Integrated Mycotoxin Management

Michigan Agribusiness Association 2020 Winter Conference
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MSU Department of Plant, Soil, and Microbial Sciences
Fungal Ear Rots

- Many of the issues with grain quality are the result of fungal activity

- Grain that is infected with ear rot is often unfit for food or feed

- Ear rots can produce mycotoxins (secondary metabolites) which can cause health problems in both humans and animals
Ear Rots

Other Factors
- Ex. Ear feeding insects

Environment
- Weather conditions
- Field management

Host
- Hybrid susceptibility
- Hybrid characteristics
- Crop growth stage (silking)

Pathogen

Disease
Contamination by Ear Rots and Mycotoxins

- Between 2012 and 2015 Michigan had an estimated yield loss of approximately 26 million bushels due to ear rots.

- During this same time, an estimated 44,000 bushels were contaminated by mycotoxins in the state of Michigan.

- Since 2015, outbreaks of mycotoxin contamination have occurred in the state of Michigan (2016 and 2018).

- Managing mycotoxin levels is important from a health and safety prospective along with an economic prospective.
Ear Rots in the U.S.

- Aspergillus Ear Rot (*Aspergillus flavus*)
- Fusarium Ear Rot (*Fusarium verticillioides*)
- Gibberella Ear Rot (*Fusarium graminearum*)
- Diplodia Ear Rot (*Stenocarpella maydis* and *S. macrospora*)
- Cladosporium Ear Rot (*Cladosporium spp.*)
- Nigrospora Ear Rot (*Nigrospora oryzae*)
- Penicillium Ear Rot (*Penicillium spp.*)
- Trichoderma Ear Rot (*Trichoderma spp.*)
Ear Rots in the U.S.

- Aspergillus Ear Rot (*Aspergillus flavus*)
- Fusarium Ear Rot (*Fusarium verticillioides*)
- Gibberella Ear Rot (*Fusarium graminearum*)
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- Penicillium Ear Rot (*Penicillium spp.*)
- Trichoderma Ear Rot (*Trichoderma spp.*)
Aspergillus ear rot (*Aspergillus flavus*)

- Olive-green ear rot
- Mycotoxin Produced
  - Aflatoxins
Fusarium ear rot (*Fusarium verticillioides*)

- Diseased kernels are often isolated
- Affected kernels appear tan or brown
- Kernels often have a starburst pattern

- Mycotoxin Produced
  - Fumonisins
Gibberella ear rot (*Fusarium graminearum*)

- Pink to red ear rot

- Mycotoxins Produced
  - Deoxynivalenol (DON)
    - Also known as vomitoxin
    - Causes:
      - Feed refusal
      - Vomiting
  - Zearalenone
Vomitoxin (Deoxynivalenol/DON) Discount Schedules in Michigan

Albion Grain Division
Corn Premium & Discount Schedule
*Subject to change without notice
Crop Year 2019-2020
Vomitoxin Discount Effective: 3/18/2019
5.1 and greater subject to rejection

CORN DISCOUNT SCHEDULE V1 09/15/17

Mac
michigan agricultural commodities, inc.
Michigan Agricultural Commodities, Inc
3346 Main St * Mariette, MI * Phone: (800) 647-4628
7115 Maple Valley * Brown City, MI * Phone: (800) 851-1448
CORN DISCOUNT SCHEDULE EFFECTIVE OCTOBER 22, 2019

YELOW CORN
ADM Grain - GRAND LEDGE, MI

VOMITOXIN

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<tr>
<td>0.0 - 7.0 ppm</td>
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>10 ppm subject to rejection

\[ \text{Discount} \]
Ear Rot and Mycotoxin Management

- **In-season**
  - Once an ear is infected, fungal growth may continue during post-harvest stages
  - **Goal:** alter conditions so that they are unfavorable for fungi i.e. reducing infection rates

- **Harvest and Drying**
  - Reduce the amount of mycotoxin contamination in harvested corn
  - Prevent further mycotoxin development in stored grain

- **Storage**
  - Limit fungal growth in storage
Management of Mycotoxins in Corn Grain
Host
Hybrid Selection

- Hybrid susceptibility/resistance
  - Silk resistance
  - Kernel resistance
- Hybrid morphology
  - Husk cover- tighter husk cover hold in more moisture
  - Ear erectness- erect ear holds more moisture
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<th>Root Strength</th>
<th>Stem Emergence</th>
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<th>Ear Flex</th>
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## Dekalb® Corn

### DKC54-38RIB Brand Blend

**164-DAY RM**

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<thead>
<tr>
<th>Category</th>
<th>Characteristic</th>
<th>Value</th>
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<td>Ear Placement</td>
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</table>

### Key Strengths
- Very good top-end yield potential
- Very good Goss’s Wilt tolerance
- Solid roots and stalks
- Good greensnap tolerance

### Management Tips
- Position in areas with moderate or worse Goss’s Wilt pressure
- Position as a product that performs well in the 100, 105 and 110 RM zones

### Plant Description
- **Leaf Color**: Dark Green
- **Anther Color**: Green - Yellow
- **Kernel Row**: 10-20
- **Kernel Cap Color**: Yellow
- **Color Code**: Red

### Diseases
- **Dipodia Ear Rot**: P

### Harvest
- **Ear Spots**: 2

### Diseases
- **Corn Earworm**: 3
- **Southern Corn Leaf Blight**: 3
- **Gray Leaf Spot**: 3
- **Eye Spot**: 3

### Management Tips
- Performs well with northern movement but later flowering might be limiting
- Good performance in areas with moderate or less drought stress

## Dekalb® Corn

### DKC55-20RIB Brand Blend

**165-DAY RM**

<table>
<thead>
<tr>
<th>Category</th>
<th>Characteristic</th>
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</table>

### Key Strengths
- High yield potential in many environments
- Very good Goss’s Wilt tolerance
- Maintains performance under drought stress
- Very gritty ears with deep kernels
- Solid overall agronomic package with very nice late season appearance

### Plant Description
- **Leaf Color**: Dark Green
- **Anther Color**: Green - Yellow
- **Kernel Row**: 20-22
- **Kernel Cap Color**: Yellow
- **Color Code**: Red

### Management Tips
- Plant at medium to medium-high populations
- Performs well with northern movement but later flowering might be limiting
- Very good late season health and strong yield performance in the 110 RM
  - RM indicates good southern movement
Host Plant Resistance- Ear Rot Incidence

**Washtenaw 2017**
- ERI (%)
- Ear Rot Rating: Below Average, Average, Above Average
- p-value: 0.0005

**Huron 2018**
- ERI (%)
- Ear Rot Rating: Below Average, Average, Above Average
- p-value: 0.051

**Montcalm 2018**
- ERI (%)
- Ear Rot Rating: Below Average, Average, Above Average
- p-value: 0.98

**Saginaw 2018**
- ERI (%)
- Ear Rot Rating: Below Average, Average, Above Average
- p-value: 0.99

No consistent difference
Host Plant Resistance - Ear Rot Severity

**Washtenaw 2017**
- ERS (%)
  - Below Average: b
  - Average: ab
  - Above Average: a
- No consistent difference

**Huron 2018**
- ERS (%)
  - Below Average: bc
  - Average: bc
  - Above Average: c
- No consistent difference

**Montcalm 2018**
- ERS (%)
  - Below Average: a
  - Average: a
  - Above Average: a

**Saginaw 2018**
- ERS (%)
  - Below Average: a
  - Average: a
  - Above Average: a

**Statistical Results**
- p=0.015
- p=0.21
- p=0.021
- p=0.94

No consistent difference
Reduce Overall Plant Stress

- Drought stress can increase aflatoxins in corn due to increased susceptibility to *A. flavus*

- High aflatoxin levels have been associated with fertility and weed stress

- In one study increased nitrogen rates consistently reduces aflatoxin levels
Management of Mycotoxins in Corn Grain

Pathogen

Host

Disease

Environment

Other Factors

Pathogen
Residue Reduction: Crop rotation and Tillage

- Inoculum is often from infected residues left in the field
- Avoid corn on corn
- Wheat affected by Fusarium head blight *Fusarium graminearum* = *Gibberella zeae*
- Greater risk of infection in corn following wheat vs alfalfa
- Conventional tillage may reduce ear rot incidence
Fungicide application

- Fungicides have been shown to decrease DON levels in some experiments, but this reduction is not always present.
- Timing is important.
- Fungicide chemistry is important (do not use strobilurins).
- Environmental conditions may determine fungicide efficacy.

[(Limay-Rios and Schaafsma, 2018)](https://example.com)
Fungicide- Ear Rot Severity

**Huron 2018**

- **Treated:**
  - ERS (%): 16

- **Non-treated:**
  - ERS (%): 18

**Montcalm 2018**

- **Treated:**
  - ERS (%): 8

- **Non-treated:**
  - ERS (%): 9

- **Pathogen:**
  - Huron 2018: p=0.038
  - Montcalm 2018: p=0.93
Fungicide- Deoxynivalenol

Fungicide did not reduce DON levels

Pathogen
Management of Mycotoxins in Corn Grain Environment
Planting Date

- Earlier planting dates generally result in a lower risk of fungal infection
  - Later planting dates generally lead to a delay in harvest which can affect dry down conditions that the crop is exposed to
- Yearly weather differences can jeopardize this advantage
Higher population densities result in higher ear rot and mycotoxin levels
- 15-56% increase in ear rot severity in three out of four years with a high population (33,200 plants $a^{-1}$) vs. a low population (26,300 plants $a^{-1}$)

Microclimatic conditions are altered as population increases

Higher populations lead to lower air flow and higher relative humidity
DON Forecasting

- Modeling efforts can be used to do a better job estimating the probability of disease in a specific region or field.
- Models can be used to make decisions about other management strategies.
- Researchers in Michigan and other nearby regions such as Ontario are working to create DON forecasting models.
Management of Mycotoxins in Corn Grain
Other Factors
Managing Ear Feeding Insects

- Physically injured kernels have a higher incidence of ear rot injury
- Wounds are an entry point for fungal spores into the ear
- Studies have found correlations between western bean cutworm damage and Gibberella ear rot
WBC and Ear Rot Incidence

**Washtenaw 2017**

- **0 mm rainfall 10 days after R1**
- \( y = 1.0594x - 5.7138 \)
- \( R^2 = 0.65 \)
- \( P < 0.001 \)

**Montcalm 2018**

- **5 mm rainfall 10 days after R1**
- \( y = 0.732x + 41.42 \)
- \( R^2 = 0.41 \)
- \( P < 0.001 \)

**Huron 2018**

- **54 mm rainfall 10 days after R1**
- \( y = 0.4399x + 68.022 \)
- \( R^2 = 0.16 \)
- \( P < 0.001 \)

**Saginaw 2018**

- **47 mm rainfall 10 days after R1**
- \( y = 0.7119x + 55.929 \)
- \( R^2 = 0.15 \)
- \( P = 0.02 \)

Other Factors

Rainfall 10 days after R1:
- 0 mm
- 5 mm
- 54 mm
- 47 mm
Ear Feeding Insect Issues in Michigan

- **Western Bean Cutworm**
  - Has been in Michigan since 2006
  - Cry1F no longer offers control due to resistance

- **European Corn Borer**
  - Regularly found in Michigan on organic or non-Bt corn
  - Not much of an issue in Michigan on Bt corn
  - Resistance found in eastern Canada to Cry1F Bt

- **Corn Earworm**
  - Little concern in the past 20 years due to Bt traits
  - Surprise for many growers in 2019- moved north earlier along with resistance issues to Cry1A.105 and Cry2Ab2
Hybrid Selection

- The use of Bt traits to control European corn borer was associated with a reduction in mycotoxin contamination

- Knowing what traits to use is important
  - Handy Bt Trait Table
### The Handy Bt Trait Table for U.S. Corn Production

The latest version of the table is always posted at [https://www.texasinsects.org/bt-corn-trait-table.html](https://www.texasinsects.org/bt-corn-trait-table.html).

For questions & corrections: Chris DiFonzo, Michigan State Univ., difonzo@msu.edu

Contributor: Pat Porter, Texas A&M University (web site host)

**Updated May 2019**

The Handy Bt Trait Table provides a helpful list of trait names (below) and details of trait packages (over) to make it easier to understand company seed guides, sales materials, and tag bags. This latest version incorporates two new findings of resistance, and categorizes western & northern corn rootworm separately.

**Breaking News #1:** Entomologists at the University of Guelph in Canada confirmed European corn borer (ECB) resistance to Cry1F Bt (the Herculex I trait) in corn. In 2019, ECB populations were collected from multiple locations in the Maritime Provinces of eastern Canada where unexpected damage was reported. Lab bioassays showed a high level of resistance to Cry1F; the registrant of the trait independently confirmed the results. This is the first case of field-evolved resistance by ECB to Bt corn.

Use of single-trait hybrids likely contributed to the problem. In eastern Canada, hybrids with only one Bt trait (Cry1F) were still being sold & planted, well after an expected phase out in favor of multi-Bt pyramids to allow for reduced 5% refuge. Although the Maritime provinces are far from the major corn production area in the central U.S., the bioassay results demonstrate that ECB resistance to Bt corn can happen, and that phasing out single-trait hybrids is critical. In short-growing season areas of the U.S. and Canada, seed options tend to be limited, so single-trait hybrids may still be available. Using them risks the development of additional resistant insect populations.

**Breaking News #2:** Entomologists at North Dakota State University confirmed northern corn rootworm resistance to Cry3Bb1 and Cry34Ab1/Cry35Ab1. Although resistance to multiple traits is well-documented in the Midwest for western corn rootworm, this is the first confirmation of field-evolved resistance by the northern corn rootworm.

<table>
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<tr>
<th>Field corn 'events' (transformations of one or more genes) and their Trade Names</th>
<th>Herbicide targets</th>
<th>Non-Bt refuge % (center)</th>
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<td>Agrigold GT</td>
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<td>EPSPS, glyphosate</td>
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<tr>
<td>Agrigold Rv</td>
<td>MR604</td>
<td>mCry3A</td>
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<td>Agrigold Vipera</td>
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<td>ViPsAa20</td>
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<td>Enlist</td>
<td>DAS-GT272</td>
<td>2,4-D &amp; herbicide detoxification</td>
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<td>Herculex (HtX) or CB</td>
<td>TC1307</td>
<td>Cry1Fe3 + PAT</td>
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<tr>
<td>Herculex CRX</td>
<td>DAS-59222-7</td>
<td>Cry3Ab1 + Cry35Ab1 + PAT</td>
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<td>Herculex XR</td>
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<td>Cry3Ab1 + Cry35Ab1 + PAT</td>
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<td>Roundup Ready 2</td>
<td>NK603</td>
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<tr>
<td>Yieldgard Corn Borer</td>
<td>MON810</td>
<td>Cry1Ab</td>
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<td>Yieldgard Rootworm</td>
<td>MON863</td>
<td>Cry3b1</td>
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<td>Yieldgard VT Pro</td>
<td>MON89034</td>
<td>Cry105 + Cry2Ab2</td>
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<tr>
<td>Yieldgard VT Rootworm</td>
<td>MON89037</td>
<td>Cry3b1 + EPSPS</td>
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**Abbreviations used in the Trait Table**

- *Insect targets*
  - SB = stalk borer
  - BCW = black cutworm
  - SCB = sugarcane borer
  - CEW = corn earworm
  - ECB = European corn borer
  - TAW = true armyworm
  - FAW = fall armyworm
  - WBC = western bean cutworm
- *Herbicide traits*
  - GT = glyphosate tolerant
  - LL = Liberty Link - glyphosate-tolerant
  - RR2 = Roundup Ready 2, glyphosate-tolerant
Bt Trait Selection

- Bt trait selection is important
  - Traits that control for European corn borer (Cy1A, Cry1Ab, and Cry2Ab) have no effect on WBC
  - Western bean cutworm
    - Cry1F
    - Vip3A
Cry1F for WBC control

No difference between SmartStax & VT Double PRO hybrids

Other Factors
Insect Trait Package-Agrisure Viptera

Viptera lowered WBC levels during the 2018 growing season.
Insect Trait Package-Agrisure Viptera

Viptera effect on DON levels was limited to one out of three locations in 2018

Huron 2018

Montcalm 2018

Saginaw 2018

Other Factors
Insecticide

- Recommended threshold in the Great Lakes region for WBC control
  - Cumulative threshold of 5% of plants
- One study in the Great Lakes region has shown 38-88% decrease in WBC incidence and 55-95% decrease in WBC severity
  - Plots with insecticides targeting early instar generally had lower DON levels than fungicides alone
  - Insecticides did not provide complete protection from injury
- Insecticide-fungicide tank mix recommended at R1 (silking) to optimize fungicide protection
Integrated Mycotoxin Management

- Hybrid selection
- Residue management
  - Crop rotation
  - Tillage
- Reduce plant stress
- Manage for uniformity
- WBC control (traits, scout and spray)
- Fungicide application (timing, chemistry)
- Harvest high risk fields first
- Post-harvest drying
Future Research- Silage Mycotoxin Management

- Objectives: Study how various management strategies impact ear rots, mycotoxins, silage yield, and silage quality
  - Determine the effects of a **foliar fungicide** in hybrids with differing **ear rot resistance** and **insect protection traits**
  - Quantify the role of **planting date** and **population**
  - Investigate impacts of various **agronomic practices**

<table>
<thead>
<tr>
<th>Experiment #1</th>
<th>Experiment #2</th>
<th>Experiment #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huron, Ingham, Ottawa counties</td>
<td>Ingham county</td>
<td>Collect samples from across the state of Michigan</td>
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<td>6 hybrids</td>
<td>3 planting dates (5/17, 5/27, 6/19)</td>
<td>Gather info about field management</td>
</tr>
<tr>
<td>Fungicide application</td>
<td>4 populations (28k-46k)</td>
<td></td>
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</tbody>
</table>
Questions?

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