

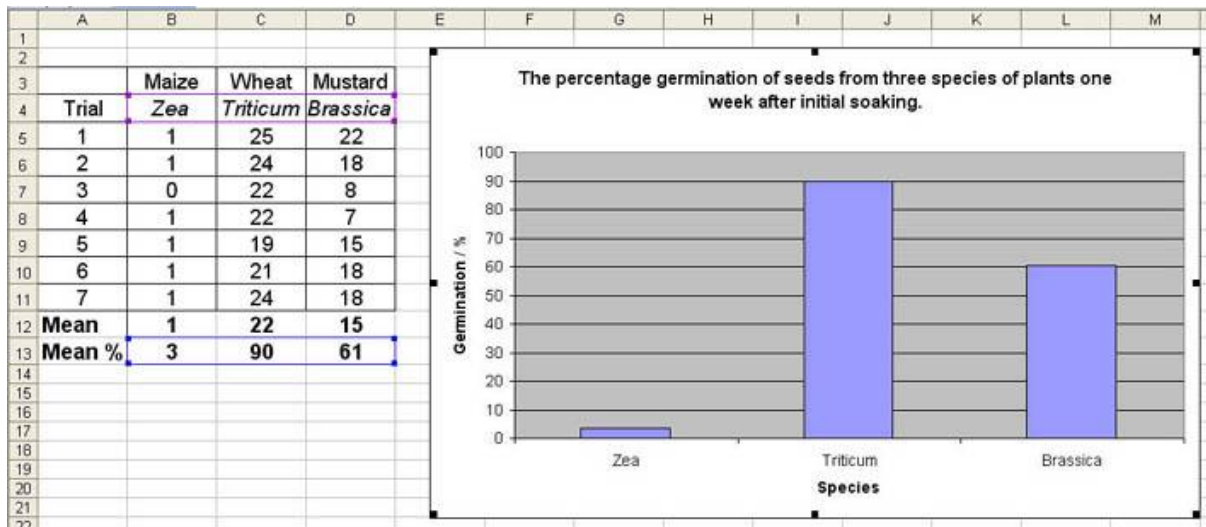
Going further with graphs I Adding Error Bars

Error bars are way of showing the degree of uncertainty in a set of data. MS Excel can add them to your graphs.

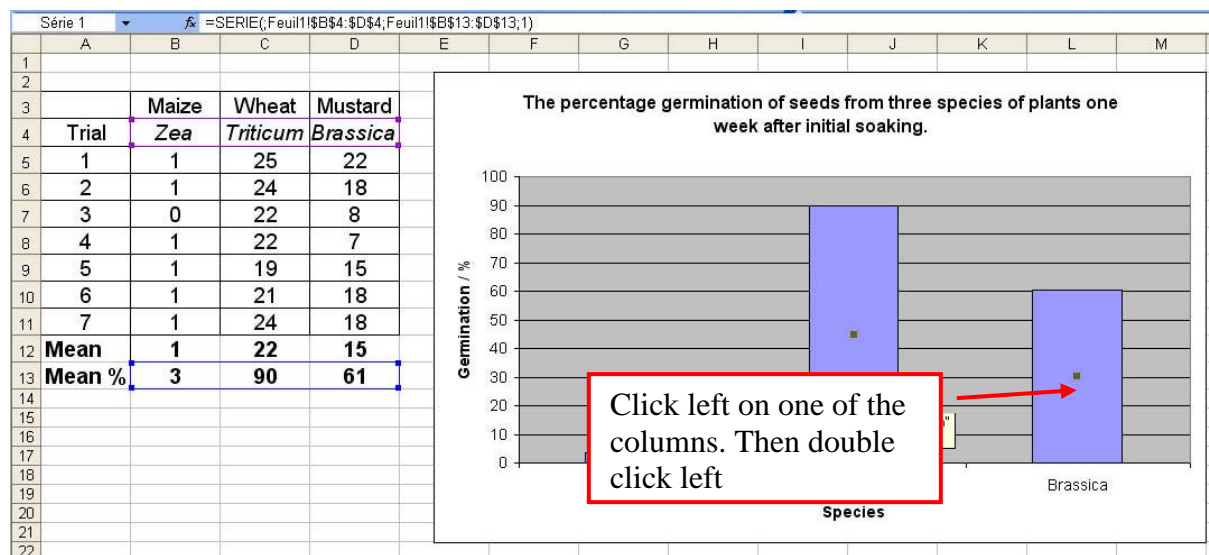
Error Bars Showing Precision

The data below show the results from an experiment where the seeds from three species of plants were germinated for one week. At the end of the week the numbers of seeds germinating were counted. 25 seeds were used in each trial.

First the data is entered onto a spread sheet. The spread sheet is used to calculate the mean and the mean percentage germination. Then a bar chart is drawn using the graphing menu.

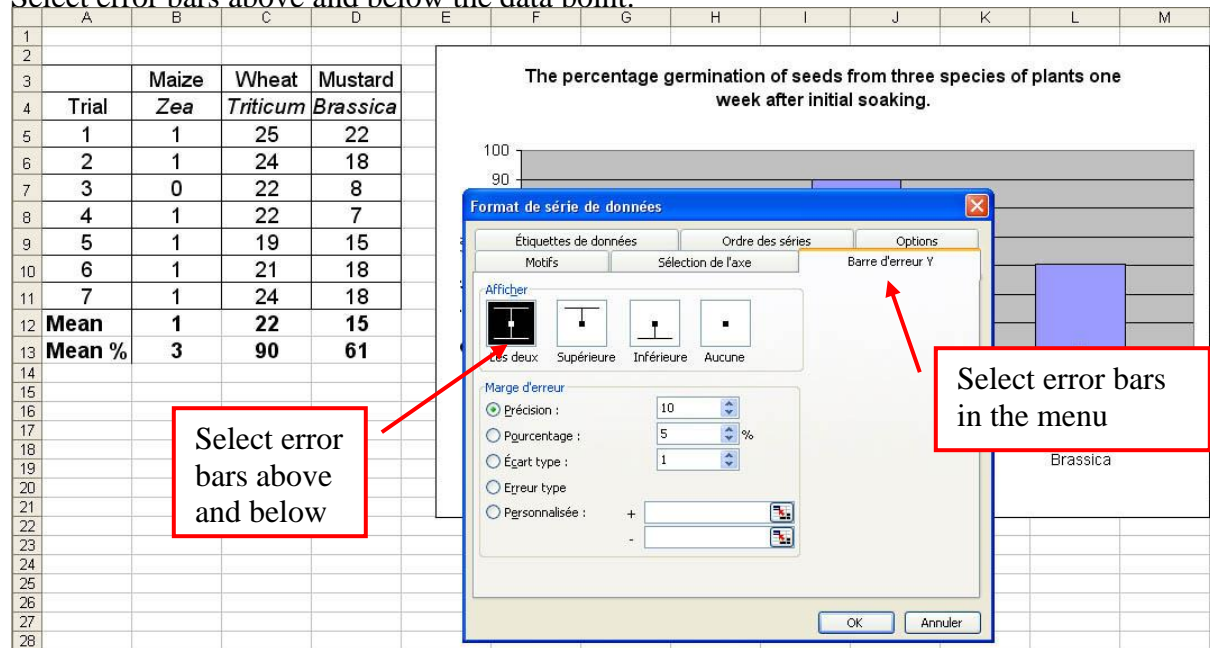


To enter the error bars first left click on one of the columns. This activates all the columns.

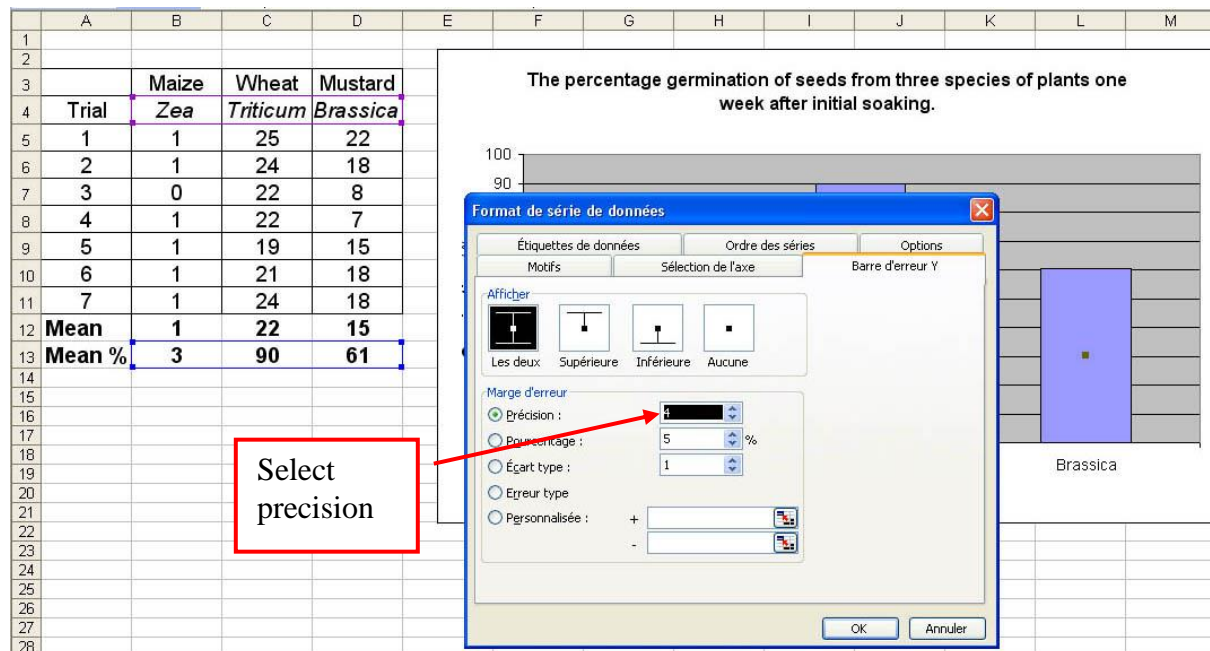


Double left click and a menu will appear. Select **error bars** (Fr *Barre d'erreur*). As this is a bar chart it will only offer to draw error bars on the y-axis.

Select error bars above and below the data point.

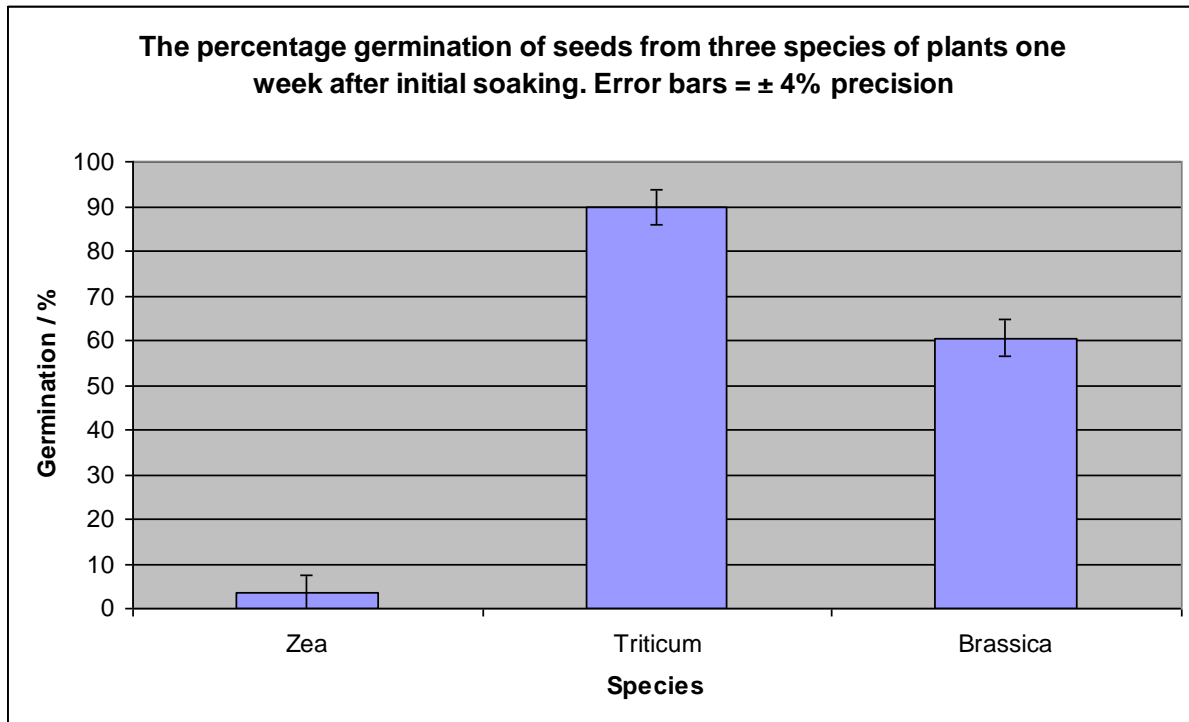


Select **precision** and enter **4**. The data is calculated from samples of 25 seeds so the degree of precision is ± 1 seed. This means each seed represents 1/25 or 4% uncertainty.



Press **Enter** or click **OK** and you will see the error bars appear on the graph.

Note: You will notice that you also have the possibility to enter percentage error, it should not be used this time as it will calculate 4% of each data point so the error bars will be proportional to the data (try it and you will see).



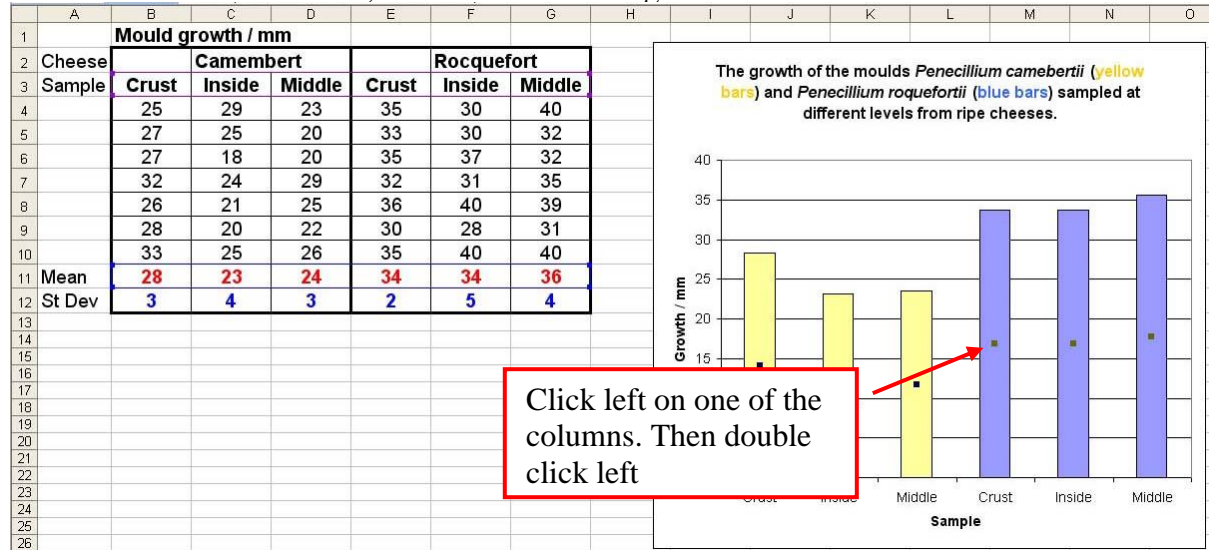
Error Bars Showing Standard Deviations

If you want to show standard deviations as error bars then you need to use a slightly different approach.

These data come from an investigation on the growth of moulds sampled from different parts of two cheeses (Camembert and Roquefort) and grown on malt agar in a Petri dish. The growth of the mould was measured after one week.

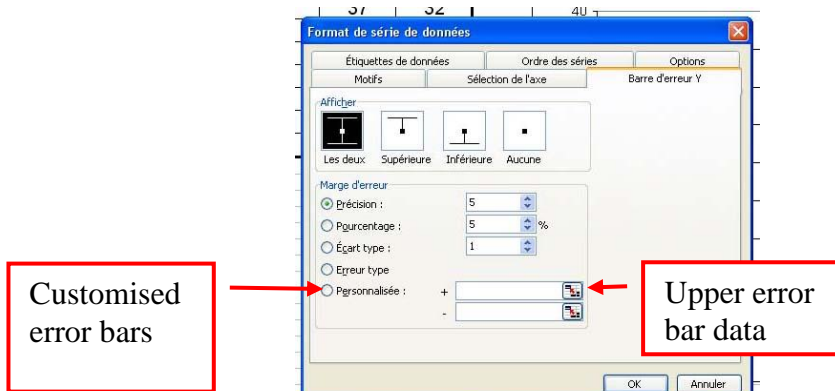
The data is entered on a spread sheet. The spread sheet is used to calculate the mean and the standard deviations. A bar chart is drawn of the results.

Click left on one of the bars, then double click to get the data format menu.

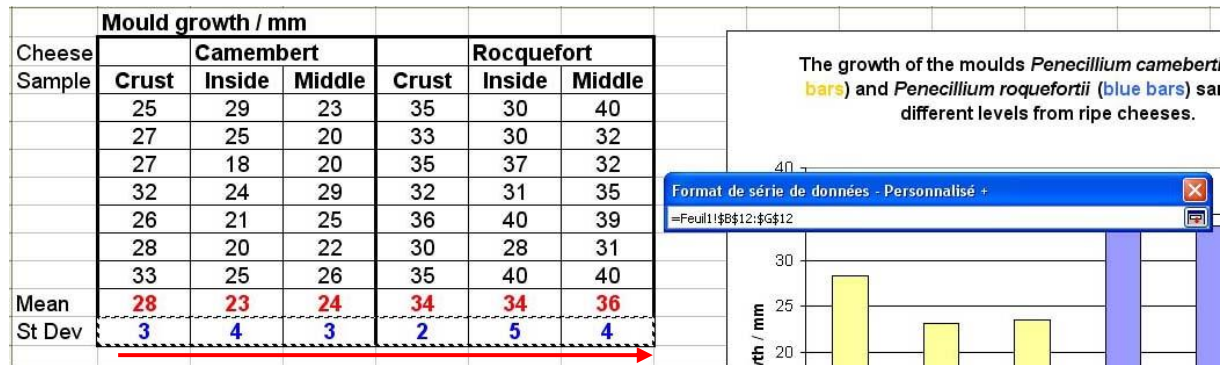


Click left on one of the columns. Then double click left

Select error bars both above and below the data point and then select **Custom** (Fr: *Personnalisée*)



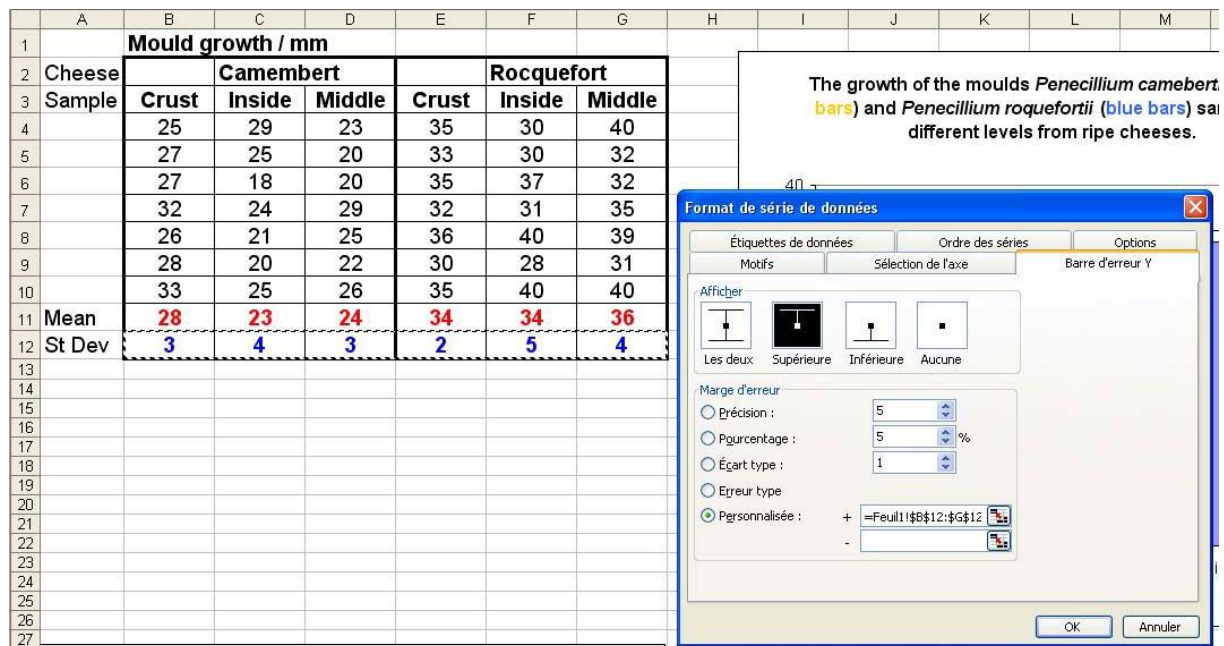
Now the data that is to be used for the error bars has to be selected. Click left on the upper bar (+) the menu will disappear and you will be left with the box in which you have to select the cells containing the data for the error bars (in this case the standard deviation).



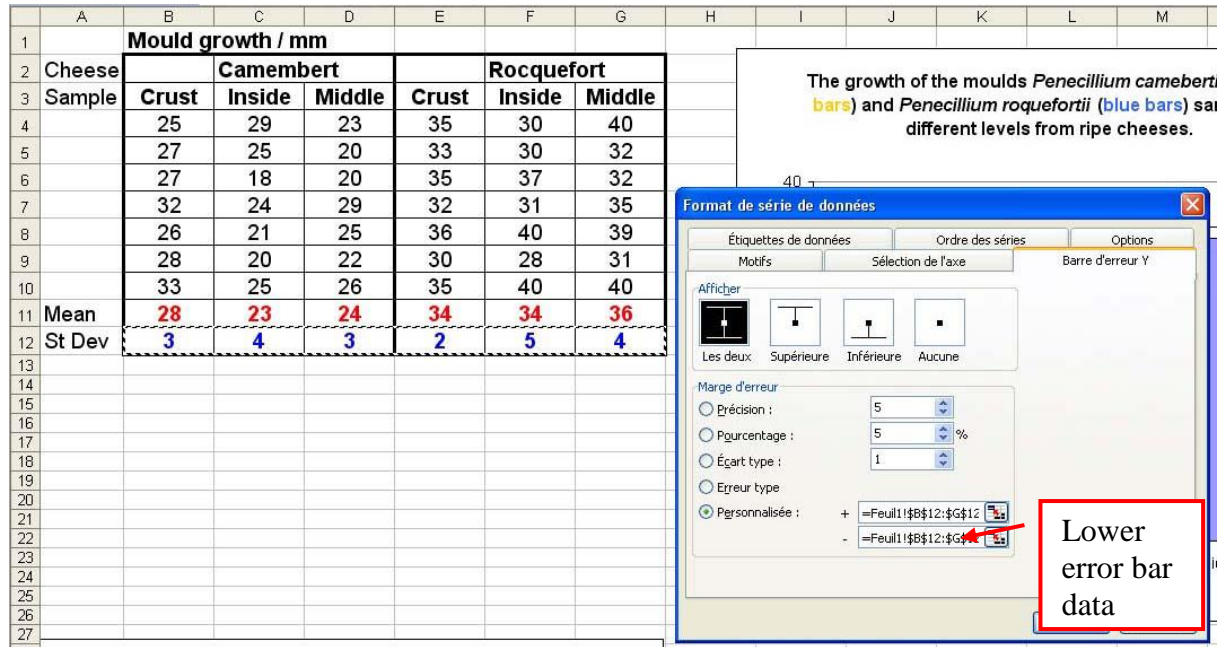
Hold down the left mouse button and pull it across these cells.

Left click on the first cell and hold the button down whilst you run along the line for standard deviations. You will see the cell coordinates appear in the box.

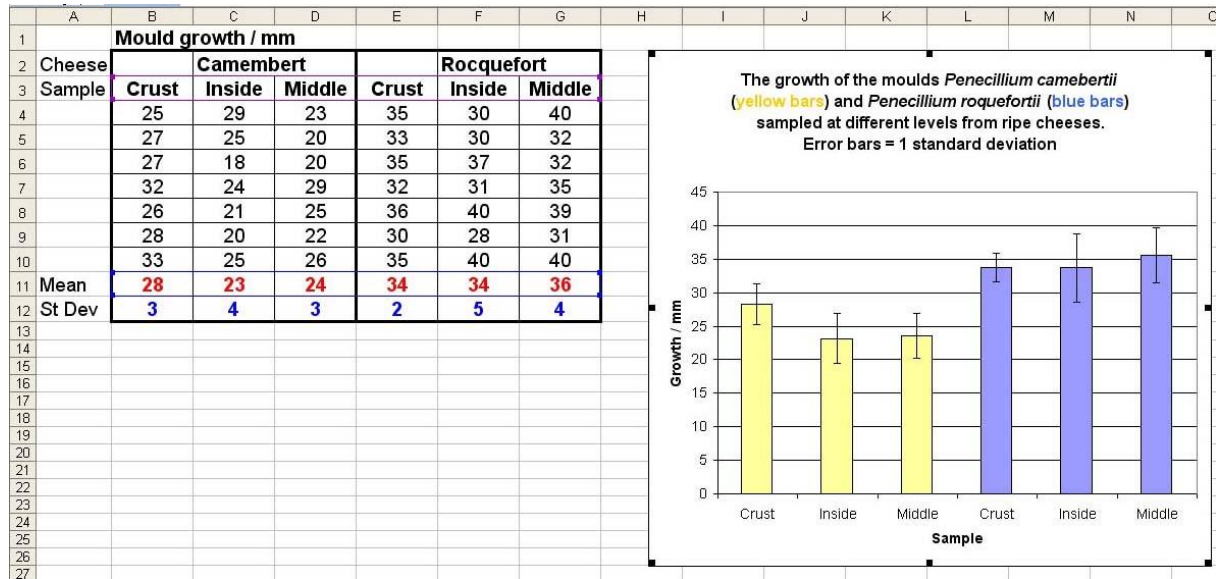
Let go of the mouse button and the menu will reappear with the upper error bar box complete.



Repeat the procedure with the box for the lower error bar (-). Use the same cells for the standard deviations as before.



Press **Enter** or click **OK** and the error bars will appear on the graph.



Entering error bars on a scatter plot

The same method can be used to put error bars on data with trend lines. This time however the menu gives you the option of x as well as y error bars.

In this example students were investigating the water potential of pieces of sweet potato tissue cut to a precise length (5 cm) and soaked in a range of sucrose solutions for 24 hours.

First the data is entered into the spread sheet. The spread sheet is then used to calculate the change in length of the tissue samples by setting up a second table.

	A	B	C	D	E	F
1	Sweet potato	Initial length = 5.0cm				
2						
3	Sucrose / mol dm ⁻³	Final lengths / cm				
4	0	5.1	5.1	5.2	5.6	5.1
5	0.2	5.2	4.8	5.0	5.1	5.1
6	0.4	5.4	4.9	5.0	5.3	5.1
7	0.6	5.1	4.8	5.0	4.9	4.8
8	0.8	5.0	5.1	5.1	4.9	5.1
9	1.0	5.1	4.8	4.8	4.8	5.1
10						
11						
12	Sucrose / mol dm ⁻³	Change in length / cm				
13	0	=B4-5				
14	0.2					
15	0.4					
16	0.6					
17	0.8					
18	1.0					
19						

To calculate the change in length enter **=B4-5**

By entering the equation =B4-5 the cell will calculate the difference between the initial length (5cm) and the final length. Press **Enter** for the result. The same calculation can be repeated down the column by holding down the left mouse button and pulling down on the bottom right hand corner of the cell.

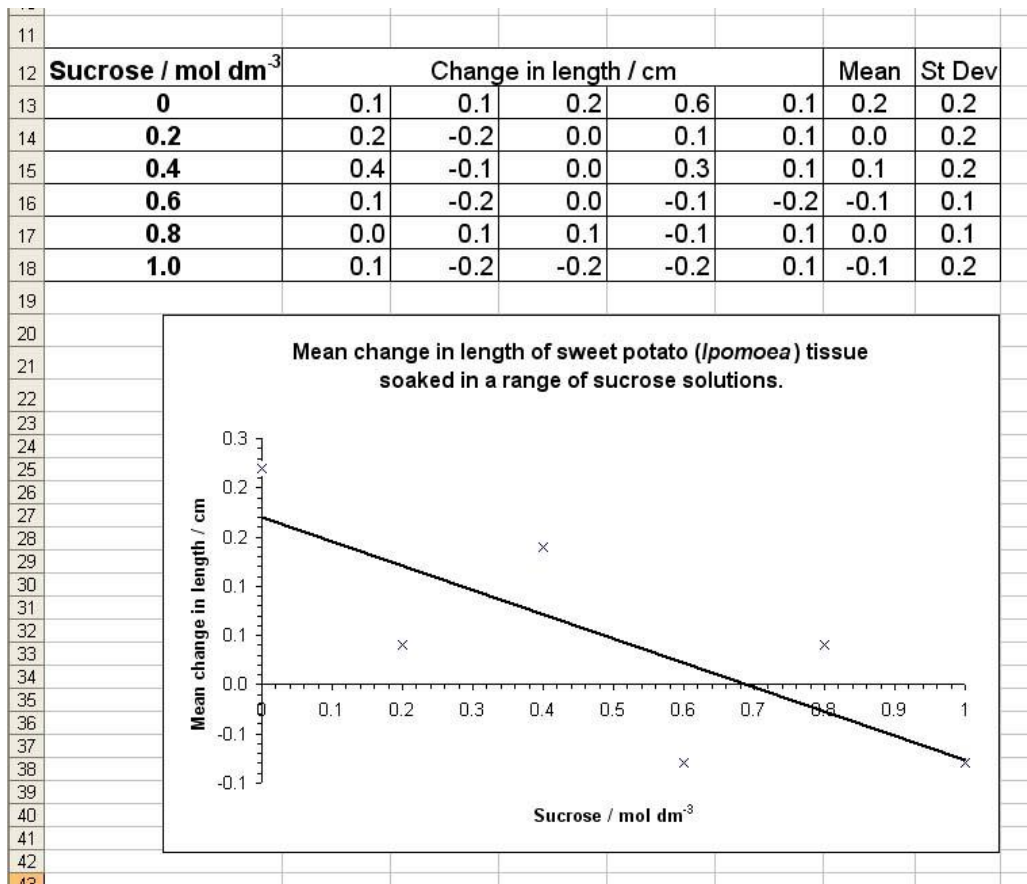
	A	B	C	D	E	F
1	Sweet potato	Initial length = 5.0cm				
2						
3	Sucrose / mol dm ⁻³	Final lengths / cm				
4	0	5.1	5.1	5.2	5.6	5.1
5	0.2	5.2	4.8	5.0	5.1	5.1
6	0.4	5.4	4.9	5.0	5.3	5.1
7	0.6	5.1	4.8	5.0	4.9	4.8
8	0.8	5.0	5.1	5.1	4.9	5.1
9	1.0	5.1	4.8	4.8	4.8	5.1
10						
11						
12	Sucrose / mol dm ⁻³	Change in length / cm				
13	0	0.1				
14	0.2	0.2				
15	0.4	0.4				
16	0.6	0.1				
17	0.8	0				
18	1.0	0.1				
19						
20						

Then repeated for all the data by pulling this highlighted area across the table in the same way

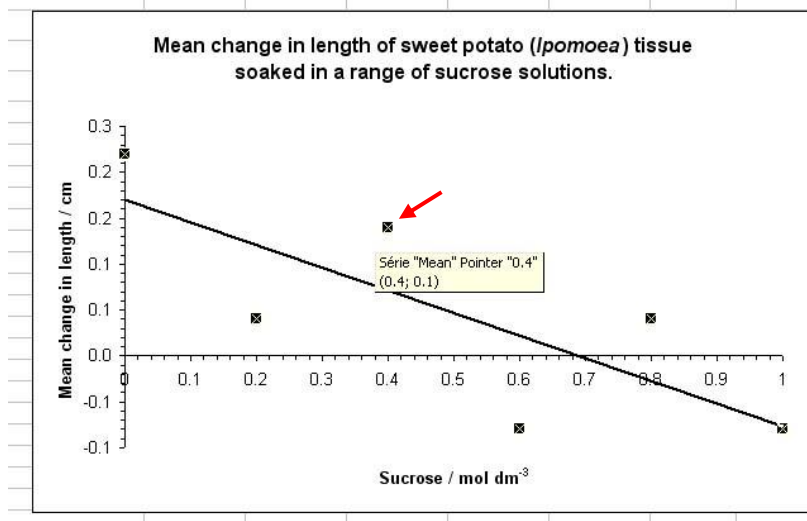
	A	B	C	D	E	F
1	Sweet potato	Initial length = 5.0cm				
2						
3	Sucrose / mol dm ⁻³	Final lengths / cm				
4	0	5.1	5.1	5.2	5.6	5.1
5	0.2	5.2	4.8	5.0	5.1	5.1
6	0.4	5.4	4.9	5.0	5.3	5.1
7	0.6	5.1	4.8	5.0	4.9	4.8
8	0.8	5.0	5.1	5.1	4.9	5.1
9	1.0	5.1	4.8	4.8	4.8	5.1
10						
11						
12	Sucrose / mol dm ⁻³	Change in length / cm				
13	0	0.1	0.1	0.2	0.6	0.1
14	0.2	0.2	-0.2	0	0.1	0.1
15	0.4	0.4	-0.1	0	0.3	0.1
16	0.6	0.1	-0.2	0	-0.1	-0.2
17	0.8	0	0.1	0.1	-0.1	0.1
18	1.0	0.1	-0.2	-0.2	-0.2	0.1
19						

Finally the mean change in length and the standard deviation of the samples can be calculated too. Note it is not necessary to calculate the percentage change in length as the tissues were all the same lengths to start with.

A scatter plot graph is drawn of the mean change in length against sucrose concentration and a trend line is added.

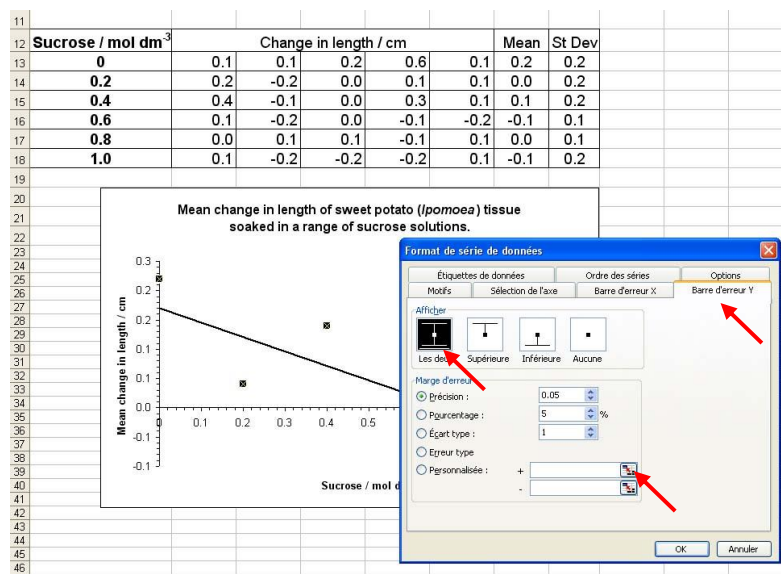


Click left on one of the data points to activate them.



Double click on the data point to open the dialogue box. Select the Y error bar menu.

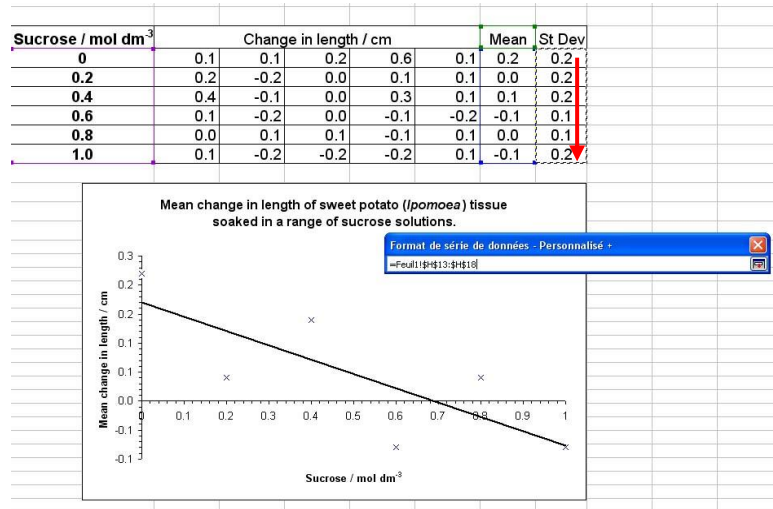
Note this time for the scatter plot you will see an X error bar menu too. So you can put in horizontal error bars too.



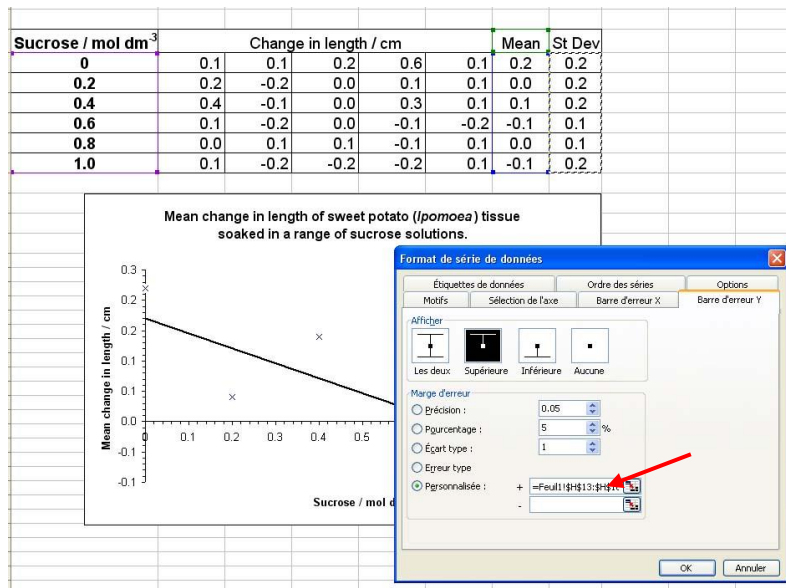
Select error bars both above and below the data point and then select Custom (Fr: *Personnalisée*)

Select the data that is to be used for the upper error bar. Click left on the upper bar (+) the menu will disappear and you will be left with the box in which you have to select the cells containing the data for the error bars (in this case the standard deviation).

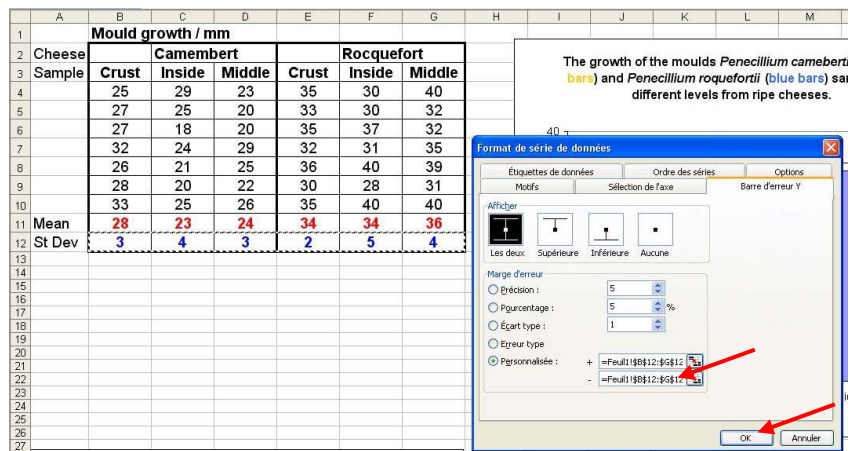
Left click on the first cell and hold the button down whilst you run along the line for standard deviations. You will see the cell coordinates appear in the box.



Let go of the mouse button and the menu will reappear with the upper error bar box complete.



Repeat the procedure with the box for the lower error bar (-). Use the same cells for the standard deviations as before.



Finally click on **OK** or press **Enter** and the error bars will appear on the graph.

