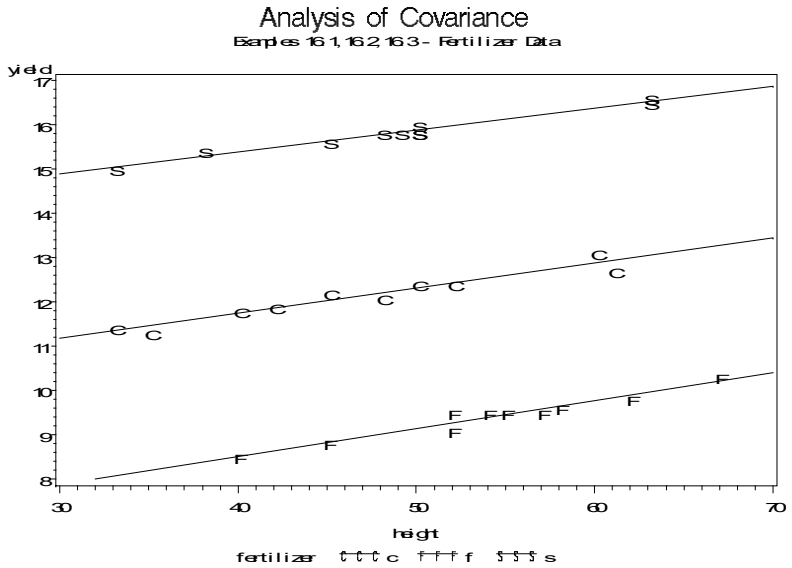
```
title1 'Analysis of Covariance';
title2 'Examples 16.1,16.2,16.3 - Fertilizer Data';
options nodate nonumber ls=80 nocenter;
data fertilizer;
input yield height fertilizer $ @@;
datalines;
12.2 45 c 12.4 52 c 11.9 42 c 11.3 35 c
11.8 40 c 12.1 48 c 13.1 60 c 12.7 61 c
12.4 50 c 11.4 33 c 16.6 63 s 15.8 50 s
16.5 63 s 15.0 33 s 15.4 38 s 15.6 45 s
15.8 50 s 15.8 48 s 16.0 50 s 15.8 49 s
9.5 52 f 9.5 54 f 9.6 58 f 8.8 45 f
9.5 57 f 9.8 62 f 9.1 52 f 10.3 67 f
9.5 55 f 8.5 40 f
;

symbol1 v='C' i=rl c=black;
symbol2 v='F' i=rl c=black;
symbol3 v='S' i=rl c=black;

proc gplot data=fertilizer;
plot yield*height=fertilizer;
run;

proc glm data=fertilizer;
class fertilizer;
model yield = fertilizer height fertilizer*height; ** test for same slope **;
run;

proc glm data=fertilizer;
class fertilizer;
model yield = fertilizer height / solution;
lsmeans fertilizer / pdiff cl adj=bon;
run;
```



Analysis of Covariance
Examples 16.1,16.2,16.3 - Fertilizer Data

The GLM Procedure

Class Level Information

Class	Levels	Values
fertilizer	3	c f s

Number of Observations Read 30
Number of Observations Used 30

Analysis of Covariance
Examples 16.1,16.2,16.3 - Fertilizer Data

The GLM Procedure

Dependent Variable: yield

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	214.4372247	42.8874449	2887.70	<.0001
Error	24	0.3564420	0.0148517		
Corrected Total	29	214.7936667			

R-Square	Coeff Var	Root MSE	yield Mean
0.998341	0.978334	0.121868	12.45667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
fertilizer	2	207.6826667	103.8413333	6991.86	<.0001
height	1	6.6932872	6.6932872	450.67	<.0001
height*fertilizer	2	0.0612708	0.0306354	2.06	0.1491

Source	DF	Type III SS	Mean Square	F Value	Pr > F
fertilizer	2	6.69631934	3.34815967	225.44	<.0001
height	1	6.65321124	6.65321124	447.97	<.0001
height*fertilizer	2	0.06127080	0.03063540	2.06	0.1491

Analysis of Covariance
Examples 16.1,16.2,16.3 - Fertilizer Data

The GLM Procedure

Class Level Information

Class	Levels	Values
fertilizer	3	c f s

Number of Observations Read 30
Number of Observations Used 30

Analysis of Covariance
Examples 16.1,16.2,16.3 - Fertilizer Data

The GLM Procedure

Dependent Variable: yield

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	214.3759539	71.4586513	4447.85	<.0001
Error	26	0.4177128	0.0160659		
Corrected Total	29	214.7936667			

R-Square	Coeff Var	Root MSE	yield Mean
0.998055	1.017537	0.126751	12.45667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
fertilizer	2	207.6826667	103.8413333	6463.47	<.0001
height	1	6.6932872	6.6932872	416.62	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
fertilizer	2	213.9038045	106.9519022	6657.08	<.0001
height	1	6.6932872	6.6932872	416.62	<.0001

Parameter	Estimate		Standard Error	t Value	Pr > |t|
Intercept	13.10089348	B	0.13958529	93.86	<.0001
fertilizer c	-3.57163712	B	0.05703267	-62.62	<.0001
fertilizer f	-6.71579273	B	0.05850799	-114.78	<.0001
fertilizer s	0.00000000	B	.	.	.
height	0.05580995		0.00273429	20.41	<.0001

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

Analysis of Covariance
Examples 16.1,16.2,16.3 - Fertilizer Data

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Bonferroni

fertilizer	yield LSMEAN	LSMEAN Number
c	12.3141728	1
f	9.1700172	2
s	15.8858099	3

Least Squares Means for effect fertilizer
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: yield

i/j	1	2	3
1		<.0001	<.0001
2	<.0001		<.0001
3	<.0001	<.0001	

fertilizer	yield LSMEAN	95% Confidence Limits	
c	12.314173	12.229721	12.398625
f	9.170017	9.084155	9.255879
s	15.885810	15.803228	15.968392

Least Squares Means for Effect fertilizer

i	j	Difference Between Means	Simultaneous 95% Confidence Limits for LSMean(i)-LSMean(j)	
1	2	3.144156	2.989662	3.298649
1	3	-3.571637	-3.717580	-3.425694
2	3	-6.715793	-6.865511	-6.566074