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Extension and Outreach

Thinking ahead: practical strategies for managing mycotoxins at harvest

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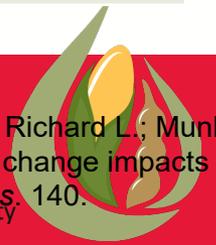
Photo: Meaghan Anderson, ISU Central IA Ext. Field Agronomist



Five principal mycotoxins of concern in grains

Mycotoxin	Fungus	Cereal crops affected	Favorable conditions	
Aflatoxin	<i>Aspergillus flavus</i> , <i>Aspergillus parasiticus</i>	Corn Rice	Hot (95 F), drought	
Deoxynivalenol	<i>Fusarium graminearum</i> , <i>Fusarium culmorum</i>	Corn Wheat Barley	Cool (68-77 F), wet	
Fumonisin	<i>Fusarium verticillioides</i> , <i>Fusarium proliferatum</i>	Corn	Warm-hot (86 F), drought during grain maturity	
Zearalenone	<i>Fusarium graminearum</i> , <i>Fusarium culmorum</i>	Corn Wheat	Cool, wet	
Ochratoxins	<i>Penicillium verrucosum</i>	Corn Wheat Barley Oats	Warm-hot, humid conditions	

*Values in parenthesis denote optimum *fungus* growth temperature¹



Action Levels for Total Aflatoxins in Livestock Feed

<u>Class of Animals</u>	<u>Feed</u>	<u>Aflatoxin Level</u>
Finishing beef cattle	Corn and peanut products	300 ppb
Beef cattle, swine or poultry	Cottonseed meal	300 ppb
Finishing swine over 100 lb.	Corn and peanut products	200 ppb
Breeding cattle, breeding swine and mature poultry	Corn and peanut products	100 ppb
Immature animals	Animal feeds and ingredients, excluding cottonseed meal	20 ppb
Dairy animals, animals not listed above, or unknown use (general market)	Animal feeds and ingredients	20 ppb

Action level: A level above which poisonous substances are believed to be harmful to humans or animals. FDA is prepared to intervene at these levels if necessary.



Aspergillus ear rot

Source: photo © Gary Munkvold



Advisory Levels for Deoxynivalenol in Livestock Feed

Class of Animal	Feed Ingredients & Portion of Diet	DON Levels in Grains & Grain By-products and (Finished Feed)
Ruminating beef and feedlot cattle older than 4 months	Grain and grain by-products not to exceed 50% of the diet	10 ppm (5 ppm)
Chickens	Grain and grain by-products not to exceed 50% of the diet	10 ppm (5 ppm)
Swine	Grain and grain by-products not to exceed 20% of the diet	5 ppm(1 ppm)
All other animals	Grain and grain by-products not to exceed 40% of the diet	5 ppm (2 ppm)

Advisory level: A level below which adverse health effects are not expected. FDA may intervene but often will not.



Gibberella ear rot
Source: Photo Courtesy of A. Robertson



Fusarium head blight
<http://www.ars.usda.gov/Main/docs.htm?docid=9765>



Guidance Levels for Total Fumonisin in Livestock Feed

Class of Animal	Feed Ingredients & Portion of Diet	Levels in Corn & Corn By-products	Levels in Finished Feeds
Equids and Rabbits	Corn and corn by-products not to exceed 20% of the diet **	5 ppm	1 ppm
Swine and Catfish	Corn and corn by-products not to exceed 50% of the diet**	20 ppm	10 ppm
Breeding Ruminants, Breeding Poultry and Breeding Mink*	Corn and corn by-products not to exceed 50% of the diet**	30 ppm	15 ppm
Ruminants >=3 Months Old being Raised for Slaughter and Mink being Raised for Pelt Production	Corn and corn by-products not to exceed 50% of the diet**	60 ppm	30 ppm
Poultry being Raised for Slaughter	Corn and corn by-products not to exceed 50% of the diet**	100 ppm	50 ppm
All Other Species or Classes of Livestock and Pet Animals	Corn and corn by-products not to exceed 50% of the diet**	10 ppm	5 ppm

Guidance level: A level that prudent practice should not exceed; insufficient scientific data to establish an action or advisory level.



Fusarium ear rot
Source: Photo Courtesy of Gary Munkvold



Scattered or groups of infected kernels are typical of Fusarium ear rot.
Source: Photo Courtesy of Pioneer HiBred Intl, Inc.

Many factors come into play when developing a grain or feed facility's mycotoxin management program. Potential harvest 2020 conditions — like specific weather conditions, outdoor storage capacity and propane shortages impacting drying — may influence mycotoxin development in your region.

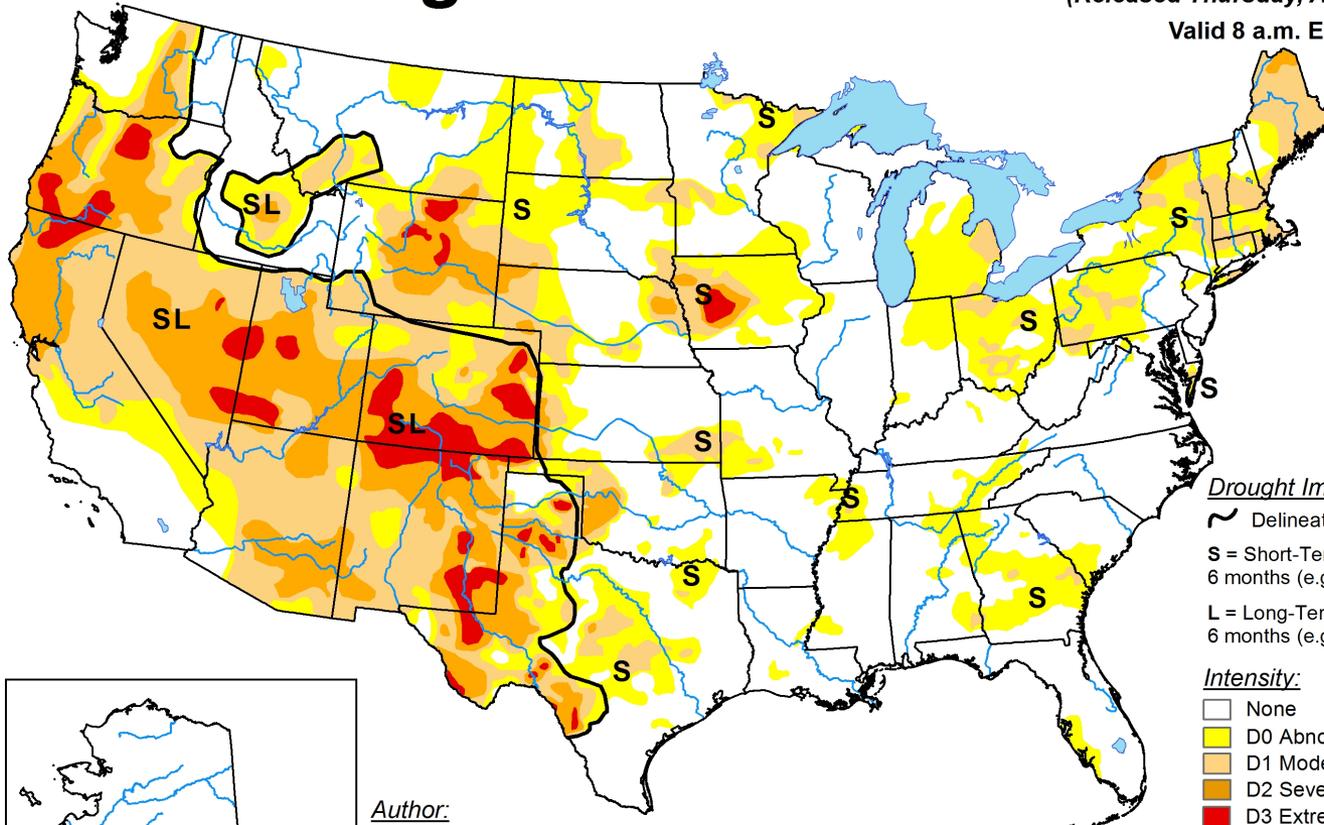
CONSIDERATIONS FOR 2020



U.S. Drought Monitor

August 4, 2020
 (Released Thursday, Aug. 6, 2020)

Valid 8 a.m. EDT

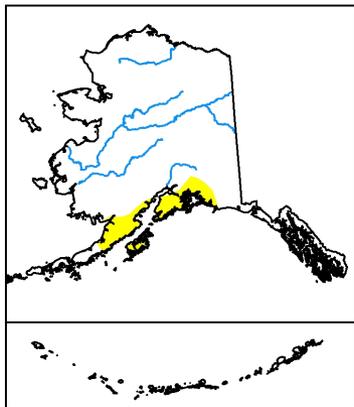


Drought Impact Types:

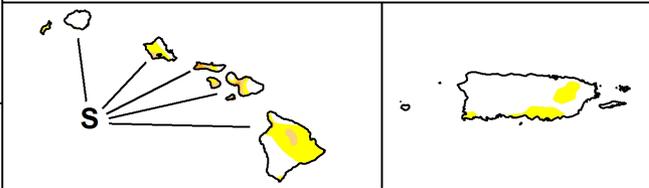
- ~ Delineates dominant impacts
- S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought



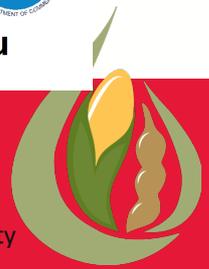
Author:
 Brian Fuchs
 National Drought Mitigation Center



The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>



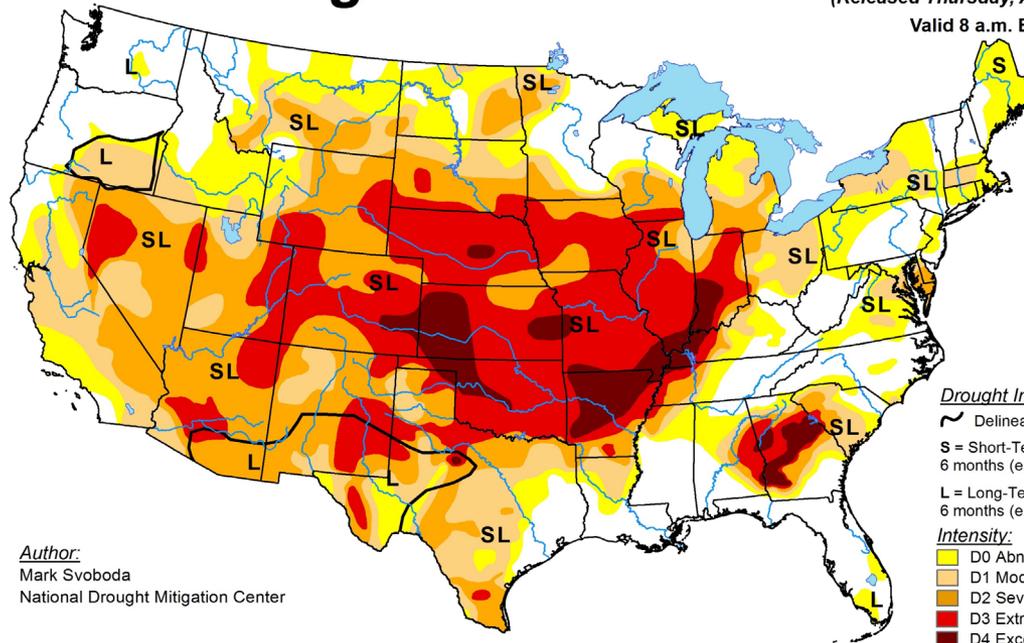
droughtmonitor.unl.edu



For reference, the same time in 2012-the last bad aflatoxin year we've had

U.S. Drought Monitor

August 7, 2012
(Released Thursday, Aug. 9, 2012)
Valid 8 a.m. EDT



Author:
Mark Svoboda
National Drought Mitigation Center

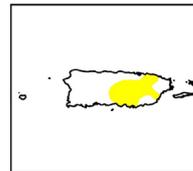
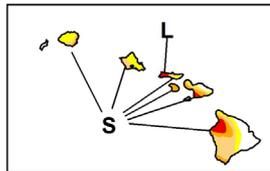
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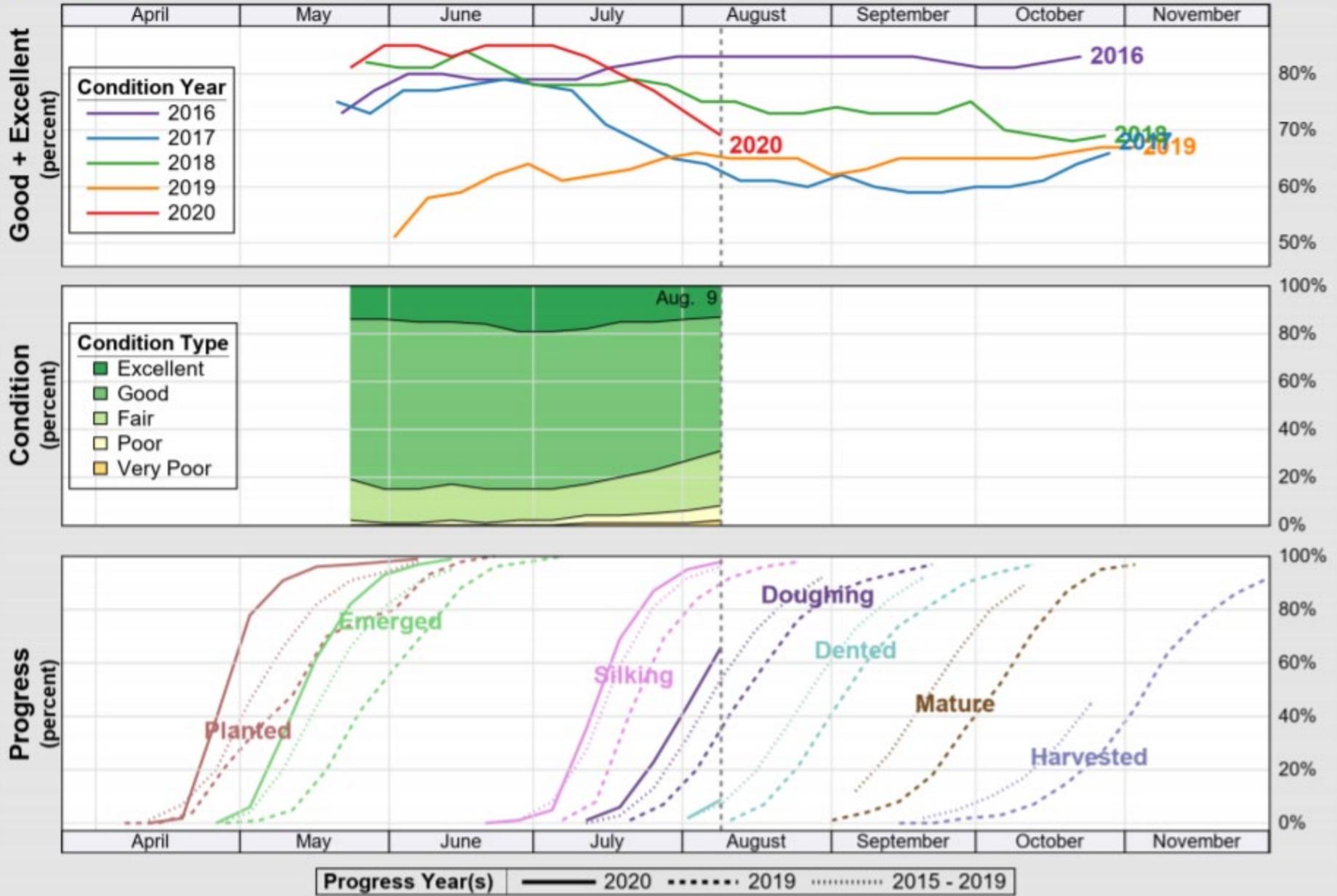
- Yellow: D0 Abnormally Dry
- Light Orange: D1 Moderate Drought
- Orange: D2 Severe Drought
- Red: D3 Extreme Drought
- Dark Red: D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.



<http://droughtmonitor.unl.edu/>





21 CFR 507.25 – Plant Operations

(b) Raw materials and other ingredients:

(1) Must be examined to ensure that they are suitable for manufacturing and processing into animal food and must be handled under conditions that will protect against contamination and minimize deterioration.

In addition: (i) Shipping containers (e.g. totes, drums, and tubs) and bulk vehicles holding raw materials and other ingredients must be examined upon receipt to determine whether contamination or deterioration of animal food has occurred;

...(2) Susceptible to contamination with mycotoxins or other natural toxins must be evaluated and used in a manner that does not result in animal food that can cause injury or illness to animals or humans



Note – Inbound Ingredient Evaluation

- Preamble points:
 - Weather can be considered when evaluating raw materials susceptible to mycotoxin contamination.
 - Not every load of grain needs to be tested as long as evaluation results in the facility using ingredients in a manner that does not result in harm to humans or animals.
 - Visual examination of ingredients or shipping containers is acceptable, with emphasis on observing any unusual residues that may contaminate the animal food.



If we are truly thinking ahead, we need to consider the possibility that

1. We are still projected to have a bumper crop
2. Propane shortage or distribution issues may occur again
3. Inbound grain quality may be an issue
4. Inbound grain safety may be an issue—depending on weather, we could have aflatoxin issues in regions with high-volume corn production



Consider your situation holistically, and in light of potential 2020 issues

- What do you receive and who are your suppliers
- Who are your customers or end users
 - What is your risk tolerance and what is theirs?
 - What role do you play in compliance with FDA levels?
- Can you test in real time (do you need to?)
 - Do you track grain once it enters your facility, at least where it went first, so that you can take action on test results?
- What will you do if there is a problem?
 - Have a contingency plan for foreseeable issues



With the knowledge that mycotoxin “limits” are end-use specific, you can assess your supply chain



Be conscious of sensitive end-users

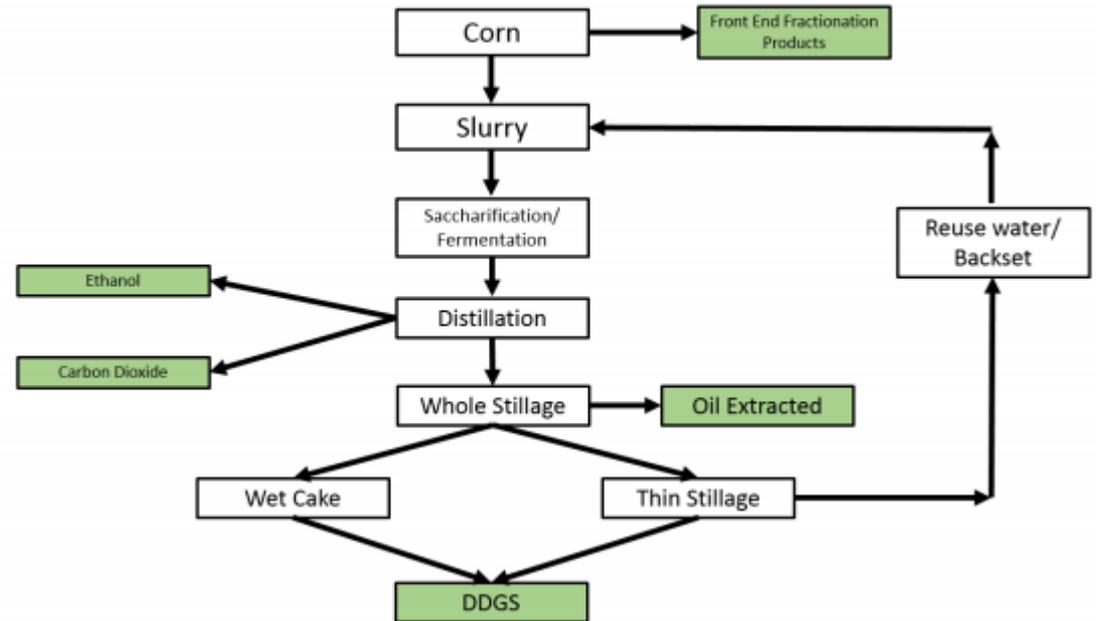
- Mycotoxins concentrate 3x in DDGS compared to grain from which they originated

aflatoxin=Adulterant

Blending with the intention of reducing [afla] in a grain lot to sell to a more sensitive market is illegal



Figure 1- Dry grind ethanol process



Cracked, broken grain and fines are more likely to contain mycotoxins



Figure 3. Diagram showing size and density segregation tests conducted at a commercial inbred seed processing facility.



Mycotoxins in screened grain

Table 3. Summary of aflatoxin reductions achieved at the inbred seed processing facility using a screen cleaner with two different round-hole sieves and a gravity table.

Process	Percent Removed ^[a]	Percent Reduction ^[b]	Aflatoxin Level ^[c] (Mean ± Std, ppb)	
	(wt,%)	(%)	Retained	Removed
Screen 5.16 mm (13/64 in.)	10.1	83.8	30 ±8	1404 ±143
Screen 6.75 mm (17/64 in.) (Pass No. 1)	3.3	1.8	27 ±1	246 ±27
Screen 6.75 mm (17/64 in.) (Pass No. 2)	2.8	9.4	13 ±2	197 ±32
Gravity Table (Pass No. 1)	4.8	12.6	7±1	384 ±27
Gravity Table (Pass No. 2)	5.4	16.4	<LOD ^d	342 ±31

^[a] Percentage of material removed is based on weight of original sample.

^[b] Percentage reduction of aflatoxin is based on initial aflatoxin level in original sample.

^[c] Aflatoxin level in original sample was 185 ±28 ppb.

^[d] LOD indicates limit of detection.



Implications

- Core bins
- Clean grain
- Don't mix old and new crop
- *Currently, this is not an FDA-approved mycotoxin mitigation strategy*



Propane shortage/distribution problems

Drying considerations

- Carefully-prevent stress cracks
- Rapidly-the time high moisture grain spends waiting to be dried after harvest gets deducted from its maximum storage time
- FUM, ZEA, DON ↑ in high moisture corn
e.g., 25% moisture corn had a 77% ↑ in fumonisins after 7 days

****Low temperature + low moisture = low water availability**

Maximum storage time (months) for corn and soybean*							
Corn temperature ° F	Moisture Content						
	Corn (top %), Soybean (bottom%)						
	13%, 11%	14%, 12%	15%, 13%	16%, 14%	17%, 15%	18%, 16%	24% N/A
40	150	61	29.0	15.0	9.4	6.1	1.3
50	84	34	16.0	8.9	5.3	3.4	0.5
60	47	19	9.2	5.0	3.0	1.9	0.3
70	26	11	5.2	2.8	1.7	1.1	0.2
80	15	6	2.9	1.6	0.9	0.9	0.06



If you know you have contaminated grain, consider the following

- Drying
 - Reduced 1-2% compared with sound, uncontaminated grain
- Cleaning grain/coring bins
 - Cracked, broken grain and fines are more likely to contain mycotoxins
 - A 5% increase in broken or injured kernels decreases the shelf life of grain by about one order of magnitude
- Isolation
 - Limit cross-contamination



Temporary storage for bumper crop

- ✓ Fill with *dried* corn at as cool a temp as possible
- Do not fill with wet corn
- ✓ Fill it as fast as possible and cover as quickly as you can (if you are able to cover it)
- Filling over a long time period just layers in all of the weather conditions experienced in the area during fill time
- ✓ Finally, use *careful* aeration (paying attention to dew point so as not to add humid air)
- ✓ Get rid of it as soon as possible



If you are going to test, make sure you have a valid, documented plan to do so.

Mycotoxins are distributed unevenly among individual grain kernels and levels within an individual, contaminated kernel can be highly variable.

Obtaining a representative sample requires planning: you have to obtain a random sample and sample enough units to have a chance of obtaining an accurate representation of the lot (or decision unit) you are trying to characterize.



3 steps in a mycotoxin testing procedure and 3 sources of variance in a mycotoxin test result

- Sampling-when, how (procedure), how many units/increments
- Sample preparation-processing and selecting test portion
- Analysis-extraction and quantification

Sampling matters! It contributes the most variability to a mycotoxin test result, followed by sample preparation and then analysis.

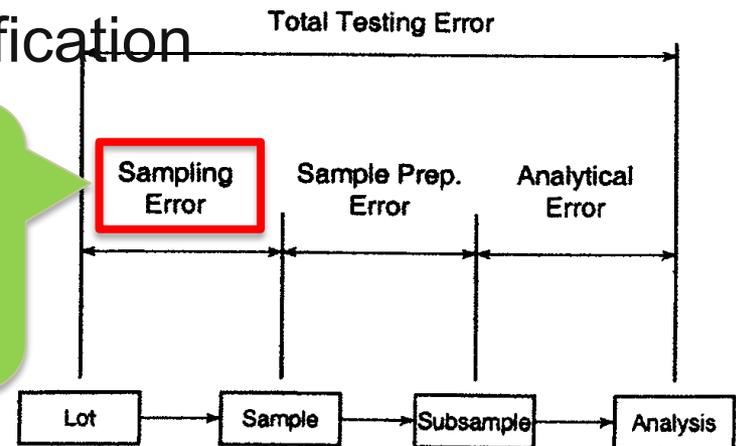
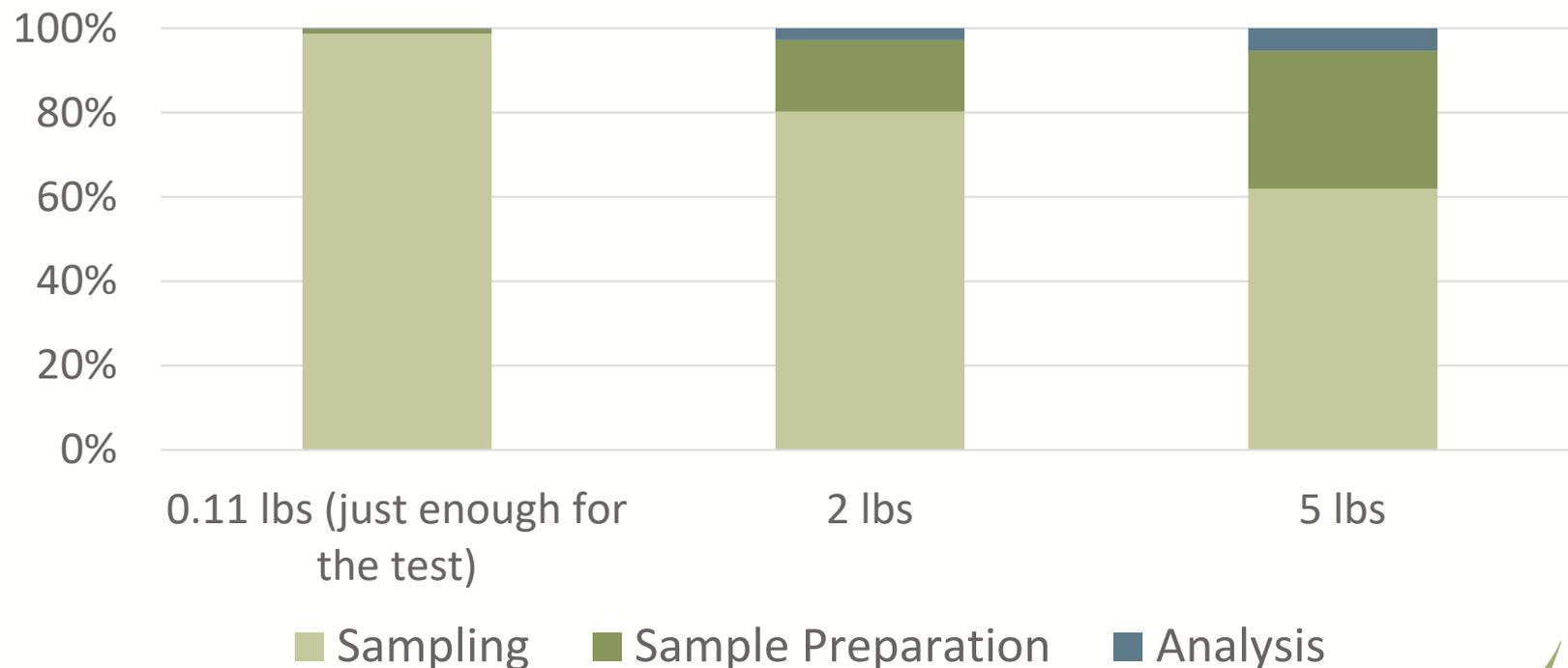


Figure 1. Total variance partitioned into sample, sample preparation, and analytical components.



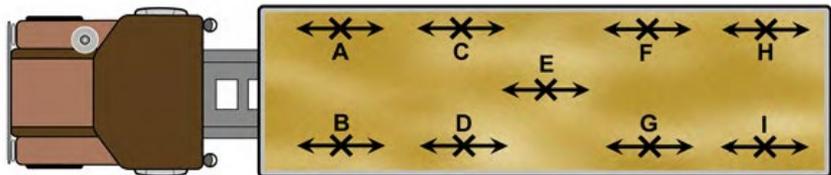
Sampling can significantly effect the variability of a test result

% of aflatoxin test result variability that can be attributed to each step of the testing plan

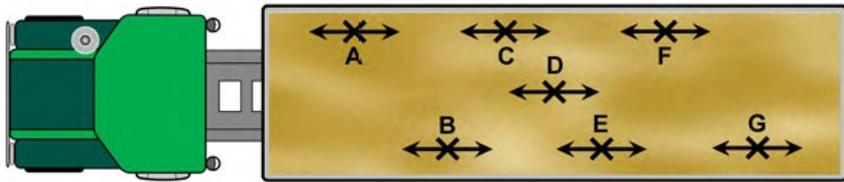


Your sample: increments → composite → laboratory → test portion

- FGIS has prescribed sampling methods for various grain transportation units—these are time-consuming
- **May not be practical or feasible to use for every load at some grain facilities**
 - Prescribed for compliance sampling (aflatoxin)
- Just remember, for your own business purposes, to define your lots (or decision units) in logical, defensible ways.



Sampling patterns for flat-bottom trucks or trailers containing grain less than 4-feet deep (top) and more than 4-feet deep (bottom)



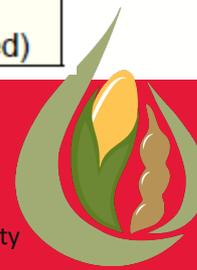
United States Department of Agriculture Federal Grain Inspection Service. 1995. Grain Inspection Handbook - Book 1 Grain Sampling. United States Department of Agriculture Grain Inspection, Packers & Stockyards Administration.

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FGIS laboratory sample sizes for *official tests*

Commodity	Official Lot Type Minimum sample size (lbs. / grams)			Submitted Samples lbs. / grams
	Trucks or Containers	Railcars	Barges, Sublots & Composite Samples	
Aflatoxin	2 lbs./908 grams	3 lbs./1,362 grams	10 lbs./4,540 grams	10 lbs./4,540 grams (Recommended)
Deoxynivalenol (DON)	200 grams 2 lbs./908 grams (corn only)	200 grams 1000 grams (corn only)	200 grams 1000 grams (corn only)	200 grams 1000 grams (corn only) (Recommended)
Zearalenone	2 lbs./908 grams	3 lbs./1,362 grams	10 lbs./4,540 grams	10 lbs./4,540 grams (Recommended)
Fumonisin	2 lbs./908 grams	3 lbs./1,362grams	10 lbs./4,540 grams	10 lbs./4,540 grams (Recommended)
Ochratoxin A	2 lbs./908 grams	1,000 grams 3 lbs./1,362 grams (corn only)	1,000 grams 10 lbs./4,540 grams (corn only)	1,000 grams 10 lbs./4,540 grams (corn only) (Recommended)



Once you have your representative laboratory sample, grind the whole sample and divide it to obtain the test portion

- Want small particle size (most recommend at least 75% of material pass through 20-mesh sieve; GIPSA 95%)



<https://www.seattlecoffeegear.com/bunn-bulk-commercial-coffee-grinder>

https://www.seedburo.com/pop.asp_Q_poptype_E_2_A_imageName_E_3010x.jpg



Analysis

- Ground test sample → extract → dilute → analyze
- Many options, best choice depends on your situation
- Many considerations with +/- for each
 - In-house/external lab
 - Analysis method
 - HPLC
 - Lateral flow
 - ELISA



Rapid test kit-applicability

- Water vs. solvent based
- Matrix appropriateness
- Personnel training
 - Skills, accuracy, consistency
- FGIS “approved” mycotoxin rapid test kits

<https://www.ams.usda.gov/sites/default/files/media/FGISApprovedMycotoxinRapidTestKits.pdf>



Finally, **COMMUNICATE AND DOCUMENT**

- Operations, marketing/sales
- Supervisors and supervisees
- Written plan-*If you didn't write it down, it didn't happen!*



Thanks for your attention!

Find more information and watch for updates throughout the season at iowagrains.org, cropprotectionnetwork.org, and Iowa State Integrated Crop Management website and blog.

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