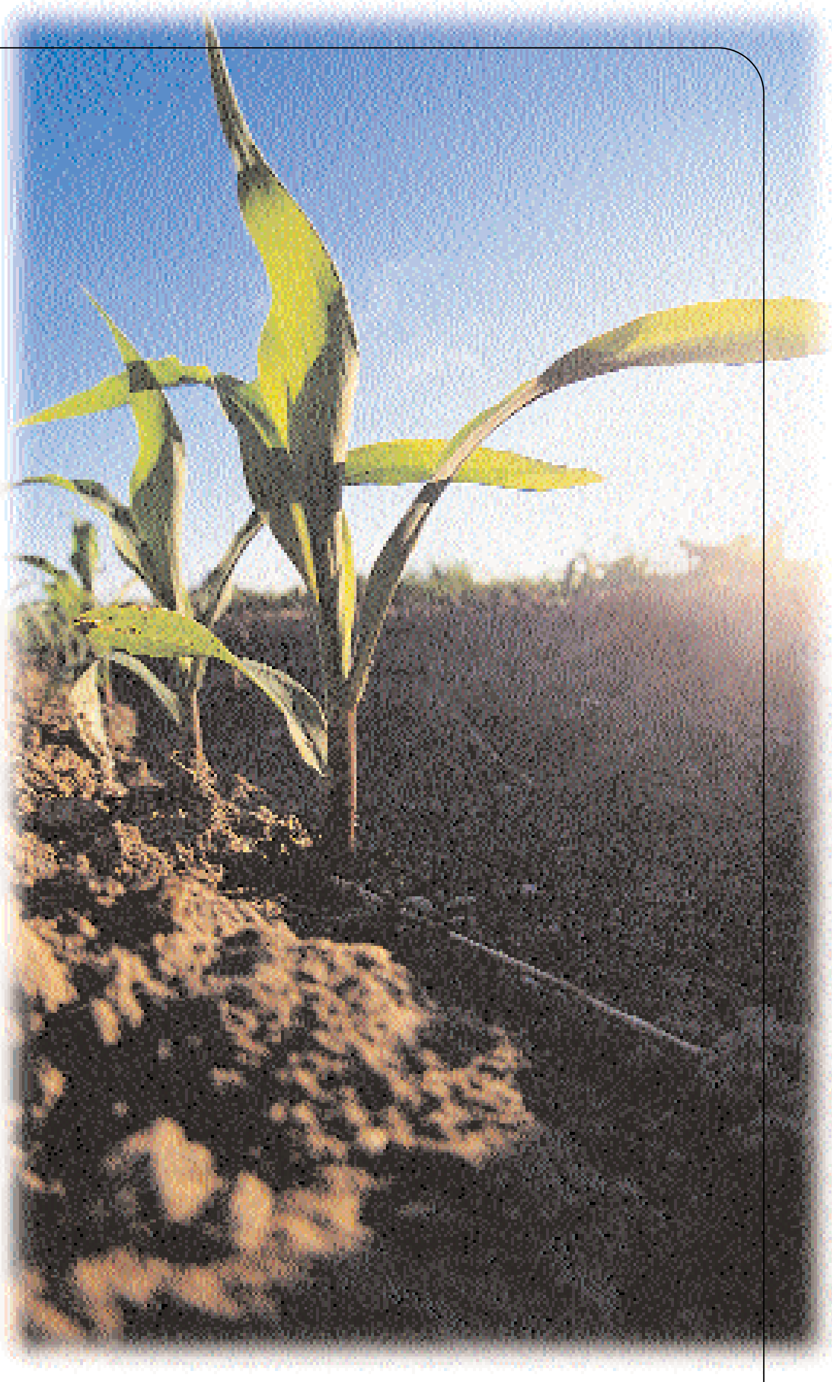

A FIELD GUIDE *for* ON-FARM RESEARCH EXPERIMENTS

The Cooperative Extension Program
North Carolina A&T State University

NC STATE UNIVERSITY
A&T STATE UNIVERSITY
COOPERATIVE EXTENSION
Helping People Put Knowledge to Work

GLOSSARY *for On-Farm Research Experiments*

Data: Data is information that you collect in a research experiment. The data can be quantitative *(numerical, e.g., pounds of yield)* or qualitative *(evaluative, e.g., superior, good, fair, poor).* Yield data from a crop is commonly collected to compare different varieties or practices.

Treatment: A treatment is a production practice that you want to investigate. Usually, an on-farm experiment compares two practices: the standard practice and a new practice. For example, you may want to compare: 1) the yield from a standard variety of beans with the yield of a new variety; 2) full tillage vs. strip-tillage; or 3) starter fertilizer vs. no starter fertilizer.

Block: A block is the basic unit of an experiment. A block contains two *(or more)* different treatments in a side-by-side comparison. A block is one replication of the comparison of treatments.

Replication: A replication is a side-by-side comparison that is identical to and takes place in the field at the same time as the original side-by-side comparison. Normally a research experiment has four to six replications *(equivalently, 4 to 6 blocks)*. The more replications that you have in your experiment, the more confident you can be in the results. The replications should be as similar as possible with respect to field conditions and agronomic practices.

Plot: A plot is an area of specific length and width *(such as 4 rows or 2 plant beds that are 100 feet long)* where a treatment takes place.

Guard Rows: The outer rows, called guard or buffer rows, protect the inner rows from the influence of different treatments in neighboring plots. Data is usually collected from inner rows in the plot.

Randomization: In a side-by-side comparison, randomization assigns Treatment 1 and Treatment 2 to their field position within a block *(e.g. to the left or right of each other)* by chance, such as by the flip of a coin.

Variability: Variability describes how conditions change in the experimental field. For example, there might be wet spots in the field or the topsoil might get deeper as we move down the slope. Since most fields are variable, we replicate and randomize to minimize the variability within a block. Variability can influence the response we see from the treatment *(data)*, and therefore the conclusions we draw from the experiment.

Statistics: Statistics is a mathematic way of comparing the data collected in all the replications. It allows us to draw "scientifically valid" conclusions from our comparisons.

INSIDE

A Field Guide for On-Farm Research Experiments

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WHAT WILL I GET FROM ON-FARM RESEARCH?

Farming is a challenging occupation. If the weather isn't giving us a headache, other problems or puzzling questions always crop up. Sometimes solutions or answers are provided to us by friends, neighboring farmers, county agents, or from other agricultural professionals. But other times answers are not readily available. The question or problem we have may be peculiar only to our own situation or specific to our own site. No one may have any answers.

In all probability, others may have asked similar questions. They, too, may be frustrated that answers are not available. For example, university researchers recommend a new bean variety. If it yields poorly in one particular county, growers in that county will probably want some answers. Are the soils or the climate different causing lower yields? Are "conventional" soil and fertility management practices in that particular county inappropriate for the new variety.

Say your neighbor is promoting a "hot new bean variety" with "higher yield." How does your neighbor know that it will produce a higher yield than the standard variety? Did the seed company representative say so? Was this claim based on scientific research? Or did your neighbor grow that variety to see for himself? Can you expect to see higher yields on your farm, also?

Here's another example: Every year you apply an herbicide, for weed control, before planting beans. You usually follow this application with a second herbicide application after weeds come up later in the season. Herbicides are expensive and you've often thought, "What if I skip the pre-plant herbicide to save money?" How will you determine if this is an effective strategy that will save you money, but still give you the yield you expect?

These examples present situations where growers may want to do their own on-farm research. They seek answers to their own questions, or, when there are questions common to a community, they may work cooperatively with other farmers. When farmers do research on their own farms, they are, in effect, taking responsibility for solving their own problems.

In actuality, farmers are always engaged in some type of research on their farms. They try something new *(tillage practice, fertility scheme, variety, etc.)*, observe the effects of that new thing *(effects on yield or income)*, and draw conclusions from what they observe *(the new practice is or is not worthwhile)*. On-farm research can be as simple as an observational study. With a little more work, growers can increase the certainty that the conclusions they draw from their observations are correct. Thus, they can reduce the risks associated with making changes that have potential for increasing farm profitability.

WHAT ARE THE DRAWBACKS TO ON-FARM RESEARCH?

Make no mistake, on-farm research requires planning to get the information you seek. It may also require some additional effort and time. You will need to remember to perform research tasks on time. Unfortunately, many of those tasks will take place during a very busy harvest period. This is usually the case when you are collecting yield information to answer your research question. Extra work may be required at this time. For example, harvested crops from each research plot must be weighed separately.

The project itself can be somewhat risky. Recognize that your research may not provide any useful information in a single year. You may discover that the old variety or the "tried and true" practice is best. If a large area on the farm has been dedicated to the research, there may be a substantial investment in research that merely validates current practices.

The research may even result in a total crop failure. That great new variety your neighbor told you about might grow like gangbusters in a year with normal rainfall. But it may fail miserably when conditions are drier. The standard variety may perform reasonably well in wet and dry years. Often this explains the reason it is a "standard variety." The use of smaller plot sizes helps to limit any financial risk to capital and labor that may accompany any experimental "misfortune."

You *(or someone you know)* must be able to do some simple math to make sense of the information *(data)* you collect. This is so that you can get a scientifically reliable answer to your research question and have confidence that the answer you get is correct. Fortunately, there are some simple worksheets that can be used to do the mathematics *(statistics)* that only require a calculator. Or, for those with computers, a very simple program — where you "fill in the blanks" — can do the statistical calculations for you.

WHAT QUESTION DO YOU WANT THE RESEARCH TO ANSWER?

Beginning, on-farm researchers should keep research projects simple and choose just one question to answer. Commonly, the question will ask whether a new way of doing things is "better" in some way than the current way of doing things. The answer to that question will either be "yes" or it will be "no." For example, your research question might be "Will this new bean variety produce a higher yield than the standard bean variety that I usually plant?"

The answer in this simple variety trial will be either, "yes, it does" or "no, it doesn't." Obviously, if the answer is yes, there is an opportunity to increase farm income by planting the new variety of beans. If the new variety yields five bushels more per acre than the standard variety, income could be increased by over $20 per acre!

Most farmers have some experience with variety trials like the one described above. There are many other yes/no questions that can be investigated in on-farm research. Here are a few more common questions that growers can ask to increase farm income:

- **Will my yield increase if I irrigate my sweet corn?**
- **Can I substitute a green manure cover crop for commercial fertilizer without lowering yield?**
- **Can I eliminate a particular pesticide application and increase my bottom line per acre?**
- **If I plant my pumpkins no-till, will my yields be reduced?**

Think about the research question as a comparison. The examples above compare two practices: 1) irrigation vs. no irrigation; 2) a cover crop vs. commercial fertilizer; 3) pesticide vs. no pesticide; and 4) tillage vs. no tillage. In each case the practices compared are called "treatments" and the on-farm research will compare Treatment 1 with Treatment 2.

FIELD VARIABILITY

In a very simple variety trial *(Figure 1)*, we could plant half of a field to a new variety of beans (Treatment 1) and the other half of the field to the standard variety of beans (Treatment 2). We would harvest beans from Treatment 1 and weigh them. Then we would harvest the beans from Treatment 2 and weigh them. Finally, we would dry the beans because the treatments may have differing amounts of moisture. If the "dry weight" yield of the new variety is greater than the standard variety, then we might conclude that the new variety is better.

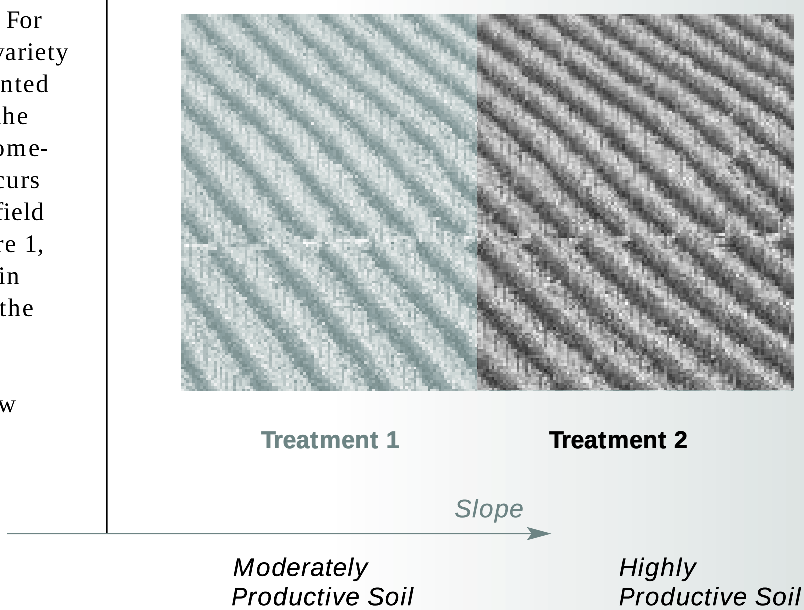
How can we be sure that any difference such as higher yield in the Treatment 2 plot is because of the variety or practice? The answer is that we can't. There may be other reasons that explain the difference in yield. For example, the new variety may have been planted in better soil than the standard variety, something that often occurs when the soil in a field is variable. In Figure 1, the Treatment 2 is in better topsoil than the Treatment 1 plot. We can naturally expect crops to grow better there.

Field variability can be present when:

- **Erosion has moved the topsoil down slope in the field**
- **Wet spots are present in the field**
- **Soil moisture increases from one end of the field to the other**
- **The soil may vary from sandy to loamy to clayey throughout the field**
- **Parts of the field get afternoon shade**
- **Weed pressure is higher in one part of the field**
- **Bean-eating deer feed in the section of the field nearest the woods**

If we are merely curious about how a new variety will perform or if a new practice is better than an old one, a side-by-side comparison may give us all the information we need. In this kind of observational study, however, we cannot be certain that field variability didn't bias the results that we observe. For an observational study, we should always try to pick a field site that is as uniform as possible. If we want to reduce the chance that variability influences results and to be more certain in our conclusions, we need to have several replications or blocks.

Figure 1.
Side-by-side observational experiment.



REPLICATION

On-farm research experiments are "replicated" to address the issue of field variability. To have confidence in our answer that "yes the new beans are better," or "no they aren't," we normally repeat the experiment four to six times! This doesn't mean that we need to repeat the experiment for six years. We usually conduct all six at the same time, in the same field, and in the same year. Because weather can affect crop performance, we often conduct the experiment two years in a row.

Each repetition *(or replicate)* is called a block. Taken together, four rows of a new variety of beans *(Treatment 1)* and four rows of the standard beans *(Treatment 2)* are a block. Four more rows of Treatment 1 and four more rows of Treatment 2 create a second block. And four more rows of Treatment 1 and four more rows of Treatment 2 create a third block. We usually continue creating new blocks until we have a minimum of four blocks and, preferably, a total of six.

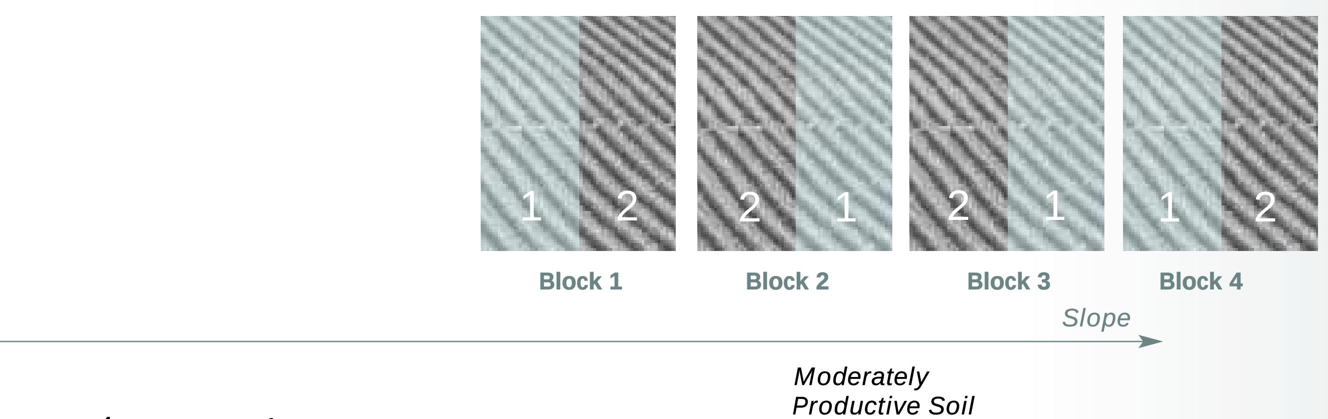
Even with replication, in a replicated experiment, we can expect the yields in six different Treatment 1 plots to be different from one another because of field variability. The same is true in the Treatment 2 plots. When we have six blocks, we may even see that Treatment 1 yields are greater than Treatment 2 yields in some blocks, but not in others. Replication helps us decide whether the treatments themselves caused the yield differences. It helps us to rule out field variability or some other random event as the cause of any difference.

RANDOMIZATION

We also address field variability by randomizing the treatments in each block. By mixing up the placement of the two treatments in each block, we adjust for any advantage the left or right position might enjoy. In Figure 1, the soil gets better as we move down the slope. If we place the blocks side by side down the slope, and if we always place Treatment 1 on the upslope *(left)* side of each block, Treatment 1 will always have better soil than Treatment 2. So we randomize the treatments in each block so that we have an experimental blueprint like that shown in Figure 2.

In on-farm research we try to avoid any influence of field variability by replicating and randomizing within each replication. Notice in Figure 2 that there are six blocks. Each block is identical because it compares Treatment 1 with Treatment 2. However, the positioning of the treatments in each block is not identical. Sometimes, Treatment 1 is on the left side of the block, and sometimes it's on the right side. You can assign a side for Treatment 1 in each block by tossing a coin: "heads, it's left," and "tails, it's right."

Figure 2. Replicated and randomized side-by-side experiment



PLOT SIZE AND DATA COLLECTION

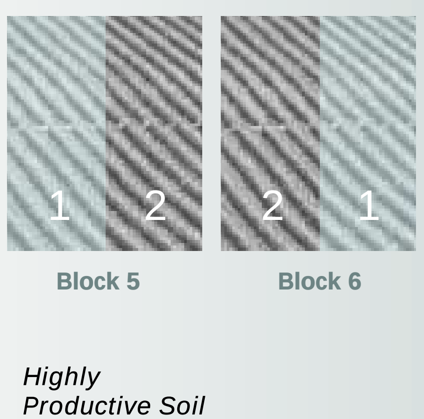
The size of the treatment plot is determined by the size of the equipment you will be using to do the fieldwork, in particular, harvesting equipment. For example, if you are using two-row equipment, the plots will need to be at least four rows wide. In a four-row plot, the two-row harvester picks the two middle rows to get yield data. The outer row on either side is called a guard row. The guard rows protect the inner rows from the influence of different treatments in neighboring plots, and are not harvested when collecting yield data.

Guard rows are most important in experiments where one treatment may affect the other. For example, a strawberry grower may want to compare two practices for managing gray mold in strawberries. Treatment 1 might be a pesticide application and Treatment 2 might be the removal of dead leaves that carry the mold through winter dormancy. Since the pesticide spray might drift from the spray treatment to the leaf removal treatment, at least one row of strawberries should be left as a guard row between the treatments. After all the yield data is collected from all the plots, the guard rows can be harvested.

When working with bedded crops, such as strawberries, two beds commonly make up one plot. Harvest data is collected from the inside rows of each bed. When hand-harvesting crops planted in single rows, data is sometimes collected from one row. In this case, the harvested row usually has guard rows *(or guard beds)* on both sides.

The length of the plot is commonly the length of a row *(row crops)* or a bed *(vegetable crops)*. However, you can decide for yourself how long the plots should be to provide a representation of a field situation.

Place the harvested product from each treatment in a separate bag or container. In a block with two treatments there will a bag for each treatment. In an experiment with six blocks you will have two bags in each block and the total number of bags will be 12 *(2 treatments X 6 blocks = 12 bags)*. Label the bags so that you will remember which treatment and block each one belongs to. Weigh the bags and record the weights. In some cases, the bags of harvested product will be completely dried after harvest. As drying proceeds, moisture will be lost from the product and it will lose weight. When dry, the bags will be weighed again to get a "dry weight."



COMMON QUESTIONS

Who might be able to help with the research?

You would be surprised how many people would like to help you with your on-farm research project. In many counties, Extension agents participate in on-farm research projects. Contact your local county agent for help. Your agent has likely had some training in on-farm research and would be happy to participate in your project. County agents have resources that will be of value, too. They have access to libraries at universities, and those universities may have reports of research that may be similar to what you have planned. Or, those reports may provide information on where to get more information.

Other agricultural professionals will also be willing to help. State Departments of Agriculture, the Natural Resources Conservation Service, other farmers, and farm organization employees have a wealth of information to share. Call on them to help you with your project. The World Wide Web has created a treasure trove of information that can be searched from a home computer. Most public libraries have computers that are connected to the Internet.

What research methods can I use to insure that the answers I get are true?

Replicate your experiment by comparing the treatments in four to six separate blocks and randomize the placement of treatments in each block. Replication and randomization will account for any differences between treatments that may be caused by field or other sources of variability.

Treat all the research plots in the same way. The only difference between any plots is the treatment. Unless they define the treatments under study, planting date/depth/spacing, tillage,

fertilizer and pesticide inputs, and harvest dates should all be the same. If nothing is different except the treatments, then any differences between the treatments are likely to be the result of the treatments.

This will help you get the best answer to your question.

Sometimes we want a research question to be answered in a certain way. For example, we may want a new variety that we "discovered" to be a humdinger, and we may give it extra special care relative to a common variety we're comparing it to. Take care that any bias does not influence the way you manage the experiment.

If I am collecting yield information, what precautions should I take at harvest?

Keep the harvested product from each treatment plot in every block in a separate container and weigh each treatment separately. Do not combine the product from all Treatment 1 plots nor from all Treatment 2 plots. You will need the results from the separate treatment plots for a statistical analysis of the data.

Can I share my conclusions with others?

By all means share your information with other farmers. But, be sure to share your "confidence" in the information at the same time. You can be most confident if you have replicated the experiment and randomized the treatments in each block.

For example, is it appropriate to recommend a new bean variety to your neighbor based on one side-by-side study on your farm? If the neighbor makes a decision to plant his whole farm to this improved variety next year, and he goes belly-up when the crop fails, how will you feel?

When you make a recommendation from on-farm research, you want to be confident that the higher yield was because one variety was better than another, and not because of some other factor. You do not want to have to wonder, following your experiment, if the higher yield was a result of sowing the test variety in a better field, or because of better weather the year the test variety was planted. Nor do you want to be left to wonder if the test variety might have produced better yield because it was given more care and attention than the old variety.

By all means, share information from your experiment with other farmers. But be aware that the more blocks you have, the more confident you can be that what you observed is scientific fact.

This is especially true if you have randomized the treatments in each block.

You can be even more confident in a recommendation if you have conducted the experiment in multiple years.

How important is picking out a site for my research?

Site variability is critically important in a research experiment. The more uniform the site *(soil, slope, moisture, etc.),* the better. Experimental sites usually vary in some way, and we try to overcome this difficulty by replicating the experiment many times in separate blocks.

We randomize treatments (left/right or right/left) in each block to account for variability in the block.

STEPS TO A SUCCESSFUL RESEARCH PROJECT

1. Put your research idea into a question. The question usually turns out to be a comparison of two treatments, and takes the form of, "Is Treatment 1 better than Treatment 2."

2. Decide what data you will collect. In most cases this will be the yield of each treatment, but it also could be other information, such as the number of diseased plants in the plot or the number of insect pests on 10 randomly chosen plants.

3. Describe what each treatment will be and a plot size that will be representative of a field situation. Remember that all farming activities will be the same for both treatments. Any differences you observe *(such as increased yield)* will be because of the difference in the treatment and not because of difference in the way that each treatment is managed.

4. Decide how many replications you want. Remember that the more replications that you have, the more confident you can be in your results and conclusions. After deciding how large treatment plots will be, make a map showing how the replications (each containing two treatment plots) will be laid out in the field. Within each replication, conditions such as slope, soil texture, exposure, drainage, etc. should be as uniform as possible. Though it is desirable for conditions in all replications to be uniform, this is usually not possible.

5. On the map, place the treatment plots side by side in each replication. Flip a coin to decide which treatment plot is on the left side of each pair. If the coin toss is heads, put Treatment 1 on the left, and if it's tails, put Treatment 2 on the left side. If the blocks themselves or the treatment plots within the blocks are separated from each other by buffer zones, be sure to include these buffer areas on your map.

6. With a tape measure lay out the plots in the field. Mark the corners of each treatment carefully, so you can find each plot later in the season when the crop *(and weeds!)* may have obliterated the original perimeter. You may want to use different colored flags for different treatments.

7. Outline your management practices (planting rates, fertilizer, pesticide applications, tillage) for the crop and the dates you expect to complete each practice. This is the time, before you get into the field, to plan how the work will get done during busy periods such as planting and harvest. Will the crop or the test be planted first? Will extra equipment or labor be needed? Who is going to do what tasks?

8. When you plant the crop, remember to randomize the treatments in each block.

9. Don't trust your memory. Keep accurate records of everything you do for the crop and when you do it. Record information about rainfall and any unusual weather *(storms, wind, or hail)*. If the plan changes *(e.g., fertilizer rates)*, record the changes and the reasons for them. Sometimes facts that don't seem very important at the time become very important in understanding why something did or didn't go the way you expected.

10. Gather your data. If you are gathering harvest information, plan for enough time to keep harvested product from each treatment in each block separate.

11. Evaluate the experiment. You can get help from Cooperative Extension for a statistical evaluation of the data you collect.

1. Keep it simple. Start with a simple comparison, with a limited number of treatments. It is far better to have a simple trial that yields clear results, than a complex trial where results are confusing. Starting with a simple research question is crucial. Rather than attacking a complex question all at once, most complex issues can be broken down into a series of simpler ones.

2. Plan for busy periods. The most crucial times for a field experiment are also the most crucial time for the crop. Planning the experiment during planting season and taking data during harvest can both be very difficult, and require time when farmers least have it. Plan the experiment well in advance, and note how things are going to happen when the time gets short.

3. Watch for unexpected results. Changes in production practices often result in changes that we don't anticipate. These changes can be good, such as reduced pest pressure when soil organic matter is increased, or bad, such as the emergence of a non-target pest. Close and periodic observation can yield important information.

4. Know how much confidence you can have in the results. Good design and numerous replications can increase your confidence in the results. Remember that results can vary from year to year. It is important to have a long-term perspective, and to wait until several years worth of data is collected before drawing conclusions.

5. Manage risk. Field experiments are a method for managing risk. If done well, they can give farmers a method for evaluating new production practices on a limited scope, reducing the chance of adopting a practice that doesn't work. Take care that the size of the experiment itself does not add too heavily to the risk level. One rule of thumb is that a field experiment needs to be big enough that the farmer cares about the result, but not so big that they lose sleep worrying about the money wrapped up in it.

6. Get help. There are many agencies and individuals who will be interested in the results of your research. Don't hesitate to ask them for help. The Cooperative Extension Service, the Natural Resources Conservation Service, the North Carolina Department of Agriculture Agronomic Division, crop consultants, non-government organizations or university researchers may all have some interest in assisting you in your work. Just make sure that you ask as far in advance as possible to give them time to include it in their planning.

STATISTICS

We can examine yield data to get answers to our research questions with some mathematics called "statistics." Importantly, statistics confirm the answer to our research question, and tell us how reliable that answer is.

What purpose do statistics serve? Most of us have heard the expression "on any given Sunday." It has to do with professional football. The "odds" may be that a superior team is going to beat an inferior team every time the two teams play. But "on any given Sunday," the opposite may happen. By luck, chance, or circumstance, there is a certain probability that a terrible team will beat a division leader. It might be a fluke play that brings defeat, or an injury to the quarterback.

Statistics allow us to account for flukes. Statistics take into account the chance that something may go unexpectedly 5% of the time. In other words, if we watch the two teams play over and over and 95% of the time one team wins, we can be confident that they are the better team. The same thing is true with on-farm research: If we get the same result or answer to our research question 95% of the time, statistics tell us that we have a valid, scientifically "proven" answer. When we have six replications of the research experiment, we can gather enough information to tell us whether we can expect the answer to our question to be the same 95% of the time.

To calculate the experimental statistics, you will need a hand calculator that will give you the square root of a number. Follow the steps outlined below.

Begin the statistics by filling in the data for each Block.

Block	Column 1 Treatment 1 data	Column 2 Treatment 2 data	Column 3 Column 1 - Column 2
1			
2			
3			
4			
5			
6			
Average			

1. Put the data *(for example, yield)* for Treatment 1 in Column 1.

2. Put the data for Treatment 2 in Column 2.

3. In Column 3, subtract the number in Column 2 from the number in Column 1. *(Some numbers in Column 3 may be negative, which is completely normal.)*

4. Calculate the AVERAGE of each column. You do this by adding up all the numbers in each column *(positive and negative)* and dividing by the total number of blocks *(in this case we have six blocks).*

5. Copy the numbers from Column 3 into Column 4 *(except the Column 3 AVERAGE DIFFERENCE).*

6. Copy the Column 3 AVERAGE into each and every row in Column 5 *(this will be the same number every row).*

7. In Column 6, subtract the number in Column 5 from the number in Column 4. *(Minus numbers can be tricky. Remember that (-5) - 5 = - 10. But also remember that subtracting a minus number is the same as adding the number. For example, (-5) - (-5) is the same as (-5) + 5 and that this sum = 0.)*

8. In Column 7, square the number in Column 6 *(multiply it by itself)*. Note that a negative number "squared" is a positive number; for example (-10) x (-10) = 100.

9. Add all the numbers in Column 7.
Record this value

10. Subtract 1 from the number of Blocks.
Record this value

11. Divide the number from Step 9 by the number in Step 10.
Record this value

12. Divide the number from Step 11 by the number of Blocks.
Record this value

13. Take the square root of the number from Step 12.

Record this value

14. Multiply the number in Step 13 by one of the numbers from Table 1 on page 12. The number you choose depends on the number of blocks in the experiment and level of confidence you want in the statistics *(90% or 95% confident that the answer to your research question is correct).* This number *(called the LSD or Least Significant Difference)* is:

The scientific method does not require 100% certainty for us to draw firm conclusions. Normally, we allow for random or chance errors and events to create false results in an experiment 5% of the time *(1 out of 20 times)*. For example, in a field, test bean A and bean B can be expected to differ by an amount as large as the LSD 5% of the time just by chance. If we can predict from statistics that our data support a conclusion that is 95% certain *(allowing for a 5% error)*, then we can be confident that we are giving people *(ourselves included)* good information when we report our results.

Statistics allow us to calculate the LSD, which tells us how large the difference between treatments needs to be to: 1) account for possible errors and random events, and 2) to provide for a 95% certainty that the difference is real or *(in scientific terms)* significant. The LSD is the smallest difference between treatments that is meaningful. If the AVERAGE DIFFERENCE between treatments *(that we calculated above)* is smaller than the LSD, it's too small a difference to draw any conclusions from the experiment. That is, it's a small enough difference that it could have been caused by chance or error. If the AVERAGE DIFFERENCE is higher than the LSD, it's too large a difference to be caused by chance or error alone. We can be more than 95% certain that the difference between treatments is real.

LSDs can be thought of as "passing grades." To pass our experimental test, the AVERAGE DIFFERENCE must be at least as large as the LSD. If we can live with greater uncertainty, we can calculate the LSD at the 90% confidence level. It expresses the difference between Treatments 1 and 2 that we can expect to occur by random chance 10% of the time. This LSD will be a smaller number than the 95% LSD; thus it takes a smaller AVERAGE DIFFERENCE between treatments to pass the test. However, in this case we have only a 90% confidence level that the difference is significant or real. Anything less than 90% certainty is usually not considered scientifically valid.

15. Compare the AVERAGE DIFFERENCE *(Column 5, step 6)* with the LSD calculated in Step 14. In order for any differences observed between treatments to be significant, the AVERAGE DIFFERENCE must be greater than the LSD. If the AVERAGE DIFFERENCE is greater than the LSD, then the treatments are significantly different. In the case of our bean A vs. bean B experiment, whichever variety has the higher average yield is the more productive variety. If it's less than the LSD, we say that there is no significant difference between treatments. In the latter case, we can't say with scientific certainty that one treatment *(bean A)* performs any better yield-wise than the other treatment *(bean B)*, even though data from all of the blocks of one treatment may be higher than in the other treatment.

Software programs are available that will do statistical calculations for you. Most spreadsheet programs will perform a simple statistical analysis after you type in your data. For more information, contact your county Extension agent.

Block	Column 4 Copy from Column 3	Column 5 Average	Column 6 Column 4 - Column 5	Column 7 Column 6 x Column 6
1				
2				
3				
4				
5				
6				

EXAMPLE STATISTICAL CALCULATION

Block	Column 1 Treatment 1 data	Column 2 Treatment 2 data	Column 3 Column 1 - Column 2
1	190	165	25
2	210	180	30
3	180	185	-5
4	190	170	20
5	185	180	5
6	195	180	15
Average	191.7	176.7	15

A grower wants to determine the effect of compost tea spray on plant pathogens of strawberry fruit. In a randomized and replicated experimental field (with buffer beds between treatment beds), she collects yield data from six beds that were sprayed with compost tea (Treatment 1) and six beds that were not sprayed with anything (Treatment 2). She calculates her statistics as follows:

1. She puts the yield data for Treatment 1 in Column 1.

2. She puts the yield data for Treatment 2 in Column 2.

3. In Column 3, she subtracts the number in Column 2 from the number in Column 1. *(Some numbers in Column 3 are negative, which is completely normal.)*

4. Next, she calculates the AVERAGE of each Column. She does this by adding up all the numbers in each column *(positive and negative)* and dividing by the total number of blocks *(in this case we have six blocks).*

5. Then she copies the numbers from Column 3 into Column 4 *(except the Column 3 AVERAGE DIFFERENCE).*

6. She copies the Column 3 AVERAGE *(15)* into each and every row in Column 5 *(note that the number 15 is placed in every row in Column 5).*

7. In Column 6, the grower subtracts the number in Column 5 from the number in Column 4. *(Minus numbers can be tricky. Remember that (-5) - 15 = -20.)*

8. In Column 7, she squares the number in Column 6 *(multiplies it by itself).* Note that a negative number squared is a positive number; for example (-10) x (-10) = 100.

9. She adds the numbers in Column 7. This value is: 850.

10. She subtracts 1 from the number of Blocks. This number is 6 - 1: 5.

Table 1.

# of Blocks	90% Confidence	95% Confidence
4	2.35	2.78
5	2.13	2.57
6	2.02	2.45

Block	Column 4 Copy from Column 3	Column 5 Average	Column 6 Column 4 - Column 5	Column 7 Column 6 x Column 6
1	25	15	10	100
2	30	15	15	225
3	-5	15	-20	400
4	20	15	5	25
5	5	15	-10	100
6	15	15	0	0

11. She divides the number from Step 9 by the number from Step 10. This value is 170 (850/5).

12. She divides the number from Step 11 by the number of Blocks. This value is 28.3 (170/6).

13. Using her pocket calculator, she calculates the square root of the number from Step 12. The square root is 5.32.

14. From Table 1 (below), she chooses a multiplier. Since she had six blocks and wants to be 95% confident that her results are significant, she chooses 2.45. She multiplies the number from Step 13 by 2.45 to get the Least Significant Difference (LSD). This value is 13.04 (5.32 x 2.45).

15. If the AVERAGE DIFFERENCE between the two treatments that she calculated above is less than this LSD, there is no statistical significant difference between the mean yields of each treatment. If the AVERAGE DIFFERENCE is greater than the LSD, then there is a statistical difference between the two yields.

16. When the grower compares the AVERAGE DIFFERENCE from Column 5, Step 6 (15) with the LSD calculated in Step 14 (13), she finds that the AVERAGE DIFFERENCE is greater than the LSD. She concludes with confidence that the compost tea treatment increased yield.

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