Design Evaluation Module in Σilver (http://silverstats.co.uk)

This tipsheet describes the procedure required to produce the Terms Relationships diagrams of the Layout and Restricted Layout Structures, as described in Bate and Chatfield (2013).

The procedure involves a three-stage process:

1) Generate the Terms Relationships diagram of the Layout Structure and also the dataset required to produce the Terms Relationship diagram of the Restricted Layout Structure.
2) Edit the dataset generated in Stage 1 to (i) include the randomisation arrows on the Terms Relationship diagram (ii) define which terms to include in the Restricted Layout Structure and (iii) re-label the terms that are included on the Terms Relationship diagram of the Restricted Layout Structure.
3) Create the Terms Relationships diagram of the Restricted Layout Structure using the dataset generated in Stage 2.

Example dataset

To illustrate the process we shall use Example 1 from the Supplementary Material (see Bate and Chatfield 2013).

This experiment, considered by Brien and Bailey (2006) Example 11, and Cochran and Cox (1957, 7.33), is an example of the use of a split-plot in a row-column design. In the study four soil treatments (Soil) are randomly assigned to four plants (Plant) on each of three benches (Bench) using a randomised complete block design. Three leaf treatments (Treat) are then assigned to leaves (Leaf) on the top, middle or bottom layer (Lyr) of each plant. The leaf treatments are randomly assigned (separately for the plants on each soil treatment) using a Latin square, where rows correspond to layers and columns correspond to benches. As commented by Brien and Bailey (2006) this experiment is unusual in that the subplot treatments are randomised within the levels of the main plot treatment.

If you wish to follow this example, then cut and paste this dataset into Excel.

Bench	Plant	Lyr	Soil	Treat	Leaf
1	1	Top	3	2	1
1	1	Middle	3	0	2
1	1	Bottom	3	1	3
1	2	Top	2	1	4
1	2	Middle	2	0	5
1	2	Bottom	2	2	6
1	3	Top	1	0	7
1	3	Middle	1	1	8
1	3	Bottom	1	2	9
1	4	Top	0	1	10
1	4	Middle	0	0	11
1	4	Bottom	0	2	12
2	5	Top	0	0	13

2	5	Middle	0	2	14
2	5	Bottom	0	1	15
2	6	Top	2	0	16
2	6	Middle	2	2	17
2	6	Bottom	2	1	18
2	7	Top	1	1	19
2	7	Middle	1	2	20
2	7	Bottom	1	0	21
2	8	Top	3	1	22
2	8	Middle	3	2	23
2	8	Bottom	3	0	24
3	9	Top	3	0	25
3	9	Middle	3	1	26
3	9	Bottom	3	2	27
3	10	Top	0	2	28
3	10	Middle	0	1	29
3	10	Bottom	0	0	30
3	11	Top	2	2	31
3	11	Middle	2	1	32
3	11	Bottom	2	0	33
3	12	Top	1	2	34
3	12	Middle	1	0	35
3	12	Bottom	1	1	36

Stage 1 – Generating the Layout Structure

Go to the website http://silverstats.co.uk

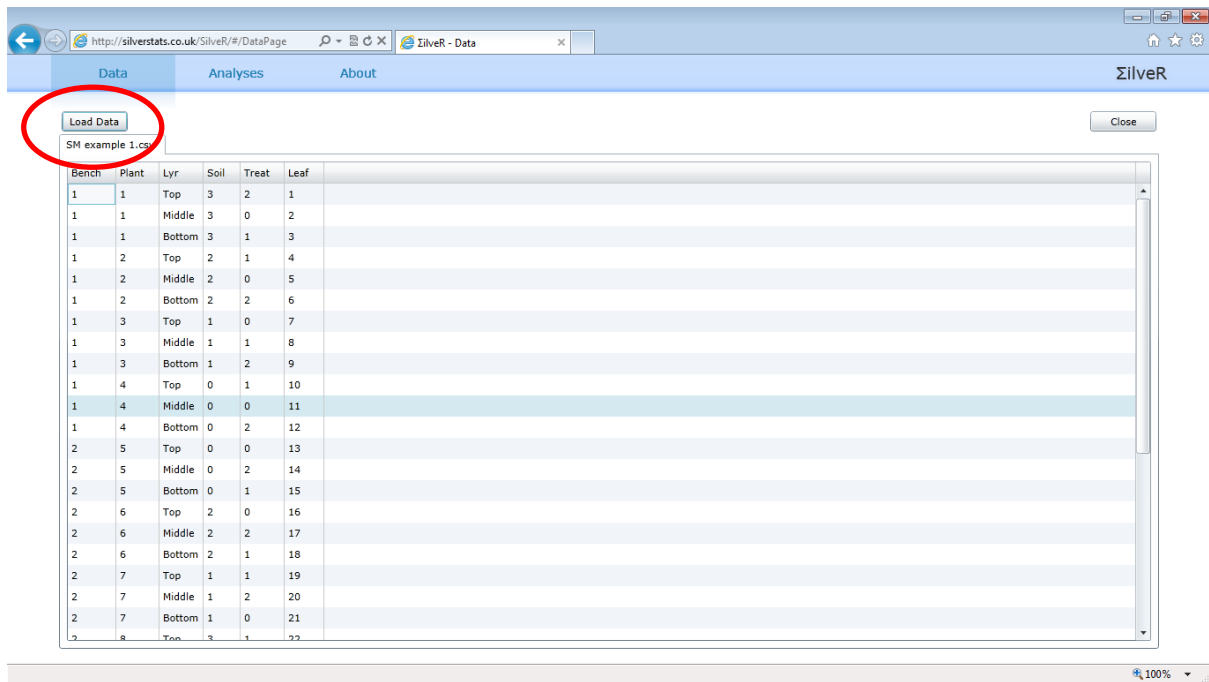At the home page, select "User Σilver".
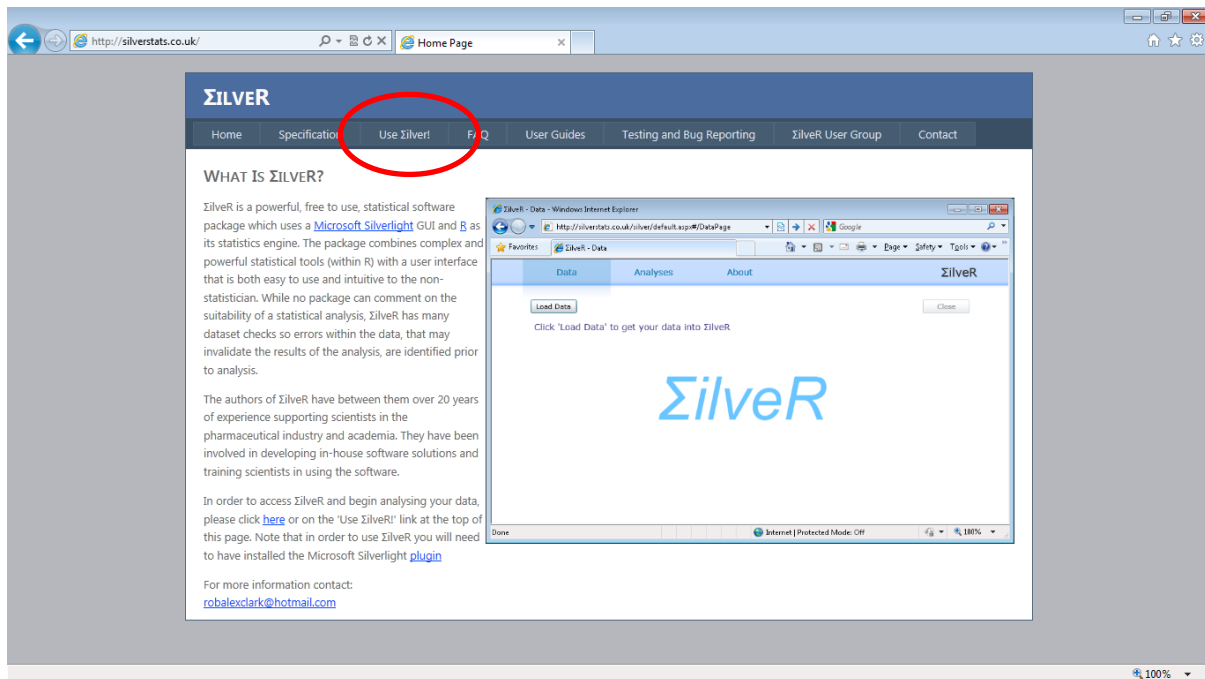
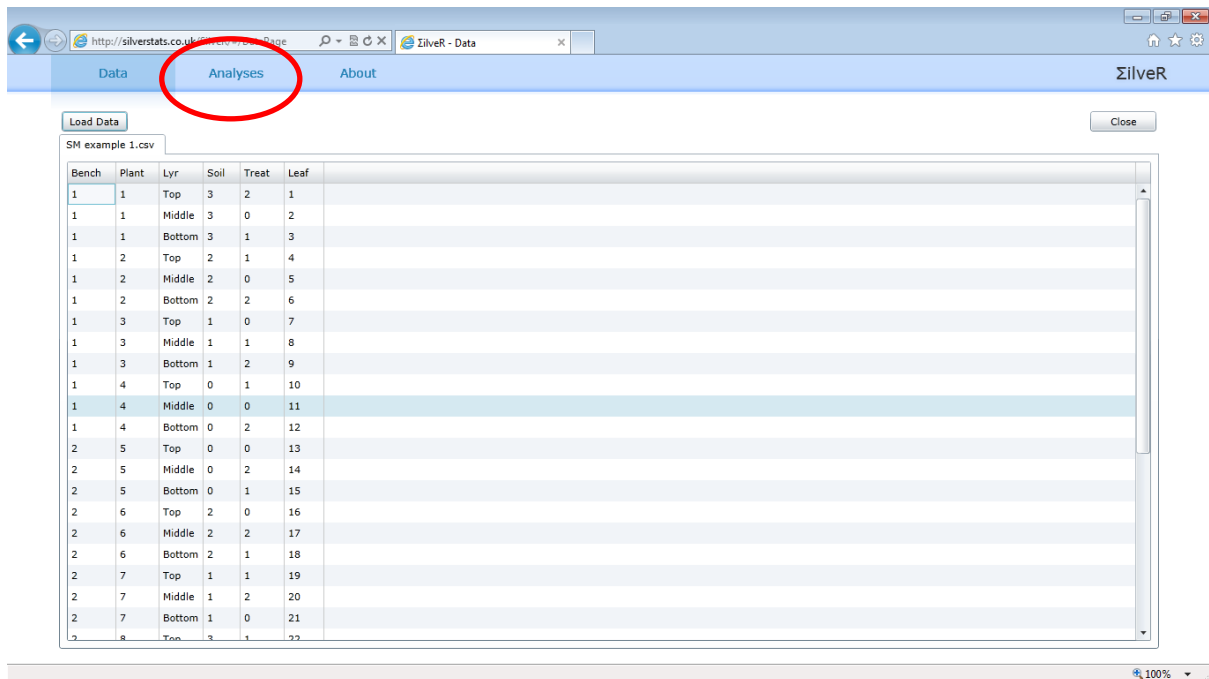Click on "Load Data" to import the dataset into Σilver.
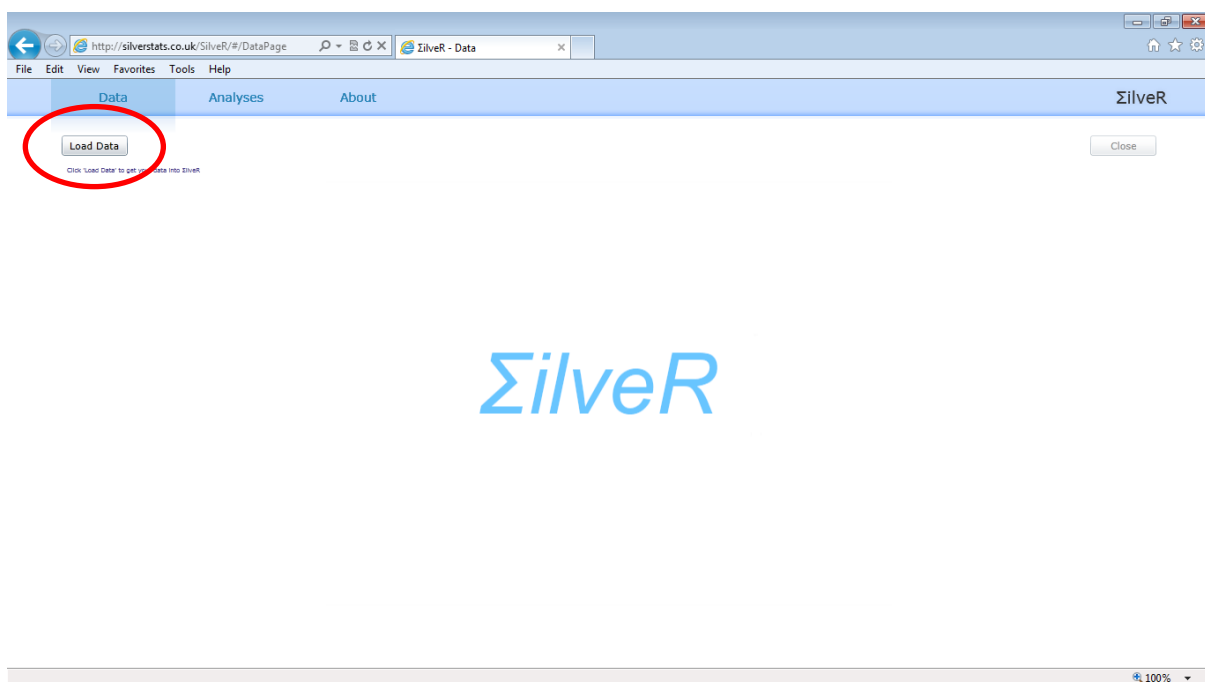
Use standard Windows methodology to locate the Excel file. Data should be stored in .csv format.
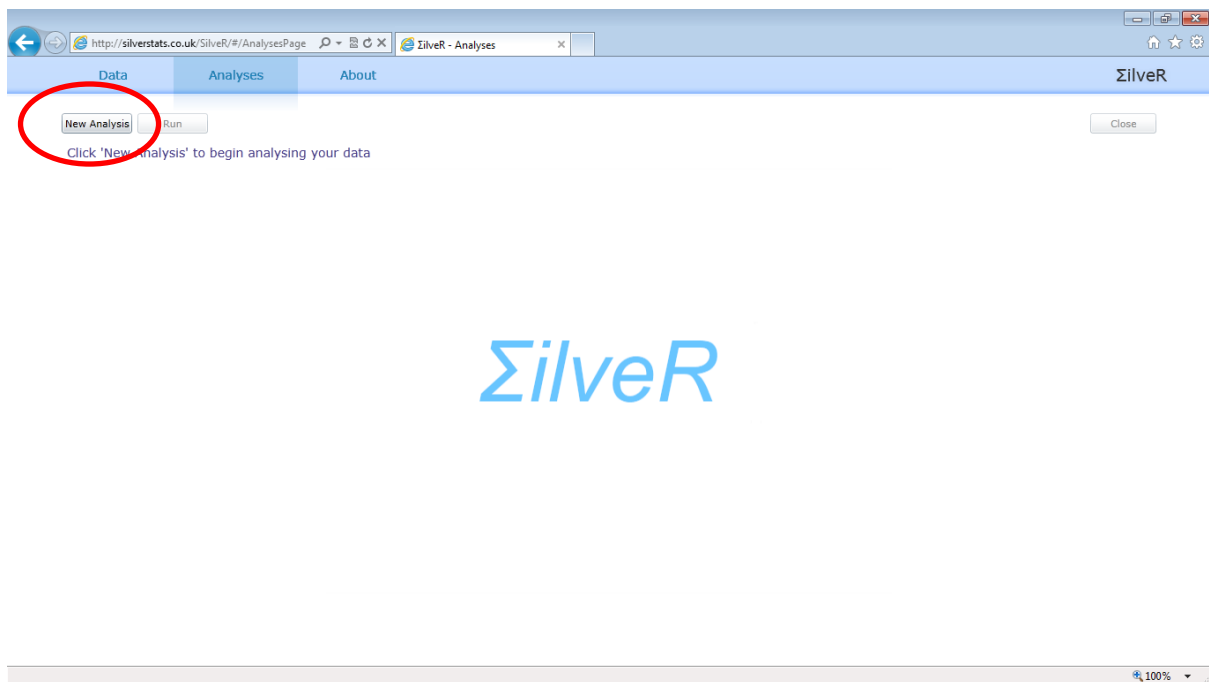
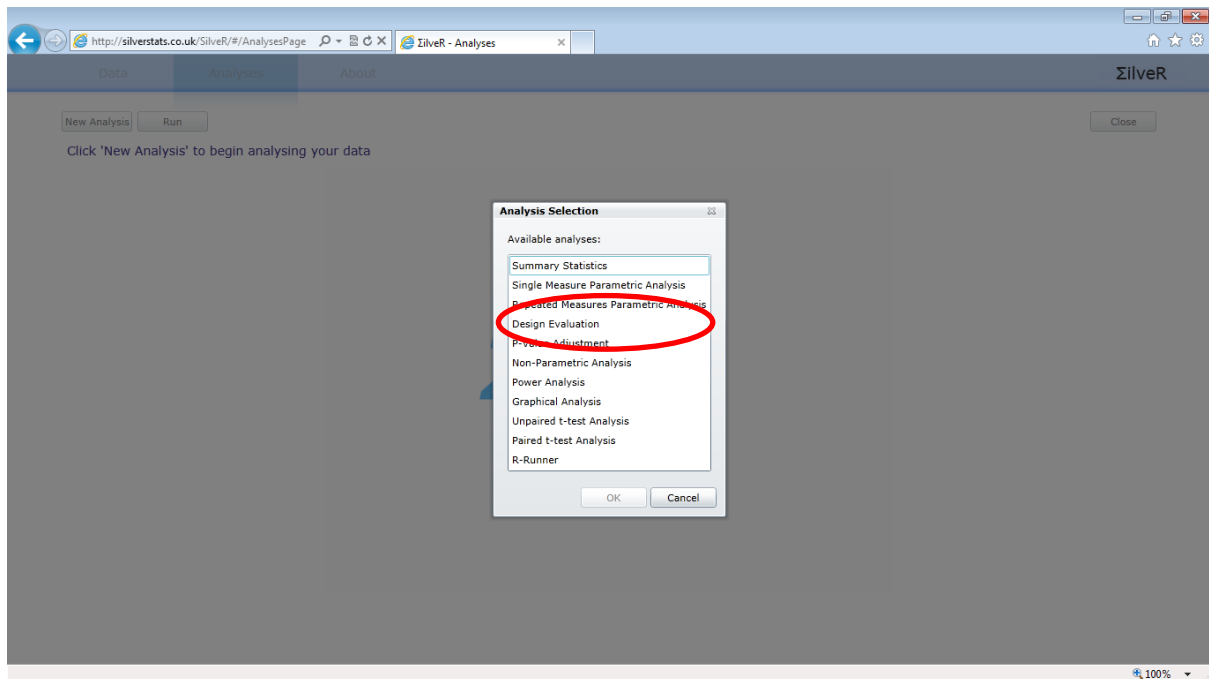Multiple datasets can be imported using the "Load Data" button on the Data window.

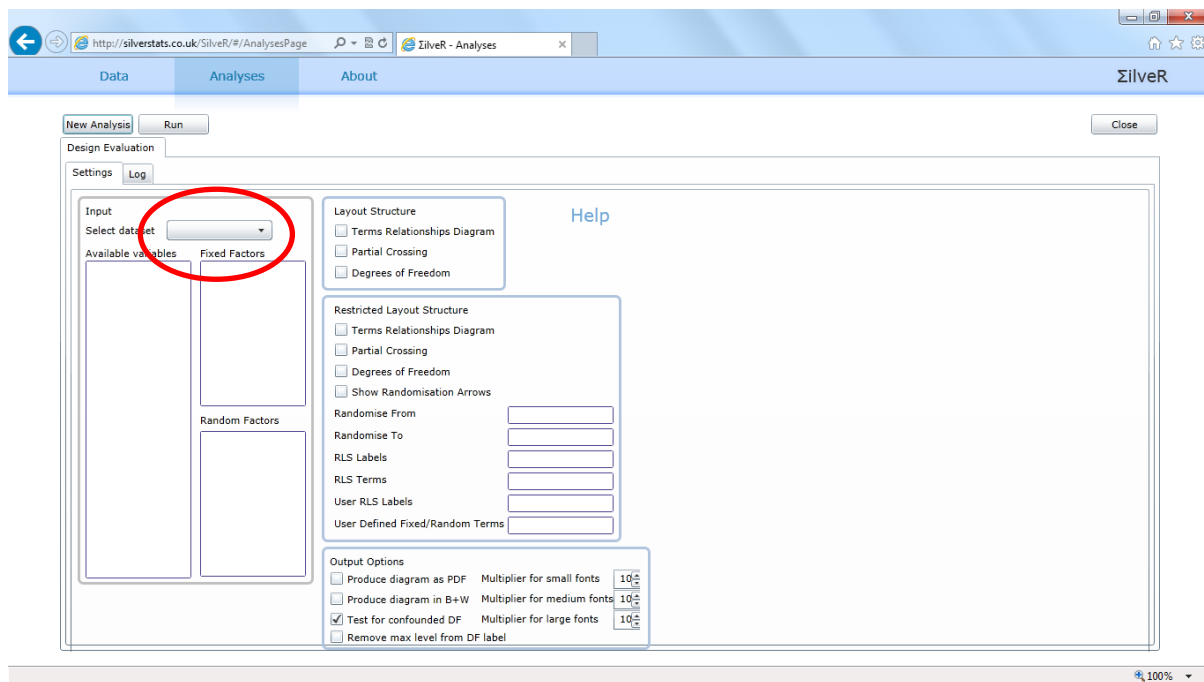Now select "Analyses" to go to the analysis window.

Click on "New Analysis".


Many analysis options are available in Σilver, select "Design Evaluation" then "OK".

Select the dataset to analyse.

Drag and drop the Factors into either the Fixed Factors or Random Factors, depending on the factor properties. **Note that the same selection of fixed and random factors and also the order that the factors appear in the two lists must be used in Stage 3 of this process.**
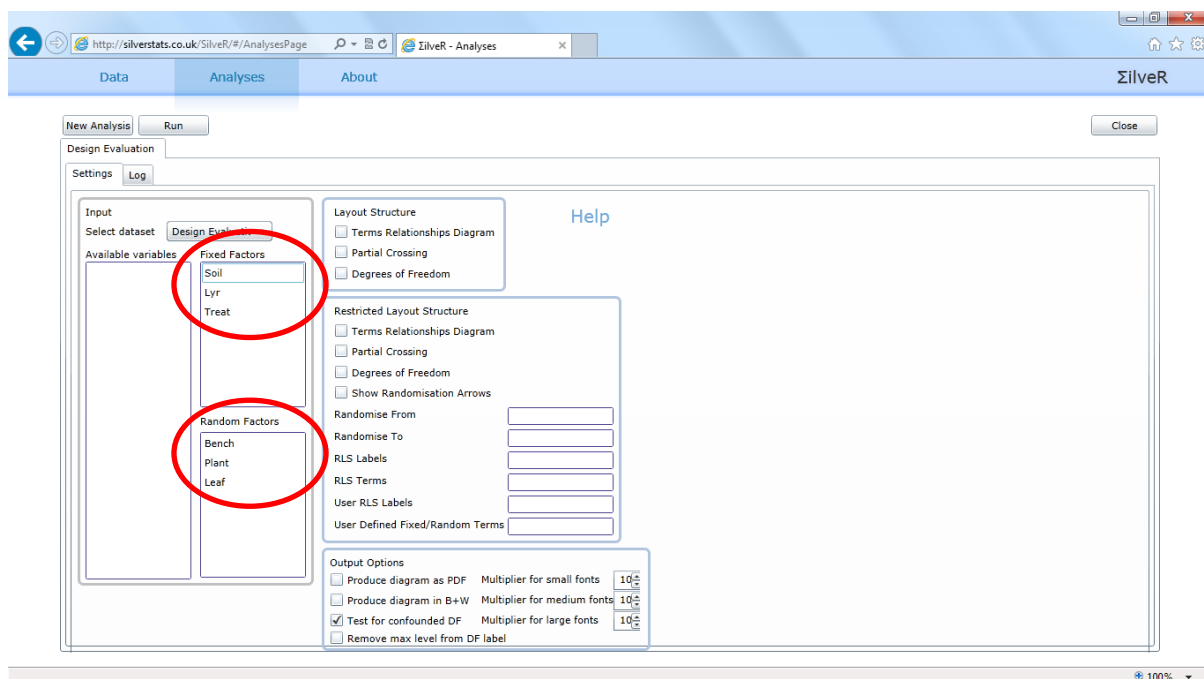
The user should now select the Layout Structure. If so desired they can also choose to show the partial crossing between the factors (recommended for smaller designs) and also the degrees of freedom (recommended).
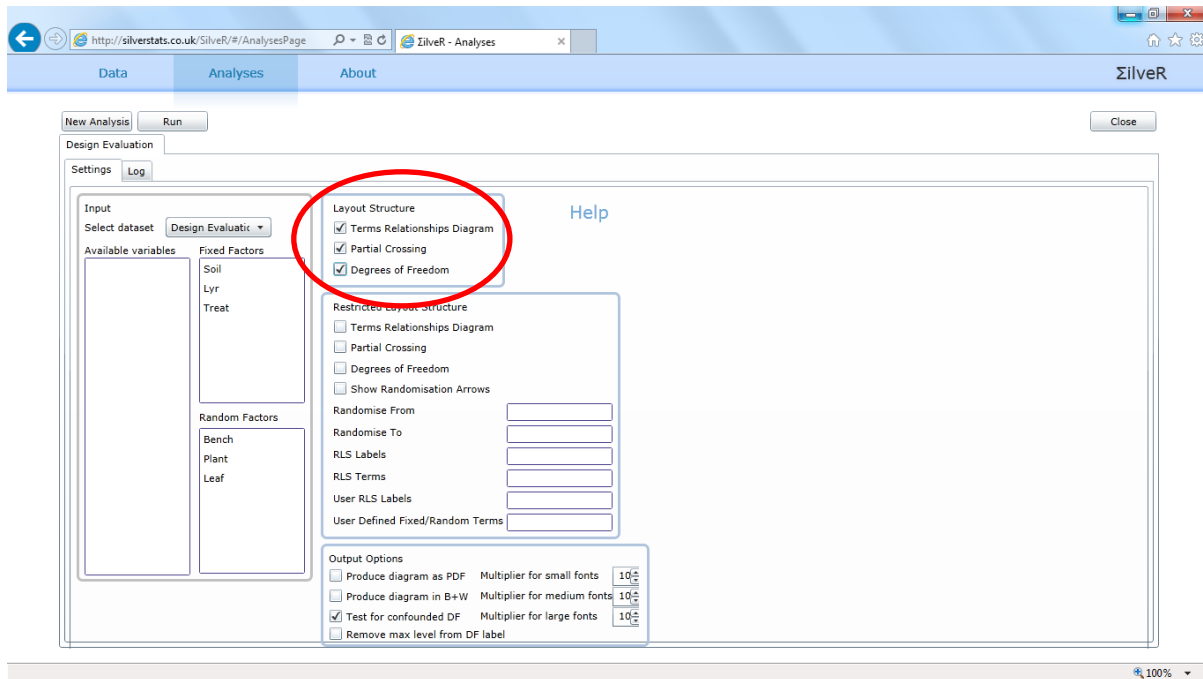
Click on "Run" to produce a) the Terms Relationships diagram for the Layout Structure and b) the dataset required for Stage 2 of the process.
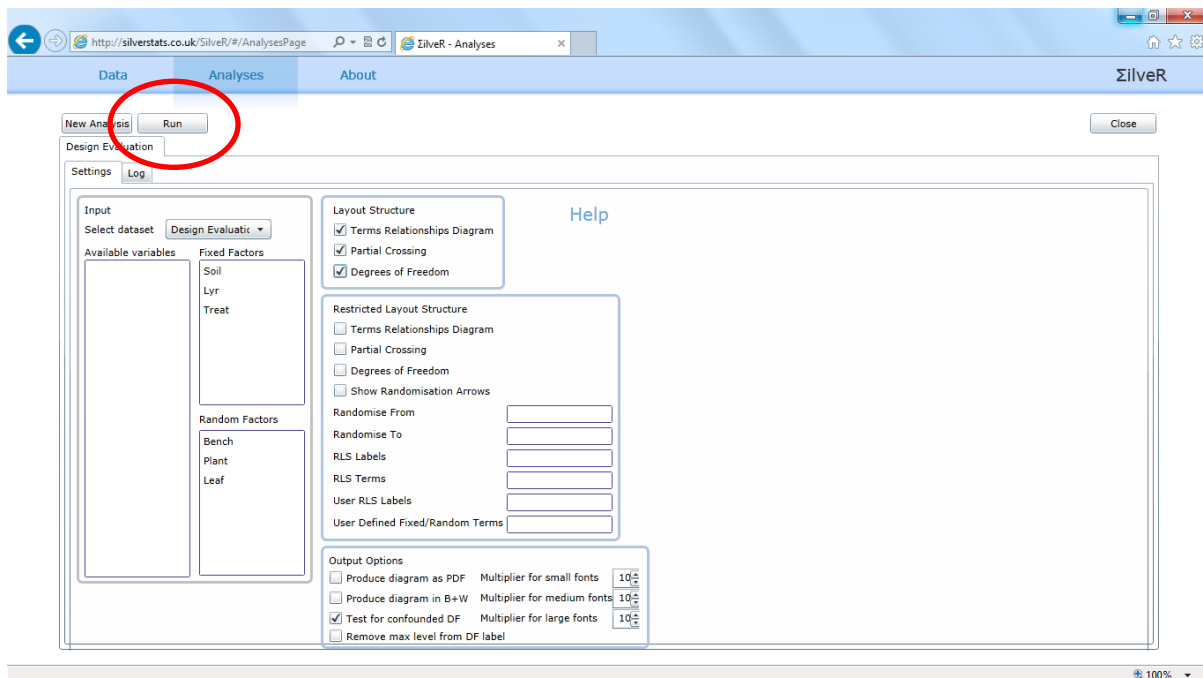
The output from ΣilveR is presented in Appendix I. The Terms Relationships diagram of the Layout Structure is given below. If there are issues with the calculated degrees of freedom (see Bate and Chatfield (2013) for more details, then a warning is given in the output.
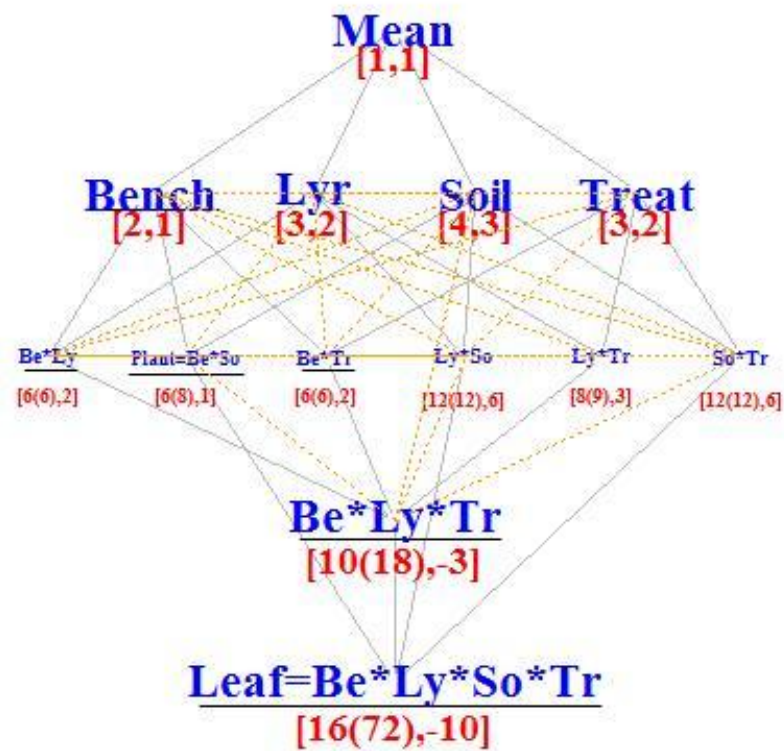
For a figure of publishable quality, it is recommended to select the "Produce plot as PDF" option on the analysis interface (see below for more details).

Also given in the output is the dataset required for Stage 2. The first fourteen rows of the dataset are given below. This dataset should be cut and pasted into Excel to complete Stage 2 of the process.

Soil	Lyr	Treat	Bench	Plant	Leaf	LS_Labels	Fixed_Random _Def	LS_Effects	Randomise _from	Randomise _to	RLS_Labels	RLS_Effects	User_RLS_Labels
'3'	Top	'2'	'1'	'1'	'1'	Mean	Fixed	Mean			Mean	Mean	Mean
'3'	Middle	'0'	'1'	'1'	'2'	Bench	Random	Bench			Bench	Bench	Bench
'3'	Bottom	'1'	'1'	'1'	'3'	Lyr	Fixed	Lyr			Lyr	Lyr	Lyr
'2'	Top	'1'	'1'	'2'	'4'	Soil	Fixed	Soil			Soil	Soil	Soil
'2'	Middle	'0'	'1'	'2'	'5'	Treat	Fixed	Treat			Treat	Treat	Treat
'2'	Bottom	'2'	'1'	'2'	'6'	Be*Ly	Random	Bench*Lyr			Be*Ly	Bench*Lyr	Be*Ly
'1'	Top	'0'	'1'	'3'	'7'	Plant=Be*So	Random	Bench*Soil			Plant=Be*So	Bench*Soil	Plant=Be*So
'1'	Middle	'1'	'1'	'3'	'8'	Be*Tr	Random	Bench*Treat			Be*Tr	Bench*Treat	Be*Tr
'1'	Bottom	'2'	'1'	'3'	'9'	Ly*So	Fixed	Lyr*Soil			Ly*So	Lyr*Soil	Ly*So
'0'	Top	'1'	'1'	'4'	'10'	Ly*Tr	Fixed	Lyr*Treat			Ly*Tr	Lyr*Treat	Ly*Tr
'0'	Middle	'0'	'1'	'4'	'11'	So*Tr	Fixed	Soil*Treat			So*Tr	Soil*Treat	So*Tr
'0'	Bottom	'2'	'1'	'4'	'12'	Be*Ly*Tr	Random	Bench*Lyr*Treat			Be*Ly*Tr	Bench*Lyr*Treat	Be*Ly*Tr
'0'	Top	'0'	'2'	'5'	'13'	Leaf=Be*Ly*So*Tr	Random	Bench*Lyr*Soil*Treat			Leaf=Be*Ly*So*Tr	Bench*Lyr*Soil*Treat	Leaf=Be*Ly*So*Tr

Note:

- The column LS_Labels is for information only.

- The Fixed_Random_Def variable contains the designation of the terms (as fixed or random) as defined by the program. They should be edited by the user as required.

- LS_Effects should be cut and pasted into the Randomised_from and Randomised_to variables as required (see below) to define the randomisation performed.

- Entries in the RLS_Labels, RLS_Effects and User_RLS_Labels should be removed if the terms are not required in the Restricted Layout Structure.

- The User_RLS_Labels variable is a free-text variable that defines the labels that appear on the Terms Relationship diagram of the Restricted Layout Structure.

Stage 2 – Editing the dataset generated in Stage 1

To begin with the user can define the randomisation arrows to include on the Terms Relationship diagram of the Restricted Layout Structure. In this case assume the randomisations performed were:

Soil → Plant(Bench)

and

Treat → {Bench*Lyr}(Soil).

The soils were randomly assigned to plant within bench by permuting the benches, and the leaf treatment were randomised by randomly permuting the benches and layers separately for each soil, see Bate and Chatfield (2013) for more details. Note *Plant(Bench)* is completely confounded with *Bench*Soil* and *{Bench*Lyr}(Soil)* is completely confounded with *Bench*Lyr*Treat*Soil*.

To define the randomisation arrows in the Restricted Layout Structure we cut and paste the relevant terms from the LS_Effects variable into the Randomise_from and Randomise_to variables. The Randomise_from variable denotes the start of the arrow and the Randomsied_to denoted the end of the arrow. Each row of the dataset (for these two variables) corresponds to one randomisation.

LS_Effects	Randomise_from	Randomise_to
Mean	Soil	Bench*Soil
Bench	Treat	Bench*Lyr*Soil*Treat
Lyr		
Soil		
Treat		
Bench*Lyr		
Bench*Soil		
Bench*Treat		
Lyr*Soil		
Lyr*Treat		
Soil*Treat		
Bench*Lyr*Treat		
Bench*Lyr*Soil*Treat		

The user should then remove rows from the final three columns that correspond to terms that are not required in the Restricted Layout Structure. For this example, the rows remaining after this are:

RLS_Labels	RLS_Effects	User_RLS_Labels
Mean	Mean	Mean
Bench	Bench	Bench
Soil	Soil	Soil
Treat	Treat	Treat
Plant=Be*So	Bench*Soil	Plant=Be*So
Ly*So	Lyr*Soil	Ly*So
So*Tr	Soil*Treat	So*Tr
Leaf=Be*Ly*So*Tr	Bench*Lyr*Soil*Treat	Leaf=Be*Ly*So*Tr

The user may choose to rename the labels on the Terms Relationship diagram of the Restricted Layout Structure to reflect the randomisation performed. This can be achieved by manually editing the User_RLS_Labels variable.

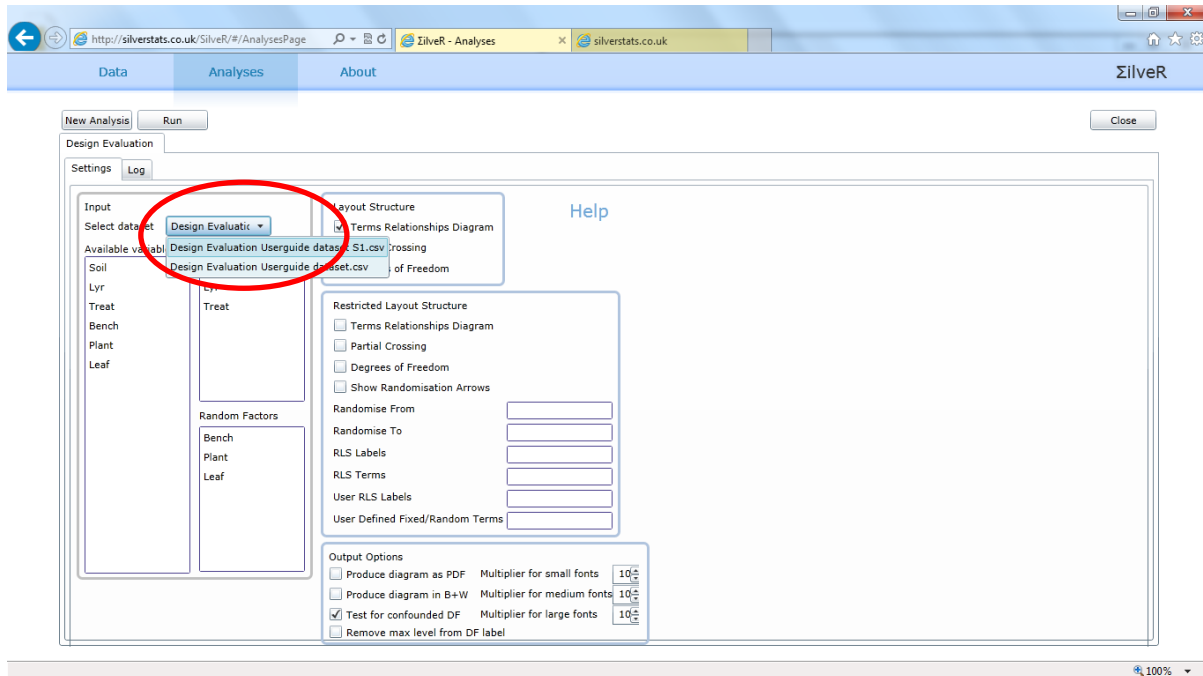| RLS_Labels	RLS_Effects	User_RLS_Labels
Mean	Mean	Mean
Bench	Bench	Bench
Soil	Soil	Soil
Treat	Treat	Treat
Plant=Be*So	Bench*Soil	Bch*Soil [Plant(Bch)]
Ly*So	Lyr*Soil	Lyr*Soil
So*Tr	Soil*Treat	Soil*Treat
Leaf=Be*Ly*So*Tr	Bench*Lyr*Soil*Treat	Leaf=Treat*Bch*Lyr(Soil) [{Bch*Lyr}(Soil)]

Finally the designation of the terms (either fixed or random) that is assigned automatically by the program can be changed by replacing the terms in the Fixed_Random_Def column. Note the Layer*Soil term has been changed to Random (it was defined as fixed by the program as the two factors Layer and Soil were defined as fixed by the user).

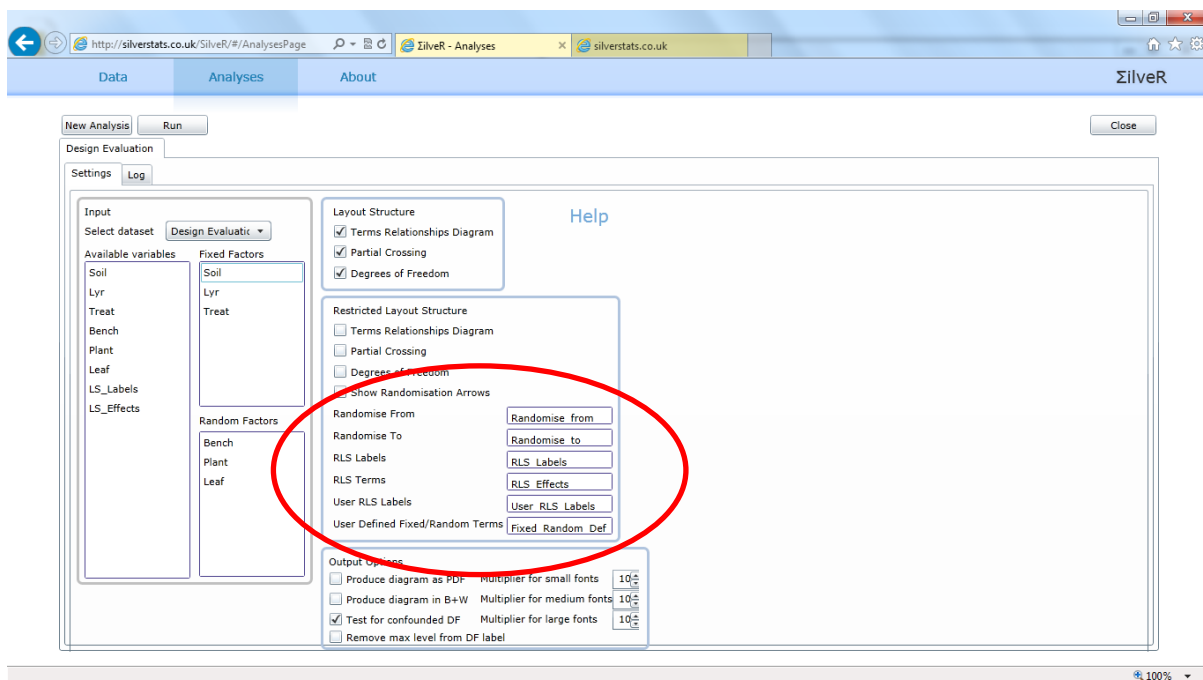| LS_Labels	Fixed_Random_Def
Mean	Fixed
Bench	Random
Lyr	Fixed
Soil	Fixed
Treat	Fixed
Be*Ly	Random
Plant=Be*So	Random
Be*Tr	Random
Ly*So	Random
Ly*Tr	Fixed
So*Tr	Fixed
Be*Ly*Tr	Random
Leaf=Be*Ly*So*Tr	Random

This new dataset should be saved as a .csv file and imported into Σilver using the above methodology.

Stage 3 - Generating the Restricted Layout Structure

Import the new dataset into SilveR. Return to the Analyses page and return to the Settings tab. The user should now select the new dataset. Notice the original fixed/random effect options will still be selected. These options should not be edited.

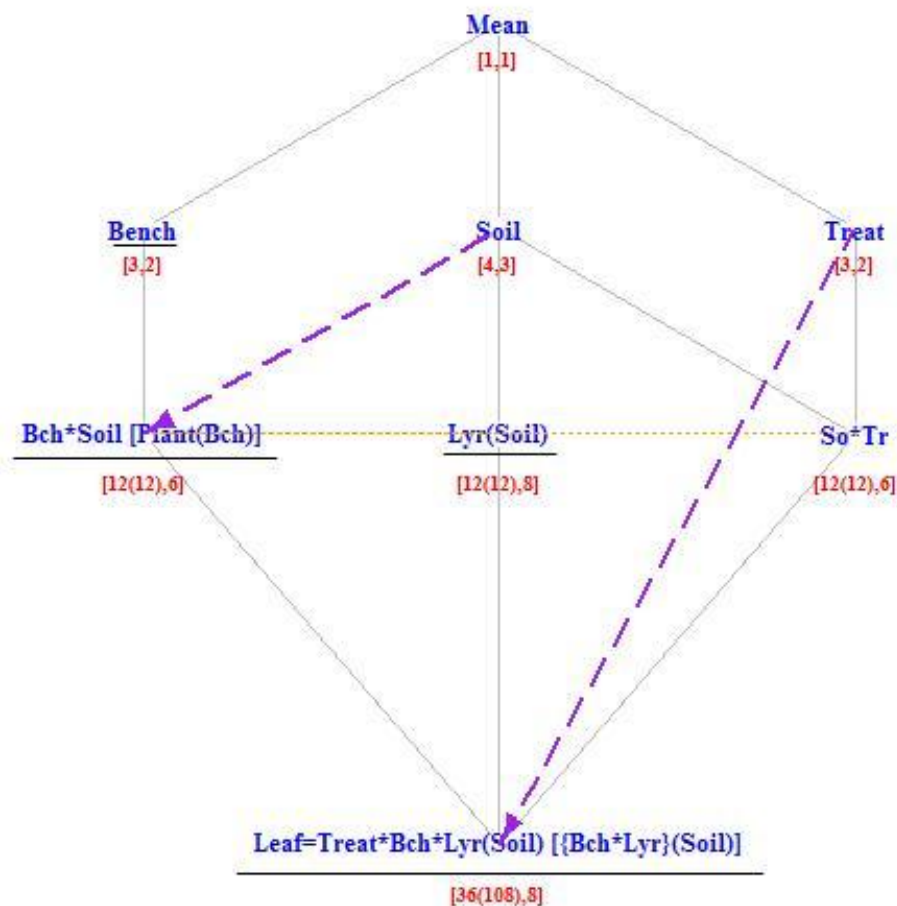The user should now drag and drop the Randomsied_from, Randomised_to, RLS_Labels, RLS_Effects, User_RLS_Labels and Fixed_Random_Def into the appropriate input selection boxes. Note the user could select variables with different names if they so choose.

The user should select the Restricted Layout Structure option and also decide if they want to show the randomisation arrows, partial crossing and the degrees of freedom on the Restricted Layout Structure.

Finally the user can decide to perform a check to see if there are confounded degrees of freedom in the structure. This is recommended for reasonably large designs but can slow the program down in larger cases.

Along with the Terms Relationships diagram of the Layout Structure (if selected) Σilver now produces a Terms Relationships diagram of the Restricted Layout Structure.

Other options

There are several other options that the available to the user:

- Users can select to produce the plots in PDF file format. This is useful for larger designs as the figures are much clearer and can be "zoomed-in" without loss of resolution. If selected, the Terms Relationships diagram is not produced within the HTML output window, but a link is to the PDF file containing the diagram is given instead. Either "left mouse click" on the link to open the pdf in a web browser, or "right mouse click" to save the PDF file to a location of your choice.
- Users can select to produce plots in black and white (for publication purposes).

- Users can choose to remove the maximum level from the degrees of freedom label. This is the number (in brackets) that denotes the maximum number of possible levels for a term. For example, with this option selected the Leaf term in the above terms relationship diagram is labelled [36, 8] rather than [36(108), 8]. Removing this additional number can be useful in more complicated diagrams.

- Finally the user can change the font size of the labels on the terms relationship diagrams, this includes:
  - o Small fonts

The small font multiplier is the multiplier for the font used to define terms on the diagram where there are five or more terms at that level in the diagram.

  - o Medium fonts

The medium font multiplier is the multiplier for the font used to define terms on the diagram involving a factor that is equivalent to an interaction term.

  - o Large fonts

The large font multiplier is the multiplier for the font used to define terms on the diagram where there are four or less terms at that level in the diagram.

References

Bate, S. and Chatfield, M.J., 2013. Using the experimental design and its randomisation to construct a mixed model. Submitted for publication.

Brien, C.J., Bailey, R.A., 2006. Multiple randomizations (with discussion). J. R. Statist. Soc. B 68, 571–609.

Cochran, W.G., Cox, G.M., 1957. Experimental Design, 2nd edn. Wiley, New York.

Appendix I – Output from Stage 1

SilveR Design Evaluation Module

This module performs the calculations required to produce Terms Relationships diagrams, as described in Bate and Chatfield (2013).

The Layout Structure

Warning

There are 6 confounded degrees of freedom

Confounded degrees of freedom often indicate that the design terms are not specified appropriately or that the design needs to be changed. However, sometimes once appropriate randomisation is performed, the Layout Structure no longer contains confounded degrees of freedom. Investigate the shared.dfs column in the following table which shows where shared degrees of freedom occur and/or proceed to the randomisation. The revised.dfs column corrects the dfs for terms which are underestimated by the subtraction method (because of shared dfs in terms above). It does not adjust individual terms for confounded degrees of freedom.

	actual.levs	dfs.by.subtract	revised.dfs	shared.dfs
Bench	3	2	2	0
Lyr	3	2	2	0
Soil	4	3	3	0
Treat	3	2	2	0
Bench*Lyr	9	4	4	4
Bench*Soil	12	6	6	4
Bench*Treat	9	4	4	4
Lyr*Soil	12	6	6	4
Lyr*Treat	9	4	4	4
Soil*Treat	12	6	6	4
Bench*Lyr*Treat	19	0	2	2
Bench*Lyr*Soil*Treat	36	-4	2	0

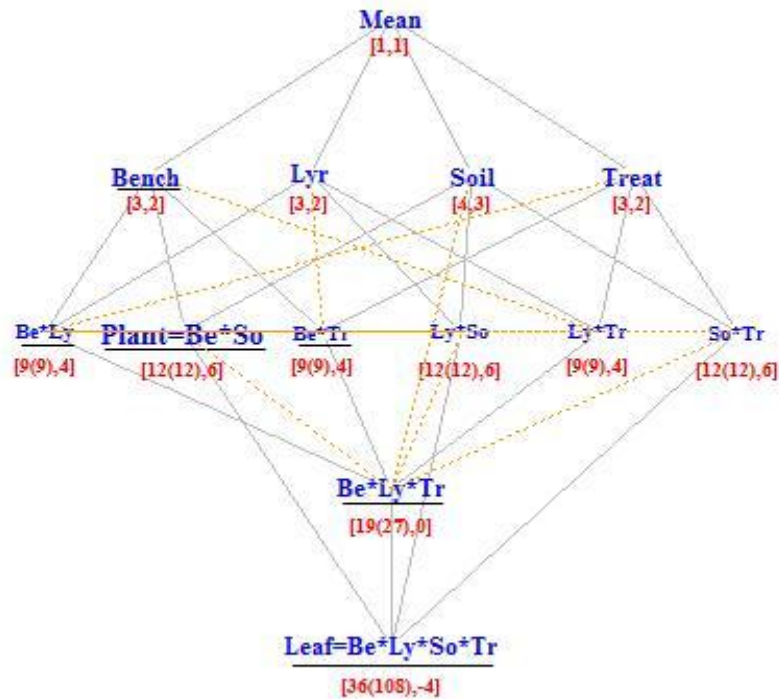## Terms Relationships diagram of the Layout Structure

Table of the data for creation of the Restricted Design Structure

	Soil	Lyr	Treat	Bench	Plant	Leaf	LS_Labels	Fixed_Random_Def	LS_Effects	Randomise_from	Randomise_to	RLS_Labels	RLS_Effects
1	'3'	Top	'2'	'1'	'1'	'1'	Mean	Fixed	Mean			Mean	Mean
2	'3'	Middle	'0'	'1'	'1'	'2'	Bench	Random	Bench			Bench	Bench
3	'3'	Bottom	'1'	'1'	'1'	'3'	Lyr	Fixed	Lyr			Lyr	Lyr
4	'2'	Top	'1'	'1'	'2'	'4'	Soil	Fixed	Soil			Soil	Soil
5	'2'	Middle	'0'	'1'	'2'	'5'	Treat	Fixed	Treat			Treat	Treat
6	'2'	Bottom	'2'	'1'	'2'	'6'	Be*Ly	Random	Bench*Lyr			Be*Ly	Bench*Lyr
7	'1'	Top	'0'	'1'	'3'	'7'	Plant=Be*So	Random	Bench*Soil			Plant=Be*So	Bench*Soil
8	'1'	Middle	'1'	'1'	'3'	'8'	Be*Tr	Random	Bench*Treat			Be*Tr	Bench*Treat
9	'1'	Bottom	'2'	'1'	'3'	'9'	Ly*So	Fixed	Lyr*Soil			Ly*So	Lyr*Soil
10	'0'	Top	'1'	'1'	'4'	'10'	Ly*Tr	Fixed	Lyr*Treat			Ly*Tr	Lyr*Treat
11	'0'	Middle	'0'	'1'	'4'	'11'	So*Tr	Fixed	Soil*Treat			So*Tr	Soil*Treat
12	'0'	Bottom	'2'	'1'	'4'	'12'	Be*Ly*Tr	Random	Bench*Lyr*Treat			Be*Ly*Tr	Bench*Lyr*Treat
13	'0'	Top	'0'	'2'	'5'	'13'	Leaf=Be*Ly*So*Tr	Random	Bench*Lyr*Soil*Treat			Leaf=Be*Ly*So*Tr	Bench*Lyr*Soil*Treat
14	'0'	Middle	'2'	'2'	'5'	'14'							
15	'0'	Bottom	'1'	'2'	'5'	'15'							
16	'2'	Top	'0'	'2'	'6'	'16'							
17	'2'	Middle	'2'	'2'	'6'	'17'							
18	'2'	Bottom	'1'	'2'	'6'	'18'							
19	'1'	Top	'1'	'2'	'7'	'19'							
20	'1'	Middle	'2'	'2'	'7'	'20'							
21	'1'	Bottom	'0'	'2'	'7'	'21'							
22	'3'	Top	'1'	'2'	'8'	'22'							
23	'3'	Middle	'2'	'2'	'8'	'23'							
24	'3'	Bottom	'0'	'2'	'8'	'24'							
25	'3'	Top	'0'	'3'	'9'	'25'							
26	'3'	Middle	'1'	'3'	'9'	'26'							
27	'3'	Bottom	'2'	'3'	'9'	'27'							
28	'0'	Top	'2'	'3'	'10'	'28'							
29	'0'	Middle	'1'	'3'	'10'	'29'							
30	'0'	Bottom	'0'	'3'	'10'	'30'							
31	'2'	Top	'2'	'3'	'11'	'31'							
32	'2'	Middle	'1'	'3'	'11'	'32'							
33	'2'	Bottom	'0'	'3'	'11'	'33'							
34	'1'	Top	'2'	'3'	'12'	'34'							
35	'1'	Middle	'0'	'3'	'12'	'35'							
36	'1'	Bottom	'1'	'3'	'12'	'36'							

To produce the Restricted Layout Structure, cut and paste this dataset into Excel and use the LS_effects variable to generate/amend the last five variables.

The columns Randomise_from and Randomise_to define the randomisations performed, one row per randomisation. The Randomise_from variable contains the terms that are at the start of the randomisation arrows (see Bate and Chatfield 2013). The Randomise_to variable contains the terms that are at the end of the randomisation arrows. The entries in these columns are taken from the LS_effects variable.

We recommend deleting rows from the RLS_Labels, RLS_Effects, User_RLS_Labels and Fixed_Random_Def variables that correspond to terms that need to be excluded from the Restricted Layout Structure.

The Fixed_Random_Def variable describes whether the term is designated as fixed or random by the program, the user can change this. The LS_Labels variable is for information only.

Statistical references

Bate S.T. and Chatfield M.J. (2013). Using experimental design and randomisation to construct a mixed model. Submitted for publication.

R references

R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Csardi G, Nepusz T: The igraph software package for complex network research, InterJournal, Complex Systems 1695. 2006. http://igraph.sf.net

Lecoutre, Eric (2003). The R2HTML Package. R News, Vol 3. N. 3, Vienna, Austria.

Appendix II – Output from Stage 3

This module performs the calculations required to produce Terms Relationships diagrams, as described in Bate and Chatfield (2013).
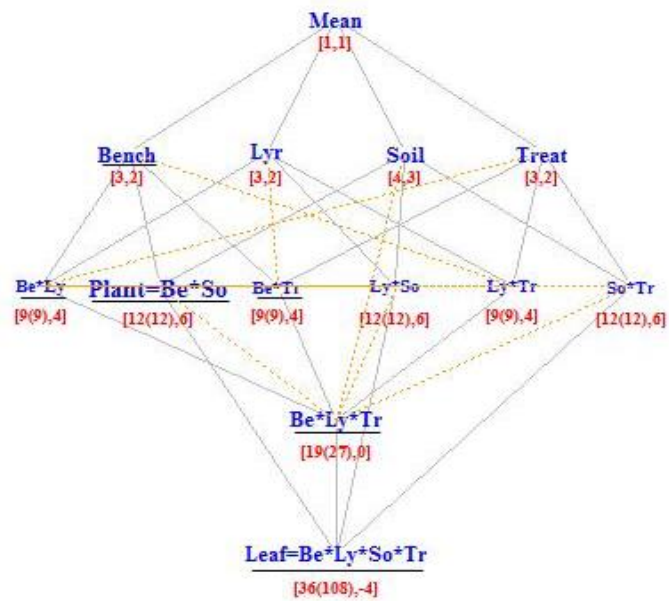
The Layout Structure

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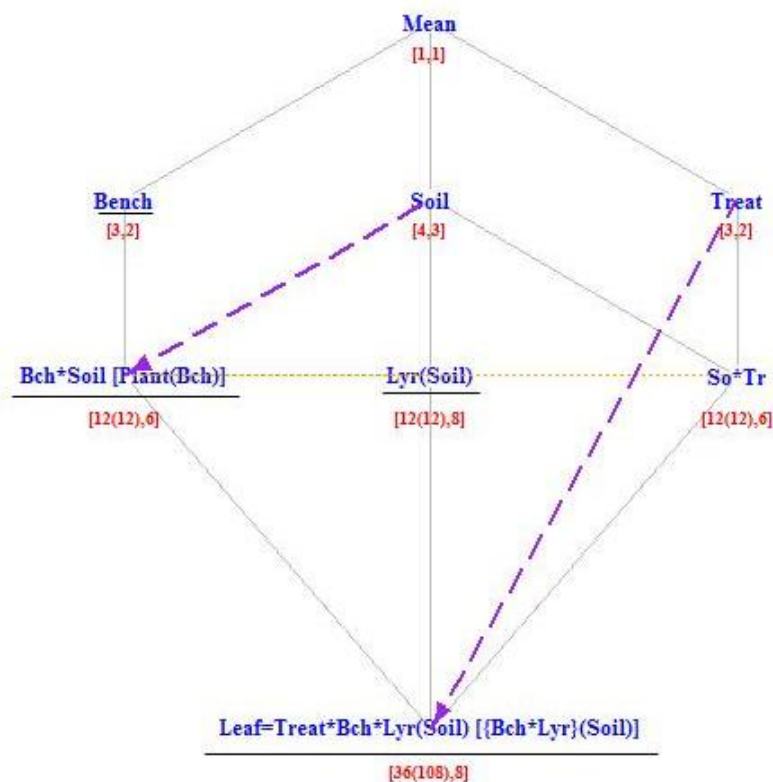
	actual.levs	dfs.by.subtract	revised.dfs	shared.dfs
Bench	3	2	2	0
Lyr	3	2	2	0
Soil	4	3	3	0
Treat	3	2	2	0
Bench*Lyr	9	4	4	4
Bench*Soil	12	6	6	4
Bench*Treat	9	4	4	4
Lyr*Soil	12	6	6	4
Lyr*Treat	9	4	4	4
Soil*Treat	12	6	6	4
Bench*Lyr*Treat	19	0	2	2
Bench*Lyr*Soil*Treat	36	-4	2	0

Terms Relationships diagram of the Layout Structure

The Restricted Layout Structure

Terms Relationships diagram of the Restricted Layout Structure

Statistical references

Bate S.T. and Chatfield M.J. (2013). Using experimental design and randomisation to construct a mixed model. Submitted for publication.

R references

R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Csardi G, Nepusz T: The igraph software package for complex network research, InterJournal, Complex Systems 1695. 2006. http://igraph.sf.net

Lecoutre, Eric (2003). The R2HTML Package. R News, Vol 3. N. 3, Vienna, Austria.