Solution to Exercise 9.4 (Version 1, 11/7/15)

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Exercise 9.4 (Data: courtesy L. Smart, Rothamsted Research)

A series of field experiments tested various 'push-pull' strategies to control insect pests in oilseed rape. In one experiment the use of turnip rape (TR) as an earlier flowering trap crop (the 'pull') was tested alongside use of an anti-feedant applied to oilseed rape in spring (S; the 'push'). Untreated oilseed rape (U) was included as a control. The experiment was set up as a 6 × 6 Latin square with two replicates of each of the three treatments per row and column. An assessment of adult pollen beetle numbers was made on 10 plants per plot in early April, one day post-spray of the anti-feedant. The unit numbers (*ID*), structural factors (Row, Column), treatment factor (Treatment) and mean pollen beetle count per plot (variate *Count*) are given in file POLLENBEETLES.DAT. Is there any evidence that either of the pull or push strategies works?

Data 9.4 (POLLENBEETLES.DAT)

Mean pollen beetle count per plot from a field experiment set up as a 6 × 6 Latin square with two replicates of each of three treatments (S, TR, U):

ID	Row	Column	Treatment	Count	ID	Row	Column	Treatment	Count
1	1	1	S	3.3	19	4	1	U	3.3
2	1	2	U	6.7	20	4	2	TR	4.4
3	1	3	U	2.6	21	4	3	TR	5.1
4	1	4	TR	7.3	22	4	4	S	2.7
5	1	5	S	1.9	23	4	5	U	3.7
6	1	6	TR	5.9	24	4	6	S	6.5
7	2	1	TR	5.3	25	5	1	TR	8.2
8	2	2	S	4.6	26	5	2	S	5.3
9	2	3	TR	5.0	27	5	3	S	6.5
10	2	4	U	8.2	28	5	4	U	7.7
11	2	5	U	6.0	29	5	5	TR	9.4
12	2	6	S	3.5	30	5	6	U	4.2
13	3	1	U	3.2	31	6	1	S	6.7
14	3	2	TR	6.5	32	6	2	U	5.5
15	3	3	U	4.6	33	6	3	S	6.5
16	3	4	S	3.6	34	6	4	TR	9.5
17	3	5	S	4.7	35	6	5	TR	9.8
18	3	6	TR	7.5	36	6	6	U	6.5

Solution 9.4

The Latin square structure has rows crossed with columns, giving a crossed structural component. There is a single treatment factor (Treatment) and so the model can be written as

Response variable:	*Count*
Explanatory component:	[1] + Treatment
Structural component:	Row * Column

This model gives the residual plots in Figure S9.4.1. These show no strong systematic patterns, and so we accept the analysis on this scale.

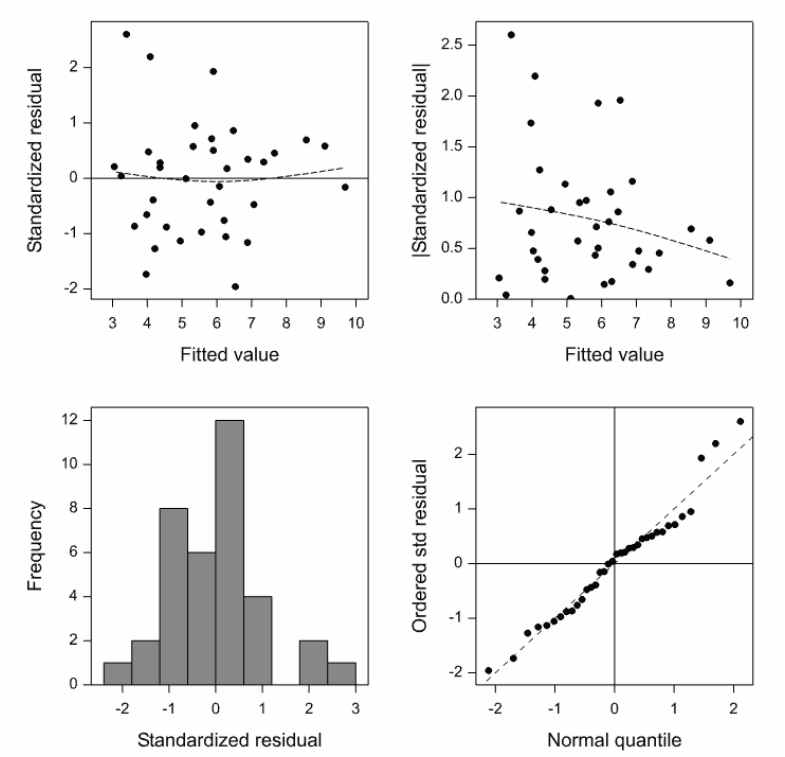

Figure S9.4.1. Composite set of residual plots based on standardized (std) residuals.

The ANOVA table for this model is given in Table S9.4.1. The treatments were applied to individual plots and so the Treatment SS appears in the Row.Column stratum. As there are only three treatments present, the residual df are larger than in a 6 × 6 Latin square with six treatments. There is strong evidence ($F_{2,23}$ = 8.132, P = 0.002) of differences in population means among the 3 treatments.

The predicted means (S: 4.65, TR: 6.99, U: 5.18 beetles) are plotted in Figure S9.4.2, with the LSD (LSD = 1.259 for α_s = 0.05, with 23 df). To assess the push-pull treatments, we compare the turnip rape treatment (TR, pull) and the anti-feedant treatment (S, push) against the control. There is evidence that the population mean of the turnip rape treatment is higher than the control, indicating potential as a pull strategy. However, although the predicted population mean of the anti-feedant was smaller than that for the control, there was no statistical evidence of a difference in population means. So if the anti-feedant had a push activity, it was small compared to plot-to-plot background variation.

Table S9.4.1 ANOVA table for pollen beetle counts.

Source of variation	df	Sum of squares	Mean square	Variance ratio	*P*
Row stratum	5	48.093	9.619	4.327	0.006
Column stratum	5	9.536	1.907	0.858	0.524
Row.Column stratum					
Treatment	2	36.152	18.076	8.132	0.002
Residual	23	51.127	2.223		
Total	35	144.908			

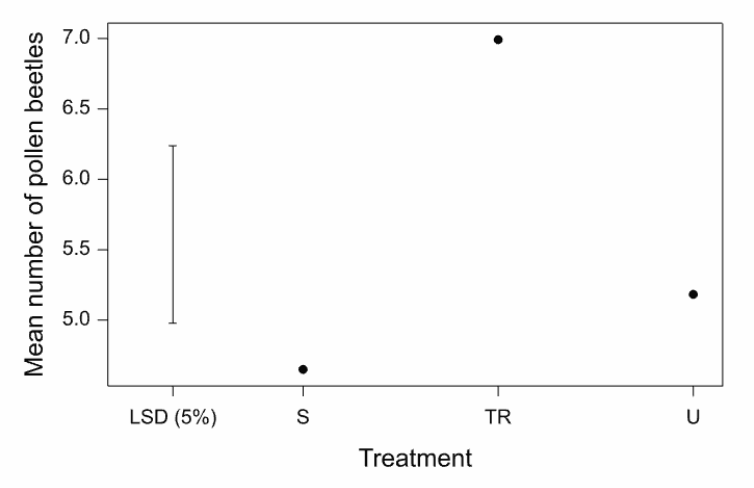

Figure S9.4.2. Predicted population mean pollen beetle counts, with LSD = 1.259 (α_s = 0.05, 23 df).