GMO vs Non-GMO
Low Lignin Alfalfa Traits: What’s the Difference?

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Extension Forage Specialist
Alfalfa The Queen of Forages...

- Nitrogen fixation, tolerance to drought
- High Digestibility
- High Intake potential
- High Milk Production
What is the Issue?

- Dairy’s most perfect feed
- Genetic Improvement of Alfalfa Forage Quality
Alfalfa DM yield and quality at different maturity stages

Total Yield

Forage Digestibility

Yield

Digestibility

Source: Collins and Fritz, 2003
<table>
<thead>
<tr>
<th>Mature Stage</th>
<th>Yield</th>
<th>Digestibility</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late Vegetative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bud</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Early Flower</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mid Flower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late Flower</td>
<td></td>
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<td></td>
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</tbody>
</table>

**Source:** Collins and Fritz, 2003
Intake of DM depends on:

- Fiber (NDF) and
- Digestibility of the fiber (NDF)
Maturity Effects on Lignin & Quality

Cell Wall
Or
Fiber

Cell Contents:
- Protein
- Soluble Sugars
Maturity Effects on Lignin & Quality

Cell Contents:
- Protein
- Soluble Sugars
Maturity Effects on Lignin & Quality

↑ Cell Wall

Or

↑ Fiber and lignin

↓ Digestibility
Lignin

- Complex organic compound that coats-binds fiber
- Adds strength to plant cell walls
- Adds rigidity to stems and plant

![Diagram of plant cell wall with lignin and other components]
Lignin

- Forages have between 3 and 15% lignin
- Resistant to degradation
- Lignin accelerates with maturity
- Digestibility decreases with maturity

Photo: Noble Foundation
The Issue

- Genetic Improvement of Alfalfa Forage Quality
Yield and Quality Curve of Alfalfa

Adapted from Undersander - UW
Types of Reduced Lignin Alfalfa

1. GMO (Genetically Modified)
2. Non GMO
Difference between GMO & Non GMO
Reduced Lignin Alfalfa

1. GMO
   (Genetic transformation, Transgenic, Biotech alfalfa)

2. Non GMO
   (Conventional breeding, non-biotech alfalfa)
Genetically Modified (GMO) Alfalfa

- Commercialization of GE alfalfa needs government deregulation from environmental risk status
Genetically Modified (GMO) Alfalfa

1st GMO trait = Roundup Ready Tolerance

• GMO alfalfa started in 1997 with glyphosate tolerance (Round up Ready, or RR alfalfa)

• GMO RR alfalfa has non-regulated status since 2011 (initially in 1995, following lawsuits or ‘RR alfalfa saga’).
Genetically Modified (GMO) Alfalfa

2nd GMO trait = Reduced Lignin
Reduced Lignin Alfalfa (GMO) 2nd GE trait

- Prior to November 2014, Reduced-lignin trait was Regulated by USDA under the Plant Pest Provision (PPA) of APHIS (Animal-Plant Health Inspection Service)

- November 2014, Deregulation of Reduced Lignin trait (by USDA)
  ... Transgenic Reduced Lignin Alfalfa can now be grown commercially & companies can sell seed
GMO Reduced Lignin Alfalfa

1. Consortium for advancement of Alfalfa:
   - Noble Foundation
   - Monsanto
   - Forage Genetics International
   - Pioneer

2. Product:
   - ‘Knockout’ gene in lignin biosynthesis
   - Trait: reduced lignin
   - Trait Trade name: HarvXtra
Transgenic Alfalfa (GMO)
Lignin Biosynthesis Gene Knockout (●)

Lignin Biosynthesis

phenylalanine → cinnamic acid → p-coumaric acid → p-coumaroyl CoA → caffeoyl CoA → feruloyl CoA → p-coumaraldehyde → coniferaldehyde → 5-hydroxyconiferaldehyde → sinapaldehyde → sinapyl alcohol

H-Lignin
G-Lignin
S-Lignin

Woody angiosperms
Gymnosperms (conifers)
Transgenic Reduced Lignin Alfalfa

- Reduction of lignin

Photo credit: Noble Foundation
3. Alfalfa companies took HarvXtra gene and put back into their genetics.

<table>
<thead>
<tr>
<th>Company</th>
<th>Lignin Reduction</th>
<th>Unit reduction (assuming 7% lignin)</th>
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<tbody>
<tr>
<td>Pioneer</td>
<td>10 to 15%</td>
<td>0.7 to 1.1</td>
</tr>
<tr>
<td>Forage Genetics</td>
<td>10 to 15%</td>
<td>0.7 to 1.1</td>
</tr>
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</table>
NDF Digestibility

West Salem, WI
Planted 2010
Harvested 2011-12

RL/RRA= Reduced Lignin
54H11= Commercial variety
Liberator= Commercial variety

Source: Undersander - UW
## Transgenic Reduced-Lignin Alfalfa

3 vs 4 cutting by Sept 1 effect on alfalfa yield, Arlington, WI

<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</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3 cut</td>
<td>2.97</td>
<td>2.43</td>
<td>2.15</td>
<td>----</td>
<td>7.55</td>
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<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>
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<tr>
<td>3rd year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 cut</td>
<td>2.32</td>
<td>1.53</td>
<td>1.24</td>
<td>----</td>
<td>5.09</td>
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<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>
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Source: Dan Undersander
GMO traits:
• Reduced Lignin
• Roundup Ready
GMO Alfalfa - Concerns

- Alfalfa is bee pollinated
GMO Alfalfa - Concerns

- Alfalfa is bee pollinated
- Outcrossing crop requiring ‘insect pollinators’ to transfer pollen for seed set
- Transfer of pollen = potential for Gene Flow
GMO Alfalfa - Concerns

- Seed growers must have bee pollinators
- Distance travelled by bees (165 ft)
- Gene flow (GF) is measurable and there has not been evidence of contamination from GMO to Non-GMO fields

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<th>Field Separation</th>
<th>165 ft</th>
<th>300 ft</th>
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<tr>
<td>Gene Flow</td>
<td>0.25%</td>
<td>0%</td>
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GMO Alfalfa - Concerns

- Seed growers must have bee pollinators
- Distance travelled by bees (165 ft)
- Gene flow (GF) is measurable
- Best management practices exist to reduce GF:
  - Field Isolation distance of 3 miles
  - Seed production of either GMO or Non GMO
Types of Reduced Lignin Alfalfa

1. GMO (Genetically Modified)
2. Non GMO
Parent plants have:

• Reduced lignin content
• Strong agronomic traits = high yielding
• After 8 yrs of testing, Alfalfa Product:
  Dormancy 3, Hi-Gest 360
  Dormancy 6, Hi-Gest 660
Alfalfa Hi-Gest 360

- Medium-tall plants
- Dense canopy of stems and leaves
- Fall Dormancy = 3; WS = Very winter hardy
- 7 to 10% Reductions of Lignin
- Lodging tolerance similar to conventional varieties
- NOT RR
Alfalfa Hi-Gest 360

- Suggested retail price: $5.80/lb
  $290/50 lb bag
- Seed availability in Spring should be plenty

Source: Dr. Don Millier – Alforex (personal comm).
# Reduced Lignin Alfalfa - Summary

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<td></td>
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<tr>
<td>Alforex</td>
<td>7 to 10</td>
<td>0.5 to 0.7</td>
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Source: Dan Undersander
Both technologies bring:

1. Harvest Flexibility maximizing yield without sacrificing forage quality compared to conventional alfalfa
2. High quality forage (additional 2.5 pounds of milk per day)
3. Reduction in production costs and potential to extend the life of the stand (3 vs 4 cuts)
GMO vs. Non-GMO Reduced Lignin Alfalfa

Summary

GMO reduced lignin alfalfa disadvantages:

1. Not suited for grass/legume associations
2. Not suited for organic production
3. Not suited for GMO-sensitive Export markets
4. Potential for unwanted gene flow from fields into unwanted cropping fields
Non GMO reduced lignin alfalfa disadvantages:

1. Absence of ‘enhanced’ weed management (RR technology):
   - No broad spectrum herbicide
   - No flexibility to control weeds of different sizes
GMO vs. Non-GMO Reduced Lignin Alfalfa

Summary

• Many advocates exist for either way of production

• GMO and Non-GMO reduced lignin alfalfa production systems is possible

• The process of co-existence has been advocated by different producers and is a must
Thank You!

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