Corn Silage Forage Quality

Joe Lawrence, Cornell PRO-DAIRY
Yield - *Let's get this out of the way up front*

- Yield is important, we are all interested in optimizing our return per acre and yield is a big part of that.
- We can’t ignore crop yield but it shouldn’t be the only criteria.

- Total Crop Yield  *vs.* Digestible Organic Matter Yield
  - *More on this later*
Yield Performance of Traited Hybrids

- **Under optimum conditions** conventional hybrids have yield potential equivalent to GE.

- **GE technology has helped to close the gap between yield potential and actual yield**
  
  - Reduces incidences of yield loss from stressors
  
  - Pest
  - Weather

- National Academies of Sciences, Engineering, and Medicine, 2016
XY Scatter Plots

Strong Positive

Weak Positive

Strong Negative

Weak Negative
Shotgun Pattern........
Forage Quality Metrics

Starch
• Ear to Stover Ratio
• Ear Maturity at Harvest

• Crop Hygiene
• Ash
• Mycotoxins

Fiber Digestibility
• Corn is an over mature grass
• BMR
• Ear to Stover Ratio
• Weather Conditions
# Corn Silage Quality Indicators for High-Producing Dairy Herds

*Slide Credit: Dr. Randy Shaver, U. of Wisconsin*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Indicates Better Quality</th>
<th>$n$</th>
<th>Average $\pm 1$ STDEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDF ($%$ DM)</td>
<td>↓</td>
<td>384,715</td>
<td>41 - 36</td>
</tr>
<tr>
<td>Lignin ($%$ DM)</td>
<td>↓</td>
<td>344,134</td>
<td>3.3 - 2.6</td>
</tr>
<tr>
<td>uNDF$_{240}$ ($%$ NDF)</td>
<td>↓</td>
<td>81,418</td>
<td>27 - 24</td>
</tr>
<tr>
<td>NDFD$_{30}$ ($%$ NDF)</td>
<td>↑</td>
<td>170,634</td>
<td>54 - 60</td>
</tr>
<tr>
<td>TTNDFFD ($%$ NDF)</td>
<td>↑</td>
<td>27,954</td>
<td>41 - 46</td>
</tr>
<tr>
<td>Starch ($%$ DM)</td>
<td>↑</td>
<td>347,759</td>
<td>32 - 39</td>
</tr>
<tr>
<td>Milk per ton</td>
<td>↑</td>
<td>136,056</td>
<td>3320 - 3683</td>
</tr>
</tbody>
</table>

*Summary of combined multi-year, multi-lab (CVAS, DairyOne, RRL, DLL) data, except TTNDFD only from RRL*
Starch

• What are the needs of your feeding program
• Cost and access to other feed ingredients

• What drive starch in corn silage?
Starch

Corn Harvester Performance Study

[Bar charts showing Starch percentage and Average Ear Weight 100% DM for different farms and hybrids]
Starch

Corn Harvester Performance Study

![Graph 1: Starch vs. Avg. Ear Weight, 100% DM]

\[ y = -0.0052x + 0.4345 \]

\[ R^2 = 0.1751 \]

![Graph 2: Starch vs. Est. Yield, 35% DM]

\[ y = 0.0542x + 23.524 \]

\[ R^2 = 0.0053 \]
Starch

Corn Harvester Performance Study

\[ y = 0.6916x + 8.9037 \]
\[ R^2 = 0.5146 \]

\[ y = 0.0568x - 0.6251 \]
\[ R^2 = 0.7293 \]
One week delay in harvest
Same 4 hybrids, same location

2018 NY & VT Corn Silage Hybrid Evaluation Program
Starch Type

• Not just total Starch but Starch Digestibility

• On going debate
  • “Traditional Dent type”   “Floury”

• Stage of fermentation

http://www.glennseed.com/hybrid-type-comparison
Starch D and Ensiling Time

![Graph showing the relationship between ivStarchD (% starch) and Ensiling time (d) for BMR, Conv., and Floury varieties.](image)

Courtesy: Luiz Ferraretto
Fiber Digestibility

• There's not much difference among dual-purpose hybrids in fiber digestibility.
• Non-BMR hybrids were within five percentage points for 30-hour NDF-d
• 1 percentage point of NDF-d is reportedly "worth" about 0.5 lbs of milk production,
  • 5 points of NDF-d certainly isn't meaningless (2.5 lbs of milk).
• However, you can't afford to give up much yield potential to gain a couple of points of digestibility--
  especially since corn silage is only one part of the ration.

CORN SILAGE QUALITY: HOW MUCH DIFFERENCE DOES HYBRID SELECTION REALLY MAKE? – Ev Thomas, 2009
Fiber Digestibility
The last 10+ years

- uNDF (undigested fiber)
- Higher Corn Silage Diets
- Volatility in commodity markets
- Emerging understanding of hybrid x growing season interactions
## Variability at same NDF

<table>
<thead>
<tr>
<th>NDF, %</th>
<th>Lignin %</th>
<th>30 hr NDFd</th>
</tr>
</thead>
<tbody>
<tr>
<td>45.0</td>
<td>3.52</td>
<td>46.0</td>
</tr>
<tr>
<td>45.0</td>
<td>3.26</td>
<td>48.4</td>
</tr>
<tr>
<td>45.0</td>
<td>3.32</td>
<td>54.4</td>
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<td>45.1</td>
<td>3.18</td>
<td>55.0</td>
</tr>
<tr>
<td>45.0</td>
<td>3.43</td>
<td>67.3</td>
</tr>
</tbody>
</table>

- Corn silage data set from Van Amburgh, 2005
- Similar relationship from 36.5 to 51.8% NDF
uNDF
Ruminal degradation rates for selected hybrids

Hybrid A

Hybrid B

Fermentability (energy value)

Intake potential (gut fill)
Corn Silage Quality Ranking Metrics

• As good as the data you put into them.
  “Garbage in, Garbage out”

• Representative forage sampling
• Green vs Fermented Samples
• Do you have every value the equation is asking for
• Always relative to the specific criteria used
Corn Silage Quality Ranking Metrics

**MILK2006**
- good tool when it came out
- Currently no update for Corn Silage
- doesn’t account for advancements in nutritional science in last decade
- More testing programs moving away from its use

- MILK2016 – alfalfa

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Cornell CALS
College of Agriculture and Life Sciences

PRODAIRY
Agricultural Cooperative Extension
Corn Silage Quality Ranking Metrics

• Model based approach
  • Predicting milk yield based on overall diet.

• CNCPS Model (Cornell Net Carbohydrate & Protein Synthesis)
  • Nutritional Model used to balance total rations for ruminants
    • Used on many farms by commercial nutritionist
  • Used in the NY & VT Corn Silage Hybrid Evaluation Program
  • Predicted hybrid performance in the context of the model inputs
    • Cow parameters
    • Fixed Starch D – Green Samples
    • Other ingredients in Diet

Corn Silage Quality Ranking Metrics

- **RFC index** (Rumen Fermentable Carbohydrate)
  \[
  \frac{(\text{NDF}_{d30} + \text{starch})}{\text{uNDF}_{30}}
  \]

- **OMD index** (Organic Matter Digestibility)
  - Being developed by Hristov (Penn St) and Canale (Cargill)
  - Accounts for content and digestibility of Fiber and Starch
  - Spreadsheet based calculation utilizing forage quality metrics from laboratory analysis
  - Planned to be included in 2019 report of PA results from PDMP and Penn St.

- **Miner Institute – Yield of Potentially Digestible NDF**
  \[
  (\text{Yield} \times \text{NDF, } \% \text{ DM}) \times (\text{NDF} - \text{uNDF}_{240}, \% \text{ DM})
  \]

Corn Silage Hybrid Fiber and Starch Yield Calculator
http://www.whminer.org/dairy/
So many options......
What to use?

• All have strengths and weaknesses
• All can be useful in the context of the dataset
• More important to understand the needs of your farm and what parameters have the most impact in your program
NY & VT Corn Silage Hybrid Evaluation

Collaboration of:

**Cornell University**
- PRO-DAIRY, Department of Animal Science
- Department of Plant Breeding & Genetics

**University of Vermont**

With support from:
- Dairy Producers
- Seed Corn Industry
- Cornell Cooperative Extension
- Cornell University Agricultural Experiment Station
Hybrid x Environment interactions

Table 1. NYS Corn Silage Trials, 2016 Weather Data

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation (inches)</th>
<th>GDD (86/50 F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aurora</td>
<td>Madrid</td>
</tr>
<tr>
<td>May</td>
<td>2.00</td>
<td>0.94</td>
</tr>
<tr>
<td>June</td>
<td>0.74</td>
<td>2.37</td>
</tr>
<tr>
<td>July</td>
<td>1.90</td>
<td>2.22</td>
</tr>
<tr>
<td>August</td>
<td>4.56</td>
<td>3.25</td>
</tr>
<tr>
<td>Seasonal</td>
<td>9.20</td>
<td>8.78</td>
</tr>
<tr>
<td>10 yr Mean</td>
<td>14.10</td>
<td>14.89</td>
</tr>
</tbody>
</table>
Impact of Weather on Corn Silage Quality

Fiber Digestibility

• Different time points (30, 120, 240 hrs) influenced by*^ 
  • Rainfall (monthly and seasonal)
    ▲ Rainfall ▼ Fiber Digestibility
  • Soil Drainage class
    ▼ Drainage ▼ Fiber Digestibility

Temperature*
Regardless of month or NDF digestibility timepoint, higher temperatures DECREASE NDF digestibility
• Starts immediately in May
• Very strong Negative relationship between June GDD and 30 hrNDF digestibility

^NY & VT Corn Silage Hybrid Trials, 2016 - 2018
Continuing to Expand
Regional Collaboration

Collaboration of:

- Cornell University
- University of Vermont
- Penn State University
- Professional Dairy Managers of Pennsylvania (PDMP)
- University of Maine Extension
- Western NY Crop Management Association (WNYCMA)
2018 Regional Hybrid Comparison

- **4 Hybrids Planted at 8 locations**

![Graph showing precipitation and growing degree days across different locations in 2018.](image)
2018 Regional Comparison
Influence of Rainfall

Combined by Location
Avg. 4 hybrids/location

R² = 0.7053

Combined by Location
Avg. 4 hybrids/location

R² = 0.1107

PA data removed
2018 Regional Comparison

Individual Hybrids
Avg. 3 reps/hybrid

NDFD240, %NDF
Seasonal Rainfall (inches)
2018 Regional Comparison Influence of Rainfall
Picking the Best fit for your Farm

- **Hybrid Evaluation**......not Hybrid Competition
  
  - How consistent does a hybrid perform across locations?
  - What hybrids perform well under conditions similar to your farm?
    - Soil Type
    - Length of Growing Season
  
  - What factors impact predicted milk yields the most?
    - Digestible Fiber
  
  - What affects digestible fiber?
    - Soil Type
    - Weather
    - Yield
Picking the Best fit for your farm

• **Hybrid Evaluation**…….not Hybrid Competition

  • What factors match your needs and feeding program?
    • Yield
      • Acreage constraints
    • Starch
    • Digestible Fiber
      • What other forages are being fed?
Comparing Data......It’s all Relative

- Is this a good Yield?
  - 26 tons/acre, 35% DM

  Compared to what?
  - Plot Mean: 21 tons/acre, 35% DM
  - OR
  - Plot Mean: 31 tons/acre, 35% DM
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average +/- 1 STDEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>uNDF240 (% NDF)</td>
<td>27-24</td>
</tr>
<tr>
<td>NDFD30 (%NDF)</td>
<td>54-60</td>
</tr>
</tbody>
</table>

**Source:** Corn Silage Quality Indicators for High Producing Dairy Herd
Dr. Randy Shaver, U. of Wisconsin

<table>
<thead>
<tr>
<th>% of Plots falling into “Average”</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
</tr>
<tr>
<td>uNDF240 (% NDF)</td>
</tr>
<tr>
<td>NDFD30 (% NDF)</td>
</tr>
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</table>
Growing Season Summary: 2016 - 2018
### Using Public data as comparison

<table>
<thead>
<tr>
<th>Relative Maturity Group</th>
<th>Growing Season</th>
<th>Location</th>
<th>Yield, 35% DM tons/acre</th>
<th>Dry Matter %</th>
<th>Starch % DM</th>
<th>Crude Protein % DM</th>
<th>Lignin % DM</th>
<th>aNDFom % DM</th>
<th>30 hr NDFDom % NDF</th>
<th>240 hr uNDFom % NDF</th>
<th>240 hr uNDFom % DM</th>
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</thead>
<tbody>
<tr>
<td>96-110 day RM</td>
<td>2017</td>
<td>Alburgh, VT</td>
<td>23.3</td>
<td>34.9</td>
<td>34.2</td>
<td>7.2</td>
<td>3.1</td>
<td>38.3</td>
<td>55.2</td>
<td>31.2</td>
<td>12.0</td>
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<tr>
<td></td>
<td></td>
<td>Aurora, NY</td>
<td>26.0</td>
<td>31.9</td>
<td>31.2</td>
<td>6.1</td>
<td>3.4</td>
<td>42.6</td>
<td>54.5</td>
<td>33.5</td>
<td>14.4</td>
</tr>
<tr>
<td></td>
<td>2018</td>
<td>Madrid, NY</td>
<td>28.6</td>
<td>32.9</td>
<td>35.4</td>
<td>7.7</td>
<td>2.5</td>
<td>35.9</td>
<td>61.2</td>
<td>27.1</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alburgh, VT</td>
<td>28.5</td>
<td>32.7</td>
<td>35.3</td>
<td>7.2</td>
<td>3.3</td>
<td>39.8</td>
<td>52.7</td>
<td>35.7</td>
<td>14.3</td>
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<td></td>
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<td>Aurora, NY</td>
<td>21.7</td>
<td>38.2</td>
<td>38.8</td>
<td>7.3</td>
<td>2.6</td>
<td>35.3</td>
<td>59.9</td>
<td>29.4</td>
<td>10.4</td>
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<td></td>
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<td>Madrid, NY</td>
<td>31.9</td>
<td>35.2</td>
<td>34.8</td>
<td>7.4</td>
<td>3.7</td>
<td>41.3</td>
<td>50.6</td>
<td>38.1</td>
<td>15.9</td>
</tr>
</tbody>
</table>

**Average**
- 10.7
- 14.9

**Helpful to**
- understand your own data on the farm
- Calibrate to what the growing season offered when reviewing company data
Quartile Plots – What’s on the axis?

Q1: Crop Yield: Above Average
    Milk Yield: Below Average

Q2: Crop Yield: Above Average
    Milk Yield: Above Average

Q3: Crop Yield: Below Average
    Milk Yield: Below Average

Q4: Crop Yield: Below Average
    Milk Yield: Above Average
Corn Harvester Performance

Part A
• Do hybrid characteristics affect chopper performance?
  • Corn Silage (Kernel) Processing Score
  • Theoretical Length of Cut

Part B
• Is there an interaction between initial CS Processing Score and the rate of improvement in Starch D?
## Hybrid Characteristics

Averaged across 5 locations

<table>
<thead>
<tr>
<th>Hybrid Code</th>
<th>Relative Maturity</th>
<th>Hybrid Description</th>
<th>Plant Height</th>
<th>Hybrid Information</th>
<th>Forage Quality Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimated yield</td>
<td>Dry Matter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tons/acre, 35% DM</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dry Wt.</td>
<td>% DM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ear to Stover Ratio</td>
<td>% DM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>240 hr</td>
<td>% DM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Starch</td>
<td>Corn Silage Processing Score</td>
</tr>
<tr>
<td>1</td>
<td>97</td>
<td>5 out of 9</td>
<td>6 out of 9</td>
<td>26.0</td>
<td>34.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.56</td>
<td>9.5</td>
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<td></td>
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<td>39.2</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>59.5</td>
</tr>
<tr>
<td>2</td>
<td>98</td>
<td>Leafy Flex</td>
<td>9 out of 9</td>
<td>25.4</td>
<td>32.2</td>
</tr>
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<td></td>
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<td>1.07</td>
<td>12.6</td>
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<td>68.9</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>Leafy, Floury Flex</td>
<td>9 out of 9</td>
<td>26.2</td>
<td>28.8</td>
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<td>1.10</td>
<td>13.3</td>
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<td>28.7</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>57.5</td>
</tr>
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</table>
Ear to Stover Ratio

<table>
<thead>
<tr>
<th>Corn Silage Processing Score</th>
<th>Starch - % of total on or below the 4.75 mm screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimally Processed</td>
<td>&gt; 70%</td>
</tr>
<tr>
<td>Adequately Processed</td>
<td>50 – 69%</td>
</tr>
<tr>
<td>Inadequately Processed</td>
<td>&lt; 50%</td>
</tr>
</tbody>
</table>
Dry Matter

<table>
<thead>
<tr>
<th>Corn Silage Processing Score</th>
<th>Starch - % of total on or below the 4.75 mm screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimally Processed</td>
<td>&gt; 70%</td>
</tr>
<tr>
<td>Adequately Processed</td>
<td>50 – 89%</td>
</tr>
<tr>
<td>Inadequately Processed</td>
<td>&lt; 50%</td>
</tr>
</tbody>
</table>

Graphs showing correlation between CS Processing Score and Dry Matter%.
Corn Silage Processing Score
Hybrid and Time

- **Optimally Processed**: > 70%
- **Adequately Processed**: 50 – 69%
- **Inadequately Processed**: < 50%

Graph showing the relationship between corn silage processing score and hybrid.
PART B

- Research has shown that Starch Digestibility increases during fermentation
- Is there an interaction between initial processing score and the improvement in Starch Digestibility?

- In Vitro Starch Digestibility testing happening at this time.

STAY TUNED