第四节　析因试验的方差分析实验

析因试验的方差分析，即多因素试验的方差分析，不仅可对试验的主效应进行分析，还可对因素间的交互效应进行分析．要想研究全部变因的效应，在试验中就必须设置重复，设置重复的目的就是要对随机误差作出一个估计，方便于研究各因素的变因．

一、多因素完全随机试验的方差分析

1．两因素完全随机试验的方差分析

例 1　在育苗试验中，研究土壤因素（A：砂土、壤土和粘土）和施肥因素（B：对照（不施）、施 N、施 N＋K 及施 N＋P）的影响，每个处理设置三个苗床，苗床呈完全随机分布，秋后落叶调查苗木高度（cm），数据见下表．试分析土壤、施肥及其交互作用对苗高生长的影响．

因素 A		A_1			A_2			A_3		
重复		1	2	3	1	2	3	1	2	3
因素 B	B_1	31	35	30	50	52	54	40	45	44
	B_2	45	43	47	61	63	65	55	52	56
	B_3	76	71	75	88	90	92	86	84	84
	B_4	60	64	62	74	75	70	70	71	69

(1) 在 SAS 软件中,可以用 ANOVA 过程进行多因素方差分析. SAS 软件中的 ANOVA 过程是一个平衡设计的方差分析过程,其调用方法在第一节已有详细介绍. 本例用下述程序分析

```
DATA XEX01;
DO B = 1 TO 4;
  DO A = 1 TO 3;
    DO R = 1 TO 3;
      INPUT Y@@;OUTPUT;
    END;
  END;
END;
CARDS;
 31 35 30 50 52 54 40 45 44
 45 43 47 61 63 65 55 52 56
 76 71 75 88 90 92 86 84 84
 60 64 62 74 75 70 70 71 69
 ;
PROC ANOVA;
  CLASS A B;
  MODEL Y = A B A * B;
  MEANS A B A * B/DUNCAN;
RUN;
```

程序执行分析结果如下

```
                    Analysis of Variance Procedure
                       Class Level Information
                      Class      Levels     Values
                      A               3     1 2 3
                      B               4     1 2 3 4
                Number of observations in data set = 36
                    Analysis of Variance Procedure
Dependent Variable: Y
                                 Sum of               Mean
Source           DF             Squares             Square    F Value     Pr > F
Model            11        10009.416667         909.946970     199.74     0.0001
Error            24          109.333333           4.555556
```

```
Corrected Total  35    10118.750000
      R-Square                C.V.        Root MSE                Y Mean
      0.989195            3.447173       2.1343747             61.916667
Source               DF       Anova SS     Mean Square   F Value    Pr > F
A                     2   1605.5000000     802.7500000    176.21    0.0001
B                     3   8328.9722222    2776.3240741    609.44    0.0001
A*B                   6     74.9444444      12.4907407      2.74    0.0357
                      Analysis of Variance Procedure
                Duncan's Multiple Range Test for variable: Y
    NOTE: This test controls the type I comparisonwise error rate,not
          the experimentwise error rate
                 Alpha= 0.05 df= 24 MSE= 4.555556
                      Number of Means    2         3
                      Critical Range 1.798 1.889
       Means with the same letter are not significantly different.
             Duncan Grouping           Mean        N    A
                           A        69.5000       12    2
                           B        63.0000       12    3
                           C        53.2500       12    1
                      Analysis of Variance Procedure
                Duncan's Multiple Range Test for variable: Y
    NOTE: This test controls the type I comparisonwise error rate,not
          the experimentwise error rate
                 Alpha= 0.05 df= 24 MSE= 4.555556
                 Number of Means     2      3      4
                 Critical Range 2.077 2.181 2.248
       Means with the same letter are not significantly different.
           Duncan Grouping             Mean         N    B
                         A           82.889         9    3
                         B           68.333         9    4
                         C           54.111         9    2
                         D           42.333         9    1
             Level of    Level of    ---------Y---------
             A      B       N       Mean               SD
             1      1       3    32.0000000         2.64575131
```

```
1    2    3    45.0000000    2.00000000
1    3    3    74.0000000    2.64575131
1    4    3    62.0000000    2.00000000
2    1    3    52.0000000    2.00000000
2    2    3    63.0000000    2.00000000
2    3    3    90.0000000    2.00000000
2    4    3    73.0000000    2.64575131
3    1    3    43.0000000    2.64575131
3    2    3    54.3333333    2.08166600
3    3    3    84.6666667    1.15470054
3    4    3    70.0000000    1.00000000
Tests of Between - Subjects Effects
```

(2) 在 SPSS 中可用 GLM-General Factorial 过程进行两因素完全随机试验的方差分析.具体步骤为:在数据输入窗口中定义变量 A(土壤:1 = “砂土”,2 = “壤土”,3 = “粘土”)、B(施肥:1 = “对照”,2 = “N”,3 = “N + K”,4 = “N + P”),R(重复)及 X(苗高),并输入数据;执行“Statistics”→“General Linear Model”→“GLM-General Factorial”过程,指定因变量 X、固定因素变量 A,B,随机因素变量 R;单击“Model”指定模型选项,选择自定义模型,并选择分析 A,B,R,A * B 效应,包含回归截距;单击“Contrasts”,设置 B 因素中的对照,选“Simple”方式,位置为“First”;单击“Post Hoc”, 选择 A 和 B 进行多重比较;方法选择 LSD 和 DUNCAN 两种,其它使用默认值,得主要结果如下

Dependent Variable: 苗高

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	138012.250	1	138012.250	42465.308	.000
	Error	6.500	2	3.250[a]		
R	Hypothesis	6.500	2	3.250	.695	.510
	Error	102.833	22	4.674[b]		
A	Hypothesis	1605.500	2	802.750	171.739	.000
	Error	102.833	22	4.674[b]		
B	Hypothesis	8328.972	3	2776.324	593.962	.000
	Error	102.833	22	4.674[b]		
A * B	Hypothesis	74.944	6	12.491	2.672	.042
	Error	102.833	22	4.674[b]		

a MS(R)　　b MS(Error)

Expected Mean Squares[a,b]

Source	Variance Component		Quadratic Term
	Var(R)	Var(Error)	
Intercept	12.000	1.000	Intercept, A, B, A * B
R	12.000	1.000	
A	.000	1.000	A, A * B
B	.000	1.000	B, A * B
A * B	.000	1.000	A * B
Error	.000	1.000	

a　For each source, the expected mean square equals the sum of the coefficients in the cells times the variance components, plus a quadratic term involving effects in the Quadratic Term cell.

b　Expected Mean Squares are based on the Type III Sums of Squares.

Multiple Comparisons

Dependent Variable: 苗高

	(I) 土壤	(J) 土壤	Mean Difference (I－J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	砂土	壤土	－16.2500 *	.883	.000	－18.0805	－14.4195
		粘土	－9.7500 *	.883	.000	－11.5805	－7.9195
	壤土	砂土	16.2500 *	.883	.000	14.4195	18.0805
		粘土	6.5000 *	.883	.000	4.6695	8.3305
	粘土	砂土	9.7500 *	.883	.000	7.9195	11.5805
		壤土	－6.5000 *	.883	.000	－8.3305	－4.6695

Based on observed means.

*　The mean difference is significant at the .05 level.

2. 三因素完全随机试验的方差分析

例 2　为研究在猪饲料中添加己氨酸(因素 A)、蛋氨酸(因素 B)和蛋白质(因素 C)对猪日增重(kg)的影响，设计了下面的试验，每组共用 2 头猪作重复，

试验结果如下表,试作方差分析.

已氨酸(A)			0			0.05			0.10			0.15		
蛋氨酸(B)			0	0.025	0.050	0	0.025	0.050	0	0.025	0.050	0	0.025	0.050
蛋白质(C)	12	1	0.61	1.39	0.85	1.80	1.33	1.12	1.22	1.64	1.34	1.19	1.66	1.46
		2	0.47	1.29	1.21	1.50	1.51	0.96	1.13	1.71	1.19	1.03	1.46	1.03
	14	1	1.52	1.57	1.67	1.55	1.54	1.76	1.38	1.80	1.46	0.80	1.72	1.62
		2	1.45	1.52	1.24	1.53	1.64	1.27	1.08	1.70	1.39	1.29	1.69	1.27

(1) 在 SAS 软件中用 ANOVA 过程进行三因素完全随机试验方差分析的分析程序如下.该模型中除包括主效应 A,B,C 外,还包括交互效应 A×B,A×C,B×C 和 A×B×C. MEANS 语句指定求 A,B,C 在各水平下的均值及 Duncan's差异显著性检验.

```
DATA XEX02;
DO A= 0,0.05,0.10,0.15;
  DO B= 0,0.025,0.050;
    DO C= 12,14;
      DO R= 1 TO 2;
        INPUT Y@@;OUTPUT;
      END;
    END;
  END;
END;
CARDS;
0.61 0.47 1.52 1.45 1.39 1.29 1.57 1.52 0.85 1.21 1.67 1.24
1.80 1.50 1.55 1.53 1.33 1.51 1.54 1.64 1.12 0.96 1.76 1.27
1.22 1.13 1.38 1.08 1.64 1.71 1.80 1.70 1.34 1.19 1.46 1.39
1.19 1.03 0.80 1.29 1.66 1.46 1.72 1.69 1.46 1.03 1.62 1.27
;
PROC ANOVA;
  CLASS A B C;
  MODEL Y=A B C A*B A*C B*C A*B*C;
  MEANS A B C/DUNCAN;
```

```
  RUN;
```

程序输出的主要结果如下

```
                 Analysis of Variance Procedure
Dependent Variable: Y
Source              DF    Sum of Squares    F Value    Pr > F
Model               23        3.59216667    4.98       0.0001
Error               24        0.75220000
Corrected Total     47        4.34436667
        R-Square               C.V.              Y Mean
        0.826856             12.96174          1.36583333
                 Analysis of Variance Procedure
Dependent Variable: Y
Source                  DF         Anova SS     F Value     Pr > F
A                        3       0.35548333        3.78     0.0236
B                        2       1.08327917       17.28     0.0001
C                        1       0.59853333       19.10     0.0002
A*B                      6       0.67160417        3.57     0.0114
A*C                      3       0.37791667        4.02     0.0189
B*C                      2       0.05702917        0.91     0.4160
A*B*C                    6       0.44832083        2.38     0.0599
```

(2) 在 SPSS 中用 GLM - General Factorial 过程也可进行三因素完全随机试验的方差分析. 首先在数据输入窗口定义变量 A(己氨酸:0,0.05,0.10,0.15),B(蛋氨酸:0,0.025,0.050),C(蛋白质:12,14),R(重复)及 X(日增重),并输入数据;单击"Statistics"→"General Linear Model"→"GLM - General Factorial"过程,选择因变量 X,固定因素变量 A,B,C,随机因素变量 R;单击"Model"指定模型选项,选择自定义模型,并选择分析 A,B,C,R,A*B,A*C,B*C,A*B*C 效应,包含回归截距; 单击"Post Hoc", 选择 A,B 和 C 进行多重比较,方法选择 LSD 和 DUNCAN 两种,其它使用默认值,主要结果如下

Tests of Between - Subjects Effects

Dependent Variable: 日增重

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	88.183	1	88.183	1124.669	.019
	Error	7.841E-02	1	7.841E-02[a]		

续表

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
A	Hypothesis	.385	3	.128	4.227	.016
	Error	.699	23	3.038E-02[b]		
B	Hypothesis	.886	2	.443	14.588	.000
	Error	.699	23	3.038E-02[b]		
C	Hypothesis	.715	1	.715	23.547	.000
	Error	.699	23	3.038E-02[b]		
A * B	Hypothesis	.629	6	.105	3.452	.014
	Error	.699	23	3.038E-02[b]		
A * C	Hypothesis	.329	3	.110	3.605	.029
	Error	.699	23	3.038E-02[b]		
B * C	Hypothesis	3.015E-02	2	1.508E-02	.496	.615
	Error	.699	23	3.038E-02[b]		
A * B * C	Hypothesis	.543	6	9.045E-02	2.977	.027
	Error	.699	23	3.038E-02[b]		
R	Hypothesis	7.841E-02	1	7.841E-02	2.581	.122
	Error	.699	23	3.038E-02[b]		

a　MS(R)　　　b　MS(Error)

Expected Mean Squares[a,b]

Source	Variance Component		Quadratic Term
	Var(R)	Var(Error)	
Intercept	24.000	1.000	Intercept,A,B,C,A * B,A * C,B * C,A * B * C
A	.000	1.000	A,A * B,A * C,A * B * C
B	.000	1.000	B,A * B,B * C,A * B * C
C	.000	1.000	C,A * C,B * C,A * B * C
A * B	.000	1.000	A * B,A * B * C
A * C	.000	1.000	A * C,A * B * C
B * C	.000	1.000	B * C,A * B * C
A * B * C	.000	1.000	A * B * C
R	24.000	1.000	
Error	.000	1.000	

a For each source, the expected mean square equals the sum of the coefficients in the cells times the variance components, plus a quadratic term involving effects in the Quadratic Term cell.

b Expected Mean Squares are based on the Type III Sums of Squares.

二、多因素随机区组试验的方差分析

随机区组试验是应用重复、随机化和局部控制三个原理设计的试验，这类试验处理次数和重复无严格限制，具有便于设计和分析的优点.

1. 二因素随机区组试验的方差分析

例3 小麦 3 个不育系(A_1、A_2、A_3)与 4 个恢复系(B_1、B_2、B_3、B_4)杂交配成 12 个 F_1，采用随机区组设计，重复 3 次，小区面积 6 m^2，试作方差分析. 随机区组设计资料见下表

不育系		A_1				A_2				A_3			
恢复系		B_1	B_2	B_3	B_4	B_1	B_2	B_3	B_4	B_1	B_2	B_3	B_4
区组	Ⅰ	5.0	5.3	5.6	5.3	4.6	5.6	5.8	5.4	4.6	5.9	7.4	5.4
	Ⅱ	5.1	5.4	5.7	5.2	4.6	5.4	5.9	5.1	4.4	5.2	6.2	5.4
	Ⅲ	4.9	5.2	5.4	5.6	4.8	5.2	5.9	5.0	4.8	6.0	7.0	4.6

(1) 在 SAS 中的分析程序如下

```
DATA XEX03;
 DO C = 1 TO 3;
  DO B = 1 TO 4;
     DO A = 1 TO 3;
        INPUT y@@;OUTPUT;
     END;
  END;
 END;
CARDS;
  5.0  4.6  4.6  5.3  5.6  5.9  5.6  5.8  7.4  5.3  5.4  5.4
  5.1  4.6  4.4  5.4  5.4  5.2  5.7  5.9  6.2  5.2  5.1  5.4
  4.9  4.8  4.8  5.2  5.2  6.0  5.4  5.9  7.0  5.6  5.0  4.6
  ;
PROC ANOVA;
  CLASS A B C;
  MODEL Y = C A B A * B;
  MEANS A B/DUNCAN;
RUN;
```

程序输出主要结果如下

Analysis of Variance Procedure

Dependent Variable: Y

Source	DF	Sum of Squares	F Value	Pr > F
Model	13	11.92027778	14.80	0.0001
Error	22	1.36277778		
Corrected Total	35	13.28305556		

R - Square	C.V.	Y Mean
0.897405	4.597184	5.41388889

Analysis of Variance Procedure

Dependent Variable: Y

Source	DF	Anova SS	F Value	Pr > F
C	2	0.24388889	1.97	0.1635
A	2	1.08222222	8.74	0.0016
B	3	8.22083333	44.24	0.0001
A * B	6	2.37333333	6.39	0.0005

Analysis of Variance Procedure

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	A
A	5.6583	12	3
B	5.3083	12	1
B	5.2750	12	2

Analysis of Variance Procedure

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	B
A	6.1000	9	3
B	5.4667	9	2
B	5.3333	9	4
C	4.7556	9	1

(2) 在 SPSS 中用 GLM-General Factorial 过程可进行二因素完全随机区组试验的方差分析. 首先在数据输入窗口中定义变量 A(不育系),B(恢复系),BLK(区组)及 X(产量),并输入数据;单击"Statistics"→"General Linear Model"→"GLM-General Factorial"过程,指定因变量 X,固定因素变量 A,B,随机因素变量 BLK;单击"Model",选择自定义模型,并选择分析 A,B,BLK,A * B 效应,包含回归截距; 单击"Post Hoc", 选择 A 和 B 进行多重比较,方法选择 LSD 和 DUNCAN 两种,其它使用默认值,主要结果如下

Tests of Between－Subjects Effects

Dependent Variable：产量

Source		Type III Sum of Square	df	Mean Square	F	Sig.
Intercept	Hypothesis	1044.367	1	1044.367	9192.472	.000
	Error	.227	2	.114[a]		
BLK	Hypothesis	.227	2	.114	1.405	.267
	Error	1.779	22	8.088E－02[b]		
A	Hypothesis	.649	2	.324	4.011	.033
	Error	1.779	22	8.088E－02[b]		
B	Hypothesis	8.465	3	2.822	34.887	.000
	Error	1.779	22	8.088E－02[b]		
A * B	Hypothesis	2.762	6	.460	5.692	.001
	Error	1.779	22	8.088E－02[b]		

a MS(BLK) b MS(Error)

Expected Mean Squares[a,b]

Source	Variance Component		Quadratic Term
	Var(BLK)	Var(Error)	
Intercept	12.000	1.000	Intercept,A,B,A * B
BLK	12.000	1.000	
A	.000	1.000	A,A * B
B	.000	1.000	B,A * B
A * B	.000	1.000	A * B
Error	.000	1.000	

a For each source, the expected mean square equals the sum of the coefficients in the cells times the variance components, plus a quadratic term involving effects in the Quadratic Term cell.

b Expected Mean Squares are based on the Type III Sums of Squares.

2．三因素随机区组试验的方差分析

例 4 有一苹果矮化中间砧试验，A 为品种（A_1：金冠，A_2：红星），B 为中间砧长（B_1：20 cm，B_2：10 cm），C 为中间砧（C_1：M_9，C_2：MM_{26}，C_3：水栒子），采用随机区组设计，重复 3 次，处理与小区产量如下表，试进行方差分析．

品种		A_1						A_2					
中间砧长		B_1			B_2			B_1			B_2		
中间砧		C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
区组	Ⅰ	12	12	10	10	9	6	3	4	7	2	3	5
	Ⅱ	14	11	9	9	9	6	2	3	6	2	4	7
	Ⅲ	13	11	9	9	8	7	4	4	7	3	5	7

（1）在 SAS 中可用下述程序进行分析

```
DATA XEX04;
 DO BLK = 1 TO 3;
  DO A = 1 TO 2;
    DO B = 1 TO 2;
      DO C = 1 TO 3;
        INPUT X@@;OUTPUT;
      END;
    END;
  END;
END;
CARDS;
  12 12 10 10 9 6 3 4 7 2 3 5
  14 11 9 9 9 6 2 3 6 2 4 7
  13 11 9 9 8 7 4 4 7 3 5 7
;
PROC ANOVA;
  CLASS BLK A B C;
  MODEL X = BLK A B C A*B A*C B*C A*B*C;
  MEANS A B C/DUNCAN T;
RUN;
```

程序分析主要结果如下

```
                    Analysis of Variance Procedure
                       Class Level Information
                      Class     Levels     Values
                     BLK             3     1 2 3
                     A               2     1 2
```

```
                    B            2    1 2
                    C            3    1 2 3
            Number of observations in data set = 36
                  Analysis of Variance Procedure
Dependent Variable: X
                                       Sum of         Mean
Source            DF      Squares       Square      F Value    Pr > F
Model             13   383.16666667   29.47435897     50.53    0.0001
Error             22    12.83333333    0.58333333
Corrected Total   35   396.00000000
         R - Square         C.V.       Root MSE        X Mean
         0.967593         10.91089     0.7637626       7.0000000
Source            DF      Anova SS    Mean Square   F Value    Pr > F
BLK                2     1.16666667    0.58333333      1.00    0.3840
A                  1   256.00000000  256.00000000    438.86    0.0001
B                  1    25.00000000   25.00000000     42.86    0.0001
C                  2     0.50000000    0.25000000      0.43    0.6568
A * B              1    18.77777778   18.77777778     32.19    0.0001
A * C              2    80.16666667   40.08333333     68.71    0.0001
B * C              2     1.50000000    0.75000000      1.29    0.2964
A * B * C          2     0.05555556    0.02777778      0.05    0.9536
```

(2) 在 SPSS 中用 GLM－General Factorial 过程进行三因素完全随机区组试验的方差分析.首先在数据输入窗口中定义变量 A(品种),B(中间砧长),C(中间砧),BLK(区组)及 X(产量),并输入数据;单击“Statistics”→“General Linear Model”→“GLM-General Factorial”过程,指定因变量 X,固定因素变量 A,B,C,随机因素变量 BLK;单击“Model”,选择自定义模型,并选择分析 A,B,C,BLK,A＊B,A＊C,B＊C,A＊B＊C 效应,包含回归截距;单击“Post Hoc”,选择 A,B 和 C 进行多重比较,方法选择 LSD 和 DUNCAN 两种,其它使用默认值,主要结果如下

Tests of Between－Subjects Effects

Dependent Variable: 产量

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	1764.000	1	1764.000	3024.000	.000
	Error	1.167[a]	2	.583		

续表

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
A	Hypothesis	256.000	1	256.000	438.857	.000
	Error	12.833[b]	22	.583		
B	Hypothesis	25.000	1	25.000	42.857	.000
	Error	12.833[b]	22	.583		
C	Hypothesis	.500	2	.250	.429	.657
	Error	12.833[b]	22	.583		
BLK	Hypothesis	1.167	2	.583	1.000	.384
	Error	12.833[b]	22	.583		
A * B	Hypothesis	18.778	1	18.778	32.190	.000
	Error	12.833[b]	22	.583		
A * C	Hypothesis	80.167	2	40.083	68.714	.000
	Error	12.833[b]	22	.583		
B * C	Hypothesis	1.500	2	.750	1.286	.296
	Error	12.833[b]	22	.583		
A * B * C	Hypothesis	5.556E-02	2	2.778E-02	.048	.954
	Error	12.833[b]	22	.583		

a MS(BLK) b MS(Error)

Expected Mean Squares[a,b]

	Variance Component		
Source	Var(BLK)	Var(Error)	Quadratic Term
Intercept	12.000	1.000	Intercept, A, B, C, A * B, A * C, B * C, A * B * C
A	.000	1.000	A, A * B, A * C, A * B * C
B	.000	1.000	B, A * B, B * C, A * B * C
C	.000	1.000	C, A * C, B * C, A * B * C
BLK	12.000	1.000	
A * B	.000	1.000	A * B, A * B * C
A * C	.000	1.000	A * C, A * B * C
B * C	.000	1.000	B * C, A * B * C
A * B * C	.000	1.000	A * B * C
Error	.000	1.000	

a For each source, the expected mean square equals the sum of the coefficients in the cells times the variance components, plus a quadratic term involving effects in the Quadratic Term cell.

b Expected Mean Squares are based on the Type III Sums of Squares.

三、裂区与条区试验设计的方差分析

在有些多因素随机区组试验中，由于情况特殊，不能在区组内将所有处理完全随机排列，这些情况导致产生了随机区组设计的一些推广设计.

1. 二裂式裂区试验的方差分析

例 5 设有一小麦中耕次数(A)和施肥量(B)试验，主处理为 A，有三个水平；副处理为 B，有四个水平，裂区设计，重复三次($R=3$)，副区计产面积 66 m^2，测得产量(kg)资料按区组和处理作两向分组如下表，试作方差分析.

主因素 A		A_1				A_2				A_3			
副因素 B		B_1	B_2	B_3	B_4	B_1	B_2	B_3	B_4	B_1	B_2	B_3	B_4
区组	Ⅰ	29	37	18	17	28	31	13	13	30	31	15	16
	Ⅱ	28	32	14	16	29	28	13	12	27	28	14	15
	Ⅲ	32	31	17	15	25	29	10	12	26	31	11	13

(1) 在 SAS 中的分析程序如下

```
DATA XEX05;
 DO A =1 TO 3;
   DO B =1 TO 4;
     DO G =1 TO 3;
       INPUT Y@;OUTPUT;
     END;
   END;
END;
CARDS;
  29 28 32 37 32 31 18 14 17 17 16 15
  28 29 25 31 28 29 13 13 10 13 12 12
  30 27 26 31 28 31 15 14 11 16 15 13
  ;
PROC ANOVA;
  CLASS G A B;
  MODEL Y = G A B;
  MEANS A B/DUNCAN;
RUN;
PROC ANOVA;
```

```
    CLASS G A B;
    MODEL Y = G A B A * B G * A G * A * B;
    TEST H = G A E  = G * A;
    TEST H = B A * B E = G * A * B;
  RUN;
```

程序中 A,B,G 分别表示主处理、副处理及区组.第一个 ANOVA 过程用于对 A,B 分别作 Duncan's 差异显著性检验,第二个 ANOVA 过程作裂区试验的统计分析.在主区部分,把 G,A 作为假设效应,把 G×A 作为主区误差,由第一个 TEST 语句实现;在副区部分,把 B,A×B 作为假设效应,把 G×A×B 作为副区误差,由第二个 TEST 语句实现.程序执行主要结果如下

```
                 Analysis of Variance Procedure
Dependent Variable: Y
Source                DF     Sum of Squares     F Value     Pr > F
Model                  7      2292.50000000      146.72     0.0001
Error                 28        62.50000000
Corrected Total       35      2355.00000000
        R - Square             C.V.              Y Mean
        0.973461           6.842912          21.8333333
                 Analysis of Variance Procedure
Dependent Variable: Y
Source                DF            Anova SS    F Value     Pr > F
G                      2         32.66666667       7.32     0.0028
A                      2         80.16666667      17.96     0.0001
B                      3       2179.66666667     325.50     0.0001
                 Analysis of Variance Procedure
Dependent Variable: Y
Source                DF     Sum of Squares     F Value     Pr > F
Model                 35      2355.00000000           .          .
Error                  0                  .
Corrected Total       35      2355.00000000
      R - Square                       C.V.       Y Mean
      1.000000                            0   21.8333333
                 Analysis of Variance Procedure
Dependent Variable: Y
Source                DF            Anova SS    F Value     Pr > F
```

```
G                  2      32.66666667       .        .
A                  2      80.16666667       .        .
B                  3    2179.66666667       .        .
A * B              6       7.16666667       .        .
G * A              4       9.16666667       .        .
G * A * B         18      46.16666667       .        .
                 Analysis of Variance Procedure
Dependent Variable: Y
Tests of Hypotheses using the Anova MS for G * A as an error term
Source            DF        Anova SS    F Value    Pr > F
G                  2     32.66666667       7.13    0.0480
A                  2     80.16666667      17.49    0.0105
                 Analysis of Variance Procedure
Dependent Variable: Y
Tests of Hypotheses using the Anova MS for
G * A * B as an error term
Source            DF        Anova SS    F Value    Pr > F
B                  3   2179.66666667     283.28    0.0001
A * B              6      7.16666667       0.47    0.8246
```

(2) 在 SPSS 中，用 GLM－General Factorial 过程进行二裂式裂区试验设计的方差分析．首先在数据输入窗口中定义变量 A(主区)，B(副区)，BLK(区组)及 X(产量)，并输入数据；单击“Statistics”→“General Linear Model”→“GLM-General Factorial”过程，指定因变量 X，固定因素变量 A，B，随机因素变量 BLK；单击“Model”，选择自定义模型，选择分析 BLK，A，A＊BLK，B，A＊B 效应，包含回归截距．注意选择这些效应时，应严格按照上述顺序输入，否则得不到正确结果．单击“Post Hoc”，选择 A 和 B 进行多重比较，方法选择 DUNCAN 两种，其他使用默认值，主要结果如下

Tests of Between-Subjects Effects

Dependent Variable: 产量

Source		Type III Sum of Square	df	Mean Square	F	Sig.
Intercept	Hypothesis	17248.444	1	17248.444	1167.188	.001
	Error	29.556[a]	2	14.778		
BLK	Hypothesis	29.556	2	14.778	7.141	.048
	Error	8.278[b]	4	2.069		

续表

Source		Type III Sum of Square	df	Mean Square	F	Sig.
A	Hypothesis	78.722	2	39.361	19.020	.009
	Error	8.278[b]	4	2.069		
A * BLK	Hypothesis	8.278	4	2.069	.807	.537
	Error	46.167[c]	18	2.565		
B	Hypothesis	2150.000	3	716.667	279.422	.000
	Error	46.167[c]	18	2.565		
A * B	Hypothesis	10.833	6	1.806	.704	.650
	Error	46.167[c]	18	2.565		

a MS(BLK)　　b MS(A * BLK)　　c MS(Error)

Expected Mean Squares[a,b]

Source	Variance Component			Quadratic Term
	Var(BLK)	Var(A * BLK)	Var(Error)	
Intercept	12.000	4.000	1.000	Intercept, A, B, A * B
BLK	12.000	4.000	1.000	
A	.000	4.000	1.000	A, A * B
A * BLK	.000	4.000	1.000	
B	.000	.000	1.000	B, A * B
A * B	.000	.000	1.000	A * B
Error	.000	.000	1.000	

a For each source, the expected mean square equals the sum of the coefficients in the cells times the variance components, plus a quadratic term involving effects in the Quadratic Term cell.

b Expected Mean Squares are based on the Type III Sums of Squares.

产量

	主区	N	Subset	
			1	2
Duncan[a,b]	2	12	20.2500	
	3	12	21.5833	
	1	12		23.8333
	Sig.		.056	1.000

Means for groups in homogeneous subsets are displayed. Based on Type III Sum of Squares The error term is Mean Square(Error) = 2.565.

a Uses Harmonic Mean Sample Size = 12.000.　　b Alpha = .05.

产量

	副区	N	Subset		
			1	2	3
Duncan[a,b]	3	9	13.8889		
	4	9	14.5556		
	1	9		28.2222	
	2	9			30.8889
	Sig.		.389	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on Type III Sum of Squares The error term is Mean Square(Error) = 2.565.

a　Uses Harmonic Mean Sample Size = 9.000.　　　b　Alpha = .05.

2. 三裂式裂区试验的方差分析

例 6　一位药物研究员研究一种特定类型的抗生素胶囊的吸收时间，主区因素是三位实验师，裂区因素是三种剂量，再裂区因素是四种胶囊糖衣厚度，重复两次，每天做一次，即天为区组. 测得数据如下：

区组	C	A_1			A_2			A_3		
		B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
1	C_1	95	71	108	96	70	108	95	70	100
	C_2	104	82	115	99	84	100	102	81	106
	C_3	101	85	117	95	83	105	105	84	113
	C_4	108	85	116	97	85	109	107	87	115
2	C_1	95	78	110	100	72	104	92	69	101
	C_2	106	84	109	101	79	102	100	76	104
	C_3	103	86	116	99	80	108	101	80	109
	C_4	109	84	110	112	86	109	108	86	113

(1) 在 SAS 中的分析程序如下

```
DATA XEX06;
 DO BLK = 1 TO 2;
   DO C = 1 TO 4;
     DO A = 1 TO 3;
       DO B = 1 TO 3;
```

```
            INPUT Y@;OUTPUT;
          END;
        END;
      END;
    END;
   CARDS;
   95 71 108 96 70 108 95 70 100
   104 82 115 99 84 100 102 81 106
   101 85 117 95 83 105 105 84 113
   108 85 116 97 85 109 107 87 115
   95 78 110 100 72 104 92 69 101
   106 84 109 101 79 102 100 76 104
   103 86 116 99 80 108 101 80 109
   109 84 110 112 86 109 108 86 113
     ;
   PROC ANOVA;
     CLASS BLK A B C;
     MODEL Y = BLK A B C;
     MEANS A B C/DUNCAN T;
   RUN;
   PROC ANOVA;
     CLASS BLK A B C;
     MODEL Y = BLK A BLK * A B A * B BLK * A * B C A * C B * C A * B * C BLK
    * A * B * C;
     TEST H = BLK A   E  = BLK * A;
     TEST H = B A * B E = BLK * A * B;
     TEST H = C A * C B * C A * B * C E = BLK * A * B * C;
   RUN;
```

程序中 A,B,C,BLK 分别表示主区、裂区、再裂区及区组.第一个 ANOVA 过程用于对 A,B,C 分别作 T 和 Duncan's 差异显著性检验,第二个 ANOVA 过程作裂区试验的统计分析.在主区部分,把 BLK,A 作为假设效应,把 BLK×A 作为主区误差,由第一个 TEST 语句实现;在裂区部分,把 B,A×B 作为假设效应,把 BLK×A×B 作为裂区误差,由第二个 TEST 语句实现;在再裂区部分,把 C,A×C,B×C,A×B×C 作为假设效应,把 BLK×A×B×C 作为再裂区误差,由第三个 TEST 语句实现.程序执行主要结果如下

Analysis of Variance Procedure

Dependent Variable: Y

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	11661.16666667	1457.64583333	119.06	0.0001
Error	63	771.27777778	12.24250441		
Corrected Total	71	12432.44444444			

R - Square	C. V.	Root MSE	Y Mean
0.937962	3.617503	3.49892904	96.72222222

Source	DF	Anova SS	Mean	Square	F Value
Pr > F					
BLK	1	0.05555556	0.05555556	0.00	0.9465
A	2	202.86111111	101.43055556	8.29	0.0006
B	2	10371.36111111	5185.68055556	423.58	0.0001
C	3	1086.88888889	362.29629630	29.59	0.0001

Analysis of Variance Procedure

Dependent Variable: Y

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	71	12432.44444444	175.10485133	.	.
Error	0	.	.		
Corrected Total	71	12432.44444444			

R - Square	C. V.	Root MSE	Y Mean
1.000000	0	0	96.72222222

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BLK	1	0.05555556	0.05555556	.	.
A	2	202.86111111	101.43055556	.	.
BLK * A	2	46.86111111	23.43055556	.	.
B	2	10371.36111111	5185.68055556	.	.
A * B	4	67.72222222	16.93055556	.	.
BLK * A * B	6	92.08333333	15.34722222	.	.
C	3	1086.88888889	362.29629630	.	.
A * C	6	152.69444444	25.44907407	.	.
B * C	6	185.52777778	30.92129630	.	.
A * B * C	12	81.38888889	6.78240741	.	.
BLK * A * B * C	27	145.00000000	5.37037037	.	.

Tests of Hypotheses using the Anova MS for BLK * A as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BLK	1	0.05555556	0.05555556	0.00	0.9656
A	2	202.86111111	101.43055556	4.33	0.1877

Tests of Hypotheses using the Anova MS for BLK * A * B as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
B	2	10371.36111111	5185.68055556	337.89	0.0001
A * B	4	67.72222222	16.93055556	1.10	0.4346

Tests of Hypotheses using the Anova MS for BLK * A * B * C as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
C	3	1086.88888889	362.29629630	67.46	0.0001
A * C	6	152.69444444	25.44907407	4.74	0.0020
B * C	6	185.52777778	30.92129630	5.76	0.0006
A * B * C	12	81.38888889	6.78240741	1.26	0.2948

(2) 在 SPSS 中,用 GLM - General Factorial 过程进行三裂式裂区试验设计的方差分析.首先在数据输入窗口中定义变量 A(主区),B(裂区),C(再裂区),BLK(区组)及 X(产量),并输入数据;单击"Statistics"→"General Linear Model"→"GLM - General Factorial"过程,指定因变量 X,固定因素变量 A,B,C,随机因素变量 BLK;单击"Model",选择自定义模型,并选择分析 BLK,A,A * BLK,B,A * B,A * B * BLK,C,A * C,B * C,A * B * C 效应,包含回归截距.注意选择这些效应时的顺序,要得到正确的结果,应严格按照上述顺序输入. 单击"Post Hoc",选择 A,B 和 C 进行多重比较,方法选择 LSD 和 DUNCAN,其他使用默认值.主要结果如下

Tests of Between - Subjects Effects

Dependent Variable: 时间

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	673573.556	1	673573.556	12124324.0	.000
	Error	5.556E - 02[a]	1	5.556E - 02		
BLK	Hypothesis	5.556E - 02	1	5.556E - 02	.002	.966
	Error	46.861[b]	2	23.431		
A	Hypothesis	202.861	2	101.431	4.329	.188
	Error	46.861[b]	2	23.431		
A * BLK	Hypothesis	46.861	2	23.431	1.527	.291
	Error	92.083[c]	6	15.347		

续表

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
B	Hypothesis	10371.361	2	5185.681	337.890	.000
	Error	92.083[c]	6	15.347		
A * B	Hypothesis	67.722	4	16.931	1.103	.435
	Error	92.083[c]	6	15.347		
A * B * BLK	Hypothesis	92.083	6	15.347	2.858	.028
	Error	145.000[d]	27	5.370		
C	Hypothesis	1086.889	3	362.296	67.462	.000
	Error	145.000[d]	27	5.370		
A * C	Hypothesis	152.694	6	25.449	4.739	.002
	Error	145.000[d]	27	5.370		
B * C	Hypothesis	185.528	6	30.921	5.758	.001
	Error	145.000[d]	27	5.370		
A * B * C	Hypothesis	81.389	12	6.782	1.263	.295
	Error	145.000[d]	27	5.370		

a MS(BLK)
b MS(A * BLK)
c MS(A * B * BLK)
d MS(Error)

Expected Mean Squares[a,b]

Source	Variance Component				Quadratic Term
	Var(BLK)	Var(A * BLK)	Var(A * B * BLK)	Var(Error)	
Intercept	36.000	12.000	4.000	1.000	Intercept, A, B, A * B, C, A * C, B * C, A * B * C
BLK	36.000	12.000	4.000	1.000	
A	.000	12.000	4.000	1.000	A, A * B, A * C, A * B * C
A * BLK	.000	12.000	4.000	1.000	
B	.000	.000	4.000	1.000	B, A * B, B * C, A * B * C
A * B	.000	.000	4.000	1.000	A * B, A * B * C
A * B * BLK	.000	.000	4.000	1.000	
C	.000	.000	.000	1.000	C, A * C, B * C, A * B * C
A * C	.000	.000	.000	1.000	A * C, A * B * C
B * C	.000	.000	.000	1.000	B * C, A * B * C
A * B * C	.000	.000	.000	1.000	A * B * C
Error	.000	.000	.000	1.000	

a For each source, the expected mean square equals the sum of the coefficients in the cells times the variance components, plus a quadratic term involving effects in the Quadratic Term cell.

b Expected Mean Squares are based on the Type III Sums of Squares.

3. 条区试验设计的方差分析

例 7　有一水稻移栽期(A:7 月 16 日、8 月 16 日、9 月 16 日)和施用绿肥(B:黄花苜蓿、苕子、不施绿肥)的双因素试验,由于移栽期和施用绿肥都希望各自连成一片,故采用条区设计,设置六个小区,测得小区产量数据如下表,试进行方差分析.

移栽期		A_1			A_2			A_3		
施用绿肥		B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
区组	1	355	376	386	446	480	496	433	455	476
	2	396	406	388	549	540	533	492	512	482
	3	387	347	337	513	500	482	476	468	435
	4	293	280	201	469	436	413	436	398	334
	5	366	356	333	474	465	425	458	434	413
	6	397	356	348	520	509	490	487	473	447

(1) 在 SAS 中的分析程序如下:

```
DATA XEX07;
 DO BLK = 1 TO 6;
     DO A = 1 TO 3;
       DO B = 1 TO 3;
         INPUT Y@;OUTPUT;
       END;
     END;
 END;
CARDS;
  355 376 386 446 480 496 433 455 476
  396 406 388 549 540 533 492 512 482
  387 347 337 513 500 482 476 468 435
  293 280 201 469 436 413 436 398 334
  366 356 333 474 465 425 458 434 413
  397 356 348 520 509 490 487 473 447
  ;
PROC ANOVA;
  CLASS BLK A B;
```

```
    MODEL Y = BLK A B;
    MEANS A B/DUNCAN T;
  RUN;
  PROC ANOVA;
    CLASS BLK A B;
    MODEL Y = BLK A BLK * A B BLK * B A * B BLK * A * B;
    TEST H = A E  = BLK * A;
    TEST H = B E = BLK * B;
    TEST H = A * B E = BLK * A * B;
  RUN;
```

程序中 A,B,BLK 分别表示移栽期、施用绿肥及区组.第一个 ANOVA 过程用于对 A,B 分别作 T 和 Duncan's 差异显著性检验,第二个 ANOVA 过程作条区试验的统计分析.在移栽期部分,把 A 作为假设效应,把 BLK×A 作为移栽期误差,由第一个 TEST 语句实现;在施用绿肥部分,把 B 作为假设效应,把 BLK×B 作为施用绿肥误差,由第二个 TEST 语句实现;在移栽期×施用绿肥部分,把 A×B 作为假设效应,把 BLK×A×B 作为移栽期×施用绿肥误差,由第三个 TEST 语句实现.程序执行主要结果如下

```
                    Analysis of Variance Procedure
Dependent Variable: Y
                               Sum of          Mean
Source            DF          Squares        Square    F Value     Pr > F
Model              9     252624.05556   28069.33951      55.01     0.0001
Error             44      22449.44444     510.21465
Corrected Total   53     275073.50000
     R - Square                  C.V.      Root MSE                 Y Mean
     0.918387                5.267298     22.587931              428.83333
Source            DF         Anova SS   Mean Square    F Value     Pr > F
BLK                5      67477.94444   13495.58889      26.45     0.0001
A                  2     176970.11111   88485.05556     173.43     0.0001
B                  2       8176.00000    4088.00000       8.01     0.0011
                    Analysis of Variance Procedure
Dependent Variable: Y
                               Sum of          Mean
Source            DF          Squares        Square    F Value     Pr > F
Model             53     275073.50000    5190.06604          .          .
```

```
Error             0          .            .
Corrected Total  53   275073.50000
    R-Square               C.V.        Root MSE              Y Mean
    1.000000                  0               0           428.83333
Source           DF       Anova SS    Mean Square    F Value    Pr > F
BLK               5    67477.94444    13495.58889          .         .
A                 2   176970.11111    88485.05556          .         .
BLK * A          10     6837.44444      683.74444          .         .
B                 2     8176.00000     4088.00000          .         .
BLK * B          10    13372.22222     1337.22222          .         .
A * B             4      307.22222       76.80556          .         .
BLK * A * B      20     1932.55556       96.62778          .         .
Tests of Hypotheses using the Anova MS for BLK * A as an error term
Source           DF       Anova SS    Mean Square    F Value    Pr > F
A                 2   176970.11111    88485.05556     129.41    0.0001
Tests of Hypotheses using the Anova MS for BLK * B as an error term
Source           DF       Anova SS    Mean Square    F Value    Pr > F
B                 2  8176.0000000    4088.0000000       3.06    0.0920
Tests of Hypotheses using the Anova MS for BLK * A * B as an error term
Source           DF       Anova SS    Mean Square    F Value    Pr > F
A * B             4  307.22222222    76.80555556       0.79     0.542
```

(2) 在 SPSS 中，也用 GLM－General Factorial 过程进行条区试验设计的方差分析．首先在数据输入窗口中定义变量 A(移栽期)，B(施用绿肥)，BLK(区组)及 X(产量)，并输入数据；单击“Statistics”→“General Linear Model”→“GLM－General Factorial”过程，指定因变量 X，固定因素变量 A，B，随机因素变量 BLK；单击“Model”，选择自定义模型，并选择分析 BLK，A，A * BLK，B，B * BLK，A * B，A * B * BLK 效应，包含回归截距．注意选择这些效应时的顺序，应严格按照上述顺序输入，否则得到的结果是错误的．单击“Post Hoc”，选择 A 和 B 进行多重比较，方法选择 LSD 和 DUNCAN 两种，其他使用默认值．主要结果如下

Tests of Between－Subjects Effects

Dependent Variable：产量

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	9930493.500	1	9930493.500	735.833	.000
	Error	67477.944[a]	5	13495.589		

续表

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
BLK	Hypothesis	67477.944	5	13495.589	7.013	.001
	Error	31526.172[b]	16.383	1924.339		
A	Hypothesis	176970.111	2	88485.056	129.412	.000
	Error	6837.444[c]	10	683.744		
A * BLK	Hypothesis	6837.444	10	683.744	7.076	.000
	Error	1932.556[d]	20	96.628		
B	Hypothesis	8176.000	2	4088.000	3.057	.092
	Error	13372.222[e]	10	1337.222		
B * BLK	Hypothesis	13372.222	10	1337.222	13.839	.000
	Error	1932.556	20	96.628		
A * B	Hypothesis	307.222	4	76.806	.795	.542
	Error	1932.556[d]	20	96.628		

a MS(BLK) b 1.000 MS(A * BLK) + MS(B * BLK) − 1.000 MS(Error)

c MS(A * BLK) d MS(Error) e MS(B * BLK)

Expected Mean Squares

Source	Variance Component				Quadratic Term
	Var(BLK)	Var(A * BLK)	Var(B * BLK)	Var(Error)	
Intercept	9.000	3.000	3.000	1.000	Intercept, A, B, A * B
BLK	9.000	3.000	3.000	1.000	
A	.000	3.000	.000	1.000	A, A * B
A * BLK	.000	3.000	.000	1.000	
B	.000	.000	3.000	1.000	B, A * B
B * BLK	.000	.000	3.000	1.000	
A * B	.000	.000	.000	1.000	A * B
Error	.000	.000	.000	1.000	

a For each source, the expected mean square equals the sum of the coefficients in the cells times the variance components, plus a quadratic term involving effects in the Quadratic Term cell.

b Expected Mean Squares are based on the Type III Sums of Squares.

四、多年多地点试验的方差分析

农林科学中的品种、措施等，常需经过多年、多地点等不同环境的考验才能得到全面可靠的结论，因而就要进行多年、多地点的试验. 如育种中的区域试验、引种试验等都是多年、多地点的随机区组试验.

例 8　在玉米品种的杂种区域试验中，五个品种（V）通过三年（W）在四个地点（U）试验的产量结果如下表，设置两个区组，试进行方差分析.

	U_1					U_2					U_3					U_4				
	V_1	V_2	V_3	V_4	V_5	V_1	V_2	V_3	V_4	V_5	V_1	V_2	V_3	V_4	V_5	V_1	V_2	V_3	V_4	V_5
W_1	6	9	7	14	8	7	9	3	20	9	10	9	4	13	8	5	8	5	15	7
	7	8	8	14	6	8	9	4	18	5	12	10	2	14	8	6	9	4	15	6
W_2	5	15	9	16	7	7	14	3	16	8	13	13	6	15	6	6	10	3	14	9
	6	13	9	12	8	6	11	5	18	8	11	15	4	11	7	6	11	4	13	8
W_3	6	10	7	13	6	8	10	3	19	7	9	9	4	17	8	7	10	4	16	8
	4	11	7	12	8	6	11	3	18	6	10	10	5	14	4	5	10	4	14	6

（1）在 SAS 中的分析程序如下

```
DATA XEX08;
 DO W =1 TO 3;
   DO R = 1 TO 2;
     DO U =1 TO 4;
       DO V =1 TO 5;
         INPUT Y@;OUTPUT;
       END;
     END;
   END;
 END;
CARDS;
  6 9 7 14 8 7 9 3 20 9 10 9 4 13 8 5 8 5 15 7
  7 8 8 14 6 8 9 4 18 5 12 10 2 14 8 6 9 4 15 6
  5 15 9 16 7 7 14 3 16 8 13 13 6 15 6 6 10 3 14 9
  6 13 9 12 8 6 11 5 18 8 11 15 4 11 7 6 11 4 13 8
  6 10 7 13 6 8 10 3 19 7 9 9 4 17 8 7 10 4 16 8
  4 11 7 12 8 6 11 3 18 6 10 10 5 14 4 5 10 4 14 6
  ;
```

```
PROC ANOVA;
  CLASS U V W R;
  MODEL Y = U V W R;
  MEANS U V/DUNCAN T;
RUN;
PROC ANOVA;
  CLASS U V W R;
  MODEL Y = R(W U) W U U * W V V * W U * V U * V * W;
  TEST H = U E = U * W;
  TEST H = V E = V * W;
  TEST H = U * V E = U * V * W;
RUN;
```

程序中 U,V,W,R 分别表示地点、品种、年份及区组.第一个 ANOVA 过程用于对 U,V 分别作 T 和 Duncan's 差异显著性检验,第二个 ANOVA 过程作多年多点试验的统计分析.在地点部分,把 U 作为假设效应,把 U×W 作为地点误差,由第一个 TEST 语句实现;在品种部分,把 V 作为假设效应,把 V×W 作为品种误差,由第二个 TEST 语句实现;在地点×品种部分,把 U×V 作为假设效应,把 U×V×W 作为地点×品种误差,由第三个 TEST 语句实现;由于区组效应包含了地点和年份,故模型中的区组用 R(W×U)表示;其他均使用随机误差进行假设检验.程序执行主要结果如下:

Analysis of Variance Procedure

Dependent Variable: Y

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	1540.7833333	154.0783333	39.04	0.0001
Error	109	430.2083333	3.9468654		
Corrected Total	119	1970.9916667			

R - Square	C.V.	Root MSE	Y Mean
0.781730	22.09459	1.9866720	8.9916667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
U	3	22.8916667	7.6305556	1.93	0.1284
V	4	1495.6166667	373.9041667	94.73	0.0001
W	2	17.0666667	8.5333333	2.16	0.1200
R	1	5.2083333	5.2083333	1.32	0.2532

Analysis of Variance Procedure

Dependent Variable: Y

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	71	1896.7916667	26.7153756	17.28	0.0001
Error	48	74.2000000	1.5458333		
Corrected Total	119	1970.9916667			

R - Square	C.V.	Root MSE	Y Mean
0.962354	13.82742	1.2433155	8.9916667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
R(U * W)	12	12.3000000	1.0250000	0.66	0.7771
W	2	17.0666667	8.5333333	5.52	0.0070
U	3	22.8916667	7.6305556	4.94	0.0046
U * W	6	7.9333333	1.3222222	0.86	0.5343
V	4	1495.6166667	373.9041667	241.88	0.0001
V * W	8	60.4333333	7.5541667	4.89	0.0002
U * V	12	241.9833333	20.1652778	13.04	0.0001
U * V * W	24	38.5666667	1.6069444	1.04	0.4410

Tests of Hypotheses using the Anova MS for U * W as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
U	3	22.89166667	7.63055556	5.77	0.0335

Tests of Hypotheses using the Anova MS for V * W as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
V	4	1495.6166667	373.9041667	49.50	0.0001

Tests of Hypotheses using the Anova MS for U * V * W as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
U * V	12	241.98333333	20.16527778	12.55	0.000

(2) 在 SPSS 中，用 GLM - General Factorial 过程进行多年多地点试验设计的方差分析. 首先在数据输入窗口中定义变量 U(地点)，V(品种)，W(年份)，R(区组)及 X(产量)，并输入数据；单击“Statistics”→“General Linear Model”→“GLM - General Factorial”过程，指定因变量 X，固定因素变量 U，V，随机因素变量 W，R；单击“Model”，选择自定义模型，并选择分析 R * U * W，U，U * W，V，V * W，U * V，U * V * W，W 效应，包含回归截距，注意选择这些效应时的顺序；单击“Post Hoc”，选择 U 和 V 进行多重比较，方法选择 LSD 和 DUNCAN 两种，其它使用默认值. 主要结果如下

Tests of Between－Subjects Effects

Dependent Variable：产量

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	9702.008	1	9702.008	1136.954	.001
	Error	17.067[a]	2	8.533		
U * W * R	Hypothesis	12.300	12	1.025	.663	.777
	Error	74.200[b]	48	1.546		
U	Hypothesis	22.892	3	7.631	5.771	.033
	Error	7.933[c]	6	1.322		
U * W	Hypothesis	7.933	6	1.322	1.217	.427
	Error	5.231[d]	4.816	1.086		
V	Hypothesis	1495.617	4	373.904	49.496	.000
	Error	60.433[e]	8	7.554		
V * W	Hypothesis	60.433	8	7.554	4.701	.001
	Error	38.567[f]	24	1.607		
U * V	Hypothesis	241.983	12	20.165	12.549	.000
	Error	38.567[f]	24	1.607		
U * V * W	Hypothesis	38.567	24	1.607	1.040	.441
	Error	74.200[b]	48	1.546		
W	Hypothesis	17.067	2	8.533	1.174	.363
	Error	51.002[g]	7.016	7.269		

a MS(W) b MS(Error) c MS(U * W)

d MS(U * W * R) + 1.000 MS(U * V * W) − 1.000 MS(Error)

e MS(V * W) f MS(U * V * W)

g −8.882E−15 MS(U * W * R) + 1.000 MS(U * W) + MS(V * W) − MS(U * V * W)

Expected Mean Squares

Source	Variance Component						
	Var(U * W * R)	Var(U * W)	Var(V * W)	Var(U * V * W)	Var(W)	Var (Error)	Quadratic Term
Intercept	5.000	10.000	8.000	2.000	40.000	1.000	Intercept, U, V, U *
U * W * R	5.000	.000	.000	.000	.000	1.000	
U	5.000	10.000	.000	2.000	.000	1.000	U, U * V

续表

Source	Variance Component						
	Var(U * W * R)	Var(U * W)	Var(V * W)	Var(U * V * W)	Var(W)	Var (Error)	Quadratic Term
U * W	5.000	10.000	.000	2.000	.000	1.000	
V	.000	.000	8.000	2.000	.000	1.000	V,U * V
V * W	.000	.000	8.000	2.000	.000	1.000	
U * V	.000	.000	.000	2.000	.000	1.000	U * V
U * V * W	.000	.000	.000	2.000	.000	1.000	
W	5.000	10.000	8.000	2.000	40.000	1.000	
Error	.000	.000	.000	.000	.000	1.000	

a　For each source, the expected mean square equals the sum of the coefficients in the cells times the variance components, plus a quadratic term involving effects in the Quadratic Term cell.

b　Expected Mean Squares are based on the Type III Sums of Squares.

五、2^k 析因试验的方差分析

2^k 析因试验设计是 k 个试验因素都设置两个水平的试验设计，共有 2^k 个处理，是多因素全因子试验中处理最少的设计．

例 9　有一 2^3 设计的随机区组试验，设置三次重复，测得数据如下表，试进行析因方差分析．

处理		$A_1B_1C_1$	$A_1B_1C_2$	$A_1B_2C_1$	$A_1B_2C_2$	$A_2B_1C_1$	$A_2B_1C_2$	$A_2B_2C_1$	$A_2B_2C_2$
重复	1	8	19	21	27	16	16	30	30
	2	10	16	22	16	16	25	24	23
	3	18	16	18	17	19	22	26	25

（1）在 SAS 中的分析程序如下：

```
DATA XEX09;
 DO R =1 TO 3;
   DO A=1 TO 2;
     DO B =1 TO 2;
       DO C =1 TO 2;
         INPUT Y@;OUTPUT;
       END;
     END;
```

```
   END;
  END;
 CARDS;
   8  19  21  27  16  16  30  30
   10 16  22  16  16  25  24  23
   18 16  18  17  19  22  26  25
   ;
 PROC ANOVA;
   CLASS A B C R;
   MODEL Y = A B C R A*B A*C B*C A*B*C;
   MEANS A B C/DUNCAN T;
 RUN;
```

程序中 A,B,C,R 分别表示三个因子及区组.程序执行主要结果如下

Analysis of Variance Procedure

Dependent Variable: Y

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	504.91666667	56.10185185	3.52	0.0174
Error	14	223.08333333	15.93452381		
Corrected Total	23	728.00000000			

R - Square	C.V.	Root MSE	Y Mean
0.693567	19.95904	3.9918071	20.000000

Source	DF	Anova SS	Mean Square	F Value	Pr > F
A	1	170.66666667	170.66666667	10.71	0.0056
B	1	253.50000000	253.50000000	15.91	0.0013
C	1	24.00000000	24.00000000	1.51	0.2400
R	2	14.25000000	7.12500000	0.45	0.6483
A*B	1	4.16666667	4.16666667	0.26	0.6171
A*C	1	0.66666667	0.66666667	0.04	0.8409
B*C	1	37.50000000	37.50000000	2.35	0.1473
A*B*C	1	0.16666667	0.16666667	0.01	0.9200

(2) 在 SPSS 中,用 GLM - General Factorial 过程进行 2^k 析因试验设计的方差分析.首先在数据输入窗口中定义变量 A,B,C,R 及 X,并输入数据;单击"Statistics"→"General Linear Model"→"GLM - General Factorial"过程,指定因变量 X,固定因素变量 A,B,C,随机因素变量 R;其它选项使用默认值,主要结果如下

Expected Mean Squares

Source	Variance Component		
	Var(R)	Var(Error)	Quadratic Term
Intercept	8.000	1.000	Intercept, A, B, C, A * B, A * C, B * C, A * B * C
R	8.000	1.000	
A	.000	1.000	A, A * B, A * C, A * B * C
B	.000	1.000	B, A * B, B * C, A * B * C
C	.000	1.000	C, A * C, B * C, A * B * C
A * B	.000	1.000	A * B, A * B * C
A * C	.000	1.000	A * C, A * B * C
B * C	.000	1.000	B * C, A * B * C
A * B * C	.000	1.000	A * B * C
Error	.000	1.000	

a　For each source, the expected mean square equals the sum of the coefficients in the cells times the variance components, plus a quadratic term involving effects in the Quadratic Term cell.

b　Expected Mean Squares are based on the Type III Sums of Squares.

Tests of Between - Subjects Effects

Dependent Variable: X

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	9600.000	1	9600.000	1347.368	.001
	Error	14.250[a]	2	7.125		
R	Hypothesis	14.250	2	7.125	.447	.648
	Error	223.083[b]	14	15.935		
A	Hypothesis	170.667	1	170.667	10.710	.006
	Error	223.083[b]	14	15.935		
B	Hypothesis	253.500	1	253.500	15.909	.001
	Error	223.083[b]	14	15.935		
C	Hypothesis	24.000	1	24.000	1.506	.240
	Error	223.083[b]	14	15.935		
A * B	Hypothesis	4.167	1	4.167	.261	.617
	Error	223.083[b]	14	15.935		

续表

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
A * C	Hypothesis	.667	1	.667	.042	.841
	Error	223.083	14	15.935		
B * C	Hypothesis	37.500	1	37.500	2.353	.147
	Error	223.083	14	15.935		
A * B * C	Hypothesis	.167	1	.167	.010	.920
	Error	223.083	14	15.935		

a MS(R) b MS(Error)

六、正交试验的方差分析

多因素试验的处理会因试验因素及其水平的增加而急剧增加，从而使试验的实施变得困难，甚至无法实施. 正交试验设计是一种在一定条件下挑选部分处理作试验，并能严格进行统计学分析的试验设计方法.

1. 一般正交试验的方差分析

例 10 电镀前金属要去油去锈，影响去油去锈时间的因素有 A(硫酸)、B(乳化剂)和 C(尿硫)，选用 $L_8(2^7)$正交表进行试验，考虑交互作用的影响，测得数据如下表，试进行析因方差分析.

行号	A	B	$A\times B$	C	$A\times C$	$B\times C$	$A\times B\times C$	X
1	1	1	1	1	1	1	1	7.7
2	1	1	1	2	2	2	2	6.1
3	1	2	2	1	1	2	2	6.0
4	1	2	2	2	2	1	1	17.7
5	2	1	2	1	2	1	2	17.3
6	2	1	2	2	1	2	1	10.5
7	2	2	1	1	2	2	1	13.3
8	2	2	1	2	1	1	2	16.2

(1) 在 SAS 中的分析程序如下

```
DATA XEX10;
  INPUT A B AB C AC BC ABC X;
CARDS;
  1  1  1  1  1  1  1  7.7
  1  1  1  2  2  2  2  6.1
  1  2  2  1  1  2  2  6.0
```

```
  1  2  2  2  2  1  1  17.7
  2  1  2  1  2  1  2  17.3
  2  1  2  2  1  2  1  10.5
  2  2  1  1  2  2  1  13.3
  2  2  1  2  1  1  2  16.2
  ;
PROC ANOVA;
  CLASS A B AB C AC BC ABC ;
  MODEL X =  A B AB C AC BC ABC;
RUN;
PROC ANOVA;
  CLASS A B AB C AC BC ABC ;
  MODEL X =  A B AC BC;
RUN;
```

程序中 A,B,AB,C,AC,BC,ABC 和 X 分别表示表中的 1－8 列,最后一列为观测值.第一个 ANOVA 过程用于计算平方和,以决定将哪些效应合并为误差.第二个 ANOVA 过程将效应 AB,C,ABC 三项合并为误差进行假设检验.程序执行主要结果如下:

```
                    Analysis of Variance Procedure
Dependent Variable: X
Source            DF    Sum of Squares    Mean Square   F Value   Pr > F
Model              7      171.28000000    24.46857143         .        .
Error              0                 .              .
Corrected Total    7      171.28000000
Source            DF           Anova SS   Mean Square   F Value   Pr > F
A                  1       49.00500000    49.00500000         .        .
B                  1       16.82000000    16.82000000         .        .
AB                 1        8.40500000     8.40500000         .        .
C                  1        4.80500000     4.80500000         .        .
AC                 1       24.50000000    24.50000000         .        .
BC                 1       66.12500000    66.12500000         .        .
ABC                1        1.62000000     1.62000000         .        .
                    Analysis of Variance Procedure
Dependent Variable: X
Source            DF    Sum of Squares    Mean Square   F Value   Pr > F
```

Model	4	156.45000000	39.11250000	7.91	0.0604
Error	3	14.83000000	4.94333333		
Corrected Total	7	171.28000000			
R - Square		C.V.	Root MSE		X Mean
0.913417		18.76254	2.2233608		11.850000
Source	DF	Anova SS	Mean Square	F Value	Pr > F
A	1	49.00500000	49.00500000	9.91	0.0513
B	1	16.82000000	16.82000000	3.40	0.1623
AC	1	24.50000000	24.50000000	4.96	0.1124
BC	1	66.12500000	66.12500000	13.38	0.0353

(2) 在 SPSS 中,用 GLM - General Factorial 过程进行正交试验设计的方差分析.首先在数据输入窗口中定义变量 A,B,AB,C,AC,BC,ABC 及 X,并按正交表输入数据;单击"Statistics"→"General Linear Model"→"GLM - General Factorial"过程,指定因变量 X,固定因素变量 A,B,AB,C,AC,BC,ABC;单击"Model",选择自定义模型,并选择分析 A,B,AB,C,AC,BC,ABC 效应,包含回归截距;主要结果如下

Tests of Between - Subjects Effects

Dependent Variable: X

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	171.280[a]	7	24.469	.	.
Intercept	1123.380	1	1123.380	.	.
A	49.005	1	49.005	.	.
B	16.820	1	16.820	.	.
AB	8.405	1	8.405	.	.
C	4.805	1	4.805	.	.
AC	24.500	1	24.500	.	.
BC	66.125	1	66.125	.	.
ABC	1.620	1	1.620	.	.
Error	.000	0	.		
Total	1294.660	8			
Corrected Total	171.280	7			

a R Squared = 1.000 (Adjusted R Squared = .)

上述结果中，由于误差项为0，故无法进行检验，故将AB，C，ABC三项效应合并作为误差，重新分析得主要结果如下

Tests of Between - Subjects Effects

Dependent Variable：X

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	156.450[a]	4	39.113	7.912	.060
Intercept	1123.380	1	1123.380	227.252	.001
A	49.005	1	49.005	9.913	.051
B	16.820	1	16.820	3.403	.162
AC	24.500	1	24.500	4.956	.112
BC	66.125	1	66.125	13.377	.035
Error	14.830	3	4.943		
Total	1294.660	8			
Corrected Total	171.280	7			

a　R Squared = .913 (Adjusted R Squared = .798)

2．设置重复的正交试验的方差分析

例11　下表为一完全随机重复三次的$L_{16}(4^5)$正交试验表，不考虑交互作用的影响，试进行析因方差分析.

行号	A	B	C	D	空列	X_1	X_2	X_3
1	1	1	1	1	1	2	2	2
2	1	2	2	2	2	4	4.5	4
3	1	3	3	3	3	5.5	6	6
4	1	4	4	4	4	6	6.5	6.7
5	2	1	2	3	4	6.3	6.5	6.7
6	2	2	1	4	3	5.1	4.8	4.6
7	2	3	4	1	2	7	7.4	7.2
8	2	4	3	2	1	8	8.5	8.7
9	3	1	3	4	2	7	7.1	7.3
10	3	2	4	3	1	8.4	8.5	8.9
11	3	3	1	2	4	6.5	6.3	6.1
12	3	4	2	1	3	7	7.3	7.1
13	4	1	4	2	3	5	4.5	4.7
14	4	2	3	1	4	6	6.5	6.7
15	4	3	2	4	1	8.5	8.5	8.7
16	4	4	1	3	2	7	6.5	6.9

（1）在 SAS 中的分析程序如下

```
DATA XEX11;
  INPUT A B C D N R X@@;
CARDS;
1  1  1  1  1  1  2    1  2  2  2  2  1  4
1  3  3  3  3  1  5.5  1  4  4  4  4  1  6
2  1  2  3  4  1  6.3  2  2  1  4  3  1  5.1
2  3  4  1  2  1  7    2  4  3  2  1  1  8
3  1  3  4  2  1  7    3  2  4  3  1  1  8.4
3  3  1  2  4  1  6.5  3  4  2  1  3  1  7
4  1  4  2  3  1  5    4  2  3  1  4  1  6
4  3  2  4  1  1  8.5  4  4  1  3  2  1  7
1  1  1  1  1  2  2    1  2  2  2  2  2  4.5
1  3  3  3  3  2  6    1  4  4  4  4  2  6.5
2  1  2  3  4  2  6.5  2  2  1  4  3  2  4.8
2  3  4  1  2  2  7.4  2  4  3  2  1  2  8.5
3  1  3  4  2  2  7.1  3  2  4  3  1  2  8.5
3  3  1  2  4  2  6.3  3  4  2  1  3  2  7.3
4  1  4  2  3  2  4.5  4  2  3  1  4  2  6.5
4  3  2  4  1  2  8.5  4  4  1  3  2  2  6.5
1  1  1  1  1  3  2    1  2  2  2  2  3  4
1  3  3  3  3  3  6    1  4  4  4  4  3  6.7
2  1  2  3  4  3  6.7  2  2  1  4  3  3  4.6
2  3  4  1  2  3  7.2  2  4  3  2  1  3  8.7
3  1  3  4  2  3  7.3  3  2  4  3  1  3  8.9
3  3  1  2  4  3  6.1  3  4  2  1  3  3  7.1
4  1  4  2  3  3  4.7  4  2  3  1  4  3  6.7
4  3  2  4  1  3  8.7  4  4  1  3  2  3  6.9
  ;
PROC  ANOVA;
  CLASS  A B C D N R ;
  MODEL  X = A B C D;
RUN;
```

程序中 A,B,C,D,N,R 和 X 分别表示表中四个因素、空列、重复和观测值.进行假设检验用的误差是由随机误差和空列效应合并的.程序执行主要结果如

下

Analysis of Variance Procedure

Dependent Variable: X

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	12	125.97166667	10.49763889	31.51	0.0001
Error	35	11.66083333	0.33316667		
Corrected Total	47	137.63250000			

R - Square	C.V.	Root MSE	X Mean
0.915276	9.143856	0.5772059	6.3125000

Source	DF	Anova SS	Mean Square	F Value	Pr > F
A	3	49.99416667	16.66472222	50.02	0.0001
B	3	33.42416667	11.14138889	33.44	0.0001
C	3	29.01083333	9.67027778	29.03	0.0001
D	3	13.54250000	4.51416667	13.55	0.0001

(2) 在 SPSS 中,用 GLM-General Factorial 过程进行正交试验设计的方差分析.首先在数据输入窗口中定义变量 A,B,C,D,N,R 及 X,并按正交表输入数据;单击"Statistics"→"General Linear Model"→"GLM-General Factorial"过程,指定因变量 X,固定因素变量 A,B,C,D,单击"Model",选择自定义模型,并选择分析 A,B,C,D 效应,包含回归截距;其它使用默认值,主要结果如下

Tests of Between-Subjects Effects

Dependent Variable: X

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	125.972	12	10.498	31.509	.000
Intercept	1912.688	1	1912.688	5740.933	.000
A	49.994	3	16.665	50.019	.000
B	33.424	3	11.141	33.441	.000
C	29.011	3	9.670	29.025	.000
D	13.542	3	4.514	13.549	.000
Error	11.661	35	.333		
Total	2050.320	48			
Corrected Total	137.632	47			

a R Squared = .915 (Adjusted R Squared = .886)

3. 混合水平的正交试验的方差分析

例 12　用 $L_{16}(2^{15})$ 正交表安排 $4^1\times2^3$ 进行试验,考虑交互作用的影响,测得数据如下表,试进行析因方差分析.

行号	A	B	$A\times B$			C	$A\times C$			$B\times C$	D	N_1	N_2	X_3
1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.41
2	1	1	1	1	1	2	2	2	2	2	2	2	2	0.25
3	1	2	2	2	2	1	1	1	1	2	2	2	2	0.37
4	1	2	2	2	2	2	2	2	2	1	1	1	1	0.30
5	2	1	1	2	2	1	1	2	2	1	1	2	2	0.13
6	2	1	1	2	2	2	2	1	1	2	2	1	1	0.25
7	2	2	2	1	1	1	1	2	2	2	2	1	1	0.08
8	2	2	2	1	1	2	2	1	1	1	1	2	2	0.31
9	3	1	2	1	2	1	2	1	2	1	2	1	2	0.33
10	3	1	2	1	2	2	1	2	1	2	1	2	1	0.58
11	3	2	1	2	1	1	2	1	2	2	1	2	1	0.39
12	3	2	1	2	1	2	1	2	1	1	2	1	2	0.51
13	4	1	2	2	1	1	2	2	1	1	2	2	1	0.29
14	4	1	2	2	1	2	1	1	2	2	1	1	2	0.48
15	4	2	1	1	2	1	2	2	1	2	1	1	2	0.35
16	4	2	1	1	2	2	1	1	2	1	2	2	1	0.44

(1) 在 SAS 中,可用 GLM 过程进行混合水平的正交设计试验,进行方差分析,由于包含有交互项,而交互项占有正交表中可能不止一列,因而需将这些列合并成为一项,在 GLM 过程中可通过选项"/SS1"来实现,它表示在求平方和时采用第一类平方和方法.本例的分析程序如下

```
DATA XEX12;
  INPUT A B AB1 AB2 AB3 C AC1 AC2 AC3 BC D N1 N2 X;
CARDS;
  1 1 1 1 1 1 1 1 1 1 1 1 1 1 0.41
  1 1 1 1 1 2 2 2 2 2 2 2 2 2 0.25
  1 2 2 2 2 1 1 1 1 2 2 2 2 2 0.37
  1 2 2 2 2 2 2 2 2 1 1 1 1 1 0.30
  2 1 1 2 2 1 1 2 2 1 1 2 2 0.13
  2 1 1 2 2 2 2 1 1 2 2 1 1 0.25
  2 2 2 1 1 1 1 2 2 2 2 1 1 0.08
  2 2 2 1 1 2 2 1 1 1 1 2 2 0.31
  3 1 2 1 2 1 2 1 2 1 2 1 2 0.33
  3 1 2 1 2 2 1 2 1 2 1 2 1 0.58
```

```
  3 2 1 2 1 1 2 1 2 2 1 2 1 0.39
  3 2 1 2 1 2 1 2 1 1 2 1 2 0.51
  4 1 2 2 1 1 2 2 1 1 2 2 1 0.29
  4 1 2 2 1 2 1 1 2 2 1 1 2 0.48
  4 2 1 1 2 1 2 2 1 2 1 1 2 0.35
  4 2 1 1 2 2 1 1 2 1 2 2 1 0.44
  ;
PROC GLM;
  CLASS A B AB1 AB2 AB3 C AC1 AC2 AC3 BC D N1 N2;
  MODEL X = A B AB1 AB2 AB3 C AC1 AC2 AC3 BC D N1 N2/SS1;
RUN;
PROC GLM;
  CLASS A B AB1 AB2 AB3 C AC1 AC2 AC3 BC D N1 N2;
  MODEL X = A B AB1 * AB2 * AB3 C AC1 * AC2 * AC3 D/SS1;
RUN;
```

程序中 A,B,AB1～3,C,AC1～3,BC,D 分别表示因素及其交互作用列,N1 和 N2 为空列,X 为观测值.第一个 GLM 过程将各列单独作为因素进行分析;第二个 ANOVA 过程将效应 BC,N1 和 N2 三项合并作为误差进行分析.程序执行主要结果如下

General Linear Models Procedure

Dependent Variable: X

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	15	0.25744375	0.01716292	.	.
Error	0	.	.		
Corrected Total	15	0.25744375			

R - Square	C.V.	Root MSE	X Mean
1.000000	0	0	0.3418750

Source	DF	Type I SS	Mean Square	F Value	Pr > F
A	3	0.14781875	0.04927292	.	.
B	1	0.00005625	0.00005625	.	.
AB1	1	0.00000625	0.00000625	.	.
AB2	1	0.00005625	0.00005625	.	.
AB3	1	0.00005625	0.00005625	.	.
C	1	0.03705625	0.03705625	.	.
AC1	1	0.01755625	0.01755625	.	.

```
AC2             1     0.01500625    0.01500625          .        .
AC3             1     0.02805625    0.02805625          .        .
BC              1     0.00005625    0.00005625          .        .
D               1     0.01155625    0.01155625          .        .
N1              1     0.00015625    0.00015625          .        .
N2              1     0.00000625    0.00000625          .        .
                    General Linear Models Procedure
Dependent Variable: X
Source          DF    Sum of Squares   Mean Square   F Value   Pr > F
Model           12    0.25722500       0.02143542    293.97    0.0003
Error            3    0.00021875       0.00007292
Corrected Total 15    0.25744375
    R-Square               C.V.          Root MSE              X Mean
    0.999150               2.497733      0.0085391          0.3418750
Source          DF    Type I SS        Mean Square   F Value   Pr > F
A                3    0.14781875       0.04927292    675.74    0.0001
B                1    0.00005625       0.00005625      0.77    0.4444
AB1 * AB2 * AB3  3    0.00011875       0.00003958      0.54    0.6858
C                1    0.03705625       0.03705625    508.20    0.0002
AC1 * AC2 * AC3  3    0.06061875       0.02020625    277.11    0.0004
D                1    0.01155625       0.01155625    158.49    0.0011
```

(2) 在 SPSS 中,用 GLM－General Factorial 过程进行混合水平正交试验设计的方差分析.首先在数据输入窗口中定义变量 A,B,AB1～3,C,AC1～3,BC,D,N1,N2 及 X,并按正交表输入数据;单击"Statistics"→"General Linear Model"→"GLM－General Factorial"过程,指定因变量 X,固定因素变量 A,B,AB1～3,C,AC1～3,BC,D,N1,N2,单击"Model",选择自定义模型,并选择分析 A,B,AB1～3,C,AC1～3,BC,D,N1,N2 效应,使用第一类求平方和方法,包含回归截距;其它使用默认值,主要结果如下

Tests of Between－Subjects Effects

Dependent Variable: X

Source	Type I Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.257	15	1.716E－02	.	.
Intercept	1.870	1	1.870	.	.
A	.148	3	4.927E－02	.	.

续表

Source	Type I Sum of Squares	df	Mean Square	F	Sig.
B	5.625E－05	1	5.625E－05	.	.
AB1	6.250E－06	1	6.250E－06	.	.
AB2	5.625E－05	1	5.625E－05	.	.
AB3	5.625E－05	1	5.625E－05	.	.
C	3.706E－02	1	3.706E－02	.	.
AC1	1.756E－02	1	1.756E－02	.	.
AC2	1.501E－02	1	1.501E－02	.	.
AC3	2.806E－02	1	2.806E－02	.	.
BC	5.625E－05	1	5.625E－05	.	.
D	1.156E－02	1	1.156E－02	.	.
N1	1.562E－04	1	1.562E－04	.	.
N2	6.250E－06	1	6.250E－06	.	.
Error	.000	0	.		
Total	2.128	16			
Corrected Total	.257	15			

a　R Squared = 1.000 (Adjusted R Squared = .)

上述结果中，由于误差项为 0，无法进行检验，故将 BC，N1 和 N2 三项效应合并作为误差，重新分析得

Tests of Between-Subjects Effects

Dependent Variable: X

Source	Type I Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.257	12	2.144E-02	293.971	.000
Intercept	1.870	1	1.870	25646.486	.000
A	.148	3	4.927E－02	675.743	.000
B	5.625E－05	1	5.625E－05	.771	.444
AB1 * AB2 * AB3	1.187E－04	3	3.958E－05	.543	.686
C	3.706E－02	1	3.706E－02	508.200	.000
AC1 * AC2 * AC3	6.062E－02	3	2.021E－02	277.114	.000
D	1.156E－02	1	1.156E－02	158.486	.001
Error	2.187E－04	3	7.292E－05		
Total	2.128	16			
Corrected Total	.257	15			

a　R Squared = .999 (Adjusted R Squared = .996)