
  - Greater tonnage per cutting
  - Make use of full growing season
  - Reduce number of cuttings
    - With 15 to 18% lignin reduction harvest 8 to 10 days later
How does lignin/digestibility of forage change?

- Less and/or different lignin in stem
  - Genetic effect
  - Environmental effect
    - Less sunlight (cloudy days) reduces lignin content
    - Cooler temperature reduces lignin content
- More leaves
  - Favorable leaf growth environment
  - Less leaf disease
  - Reduce harvesting leaf loss

Alfalfa Leaf Loss Effect on Forage Quality

- Leaves higher in quality than stems

Leaves 15 to 20% NDF
Stems 60 to 70% NDF

Effect of leaf percentage on RFQ

\[
y = 0.52x - 28.32 \\
R^2 = 0.71
\]
Wide swath benefits

- Faster drying
- Higher forage quality
Leaf Content at Harvesting Stages

Data from Winfield, 2016

Three-state rake/merger trial, 2015
Retaining leaves increases yield

- Reduced leaf loss
  - 5 to 20% yield reduction

Yield effect of leaf loss

![Bar chart showing yield effect of leaf loss](image)

Precut mowed raked baled

Stems Leaves

Retaining leaves increases yield

- Reduced leaf loss
  - 5 to 20% yield reduction

Yield effect of leaf loss

![Bar chart showing yield effect of leaf loss](image)

Precut harvested

Stems Leaves

Dan Undersander-Agronomy © 2017
Forage quality losses during harvesting

- Ash content
- Leaf loss
  - Disease on standing crop

Leaves on ground prior to mowing
Leaves on ground after mowing

Leaf Loss during harvesting
Remove hay/haylage from field rapidly to minimize wheel traffic damage

Wheel traffic 5 days after cutting

Alfalfa regrowth 10 days after cutting

Wheel traffic damage principles

- Traffic closer to cutting does less damage
- Traffic covering less of the field does less damage
Cutter bar width effect on yield

Percentage of field covered with wheel traffic during harvesting

- **Mowing**
  - 10’ mower
    - Two tractor tires (20”) and two mower tires 15’ = 70”/120” = 58%

- **Raking/merging**
  - If 10’
    - 58%
  - If 20’
    - 29%

- **Baling/chopping**
  - 29% plus traffic to haul wagon/truck or bales off field

<table>
<thead>
<tr>
<th>Percentage trafficked</th>
<th>% trafficked</th>
</tr>
</thead>
<tbody>
<tr>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>58</td>
<td>29</td>
</tr>
<tr>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>145</td>
<td>116</td>
</tr>
</tbody>
</table>
Percentage of field covered with wheel traffic during harvesting

- **Mowing**
  - 13’ mower
    - Two tractor tires (20”) and two mower tires 15’ = 70”/192” = 44%

- **Raking/merging**
  - If 13’ % trafficked 44 44
  - If 26’ % trafficked 22 22

- **Baling/chopping**
  - 22% plus traffic to haul wagon/truck or bales off field

Mowed swaths in pairs
Effect of cutter bar width on alfalfa yield

<table>
<thead>
<tr>
<th>Year</th>
<th>Cutter bar width</th>
<th>Yield increase /year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>9’ vs 12’</td>
<td>0.5 t dm</td>
</tr>
<tr>
<td>2014</td>
<td>10’ vs 13’</td>
<td>0.5 t dm</td>
</tr>
<tr>
<td>2016</td>
<td>10’ vs 13’</td>
<td>1.0 t dm</td>
</tr>
</tbody>
</table>

Summary

- Reduced lignin can either:
  - produce higher quality or
  - allow delay in harvest at same quality
- Leaf loss can reduce both quality and yield
- Minimize wheel traffic to minimize yield loss