Using R to do two-way ANOVA and checking assumptions

Example: Study whether preheating milk can increase the cheese yield.
The following data contain yield from 5 lots. Each lot tried the production at four conditions (contained in the Temp variable): (1) no preprocess at all, (2) cold milk coming directly from storage, (3) preheat to 70 ^{o}F and (4) preheat to 80 ^{o}F.

```
yield temp lot
2.89 1 1
2.95 2 1
3.10 3 1
3.23 4 1
2.86 1 2
3.20 2 2
3.03 3 2
3.18 4 2
3.18 1 3
3.06 2 3
3.15 3 3
3.18 4 3
2.92 1 4
3.15 2 4
3.26 3 4
3.32 4 4
3.09 1 5
3.25 2 5
3.22 3 5
3.26 4 5
```

```
> #####
> # Import data set. This is formated 3columns/variables
> Cheese.data <- read.table(file="CheeseYield.txt", header=TRUE)
>
> # Categorical (factor) variables
> Cheese.data$temp<-as.factor(Cheese.data$temp)
> Cheese.data$lot<-as.factor(Cheese.data$lot)
>
> # One-way ANOVA of yield over temperature
> summary(aov(yield~temp, data=Cheese.data))
            Df Sum Sq Mean Sq F value Pr(>F)
temp         3 0.1569 0.05231   4.589 0.0168 *
Residuals   16 0.1824 0.01140
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> # Mean yields for lots are different, consider blocking for lots.
> vapply(levels(Cheese.data$lot), FUN=function(x) mean(Cheese.data$yi
eld[Cheese.data$lot==x]), FUN.VALUE = 0)
     1      2      3      4      5
3.0425 3.0675 3.1425 3.1625 3.2050
```

```
> # Two-way ANOVA with temperature and lot (block)
> summary(aov(yield~temp+lot, data=Cheese.data))
            Df  Sum Sq Mean Sq F value Pr(>F)
temp         3 0.15692 0.05231   5.733 0.0114 *
lot          4 0.07288 0.01822   1.997 0.1591
Residuals   12 0.10948 0.00912
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> # Full two-way ANOVA with temperature and lot
> summary(aov(yield~temp*lot, data=Cheese.data))
            Df  Sum Sq Mean Sq
temp         3 0.15692 0.05231
lot          4 0.07288 0.01822
temp:lot    12 0.10948 0.00912

> # Check one-way ANOVA fit
> ##### Diagnostic plots, put 4 in one page (2 rows by 2 columns).
> par(mfrow=c(2,2)) #set layout, 2 rows by 2 columns
> plot(aov(yield~temp, data=Cheese.data))
```