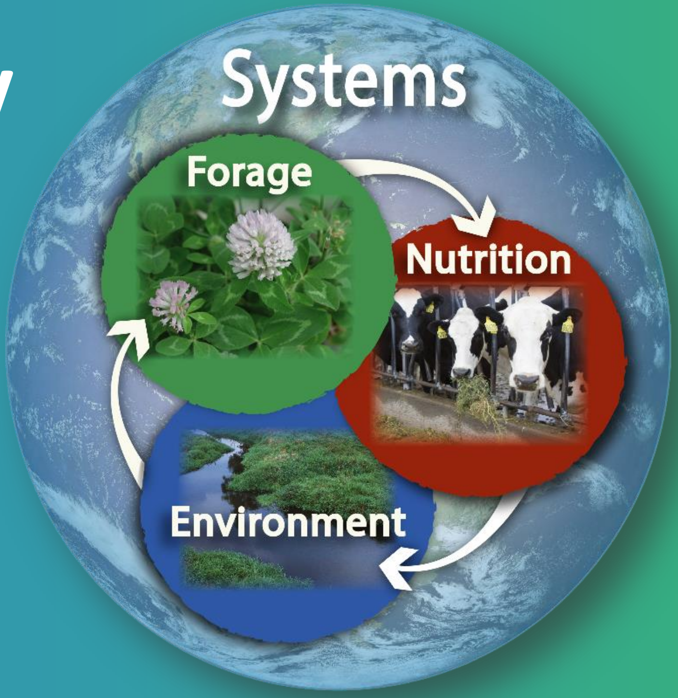
United States Department of Agriculture

# Utilization of silages in the diets of high producing dairy cows: Limitations and opportunities

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**U.S. Dairy Forage Research Center**

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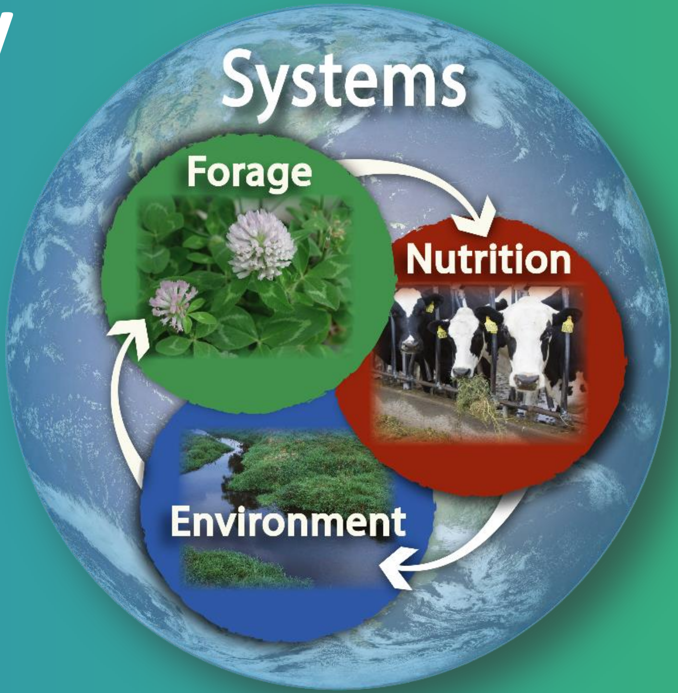


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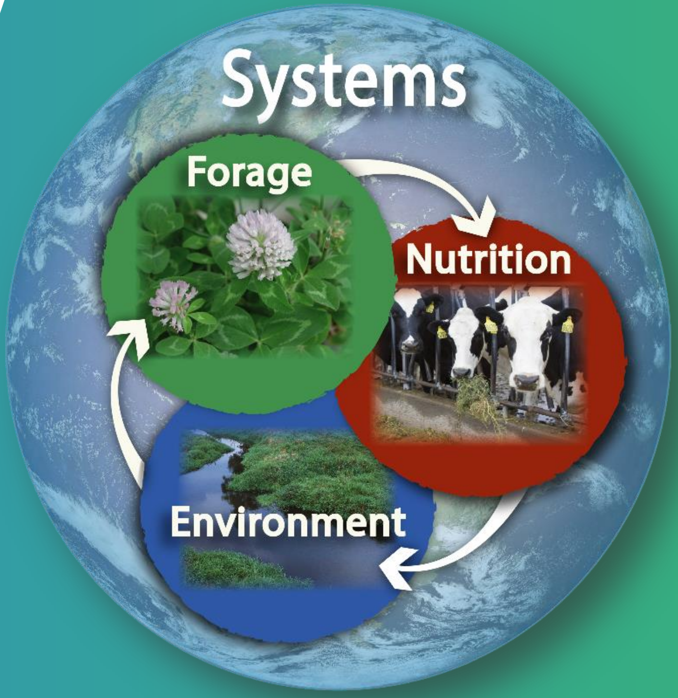
# Utilization of silages in the diets of high producing dairy cows: Limitations and opportunities/An U.S. perspective/A nutritionist perspective

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# Outline

1. **Forage utilization in the U.S.**
2. **Formulation of silages into lactating dairy cow diets**
3. **Limitations and Opportunities**

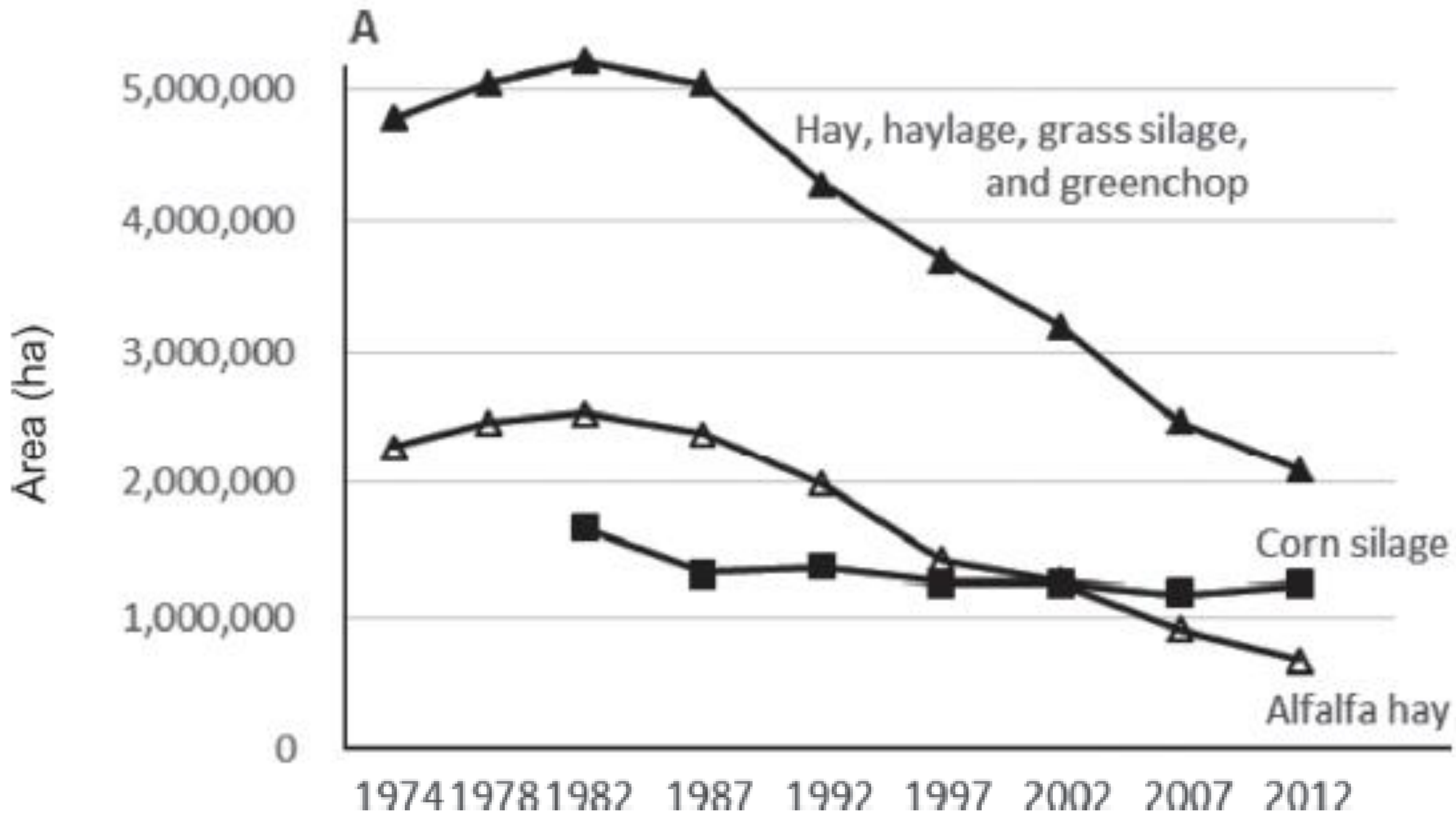
# 1. Forage utilization in the U.S.

# Forage utilization in the U.S.

- **Choice of forages for silage in the dairy ration vary depending on climate, soil types and growing conditions of that region.**

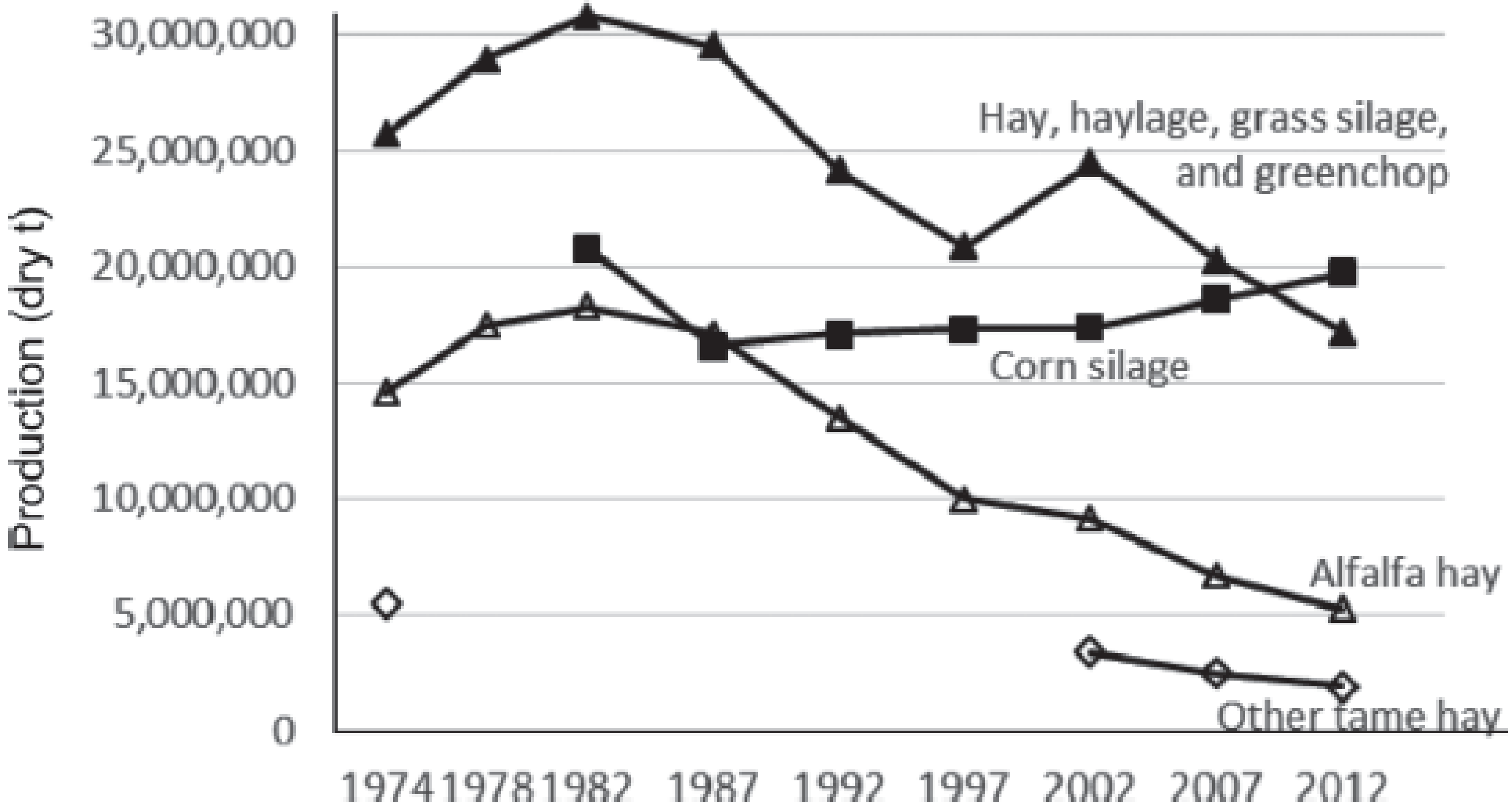
- **What types of forages for silages are commonly used in the U.S.?**

# Forage utilization in the U.S.




Martin et al. 2017

# Forage utilization in the U.S.




Martin et al. 2017

# Forage utilization in the U.S.

- **In much of the U.S., corn silage is the dominant silage used in dairy cow rations.  And it's growing. Why?**

# Forage utilization in the U.S.

- **In much of the U.S., corn silage is the dominant silage used in dairy cow rations.  And it's growing. Why?**
  - Higher energy forage
  - Higher biomass yield
  - Management – less harvesting time and labor, more consistent quality

# Forage utilization in the U.S.

- **2nd most popular**
  - Alfalfa silage
- **Dry climates of southwest U.S.**
  - Forage sorghum silage
- **Additional silage crops**
  - Grass silages
  - Annual grain silages

# 2. Formulation of silages into lactating dairy cow diets

# Importance of silages in diets

- **Silages are critical for providing necessary fiber for dairy cow diets**
  - Provides energy
  - Regulates the intake of feed
  - Stimulates chewing, saliva production, and rumination
  - Increases buffering of the rumen
  - Regulates rumen function
  - Provides a source of precursors for milk fat

# Importance of silages in diets

- **NRC (2001) recommendations**
  - NDF >25% of the diet DM in lactating dairy cow diets.
  - Forage NDF should be 19% of the diet DM or greater.

# Reasons to increase silage in diets of lactating dairy cows

1. **There is a need to increase animal productivity to meet the increasing demand for animal-sourced food.**
2. **Increase utilization of feeds that are not in direct competition with human food, monogastric feed, and biofuel feedstock.**
3. **Lower the cost of the diet.**

# Nutrient composition of alfalfa and corn silage

| Nutrient (% of DM) | Alfalfa | Corn |
|---|---|---|
| DM (% as is) | 40.3 ± 12.0 | 33.7 ± 9.15 |
| CP | 21.6 ± 2.99 | 8.3 ± 1.06 |
| NDF | 44.1 ± 5.76 | 43.6 ± 5.91 |
| ADF | 34.4 ± 4.24 | 25.7 ± 4.04 |
| Lignin | 7.71 ± 3.71 | 3.25 ± 0.68 |
| Starch | 2.05 ± 1.26 | 31.8 ± 7.41 |
| WSC | 6.10 ± 4.79 | 3.24 ± 1.56 |
| Crude fat | 3.81 ± 0.74 | 3.29 ± 0.48 |
| Ash | 11.1 ± 2.09 | 4.30 ± 1.22 |

Dairy One Interactive Feed Composition Libraries (2018)

# Increasing forage concentration in the diet

- **Schuler et al. (2013)**
  - Evaluated the optimum dietary forage concentration when using canola meal as a primary protein source.
  - Forage was increased from 42% to 66% of the diet.

# Ingredient composition

| Ingredient (% of DM) | Forage % | | | |
| --- | --- | --- | --- | --- |
| | 42F | 50F | 58F | 66F |
| Alfalfa haylage | 12.6 | 15.0 | 17.4 | 19.8 |
| Corn silage | 29.4 | 35.0 | 40.6 | 46.2 |
| Canola meal | 11.0 | 11.0 | 11.0 | 11.0 |
| Ground corn | 17.7 | 16.7 | 15.7 | 14.6 |
| Beet pulp | 3.43 | 2.30 | 1.10 | 0 |
| Corn gluten feed | 10.30 | 6.90 | 3.40 | 0 |
| Soy plus | 2.00 | 2.70 | 3.50 | 4.20 |
| Soybean hulls | 9.30 | 6.20 | 3.10 | 0 |
| Rumen inert fat | 2.30 | 2.30 | 2.30 | 2.30 |
| Vit/Min | 1.97 | 1.97 | 1.97 | 1.97 |

# Production responses

| | Forage % | | | | | Contrast |
|---|---|---|---|---|---|---|
| Item | 42F | 50F | 58F | 66F | SEM | *P*[a] |
| DMI, kg | 28.0 | 27.0 | 25.8 | 24.8 | 0.69 | L |
| Milk, kg | 40.1 | 40.4 | 40.8 | 39.1 | 1.12 | NS |
| ECM, kg/d | 38.0 | 38.4 | 39.5 | 38.7 | 1.23 | NS |
| FE (ECM/DMI) | 1.36 | 1.44 | 1.54 | 1.57 | 0.047 | L |

[a] L=Linear response ($P<0.05$).

Schuler et al., 2013

# 3. Limitations and Opportunities

# 3. Limitations and Opportunities: Protein

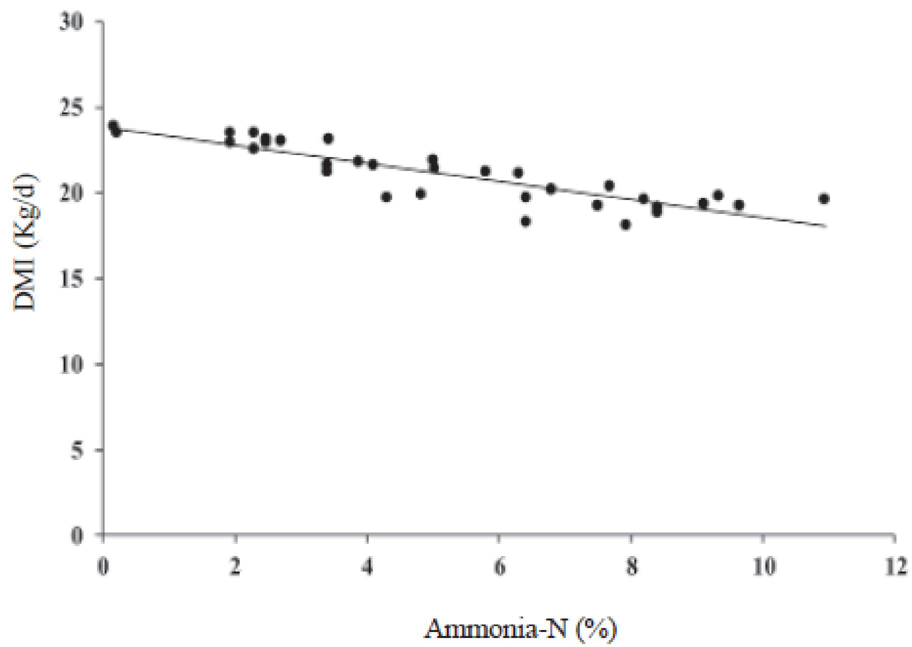
# Protein

- **Limitation:**
  - Proteolysis of true protein during the ensiling process and its high rumen degradability limit the addition of alfalfa silages in the diet of lactating dairy cows.

# Protein

- **Challenge with alfalfa silage**
  - High buffering capacity of alfalfa slows the decrease in pH during ensiling resulting in greater proteolysis.
  - Sanchez-Duarte and Garcia (2017) showed a linear DMI response to increasing ammonia-N concentration in alfalfa silage ($P < 0.001$).

$$DMI = 24.551 - 0.422 \times \text{ammonia-N}$$



# Protein

- **2nd Challenge with alfalfa silage**
  - High in rumen degradable protein (RDP)
  - High inclusion of alfalfa silage result in excessive concentrations of RDP.
  - Excessive protein will be lost as urinary nitrogen and will not be utilized efficiently for milk production (Jonker et al., 1998).

# Protein

- **Decreasing proteolysis during ensiling or decreasing overall degradability of the protein would result in greater value of the alfalfa silage formulated in lactating dairy cow diets.**
- **Long term research solutions:**
  - Increase the activity of polyphenol oxidase to reduce proteolysis in silages (Lee et al. 2006; Sullivan and Hatfield, 2006).
  - Increase the concentration of condensed tannins to reduce RDP from alfalfa silage (Potkański et al., 2002; Coblentz and Grabber, 2013).

# 3. Limitations and Opportunities: Fiber

# Fiber

- **Limitation:**
  - High fiber concentration or poor digestibility of fiber limits intake of high producing dairy cow resulting in less than desirable milk production.

# Methods to improve NDF digestibility to increase silage utilization in dairy cow diets

- **Physical treatments**
  - Chopping, shredding, grinding, pelleting, steaming
- **Biological treatments**
  - Enzymes, inoculants, yeast, fungi
- **Chemical treatments**
  - Acids, hydrolyzing alkalis
- **Genetic technologies**
  - Variety selections available to producers

# Corn silage

# Brown mid-rib (BMR) varieties

- **BMR mutation reduces lignin concentration**
- **Characteristic brown mid-rib color on the leaf**
- **Improvement in digestibility outweighs negative agronomic characteristics (lower yield, potential for lodging, more stressed by drought, and more susceptible to northern corn leaf blight).**



# Advantages of BMR corn silage

- **Lower in lignin content, higher in fiber digestibility, results in greater DMI (Holt et al., 2013).**
- **Miner Institute has reported that cows fed BMR corn silage (Thomas, 2018):**
  - Consumed more feed, but ruminated 20-25 minutes less per lb of NDF consumed.
  - Spent 5-10 minutes less time eating per pound of NDF consumed.
  - Spent up to 30 minutes/day less time at the feed bunk.

# Corn hybrid effects

## Meta-analysis of 48 studies

| | Corn silage | | | |
|---|---|---|---|---|
| Item | CONV | BMR | SEM | *P*-value |
| DMI, kg/d | 24.0[b] | 24.9[a] | 0.4 | 0.001 |
| Milk, kg/d | 37.2[b] | 38.7[a] | 0.8 | 0.001 |
| Fat, % | 3.63[a] | 3.52[b] | 0.06 | 0.01 |
| Protein, % | 3.06 | 3.07 | 0.03 | 0.42 |
| MUN, mg/dL | 15.0[a] | 14.0[b] | 0.6 | 0.02 |
| NDFD, % of NDF | 42.3[b] | 44.8[a] | 1.7 | 0.001 |

Ferraretto and Shaver (2015)

# Low-lignin alfalfa

# Low-lignin alfalfa

**HiGest™ 360 - developed by Alforex Seeds**

- 7-10% reduction in lignin

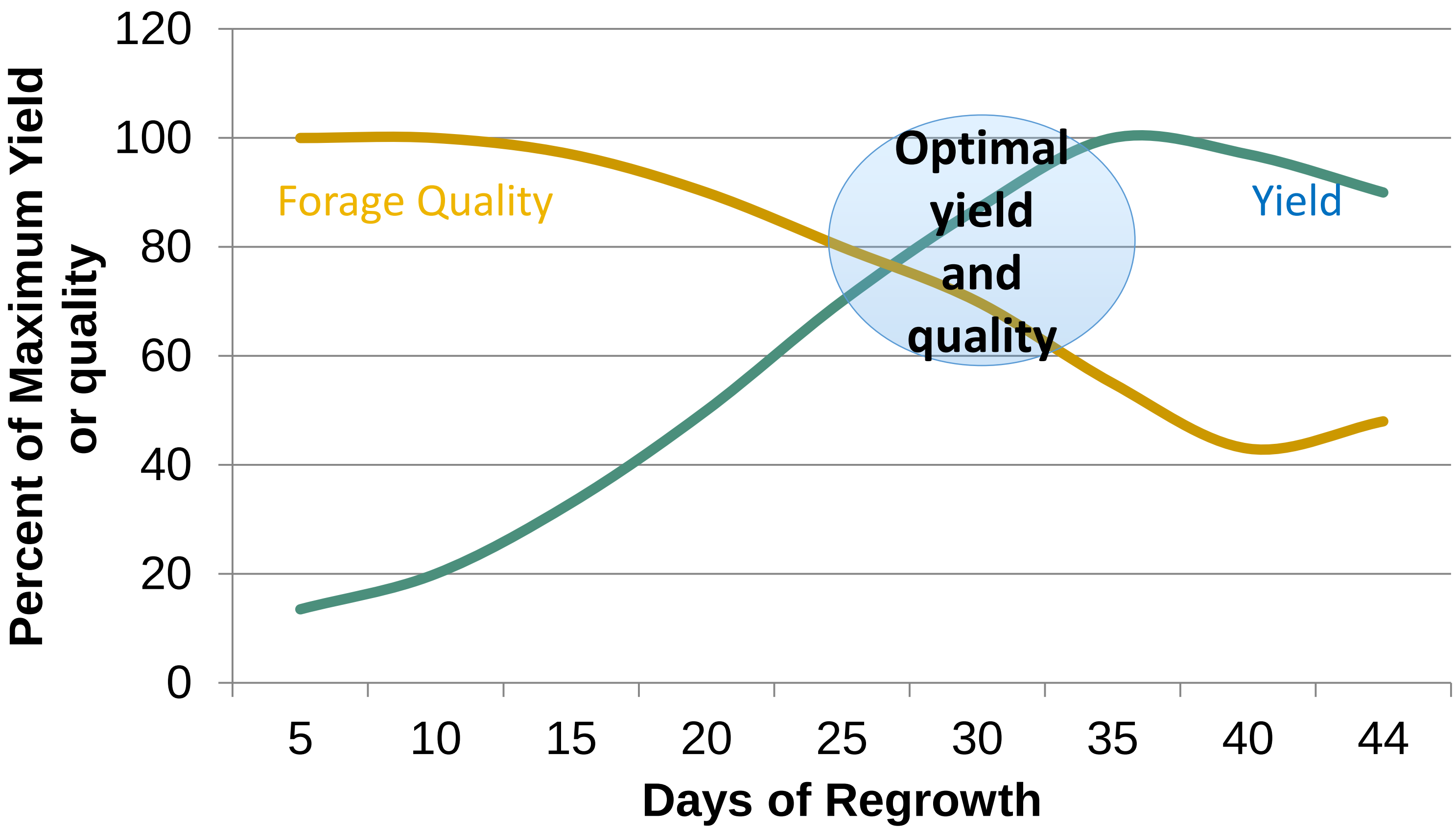
**HarvXtra™ - Developed by Forage Genetics International**

- 10-15% reduction in lignin

# Value of low-lignin alfalfa varieties

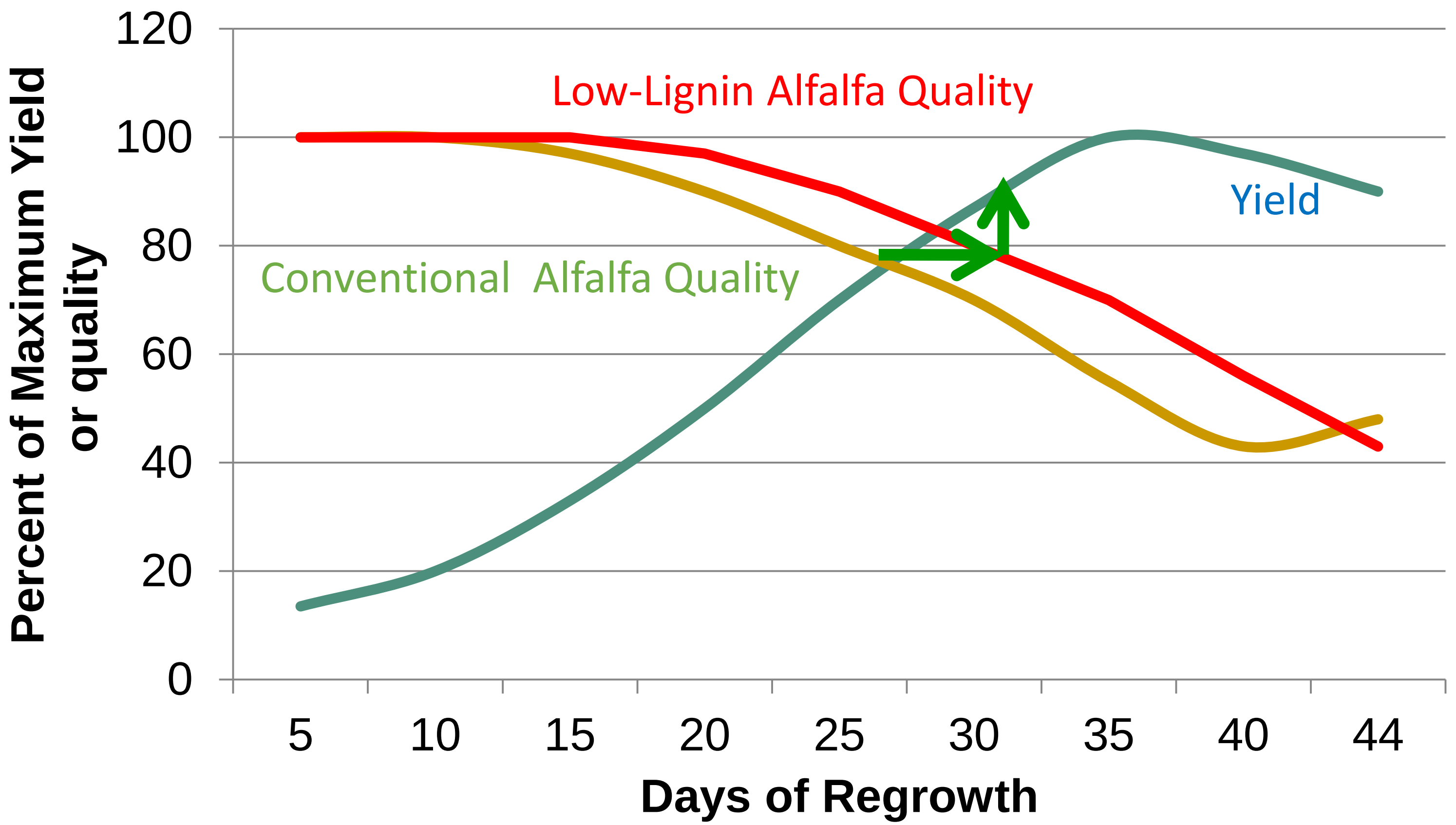
- **Wider harvest window?**
- **Later harvest**
  - Greater tonnage per cutting
  - Make use of full growing season
  - Reduce number of cuttings
    - a 15 to 18% lignin reduction means we could harvest 8 to 10 days later
- **Improved forage quality**

# Yield and quality curve of alfalfa




Courtesy of Dr. Dave Combs

# Yield and quality curve of alfalfa

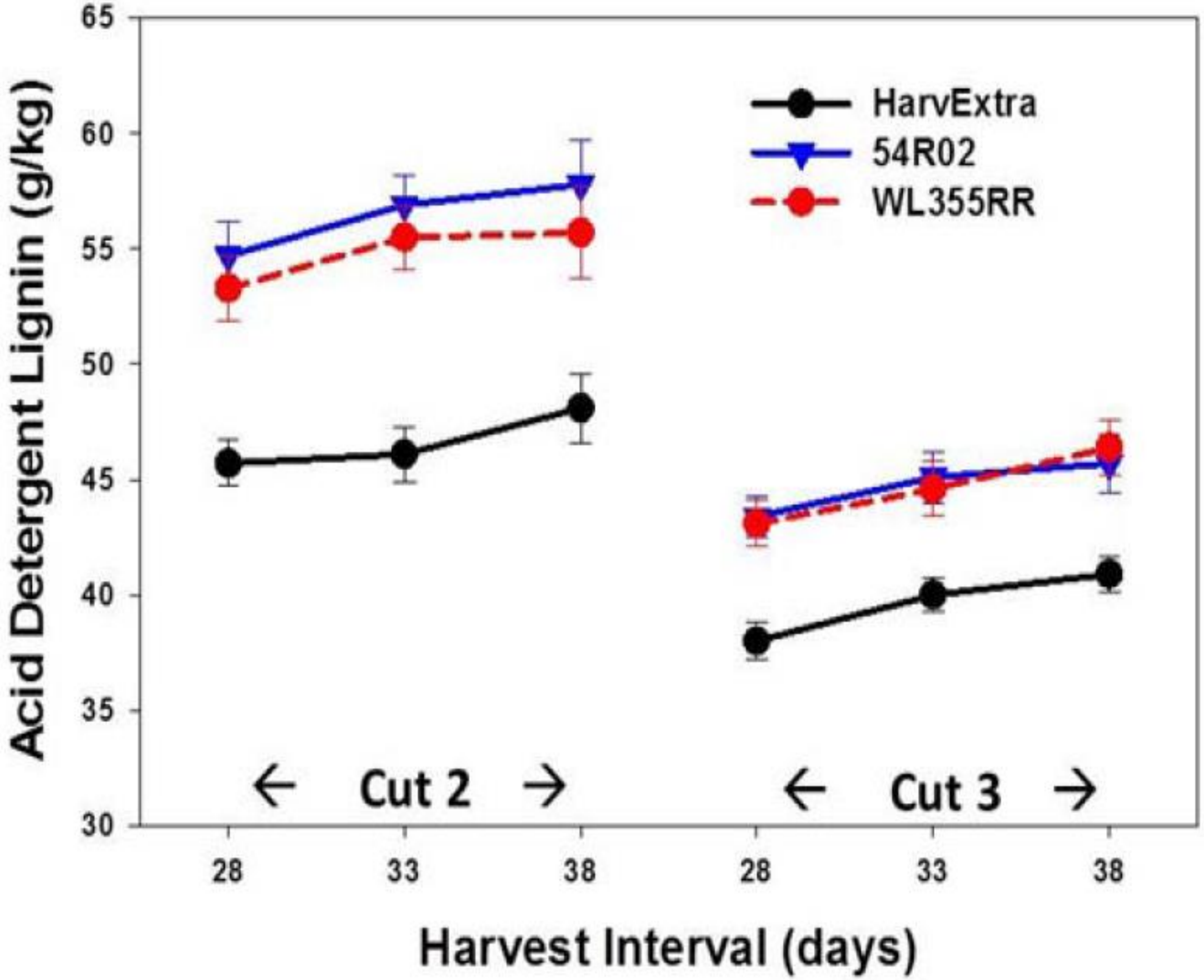



Courtesy of Dr. Dave Combs

# Low-lignin alfalfa plot studies

- **Grev et al. (2017). Agron. J.**
  - University of Minnesota. 4 locations over 2 years.
  - Reduced lignin alfalfa (HarvXtra) averaged 8% less acid detergent lignin and 10% greater NDFD compared to 3 other varieties.
  - Delaying reduced lignin alfalfa harvest increased forage mass and maintained quality.
- **Sulc et al. (2016)**
  - Six states (KS, MI, OH, PA, CA, WI).
  - Three varieties (HarvXtra) vs. 2 other varieties.

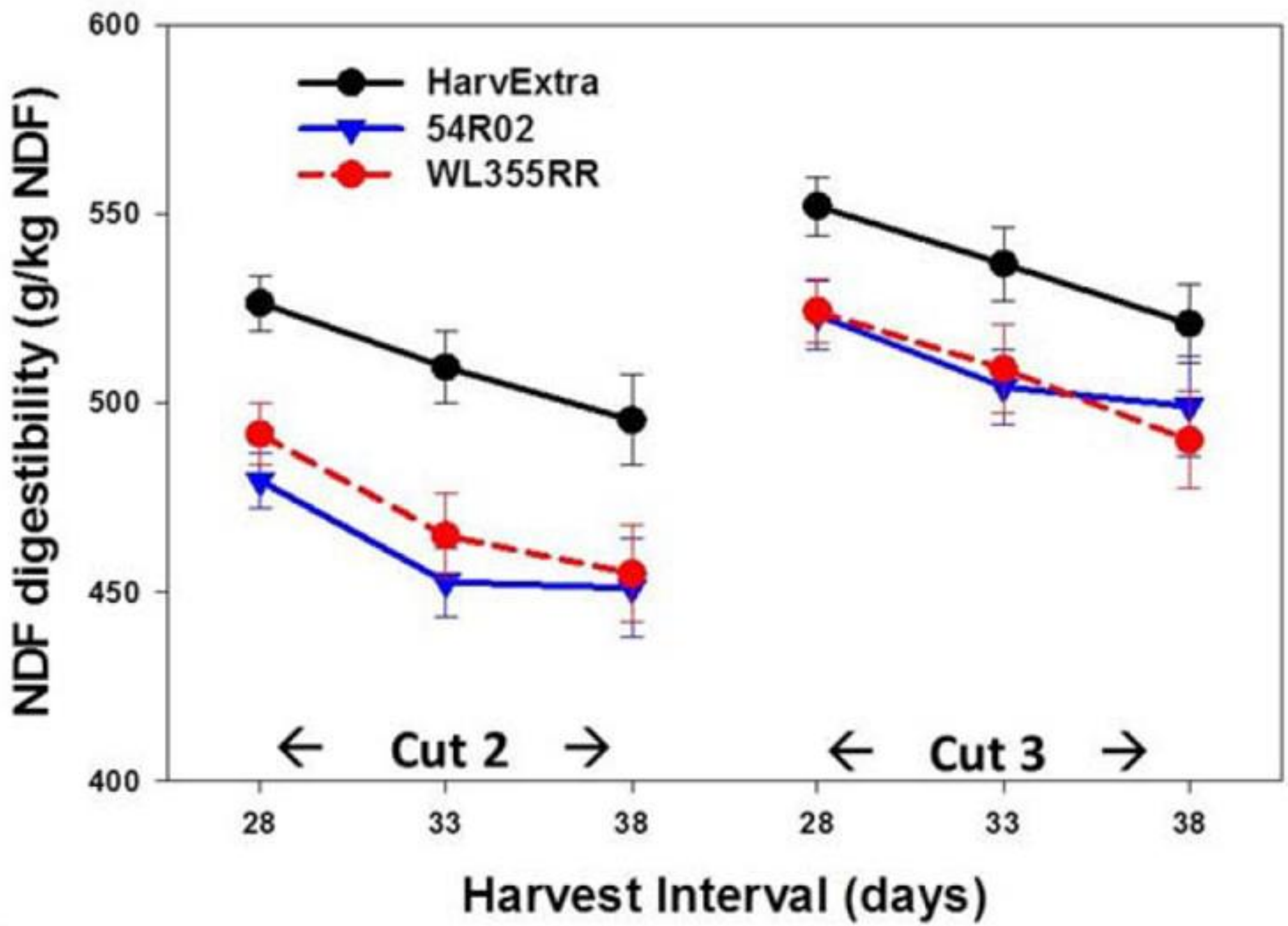
# Lignin




18% lower in lignin

Sulc et al. (2016)

# NDFD




10% higher in NDF digestibility

Sulc et al. (2016)

# Low-lignin alfalfa plot studies

- **Donnelly et al. (2018).**
  - University of Wisconsin.  4 alfalfas: two control varieties, HarvXtra, and HiGest.
  - Fields were sampled twice per week from May 4th to June 19th.

# Low-lignin alfalfa plot study

| | Alfalfa variety | | | | | *P* |
|---|---|---|---|---|---|---|
| Variable | C1 | C2 | HX | HG | SEM | V |
| L:S ratio, DM | 0.57[b] | 0.59[b] | 0.64[a] | 0.65[a] | 0.01 | < 0.01 |
| Stem composition | | | | | | |
| ADL, % DM | 7.61[b] | 7.95[a] | 6.74[c] | 7.42[b] | 0.08 | < 0.01 |
| NDF, % DM | 46.0 | 48.4 | 45.7 | 45.8 | 0.8 | 0.06 |
| iNDF, % NDF | 45.6[ab] | 48.8[a] | 41.3[b] | 45.2[ab] | 1.6 | < 0.04 |
| TTNDFD, % NDF | 39.5[bc] | 37.3[c] | 43.5[a†] | 41.5[ab] | 0.6 | < 0.01 |
| Kd, %/h | 5.98[ab] | 5.14[b] | 6.13[ab] | 7.28[a] | 0.4 | < 0.01 |

[a,b,c] Means within a row with different superscripts differ ($P < 0.05$).

[†]The HX and HG varieties differed ($P < 0.10$), C1 and C2 differed from each other ($P < 0.10$).

Donnelly et al. (2018)

# Feeding low-lignin alfalfa

- **Weakley et al. (2008)**
  - NDFD was improved 42.5 vs 53.5% for control vs. low-lignin alfalfa ($P < 0.05$).
  - Milk yield was improved 27.2 vs 38.4 kg/d for control vs. low-lignin alfalfa ($P < 0.05$).

- **Additional feeding studies will be needed to investigate how low-lignin alfalfa silages can best be formulated in lactating dairy cow diets.**

# Feeding low-lignin alfalfa silage with BMR corn silage

- **Interest by commercial dairies to combine both of these varieties to continue to increase silages in diets.**
- **No research data to date.**

# 3. Limitations and Opportunities: Energy

# Energy

- **Limitation:**
  - Meeting the energy requirements for high producing dairy cows continues to be a major limitation for cows on high silage diets.
  - Need to find higher energy forages that can be ensiled which can replace concentrate feeds.

# Corn silage

- **Corn silage will continue to be a major ingredient in high producing dairy cow diets.**

# Opportunities - energy

Feedstuffs

NUTRITION & HEALTH

## Key step forward for game-changing grass

New Zealand researchers developing ryegrass that may boost animal growth and cut methane emissions.

Jul 12, 2018

# Conclusions

- **With the goal to increase silage utilization in the dairy cow diets:**
  - Protein utilization
  - Fiber utilization
  - Energy availability
- **Opportunities are on the horizon to improve the utilization of these nutrients leading to greater inclusion of silages in the diets of high producing dairy cows.**

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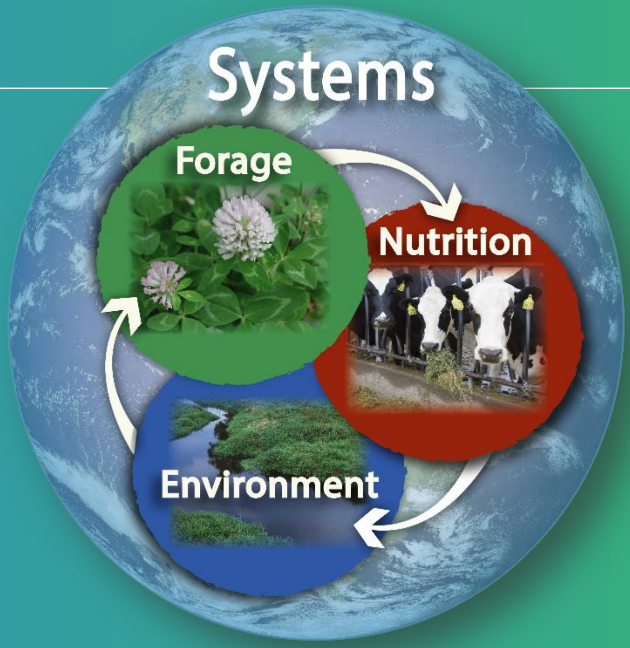
# QUESTIONS?

*Leading the world in integrated dairy forage systems research.*

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