Impact of hail damage on grain quality

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Northeast storm

- July 24, 2009
- ~400,000 acres damaged
- Estimated 10% of acreage had 100% yield loss

“Sac to Grundy” storm

- August 9, 2009
- Travelled ~150 miles; 900,000 acres
- Hail swath ~10 miles wide; middle 3 miles (~30%) had 100% damage

Hail damage, Sac County, 8-09-2009

Photos courtesy: Mark Licht, ISU Extension

Hail damage, Callendar area, August 2009

Photos courtesy: John Holmes, ISU Extension

Relevant Questions

1. **How much does hail damage increase susceptibility to ear rots?**

2. **What is the severity of mycotoxin risk associated with hail-damaged grain?**

3. **How does hail damage affect grain quality characteristics** (test weight, seed weight, moisture, protein, oil, starch and density)?

Methods

1. Fields identified
2. 24 ears collected within 48 hours of harvest
    i. ears from 8 locations per field
    ii. @ each location: 3 ears from three consecutive plants
    iii. Husks intact
    iv. Grain sample (~10lb) from combine
3. Ears placed in a box/paper bag
4. Overnight shipped to campus

Field information required

- Location
- Hybrid
- Storm details:
  - ✓ Date
  - ✓ Size of hail stones
  - ✓ Duration
- Percent damage to crop
- Growth stage of crop at time of storm
- Fungicide applied

Assessments

Sample received and ID number assigned

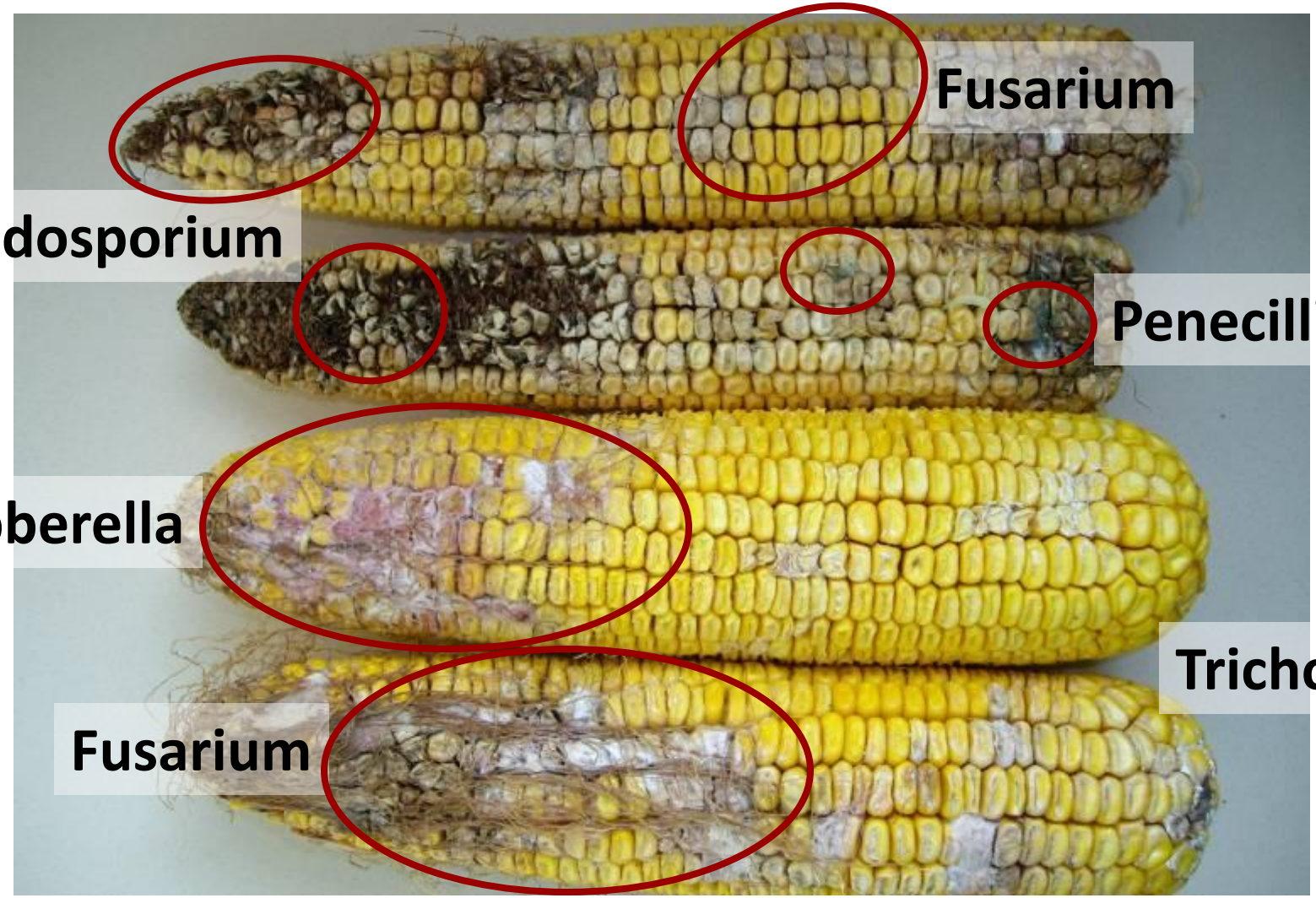
Field information captured

Visual assessment of ear sample:

a. **percent hail damage**
b. **percent ear rot severity**
c. **molds present**

Hail damage assessments - percent damage

Ear rot assessments – percent severity; rot present



Assessments

Sample shelled and aspirated (Kice Lab Aspirator)
Simulate combine

clean grain subsample **liftings subsample**

For each subsample:

test weight (G,L)
seed weight

moisture (G,L)
density

protein
oil
starch

Clean grain vs liftings

Assessments

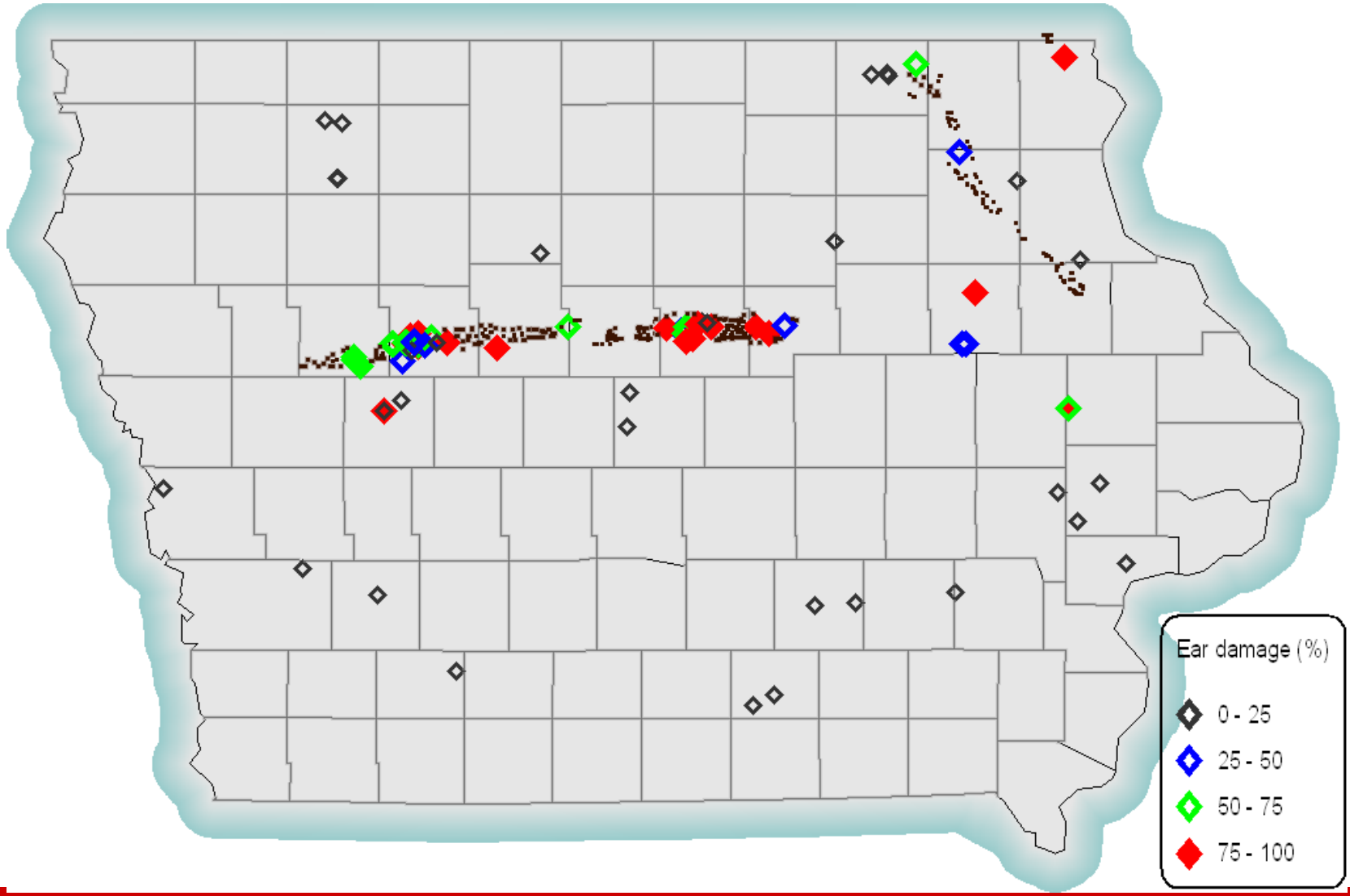
Subsamples (G, L) dried to <15% moisture

Ground (G, L) (Romer mill)

Mycotoxin analysis (G, L)(lateral flow strips and HPLC)

i. **aflatoxin**
ii. **fumonisins**
iii. **DON (vomitoxin)** → **ZEN**

Sample Locations and Percent Hail Damage



RESULTS

103 samples received:

- 63 ear samples from hail damaged fields:
  - 7 from July storms
  - 56 from Sac-to-Grundy storm
  - 2 from other early August storms
- 26 “background” ear samples
- 2 ear samples from bird damage
- 12 grain samples

RESULTS

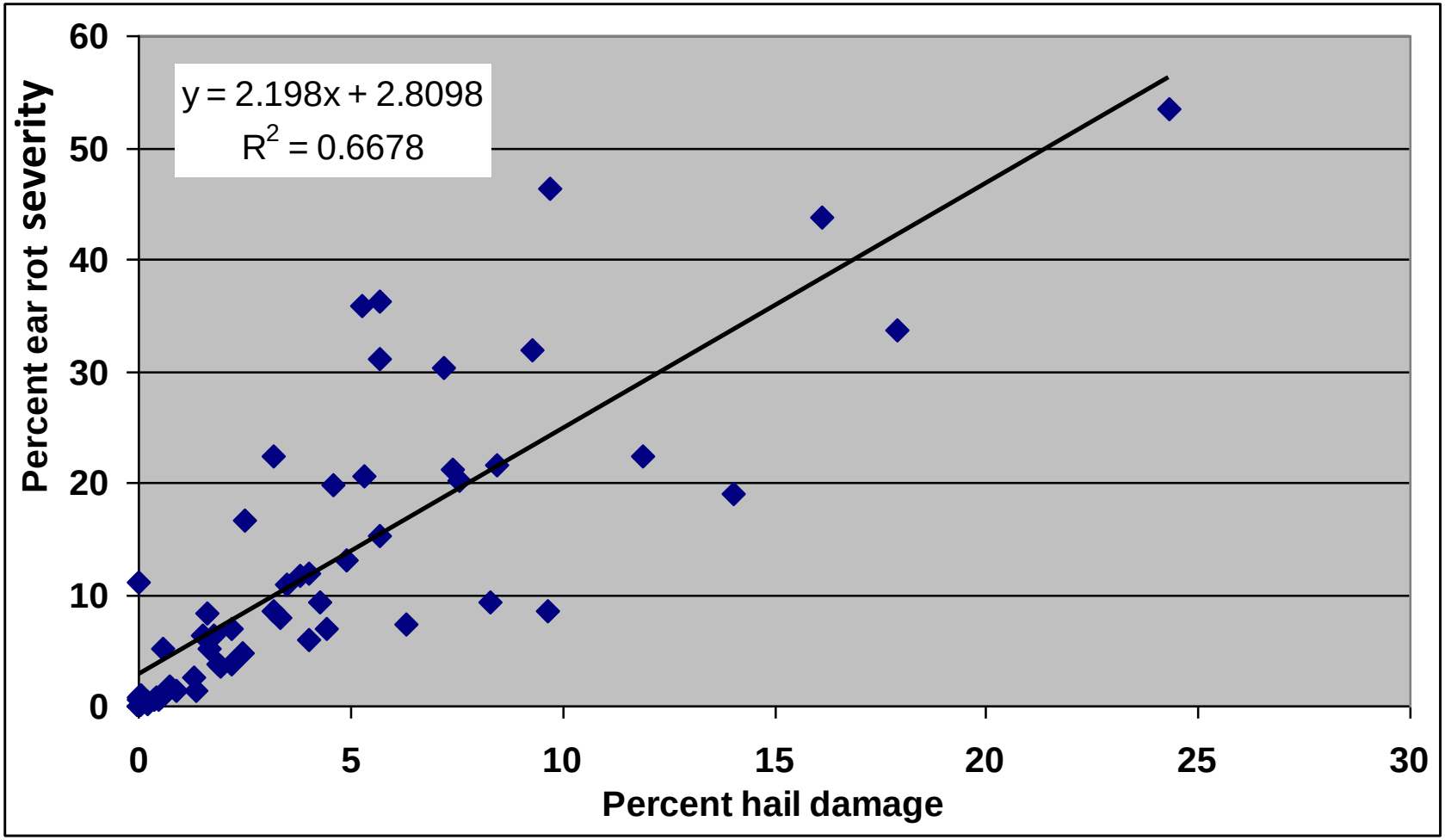
- Hail stones: 1/4” to golf ball
- Length of storm: 30s to 30 min
- Growth stage: V18 to R3
- % damage to crop: 2 to 100

Ear Rot Summary

	Mean	High	Low	Ear rot*
Hail samples *(N=63)*				
Hail damage (%)	3.9	24.3	0.0	
Ear rot severity (%)	11.3	53.4	0.0	Fusarium, Gibberella
Background samples (N=26)				
Ear rot severity (%)	3.2	16.4	0.0	Cladosporium

* Predominant ear rots present

Ear rot severity (%) increased with greater hail damage (%)



Effect of storm duration, stone size, and growth stage on percent ear rot severity

H_o: duration, stone size and growth stage have no linear effect on ear rot

	P
Duration	0.21
Size	0.06
Growth stage	0.01

Ear rot severity (%) was affected by growth stage

Hail damage at R3 increases In (percent ear rot severity) 1.5 units

	Estimate	Standard error	P
R1 (silking)	0.10	0.83	0.91
R2 (blister)	-0.56	0.83	0.51
R3 (milk)	1.46	0.66	0.03
R4 (dough)	0.91	1.00	0.37
VT (tasseling)	0		

Mycotoxin Summary

	Hail	Total No. samples	No. positive	Mean	High	Low
DON	Yes	55	54	1.71	>6.0	ND
(ppm)	No	5	3	0.67	2.4	ND
ZEN	Yes	55	43	0.31	>1.4	ND
(ppm)	No	5	2	0.02	0.04	ND
Fum	Yes	55	40	0.25	4.8	ND
(ppm)	No	5	3	0.05	0.1	ND

FDA Advisory Limits for Fumonisins

- 5 ppm for horses and other equine
- 10 ppm for swine
- 50 ppm for cattle and poultry (except for turkeys where there is not sufficient data to determine the proper levels)
- 4 ppm – human food corn products except
- 3 ppm - popcorn

FDA Advisory Limits for DON

- No advisory limit for raw wheat
- 1 ppm for finished wheat products for human consumption
- 5 ppm for swine and other animals (except cattle and chickens); not to exceed 20% of swine diet and 40% for other animals.
  → **Therefore threshold for DON in swine feed = 1 ppm of total ration**
- 10 ppm for beef and feedlot cattle older than 4 months and for chickens; not to exceed 50% of the diet

ISU guidelines for ZEN

Diet should contain:

- <1 ppm for prepubertal gilts
- <3 ppm for sexually mature sows, bred sows
- <20 ppm for young boars
- <100 ppm for mature boars

- <10ppm for virgin heifers

Osweiler (1996) *Toxicology, The National Veterinary Medical Series for Independent Study*, Williams & Wilkins, Media, PA: 421.

Quality Summary

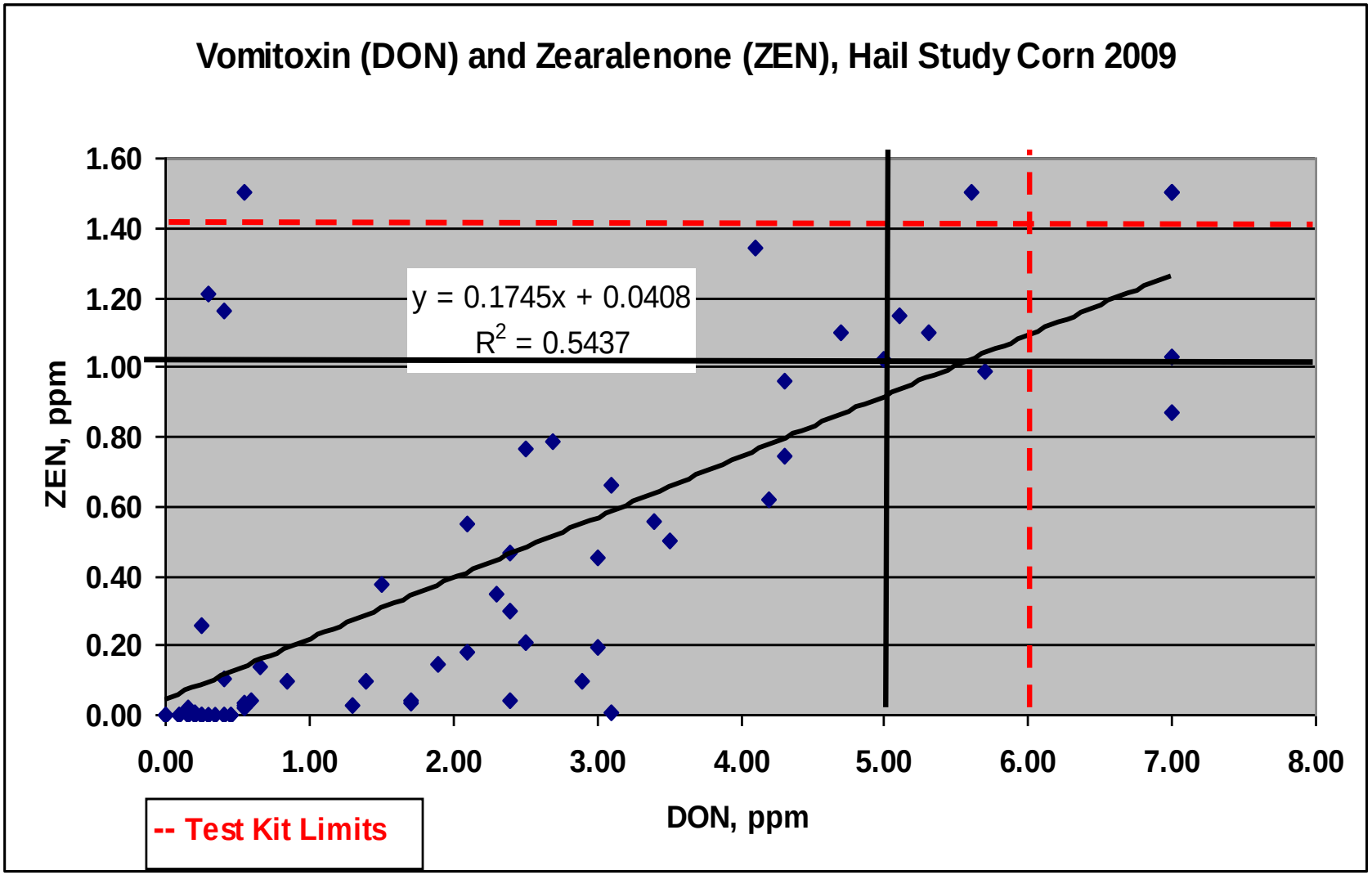
		Mean	High	Low
Test Wt.	lb/bu	51.6	58.9	42.3
Protein	%@15M	7.7	10.1	6.4

Correlations

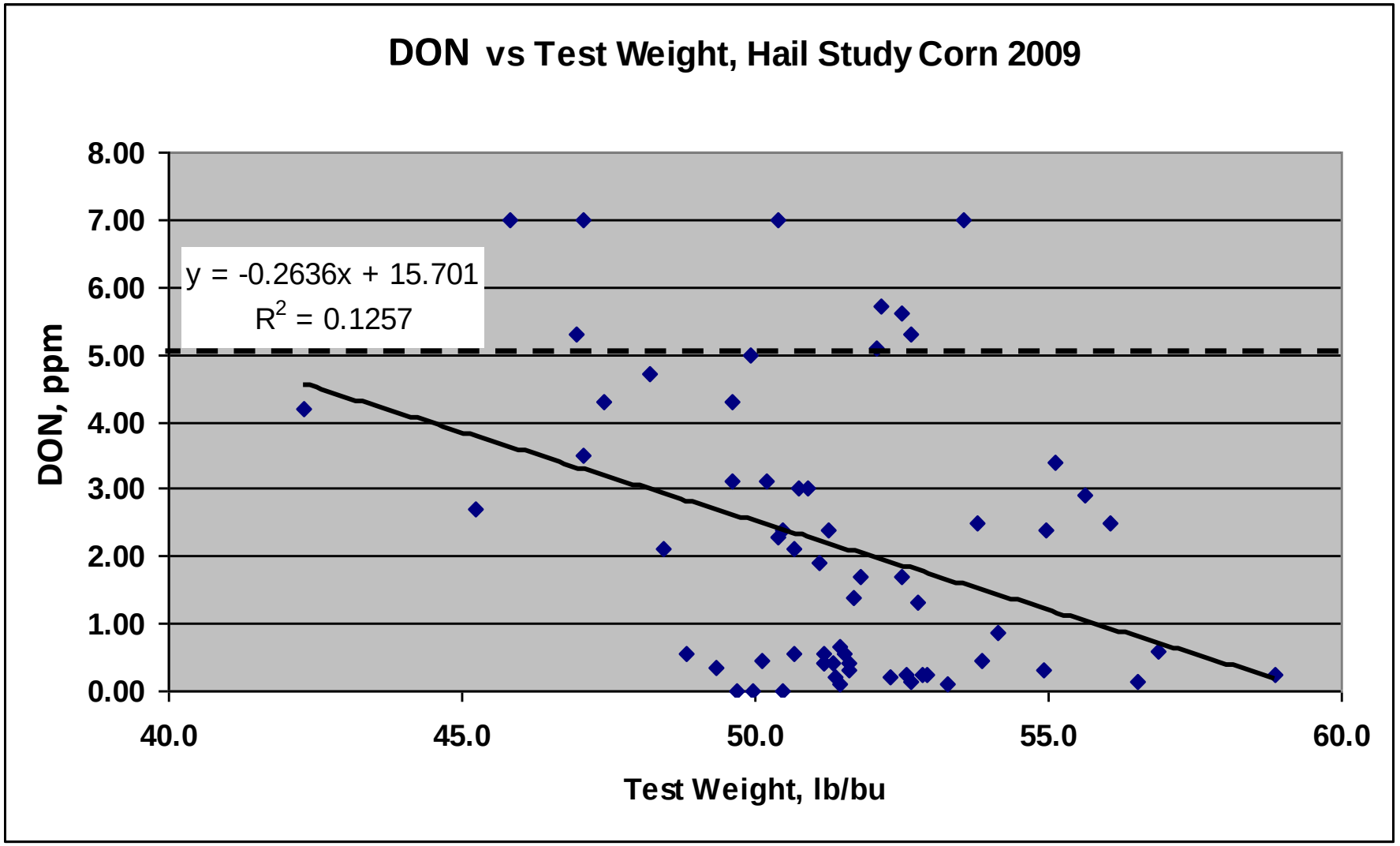
	ZEN	Fum	Test Wt.	Protein	Hail Damage	Ear rot Severity
DON	**0.74**	0.06	-0.35	0.31	**0.53**	**0.72**
ZEN		0.32	-0.25	**0.49**	**0.57**	**0.69**
Fum			-0.06	0.39	**0.57**	0.11
Test Wt.				-0.35	**-0.47**	**-0.43**
Protein					**0.65**	**0.61**
Hail Damage						**0.85**

Indicates highly significant relationship ($p<0.01$)

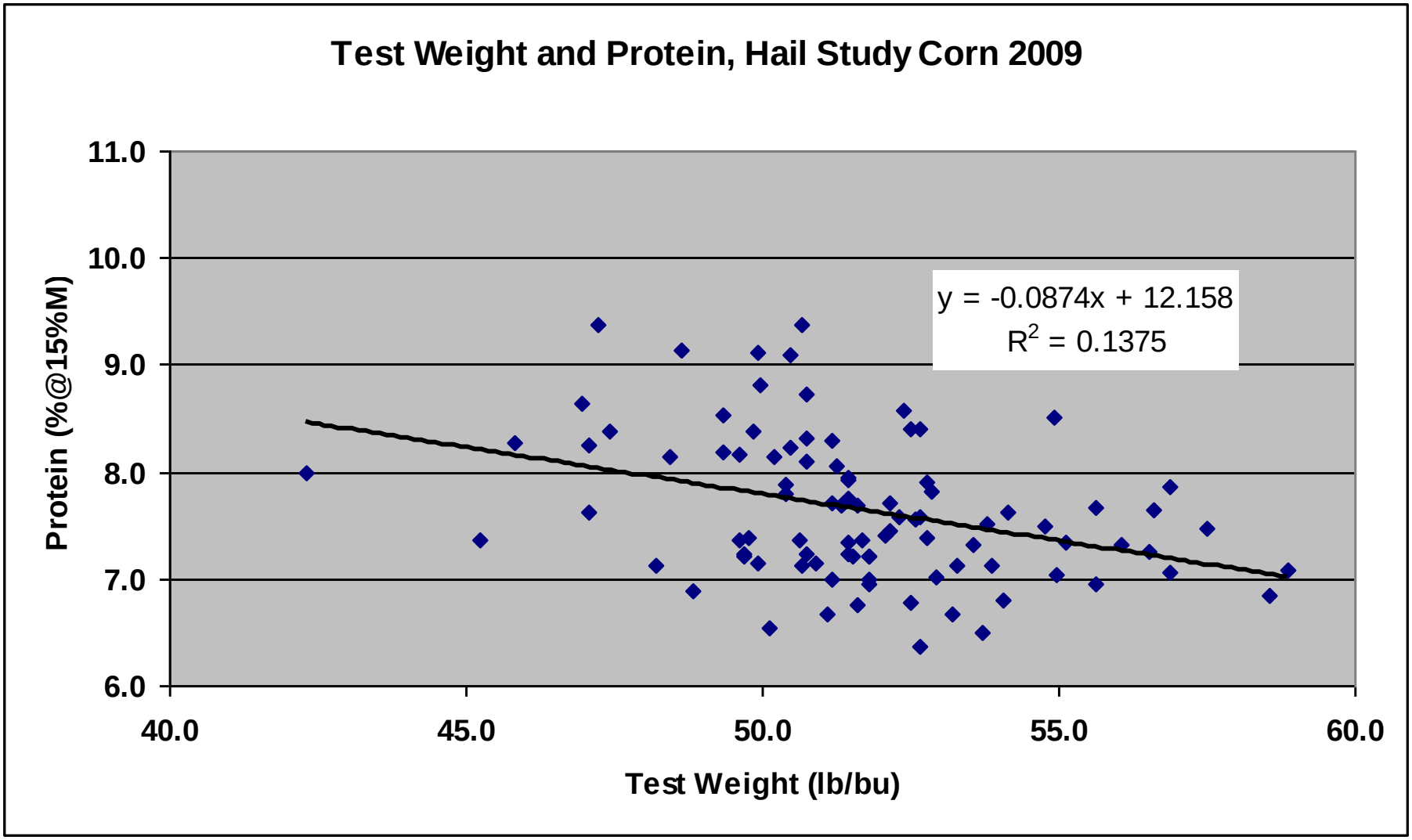
When there was DON, there was ZEN



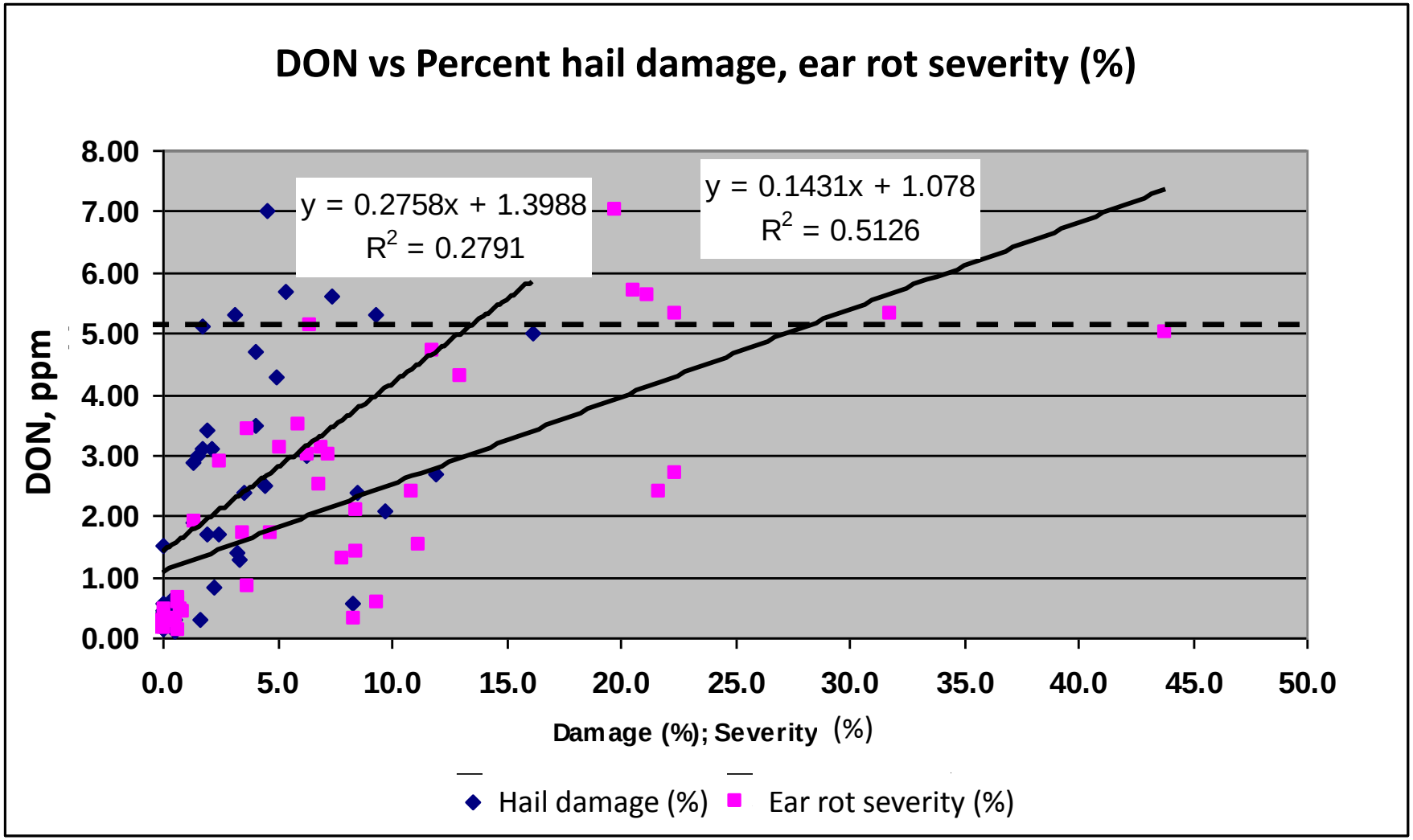
Test Weight did not predict DON well



Low Test Weight is not low protein



Visual count and severity - best indicators



Summary

- Hail damage predisposed ears to ear rots.
- Milk stage (R3) was most susceptible to damage/ear rot.
- Gibberella and Fusarium ear rots were most prevalent.



Summary

- Visually damaged samples had detectable toxin levels (DON, ZEN, FUM); positive correlation.
- ~10% over FDA advisory values for corn.
- ~50% over ethanol concentration limit.

Summary

- Physical, chemical properties were poor predictors of toxin presence.
- **Preharvest evaluation was the best indicator of toxin presence**.
- Does this mean that toxin levels in stored corn are correlated with Total Damage?

Photos courtesy: Mark Licht, ISU Extension