Conducting Meaningful On-Farm Research and Demonstrations

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Presented at the
Wisconsin Crop Management Conference
Madison, WI
January 14, 2009

Science and Research

- **Science: Any domain of knowledge accumulated by systematic study and organized by general principals.**
- **Research: A systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalized knowledge.**
- **So …**
  - ✓ Research can lead to science (knowledge), but only if it's done well
  - ✓ Done "well" means using accepted scientific methods, which often include statistics
  - ✓ If not done well, can lead to more harm than good.

Applied Agronomic Research

- **A set of *planned comparisons* carried out over an *adequate number of fields and years* (sets of weather), with results accumulated and analyzed to allow us to *predict* the response from tested inputs or practices when we use them in the future.**
  - ✓ Usually includes economics
  - ✓ We might think of this as a “branch” of science, in which probabilities of certain outcomes suggest whether or not to use certain inputs.

Definitions

- **“Planned comparison:” careful choice and placement of treatments to establish two or more (crop) inputs under the same (neutral) conditions, with results (yield, quality) from each input carefully measured**
  - ✓ An “unplanned” comparison can become planned, but only if it meets the “same conditions” test.
- **“Adequate” number of fields and years:**
  - ✓ Depends on the expected variability of response, from none to some
  - ✓ Depends on the frequency and cost of yield loss from using an input
  - ✓ Depends on the cost of the product
  - ✓ Before we do the research, this obviously requires some guesswork
- **“Prediction:” a statement of likelihood of expected results from use of a particular input:**
  - ✓ Usually includes “average” expected result: “Product X increases yield by 3.4 bushels on average”
  - ✓ Should include an economic assessment: “The average return to using Product X is $3.50 per acre, after subtracting its cost of $2.20 per acre”
  - ✓ Should include some measure of uncertainty: “Product X is expected to provide a positive return 70 percent of the time, and net return is expected to range from -$2.20 (product cost, with no effect on yield) to +$10.50 per acre.”
  - ✓ If appropriate, “condition” statements should be included: “There is little return to use of this product under poor drainage conditions.”

Objective and Overview

- **The <u>objective</u> of this presentation is to describe the principles of on-farm research and the statistical analysis involved for making decisions.**

<u>Overview</u>

- **Research v. On-Farm Research v. Demonstration**
- **Components of On-Farm Trials**
- **Consequences of Decisions**
  - ✓ Experimental units
  - ✓ Error
  - ✓ H_o Testing
- **Comparing treatments**

What's Special About "On-Farm" Research?

- **From a standpoint of actually doing trials, nothing much:**
  - ✓ Limits the number of comparisons
  - ✓ Doesn't allow some treatments that require special equipment
  - ✓ Timeliness/priority can be an issue
  - ✓ It is, though, "real" field conditions

- **The main advantage for On-Farm Research is that it makes it possible to test over a large number of sites, thus it can more easily move research from "description" to "prediction"**

Research versus On-Farm Research

- **Why Do Research?**
  - ✓ To ANSWER a question for which no answer exists.
  - ✓ Then use that answer to predict FUTURE performance to some change in management.
- **Why Do On-Farm Research?**
  - ✓ Similarly, to ANSWER a question for which no answer exists.
  - ✓ To VALIDATE answers for a question.
  - ✓ To CONVINCE yourself that a management practice is profitable.
- **The goal of research is <u>to predict future responses</u>.**
  - ✓ Well designed experiments
  - ✓ Statistical analysis

On-Farm Demonstration

- **Is <u>not</u> the same as research.**
- **The goal of demonstration is to ...**
  - ✓ Acquire experience with new technology
  - ✓ Expose others to new technology
- **Yield or other data need not be measured or analyzed.**

Small Plot Research versus On-Farm Research:

Traditional small plot research

- Targets uniform area in order to minimize error for detecting true treatment effects.
- Allows many treatments to be evaluated in research area.
- Often requires specialized or small-scale research plot equipment.

On-farm research plots

- Targets "real world" fields that are more variable.
- Limits treatments evaluated due to large plot size.
- Accommodates commercial-scale field equipment & yield monitoring.

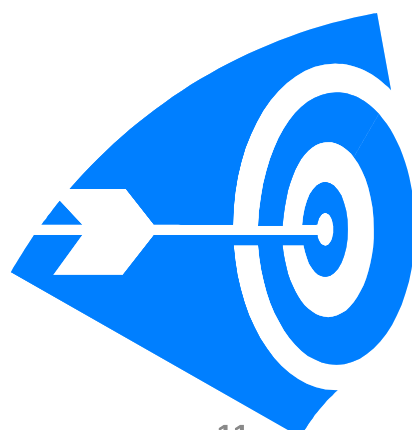
Growers like on-farm research trials because:

- **"I believe it because I did it."**
- **It was close to my farm.**
- **It was done under conditions similar to my farm (soil type, rainfall, equipment, management practices, etc.)**

- **The question of whether research results are relevant to the producer's soil types and management strategies is answered immediately.**
- **Best of all, the producer decides what topic to research.**

Objectives of on-farm trials

- **Grower objectives**
  - ✓ Become familiar with a new product or practice
  - ✓ Gain confidence with a new technology
  - ✓ Determine management zones for application of a product
- **Agent / Consultant / Dealer Objectives**
  - ✓ Establish relationship with growers/customers
  - ✓ Transfer technology to growers/customers
  - ✓ Advertisement and visibility (plot tours, signs, meetings)



Components of on-farm research

- **Formulating a question (hypothesis)**
  - ✓ Develop a well-defined research question
  - ✓ Answer question with data that you can collect from the field.
  - ✓ Research project is planned to objectively (without bias) test the question.
- **Testing the hypothesis**
  - ✓ Decide what treatments to compare
  - ✓ Design the field layout of the experiment
  - ✓ Determine what you will measure.
- **Drawing a conclusion**
  - ✓ Statistically analyze data (determines probabilities that the differences were caused by treatments versus chance, random variation, or error)
  - ✓ Focus on economics
    - ❑ What is the cost:benefit ratio?
    - ❑ Consider non-tangible benefits (i.e. soil quality, environment, etc.)
  - ✓ Draw conclusions from more than one location and/or year

When developing questions (hypotheses) …

- **Keep it simple, simple, simple!**
  - ✓ Trials require time, energy & money.
  - ✓ Complex trials involve more of each.
- **Best questions involve a yes/no answer.**
  - ✓ Herbicide 'A' versus herbicide 'B'
  - ✓ Treated soybean versus non-treated
- **Request help: A poorly planned (statistically-speaking) on-farm research trial has a high risk of failure.**
  - ✓ Treatment choice, field selection, treatment replication, treatment randomization, plot layout & size, etc.
  - ✓ If research is not your profession, then ask for help from those who conduct research for a living.
    - ❑ University researchers & Extension specialists
    - ❑ Industry researchers & agronomists
    - ❑ County Agents and Crop consultants

Selecting treatments for on-farm trials

- **Choose treatments to meet objectives**
- **Keep the trial manageable**
  - ✓ Usually two treatments
  - ✓ No more than 12 plots (JL)
- **Include a control or check treatment.**
  - ✓ A good control may be the grower's standard practice.
- **Experimental designs**
  - ✓ Paired comparisons (two treatments)
  - ✓ Randomized complete blocks (three or more treatments)
- **Include a range of treatment levels if variable inputs are tested**
  - ✓ e.g., corn plant densities of 25K, 30K, 35K, and 40K seeds per acre
- **To improve efficiency of managing the experiment, you need to consider grower equipment for experiment layout**
  - ✓ Planter
  - ✓ Combine
  - ✓ Sprayer

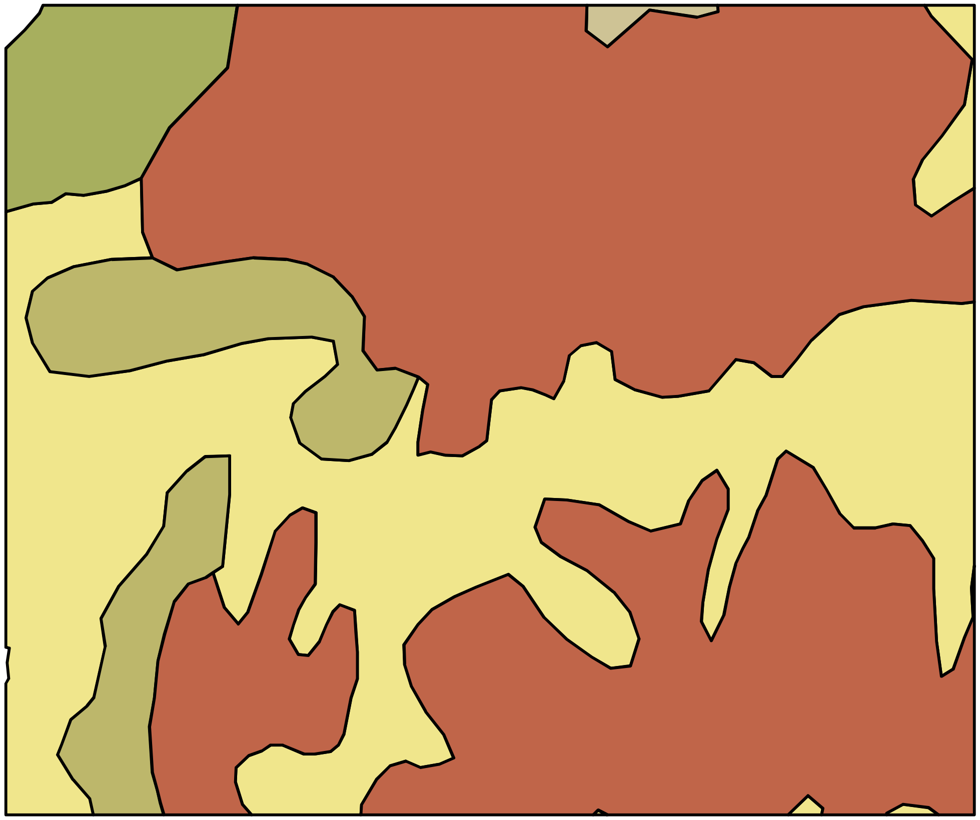
Randomization and Replication

- **Randomization – Eliminates bias when assigning treatments to experimental units**
- **Replication – Improves the estimate of the treatment effect and provides estimate of error**
  - ✓ Number of replications for on-farm trials
    - ❑ Minimum is two
    - ❑ Recommend three or four within a field
    - ❑ Can replicate by fields and farms

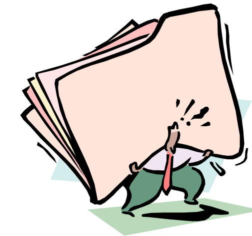
- **These two factors separate on-farm research experiments from demonstration plots**
  - ✓ Grower can make valid conclusions and ultimately wise business decisions

Location of on-farm trials

- Choose a uniform field
- Soil type
- Slope
- Fertility
- Tillage
- Crop history
- Incorporate field and plot border/buffer areas to ensure that treatments do not influence each other
    - ✓ Do not use compacted end rows, fence line grasses, or field roads



Records for on-farm trials



- **Keep good records (diary of crop and weather conditions, photos)**
  - ✓ Identifying and labeling strips in the field
    - ❑ Mark strips in the field with stags or pvc flags (and GPS record)
    - ❑ Code the identification until all data are recorded
    - ❑ Uncode when results are summarized
  - ✓ Write it down (or electronic files)
  - ✓ Draw a sketch (map) of the experiment layout for later reference
- **Data collection for each experimental unit**
  - ✓ Use properly calibrated weigh wagon or yield monitor for harvest weights
  - ✓ Collect moisture and test weight
  - ✓ Record all information that may affect results (notes, soil fertility, plant height, insect thresholds, weed densities, planting and harvest populations, protein)

Consequences of Decisions

- **Determine there is a difference between treatments:**
  - ✓ If there really is, it's a CORRECT decision
  - ✓ If there isn't, the consequence is the cost of the treatment lowers profitability
- **Determine there is no difference between treatments:**
  - ✓ If really no difference, it's a CORRECT decision
  - ✓ If really a difference, the grower loses potential profitability
- **Grower Production Decisions**
  - ✓ Should be GOOD decisions
    - ❑ Correct decisions
    - ❑ Profitable decisions

Experimental Unit

- **The "Experimental Unit" is the experimental material to which a treatment is applied.**
- **Sometimes it can be difficult to identify**
    - ✓ For field experiments, the Experimental Unit is usually some land area

Experimental Error

- **Any measurement on an experimental unit has a certain amount of error associated with it.**
  - ✓ Error consists of variability among plots due to other, uncontrolled, trait influencing factors.
- **Statistics allow us to quantify and assess error.**
- **Error cannot be assessed with one measurement.**
  - ✓ Need multiple measurements (replications).

Error can be ...

- **Human error in conducting the trial.**
  - ✓ Mistake in calculations (e.g. area of plot)
  - ✓ Wrong plot, transcription, misread scale
- **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 error, 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 error.
    - ❑ 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!

Hypothesis Testing

- **The Hypothesis (H_o) –**
  - ✓ In Words: The population mean of one treatment = the population mean of another treatment
  - ✓ In Formula: H_o: $u_1 = u_2$
  - ✓ Fact: The hypothesis may be True or False

Hypothesis Testing

$$H_o: u_1 = u_2$$

- "Reject the Null Hypothesis": Conclusion is there is a difference between the treatments for the trait measured.
- "Do not reject the Null Hypothesis": Conclusion is there is no difference between the treatments for the trait measured.

Real condition of the Null Hypothesis	REJECT	DO NOT REJECT
TRUE ($u_1 = u_2$)	Type I Error	No Error
FALSE ($u_1 \neq u_2$)	No Error	Type II Error

Type I Error

- **The act of rejecting a true null hypothesis:**
  - ✓ This leads to the conclusion that a treatment effect exists when in fact none does
  - ✓ Probability of committing a Type I error = *a* (“alpha”)
    - ❑ Experimenter (You) sets alpha
    - ❑ One normally sets alpha low so confidence is high when the null hypothesis is rejected.
    - ❑ When a treatment doesn’t cost more than another (e.g. choice between two hybrids) then alpha can be increased
    - ❑ When a treatment is very expensive, then alpha should be low to increase our confidence
  - ✓ Confidence of the statistical decision is 1 – alpha
  - ✓ “False positive”
- **Consequence is we might adopt a practice that does not pay off.**

Type II Error

- **The act of not rejecting a false null hypothesis:**
  - ✓ This leads to the conclusion that a treatment effect does not exist when in fact one does
  - ✓ Chances of committing a Type II error increase as alpha is decreased
  - ✓ "False negative"
- **Consequence is we don't adopt a practice that might have paid off.**

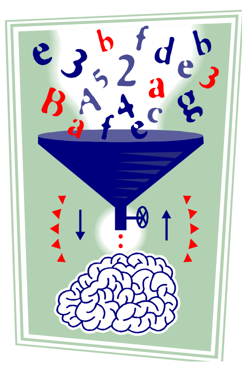
The t Test

$$t = \frac{\textbf{Difference between two treatment means}}{\textbf{Standard deviation of the difference between two means}}$$

- **When the number of replications is increased:**
  - ✓ Get a better estimate of the treatment means
  - ✓ Reduces the size of the standard deviation of the difference between two means
  - ✓ Increases the size of the t value
  - ✓ Reduces the tabled value for significance at any level of confidence
  - ✓ Increases the chance of detecting treatment differences.

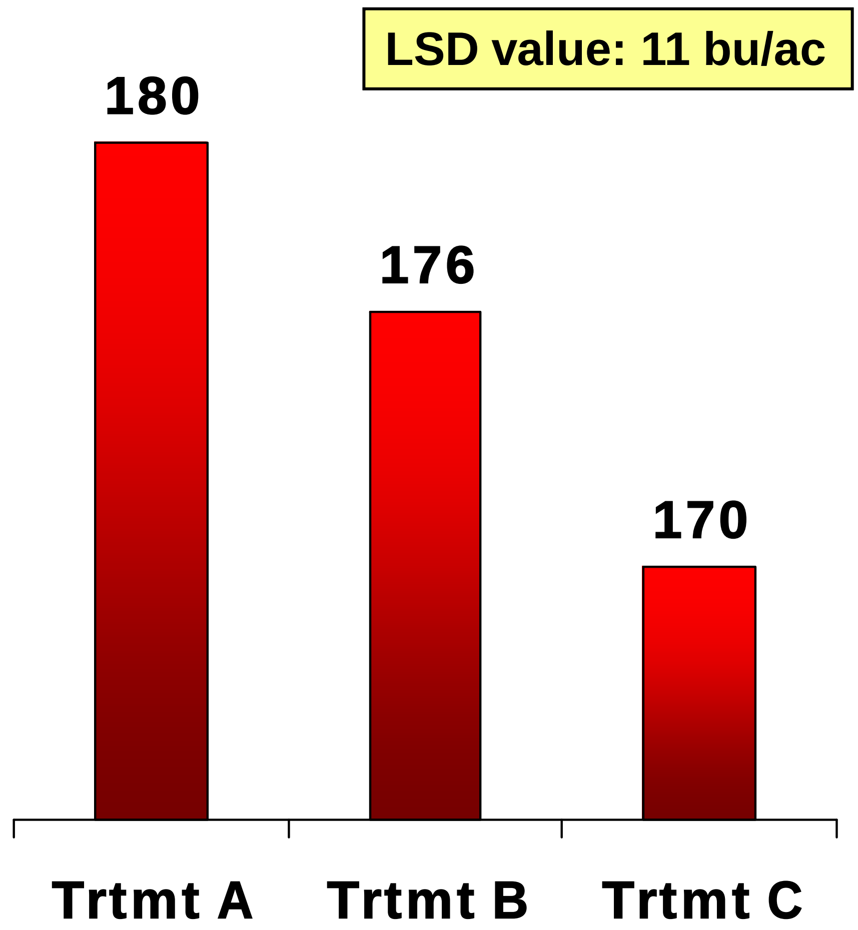
Comparing treatments…

- **Statistical analysis allows for the calculation of a value that is used to estimate whether the difference between two treatments is due to treatment effects or is simply error.**
  - ✓ Least Significant Difference (LSD)
  - ✓ If two treatment means differ by more than the LSD value, then conclude that the difference is due to treatment effects AND that similar results will be observed in the future.
  - ✓ If two treatment means differ by less than the LSD value, then conclude that the difference is due to random chance or error AND may not be observed again in the future.



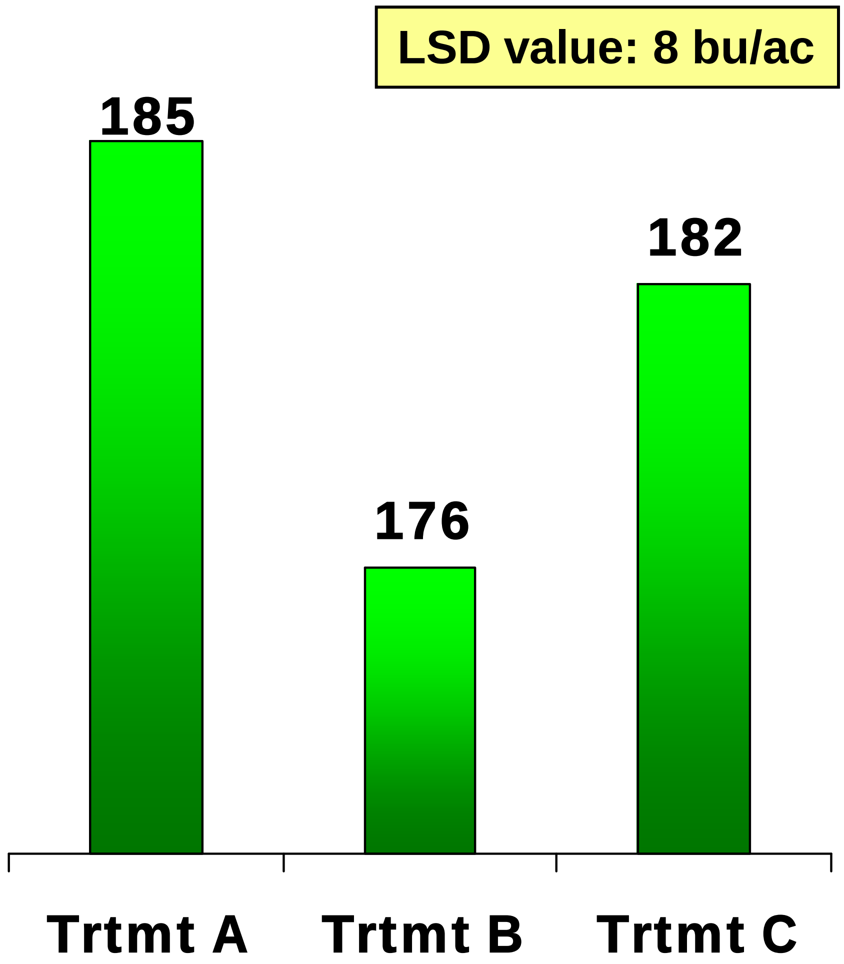
Example of using LSD values

- **Conclusion: 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 error, and
  - ✓ Observed treatment trends would NOT repeat in subsequent trials.



Example of using LSD values

- **Conclusion: Treatment A significantly out-yielded Treatment B and will likely do so again in future field trials.**
  - ✓ But Treatment C did not yield significantly different than the other two.



Rules for good on-farm trials

- **Define the objective and "stick to the plan"**
  - ✓ Keep the trials simple – usually two treatments
- **Choose good locations**
- **Replicate within fields, by fields, and farms**
  - ✓ Use 2 to 4 reps per location, depending on variability and number of locations
- **Randomize treatments within each rep (even with only two treatments), if possible.**
  - ✓ Split-planter? Can do after the fact
- **Measure yields accurately**
  - ✓ Convert to standard moisture in a standard way
  - ✓ Yield monitors are for strips, not bits of strips
    - ❑ Use a strip size wider than the combine to allow borders (with exceptions)
    - ❑ Yield monitor issues with harvest width (drills)
- **Keep track of where things are!**
  - ✓ Keep good records. Communicate results and conclusions to cooperators
- **Evaluate and plan for next year**

Bottom line…

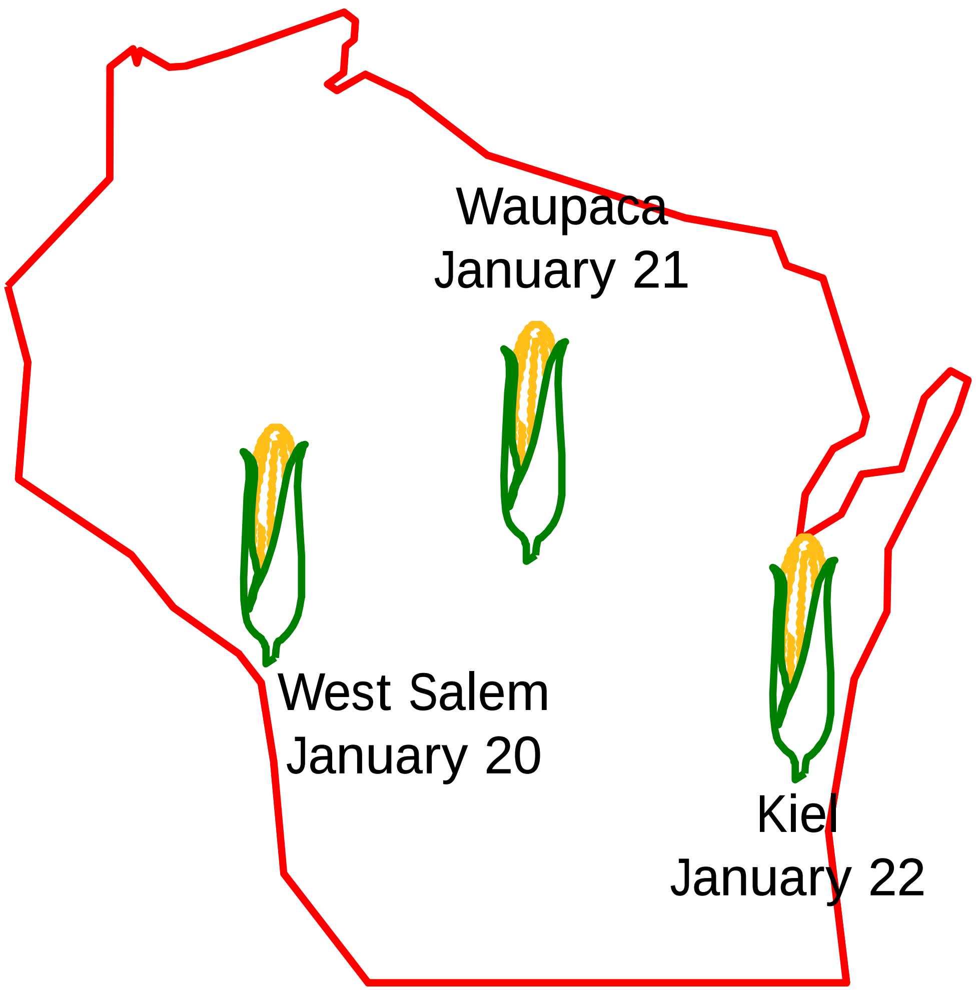
- On-farm research can help answer questions important to growers, but requires sound planning and attention to detail.
- Error can play havoc with your ability to detect true treatment effects.
- Sound research design AND statistical analyses can help isolate error and improve your success in answering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

References

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

Thanks for your attention!
Questions?

2009 Corn Conferences



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