Does that new product really work? The basics for conducting on-farm research

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New products and farming practices related to agricultural production are coming to market every season. Regionally or locally specific (and non-biased or objective) data for many of these techniques or products is often limited or non-existent, and questions do arise if research conducted at select locations using specific practices will still be applicable in other environments with different production practices (i.e., tillage, soil type and fertility levels, cropping sequence). Because each farm (and field) is unique, it may be difficult to make large-scale management decisions for many acres based on the available information. One of the options open to producers is conducting on-farm large-plot strip trials to evaluate a new "improved" agricultural product or practice side-by-side with the conventional practice. The advantage of these experiments is that the data generated is locally specific, they can be tailored to address specific questions, and they can be used to help inform farmers and industry professionals prior to making a management decision that might impact a large acreage. The objective of this chapter is to introduce some basic concepts for on-farm experimental design and basic analysis tools to help industry professionals and growers correctly produce locally or regionally specific data to evaluate new products and production practices.

Determining your goal, research question, and treatments

Before establishing a research trial, you or your client must identify the goal or purpose for conducting the trial. Often, there is a question that you wish to answer such as:

- Will using product "X" increase my yield?
- Will production practice "Y" impact my plant date next spring?
- What rate of product "Z" will give me the best result?
- How does product "A" compare to product "B"?
- Will an application of product "C" pay for itself in yield gain at the end of the season?

Once a goal or a question has been identified, a treatment list can be designed to address the research question. A treatment can be defined as any imposed factor (i.e., seed treatment, growth regulator, variety, seeding rate, fungicide application) that will potentially impact the answer to the question asked. One treatment in every trial likely will be some sort of control (i.e., current production practice) to allow for assessment of the new practice to the current practice. Additionally, the goal can determine what data should be collected during and after the season to answer the question (i.e., emergence, disease level, yield).

Typically two to three treatments are adequate to answer the question of interest for most on-farm trials, but more treatments may be necessary depending on the question. For example, determination of the optimal application rate of a new product may require 4 or 5 treatments (control plus 3 to 4 different product rates). All other management factors for the trial should be kept constant to maximize your ability to detect the treatment effect. Multiple factor designs are more complex and can require more complex analysis methods. Manipulation of too many factors can also confound the results and make treatment effects more difficult to detect. Please consult with your local extension agricultural educator or agronomist prior to implementation to ensure your trial and treatment design is adequate to address your question.

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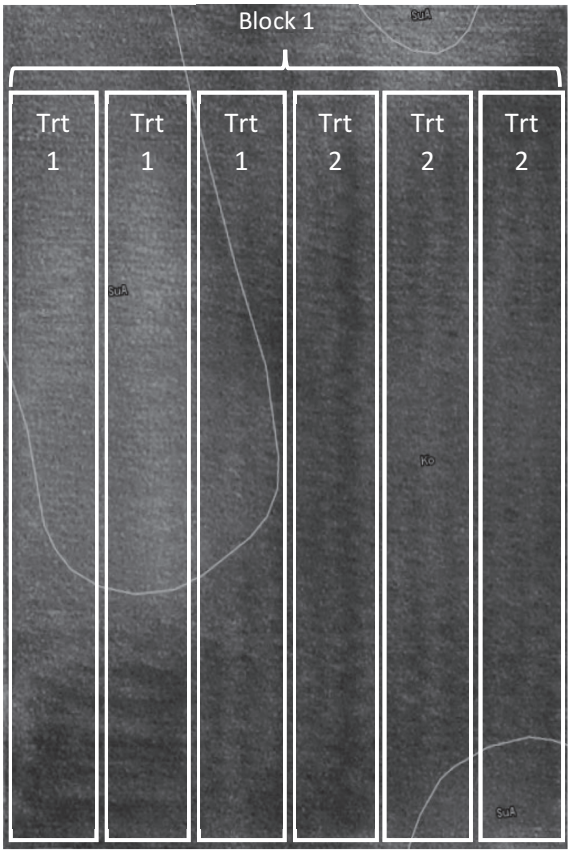
Trial design and replication are key

To be a valid study, the treatments need to be compared side-by-side within the same field (randomization) and be repeated multiple times within the study (replication). Often it is helpful to have a base-line or control treatment, which is typically the current practice for comparison to the new proposed practice. Splitting a field in half and applying the same treatment in adjacent strips may be tempting, but this does not provide true randomization or replication (Figure 1A). Repeating a treatment within the same field half provides "pseudo-replication," and each strip acts as a subunit within a larger treatment unit. Inherent differences within the field (i.e., slope, texture, cropping history) could also give one treatment a yield advantage that may be due to field variability rather than a true treatment effect. Randomizing your treatment passes within the same field will decrease the likelihood that unseen, or unplanned, factors such as environmental variability will affect your ability to detect true treatment differences (Figure 1B).

A) An incorrect treatment layout. Each box represents one pass.



B) A correct treatment layout. Each box represents one pass.

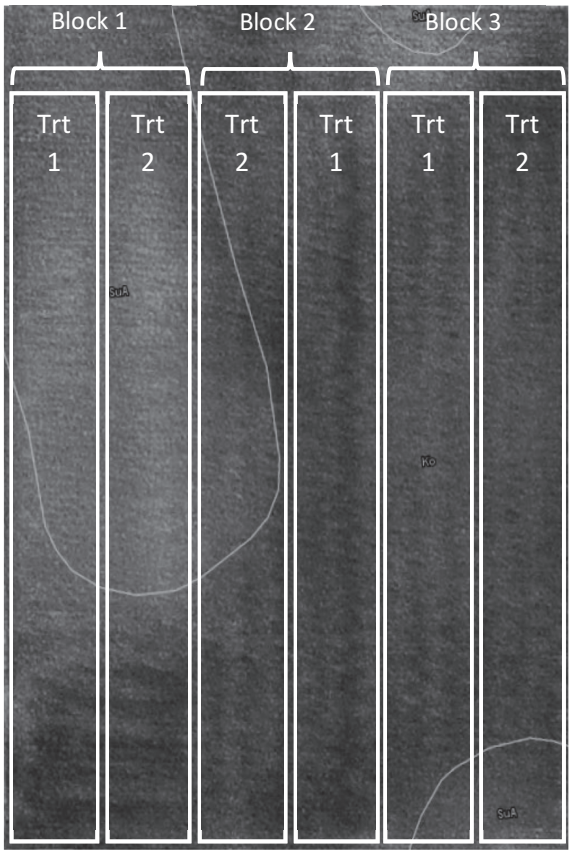


Figure 1. Each design contains three passes of each treatment (Trts 1 and 2), but have major differences in the power of the data collected. **A)** Applying a treatment in adjacent strips may be easier, but inherent differences in the environment may give an advantage (bias) to one of the treatments. In this example, Trt 1 was planted in an area with lighter soil and Trt 2 was planted in a darker soil. Any differences between the treatments may be due to the soil properties rather than a treatment effect. This design provides "pseudo-replication" because there is one large group of each treatment made of three smaller passes, and is incorrect because it only provides one true block (field replication). **B)** Randomizing strips of each treatment within the same field reduces bias, and increases the likelihood of detecting treatment differences. Each treatment pair is a block or replicate.

Each group of treatments can be called a block in the field (Figure 1B). One of the most common designs implemented in field research is the Randomized Complete Block design (or RCBD), which means: (i) each block (or replicate) contains a full set of treatments; (ii) the treatment order within each block is randomized; and (iii) the differences within the block between treatments is expected to be less than the differences between the blocks. Blocking also allows for some control of the environmental variability, which can increase the discernment of treatment differences. Each block should be planted at least three times to ensure adequate replication of each treatment. Replicating the blocks in multiple areas of the field will allow you to evaluate the treatments in different microenvironments, and can increase your ability to use the information to make management decisions. In Figure 1B, Block 1 allows both treatments to be evaluated in the lighter soil type, and Block 3 allows for the same comparison in the darker soil type. The position of each treatment within each block is also randomized to decrease bias in the trial. Flipping a coin to determine treatment order in each block is a simple way to randomize your treatments in a two treatment study. Additionally, there is an app that has been developed by researchers at The Ohio State University designed to help establish a randomized and replicated treatment design, organize on-farm trial data and allow for real-time data entry, as well as perform some basic statistical analysis for an RCBD trial. The app is called "Ohio State Precision Led On-Farm Trial Support", or "Ohio State PLOTS" for short, and is available for both iOS and Android devices.

Designing your plot width to align with your treatment applicator (i.e. planter, tillage implement, sprayer) and harvester (combine swath, planter width) is an easy way to design a strip trial with minimal adjustments come evaluation time. Plot length should be pre-determined and uniform across treatments. Differences in plot length can influence yield from that harvest pass, which could impact your results. Keeping strip length consistent will minimize this error. If the field is variable in its width due to a non-conventional shape, it is better to make the plot length of each strip the same as the smallest pass length to allow for fair comparisons. The increased use of georeferencing tools such as GPS and yield mapping may enable producers to maintain and mark plots without needing to physically mark them in the field.

So how do I make sense of the data?

Conducting on-farm research is most helpful when you can compare the treatments and make management decisions based on the results from the trial. Analyzing the data can help provide confidence that any observed differences are truly due to the treatment and not just to chance. For more information regarding statistical terminology as well as more information on why statistics can be used to help interpret data in agricultural research, please consult the 2016 Ohio State University fact sheet "Statistics and Agricultural Research" available at ohioline.osu.edu. A spreadsheet tool such as Excel can be used to organize trial data as well as run some basic statistics, but the analysis capability of Excel is typically limited to a single trial in a single year. Completing multiple years of a trial across multiple fields can test a new product in a wide range of environments in a relatively short amount of time, but the analysis for this type of dataset is more complex. Prior to conducting data analysis, please consult with your extension agricultural educator or agronomist to ensure you are conducting the correct tests for the research goals and treatment design.

Excel can be used to calculate basic statistics, such as averages (mean), paired t-tests, variance, and standard deviation. Additionally, the statistical values calculated by Excel can be used to determine the "least significant difference" (LSD) value for a trial. In versions of Excel 2003 and later, there is an "Add-in" option for Excel that enables you to conduct simple statistics using the "Analysis ToolPak." In order

to load the ToolPak into your specific version of Excel, search a phrase similar to “installing data analysis toolpak in Excel” in a search engine for step-by step instructions. For newer versions of Excel, this can typically be achieved by going into the File >> Options >> Add-Ins; within the Add-Ins menu in the “Manage” box, select “Excel Add-ins” from the drop-down menu, and click “Go”. In this menu, select the “Analysis ToolPak” box and click “OK.” A new button should appear in the Data tab of toolbar within Excel (Figure 2).

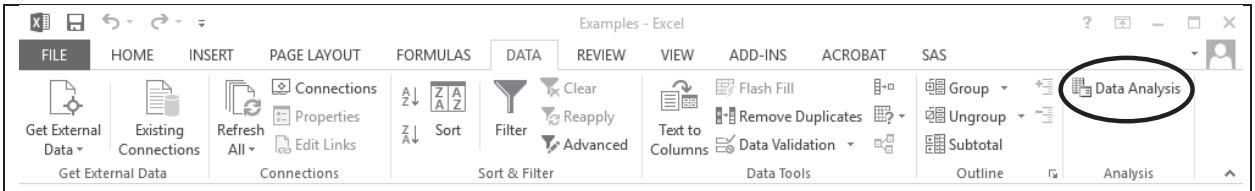


Figure 2. The new “Data Analysis” ToolPak (circled) should appear in the Data tab of the toolbar.

Performing the data analysis – A few examples

The following example on-farm field trial will be used to demonstrate the use of Excel for analysis:

“Your trusted agricultural chemical salesperson in your area asked you to consider applying a new foliar product (Treatment B) this year to see if it increases the yield on your farm. He suggests you compare it to your current production practice (using Treatment A) to see if the new product will improve your yield beyond current levels. To do this, you alternate your passes with the sprayer to contain the treatments of interest (Figure 3). Sometimes the new product is on the north side, other times the new product is on the south side compared to the control (achieving randomization). At the end of the season, you harvest each pass separately and obtain the results presented in Table 1.”

Table 1. Yield data obtained from an on-farm trial with two treatments and four true replications.

Block	Treatment A (control)	Treatment B
	Yield (bu/A)	
1	47	45
2	46	50
3	51	60
4	48	57

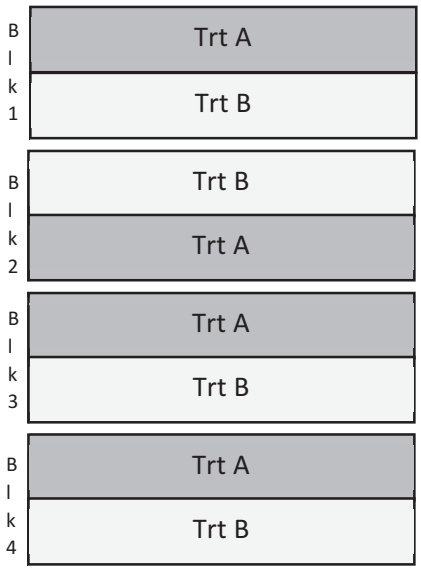


Figure 3. The test plot arrangement for comparison ofa new foliar treatment (Trt B) to the known practice (Trt A) using a randomized complete block design.

Example 1 – Paired t-Test analysis

Step 1: Data Entry

Organizing your data is key to efficiently analyze the data. For Excel, entering the values as seen in Figure 4 is a good way to manage the data and compare the results. In this example, each cell is the yield from one individual plots or strips from the field. Each row contains the yield from each block (or replicate) from the field, and each column contains the yield from each tested treatment.

	A	B	C
1		Yield (bu/a)	
2	Block	Trt A	Trt B
3	1	47	45
4	2	46	50
5	3	51	60
6	4	48	57

Figure 4. Data entered into Excel for analysis.

Step 2: Data Analysis

The next step is to use the correct analysis procedure to best interpret the results of the trial. For this research question, the objective was to determine if there was a yield difference between Treatment A and Treatment B. The first step is to calculate the average (or mean) yield of each treatment, which can be calculated using the equation shown in the top-right of Figure 5. In this example, a 5 bu/a yield difference was recorded between the two treatments. However, it is not clear if this difference is due to the application of Treatment B or if another uncontrolled factor like environmental variability was contributing to the yield difference. More statistical analysis can be conducted to determine the probability that the difference in yield was caused by a true treatment difference (rather than environmental variability).

B7 =AVERAGE(B3:B6)

	A	B	C	D
1		Yield (bu/a)		
2	Block	Trt A	Trt B	
3	1	47	45	
4	2	46	50	
5	3	51	60	
6	4	48	57	
7	Average	48	53	

Figure 5. The mean or average yield for the treatments in Example 1. The formula used for calculation of the average of Treatment A shown in the upper right.

A paired t-test can be used to calculate the probability that the yield difference observed was truly due to an imposed treatment. This test is available in the Data Analysis ToolPak described earlier in the chapter. To conduct a paired t-test, click the “Data Analysis” button in the ‘Data’ tab shown in Figure 2. This should open a window with multiple statistical analysis choices, but the option of interest in this example is called “t-Test: Paired Two Sample for Means”. Select this option and click “OK” as shown in Figure 6A.

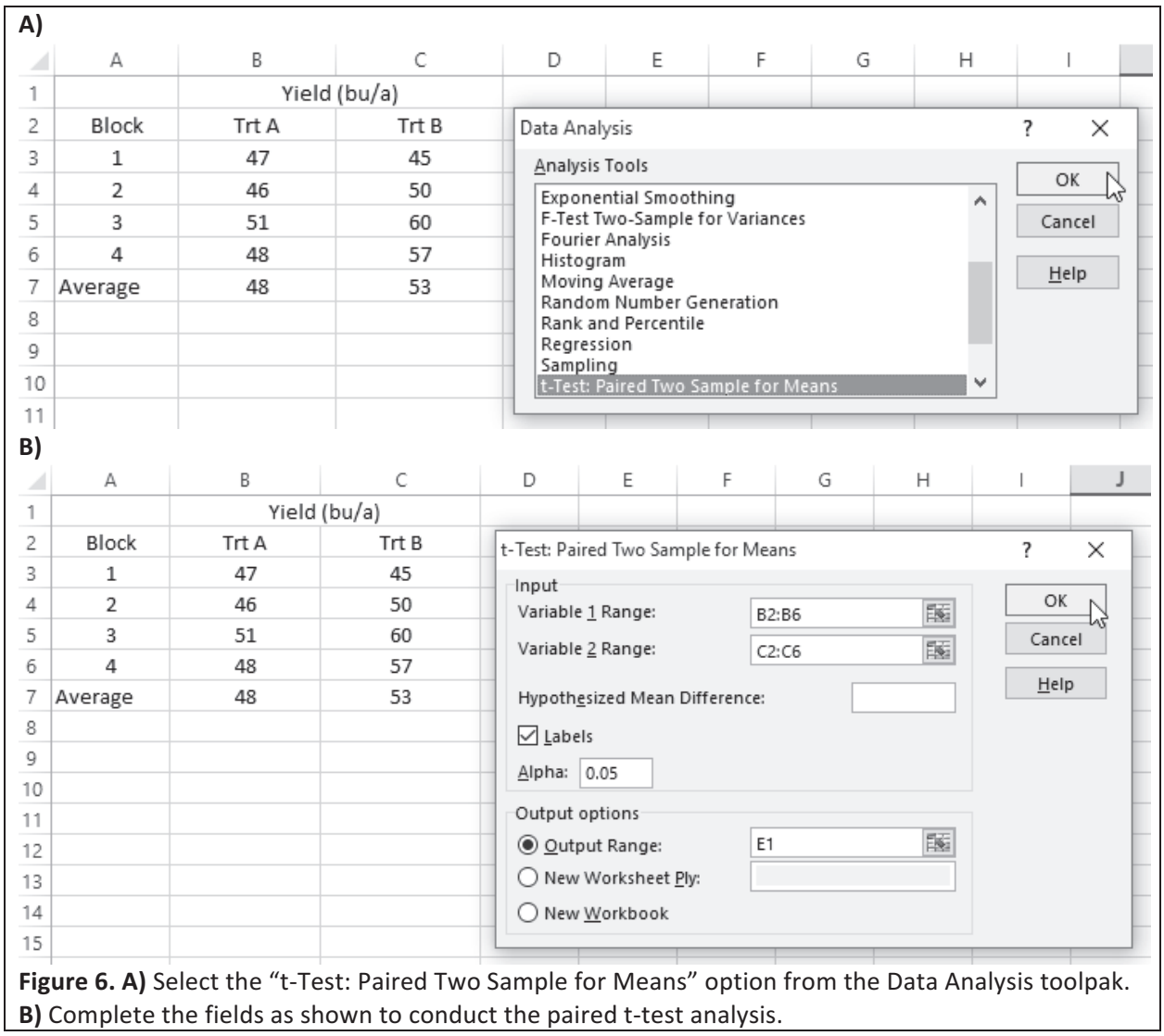


Figure 6. A) Select the "t-Test: Paired Two Sample for Means" option from the Data Analysis toolpak. **B)** Complete the fields as shown to conduct the paired t-test analysis.

Once selected, a window will appear asking for cells to be selected for analysis (Figure 6B). In "Variable 1 Range" box, select the name of the first treatment and all the data for that treatment (in this case, Treatment A is cells B2-B6). Do the same for the "Variable 2 Range" box (Treatment B would be cells C2-C6). Be sure to check the box called "Labels" as well since the names of the treatments were selected. The "Alpha" value listed is the significance level for the trial, and defaults to a value of 0.05. A significance level (or alpha) of 0.05 indicates acceptance of a 5% probability that the differences observed are due to chance. Similarly, a significance level of 0.1 would indicate a 10% probability the differences observed were due to chance. Some research requires a low (conservative) probability of <0.05, especially if the treatment (new product or practice) cost is high. On-farm research is sometimes less conservative, and a probability of <0.1 is considered acceptable. Certain studies, such as those with a low treatment cost are considered acceptable with a probability <0.2. For the following example, the Alpha level of 0.05 will continue to be used. In the "Output Range" box enter E1 (Figure 6B), click "OK," and the results of the paired t-test will appear within the same worksheet beginning in cell E1 (Figure 7).

The mean values shown in row 4 of Figure 7 are identical to the averages calculated in Figure 5. The probability generated by the paired t-test is shown in cell F13 in Figure 7. The two-tailed test probability should be considered because this simultaneously tests if yield increased and if yield decreased with the application of Treatment B. The probability using a one-tailed test shown in cell F11 only allows you to determine if the yield after using Treatment B was greater than the control, but does not allow you to test if Treatment B decreased yield. The probability or P-value of 0.152 indicates there is a 15.2% chance the 5 bu/a yield difference between treatments was due solely to chance. Alternatively, the result could be stated that there is an 84.8% chance the yield difference observed was due to a true treatment difference. This 15.2% uncertainty could indicate that other factors like environmental variability contributed to the observed 5 bushel yield difference.

	E	F	G
1	t-Test: Paired Two Sample for Means		
2			
3		*Trt A*	*Trt B*
4	Mean	48	53
5	Variance	4.667	46
6	Observations	4	4
7	Pearson Correlation	0.796	
8	Hypothesized Mean Difference	0	
9	df	3	
10	t Stat	-1.913	
11	P(T<=t) one-tail	0.076	
12	t Critical one-tail	2.353	
13	P(T<=t) two-tail	0.152	
14	t Critical two-tail	3.182	

Figure 7. Results of the paired t-test analysis for Example 1.

Using the same approach with the data shown in Table 2, the 5 bu/a yield difference still exists between Treatment A and B. However, there is less intrinsic variation among the replications (Figure 8). The paired t-test resulted in a probability value of 0.001 (cell F13), indicating there is only a 0.1% probability that the differences in treatment yield were due to chance. Although the same yield difference was observed between treatments in both Tables 1 and 2, the lower variance of the data in Table 2 resulted in greater confidence to say there was a true treatment difference. The paired t-test allows for more in-depth analysis of the results to provide additional information to help with future recommendations.

Table 2. Yield data obtained from an on-farm trial with two treatments and four true replications.

Block	Treatment A (control)	Treatment B
	Yield (bu/A)	
1	45	50
2	47	52
3	52	56
4	48	54

	E	F	G
1	t-Test: Paired Two Sample for Means		
2			
3		*Trt A*	*Trt B*
4	Mean	48	53
5	Variance	8.667	6.667
6	Observations	4	4
7	Pearson Correlation	0.965	
8	Hypothesized Mean Difference	0	
9	df	3	
10	t Stat	-12.247	
11	P(T<=t) one-tail	0.001	
12	t Critical one-tail	2.353	
13	P(T<=t) two-tail	0.001	
14	t Critical two-tail	3.182	

Figure 8. Paired t-test analysis for the data presented in Table 2.

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Example 2 – Calculation of an LSD from an experiment using Randomized Complete Block Design
For a trial with three or more treatments, calculation of an LSD may help make comparisons among the treatment means. If the chemical salesperson asked you to try two new treatments against your known treatment, an LSD would enable you to compare the treatments to one another. For this example, we will use the data shown in Table 3.

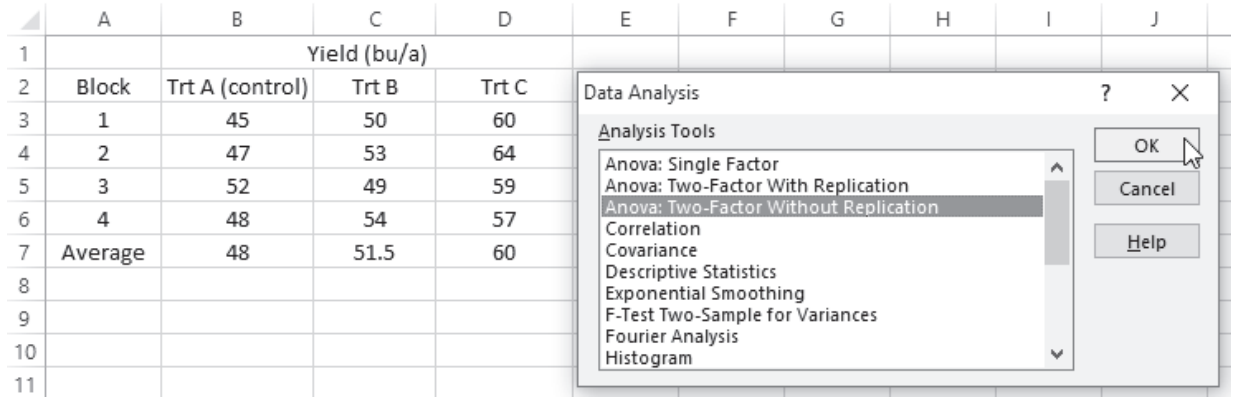
Table 3. Yield data from on-farm trial with three treatments and four true replications.

Block	Treatment A (control)	Treatment B	Treatment C
	Yield (bu/A)		
1	45	50	60
2	47	53	64
3	52	49	59
4	48	54	57

Step 1: Enter data into Excel
Enter the data into Excel as has been done in the previous example using the rows as each block (or replicate) and the columns as each treatment.

Step 2: Conduct a Two-Way Analysis of Variance (ANOVA) Test
Once the data is entered, click the "Data Analysis" option shown in Figure 2. A box should appear showing multiple options of statistical tests to conduct, and for this example select the option called "Anova: Two-Factor Without Replication" (Figure 9A). This option is appropriate for a randomized complete block design because the "Two-Factor" refers to two factors of interest, which are block and treatment for this design. The "Without Replication" refers to "without replication in time or space," which also means the was data collected from a single site in a single year. Once this option has been selected, click "OK."

A)



B)

	A	B	C	D
1		Yield (bu/a)		
2	Block	Trt A (control)	Trt B	Trt C
3	1	45	50	60
4	2	47	53	64
5	3	52	49	59
6	4	48	54	57
7	Average	48	51.5	60
8				
9				
10				
11				
12				

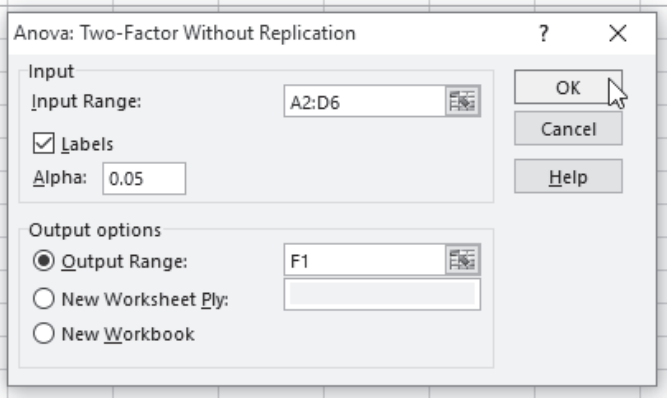


Figure 9. A) Select the "Anova: Two-Factor Without Replication" option. **B)** Input the values as shown for the "Input Range," "Alpha", and "Output Range" boxes to generate an ANOVA table based on these results.

In the prompt window shown in Figure 9B, place the cursor in the "Input Range" box and select all cells from A2 through D6. Once completed, make sure the box next to the word "Labels" is checked. The Alpha denoted describes the significance level, and it defaults to 0.05. In the Output options, enter the "Output Range" as F1 to ensure the ANOVA table appears within the same worksheet. Once all this has been entered, click "OK", and Figure 10 should be present in the Excel worksheet beginning in cell F1.

	F	G	H	I	J	K	L
1	Anova: Two-Factor Without Replication						
2							
3	*SUMMARY*	*Count*	*Sum*	*Average*	*Variance*		
4	1	3	155	51.667	58.333		
5	2	3	164	54.667	74.333		
6	3	3	160	53.333	26.333		
7	4	3	159	53	21		
8							
9	Trt A (control)	4	192	48	8.667		
10	Trt B	4	206	51.5	5.667		
11	Trt C	4	240	60	8.667		
12							
13							
14	ANOVA						
15	*Source of Variation*	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
16	Rows	13.667	3	4.556	0.494	0.700	4.757
17	Columns	304.667	2	152.333	16.518	0.004	5.143
18	Error	55.333	6	9.222			
19							
20	Total	373.667	11				

Figure 10. Results of the Two-Way ANOVA analysis given the data in Table 3.

The first table in Figure 10 shows the data from each row summarized (the four blocks for this example) followed by the data from each column summarized (the treatments for this example example). The second table generated shows the results of the ANOVA analysis. In our data set, the "Source of Variation" called Rows is the blocks or replications, and the Columns represent the treatments evaluated. Contained in the "*P-value*" column of the second table is the probability that the differences recorded are due to chance. In this case, there is approximately a 70% probability that the differences between replications were caused by chance. Conversely, there was only a 0.4% probability the differences we observed in treatment were caused by chance. This gives us confidence that it is acceptable to calculate an LSD to compare the treatment means based on our trial results.

The final process is a step-by-step procedure to calculate the LSD for the trial:

1. **Locate the Mean Square for the Error (MSE) term from cell I18 (9.222) in Figures 10 and 11A.**
2. **Calculate the Standard Error of the Difference (SED) between two treatment means (Figure 11A).** This is completed by (i) multiplying the MSE by 2; (ii) dividing by the number of blocks or replications (in this example 4); and (iii) take the square root of the entire value. This can be achieved with the formula "=SQRT(I18*2/4)" in this example, resulting in an SED of 2.147 (cell I22).
3. **Determine the Critical t-Value to use for the calculation (Figure 11B).** The critical t-value is different than the paired t-test conducted in Example 1 because it is not a direct probability measurement. A t-value is determined by two main components: the significance level; and the degrees of freedom (df) of the error term (found in cell H18 in Figure 10). The significance level can vary based on the trial type and desired confidence, and the degrees of freedom are determined by the number of plots, treatments, and replicates used in the trial. Because the research question is related to yield differences, the critical t-value from a two-tailed distribution is needed (tests for yield increase and decrease simultaneously). For this example, the significance level is set as 0.05, and the degrees of freedom value is 6. Entering the formula "=T.INV.2T(0.05,6)" results in a Critical t-Value of 2.447 (cell I23).
4. **Multiply the Standard Error for the Difference by the Critical t-Value to produce the LSD for the trial (Figure 11C).** Multiplying the SED (2.147, cell I22) by the Critical t-Value (2.447, cell I23) produces the LSD for the trial (5.25 bu/a, cell I24). The "(0.05)" following the LSD denotes the significance level for the trial. The value of 5.25 bu/a indicates the treatments that produced yield within 5.25 bu/a of one another are not statistically different. In this case, Treatment A and Treatment B produced similar yield to one another (48 bu/a and 51.5 bu/a, respectively), but Treatment C produced greater yield (60 bu/a) than both A and B.

A)

I22 | =SQRT(I18*2/4)

	F	G	H	I	J
1	Anova: Two-Factor Without Replication				
2					
14	ANOVA				
15	*Source of Variation*	*SS*	*df*	*MS*	*F*
16	Rows	13.667	3	4.556	0.494
17	Columns	304.667	2	152.333	16.518
18	Error	55.333	6	9.222	
19					
20	Total	373.667	11		
21					
22	Standard Error of the Difference (SED)			2.147	

B)

I23 | =T.INV.2T(0.05,6)

	F	G	H	I	J
1	Anova: Two-Factor Without Replication				
2					
14	ANOVA				
15	*Source of Variation*	*SS*	*df*	*MS*	*F*
16	Rows	13.667	3	4.556	0.494
17	Columns	304.667	2	152.333	16.518
18	Error	55.333	6	9.222	
19					
20	Total	373.667	11		
21					
22	Standard Error of the Difference (SED)			2.147	
23	Critical t-Value			2.447	

C)

I24 | =I22*I23

	F	G	H	I	J
1	Anova: Two-Factor Without Replication				
2					
14	ANOVA				
15	*Source of Variation*	*SS*	*df*	*MS*	*F*
16	Rows	13.667	3	4.556	0.494
17	Columns	304.667	2	152.333	16.518
18	Error	55.333	6	9.222	
19					
20	Total	373.667	11		
21					
22	Standard Error of the Difference (SED)			2.147	
23	Critical t-Value			2.447	
24	LSD (0.05)			5.25	

Figure 11. A) Calculation of the Standard Error of Difference between two treatment means using the ANOVA results. The formula used to calculate this value is shown in the formula bar in the upper right. **B)** Determination of the critical t-value using a two-tailed distribution with a significance level of 0.05 and the degrees of freedom (df) for the error from the ANOVA table. **C)** Calculation of the LSD at the 0.05 significance level by multiplying the critical t-value by the standard error of difference. The units of the LSD are the same as for the treatment means (in this case, bu/a).

Summary

On-farm research can be extremely valuable to generate regionally or locally specific data, but each trial needs to be designed with a specific question in mind. Implementing randomization and replication is necessary to be able to interpret and use the data generated from on-farm trials. Additionally, blocking can help differentiate treatment effects from environmental variability during analysis. On-farm data can also be used to compare the locally-generated data to other trials available (i.e., local demonstration plots, university data) to look for consistent trends and help validate any claims being made. Conducting basic statistical analysis will provide valuable information to help a producer or consultant make a local recommendation using data from on-farm research trials. The statistical analysis processes outlined here can be conducted using Excel to quickly analyze the data without purchasing a new software program, and can help provide more detailed information beyond an average value. Even if the trial is replicated and produced reliable data, the analysis procedures outlined are limited to specific trial

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designs and single site-years. Testing at multiple locations across multiple years may be a more reliable method to ensure detection of a treatment effect, but requires more complex analysis techniques. Please consult with your agronomist or extension agricultural educator about conducting on-farm research if this is a topic of interest.

Using a TI-84 Calculator to complete a matched pairs t-test

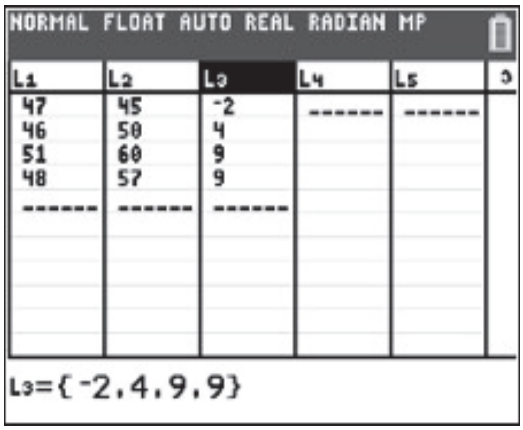
Directions for performing a matched pairs t-test on the TI-84 calculator:

1.) Enter the data:

a) Press the STAT button

b) Select the first option 1:Edit…

c) Enter the treatment 1 data into List 1 (LI), the treatment 2 data into List 2 (L2), and the differences (treatment 2 – treatment 1) into List 3 (L3).

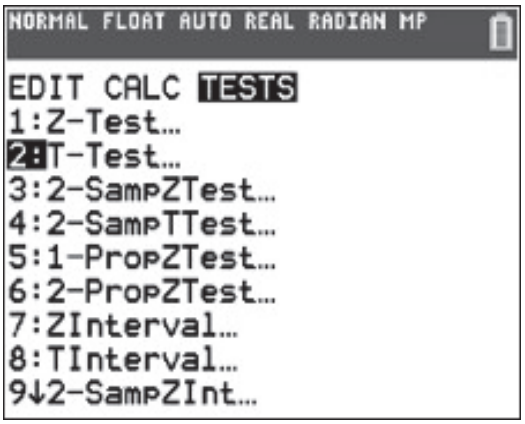


2.) Run the analysis:

a) Press the STAT button.

b) Arrow over to TESTS.

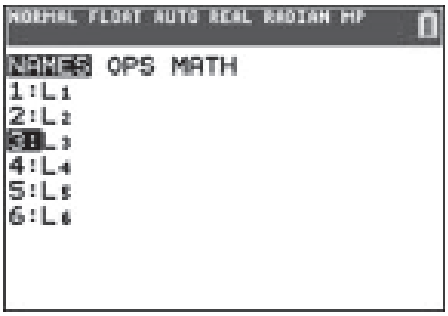
c) Arrow down and select 2:T-Test



d) In the t-test window, select DATA for the first option since we have the data entered.

e) Leave μ_0: 0. This means we are comparing the mean difference between the treatments to a mean difference of 0. (This is the *null hypothesis* of the t-test, that there is no difference between the treatments).

f) Now we need to tell the calculator where the data is located. Change the next menu item from List:L_1 to List:L_3. With the L_1 highlighted, press 2^{nd}, STAT, then arrow down so that L_3 is highlighted. Press ENTER. L_3 should now appear in the t-test window instead of L_1.

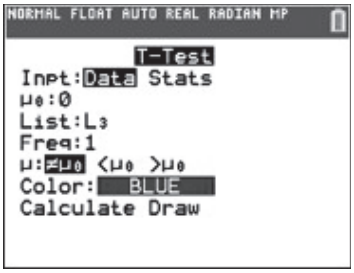


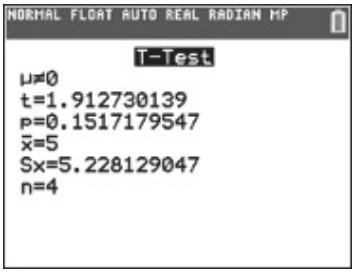
g) Keep Freq:1 the same.

h) Keep $\mu: \neq \mu_0$. This means we are performing a *two-sided* hypothesis test.

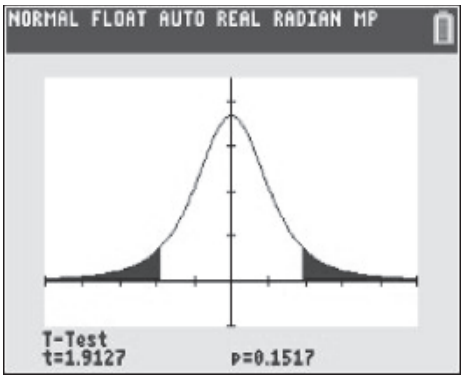
i) Depending on the version of the TI-84 you are using you may have a color option. Choose accordingly.

j) The last option allows us to perform the calculations. Highlight CALCULATE and press ENTER. A screenshot with the appropriate selections is shown below along with the resulting output.





k) We can also have the calculator draw a shaded t-distribution to show how the test statistic (t) compares to the null hypothesis of 0 (that there is no difference between the treatments). Repeat all of the steps above, but select DRAW at the bottom of the screen instead of CALCULATE. You should see the picture shown below:



Note: This is a standardized t-distribution. It is a mathematical model that shows us the kind of variability we can expect to see, even if there is no difference in effectiveness of the treatments. This variability is caused by uncontrolled factors such as soil structure, drainage, topography, etc. The shaded area under the curve measures the probability of getting results as extreme or more extreme than what we did, *if there is no difference in the treatments*. More shading under the curve indicates a greater probability that the results are due to chance rather than the treatment. In statistics, this shaded area is called the *p-value* and it is provided under the graph along with the test statistic. Notice that this is a two-sided test, as both sides of the curve are highlighted.

On-Farm Stats: Practice using data analysis

Does that new product really work?

Ohio Learning Standards Emphasized: Technological and Engineering Design (applying research), Instructional Strategies (investigations through inquiry), Interpreting and Communicating Science Concepts, Global Environmental Problems and Issues (sustainability, food production and availability).

1) Read "Does that new product really work? The basics for conducting on-farm research"

Potential assessment questions:

a. How should various treatment blocks be laid out in a field? Explain.

b. How many different replications/trials should be performed?

(See Ohio PLOTS app for additional information)

c. See http://ohioline.osu.edu/factsheet/anr-40 for an overview of statistical terms and more info)

2) To work the problems presented and install the Analysis Toolpak follow the instructions below:

Open Excel

For Macs:

Go to Tools

Select add-ins, check Analysis ToolPak

Data analysis will be available on the tool bar at the far right

For PC's:

Click the **File** tab, click **Options**, and then click the **Add-Ins** category.

*If you're using Excel 2007, click the **Microsoft Office Button**  , and then click **Excel Options**

In the **Manage** box, select **Excel Add-ins** and then click **Go**.

Some definitions:

foliar product – a spray that is applied to the leaves of a plant (could be pesticide or fertilizer).

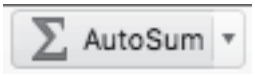
bu/A—bushels per acre

I. Example 1

3) Create the chart in Excel shown with Example 1

a. In order to make the Yield (bu/a) show in columns B and C, highlight both cells B1 and C1, click on Merge & Center in the tool bar (under home tab)

b. Enter the data in the chart as it appears in Figure 4

c. To calculate the average, highlight cells B3 thru B6. Click on the down arrow next to AutoSum, 

pull down to average. Or type in this formula: =AVERAGE(B3:B6)

4) Although the average of Treatment B is larger, in order to determine if that difference in yield was caused by a true treatment difference rather than environmental variability or chance, a paired t-test can be performed.

a. Click on Data tab; click on Data Analysis, choose t-Test: Paired Two Sample for Means (Figure 6A)

b. fill in the boxes (Figure 6B)

c. Press OK

d. The table in Figure 8 should appear

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USDA United States Department of Agriculture
National Institute of Food and Agriculture

More definitions:
variance—range
t-test—The t-test assesses whether the means of two groups are *statistically* different from each other by judging the difference between their means relative to the spread or variability of the scores. This test can be used for comparing the means of two groups, and especially as the analysis for a posttest-only, two-group randomized experimental design such as this example.
Pearson correlation—details the linear correlation between two values; it has a value between +1 and −1, where 1 is total positive linear correlation, 0 is no linear correlation, and −1 is total negative linear correlation.
One-tailed vs two-tailed test—one-tailed tests only determine the statistic in one direction (if treatment B increased yield) but in this example, we want to know if treatment B increased **OR** decreased the yield, therefore we use a two-tailed test

5) When looking at the P two tail test between Figure 7 and Figure 8, the smaller number in figure 8, shows that the difference due to chance variation in the environment is 0.1%, while the difference in Figure 7 shows that there is a 15.2% chance that the difference is due to chance. Which is data is more convincing?