Moulds and Mycotoxin Problems Associated With Corn

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Key Factors For Occurrence of Disease

- Pathogens differ in adaptation to the environment
- Environmental influences can be manipulated for management
- Hybrid selection is the most promising tool
- Must be managed both pre- and post-harvest
Molds and Mycotoxins Found in Ensiled Forages and Grains

Where Mycelium Grow in Life Cycle of Fungi and Produce Mycotoxins
Metabolites are Produced at Growing Tip of Mycelium
Environmental Differences Between Field and Silage Produced Molds

- Oxygen rich
- Neutral pH
- High humidity

- Micro-aerophilic
- Acidic pH
- High humidity
Modes of Spore Entry Into the Corn Plant In the Field

- **Pollination time when fungal spores travel down the lumen of the corn silk**
  - Primary mode of entry
  - Where plant genetics can instill resistance

- **Physical damage to the crop**
  - Second most common mode of entry
  - Insects
  - Weather events such as hail

- **Soil entry at time of germination**
  - Least common mode of entry
  - Explains most mold stalk rots
  - Another area where plant researchers can instill resistance
Mycotoxin Contamination of Silage From “Field Fungi”

- Common “field” fungi (Fusarium, Gibberella, some Aspergillus & Penicillium) are not well adapted to silage conditions
  - They are aerobic organisms
  - They are intolerant of low pH

- They do not grow and produce mycotoxins in silage unless conditions are poor
  - Moisture too high or low
  - Too much air

- Mycotoxins existing in the crop before ensiling will usually remain intact
  - Concentrated in kernels and cobs
  - Diluted by stalk and leaf material
  - DON is the most common of these mycotoxins in silage
Environmental Influences On Mold Growth and Potential Mycotoxins In Corn While Growing In Field

- Direct influence on fungal development & infection
- Enhanced plant susceptibility
- Effects on insect activity

<table>
<thead>
<tr>
<th></th>
<th>Aspergillus</th>
<th>Fusarium</th>
<th>Gibberella</th>
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<tbody>
<tr>
<td>Temperature</td>
<td>Optimum 90° + F</td>
<td>Optimum 80-85°</td>
<td>Optimum ~75° F</td>
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<td>Moisture</td>
<td>Grain-fill drought stress</td>
<td>Early drought, then humidity</td>
<td>Wet during flowering</td>
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<td>Insects</td>
<td>Important</td>
<td>Very important</td>
<td>Less important</td>
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Gibberella ear rot

- Infection of primary concern to Canadian farmers
- *Gibberella zeae* *(Fusarium graminearum)*
- Pinkish-red, whitish
- Produces mycotoxins: Vomitoxin, zearalenone, and T2.
Gibberella Ear Rot

- *Gibberella zeae* spores is the same fungus that causes head scab of wheat
- Spores from corn or wheat residue can blow in wind and infection occurs through the young silks
- Favored by relatively cool, wet weather during pollination and afterwards
  - Warm days
  - Cool evenings
  - Morning fog/dew...condensation
- Insects typically play only a minor role in the disease cycle of Gibberella ear rot
Aspergillus Kernel Rot

- Canadians will primarily see with imported grains or commodities (cottonseed)
- *Aspergillus flavus, A. parasiticus*
- Mycotoxins: Aflatoxins,
- High temperatures, drought conditions (drought) – uncommon in Wisconsin
- Insect injury
Fusarium ear rot

- Of least concern to Canadian dairymen; primarily comes in from the south
- *Fusarium verticillioides* (*F. moniliforme*),
- Whitish, Often associated with insect injury
- Mycotoxins: Fumonisin,
Other Ear Molds That Aren’t Associated with Known Mycotoxins

Cladosporium

Penicillium

Diploidia

Trichoderma


**Bt Corn Influence on Mycotoxin Risk**

- **Extensive data on fumonisins**
  - Multiple US states, Spain, France, Italy, Argentina, Philippines
  - Bt hybrids can be 90% lower in fumonisins due to insect protection
    - Insect injury causes elevated fumonisins in conventional hybrids
    - Difference between Bt and conventional hybrids depends on insect pressure
    - In the absence of insect injury, Bt & conventional hybrids are no different

- **Data on DON and other toxins**
  - Canada, Germany, France, southern US
  - Similar trend as with fumonisins, but not as dramatic
  - 2001 German study show lower DON/ZEN with Bt
Hybrid and Harvest Management to Mitigate Mold/Mycotoxin Issues

- Prevention and limiting spread
  Hybrid influence: Maturity, Husk tightness, Upright ear, grain drydown, Genetic resistance

- Identify problematic fields (10% of ears showing 20% or more of the ear moldy)

- Harvest opportunities: Corn silage → HMEC → HMC → Dry corn

- Combine sieve concave settings to remove moldy kernels

- Screen grain…bees wings

- Dry grain fast as possible <15%

- HMC grain 25-28% is ideal…preferred over HMEC
  - Inoculant doesn’t degrade mycotoxin
  - Acids don’t degrade mycotoxin

- Segregate infected crop

- If stored as grain, monitor condition every 1-2 weeks
Ear Rot Infected Corn Grain Storage Considerations

- **Options**
  - HMEC (high moisture ear corn, snaplage)
  - HMC (high moisture corn)
  - Dry Corn

- **HMEC Storage:**
  - additional potential mycotoxin may exist in the cob and bees wings that could result in an even higher level of mycotoxin.
  - Al Gotlieb, former plant pathologist at U. of VT (now retired) did a DON mycotoxin screening on parts of the ear years ago and found that while grain was showing something like 3-4 ppm DON, that at times the cob DON was approaching 20 ppm DON.

- **Combining and storing as HMC or dry corn cleans the grain**
  - Needs to be in separate silo or bin
  - Maximize elimination of bees wings, fines, and cracks
    - Sieve setting on combine
    - Screening at bin auger
  - Dry Grain--make sure the grain is dried down to at least 15%--preferably down to 13% then you’re assured of this grain not going out of condition.

- **During periods of slow drydown**
  - Dry grain storage is last option since molding will only get worse
  - Waiting for HMC moistures (24-32%) may not be option leaving HMEC at 32 – 40% moisture the next viable option.
When Are Molds Produced Within Silos?

- When temperature, moisture, and oxygen are present (all ensiled feedstuffs in general)
- Oxygen, and pH acts as “on-off” switch
- Moldy pockets may exist throughout silo
Incidence of Molds in Silage Based on International Studies

J. Fink-Gremmels, Netherlands
Mycotoxins in Forages Ch 11,
The Mycotoxin Blue Book

◆ **Penicillium rouqueforti** most prevalent
◆ **Aspergillus fumigatus** 2nd most prevalent
◆ **Monascus ruber** 3rd most prevalent
Characteristics of *Penicillium roquefortii*

- All Penicilliums alter silage quality
  - Reduced palatability
  - Depressed feed intakes
  - Result in production loss and health problems
- **Metabolic end-products produced and classified as mycotoxins**
  - Primary ones
    - PR toxin
    - mycophenolic acid
    - roquefortine
    - patulin
    - penicillic acid
  - Many others....

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The Mycotoxin Blue Book

Mycotoxins in Forages Ch 11, p 258-259
References to Impact of *Penicillium roquefortii* Mycotoxins on Cattle

- **Modified ruminal fermentation**
  - Antimicrobial effect on rumen microbes
  - Research

- **Altered central nervous system**
  - Neurotoxins (at high doses)
    - Patulin
    - Roquefortine C
  - Kellerman et al. 1984

- **Localized inflammatory responses**
  - E.g.: Rumenitis in cattle
    - Penicillic acid
    - Mycophenolic acid
  - Kopp-Holtwiesche and Rehm. 1990. Italy
Characteristics of *Aspergillus fumigatus*

- **Common soil contaminant**
- **Altered silage quality**
  - Reduced palatability
  - Depressed feed intakes
  - Result in production loss and health problems
- **Mycotic infections**
  - Sporadic abortions (Sarfati et al. 1996)
  - From consumption, orifice entry, and mold dust inhalation
- **Metabolic end-products produced and classified as mycotoxins**
  - Primary ones
    - verrucogen
    - fumitremorgens
    - Penitrem A
    - gliotoxin

*J. Fink-Gremmels, Netherlands*
*The Mycotoxin Blue Book*
*Mycotoxins in Forages Ch 11, p 258-259*
References to Impact of *Aspergillus fumigatus* Mycotoxins on Cattle

- **Hemmorhagic jejunal syndrome**
  - Immune Suppression
  - Gliotoxin + effects of T-2
  - Forsburg et al. Oregon.

- **Therapy resistant mastitis**
  - Fungus crosses intestinal barrier
    - produces gliotoxin in various tissues

- **Powerful immunosuppressive agent**
  - Mycotoxins
    - gliotoxin
    - verrucolegen
    - fumitremorgens
    - fumagillin
    - helvolic acide
  - Watanabe et al. 2003
Sometimes Molds Display Brilliant Colors…… Monascus ruber
References to Impact of Monascus Ruber Mycotoxins on Cattle

- Common soil contaminant
- More common in grass silages
  - Presence reduces prevalence of *P. rouquefortii*
- Altered silage quality
  - Reduced palatability
  - Depressed feed intakes
  - Result in production loss and health problems
- Mycotic infections
  - From consumption, orifice entry, and mold dust inhalation
- Metabolic end-products produced and classified as mycotoxins
  - Citrinin
    - Hepatotoxic
    - Nephrotoxic
    - Antimicrobial effect…therefore likely impacts rumen function

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The Mycotoxin Blue Book
Mycotoxins in Forages Ch 11, p 258-259
Effects of Molds on Cattle

- **Moldy corn and silage has a musty smell**
  - Unpalatability
  - Depressed intakes

- **Molds rob the corn of nutrient value**
  - Corn grain may have lowered starch content
  - Need to adjust rations to meet nutrient needs of the cow

- **Ingested molds can result in**
  - Rumen mycotic events
  - Abortions
  - Other systemic mycotic problems
Effects of Mycotoxins on Ruminants

Mycotoxin effects may be worse for cattle due to complexity of feed ingredients in ration (e.g. concentrates and silages)

Rumen has ability to degrade DON and zearalenone into other metabolites

Specific effects of various commonly known mycotoxins

- DON: high levels impede microbial protein production in rumen and perhaps has oxidative properties leading to immunosuppression
- Zearalenone: depressed fertility
- T-2: Hemorrhagic enteritis
- Aflatoxin: > 20 ppb will cause milk residues; toxic > 300 ppb

Mycotoxins unique to silage and produced by spoilage molds:

- PR
- Mycophenloic
- Ochratoxin
- Citrinin
- Patulin
Mycotoxin Tests Available

- **ELISA** (enzyme-linked immune stimulant assay)
  - fast, in house test
  - economical
  - general screen designed for dry grains only
  - **false positives** in forages and HM grains

- **Chromatography**
  - slower lab test
  - less economical
  - types
    - HPLC (high pressure liquid chromatography)
    - GC (gas chromatography)
    - TLC (thin layer chromatography)
Gas Chromatography Versus ELISA When Testing Forages For Mycotoxin

◆ Clean up procedure determines accuracy, precision, and reliability
  - Forage debris causes problems
  - Most ELISA kits don’t have clean up procedure

◆ ELISA may deliver false positive results

◆ Example:
  - Aflatoxin present with ELISA
  - Aflatoxin negative with gas chromatography
  - Aflatoxin is mainly a southeast U.S. problem
Feeding Management Guidelines

- Dilution is part of the solution
  - Test corn for mycotoxins
  - Then dilute in ration until mycotoxin concentration is below concern levels
  - E.G.: Cattle feeding guidelines suggest < 5 ppm in total ration fed to feeder cattle.
    - compromised corn shows 10 ppm DON and clean grain has no mycotoxin,
    - then the customer would blend no more than 50% compromised to 50% clean corn to obtain the 5 ppm level in the ration.

- If dry grain will be fed out over several months, make sure to monitor the corn for taking on moisture and hot spots and aerate as needed during bin storage. Otherwise further mycotoxin production may occur.

- Run mycotoxin tests on several samples during feedout for
  - DON, zearalenone, and T-2 in northern environments
  - Fumonisin and aflatoxin for southern environments

- Mycotoxin adsorbent advised regardless how much mycotoxin exists
  - Binding sites up being fed to the cattle.
  - There’s not good data showing the mycotoxin adsorbents work in cattle, but anecdotal observations from cattle feeders, veterinarians, and nutritionists is that the potential benefit outweighs the reason not to use adsorbents lacking scientific evidence as being efficacious for cattle.
  - Some mycotoxin binders include: 1) bentonite, 2) Novasil, 3) MTB-100, and AB-20. It’s best to see what the attending nutritionist or veterinarian is comfortable with when recommending use of one of these products.
Safety and Human Health in Working Around Moldy Silages

◆ Organic Dust Toxic Syndrome (ODTS)
  • Polyclonal cell activators creates acute cell mediated hypersensitivity inflammatory reaction
  • Creates “hypersensitivity pneumonitis”
  • Make-up of agricultural dust
    – Fungi and bacterial components
    – Mycotoxins not considered part of the make-up
    – Animal matter

◆ DO NOT SMELL MOLDY SILAGE!

Safety and Human Health in Working Around Moldy Silages

◆ Acute symptoms of ODTS
  - Headache
  - Malaise
  - Fever
  - Lethargy
  - Chills
  - Cough
  - Dyspnea

◆ Chronic symptoms of ODTS
  - Cough
  - Dyspnea
  - Depressed pulmonary function tests
  - Intermittent acute episodes
  - Interstitial fibrosis

Prevention and Management of ODTS

- Working around moldy silages
  - Open ventilation
  - Use masks with special filters
  - Do not directly inhale moldy silages

- Treatment of ODTS
  - Avoid precipitating factors
  - Corticosteroids

The End!

Questions?