

## Welcome to the wonderful world of EXCEL!

You can use the same copy, paste, cut shortcut keys that you use in Microsoft Word in EXCEL, or mouse right click.

- Control-x: cut
- Control-c: copy
- Control-p: paste

### When dealing with data:

- Always double check your numbers after you enter the data.
- If you see a value that looks really weird, try to see if there was a mistake or if there is a reason for an extremely high or low value (so if you see a caterpillar value that looks 'off' ask the person whose caterpillar it is.)
- Keep one copy of your raw data untouched, copy the values to another worksheet and work with the data there.

**Functions:** in EXCEL anytime you type '=' into a cell then EXCEL expects a function or formula to follow. EXCEL can calculate hundreds of formulas/function. To search for a specific function (or browse them all for fun), click on the formula tab at the top of your screen.

A few common functions:

- To calculate a column or row mean:
  - =average(highlight row or column that you want to average)
  - Example: To calculate the average of all the values A1 – A25, =average(A1:A25)
- To calculate the sum of all values: =sum(A1:A21)
- To count all the values (i.e. determine sample size): =count(A1:A25)
- To calculate standard deviation =stdev.s (range of values)
- To calculate a square root: =sqrt(value)

1. Copy the raw data into another worksheet (this way if you inadvertently delete or change a data value, you still have a clean copy of your data).
2. Sort the data based on treatment type.
3. Optional: Cut and paste the data into separate treatment columns.
4. Calculate the average and standard deviation for each treatment group.

Use the formulas =average(C2:C22) and =stdev.s(average(C2:C22)) to calculate sample standard deviation and average.

Drag these formulas under the fertilizer column to automatically calculate those values.

ID	Treatment	Control	Fertilizer (mass day10 grams)
3	Control	0.0585	0.063
4	Control	0.102	0.123
6	Control	0.07	0.017
7	Control	0.022	0.09
8	Control	0.051	0.09
10	Control	0.12	0.126
14	Control	0.0423	0.059
15	Control	0.027	0.075
17	Control	0.023	0.079
19	Control	0.045	0.1
22	Control	0.112	0.07
23	Control	0.062	0.17
26	Control	0.01	0.065
27	Control	0.078	0.075
30	Control	0.067	0.098
31	Control	0.01	0.08
32	Control	0.03	0.086
33	Control	0.07	0.102
34	Control	0.072	0.068
35	Control	0.027	0.1
38	Control	0.029	
average		0.053704762	
stdev:		=STDEV.S(C2:C22)	

EXCEL does not have a standard error function. So you'll have to calculate standard deviation and then use that to calculate standard error (standard error = standard deviation / square root of the sample size).

## Making beautiful bar charts in EXCEL

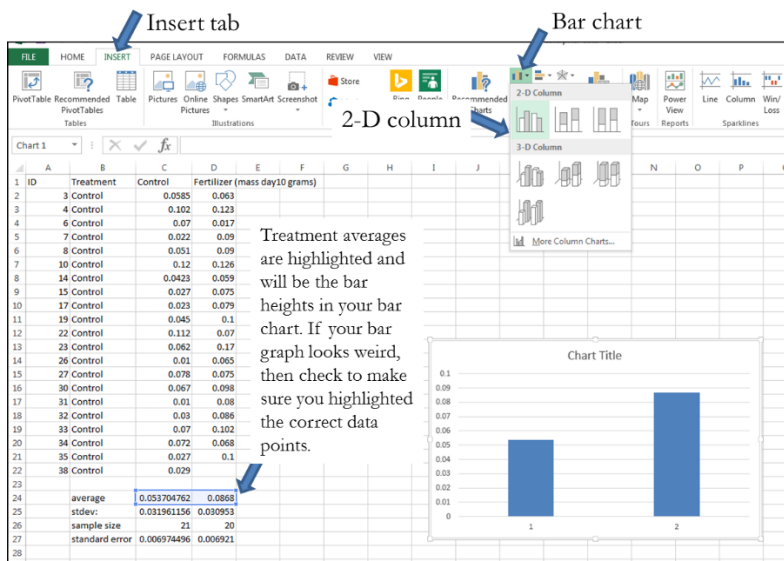
- Please note that the numbers used in this handout are from a previous class, so your numbers will be different.
  - These instructions are for Microsoft Office 365 using a PC.
1. Sort your data so you can easily calculate the appropriate averages (data tab, highlight data, sort by treatment).
  2. Calculate the average, standard deviation, and sample size for each category. I like to setup the summary statistics in a 'table' that I make myself.

	A	B	C	D	E	F
1	ID	Treatment	Control	Fertilizer (mass day10 gram		
2	3	Control	0.0585	0.063		
3	4	Control	0.102	0.123		
4	6	Control	0.07	0.017		
5	7	Control	0.022	0.09		
6	8	Control	0.051	0.09		
7	10	Control	0.12	0.126		
8	14	Control	0.0423	0.059		
9	15	Control	0.027	0.075		
10	17	Control	0.023	0.079		
11	19	Control	0.045	0.1		
12	22	Control	0.112	0.07		
13	23	Control	0.062	0.17		
14	26	Control	0.01	0.065		
15	27	Control	0.078	0.075		
16	30	Control	0.067	0.098		
17	31	Control	0.01	0.08		
18	32	Control	0.03	0.086		
19	33	Control	0.07	0.102		
20	34	Control	0.072	0.068		
21	35	Control	0.027	0.1		
22	38	Control	0.029			
23						
24		average	0.053704762	0.0868		
25		stdev:	0.031961156	0.030953		
26		sample size	21	20		
27		standard error	=C25/sqrt(C26)			

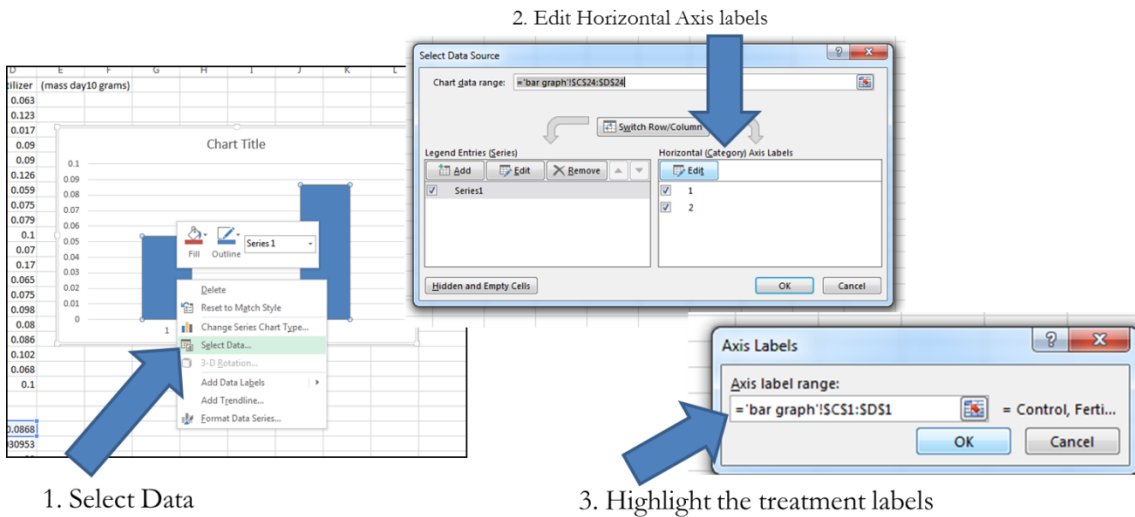
Raw data

Table of summary statistics

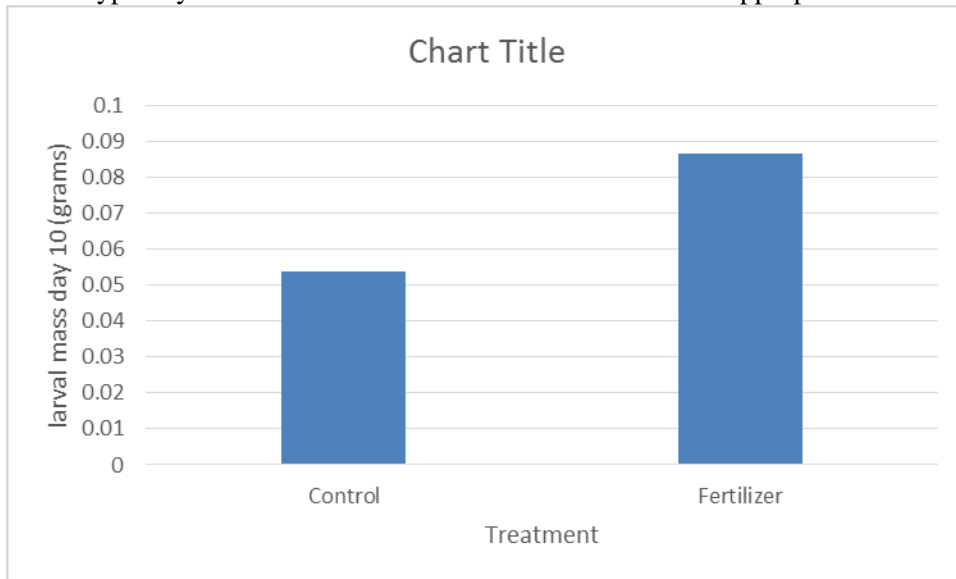
3. Calculate standard error:  $\text{standard error} = \text{stdev.s}(\text{values})/\sqrt{\text{sample size}}$
4. Once you have done this for both treatments, then highlight the values for your bar chart. In this example, the height of the bars will be equal to the mean values of the fertilizer and control treatment.
5. Click on the 'insert' tab at the top of the screen.
6. In the 'charts section' in the middle, click on 'columns'. Select a 2D column. The point of having a figure is to visually describe your data. 3D graphics don't help. Ridiculous colors don't help. Patterns don't help. Weird shapes don't help. Keep it simple.



- Now we need to add treatments labels. Right click on the chart. Select 'Select data'. The 'Select data source' box will appear. Click on the edit button for horizontal 'category' axes labels (on the right side of the 'data source box'). The 'axes labels' range box will appear. Click on the 'select range' icon. Select the labels. Click OK. Click OK again. At this point the category labels will be below each bar.

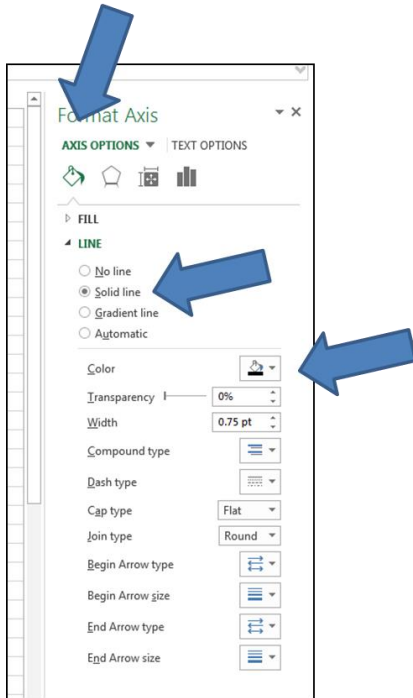


- Now we need axes labels. Click on the chart. Click on the plus sign to the right of the chart. Select 'axis titles' icon. Type in your axes labels on the chart. Add units where appropriate.



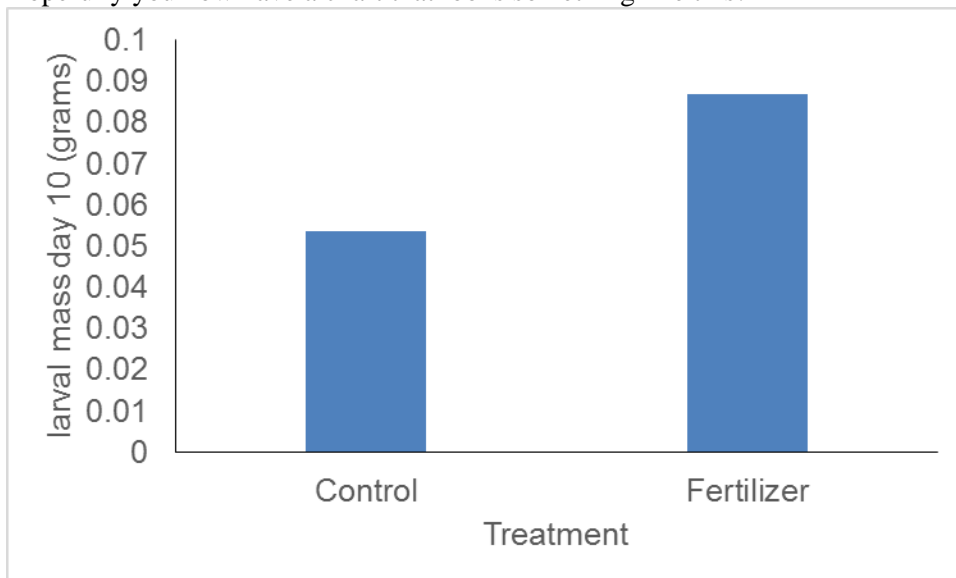
- Check the axes units – are they appropriate? For example, our balance only measures to 1/1000 of a gram, so you don't want your graph to have more than 3 decimal places along the y-axis because this would make our measurements seem more precise than they really are. Reduce the number of decimal points in the average values if you need to. Right click on the y-axis, select 'Format axis', select 'Number', and change the # of decimal places.
- Check the axes units – do you need to increase or decrease the major units along the axes (the numbers along the axes)? Basically you want enough numbers to convey the scale your measure, but not so many that the axis looks cluttered. To format an axis, right click on the axis and select 'format axis'. The 'format axis' task pane appears. You can change units under the 'axis option' tab. Change the 'major units' to 'fixed' instead of 'auto' and type in your new unit.

11. If you can't see the x or y-axis lines, then you need to change their color. Right click on the axis. Select "Format axis". Select the paint bucket icon. Select "Line". Choose "Solid line" and then select a color.



12. I really don't like gridlines (the horizontal bars across the chart area), so please delete them in my class (right click on them so they are highlighted and hit delete).
13. Check font size. If you want to change font size/type right click on the chart and then change the font size/type. I typically go with 12-point font, not-bolded. It depends on what size your figure will be in the final product.
14. Delete the "chart title" you do not need a chart title for your lab reports.

Hopefully you now have a chart that looks something like this!



15. Time to add standard error bars. You do **not** want to use the standard error bars automatically calculated by EXCEL. Click on your chart. Within 'Chart Tools' section at the top of the screen select the 'Design' tab. Click on 'Add chart elements' on the far left. Select "Error bars". Select 'More Error Bar Options' (bottom of the list).

1. Chart tools: Design

2. Add chart elements

3. Error bars

4. More error bars

Control	Fertilizer (mass day10 grams)
0.0585	0.063
0.062	0.17
0.01	0.065
0.078	0.075
0.067	0.098
0.01	0.08
0.03	0.086
0.07	0.102
0.072	0.068
0.027	0.1
0.029	
average	0.053704762 0.0868
stdev:	0.031961156 0.030953
sample size	21 20

16. The 'Format Error Bars' box will appear. Select Custom, click on 'specify value'. The 'custom error bar' box will appear. With that box, click on the select range icon under the positive error value (this is the part of the error bar going up) and highlight the standard error values for both treatments. Repeat for the negative error value, the numbers will be the exact same. Click OK. You may need to move the 'format error bars' and 'custom error bar' box to the side in order to highlight your standard error values.

Format Error Bars

ERROR BAR OPTIONS

VERTICAL ERROR BAR

Direction

Both

Minus

Plus

End Style

No Cap

Cap

Error Amount

Fixed value 0.01

Percentage 5.0 %

Standard deviation(s) 1.0

Standard error

Custom Specify Value

1

2

3

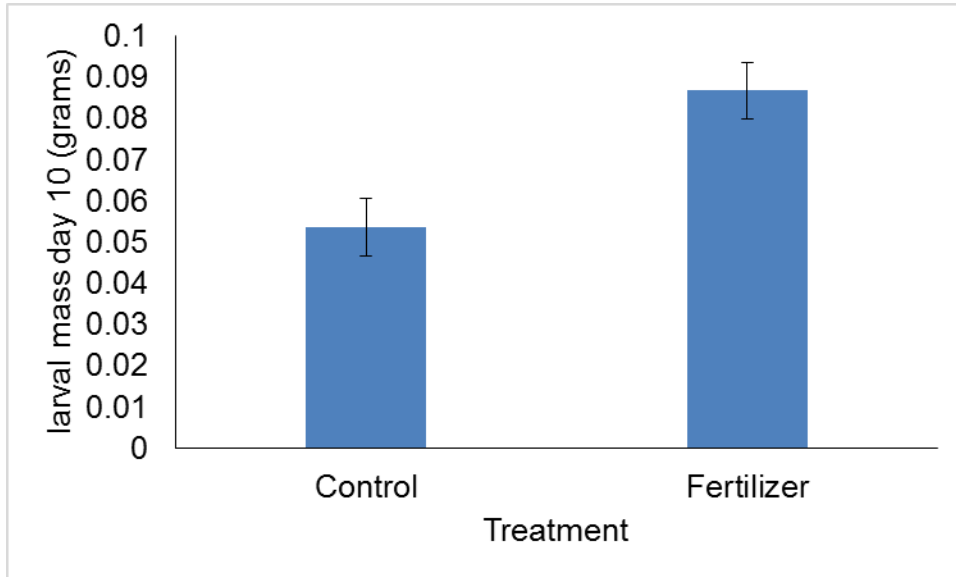
4

Don't panic if your chart looks momentarily weird.

ID	Treatment	Control	Fertilizer (mass day10 grams)
3	Control	0.0585	0.063
4	Control	0.102	0.123
6	Control	0.07	0.017
7	Control	0.022	0.09
8	Control	0.051	0.09
10	Control	0.12	0.126
14	Control	0.0423	0.059
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32	Control	0.03	0.086
33	Control	0.07	0.102
34	Control	0.072	0.068
35	Control	0.027	0.1
38	Control	0.029	
average		0.053704762	0.0868
stdev:		0.031961156	0.030953
sample size		21	20
standard error		0.006974496	0.006521

17. Check to make sure the standard error values you calculated in the table match the value of the bars. If not, you may have highlighted the wrong numbers.

Hopefully you now have a graph that looks like this. TahDah! Its ready to be included in your lab report (along with a figure caption).



### Box Plots in EXCEL

EXCEL does not have a easy , intuitive way to make boxplots. There are programs that you can download or buy, so if you have one of those feel free to use it. Below are the steps to ‘trick’ EXCEL into making a box plot.

To avoid lots of clutter and confusion, I suggest copy and pasting your raw data into a new worksheet.

1. First you need to calculate the parts of a boxplot: quartile 1, minimum, median, maximum, and quartile 3.

EXCEL functions:

- Q1: =quartile(raw data values, 1) example =quartile(B2:B21, 1), the ‘1’ tells EXCEL to calculate the first quartile.
- Minimum =min(raw data values) example =min(B2:B21)
- Median =median(B2:B21)
- Maximum =max(B2:B21)
- Quartile 3 =(B2,B21, 3)

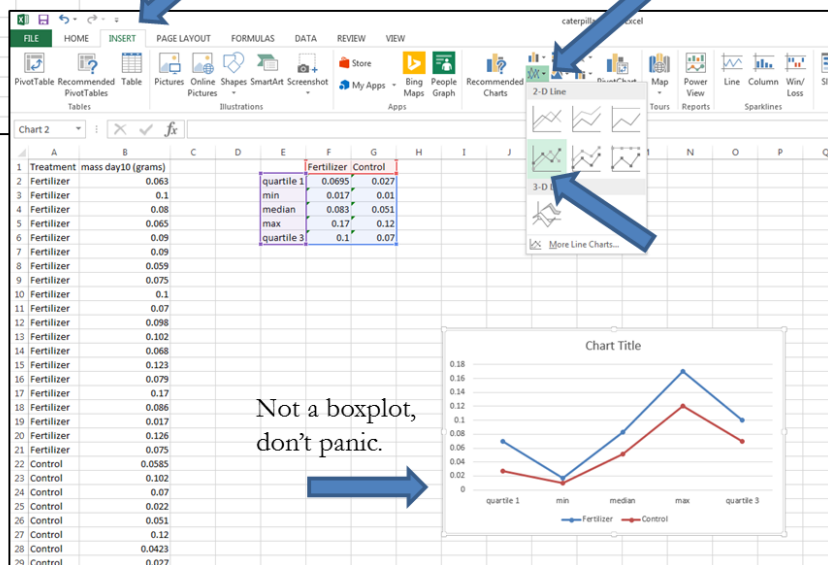
Put the values in a table that you make yourself, the order is important.

- Highlight the whole table, including all labels, then select the **Insert** tab at the top of the screen. Under Charts select a Line chart and choose the Line with Markers option. The results won't look anything like a box plot.

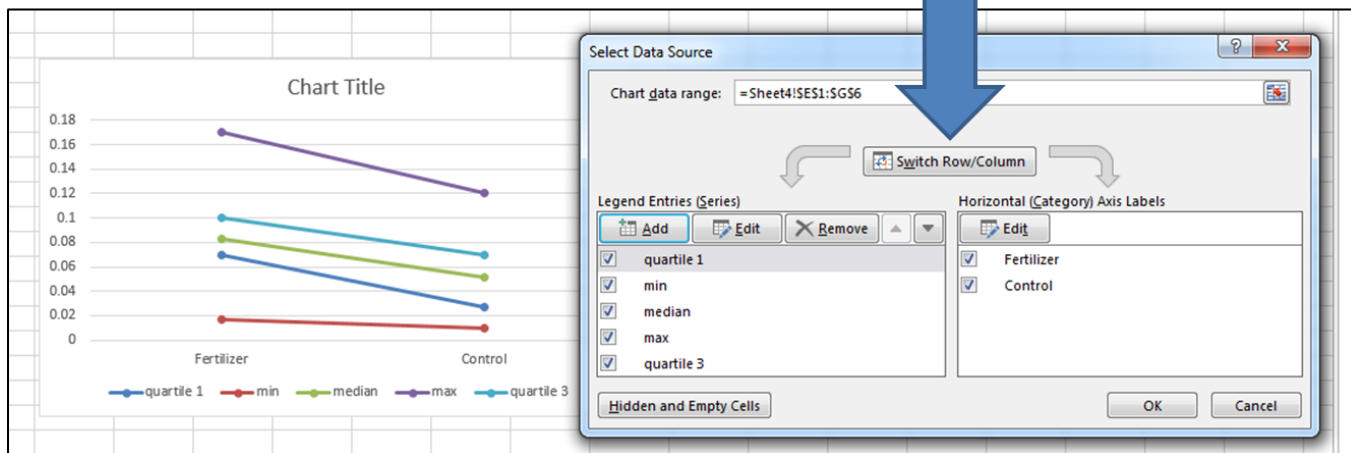
Treatment	mass day10 (grams)		Fertilizer	Control
Fertilizer	0.063	quar 1	0.0695	0.027
Fertilizer	0.1	min	0.017	0.01
Fertilizer	0.08	median	0.083	0.051
Fertilizer	0.065	max	0.17	0.12
Fertilizer	0.09	quartile 3	0.1	0.07
Fertilizer	0.09			
Fertilizer	0.059			
Fertilizer	0.075			
Fertilizer	0.1			
Fertilizer	0.07			
Fertilizer	0.098			
Fertilizer	0.102			
Fertilizer	0.068			
Fertilizer	0.123			
Fertilizer	0.079			

- Calculate the data you need for your box plot. Make sure you put the summary statistics in the correct order.

- Highlight the entire table and select a line chart with markers.

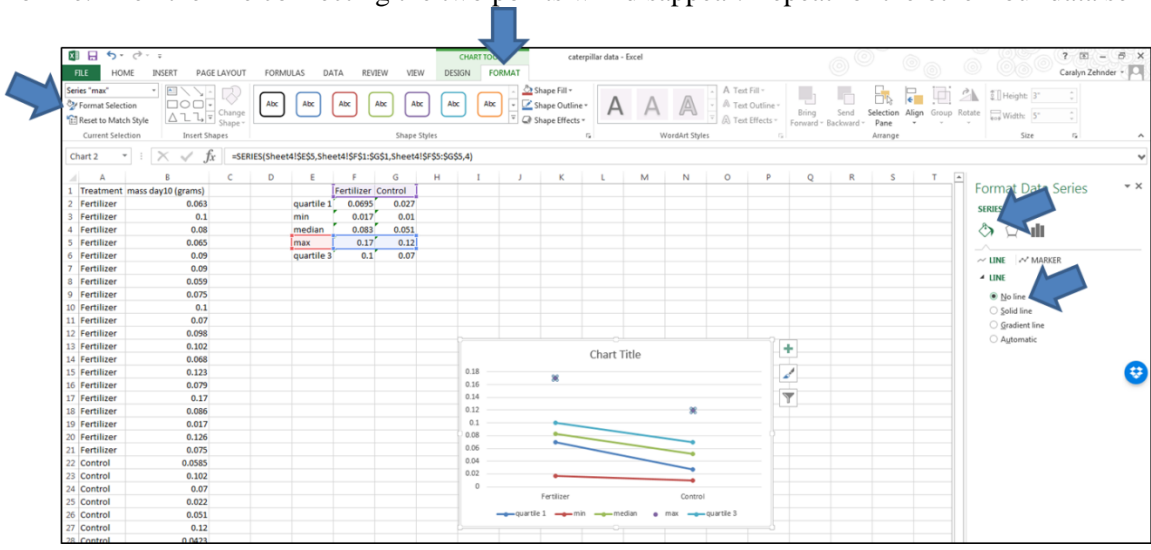


- Right click on the chart, choose **Select Data** and click on **Switch Row/Column**. Select **OK**.

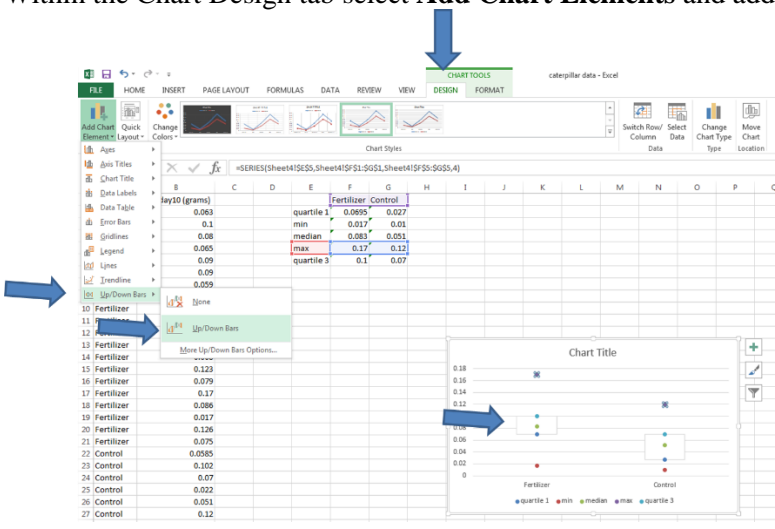




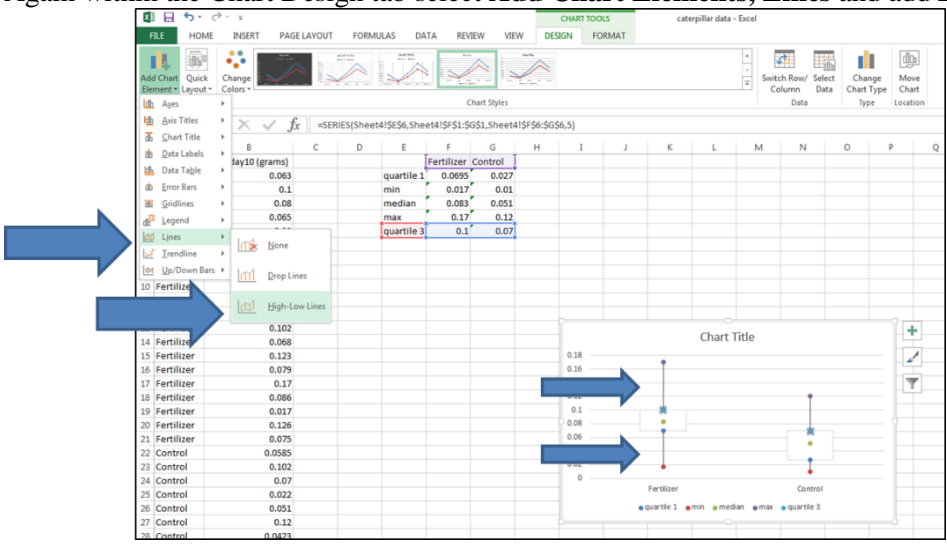
4. Within the Chart Tools tab, select Format. Show the Format task pane by clicking on the Format selection button in the far left corner. Right-click on the top line. Select the paint bucket in the Format task pane. Select no line. Then the line connecting the two points will disappear. Repeat for the other four data series.



5. Within the Chart Design tab select **Add Chart Elements** and add **Up/Down bars**.



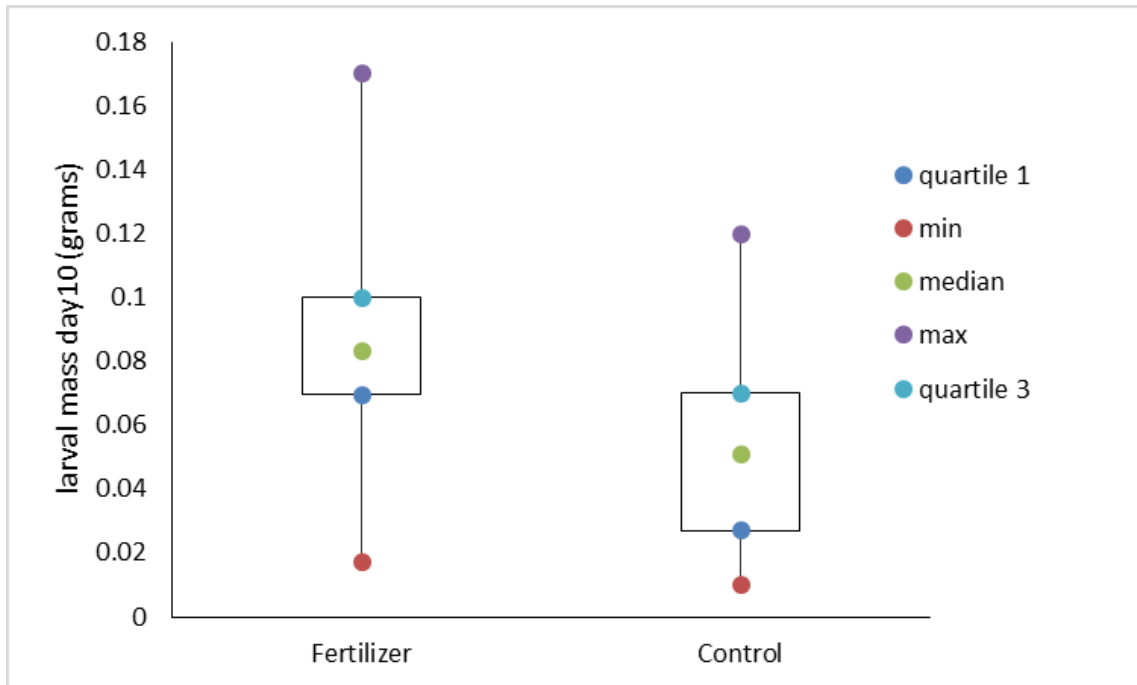
6. Again within the Chart Design tab select **Add Chart Elements, Lines** and add **High-Low lines**.





7. Delete gridlines, add labels, move the legend.

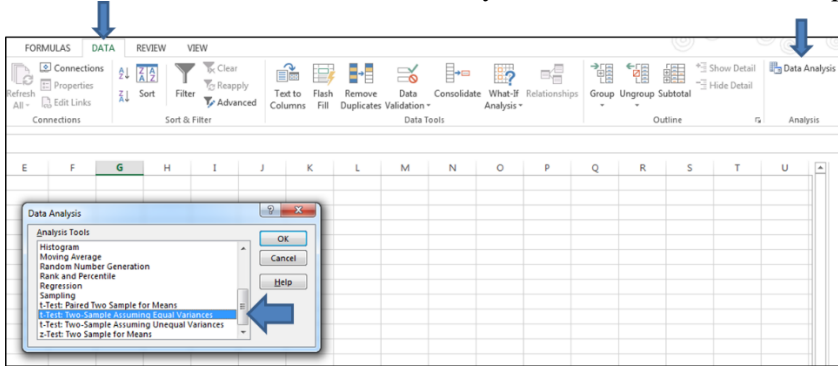
Now it looks like a box plot!



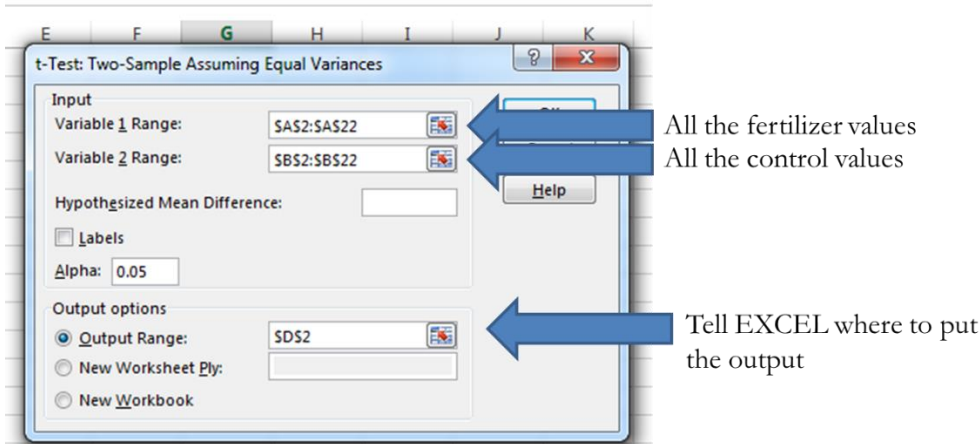
## t-tests in EXCEL

You will need to install the Data Analysis toolpak (it is an add-in with EXCEL).

1. Install the data analysis toolpak: File > Options > Add-Ins > Manage Excel Add-in (Go), Analysis Toolpak (OK).
2. Select the data tab and then the data analysis icon. Select t-test, 2-sample assuming equal variances.



3. In the **Variable 1 Range**, highlight all of the fertilizer values. In the **Variable 2 Range**, highlight all of the control values. In the output range, highlight where you want EXCEL to put the output.



4. Examine the results. Check to make the mean and the observations number are correct. EXCEL provides you with both the one-tail and two-tail p-values. For this experiment, you use a two-tail p-value.

1	Fertilizer	Control	
2	0.063	0.0585	t-Test: Two-Sample Assuming Equal Variances
3	0.1	0.102	
4	0.08	0.07	Variable 1 Variable 2
5	0.065	0.022	Mean 0.0868 0.053705
6	0.09	0.051	Variance 0.000958 0.001022
7	0.09	0.12	Observations 20 21
8	0.059	0.0423	Pooled Variance 0.000991
9	0.075	0.027	Hypothesized Mean Difference 0
10	0.1	0.023	df 39
11	0.07	0.045	t Stat 3.365491
12	0.098	0.112	P(T<=t) one-tail 0.000863
13	0.102	0.062	t Critical one-tail 1.684875
14	0.068	0.01	P(T<=t) two-tail 0.001726
15	0.123	0.078	t Critical two-tail 2.022691
16	0.079	0.067	
17	0.17	0.01	
18	0.086	0.03	
19	0.017	0.07	
20	0.126	0.072	
21	0.075	0.027	
22		0.029	
23			
24			

Write up your results (one sentence) with the statistics as you would in the results section of your lab report: