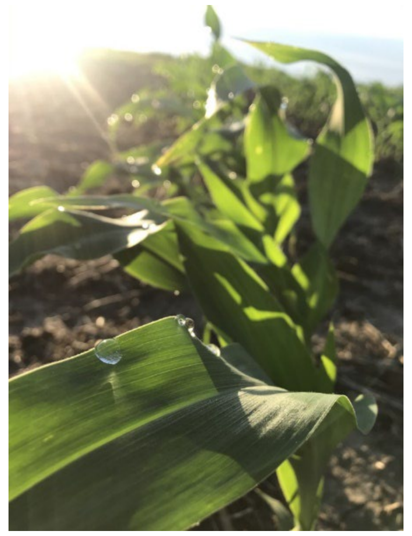
Abnormal Ear Development in Corn













Osler Ortez

Corn & Emerging Crops

Dept. of Horticulture and Crop Science

THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

December 2022

Indiana CCA Conference

Today's Outline

Background

PHASE I
Literature Review, Potential Factors

PHASE II
Summary of Ear Symptoms

PHASE III
Survey, Farmer Fields

PHASE IV
G x E x M Research

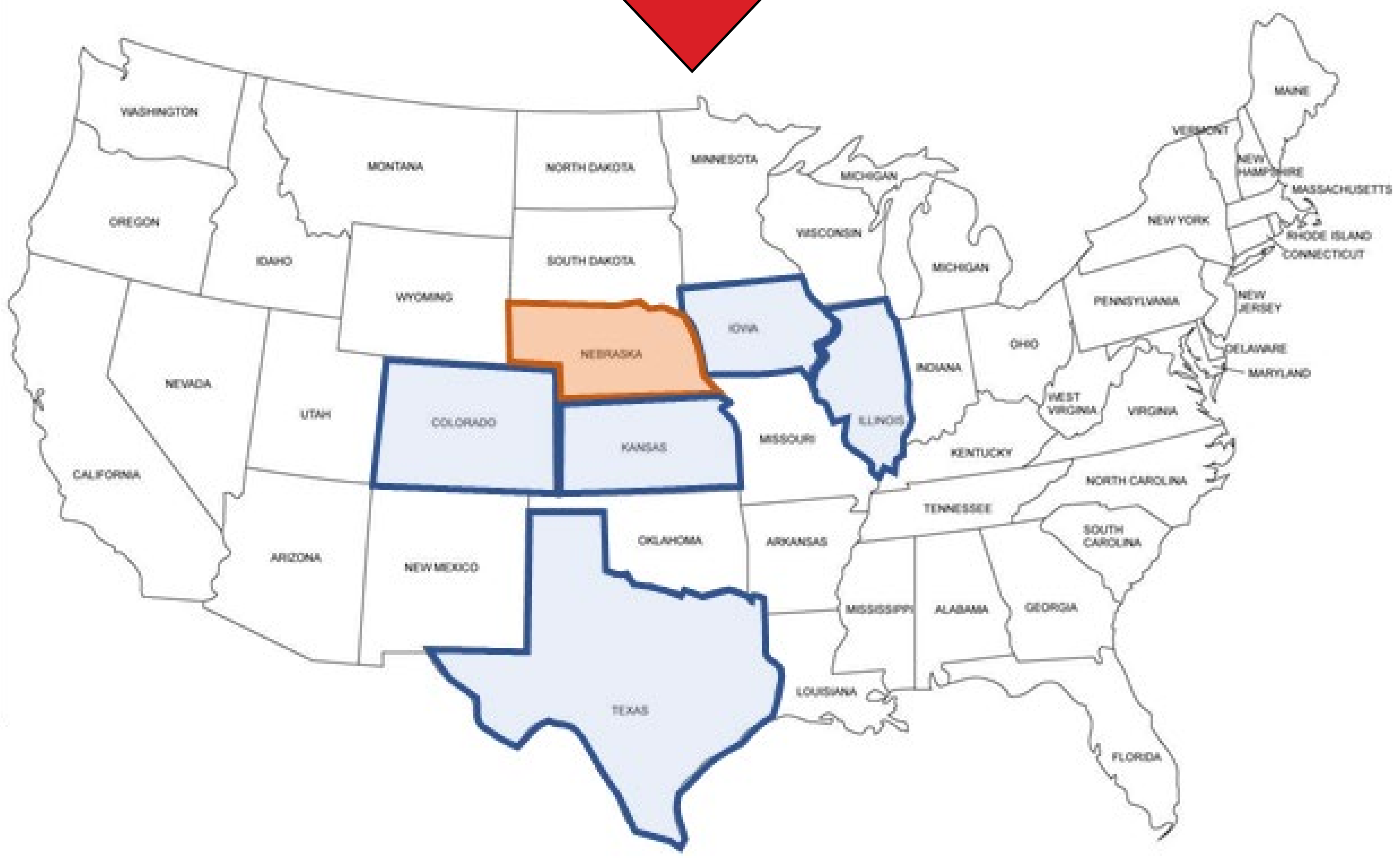
Conclusions

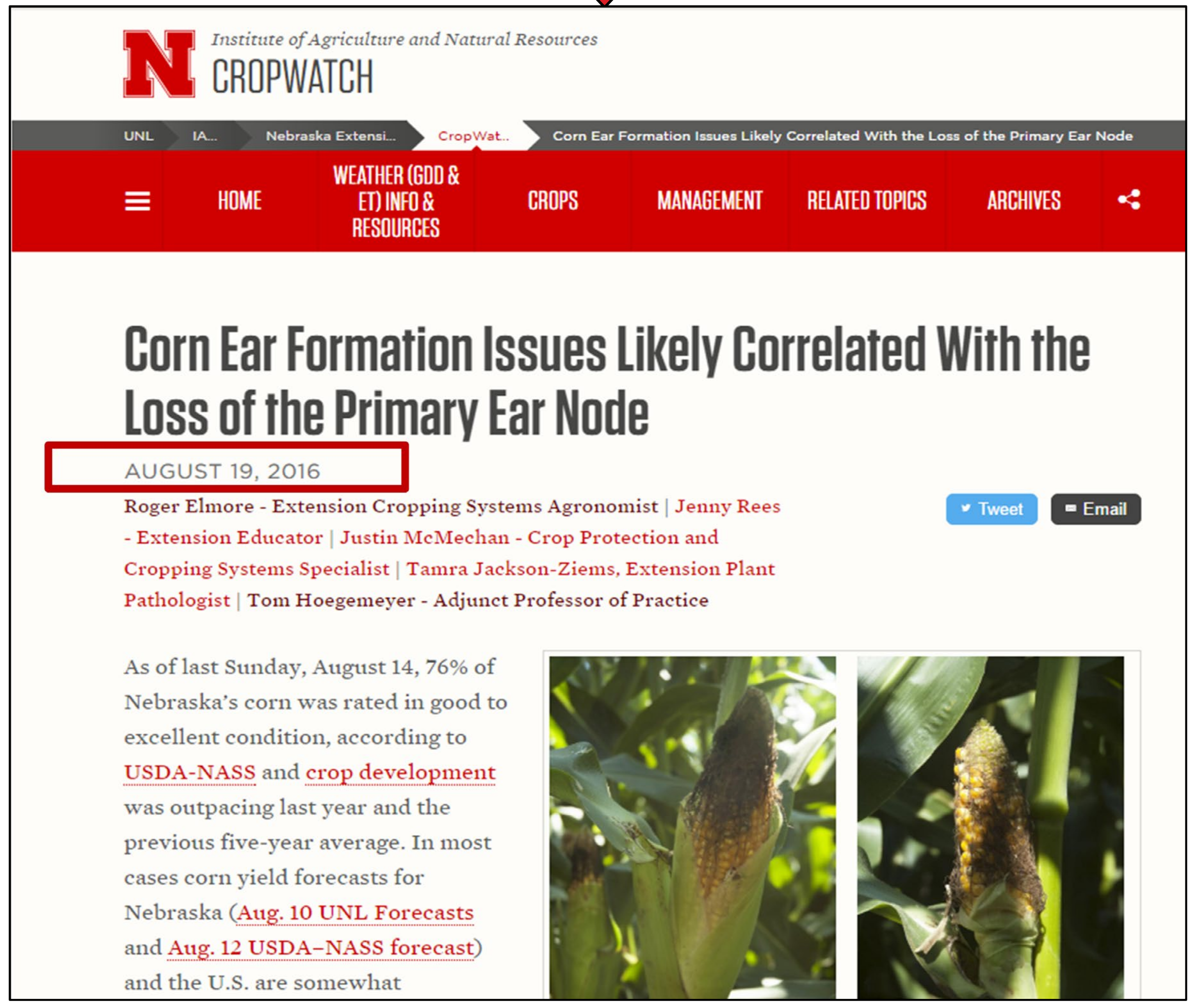
Reports of **abnormal ears** and **yield losses** in **August 2016**

Initially thought it was isolated to **Nebraska**

Additional **reports** from:

- **Texas Panhandle**
- **Eastern Colorado**
- **Kansas**
- **Iowa**
- **Illinois**




Institute of Agriculture and Natural Resources
CROPWATCH

UNL | IA... | Nebraska Extensi... | CropWat... | Corn Ear Formation Issues Likely Correlated With the Loss of the Primary Ear Node

HOME | WEATHER (GDD & ET) INFO & RESOURCES | CROPS | MANAGEMENT | RELATED TOPICS | ARCHIVES

Corn Ear Formation Issues Likely Correlated With the Loss of the Primary Ear Node

AUGUST 19, 2016

Roger Elmore - Extension Cropping Systems Agronomist | Jenny Rees - Extension Educator | Justin McMechan - Crop Protection and Cropping Systems Specialist | Tamra Jackson-Ziems, Extension Plant Pathologist | Tom Hoegemeyer - Adjunct Professor of Practice

Tweet | Email

As of last Sunday, August 14, 76% of Nebraska's corn was rated in good to excellent condition, according to USDA-NASS and crop development was outpacing last year and the previous five-year average. In most cases corn yield forecasts for Nebraska (Aug. 10 UNL Forecasts and Aug. 12 USDA-NASS forecast) and the U.S. are somewhat

Abnormal ears were **likely** the result of **interactions** among **G × E × M**

… but **specific causes** were **yet to be studied!**

What was being reported?

More than **100 years** of **corn research**, **abnormalities** are not **completely** understood (Emerson, **1912**; Kempton, **1913**)...

Abnormal ears reduce yields... Hence, affect productivity!

Crop, Forage & Turfgrass Management

REVIEW | Open Access

Conditions potentially affecting corn ear formation, yield, and abnormal ears: A review

Osler A. Ortez, Anthony J. McMechan, Thomas Hoegemeyer, Ignacio A. Ciampitti, Robert L. Nielsen, Peter R. Thomison, Lori J. Abendroth, Roger W. Elmore

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Crop, Forage & Turfgrass Management

REVIEW

Crop Management

Conditions potentially affecting corn ear formation, yield, and abnormal ears: A review

Osler A. Ortez[1,5] | Anthony J. McMechan[2] | Thomas Hoegemeyer[1] | Ignacio A. Ciampitti[3] | Robert L. Nielsen[4] | Peter R. Thomison[5] | Lori J. Abendroth[6] | Roger W. Elmore[1]

[1]Dep. of Agronomy and Horticulture, Univ. of Nebraska-Lincoln, Lincoln, NE 68583, USA

[2]Dep. of Entomology, Univ. of Nebraska-Lincoln, Lincoln, NE 68583, USA

[3]Dep. of Agronomy, Kansas State Univ., Manhattan, KS 66506, USA

[4]Dep. of Agronomy, Purdue Univ., West Lafayette, IN 47907, USA

[5]Dep. of Horticulture and Crop Science, Ohio State Univ., Columbus, OH 43210, USA

[6]Agricultural Research Service, USDA, Columbia, MO 65211, USA

Correspondence
Osler Ortez, current address, Dep. of Horticulture and Crop Science, College of Food, Agriculture, and Environmental Sciences, Ohio State Univ., Columbus, OH 43210, USA.
Email: oortez94@hotmail.com

Assigned to Associate Editor Brett Allen.

Abstract

Abnormal ear development in corn (*Zea mays* L.) has been reported for more than 100 years. More recently, in 2016, widespread abnormal multiple ears per stalk node (herein termed as multi-ears), barbell ears, and short husks were reported in cornfields located in the western and central Corn Belt (Illinois, Iowa, Nebraska, and Kansas), Eastern Colorado, and the Texas Panhandle region in the United States. Little was known about the underlying causes of these abnormalities. A literature review examining conditions potentially affecting corn ear formation, yield, and abnormal ears was conducted. Several abnormal ear symptoms appear to be formed by stress conditions such as extreme weather, limited solar radiation, and responses to plant growth regulators. The accumulation of these effects can result in the abortion of primary ears and the development of secondary abnormal ears, which has been a hypothesis for the last 15 years. Whether or not primary ear abortion is one of the factors for abnormal ears remains a valid question. Abnormal ears can be understood as the result of an "expression triangle": susceptible genetics, conducive environmental conditions, and unfavorable management practices. Together, these factors can interact and cause abnormal ears and lower yields. Active knowledge gaps include the environmental and physiological pathways to abnormal ears, their impact on grain quality and yield, their effect on other processes such as dry-down and harvest ease, and an in-depth understanding of differing genetics, environment, and management.

Open Access: https://doi.org/10.1002/cft2.20173

CFAES

Rationale

- Need for **better understanding** of abnormal ears
- Several **factors** potentially affect **abnormal ears**

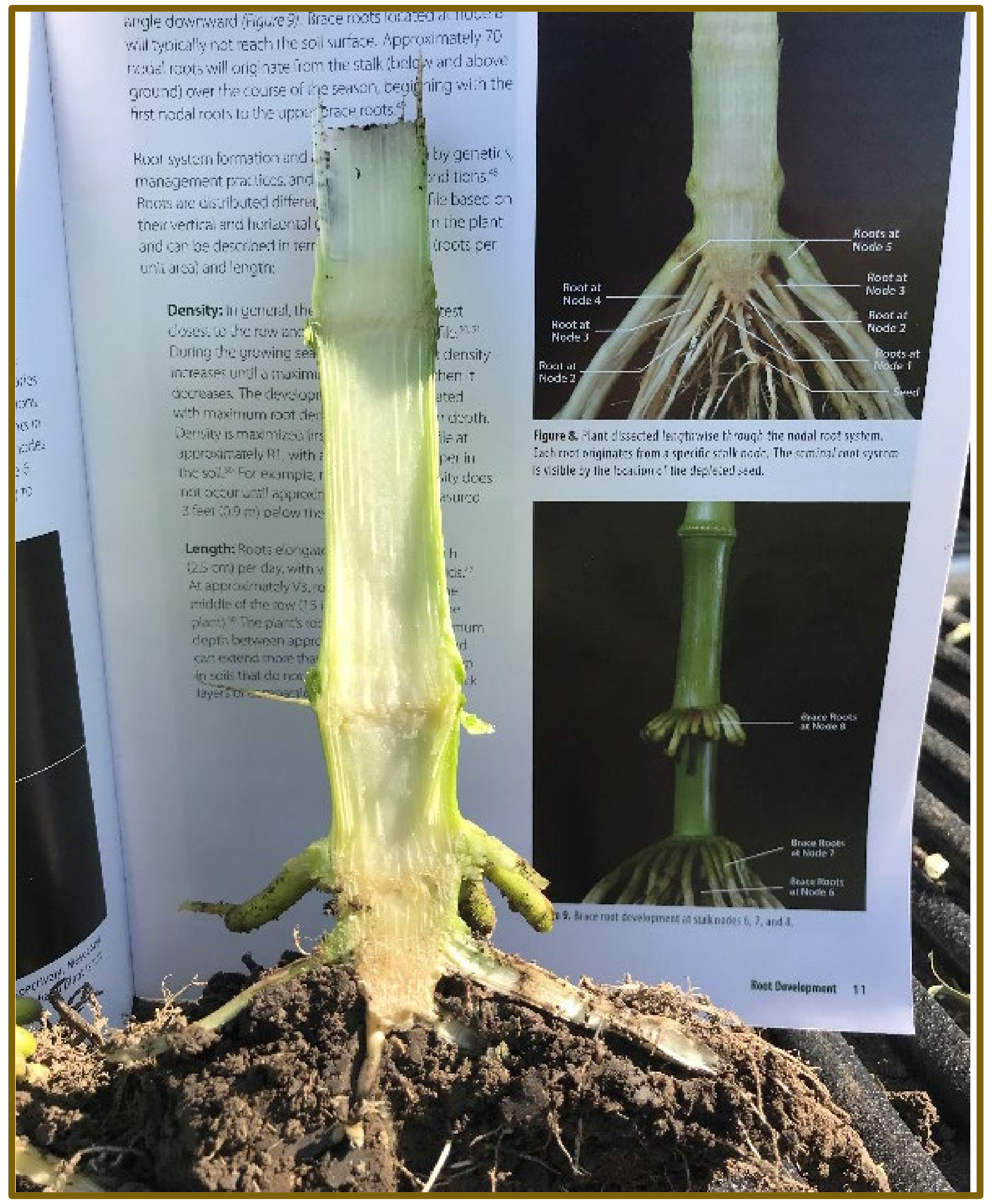
Objectives

- Identify **environmental** and **physiological** factors that can affect **ear formation**, **yield**, and **abnormal ears**

Methods

- Review of literature on
  - Extreme **weather**
  - Solar **radiation** availability
  - Plant growth **regulators**
  - Primary ear **abortion**

Nodal root system, V9 plant



Dissected V9 plant

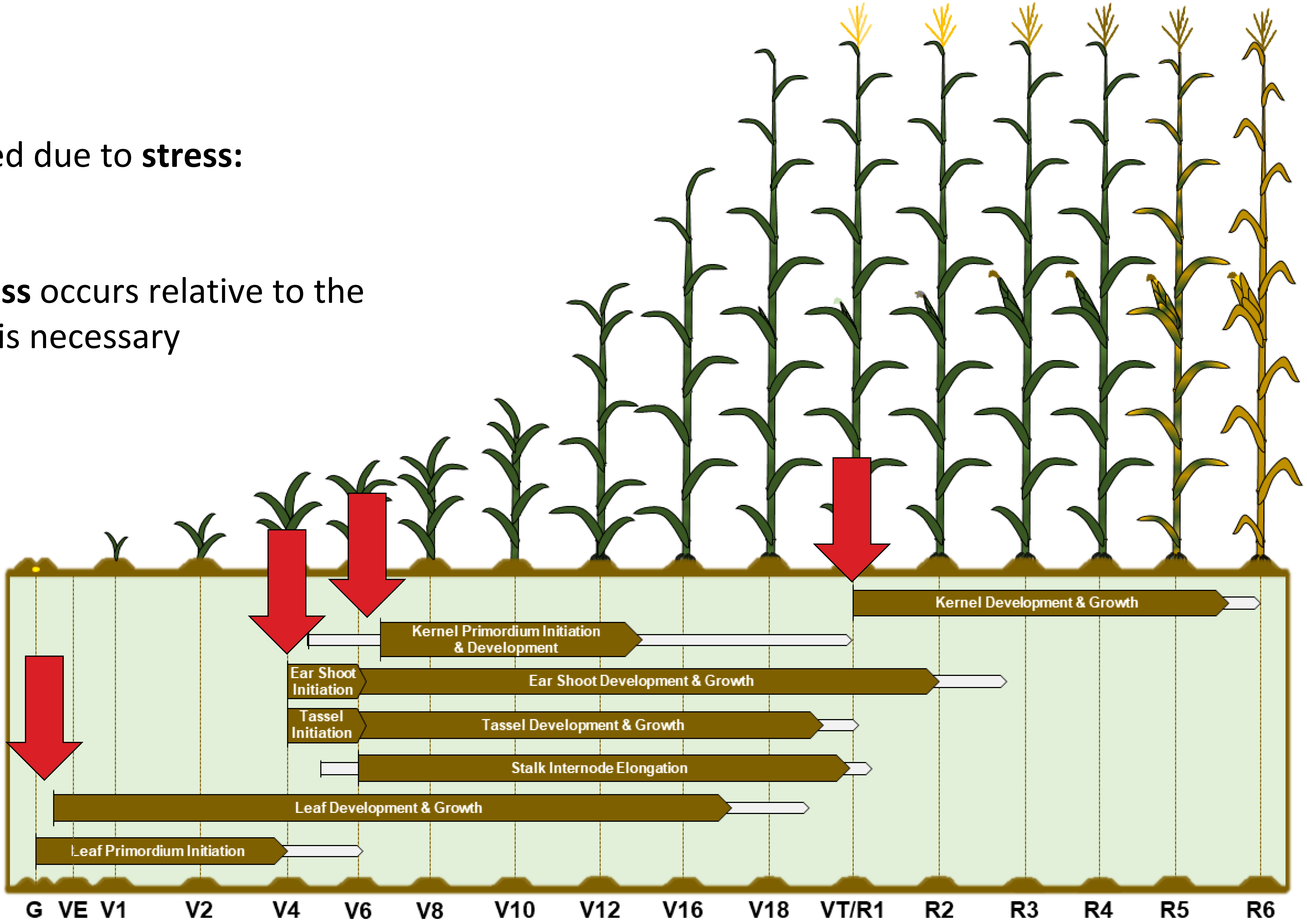
Ortez et al. (2022a), *Crop, Forage & Turfgrass Management*

- Axillary **ear meristems**, which potentially initiate **ears or tillers**, are initiated acropetally (i.e., **from base to tip**) at every node of the plant's stalk (Lejeune & Bernier, 1996)

Initiated ears at every above ground node of the **plant's stalk** except for the uppermost nodes.

Dissected plant at **V18 stage**

- Abnormal ears can be formed due to **stress: biotic or abiotic**
- Understanding of **when stress** occurs relative to the formation of **ears and yield** is necessary

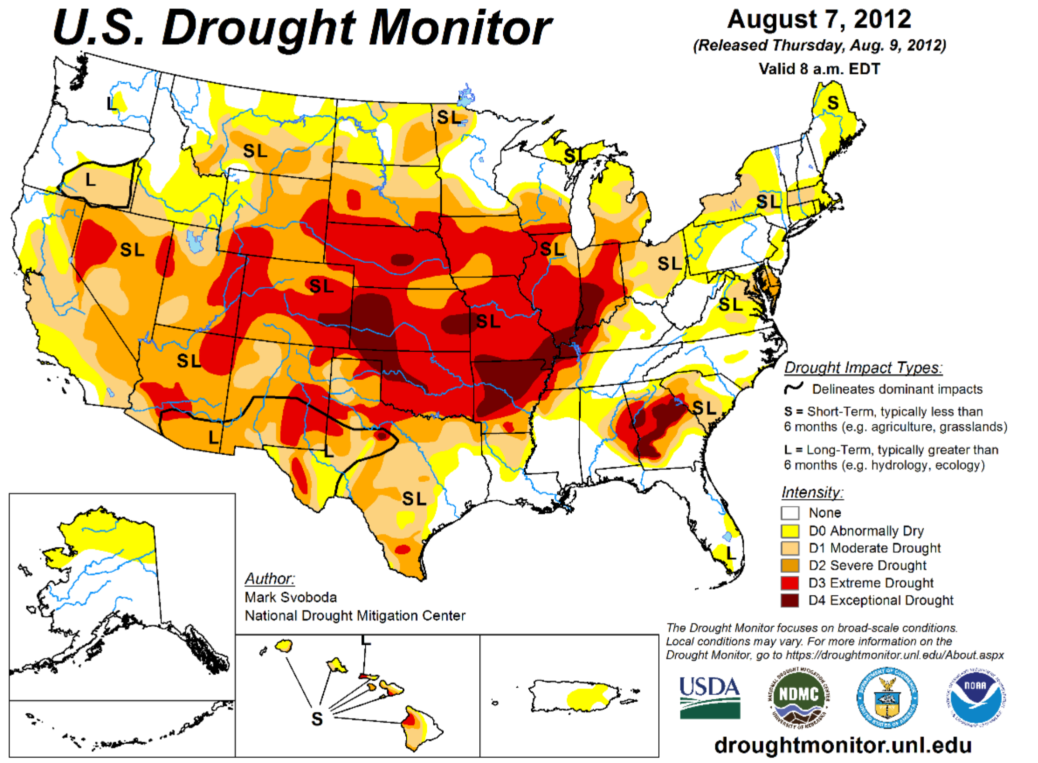


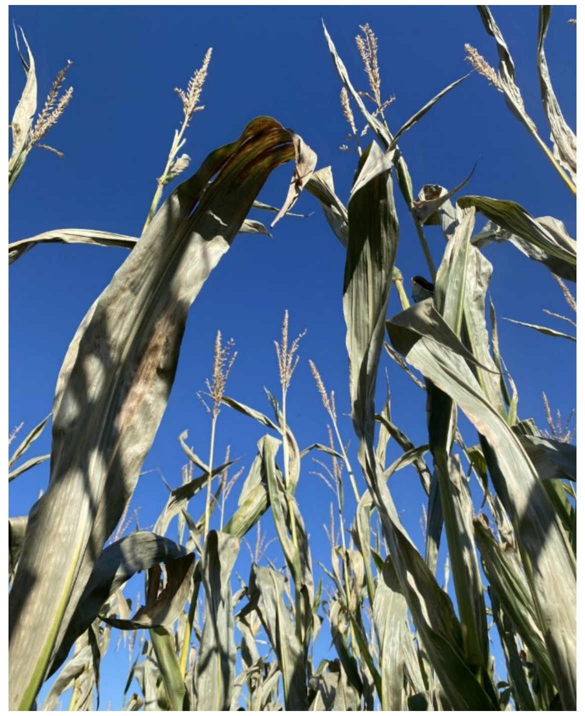
Ortez et al. (2022a), *Crop, Forage & Turfgrass Management*

Corn growth & development: initiation & period

Extreme weather:

- Widespread **drought in 2012** caused a 23% loss of production in the US, relative to the yield trends (USDA-NASS,2013).
- **Abortion of primary ear**, induced by cold treatment of 10˚C (50˚F) for 5-7 days right before tassel initiation, ~V5 stage (Lejeune and Bernier, 1996).
- **Stress sources**: cold, flood, drought, heat, wind, hail, freeze (Foyer et al., 1994, Perata & Alpi, 1993).
- **Hybrids** differ in their response to stress.

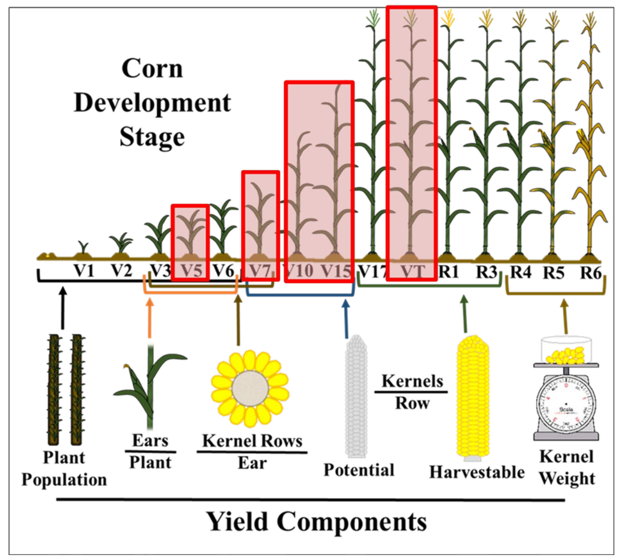




Solar radiation:

- **Light availability** is critical for corn yield (Hashemi-Dezfouli & Herbert,1992; Liu & Tollenaar,2009; Reed et al.,1988)
- Increased **light interception** in the lower plant canopy increased the number of harvestable ears per plant (Prine,1971).
- **Lower light** availability decreased grain, stover, total protein, and total oil (Earley et al., 1966).
- A 60, 70, 80, and 90% shading between17 July and 7 August produced **barbell-shaped ears and arrested ears** in Illinois (Earley et al., 1967).

Ortez et al. (2022a), *Crop, Forage & Turfgrass Management*



Plant growth regulators:

- Plant hormones control several aspects of **plant growth** (Ross& O'Neill,2001):
  Inhibitors and promoters, flowering & axillary meristems (Cline,1994; Lejeune et al.,1994; Mok,1994).
- Plant **growth regulators**, abscisic acid, and ethylene are involved in **plants' stress**:
  - Auxinic compounds applied at the floral transition stage (~V4 and V6), **ear shoot abortion** increases (Lejeune et al.,1998).

- **Ethephon** (ethylene-based growth regulator), decreased kernel number (Cox & Andrade,1988).
- Ethylene and alkylphenol ethoxylate (APE) share ethylene oxide as a biological metabolite (Dodds & Hall,1982; Jones& Westmoreland,1998; Ying et al.,2002)
  - APE is a common component of **nonionic surfactant (NIS)** (Schmitz et al.,2011).

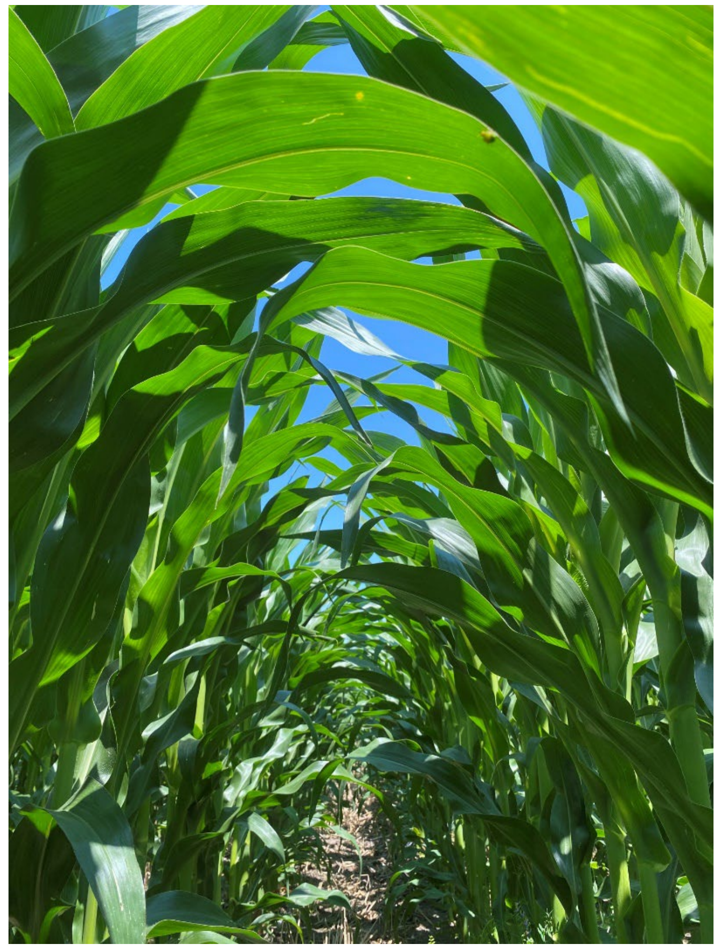
- Foliar application of **NIS resulted in arrested ear development** when applied at the V10 to V14 development stages (Schmitzet al.,2011).

- Plant **growth regulators** are essential in determining **plants' responses to stress**, ear formation, yield, and primary ear abortion in corn.

These effects can result in the **abortion of primary ears** and development of **abnormal secondary ears…** Still a **hypothesis!**

Ortez et al. (2022a), *Crop, Forage & Turfgrass Management*

Key Findings:



- Extreme **weather**, low solar **radiation**, and growth **regulators** can be some of the causes.
- **Primary ear abortion** correlate with the occurrence of abnormal ears.
- Factors affecting corn ear formation and abnormal ears result in **lower yields**.
- **Genetic × environment × management** interactions affect **ear formation, yield, and abnormal ears**.

Ortez et al. (2022a), *Crop, Forage & Turfgrass Management*

Agronomy Journal

REVIEW | Open Access

Abnormal ear development in corn: A review

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Agronomy Journal

REVIEW

Crop Ecology and Physiology

Abnormal ear development in corn: A review

Osler A. Ortez[1,2] | Anthony J. McMechan[3] | Thomas Hoegemeyer[1] | Ignacio A. Ciampitti[4] | Robert Nielsen[5] | Peter R. Thomison[2] | Roger W. Elmore[1]

[1] Dep. of Agronomy and Horticulture, Univ. of Nebraska-Lincoln, Lincoln, NE 68583, USA

[2] Dep. of Horticulture and Crop Science, The Ohio State Univ., Columbus, OH 43210, USA

[3] Eastern Nebraska Research and Extension Center, Univ. of Nebraska-Lincoln, Ithaca, NE 68033, USA

[4] Dep. of Agronomy, Kansas State Univ., Manhattan, KS 66506, USA

[5] Dep. of Agronomy, Purdue Univ., West Lafayette, IN 47907, USA

Correspondence

Osler A. Ortez, Dep. of Agronomy and Horticulture, Univ. of Nebraska-Lincoln, Lincoln, NE 68583, USA; current address: Dep. of Horticulture and Crop Science, The Ohio State Univ., Columbus, OH 43210, USA.
Email: oortez94@hotmail.com

Assigned to Associate Editor Hanna Poffenbarger.

Abstract

Intensive study for more than 100 yr has resulted in a good understanding of corn's (*Zea mays* L.) growth and development. However, abnormal development of ears in corn was reported in several U.S. states, including Texas, Colorado, Kansas, Nebraska, Iowa, and Illinois, during 2016, stretching our understanding. A comprehensive review of the literature was conducted to identify abnormal ears' symptoms, causes, and timing of development. This study aimed to (a) describe and summarize previously reported ear symptoms, (b) document recent widespread symptoms of major concern, and (c) describe our current understanding of the potential cause(s) and expected development timing for abnormal ears. In total, 10 previously reported symptoms of corn ears were found, including tassel, fasciated, arrested, pinched, blunt, silk-balled, incomplete kernel set, banana-shaped, zipper, and tipped-back. Three additional recent widespread symptoms of major concern associated with significant yield reduction across a wide area in 2016 were described: multi-ears, barbell-ears, and short-husk ears. The information available on several of the symptoms was limited, and the specific causes were unknown, highlighting the need for more research in this area. Despite this and based on existing knowledge, possible causal factors and postulated development timing (i.e., when the stress may have occurred) are presented for all symptoms. Abnormal ear development can be seen as the response to complex interactions among genetics, environment, and management practices. Ear abnormalities are detrimental to grain yield and quality, and their mitigation is imperative to efficient corn systems, crop resiliency, and sustainability.

Open Access: https://doi.org/10.1002/agj2.20986

Rationale

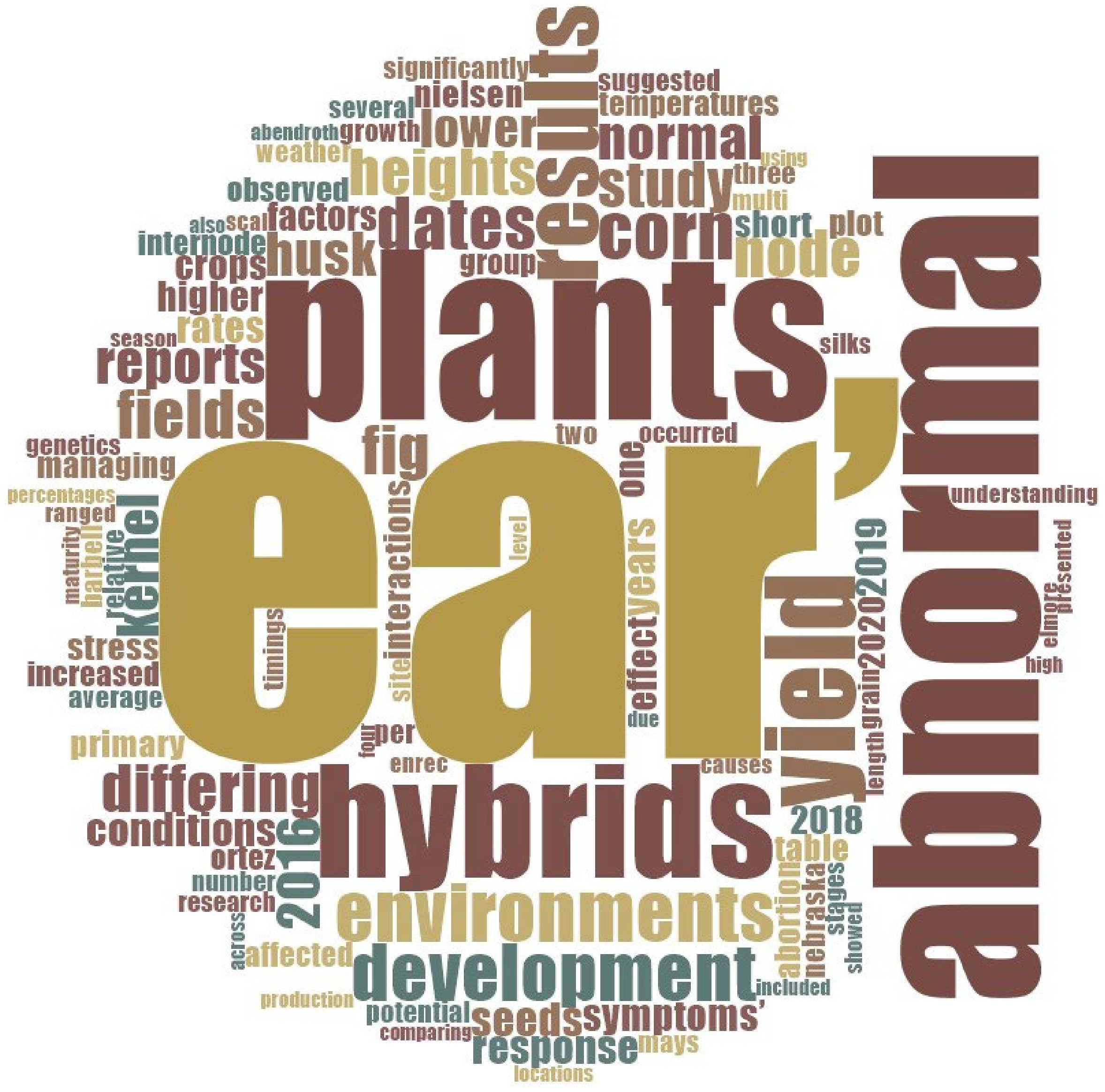
- **Several** abnormal symptoms reported in previous years
- Abnormal ear **reports, 2016**

Objectives

- Describe and summarize **previously reported** ear symptoms
- Document **recent widespread** symptoms of major concern

Methods

- Comprehensive **review** of the literature
- Compiled **extension & peer-reviewed** (few) reports



Ear abnormalities	Possible causal factors	Postulated development timing
---------------------------------- Previously reported symptoms ----------------------------------		
1. Tassel ears	Lower populations, end or border rows, growing point damage, genetics	Initiation and differentiation of tiller's apical meristem into floral structure
2. Fasciated ears	Specific mutants (i.e., genetics), cold temperatures	Ear initiation and development, V4 to V7
3. Arrested ears	Non-ionic Surfactant (NIS) formulations	Ear size determination period, V6 to V12; and up to V16
4. Pinched ears	Cell division inhibitors, e.g., sulfonylurea herbicides	Ear size determination period, V6 to V12
5. Blunt ears	Plant stressors (e.g., chemicals or environment), genetics, management	Ear size determination period, V6 to V12
6. Silk-balled ears	Cold temperatures, drought, genetics	Silk elongation, V12 to R1
7. Incomplete kernel set	Silks damage, drought, high temperatures, pollination issues, phosphorus shortages, herbicide injury, cloudy days	Pollination, VT or R1; and early reproductive stages, R1 to R3
8. Banana ears	Severe weather, chemical applications, heat or drought, stink bug injury	Pollination, VT or R1; and early reproductive stages, R1 to R3
9. Zipper ears	Higher seeding rates, drought stress, genetics, defoliation, deficient pollination	Pollination, VT or R1; and early reproductive stages, R1 to R3
10. Tipped-back ears	Pollen and silk availability, kernel abortion, cloudy days, heat, drought, genetics, higher seeding rates	Pollination, VT or R1; and early reproductive stages, R1 to R3

Ortez et al. (2022b), *Agronomy Journal*

Photo: O. Ortez

Photo: B. Nielsen

TASSEL EAR

Ears at the top of tiller plants in place of tassels

POSSIBLE FACTORS

Lower populations, end or border rows, growing point damage, genetics (i.e., hybrid specific)

EXPECTED TIMING

Initiation and differentiation of tiller's apical meristem into floral structure

Photos: O. Ortez

FASCIATED EAR

Increased and non-organized kernel rows

POSSIBLE FACTORS

Specific mutants (i.e., genetics), cold temperatures

EXPECTED TIMING

Ear initiation and development, V4 to V7

Ortez et al. (2022b), *Agronomy Journal*

Photo: O. Ortez

Photo: B. Nielsen

ARRESTED EAR

Ear development arrested or stopped prematurely

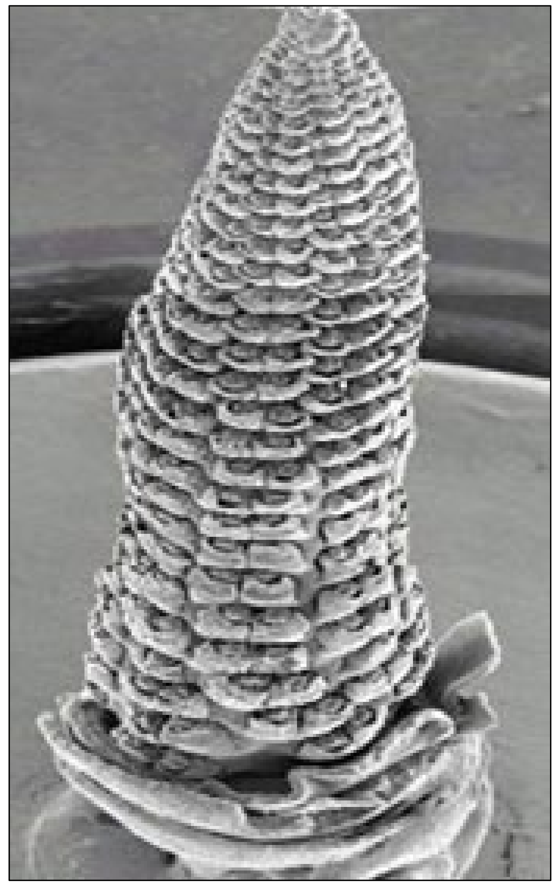
POSSIBLE FACTORS

Non-ionic Surfactant (NIS) formulations

EXPECTED TIMING

Ear size determination period, V6 to V12; and up to V16

Photos: A. Perdomo



PINCHED EAR

Abrupt change to fewer kernel rows in the ear

POSSIBLE FACTORS

Cell division inhibitors, e.g., sulfonylurea herbicides

EXPECTED TIMING

Ear size determination period, V6 to V12

Ortez et al. (2022b), *Agronomy Journal*

BLUNT EAR

Noticeably shorter and stunted ears

POSSIBLE FACTORS

Plant stressors (e.g., chemicals or environment), genetics, management

EXPECTED TIMING

Ear size determination period, V6 to V12

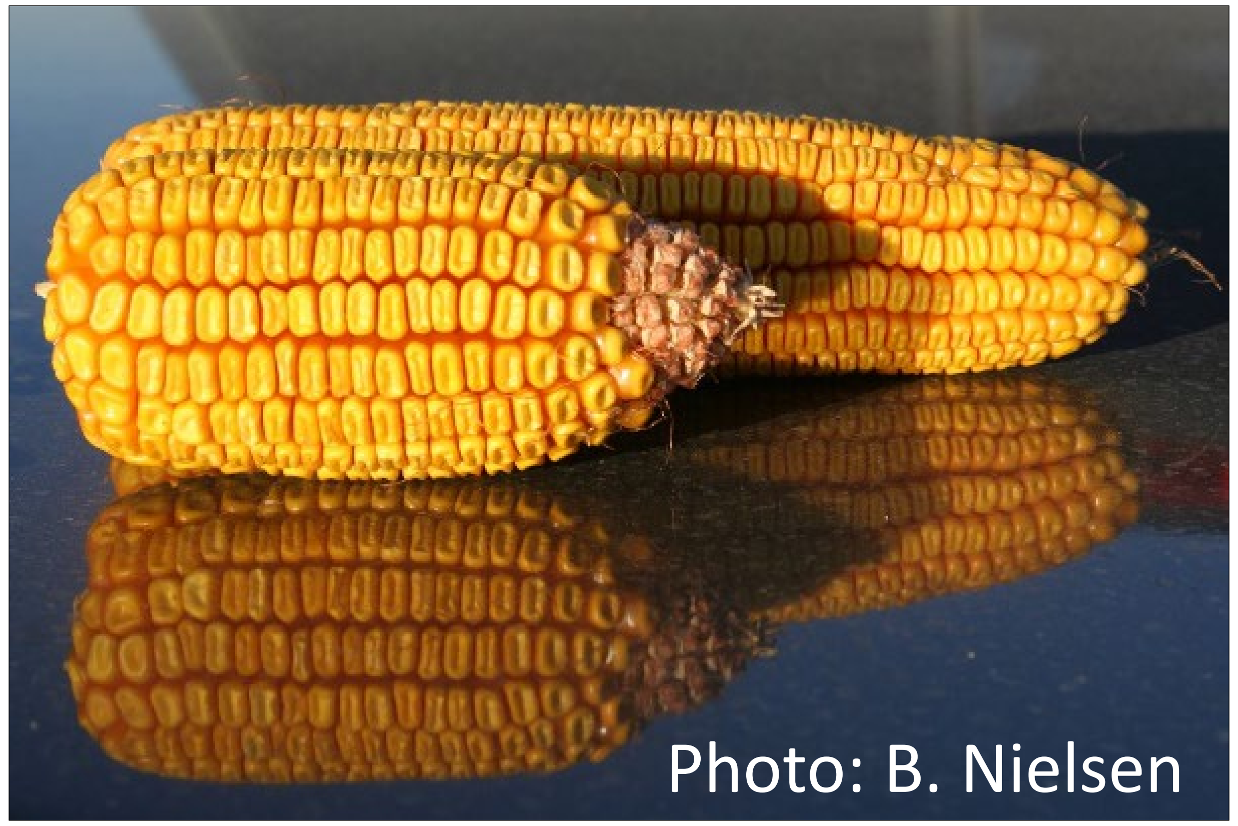


Photo: J. Hardwick

Photos: B. Nielsen

SILK-BALLED EAR

Silks fail to elongate toward the ear tip properly

POSSIBLE FACTORS

Cold temperatures, drought, genetics

EXPECTED TIMING

Silk elongation, V12 to R1

Ortez et al. (2022b), *Agronomy Journal*

Photo: B. Nielsen

Photo: P. Thomison

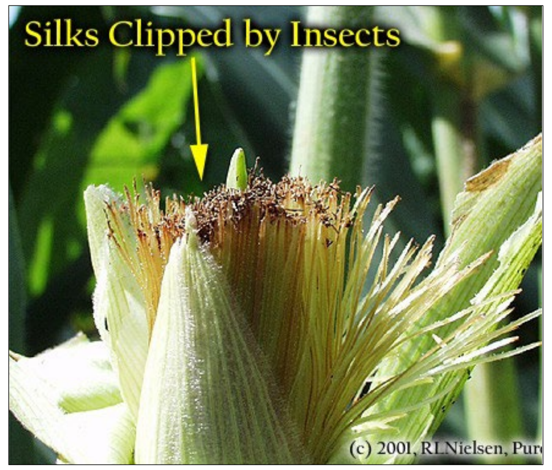


Photo: O. Ortez

INCOMPLETE KERNEL SET

Poor or scattered kernel set in the ear

POSSIBLE FACTORS

Silks damage, drought, high temperatures, pollination issues, phosphorus deficiency, herbicide injury, cloudy days

EXPECTED TIMING

Pollination, VT or R1; and early reproductive stages, R1 to R3

BANANA EAR

Curvature of the cob toward a damaged side of the ear

POSSIBLE FACTORS

Severe weather, chemical applications, heat or drought, stink bug injury

EXPECTED TIMING

Pollination, VT or R1; and early reproductive stages, R1 to R3

Photos: O. Ortez

Ortez et al. (2022b), *Agronomy Journal*



Photo: O. Ortez

ZIPPER EAR

Ears with missing kernel rows

POSSIBLE FACTORS

Higher seeding rates, drought stress, genetics, defoliation, deficient pollination

EXPECTED TIMING

Pollination, VT or R1; and early reproductive stages, R1 to R3

TIPPED-BACK EAR

Missing kernels at the tip of the ear

POSSIBLE FACTORS

Pollen and silk availability, kernel abortion, cloudy days, heat, drought, genetics, higher seeding rates

EXPECTED TIMING

Pollination, VT or R1; and early reproductive stages, R1 to R3



Photos: O. Ortez

Ortez et al. (2022b), *Agronomy Journal*

Ear abnormalities	Possible causal factors	Postulated development timing
------------------------- **Recent widespread symptoms of major concern** -------------------------		
1. Multi-ears per node	Environmental stress (e.g., cold), low seeding rates, genetics, damage to primary ear	After ear initiation (V4 to V6) and before pollination (VT or R1)
2. Barbell-ears	Temperature stress, limited solar radiation, ethylene, hormones, chemical applications, genetics, damage to primary ear	During ear size determination period, V6 to V12; and up to R1
3. Short-husk ears	Short term stress, e.g., heat or drought followed by cooler temperatures and precipitation, high-speed winds or storms, genetics	Close to tasseling and pollination, V18 to R1

Ortez et al. (2022b), *Agronomy Journal*

MULTI-EAR

Multiple ears at individual stalk nodes or same ear shank




Photos: O. Ortez

Photo: B. Nielsen

POSSIBLE FACTORS

Environmental stress (e.g., cold), low seeding rates, genetics, damage to primary ear

EXPECTED TIMING

After ear initiation (V4 to V6) and before pollination (VT or R1)

Ortez et al. (2022b), *Agronomy Journal*

BARBELL-EAR

Missing kernels and diameter decrease in the cob



Photos: O. Ortez

POSSIBLE FACTORS

Temperature stress, limited solar radiation, ethylene, hormones, chemical applications, genetics, damage to primary ear

Photo: B. Nielsen

EXPECTED TIMING

During ear size determination period, V6 to V12; and up to R1

Ortez et al. (2022b), *Agronomy Journal*

SHORT-HUSK EAR

Shortened husk leaves with ears protruding beyond the husks




Photos: O. Ortez

Photo: B. Nielsen

POSSIBLE FACTORS

Short term stress, e.g., heat or drought followed by cooler temperatures and precipitation, high-speed winds or storms, genetics

EXPECTED TIMING

Close to tasseling and pollination, V18 to R1

Ortez et al. (2022b), *Agronomy Journal*

Key Findings:

- Abnormal ears are a likely response to **G×E×M interactions**.
- Characterized **ten previously reported abnormality symptoms** discussed.
- Characterized **three recent widespread symptoms** of major concern associated with lower yields.
- Abnormal ears can reduce **grain yield and quality**.
- The understanding and mitigation of abnormal ears are **imperative for sustainable agriculture**.

Ortez et al. (2022b), *Agronomy Journal*

Agrosystems, Geosciences & Environment OPEN ACCESS

ORIGINAL RESEARCH ARTICLE | Open Access

Abnormal ear development in corn: A field survey

Osler A. Ortez, Anthony J. McMechan, Thomas Hoegemeyer, Jennifer Rees, Tamra Jackson-Ziems, Roger W. Elmore

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Agrosystems, Geosciences & Environment

ORIGINAL RESEARCH ARTICLE

Agrosystems

Abnormal ear development in corn: A field survey

Osler A. Ortez[1] | Anthony J. McMechan[2] | Thomas Hoegemeyer[1] | Jennifer Rees[3] | Tamra Jackson-Ziems[4] | Roger W. Elmore[1]

[1] Dep. of Agronomy and Horticulture, Univ. of Nebraska-Lincoln, Lincoln, NE 68583, USA

[2] Eastern Nebraska Research and Extension Center, Univ. of Nebraska-Lincoln, Lincoln, NE 68033, USA

[3] Institute of Agriculture and Natural Resources, Univ. of Nebraska-Lincoln, Lincoln, NE 68583, USA

[4] Dep. of Plant Pathology, Univ. of Nebraska-Lincoln, Lincoln, NE 68503, USA

Correspondence
Osler A. Ortez and Roger W. Elmore, Dep. of Agronomy and Horticulture, Univ. of Nebraska-Lincoln, Lincoln, NE 68583, USA. Anthony J. McMechan, Eastern Nebraska Research and Extension Center, Univ. of Nebraska-Lincoln, Lincoln, NE 68033, USA.
Email: oortez94@hotmail.com, roger.elmore@unl.edu, justin.mcmechan@unl.edu

Assigned to Associate Editor Daryl B. Arnall.

Abstract

In July of 2016, abnormal ear development in corn (*Zea mays* L.) (barbell-ears, multiple ears per node herein termed as multi-ears, and short-husks) was reported in several cornfields that extended from the Texas Panhandle to eastern Colorado and East through Kansas, Nebraska, Iowa, and Illinois. Field surveys were conducted to study these ear abnormalities. Affected and unaffected plants were sampled from 15 farmer fields located in central and eastern Nebraska. Each plant was evaluated for ear type, ear placement, internode length, and grain yield. Along with plant evaluations, management practices and weather information were collected from the surveyed fields. Of the 15 surveyed fields, nine were grouped as affected (more than 10% abnormalities), and six were grouped as checks (<10% abnormalities). Affected fields averaged 26% of abnormalities, whereas check fields averaged only 4%. Ear abnormalities occurred on ears that seemed to be placed lower on plants relative to normal ears. Plants with abnormal ears had yield reductions between 35 and 91%, compared to plants with normal ears. Findings suggested that ear abnormalities may be a cumulative result from the classic genetic (hybrid-specific), environmental (stress factors), and management interactions. The study of underlying causes for abnormal ear development in corn is imperative for understanding the likelihood of future events occurring and providing critical information to potentially manage and mitigate these issues.

Open Access: https://doi.org/10.1002/agg2.20242

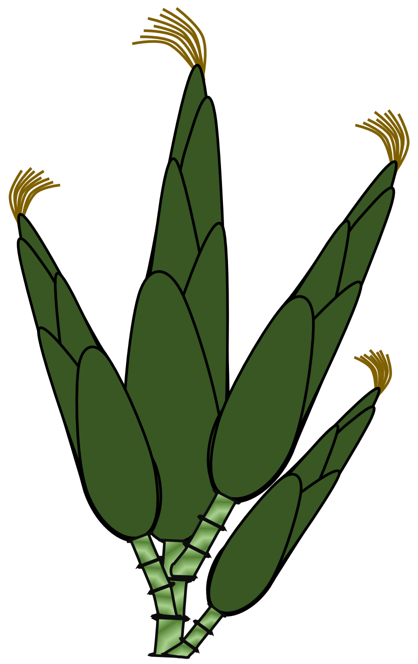
Rationale

- **Abnormal ears** in farmer fields (2016): **multi-ears**, **barbell-ears**, **short-husks**
- **Texas Panhandle** to **eastern Colorado** and east through **Kansas**, **Nebraska**, **Iowa**, and **Illinois**

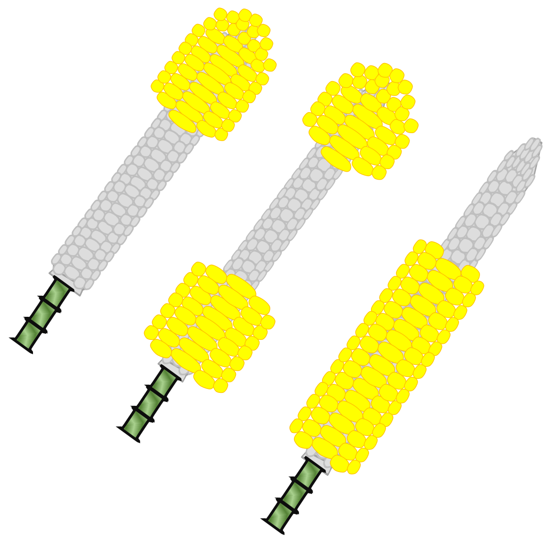
Objectives

- **Conducted field surveys** to ***study:***
  - **Frequency** and **distribution**
  - Ear **classification** and **symptoms**
  - Effect on **grain yields**

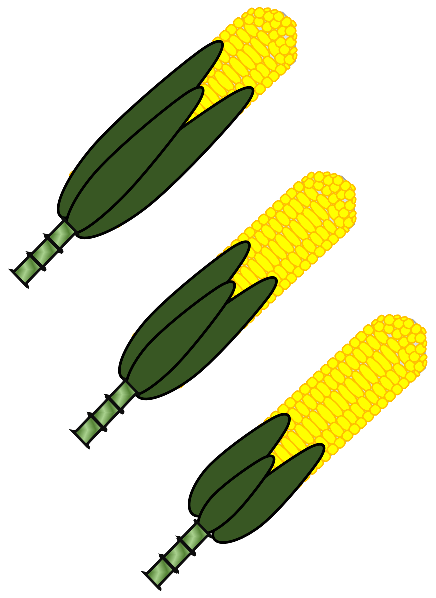
Multi-Ears



Barbell-Ears



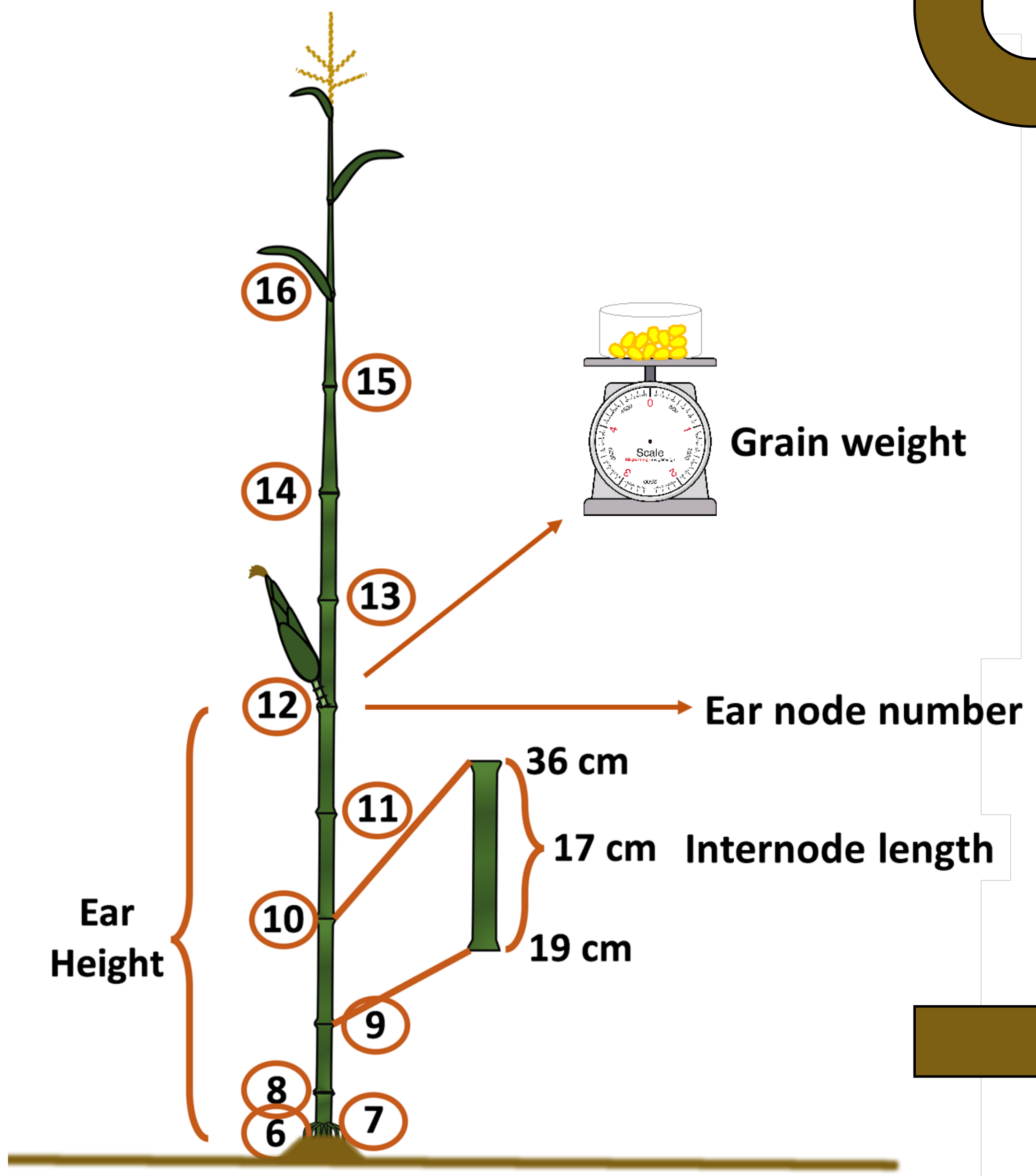
Short-Husks

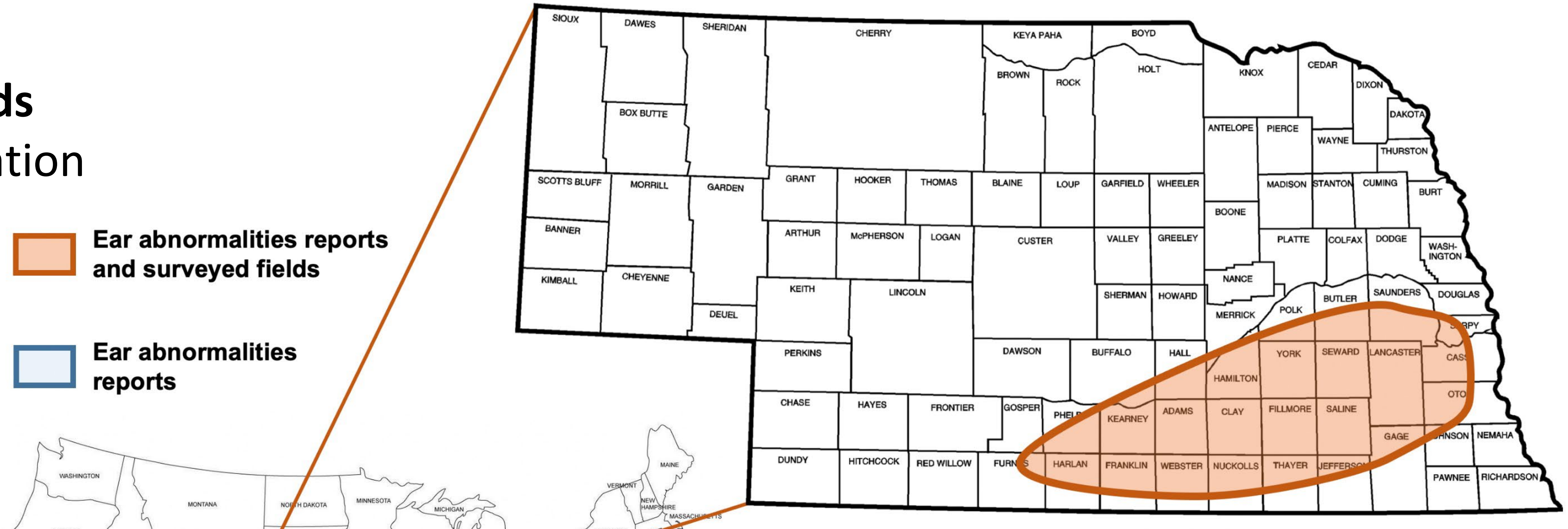


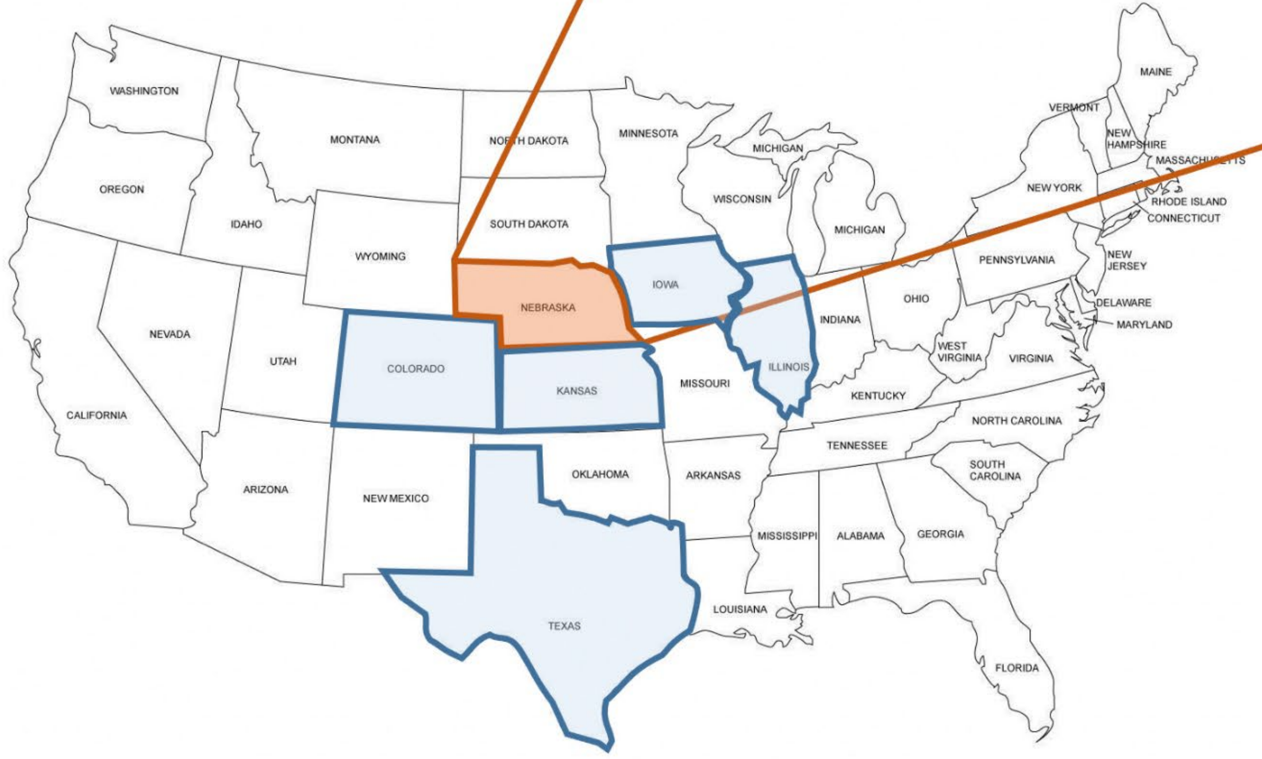
Ortez et al. (2022c), *Agrosystems, Geosciences & Environment*

Methods

- Surveys in **15 Nebraska farmer fields**
- General **crop management** information
- Collected 1,259 **plant samples:**
  - **Affected** and **unaffected**



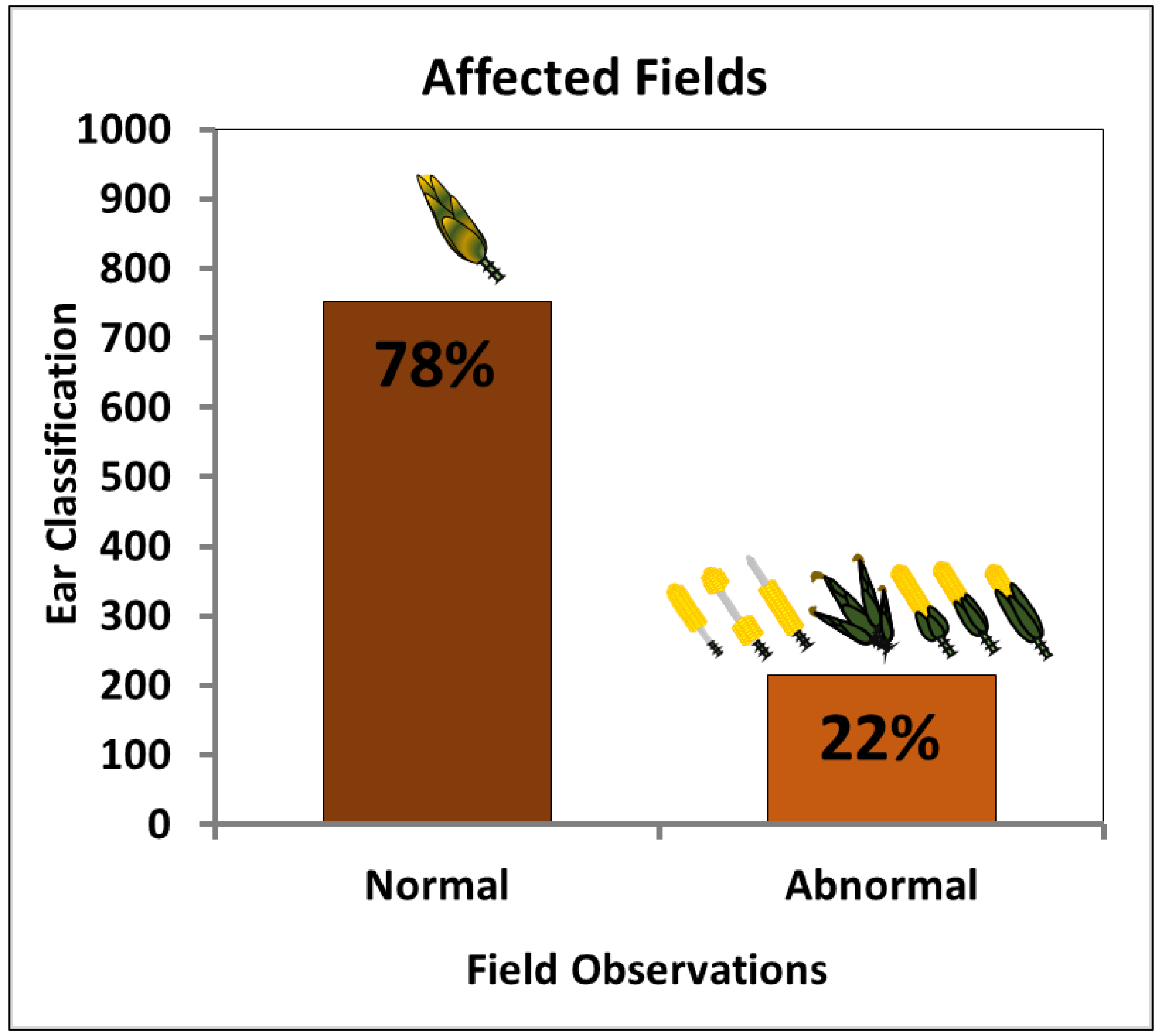




- Data from each plant sample:
  - **Ear type**, **ear placement**, **internode length**, and **yield**

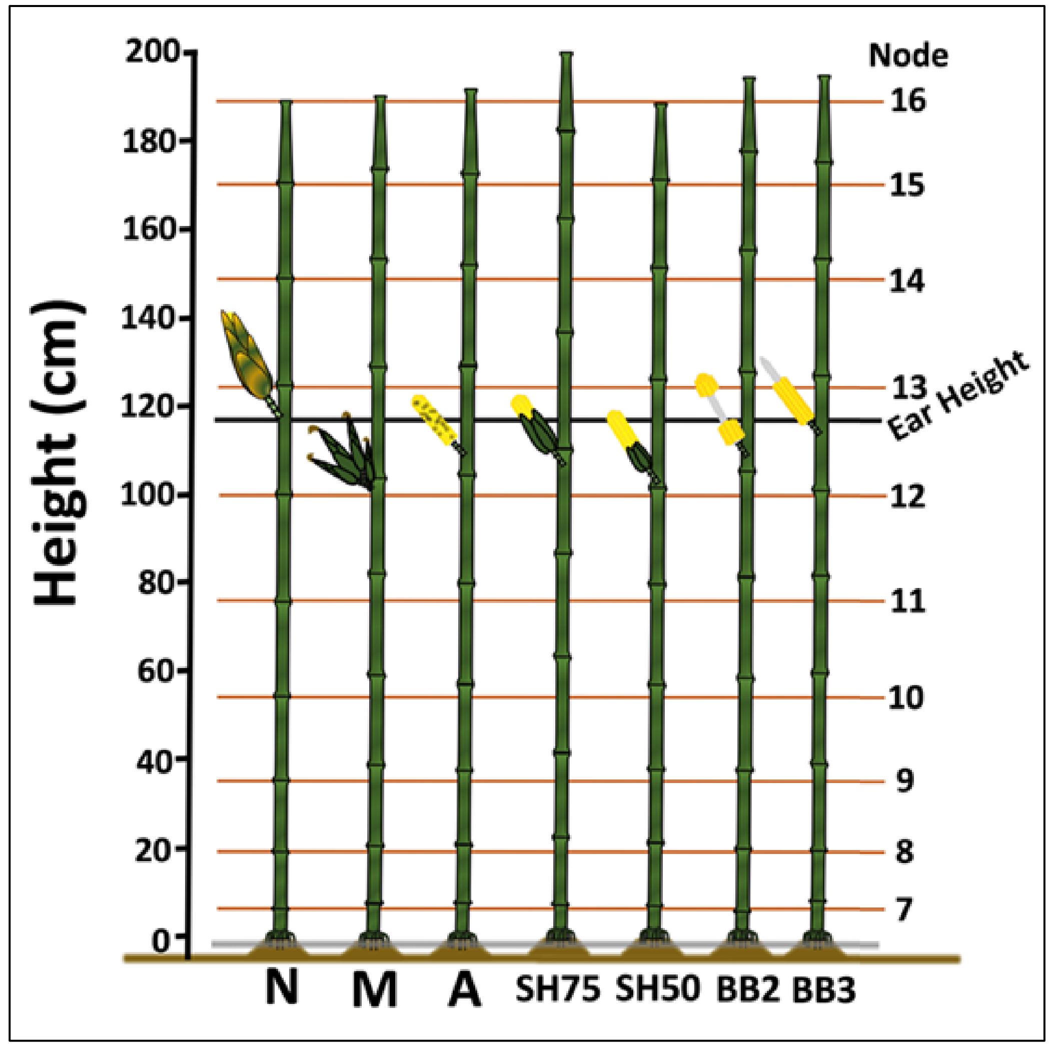
Findings, field survey *(1,259 plant samples)*

Ear Types



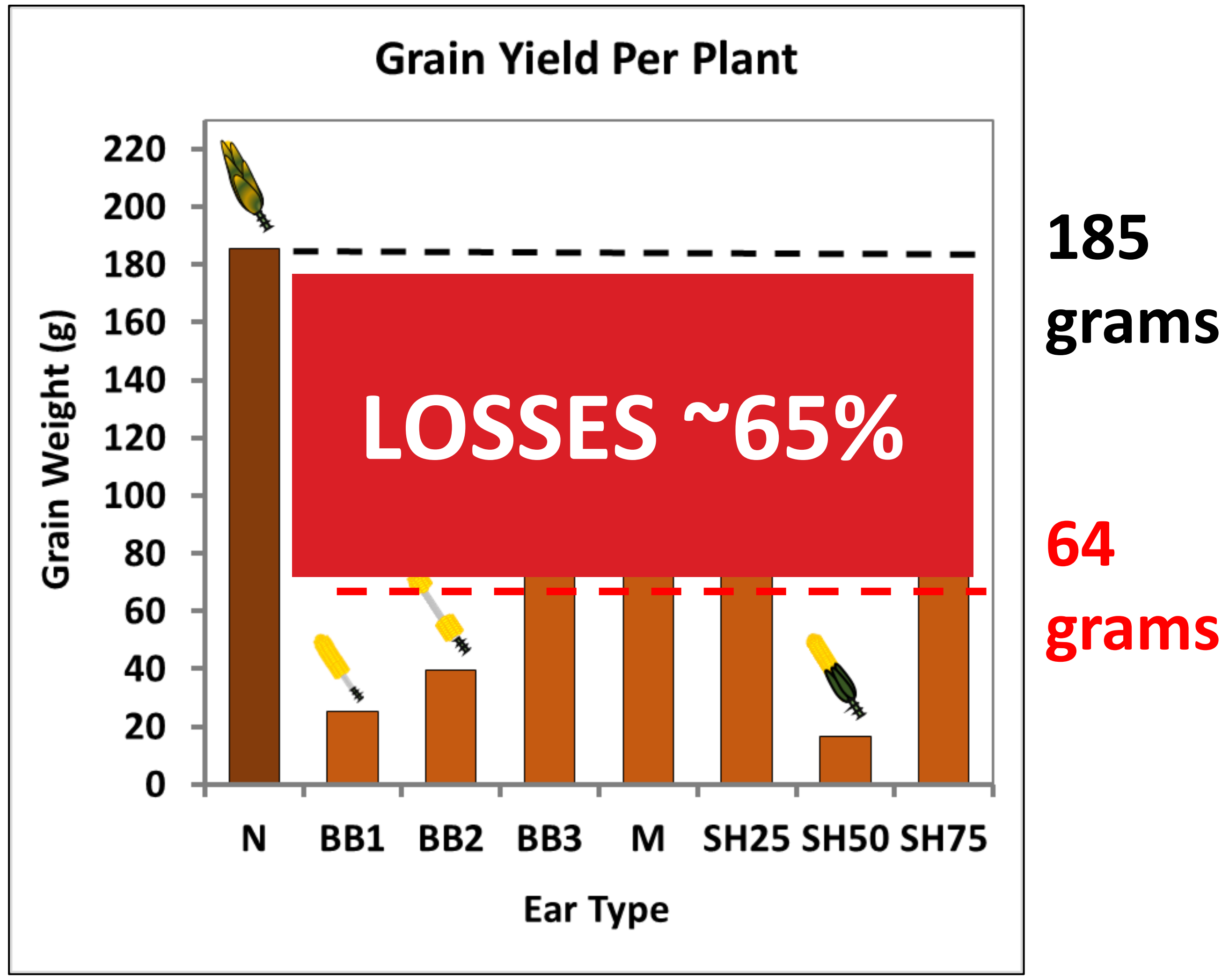
Up to 49% abnormal ears for a given field, **22% overall**

Ear Placement



Lower ear **placement** for **abnormal** ears

Grain Yield



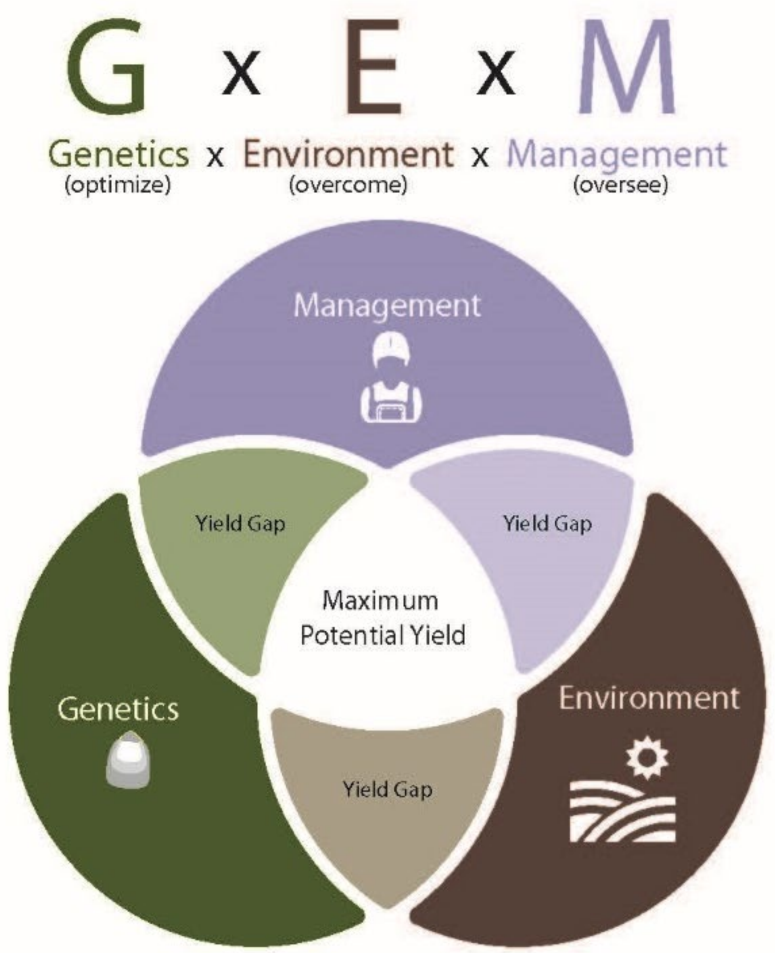
Lower yield per plant for **abnormal** ears, **35** to **91% losses**

Ortez et al. (2022c), *Agrosystems, Geosciences & Environment*

Key Findings:

- **Affected fields averaged 26% abnormal ears**, up to 49% in a given field.
- Abnormal ears **reduced yield**, between **35 and 91%** relative to normal ears.
- Abnormal ear **placement seemed to be lower** compared to normal ears.
- Ear abnormalities may be the **cumulative result** of classic **G×E×M** interactions.

Ortez et al. (2022c), *Agrosystems, Geosciences & Environment*



USDA-ARS

GENETICS

ENVIRONMENT

MANAGEMENT

Hybrids, Environments, & <u>Seeding Rates</u>

Objectives

- Study **hybrids**, **environments**, and **seeding rates**
- Determine the **distribution of ear types**
- Compare **normal vs. abnormal** ear's heights

Methods

Eight **environments** | Eight **hybrids**

Five **seeding rates** | **RCBD**, with split-plots

Field Trials, 2018 & 2019

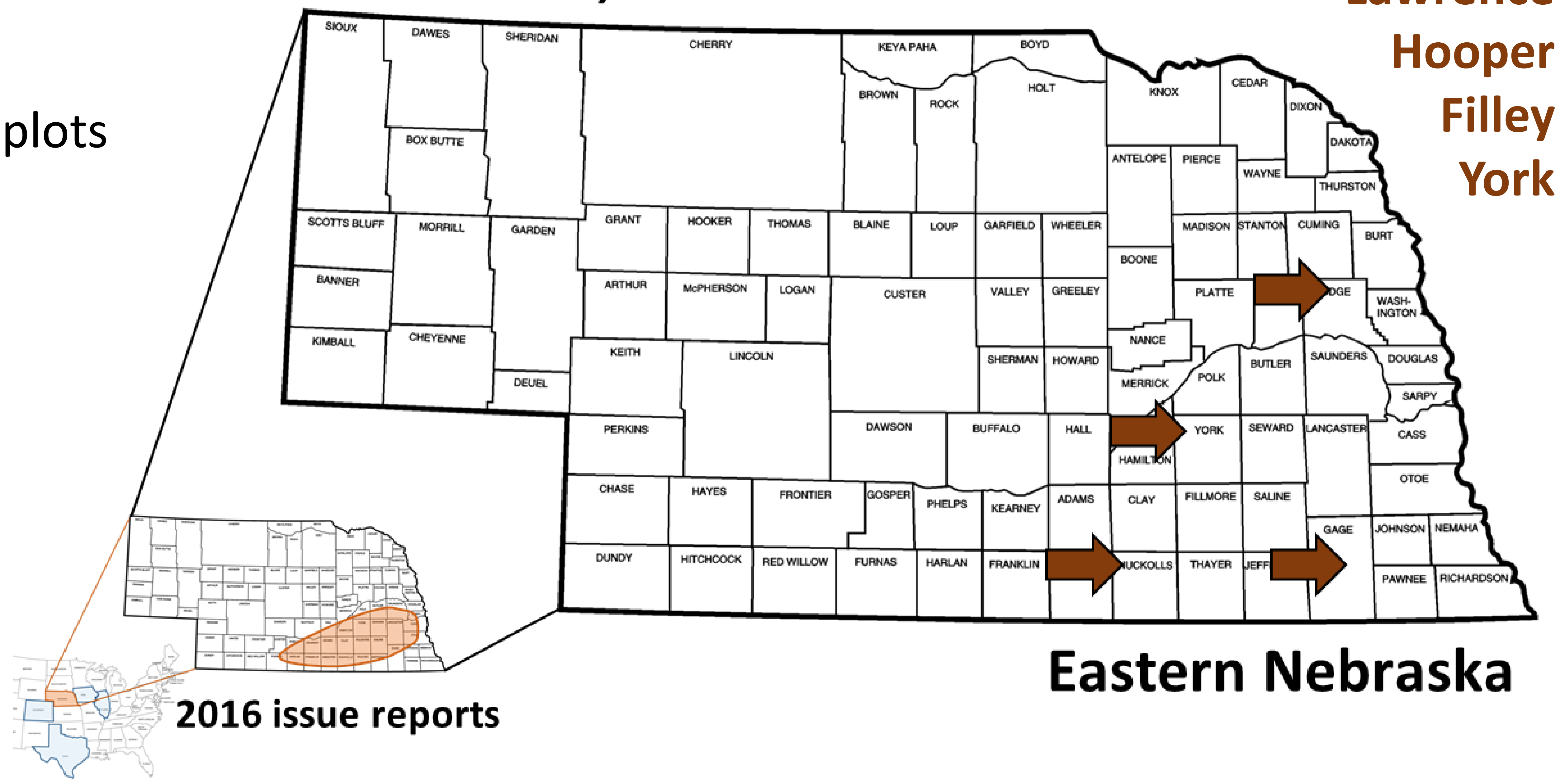
Industry Fields (4):

Lawrence

Hooper

Filley

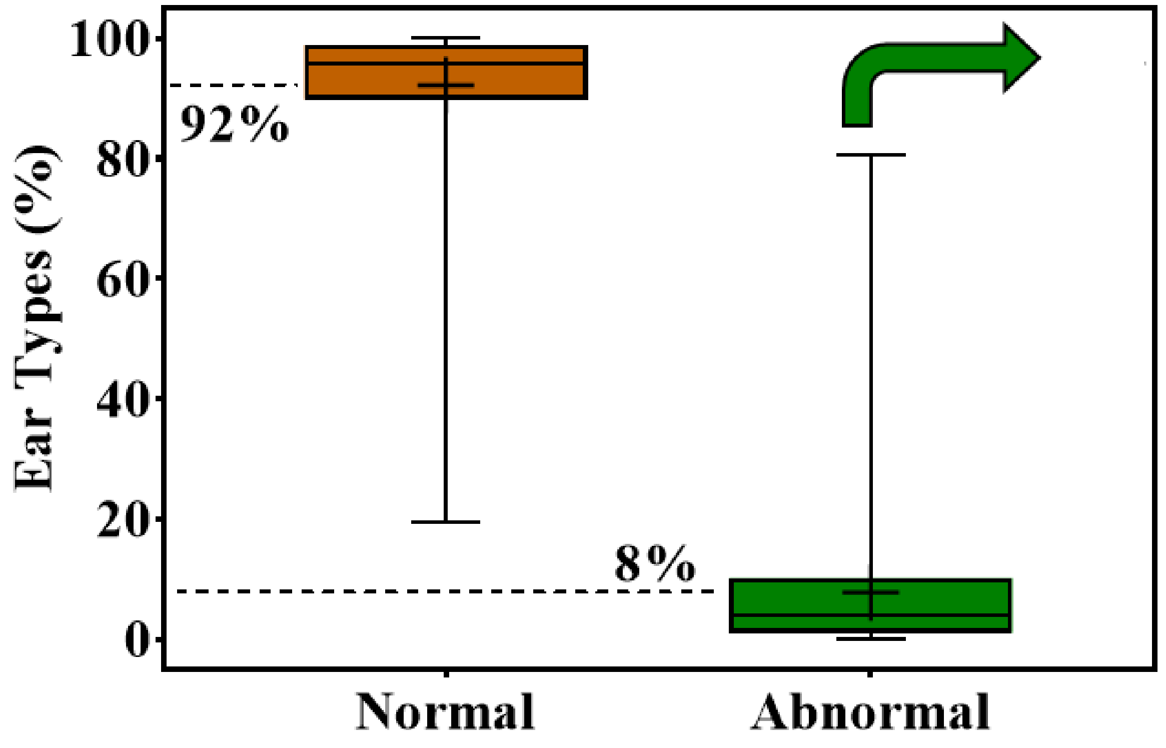
York



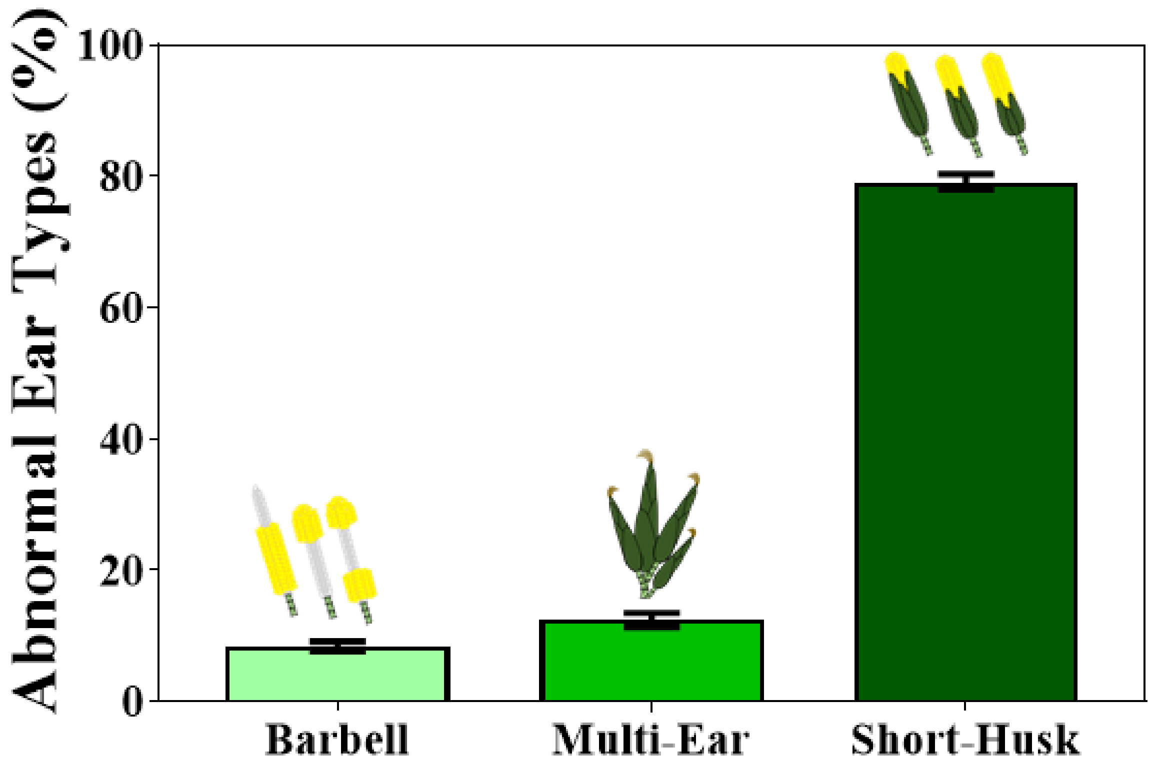
Ortez et al., *under revision, Agronomy Journal*

*Hybrids, Environments, & **Seeding Rates*** *(63,500 plants)*

Label	Factor	Grain Yield	Abnormal Ears, Percentage (%)	Ear Heights, centimeters (cm)
		P value	**P value**	**P value**
G	Hybrid	<.0001	**<.0001**	<.0001
E	Environment	<.0001	**0.0012**	<.0001
M	Seeding Rate	<.0001	0.1057	<.0001
G × E	Hybrid × Environment	<.0001	**<.0001**	<.0001
G × M	Hybrid × Seeding Rate	<.0001	**<.0001**	0.1841
E × M	Environment × Seeding Rate	<.0001	0.6831	0.2501
G × E × M	**Hybrid × Environment x Seeding Rate**	**0.0314**	**<.0001**	**0.9216**



Across conditions,
8% of abnormal ears



Majority, **short-husks**,
about **80%**

Ortez et al., *under revision, Agronomy Journal*

Abnormal Ears, Percentage (%)

Seeding Rate Seeds ha^{-1}	P0157	P0339	P0801	P0801†	P0832	P1311	P1311†	P1370
Filley 2018								
44000			0.6Ab	0.9Aa				
64000			5.6Aab	0.7Aa				
84000			9.3Aab	7.3Aa				
104000			9.7Aab	6.6ABa				
124000			10.1Aa	9.6ABa				
Hooper 2018								
44000		32.8Aa						
64000		3.3Ab						
84000		1.0Ab						
104000		3.1Ab						
124000		1.7Ab						
Lawrence 2018								
44000								
64000								
84000								
104000								
124000								
York 2018								
44000			1.6Ac	4.3Ac				
64000			10.3Abc	9.4Abc				
84000			21.8Aab	17.5ABb				
104000			22.9Aa	18.5ABb				
124000			21.2ABab	31.3Aa				

Seeding Rate Seeds ha^{-1}	P0157	P0339	P0801	P0801†	P0832	P1311	P1311†	P1370
Filley 2019								
44000			5.4Ab	9.8Ab				
64000			10.9Ab	11.6Ab				
84000			28.1Aa	23.2Aab				
104000			26.9Aa	28.1Aa				
124000			40.3Aa	34.5Aa				
Hooper 2019								
44000	27.9Aa	6.0Bab	8.2Bc	3.7Bc		1.8Bbc	1.0Ba	
64000	18.0Aab	13.6Aa	7.9Ac	11.2Abc		1.4Ac	0.0Aa	
84000	18.9Bab	5.8CDab	33.0Ab	15.6BCb		9.6BCDabc	3.6Da	
104000	13.2Bbc	7.7Bab	39.6Aab	36.4Aa		12.3Bab	7.4Ba	
124000	7.4BCc	4.9Cb	54.1Aa	42.4Aa		14.4Ba	13.8Ba	
Lawrence 2019								
44000	57.3Aa		12.0Bb	6.2Bb				
64000	24.1Ab		11.5ABb	6.0Bb				
84000	20.0Ab		15.8ABb	15.5ABab				
104000	5.4BCc		20.9Aab	22.6Aa				
124000	5.6BCc		29.7Aa	25.6Aa				
York 2019								
44000	36.8Aa		3.6Bb	2.8Bd				
64000	24.0Aab		4.9Bb	11.9ABcd				
84000	14.2Abc		14.8Ab	22.0Abc				
104000	11.2BCc		41.4Aa	29.8Aab				
124000	12.9Bbc		34.7Aa	41.7Aa				

\- Decrease with higher SR

\+ Increase with higher SR

SUSCEPTIBLE HYBRID

CHECK HYBRID

CFAES

*Hybrids, Environments, & **Seeding Rates*** *(63,500 plants)*

- **G × E × M interactions**
- **More abnormal** ears **in 2019** (~**11%), compared to 2018 (~5%)**
- Yield range: **68 to 319 Bu/Ac**; **higher yields**, **fewer abnormalities**
- Variable **hybrid** response to **seeding rates (+/-)**
- **Hybrid selection** & **optimum seeding rates** could mitigate abnormal ears
- In most cases, **abnormal ears had lower heights**

Ortez et al., ***under revision, Agronomy Journal***

Hybrids, Environments, & <u>Planting Dates</u>

Rationale

- Abnormal ears as a **likely** result of **G × E × M**

Objectives

- Study **hybrids**, **environments**, and **planting dates**
- Determine the **distribution of ear types**
- Compare **normal vs. abnormal** ear heights

Methods

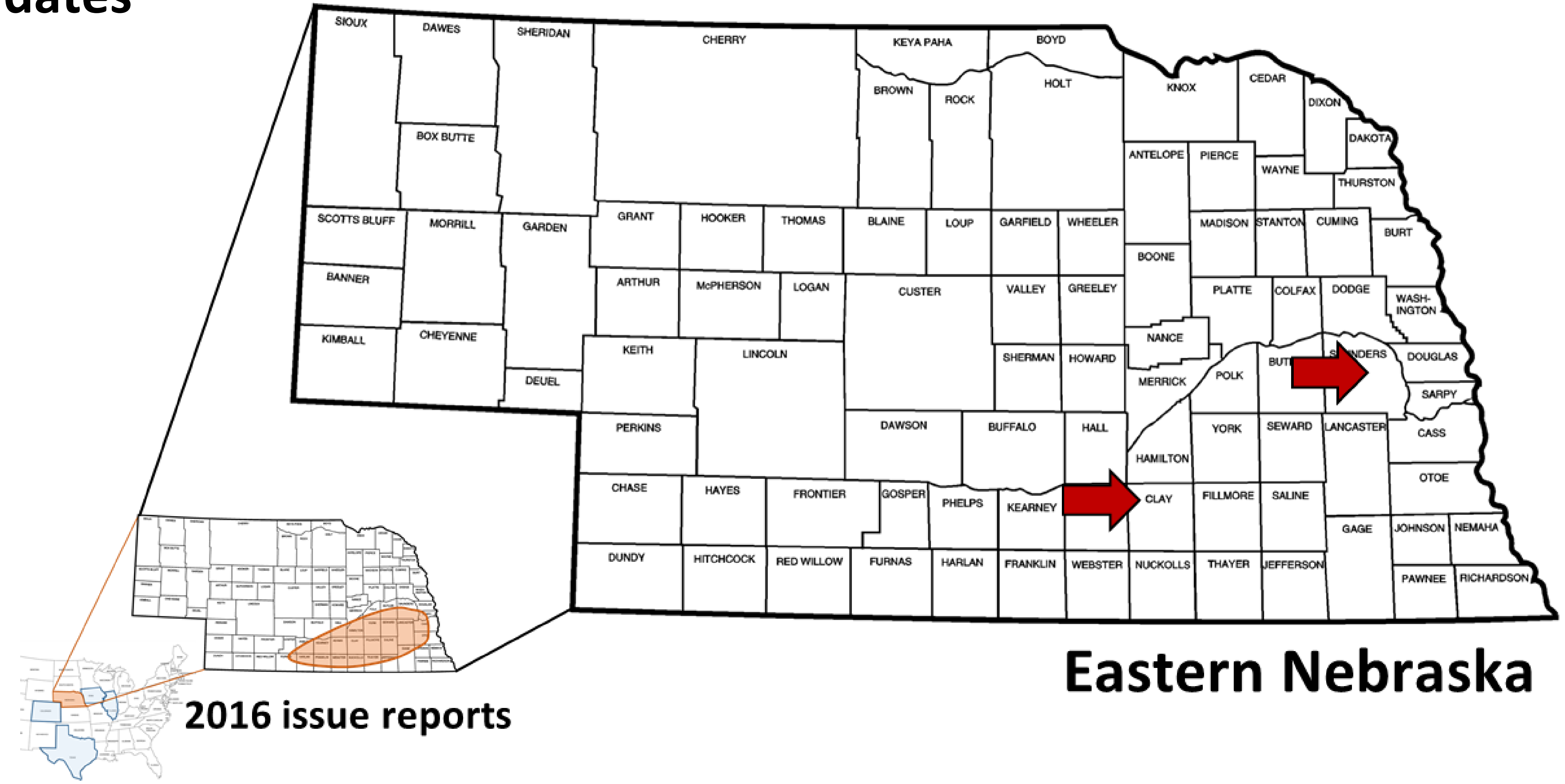
- Six **environments** (two fields, three years)
- Six **hybrids**
- Four **planting dates**
- **RCBD**, with split-plots

UNL Fields (2):

ENREC, Mead

SCAL, Clay Center

Field Trials, 2018 through 2020

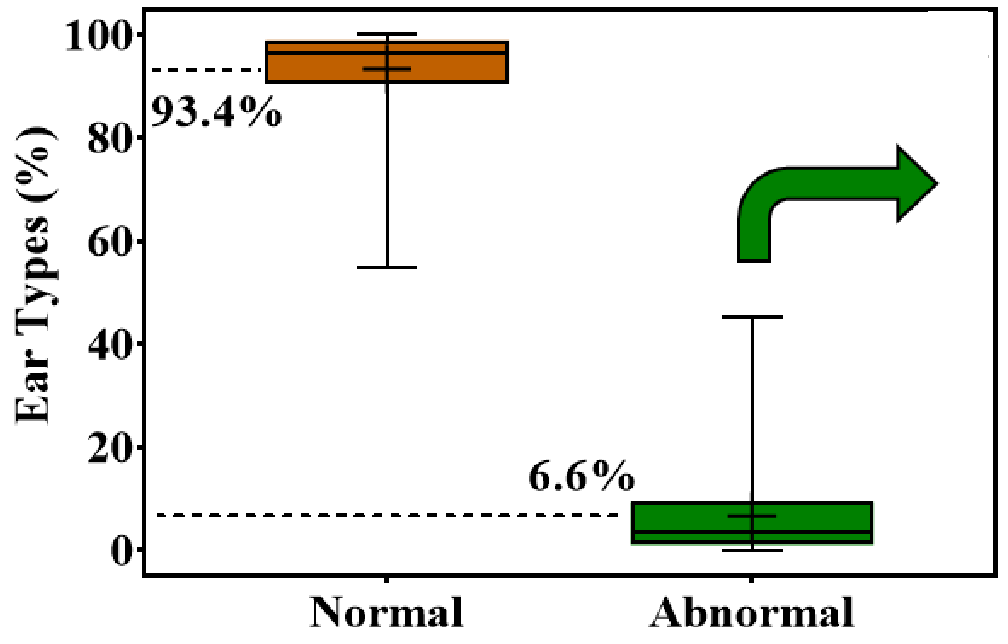


2016 issue reports

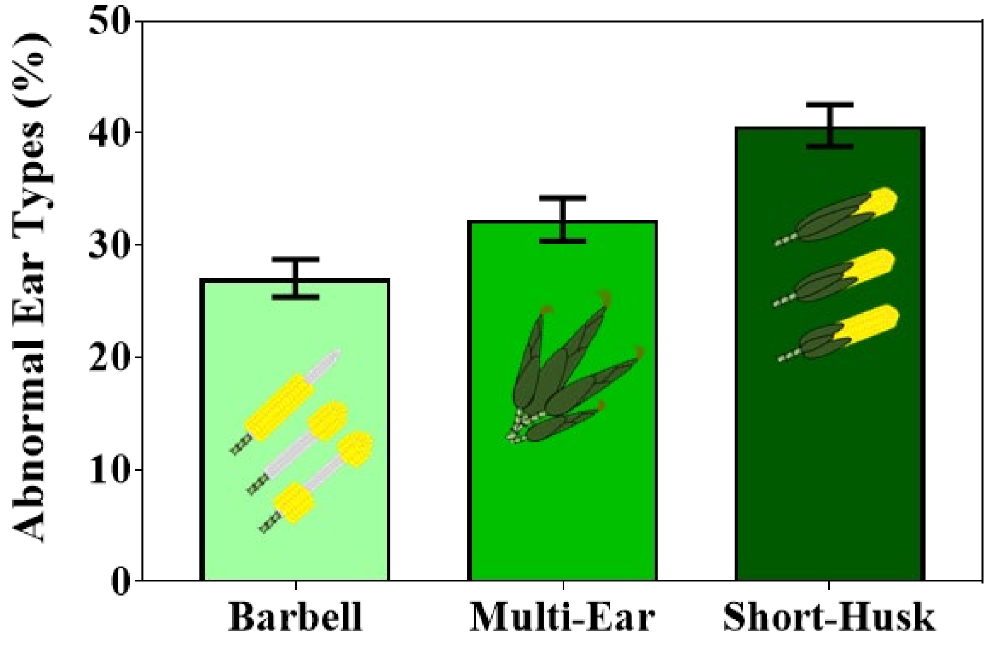
Eastern Nebraska

*Hybrids, Environments, & **Planting Dates*** *(59,200 plants)*

Label	Factor Tested	Grain Yield	Abnormal Ears, Percentage (%)	Ear Heights, centimeters (cm)
		P value	P value	P value
G	Hybrid	<.0001	**<.0001**	<.0001
E	Environment	<.0001	**<.0001**	<.0001
M	Planting Date	<.0001	**0.0037**	<.0001
G × E	Hybrid × Environment	<.0001	**<.0001**	<.0001
G × M	Hybrid × Planting Date	0.1345	**0.0201**	0.5179
E × M	Environment × Planting Date	<.0001	**0.0006**	<.0001
G × E × M	**Hybrid × Environment × Planting Date**	**0.0032**	**<.0001**	**<.0001**



Across all conditions,
6.6% of abnormal ears



Majority corresponded to
short-husks, **~41%**

Ortez et al., *in preparation*

Decrease – with delayed planting

Increase + with delayed planting

Planting Date (PD)†	ENREC P0157	ENREC P0339	ENREC P0801	ENREC P0832	ENREC P1311	ENREC P1370	SCAL P0157	SCAL P0339	SCAL P0801	SCAL P0832	SCAL P1311	SCAL P1370
	Abnormal Ears, Percentage (%)											
	ENREC 2018						**SCAL 2018**					
PD1					16.1Aa		6.6Bbc	7.4Ba	21.1Aa		5.1Ba	
PD2					6.1Ab		11.2Ab	3.9BCab	14.8Aab		4.7Ba	
PD3					1.7Bc		3.9BCc	5.4ABab	10.8Ab		2.3BCab	
PD4					2.0Cc		23.2Aa	2.9Cb	9.8Bb		1.3Cb	
	ENREC 2019						**SCAL 2019**					
PD1							24.5Aa	0.7Cb			0.7Cb	
PD2							14.0Ab	1.5BCab			0.5Cb	
PD3							13.3Ab	3.8BCa			2.6BCb	
PD4							14.5Ab	4.1BCa			13.8Aa	
	ENREC 2020						**SCAL 2020**					
PD1					2.1CDb		3.4Ac	3.2Ab	1.9Ab			
PD2					4.3Bab		15.3Ab	5.1Bab	3.2BCb			
PD3					9.2Ca		12.7Ab	3.9BCab	8.0ABa			
PD4					7.6CDa		36.5Aa	7.9Ba	11.9Ba			

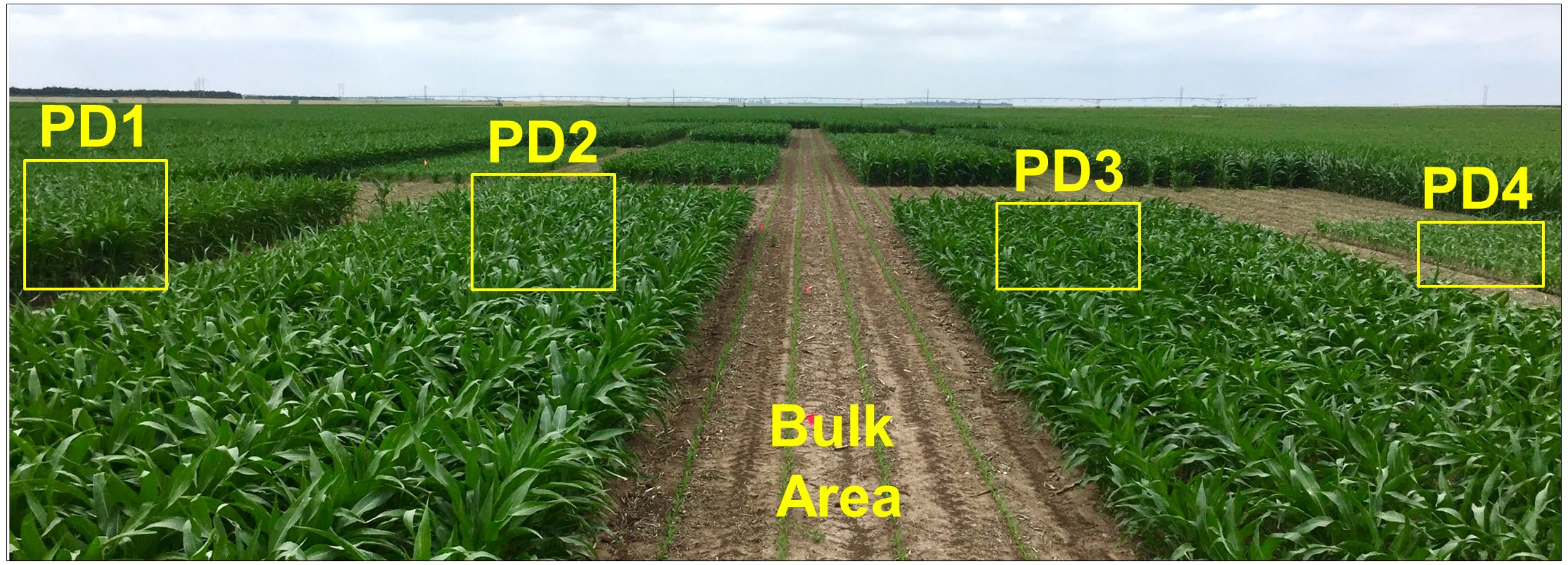
SUSCEPTIBLE HYBRID

CHECK HYBRID

Ortez et al., *in preparation*

Hybrids, Environments, & Planting Dates *(59,200 plants)*

- Abnormalities result from **G × E × M interactions**
- Despite low percentage of **abnormalities (6.6%)**, significant **effects detected**
- Yields ranged from **82 to 356 Bu/Ac**; hybrids with **more abnormalities, lower yields**
- Variable **hybrid** response to **planting dates (+/-)**
- **Hybrid selection** and **planting dates** could help mitigate abnormal ears



- In most cases, **abnormal ears had lower heights**, suggesting primary ear loss as a possibility

Ortez et al., ***in preparation***

FROM FIELD CONCERNS TO PLANT-LEVEL RESEARCH

CONCLUSIONS

------------ *Overriding Conclusions, 2016 through 2022* -------------

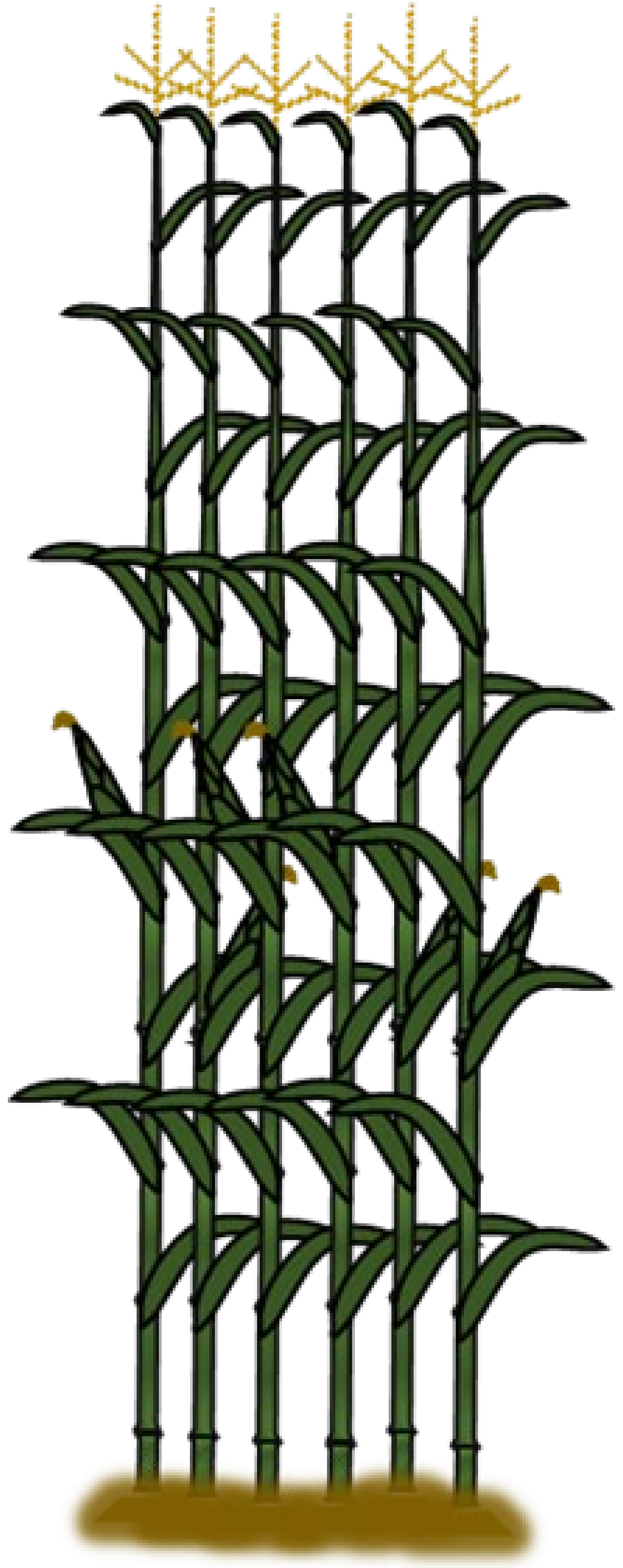
1) **Abnormal ears** affect cornfields, it is essential to continue **investigating** the leading **causes** while identifying **mitigation** strategies

2) **Abnormal ears** decrease grain yields, damage depends on the **frequency** and **severity** of symptoms

3) **The selection** of resistant **hybrids** and appropriate **management** are critical for crop **adaptation**, **mitigation**, and **managing** unfavorable conditions

4) Plant **morphological** characteristics can help as **diagnostic tools** to differentiate plants with **normal** and **abnormal** ears

5) **Abnormal ears** must be understood as a result of **interactions** among **genetics (G)**, **environment (E)**, and **management (M)**

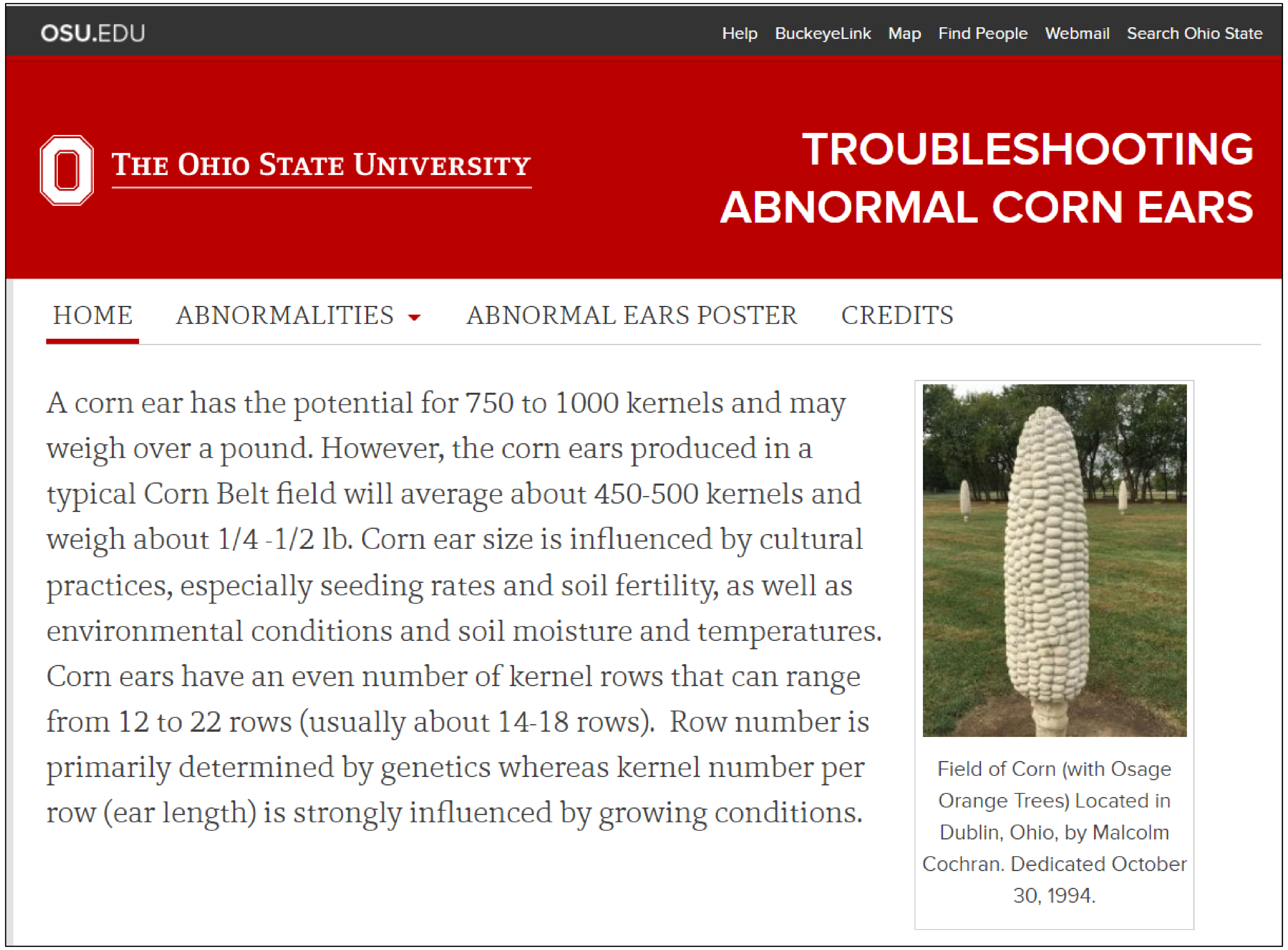


Ortez et al. (2022a; 2022b; 2022c)

Importantly, results highlighted the **need for more research…**

- **Random spread**
- **Many unknowns**
- **Hard to replicate**
- **Combination of factors**
- **No control over weather, unless greenhouse/growth chambers**

Want to learn more?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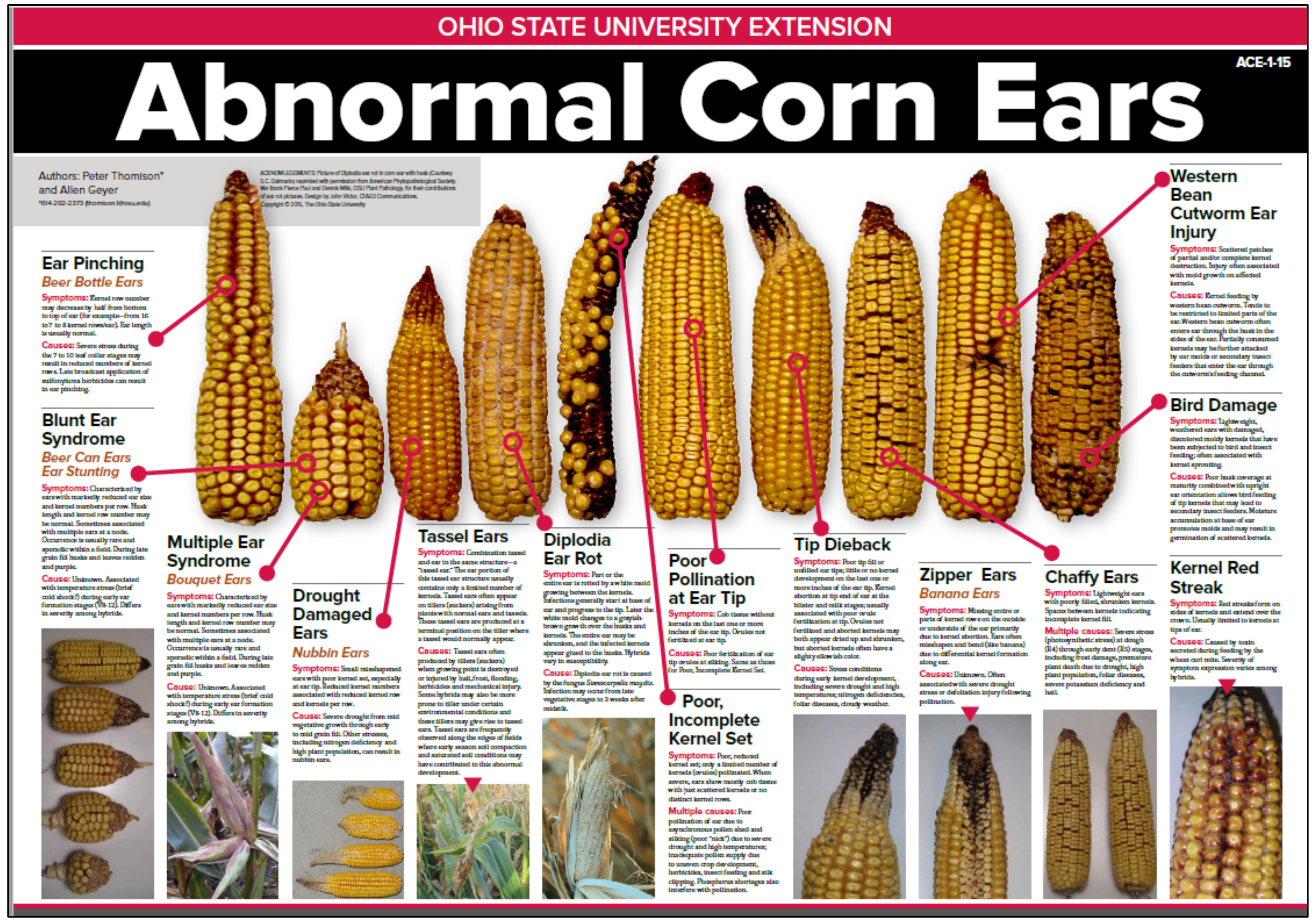
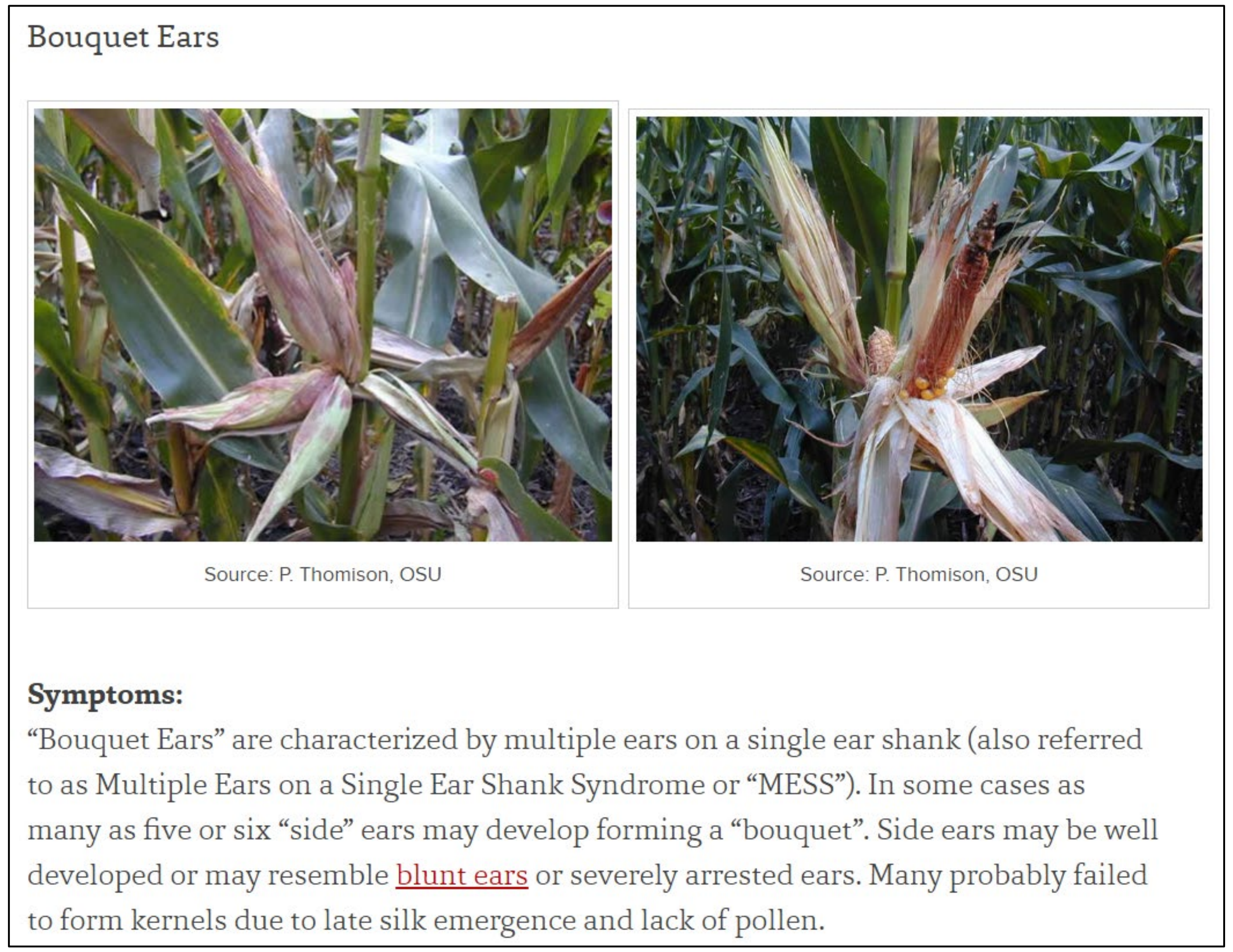
TROUBLESHOOTING ABNORMAL CORN EARS

HOME ABNORMALITIES ABNORMAL EARS POSTER CREDITS

A corn ear has the potential for 750 to 1000 kernels and may weigh over a pound. However, the corn ears produced in a typical Corn Belt field will average about 450-500 kernels and weigh about 1/4 -1/2 lb. Corn ear size is influenced by cultural practices, especially seeding rates and soil fertility, as well as environmental conditions and soil moisture and temperatures. Corn ears have an even number of kernel rows that can range from 12 to 22 rows (usually about 14-18 rows). Row number is primarily determined by genetics whereas kernel number per row (ear length) is strongly influenced by growing conditions.

Field of Corn (with Osage Orange Trees) Located in Dublin, Ohio, by Malcolm Cochran. Dedicated October 30, 1994.




Bouquet Ears

Source: P. Thomison, OSU

Source: P. Thomison, OSU

Symptoms:

“Bouquet Ears” are characterized by multiple ears on a single ear shank (also referred to as Multiple Ears on a Single Ear Shank Syndrome or “MESS”). In some cases as many as five or six “side” ears may develop forming a “bouquet”. Side ears may be well developed or may resemble blunt ears or severely arrested ears. Many probably failed to form kernels due to late silk emergence and lack of pollen.

Access here: https://u.osu.edu/mastercorn/

Osler Ortez @OrtezCornCrops · Aug 23

Columbus, Ohio, 8/16/22:
This is what stress conditions can do to corn (sweetcorn this time!).

Temperature & drought stress noted for 3 consecutive days during ear size determination stages = BARBELL EARS.

Summary on this and other abnormal ears: doi.org/10.1002/agj2.2...

2 11 73

... Abnormal ears still affect cornfields, reducing productivity, underlying causes???

Abnormal ears reported every year...

Be prepared for more to come...

THANK YOU

Osler Ortez
Corn & Emerging Crops
ortez.5@osu.edu || (330) 263-9725

THE OHIO STATE UNIVERSITY
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