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CORN GUY INDIANA

Agronomic Practices for Irrigated Corn Production

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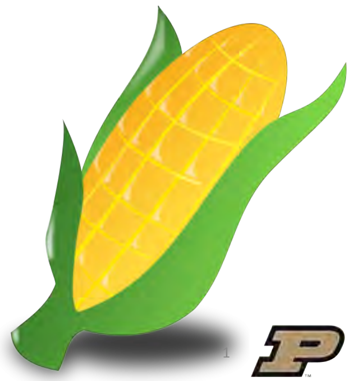

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Irrigation vs. Rainfall…

- Irrigation is recycled rainfall.
- Most of the production practices for high yielding corn under irrigation are similar to high yielding corn grown under adequate rainfall.

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Our greatest agronomic challenge…

…is figuring out how to stress-proof our crops against "normal" weather.

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"Normal" Weather

"Normal" weather can be defined by an unpredictable number of unpredictable **extreme weather** events, each occurring unpredictably, with unpredictable severity.

Greater climate variability today = Higher frequency of extreme weather events

Image: http://www.keepbanderabeautiful.org/climate-change.jpg

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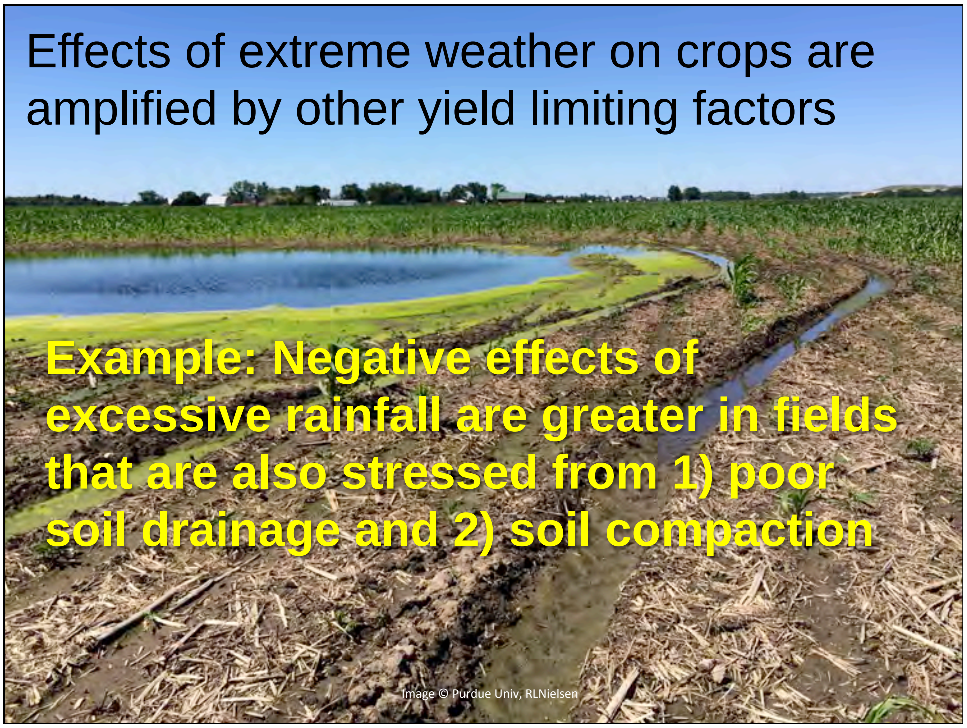

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The opportunity…

Identifying and managing these other yield limiting factors can help improve the **resilience** of your crops against the uncertainty of Mother Nature.

Image source: http://typesofpoetry99.blogspot.com/2010/01/mother-nature.html

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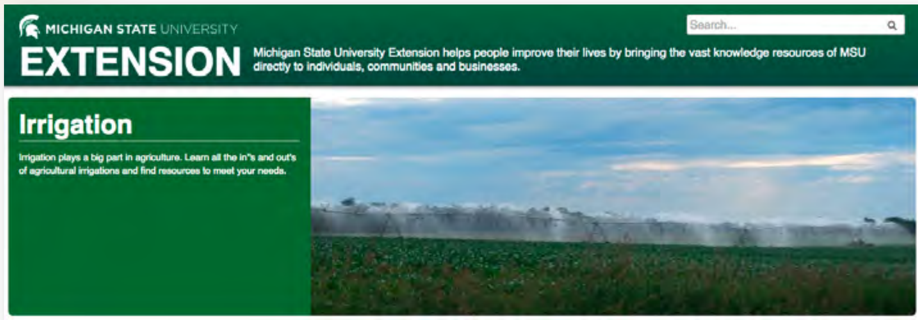
Irrigation Information



http://msue.anr.msu.edu/program/info/irrigation

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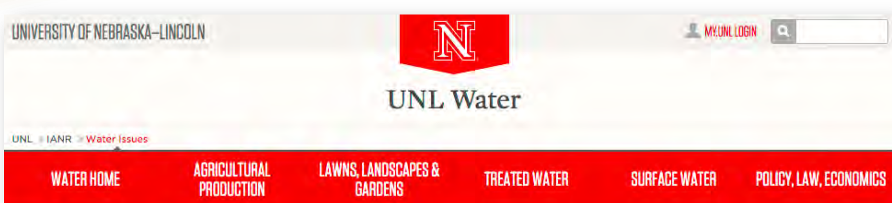
Irrigation Information



http://water.unl.edu/

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Timely agronomic information

www.kingcorn.org/cafe

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Grain yield is the product of the season-long development of the individual components of yield.

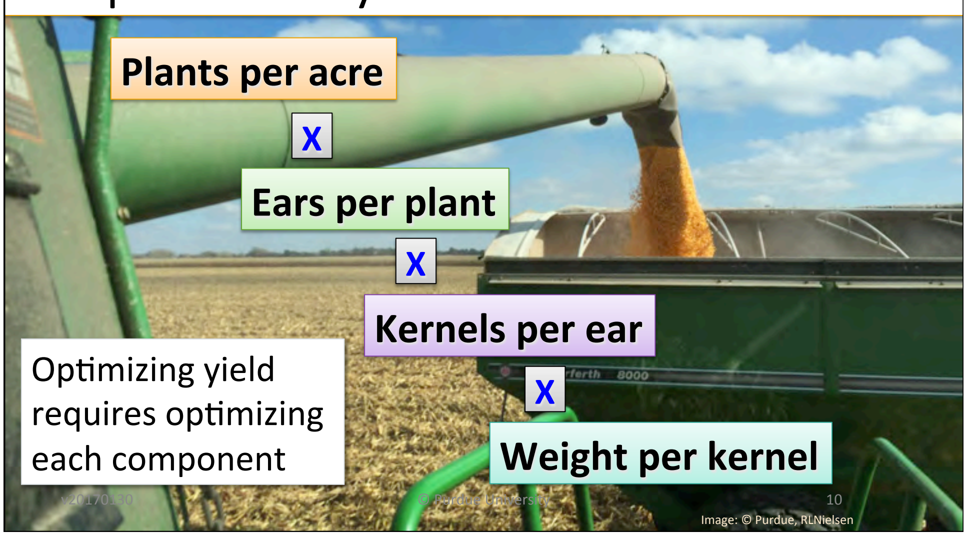

Image: © Purdue, RLNielsen

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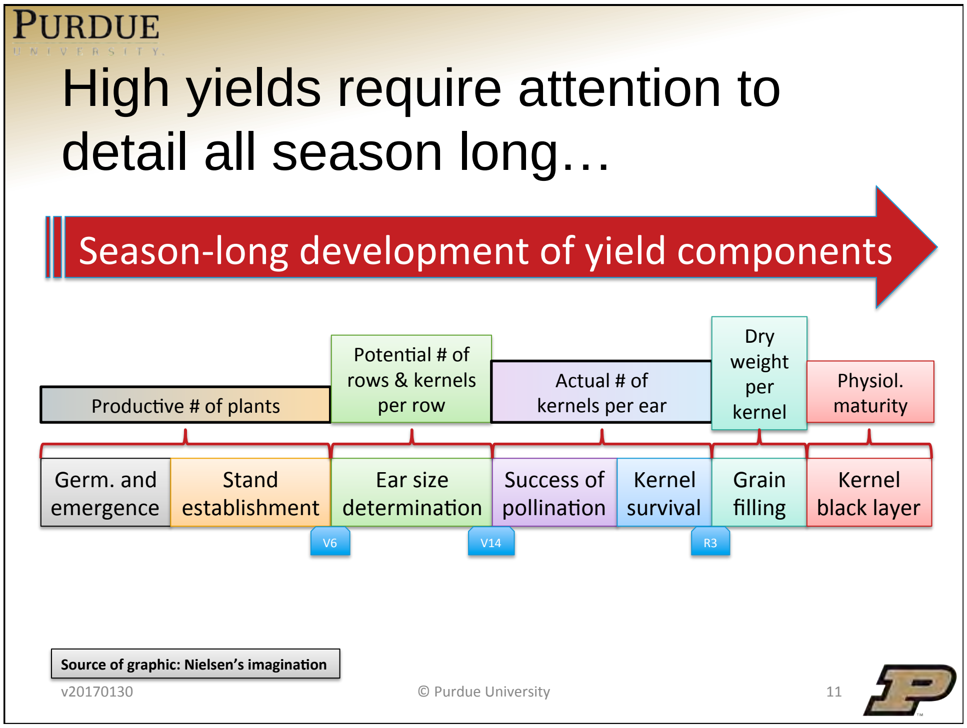
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High yields require attention to detail all season long…
Season-long development of yield components
Productive # of plants
Potential # of rows & kernels per row
Actual # of kernels per ear
Dry weight per kernel
Physiol. maturity
Germ. and emergence
Stand establishment
Ear size determination
Success of pollination
Kernel survival
Grain filling
Kernel black layer
V6
V14
R3
Source of graphic: Nielsen's imagination
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The key to **consistently** producing high-yielding corn...
…is the ability to accurately identify AND successfully mitigate the **Yield Limiting Factors (YLFs) specific to your farming operation**.
Image: RLNielsen

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If you fail to do so…

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How to identify YLFs?

- Get your butt out in the field and spend some quality time with your crops.
- Take advantage of available resources for crop diagnostics.
- Get help from local agronomists, tech reps, crop consultants, Extension (county/campus).

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Field image © Purdue, RLNielsen

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Use Precision Ag technologies to supplement old-fashioned "boots on the ground" technology.

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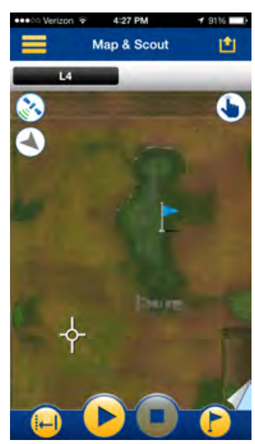
Take advantage of mobile GPS technologies to map, GPS-tag & document problem areas in fields

- Crop scouting & mapping "apps"
- Simple note-taking "apps"
- Smartphone cameras that geo-tag images to the location
- This information supplements other GIS information to help diagnose causes of problems



Trimble® ConnectedFarm®

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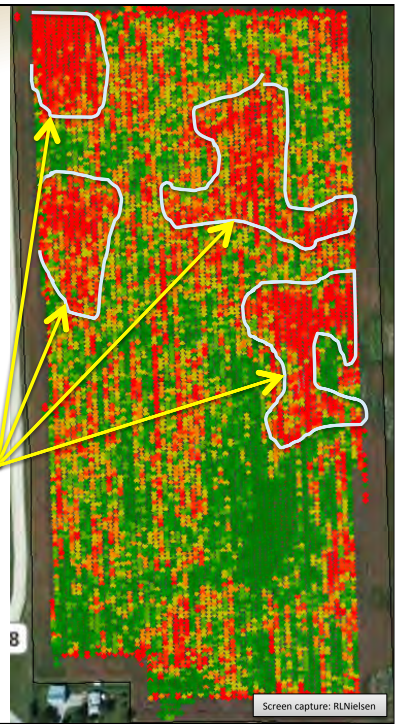
Use yield monitor data to help visualize problem areas

Create spatial boundaries with mapping program, upload those to a mobile scouting "app", & focus your crop diagnostic efforts on troubleshooting those specific areas in the field.



Screen capture: RLNielsen

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Remotely sensed imagery

- Equipment-mounted crop sensors
  - e.g., GreenSeeker®, OptRx®
- Satellite imagery
- Aerial imagery
  - Handheld cameras
  - Professional cameras
  - Unmanned aircraft systems (UAS)

Image: http://aerialfarmer.blogspot.com/

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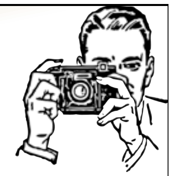
Remotely sensed imagery…



- …supplements yield maps in identifying and locating problem areas within your fields.
- …can identify problem areas prior to harvest.
  - May enable earlier & more accurate crop problem diagnostics and, possibly, in-season mitigation of crop problems (foliar fungicide, late N applic's).
- …does not, however, diagnose the causes of crop problems by itself.
  - E.g., light green corn is not always N deficient.

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Corn needs a lot of water

- From 20 to 25 inches (soil reserves + rainfall + irrigation).
  - An acre-inch of water equals 27,154 gallons; so an acre of corn requires as much as 678,850 gallons of water in a growing season.
  - Potential soil moisture reserve depends primarily on soil texture, but also on soil organic matter, rooting depth, & infiltration.

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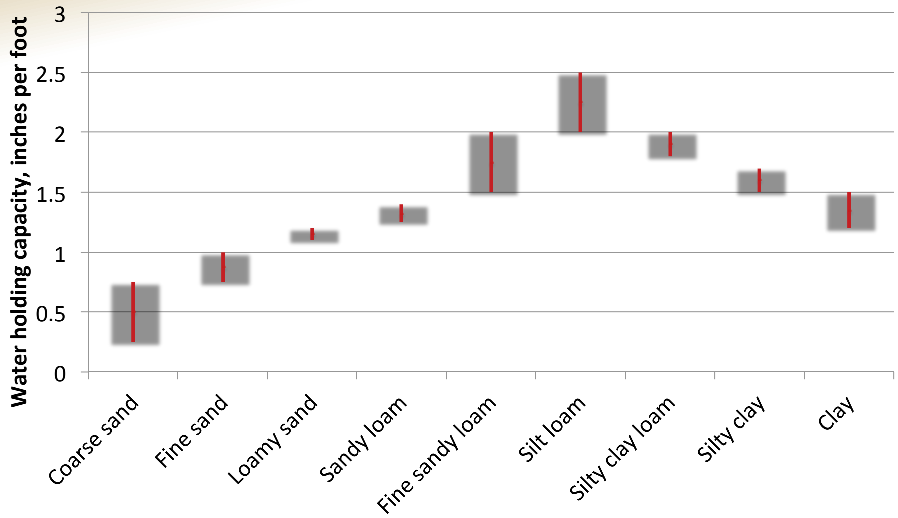
Range of Water Holding Capacities Among Soil Textures



Source: Physical Properties of Soil and Soil Water. Univ of Nebraska; Plant & Soil Sciences eLibrary. http://passel.unl.edu/pages/printinformationmodule.php?idinformationmodule=1130447039

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Soil moisture availability…

- Also depends on the effective rooting depth of the crop.
- Root depth in corn is easily 3 to 4 ft; up to as much as 5 to 6 ft.
- However, "effective" rooting depth varies a lot one field to another.

Weaver, 1926 FIG. 85.—Mature root system of corn.

Image: Weaver, 1926, Root Development of Field Crops, McGraw-Hill Book Co.

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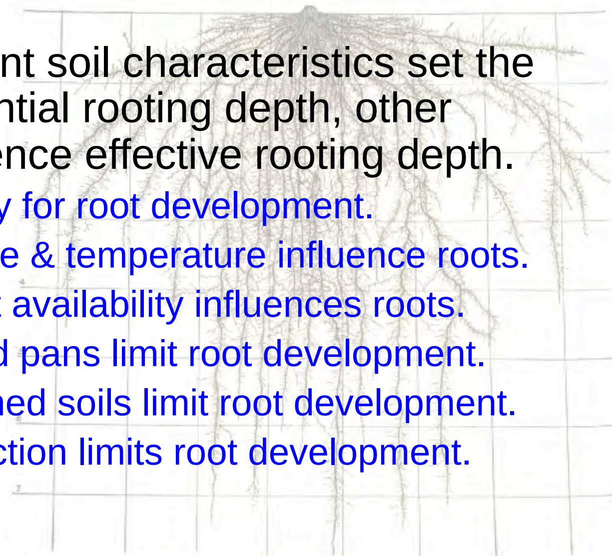
Effective rooting depth in corn



- While inherent soil characteristics set the limit on potential rooting depth, other factors influence effective rooting depth.
  - Hybrids vary for root development.
  - Soil moisture & temperature influence roots.
  - Soil nutrient availability influences roots.
  - Natural hard pans limit root development.
  - Poorly-drained soils limit root development.
  - Soil compaction limits root development.

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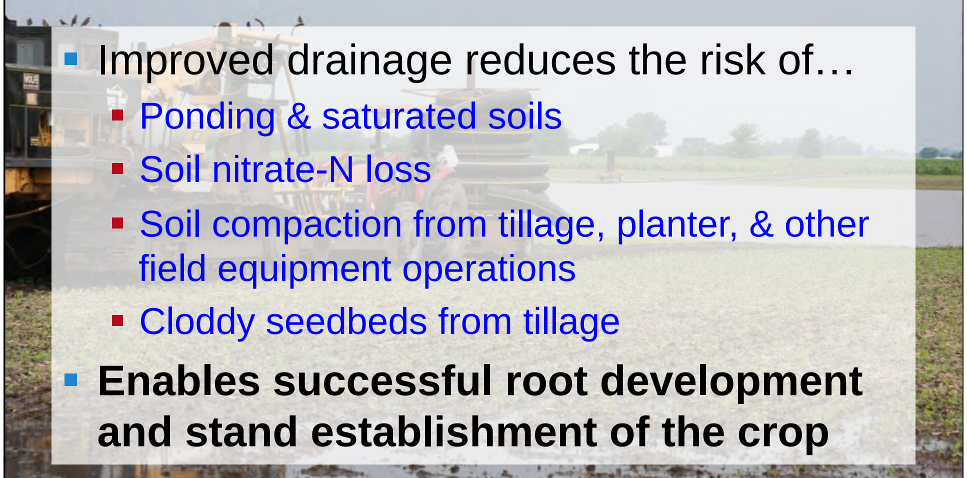
Weaver, 1926 Fig. 85.—Mature root system of corn.

Improve soil drainage where needed and feasible



- Improved drainage reduces the risk of…
  - Ponding & saturated soils
  - Soil nitrate-N loss
  - Soil compaction from tillage, planter, & other field equipment operations
  - Cloddy seedbeds from tillage
- **Enables successful root development and stand establishment of the crop**

Image © Purdue Univ; RLNielsen

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Soil compaction & Crop resilience

- Risk of soil compaction goes hand-in-hand with poor soil drainage plus large & heavy field equipment.
- Compaction makes poor drainage even poorer and saturated soils last longer.
- Soils most vulnerable to compaction when soil moisture is near field capacity.
- Compaction limits rooting depth and, subsequently, crop resilience to stress.

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Excellent Reference

Focuses on compaction caused by tire traffic. Remember that tillage tools themselves can also cause topsoil compaction.

Avoiding Soil Compaction

Duiker, Sjoerd. 2004. Penn. State Extension Pub. UC186

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Agricultural Research and Cooperative Extension

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Tillage & soil compaction

- Reduce the # of tillage trips
  - Fewer opportunities to create soil compaction.
  - Reduces soil moisture evaporation.
  - Increases snow capture and rainfall infiltration while lowering risk of surface run-off.
- Minimize soil compaction opportunities due to tillage tools, planters, combines, spreaders & applicators, grain carts, etc.

Yeah, but all this corn stover…

Options to manage the stover…

- Stalk chopping, rolling, mashing with the combine header during harvest
- Fall stalk mowing or shredding
- Baling and removing some of it
- Vertical tillage that "sizes" stover into smaller pieces and buries some of it
- Strip tillage (planter performance)
- Row cleaners (trash whippers) on planter
- Aggressive fall / spring tillage

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Irrigation management…

- Irrigation efficiency relies partly on optimum maintenance & proper operation of the irrigation system (Lyndon Kelley).
  - The results of over 400 system evaluations in Delaware showed over 50% applied 20% less water than the timer setting charts predicted.

Source: James Adkins, Univ of Delaware

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Irrigation management…

- Also relies on deciding when to irrigate and how much water to apply.
  - Capacity of irrigation water supply
    - Well, reservoir, river, drainage ditch
    - Pump capacity (gal/min)
  - Efficiency (accuracy) of irrigation system
  - Soil water holding capacity & current status
  - Actual and anticipated rainfall
  - Water needs (ET) of the crop

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Evapo-transpiration (ET) by corn

- Early in the season, ET is primarily driven by soil moisture evaporation.
- As plants develop, ET is driven primarily by transpiration by the plants, but declines as plants mature during grain fill.
- Thus, seasonal ET for a corn crop looks like a typical "bell" curve…

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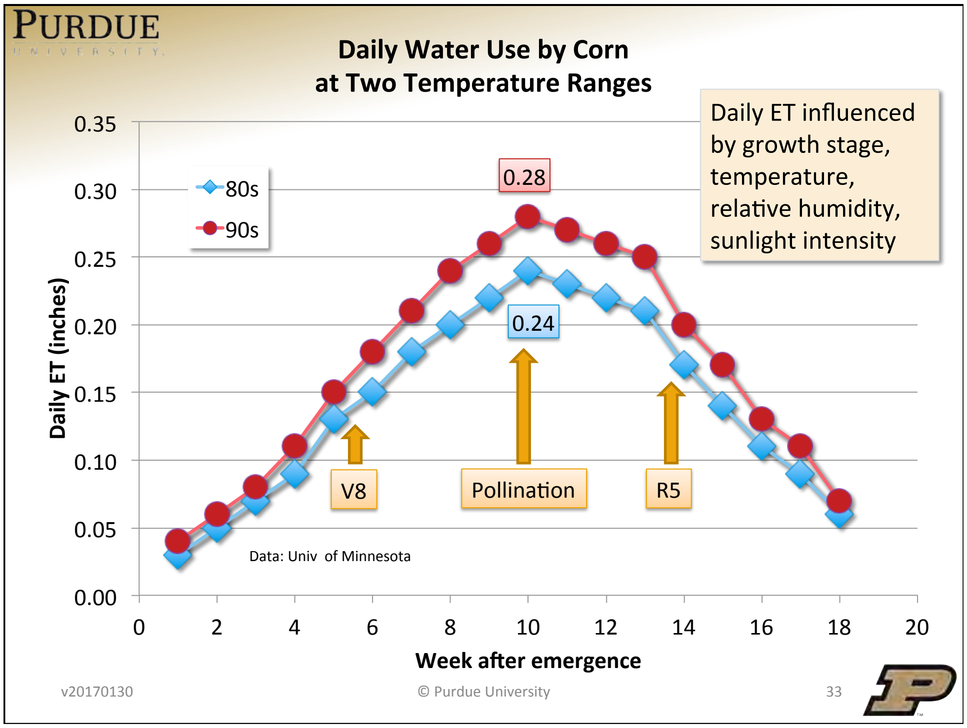

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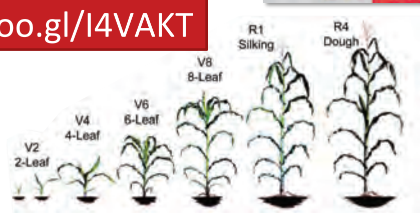
Crop Water Use by Growth Stage – Corn

Nebraska Lincoln EXTENSION

https://goo.gl/I4VAKT

Corn Growth Stages
2 leaf (V2): Two collars visible.
4 leaf (V4): Four collars visible.
6 leaf (V6): Growing point above ground, tassel forms.*
8 leaf (V8): Ear formation begins.
Silking (R1): Silks are visible outside husk.
Dough (R4): Endosperm milk turns thick and pasty.

*** Paint/Mark V6 leaf to make counting easier!**



Weekly ETgage® Change in Inches

Crop Stage	Kc	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00
V2	0.10	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30
V4	0.18	0.18	0.20	0.22	0.23	0.25	0.27	0.29	0.31	0.32	0.34	0.36	0.38	0.40	0.41	0.43	0.45	0.47	0.49	0.50	0.52	0.54
V6	0.35	0.35	0.39	0.42	0.46	0.49	0.53	0.56	0.60	0.63	0.67	0.70	0.74	0.77	0.81	0.84	0.88	0.91	0.95	0.98	1.02	1.05
V8	0.51	0.51	0.56	0.61	0.66	0.71	0.77	0.82	0.87	0.92	0.97	1.02	1.07	1.12	1.17	1.22	1.28	1.33	1.38	1.43	1.48	1.53
V10	0.69	0.69	0.76	0.83	0.90	0.97	1.04	1.10	1.17	1.24	1.31	1.38	1.45	1.52	1.59	1.66	1.73	1.79	1.86	1.93	2.00	2.07
V12	0.88	0.88	0.97	1.06	1.14	1.23	1.32	1.41	1.50	1.58	1.67	1.76	1.85	1.94	2.02	2.11	2.20	2.29	2.38	2.46	2.55	2.64
V14	1.01	1.01	1.11	1.21	1.31	1.41	1.52	1.62	1.72	1.82	1.92	2.02	2.12	2.22	2.32	2.42	2.53	2.63	2.73	2.83	2.93	3.03
V16, Silking, Blister, Dough, Begin Dent.	1.10	1.10	1.21	1.32	1.43	1.54	1.65	1.76	1.87	1.98	2.09	2.20	2.31	2.42	2.53	2.64	2.75	2.86	2.97	3.08	3.19	3.30
Full dent	0.96	0.96	1.06	1.15	1.25	1.34	1.44	1.54	1.63	1.73	1.82	1.92	2.02	2.11	2.21	2.30	2.40	2.50	2.59	2.69	2.78	2.88
Black layer	0.60	0.60	0.66	0.72	0.78	0.84	0.90	0.96	1.02	1.08	1.14	1.20	1.26	1.32	1.38	1.44	1.50	1.56	1.62	1.68	1.74	1.80
Full maturity	0.10	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30

This chart can be used with readings from an ETgage® or other ET reference. First, identify the change in the ET rate across the horizontal row and then identify the current growth stage in the left column. Follow the two columns to the point where they intersect to identify the ET rate to use in your irrigation scheduling. When planning irrigation, account for soil moisture, precipitation, weather conditions, and the ET rate for growth stage of your crop.

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Watering rules of thumb

- Soil moisture near field capacity at planting favors rapid germination & seedling growth.
- Avoidance of excessive soil moisture during the first 30 to 45 days after planting favors deeper rooting of the crop.
- Avoid "getting behind" on soil moisture as the crop moves through the pollination and early kernel set phases.
- Maintain adequate soil moisture to meet crop ET all the way to kernel black layer.

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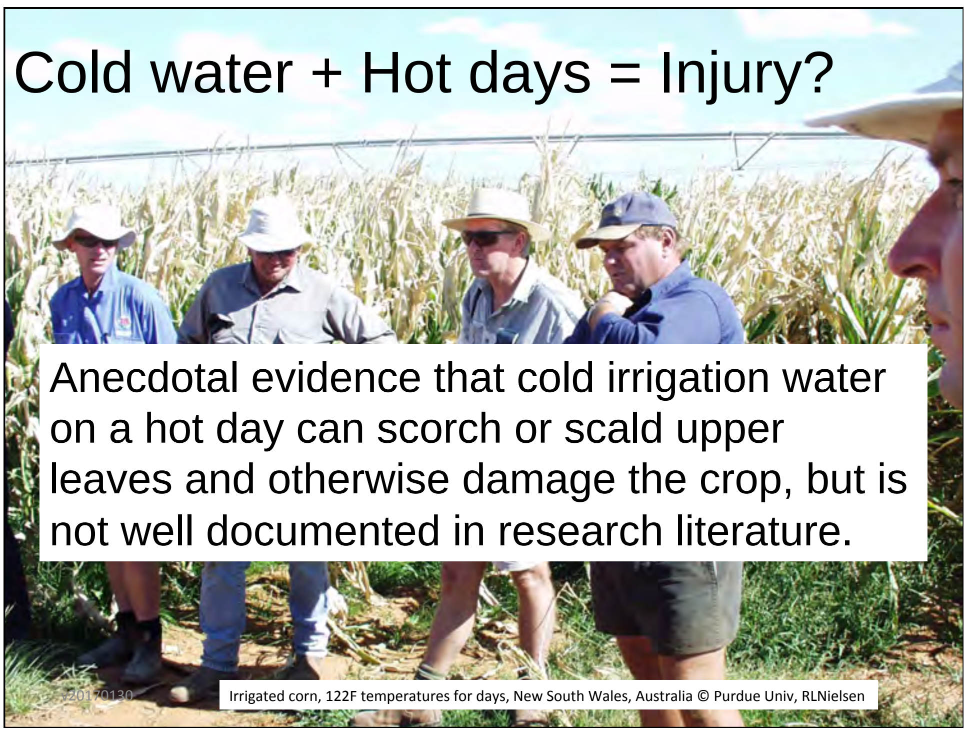
Cold water + Hot days = Injury?

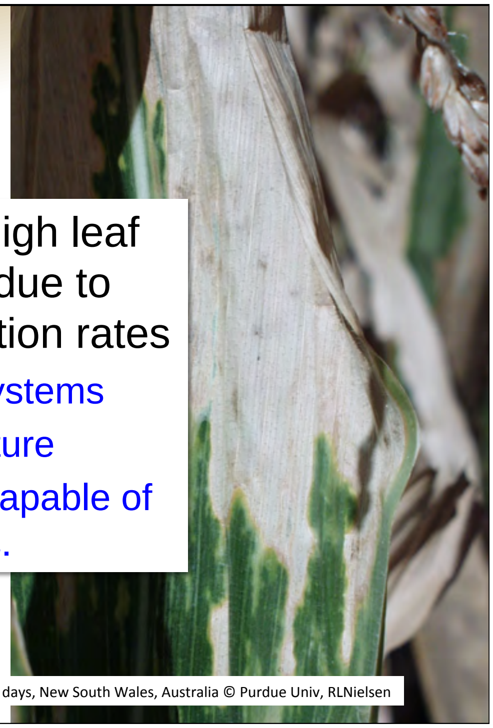


Anecdotal evidence that cold irrigation water on a hot day can scorch or scald upper leaves and otherwise damage the crop, but is not well documented in research literature.

v20170130 Irrigated corn, 122F temperatures for days, New South Wales, Australia © Purdue Univ, RLNielsen

Cold water + Hot days = Injury?

- More likely… lethal high leaf tissue temperatures due to inadequate transpiration rates
  - Poor / shallow root systems
  - Inadequate soil moisture
  - Irrigation systems incapable of meeting ET demands.



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High Yield Corn Management:

PLANT POPULATIONS

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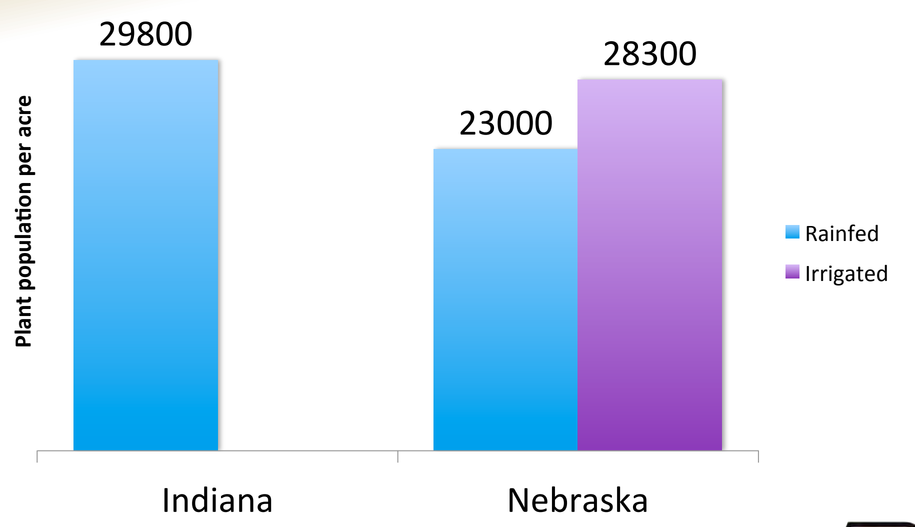
Reported Plant Populations – Indiana vs. Nebraska USDA-NASS, 2016



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Kansas State guidelines

Table 6. *Suggested final corn populations.*

Dryland		
Area	**Environment**	**Final Plant Population (plants per acre)**
Northeast	100- to 150-bushel potential	22,000-25,000
	150+ bushel potential	24,000-28,000
Southeast	Short-season, upland, shallow soils	20,000-22,000
	Full-season, bottomground	24,000-26,000
Northcentral	All dryland environments	20,000-22,500
Southcentral	All dryland environments	18,000-22,000
Northwest	All dryland environments	16,000-20,000
Southwest	All dryland environments	14,000-20,000
Irrigated		
Environment	**Hybrid maturity**	**Final Plant Population**
Full irrigation	Full-season hybrids	28,000-34,000
	Shorter-season hybrids	30,000-36,000
Limited irrigation	All hybrids	24,000-28,000

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Purdue plant population trials…

- Since 2008, we've conducted ~ 90 field scale trials around the state.
  - Majority were on-farm trials.
  - Trials ranged in size from 30 to 100 acres.
  - Various hybrids, but 27 trials were split-planter hybrid comparisons, purposefully chosen.
- FEW IRRIGATED TRIALS
  - But honestly, response is probably similar to high-yield rain-fed conditions

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Consider on-farm seeding rate trials

- Help you identify your overall "ballpark" optimum plant populations.
- Help you "tease out" specific yield responses to plant population for hybrids, N rates, spatial "zones" in fields.
- Help you maximize $ return to you from your seed input investment.

We particularly need trials in mucks & irrigated sands

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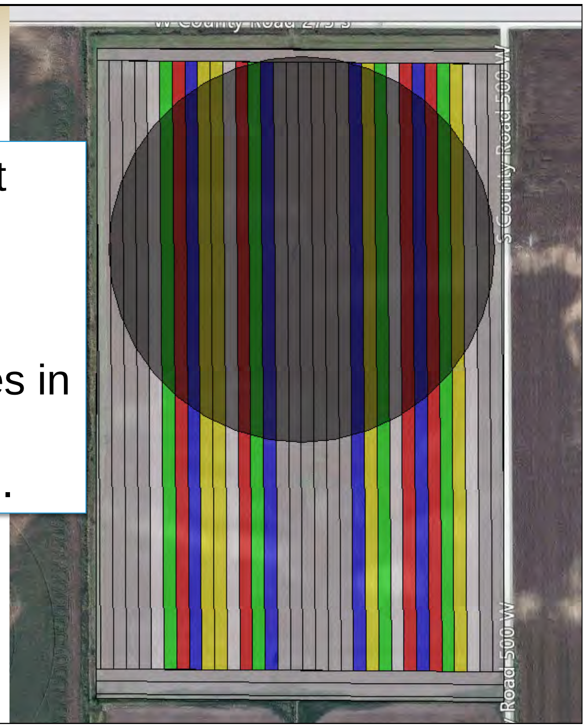
The layout might look like this…

5 seeding rates replicated 4 times in a field with and without irrigation.



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Bottom line on trial results…

- Two "sweet spots" for plant population that maximize corn yield in Indiana.
  - Challenging soils: Low 20's FINAL stand
    - Routinely yielding less than ~ 130 bu/ac
  - Productive soils: Low 30's FINAL stand
    - Within range of ~ 140 to 240 bu/ac

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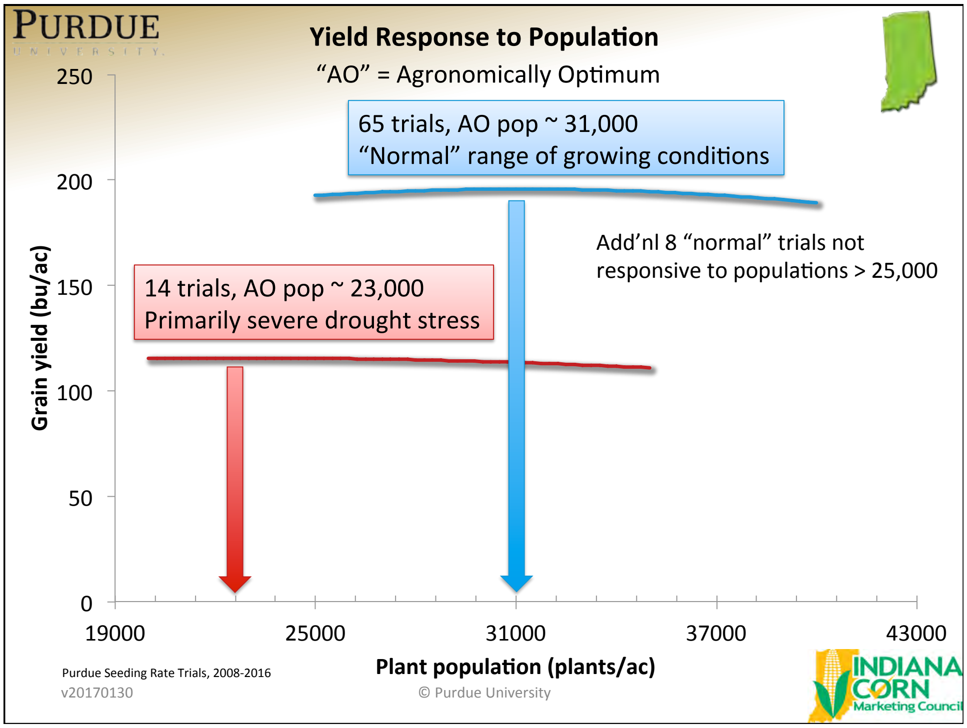

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Bottom line on plant population

- Two "sweet spots" for plant population that maximize corn yield in Indiana.
- However, the "sweet spots" are not specific "spots", but rather "ranges" of populations that maximize grain yield.

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Image: http://www.gnbco.com/bow_length.php

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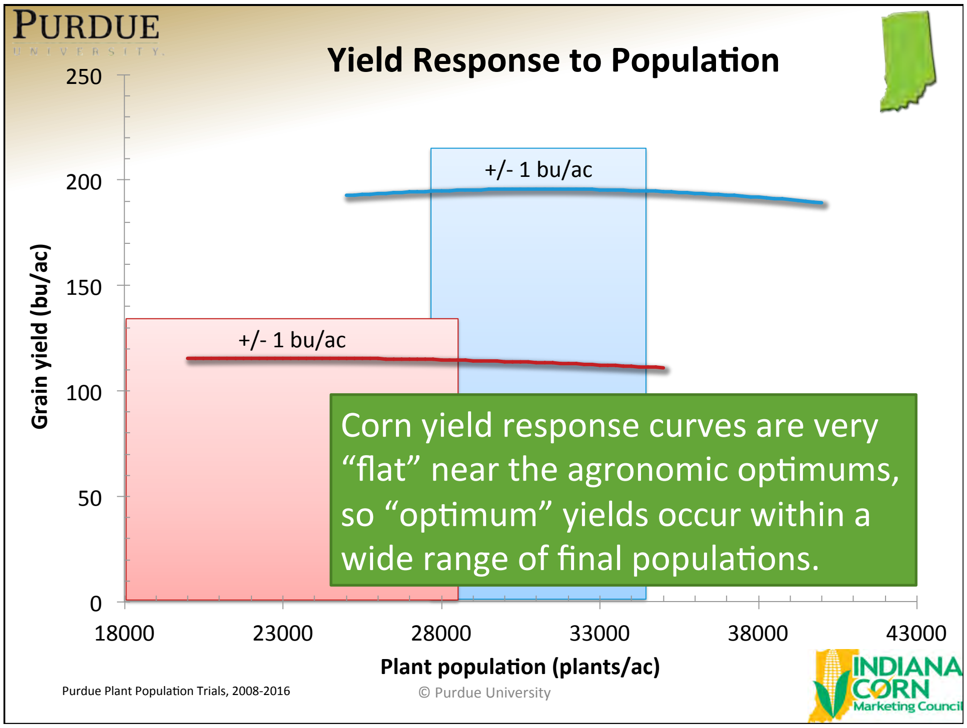
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Yield Response to Population
Grain yield (bu/ac)
250
200
150
100
50
0
+/- 1 bu/ac
+/- 1 bu/ac
Corn yield response curves are very "flat" near the agronomic optimums, so "optimum" yields occur within a wide range of final populations.
18000
23000
28000
33000
38000
43000
Plant population (plants/ac)
Purdue Plant Population Trials, 2008-2016
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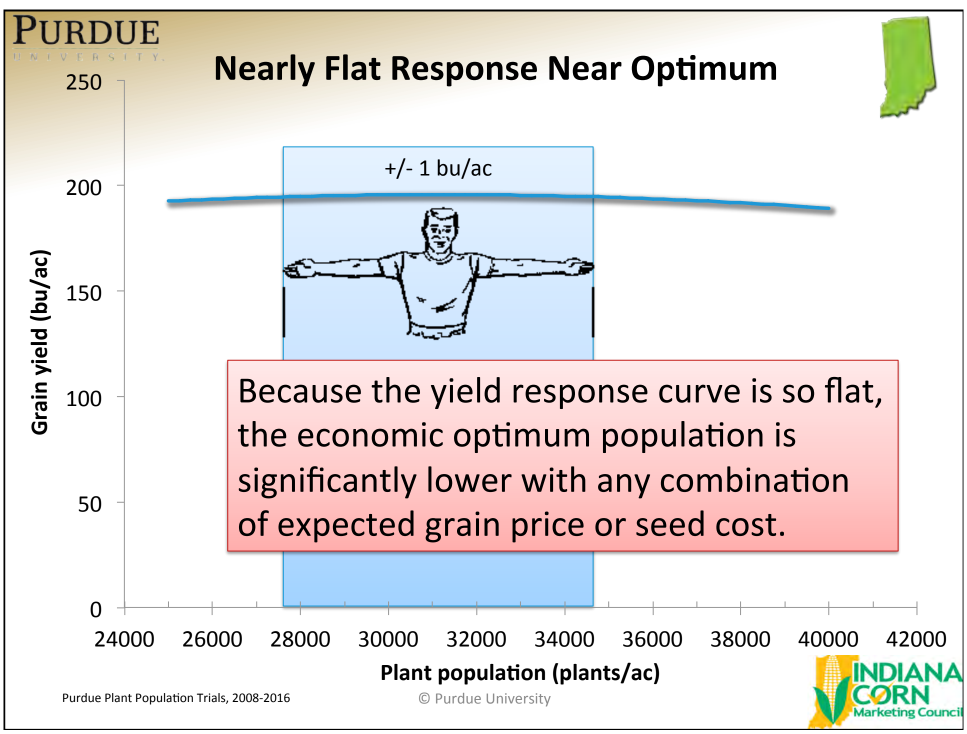
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Nearly Flat Response Near Optimum
Grain yield (bu/ac)
250
200
150
100
50
0
+/- 1 bu/ac
Because the yield response curve is so flat, the economic optimum population is significantly lower with any combination of expected grain price or seed cost.
24000
26000
28000
30000
32000
34000
36000
38000
40000
42000
Plant population (plants/ac)
Purdue Plant Population Trials, 2008-2016
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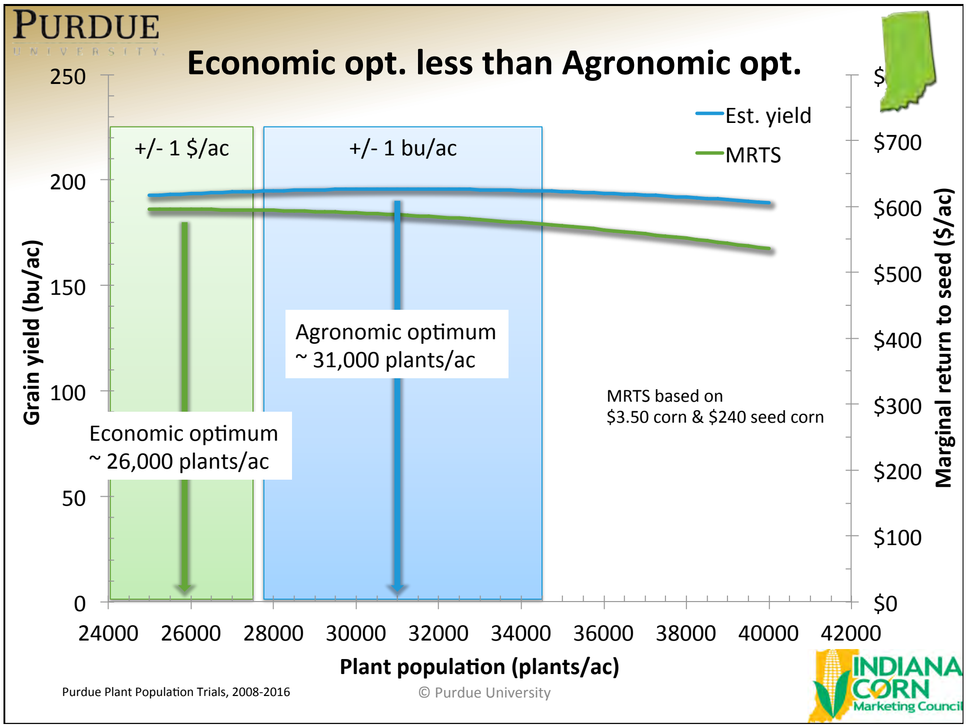

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Economic optimum populations

Applicable to majority of productive soils across the state

Seed $ ↓	Grain $ → $2.50	$3.00	$3.50	$4.00	$4.50	$5.00	$5.50	$6.00
$175	25827	26710	27341	27815	28183	28477	28718	28919
$200	25070	26080	26801	27341	27762	28098	28374	28603
$225	24313	25449	26260	26868	27341	27720	28030	28288
$250	23556	24818	25719	26395	26921	27341	27686	27972
$275	22799	24187	25178	25922	26500	26963	27341	27657
$300	22042	23556	24637	25449	26080	26584	26997	27341
$325	21284	22925	24097	24975	25659	26206	26653	27026
$350	20527	22294	23556	24502	25238	25827	26309	26710

Purdue Plant Population Trials, 2008 – 2016

Seeding rates = Population by average % stand

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High Yield Corn Management

HYBRID SELECTION…

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Hybrid selection…

- More $$ to be gained or lost with this agronomic decision than almost any other!
  - Yields among “good” hybrids can easily vary 20 to 40 bu/ac in same field!
- Identifying good hybrids is NOT easy!
- Farmers ought not to relegate this decision solely to their seed dealer.

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Hybrid selection is not simply about genetic yield potential

- But, also the ability of hybrids to perform consistently well across a wide range of growing conditions (i.e., stress tolerance).
- Tolerance to a wide array of stresses is important because we cannot accurately forecast next year's growing conditions.

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A Good Indicator of Hybrid Stress Tolerance:

- Hybrid performance, relative to others, across a wide number of variety trials within a given geographic area.
  - The idea is that those many trials will represent the range of growing conditions that your fields may experience in the future.
- Look for hybrids that consistently yield near the top of the majority of the trials.

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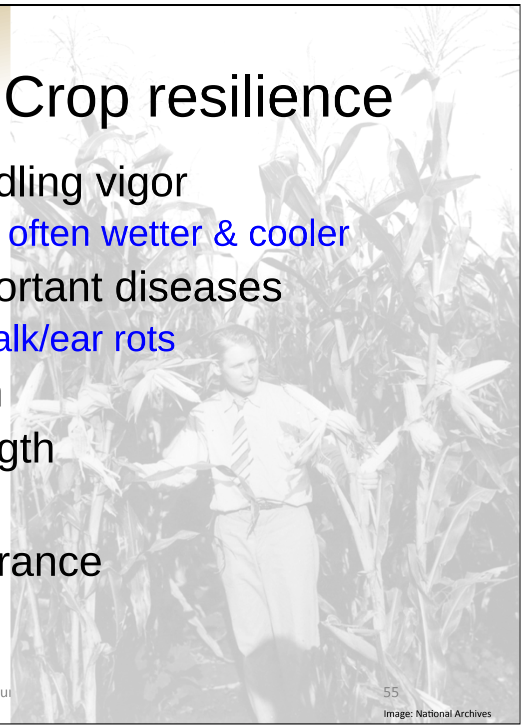
Hybrid traits & Crop resilience



- Emergence & seedling vigor
  - Early season soils often wetter & cooler
- Resistance to important diseases
  - Seedling, foliar, stalk/ear rots
- Stalk & root health
- Overall stalk strength
- Drought tolerance
- Overall stress tolerance

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