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EST. 1870

WE SUSTAIN LIFE

What can be done when the weather turns weird? Corn management choices

Presented by Alex Lindsey, Crop Ecophysiology

Department of Horticulture and Crop Science

Adapted from Severe Storm Damage and Short-Term Weather Stresses on Corn: A Review
Alexander J. Lindsey[*1], Osler A. Ortez[2], Peter R. Thomison[1], Paul R. Carter[3], Jeff A. Coulter[4], Greg W. Roth[5], Daniela R. Carrijo[5], Daniel J. Quinn[6], and Mark A. Licht. Crop Science 2023 [In Review].*

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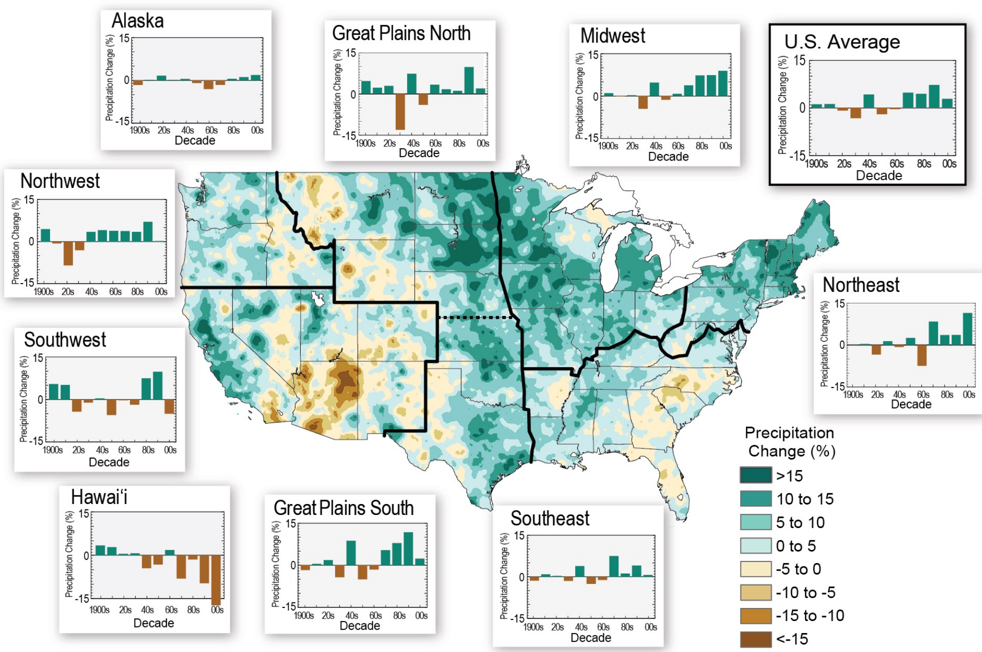
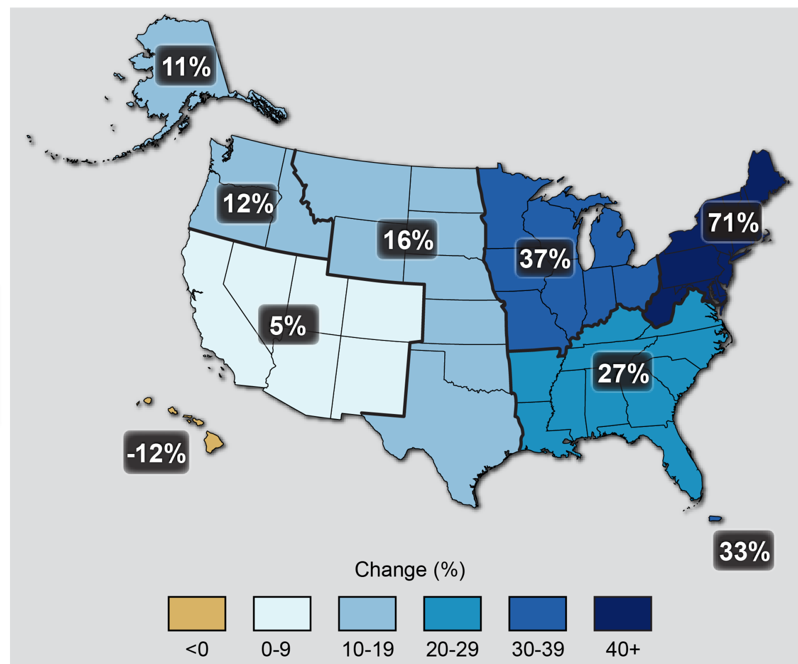
Strong Storm Frequency

Observed U.S. Precipitation Change

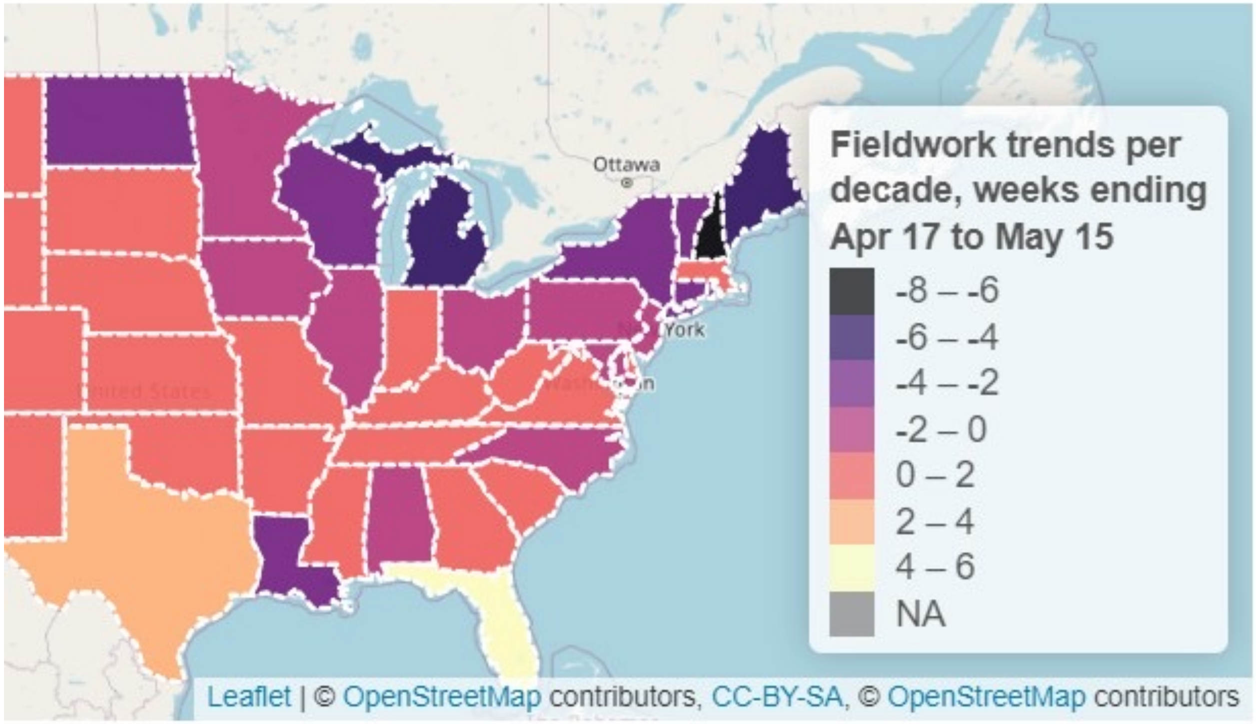


Observed Change in Very Heavy Precipitation



Days Suitable for Fieldwork

- Temperatures warming
  - Frost-free date earlier
  - Above freezing
  - Still cold (<50°F)
- Rain, not snow
  - Cold, non-frozen
- Declining days for fieldwork

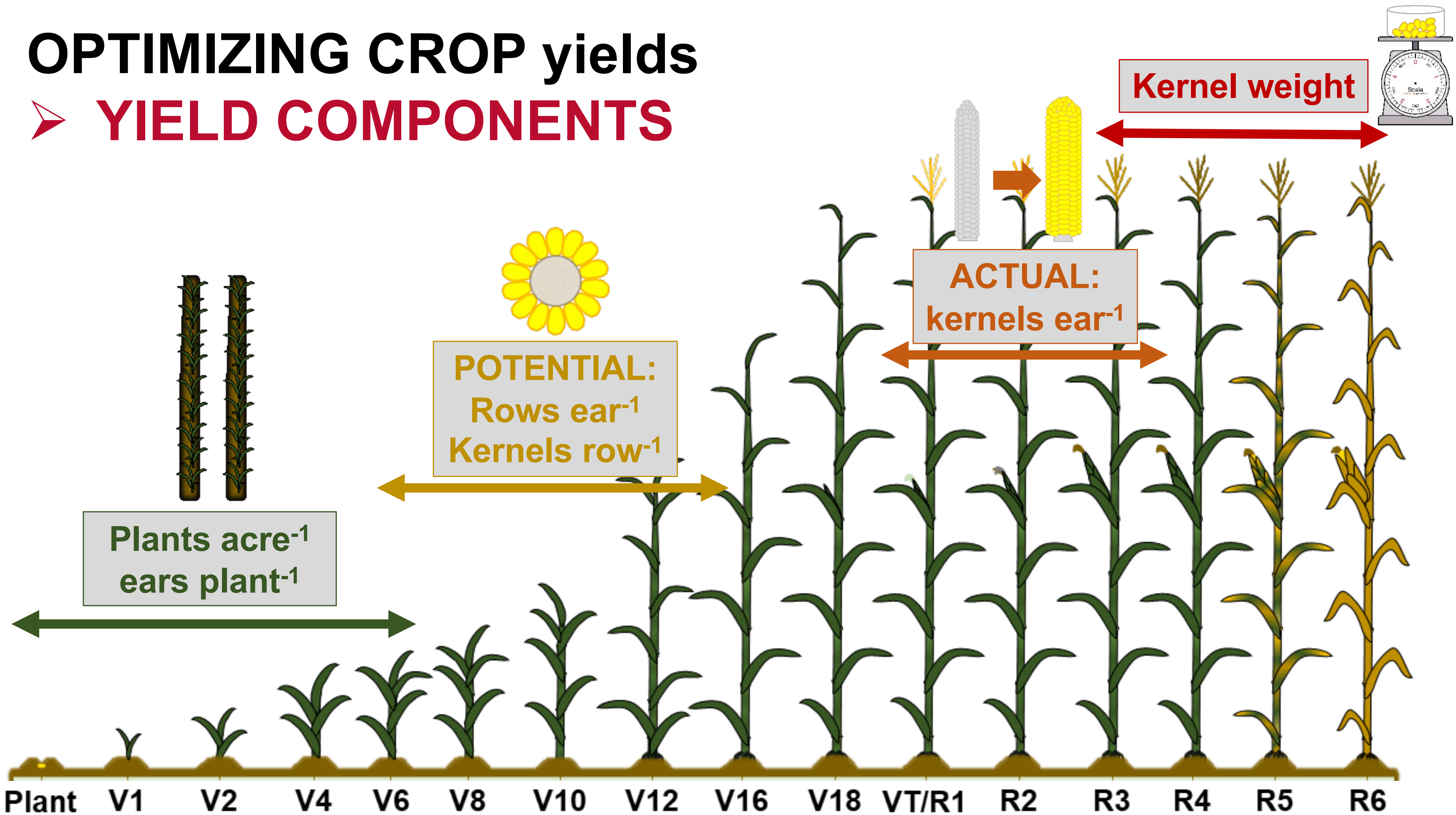


Implications

- Planting Decisions
  - Time of year?
  - Soil conditions?
  - Concerns for immediate future?
- Field Activities
  - Wet soils and tillage/fertilizer
  - Planting
  - Sprays for weed control
- Hybrid selection
  - Maturity
  - Abiotic stress tolerances?
- Response after storms
  - How bad is it?
  - What can be done?
  - Could I have acted differently?

OPTIMIZING CROP yields

➢ YIELD COMPONENTS



Corn response to strong storms

(and the aftermath of those events)

1. Frontal boundaries bringing cold temperatures

2. Flooding and waterlogging impacts

3. Hail damage and yield losses

4. Wind damage

Planting into marginal soils

- Wet soils leads to sidewall compaction
- Risk sealing rain to cause soil crusting

- Risk of cold temperatures after planting
  - What does 50F mean?
  - Is there more damage from imbibitional chilling or cold damage?
    - What's the difference?

Corn seedling experiencing abnormal mesocotyl growth and premature leaf emergence as a result of cold temperature stress. Photo from Mark Licht, Iowa State University (used with permission).

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Imbibitional Chilling vs. Cold Injury

- Imbibitional chilling is when cold water is absorbed by the seed
  - Damage occurs within 24-48hrs of planting
  - Exact range isn't well known
  - Occurs when temperatures are below 39F
- Cold injury occurs after imbibition during emergence
  - Can occur when exposed to cold temperatures (below 46F)
  - Extended durations
  - Not sure what brief periods of cold temperature exposure would do
- Result is similar – uneven emergence and poor stand.

Cold after emergence

Photo courtesy of Paul Carter, Corteva Agrisciences (used with permission).

Brief exposure to cold temperatures can kill tissues

- 2 hrs at 21°F killed 50% of emerged plants
- 48 hrs at 28°F

Radiant freezes can cause tissue damage even at above-freezing air temperatures

Tassel formation/anthesis can be shortened after early-season cold conditions

Other early-season cold issues

- Pathogens/seedling blights
- Potential herbicide injury from seedling growth inhibitors
  - Most formulated with a safener these days to minimize likelihood
- Bigger concern is limited herbicide efficacy at cold temperatures
  - Slower canopy development
  - Complete closure may be difficult

What can be done?

Cold temperatures

- Stagger planting dates
  - Use seed treatment
  - Consider P starter
  - Examine seed lot vigor prior to planting
  - Consider planting soybeans first
- Assess stands
  - Watch for changes due to pathogen losses
  - Consider replanting if severe
  - Wait 3-5 days to do (some recovery may be evident)
- Clipping plants to remove dead tissue?
  - 8-36% yield reduction at 6 of 9 sites
  - 0% yield gain at one site
  - 10 or 40% yield gain at two sites
- Even if 55-70% damage is seen at V4, recommendation is to let it go
- Treatment with brassinolide or biologicals?
  - Field trials needed to validate these results

Flooding and Waterlogging

- Strong storms may bring standing water
- After planting before emergence?
  - Colder temperatures (60°F)– Loss of stand is less from flooding, but stands are reduced even in the absence of flood
    - 80% to 70% or unchanged for 48 hr
    - Similar for 96hr duration
- Warm temperatures (80°F)– Causes greater magnitude of stand loss
  - 90 to 60% germination after 48 hrs
  - Drops to 10-30% after 96 hrs
- Alleviating standing surface water is key post-planting

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Flooding after emergence?

- Yield losses greater in vegetative stages
  - 20-30% yield loss for flooding 4d or less
  - 30-100% loss for flooding longer than 5d
  - Paired/confounded with N availability
  - Remedial N applications can reduce yield losses
- Flooding during flowering/grain fill
  - 0-20% if 8d or less
  - 20-30% if 10d

- Limitations of current work
  - Use applied irrigation, unknown how temp/oxygen levels affect these values
  - BUT provides an estimate (for now)

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- Flooding during flowering/grain fill
  - 0-20% if 8d or less
  - 20-30% if 10d

- Other concerns
  - Mud covering tissue
  - Grain sprouting
  - Silage use?

Photo courtesy of Chad Lee, Corteva Agrisciences (used with permission).

What can be done?

Flooding and waterlogging

- Assess drainage/surface crusting
- Stagger planting dates
  - Consider post-emerge N applications
- Assess stands
  - Rotary hoe if possible
  - Watch soil temps during flood
  - Consider replanting if severe
- Hormone treatment?
  - At flooding onset
  - Aerial application
- Wash off tissue
- Waterlogging tolerant hybrids?

Hail damage

50% of hailstorms in the US happen from March-May

33% happen from June to September

Photo courtesy of Mark Licht, Iowa State University (used with permission).

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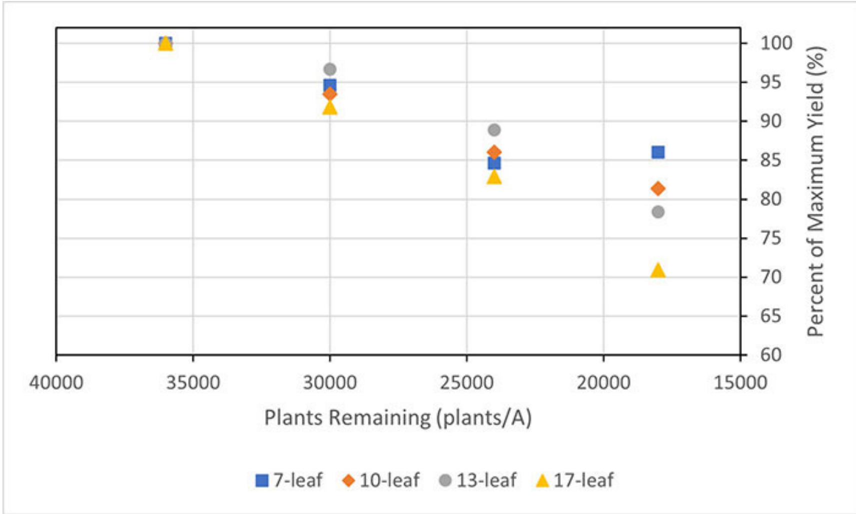
OSU Fact Sheet – Strong Storm Damage

https://ohioline.osu.edu/factsheet/ac-1054

- Summarizes past Ohio work
  - Published in 2022
  - Early season stand loss
  - Most common issue from early hail events

- Only simulates stand losses after emergence
  - Does not defoliate remaining plants
  - No stem bruising



Hail Damage

- Multiple defoliation events
- Tassel deformations
  - Only some genotypes defoliated at V8

Table 1. Defoliation intensity and development stage impacts on grain yield loss in corn.

Stage of defoliation and amount (%)						Yield reduction	Years of data	Tassel deformation in select hybrids
10-leaf (V8)†	15-leaf (V13)	Tassel (VT)	Blister (R2)	Milk (R3)	Soft dough (R4)	%		Rating (1–3)‡
50						4	6	1.2
100						2	3	2.7
	50					12	6	1.1
	100					35	3	1.0
		50				20	3	1.1
			50			23	3	–
				50		14	3	–
					50	7	3	–
50	50					13	3	1.2
100	50					18	3	2.6
50		50				23	3	1.5
100		50				25	3	2.7
50			50			22	3	–
50				50		20	3	–
50					50	15	3	–
	50	50				15	3	1.0
	100	50				46	3	1.1
	50		50			24	3	–
	50			50		24	3	–
	50				50	20	3	–
50	50	50				22	3	1.2

What can be done?

Hail and defoliation

- Assess damage at least 7d after storm
  - Yield losses from stand reduction
  - Yield losses from leaf losses
  - Crop Insurance Adjustments
  - Remote sensing using NDVI?
- Foliar fungicide after VT?
  - Limited benefit if low disease pressure
  - “Plant Health” gains not reported to date
- Consider varying planting date and hybrid maturity
  - Spreads crop stages
  - Minimizes direct damage at flowering
- Current work focuses on defoliations
- Limited work on grain quality effects (mycotoxins, etc.)

Wind damage

- Root lodging
  - Earlier in season
- Rootless/floppy corn
  - Poor root development
  - Hot, dry soils
  - Sidewall compaction
  - Manifest when plants are larger

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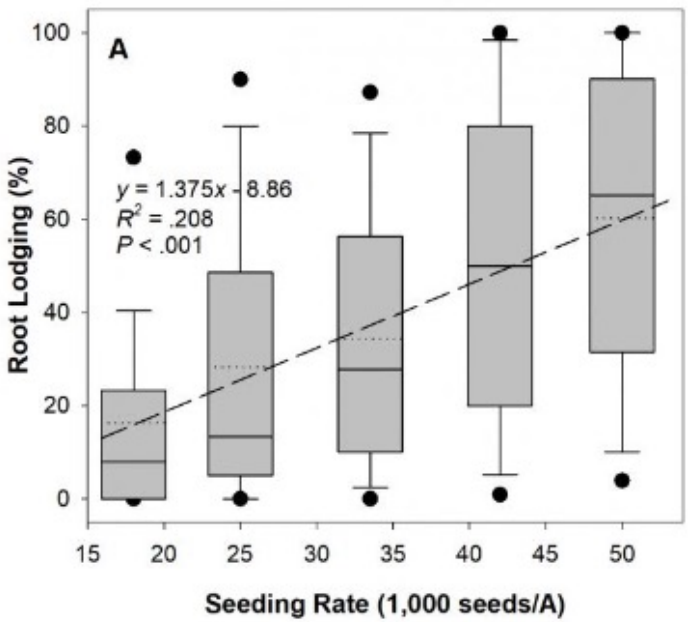
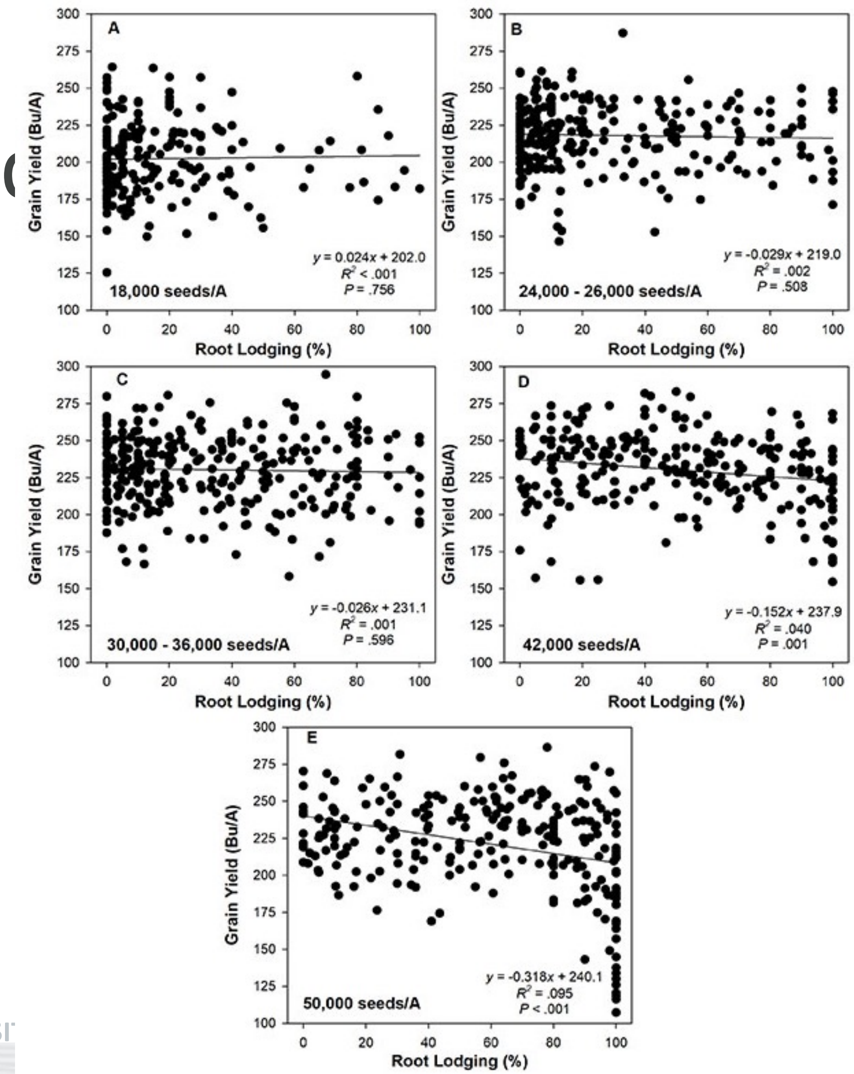
Wind damage

- Root lodging
  - Earlier in season

- Root lodging
  - Partial root mass removal from soil
  - Stem intact
  - Plant tips over
  - Recovery seen within 3d
    - Yield losses range from 5-40%

Root lodging and see





Wind damage

- Willowed corn
- Newer term for lodging
  - Stem intact
  - Plant bends
  - Limited to no recovery
- Very little information on yield loss from this

Photo by Carl Joern, Corteva Agriscience, used with permission.

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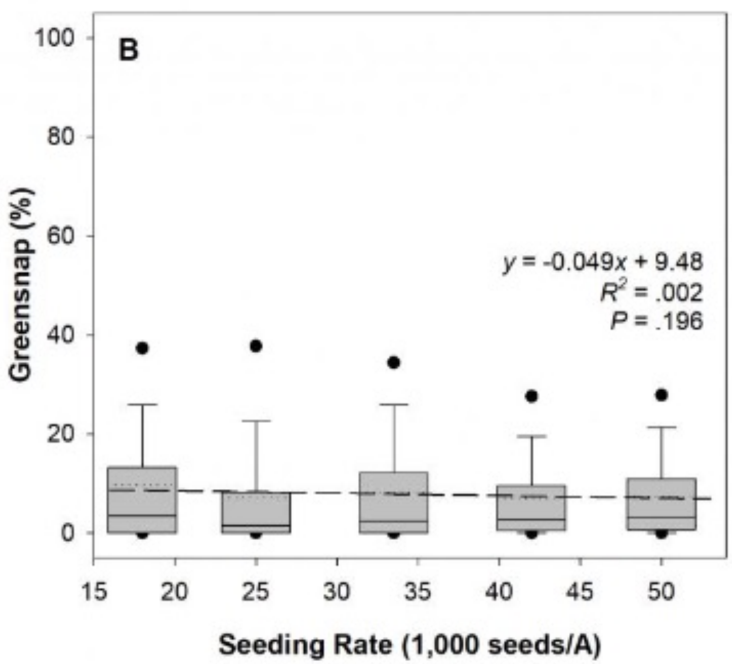
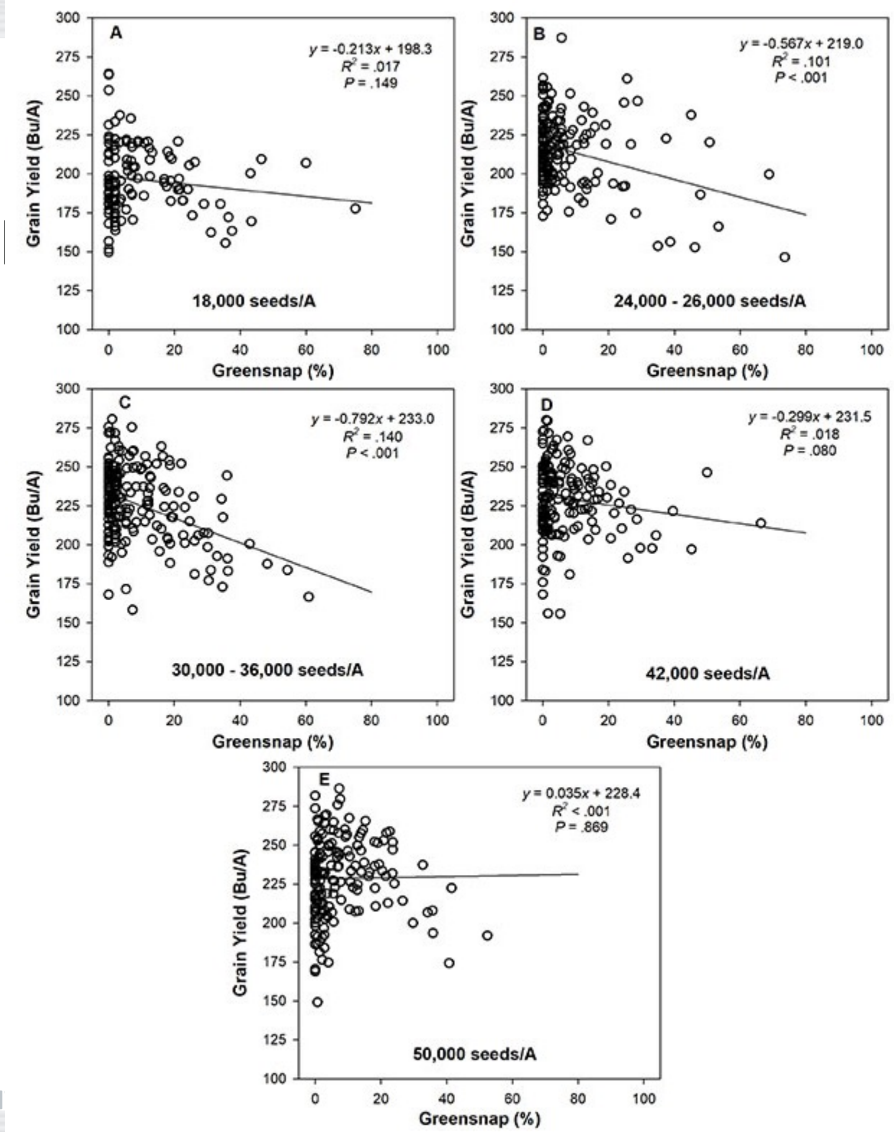
Wind damage

- Stalk crimping
- Greensnap
- Stems break
  - Complete (snap)
  - Bend then recovery (crimping)

Photos by Peter Thomison and Alex Lindsey, The Ohio State University, used with permission.

Greensnap and seedi





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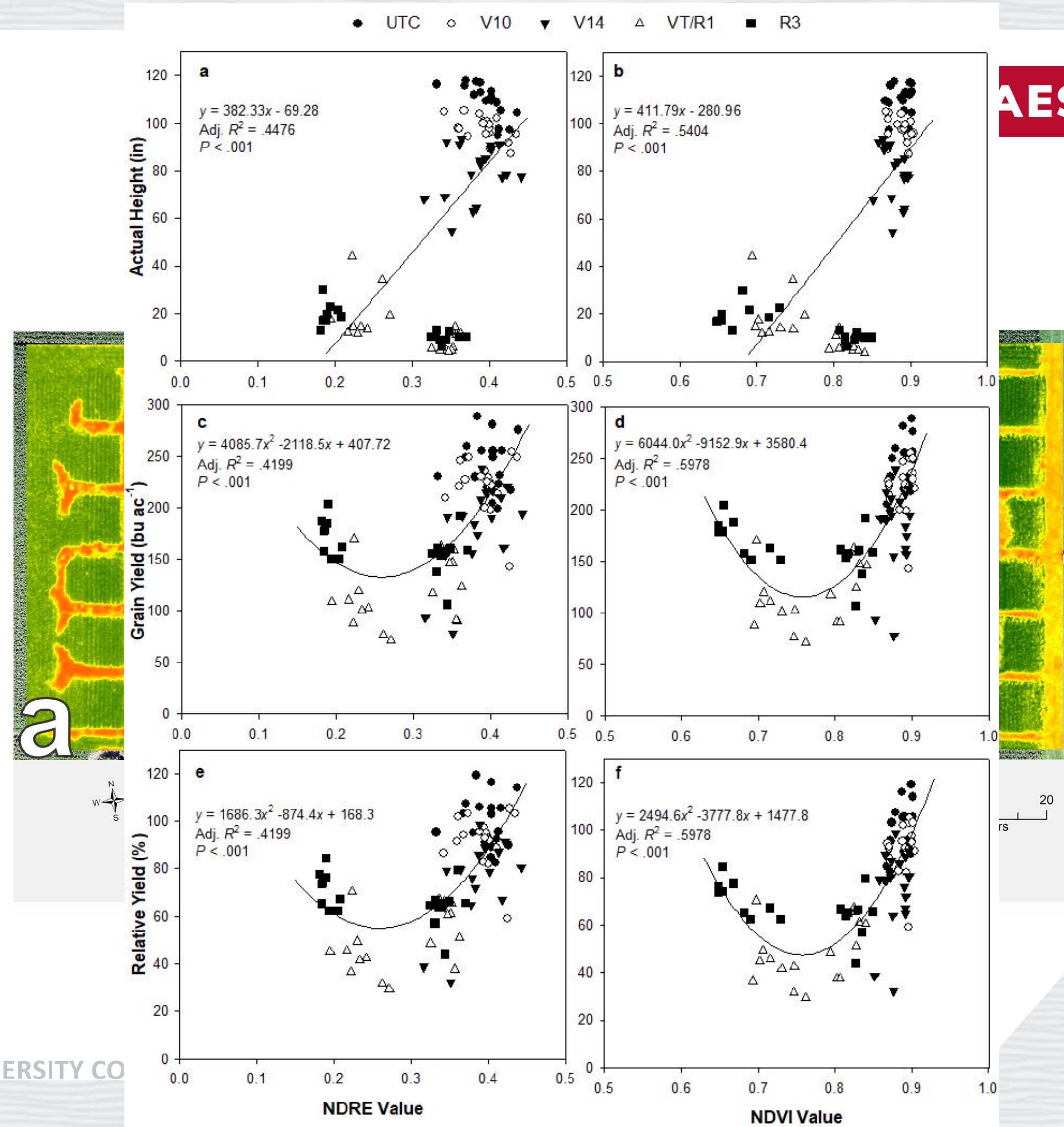
Stalk lodging

- Stalk breakage below the ear
  - Usually during grain fill (R4 or later)
- Stalk integrity issues
  - Diseases
  - Insect feeding
  - Rind strength
- Yield losses range 5-25%
  - Mainly from inability to harvest
  - Ear/grain quality concerns

What can be done?

Wind damage and lodging

- Quantify lodging using aerial imagery
  - Use vegetation indices to measure recovery
  - NDVI or NDRE worked well



What can be done?

Wind damage and lodging

- Quantify lodging using aerial imagery
  - Use vegetation indices to measure recovery
- Use of a fungicide at flowering
  - May be less effective is applied post-lodging
  - Could protect stalks from late-season disease
- Harvesting downed corn
  - Zero-clearance header
  - Reel or roller bars to assist
  - Concerns on grain quality
- Last resort- till field under
  - Reduce residue size
  - Volunteer corn concerns

Conclusions

Strong Storms and Short-term Weather

- Strong storms can cause damage
  - Severity dependent on stage
  - Many cases looks worse than it may be
- Yield losses often ranged from 5-35%
  - If it was bad though, it would be 80-100%
  - Limited ability to simulate true stress conditions
- Much of the work referenced in this presentation on yield loss/stress was published pre 1995
  - Currently looking for ways to update this information
  - New tools need to be evaluated more robustly

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Long-Range Weather Impacts

1. Drought & Heat Stress
2. Light Interception & Solar Radiation
3. Heat Unit Accumulation

Summary

What about longer-range weather patterns (10 days or more)?*

Adapted from ***Corn Response to Long-Term Seasonal Weather Stressors: A Review***

Osler Ortez, Alexander Lindsey, Peter Thomison, Paul Carter, Jeff Coulter, Greg Roth, Daniela Carrijo, Daniel Quinn, Mark Licht, and Leo Bastos*

Crop Science Journal, 2023 6:3210-3235.

*Most slides originally developed by Osler Ortez

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Summary

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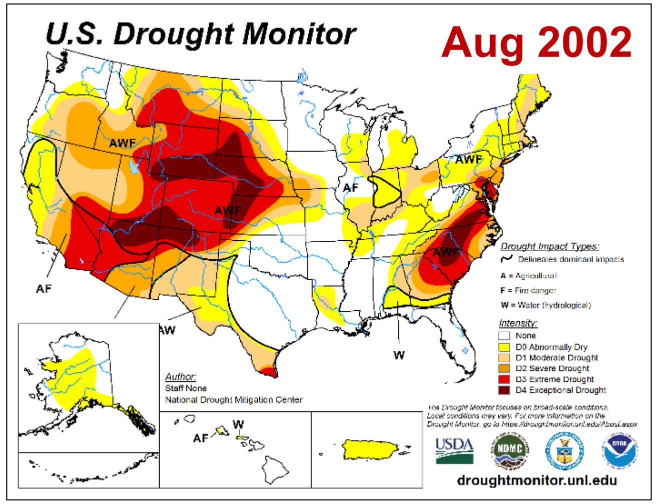
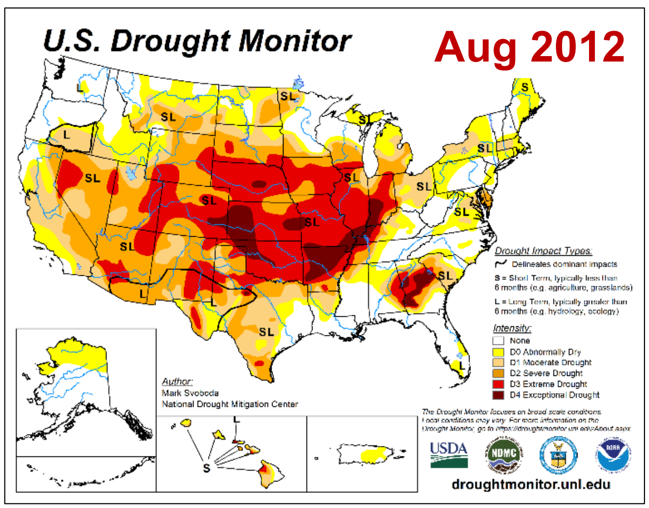
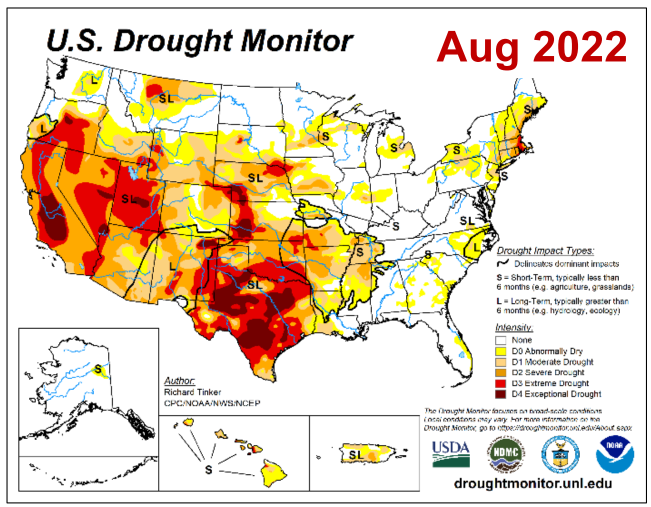
1. Drought & Heat Stress

Between **2000-2019**, **droughts** affected corn during reproductive stages in the **US Midwest in 9 out of the 19yr period**
(Ao et al., 2020a; National Drought Mitigation Center, 2022)







Widespread drought in 2012 contributed to **production losses of 23% in the US,** relative
to US yield trends
(USDA-NASS, 2013)

1. Drought & Heat Stress

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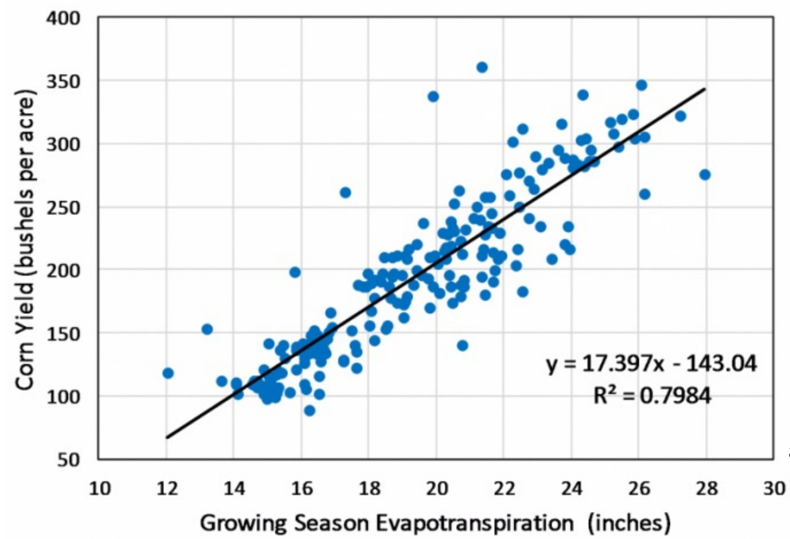
What is Corn doing right around August?

Stage	Water Use Inch/day
<12-leaf stage (<V12)	<0.20
12-leaf stage (V12)	0.24
Early tassel (VT)	0.28
Silking (R1)	**0.30**
Blister (R2)	0.26
Milk (R3)	0.24
Dent (R5)	0.20



200 Bu = 20 inch

https://crops.extension.iastate.edu/cropnews/2017/06/corn-water-use-and-evapotranspiration

More on this here: https://agcrops.osu.edu/newsletter/corn-newsletter/2022-23/crop-water-use-corn-%E2%80%93-what-do-we-know

1. Drought & Heat Stress >> What can be done?

Adjust planting dates:

- "Attempt" to adjust, avoid periods of in-season risk
- Vary PDs & hybrid maturities for variation in flowering

Optimum seeding rates:

- Lower/higher interplant competition
- Can be a mitigation strategy
- A push to higher seeding rate may help if planting late (OH data)

Nutrient mgmt. actions:

- Less transport, N and K
- 4 R's (source, rate, placement, timing)
- Split applications, slow-release sources

1. Drought & Heat Stress >> What can be done?

Drought-Tolerant Corn Hybrids: A Risk Management Tool for Ohio?

Agronomic optimum plant population (AOPP), and yield at that population for each hybrid type (**AQUAmax** only). The last column (Yield Across Populations) contains data for both **AQUAmax and Artesian hybrids**.

Plant Date	Hybrid Type	AOPP	Yield at AOPP	Yield Across Populations
		Plants/Ac	----------- bu/Ac -----------	
May	**Drought-Tolerant**	**37,928**	199.9	200.0b
	Conventional	39,507	199.9	203.1a
June	**Drought-Tolerant**	**38,111**	180.8	177.9c
	Conventional	46,899	176.4	176.3c

Source: https://ohioline.osu.edu/factsheet/agf-517

DroughtGard® HYBRIDS Artesian™ Optimum® AQUAmax®

1. Drought & Heat Stress >> What can be done?

Long-range solutions?

Water mgmt. actions:

- Crop rotations, lower water demand (e.g., sorghum in NE)
- Infiltration rates, water holding capacity, water loss
- Retention, savings, re-use, efficiencies
- Controlled drainage (retention, recharge)

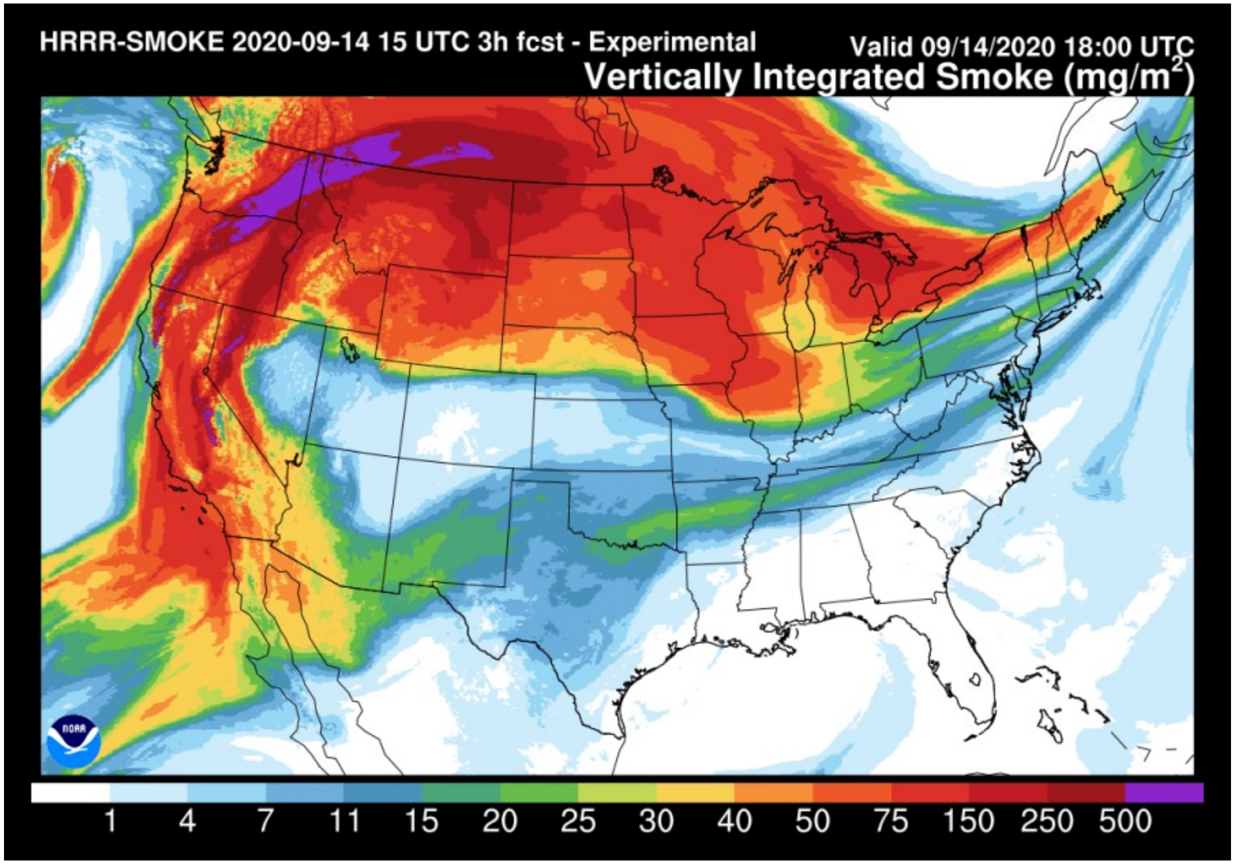
Irrigation as a potential strategy:

- Rain 360 out there (OH)
- Plenty of pivots in Western Corn Belt (NE)

- Long-Range Weather Impacts
- 1. Drought & Heat Stress
- **2. Light Interception & Solar Radiation**
- 3. Heat Unit Accumulation
- Summary

2. Light Interception & Solar Radiation

Dust storms, wind erosion, pollution, haze, wildfire's smoke, cloud cover



A **well-widespread** concern!

Most of the northern US, including the **Midwest,**
Corn Belt region

A 46% lower radiation in **1-week cloudy period,** dough stage (R4, 19–25 Aug), **Nebraska**: Estimated **yield reduction 5.2%**
(Elmore et al., 2019)

2. Light Interception & Solar Radiation

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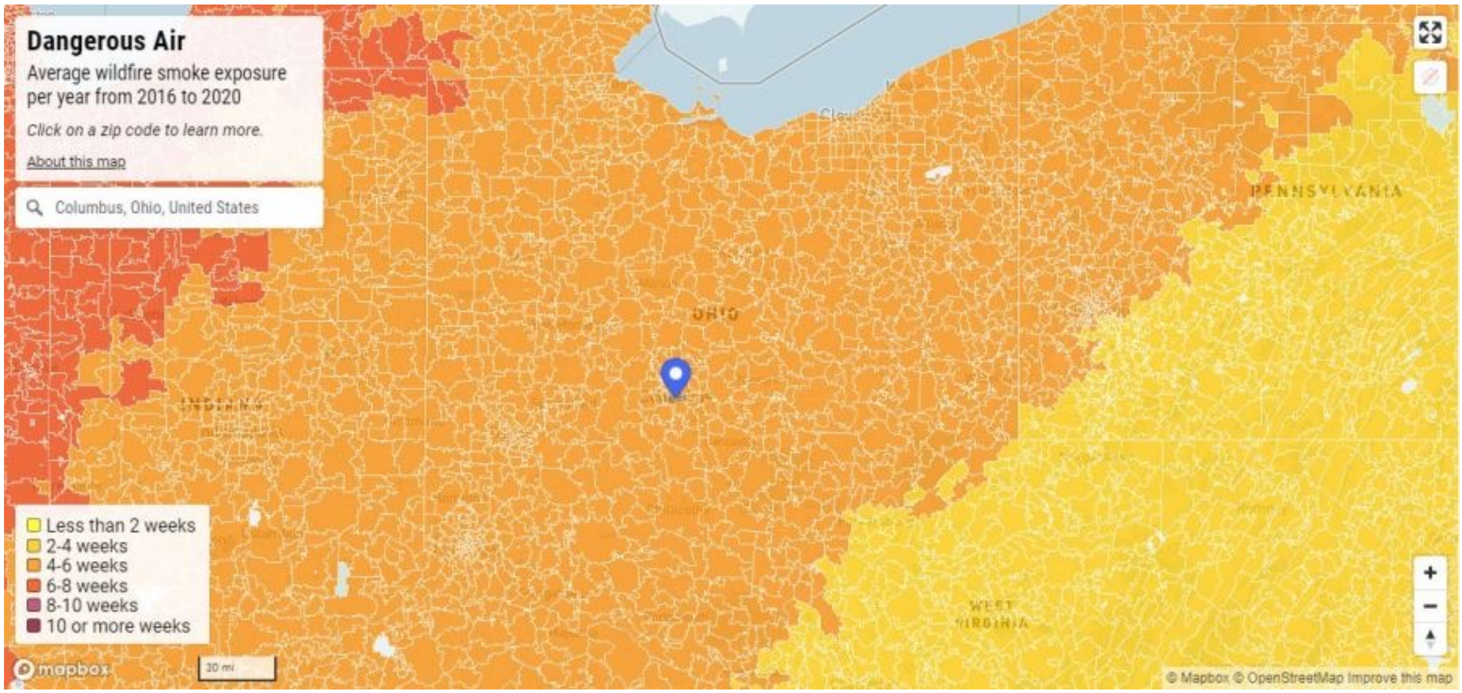
Dust storms, wind erosion, pollution, haze, wildfire's smoke, cloud cover



From 2016-2020: most of Ohio saw 4-6 weeks of wildfire smoke per year, 28 to 42 days >> ~half of the grain fill in corn if altogether!!

Short-term light reductions may not translate to long-term losses

- Quantity reduced
- Duration of reduction
- Timing relative to crop growth

Source: https://www.nbc4i.com/weather/climate-columbus/central-ohio-is-seeing-more-smoky-days-from-western-wildfires-threatening-health-and-crops/

2. Light Interception & Solar Radiation

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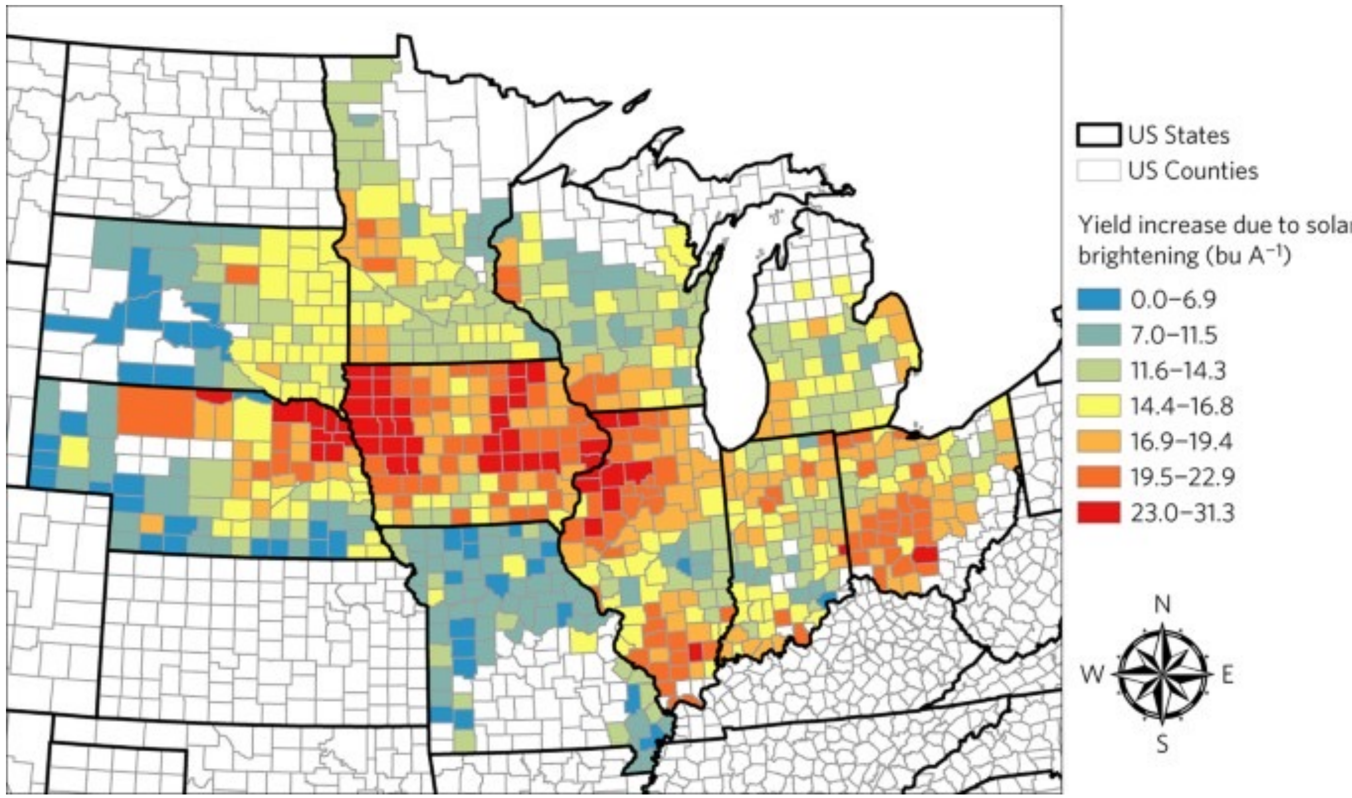
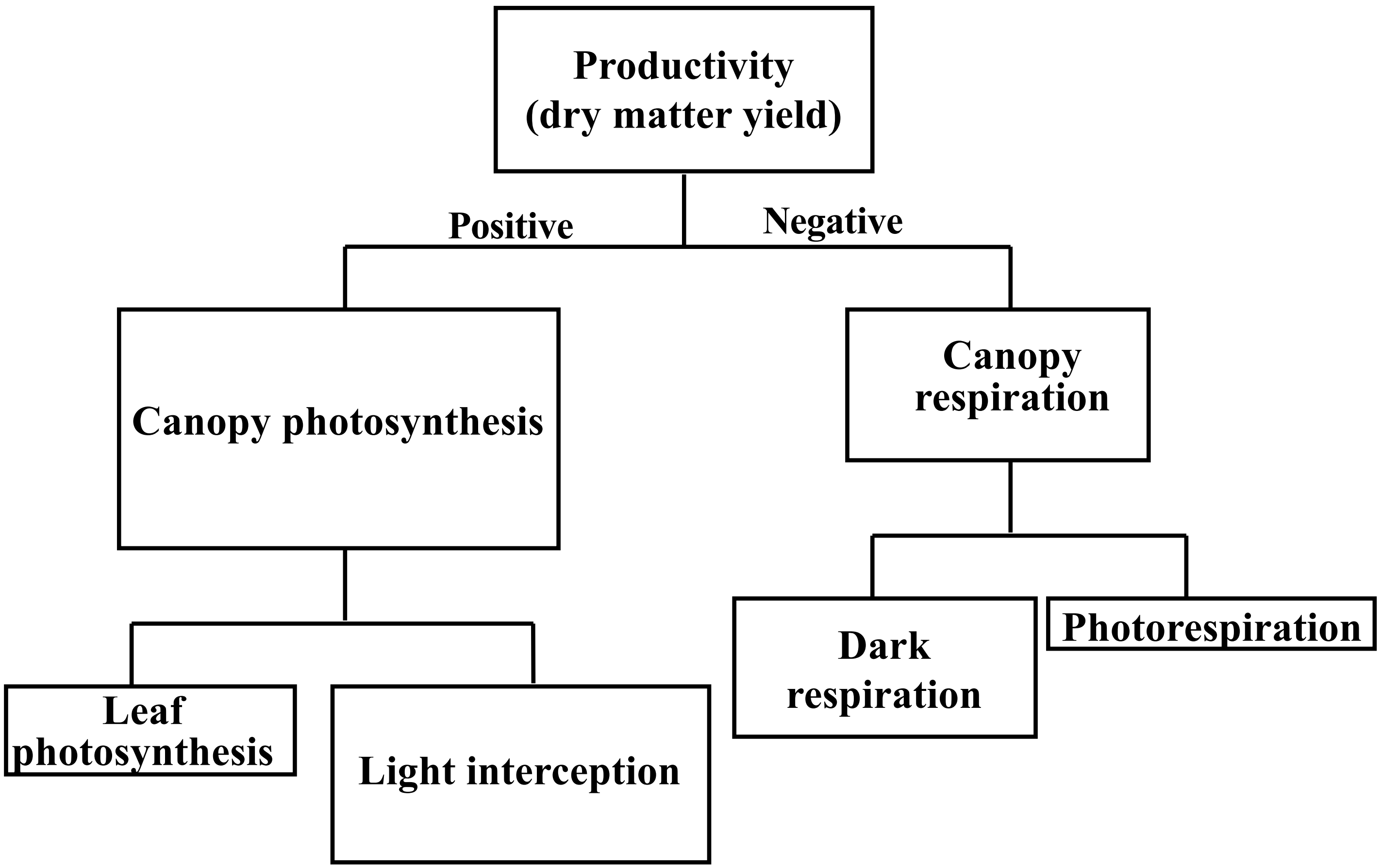
Yields increases (bu/Ac) 1984 to 2013, attributable to solar brightening across ten US Corn Belt states.



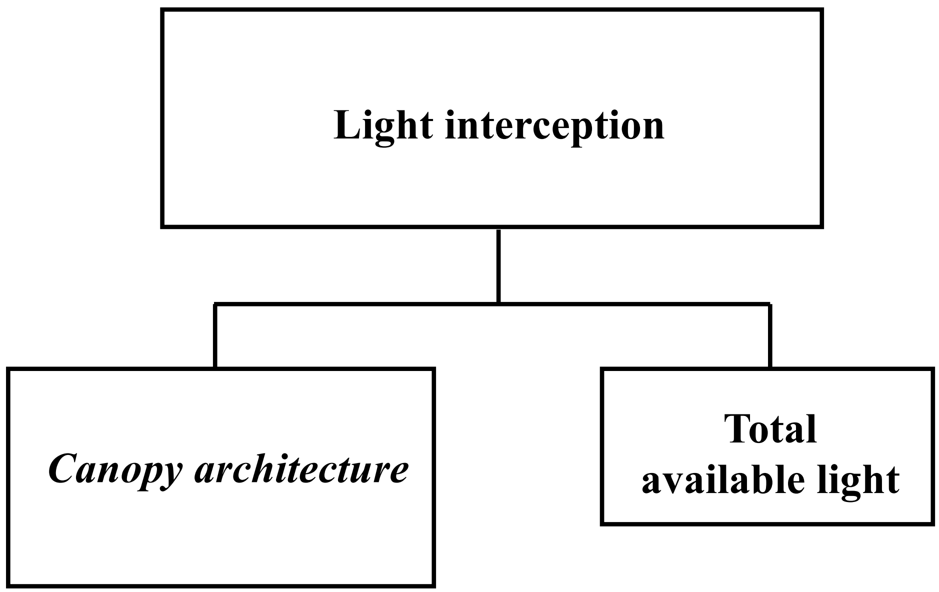
Source: https://doi.org/10.1038/nclimate3234

Net Productivity Determinators

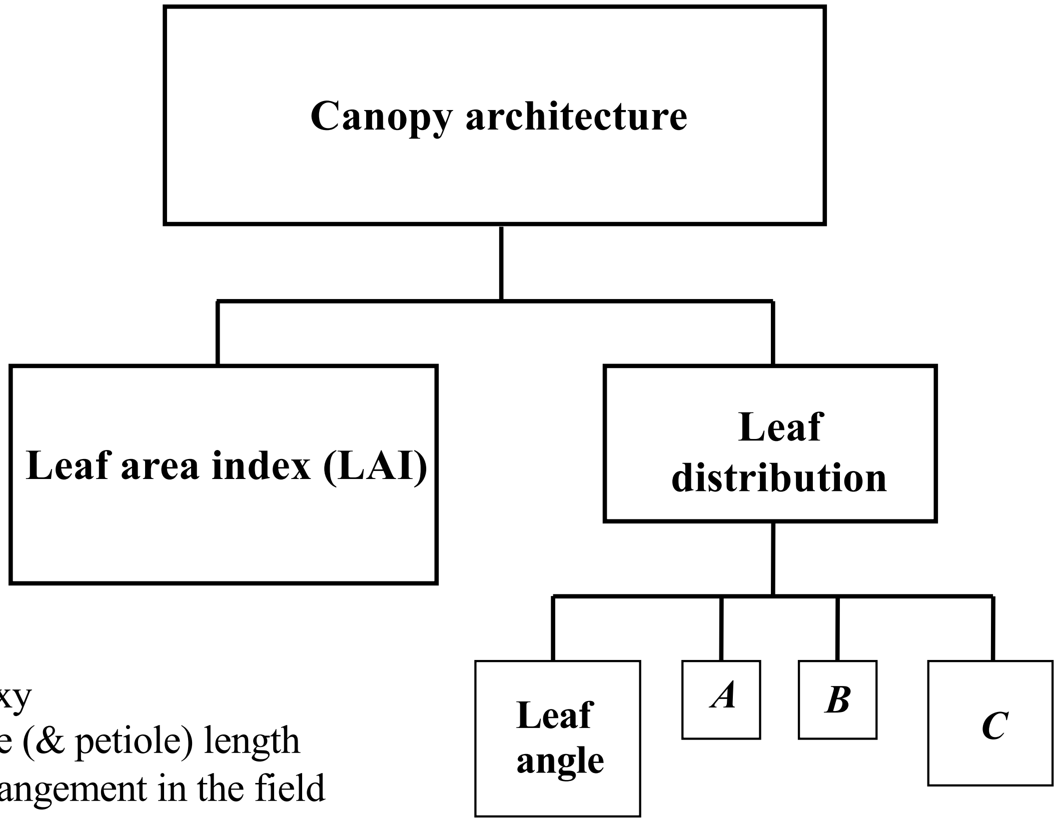


Note: the size of the box indicates relative contribution to productivity

Light interception is in part determined by available light, but effiency of capture is a larger contributor to productivity



Canopy architecture is comprised of two main sectors – gross leaf area and distribution of leaves



A. Phyllotaxy
B. Internode (& petiole) length
C. Plant arrangement in the field

2. Light Interception & Solar Radiation >> What can be done?

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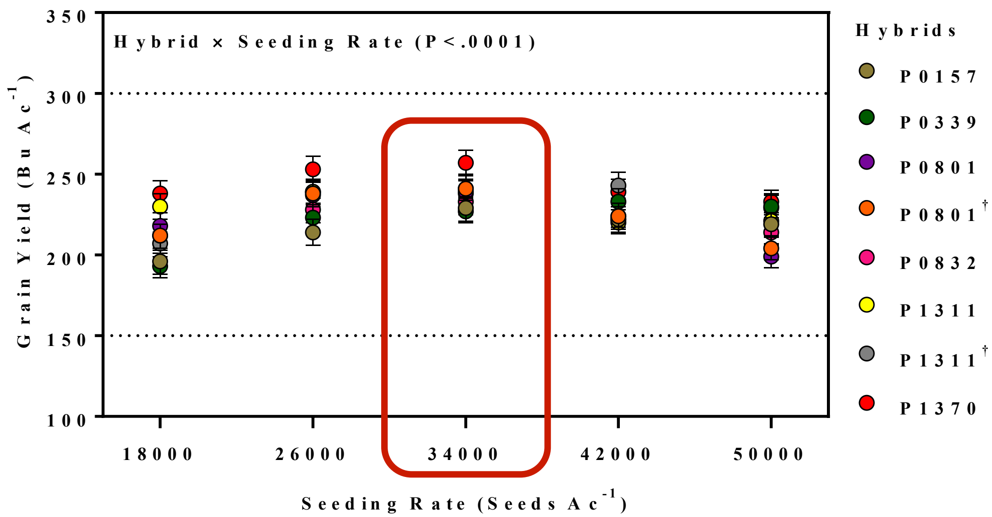
Optimizing seeding rate



(**8 site-years**, NE, 2018-2019. Ortez et al, 2021)

Optimum seeding rate: ~**34,000 seeds/Ac**

Average **yield**: **240 bu/Ac**

Nebraska Lincoln · HOEGEMEYER · N EXTENSION · PIONEER BRAND · SEEDS · Water for Food Daugherty Global Institute at the University of Nebraska

2. Light Interception & Solar Radiation >> What can be done?

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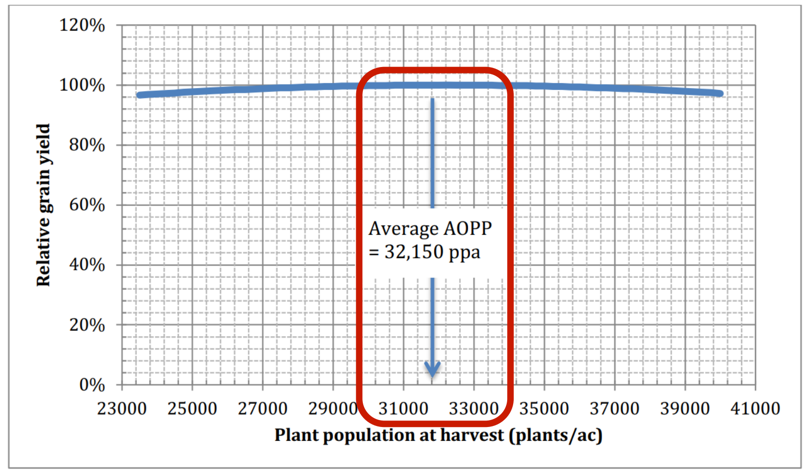
PURDUE UNIVERSITY
Agronomy

Optimizing plant density



(**83 field trials**, IN 2008-2018. Nielsen et al., 2019)

Agronomic **optimum** plant population: **32,150 plants/Ac**

Average **yield**: **195 bu/Ac**

2. Light Interception & Solar Radiation >> What can be done?

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- **Row spacing** to optimize light capture
- **0-16% yield advantage** when changing to narrow rows
  (Andrade and Ferriero, 1996; Nielsen, 1998; Widdicombe and Thelen, 2002; Licht et al., 2019)
- **Supplemental lighting in canopy**?

2. Light Interception & Solar Radiation >> What can be done?

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- **Grain from tillers** can contribute to yield. Tiller’s **yield contributions** may have been from increased radiation capture at lower densities by tiller leaves.
- **Tiller removal** negatively affected yield at high plant densities. Revisiting the role of tillers in **light capture** at **higher plant densities** may be relevant.

(Veenstra et al., 2020 & 2021)

Solar radiation reduction vary **by hybrid type and plant density** (Stinson & Moss, 1960).

Targeting **leaf canopy structure** (i.e., leaf area, angle to affect light attenuation), in addition to tolerance to **fluctuating light conditions** (Burgess and Cardoso, 2022).

Stay-green and **photosynthetic efficiency** under low populations can help (Yang et al., 2021).

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Long-Range Weather Impacts

1. Drought & Heat Stress

2. Light Interception & Solar Radiation

3. Heat Unit Accumulation

Summary

SO, WET/COLD springs & planting DELAYS

vs.

Hence, lower potential for heat unit accumulation

3. Heat Unit Accumulation

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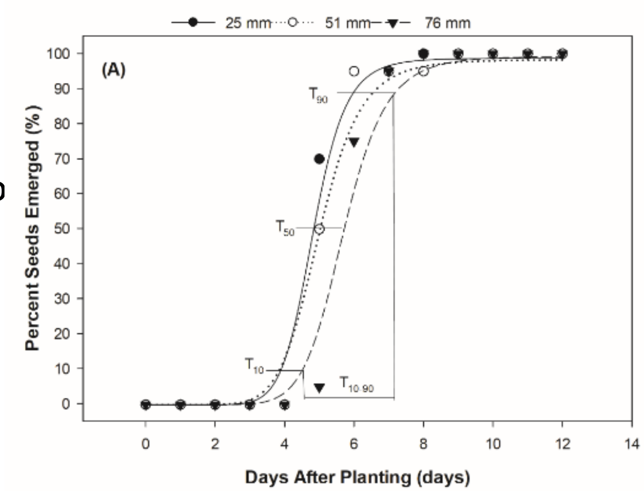
Vegetative growth stage progression:

- **Soil heat unit accumulation** primary driver to V6
  (Imholte and Carter, 1987; Swan et al., 1987)
- **Air heat unit accumulation** primary driver after V6
- Emergence may be slow if cool weather experienced
  - Approximately 150 soil-accumulated GDDs to 50% emergence (Nemergut et al., 2021)
- Challenges at ensuring fast, uniform emergence



3. Heat Unit Accumulation

Reproductive growth stage progression:

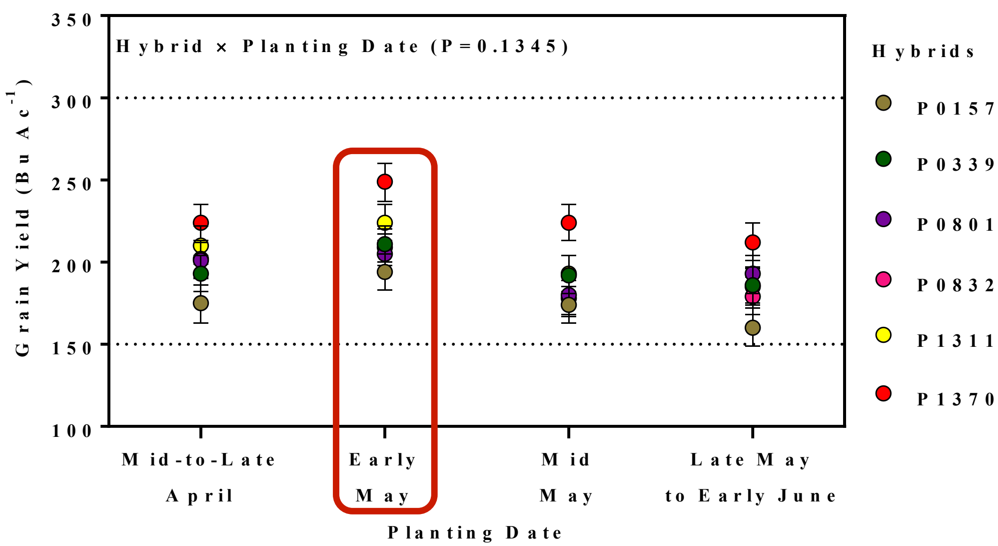
- **Varies with hybrids,** though method for quantifying is not consistent across companies
  - Does not correspond to calendar dates

- Achievement of growth stages may vary with weather
  - GDD compression phenomenon (fewer GDDs needed than stated to achieve maturity)
  - Elongation (taking longer than expected to achieve black layer)

- Productivity may also be linked to available light AND heat unit accumulation
  - Photothermal quotient

3. Heat Unit Accumulation >> What can be done?

Optimizing planting date



Nebraska Lincoln · Hoegemeyer · Nebraska Extension · Pioneer Brand Seeds · Water for Food Daugherty Global Institute at the University of Nebraska

(**6 site-years**, 2018-2020. Source: Ortez et al, UNL)

Optimum planting date: **early May**
Average **yield**: **235 bu/Ac**

3. Heat Unit Accumulation

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IF replanting…

For corn, early planting dates with lower stands can still produce good yields.

From research, a stand of **20,000 plants** per acre planted on **April 20** can yield **91% of the optimum.**

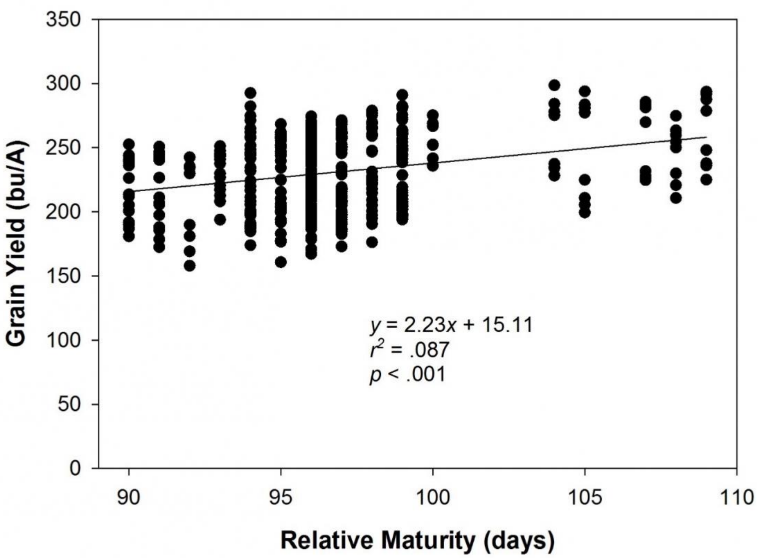
Planting Date	Plants per acre at harvest					
	10,000	15,000	20,000	25,000	30,000	35,000
	% of optimum yield					
April 10	62	76	83	92	94	93
April 20	67	81	**91**	97	99	97
April 30	68	82	92	98	**100**	98
May 9	65	79	89	95	97	96
May 19	59	73	84	89	**91**	89
May 29	49	62	73	79	81	79

More on this here:
https://agcrops.osu.edu/newsletter/corn-newsletter/2022-14/replanting-decisions-corn-and-soybeans%E2%80%A6-what-consider

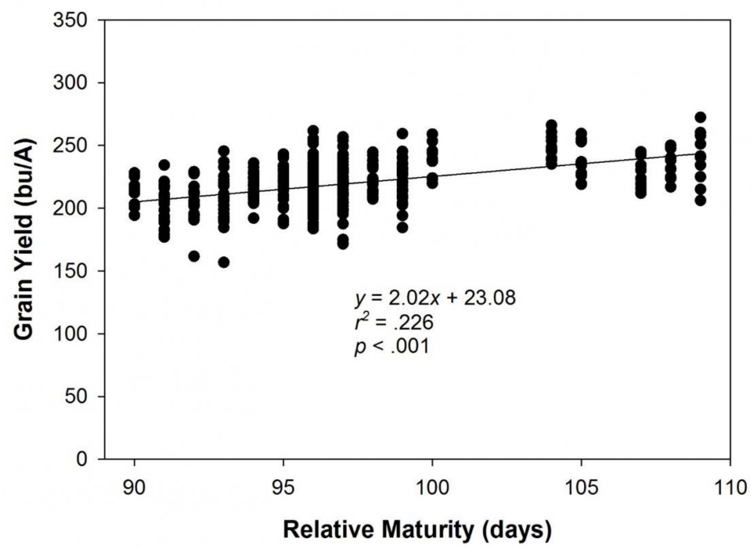
3. Heat Unit Accumulation >> What can be done?

Optimizing relative **maturities**
Maximizing growing season

Interaction of planting date and maturities is a tool, **though variable across environments**



Northcentral-east Ohio,
Mid-May Planting Date



Northcentral-east Ohio,
Late-May/Early June Planting Date

Common for Ohio
-Maturities 105 to 114 days
-Approx. 2500-2800 GDDs

'Ultra-Early' hybrids
-Maturities 90-100 days
-Approx. 2150-2450 GDDs

(Source: P. Thomison, OSU) https://ohioline.osu.edu/factsheet/anr-94

3. Heat Unit Accumulation

>> What can be done?

Useful-to-Useful Tool: U2U

Freeze in the Spring and freeze in the Fall

Assess **silking dates**, **black layer** dates

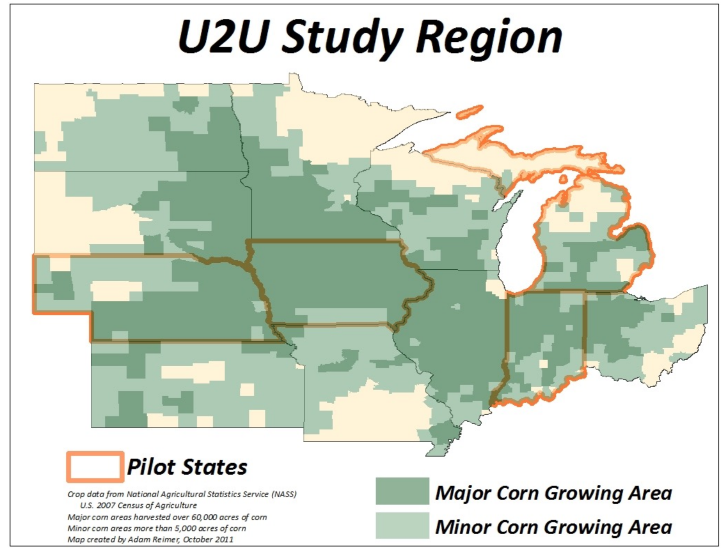
***GDD compression** as potential limitation in U2U

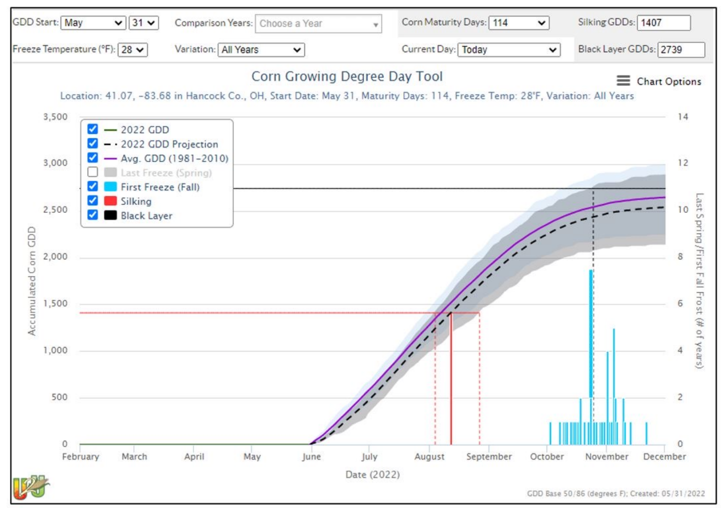
Other tools from industry?

May also struggle to accurately predict for entire season

Understand tool limitations

Verify stages prior to management with scouting





More on this here: https://agcrops.osu.edu/2022-16/delayed-corn-planting-and-u2u-tool

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Long-Range Weather Impacts

1. Drought & Heat Stress
2. Light Interception & Solar Radiation
3. Heat Unit Accumulation

Summary

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SUMMARY

- **Corn growth & development** to **OPTIMIZE CROP YIELDS.** Reduce and/or mitigate **STRESS**!

- Adverse **long-term weather** affect corn **growth, development, and yield**.

- Periods of **high heat, water deficit,** and **haze/cloudiness** challenge the ability to maximize corn yields.

- There is continued need to improve current **crop phenology** models to accurately **forecast crop development under new crop conditions** (e.g., U2U, GDDs, GDUs).

Thank you, questions?

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