The manova1 data

March 8, 2011

The data:

```
low 34 10
low 29 14
low 35 11
low 32 13
high 33 14
high 38 12
high 34 13
high 35 14
```

The SAS code and output:

```
data manova1;
  infile "manova1.dat";
  input fertilizer $ yield weight;

proc means;
  var yield weight;
  class fertilizer;

proc glm;
  class fertilizer;
  model yield=fertilizer;

proc glm;
  class fertilizer;
  model weight=fertilizer;

proc gplot;
  plot yield*weight=fertilizer;

proc glm;
  class fertilizer;
  model yield weight=fertilizer;
  manova h=_all_;
```

```
proc discrim can out=fred;
  class fertilizer;
  var yield weight;

proc print data=fred;

run;
```

The MEANS Procedure

fertilizer	N Obs	Variable	N	Mean	Std Dev	Minimum	N
high	4	yield	4	35.0000000	2.1602469	33.0000000	38.0
		weight	4	13.2500000	0.9574271	12.0000000	14.0
low	4	yield	4	32.5000000	2.6457513	29.0000000	35.0
		weight	4	12.0000000	1.8257419	10.0000000	14.0

The GLM Procedure

Class Level Information

Class	Levels	Values
fertilizer	2	high low

Number of Observations Read   8
Number of Observations Used   8

The GLM Procedure

Dependent Variable: yield

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	12.50000000	12.50000000	2.14	0.1936
Error	6	35.00000000	5.83333333		
Corrected Total	7	47.50000000			

R-Square	Coeff Var	Root MSE	yield Mean
0.263158	7.156235	2.415229	33.75000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
fertilizer	1	12.50000000	12.50000000	2.14	0.1936

Source	DF	Type III SS	Mean Square	F Value	Pr > F
fertilizer	1	12.50000000	12.50000000	2.14	0.1936

The GLM Procedure

Class Level Information

```
Class             Levels    Values
fertilizer            2     high low

Number of Observations Read          8
Number of Observations Used          8

The GLM Procedure
Dependent Variable: weight
                                     Sum of
Source                   DF         Squares      Mean Square    F Value    Pr > F
Model                     1      3.12500000       3.12500000       1.47    0.2708
Error                     6     12.75000000       2.12500000
Corrected Total           7     15.87500000

R-Square      Coeff Var     Root MSE      weight Mean
0.196850      11.54644      1.457738        12.62500

Source                   DF       Type I SS      Mean Square    F Value    Pr > F
fertilizer                1      3.12500000       3.12500000       1.47    0.2708

Source                   DF     Type III SS      Mean Square    F Value    Pr > F
fertilizer                1      3.12500000       3.12500000       1.47    0.2708

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```

```
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```

The GLM Procedure
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The GLM Procedure
Multivariate Analysis of Variance
Characteristic Roots and Vectors of: E Inverse * H, where
      H = Type III SSCP Matrix for fertilizer
             E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector V'EV=1 yield	weight
4.03885481	100.00	0.31299419	0.51086408
0.00000000	0.00	0.07955573	-0.15911146

MANOVA Test Criteria and Exact F Statistics for the Hypothesis of No Overall fertilizer Effe
                  H = Type III SSCP Matrix for fertilizer
                    E = Error SSCP Matrix
                      S=1   M=0   N=1.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.19845779	10.10	2	5	0.0175
Pillai's Trace	0.80154221	10.10	2	5	0.0175
Hotelling-Lawley Trace	4.03885481	10.10	2	5	0.0175
Roy's Greatest Root	4.03885481	10.10	2	5	0.0175

The DISCRIM Procedure

Total Sample Size	8	DF Total	7
Variables	2	DF Within Classes	6
Classes	2	DF Between Classes	1

Number of Observations Read	8
Number of Observations Used	8

```
                            Class Level Information
                  Variable                                               Prior
fertilizer        Name        Frequency       Weight    Proportion    Probability
high              high                4       4.0000      0.500000       0.500000
low               low                 4       4.0000      0.500000       0.500000


Pooled Covariance Matrix Information
                  Natural Log of the
 Covariance       Determinant of the
Matrix Rank        Covariance Matrix
          2                   1.22255


The DISCRIM Procedure
Pairwise Generalized Squared Distances Between Groups
 2             _   _         -1   _   _
D (i|j) = (X - X )'  COV    (X - X )
           i   j              i   j


Generalized Squared Distance to fertilizer
From
fertilizer              high              low
high                       0         12.11656
low                 12.11656                0


The DISCRIM Procedure
Canonical Discriminant Analysis
                          Adjusted      Approximate         Squared
            Canonical     Canonical       Standard        Canonical
           Correlation   Correlation         Error       Correlation
       1     0.895289      0.892147       0.075010         0.801542
                                                      Test of H0: The canonical correlations
                    Eigenvalues of Inv(E)*H                 current row and all that follow are
                      = CanRsq/(1-CanRsq)
                                                     Likelihood Approximate
            Eigenvalue Difference Proportion Cumulative    Ratio      F Value Num DF Den DF P
       1       4.0389                 1.0000     1.0000 0.19845779      10.10      2      5 0.
NOTE: The F statistic is exact.


The DISCRIM Procedure
Canonical Discriminant Analysis
Total Canonical Structure
Variable                Can1
yield               0.572987
weight              0.495570
```

```
Between Canonical Structure
Variable            Can1
yield             1.000000
weight            1.000000


Pooled Within Canonical Structure
Variable            Can1
yield             0.297366
weight            0.246343


The DISCRIM Procedure
Canonical Discriminant Analysis
Total-Sample Standardized Canonical Coefficients
Variable            Can1
yield           1.997145424
weight          1.884468331


Pooled Within-Class Standardized Canonical Coefficients
Variable            Can1
yield           1.851698615
weight          1.824149648


Raw Canonical Coefficients
Variable            Can1
yield           0.766676064
weight          1.251356335


Class Means on Canonical Variables
fertilizer          Can1
high            1.740442790
low            -1.740442790


The DISCRIM Procedure
Linear Discriminant Function
                  _      -1 _                                      -1 _
Constant = -.5 X' COV    X        Coefficient Vector = COV    X
               j         j                                       j


Linear Discriminant Function for fertilizer
Variable          high            low
Constant     -943.76534     -798.70399
yield          33.60736       30.93865
weight         53.68098       49.32515


The DISCRIM Procedure
Classification Summary for Calibration Data: WORK.MANOVA1
```

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Resubstitution Summary using Linear Discriminant Function
Generalized Squared Distance Function

$$D_j^2(X) = (X-\bar{X}_j)' \, COV^{-1} \, (X-\bar{X}_j)$$

Posterior Probability of Membership in Each fertilizer

$$Pr(j|X) = \exp(-.5 \, D_j^2(X)) \, / \, \underset{k}{SUM} \, \exp(-.5 \, D_k^2(X))$$

Number of Observations and Percent Classified into fertilizer

From fertilizer	high	low	Total
high	4	0	4
	100.00	0.00	100.00
low	0	4	4
	0.00	100.00	100.00
Total	4	4	8
	50.00	50.00	100.00
Priors	0.5	0.5	

Error Count Estimates for fertilizer

	high	low	Total
Rate	0.0000	0.0000	0.0000
Priors	0.5000	0.5000	

Obs	fertilizer	yield	weight	Can1	Can2	high	low	_INTO_
1	low	34	10	-3.09314	.	0.00002	0.99998	low
2	low	29	14	-1.92110	.	0.00125	0.99875	low
3	low	35	11	-1.07511	.	0.02315	0.97685	low
4	low	32	13	-0.87242	.	0.04579	0.95421	low
5	high	33	14	1.14561	.	0.98180	0.01820	high
6	high	38	12	2.47628	.	0.99982	0.00018	high
7	high	34	13	0.66093	.	0.90893	0.09107	high
8	high	35	14	2.67896	.	0.99991	0.00009	high