Foliar fungicide application on corn can enhance dairy cow performance

Phil Cardoso, DVM, MS, PhD
More than half of world's maize is produced in USA (35%) and China (22%)
- Other top 5 maize producing countries: Brazil (8%), Argentina (3.2%), Ukraine (3%), India (2.3%) and Mexico (2.2%)
- Maize yields have significantly increased in all the countries

Source: FAOSTAT 2015
• Introduction
• Effects of corn silage treated with various applications of foliar fungicide on
  – corn silage quality and cow performance
  – *in situ* digestibility in Holstein cows
• Economic considerations and concluding remarks
Introduction

• Fungus...
  – Very diverse kingdom of organisms including yeasts and molds
  – May be beneficial
    • Recent research done shows that fungi may be a useful tool in helping to decrease the spread of malaria
    • Ergot may help plant growth
  – May be detrimental
    • Fungus may be harmful to CCD insects
    • May be toxic when ingested by humans and animals

Corn Varieties

https://extension.psu.edu/forage-and-food-crops/agronomic-crops
Fungus in Corn – Scout!


Fungus in Corn

PLANT DISEASE TRIANGLE

- Disease only occurs if these things exist at the same time
- Phytophthora
- Root
- Environment
- Maneuvering a component or combinations of triangle components influences the incidence and severity of disease

http://fci.illinois.edu/fieldcropspathology/2015/07/19/corn-diseases-of-2015-and-should-i-spray/
**Fungus in Corn**

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**Corn Silage**

- Process dates back thousands of years
- Popularity has increased since the 60’s when the forage harvester was invented (Wilkinson et al., 2003)
- Popular due to its ability to keep nutritive value, and increase digestibility over time
- NASS estimates that in 2014 corn silage production was
  - 128 million tons
  - 20.1 tons/acre (as fed)
Fungicide Use in Corn

• Common practice on modern farms
  – Disease scoring done to determine need for application
  – May be applied once twice or none
  – In 2007 it was estimated that 16% of corn planted was sprayed with foliar fungicide (Bradley and Ames, 2009)

• Most common fungicides are
  – Strobilurin
  – Triazole

Fungicide Use in Corn: Plant Yield Effect

• Foliar fungicide (Pyraclostrobin) may increase crop yield by 255 kg/ha (5 bu/acre) (Paul et al., 2011)
  – Due to control of infection (Blandino et al., 2012)
  – Physiological effects caused by foliar fungicide (Kohle et al., 2002)

• 46% of trials conducted using a Quinone outside inhibitor (QoI) found a significant yield increase
  – Disease severity < 5% : 1.5 bu/acre increase
  – Disease severity >5% : 9.6 bu/acre increase (Wise & Mueller, 2011)
Fungicide Use in Corn: Plant Yield Effect

Adapted from Carl Bradley

Pyraclostrobin: Plant Health Effects

- Increases nitrate assimilation
- Increases grain fill by increasing photosynthesis
- Decreases oxidative stress by increasing peroxidases
- Less stress may decrease lignification

Adapted from Carl Bradley
Pyraclostrobin: Grain Fill

- Decreased leaf senescence in upper canopy
  - Area under green leaf incidence curve greater for corn treated with fungicide (Byanukama et al., 2013)
- Linear decrease in yield response to defoliation
  - 11% decrease in yield when leaves dropped prior to silking
- Leaf dropping may be due to
  - Decrease in disease severity
Cell wall fraction makes up approximately 70% 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 *Aspergillus, Penicillium, Fusarium*, and *Alternaria* (Keller et al., 2013)
  - Field disease scoring for infection may not be adequate to determine mycotoxin content (Eckard et al., 2011)
  - Can lead to loss of nutrients, dry matter, and palatability, can also decrease rumen function and decrease reproductive performance (Scudamore & Livesy, 1998)
### Mycotoxins

#### Fusarium
- Responsible for production of fumonisin
  - Deoxynivalenol, HT-2, T-2, and zearalenone
- May reduce nutritive value of plant
- Ruminants are more resistant to zearalenone
- May alter immune mediated responses
  (Keller et al., 2003, Miller et al., 1983)

#### Aspergillus flavus
- Spores of *A. flavus* are spread through soil & insects
- Develops pre-harvest and thrives in mild temperatures and drought conditions
- Responsible for production of aflatoxins
  - B1 is carcinogenic and can be passed into milk
  (Keller et al., 2003, Diener et al., 1987)

### Fungicide Effects on Corn Silage
- Corn treated with Headline® (pyraclostrobin) and harvested for silage when compared to control
  - Increased yield by 0.7 tons DM/acre
  - Decreased NDF content while increasing NDFD content
  - Predicted increase of 75 lbs milk/ton and 2,500 lbs milk/acre using MILK 2006
  (Esker & Blond, 2007)
Objective

- To determine if corn treated with foliar fungicide and ensiled has increased nutrient density, digestibility, and increased cow productivity.
Materials and Methods

• 4 Treatments

<table>
<thead>
<tr>
<th>CON: No Applications of foliar fungicide</th>
<th>1X: 1 Application of Headline® at V5</th>
<th>2X: 1 Application of Headline® at V5, 1 Application of Headline® AMP at R1</th>
<th>3X: 1 Application of Headline® at V5, 1 Application of Headline® AMP at R1 and R3</th>
</tr>
</thead>
</table>

Active ingredient in Headline®: Pyraclostrobin
Headline® AMP: Pyraclostrobin + Metconazole

Materials & Methods

• Corn

  – Variety: LG seeds/ CPS variety LG2636 VT3P RIB
  – Planting date: June, 5 2013
  – Harvest date: September 27, 2013
    • DM: 33, 30, 30, & 32.5% for CON, 1X, 2X, and 3X
  – Disease scoring at silk emergence and kernel milk stage (August 2nd and August 16th)
    • No Evidence of plant disease
  – Theoretical length of chop
    • ¾ inch
Materials & Methods

• Cows
  – 64 multiparous and primiparous Holstein cows (DIM 161 ± 51)
  – Housed in tie stall barn
  – Fed at 3PM
  – Milked 3x at 4 AM, 12 PM, and 8 PM
  – Fed diet to meet NRC requirements

Diet Composition

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>% DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay</td>
<td>6.90</td>
</tr>
<tr>
<td>Corn silage</td>
<td>34.9</td>
</tr>
<tr>
<td>Alfalfa silage</td>
<td>6.09</td>
</tr>
<tr>
<td>Cottonseed</td>
<td>3.25</td>
</tr>
<tr>
<td>Wet brewers grain</td>
<td>8.12</td>
</tr>
<tr>
<td>Soy hulls</td>
<td>4.87</td>
</tr>
<tr>
<td>Concentrate mix</td>
<td>45.7</td>
</tr>
</tbody>
</table>
Materials & Methods

- **Aerobic Stability**
  - A representative sample of corn silage was obtained and aerated in a bucket
  - 3 loggers were put into each treatment and temperature after 38 h was considered aerobic stability
  - Environmental temperature was used as a covariate
  - Replicated 3x

- **Density**
  - Taken 2x per week using master forage probe
  - Samples taken from 5 different locations & depth was recorded
  - DM was then taken to calculate DM density

Statistical Analysis

- **Contrasts**
  - CON vs TRT:
    - Control vs the average of 1X, 2X, and 3X
  - Linear
  - Quadratic

- Significance declared at $P \leq 0.05$
- Tendencies at $0.05 < P \leq 0.10$
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)

Dry matter intake decreased with fungicide application

CON vs TRT: \( P = 0.08 \)
Linear: \( P = 0.01 \)
Quad: \( P = 0.11 \)
Milk yield kept the same

CON vs TRT: $P > 0.79$
Linear: $P > 0.69$
Quad: $P > 0.67$

So...

- The diet had the same analyzed energy content but cows fed treated corn silage tended to eat less than cows eating CON
- However milk production remained the same
Feed efficiency increased with fungicide application

Fiber content decreases as amount of applications increase
Sugar content increases as application number increases

- **Treatment**
  - Fat
  - Sugar

- **CON vs TRT**:
  - Linear: $P = 0.01$
  - Quad: $P = 0.13$

- **CON vs TRT**:
  - Linear: $P < 0.001$
  - Quad: $P = 0.02$

**Mycotoxins**

- **15-acetyl Deoxynicalenol**

- **PPM**
  - Block 1
  - Block 2
Mycotoxins

• Deoxyscirepenol

![Deoxyscirepenol Graph]

Mycotoxins

• Zearalenone

![Zearalenone Graph]
Toxins were lower in treated silage, but even CON had no visible sign of infections, and relatively low concentrations of toxins.

### Potentially Harmful Toxin Levels 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>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Ochratoxin</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>750</td>
<td>300</td>
</tr>
<tr>
<td>Ergot toxins (combined)</td>
<td>5</td>
<td>5</td>
<td>700</td>
<td>700</td>
<td>35</td>
</tr>
</tbody>
</table>

### Corn Silage Density (bag)

- **Con vs TRT**: $P = 0.42$
- **Trt* Time**: $P = 0.99$
- **Linear**: $P = 0.23$
- **Quad**: $P = 0.86$

- 13.7 lb/ft³
- 11.2 lb/ft³
- 8.7 lb/ft³
Aerobic Stability

Summary

- Differences in
  - DMI
  - Feed conversion
  - Silage NDF, ADF, Sugar
  - Aerobic Stability
• Even though DMI decreased, because milk production did not decrease, overall efficiency increased

Project Outline

- Corn Plant
- Corn Silage
- Cow
- Profitability
Effects of Corn Treated with Various Applications of Foliar Fungicide on in situ Corn Silage Degradability in Holstein Cows

Research Paper

Effects of corn treated with foliar fungicide on in situ corn silage degradability in Holstein cows


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Department of Zootechnics, Universidade Federal de Lavras, Lavras, MG 37230-000, Brazil
Department of Crop Sciences, University of Illinois, Urbana, IL 61801, USA
BASF Corporation, Research Triangle Park, NC 27709, USA
Dry matter degradability is increased with fungicide application

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

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

Lag: Non significant

Degradable feed: Linear effect: ($P = 0.006$)

Undegradable feed: Non significant

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

Economic Considerations

Haerr et al., 2016
MILK 2006 Predictions

http://shaverlab.dvsci.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
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
Fungus in Corn

Percent of Disease Incidence 2015

21% total diseased
19% total diseased

Common Rust
Northern Leaf Blight
Gray Leaf Spot

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**

Kalebich et al., 2017

TRT x TP

\[ P = 0.03 \]
Leaves fiber content

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
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
Corn Silage Conclusions

• 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
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!

Questions?