# 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

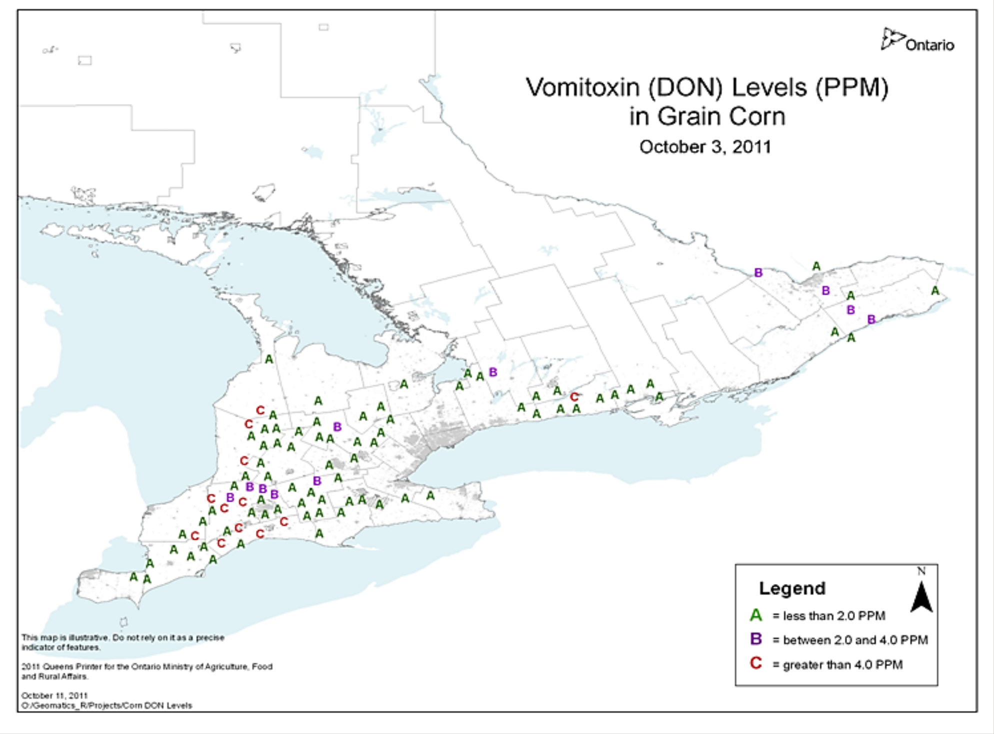
## Corn

- *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

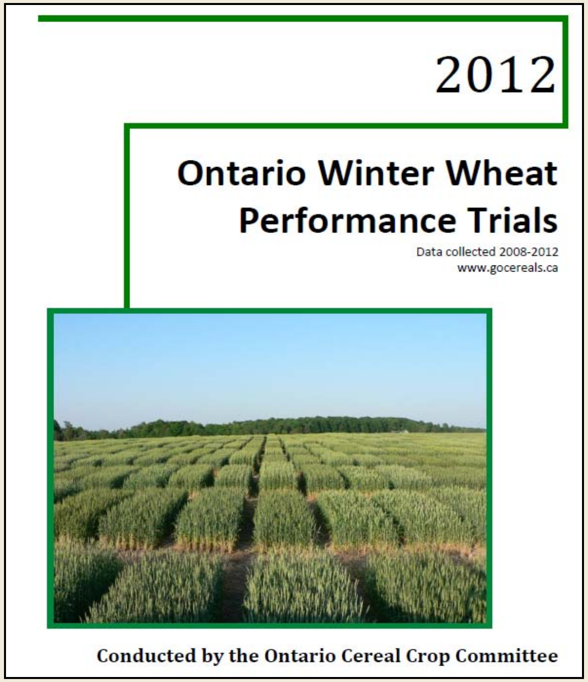
# Seed Selection to Mitigate Toxin Accumulation

## 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

| Class and Grade | Allowable levels of fusarium-damaged kernels (% by weight) |
|---|---|
| **Soft White Spring/White Winter/Amber Durum** | |
| No. 1 CE | 1.0 % |
| No. 2 CE | 1.0 % |
| No. 3 CE | 1.0 % |
| CE Feed Wheat | 5.0 % |
| CE Feed Durum | 5.0 % |

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

GRAIN FARMERS OF ONTARIO

# 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

| Project Title | Year Initiated |
|---|---|
| Measuring ear mold tolerance in corn | 1987 |
| Rapid method for assessing *Gibberella* ear rot in resistance in segregating germplasm | 1988 |
| Screening of Ontario corn hybrids for ear mold resistance | 1988 |
| Mycotoxin testing for Ontario corn samples | 1990 |
| Testing corn hybrids for resistance to *Gibberella* ear rot | 1991 |
| Screening corn hybrids for resistance to *Fusarium* ear rot | 1991 |
| Management of *Fusarium* toxins: Temperature effects on epidemiology | 1997 |
| *Fusarium* resistance and genetic improvements via biotechnology | 1997 |
| Development of multiple pest resistance in Ontario | 2001 |
| Molecular approaches toward improving *Fusarium* resistance in corn | 2006 |
| Learning from 2006 to reduce future impacts of *Fusarium* epidemics to stakeholders in the corn industry | 2006 |
| Standardization of sampling and analytical procedures for vomitoxin testing in corn | 2007 |
| Strategic fungicide application advisory for diseases in corn | 2008 |

# 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


**Grain Farmers of Ontario**

100 Stone Road West
Suite 201
Guelph, ON  N1G 5L3

Tel:  1-800-265-0550
Fax:  1-519-767-9713

www.gfo.ca