A Brief Introduction…

- Why are you here?
- What do you hope to get out of today?
- What kind of ideas for research do you have?
Outline

- Why perform research?
- How to statistic
- Reviewing scientific literature
- Developing successful field trials

- Some slides adapted from “Are Those Real Difference I am Seeing?”, a presentation by Bob Nielson, Purdue University

Why do research?

- Fact-based answer to a question
- Use answer to predict future behavior or response
Small Plot Research at RECs

- Small, uniform area (partial field)
- Multiple treatments and complicated study design
- Use small research equipment

- Is on farm research performed for the same purpose?

On-farm Research

- Similar purpose – to answer a question
- May validate a previously determined answer
  - Will the response seen on small plots apply to a larger field?
- Demonstrate that a practice is feasible or profitable
- Account for use of commercial-scale equipment
On-farm **Research** vs. **Demonstration**

- Not synonymous
- **Research** utilizes statistically sound practices to answer a question
- **Demonstration** may expose farmers to new technology
  - No data will be collected or analyzed

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**History vs. Future**

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FEARLESS IDEAS
History vs. Future

“N60F yielded higher than N61P on my farm last year”

“I am not planting N61P next year because it will not perform well”

• Historical performance does not always predict future performance
• Background “noise” confuses the yield difference observed
  • Environmental conditions
  • Differences between the hybrids introduced by humans
Background “noise”

- Always present within field research
- Masks the effect you are trying to determine
  - Hybrid performance difference could be due to background noise
  - Background noise could prevent a hybrid performance difference from appearing

Examples of background noise?

- Human error
- Variability in soil conditions in one field
- Insect or disease variability in field
  - Raccoon damage
- Plot placement in field
  - Edge of field may have more deer pressure
- Weather variability from year to year
What caused N60F to yield higher than N61P?

- Hybrid performance?
- Soil conditions?
- Fertilizer application error?
- Different planting dates?

Why do research?

- Utilize well-designed field plots and sound statistical practices to go beyond documenting history to predicting future responses by determining a treatment difference through identification of background noise
- To do this, we need statistics
Statistical Analysis

- Mathematically identify and isolate background noise to make true treatment effects visible

- Estimate whether the observed differences are real and assign probability of being correct

What does this mean?!?!
“Estimate whether observed differences are real and assign probability”

- We can never be 100% certain that treatment differences are due solely to the treatments
- With sound practices and the help of statistics, we can say we are confident that background noise has been accounted for and it is highly probable that our response is due to the treatments imposed

“Estimate whether observed differences are real and assign probability”

- P value
  - Probability that experimenter concludes that treatments were significant different when, in fact, they were not
- Typically 0.05 or 5% in agricultural research
- This threshold is selected in the planning process and does not change after you see the data
We are never 100% sure

- There is always a chance of having come to an incorrect conclusion
  - One can conclude that there is a significant difference between treatments when, in fact, the differences observed occurred by chance alone (false positive)
  - One concludes that there is no significant difference between treatments when in fact there is a real difference (false negative)
- Alpha of 0.05 strikes a balance between the two types of errors

How to “statistic”?

- **Sound plot design and maintenance will make analysis and interpretation exponentially easier**
- Programs available to perform analysis
  - Excel – applicable for simple comparisons
  - SAS – expensive, requires knowledge of coding (JMP is free version with minimal coding)
  - R – free, open source codes available
When comparing treatments...

- Mathematical calculation of a value that is used to estimate whether measured differences between treatments are due to treatment or are just background noise
  - Threshold value that treatment difference must overcome to be considered significantly different
  - Least Significant Difference (LSD)
Least Significant Difference

- If two treatment means differ by **MORE** than LSD value, you conclude the difference is a result of treatments and you would predict similar results in the future.

Least Significant Difference

- If two treatment means differ by **LESS** than LSD value, you conclude the observed difference is likely due to random chance or background noise and it may not be observed again in the future.
What are your initial conclusions??

Corn Yield, bu/ac

<table>
<thead>
<tr>
<th>TRT A</th>
<th>TRT B</th>
<th>TRT C</th>
</tr>
</thead>
<tbody>
<tr>
<td>180</td>
<td>147</td>
<td>192</td>
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</table>

FEARLESS IDEAS
What are your conclusions now??

LSD value = 14 bu/ac

Treatment B is different than Treatments A and C but Treatments A and C are similar to each other – expect to see these results again in the future.
What are your initial conclusions??

![Bar chart showing corn yield by treatment with values TRT A: 180, TRT B: 176, TRT C: 170, and LSD value = 12 bu/ac.]

What are your conclusions now??

![Bar chart showing corn yield by treatment with values TRT A: 180, TRT B: 176, TRT C: 170, and LSD value = 12 bu/ac.]

LSD value = 12 bu/ac

No difference between treatments – yield difference due to background noise; may not see similar results in the future
Figure 8a: The least significant difference (LSD) value calculated from the statistical analysis of the data was 11 bushels per acre. None of the pairs of treatment means differ by more than this LSD value, so the appropriate conclusion is that 1) the treatment effects on yield were similar; 2) the observed differences are likely due simply to random chance or background "noise;" and 3) the apparent trends in treatment yields (A>B>C) would likely not be repeated in subsequent trials comparing these same treatments. Figure 8b: In this example, the LSD value is 8 bushels per acre. Based on that LSD value, you can confidently conclude that Treatment A significantly out-yielded Treatment B and will likely do so again in future field trials, but was statistically similar to Treatment C. Treatment C was also statistically similar to Treatment B.
Developing Successful Field Trials

Successful On-Farm Research

- Valuable information gained and questions answered if executed well
- Poorly designed trial (statistically-speaking) has high risk of failure and will be a waste of limited resources
  - Time
  - Energy
  - Money
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Spend extra time in the planning stage to ensure return on investment of resources

- Time
- Energy
- Money

Recipe for Successful Field Research

1. Ask an appropriate research question
2. Develop a thorough plan for execution
   a) Variability
   b) Replication
   c) Randomization
3. Calibrate equipment and collect good data
4. Statistical analysis – should be easy!
Appropriate Research Question

- Is organic food more healthy than conventionally grown food?
  - Who is the subject?
  - How do you measure or assess “healthy”?
  - Can one study answer this question?

- This example is a good question, but way too complex

Appropriate Research Question

- Best plan is to keep the question simple
- Something that can be easily answered with one trial
  - Every plot costs resources – time & money
  - More trials = more resources

- Yes/no questions
  - Herbicide A versus herbicide B
  - Treated versus non-treated soybean seed
Examples???

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Plan for Execution – Treatment Selection

- Good practice to include a control or check treatment
- Can be standard practice on the farm
- Include a wide range of treatment levels
  - Especially with fertility work
  - Want to see a plateau in response variable
Plan for Execution – Variability

- When selecting a location to place plots, aim to minimize environmental variability
  - Soils, irrigation, pest, edge-of-field
  - Select a different location if too much variability exists

Plan for Execution – Variability

- Equipment considerations – small plot or commercial scale?
- Ensure there is ample space for replication and randomization based on the size of equipment → size of plots
Plan for Execution – Replication

- Ensure enough space for ample replication
  - Don’t bother if you cannot replicate
- Replication enables the mathematical separation of the true treatment effects from background noise
  - Lowers the threshold for LSD

Plan for Execution – Randomization

- Randomly assign treatments within a replicate
  - Removes effect of spatial variability
- Can be a headache on farm but best way to remove risk of bias in data
Calibration and Data Collection

- Any equipment that will impact your plots
  - Application or harvest equipment
- Do not ruin a whole growing season with poorly applied treatments or uncalibrated yield monitor
Statistical Analysis

- After expending effort planning, maintaining plots during season, and harvesting carefully, statistical analysis should be easy
- Be sure to ask for help!

Some Considerations

- What size do the plots have to be?
  - Based on using commercial sized equipment
- With that size plot, how will you layout your plots?
- Will it be too big for that space?
  - Can you find a different field?
Exercise

• Given the field in the next slides, how would you lay out a study with three treatments and four replications?
  • Pros and cons of each field