Homework 8 Solutions (lesson 11)

Answer Key

Stat 502

a) (40pts) Plot the data. This can be done any way you choose (Excel scatter plot, Minitab, or SAS) to show the response (seed\_yield vs. height). It is important here to label the points on the scatter plot to indicate the treatment level they belong to.

b) (20pts) Fit a simple linear regression for each fertilizer treatment separately and determine if any of the regressions are significant. Include the output for the regression tests of significance.

c) (40pts) Following the Steps of ANOVA, run the appropriate models to come up with a final model. Include a description of the process (steps) you are using, and include output associated with the steps you follow. Identify your final model and draw a conclusion about the Null Hypothesis of equality of the means for the fertilizer levels.

1) a. Plot of Yield vs. Height for each Trt (here shown in Excel)

b) Step 1: Are *individual* regressions significant? (at least one needs to be). Using either Minitab or SAS, see that each of the three separate regressions (one for each treatment) are significant (p<0.05 for slope = 0 in each treatment.

SAS output for individual regressions

Treatment = S

Parameter Estimates

Parameter Standard

Variable DF Estimate Error t Value Pr > |t|

Intercept 1 13.39833 0.14016 95.59 <.0001

ht 1 0.04973 0.00282 17.63 <.0001

Treatment = C

Parameter Estimates

Parameter Standard

Variable DF Estimate Error t Value Pr > |t|

Intercept 1 9.49177 0.25214 37.64 <.0001

ht 1 0.05661 0.00531 10.66 <.0001

Treatment = F

Parameter Estimates

Parameter Standard

Variable DF Estimate Error t Value Pr > |t|

Intercept 1 5.97215 0.28968 20.62 <.0001

ht 1 0.06343 0.00530 11.98 <.0001

Step 2: Run full ANCOVA model:

Model: Yield = Trt Ht Trt\*ht

This provides the critical test in ANCOVA – are slopes equal. The p-value for the trt\*ht term is the appropriate one, and we see its not significant. Therefore, we have equal slopes and can proceed with the ANCOVA adjustment process to take out the effect of Ht. Minitab output:

**General Linear Model: yield versus trt**

Factor Type Levels Values

trt fixed 3 c, f, s

Analysis of Variance for yield, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P

trt 2 207.683 6.696 3.348 225.44 0.000

ht 1 6.693 6.653 6.653 447.97 0.000

**trt\*ht** 2 0.061 0.061 0.031 2.06 **0.149**

Error 24 0.356 0.356 0.015

Total 29 214.794

c) So now we need to fit a common slope model (by removing the trt\*covariate term) and from this analysis produce the least squares means and mean comparisons.

**General Linear Model: yield versus trt**

Factor Type Levels Values

trt fixed 3 c, f, s

Analysis of Variance for yield, using Adjusted SS for Tests

Source DF Seq SS Adj SS Adj MS F P

**trt** 2 207.683 213.904 106.952 6657.08 **0.000**

ht 1 6.693 6.693 6.693 416.62 0.000

Error 26 0.418 0.418 0.016

Total 29 214.794

Therefore, Reject :

(*optional, not called for in the question):*

Grouping Information Using Tukey Method and 95.0% Confidence

trt N Mean Grouping

s 10 15.9 A

c 10 12.3 B

f 10 9.2 C

Same final model in SAS:

/\* ANCOVA step 2: test for equal slopes \*/

proc mixed data=peanuts;

class trt;

model yield=trt ht trt\*ht;

run;

/\*Step three: Common Slope model \*/

proc mixed data=peanuts;

class trt;

model yield = trt ht;

lsmeans trt / pdiff adjust=tukey;

run;

Output:

First step ANOVA output:

Type 3 Tests of Fixed Effects

Num Den

Effect DF DF F Value Pr > F

trt 2 24 225.44 <.0001

ht 1 24 447.97 <.0001

**ht\*trt** 2 24 2.06 **0.1491**

Common Slope final model output:

The Mixed Procedure

Type 3 Tests of Fixed Effects

Num Den

Effect DF DF F Value Pr > F

**trt 2 26 6657.08 <.0001**

ht 1 26 416.62 <.0001

Least Squares Means

Standard

Effect trt Estimate Error DF t Value Pr > |t|

trt c 12.3142 0.04109 26 299.72 <.0001

trt f 9.1700 0.04177 26 219.53 <.0001

trt s 15.8858 0.04018 26 395.41 <.0001

Differences of Least Squares Means

Standard

Effect trt \_trt Estimate Error DF t Value Pr > |t| Adjustment Adj P

trt c f 3.1442 0.06037 26 52.08 <.0001 Tukey-Kramer <.0001

trt c s -3.5716 0.05703 26 -62.62 <.0001 Tukey-Kramer <.0001

trt f s -6.7158 0.05851 26 -114.78 <.0001 Tukey-Kramer <.0001