Forage Management:
Low Lignin Alfalfa
Leaf Loss at Harvest

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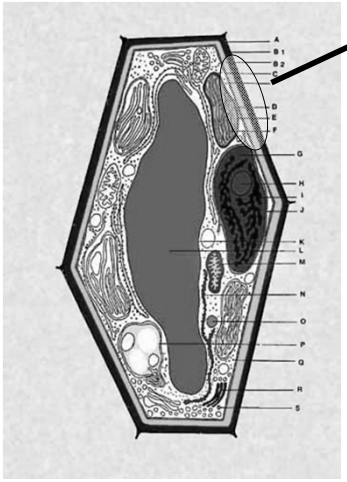
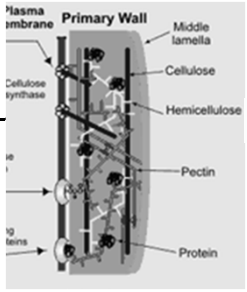
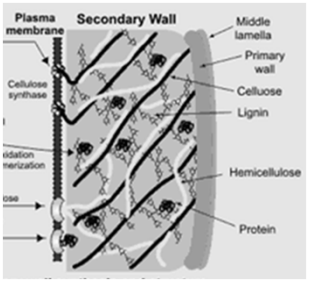
University of Wisconsin

Cell Wall





Developing cell wall

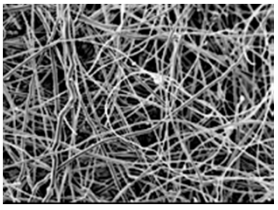


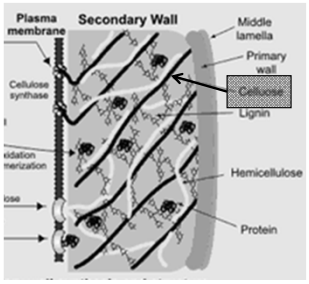
Mature cell wall

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

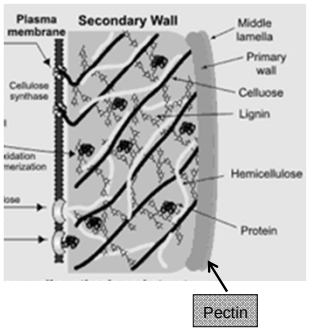
Pure cellulose fibers





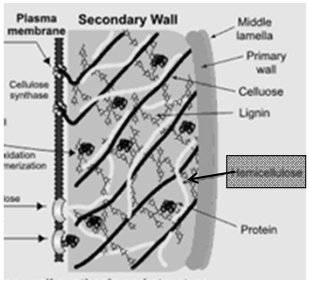
Pectin – to congeal

- 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,



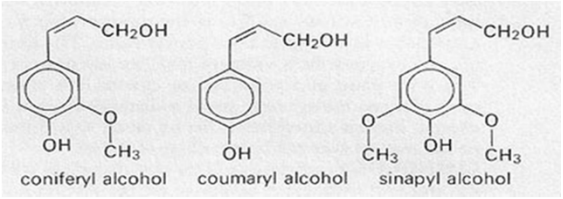
Hemicellulose

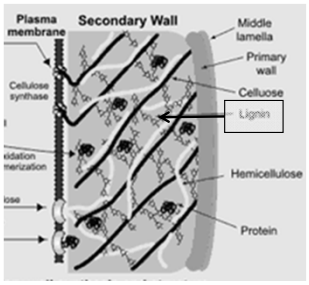
- Is a polymer of several sugars
- Besides glucose, sugars can include xylose, mannose, galactose, rhamnose, and arabinose.
- Has a random, amorphous, branched structure with little strength.
- Is easily hydrolyzed by dilute acid or base as well as hemicellulase enzymes.



Lignin

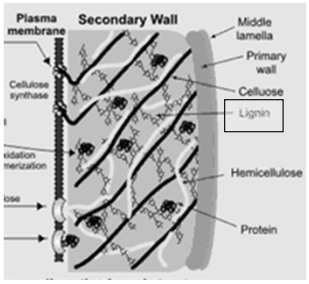
- Is a polymer of aromatic alcohols





Importance of Lignin

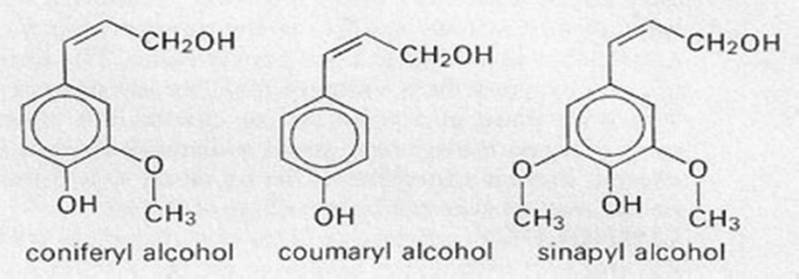
- Lignin:
  - is second most abundant organic compound on earth
  - constitutes 30% of non-fossil organic carbon
  - fills spaces in the cell wall
  - is linked to hemicellulose



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

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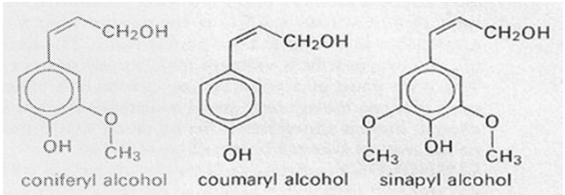
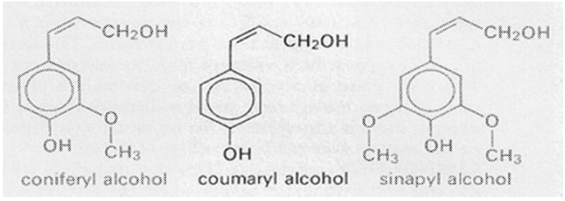


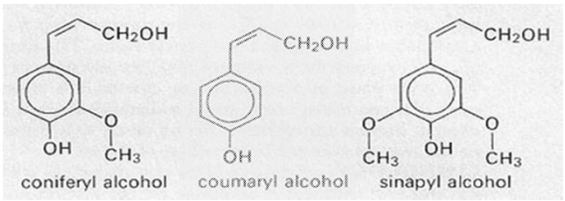
Plant lignins can be broadly divided into three classes

- 1) softwood (gymnosperm) composed principally of coniferyl alcohol units
- 2) hardwood (angiosperm) composed of coniferyl and sinapyl alcohol units.



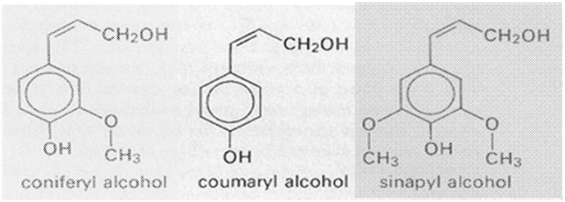
Plant lignins can be broadly divided into three classes

- 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.

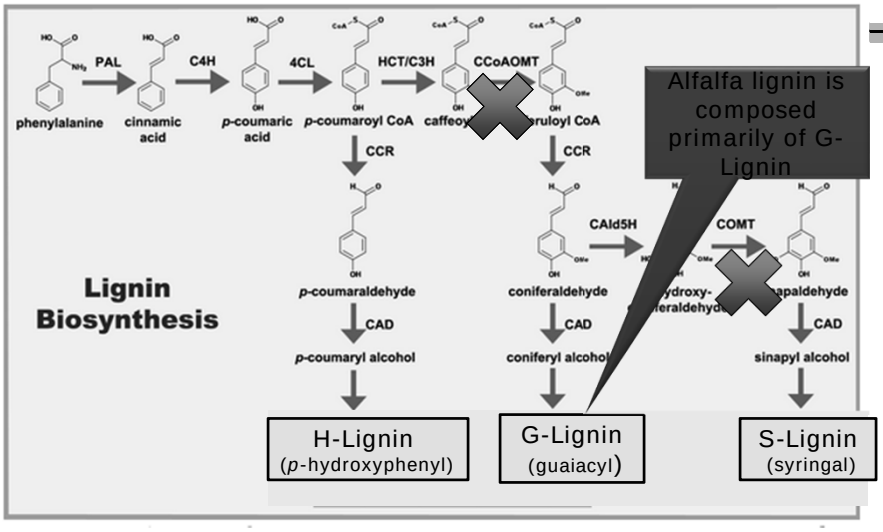


Plant lignins can be broadly divided into three classes

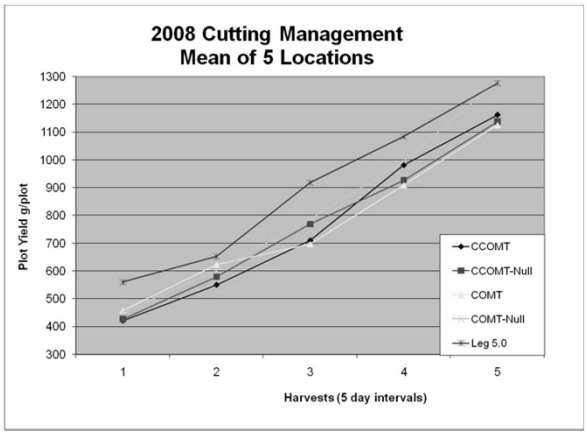
- Alfalfa is composed principally of coniferyl alcohol units (like softwoods).



Nobel Foundation gene knockouts -low lignin alfalfa



Planted at 5 locations to determine response in harvest system



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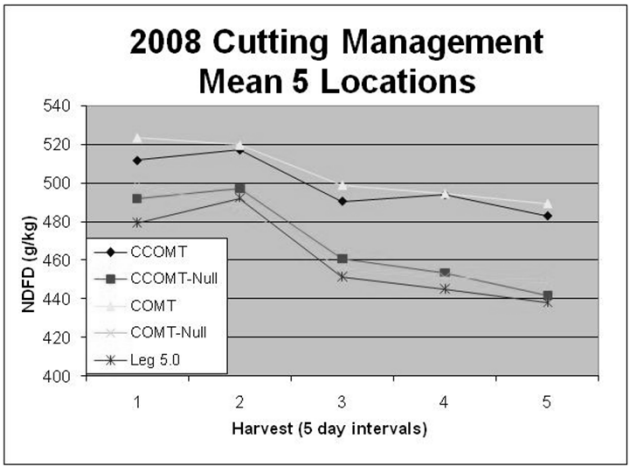
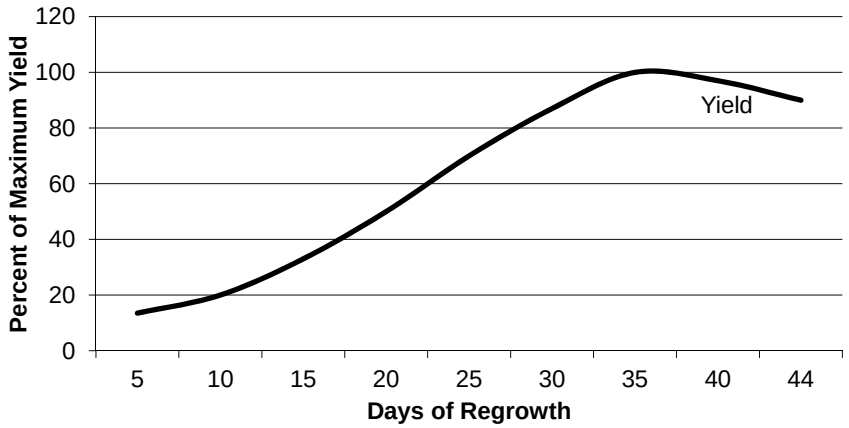
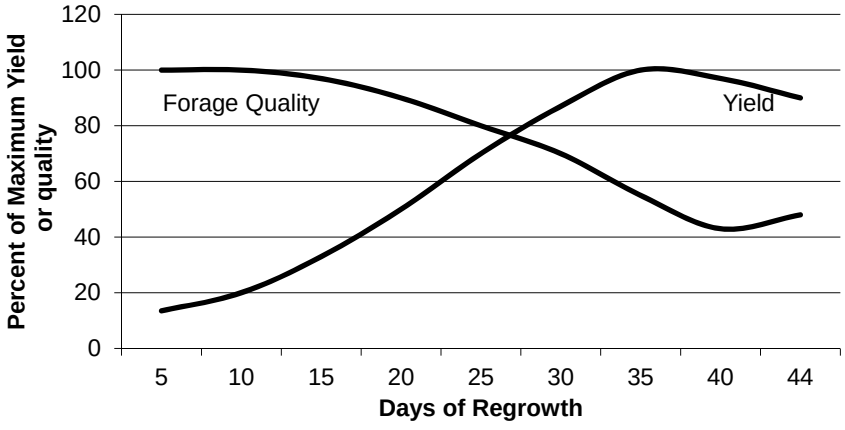


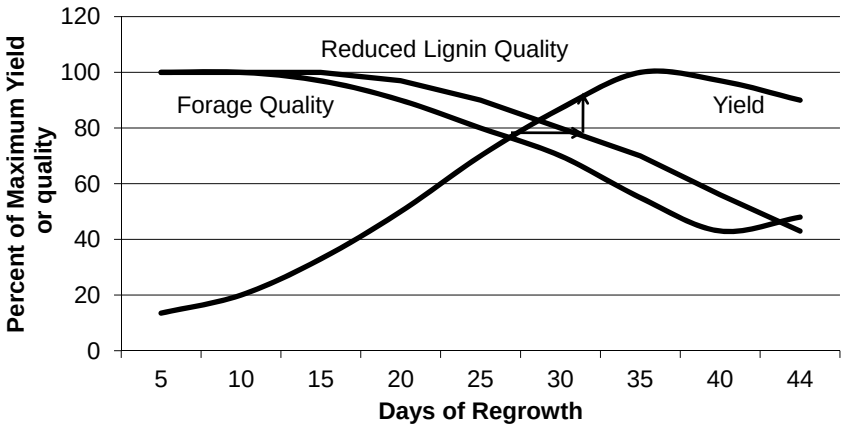
Yield Curve of Alfalfa



Yield and Quality Curve of Alfalfa

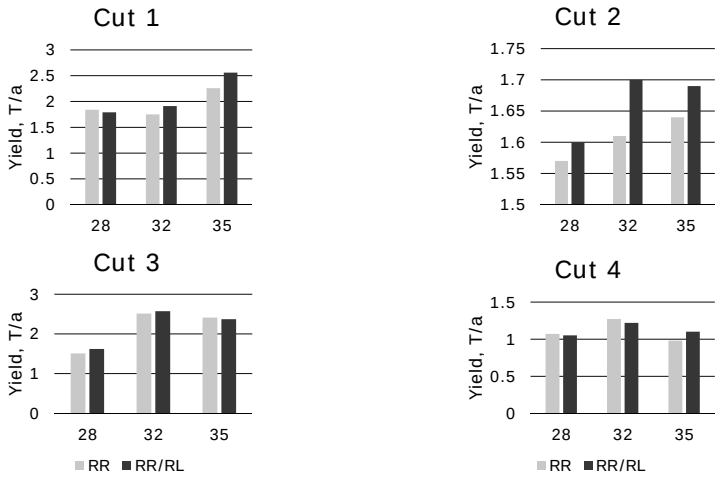


Yield and Quality Curve of Alfalfa



UW Extension

Effect of harvest delay on alfalfa yield, at each of 4 cuttings, Wisconsin 2015

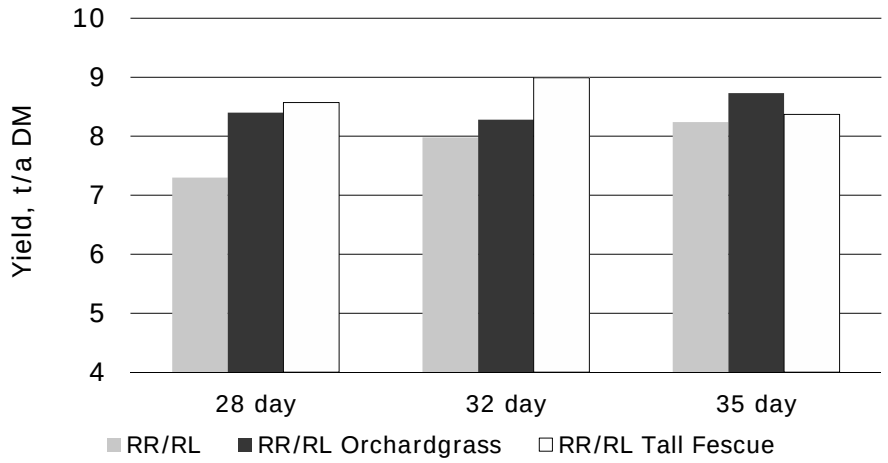


UW Extension

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

		1st cutting	2nd cutting	3rd cutting	4th cutting	Season Total	
2nd year	3 cut	2.97	2.43	2.15	----	7.55	17%
	4 cut	1.66	1.48	1.71	1.68	6.53	
3rd year	3 cut	2.32	1.53	1.24	----	5.09	25%
	4 cut	1.31	1.18	0.75	0.83	4.07	

Yield of RR/RL alfalfa with grass



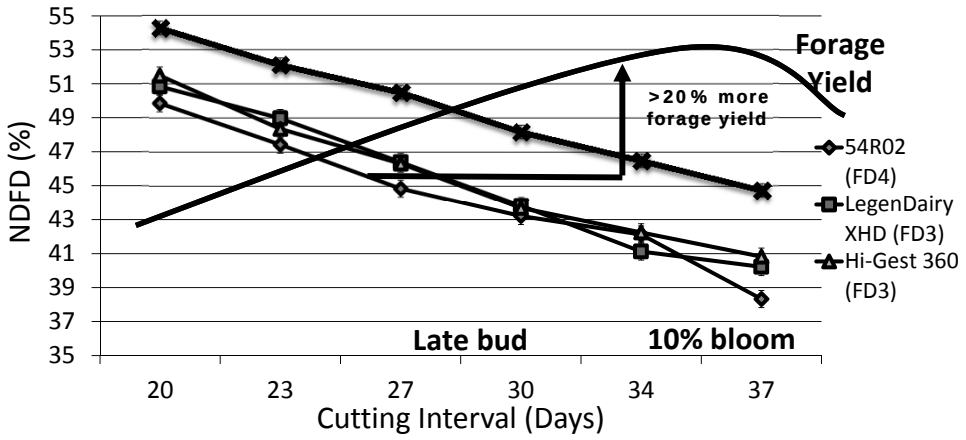
Low lignin alfalfa varieties

Type/Company	Lignin Reduction
Conventional/Alforex	7 to 10%
GM/Forage Genetics	15 to 20%

Low lignin alfalfa varieties

Type/Company	Lignin Reduction	Unit reduction (assuming 7% lignin)
Conventional/Alforex	7 to 10%	0.5 to 0.7
GM/Forage Genetics	15 to 20%	1.1 to 1.4

Delay Harvest for Yield



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?

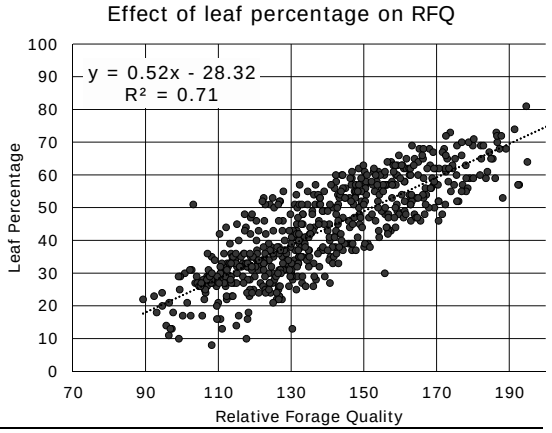
- Less and/or different lignin in stem
  - Genetic effect
  - Environmental effect
    - Less sunlight (cloudy days) reduces lignin content
    - Cooler temperature reduces lignin content
- More leaves
  - Favorable leaf growth environment
  - Less leaf disease
  - Reduce harvesting leaf loss

Alfalfa Leaf Loss Effect on Forage Quality

- Leaves higher in quality than stems

Leaves 15 to 20% NDF

Stems 60 to 70% NDF



Wide swath benefits

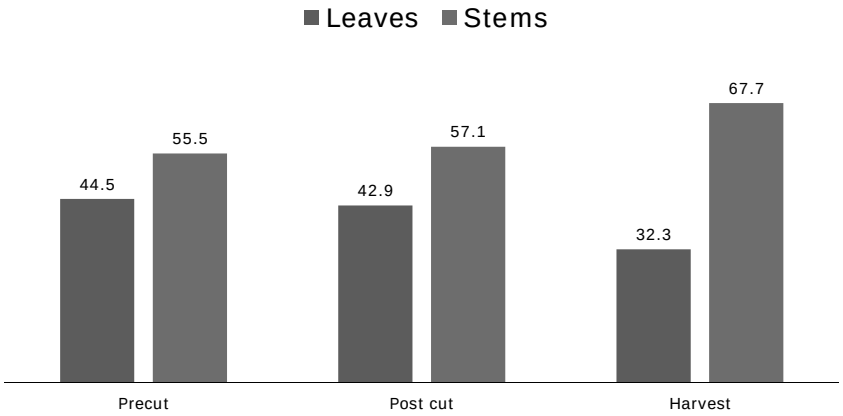
- Faster drying
- Higher forage quality

Narrow windrow

Wide Swath

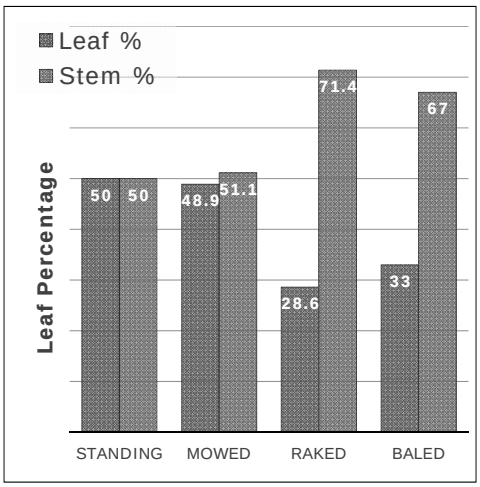
Wide Swath

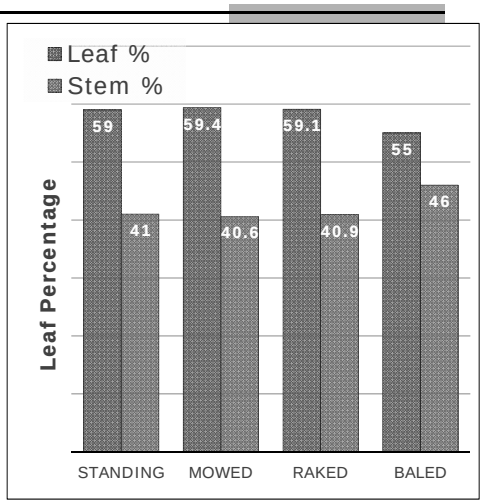
Leaf Content at Harvesting Stages



Data from Winfield, 2016

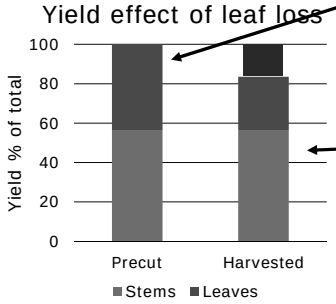
Three-state rake/merger trial, 2015

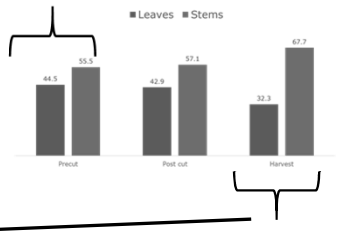




Retaining leaves increases yield

- Reduced leaf loss
  - 5 to 20% yield reduction





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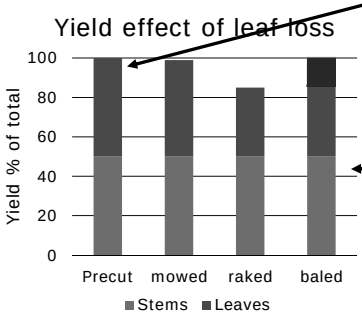
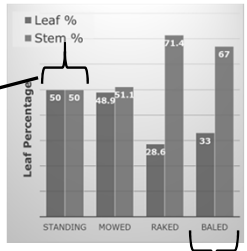
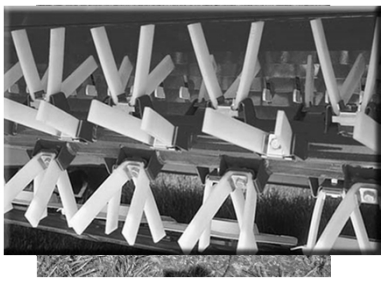




Forage quality losses during harvesting

- Ash content
- Leaf loss
  - Disease on standing crop

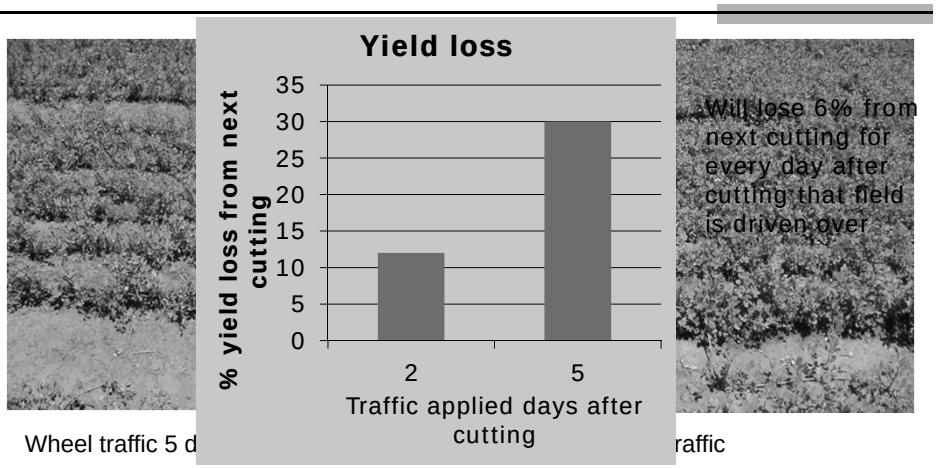


Leaves on ground prior to mowing

Leaves on ground after mowing

Leaf Loss during harvesting

Remove hay/haylage from field rapidly to minimize wheel traffic damage



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

% trafficked	
58	58
58	29
29	29
145	116

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’
    - 44%
  - If 26’
    - 22%
- ✓ Baling/chopping
    - 22% plus traffic to haul wagon/truck or bales off field

% trafficked	
44	44
44	22
22	22
110	88

Mowed swaths in pairs

Effect of cutter bar width on alfalfa yield

Year	Cutter bar width	Yield increase /year
2001	9’ vs 12’	0.5 t dm
2014	10’ vs 13’	0.5 t dm
2016	10’ vs 13’	1.0 t dm

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