HW4-ADA

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1.a. Complete the table.

From the description, we have $a = 2,\ b = 3,\ n = 3.$ So the table is as following:

Source	df	SS	MS	F
Popper (A)	1	4.5	4.5	32.374
Corn (B)	2	15.75	7.875	56.655
Interaction (A*B)	2	0.08	0.04	0.288
Error	12	1.67	0.139	1
Total	17	22.00		

1.b. Test H0 : No interaction against H1 : there is an interaction, use $\alpha = 0.05$.

If $F = \frac{MSAB}{MSE} > F_{\alpha}((a-1)(b-1), ab(n-1))$, we could reject H_0.

```
qf(1-0.05, df1=2, df2=12)
```

```
## [1] 3.885294
```

From above, $F = 0.288$ while $F_{0.05}(2, 12) = 3.885,\ F < F_{0.05}(2, 12).$ So we could not reject H_0 and there is no interaction.

1.c/d. Complete the table.

Source	df	SS	MS	F
Popper (A)	1	4.5	4.5	36
Corn (B)	2	15.75	7.875	63
Error	14	1.75	0.125	1
Total	17	22.00		

1.e. Test H0 : No popper effect against H1 : there is a popper effect. use $\alpha = 0.05$.

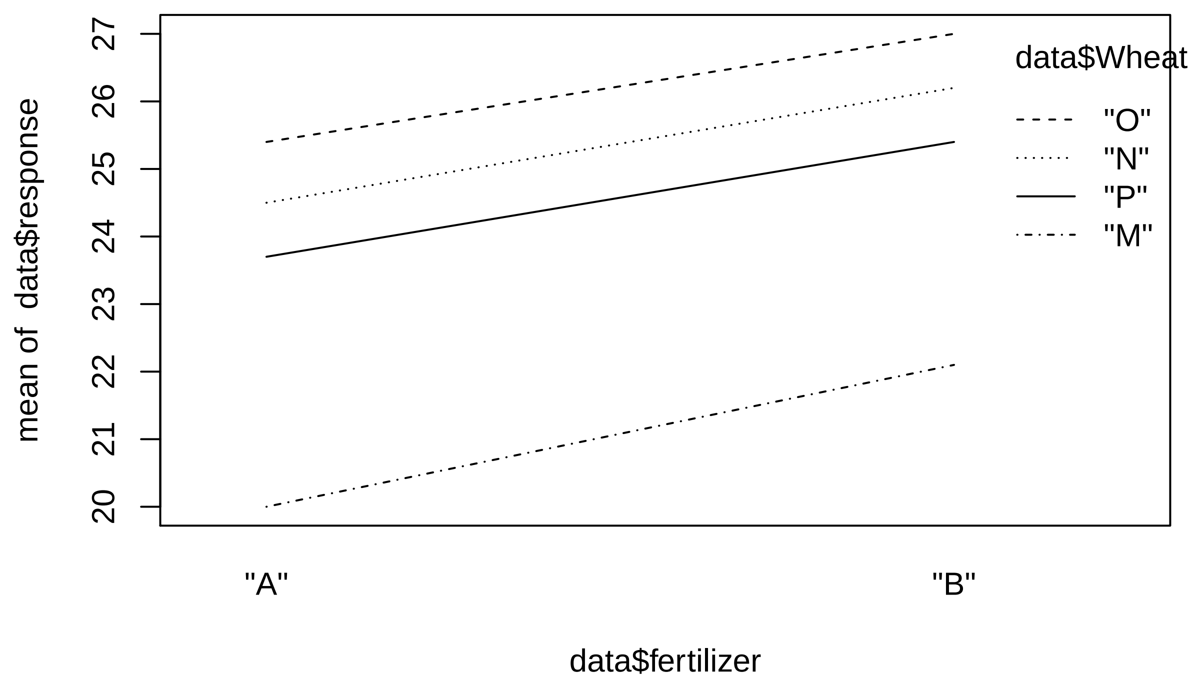
Since there is no interaction between A and B, if $F = \frac{MSA}{MSE} > F_{\alpha}(1, 14)$, we could reject H_0. From above, $F = 36$ while $F_{0.05}(1, 14) = 4.6,\ F > F_{0.05}(1, 14)$. So we could reject H_0 and conclude that there is a popper effect.

1.f. Test H0 : No corn effect against H1 : there is a corn effect. use $\alpha = 0.05$.

Since there is no interaction between A and B, if $F = \frac{MSB}{MSE} > F_{\alpha}(2, 14)$, we could reject H_0. From above, $F = 63$ while $F_{0.05}(2, 14) = 3.74,\ F > F_{0.05}(2, 14)$. So we could reject H_0 and conclude that there is a corn effect.

2.a. Construct an interaction plot.

```
data<-read.csv('~/Desktop/AdvancedDA/HW/HW4/HW4DATA.csv', header=TRUE)
interaction.plot(data$fertilizer,data$Wheat,data$response)
```



From the interaction plot above, we could see that the four lines seem to be parallel which suggests that there is no interaction between fertilizer type and wheat type.

2.b. Test H0 : No interaction against H1 : there is an interaction, use $\alpha = 0.05$.

```
summary(aov(data$response~data$fertilizer*data$Wheat))
```

```
##                              Df Sum Sq Mean Sq F value   Pr(>F)
## data$fertilizer               1  18.90  18.904   48.63 3.14e-06 ***
## data$Wheat                    3  92.02  30.674   78.90 8.37e-10 ***
## data$fertilizer:data$Wheat    3   0.22   0.074    0.19    0.902
## Residuals                    16   6.22   0.389
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

In the above ANOVA table, we could see that Pr(>F) for interaction is 0.902, which is larger than $\alpha = 0.05$. So we could not reject H_0 and there is no interaction between fertilizer and wheat effects.

2.c. Fit a model without an interaction and test H0 : No fertilizer effect against H1 : there is a fertilizer effect. Use $\alpha = 0.05$ if you reject H0, use Tukey's method to do pairwise comparisons of the different fertilizer types.

```
summary(aov(data$response~data$fertilizer+data$Wheat))
```

```
##                 Df Sum Sq Mean Sq F value   Pr(>F)
## data$fertilizer  1  18.90  18.904   55.76 4.59e-07 ***
## data$Wheat       3  92.02  30.674   90.48 1.97e-11 ***
## Residuals       19   6.44   0.339
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

From the above ANOVA table for model without interactions, we could see that Pr(>F) for fertilizer is 4.59e-07, which is smaller than $\alpha = 0.05$. So we could reject H_0 and there is a fertilizer effect.

```r
fit<-aov(data$response~data$fertilizer+data$Wheat)
TukeyHSD(fit, "data$fertilizer")
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = data$response ~ data$fertilizer + data$Wheat)
##
## $`data$fertilizer`
##          diff      lwr      upr p adj
## "B"-"A" 1.775 1.277484 2.272516 5e-07
```

In the above, we use Tukey's method to do pairwise comparisons of different fertilizer types. We could see that the 95% confidence interval for B-A is [1.277484, 2.272516], which doesn't cover 0. So there is fertilizer effect and fertilizer B leads to more yields than A.

2.d. Test H0 : No wheat effect against H1 : there is a wheat effect. Use $\alpha = 0.05$ if you reject H0, use Tukey's method to do pairwise comparisons of the different wheat types.

From the ANOVA table in 2.c., we could find that Pr(>F) for wheat is 1.97e-11, which is smaller than $\alpha = 0.05$. So we could reject H_0 and there is a wheat effect.

```r
TukeyHSD(fit, "data$Wheat")
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = data$response ~ data$fertilizer + data$Wheat)
##
## $`data$Wheat`
##          diff         lwr        upr     p adj
## "N"-"M"  4.30  3.35476633  5.2452337 0.0000000
## "O"-"M"  5.15  4.20476633  6.0952337 0.0000000
## "P"-"M"  3.50  2.55476633  4.4452337 0.0000000
## "O"-"N"  0.85 -0.09523367  1.7952337 0.0872269
## "P"-"N" -0.80 -1.74523367  0.1452337 0.1152696
## "P"-"O" -1.65 -2.59523367 -0.7047663 0.0005208
```

Using Tukey's method to do pairwise comparisons of the different wheat types, we could find that M is a separate group which has lower yields than N, O and P. It is impossible to set up consistent groups for N, O and P: O and N are not significantly different; P and N are not significantly different; but P has lower yields than O.