Outline

- 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

- Why 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 play a role in CCD in bees?
    - May be toxic when ingested by humans and animals
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

Active Ingredient: Metconazole
• Demethylation inhibitor
  – Class: Triazole
  – Works through inhibition of sterol production
  – Systemic reaction
  – Moderate risk for resistance
  – Treatment
  – Very effective against Fusarium Spp.
Active Ingredient: Pyraclostrobin

- Works as a quinone outside inhibitor (QoI)
  - Class: Strobilurin
  - Inhibits cytochrome III (bc) complex in electron transport chain
  - Decreases mitochondrial respiration
  - High risk for resistance
  - Preventative and treatment

Fungicide Use in Corn: Plant Yield Effect

- Foliar fungicide (Pyraclostrobin) may increase crop yield by 255 kg/ha (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)
Leaf dropping may be due to:

- Decrease in yield 
- 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
  - Decrease in ACC synthase decrease in ethylene
  - Plant stress hormone (Köhle et al., 2003)
  - Due to
    - Increase in peroxidase activity (SOD)
    - Decrease in reactive oxygen species (Wu & Tiedemann, 2001)

Increases nitrate assimilation

Decreases oxidative stress by increasing peroxidases

Less stress may decrease lignification

Increases grain fill by increasing peroxidases

Decrease in ACC synthase

Increase in peroxidase activity (SOD)

Decrease in reactive oxygen species (Wu & Tiedemann, 2001)
Pyraclostrobin: Increase in Nitrogen Assimilation

- Nitrogen uptake was greater after Pyraclostrobin application (Köhle, 2003)
- Nitrogen assimilation reaction
  - Nitrate → Nitrite
    - Catalyzed by NADH nitrate reductase
    - Limiting step
- Other strobilurin fungicides act on NADH nitrate reductase (Glazz & Kaser, 1999)
  - These exact results not replicated in vivo with Pyraclostrobin
  - Increase may be due to increase overnight activity of NADH nitrate reductase (Venancio et al., 2009)

Key Forage Quality Factors

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 6 kg/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)
Key Forage Quality Factors

- **Starch**
  - Digestibility greatly effected by processing, maturity, environment, and hybrid (Bul et al., 2003)
  - Fungal infections can infect kernels

- **Other NFC can be readily used by fungi for energy**
  - This is true for fat as well
  - Corn with infected with fungi has less crude fat content (Williams et al., 1992)

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 (Kiekael 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 fumonisins
  - 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)

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**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
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>
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<tbody>
<tr>
<td>Alfalfa hay</td>
<td>6.90</td>
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<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>
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<tr>
<td>Wet brewers grain</td>
<td>8.12</td>
</tr>
<tr>
<td>Soy hulls</td>
<td>4.87</td>
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<tr>
<td>Concentrate mix</td>
<td>45.7</td>
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</table>
Materials & Methods

- TMR daily intake measured
  - Analyzed for
    - Physical characteristics (PSFP)
    - Core nutrients
    - Total Digestibility (TMR & Fecal)
- Corn Slage
  - Analyzed for
    - Physical characteristics (PSFP)
    - Core nutrients
    - Mold & yeasts
    - Toxic screen (ns)
    - Density
    - Aerobic stability
- Health daily
  - Fecal score
  - GA

- Blood
  - Analyzed for
    - Glucose and Blood Urea Nitrogen
- Milk
  - Daily production
  - Composition (D1 & D4 of Wt)
  - Fat
  - Protein
  - Lactose
  - Milk Urea Nitrogen
  - Somatic Cell Count

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

- 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)

Results – Dry Matter Intake

- CON vs TRT: P < 0.08
- Linear: P = 0.01
- Quad: P < 0.11

Results – Milk

- CON vs TRT: P > 0.79
- Linear: P > 0.69
- Quad: P > 0.67
Results

- 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.

Results – Feed Conversion

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

Results - Toxins

• 15-acetyl Deoxynicalenol

Results - Toxins

• Deoxyscirepenol
Results - Toxins

- Zearalenone

<table>
<thead>
<tr>
<th>Toxin</th>
<th>Dairy</th>
<th>Feedlot</th>
<th>Storage</th>
<th>Purity</th>
<th>Complex</th>
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<tbody>
<tr>
<td>Alkaloids</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
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<tr>
<td>Decarboxylic (CON on Vinson) &amp;</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
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<tr>
<td>Fusarium</td>
<td>2</td>
<td>7</td>
<td>20</td>
<td>20</td>
<td>20</td>
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<tr>
<td>Zearalenone</td>
<td>480</td>
<td>5</td>
<td>300</td>
<td>10</td>
<td>50</td>
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<tr>
<td>Other</td>
<td>5</td>
<td>5</td>
<td>700</td>
<td>700</td>
<td>35</td>
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</table>

Discussion

- Toxins were lower in treated silage, but even CON had no visible sign of infections, and relatively low concentrations of toxins.

Results – Density

Con vs TRT: P = 0.42
Trt* Time: P = 0.89
Linear: P = 0.53
Quad: P = 0.86
Results – Aerobic Stability

Summary

• Differences in
  – DMI
  – Feed conversion
  – Silage NDF, ADF, Sugar
  – Aerobic Stability
  – Linear effect for NRC calculations and fat

Discussion

• Even though DMI decreased, because milk production did not decrease, overall efficiency increased
Effects of Corn Treated with Various Applications of Foliar Fungicide on \textit{in situ} Digestibility in Holstein Cows

Results- DM Digestibility

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

Degradable feed: Con vs Trt. ($P = 0.00$)
Linear effect ($P = 0.000$)

Undegradable feed: Non-significant

Leg: Non-significant
Economic Considerations

MILK 2006 Predictions

• 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>
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<tbody>
<tr>
<td></td>
<td>Estimated</td>
<td>Calculated</td>
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<tr>
<td>CON</td>
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<td>2898</td>
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<tr>
<td>1X</td>
<td>3010</td>
<td>3006</td>
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<tr>
<td>2X</td>
<td>3016</td>
<td>3106</td>
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<tr>
<td>3X</td>
<td>3057</td>
<td>3222</td>
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</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
Economics

• Income over feed cost

<table>
<thead>
<tr>
<th></th>
<th>Feed Cost</th>
<th>Milk Income</th>
<th>IOFC*</th>
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<tbody>
<tr>
<td>CON</td>
<td>$ 0.121</td>
<td>$ 6.30</td>
<td>$ 13.65</td>
</tr>
<tr>
<td>1X</td>
<td>$ 0.121</td>
<td>$ 6.11</td>
<td>$ 13.66</td>
</tr>
<tr>
<td>2X</td>
<td>$ 0.122</td>
<td>$ 5.23</td>
<td>$ 13.54</td>
</tr>
<tr>
<td>3X</td>
<td>$ 0.122</td>
<td>$ 5.79</td>
<td>$ 13.62</td>
</tr>
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</table>

CON vs TRT: $ 7.34 vs $7.89

• Income over feed cost calculated as IOFC = milk income - total feed cost

Conclusions & Implications

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

• Cows fed silage receiving foliar fungicide had
  – Lower DMI
  – Higher feed conversion
  – Higher IOFC

www.dairyfocus.illinois.edu