Oats Example: Split-Plot Analysis

Lot = Whole Plot Factor, Trt = Sub Plot Factor

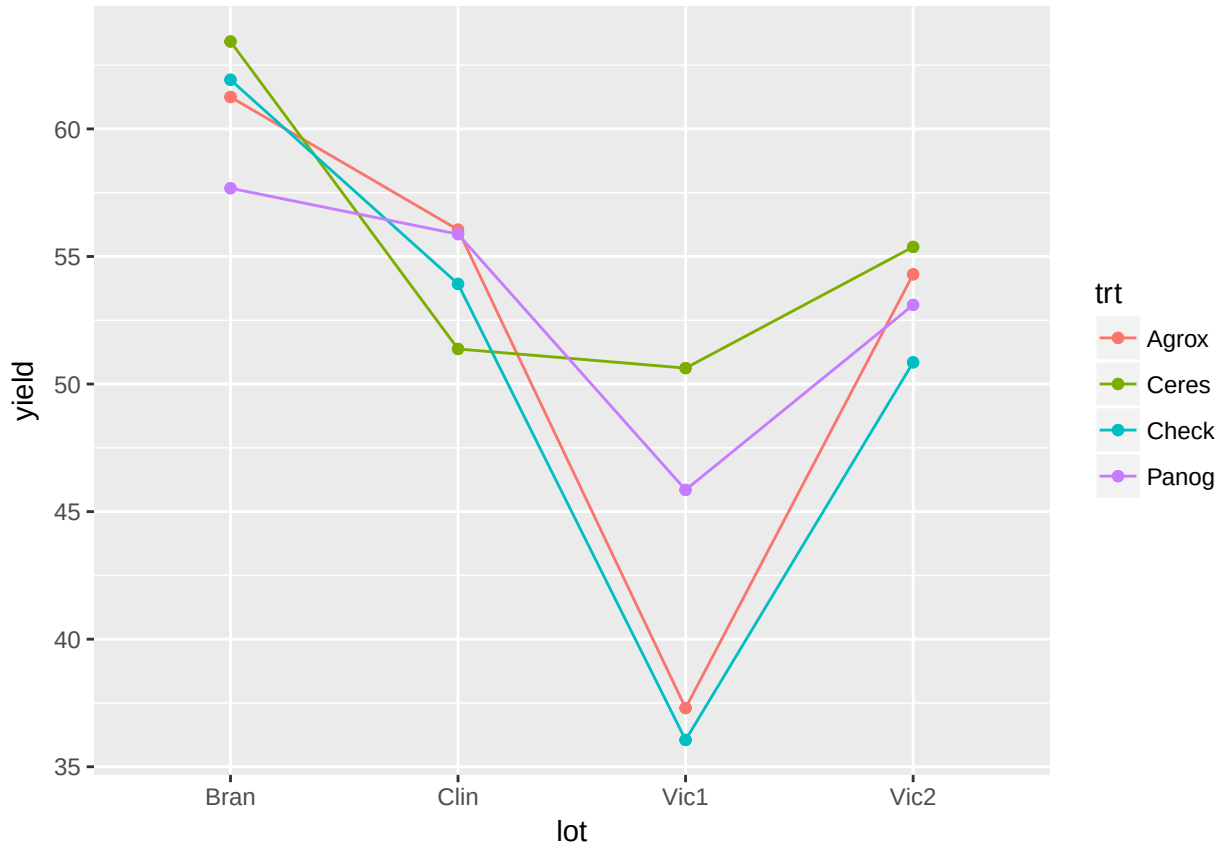
```
library(ggplot2)
library(lme4)
library(lmerTest)
library(pbkrtest)
library(emmeans)
Oats <- read.csv("C:/hess/STAT512/RNotes/Random2/R2_Oats_SplitPlot.csv")
str(Oats)
```

```
## 'data.frame':    64 obs. of  4 variables:
##  $ lot  : Factor w/ 4 levels "Bran","Clin",..: 3 3 3 3 3 3 3 3 3 3 ...
##  $ trt  : Factor w/ 4 levels "Agrox","Ceres",..: 3 2 4 1 3 2 4 1 3 2 ...
##  $ blk  : int  1 1 1 1 2 2 2 2 3 3 ...
##  $ yield: num  42.9 53.8 49.5 44.4 41.6 58.5 53.8 41.8 28.9 43.9 ...
```

```
#Important: Need to define block as.factor!!!
Oats$blk <- as.factor(Oats$blk)
#Interaction Plot
AvgData <- aggregate(yield ~ lot + trt, data = Oats, mean)
str(AvgData)
```

```
## 'data.frame':    16 obs. of  3 variables:
##  $ lot  : Factor w/ 4 levels "Bran","Clin",..: 1 2 3 4 1 2 3 4 1 2 ...
##  $ trt  : Factor w/ 4 levels "Agrox","Ceres",..: 1 1 1 1 2 2 2 2 3 3 ...
##  $ yield: num  61.2 56 37.3 54.3 63.4 ...
```

```
p <- qplot(x = lot, y = yield, colour = trt, group = trt, data = AvgData)
p + geom_line() + geom_point()
```




```
Model1 <- lmer(yield ~ lot*trt + (1|blk) + (1|blk:lot), data=Oats)
summary(Model1)
```

```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula: yield ~ lot * trt + (1 | blk) + (1 | blk:lot)
##    Data: Oats
##
## REML criterion at convergence: 325.4
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.27893 -0.41191  0.02627  0.41062  2.39644
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  blk:lot  (Intercept) 12.10    3.478
##  blk      (Intercept) 54.93    7.412
##  Residual             20.31    4.507
## Number of obs: 64, groups:  blk:lot, 16; blk, 4
##
## Fixed effects:
##                  Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)        61.250      4.673   6.390  13.108 7.43e-06 ***
## lotClin            -5.200      4.025  26.780  -1.292   0.2075
## lotVic1           -23.950      4.025  26.780  -5.950 2.50e-06 ***
```

```
## lotVic2            -6.950      4.025  26.780  -1.727   0.0958 .
## trtCeres            2.175      3.187  36.000   0.683   0.4993
## trtCheck            0.675      3.187  36.000   0.212   0.8334
## trtPanog           -3.575      3.187  36.000  -1.122   0.2694
## lotClin:trtCeres   -6.850      4.507  36.000  -1.520   0.1373
## lotVic1:trtCeres   11.150      4.507  36.000   2.474   0.0182 *
## lotVic2:trtCeres   -1.100      4.507  36.000  -0.244   0.8086
## lotClin:trtCheck   -2.800      4.507  36.000  -0.621   0.5383
## lotVic1:trtCheck   -1.925      4.507  36.000  -0.427   0.6718
## lotVic2:trtCheck   -4.125      4.507  36.000  -0.915   0.3661
## lotClin:trtPanog    3.400      4.507  36.000   0.754   0.4555
## lotVic1:trtPanog   12.125      4.507  36.000   2.690   0.0108 *
## lotVic2:trtPanog    2.375      4.507  36.000   0.527   0.6014
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(Model1, ddf="Kenward-Roger")
```

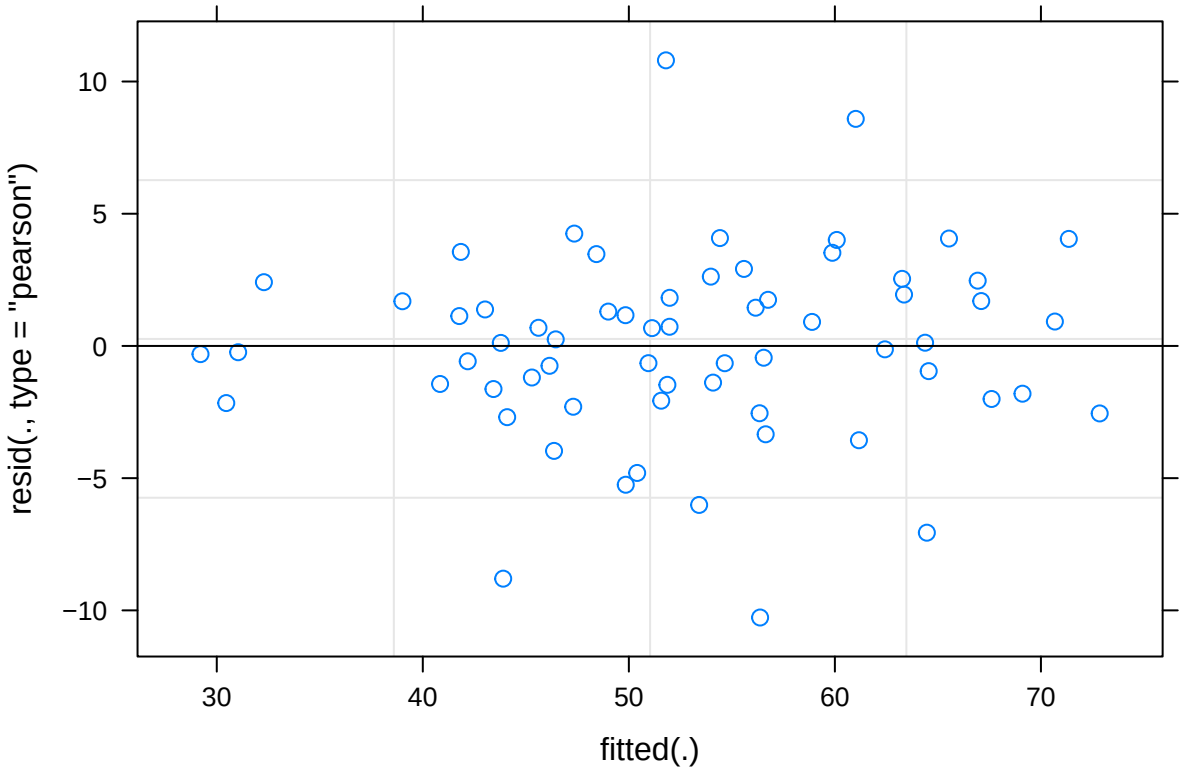
```
## Analysis of Variance Table of type III  with  Kenward-Roger
## approximation for degrees of freedom
##         Sum Sq Mean Sq NumDF DenDF F.value   Pr(>F)
## lot     842.03 280.675     3     9 13.8188 0.001022 **
## trt     170.54  56.846     3    36  2.7987 0.053859 .
## lot:trt 586.47  65.163     9    36  3.2082 0.005945 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
emmeans(Model1, pairwise ~ trt|lot)
```

```
## $emmeans
## lot = Bran:
##  trt   emmean       SE   df lower.CL upper.CL
##  Agrox 61.250 4.672822 6.39 49.98236 72.51764
##  Ceres 63.425 4.672822 6.39 52.15736 74.69264
##  Check 61.925 4.672822 6.39 50.65736 73.19264
##  Panog 57.675 4.672822 6.39 46.40736 68.94264
##
## lot = Clin:
##  trt   emmean       SE   df lower.CL upper.CL
##  Agrox 56.050 4.672822 6.39 44.78236 67.31764
##  Ceres 51.375 4.672822 6.39 40.10736 62.64264
##  Check 53.925 4.672822 6.39 42.65736 65.19264
##  Panog 55.875 4.672822 6.39 44.60736 67.14264
##
## lot = Vic1:
##  trt   emmean       SE   df lower.CL upper.CL
##  Agrox 37.300 4.672822 6.39 26.03236 48.56764
##  Ceres 50.625 4.672822 6.39 39.35736 61.89264
##  Check 36.050 4.672822 6.39 24.78236 47.31764
##  Panog 45.850 4.672822 6.39 34.58236 57.11764
##
## lot = Vic2:
##  trt   emmean       SE   df lower.CL upper.CL
##  Agrox 54.300 4.672822 6.39 43.03236 65.56764
##  Ceres 55.375 4.672822 6.39 44.10736 66.64264
```

```
##  Check 50.850 4.672822 6.39 39.58236 62.11764
##  Panog 53.100 4.672822 6.39 41.83236 64.36764
##
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
##
## $contrasts
## lot = Bran:
##  contrast      estimate       SE df t.ratio p.value
##  Agrox - Ceres   -2.175 3.186784 36  -0.683  0.9031
##  Agrox - Check   -0.675 3.186784 36  -0.212  0.9966
##  Agrox - Panog    3.575 3.186784 36   1.122  0.6787
##  Ceres - Check    1.500 3.186784 36   0.471  0.9650
##  Ceres - Panog    5.750 3.186784 36   1.804  0.2880
##  Check - Panog    4.250 3.186784 36   1.334  0.5481
##
## lot = Clin:
##  contrast      estimate       SE df t.ratio p.value
##  Agrox - Ceres    4.675 3.186784 36   1.467  0.4674
##  Agrox - Check    2.125 3.186784 36   0.667  0.9089
##  Agrox - Panog    0.175 3.186784 36   0.055  0.9999
##  Ceres - Check   -2.550 3.186784 36  -0.800  0.8539
##  Ceres - Panog   -4.500 3.186784 36  -1.412  0.5002
##  Check - Panog   -1.950 3.186784 36  -0.612  0.9276
##
## lot = Vic1:
##  contrast      estimate       SE df t.ratio p.value
##  Agrox - Ceres  -13.325 3.186784 36  -4.181  0.0010
##  Agrox - Check    1.250 3.186784 36   0.392  0.9792
##  Agrox - Panog   -8.550 3.186784 36  -2.683  0.0512
##  Ceres - Check   14.575 3.186784 36   4.574  0.0003
##  Ceres - Panog    4.775 3.186784 36   1.498  0.4490
##  Check - Panog   -9.800 3.186784 36  -3.075  0.0200
##
## lot = Vic2:
##  contrast      estimate       SE df t.ratio p.value
##  Agrox - Ceres   -1.075 3.186784 36  -0.337  0.9866
##  Agrox - Check    3.450 3.186784 36   1.083  0.7022
##  Agrox - Panog    1.200 3.186784 36   0.377  0.9815
##  Ceres - Check    4.525 3.186784 36   1.420  0.4955
##  Ceres - Panog    2.275 3.186784 36   0.714  0.8909
##  Check - Panog   -2.250 3.186784 36  -0.706  0.8940
##
## P value adjustment: tukey method for comparing a family of 4 estimates
```

```
plot(Model1)
```


resid(., type = "pearson")
10
5
0
−5
−10
30
40
50
60
70
fitted(.)