Translational Research for the Management of Ear Rots and Mycotoxins in Corn

2016 Indiana CCA Conference
Indianapolis, IN
December 14, 2016

Cornmycotoxins.com
Your source for ear rot & mycotoxin information
Corntoxins.org
Funding provided by USDA NIFA

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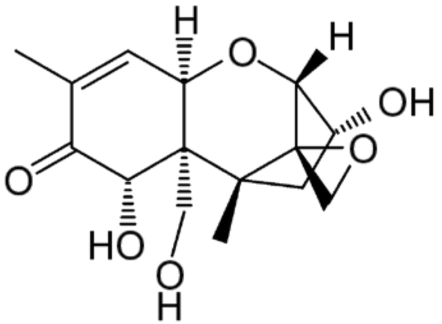
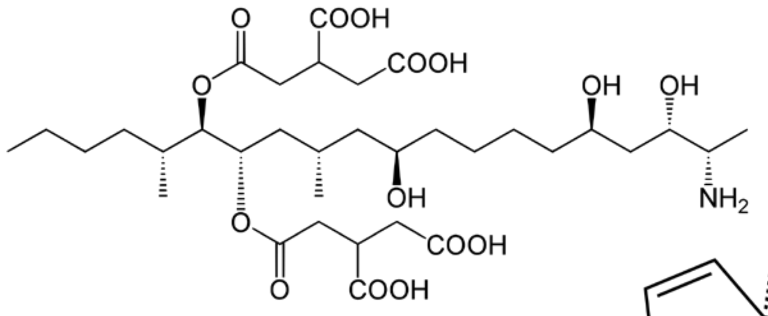
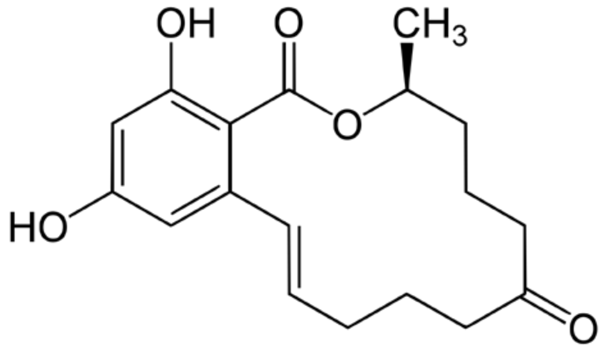
1. Review preharvest ear rots and mycotoxins
2. What happened in 2016?
3. Information resources
4. Research effort

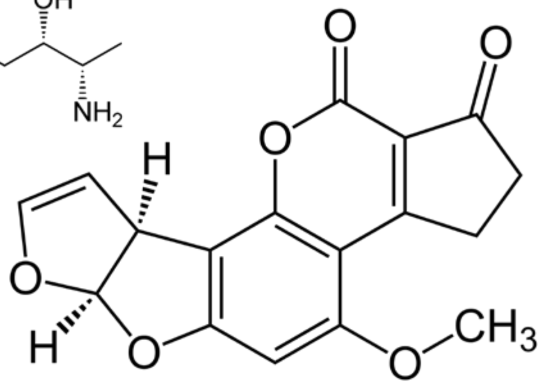
Mycotoxins



- Compounds produced by fungi that accumulate in grains
- Extremely stable
- Toxic if consumed by humans and/or livestock







Ear Rots in Indiana Corn Crop

Aspergillus Ear rot

Gibberella Ear Rot

Fusarium Ear Rot

Diplodia Ear Rot

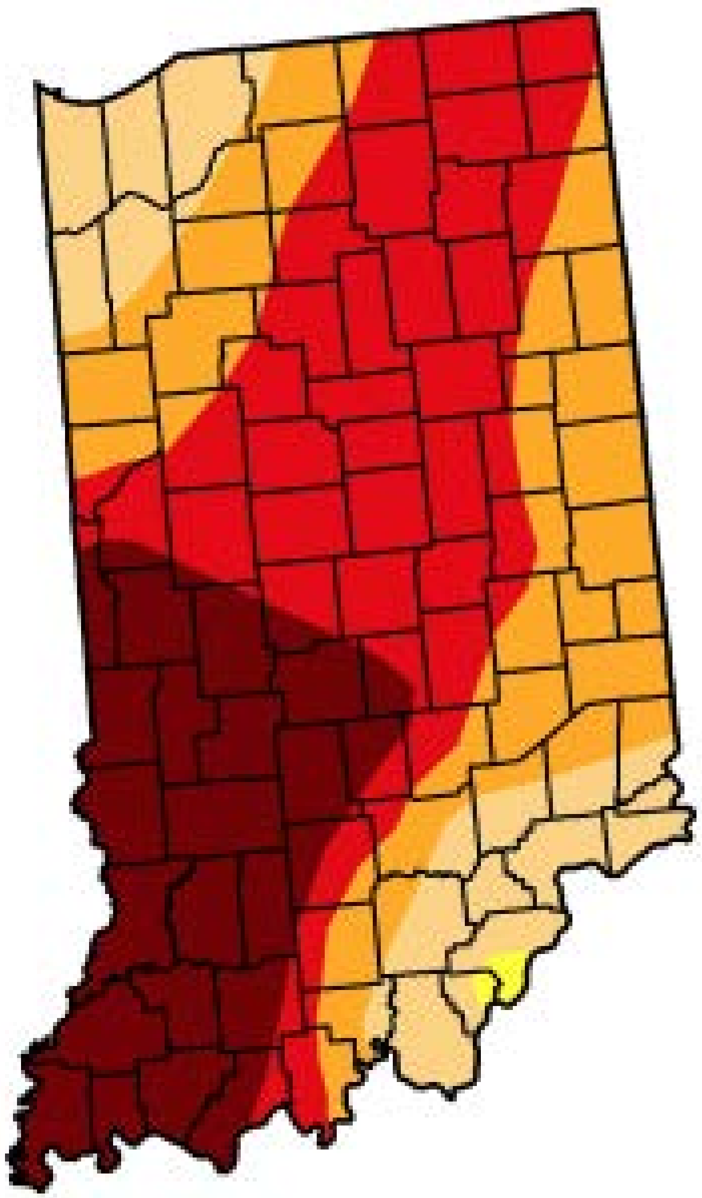
ASPERGILLUS EAR ROT

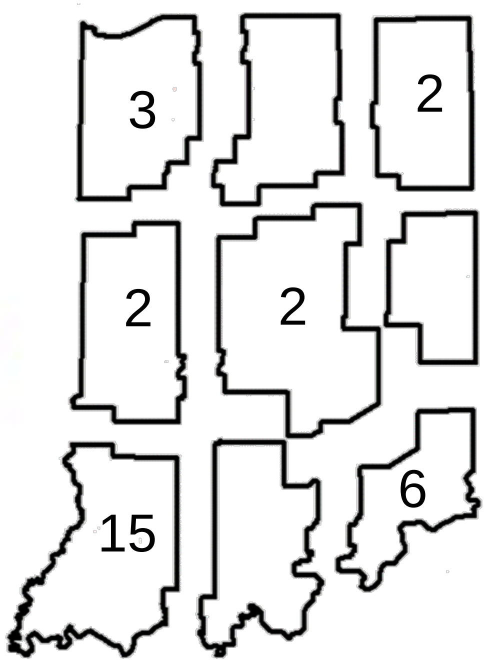
Aflatoxins	Hepatotoxicity, cancer, immunosuppression

Factors affecting Aspergillus Ear Rot Diseases

Inoculum Source	Host Resistance	Conducive Environment
Soil, Debris	Very Little	Drought &Heat Stress

2012: Drought and heat resulted in many reports of aflatoxin





Gibberella Ear Rot

Head Blight (Scab)

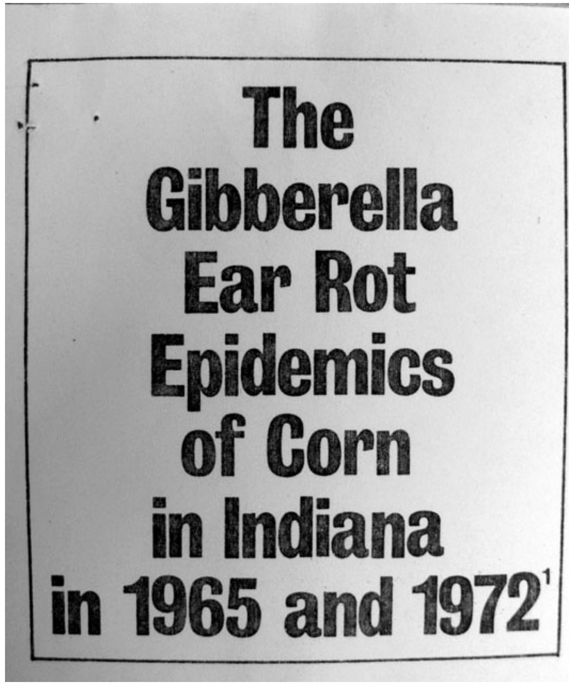
Deoxynivalenol Vomitoxin, DON	Gastrointestinal toxicity, inflammation of central nervous system
Zearalenone	Infertility, abortions, other reproductive problems

Factors Affecting Gib Ear Rot Disease

Inoculum Source	Host Resistance	Conducive Environment
Debris	Very Little	Cool & Wet @ Flowering

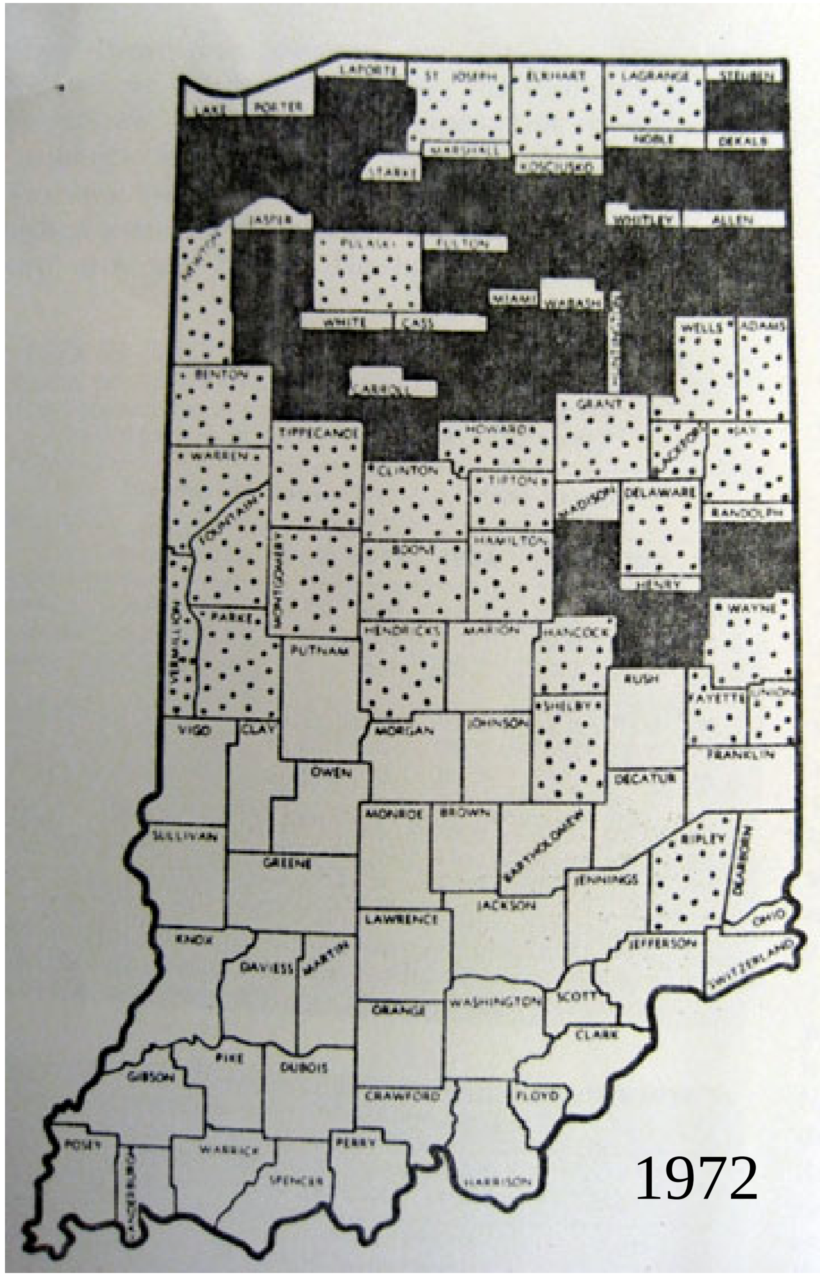
2009: Excessive rain and cool temperatures resulted in many reports of DON in North

- Reports of livestock feeding issues
- Issues with dockage due to damage and high levels of mycotoxins
- Loads rejected at elevators and refused at ethanol plants



The Gibberella Ear Rot Epidemics of Corn in Indiana in 1965 and 1972[1]

J. Tuite, G. Shaner, G. Rambo,
J. Foster, and R. Caldwell
Cereal Science Today 1974



1972

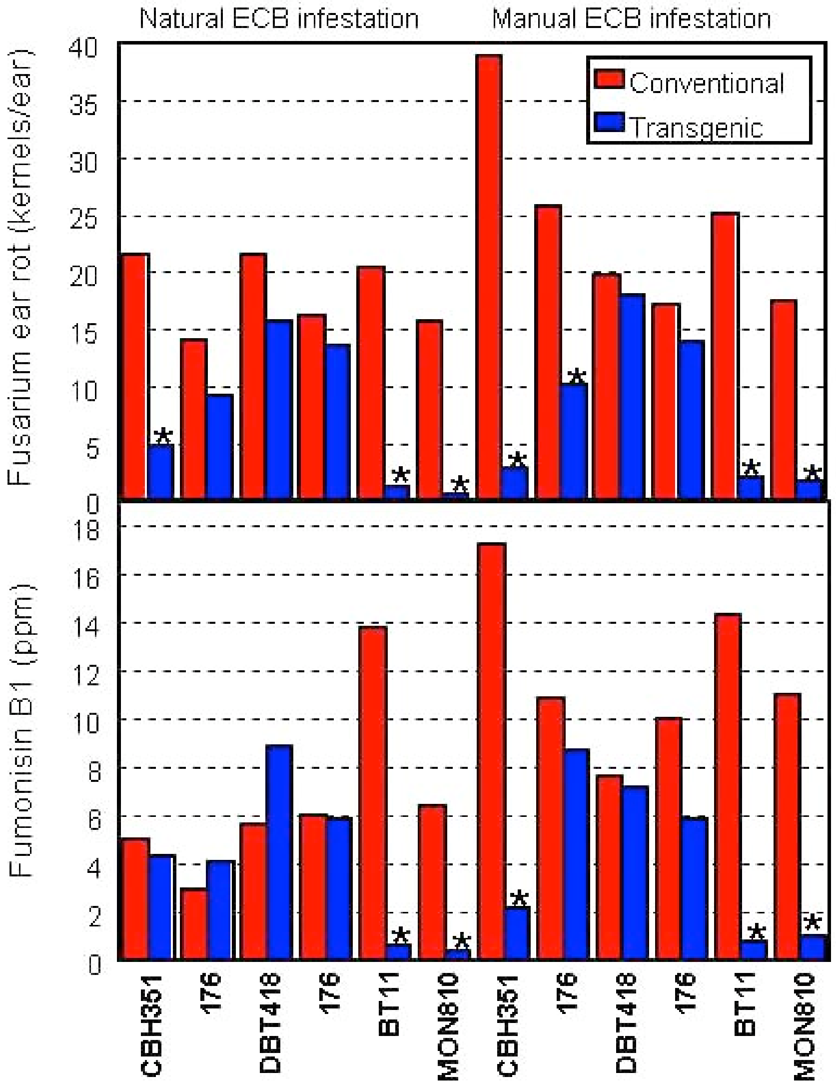
FUSARIUM EAR ROT

Fumonisins	Hepatotoxicity, cancer, pulmonary edema, leukoencephalomalacia

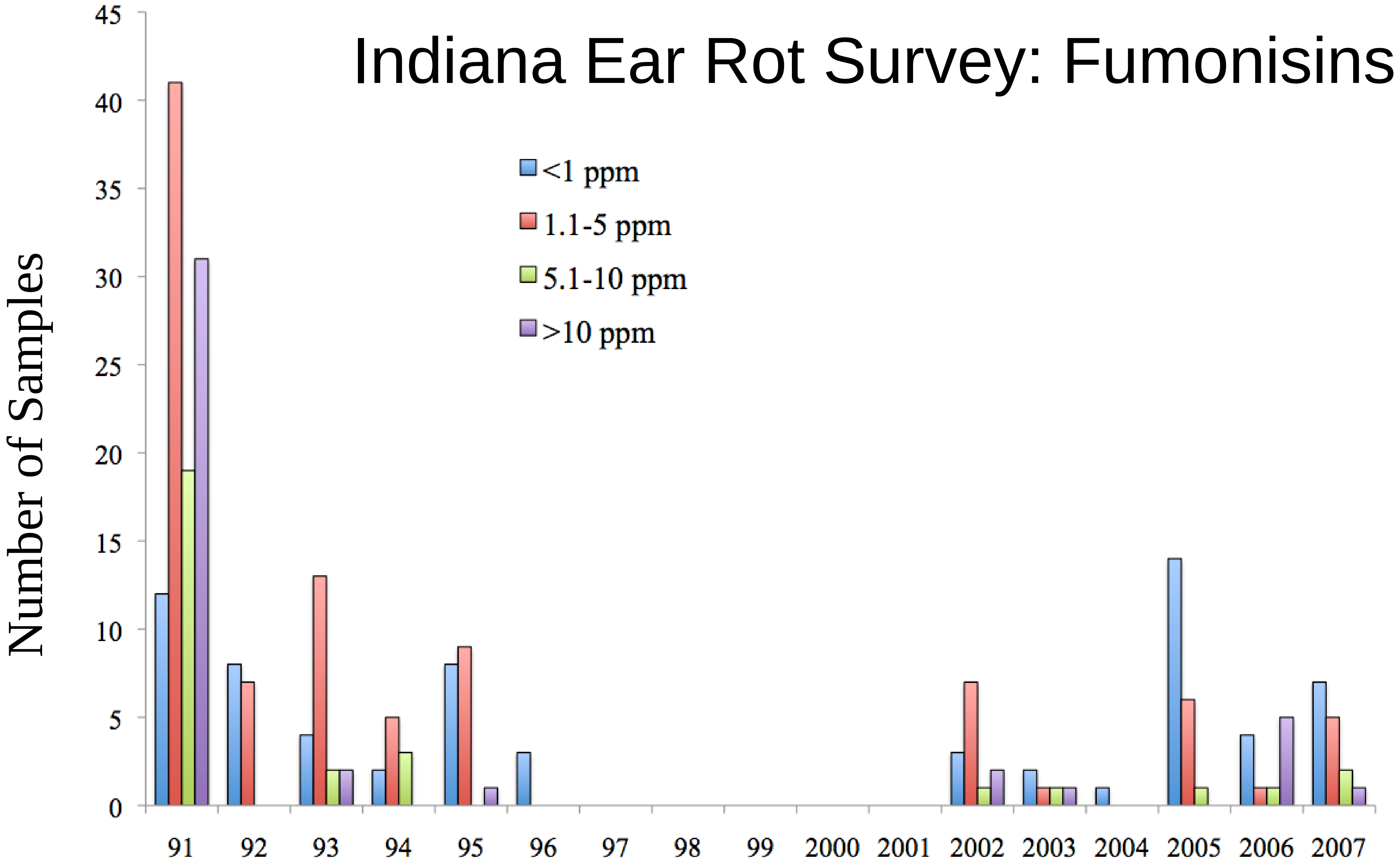
Factors Affecting Fusarium Ear Rot Diseases

Inoculum Source	Host Resistance	Conducive Environment
Soil, Debris	Very Little, BT	Heat & Insect Stress

Munkvold, G. P., Hellmich, R. L. 1999. Genetically modified insect resistant corn: Implications for disease management. APSnet Feature, October 15-November 30, 1999. http://www.apsnet.org/



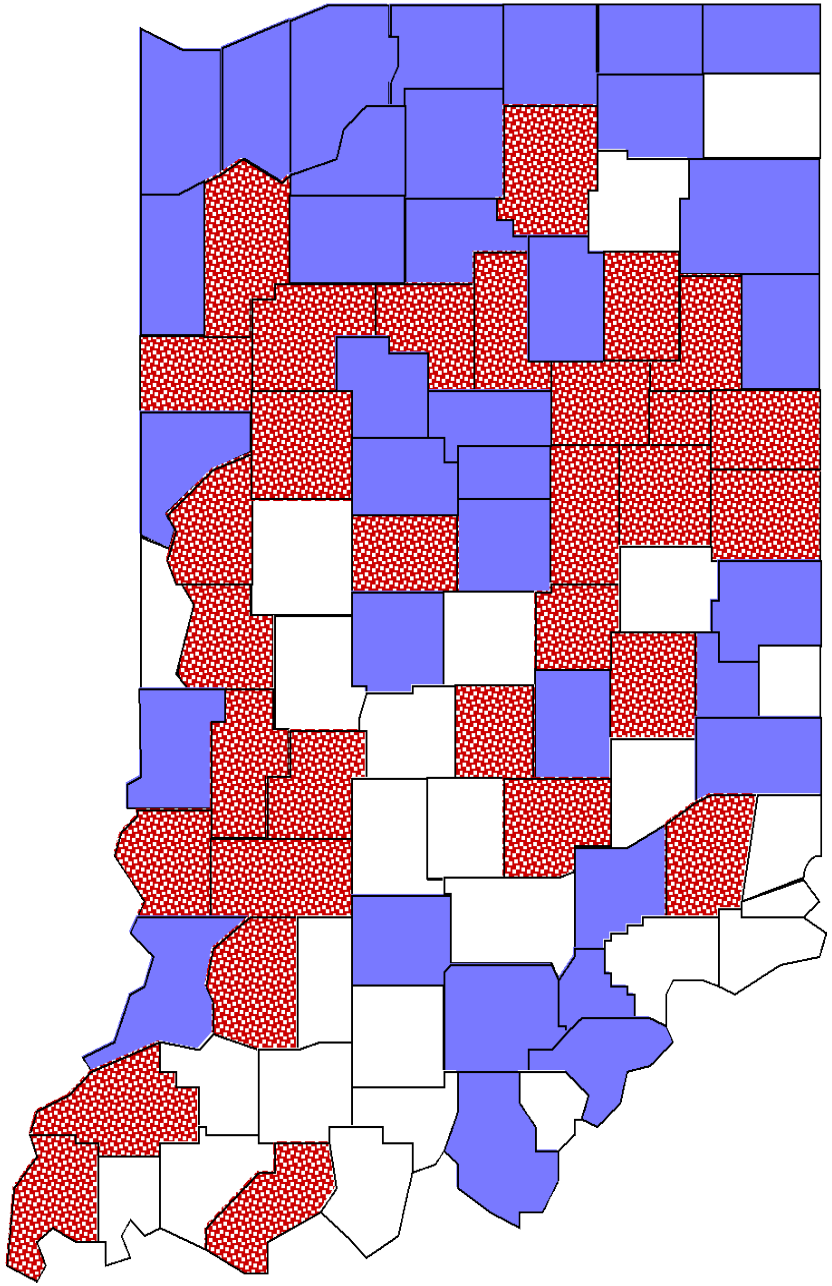
Indiana Ear Rot Survey: Fumonisins



Diplodia Ear Rot

Factors Affecting Diplodia Ear Rot Disease

Inoculum Source	Host Resistance	Conducive Environment
Debris	Some hybrids less susceptible	Wet @ Flowering



2000

- 2000- 55 (17%)
- 1999- 2
- 1998- 7
- 1997- 6

159 FIELDS from 66 Counties

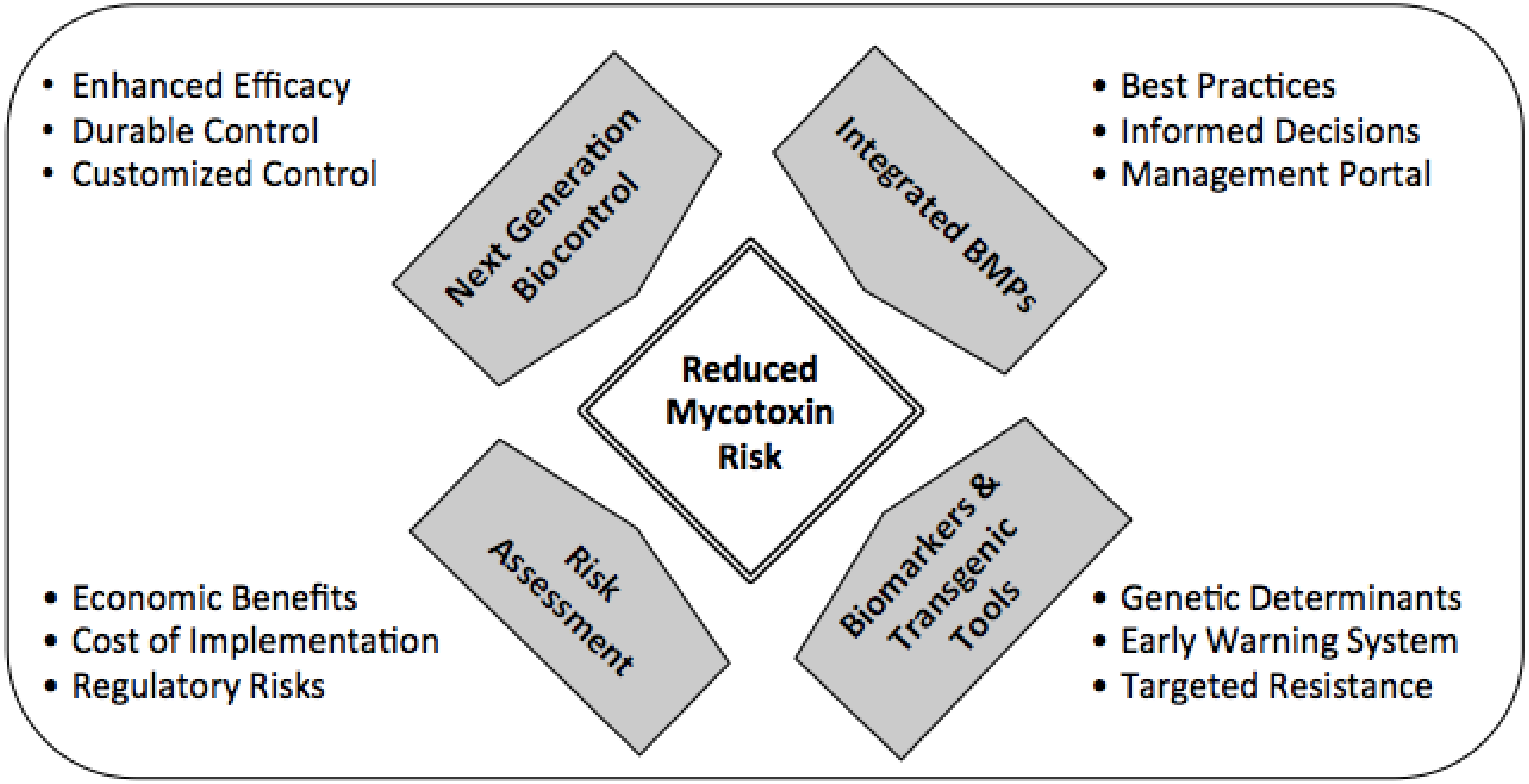
318 SAMPLES

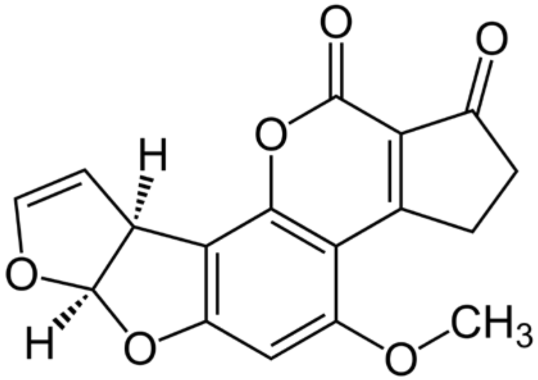
1590 EARS

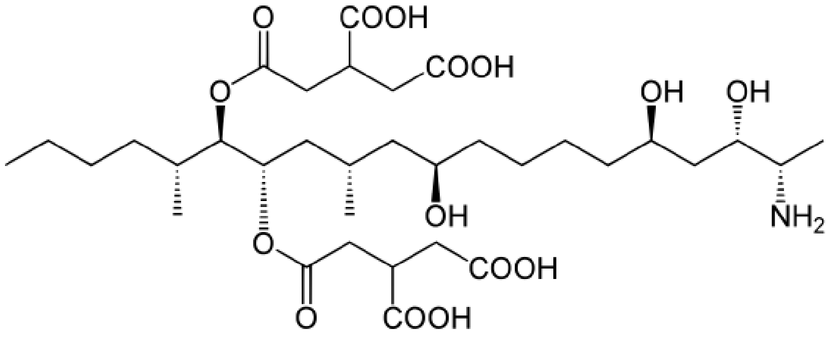
What about 2016?

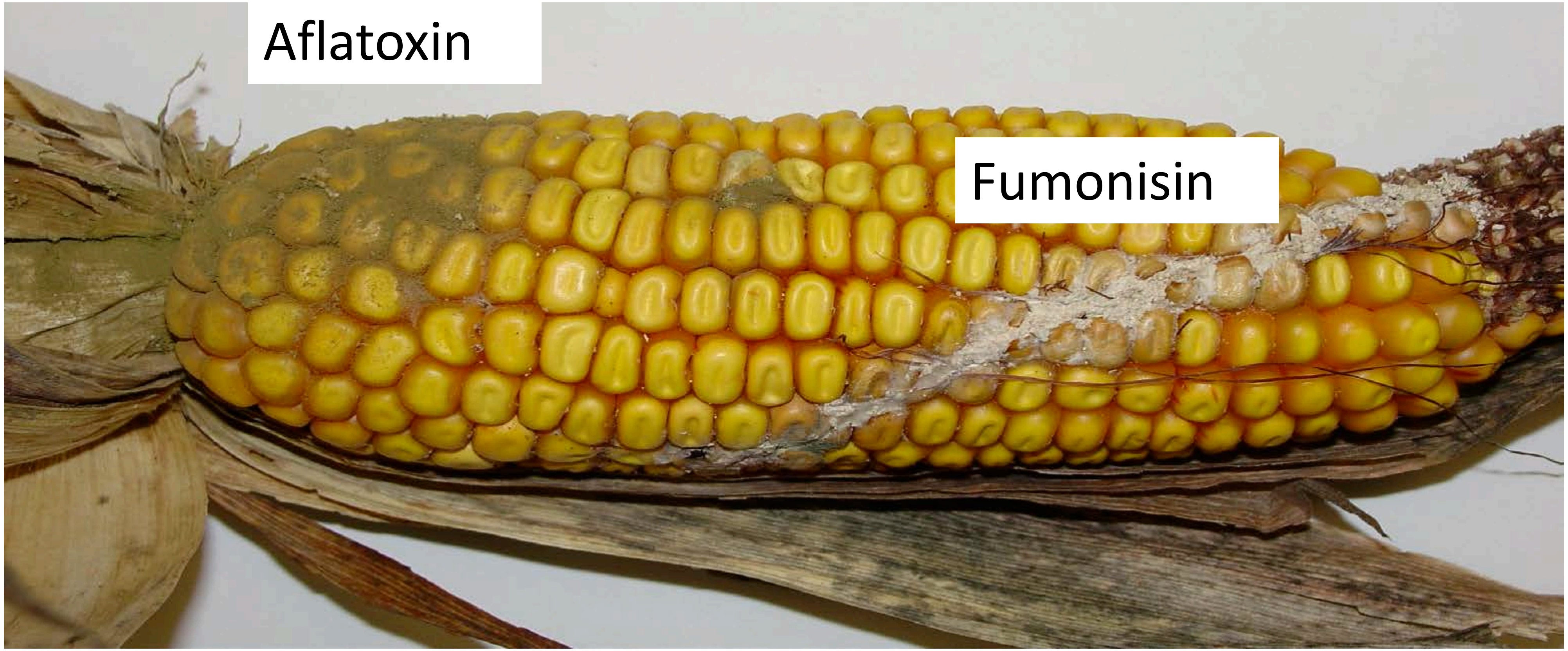
Trichoderma Ear Rot

Integrated Management Strategies for *Aspergillus* and *Fusarium* Ear Rots of Corn

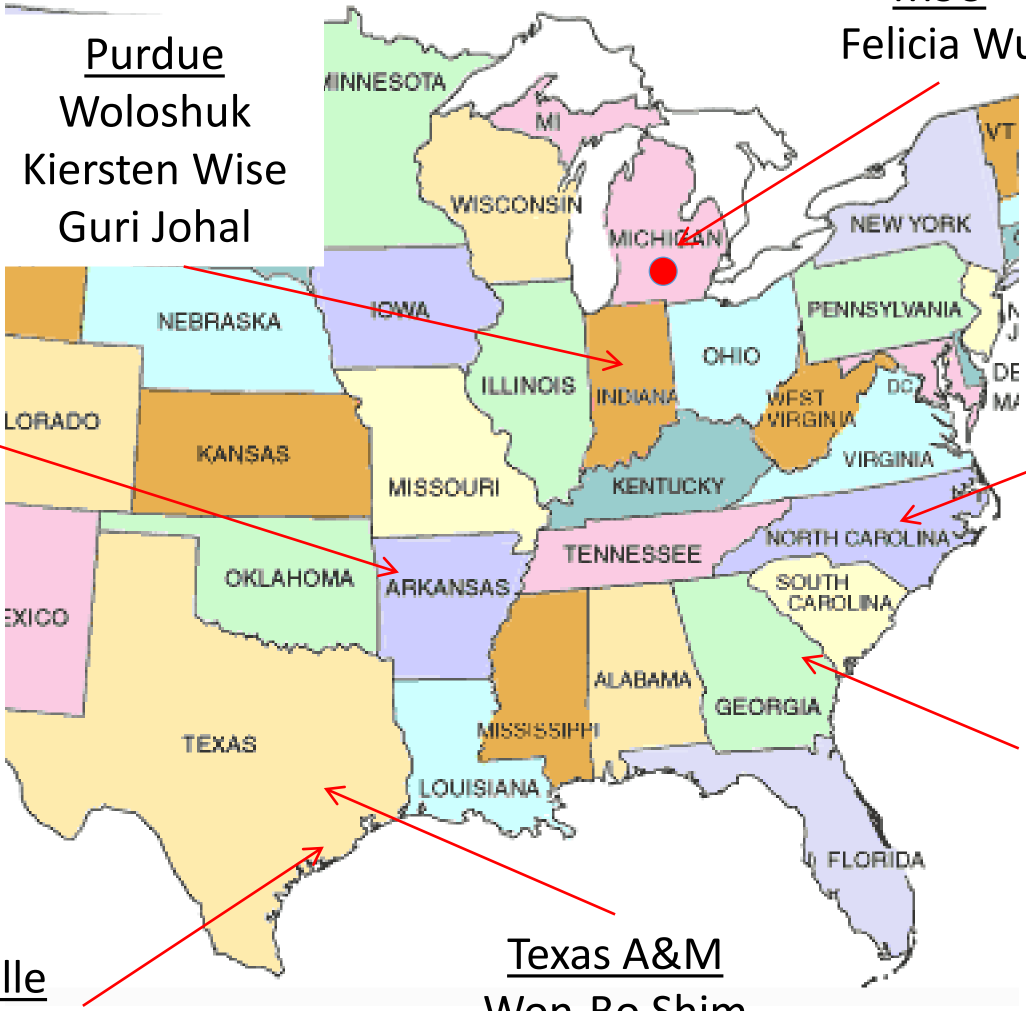







Aflatoxin
Fumonisin

Principal Investigators



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<u>U of Arkansas</u>
Burt Bluhm

<u>NCSU</u>
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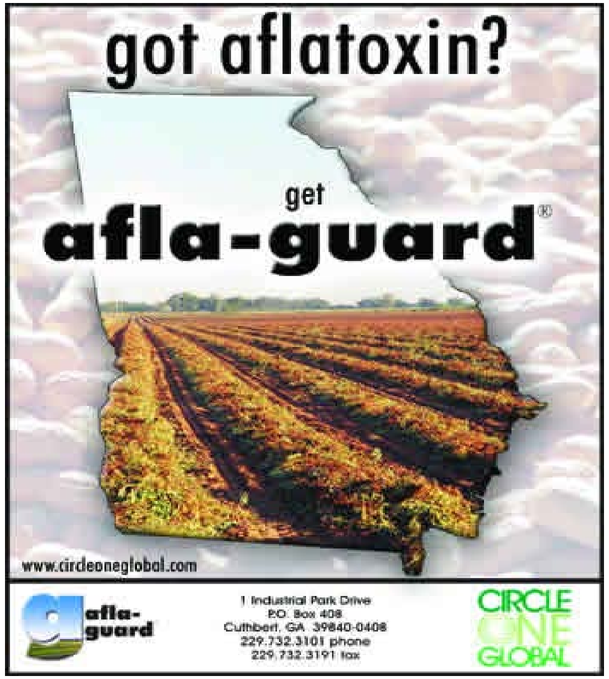
<u>Texas A&M</u>
Won-Bo Shim
Tom Isakeit
B.J. Yoon

Estimated economic losses in millions USD for corn growers in 3 prominent regions

US Region	Aflatoxin			Fumonisin		
	2011	2012	2013	2011	2012	2013
Upper Midwest	--	78.32	--	--	--	--
Ohio Valley	391.84	248.32	27.84	95.89	84.17	483.69
South/Southeast/Southwest	582.49	692.37	852.18	57.95	75.00	104.67
Total US losses	**974.34**	**1019.02**	**880.03**	**153.84**	**159.17**	**588.36**

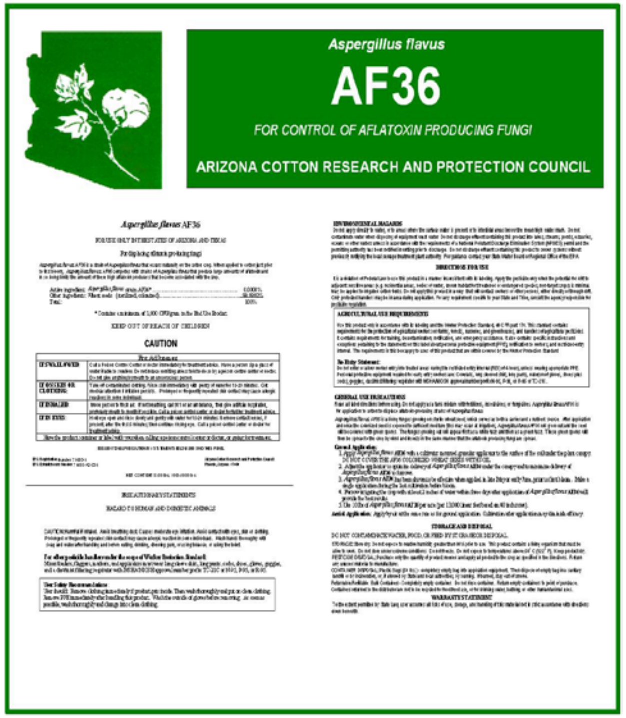
Baseline analysis by Felicia Wu, MSU

Biological control strains AF36 and Afla-Guard® registered by the EPA to reduce aflatoxin contamination



Afla-Guard® (AG)

- **2004**
- **Peanuts & corn**



AF36

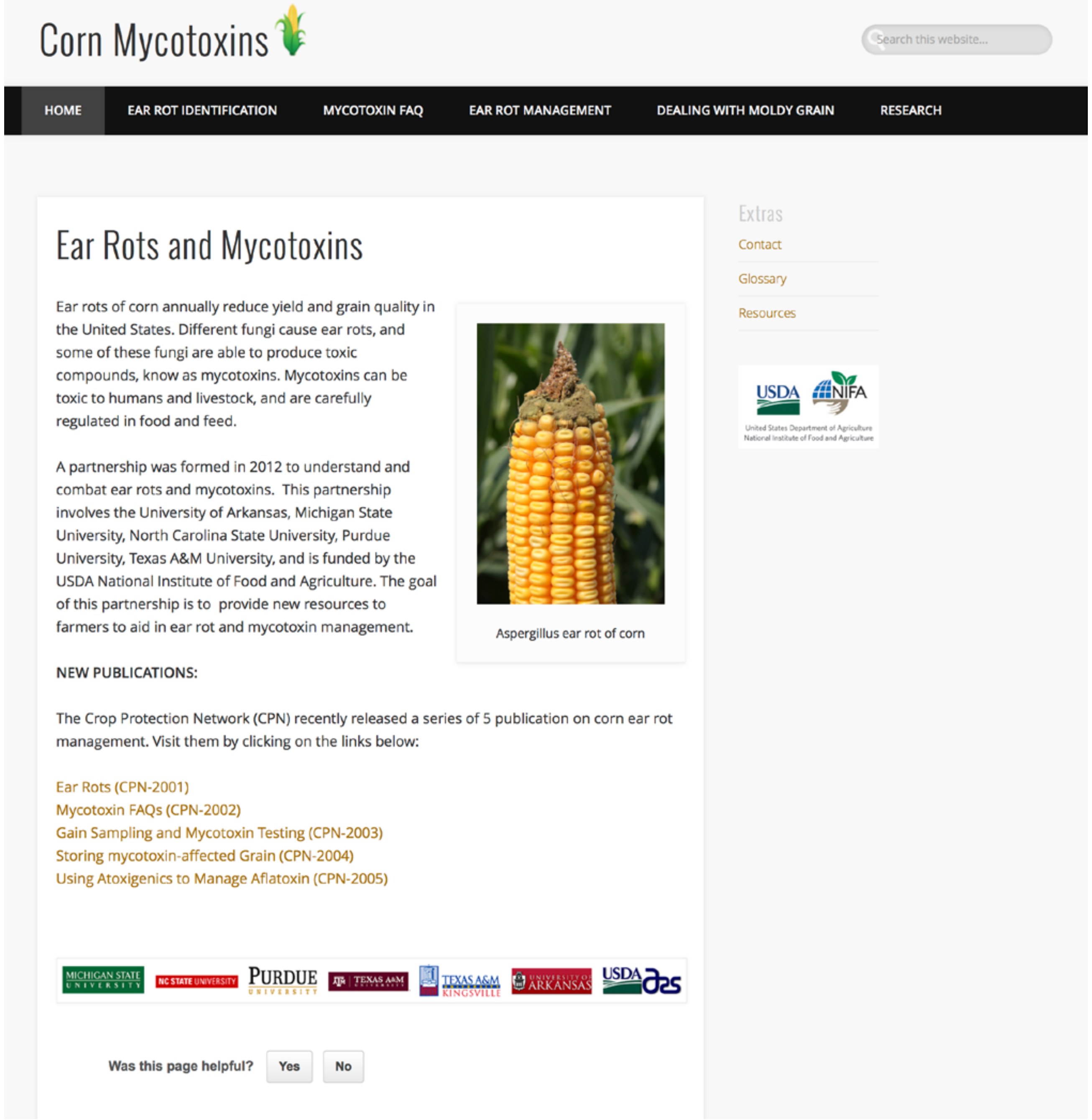
- **2003**
- **Corn & cottonseed**

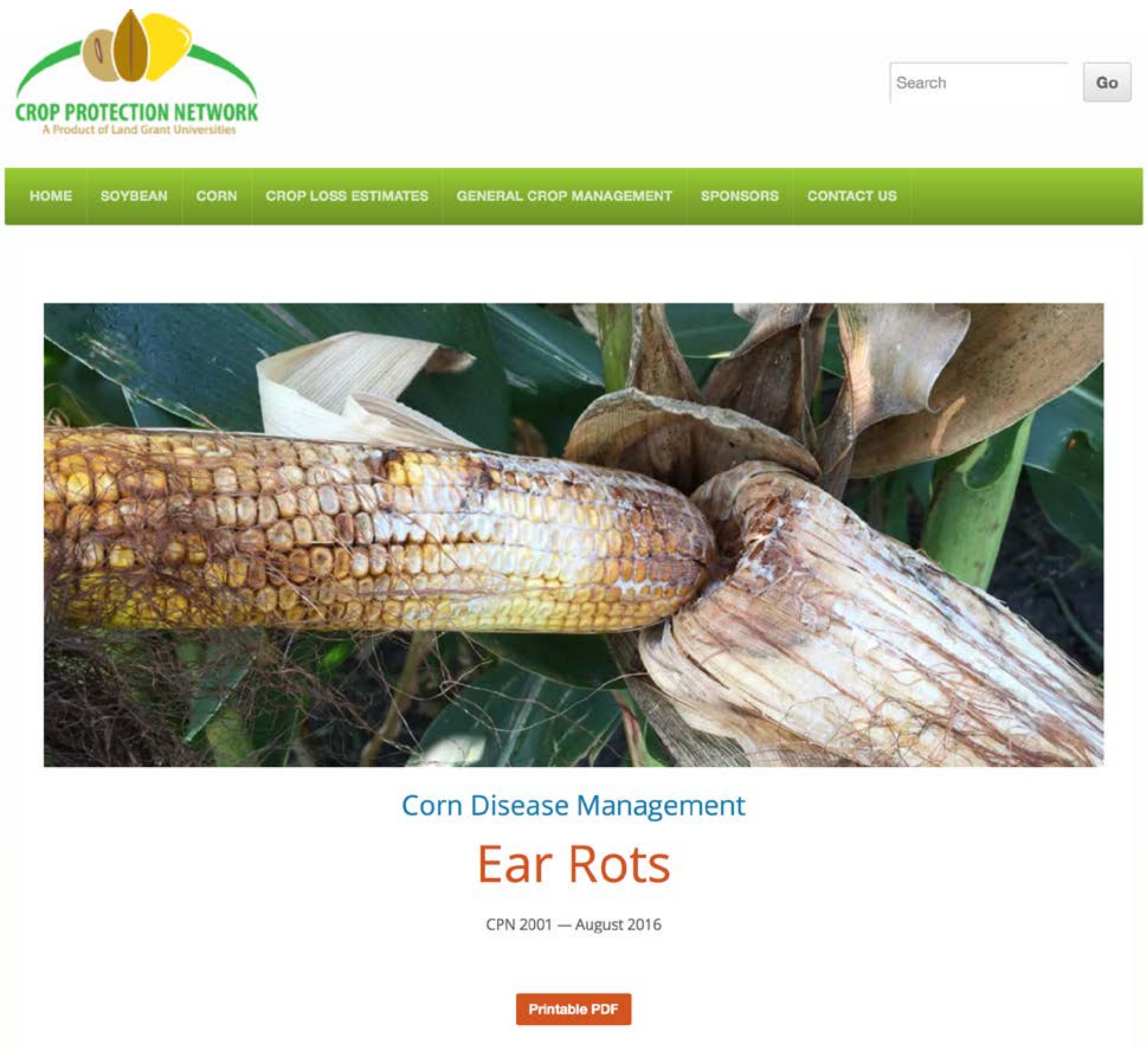
$20 per acre per year to apply biocontrol

Design and Deliver Best Management Practices (BMPs) for Mycotoxin Reduction

- Determined region-specific recommendations for use of atoxigenic biocontrols
  - TX: V5 application most effective
  - NC: Flexibility in application timing (V5 or V10)
  - IN: Application not needed (saves farmers money)
- Found that fungicides do not reduce plant stress or ear rot/mycotoxin issues
  - Information will help save farmers money by preventing unnecessary applications

Information Resources

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Research Update:
IPM Strategies for
Mycotoxin Production
in Corn
0:01 / 5:57

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BP-33-W

DISEASES OF WHEAT

Fusarium Head Blight (Head Scab)

Authors:
Kiersten Wise
Charles Woloshuk

In Indiana, Fusarium head blight of wheat (FHB), also called head scab, is caused mainly by the fungus *Gibberella zeae* (also known as *Fusarium graminearum*). This disease periodically causes significant yield loss and reduced grain quality. *Gibberella zeae* also produces mycotoxins, which are chemicals that are toxic to humans and livestock.

This publication describes:

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BP-75-W

DISEASES OF CORN

Diplodia Ear Rot

Authors:
Charles Woloshuk
Kiersten Wise

www.btny.purdue.edu

EXPERT REVIEWED

Photos by Charles Woloshuk

Diplodia ear rot, caused by the fungus, *Stenocarpella maydis*, has become a common and troublesome fungal disease on Indiana corn. The increase in no-till or reduced-till acreage, plus continuous corn without rotation are factors that favor Diplodia ear rot. Hybrid susceptibility and weather also contribute to disease development.

This bulletin describes:

1. How to recognize the disease
2. A description of the conditions that favor disease development
3. How to minimize losses
4. How to handle diseased grain after harvest

Recognizing the Disease

Diplodia ear rot is easy to recognize when present (Figure 1). There is grayish or grayish-brown mold on and between the kernels, and usually only on part of the ear.

The disease typically starts at the base of the ear and progresses toward the tip (Figure 2). Occasionally, disease symptoms occur only at the tip end or middle part of the ear.

Figure 1. The white to gray mold on the kernels of this infected ear is characteristic of Diplodia ear rot.

Figure 2. This photo shows Diplodia ear rot progressing from the base of the ear.

Infected ears also weigh noticeably less than uninfected ears.

Another diagnostic feature of Diplodia ear rot is pycnidia, the spore-producing structures of the fungus. Pycnidia appear as black specks that may be scattered on the husks, cobs, and sides of kernels (Figure 3).

Figure 3. Spore-producing pycnidia appear as black specks on infected ears.

Understanding the Disease Cycle

Pycnidia overwinter on corn debris and are the source of infection for the following year. Dry weather prior to silking, followed by wet conditions at and just after silking favor Diplodia infection.

Ears are most susceptible to this disease during the first 21 days after silking. Earworm damage at the ear shank is often associated with the disease (Figure 4).

Minimizing Economic Losses

Diplodia-infected corn will result in potentially significant discounts when graded at the first point of sale. The lighter kernels caused by the disease will lower the test weight of a sample. Kernels from a

1

PURDUE EXTENSION | LOCAL FACES COUNTLESS CONNECTIONS

BP-86-W

DISEASES OF CORN

Fusarium Ear Rot

Authors:
Charles Woloshuk

…his is called the "star burst" symptom …d is caused by the pathogen growing …nder the kernel pericarp (seed coat) …igure 3).

…ure 1. Brown kernels are symptomatic of Fusarium ear rot.

…ure 2. Fungal growth on Fusarium-affected ears can …e white, gray, or pink.

…ure 3. White streaks or "starbursts" visible around kernels …ymptomatic of Fusarium ear rot.

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PURDUE EXTENSION

BP-77-W

DISEASES OF CORN

Gibberella Ear Rot

Authors:
Charles Woloshuk
Kiersten Wise

…ish mold at ear tips is characteristic of …t

…erella ear rot typically affects only part of the ear.

…he ears. Look for a pink to …ld that begins at the tip of …l develops toward the base …nd 2).

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PURDUE EXTENSION

BP-83-W

DISEASES OF CORN

Aspergillus Ear Rot

Authors:
Charles Woloshuk
Kiersten Wise

www.btny.purdue.edu

EXPERT REVIEWED

Photos by Burt Bluhm, University of Arkansas, and Charles Woloshuk

The fungus *Aspergillus flavus* causes Aspergillus ear rot, one of the most important diseases in corn. The fungus produces a mycotoxin — known as aflatoxin — inside the diseased corn kernels.

Figure 1. Powdery olive-green fungal spores are characteristic of Aspergillus ear rot.

The presence of aflatoxin will affect grain quality and marketability, as well as livestock health if the grain is consumed.

Aspergillus ear rot is commonly observed during hot, dry years on stressed plants (such as those exhibiting symptoms of nutrient deficiency or drought stress). Feeding damage from ear-invading insects also contributes to disease development and aflatoxin contamination.

This bulletin describes:

1. How to identify the disease
2. Its danger to livestock
3. Mycotoxin testing
4. How to minimize losses and handle diseased grain after harvest
5. How to manage the disease

Scouting and Identifying the Disease

Scout for Aspergillus ear rot by inspecting at least 10 ears in several locations (minimum of 30 ears) in a field prior to harvesting.

Plants that grow in dry areas within a field (such as on hillsides, or light, sandy soils) will be the first to exhibit ear mold symptoms. These plants likely will be stunted with small ears.

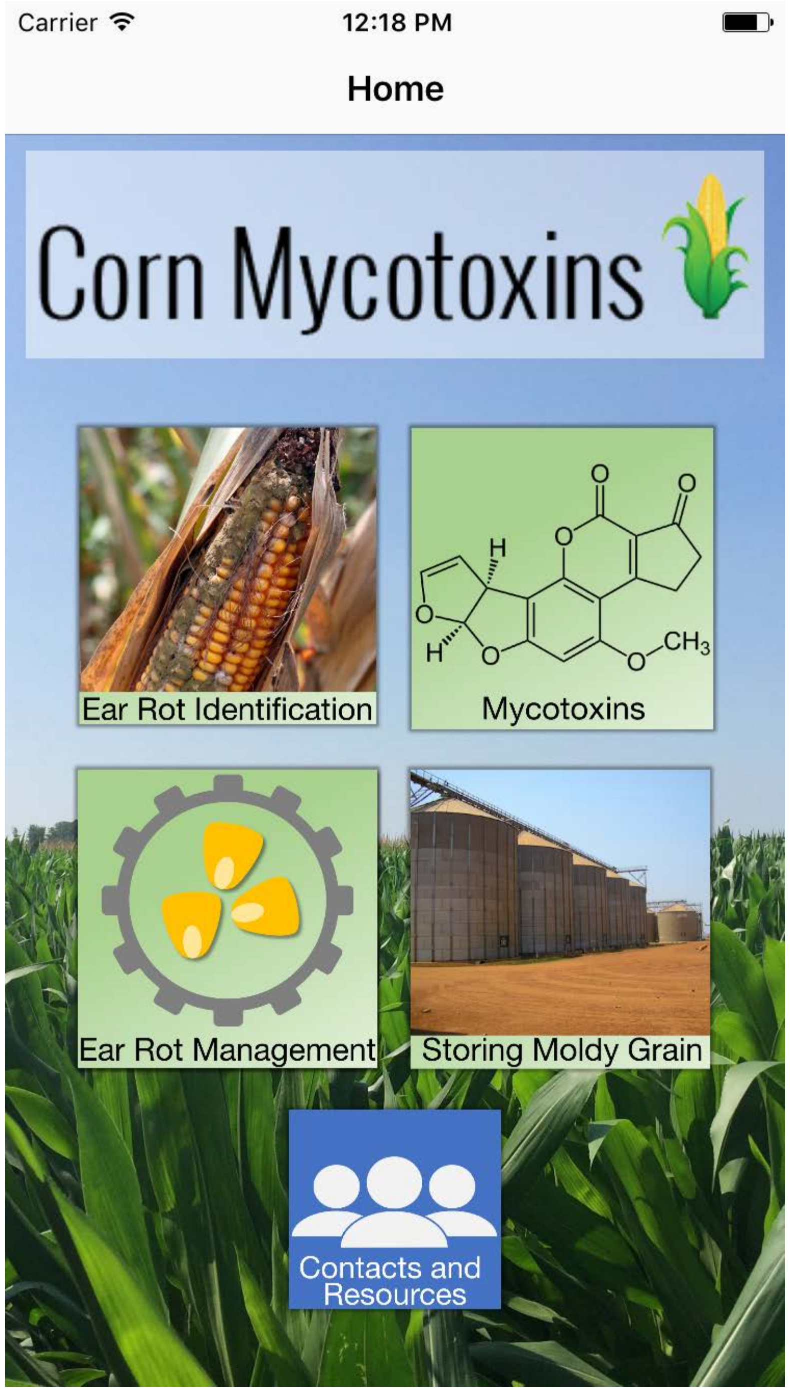
After collecting the ears, peel back the husks and look for an olive-green mold on the ears (Figure 1). The fungal spores, which are the olive-green mold, will appear powdery and may disperse like dust when the husk is pulled back. Symptoms are mostly observed at the tip of the ear, but when the disease is severe the mold can be found all the way to the base.

Other fungi also infect ears and produce black or bluish spores, or pink or white molds on ears. However, the presence of an olive-green mold is diagnostic of Aspergillus ear rot (Figure 2).

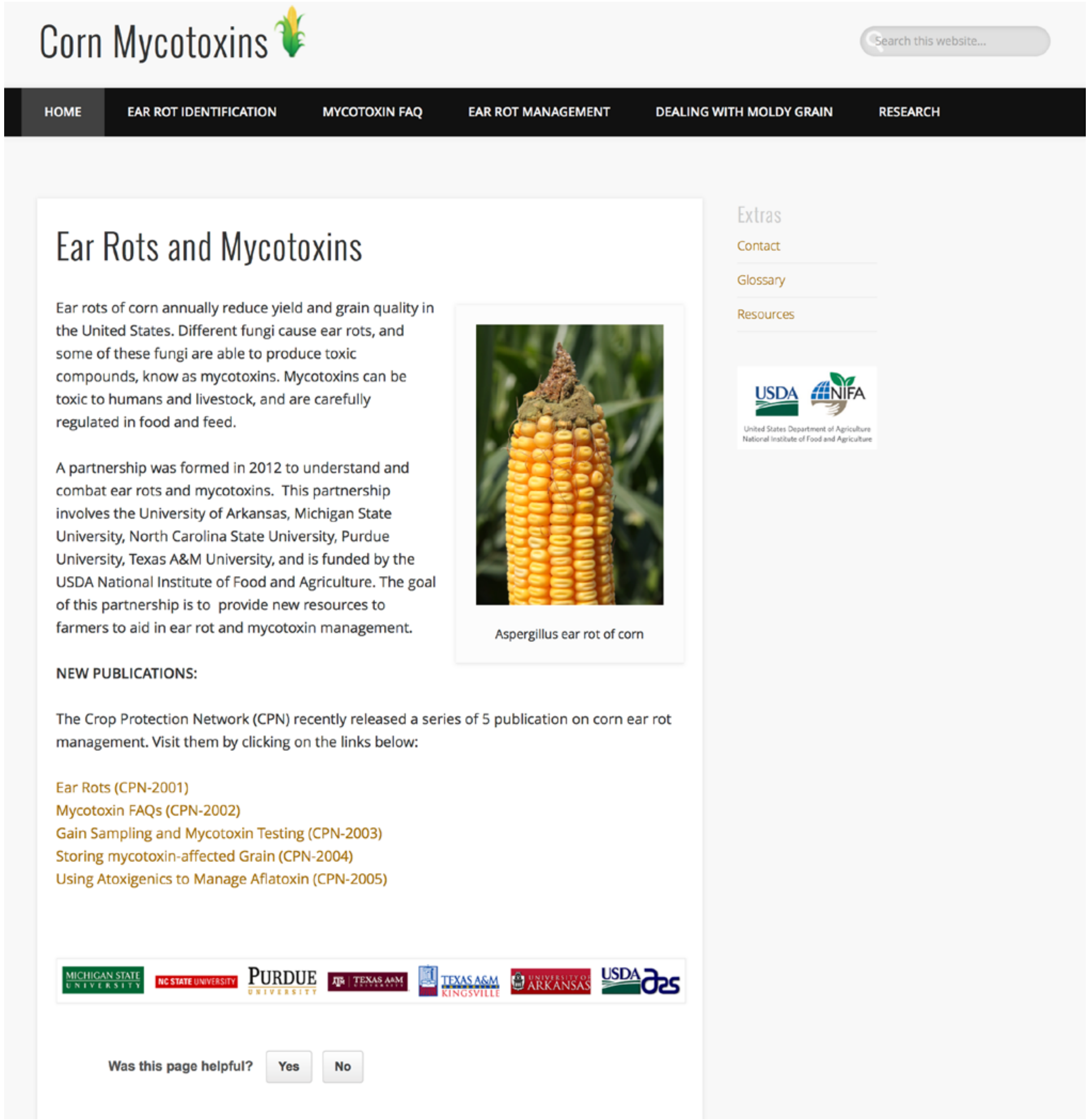
1

Smart Phone App

Available Free: Early 2017

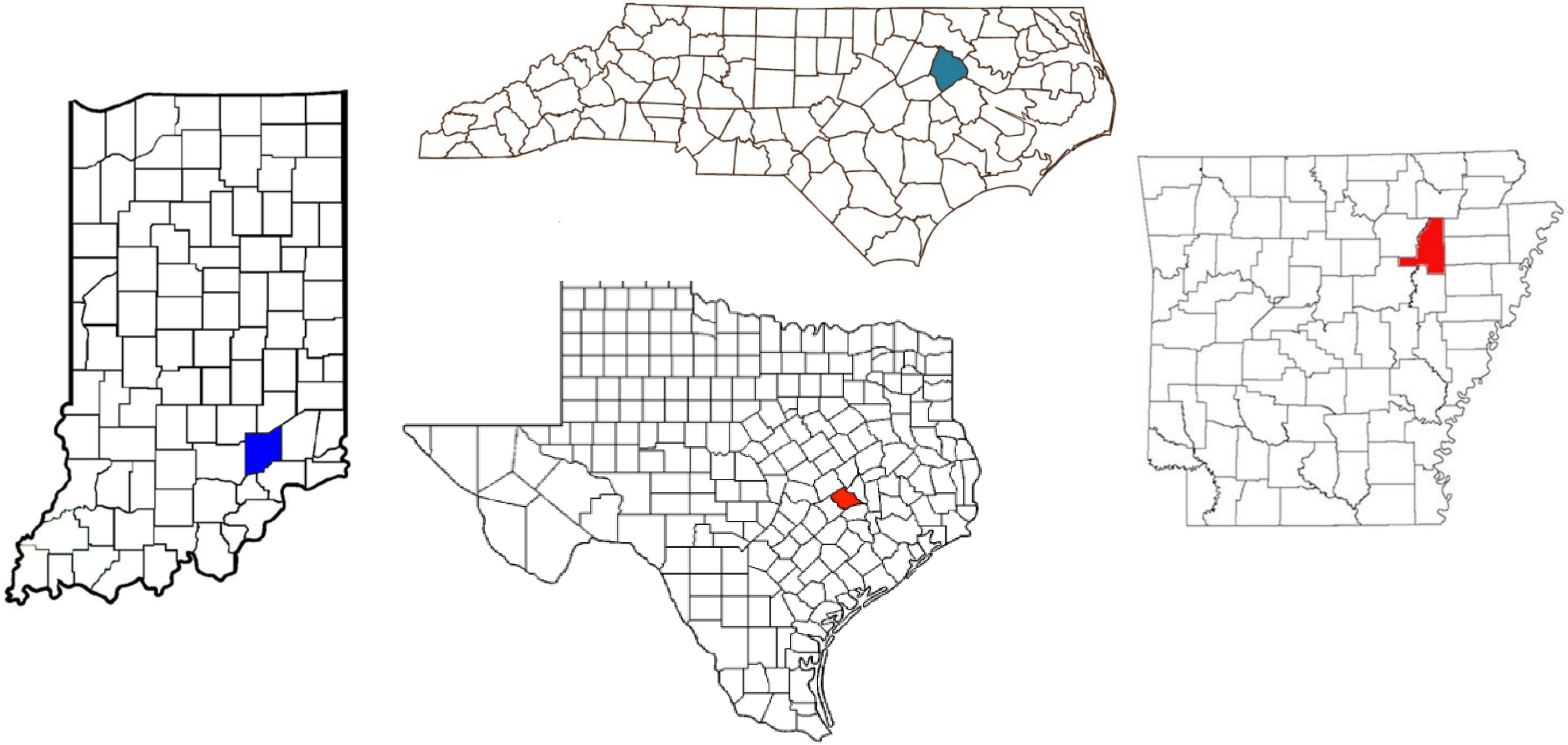


Research Page



Research Page

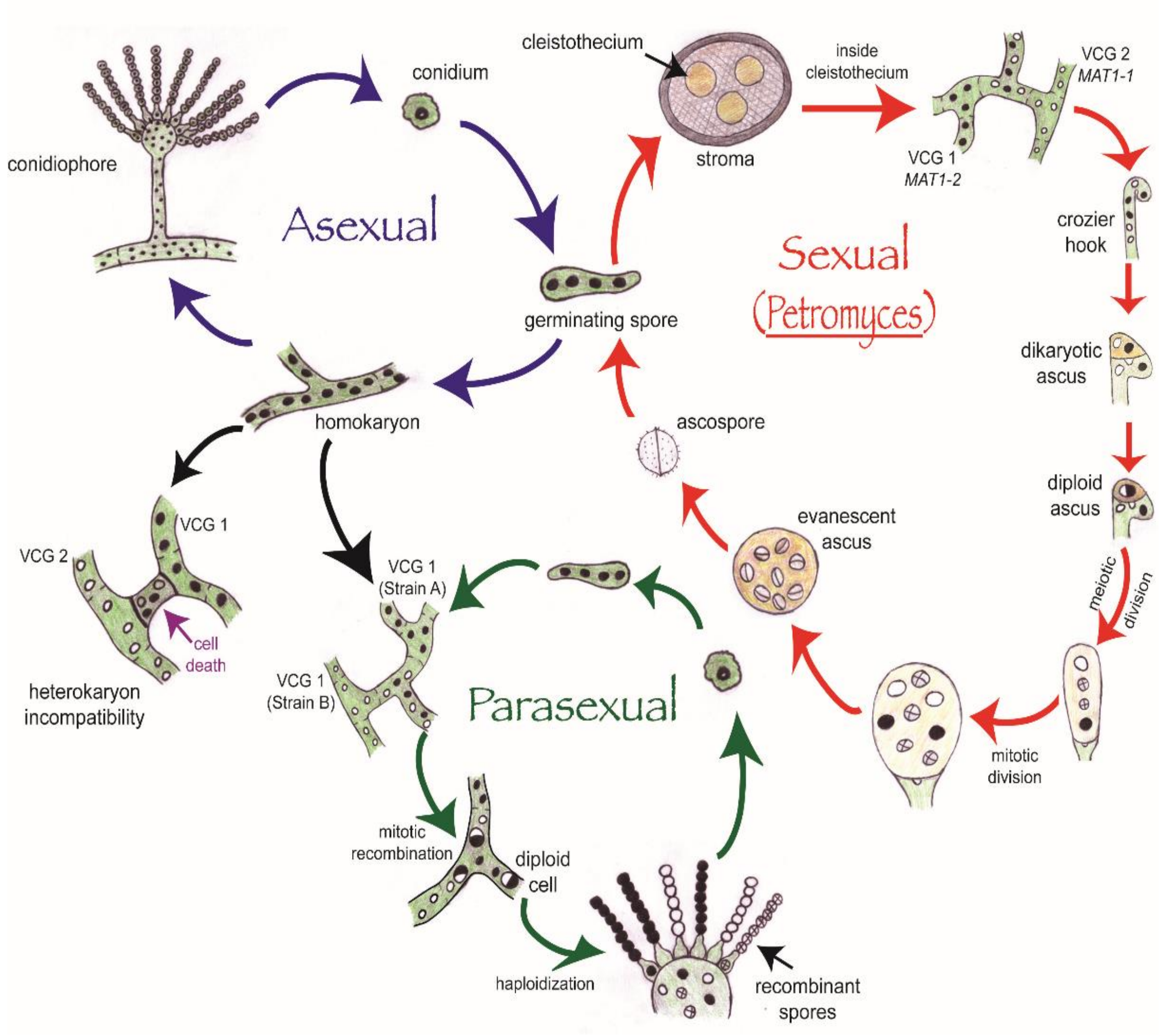
Develop Next Generation of Biological Control



Research fields never treated with *A. flavus* biocontrol

Where do the biocontrol strains go?

- Neither AF36 nor Afla-Guard are persistent in soil



Goal: Track the fate of biocontrol strains in field populations. Look for evidence of recombination with native strains.

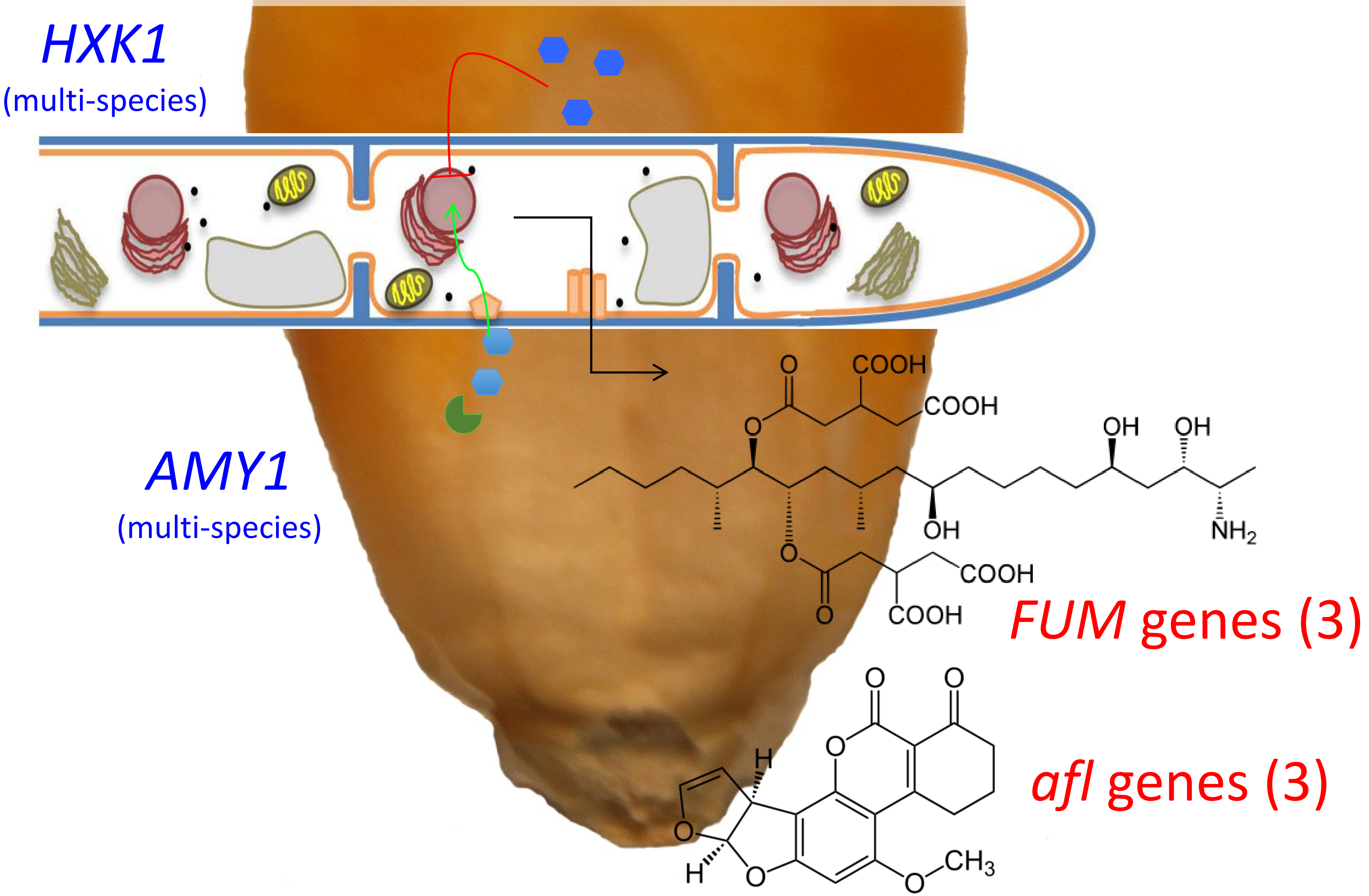
Genotyping *A. flavus* populations in NC, TX, AR, & IN

- Sampling & DNA sequencing
- Mating type distributions
- Proportion of aflatoxigenic strains
- Chromosome-specific genotyping of strains

➢ Chromosome shuffling between biocontrol strains and native strains

➢ New strains were selected that are regionally specific for Texas, North Carolina, Arkansas, and Indiana

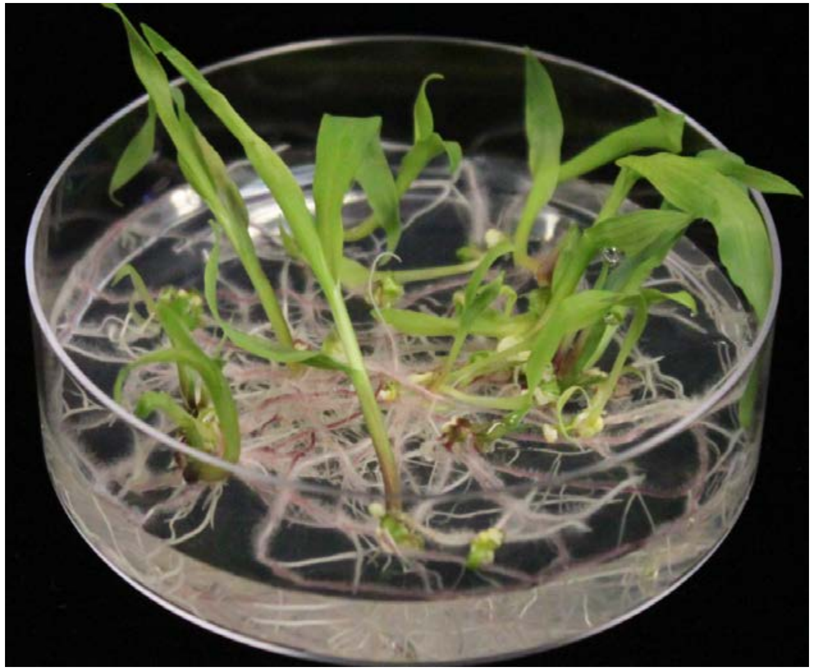
Generate RNAi-based Transgenics for Resistance

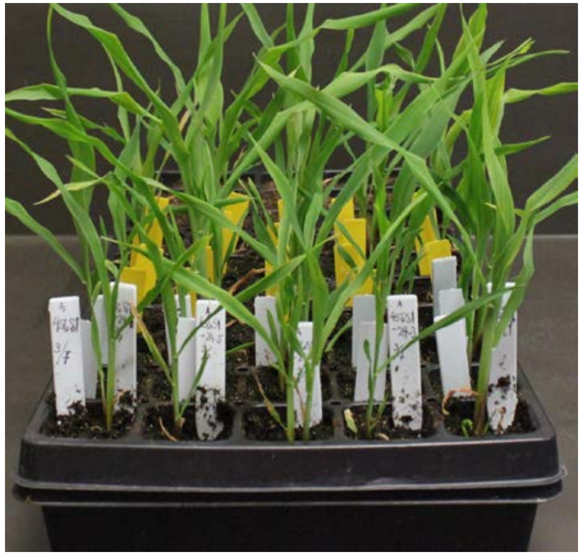


Select fungal genes involved in mycotoxin biosynthesis to target

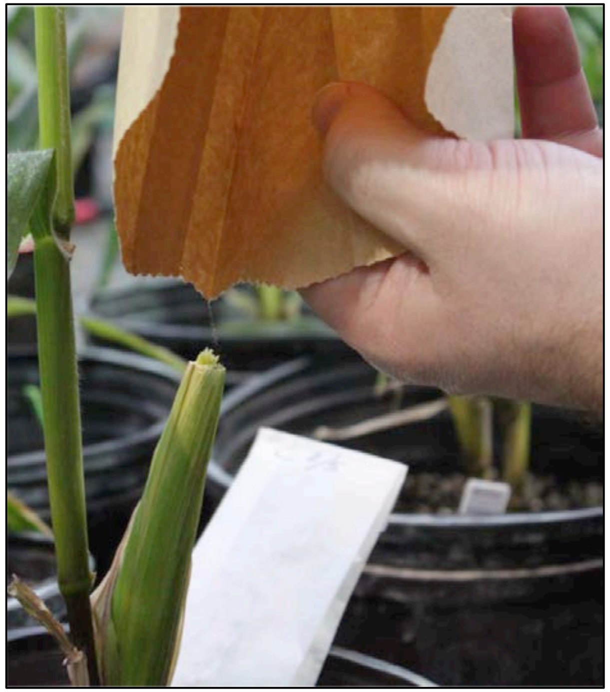
Build an RNAi construct targeting the gene(s) of interest

Generate transgenic corn expressing hpRNA

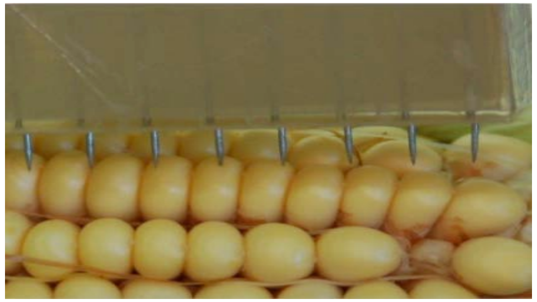




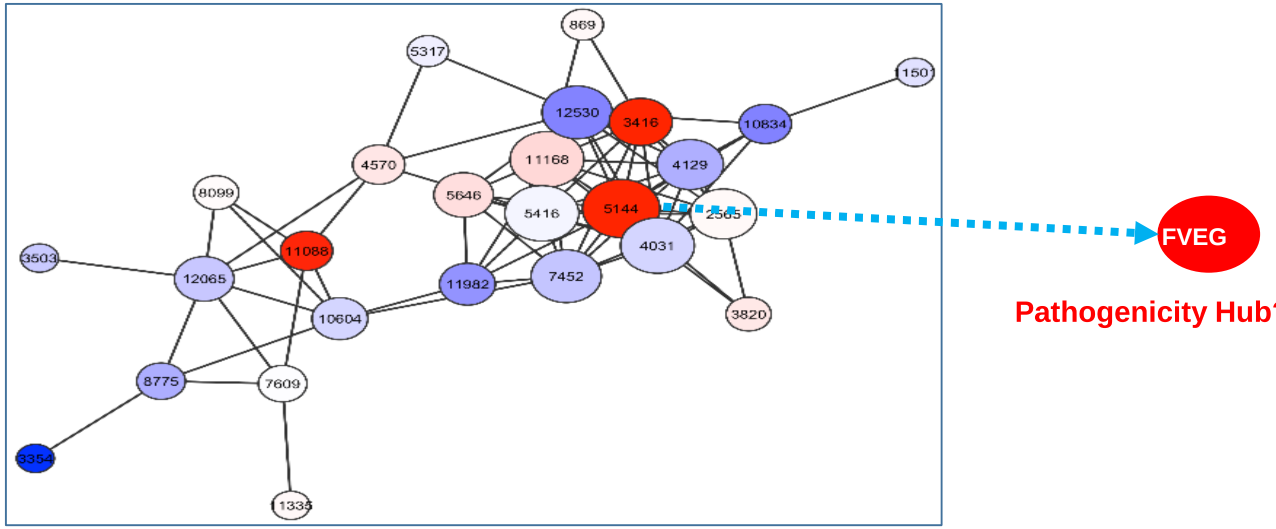


Discover Novel Targets for RNAi through Gene Subnetwork Module Analyses

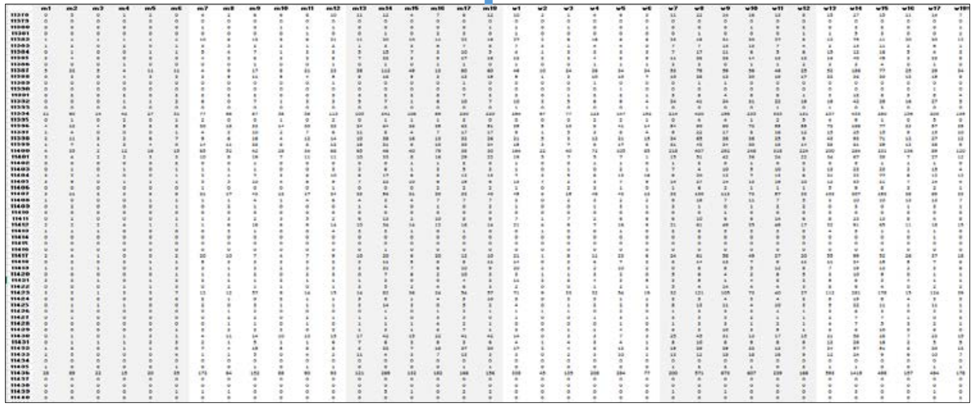


F. verticillioides on maize



Pathogenicity Hub?

Subnetwork modules associated with ear rot pathogenicity

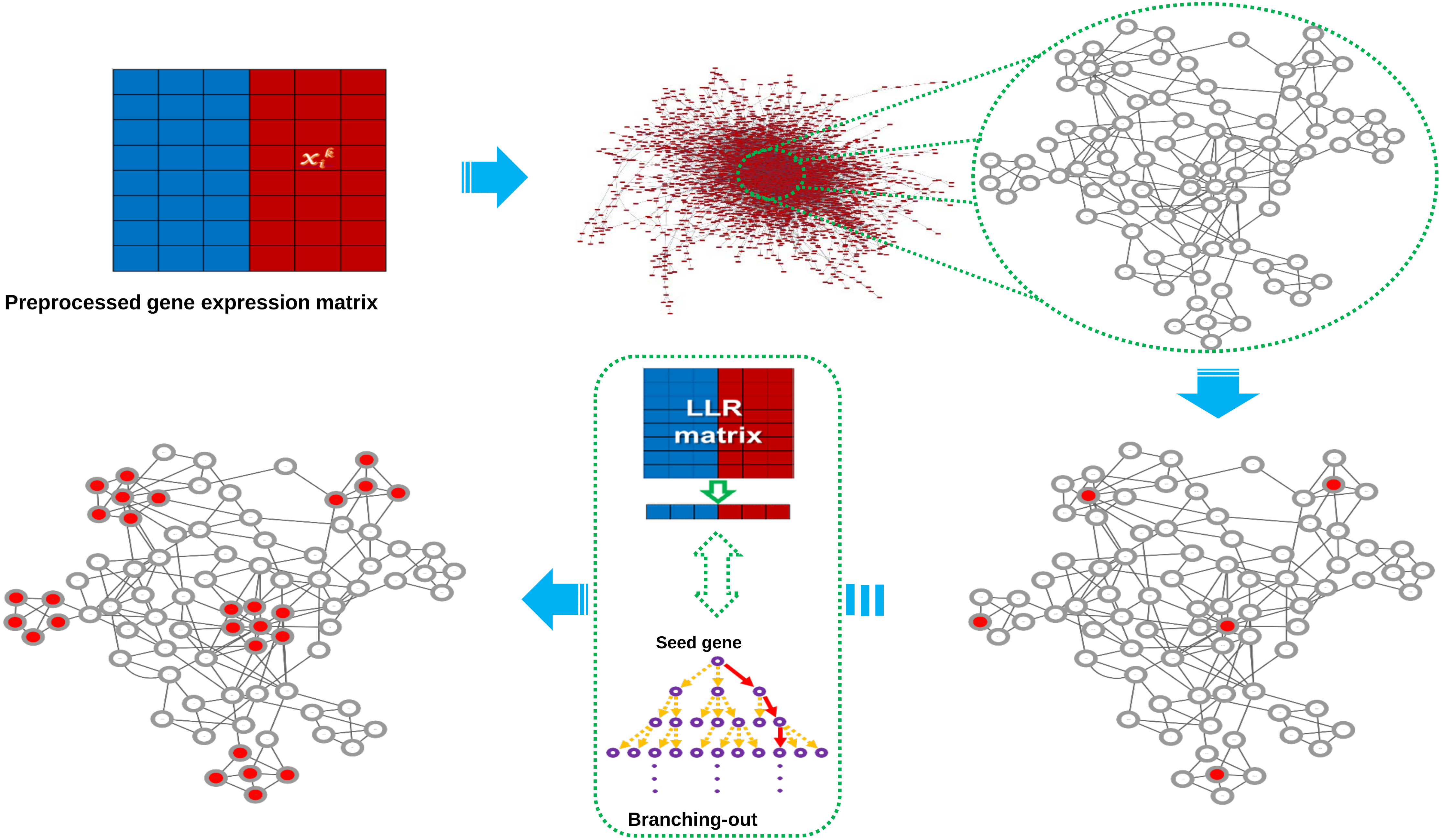


Transcriptomic data

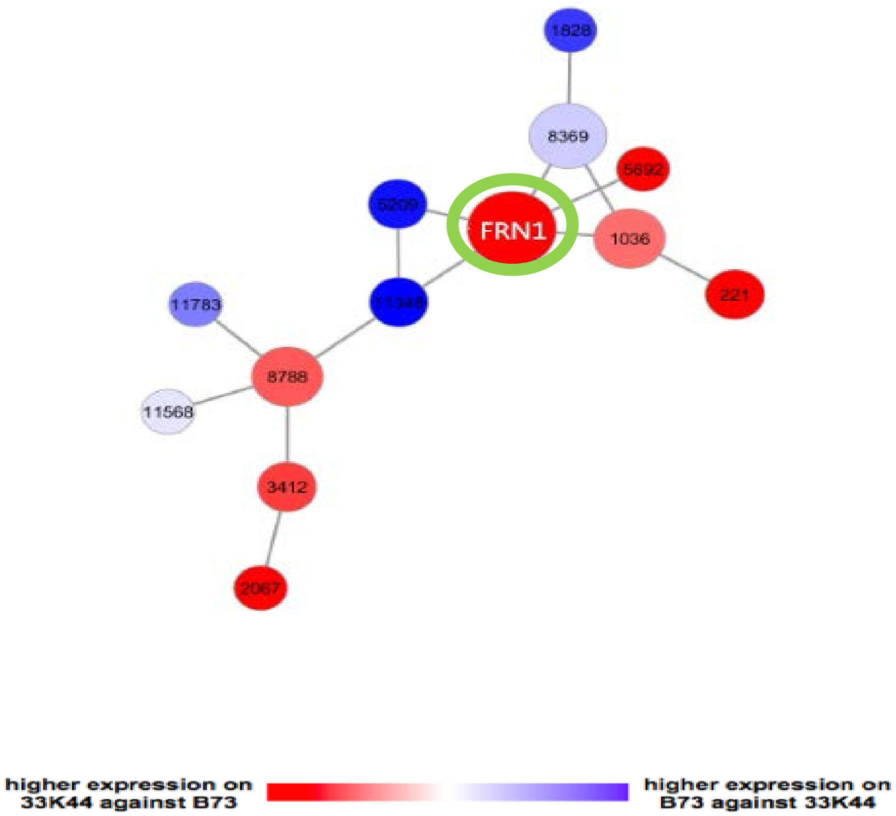
Experiments

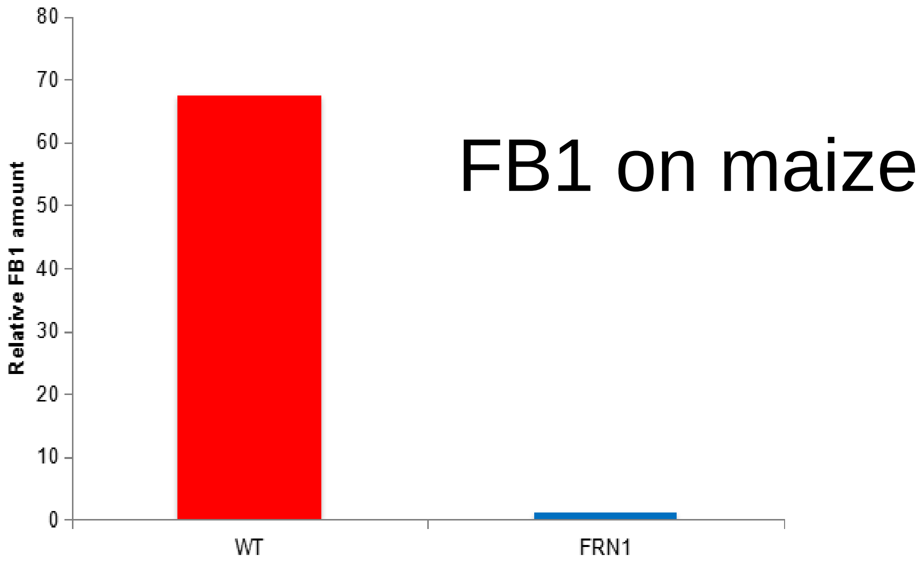
- Texas A&M: Kernels inoculated with *F. verticillioides* under controlled environment
  - Maize: B73 (moderate resistance) vs 33K44 (susceptible)
  - Sampled at 0, 2, 4, 6, 8 days post-inoculation
- North Carolina: field inoculation with *A. flavus* and *F. verticillioides* using a pinbar
  - Field grown inbred B73 and hybrid N78S-3111 (R3~R4)
  - Harvested at 0, 2, 3, 4, 5, 6 days (N78S-3111) and 0, 4, 6, 12, 18, 24, 30, 36, 42, and 48 hours (B73) post inoculation
- Purdue: Kernels inoculated with *A. flavus* under controlled environment
  - Maize: B73 (living) vs 33K44 (autoclaved)
  - Sampled at 0, 2, 4, 6, 8 days post-inoculation

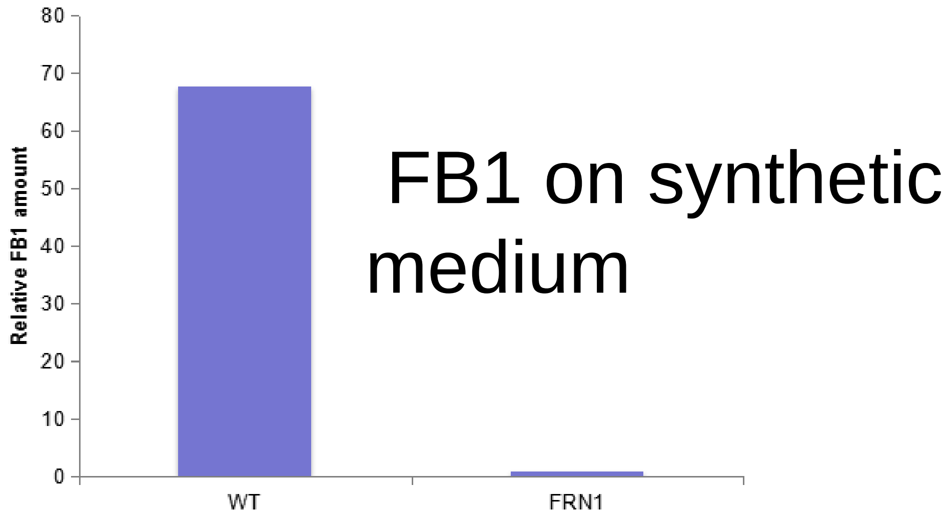
Gene regulatory logic of our network-based approach



FNR1 encoding a hypothetical protein







Summary

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