Low Lignin Trait in Alfalfa – What are the Possibilities?

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What about Fiber?

33%-55% Cell Wall (NDF-Fiber)

The high fiber becomes higher over time
NDF/ADF increases each day
Figure 4. Effect of harvest scheduling on yield and quality (Data from Marble, 1974, Davis, CA). Classifications are as per USDA-Hay Market Guidelines (2016). Note that most nutritionist desire additional analyses to predict quality, particularly fiber digestibility estimates.
Lignin in Alfalfa

- Alfalfa has ~ 6-8% (%DM) lignin
- Structural support
- Lignin increases with maturity
- Negatively related to fiber digestibility
-Limits NDFD, DMI, and energy production efficiency
Why Lignin?

- Lignin is an indigestible phenolic compound in alfalfa cell walls
- As alfalfa matures, lignin content increases.
- Lignin cross-links with cellulose which decreases digestibility of fiber (dNDF)
- A 10% increase in fiber digestibility
  - Increase milk/beef by $350M/yr
  - Decrease manure by 2.8M T/yr

Consortium for Alfalfa Improvement
‘Reduced Lignin Trait’

- ‘HarvXtra’ Trait GE deregulated 2014 (FGI Int’l)- consortium of USDA-ARS, Noble Foundation
- Commercialized 2015-2017 (different dormancies)
- ‘HiGest’ alfalfa released by Alforex 2014 (non-GE)
- How do these perform?
Alleviating the Dilemma

Source: Undersander et al., 39th Western Alfalfa & Forage Conference, 2-4 December 2009, Reno, Nevada, Department of Agronomy and Range Science Extension, University of California, Davis, CA 95616
Harvest for Yield/Quality

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

Forage Yield

- 54R02
- Lg XHD
- Hi-Gest
- HarvXtra

>35% more forage yield *

* Undersander, et. al. Low lignin alfalfa: Redefining the yield/quality tradeoff, 2009 Western Alfalfa & Forage Conference
1. Is forage nutritive value of HarvXtra superior to that other alfalfa varieties as the crop matures?

2. How does HarvXtra compare with other varieties when managed under 28-, 33-, and 38-day harvest schedules?
Field Studies

- **Six locations:** CA, KS, WI, MI, OH, PA
- **Alfalfa varieties**
  - HarvXtra–008 Reduced Lignin  FD 4
  - 54R02 – Yield FD 4
  - WL 355RR – Quality FD 4
  - Hi-Gest 360 – conventional, selected for reduced lignin (included in CA and PA tests only), FD 3
- **Sown at 18 lbs/acre pure live seed**
- **Replicated 4 times each location**
NDFD in 2015 – 6 location average

2nd growth cycle

3rd growth cycle

Source: Sulc et al., CA Alfalfa Symposium, 2016
Average in 2015
(2 cuttings & 6 locations)

<table>
<thead>
<tr>
<th>Variety</th>
<th>ADL</th>
<th>NDF</th>
<th>RFQ</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>HarvXtra-008</td>
<td>4.0 b</td>
<td>26.7 c</td>
<td>297 a</td>
<td>26.4 a</td>
</tr>
<tr>
<td>WL355RR</td>
<td>4.9 a</td>
<td>28.7 b</td>
<td>262 b</td>
<td>25.8 b</td>
</tr>
<tr>
<td>54R02</td>
<td>5.0 a</td>
<td>30.5 a</td>
<td>243 c</td>
<td>25.0 c</td>
</tr>
</tbody>
</table>

-19%  -7%  +13%  +22%

Source: Sulc et al., CA Alfalfa Symposium, 2016
## Average of 3 cuttings in 2016 CA only

<table>
<thead>
<tr>
<th>Variety</th>
<th>NDFD</th>
<th>ADL</th>
<th>NDF</th>
<th>RFQ</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>HarvXtra-008</td>
<td>51.9**</td>
<td>4.3**</td>
<td>31.9*</td>
<td>228*</td>
<td>23.6</td>
</tr>
<tr>
<td>WL355RR</td>
<td>48.8</td>
<td>5.0</td>
<td>32.6</td>
<td>216</td>
<td>23.6</td>
</tr>
<tr>
<td>54R02</td>
<td>49.3</td>
<td>5.0</td>
<td>33.5</td>
<td>209</td>
<td>23.1</td>
</tr>
<tr>
<td>Hi-Gest</td>
<td>50.1</td>
<td>4.8</td>
<td>31.3*</td>
<td>230*</td>
<td>24.4*</td>
</tr>
</tbody>
</table>

Source: Sulc et al., CA Alfalfa Symposium, 2016

+3.5% to 6%    \(-10\%\) to -14%
NDFD in 2016 – CA only

1st growth cycle

NDFD (%)

Sample day in June

Days of regrowth

Source: Sulc et al., CA Alfalfa Symposium, 2016
Effect of Harvest Schedules – Seeding Year
NDFD (6 location average)

<table>
<thead>
<tr>
<th>Harvest Schedule</th>
<th>NDF Digestibility (g/kg NDF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut 2</td>
<td>54R02 WL355RR</td>
</tr>
<tr>
<td>Cut 3</td>
<td>54R02 WL355RR</td>
</tr>
</tbody>
</table>

Source: Sulc et al., CA Alfalfa Symposium, 2016
Effect of Harvest Schedules – Seeding Year Total Yield (6 location average)

<table>
<thead>
<tr>
<th>Harvest Interval (days)</th>
<th>Total Yield (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28-d</td>
<td>2.0</td>
</tr>
<tr>
<td>33-d</td>
<td>2.5</td>
</tr>
<tr>
<td>38-d</td>
<td>3.0</td>
</tr>
</tbody>
</table>

* = different than HarvXtra at 38-d

Source: Sulc et al., CA Alfalfa Symposium, 2016
HarvXtra trait (4 exp. Varieties, 2 years, 5 harvests/year), UC Davis, CA – 35 day schedule (FD 4 varieties)

<table>
<thead>
<tr>
<th>Variety</th>
<th>ADF</th>
<th>NDF</th>
<th>CP</th>
<th>ADL</th>
<th>NDFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>54R01 (control)</td>
<td>26.2</td>
<td>30.8</td>
<td>23.4</td>
<td>5.0</td>
<td>48.8</td>
</tr>
<tr>
<td>Ameristand 405TRR (control)</td>
<td>27.9</td>
<td>32.6</td>
<td>22.8</td>
<td>55.3</td>
<td>47.3</td>
</tr>
<tr>
<td>Liberator (control)</td>
<td>26.8</td>
<td>31.5</td>
<td>23.0</td>
<td>5.1</td>
<td>48.3</td>
</tr>
<tr>
<td>WL 355RR (Control)</td>
<td>27.5</td>
<td>32.2</td>
<td>22.8</td>
<td>5.3</td>
<td>47.4</td>
</tr>
<tr>
<td>12RRL-1</td>
<td>25.6</td>
<td>30.1</td>
<td>22.9</td>
<td>4.5</td>
<td>51.3</td>
</tr>
<tr>
<td>12RRL-2</td>
<td>26.3</td>
<td>31.2</td>
<td>23.0</td>
<td>4.5</td>
<td>51.3</td>
</tr>
<tr>
<td>12RRL-3</td>
<td>25.4</td>
<td>30.3</td>
<td>23.2</td>
<td>4.4</td>
<td>51.8</td>
</tr>
<tr>
<td>12RRL-4</td>
<td>26.0</td>
<td>31.0</td>
<td>22.9</td>
<td>4.6</td>
<td>51.1</td>
</tr>
</tbody>
</table>

Sign. Of Variety: *** ** n.s. *** ***
Remember:
Fall Dormancy Affects Quality (3 yr average)
Variety, Quality and Yield

2002-2004 All Harvests

Yield: $y = -0.147x^2 + 2.6161x + 12.633$
$R^2 = 0.7418$

Quality: $ADF: y = 6.1542x + 243.15$
$R^2 = 0.9279$

FALL DORMANCY SCORE

YIELD (Mg ha-1)

Yield

Quality

ADF (g kg-1)
Is this a quality trait or a yield trait?

- Both
- Delayed harvests = higher yields with similar quality to earlier harvests
- Reports of survey of Midwest: 75% primarily interested in yield aspects, 25% in quality improvement (FGI market report)
Summary

- HarvXtra alfalfa maintained consistently less lignin and greater NDFD than standard alfalfa varieties.
- HarvXtra had higher or similar nutritive value to standard alfalfas harvested 5 to 10 days earlier.
- Two year results suggest it will be possible to harvest HarvXtra alfalfa later and still maintain similar yield and nutritive value to standard alfalfas that are harvested earlier and more frequently.
- Implications: Effects on yield, water use efficiencies, harvest costs?
Issues – Remaining questions

- GE trait (approval sought in China, Japan)
- Measuring of digestibility of fiber not just fiber (ADF, NDF)
- Recognition in market of different measurements of quality (e.g. NDFD, digestibility)
- Value of quality? Yield?
- A Game-changer