Corn Silage Hybrids for Best Performance

Joe Lauer
University of Wisconsin
The UW Corn Silage Team

Dr. Jim Coors
Corn Breeder

Dr. Randy Shaver
Dairy Nutritionist

Dr. Joe Lauer
Corn Agronomist
Desirable Forage Characteristics

• What makes a good forage? (Carter et al., 1991)
  ✓ High yield
  ✓ High energy (high digestibility)
  ✓ High intake potential (low fiber)
  ✓ High protein
  ✓ Proper moisture at harvest for storage

• Ultimate test is animal performance
  ✓ Milk2000 is our best predictor for performance (Schwab - Shaver equation)
# What Do We Want in Grain versus Silage Hybrids?

<table>
<thead>
<tr>
<th>Trait</th>
<th>Grain</th>
<th>Silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield</td>
<td>High</td>
<td>Adequate</td>
</tr>
<tr>
<td>Forage yield</td>
<td>Adequate</td>
<td>High</td>
</tr>
<tr>
<td>Hybrid range</td>
<td>60 bu/A</td>
<td>8,000 lb Milk/A</td>
</tr>
<tr>
<td>Stalks</td>
<td>Standability</td>
<td>Digestibility</td>
</tr>
<tr>
<td>Leaves</td>
<td>Unknown</td>
<td>Digestibility</td>
</tr>
<tr>
<td>Kernel hardness</td>
<td>Hard</td>
<td>Soft</td>
</tr>
<tr>
<td>Plant drydown</td>
<td>“Stay-green”</td>
<td>Synchronous</td>
</tr>
<tr>
<td>Plant maturity</td>
<td>“Full-season”</td>
<td>5-10 d longer</td>
</tr>
</tbody>
</table>
Corn Silage

**Grain = ~40-45% DM**
- 80 to 100% digestible
- Kernel maturity
- Starch digestibility

**Stover = ~55-60% DM**
- Leaves = 15% DM
- Stem = 10% DM
- Cob + Shank + Husk = 20% DM
- 40 to 55% digestible
- Cell wall digestibility

? Kinetics?
Whole-plant yield = 0.76x + 2.90
R² = 0.93

Stover yield = 0.25x + 2.12
R² = 0.93

Relationship between corn forage dry matter yield and era of release for whole-plant and stover.
Relationship between corn forage *in vitro* true digestibility and era of release for whole-plant and stover.
NIRS Global Equation Calibration for *in vitro* True Digestibility (602 samples submitted)

1990-1998
R² = 0.93
n = 571

IVTD Predicted from Global Equation (%)

IVTD Measured in Lab (%)
Wisconsin Corn Hybrid Silage Performance Trials 1995-present
# 2001 Wisconsin Corn Performance Trials - Silage Summary

<table>
<thead>
<tr>
<th>Location</th>
<th>N</th>
<th>Yield</th>
<th>T/A</th>
<th>N</th>
<th>Yield</th>
<th>T/A</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arlington</td>
<td>463</td>
<td>9.5</td>
<td>T/A</td>
<td>75</td>
<td>10.5</td>
<td></td>
<td>+ 11</td>
</tr>
<tr>
<td>Lancaster</td>
<td>386</td>
<td>7.8</td>
<td>T/A</td>
<td>75</td>
<td>8.0</td>
<td></td>
<td>+ 3</td>
</tr>
<tr>
<td>Fond du Lac</td>
<td>352</td>
<td>8.6</td>
<td></td>
<td>68</td>
<td>8.2</td>
<td></td>
<td>- 5</td>
</tr>
<tr>
<td>Galesville</td>
<td>352</td>
<td>8.3</td>
<td></td>
<td>68</td>
<td>9.6</td>
<td></td>
<td>+ 16</td>
</tr>
<tr>
<td>Marshfield</td>
<td>428</td>
<td>6.8</td>
<td></td>
<td>55</td>
<td>7.3</td>
<td></td>
<td>+ 7</td>
</tr>
<tr>
<td>Valders</td>
<td>387</td>
<td>6.7</td>
<td></td>
<td>57</td>
<td>4.1</td>
<td></td>
<td>- 39</td>
</tr>
<tr>
<td>Ashland</td>
<td>125</td>
<td>6.8</td>
<td></td>
<td>16</td>
<td>7.3</td>
<td></td>
<td>+ 7</td>
</tr>
</tbody>
</table>
### Table 15. North Central Zone - Early Maturity Silage Trial 2000

<table>
<thead>
<tr>
<th>BRAND</th>
<th>HYBRID</th>
<th>Kernel Yield</th>
<th>Moist T/A</th>
<th>Milk %</th>
<th>CP %</th>
<th>ADF %</th>
<th>NDF %</th>
<th>IVD %</th>
<th>CWD %</th>
<th>Starch %</th>
<th>MILK PER TON</th>
<th>ACRE</th>
<th>MAR Yield T/A</th>
<th>VAL Yield T/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trelay</td>
<td>2008</td>
<td>8.3 * 55.3</td>
<td>30</td>
<td>7.0</td>
<td>25</td>
<td>52</td>
<td>72</td>
<td>46</td>
<td>28</td>
<td>2670</td>
<td>22300 *</td>
<td>8.3 *</td>
<td>8.3 *</td>
<td></td>
</tr>
<tr>
<td>Carhart's Blue Top</td>
<td>CX8500A</td>
<td>7.4 * 58.7</td>
<td>50</td>
<td>7.3</td>
<td>24</td>
<td>49</td>
<td>73</td>
<td>46</td>
<td>29</td>
<td>2770 *</td>
<td>20700 *</td>
<td>7.9 *</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>NK Brand</td>
<td>N27-M3</td>
<td>7.0 * 59.2</td>
<td>30</td>
<td>7.1</td>
<td>24</td>
<td>48</td>
<td>74</td>
<td>45</td>
<td>31</td>
<td>2810 *</td>
<td>19800 *</td>
<td>7.4</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Pioneer</td>
<td>39D81</td>
<td>5.2 * 59.6</td>
<td>10</td>
<td>7.1</td>
<td>26</td>
<td>53</td>
<td>71</td>
<td>45</td>
<td>26</td>
<td>2620</td>
<td>13600</td>
<td>5.7</td>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td>Renk</td>
<td>RK394</td>
<td>7.8 * 59.6</td>
<td>30</td>
<td>7.0</td>
<td>28</td>
<td>55</td>
<td>70</td>
<td>46</td>
<td>24</td>
<td>2580</td>
<td>20200</td>
<td>8.3</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>Dairyland</td>
<td>Stealth 1280</td>
<td>7.7 * 59.9</td>
<td>30</td>
<td>7.1</td>
<td>25</td>
<td>52</td>
<td>72</td>
<td>45</td>
<td>28</td>
<td>2690</td>
<td>20800</td>
<td>8.3</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td><strong>85-DAY HYBRID TRIAL AVERAGE##</strong></td>
<td></td>
<td>60.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LG Seeds</td>
<td>LG2367</td>
<td>7.3 * 60.4</td>
<td>30</td>
<td>6.9</td>
<td>26</td>
<td>53</td>
<td>72</td>
<td>47</td>
<td>27</td>
<td>2700</td>
<td>19800</td>
<td>8.3</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td>Carhart's Blue Top</td>
<td>CX290A</td>
<td>7.4 * 60.6</td>
<td>40</td>
<td>7.2</td>
<td>22</td>
<td>46</td>
<td>75</td>
<td>45</td>
<td>34</td>
<td>2900 *</td>
<td>21300 *</td>
<td>7.2</td>
<td>7.5 *</td>
<td></td>
</tr>
<tr>
<td>Dairyland</td>
<td>Stealth 1289</td>
<td>7.0 * 60.7</td>
<td>20</td>
<td>8.1</td>
<td>28</td>
<td>55</td>
<td>70</td>
<td>46</td>
<td>24</td>
<td>2570</td>
<td>18100</td>
<td>7.3</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Brown</td>
<td>2080</td>
<td>6.8 * 61.3</td>
<td>40</td>
<td>7.0</td>
<td>23</td>
<td>48</td>
<td>74</td>
<td>45</td>
<td>31</td>
<td>2830 *</td>
<td>19200</td>
<td>6.5</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td>Carhart's Blue Top</td>
<td>CX1187A</td>
<td>6.9 * 61.4</td>
<td>30</td>
<td>7.2</td>
<td>25</td>
<td>51</td>
<td>73</td>
<td>46</td>
<td>29</td>
<td>2780 *</td>
<td>19200</td>
<td>6.8</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td><strong>90-DAY HYBRID TRIAL AVERAGE##</strong></td>
<td></td>
<td>62.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dekalb</td>
<td>DKC39-45</td>
<td>7.1 * 63.8</td>
<td>40</td>
<td>6.8</td>
<td>23</td>
<td>47</td>
<td>74</td>
<td>45</td>
<td>31</td>
<td>2920 *</td>
<td>20600 *</td>
<td>6.7</td>
<td>7.4 *</td>
<td></td>
</tr>
<tr>
<td>NK Brand</td>
<td>N2555BT</td>
<td>7.1 * 64.2</td>
<td>40</td>
<td>7.4</td>
<td>26</td>
<td>51</td>
<td>72</td>
<td>45</td>
<td>27</td>
<td>2760 *</td>
<td>19800 *</td>
<td>7.7</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>Ramy Seed</td>
<td>PG1455</td>
<td>8.6 * 64.6</td>
<td>60</td>
<td>7.3</td>
<td>25</td>
<td>50</td>
<td>73</td>
<td>46</td>
<td>28</td>
<td>2850 *</td>
<td>24500 *</td>
<td>8.7</td>
<td>8.4 *</td>
<td></td>
</tr>
<tr>
<td>Golden Harvest</td>
<td>H6675</td>
<td>8.2 * 66.4</td>
<td>40</td>
<td>7.7</td>
<td>25</td>
<td>50</td>
<td>72</td>
<td>44</td>
<td>26</td>
<td>2780 *</td>
<td>22900 *</td>
<td>8.4</td>
<td>8.1 *</td>
<td></td>
</tr>
<tr>
<td><strong>MEAN</strong></td>
<td></td>
<td>7.3 * 61.1</td>
<td>40</td>
<td>7.2</td>
<td>25</td>
<td>51</td>
<td>72</td>
<td>46</td>
<td>28</td>
<td>2750</td>
<td>20200</td>
<td>7.6</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td><strong>LSD(0.10)</strong></td>
<td></td>
<td>0.9 * 3.9</td>
<td>10</td>
<td>0.5</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>200</td>
<td>3100</td>
<td>1.1</td>
<td>1.1</td>
<td></td>
</tr>
</tbody>
</table>
Calculating Milk per Ton
Milk per Acre = Yield x Milk per Ton

<table>
<thead>
<tr>
<th>Milk1991</th>
<th>Milk2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Dry matter intake estimated using NDF</td>
<td>• Dry matter intake estimated using NDF and Cell wall digestibility</td>
</tr>
<tr>
<td>• Net energy of lactation (Mcal/lb) estimated using ADF</td>
<td>✓ Base dry matter intake adjusted 0.374 lb. per 1% unit change in CWD above or below the trial average CWD (Allen et al.)</td>
</tr>
<tr>
<td>Milk1995</td>
<td>• Starch digestibility is adjusted for dry matter content and kernel processing</td>
</tr>
<tr>
<td>• Dry matter intake estimated using NDF</td>
<td>• Net energy of lactation (Mcal/lb) estimated using multi-component summative equation approach</td>
</tr>
<tr>
<td>• Net energy of lactation (Mcal/lb) estimated using IVD</td>
<td>• Net energy of lactation (Mcal/lb) estimated using multi-component summative equation approach</td>
</tr>
</tbody>
</table>
2001 Wisconsin Corn Hybrid Performance Trial Results – Table 12 Southern Zone, Late Maturity Trial at Arlington and Lancaster

- Table 12

<table>
<thead>
<tr>
<th>Hybrid n=47</th>
<th>Dent Mean n=24</th>
<th>Bt Mean n=11</th>
<th>leafy Mean n=4</th>
<th>bmr</th>
</tr>
</thead>
<tbody>
<tr>
<td>High yield</td>
<td>21000</td>
<td>2500</td>
<td>2600</td>
<td>2700</td>
</tr>
<tr>
<td>High yield &amp; quality</td>
<td>25000</td>
<td>29000</td>
<td>31000</td>
<td>23000</td>
</tr>
</tbody>
</table>

- Milk per Acre (lb/A) vs. Milk per Ton (lb/T) graph

- Key points:
  - Hybrid n=47
  - Dent Mean n=24
  - Bt Mean n=11
  - leafy Mean n=4
  - bmr

Lauer, © 1994-2002
University of Wisconsin – Agronomy
Dent (due to soft floury endosperm)

Floury endosperm.
- More “open” in structure yet opaque in appearance.
- Dent corn has about equal proportions of horny to floury starch (vs popcorn w/ mostly vitreous starch).

Vitreous endosperm.
- Also called horneous, corneous or hard endosperm.
- Primary starch in flint corn.
- Source of dry milling grits.
- Tightly compacted and translucent.
- Higher in CP than floury starch.
- More of this starch in mature, high test weight kernels.
- The last starch laid down in the kernel during the last few weeks of development.

Pericarp (bran)

Germ scutellum and embryonic axis.
- Germ larger in short season corn and in HOC (at the expense of starch).
- In HOC, each 1% unit increase in oil, expect 1.3% unit lower starch.

Hilum or abscission layer. Also called black layer.
- Caused by collapse and compression of several layers of cells at physiological maturity.
- Cool weather can cause premature BL.

Corn Silage Yield and Quality Changes During Development

Milk per Ton (lb/T) vs Milk per Acre (lb/A)

Pioneer 3578
Arlington, WI - 1993

Harvest date

Lauer, © 1994-2002
University of Wisconsin – Agronomy
Corn Silage Drydown Rate in Manitowoc County, WI.

Forage moisture (%)

Sample date

22-Aug 29-Aug 5-Sep 12-Sep 19-Sep 26-Sep 3-Oct

1996 = -0.4  R² = 0.77
1997 = -0.6  R² = 0.96
1998 = -0.6  R² = 0.91
1999 = -0.7  R² = 0.92
2000 = -0.7  R² = 0.89
2001 = -0.4  R² = 0.93

Lauer, © 1994-2002
University of Wisconsin – Agronomy
Relationship Between Forage Moisture and Kernel Milk Stage (1990 - 2000)

Whole plant moisture (%) vs. Kernel milk stage

- n = 2245
In-season Guidelines for Predicting Corn Silage Harvest Date

• Note hybrid maturity and planting date of fields intended for silage.

• Note tasseling (silking) date.
  ✓ Kernels will be at 50% kernel milk (R5.5) about 42 to 47 days after silking.

• After milkline moves, use kernel milk triggers to time corn silage harvest.
  ✓ Use a drydown rate of 0.5% per day to predict date when field will be ready for the storage structure.
  ✓ See http://cf.uwex.edu/ces/ag/silagedrydown/

• Do final check prior to chopping.
Relationship between corn silage yield and plant density in WI

Average of six locations 1994-1996

Cusicanqui and Lauer, 1999
Relationship between corn silage Milk per Ton and plant density in WI

Average of six locations 1994-1996

Cusicanqui and Lauer, 1999
Relationship between corn silage Milk per Acre and plant density in WI

Average of six locations 1994-1996

Cusicanqui and Lauer, 1999
Relative change in silage yield & quality at different cutting heights during 1996

Cusicanqui and Lauer, 1996
Corn Silage Yield Response to Row Spacing in WI (UW and On-Farm trials)

Change in Yield over 30-inch (%)

-10 -5 0 5 10 15 20

Yield Environment (Highest - Lowest)

98FON06 * 98VAL06 + 97ARL06 99FON06 99ARL06 98ARL06 99VAL06 98SPAYE06 ** 97SPAYE06 ** 97SPAN05 + 97SHE06 * 99SHE06 + 98SHE06

n = 13

Lauer, 1999
Summary

• Many ways to achieve high quality corn silage
  ✓ Many ways to “skin the cat”
  ✓ Hybrid selection depends upon objectives of farmer
  ✓ Management and hybrid selection go hand-in-hand

• Future direction
  ✓ Starch degradation
  ✓ Stover digestibility (digestion kinetics)
  ✓ Continued improvement of Milk2000
  ✓ Key: Animal feeding verification studies