

**StatSoft®**

**Business White Paper**

## **Analysis of a Split-Plot Design in *STATISTICA***

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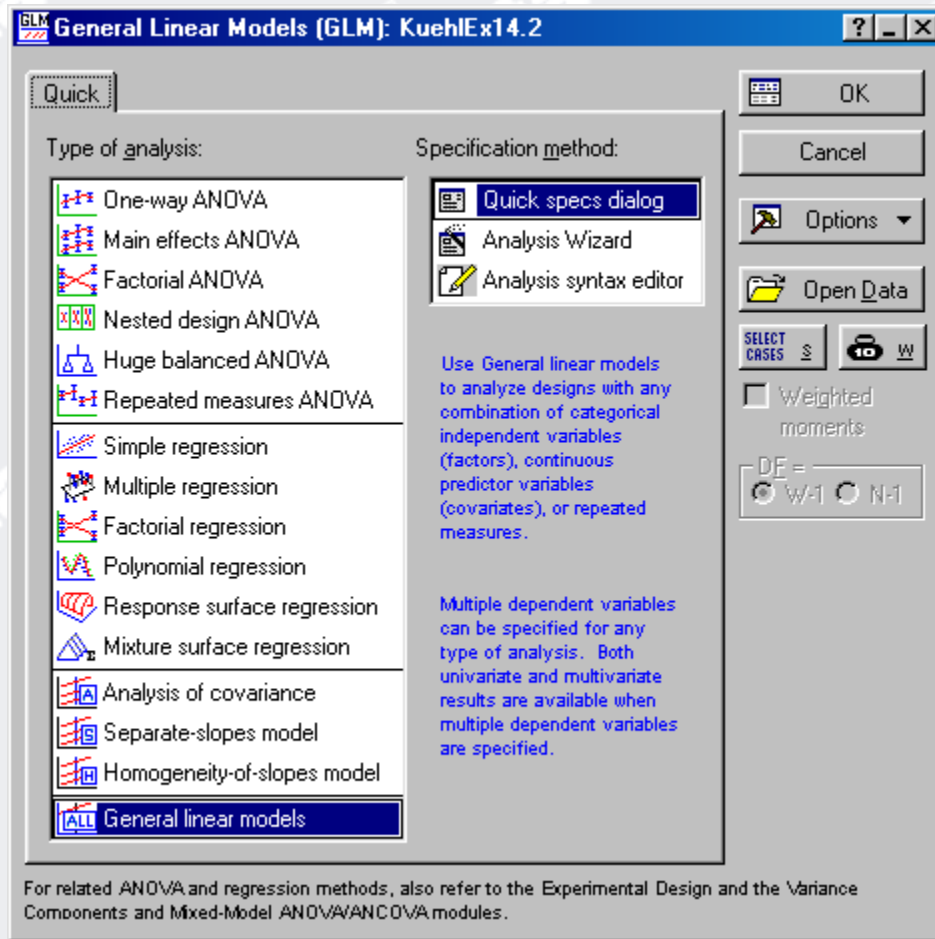
## The Data

The data for this example is taken from Example 14.2 of the 2nd edition of Robert Kuehl's *Design of Experiments: Statistical Principles of Research Design and Analysis*. Measurements of the chlorophyll content of Penncross creeping bentgrass clippings were made on turfgrass plots with varying forms of nitrogen fertilizer applied and years of thatch accumulation. The dataset is as follows:

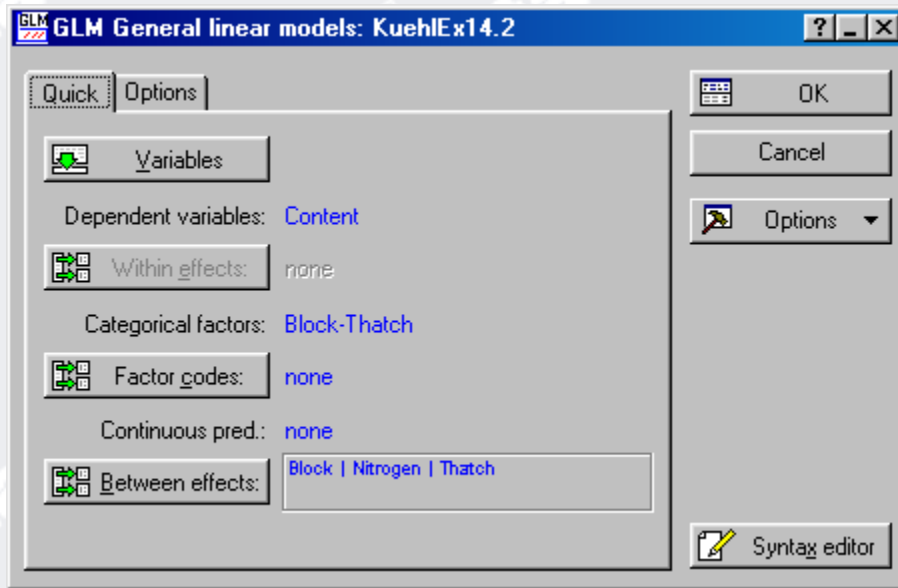
| Chlorophyll content (mg/gm) of Penncross creeping bentgrass clippings |       |   |        |         |
|---|-------|---|--------|---------|
|   | 1     | 2   | 3      | 4       |
|   | Block | Nitrogen  | Thatch | Content |
| 1   | 1     | Urea  | 2      | 3.8     |
| 2   | 1     | Urea  | 5      | 5.3     |
| 3   | 1     | Urea  | 8      | 5.9     |
| 4   | 1     | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 2      | 5.2     |
| 5   | 1     | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 5      | 5.6     |
| 6   | 1     | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 8      | 5.4     |
| 7   | 1     | IBDU  | 2      | 6       |
| 8   | 1     | IBDU  | 5      | 5.6     |
| 9   | 1     | IBDU  | 8      | 7.8     |
| 10  | 1     | UreaSC  | 2      | 6.8     |
| 11  | 1     | UreaSC  | 5      | 8.6     |
| 12  | 1     | UreaSC  | 8      | 8.5     |
| 13  | 2     | Urea  | 2      | 3.9     |
| 14  | 2     | Urea  | 5      | 5.4     |
| 15  | 2     | Urea  | 8      | 4.3     |
| 16  | 2     | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 2      | 6       |
| 17  | 2     | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 5      | 6.1     |
| 18  | 2     | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 8      | 6.2     |
| 19  | 2     | IBDU  | 2      | 7       |
| 20  | 2     | IBDU  | 5      | 6.4     |
| 21  | 2     | IBDU  | 8      | 7.8     |
| 22  | 2     | UreaSC  | 2      | 7.9     |
| 23  | 2     | UreaSC  | 5      | 8.6     |
| 24  | 2     | UreaSC  | 8      | 8.4     |

## The Analysis

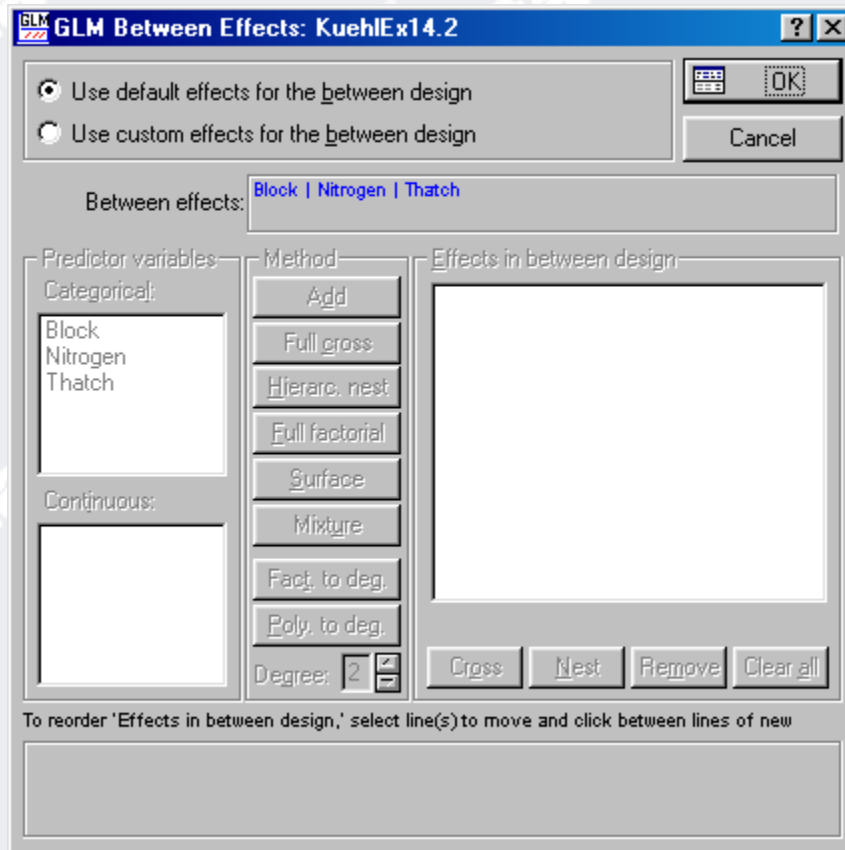
After selecting *General Linear Models* from the *Statistics » Advanced Linear/Nonlinear Models* menu, you will receive the *GLM Startup* dialog.



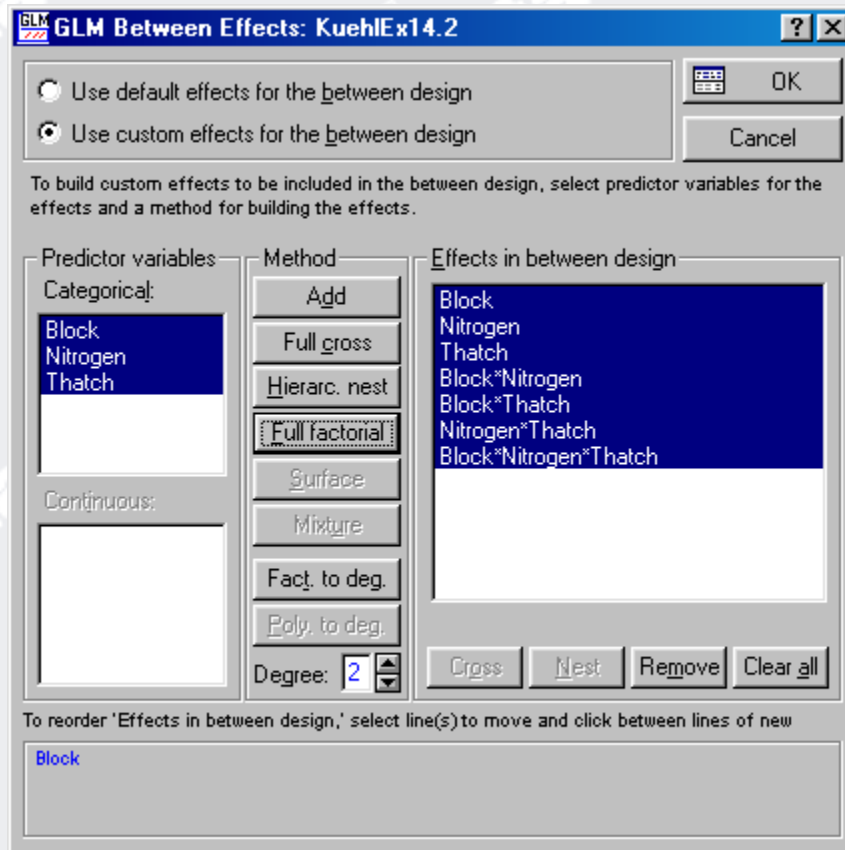
Choose *General linear models* from the *Type of analysis* list and click **OK**. Next you will see the *GLM* variable (and model) specification dialog.



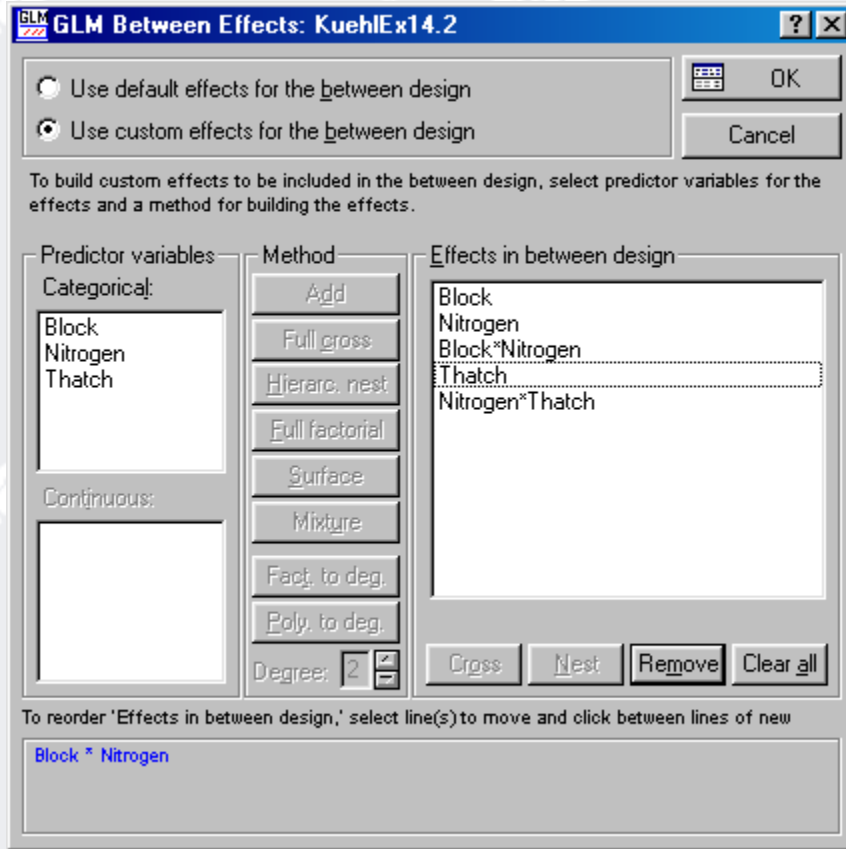
Click the *Variables* button on this dialog. Select *Content* as the Dependent variable and *Block*, *Nitrogen*, and *Thatch* as the Categorical predictors. The typical split-plot model has Blocks, Whole-plot units, a Whole-plot error term, Sub-plot units, and a Sub-plot error term. By default, *STATISICA* specifies a full 3-way interaction model. This would result in zero degrees of freedom for the ANOVA Error term and no F-tests. Thus, the default model must be modified. Now click the *Between effects* button to specify an appropriate split-plot model.



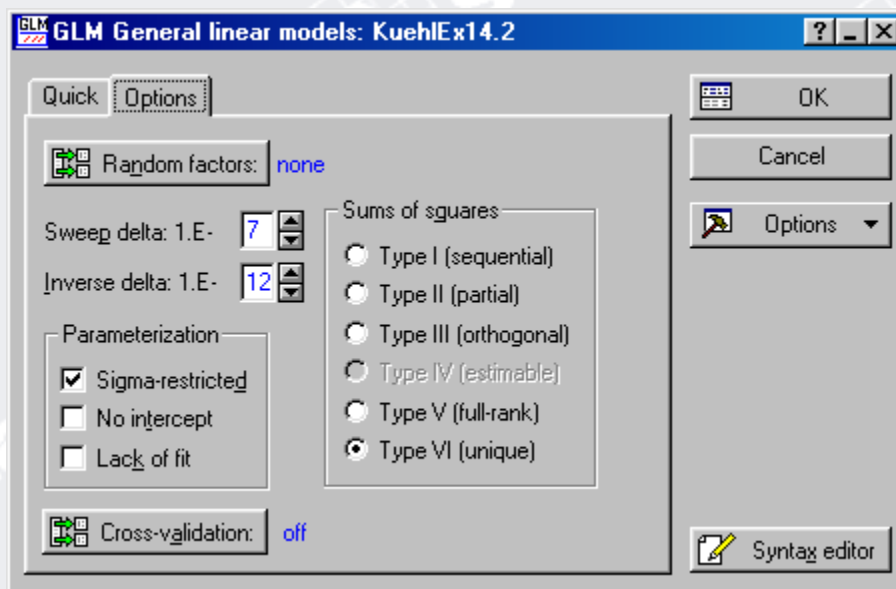
When it first appears, the Between effects dialog looks like this. Select *Use custom effects for the between design*. Notice that our categorical predictors are now available to be selected. Highlight them all and then click the *Full factorial* button.

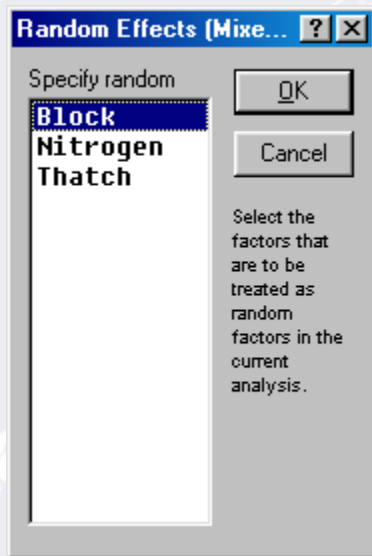


This places all main effects and their interaction into the model. However, in order to get the appropriate ANOVA tests for the Sub-plot units, the *Block*×*Thatch* and *Block*×*Nitrogen*×*Thatch* must be removed from the model (i.e., pooled into the overall Error). Do this by highlighting only those 2 terms in the list of terms on the right and clicking Remove. Next, reorder the terms so that the *Block*×*Nitrogen* interaction (the Whole-plot error term) follows *Nitrogen* (highlight *Block*×*Nitrogen*, place your mouse cursor between *Nitrogen* and *Thatch*, and left-click).



Once the *Between effects* dialog looks like this, click *OK* to return to the *GLM* variable specification dialog. On the *Options* tab click the *Random effects* button and specify *Block* as a random effect for this design.





This will ensure that the correct F-test is computed for the *Nitrogen* effect through denominator synthesis. Now click *OK* twice to run the model.

### Results

Clicking the All effects button on the resulting *GLM* Results dialog will now give the appropriate ANOVA table for this design.

| Univariate Tests of Significance for Content (KuehlEx14.2) |              |          |                  |          |                   |                   |          |          |
|--|--------------|----------|------------------|----------|-------------------|-------------------|----------|----------|
| Over-parameterized model                                   |              |          |                  |          |                   |                   |          |          |
| Type III decomposition                                     |              |          |                  |          |                   |                   |          |          |
| Effect   | Effect (F/R) | SS       | Degr. of Freedom | MS       | Den.Syn. Error df | Den.Syn. Error MS | F        | p        |
| Intercept  | Fixed        | 969.0104 | 1                | 969.0104 | 1.000000          | 0.510417          | 1898.469 | 0.014608 |
| Block  | Random       | 0.5104   | 1                | 0.5104   | 3.000000          | 0.419306          | 1.217    | 0.350450 |
| Nitrogen   | Fixed        | 37.3246  | 3                | 12.4415  | 3.000000          | 0.419306          | 29.672   | 0.009896 |
| Block*Nitrogen   | Random       | 1.2579   | 3                | 0.4193   | 8.000000          | 0.214583          | 1.954    | 0.199570 |
| Thatch   | Fixed        | 3.8158   | 2                | 1.9079   | 8.000000          | 0.214583          | 8.891    | 0.009270 |
| Nitrogen*Thatch  | Fixed        | 4.1542   | 6                | 0.6924   | 8.000000          | 0.214583          | 3.227    | 0.064605 |
| Error  |              | 1.7167   | 8                | 0.2146   |                   |                   |          |          |