Stat/For/Hort 572 – Midterm II, Spring 2004 — Brief Solutions for Problem 2

The experiment is a randomized complete block design. The plots are the experimental units and the fields are the blocks. Arrange the data in the file `n.dat`.

```
trt blk yield site field
1 1 10.75 1 1
1 2 12.37 1 2
1 3  6.33 2 3
1 4 11.19 2 4
2 1 18.66 1 1
2 2 16.36 1 2
2 3 14.97 2 3
2 4 15.48 2 4
3 1 21.15 1 1
3 2 19.39 1 2
3 3 19.02 2 3
3 4 16.78 2 4
4 1 20.76 1 1
4 2 17.57 1 2
4 3 20.25 2 3
4 4 17.91 2 4
5 1 13.97 1 1
5 2 15.89 1 2
5 3 11.64 2 3
5 4 11.19 2 4
6 1 19.84 1 1
6 2 19.56 1 2
6 3 14.15 2 3
6 4 10.02 2 4
7 1 17.24 1 1
7 2 15.89 1 2
7 3 11.69 2 3
7 4  9.06 2 4
```

We analyze the data using the following SAS commands.

```
data nitro;
  infile "n.dat" missover firstobs=2;
  input trt blk yield site field;
run;
proc glm data=nitro;
  classes trt blk;
  model yield = trt blk;
  output out=nitro2 p=pred r=resid;
  means trt / lsd lines;
  contrast "control vs trt" trt 6 -1 -1 -1 -1 -1 -1;
  contrast "FP linear" trt -3 -1 1 3 0 0 0;
  contrast "FP quadratic" trt 1 -1 -1 1 0 0 0;
  contrast "FP cubic" trt -1 3 -3 1 0 0 0;
run;
proc plot data=nitro2;
  plot resid*pred / vref=0;
run;
```

The (edited) SAS output looks like the following. The residual plot (not shown) looks fine when checking for the usual 4 assumptions. A mean profile plot shows that there might be an interaction between the treatments and blocks, but a formal test would be required to test for the interaction.

```
Dependent Variable: yield
                                    Sum of
Source                      DF       Squares    Mean Square   F Value   Pr > F
Model                        9    352.1452571     39.1272508      9.18   <.0001
Error                       18     76.7378286      4.2632127
Corrected Total             27    428.8830857

Source                      DF      Type I SS    Mean Square   F Value   Pr > F
trt                          6    258.8758857     43.1459810     10.12   <.0001
blk                          3     93.2693714     31.0897905      7.29   0.0021

Source                      DF    Type III SS    Mean Square   F Value   Pr > F
trt                          6    258.8758857     43.1459810     10.12   <.0001
blk                          3     93.2693714     31.0897905      7.29   0.0021

                        t Tests (LSD) for yield
                  Alpha                            0.05
```

```
   Error Degrees of Freedom           18
   Error Mean Square            4.263213
   Critical Value of t           2.10092
   Least Significant Difference   3.0674

t Grouping          Mean      N    trt
         A        19.123      4    4
         A
         A        19.085      4    3
         A
    B    A        16.368      4    2
    B
    B    C        15.893      4    6
    B    C
    B    C        13.470      4    7
         C
    D    C        13.173      4    5
    D
    D             10.160      4    1
```

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
control vs trt	1	124.4592857	124.4592857	29.19	<.0001
FP linear	1	175.2912050	175.2912050	41.12	<.0001
FP quadratic	1	38.0689000	38.0689000	8.93	0.0079
FP cubic	1	0.1312200	0.1312200	0.03	0.8627

(a) Based on the first contrast in the SAS printout, we conclude that there is evidence of a treatment effect compared to control ($p < 0.0001$).

(b) The LSD suggests that the 4th and the 3rd treatments, corresponding to fresh poultry at 202 kg/ha and 134 kg/ha give the most yield.

(c) By using the linear, quadratic, and cubic contrasts, we conclude that there is strong evidence that the yield is related to the nitrogen levels in a quadratic fashion ($p < 0.0001$).

(d) The 95% confidence interval of the among-plot variability is

$$\frac{\text{SSE}}{\chi^2_{18,0.975}} < \sigma^2 < \frac{\text{SSE}}{\chi^2_{18,0.025}},$$

where SSE = 76.74, $\chi^2_{18,0.025} = 8.23$, and $\chi^2_{18,0.975} = 31.53$. Hence the CI is (2.43,9.32).

(e) There are various ways of evaluating the field and site effects. One possibility is to recognize that the blocking factor `field` is nested within the other blocking factor `site`. The relevant SAS commands and output are as follows. To test for the site effect, use $f = \frac{88.28}{2.49} = 35.45$ and compare with F on df = (1,2). The p-value is 0.027, indicating a significant difference between the two sites. The fields within the sites are however not significantly different with a p-value of 0.57.

```
proc glm data=nitro;
  classes trt site field;
  model yield = site field(site) trt;

Dependent Variable: yield
```

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	352.1452571	39.1272508	9.18	<.0001
Error	18	76.7378286	4.2632127		
Corrected Total	27	428.8830857			

Source	DF	Type I SS	Mean Square	F Value	Pr > F
site	1	88.2885143	88.2885143	20.71	0.0002
field(site)	2	4.9808571	2.4904286	0.58	0.5678
trt	6	258.8758857	43.1459810	10.12	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
site	1	88.2885143	88.2885143	20.71	0.0002
field(site)	2	4.9808571	2.4904286	0.58	0.5678
trt	6	258.8758857	43.1459810	10.12	<.0001