2 way ANOVA with interaction

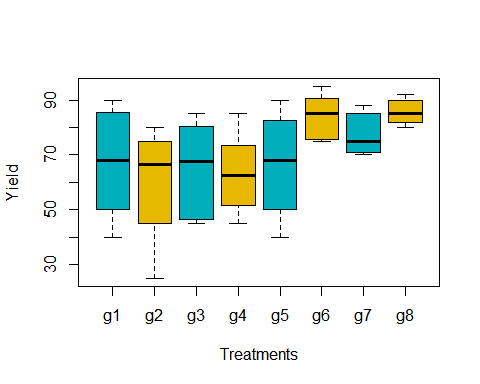
Jeevan

26/06/2019

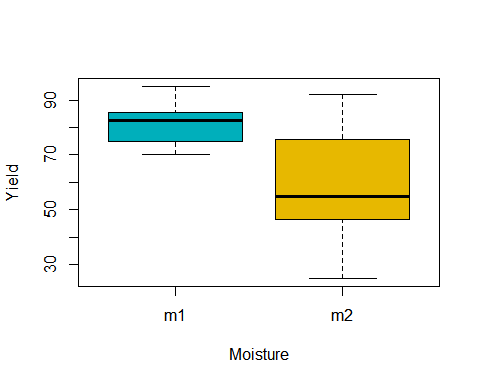
maize<-read.table(file = "clipboard",header = TRUE)  
str(maize)

## 'data.frame': 64 obs. of 5 variables:  
## $ Yield : int 85 80 80 85 90 90 85 90 50 50 ...  
## $ Treatments : Factor w/ 8 levels "g1","g2","g3",..: 1 2 3 4 5 6 7 8 1 2 ...  
## $ Moisture : Factor w/ 2 levels "m1","m2": 1 1 1 1 1 1 1 1 2 2 ...  
## $ Repetition : Factor w/ 4 levels "r1","r2","r3",..: 1 1 1 1 1 1 1 1 1 1 ...  
## $ Interaction: Factor w/ 16 levels "m1g1","m1g2",..: 1 2 3 4 5 6 7 8 9 10 ...

boxplot(Yield~Treatments, data = maize, xlab = "Treatments", ylab = "Yield", col = c("#00AFBB", "#E7B800"))



boxplot(Yield~Moisture, data = maize, xlab = "Moisture", ylab = "Yield", col = c("#00AFBB", "#E7B800"))



boxplot(Yield~Interaction, data = maize, xlab = "Treatment\*Moisture", ylab = "Yield",col = c("#00AFBB", "#E7B800"))  
model<-aov(Yield~Treatments+Moisture+Treatments\*Moisture, data = maize)  
summary(model)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Treatments 7 5530 790 21.48 8.45e-13 \*\*\*  
## Moisture 1 7526 7526 204.66 < 2e-16 \*\*\*  
## Treatments:Moisture 7 3997 571 15.53 1.97e-10 \*\*\*  
## Residuals 48 1765 37   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

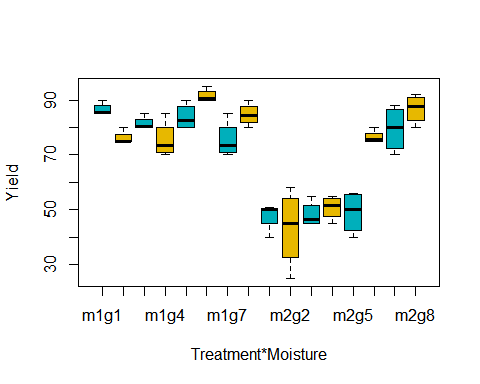
library(lsmeans)

## Warning: package 'lsmeans' was built under R version 3.5.3

## Loading required package: emmeans

## Warning: package 'emmeans' was built under R version 3.5.3

## The 'lsmeans' package is now basically a front end for 'emmeans'.  
## Users are encouraged to switch the rest of the way.  
## See help('transition') for more information, including how to  
## convert old 'lsmeans' objects and scripts to work with 'emmeans'.



lm1<-lm(Yield~Treatments+Moisture+Treatments\*Moisture, data=maize)   
lsm1<-lsmeans(lm1,"Treatments")

## NOTE: Results may be misleading due to involvement in interactions

pairs(lsm1)

## contrast estimate SE df t.ratio p.value  
## g1 - g2 7.38 3.03 48 2.432 0.2497   
## g1 - g3 2.25 3.03 48 0.742 0.9951   
## g1 - g4 4.00 3.03 48 1.319 0.8870   
## g1 - g5 0.75 3.03 48 0.247 1.0000   
## g1 - g6 -16.88 3.03 48 -5.566 <.0001   
## g1 - g7 -10.38 3.03 48 -3.422 0.0259   
## g1 - g8 -18.62 3.03 48 -6.143 <.0001   
## g2 - g3 -5.12 3.03 48 -1.690 0.6932   
## g2 - g4 -3.38 3.03 48 -1.113 0.9508   
## g2 - g5 -6.62 3.03 48 -2.185 0.3786   
## g2 - g6 -24.25 3.03 48 -7.998 <.0001   
## g2 - g7 -17.75 3.03 48 -5.854 <.0001   
## g2 - g8 -26.00 3.03 48 -8.575 <.0001   
## g3 - g4 1.75 3.03 48 0.577 0.9990   
## g3 - g5 -1.50 3.03 48 -0.495 0.9996   
## g3 - g6 -19.12 3.03 48 -6.308 <.0001   
## g3 - g7 -12.62 3.03 48 -4.164 0.0030   
## g3 - g8 -20.88 3.03 48 -6.885 <.0001   
## g4 - g5 -3.25 3.03 48 -1.072 0.9596   
## g4 - g6 -20.88 3.03 48 -6.885 <.0001   
## g4 - g7 -14.38 3.03 48 -4.741 0.0005   
## g4 - g8 -22.62 3.03 48 -7.462 <.0001   
## g5 - g6 -17.62 3.03 48 -5.813 <.0001   
## g5 - g7 -11.12 3.03 48 -3.669 0.0131   
## g5 - g8 -19.38 3.03 48 -6.390 <.0001   
## g6 - g7 6.50 3.03 48 2.144 0.4030   
## g6 - g8 -1.75 3.03 48 -0.577 0.9990   
## g7 - g8 -8.25 3.03 48 -2.721 0.1412   
##   
## Results are averaged over the levels of: Moisture   
## P value adjustment: tukey method for comparing a family of 8 estimates

lsm2<-lsmeans(lm1,"Moisture")

## NOTE: Results may be misleading due to involvement in interactions

pairs(lsm2)

## contrast estimate SE df t.ratio p.value  
## m1 - m2 21.7 1.52 48 14.306 <.0001   
##   
## Results are averaged over the levels of: Treatments

lsm3<-lsmeans(lm1,~Treatments:Moisture)  
pairs(lsm3)

## contrast estimate SE df t.ratio p.value  
## g1,m1 - g2,m1 10.25 4.29 48 2.390 0.5632   
## g1,m1 - g3,m1 5.00 4.29 48 1.166 0.9981   
## g1,m1 - g4,m1 11.00 4.29 48 2.565 0.4447   
## g1,m1 - g5,m1 2.75 4.29 48 0.641 1.0000   
## g1,m1 - g6,m1 -5.00 4.29 48 -1.166 0.9981   
## g1,m1 - g7,m1 11.00 4.29 48 2.565 0.4447   
## g1,m1 - g8,m1 1.75 4.29 48 0.408 1.0000   
## g1,m1 - g1,m2 38.75 4.29 48 9.037 <.0001   
## g1,m1 - g2,m2 43.25 4.29 48 10.087 <.0001   
## g1,m1 - g3,m2 38.25 4.29 48 8.921 <.0001   
## g1,m1 - g4,m2 35.75 4.29 48 8.338 <.0001   
## g1,m1 - g5,m2 37.50 4.29 48 8.746 <.0001   
## g1,m1 - g6,m2 10.00 4.29 48 2.332 0.6034   
## g1,m1 - g7,m2 7.00 4.29 48 1.633 0.9537   
## g1,m1 - g8,m2 -0.25 4.29 48 -0.058 1.0000   
## g2,m1 - g3,m1 -5.25 4.29 48 -1.224 0.9968   
## g2,m1 - g4,m1 0.75 4.29 48 0.175 1.0000   
## g2,m1 - g5,m1 -7.50 4.29 48 -1.749 0.9219   
## g2,m1 - g6,m1 -15.25 4.29 48 -3.557 0.0578   
## g2,m1 - g7,m1 0.75 4.29 48 0.175 1.0000   
## g2,m1 - g8,m1 -8.50 4.29 48 -1.982 0.8227   
## g2,m1 - g1,m2 28.50 4.29 48 6.647 <.0001   
## g2,m1 - g2,m2 33.00 4.29 48 7.696 <.0001   
## g2,m1 - g3,m2 28.00 4.29 48 6.530 <.0001   
## g2,m1 - g4,m2 25.50 4.29 48 5.947 <.0001   
## g2,m1 - g5,m2 27.25 4.29 48 6.355 <.0001   
## g2,m1 - g6,m2 -0.25 4.29 48 -0.058 1.0000   
## g2,m1 - g7,m2 -3.25 4.29 48 -0.758 1.0000   
## g2,m1 - g8,m2 -10.50 4.29 48 -2.449 0.5231   
## g3,m1 - g4,m1 6.00 4.29 48 1.399 0.9878   
## g3,m1 - g5,m1 -2.25 4.29 48 -0.525 1.0000   
## g3,m1 - g6,m1 -10.00 4.29 48 -2.332 0.6034   
## g3,m1 - g7,m1 6.00 4.29 48 1.399 0.9878   
## g3,m1 - g8,m1 -3.25 4.29 48 -0.758 1.0000   
## g3,m1 - g1,m2 33.75 4.29 48 7.871 <.0001   
## g3,m1 - g2,m2 38.25 4.29 48 8.921 <.0001   
## g3,m1 - g3,m2 33.25 4.29 48 7.755 <.0001   
## g3,m1 - g4,m2 30.75 4.29 48 7.171 <.0001   
## g3,m1 - g5,m2 32.50 4.29 48 7.580 <.0001   
## g3,m1 - g6,m2 5.00 4.29 48 1.166 0.9981   
## g3,m1 - g7,m2 2.00 4.29 48 0.466 1.0000   
## g3,m1 - g8,m2 -5.25 4.29 48 -1.224 0.9968   
## g4,m1 - g5,m1 -8.25 4.29 48 -1.924 0.8519   
## g4,m1 - g6,m1 -16.00 4.29 48 -3.731 0.0366   
## g4,m1 - g7,m1 0.00 4.29 48 0.000 1.0000   
## g4,m1 - g8,m1 -9.25 4.29 48 -2.157 0.7203   
## g4,m1 - g1,m2 27.75 4.29 48 6.472 <.0001   
## g4,m1 - g2,m2 32.25 4.29 48 7.521 <.0001   
## g4,m1 - g3,m2 27.25 4.29 48 6.355 <.0001   
## g4,m1 - g4,m2 24.75 4.29 48 5.772 0.0001   
## g4,m1 - g5,m2 26.50 4.29 48 6.180 <.0001   
## g4,m1 - g6,m2 -1.00 4.29 48 -0.233 1.0000   
## g4,m1 - g7,m2 -4.00 4.29 48 -0.933 0.9999   
## g4,m1 - g8,m2 -11.25 4.29 48 -2.624 0.4072   
## g5,m1 - g6,m1 -7.75 4.29 48 -1.807 0.9016   
## g5,m1 - g7,m1 8.25 4.29 48 1.924 0.8519   
## g5,m1 - g8,m1 -1.00 4.29 48 -0.233 1.0000   
## g5,m1 - g1,m2 36.00 4.29 48 8.396 <.0001   
## g5,m1 - g2,m2 40.50 4.29 48 9.445 <.0001   
## g5,m1 - g3,m2 35.50 4.29 48 8.279 <.0001   
## g5,m1 - g4,m2 33.00 4.29 48 7.696 <.0001   
## g5,m1 - g5,m2 34.75 4.29 48 8.104 <.0001   
## g5,m1 - g6,m2 7.25 4.29 48 1.691 0.9392   
## g5,m1 - g7,m2 4.25 4.29 48 0.991 0.9997   
## g5,m1 - g8,m2 -3.00 4.29 48 -0.700 1.0000   
## g6,m1 - g7,m1 16.00 4.29 48 3.731 0.0366   
## g6,m1 - g8,m1 6.75 4.29 48 1.574 0.9655   
## g6,m1 - g1,m2 43.75 4.29 48 10.203 <.0001   
## g6,m1 - g2,m2 48.25 4.29 48 11.253 <.0001   
## g6,m1 - g3,m2 43.25 4.29 48 10.087 <.0001   
## g6,m1 - g4,m2 40.75 4.29 48 9.504 <.0001   
## g6,m1 - g5,m2 42.50 4.29 48 9.912 <.0001   
## g6,m1 - g6,m2 15.00 4.29 48 3.498 0.0669   
## g6,m1 - g7,m2 12.00 4.29 48 2.799 0.3042   
## g6,m1 - g8,m2 4.75 4.29 48 1.108 0.9989   
## g7,m1 - g8,m1 -9.25 4.29 48 -2.157 0.7203   
## g7,m1 - g1,m2 27.75 4.29 48 6.472 <.0001   
## g7,m1 - g2,m2 32.25 4.29 48 7.521 <.0001   
## g7,m1 - g3,m2 27.25 4.29 48 6.355 <.0001   
## g7,m1 - g4,m2 24.75 4.29 48 5.772 0.0001   
## g7,m1 - g5,m2 26.50 4.29 48 6.180 <.0001   
## g7,m1 - g6,m2 -1.00 4.29 48 -0.233 1.0000   
## g7,m1 - g7,m2 -4.00 4.29 48 -0.933 0.9999   
## g7,m1 - g8,m2 -11.25 4.29 48 -2.624 0.4072   
## g8,m1 - g1,m2 37.00 4.29 48 8.629 <.0001   
## g8,m1 - g2,m2 41.50 4.29 48 9.679 <.0001   
## g8,m1 - g3,m2 36.50 4.29 48 8.512 <.0001   
## g8,m1 - g4,m2 34.00 4.29 48 7.929 <.0001   
## g8,m1 - g5,m2 35.75 4.29 48 8.338 <.0001   
## g8,m1 - g6,m2 8.25 4.29 48 1.924 0.8519   
## g8,m1 - g7,m2 5.25 4.29 48 1.224 0.9968   
## g8,m1 - g8,m2 -2.00 4.29 48 -0.466 1.0000   
## g1,m2 - g2,m2 4.50 4.29 48 1.049 0.9994   
## g1,m2 - g3,m2 -0.50 4.29 48 -0.117 1.0000   
## g1,m2 - g4,m2 -3.00 4.29 48 -0.700 1.0000   
## g1,m2 - g5,m2 -1.25 4.29 48 -0.292 1.0000   
## g1,m2 - g6,m2 -28.75 4.29 48 -6.705 <.0001   
## g1,m2 - g7,m2 -31.75 4.29 48 -7.405 <.0001   
## g1,m2 - g8,m2 -39.00 4.29 48 -9.096 <.0001   
## g2,m2 - g3,m2 -5.00 4.29 48 -1.166 0.9981   
## g2,m2 - g4,m2 -7.50 4.29 48 -1.749 0.9219   
## g2,m2 - g5,m2 -5.75 4.29 48 -1.341 0.9919   
## g2,m2 - g6,m2 -33.25 4.29 48 -7.755 <.0001   
## g2,m2 - g7,m2 -36.25 4.29 48 -8.454 <.0001   
## g2,m2 - g8,m2 -43.50 4.29 48 -10.145 <.0001   
## g3,m2 - g4,m2 -2.50 4.29 48 -0.583 1.0000   
## g3,m2 - g5,m2 -0.75 4.29 48 -0.175 1.0000   
## g3,m2 - g6,m2 -28.25 4.29 48 -6.588 <.0001   
## g3,m2 - g7,m2 -31.25 4.29 48 -7.288 <.0001   
## g3,m2 - g8,m2 -38.50 4.29 48 -8.979 <.0001   
## g4,m2 - g5,m2 1.75 4.29 48 0.408 1.0000   
## g4,m2 - g6,m2 -25.75 4.29 48 -6.005 <.0001   
## g4,m2 - g7,m2 -28.75 4.29 48 -6.705 <.0001   
## g4,m2 - g8,m2 -36.00 4.29 48 -8.396 <.0001   
## g5,m2 - g6,m2 -27.50 4.29 48 -6.414 <.0001   
## g5,m2 - g7,m2 -30.50 4.29 48 -7.113 <.0001   
## g5,m2 - g8,m2 -37.75 4.29 48 -8.804 <.0001   
## g6,m2 - g7,m2 -3.00 4.29 48 -0.700 1.0000   
## g6,m2 - g8,m2 -10.25 4.29 48 -2.390 0.5632   
## g7,m2 - g8,m2 -7.25 4.29 48 -1.691 0.9392   
##   
## P value adjustment: tukey method for comparing a family of 16 estimates

library(multcompView)

## Warning: package 'multcompView' was built under R version 3.5.3

CLD(lsm1,Letters = "abcde")

## Warning: 'CLD' will be deprecated. Its use is discouraged.  
## See '? CLD' for an explanation. Use 'pwpp' or 'multcomp::cld' instead.

## Treatments lsmean SE df lower.CL upper.CL .group  
## g2 59.8 2.14 48 55.4 64.1 a   
## g4 63.1 2.14 48 58.8 67.4 a   
## g3 64.9 2.14 48 60.6 69.2 a   
## g5 66.4 2.14 48 62.1 70.7 a   
## g1 67.1 2.14 48 62.8 71.4 a   
## g7 77.5 2.14 48 73.2 81.8 b   
## g6 84.0 2.14 48 79.7 88.3 b   
## g8 85.8 2.14 48 81.4 90.1 b   
##   
## Results are averaged over the levels of: Moisture   
## Confidence level used: 0.95   
## P value adjustment: tukey method for comparing a family of 8 estimates   
## significance level used: alpha = 0.05

CLD(lsm2,Letters = "abcdefgh")

## Warning: 'CLD' will be deprecated. Its use is discouraged.  
## See '? CLD' for an explanation. Use 'pwpp' or 'multcomp::cld' instead.

## Moisture lsmean SE df lower.CL upper.CL .group  
## m2 60.2 1.07 48 58.1 62.4 a   
## m1 81.9 1.07 48 79.8 84.1 b   
##   
## Results are averaged over the levels of: Treatments   
## Confidence level used: 0.95   
## significance level used: alpha = 0.05

CLD(lsm3,Letters = "abcdefgh")

## Warning: 'CLD' will be deprecated. Its use is discouraged.  
## See '? CLD' for an explanation. Use 'pwpp' or 'multcomp::cld' instead.

## Treatments Moisture lsmean SE df lower.CL upper.CL .group  
## g2 m2 43.2 3.03 48 37.2 49.3 a   
## g1 m2 47.8 3.03 48 41.7 53.8 a   
## g3 m2 48.2 3.03 48 42.2 54.3 a   
## g5 m2 49.0 3.03 48 42.9 55.1 a   
## g4 m2 50.8 3.03 48 44.7 56.8 a   
## g4 m1 75.5 3.03 48 69.4 81.6 b   
## g7 m1 75.5 3.03 48 69.4 81.6 b   
## g2 m1 76.2 3.03 48 70.2 82.3 bc   
## g6 m2 76.5 3.03 48 70.4 82.6 bc   
## g7 m2 79.5 3.03 48 73.4 85.6 bc   
## g3 m1 81.5 3.03 48 75.4 87.6 bc   
## g5 m1 83.8 3.03 48 77.7 89.8 bc   
## g8 m1 84.8 3.03 48 78.7 90.8 bc   
## g1 m1 86.5 3.03 48 80.4 92.6 bc   
## g8 m2 86.8 3.03 48 80.7 92.8 bc   
## g6 m1 91.5 3.03 48 85.4 97.6 c   
##   
## Confidence level used: 0.95   
## P value adjustment: tukey method for comparing a family of 16 estimates   
## significance level used: alpha = 0.05