```
options ps=80 nocenter;

/*  SAS code for analyzing the data from the
    split plot experiment corresponding to
    example 9.3 in class   */


data set1;
  infile 'c:\stat504\grass.dat';
  input block cultivar $ innoc $ yield;
  run;


proc print data=set1;  run;


proc mixed data=set1;
  class block cultivar innoc;
  model yield = cultivar innoc cultivar*innoc / ddfm=satterth;
  random block block*cultivar;
  lsmeans cultivar / e  pdiff tdiff;
  lsmeans innoc / e pdiff tdiff;
  lsmeans cultivar*innoc / e pdiff tdiff;
  estimate  'a:live vs b:live'  cultivar 1 -1 innoc 0 0 0
                          cultivar*innoc 0 0 1 0 0 -1;
  estimate  'a:live vs b:live'  cultivar 1 -1 innoc 0 0 1
                       cultivar*innoc 0 0 1 0 0 -1 / e;
  estimate  'a:live vs a:dead'  cultivar 0 0 innoc 0 -1 1
                       cultivar*innoc 0 -1 1 0 0 0 / e;
run;



/*  Use Proc GLM to compute an ANOVA table */

proc glm data=set1;
  class block cultivar innoc;
  model yield = cultivar block cultivar*block
              innoc cultivar*innoc;
  random block block*cultivar;
  test h=cultivar block e=cultivar*block;
run;
```

OBS	block	cultivar	innoc	yield
1	1	A	CON	27.4
2	1	A	DEA	29.7
3	1	A	LIV	34.5
4	1	B	CON	29.4
5	1	B	DEA	32.5
6	1	B	LIV	34.4
7	2	A	CON	28.9
8	2	A	DEA	28.7
9	2	A	LIV	33.4
10	2	B	CON	28.7
11	2	B	DEA	32.4
12	2	B	LIV	36.4
13	3	A	CON	28.6
14	3	A	DEA	29.7
15	3	A	LIV	32.9
16	3	B	CON	27.2
17	3	B	DEA	29.1
18	3	B	LIV	32.6
19	4	A	CON	26.7
20	4	A	DEA	28.9
21	4	A	LIV	31.8
22	4	B	CON	26.8
23	4	B	DEA	28.6
24	4	B	LIV	30.7

The Mixed Procedure

Model Information

Data Set	WORK.SET1
Dependent Variable	yield
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
block	4	1 2 3 4
cultivar	2	A B
innoc	3	CON DEA LIV

Dimensions

Covariance Parameters	3
Columns in X	12
Columns in Z	12
Subjects	1
Max Obs Per Subject	24

Number of Observations

Number of Observations Read	24
Number of Observations Used	24
Number of Observations Not Used	0

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	75.18505361	
1	1	65.06261676	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate
block	0.8800
block*cultivar	0.8182
Residual	0.7054

Fit Statistics

-2 Res Log Likelihood	65.1
AIC (smaller is better)	71.1
AICC (smaller is better)	72.8
BIC (smaller is better)	69.2

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
cultivar	1	3	0.76	0.4471
innoc	2	12	83.76	<.0001
cultivar*innoc	2	12	1.29	0.3098

Coefficients for a:live vs b:live

Effect	cultivar	innoc	Row1
Intercept			
cultivar	A		1
cultivar	B		-1
innoc		CON	
innoc		DEA	
innoc		LIV	1
cultivar*innoc	A	CON	
cultivar*innoc	A	DEA	
cultivar*innoc	A	LIV	1
cultivar*innoc	B	CON	
cultivar*innoc	B	DEA	
cultivar*innoc	B	LIV	-1

Coefficients for a:live vs a:dead

Effect	cultivar	innoc	Row1
Intercept			
cultivar	A		
cultivar	B		
innoc		CON	
innoc		DEA	-1
innoc		LIV	1
cultivar*innoc	A	CON	
cultivar*innoc	A	DEA	-1
cultivar*innoc	A	LIV	1
cultivar*innoc	B	CON	
cultivar*innoc	B	DEA	
cultivar*innoc	B	LIV	

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|
a:live vs b:live	-0.3750	0.8728	5.98	-0.43	0.6825
a:live vs b:live	Non-est	.	.	.	.
a:live vs a:dead	3.9000	0.5939	12	6.57	<.0001

Coefficients for cultivar Least Squares Means

Effect	cultivar	innoc	Row1	Row2
Intercept			1	1
cultivar	A		1	
cultivar	B			1
innoc		CON	0.3333	0.3333
innoc		DEA	0.3333	0.3333
innoc		LIV	0.3333	0.3333
cultivar*innoc	A	CON	0.3333	
cultivar*innoc	A	DEA	0.3333	
cultivar*innoc	A	LIV	0.3333	
cultivar*innoc	B	CON		0.3333
cultivar*innoc	B	DEA		0.3333
cultivar*innoc	B	LIV		0.3333

Coefficients for innoc Least Squares Means

Effect	cultivar	innoc	Row1	Row2	Row3
Intercept			1	1	1
cultivar	A		0.5	0.5	0.5
cultivar	B		0.5	0.5	0.5
innoc		CON	1		
innoc		DEA		1	
innoc		LIV			1
cultivar*innoc	A	CON	0.5		
cultivar*innoc	A	DEA		0.5	
cultivar*innoc	A	LIV			0.5
cultivar*innoc	B	CON	0.5		
cultivar*innoc	B	DEA		0.5	
cultivar*innoc	B	LIV			0.5

Coefficients for cultivar*innoc Least Squares Means

Effect	cultivar	innoc	Row1	Row2	Row3	Row4	Row5	Row6
Intercept			1	1	1	1	1	1
cultivar	A		1	1	1			
cultivar	B					1	1	1
innoc		CON	1			1		
innoc		DEA		1			1	
innoc		LIV			1			1
cultivar*innoc	A	CON	1					
cultivar*innoc	A	DEA		1				
cultivar*innoc	A	LIV			1			
cultivar*innoc	B	CON				1		
cultivar*innoc	B	DEA					1	

Least Squares Means

Effect	cultivar	innoc	Estimate	Standard Error	DF	t Value	Pr > |t|
cultivar	A		30.1000	0.6952	4.97	43.30	<.0001
cultivar	B		30.7333	0.6952	4.97	44.21	<.0001
innoc		CON	27.9625	0.6407	4.06	43.65	<.0001
innoc		DEA	29.9500	0.6407	4.06	46.75	<.0001
innoc		LIV	33.3375	0.6407	4.06	52.04	<.0001
cultivar*innoc	A	CON	27.9000	0.7752	7.5	35.99	<.0001
cultivar*innoc	A	DEA	29.2500	0.7752	7.5	37.73	<.0001
cultivar*innoc	A	LIV	33.1500	0.7752	7.5	42.76	<.0001
cultivar*innoc	B	CON	28.0250	0.7752	7.5	36.15	<.0001
cultivar*innoc	B	DEA	30.6500	0.7752	7.5	39.54	<.0001
cultivar*innoc	B	LIV	33.5250	0.7752	7.5	43.25	<.0001

Differences of Least Squares Means

Effect	cultivar	innoc	_cultivar	_innoc	Estimate	Standard Error	DF	t Value	Pr > |t|
cultivar	A		B		-0.6333	0.7257	3	-0.87	0.4471
innoc		CON		DEA	-1.9875	0.4199	12	-4.73	0.0005
innoc		CON		LIV	-5.3750	0.4199	12	-12.80	<.0001
innoc		DEA		LIV	-3.3875	0.4199	12	-8.07	<.0001
cultivar*innoc	A	CON	A	DEA	-1.3500	0.5939	12	-2.27	0.0422
cultivar*innoc	A	CON	A	LIV	-5.2500	0.5939	12	-8.84	<.0001
cultivar*innoc	A	CON	B	CON	-0.1250	0.8728	5.98	-0.14	0.8908
cultivar*innoc	A	CON	B	DEA	-2.7500	0.8728	5.98	-3.15	0.0199
cultivar*innoc	A	CON	B	LIV	-5.6250	0.8728	5.98	-6.44	0.0007
cultivar*innoc	A	DEA	A	LIV	-3.9000	0.5939	12	-6.57	<.0001
cultivar*innoc	A	DEA	B	CON	1.2250	0.8728	5.98	1.40	0.2102
cultivar*innoc	A	DEA	B	DEA	-1.4000	0.8728	5.98	-1.60	0.1600
cultivar*innoc	A	DEA	B	LIV	-4.2750	0.8728	5.98	-4.90	0.0027
cultivar*innoc	A	LIV	B	CON	5.1250	0.8728	5.98	5.87	0.0011
cultivar*innoc	A	LIV	B	DEA	2.5000	0.8728	5.98	2.86	0.0288
cultivar*innoc	A	LIV	B	LIV	-0.3750	0.8728	5.98	-0.43	0.6825
cultivar*innoc	B	CON	B	DEA	-2.6250	0.5939	12	-4.42	0.0008
cultivar*innoc	B	CON	B	LIV	-5.5000	0.5939	12	-9.26	<.0001
cultivar*innoc	B	DEA	B	LIV	-2.8750	0.5939	12	-4.84	0.0004

The GLM Procedure

Dependent Variable: yield

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	157.2083333	14.2916667	20.26	<.0001
Error	12	8.4650000	0.7054167		
Corrected Total	23	165.6733333			

R-Square	Coeff Var	Root MSE	yield Mean
0.948905	2.761285	0.839891	30.41667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cultivar	1	2.4066667	2.4066667	3.41	0.0895
block	3	25.3200000	8.4400000	11.96	0.0006
block*cultivar	3	9.4800000	3.1600000	4.48	0.0249
innoc	2	118.1758333	59.0879167	83.76	<.0001
cultivar*innoc	2	1.8258333	0.9129167	1.29	0.3098

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cultivar	1	2.4066667	2.4066667	3.41	0.0895
block	3	25.3200000	8.4400000	11.96	0.0006
block*cultivar	3	9.4800000	3.1600000	4.48	0.0249
innoc	2	118.1758333	59.0879167	83.76	<.0001
cultivar*innoc	2	1.8258333	0.9129167	1.29	0.3098

Source	Type III Expected Mean Square
cultivar	Var(Error) + 3 Var(block*cultivar) + Q(cultivar,cultivar*innoc)
block	Var(Error) + 3 Var(block*cultivar) + 6 Var(block)
block*cultivar	Var(Error) + 3 Var(block*cultivar)
innoc	Var(Error) + Q(innoc,cultivar*innoc)
cultivar*innoc	Var(Error) + Q(cultivar*innoc)

Dependent Variable: yield

Tests of Hypotheses Using the Type III MS for block*cultivar as an Error Term

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cultivar	1	2.40666667	2.40666667	0.76	0.4471
block	3	25.32000000	8.44000000	2.67	0.2206