What is the greatest single obstacle to consistently achieving higher corn yields?

“Normal” growing seasons!
- “Normal” growing seasons are those that involve an unpredictable number of unpredictable extreme weather events, each occurring unpredictably, with unpredictable severity.
- The frequency of extreme weather events is becoming more prevalent.

Consequently, our greatest agronomic challenge today is to stress-proof our crops against unpredictable, extreme weather events.

Bad news & Good news
- The effects of weather stress on crop growth and yield are compounded by the presence of other yield-limiting factors.
  - Soil compaction, nutrient deficiencies, disease damage, insect injury, weed competition, poorly drained soils, or any of the other gazillion yield-limiting factors that influence crop growth & yield.
  - That’s the bad news.

Also good news because...
- If you can identify and manage other yield-limiting factors, this will help you “stress-proof” your cropping system against the vagaries of Mother Nature.
Yield influencing factors (YIFs)

- Can be positive or negative.
  - Pay attention to both.
- Some occur every year; some do not.
- Often interact with each other.
- Often influence different crops differently.
- Almost always interact with the weather.

How to identify YIFs?

- Spend time with your crops.
- Educate yourself.
- Consult folks w/ experience.
- Document everything.
- Spend time with your crops.
- Attention to detail.
- Identify problems early.
- Diagnose every problem.
- Spend time with your crops.

Optimum grain yield develops throughout the entire growing season.

- Establishing a healthy, vigorous stand of corn by the time the crop has reached about V6 (knee-high).
  - Choice or luck with planting dates.
  - Seedbed & initial growing conditions.
  - Speed & uniformity of germination / emergence.
  - Initial population vs. seeding rate.
  - Success of initial root development.

Optimum grain yield begins with...

- Maintaining the health of the root system and crop canopy throughout the entire growing season.
  - Soil fertility / plant nutrition
  - Plant health (diseases)
  - Plant health (insects)
  - Soil tilth, health, quality factors

Optimum yield continues with...

- I do not have all the answers.
- But, then, neither does anyone else.
- Let me share with you some of the key factors that I believe to be important for raising the “yield bar” for corn in the eastern Corn Belt.
  - Maybe some of these agronomic factors will resonate with you also.
Common thread of first 3 factors:
- Water…
  - Too much
  - Not enough
  - Seasonal rainfall distribution
  - Soil water-holding capacity
  - Water infiltration vs. runoff

Soil drainage…
- Improve drainage (tile, surface) in naturally poorly-drained soils.
  - Reduces risk of ponding and saturated soils.
  - Reduces risk of soil N loss.
  - Reduces risk of soil compaction from tillage, planter, & other equipment.
  - Reduces risk of cloddy seedbeds from tillage.
  - Enables successful root development and stand establishment of the crop.

Moisture conservation…
- And soil erosion control (water, wind) on rolling topography or sandy soils.
  - No-till or reduced tillage
  - Contour farming and/or strip cropping
  - Terraces & other water control structures
  - Fall / winter cover crops
  - All help maximize soil moisture availability later in the season.

Irrigation…
- Supplement rainfall w/ irrigation
  - Above-ground irrigation (row, pivots, etc.)
  - Sub-irrigation via back-filling of tile drains or drainage ditches.
  - Requires informed decision-making relative to irrigation scheduling.
  - Requires optimum maintenance & proper operation of irrigation systems.

Pollination: Synchrony & viability
- Synchrony between silk emergence & pollen shed
- Viability of exposed silks & airborne pollen
- Adequate Ps rates to avoid kernel abortion
- Adequate Ps rates to maximize kernel weight
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...

Seasonal water use by corn

Water requirements for corn
- From 20 to 25 inches total (soil reserves + rainfall + irrigation).
  - For you trivia fans, 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.
  - Depending on soil texture and depth, soil moisture capacity may be as great as 10 to 12 inches.

Maximum water holding capacity among soil texture classes

Improved irrigation management
- Make more informed decisions on 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
  - Water needs (ET) of the crop
  - Anticipated rainfall

Irrigation Management for Corn
William L. King, Irrigation Specialist, Northeast Research and Extension Center, Vermont; James R. Anderson, Irrigation Specialist, Southwest Research and Extension Center, Oregon; William L. King, Irrigation Specialist, Northeast Research and Extension Center, Vermont

http://www.ianpubs.unl.edu/epublic/live/g1850/build/g1850.pdf

Also, this one from Michigan State Univ:
http://msue.anr.msu.edu/news/drought_irrigation_management
Hybrid selection

- There is a lot of money to be made or lost with this one decision.
  - As much or more than any other crop input decision corn growers make every year.
- Just look at the bushel differences between the highest to lowest yielding hybrids in any public variety trial.
  - Assuming companies do not enter crappy™ hybrids in variety trials!

Bushel difference – hi vs low

<table>
<thead>
<tr>
<th>Location</th>
<th>N1</th>
<th>N2</th>
<th>N3</th>
<th>N4</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
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<tr>
<td>Indiana</td>
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<td>71</td>
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<td>49</td>
<td>50</td>
<td>23</td>
<td></td>
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</tbody>
</table>

Let’s see... With $7 corn... A lot of money!

Yield potential AND consistency

- In the absence of stress, hybrids yield differently simply due to differences in genetic yield potential.
- CONSISTENCY of yield performance over years and across locations is based on how well hybrids tolerate unforeseen and unpredictable stresses.

So, your challenge is to...

- Identify hybrids that tolerate a wide range of growing conditions.
  - Evaluate variety trial results from a lot of locations (i.e., growing conditions) and look for hybrids whose yields are at least 90% that of the highest yielding hybrid in almost every variety trial you can find.
  - Do not relegate this decision solely to your seed dealer. Be a participant in the process!

Drought tolerant hybrids?

- There is no single common trait among hybrids currently labeled “drought tolerant”
  - Simply have shown the ability to yield better than others under water-limited conditions.
- If you can find the evidence that supports their superiority for yield and consistency of yield across a wide range of growing conditions, go for it.

Drought “tolerance” vs. “resistance”

- It is important to recognize that these hybrids are not RESISTANT to drought.
- In other words, the current drought tolerant hybrids still need water to produce grain. They will suffer under drought; but not, apparently, as much as other hybrids.
Drought “tolerance”; not “resistance”

- E.g., Pioneer AQUAmax™ 2012 reports*
  - Across 3,606 water-limited environments, out-yielded “competitive” hybrids 69% of the time by an average of 8.9% or about 8.5 bu/ac.
- Let’s do the math:
  8.5 bu = 8.9% better than competitors
  Therefore, competitors’ avg yield = ??


Soil tilth, “health”, or “quality”

- Minimize the risk of soil compaction caused by tillage or other equipment.
- Minimize tillage traffic or adopt outright no-till where appropriate.
- Minimize grain cart traffic and other heavy equipment on your fields.
- Include fall or winter cover crops where appropriate.

Crop rotation...

- Avoid continuous corn, especially no-till corn after corn… Too many challenges.
  - Surface corn stover delays soil drying / warming and can interfere with planter operation.
  - Decomposing corn stover immobilizes soil N.
  - Corn stover harbors disease inoculum.
  - Continuous cropping puts “all the eggs into one basket” in terms of weather stresses.

Relative Crop Yield Loss
2012 Indiana

<table>
<thead>
<tr>
<th>Crop</th>
<th>Percent Departure from Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>-38.1%</td>
</tr>
<tr>
<td>Soybean</td>
<td>-9.3%</td>
</tr>
<tr>
<td>Wheat</td>
<td>-6.60%</td>
</tr>
</tbody>
</table>

Timing of weather stress dictates which crop suffers less, but not always predictable.

Starter fertilizer...

- Adopt a robust 2x2 starter fertilizer program; especially in terms of starter N.
  - In challenging conditions, starter N aids young corn plants (V3 – V5) as they “wean” themselves from the kernel reserves to dependence on nodal roots.
  - Consider starter N rates no less than 30 lbs actual N/ac, and maybe higher for no-till continuous corn or corn into cover crops.

Nitrogen management...

- Implement nitrogen management practices that minimize risk of N loss and maximize N use efficiency by the corn crop.
  - Avoid fall N applications (risk of N loss).
  - Avoid early spring N applications (N loss)
  - Avoid surface-applied urea-based fertilizers without incorporation (risk of N loss).
  - Sidedress or split-apply N where practical.
Risk of N loss with irrigation:

- Is inherently greater than many rain-fed situations elsewhere, primarily because of sandier soils that cannot "hang on" to nitrate-nitrogen.
- Thus, greater value to...
  - Sidedressing or fertigation
  - Ammonia vs. UAN; especially pre-plant
  - Nitrification or urease inhibitors; esp. pre-plant

Thoughts on N fertilizer rates:

- Optimum N fertilizer rate is not correlated with yield potential!
  - Corn generally requires about 275 TOTAL lbs of actual N per acre (soil + fertilizer).
- Rotation corn N guidelines (lbs of actual N applied per acre)
  - Low risk of N loss: 180 – 190 lbs
  - High risk of N loss: 210 – 220 lbs
- Continuous corn about 40 lbs higher

Yield Response to Applied N
Irrigated Loamy Sand, fine Sandy Loam

By comparison, average opt. N rate in 9 non-irrig. sandy trials = 203 lbs N / ac

Max. yield @ 225 lbs N / ac

We’re looking for collaborators...

- To participate in on-farm trials evaluating N fertilizer rates under irrigated and non-irrigation conditions.
- Variable rate, Rx-driven controller simplifies logistics.
- Auto-steer may be beneficial.
- GPS-enabled grain yield monitor simplifies harvest.

On-farm corn N rate trials

- Typically, five to six N rates.
  - Range of rates negotiable, but low to high
- Replicated 3 to 6 times.
  - Field length plots, ~ twice combine width
- Option to include seeding rates.
- Option to include 2 hybrids (split-planter).

Disease management...

- Yield losses from foliar diseases can easily lower corn yields by 20% or more.
- Implement sound disease management strategies that include...
  - Hybrid selection for disease resistance
  - Crop rotation
  - Tillage (where appropriate)
  - Foliar fungicides (if needed).
Surface “trash” in no-till...
- Manage surface “trash” in no-till to hasten drying / warming of soil, facilitate effective planter operation, and improve crop emergence & stand establishment.
  - Kill winter annual weeds and / or cover crops before their growth becomes unmanageable.
  - Use row-cleaners on the planter row units.
  - Minimize the risk of furrow sidewall or surface compaction by avoiding planting when soil moisture is “on the wet side”.

Seeding Rates

Balancing act for corn...
- More plants per unit area equals more ears per unit area. (that’s good)
- But, ear size per plant decreases with increasing plant density. (that’s not good)
- The optimum final stand is that which best balances the decrease in ear size per plant with the gain in ears per unit area.
- Furthermore, stalk health & integrity at higher populations sometimes falters.

General observations
- Little difference for optimum harvest population at yield levels ranging from low 100’s to low 200’s.
- Few differences between well-rainfed and irrigated corn.
- Few differences among hybrids.
- Little evidence that higher seeding rates require more N fertilizer.

On-farm corn seeding rate trials
- Since 2010, I have been involved with 27 field-scale or on-farm seeding rate trials around the state.
  - Other field-scale trials back in the early 2000’s bring the total number up to 37 trials.
Variable seeding rates...

- In all honesty, there is probably a maximum of two meaningful seeding rates that might be used in any given field...
  - A rate on the lower end for challenging soils.
    - Approximately 130 bpa or lower.
    - Seeding rates ~ 25,000 spa
  - A rate on the higher end for everything else.
    - Seeding rates ~ 32,000 spa

We're looking for collaborators...

- To participate in on-farm trials evaluating seeding rates under irrigated and non-irrigated conditions.
- Variable rate, Rx-driven controller simplifies logistics.
- Auto-steer can be beneficial.
- GPS-enabled grain yield monitor simplifies harvest.

On-farm corn seeding rate trials

- Typically, five to six seeding rates.
  - Range of rates negotiable, but ~25 to 45k
- Replicated 3 to 6 times.
  - Field length plots, ~ twice combine width
- Option to include nitrogen rates.
- Option to include 2 hybrids (split-planter).

Remember, it ain't rocket science!

- The key factor is to identify those yield limiting factors that are most important for your specific farming operation.
- Together with your crop advisor(s), identify & implement good agronomic management practices to target those yield limiting factors.