Two-way ANOVA without replication

This version of the ANOVA is used when there is only one **observation** in each block. Each **treatment** is represented once only in each block and the treatments are allocated to positions in a random manner. This design is known as a randomized block design or a randomized complete block design (Fig. WEA1.).

Fig. WEA1. A randomized block design

	TREATMENTS				
Block 1	T1	T5	T2	T3	T4
Block 2	T3	T2	T5	T4	T1
Block 3	T4	T1	T3	T5	T2
Block 4	T1	T4	T2	T3	T5
Block 5	T2	T5	T4	T1	T3
Block 6	T3	T1	T2	T4	T5
Block 7	T5	T3	T4	T1	T2

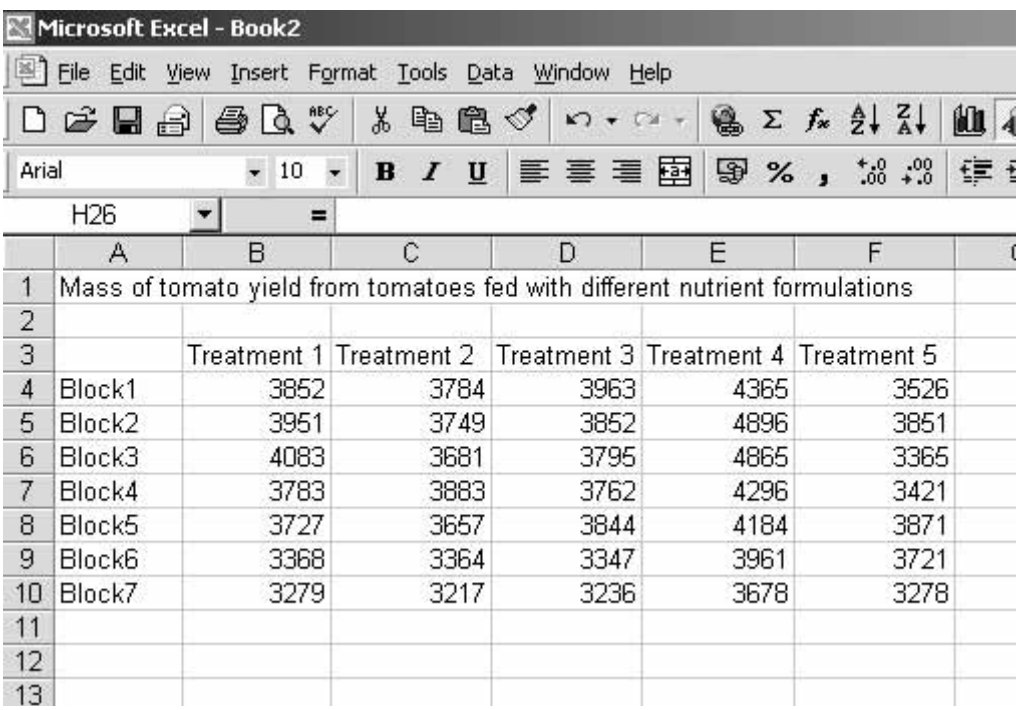
An example of this type of design could occur where tomato plants have been fed with different feed formulations and grown in a polytunnel. The treatments within each block stretch across the width of the polytunnel, and the blocks spread down the length of the polytunnel, and hence experience different environmental conditions. By using a randomized block design and a two-way ANOVA without replication, the variability can be partitioned into variability due to treatment and variability due to environment. Hence the effect of the treatments can be investigated without the environmental effect masking the outcome of the test.

In this trial, fruit would be harvested at a certain date and the mass recorded (in grams). The data are given in the spreadsheet shown in step 2.

Step 1. First check that the variances of the data are similar by using the F_{max} test.

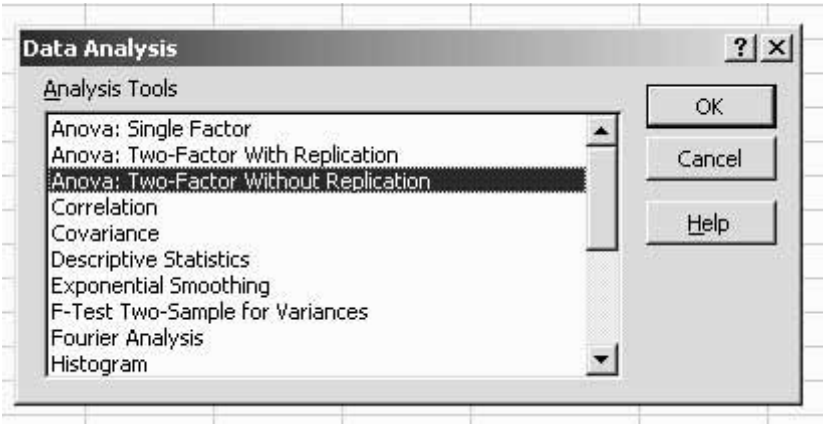
(In practice it is quicker to do this after the ANOVA test as this generates summary statistics including the variances.) It is very quick then to select a cell on the spreadsheet to complete the calculation for the F_{max} value. As before, select and empty cell and click on it. Put '=' in the cell, then click on the cell with the highest variance value – the cell location will be entered into the selected cell. Then enter '/', indicating division. Then click on the cell containing the lowest variance and press 'Enter' and the value for F_{max} will be returned. Check this value against the critical value found in the statistical tables. If F_{max} (calculated) is less than F_{max} (critical) then the variances are similar.

Step 2. If all other criteria are met the ANOVA may be carried out. First the data must be entered into the Excel spreadsheet in the appropriate rows and columns. Note that labels are included for both rows (Blocks) and columns (Treatments). This must be done, as Excel will read the first row and column values as labels. If one set of labels is omitted, Excel will read the numerical data as labels.

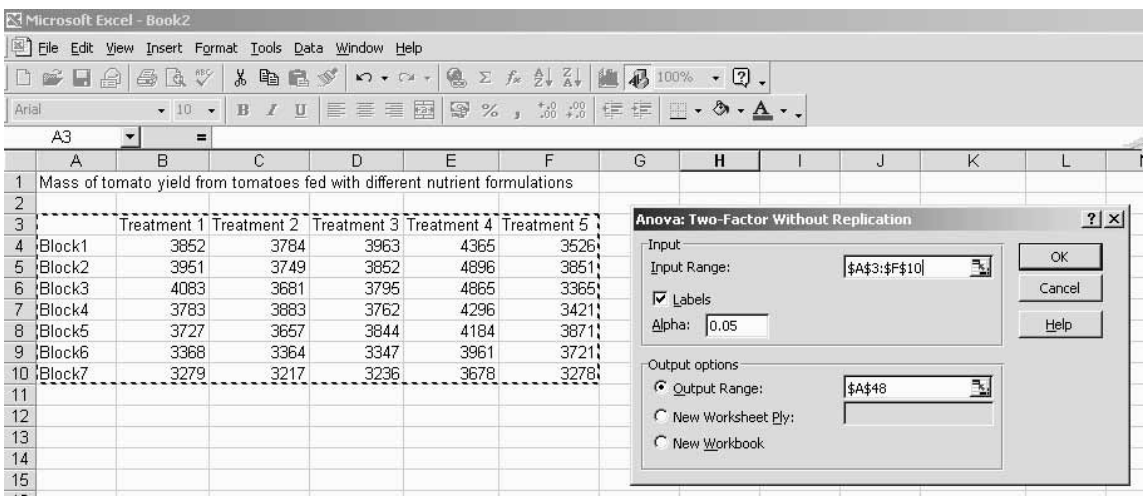


	A	B	C	D	E	F
1	Mass of tomato yield from tomatoes fed with different nutrient formulations					
2						
3		Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
4	Block1	3852	3784	3963	4365	3526
5	Block2	3951	3749	3852	4896	3851
6	Block3	4083	3681	3795	4865	3365
7	Block4	3783	3883	3762	4296	3421
8	Block5	3727	3657	3844	4184	3871
9	Block6	3368	3364	3347	3961	3721
10	Block7	3279	3217	3236	3678	3278
11						
12						
13						

Step 3. After entering the data, click on 'Tools', then 'Data Analysis' and select 'Anova: Two-Factor Without Replication' from the menu. A dialogue box will open.



It is essential to enter all cells including the column and row labels as one block into the input range.

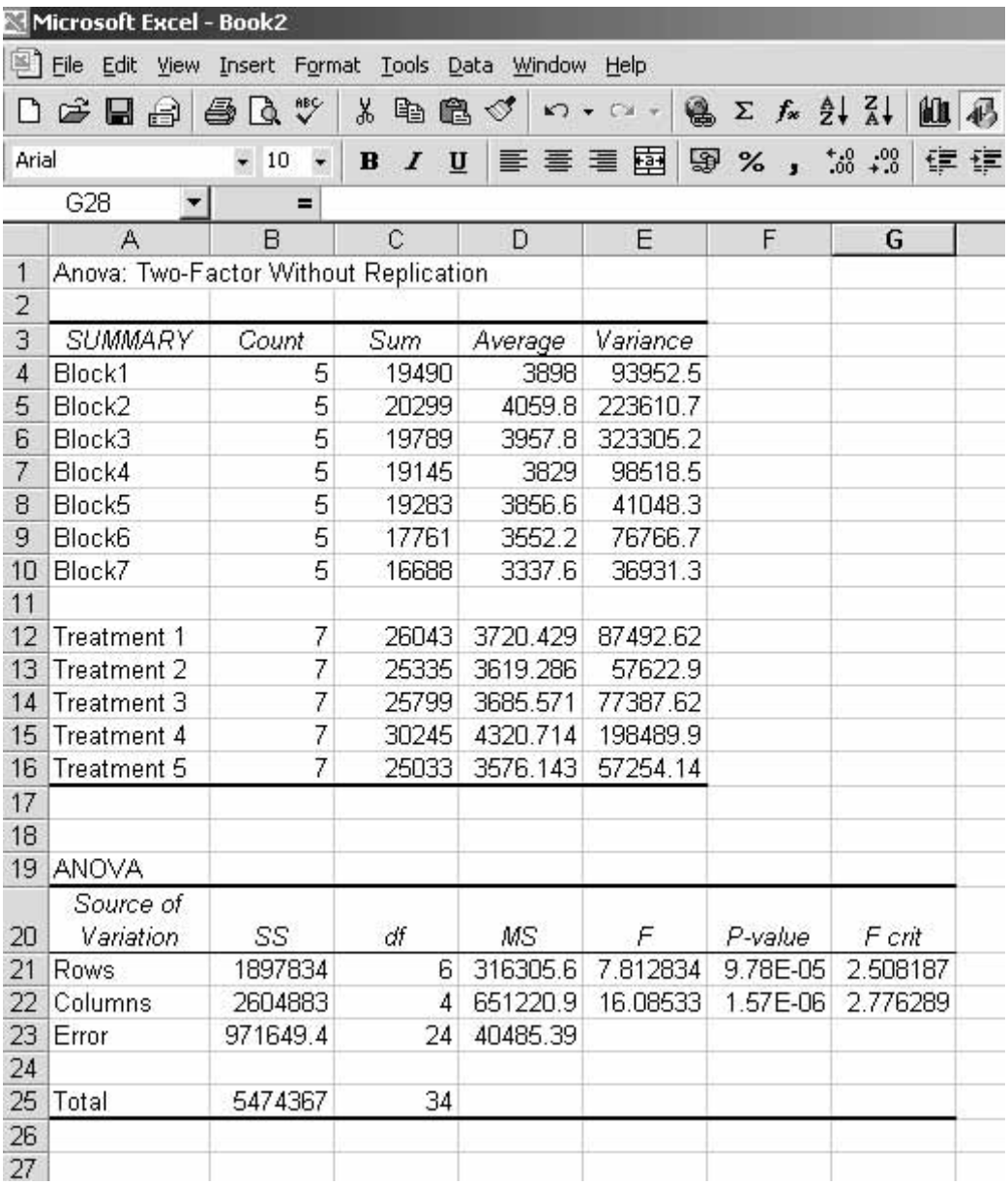


Click on the box to indicate that labels are present. Alpha (p) defaults to 0.05 but can be changed if desired.

Step 4. 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.



	A	B	C	D	E	F	G
1	Anova: Two-Factor Without Replication						
2							
3	*SUMMARY*	*Count*	*Sum*	*Average*	*Variance*		
4	Block1	5	19490	3898	93952.5		
5	Block2	5	20299	4059.8	223610.7		
6	Block3	5	19789	3957.8	323305.2		
7	Block4	5	19145	3829	98518.5		
8	Block5	5	19283	3856.6	41048.3		
9	Block6	5	17761	3552.2	76766.7		
10	Block7	5	16688	3337.6	36931.3		
11							
12	Treatment 1	7	26043	3720.429	87492.62		
13	Treatment 2	7	25335	3619.286	57622.9		
14	Treatment 3	7	25799	3685.571	77387.62		
15	Treatment 4	7	30245	4320.714	198489.9		
16	Treatment 5	7	25033	3576.143	57254.14		
17							
18							
19	ANOVA						
20	*Source of Variation*	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
21	Rows	1897834	6	316305.6	7.812834	9.78E-05	2.508187
22	Columns	2604883	4	651220.9	16.08533	1.57E-06	2.776289
23	Error	971649.4	24	40485.39			
24							
25	Total	5474367	34				
26							
27							

Step 5. Summary data are given first for both rows and columns followed by the ANOVA table. Note that with this design that only two *F* values are given, one relating to the 'rows' (Blocks) data and the other to the 'columns' (Treatments) data.

As in both cases the *F* (calculated) value is greater than its respective *F crit* value, both results are significant and so there is a difference in mean mass for both treatments and blocks. The *P-values* indicate that the results are very highly statistically significant. In this version of the two-way ANOVA there is no value for interaction as there are no replicates within the blocks.

You may then complete a Tukey's test to ascertain where the differences lie.