PURDUE UNIVERSITY

Using On-Farm Research:

Are Those Real Differences I'm Seeing?

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Purpose and outline…

- The purpose of this presentation is to help growers and consultants better understand a few of the fundamental concepts of on-farm research.
- Outline
  - On-Farm research: Why do it?
  - Is it real or is it "noise"?
  - Statistical analysis: Who cares?

Why Do Research?

- Primarily to come up with a fact-based answer to a question for which no sound answer previously exists.
  - Then use that answer to predict FUTURE performance or response of the crop to some change in management practices.

Why Do **On-Farm** Research?

- Similarly, to answer a question for which no answer previously exists.
  - Secondarily, to validate previously discovered answers for a question of interest.
  - Secondarily, to convince own self that some alternative management practice is profitable for own conditions.

On-Farm versus Small Plots:

Traditional small plot research

- Targets uniform experimental area in order to minimize "noise" and enhance researcher's ability to detect true treatment effects.
- Allows many treatments to be evaluated per acre of research area.
- Often requires specialized or small-scale research plot equipment.

Source of image: http://www.usda.gov/oc/photo/01di1431.htm

On-Farm versus Small Plots:

On-farm research plots

- Target "real world" fields that, by nature, are typically more variable (more "noisy").
- Limit the number of treatments evaluated per acre due to the larger plot size (equipment width by field lgth).
- Accommodate commercial-scale field equipment & yield monitoring due to the larger plot size.

On-Farm Demonstrations

- Are not synonymous with research.
- Their purpose is not to identify or validate answers to research questions, but rather to simply…
  - Acquire experience with new technology
  - Expose others to new technology
- Yield response or other data need not be measured or analyzed.

Research answers questions…

- ***"My hybrid beat your hybrid on my farm last year by 10 bu/ac."***
  - This is an undisputed historical fact and clearly answers the question of which hybrid performed better last year.

- ***"Therefore, I am not going to plant your hybrid on my farm next year!"***
  - Why is this possibly a stupid conclusion?

Purpose of research…

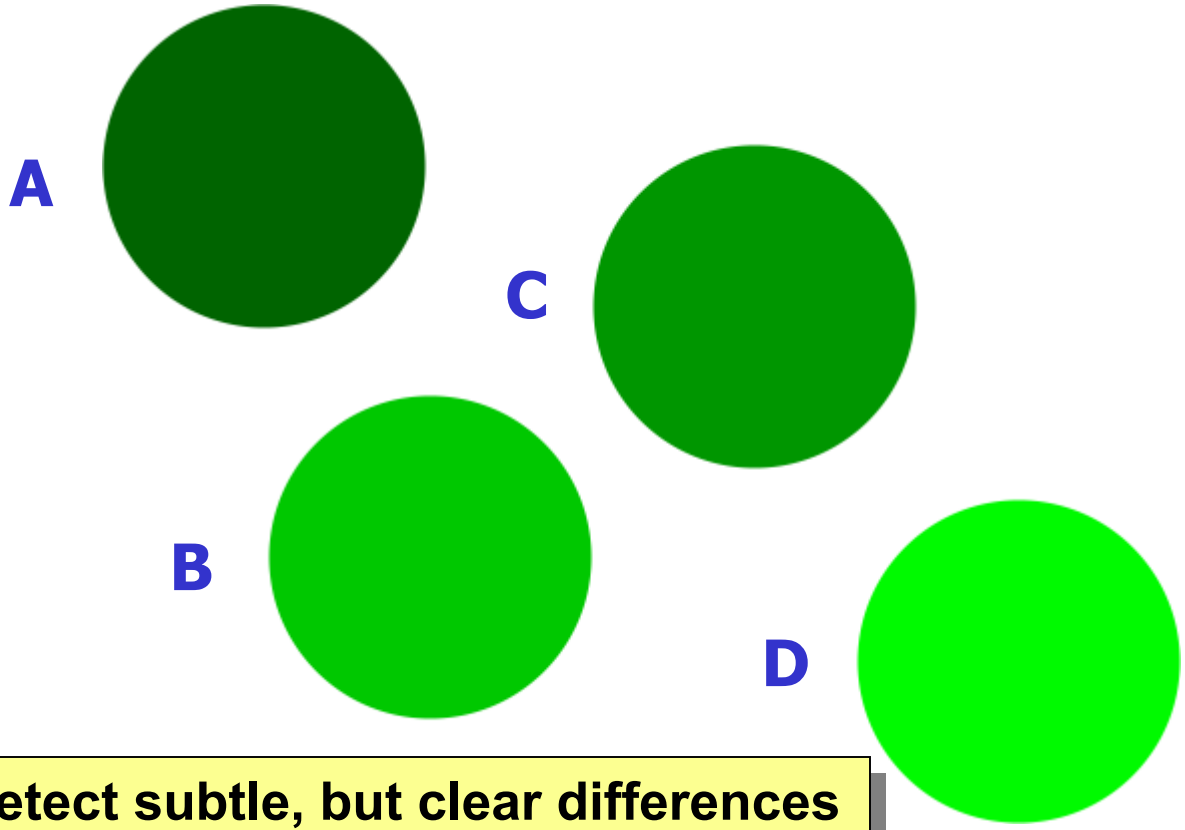
- The goal of well-designed field research and statistical analysis of measured data is NOT to document history, but rather…
- To predict future responses.

This is the most important take-home message of this presentation!!

History versus future

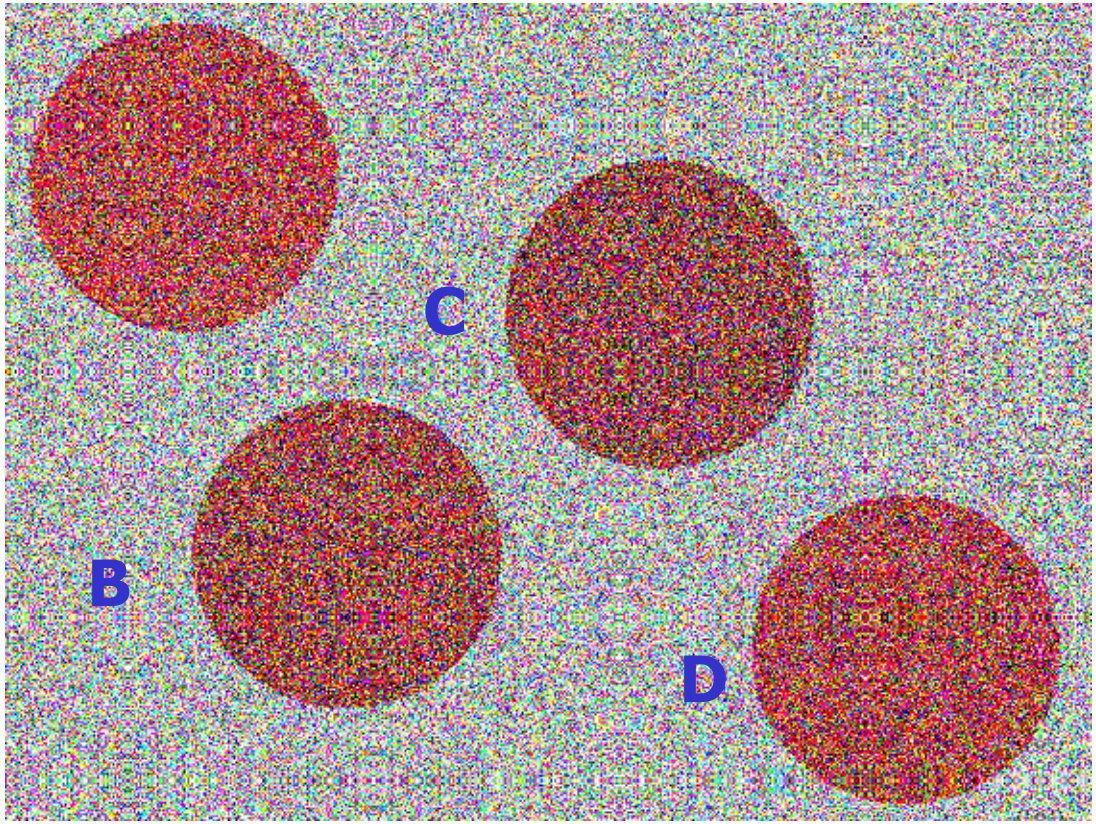
- Historical performance does not always predict future performance because background "noise" always confuses the yield differences measured among research plots.
  - In other words, the treatment differences you think you see may be due to "noise".
  - Or "noise" may prevent you from seeing treatment differences in the first place.

Which of these are different?



Most will detect subtle, but clear differences among these four shades of green.

Similar or different colors?



Excessive background "noise" can mask differences.

Is it real, or is it "noise"?

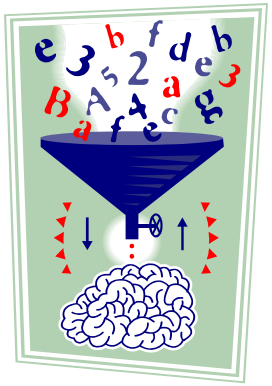
- Field research is often plagued by the confounding effects of background "noise" that tend to camouflage the effects of the treatments being evaluated.
  - Also referred to as "experimental error".
  - Background "noise" consists of variability among plots due to other, uncontrolled, yield influencing factors.

Background noise can be…

- Human error in conducting the trial.
- Variable soil characteristics within a field.
  - Soil texture, drainage, compaction, elevation
- Within-field variability for insect & disease damage, herbicide injury, weather, etc.
- From year to year, weather variability creates a lot of "background noise", especially as it interacts with other factors.

Your challenge is…

- To sort out the true yield effects of the treatments from those effects caused by "background noise".
  - You can never be 100% certain that yield differences in a trial are solely due to the treatments being evaluated.
- Fortunately, that's why statistical analysis was invented!



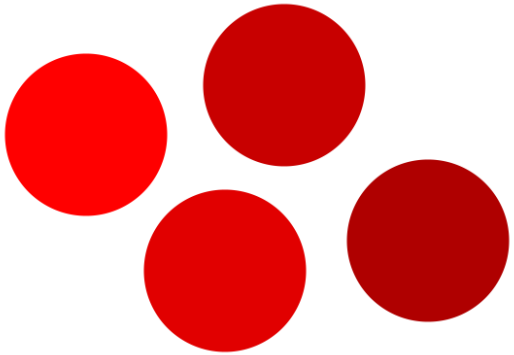
Statistics: Who cares?

- "There are three kinds of lies: lies, damn lies, and statistics."
  -- Mark Twain
- “Figures don’t lie, but liars figure.”
  -- Anonymus
- “According to the latest official figures, 43% of all statistics are totally worthless.”
  -- A. Brilliant
- “Statistics are but a sub-category of lying.”
  -- K. Day

Source of Mark Twain image: http://www.cmp.ucr.edu/site/exhibitions/twain/default.html

Statistical analyses…

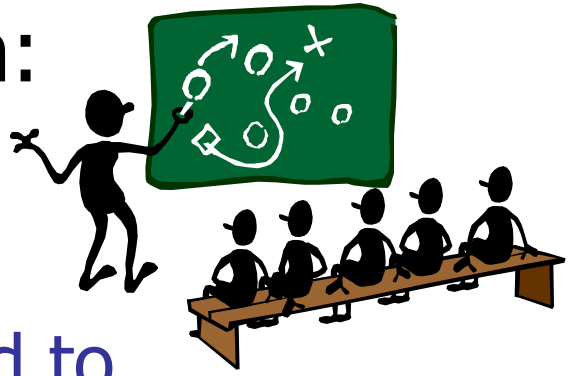
- Allow the researcher to mathematically identify and isolate "background noise" so that the true treatment effects are more clearly visible.



- Help estimate whether observed differences are real and assigns a certain probability of being correct.

Well-designed trials…

- Follow a systematic approach:
  - A meaningful question or hypothesis is developed.
  - The research project is planned to objectively (without bias) test the question.
  - Data are carefully measured & recorded.
  - Results are statistically interpreted to answer the research question.



When developing questions…

- Keep it simple, simple, simple!
  - Trials require time, energy & money.
  - Complex trials involve more of each.
  - Are you a researcher or do you work for a living?
- Best questions involve a yes/no answer.
  - Herbicide 'A' versus herbicide 'B'
  - Treated soybean versus non-treated

When selecting treatments…

- Include a control or check treatment.
  - A logical choice for a control may be your standard practice.
- Include a range of treatment levels if variable inputs such as seeding rates or fertilizer rates are being tested.
  - e.g., corn seeding rates of 25, 30, 35, and 40 thousand seeds per acre

Plan the research project

- Understand and practice the three R's of on-farm trials:

- **R**equest help
- **R**eplicate
- **R**andomize

Request help…

- A poorly planned (statistically-speaking) on-farm trial has a high risk of failure.
  - Field selection, treatment replication, treatment randomization, plot layout & size, treatment choice
- If research is not your vocation, then don't be shy about requesting help from those who conduct research for a living.
  - University researchers & Extension specialists
  - Industry researchers & agronomists
  - Crop consultants

Replicate treatments

- Replicating or repeating treatments in a trial enables the mathematical separation of the true treatment effects from those due to "background noise".
  - For example, the background effects of soil variability and yearly weather patterns

Replicating wisely

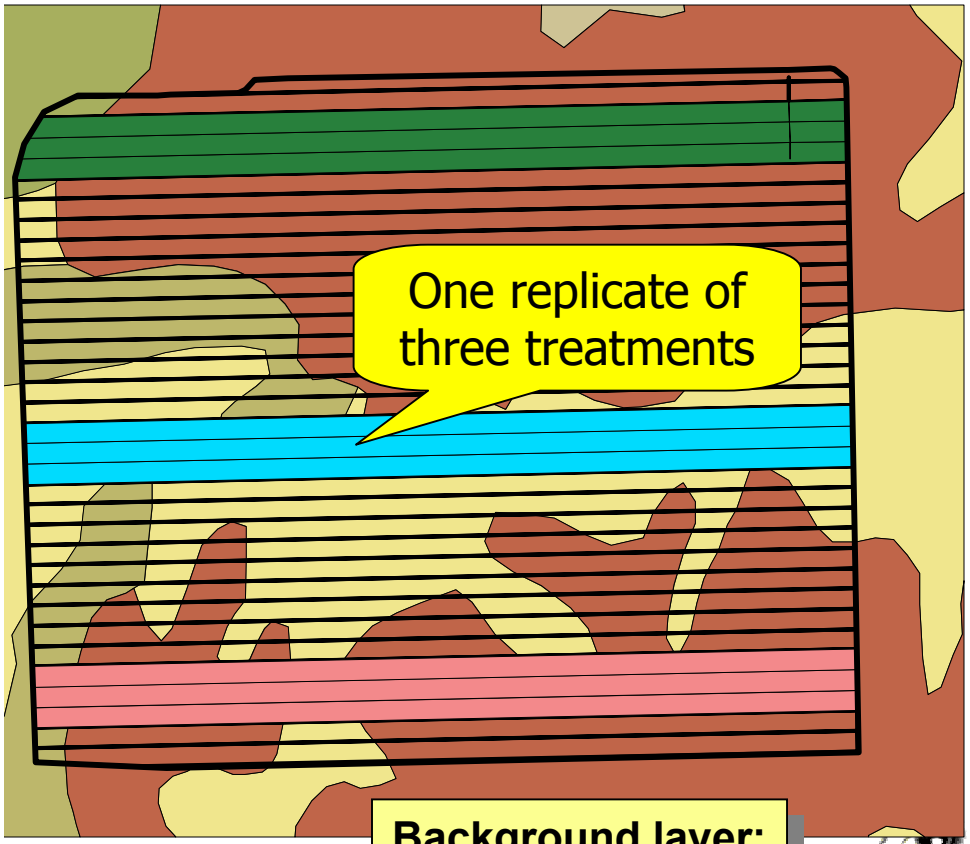
- If spatial variability can be consistently identified (e.g., soil types), then design replicates such that each "rep" of plots is reasonably uniform within itself.
  - The goal being to best minimize the "noise" level among plots within a single rep.

Software tools such as FarmWorks' SiteMate™ or the EFRA extension for ArcView™ can aid in visually designing on-farm trials.

An example:

Treatment reps & soil types

- A 3 treatment trial:
  - 30-ac field
  - 45-ft wide trtmt plots
  - 10 replicates
  - Total of 30 plots
- "Noise" among plots within a rep due to soil type variability is reasonably minimal.



Background layer:

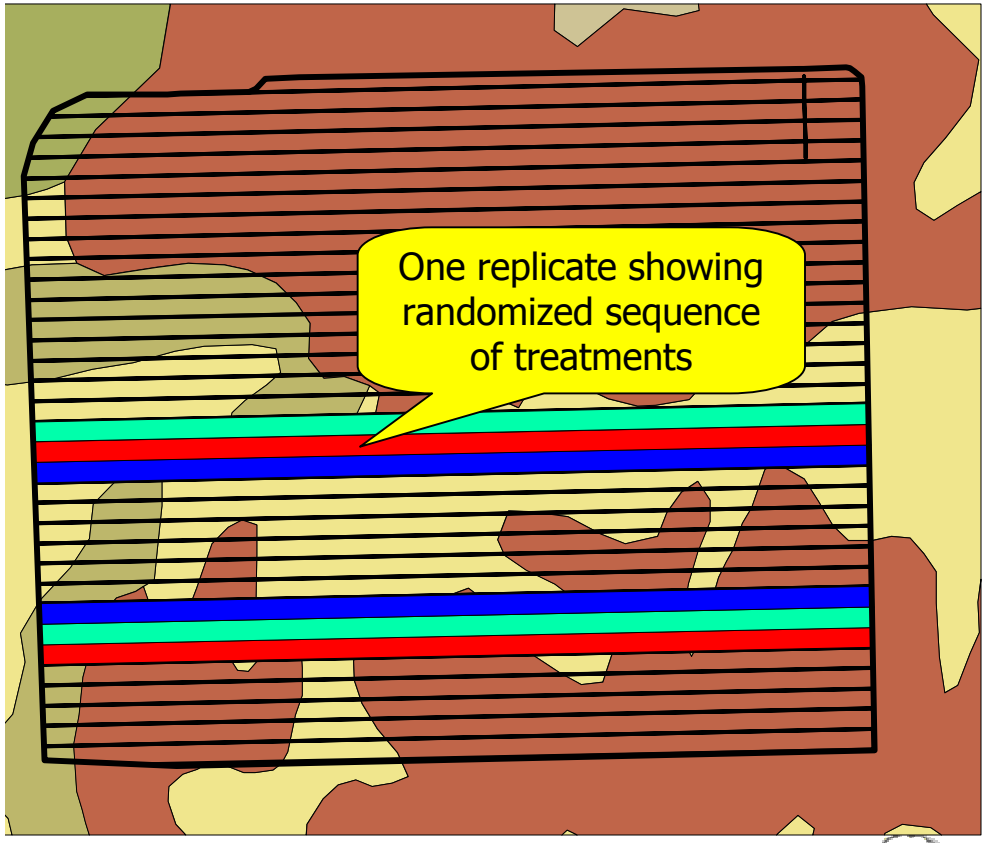
Soil mapping units

Randomize treatments

- Randomizing the location of each treatment within a replicate decreases the odds that spatial variability (foreseeable or not) will influence or blur the treatment effects.
  - For example, plots in low ground stressed more (soggy soils) than plots in high ground (better drainage).

Treatment randomization

- Randomization of treatments in an on-farm trial often creates logistical headaches relative to field operations.
  - But, randomization best minimizes the risk of unforeseen bias or influence on the data.



"Listen" for "noise"

- During the season, take notes on any possible "noise" that may influence the outcome of the test, especially if not distributed equally over field.
  - Field operations, human error, crop stresses
  - Variable crop appearance is often your clue that background "noise" is developing.

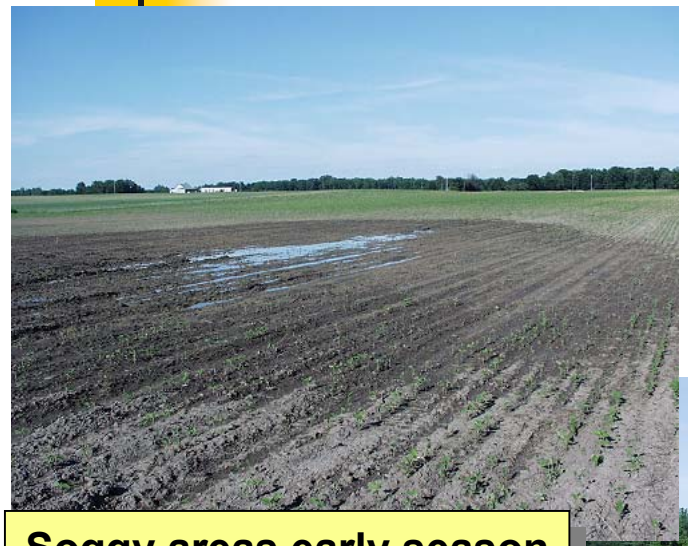
Consequence:

You may decide to abandon some or all plots if spatial variability of crop stress will unfairly influence results.

Mapping "noise" factors…

- Today's handheld GPS scouting systems offer opportunities for mapping recognizable patterns of background "noise".
- Aerial imagery taken mid- to late season greatly aids in detecting spatial crop stress.

An example of mapping "noise" due to soggy soils…



Soggy areas early season

Mapping boundaries w/ portable GPS unit

Map of soggy soil areas

Minimize harvest "noise"

- Whether weigh wagon or yield monitor, minimize risk of harvest "noise" by faithfully calibrating scales or sensors.
  - This includes grain moisture sensors.
- Triple-check yield monitor settings!
  - Logging of data to card
  - Swath width
  - Load identification

Interpret the Results

- Data analysis and interpretation can be challenging if the research project was not well designed and/or maintained.
  - Excel™ is capable of simple statistical analyses, but is not intuitive to set up.
  - AgStats02 (Washington State Univ.) is a simple to use program, but limits analysis to one year and one location.
    - http://pnwsteep.wsu.edu/onfarmtesting/

Comparing treatments…

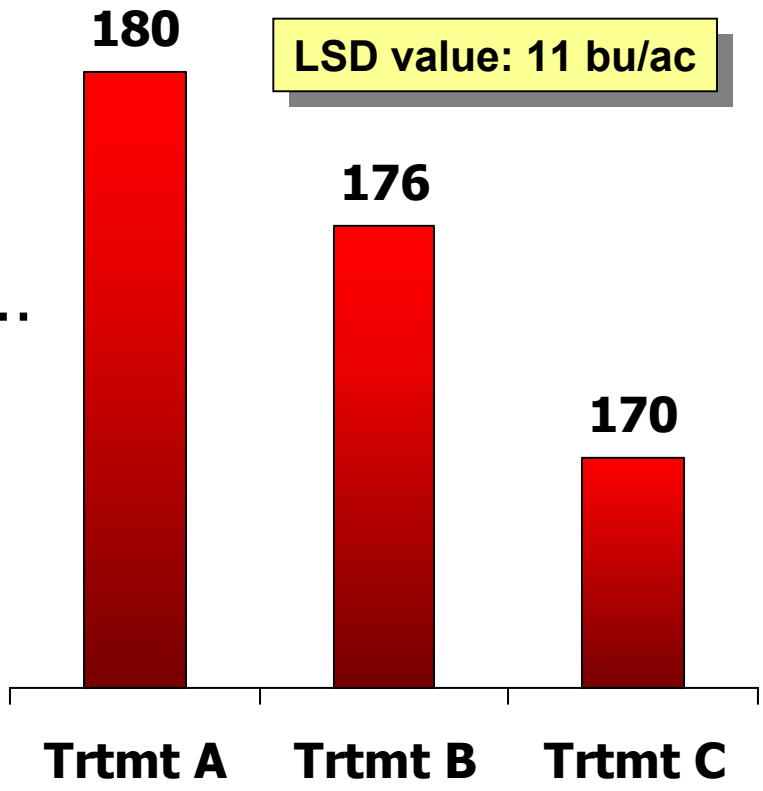
- Statistical analysis of data allows for the calculation of a value that can be used to estimate whether measured differences between two treatments are truly due to the treatment effects or are simply a result of background "noise".
  - **L**east **S**ignificant **D**ifference (LSD)

Least Significant Difference

- If two treatment means (averages) differ by more than the LSD value, then you can conclude that the difference is truly due to the treatment effects AND that similar results will be observed in the future.
- If the treatment means differ by less than the LSD value, then the observed difference is likely due simply to random chance or "noise" and may not be observed again in future trials.

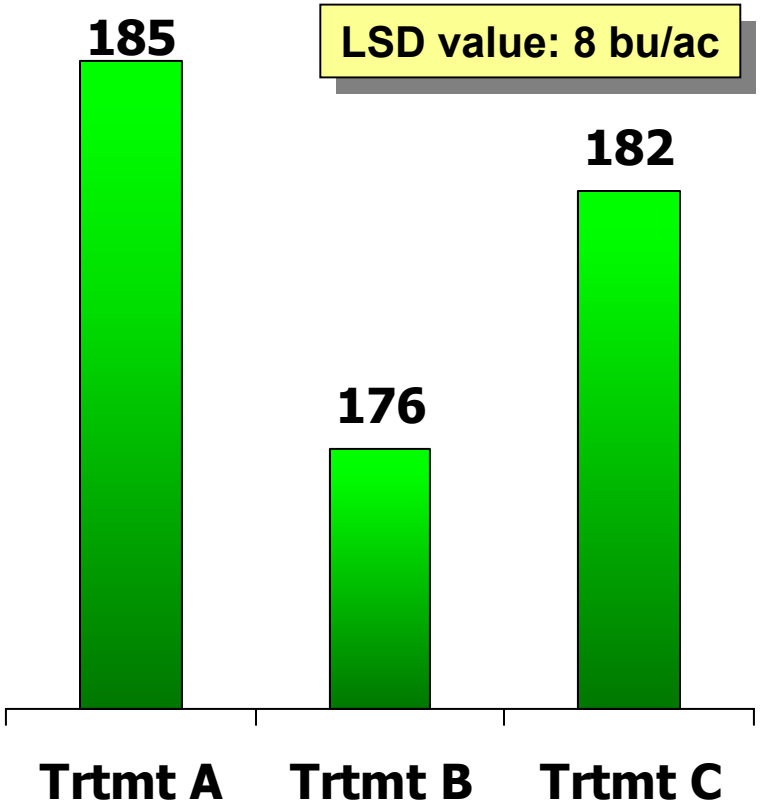
Example of using LSD values

- In this example, none of the pairs of treatment means differ by more than the LSD value, so you must conclude…
  - Treatment effects are similar,
  - Observed differences likely due to background "noise", and
  - Observed treatment trends would NOT repeat in subsequent trials.



Example of using LSD values

- In this second example, you can conclude that Trtmt A significantly out-yielded Trtmt B and will likely do so again in future field trials,
  - But Trtmt C did not yield significantly different than the other two.



Bottom line…

- On-farm research can help answer questions important to growers, but requires sound planning and attention to detail.
- Background "noise" can play havoc with your ability to detect true treatment effects.
- Sound research design + statistical analyses can help isolate "noise" and improve your success in answering questions with on-farm research.

Selected references

- AgStats02. A simple statistical analysis program for on-farm testing. Pacific Northwest Conservation Tillage Systems Information Source.
  - http://pnwsteep.wsu.edu/onfarmtesting/
- Brouder, Sylvie and Robert Nielsen. 2000. On-Farm Research. A chapter in "Precision Farming Profitability". Purdue Univ., W. Lafayette, IN 47907.

Selected references

- Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedures for Agricultural Research, 2nd Edition. Interscience.
  - http://www.amazon.com
- Little, Thomas M. and F. Jackson Hills. 1978. Agricultural Experimentation : Design and Analysis. John Wiley & Sons.
  - http://www.amazon.com

Selected software aids…

- Enhanced Farm Research Analyst (tools for ArcView®)
  - http://www.farmresearch.com/efra/
- Esri (ArcView® and related products)
  - http://www.esri.com/
- Farm Works Software.
  - http://www.farmworks.com