PROC GLM AND PROC MIXED FOR TREND ANALYSIS OF INCOMPLETE BLOCK AND LATTICE RECTANGLE DESIGNED EXPERIMENTS

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Walter T. Federer
Dept. of Biometrics
Cornell University

Russell D. Wolfinger
SAS Institute, Inc.
R52, SAS Campus Dr.
Cary, NC 27513

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Abstract: Purpose: for resolvable row-column or lattice rectangle designs, a variety of analysis options are given below. These are for a randomized complete block design with rows (columns) as blocks, standard textbook analysis, differential gradients within rows (columns), and trend analysis using orthogonal polynomial regression functions of the rows and columns and their interactions. The example used maybe found in Table 12.5 of W.G. Cochran and G.M. Cox's 1957 book Experimental Designs as well as in other reports in this volume. There are 156 insecticide treatments arranged in four rows and four columns within each of five complete blocks (replicates) to for a balanced lattice square. The data are averages of three counts of plants infected with boll weevil. The trend analysis is the most appropriate analysis for these data. The code can also be used for incomplete block design by either deleting the row or the column category.

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Authors: Walter T. Federer, 434 Warren Hall, Cornell University, Ithaca, NY 14853; e-mail WTF1@cornell.edu, and Russell D. Wolfinger, SAS Institute R52, SAS Campus Drive, Cary, NC 27513

Purpose: For resolvable row-column or lattice rectangle designs, a variety of analysis options are given below. These are for a randomized complete block design, an incomplete block design with rows (columns) as blocks, standard textbook analysis, differential gradients within rows (columns), and trend analysis using orthogonal polynomial regression functions of the rows and columns and their interactions. The example used may be found in Table 12.5 of W. G. Cochran and G. M. Cox's 1957 book Experimental Designs as well as in other reports in this volume. There are 16 insecticide treatments arranged in four rows and four columns within each of five complete blocks (replicates) to for a balanced lattice square. The data are averages of three counts of plants infected with boll weevil. The trend analysis is the most appropriate analysis for these data. The code can also be used for incomplete block design by either deleting the row or the column category.

SAS Code

```
options ls = 76;
proc iml;
  opn4=orpol(1:4,3); /* 4 columns and 3 regressions. */
  opn4[,1] = (1:4)`;
  op4= opn4;   print op4;
  create opn4 from opn4[colname={'COL' 'C1' 'C2' 'C3'}];
  append from opn4;
  close opn4;
run;
  opn3=orpol(1:4,3); /* 4 rows and 3 regressions. */
  opn3[,1] = (1:4)`;
  op3 = opn3;  print op3;
  create opn3 from opn3[colname={'ROW' 'R1' 'R2' 'R3'}];
  append from opn3;
  close opn3;
run;
data lsgr;
  infile 'lsgr1645.dat'; /* Name of data file. */
  input count rep ROW COL treat;
data lsbig; set lsgr; /* Name of lsgr after adding 6 polynomial regressions. */
  idx = _n_; run;
proc sort data= lsbig;
  by    COL ; run;
data lsbig;
  merge lsbig opn4;
  by    COL;  run;
proc sort data = lsbig;
  by    ROW;  run;
data lsbig;
  merge lsbig opn3;
  by    ROW;  run;
proc sort data = lsbig; by idx; run;
proc print; run; /* Print only if desired. */

/* Randomized complete block design analysis. */
proc glm data = lsbig;
  class rep row col treat;
  model count = rep treat;
```

```
run;

/* Incomplete block (row) analysis. */
proc glm data = lsbig;
  class rep row col treat;
  model yield = rep row(rep) treat;
run;
proc mixed data = lsbig;
  class rep row col treat;
  model count = treat;
  ramdom rep row(rep);
  lsmeans treat;
run;

/* Standard textbook lattice square analysis. */
proc glm data = lsbig;
  class rep row col treat;
  model count = rep treat row(rep) col(rep);
run;
proc mixed data - lsbig;
  class rep row col treat;
  model count = treat;
  random rep row(rep) col(rep);
  lsmeans treat;
run;

/* Differential linear gradients within rows analysis. Quadratic and cubic gradients did not appear to be present for
these data. This analysis is deemed appropriate for the data in Table 12.3 of W. G/ Cochran and G. M. Cox's 1957
book entitled Experimental Designs, but not for this example. */
proc glm data = lsbig;
  class rep row col treat;
  model count = rep treat row(rep) C1*row(rep);
run;
proc mixed data = lsbig;
  class rep row col treat;
  model count = treat/solution;
  random rep row(rep) C1*row(rep);
  lsmeans treat;
run;

/* Trend analysis using polynomial regressions and their interactions. */
proc glm data = lsbig;
  class rep row col treat;
  model count = rep treat r1*rep  r2*rep  c1*rep  c1*r1*rep
  c2*r1*rep c2*r2*rep c3*r2*rep;
run;
proc mixed  data = lsbig;
  class rep row col treat;
  model count = treat/solution;
  random rep r1*rep r2*rep c1*rep c1*r1*rep c2*r1*rep c2*r2*rep c3*r2*rep;
  lsmeans treat;
run;
```

An abbreviated part of the output of the above code is given below.

```
/* Linear, quadratic, and cubic polynomial regression coefficients. */
```

OP3			
1	-0.67082	0.5	-0.223607
2	-0.223607	-0.5	0.6708204
3	0.2236068	-0.5	-0.67082
4	0.6708204	0.5	0.2236068

/ Randomized complete block analysis. */*

Dependent Variable: COUNT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	19	1275.76500	67.14553	1.73	0.0564
Error	60	2332.77300	38.87955		
Corrected Total	79	3608.53800			

Source	DF	Type I SS	Mean Square	F Value	Pr > F
REP	4	31.56300	7.89075	0.20	0.9358
TREAT	15	1244.20200	82.94680	2.13	0.0200

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REP	4	31.56300	7.89075	0.20	0.9358
TREAT	15	1244.20200	82.94680	2.13	0.0200

*/*Standard textbook analysis. */*

Dependent Variable: COUNT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	49	2928.37008	59.76265	2.64	0.0029
Error	30	680.16792	22.67226		
Corrected Total	79	3608.53800			

Source	DF	Type I SS	Mean Square	F Value	Pr > F
REP	4	31.56300	7.89075	0.35	0.8433
TREAT	15	1244.20200	82.94680	3.66	0.0012
ROW(REP)	15	1093.01550	72.86770	3.21	0.0032
COL(REP)	15	559.58958	37.30597	1.65	0.1197

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REP	4	31.56300	7.89075	0.35	0.8433
TREAT	15	319.45208	21.29681	0.94	0.5350
ROW(REP)	15	1026.75583	68.45039	3.02	0.0049
COL(REP)	15	559.58958	37.30597	1.65	0.1197

/ Differential linear gradients within rows and replicates. This is an appropriate analysis for the data in Table 12.3 of Cochran and Cox (1957). Experimental Designs but not for this data set. */*

Dependent Variable: COUNT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	54	3134.27638	58.04216	3.06	0.0016
Error	25	474.26162	18.97046		
Corrected Total	79	3608.53800			

R-Square	C.V.	Root MSE	COUNT Mean
0.868572	39.94048	4.35551	10.9050

Source	DF	Type I SS	Mean Square	F Value	Pr > F
REP	4	31.56300	7.89075	0.42	0.7955
TREAT	15	1244.20200	82.94680	4.37	0.0006

ROW(REP)	15	1093.01550	72.86770	3.84	0.0015
C1*ROW(REP)	20	765.49588	38.27479	2.02	0.0488

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REP	4	31.563000	7.890750	0.42	0.7955
TREAT	15	347.188383	23.145892	1.22	0.3202
ROW(REP)	15	884.112744	58.940850	3.11	0.0060
C1*ROW(REP)	20	765.495883	38.274794	2.02	0.0488

/ Polynomial regression trend analysis considered appropriate for this example.*/*

Dependent Variable: COUNT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	54	3384.66411	62.67896	7.00	0.0001
Error	25	223.87389	8.95496		
Corrected Total	79	3608.53800			

R-Square	C.V.	Root MSE	COUNT Mean
0.937960	27.44139	2.99248	10.9050

Source	DF	Type I SS	Mean Square	F Value	Pr > F
REP	4	31.56300	7.89075	0.88	0.4893
TREAT	15	1244.20200	82.94680	9.26	0.0001
R1*REP	5	845.22838	169.04568	18.88	0.0001
R2*REP	5	246.02137	49.20427	5.49	0.0015
C1*REP	5	434.80006	86.96001	9.71	0.0001
R1*C1*REP	5	118.25808	23.65162	2.64	0.0475
R1*C2*REP	5	174.90489	34.98098	3.91	0.0094
R2*C2*REP	5	156.38244	31.27649	3.49	0.0157
R2*C3*REP	5	133.30389	26.66078	2.98	0.0305

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REP	4	31.563000	7.890750	0.88	0.4893
TREAT	15	421.496008	28.099734	3.14	0.0056
R1*REP	5	809.864820	161.972964	18.09	0.0001
R2*REP	5	177.016456	35.403291	3.95	0.0089
C1*REP	5	352.057631	70.411526	7.86	0.0001
R1*C1*REP	5	96.281349	19.256270	2.15	0.0923
R1*C2*REP	5	204.368728	40.873746	4.56	0.0043
R2*C2*REP	5	138.464513	27.692903	3.09	0.0262
R2*C3*REP	5	133.303894	26.660779	2.98	0.0305

Cov Parm	Estimate
REP	0.00000000
R1*REP	53.23803826
R2*REP	9.80562147
C1*REP	23.76781000
R1*C1*REP	9.98969710
R1*C2*REP	45.69858595
R2*C2*REP	31.54099937
R2*C3*REP	21.49617387
Residual	9.00079394

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F

TREAT	15	25	3.41	0.0033

Least Squares Means

Effect	TREAT	LSMEAN	Std Error	DF	t	Pr > |t|
TREAT	1	5.10314265	1.63982935	25	3.11	0.0046
TREAT	2	13.43151284	1.75595605	25	7.65	0.0001
TREAT	3	9.78194530	1.71248681	25	5.71	0.0001
TREAT	4	11.59100160	1.70310420	25	6.81	0.0001
TREAT	5	12.04012050	1.77463190	25	6.78	0.0001
TREAT	6	6.46087629	1.71679001	25	3.76	0.0009
TREAT	7	4.87293305	1.65381037	25	2.95	0.0069
TREAT	8	11.43810953	1.88342899	25	6.07	0.0001
TREAT	9	9.89142127	1.65449886	25	5.98	0.0001
TREAT	10	15.19391731	1.92490202	25	7.89	0.0001
TREAT	11	15.29420036	1.80297734	25	8.48	0.0001
TREAT	12	11.46771203	1.69521361	25	6.76	0.0001
TREAT	13	10.39896987	1.63737478	25	6.35	0.0001
TREAT	14	15.23542928	1.71894217	25	8.86	0.0001
TREAT	15	8.54488157	1.66229114	25	5.14	0.0001
TREAT	16	13.73382654	1.67968857	25	8.18	0.0001