

## 7.5. Parametric one-way ANOVA with equal numbers of replicates

**EXAMPLE 7.4.** The effectiveness of weaning plantlets of *Lobelia* 'Hannah' from tissue culture onto one of four composts

**BOX 7.6.** How to carry out a one-way parametric ANOVA with equal replicates

**Step 1.** First confirm that the data may be analysed using a **parametric** ANOVA including using the  $F_{\max}$  test (BOX 7.5.). The spreadsheet created for the  $F_{\max}$  test may now be used for the ANOVA.

**Step 2.** Returning to the spreadsheet, select 'Tools' from the toolbar and then 'Data Analysis' from the dropdown menu. In the dialogue box which opens, select 'ANOVA: Single Factor' and click 'OK'.

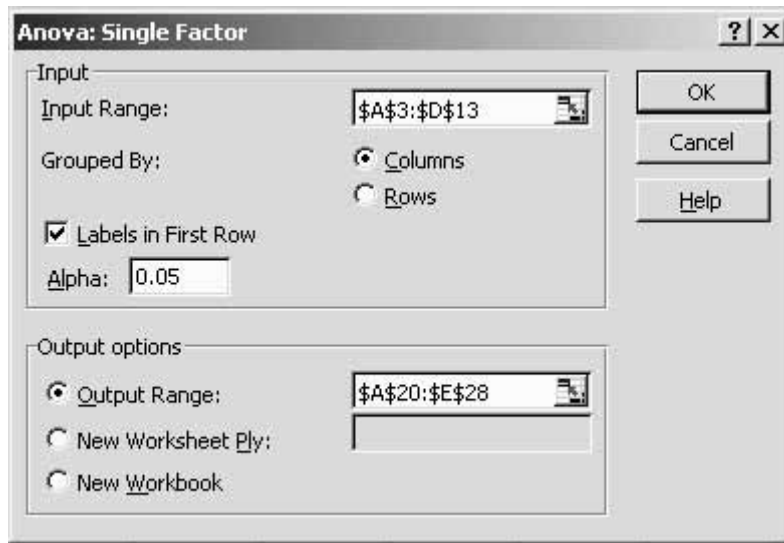
The screenshot shows a Microsoft Excel spreadsheet with the following data:

	A	B	C	D
1	Fresh weight (g) of <i>Lobelia</i> 'Hannah' weaned in one of four composts (A – D).			
2				
3	A	B	C	D
4	7.04	3.18	3.2	4.16
5	4.86	1.52	3.93	2.94
6	7.47	3.85	3.21	3.62
7	4.49	1.42	3.01	2.09
8	3.06	4	3.93	3.83
9	2.48	2.18	5.11	3.71
10	3.03	2.12	5.32	1.6
11	4.21	1.27	3	1.6
12	6.03	2.03	2.25	2.14
13	4.77	4.82	3.53	3.16
14				
15	2.846627	1.536832	0.919988	0.923072
16				
17	Fmax=	3.094201		

The 'Data Analysis' dialog box is open, showing the following options:

- Analysis Tools:
  - Anova: Single Factor (selected)
  - Anova: Two-Factor With Replication
  - Anova: Two-Factor Without Replication
  - Correlation
  - Covariance
  - Descriptive Statistics
  - Exponential Smoothing
  - F-Test Two-Sample for Variances
  - Fourier Analysis
  - Histogram

Buttons: OK, Cancel, Help.



Check that the cursor is flashing in the 'Input Range' box. First, input the cell references of the data as before by dragging over the area. Start at cell A3 and drag across and down to cell D13 (these cells include the sample labels). Click on the button that indicates that the data are grouped by columns. Click in the box indicating that 'labels' are present 'in the first row'. Note that it is useful to use the labels to identify your data. These labels are used by Excel to identify the output data. The default value for alpha ( $p$ ) is 0.05; this can be changed if required, but you will not normally need to do so.

**Step 3.** Next, select the output options. To return the output data below the input data, select 'Output Range:' and then click in the box (the cursor will now flash in the box). Drag over an area where you want the results to be displayed. Note that you could just select a couple of cells – Excel will determine the actual size that it requires for the results table. Note too, that it is essential to click in the box as well as selecting the 'Output Range' button. If this is not done the location is entered into the 'Input Range' box and the analysis cannot be completed.

You can choose to have the results entered on to a 'New Worksheet Ply', in which case the results will be given on a fresh sheet, accessed by the tabs at the bottom of the current sheet. Alternatively a 'New Workbook' can be selected. Click 'OK' to obtain the output data.

19							
20	Anova: Single Factor						
21							
22	SUMMARY						
23	<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>		
24	A	10	47.44	4.744	2.846627		
25	B	10	26.39	2.639	1.536832		
26	C	10	36.49	3.649	0.919988		
27	D	10	28.85	2.885	0.923072		
28							
29							
30	ANOVA						
31	<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
32	Between Groups	26.87561	3	8.958536	5.755085	0.002535	2.866265
33	Within Groups	56.03867	36	1.55663			
34							
35	Total	82.91428	39				
36							

**Step 4.** Note that in the output, first the summary statistics are given and that the sample labels have been used to name the ‘Groups’. The ANOVA table then follows giving all the values that would have been worked out individually by calculator.

As with your calculations by hand, interim values are calculated: sums of squares (SS), degrees of freedom (df), and mean square (MS, or variance).

In the table,  $F$  is the calculated test statistic (5.755085) and this is compared with  $F_{crit}$  (2.866265), the critical value at  $p=0.05$  at the appropriate **degrees of freedom**. Hence the null hypothesis can be rejected.  $P$ -value gives the actual probability of the calculated statistic (0.002535). Hence the probability is  $0.01 > p > 0.001$ , so is significant with a \*\* rating. Therefore, using Excel gives a more precise value for the probability of the result.