16. SAS Analysis of Split-Plot Experiments

Field Split-Plot Experiment

Field

	Genotype C				Genotype A				Genotype B			
Block 1	0	100	150	50	50	100	150	0	150	100	50	0

	Genotype B				Genotype A				Genotype C			
Block 2	150	100	50	0	0	50	150	100	100	50	150	0

	Genotype A				Genotype B				Genotype C			
Block 3	100	50	0	150	0	100	150	50	50	100	150	0

	Genotype B				Genotype C				Genotype A			
Block 4	0	50	100	150	150	100	50	0	50	150	100	0

Read Data

```
proc import datafile='C:\Data\FieldSplitPlotData.txt'
  dbms=TAB replace out=Field;
run;

proc print data=Field (obs=14);
run;
```

Obs	block	geno	fert	y
1	1	1	0	148.7
2	1	1	50	150.4
3	1	1	100	166.7
4	1	1	150	156.5
5	1	2	0	162.5
6	1	2	50	168.6
7	1	2	100	180.2
8	1	2	150	181.1
9	1	3	0	144.5
10	1	3	50	177.3
11	1	3	100	188.1
12	1	3	150	199.1
13	2	1	0	114.2
14	2	1	50	131.5

Fit Linear Mixed-Effects Model

```
proc mixed data=Field;
  class block geno fert;
  model y=geno fert geno*fert / ddfm=satterthwaite;
  random block block*geno;
```

The Mixed Procedure

Model Information	
Data Set	WORK.FIELDEXP
Dependent Variable	y
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
geno	3	1 2 3
fert	4	0 50 100 150

The Mixed Procedure

Dimensions	
Covariance Parameters	3
Columns in X	20
Columns in Z	16
Subjects	1
Max Obs per Subject	48

Number of Observations	
Number of Observations Read	48
Number of Observations Used	48
Number of Observations Not Used	0

Iteration History			
Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	314.54790074	
1	1	275.05625945	0.00000000

Convergence criteria met.

Covariance Parameter Estimates	
Cov Parm	**Estimate**
block	122.85
block*geno	67.2981
Residual	39.7061

Fit Statistics	
-2 Res Log Likelihood	275.1
AIC (Smaller is Better)	281.1
AICC (Smaller is Better)	281.8
BIC (Smaller is Better)	279.2

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
geno	2	6	8.48	0.0179
fert	3	27	73.35	<.0001
geno*fert	6	27	6.54	0.0002

Example Estimate Statements

```
estimate 'geno 1'
  intercept 4 geno 4 0 0 fert 1 1 1 1
  geno*fert 1 1 1 1 0 0 0 0 0 0 0 0 / divisor=4 cl;


estimate 'geno 1 - geno 2'
  geno 4 -4 0
  geno*fert 1 1 1 1 -1 -1 -1 -1 0 0 0 0 / divisor=4 cl;


estimate 'geno 1 - geno 2 with no fertilizer'
  geno 1 -1 0 geno*fert 1 0 0 0 -1 0 0 0 0 0 0 0 / cl;
run;
```

The Mixed Procedure

Estimates								
Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
geno 1	139.83	7.0725	5.13	19.77	<.0001	0.05	121.78	157.87
geno 1 - geno 2	-24.8812	6.2139	6	-4.00	0.0071	0.05	-40.0861	-9.6764
geno 1 - geno 2 with no fertilizer	-22.5000	7.3145	11.2	-3.08	0.0104	0.05	-38.5725	-6.4275

Refit Model with Fixed Block Effects

```
proc mixed data=Field;
  class block geno fert;
  model y=block geno fert geno*fert / ddfm=satterthwaite;
  random block*geno;
```

The Mixed Procedure

Model Information	
Data Set	WORK.FIELDEXP
Dependent Variable	y
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
geno	3	1 2 3
fert	4	0 50 100 150

The Mixed Procedure

Dimensions	
Covariance Parameters	2
Columns in X	24
Columns in Z	12
Subjects	1
Max Obs per Subject	48

Number of Observations	
Number of Observations Read	48
Number of Observations Used	48
Number of Observations Not Used	0

Iteration History			
Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	264.34894774	
1	1	250.15263205	0.00000000

Convergence criteria met.

The Mixed Procedure

Covariance Parameter Estimates	
Cov Parm	Estimate
block*geno	67.2981
Residual	39.7061

Fit Statistics	
-2 Res Log Likelihood	250.2
AIC (Smaller is Better)	254.2
AICC (Smaller is Better)	254.6
BIC (Smaller is Better)	255.1

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
block	3	6	5.77	0.0335
geno	2	6	8.48	0.0179
fert	3	27	73.35	<.0001
geno*fert	6	27	6.54	0.0002

Example Estimate Statements

```
estimate 'geno 1'
  intercept 4 block 1 1 1 1 geno 4 0 0 fert 1 1 1 1
  geno*fert 1 1 1 1 0 0 0 0 0 0 0 0 / divisor=4 cl;

estimate 'geno 1 - geno 2'
  geno 4 -4 0
  geno*fert 1 1 1 1 -1 -1 -1 -1 0 0 0 0 / divisor=4 cl;

estimate 'geno 1 - geno 2 with no fertilizer'
  geno 1 -1 0 geno*fert 1 0 0 0 -1 0 0 0 0 0 0 0 / cl;
run;
```
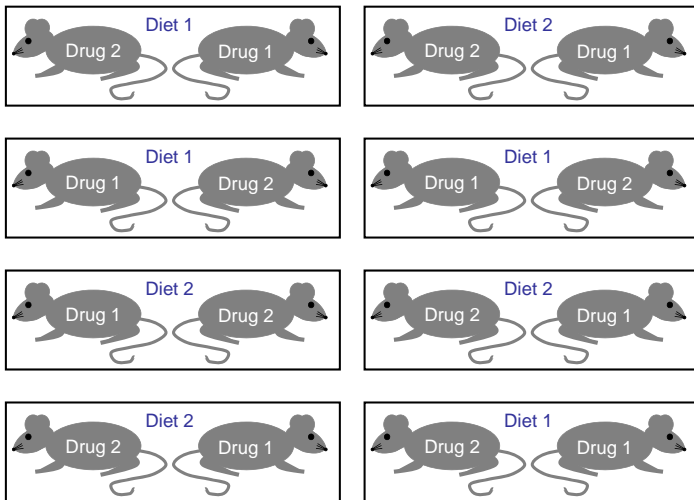
The Mixed Procedure

Estimates								
Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
geno 1	139.83	4.3939	6	31.82	<.0001	0.05	129.07	150.58
geno 1 - geno 2	-24.8812	6.2139	6	-4.00	0.0071	0.05	-40.0861	-9.6764
geno 1 - geno 2 with no fertilizer	-22.5000	7.3145	11.2	-3.08	0.0104	0.05	-38.5725	-6.4275

Diet and Drug Split-Plot Experiment

Read Data

```
proc import datafile='C:\Data\DietDrugSplitPlotData.txt'
  dbms=TAB replace out=DietDrug;
run;

proc print data=DietDrug;
run;
```

The SAS System

Obs	litter	diet	drug	y
1	1	1	2	18.8
2	1	1	1	10.3
3	2	2	2	14.5
4	2	2	1	18.5
5	3	1	1	16.8
6	3	1	2	27.2
7	4	1	1	11.5
8	4	1	2	20.5
9	5	2	1	11.9
10	5	2	2	11.3
11	6	2	2	16.4
12	6	2	1	17.6
13	7	2	2	15.4
14	7	2	1	18
15	8	1	2	26.8
16	8	1	1	15.7

Fit Linear Mixed-Effects Model

```
proc mixed data=DietDrug;
  class litter diet drug;
  model y=diet drug diet*drug / ddfm=satterthwaite;
  random litter(diet);
```

The SAS System

The Mixed Procedure

Model Information	
Data Set	WORK.DIETDRUG
Dependent Variable	y
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
litter	8	1 2 3 4 5 6 7 8
diet	2	1 2
drug	2	1 2

The Mixed Procedure

Dimensions	
Covariance Parameters	2
Columns in X	9
Columns in Z	8
Subjects	1
Max Obs per Subject	16

Number of Observations	
Number of Observations Read	16
Number of Observations Used	16
Number of Observations Not Used	0

Iteration History			
Iteration	**Evaluations**	**-2 Res Log Like**	**Criterion**
0	1	68.07389478	
1	1	57.36070457	0.00000000

Convergence criteria met.

The Mixed Procedure

Covariance Parameter Estimates	
Cov Parm	Estimate
litter(diet)	9.7871
Residual	0.9408

Fit Statistics	
-2 Res Log Likelihood	57.4
AIC (Smaller is Better)	61.4
AICC (Smaller is Better)	62.7
BIC (Smaller is Better)	61.5

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
diet	1	6	1.75	0.2335
drug	1	6	62.20	0.0002
diet*drug	1	6	149.25	<.0001

Estimating Marginal Means, Means, and Contrasts

```
lsmeans diet drug diet*drug;




estimate 'diet 1 - diet 2' diet 2 -2
                    diet*drug 1 1 -1 -1 / divisor=2;




estimate 'drug 1 - drug 2' drug 2 -2
                    diet*drug 1 -1 1 -1 / divisor=2;
```

More Estimate Statements

```
estimate 'diet 1 - diet 2 for drug 2' diet 1 -1
                              diet*drug 0 1 0 -1;




estimate 'drug 1 - drug 2 for diet 2' drug 1 -1
                              diet*drug 0 0 1 -1;
run;
```

The Mixed Procedure

Estimates					
Label	Estimate	Standard Error	DF	t Value	Pr > |t|
diet 1 - diet 2	3.0000	2.2647	6	1.32	0.2335
drug 1 - drug 2	-3.8250	0.4850	6	-7.89	0.0002
diet 1 - diet 2 for drug 2	8.9250	2.3160	6.55	3.85	0.0071
drug 1 - drug 2 for diet 2	2.1000	0.6859	6	3.06	0.0222

Least Squares Means							
Effect	diet	drug	Estimate	Standard Error	DF	t Value	Pr > |t|
diet	1		18.4500	1.6014	6	11.52	<.0001
diet	2		15.4500	1.6014	6	9.65	<.0001
drug		1	15.0375	1.1580	6.55	12.99	<.0001
drug		2	18.8625	1.1580	6.55	16.29	<.0001
diet*drug	1	1	13.5750	1.6377	6.55	8.29	0.0001
diet*drug	1	2	23.3250	1.6377	6.55	14.24	<.0001
diet*drug	2	1	16.5000	1.6377	6.55	10.08	<.0001
diet*drug	2	2	14.4000	1.6377	6.55	8.79	<.0001