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Life's Little Corn Problems:
Tips on Crop Diagnostics

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Basics of troubleshooting

- Establish the facts
  - Records & recollections
- Identify & examine ALL clues
  - Evidence & diagnostics
- Eliminate possible causes
  - Reasoning & intuition
- Arrive at solution
  - Not always black & white

Always Remember:
Crop problem troubleshooting offers many teachable moments.

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What I'm gonna talk about...

- Prepare for upcoming season
- Sources of information
- Tools of the trade
- Working a troubleshoot
- Digital imagery
- Some of my cases

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Prepare for upcoming season

- Good diagnostic skills begin with serious pre-season homework on your part.
  - Impt because many of us 'flush' information from our brains one year to the next
  - Less chance you will be caught by surprise when problems arise
  - May allow you to warn your clientele of impending calamities (aka fearmongering)

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Pre-season homework...

- Refresh yourself on the basics.
- Attend winter conferences/seminars
- Identify and study ahead of time the common problems that can occur throughout the growing season.
- Become familiar with new pesticides, genetics, and other emerging technologies.

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Refresh yourself on...

- Crop growth and development
- Current crop varieties
- Insect & disease pests
- Nutrient deficiencies
- Weed identification

- Herbicide modes of action
- Herbicide crop injury symptoms
- Herbicide label restrictions, esp. relative to crop growth stage

Sources of information

- Your personal library of crop production resources might include...
  - ASA's Corn & Corn Improvement
    - www.agronomy.org (online store, monographs)
  - Modern Corn & Soybean Production
    - www.mcsp-pubs.com/
- Purdue's ID-179 Corn & Soy Field Guide
  - Media.Order@ces.purdue.edu
- Purdue's Corn (CD-AY-1, CD-AY-2) and Weed (CD-AY-3) CDs
  - Media.Order@ces.purdue.edu
- Nebraska's WeedSOFT™ software
  - weedsoft.unl.edu/

Sources of information

- The World Wide Web
  - My first source for information
    - Granted, I have T1 connections 24/7 on campus
    - Or, fast DSL connection at home
    - A 28 to 48k dialup is acceptable
    - Less than 28k is admittedly unsatisfactory
  - Is an overwhelming amount of information
    - That's why I've developed one-stop Web sites for crop production information...

Web sites I recommend...

- www.kingcorn.org (THE Corn Site)
- www.kingcorn.org/cafe (timely info)
- www.kingcorn.org/news/index-cnn.html (my newsletter archives)
- www.kingcorn.org/cgg6.htm (references)
- www.agry.purdue.edu/ext (for soybean, forages, small grains)
- www.google.com (search engine)

Your traveling library...

- Establish a minimal set of references to carry in your vehicle all summer.
  - Weed, nutrients, insect & disease resources
    - APS' disease compendia for corn & soy
    - Purdue's ID-179 Corn & Soy Field Guide
  - Herbicides & herbicide pre-mix info and modes of action
    - Iowa State Univ. Weed Sci is a good source
  - Pertinent articles from recent newsletters
    - www.kingcorn.org/cafe is a good source
  - Phone lists of agronomic experts

Encourage early diagnostics

- Remind your clientele that early identification and diagnosis of crop problems are important to sound crop management strategies.
  - 'Early season' because evidence quickly decomposes or disappears.
  - 'Early season' because sometimes damage-control steps can still be taken by the farmer.

Encourage documentation

- Remind your clientele that thorough documentation of field operations, crop inputs and weather variables greatly improves the odds of accurate diagnoses of crop problems.
  - Desktop programs like Purdue's "WinMax"
    - www.agry.purdue.edu/max
  - Handheld programs like FarmWorks "TracMate"
    - www.farmworks.com
  - At a minimum, pen & paper
    - www.walmart.com

Tools of the trade

- Digger or trowel
- Knives (small & large)
- Spade or shovel
- Soil prob[illegible] for me)
- Plastic b[illegible] for roots)
- Soil sam[illegible]ne
- Plastic bucket
- Magnifying lens
- Colored plot flags
- Colored flagging tape
- Garden stakes
- Magic markers
- Measuring tape
- Digital camera
- GPS + handheld PC
- Notepad + pencil or
- Voice recorder

The most important tool:
An open mind!

Plastic storage box for your vehicle

Tool bag for the field

Working the 'crime scene'...

- Homework before the visit
  - Establish the facts
  - Refresh your knowledge
- Detective work in the field
  - Big picture vs. details
  - Opinion vs. facts
- Establish field patterns with today's GPS 'toys'
  - Boundaries vs. data

Pre-visit homework

- Obtain as much information as possible prior to visiting the field, including ...
  - Client's description of symptom.
  - When did symptom appear?
  - Client's opinion of cause.
  - Other players' opinions of cause.
  - Genetics involved in the case.
  - Cropping history, this year and last.
  - Identities and personal issues, if any, of other 'players'.

Arrange for the field visit

- Arrange for as many of the 'players' as possible to meet at the field
  - Finger-pointing somewhat less likely
  - Answers to some questions more likely
- Ask that records be available that day
- Don't promise an answer or speculate prematurely about the causes of the problem over the phone.

Prepare for the visit...

- Summarize weather data since planting
  - State climatology data or your own data
- Familiarize w/ pesticide labels, if necessary
- Familiarize w/ varieties, if necessary
- Browse recent or archived articles on similar symptomology
  - www.kingcorn.org/cafe (Chat 'n Chew Café)
- Check the condition of the batteries in all of your gadgets!

At the field...

- Ask again for the background information and other details
  - Does today's story corroborate with the one you were told earlier on the phone?
- Any new developments since you were last contacted?
  - Are the symptoms worse or better?
  - Have they spread farther throughout field?

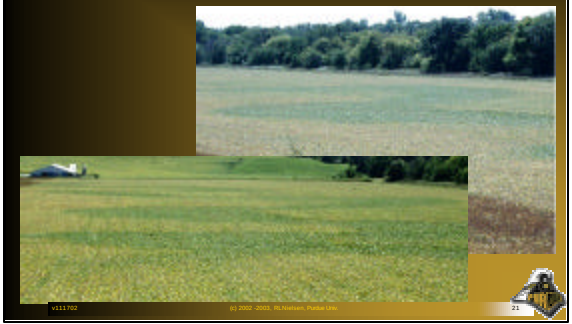
Grains of salt...

- Often, there is no shortage of opinions from the 'players' assembled at the field
  - Some have positions to defend
  - Some have axes to grind (aka "axes of evil")
  - Some are misinformed
  - Some are thinking ahead to lawsuits
  - Some are simply ignorant

Forest for the trees...

- Assess the 'big picture' first.
  - Are there obvious field patterns?
    - Man-made or naturally spatial?

Manmade or natural?



Forest for the trees...

- Assess the 'big picture' first.
  - Are there obvious field patterns?
  - Are there any odd variables or characteristics?
    - e.g., Planter ruts that suggest planting was done on the 'wet side'?
  - Are there obvious discrepancies with the story you've been told?
    - Small acreage affected, not the whole #%! field

Closer look at the problem...

- Identify all symptoms, not just the ones described by the other 'players'.
  - Which plant parts are affected?
    - With leaf symptoms, older or newer leaves?
    - With early season problems, dig plants and assess condition of seed, roots, and mesocotyl (of corn).
  - Are symptoms on all plants in the field, only in an area, or just on randomly scattered plants?
    - Estimate percent field damage for calculating yield loss estimate later.

Closer look at the problem...

- Crop developmental stage today
- Developmental stage at time of damage as suggested by symptomology
  - By which plant parts are affected
  - By recovery, or lack thereof, subsequent to damage
  - By your estimate of Vstage according to cumulative GDD since planting

www.kingcorn.org/news/articles.01/Corn_Phenology-0423.html

Plants can confirm...

- Plant injury by Hornet™ + 2,4-D herbicides
  - Lower 9 to 10 leaves appeared normal in color and size
  - Remainder of leaves, stalk, and tassel severely stunted and malformed
- Plant appearance + GDD data supported V9 or V10 as timing of application.
  - Beyond V5 or V6 label limits

Closer look at the problem...

- Look at good areas of field, not just the bad
  - Partly to remind 'players' what 'normal' looks like
- Look at plants in adjacent fields
  - Sometimes the neighbor's 'good' field also has the symptoms.

What else is going on?

- Are adjacent fields of same or different crops affected, regardless of similarity?
- Are the weeds in or adjacent to the field also affected?
- Are other fields of same variety or seed lot also affected?
- Are other fields of same planting date also affected?

Think like a detective...

- Success in troubleshooting crop problems often depends on your ability to ask the right questions.

- Asking the right questions often depends on your ability to identify and assimilate all of the evidence 'on the fly'.
  - Doing that homework before the field visit helps kick start the diagnostic process in your head.

The missing puzzle piece...

- Asking the right question can often lead you to that one missing piece of the puzzle that will diagnose the problem.

- Sometimes, the missing puzzle piece is never found.
- Sometimes, pieces of the puzzle don't match up with each other.

Multiple puzzle pieces...

- Sometimes, there is more than one piece to the crop diagnostic puzzle.
  - i.e., Multiple stresses often interact to injure a crop.

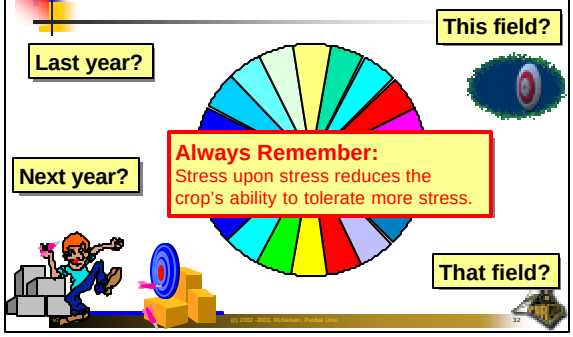
On the other hand, hot soils + dry soils + CRW injury + soil compaction + sidewall compaction also = TROUBLE!

- Consequently, sometimes the diagnosis is gray; not black and white.
  - Unfortunately, clients don't often like that answer, do they?

Yield influencing factors

- Crops are influenced by vast array of yield influencing factors (YIFs)
  - Some influence yield directly
  - Some interact with others
  - Some occur every year, others do not
  - Some influence different crops differently
  - Weather interacts with most of them

Which YIFs Are Most Important?



Identifying patterns...

- Today's handheld GPS mapping 'toys' offer opportunities for identifying recognizable patterns of symptoms across a field if they exist.
  - Compaq® iPAQ®
  - NavMan® GPS sleeve or TeleType® World Navigator® CF receiver (both WAAS-enabled)
  - Field mapping software (e.g., Farmworks® Site Mate®)

Advantages:
Relatively cheap & extremely portable

Disadvantages:
Handheld WAAS reception is not the most reliable.

Simple boundaries...

- Spatial technologies create opportunities for mapping the pattern of a problem area in a field.
  - Handhelds + GPS
  - Remote sensing

Typical Indiana soggy early season soils

Simple boundaries...

- Visually definable patterns lend themselves well to simple boundary mapping exercises.
  - Reasonably quick
  - By foot or by ATV

Mapping soggy soil patterns

Simple boundaries...

- Mapping software designed for scouting allows for annotation of lines, points, or polygons.
  - Esri ArcPad®
  - HGIS StarPal®
  - FarmWorks Site Mate®

Assign rating for soil moisture:
1 = Moist, 2 = Soggy, or 3 = Standing water

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Such simple maps may...

- Offer insight for current or future troubleshooting.
- Help interpret causes of spatial variability in yield maps.
- Guide current or future crop management decisions.

Soggy soils (green) and water flow (purple)

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Simple doesn't always suffice

- The problem's boundaries may not be clearly distinguishable.
- There may be a need to quantify the problem's severity as well as draw boundaries.
- There may be times where some carefully collected spatial data would help delineate the problem.

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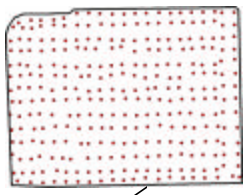
An Example:
Spatially Mapping Soybean Plant Populations

Spatial plant count data...

- Approx. 10 plant population checks per acre on a fairly equal grid basis
  - Pre-planned grid
  - 292 total data points on 30 acres
  - Cost: Three bodies, two GPS units, one day



30-acre soybean field

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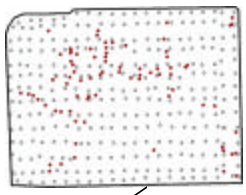
Additional (directed) sampling

- Our eyeballs suggested a need for some add'nl counts in 'odd' areas not covered by grid.
  - Add'nl 80 counts
  - 372 data points
  - Cost: Included in first day's work



30-acre soybean field

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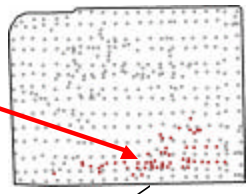
Revisited field, second day

- GIS map did not agree completely with what we remembered, so we revisited the field
  - Added another 54 population checks
  - Total of 426 data points on 30 acres
  - Cost: Three bodies, one GPS unit, one day



30-acre soybean field

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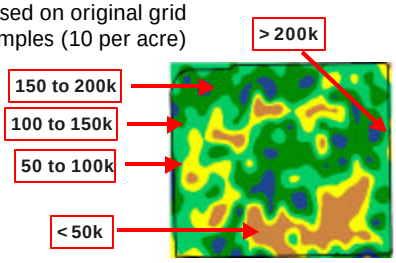
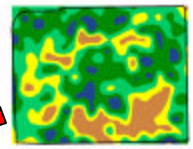
Soy population map

- Based on original grid samples (10 per acre)

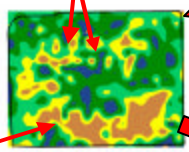


Did add'nl sampling help?

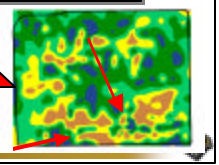


Original data

Minor, but potentially useful improvements if map were used to control a VR replanting operation.



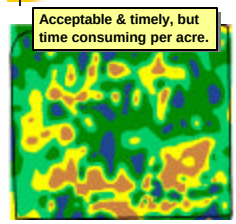
Original data plus directed samples on the fly



Plus revisit

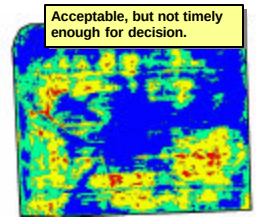
How accurate were we?

Acceptable & timely, but time consuming per acre.



Our map of populations (17 June)

Acceptable, but not timely enough for decision.



Green vegetation index (NDVI) from IR aerial image (8 July)

So, are these 'toys' worth it?

- Spatial mapmaking can easily lengthen the troubleshooting process.
  - Clientele may not have the patience.
  - You may not have the time.
- No guarantee of providing an answer.
  - Same is true for our other shenanigans.
- But, 'seeing' the pattern is often what we desire when troubleshooting.

Take a hike...

- Find the opportunity to walk away from the rest of the 'players' and study the problem by yourself.
  - This is why I suggest assembling a 'cast of players' to visit the field

- Let your eyes wander casually for overlooked symptoms or patterns
- Let your mind wander over the possibilities

Find time to re-visit fields...

- Illustrates your concern about the farmer's problem.
- Verifies whether your diagnosis was correct.
  - Reinforces your confidence (and the client's) in your troubleshooting skills.

- Documents whether the problem(s) worsened or improved.
- Documents recovery of damaged plants.
  - Esp plants that you marked on 1st trip
- A handheld GPS (e.g. Garmin eTrex Legend) is good for marking the field location for future visits.

Photographic evidence...

- Useful for future personal reference and use in newsletters, Web-based image libraries, and con't education programs.
- Can help you focus on the details of the problem.
- Traditional 35mm cameras or today's digital cameras

Advantages to digitals?

- Early digitals were 'toys', today's digitals are tools.
- Quicker transition from field to newsletters (esp Web-based), laptop presentations, and image databases.
- No more wasted film, take as many shots as memory card will store.
- Image editing software offers tremendous power in working with images.

What I look for in a digital...

- Megapixel rating
  - No less than 2.5M
- Resolution
  - 1738 x 1368 pixels
- Macro capability
  - Down to 1-inch from subject
- Through the lens metering
  - Better WYSIWYG
- Camera body with good grip for one-handed shots
- Decent battery life
- Spot metering
  - Dark subjects and light background
- Decent flash
- Optical zoom
  - No less than 3X
- Image storage
  - CF card (same as used for my handhelds)

Camera accessories

- 6-inch ruler for perspective on size
- Small tripod for macro or long shutter speeds
- Image backgrounds
  - Blue or black cloth or black rubber truck floor mat
- Extra batteries & charger
- Extra CF memory card(s)
  - About 90 images per 64MB card
- PCMCIA adapter for CF card or CF card reader
- Padded Cordura camera case

Capturing the scene...

- Capture all aspects of the problem.
- Compose sequential shots.
  - Whole field down to super macro
  - Severity of damage, including normal
- Take full advantage of super macro setting.
  - Close-up details of symptoms
- Use flash and/or spot metering for dark subjects against light or bright backgrounds.
  - Image editing software can further enhance underexposed images

Sequential imaging...

Document those images!

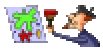
- Document the details of the images you take on a troubleshoot.
  - Esp if you suffer from 'Sometimers' disease!
- Alternatives include
  - Handheld voice recorders
  - Pen & notepad, or
  - The audio recording capability of some newer digital cameras.

Remember:

Also document other aspects of your field visit!

Image editing...

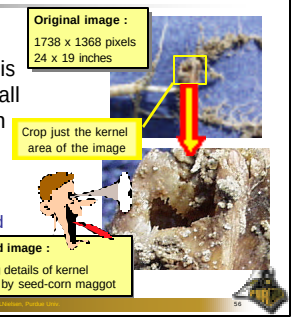
- Why edit?
  - To improve or enhance image appearance or particular details of image.
- Are many software choices, I happen to use:
  - Adobe Photoshop & ULead Photoimpact
  - Each has own strengths and weaknesses



- Useful features
  - Cropping to remove unwanted parts of image
  - Focus or sharpening to improve clarity
  - Contrast & color enhancement
  - Re-sizing to match intended use
  - Optimizing or reducing file size for faster Web downloads
  - Inserting text & symbols

Virtual closeups w/ cropping...

- Because the true size of a high resolution image is immense, cropping a small area results in a net gain in magnification.
  - Image details become visible that could not be seen easily with the naked eye.



Managing images...

- Managing thousands of images, whether digital or slide, is an immense challenge.
  - Image details
    - Where, what, & why?
  - Image location
    - Where did I file that?
  - Image matches
    - All frost damage images in my collection?

An image database I like...

- IMatch™ image management database
  - www.photools.com
  - Folder management-like interface
  - Allows annotation of each image
  - Allows assignment of categories to images
  - Does more than I yet understand
  - Unbelievably cheap ($49.95)

Three interesting cases...

- When good corn fields turn bad (2000)
- Unsuccessful sex in the corn field (2001)
- Sidewall compaction (2002)

When Good Fields Turn Bad: Another Example

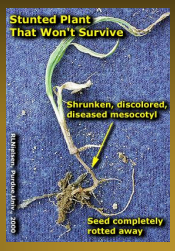
Seedling Blight in Corn

- Example of a field of corn in northwest Indiana planted mid-April 2000 under “good” conditions.
  - Emergence described as uniform and acceptable
  - Early seedling development described as uniform and acceptable

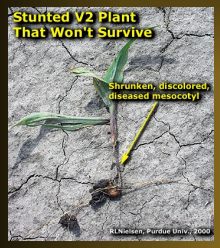
Stunting & death of plants

- Areas of fields with significant plant stunting or death developed 4 to 6 wks after planting
  - Often on 'higher' and 'lighter' areas of field
    - Not where you would expect seedling blight

'Normal' and stunted plants



Seedling blight on young corn



Farmer: Why seedling blight?

- After all, seed fungicide treatments are better than ever!
  - Captan®, Maxim®, Apron®
- Furthermore, problems were not always occurring in lower wetter areas of fields.
  - Where we usually worry about disease
  - Rather, on the higher & lighter soils

Purpose of seed treatments?

- Obviously, to protect seed and seedling from early fungal diseases.
  - Pythium, rhizoctonia, etc.
- More specifically, protection until the plants' permanent (nodal) roots are well established.
  - Generally 'in place' by V4 to V6.

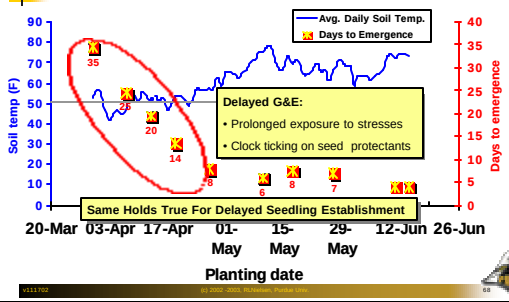
Fungicidal seed treatments

- Sadly, the life span of seed treatments is typically no longer than 2 to 3 weeks after planting.
- Furthermore, once seed coat breaks due to germination, fungicidal protection is often compromised.

So, why seedling blight?

- Early planting, cool soils, slow G&E
  - Pronounced on lighter colored soils
- Cool soils for 4 to 6 wks after planting
  - Pronounced on lighter colored soils
  - Slow corn seedling development
    - Including nodal root development
- Seed treatment eventually 'gives up ghost'
  - Pathogens 'move in for the kill'

Soil temperature & corn emergence



Unsuccessful Corn Field Sex:

Pollination & Kernel Set Problems

- Numerous reports of poor kernel set, poor tip fill, and kernel abortion in 2001.
- Classic example of similar symptoms with multiple causes.

Causes of Poor Kernel Set:

Typically, we think of...

- Persistent silk clipping by insects during pollen shed.
- Silk delay from drought stress.
- Silk dessication by heat & low humidity.
- Herbicide injury to tassel or ear development.
- Silk 'balling' or 'knotting up' inside the husk leaves

How to decide?

- Pollination evidence
  - Aborted ovules vs unfertilized kernels
  - Spent anthers on ground, leaves, and behind leaf sheaths
  - Presence of pollen as indicated by discolored areas (decomposing pollen) behind leaf sheaths
  - Tassel appearance
  - Silk length or absence
  - Presence of CRW or Japanese beetles

How to decide?

- Symptom patterns in the field
  - Herb. applic. spray boom patterns
  - Soil type patterns
  - Topography patterns
  - Hybrid variability for symptoms
  - Field pattern; edges vs. middle or N-S-E-W differences

In 2001, we considered...

- Aggressive silk clipping by CRW beetles and Japanese beetles
  - Esp in odd-ball planting dates

Half of Indiana's corn crop was planted over a seven-day period from Apr 29 to May 6!

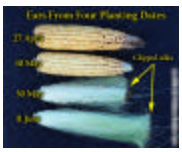
  - Esp in fields with delayed emergers
    - Perhaps only days difference!

Uneven silk emergence & CRW

Beetles were attracted to late emergers like Cornhusker fans are to football games!

Another example of CRW...

Silk clipping by planting date



In 2001, we also considered...

- Silk emergence delay or dessication due to drought & heat stress near pollination
  - Not many areas of Indiana, but occurred elsewhere in the Midwest

In 2001, we also considered...

- Consequences of silk clipping or drought in hybrids produced via male-sterile systems and marketed with high percent male sterile seed.
  - Probably cannot be discounted as a contributing factor for some pollination failure situations.
  - But, difficult to prove in the field.

In 2001, we also considered...

- Some unidentified 'weakness' in particular genetic lines that responded to certain stresses in terms of defective anthers or ovules; or kernel abortion.
  - Again, probably cannot be discounted.
  - But, difficult to prove in the field.

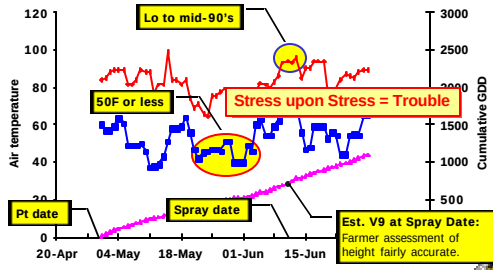
In 2001, we also considered...

- Herbicide injury to developing anthers or ovules resulting from off-label post-emergence applications, even on tolerant hybrids.
  - Evidence supported this in some fields, but by no means all situations.
  - Remember that herbicide 'tolerant' hybrids are not herbicide 'resistant'.

One situation w/ HT hybrid...

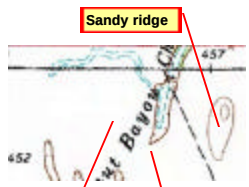
- Ear symptoms
  - Random aborted or defective kernels & unfertilized ovules
  - Silk length normal
- Plant appearance
  - Normal, except in affected areas where 'tight' tassels were found w/o apparent anther exsertion
- Farmer recollection
  - Waist high at appl'n
  - No drops on sprayer

Appl'n timing, Vstage, temps



Field evidence...

- Worse where spray passes overlapped first 20' beyond end rows into bulk of field.
- Normal ears in swale. Affected ears found elsewhere at varying frequencies. **Why?**



Conclusions in this field?

- Herbicide injury to either tassel or ear development prior to pollination, encouraged by...
  - Stress on crop from 14 days of sub-50F daily low temperatures ending one week prior to application
  - Stress on crop from mid-90's temperatures at time of application
  - Off-label application of chemical (over the top beyond rated label height)
  - Spray boom overlap extending out from end rows

Conclusions in 2001?

- Was likely no single cause of the pollination failure reported in 2001.
- Many situations in Indiana were the result of aggressive beetle silk clipping.
- Herbicide injury, primarily off-label applications, was to blame in some fields.
- Hybrid responses to stressful growing conditions likely contributed to the problem.
- Some fields suffered from multiple causes.

When Good Fields Turn Bad: Another Example

Sidewall compaction - 2002

- Lengthy, wet spring delayed field work
- Tillage often done on the "wet side"
  - Shallow horizontal compaction
- Corn often planted on the "wet side"
  - Sidewall compaction
- Followed by rapid onset of drought conditions during early nodal root development

Key factors influencing injury

- The unusual timing of the stresses relative to crop growth stage
  (aka the "alignment of the stars")
  - Early stages of nodal root formation +
  - Sidewall compaction +
  - Tillage compaction +
  - Onset of severe soil drying +
  - Onset of unusual heat

When Good Fields Turn Bad: Another Example

Beer cans & hand grenades...

- This unusual form of arrested ear development was observed again in 2001 in northeast Indiana.
  - Nearly normal row number on lower half of ear
  - Ear development totally arrested beyond that
  - Hybrid variability observed in a company hybrid research plots.

Past occurrences...

- This phenomenon has been reported off and on for more than 10 years throughout the U.S. Midwest and East.
- No consensus yet on the cause of the symptom.
  - Nutrient, pH, tillage, plant population, and disease have all been investigated to no avail.

One dummy's theory...

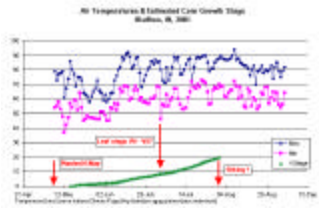
- The complete arrest of ear development suggests a single stress event that simply stopped further development, not a lingering or cumulative form of stress.
- Possible causes?
  - Herbicide injury? No common links among affected fields.
  - Chilling injury?

What does the ear tell us?

- Appears that ear development is arrested ¼ to ½ of the way through the process.
  - About V9 or so

The 2001 Episode:

A single chilling event (40's) occurred in NE Indiana at about the time that this field was estimated to be at leaf stages V8 to V9.



Chilling as a culprit?

- Similar chilling events have occurred at about the right leaf stage for other years' beer canning events.
- Belgium research documents potential for ear abortion and tassel deformation due to chilling injury at about V5.
- We aim to investigate this potential culprit with upcoming growth chamber studies using a frequently affected hybrid pedigree.

What I talked about...

- Prepare for upcoming season
- Sources of information
- Tools of the trade
- Working a troubleshoot
- Digital imagery
- Some of my cases

PURDUE
Hungry for More?
Or didn't catch what I said the first time?
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Where the coffee is strong and the gossip is fresh!
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