Practicality of Managing Mycotoxins in our Grain System

Grain Farmers of Ontario
Grain Farmers of Ontario

Our Vision:

• To drive the Ontario grain industry to become a global leader

Our Mission:

• To develop and promote an innovative and successful business environment which will allow our farmer members the opportunity for profitable growth
Grain Farmers of Ontario

• 28,000 farmer members
• 5 million acres growing the three largest crops in Ontario:
  
  Corn: 5.5 million tonnes

  Soybeans: 2.3 million tonnes

  Wheat: 1.5 million tonnes
Grain Farmers of Ontario

Research & Innovation

- Set research priorities to influence the sector
- Invest $1.5 M annually in agricultural research
- Leverage our investment through funding programs, total contribution of $5.5 M in 2012
Mycotoxins in Ontario

Deoxynivalenol (DON, vomitoxin) produced by *Fusarium/Gibberella*
- Ochratoxin A produced by *Penicillium verrucosum*
- Zearalenone produced by *Fusarium/Gibberella*
- Fumonisin produced by *Fusarium*
- T-2 and HT-2 produced by *Fusarium*
- Alkaloids produced by ergot

*Fusarium* head blight
*D. Malvick, University of Illinois*

*Gibberella* ear rot
*A. Roberts, Iowa State University*

*Fusarium* ear rot
*G. Munkvold, Iowa State University*
Mycotoxins in Ontario

Weather and microclimates are the #1 factor in disease development

Corn

- Gibberella can infect through silks or establish after pollination in wounds created by insects or birds
- Rainy weather or long dews any time after pollination may lead to Gibberella ear rot in wounded cobs
- Extended periods of rain in the fall delay dry down and can increase disease severity

Bird damage
OMAFRA
Mycotoxins in Ontario

• Southern Ontario and NY State have the most severe and frequent DON problems in North America, levels decrease as you move West

• Mycotoxin development is variable across the province, but we see Gibberella and Fusarium every year in Ontario

• Most corn and wheat used domestically - Great Lakes Basin
Breeding for Disease Resistance

Breeding for resistance is likely the most effective way to control disease, economically and environmentally.

Challenges in corn breeding

- Possible to breed highly resistant inbred-lines, but usually they have low yield potential.
- Private breeders have many resources but tend to focus on yield.
- Different modes of fungal entry; through silks or kernel wounds.
- Mechanisms of resistance: resist invasion, spreading, toxin accumulation, kernel infection, or tolerance of infection.
- It can take 10 – 20 yrs to get a good hybrid to market.
Breeding for Disease Resistance

Advancements in corn breeding

- Understand the many factors at play: kernel composition, cob composition, husk tightness, husk cover, silk characteristics, ear inclination, insect resistance, secondary metabolite production
- Insect resistance/Bt has reduced points of infection for disease
- Continued improvements with marker assisted breeding, although in-season typically use phenotypic selection
Breeding for Disease Resistance

Advancements in **wheat breeding**

- Improved implementation of screening programs using artificial inoculation
- Winter hardy spring wheat for faster breeding cycle (UofG)
- Variety registration requirements drive continued improvements in resistance
Research Projects on Breeding for Resistance

GFO and founding organizations have a long history of investing in public research on solutions for fungal diseases and mycotoxins

- Molecular approaches toward improving *Fusarium graminearum* resistance in corn
  *P. Pauls, U of Guelph. 2006-2007*

- *Fusarium* resistant corn inbreds
  *L. Kott, U of Guelph. 2009-2012*

- Evaluating effectiveness of transgenes in reducing DON in corn
  *P. Pauls, U of Guelph. 2011-2013*
Research Projects on Breeding for Resistance

- Advancing Canadian field crops through breeding for production, efficiency, pest resistance and consumer quality

Canadian Field Crop Research Coalition, DIAP funding

- Development of corn inbreds with improved resistance to Gibberella ear rot as well as rapid kernel dry down
  - L. Reid, AAFC

- Marker development for alleles for FHB resistance in wheat
  - G. Fedak, AAFC

- Development of new winter wheat cultivars with improved Fusarium resistance
  - L. Tamburic, U of Guelph

- Monitor changes in populations of Fusarium spp. and mycotoxin profiles
  - L. Tamburic, U of Guelph
Seed Selection to Mitigate Toxin Accumulation

• Most important factor in farmer’s control for mitigating risk is variety/hybrid selection
• Consider disease susceptibility, stand-ability, maturity and yield performance
• Maturity a key factor
  ✓ Later maturing hybrids capture max yield potential with early planting, normal heat units accrued, lack of early frost
  ✓ If these things don’t happen dry down period may be longer
Seed Selection to Mitigate Toxin Accumulation

Wheat in Ontario
• Variety registration required, includes disease susceptibility compared to resistant check/control varieties

Corn in Ontario
• Registration not required, info on disease susceptibility not available to farmers
• Bt hybrids which reduce insect damage have reduced level of fungal infection
Agronomics for Mitigating Toxin Accumulation

Disease survives in crop residue in the field

• It is possible to have limited visible mould and relatively high levels of mycotoxins

• Management options to reduce risk:
  ✓ Crop rotation
  ✓ Tillage
  ✓ Good fertility program to reduce crop stress
  ✓ Fungicide application or biological controls
  ✓ Insect control
  ✓ Scouting to prioritize harvest and storage, determine need for toxin tests
  ✓ Harvest timing
Agronomics for Mitigating Toxin Accumulation

- Majority of wheat acres in Ontario are sprayed with fungicide
- Strobilurin fungicides can increase mycotoxin levels
- Proline® is the only product registered in corn for *Fusarium*, an expensive option
- Spraying fungicides in corn requires specialized equipment
Research on Agronomics

DONcast

Weather Innovations

- Developed with support from Ontario Wheat Producers
- Predicts DON accumulation levels based on weather
- Online tool to assist farmers in making decisions about spraying fungicides
Research on Agronomics

Management of mycotoxins and insect damage in Ontario grain corn

A. Schaafsma, U of Guelph. 2012-2014

- Study the biological significance of interactions among ear-feeding insect pests, ear mould pathogens and mycotoxin accumulation in grain corn
- Focused on Western bean cutworm and Gibberella ear mould
Research on Agronomics

Development of an integrated mycotoxin management system in Ontario cereals
A. Schaafsma, U of Guelph, 2008-2012
  • In-crop surveillance, weather based forecasting, analytical support, hybrid selection and fungicide application technology

Development of novel methods to control Fusarium head blight and sclerotinia stem rot
G. Subramaniam, AAFC, 2011-2014
  • Prime the immune response of wheat with non-virulent strains of Fusarium to protect from future infection
  • Development of a bio-pesticide
Harvesting Infected Grain

- Harvest affected fields first to mitigate toxin accumulation, and dry to reduce moisture quickly
- Adjust combine for maximum cleaning to minimize number of infected kernels and fines
- Set equipment to leave tip kernels attached to cob
- Additional post-combine grain cleaning may reduce mycotoxin levels in remaining grain
Grain Inspection

- Standards based on FDK, which is very subjective
- Many grain elevators monitor for mycotoxins, but do not test each incoming lot unless a bad year
- Current accurate testing methodologies are too technical and time consuming for use at elevators
- Quick tests typically measure above or below a threshold toxin level, do not quantify
Grain Inspection

- Proper sampling is critical for accurate toxin analysis

<table>
<thead>
<tr>
<th>Class and Grade</th>
<th>Allowable levels of fusarium-damaged kernels (% by weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft White Spring/White Winter</td>
<td></td>
</tr>
<tr>
<td>No. 1 CE</td>
<td>1.0 %</td>
</tr>
<tr>
<td>No. 2 CE</td>
<td>1.0 %</td>
</tr>
<tr>
<td>No. 3 CE</td>
<td>1.0 %</td>
</tr>
<tr>
<td>CE Feed Wheat</td>
<td>5.0 %</td>
</tr>
<tr>
<td>CE Feed Durum</td>
<td>5.0 %</td>
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</tbody>
</table>

[Image of grains]  
[Website: www.grainscanada.gc.ca]
Storage of Infected Grain

- DON levels do not typically increase in proper storage
- Ochratoxin A (OTA) accumulates during storage
- Elevators practice good management to prevent mould and toxin accumulation in stored grain
- Grading and sampling occurs when grain is still in truck
Storage of Infected Grain

• In practice, can be difficult to get good segregation at elevators
  ✓ Typically have 1 or 2 receiving pits and just 1 dryer
  ✓ Some dryers are continuous feed
  ✓ Harvest period condensed, larger amount of grain coming in shorter period of time

• Blending at elevators can add value and is typically done by end users
  ✓ FDA recently approved blending of corn containing aflatoxin in Iowa

• Increased on-farm storage a challenge for dealers, testing does not occur until grain reaches end user
Ochratoxin A (OTA) Management

Current study:

Integrated management system of OTA in winter wheat

A. Schaafsma, U of Guelph
Funded by GFO and CAAP program

- Survey of 40 on-farm storage bins for OTA and *P. verrucosum*
- Monitoring 20 farms for *P. verrucosum* in soil, residue on equipment, residue in bins, hand harvested grain in field and in tram lines
- Mini bin study with sensors for temperature, relative humidity and fungal growth and grain stored in conditions conducive to toxin accumulation
Ochratoxin A (OTA) Management

Integrated management system of OTA in winter wheat

Results to date:

• 28% of sampled bins tested positive for *P. verrucosum*, 1 bin out of 40 positive for OTA
• Highest concentration of *P. verrucosum* in roof of bin near grain down spout, where condensation occurring
• Hand harvested grain only positive for *P. verrucosum* where wheat heads touched the ground (in tram lines)
Market Opportunities for Contaminated Grain

• Testing must occur before grain enters food production chain
• Mycotoxins are stable, cannot clean the grain to remove or break down by cooking/heating
• If contaminated grain is segregated it can move into different markets
• Potential for IP wheat markets for baby food
• Can use feed additives that reduce mycotoxin bioavailability
Market Opportunities for Grain
Mycotoxin Epidemics in Ontario

1996 *Fusarium* epidemic in wheat
- 40% yield loss of wheat
- 90% of wheat graded feed
- Stakeholders came together and developed strategies to diminish effects
- Advancements made in breeding, variety registration, production recommendations

1986 and 2006 *Gibberella* epidemics in corn
- High cost to grain and swine producers
- Lack of coordinated effort to mitigate effects
- More opportunity to manage contaminated corn than wheat, multiple end uses, greater volumes
Research Funding Program

• Mycotoxin issues are always ranked as a high priority when we survey our members on research topics

• Good research proposals on mycotoxin issues are always favourably reviewed by the GFO Research Committee

• Throughout the history of our founding organizations and GFO, Ontario farmers have been investing in research on issues related to fungal diseases and mycotoxins
<table>
<thead>
<tr>
<th>Project Title</th>
<th>Year Initiated</th>
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</thead>
<tbody>
<tr>
<td>Measuring ear mold tolerance in corn</td>
<td>1987</td>
</tr>
<tr>
<td>Rapid method for assessing <em>Gibberella</em> ear rot in resistance in segregating germlasm</td>
<td>1988</td>
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<tr>
<td>Screening of Ontario corn hybrids for ear mold resistance</td>
<td>1988</td>
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<tr>
<td>Mycotoxin testing for Ontario corn samples</td>
<td>1990</td>
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<tr>
<td>Testing corn hybrids for resistance to <em>Gibberella</em> ear rot</td>
<td>1991</td>
</tr>
<tr>
<td>Screening corn hybrids for resistance to <em>Fusarium</em> ear rot</td>
<td>1991</td>
</tr>
<tr>
<td>Management of <em>Fusarium</em> toxins: Temperature effects on epidemiology</td>
<td>1997</td>
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<tr>
<td><em>Fusarium</em> resistance and genetic improvements via biotechnology</td>
<td>1997</td>
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<tr>
<td>Development of multiple pest resistance in Ontario</td>
<td>2001</td>
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<tr>
<td>Molecular approaches toward improving <em>Fusarium</em> resistance in corn</td>
<td>2006</td>
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<tr>
<td>Learning from 2006 to reduce future impacts of <em>Fusarium</em> epidemics to stakeholders in the corn industry</td>
<td>2006</td>
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<tr>
<td>Standardization of sampling and analytical procedures for vomitoxin testing in corn</td>
<td>2007</td>
</tr>
<tr>
<td>Strategic fungicide application advisory for diseases in corn</td>
<td>2008</td>
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Moving Forward

• Continued research in breeding, production, and storage
• Open dialogue with regulators, seed developers, farmers and end users
• Continued education of farmers
• Development of practical solutions to mitigating mycotoxin accumulation and handling contaminated grain
Thank you for your time

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