Corn Silage Mycotoxins... and more

Dairy Forage Seminar

October 5th, 2018

Phil Cardoso, DVM, MS, PhD
Corn Silage Numbers...

- NASS estimated that in 2014:
  - 89.4% of dairy farms incorporated CS in diets
  - 14% of total corn production → CS
Corn Silage Quality

- **Planting practices**
  - Planting date, population, row spacing, **disease control**
- **Fertility management**
  - Crop rotation, soil management
- **Hybrids**
  - Yield potential, forage quality
- **Harvesting**
  - Moisture, additives, processing, **cut height**
- **Storage**
  - Bunker, plastic, holes
Fungicide Use in Corn: Plant Yield Effect

Adapted from Carl Bradley
Cell wall fraction makes up approximately 40% of corn silage
Key Forage Quality Factors

NDF
- Cellulose, hemicellulose, lignin
- Going from low to high NDFD can increase milk 11 lb/d (Grant et al, 1995)
- Plant stress can cause more lignin content and decrease NDFD (Yates et al., 1997)
  - Cold stress
  - Drought stress
  - Infection stress

ADF
- Cellulose, lignin
- Related to plant cell wall digestibility
- Negative correlation between ADF and DMI (Van Soest, 1965)
- Negative correlation with in vitro NDFD (Allen et al, 2003)
Other Forage Quality Factors

- **Mycotoxins**
  - Produced by secondary metabolism of (Keller et al., 2013):
    - *Aspergillus* (Aflatoxin; Ochratoxin A (OTA); Citrinin)
    - *Penicillium* (Cyclopiazonic acid (CPA); Citrinin)
    - *Fusarium* (Fumonisins; Zearalenone; Deoxynivalenol=Vomitoxin; T-2)
- Field disease scoring for infection may not be adequate to determine mycotoxin content (Eckard et al., 2011)
  - Common rust (*Puccinia triticina*)
  - Grey leaf spot (*Cercospora zeae-maydis*)
  - Northern leaf blight (*Exserohilum turcicum*)
- Can lead to loss of nutrients, dry matter, and palatability, can also decrease rumen function and decrease reproductive performance (Scudamore & Livesy, 1998)
# Mycotoxins in Corn Silage (2017)

<table>
<thead>
<tr>
<th>Mycotoxin</th>
<th>Total samples (n)</th>
<th>Positive samples (n)</th>
<th>Positive samples (%)</th>
<th>Average ± 1 STDEV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aflatoxin, ppb</strong></td>
<td>3,380</td>
<td>426</td>
<td>12.6</td>
<td>10 - 8.5</td>
</tr>
<tr>
<td><strong>Zearalenone, ppb</strong></td>
<td>3,380</td>
<td>652</td>
<td>19.3</td>
<td>330 - 320</td>
</tr>
<tr>
<td><strong>Vomitoxin, ppm</strong></td>
<td>3,380</td>
<td>2,286</td>
<td>67.6</td>
<td>2.6 - 2.9</td>
</tr>
<tr>
<td><strong>Fumonisin, ppm</strong></td>
<td>3,380</td>
<td>11</td>
<td>0.3</td>
<td>4.6 - 3.5</td>
</tr>
<tr>
<td><strong>T-2, ppm</strong></td>
<td>3,380</td>
<td>135</td>
<td>4.0</td>
<td>110 - 248</td>
</tr>
</tbody>
</table>

Summary of combined 2017, multi-lab (DairyOne, Dairyland Lab, and AnaLab) data
Potentially harmful toxin concentrations for a total diet (DM)

<table>
<thead>
<tr>
<th>Toxin</th>
<th>Dairy</th>
<th>Feedlot</th>
<th>Swine</th>
<th>Poultry</th>
<th>Equine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Deoxynivalenol (DON or Vomitoxin)*</td>
<td>0.5 to 1.0</td>
<td>10</td>
<td>1</td>
<td>2</td>
<td>500</td>
</tr>
<tr>
<td>Fumonisin</td>
<td>2</td>
<td>7</td>
<td>10</td>
<td>20</td>
<td>500</td>
</tr>
<tr>
<td>T-2 Toxin</td>
<td>100</td>
<td>500</td>
<td>100</td>
<td>100</td>
<td>NA</td>
</tr>
<tr>
<td>Zearalenone</td>
<td>400</td>
<td>5</td>
<td>300</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Ochratoxin</td>
<td>5</td>
<td>5</td>
<td>700</td>
<td>700</td>
<td>35</td>
</tr>
<tr>
<td>Ergot toxins (combined)</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>750</td>
<td>300</td>
</tr>
</tbody>
</table>

Values listed in blue are PPM, all other listed in PPB
Corn Varieties

Fungus in Corn – Scout!

Corn silage from corn treated with foliar fungicide and performance of Holstein cows

K. J. Haerr,* N. M. Lopes,*† M. N. Pereira,† G. M. Fellows,‡ and F. C. Cardoso*†

*Department of Animal Sciences, University of Illinois, Urbana 61801
†Departamento de Zootecnia, Universidade Federal de Lavras, Lavras, MG, Brazil 37200-000
‡BASF Corporation, Research Triangle Park, NC 27709
Materials and Methods

• 4 Treatments

- **CON**: No Applications of foliar fungicide
- **1X**: 1 Application of Headline® at V5
- **2X**: 1 Application of Headline® at V5, 1 Application of Headline® AMP at R1
- **3X**: 1 Application of Headline® at V5, 1 Application of Headline® AMP at R1 and R3

Active ingredient in Headline®: Pyraclostrobin
Headline® AMP: Pyraclostrobin + Metconazole
Corn silage yield did not change

- No symptoms of foliar disease
- Yield
  - CON: 61.12 Mg/ha or 9 tons/acre (DM)
  - 1X: 59.70 Mg/ha or 8.0 tons/acre (DM)
  - 2X: 63.99 Mg/ha or 9.2 tons/acre (DM)
  - 3X: 61.22 Mg/ha or 9 tons/acre (DM)
Feed efficiency increased with fungicide application.

CON vs TRT: $P = 0.14$
Linear: $P = 0.03$
Quad: $P = 0.95$

CON vs TRT: $P = 0.09$
Linear: $P = 0.01$
Quad: $P = 0.94$

CON vs TRT: $P = 0.08$
Linear: $P = 0.02$
Quad: $P = 0.99$
Fiber content decreases as amount of applications increase.

- CON vs TRT: $P = 0.05$
  - Linear: $P = 0.06$
  - Quad: $P = 0.39$

- Treatment
  - NDF
  - ADF

- CON vs TRT: $P = 0.008$
  - Linear: $P = 0.02$
  - Quad: $P = 0.43$
Effects of corn treated with foliar fungicide on in situ corn silage degradability in Holstein cows


a Department of Animal Sciences, University of Illinois, Urbana, IL 61801, USA
b Departamento de Zootecnia, Universidade Federal de Lavras, Lavras, MG 37200-000, Brazil
c Department of Crop Sciences, University of Illinois, Urbana, IL 61801, USA
d B.A.S.F. Corporation, Research Triangle Park, NC 27709, USA
Dry matter degradability is increased with fungicide application.

Soluble feed:
Linear effect ($P = 0.04$)

Lag:
Non significant

Degradable feed:
Con vs Trt:
($P = 0.01$)
Linear effect:
($P = 0.006$)

Undegradable feed:
Non significant

$K_d$:
Linear effect: ($P = 0.04$)

Haerr et al., 2016
Economic Considerations
MILK 2006 Predictions

http://shaverlab.dysci.wisc.edu/spreadsheets

- Developed by the University of Wisconsin
  - Relative quality of a forage based on energy value which is predicted from ADF, and potential intake using NDF and NDFD.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Milk Per Ton</th>
<th>Milk per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimated</td>
<td>Calculated</td>
</tr>
<tr>
<td>CON</td>
<td>2952</td>
<td>2898</td>
</tr>
<tr>
<td>1X</td>
<td>3010</td>
<td>3006</td>
</tr>
<tr>
<td>2X</td>
<td>3016</td>
<td>3506</td>
</tr>
<tr>
<td>3X</td>
<td>3057</td>
<td>3222</td>
</tr>
</tbody>
</table>
Cost of Fungicide

• Cost of fungicide per acre
  – 1X: $ 30.00
  – 2X: $ 60.00
  – 3X: $ 90.00

• Cost per pound of silage
  – CON: $ 0.044
  – 1X: $ 0.046
  – 2X: $ 0.047
  – 3X: $ 0.049
It seems to pay off...

Income over feed cost (IOFC)*

<table>
<thead>
<tr>
<th></th>
<th>$/lb DM</th>
<th>Feed Cost (consumed)</th>
<th>Milk Income</th>
<th>IOFC*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON</td>
<td>$0.121</td>
<td>$6.30</td>
<td>$13.65</td>
<td>$7.34</td>
</tr>
<tr>
<td>1X</td>
<td>$0.121</td>
<td>$6.11</td>
<td>$13.66</td>
<td>$7.54</td>
</tr>
<tr>
<td>2X</td>
<td>$0.122</td>
<td>$5.23</td>
<td>$13.54</td>
<td>$8.31</td>
</tr>
<tr>
<td>3X</td>
<td>$0.122</td>
<td>$5.79</td>
<td>$13.62</td>
<td>$7.83</td>
</tr>
</tbody>
</table>

CON vs TRT: $7.34 vs $7.89

* Income over feed cost calculated as IOFC = milk income - total feed cost
Fungus in Corn

Percent of Disease Incidence

- Common Rust
- Northern Leaf Blight
- Gray Leaf Spot

2015

21% total diseased

19% total diseased

Kalebich et al., 2017
Foliar fungicide (pyraclostrobin) application effects on plant composition of a silage variety corn

C.C. Kalebich\textsuperscript{a}, M.E. Weatherly\textsuperscript{a}, K.N. Robinson\textsuperscript{a}, G.M. Fellows\textsuperscript{b}, M.R. Murphy\textsuperscript{a}, F.C. Cardoso\textsuperscript{a,\textdagger}

\textsuperscript{a} Department of Animal Sciences, University of Illinois, Urbana, IL 61801, USA
\textsuperscript{b} B.A.S.F. Corporation, Research Triangle Park, NC 27709, USA
Material and Methods

During summer 2015:

4 Treatments

- **CON**: no application of fungicide
- **V5**: one application of Priaxor ® at V5
- **V5+R1**: one application of Priaxor ® at V5 and one of Headline AMP ® application at R1
- **R1**: one application of Headline AMP ® at R1

Active Ingredient in Priaxor ®: Pyraclostobin + Fluxapyroxad
Active Ingredient in Headline AMP ®: Pyraclostobin + Metaconzole
Material and Methods

- **Corn:**
  - Seed: 1417 AMXRR, Pioneer
  - Type: Silage
  - Planted: April 30, 2015 at 32,000 plants/acre
  - Disease Evaluation:
    - July 11, 2015 – R1
    - August 13, 2015 – R3
  - Removed stalks from field at R1 and R3
    - July 12, 2015 – R1
    - August 18, 2015 – R3
Plant parts collected

Collection at each R1 and R3

Sampling as full plant:
- Weight of full plant
- Height of full plant
- Number of leaves
- Number of green leaves
- Number of yellow leaves

1. Flag Leaf
   - Composited

2. Leaves
   - Composited

3. Ears = cobs + kernels
   - Weight of ears
   - Composited

4. Stalks
   - Composited

Kalebich et al., 2017
Height of corn stalk

Kalebich et al., 2017

TRT x TP

\( P = 0.02 \)
Number of yellow leaves

TRT x TP

$P = 0.03$

Kalebich et al., 2017
Leaves fiber content

TRT x TP
$P = 0.008$

Kalebich et al., 2017
Corn Plant Conclusions

• Applications of fungicide on corn resulted in
  – Less yellow leaves
  – Taller plants

• Applications at both V5 and R1
  – Reduced NDF and ADF content in leaves
  – Increased lignin in stalks

• Implication:
  – Fungicide on corn may reduce stress impacts from disease and reduce the fibrous content in the leaves, while improving stalk strength
Foliar fungicide (pyraclostrobin) application on corn and its effects on corn silage composition

C.C. Kalebich\textsuperscript{a}, M.E. Weatherly\textsuperscript{a}, K.N. Robinson\textsuperscript{a}, G.M. Fellows\textsuperscript{b}, M.R. Murphy\textsuperscript{a}, F.C. Cardoso\textsuperscript{b,\ast}

\textsuperscript{a} Department of Animal Sciences, University of Illinois, Urbana, IL, 61801, USA
\textsuperscript{b} B.A.S.F. Corporation, Research Triangle Park, NC 27709, USA
Material and Methods

Harvest:

• August 25, 2015 for CON, V5, V5+R1, R1
  – 26.5%, 34.4%, 27.7% and 33.2%, respectively

• 1.9 cm theoretical length of chop

• Kernel Processor
Water soluble carbohydrates (WSC) in corn silage

Kalebich et al., 2017

TRT x TP

*$P = 0.03$
Lactic acid in corn silage

Kalebich et al., 2017

TRT x TP

$P = 0.03$
Applications of fungicide on corn resulted in
- Greatest water soluble carbohydrate (WSC) content
- Greatest lactic acid content

Implication:
- Applications at V5 or R1 may reduce the fibrous content of corn silage, increase the fermentation products during ensiling, and yield greater milk when fed to dairy cattle
Fungus in Corn

Weatherly et al., unpublished
Many different varieties and hybrids to choose from …

1) Floury (FLY):
   - Great DM yield
   - Very low in prolamin proteins (starch-encapsulating storage proteins) → the starch is highly available in the rumen
   - Higher lignin content → greater structural components = able to withstand wind/weather in field
   - Lower whole plant fiber digestibility
     (Sniffen, 2016, Mahanna, 2009)

2) Brown mid-rib (BMR):
   - Lower lignin
   - Greater whole plant fiber digestibility
   - Lower DM yield
   - Less ability to withstand wind in field
     (Block et al., 1981; Oba and Allen, 1999; Dominguez et al., 2002)
Treatments

Headline® AMP: Pyraclostrobin (13.64%) + Metconazole (5.14%)

Weatherly et al., unpublished
## Results: Yield

<table>
<thead>
<tr>
<th></th>
<th>BMR</th>
<th>FLY</th>
<th>SEM</th>
<th>Variety</th>
<th>Treatment</th>
<th>Variety x Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross silage yield per acre, tons</td>
<td>28.6 30.3</td>
<td>27.9 30.2</td>
<td>0.8</td>
<td>0.57</td>
<td>0.08</td>
<td>0.66</td>
</tr>
<tr>
<td>DM, %</td>
<td>31.2 26.7</td>
<td>29.5 28.1</td>
<td>0.01</td>
<td>0.84</td>
<td>&lt;0.0001</td>
<td>0.006</td>
</tr>
<tr>
<td>DM silage yield per acre, tons</td>
<td>9.0 8.1</td>
<td>8.4 8.4</td>
<td>0.3</td>
<td>0.57</td>
<td>0.10</td>
<td>0.02</td>
</tr>
<tr>
<td>Kernel Processing Score, %</td>
<td>76.0 72.5</td>
<td>68.0 72.8</td>
<td>0.03</td>
<td>0.35</td>
<td>0.79</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Weatherly et al., *unpublished*
Corn: BMR (P1180XR).
Fungicide: Prothioconazole and trifloxystrobin (Delaro, Bayer CropScience).
Treatments: CON; V5; V5R1; R1
Fungus in BMR Corn

2017

Damery et al., unpublished

[Graph showing percent of individual plant infected with Avg Total Disease and Common Rust at different stages: V5, VT, R5, V5, VT, R5, V5, VT, R5, V5, VT, R1.]

- CON
- V5
- V5R1
- R1

Avg Total Disease
Common Rust
<table>
<thead>
<tr>
<th>Yield, tons/acre</th>
<th>12&quot;</th>
<th>22&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P</strong> = 0.0023</td>
<td>16.9</td>
<td>15.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dry Matter, %</th>
<th>12&quot;</th>
<th>22&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P</strong> = 0.0012</td>
<td>33.43</td>
<td>34.58</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DM Yield, tons/acre</th>
<th>12&quot;</th>
<th>22&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P</strong> = 0.03</td>
<td>5.6</td>
<td>5.3</td>
</tr>
</tbody>
</table>

**Difference**

Yield = 1.4 tons/acre (8.3%)

DM Yield = 0.3 tons/acre (5.3%)
<table>
<thead>
<tr>
<th>Part 1. Determining the costs of corn silage standing in the field.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Corn Price</strong></td>
</tr>
<tr>
<td><strong>Silage Yield</strong></td>
</tr>
<tr>
<td><strong>Corn Silage Dry Matter</strong></td>
</tr>
<tr>
<td><strong>Corn Silage Yield (dry)</strong></td>
</tr>
<tr>
<td><strong>Estimated Grain Yield</strong></td>
</tr>
<tr>
<td><strong>Corn Grain Harvesting, Drying and Storage Costs</strong></td>
</tr>
<tr>
<td><strong>Net Value of Stover Removed</strong></td>
</tr>
<tr>
<td><strong>Corn Silage Value - Dry</strong></td>
</tr>
<tr>
<td><strong>Corn Silage Value - Dry</strong></td>
</tr>
<tr>
<td><strong>Corn Silage Value - Wet</strong></td>
</tr>
<tr>
<td><strong>Value Per Acre to Crop Grower</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part 2. Determining the costs of corn silage at feeding.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Harvest, Hauling and Storage Cost</strong></td>
</tr>
<tr>
<td><strong>Cost of Silage to Producer (before shrink)</strong></td>
</tr>
<tr>
<td><strong>Shrink</strong></td>
</tr>
<tr>
<td><strong>Cost of Silage Lost to Shrink</strong></td>
</tr>
<tr>
<td><strong>Total Cost of Silage to Producer</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chop height 12”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Estimated Grain Yield</strong></td>
</tr>
<tr>
<td><strong>Net Value of Stover Removed</strong></td>
</tr>
<tr>
<td><strong>Corn Silage Value - Dry</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chop height 22”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Estimated Grain Yield</strong></td>
</tr>
<tr>
<td><strong>Net Value of Stover Removed</strong></td>
</tr>
<tr>
<td><strong>Corn Silage Value - Dry</strong></td>
</tr>
</tbody>
</table>


Damery et al., *unpublished*
TAKE HOME MESSAGE

Phil          Dr. Phil
Conclusions & Implications

• Corn treated with foliar fungicide had
  – Less fiber, more sugar and fat
  – Better aerobic stability
  – Higher DM digestibility
  – Improved corn plant and corn silage quality

• Cows fed silage receiving foliar fungicide had
  – Lower DMI
  – Higher feed efficiency
  – Higher IOFC
For the road...

- **Scout corn at V5**
  - If diseased (> 5%) apply fungicide at V5 and R1

- **Scout corn at R1** (may be too late 😞)
  - If diseased (> 5%) apply fungicide at R1

- **ONE Fungicide application at VT/R1**, even if corn is not diseased, seems to improve corn silage quality and milk production

**How tall can you go?**
THANK YOU!

Phil Cardoso
Department of Animal Sciences
University of Illinois

cardoso2@illinois.edu

www.dairyfocus.illinois.edu