

# Two-way Anova for RCBD Design

Jeevan Koshy

July 16, 2019

## **Question**

In order to select tree species for fuel, fodder and timber an experiment was conducted at Kanpur in a randomized complete block design with ten different trees and four replications. The plant height was recorded in cms. Analyse the data and draw your conclusions.

## **Test used**

Two-way Anova.

## **Aim**

## **Blocks**

H0: There is no significant difference between the means of the different blocks.

H1: There is a significant difference between atleast one pair of means of the different blocks.

## **Factor 2**

H0: There is no significant difference between the means of the different treatments.

H1: There is a significant difference between atleast one pair of means of the different treatments.

**Alpha level** = 0.05

## **Procedure**

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

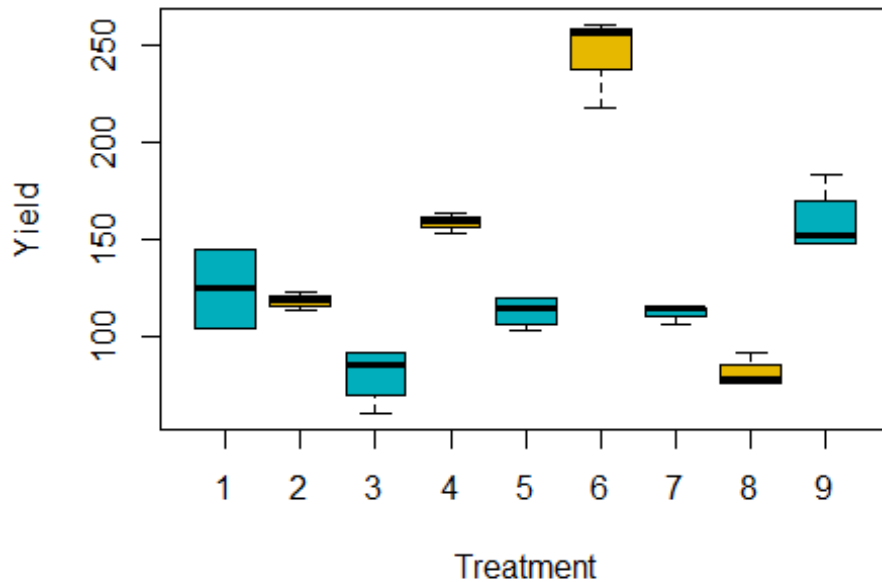
```
## 'data.frame':    36 obs. of  3 variables:
## $ treatment: int  1 2 3 4 5 6 7 8 9 1 ...
## $ block    : int  1 1 1 1 1 1 1 1 1 2 ...
## $ yield    : num 144.4 113.5 60.9 163.4 110.1 ...
```

Treatment and blocks are categorical variables. Therefore, they are being converted into factors in R.

```
attach(data)
treatment <- as.factor(data$treatment)
block <- as.factor(data$block)
str(data)
```

```
## 'data.frame':    36 obs. of  3 variables:
## $ treatment: int  1 2 3 4 5 6 7 8 9 1 ...
## $ block    : int  1 1 1 1 1 1 1 1 1 2 ...
## $ yield    : num 144.4 113.5 60.9 163.4 110.1 ...
```

```
boxplot(data$yield ~ data$treatment, xlab = "Treatment", ylab = "Yield",
        col = c("#00AFBB", "#E7B800"))
```



```
m1 <- aov(data$yield ~ data$treatment + data$block)
summary(m1)
```

```
##              Df Sum Sq Mean Sq F value Pr(>F)
## data$treatment  1   2094   2094.0    0.803  0.0377
## data$block      1    232    232.2    0.089  0.767
## Residuals     33  86110   2609.4
```

Probability value for treatment is less than 0.05. Hence, the treatments are significantly different. We proceed with post-hoc test.

```
lm1 <- lm(yield~treatment+block)
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'.
```

```
lsm1 <- lsmeans(lm1,"treatment")
pairs(lsm1)
```

```
## contrast estimate SE df t.ratio p.value
## 1 - 2         6.317 9.61 24    0.658 0.9989
## 1 - 3        43.710 9.61 24    4.549 0.0035
## 1 - 4       -33.830 9.61 24   -3.521 0.0383
## 1 - 5        11.585 9.61 24    1.206 0.9474
```

```

## 1 - 6      -122.825 9.61 24 -12.783 <.0001
## 1 - 7       12.225 9.61 24   1.272 0.9299
## 1 - 8       43.472 9.61 24   4.525 0.0037
## 1 - 9      -34.182 9.61 24  -3.558 0.0353
## 2 - 3       37.392 9.61 24   3.892 0.0166
## 2 - 4      -40.148 9.61 24  -4.179 0.0085
## 2 - 5        5.268 9.61 24   0.548 0.9997
## 2 - 6     -129.143 9.61 24 -13.441 <.0001
## 2 - 7        5.907 9.61 24   0.615 0.9993
## 2 - 8       37.155 9.61 24   3.867 0.0175
## 2 - 9      -40.500 9.61 24  -4.215 0.0078
## 3 - 4      -77.540 9.61 24  -8.070 <.0001
## 3 - 5      -32.125 9.61 24  -3.344 0.0563
## 3 - 6     -166.535 9.61 24 -17.333 <.0001
## 3 - 7      -31.485 9.61 24  -3.277 0.0649
## 3 - 8       -0.237 9.61 24  -0.025 1.0000
## 3 - 9      -77.892 9.61 24  -8.107 <.0001
## 4 - 5       45.415 9.61 24   4.727 0.0023
## 4 - 6      -88.995 9.61 24  -9.263 <.0001
## 4 - 7       46.055 9.61 24   4.793 0.0019
## 4 - 8       77.302 9.61 24   8.046 <.0001
## 4 - 9       -0.352 9.61 24  -0.037 1.0000
## 5 - 6     -134.410 9.61 24 -13.989 <.0001
## 5 - 7        0.640 9.61 24   0.067 1.0000
## 5 - 8       31.887 9.61 24   3.319 0.0594
## 5 - 9      -45.767 9.61 24  -4.763 0.0021
## 6 - 7      135.050 9.61 24  14.056 <.0001
## 6 - 8      166.298 9.61 24  17.308 <.0001
## 6 - 9       88.642 9.61 24   9.226 <.0001
## 7 - 8       31.247 9.61 24   3.252 0.0683
## 7 - 9      -46.407 9.61 24  -4.830 0.0018
## 8 - 9      -77.655 9.61 24  -8.082 <.0001
##
## Results are averaged over the levels of: block
## P value adjustment: Tukey method for comparing a family of 9 estimates

```

## Conclusion

1. The calculated probability value for the blocks is greater than 0.05. Hence, it can be concluded that the means of the blocks are not significantly different.
2. The calculated probability value for the treatment is less than 0.05. Therefore, the null hypothesis is rejected. Hence, we can conclude that there is a significant difference between atleast one pair of means of the treatments. The results of the post hoc test indicates that treatment 6(L Loucoc Tree) has the highest yield and can be chosen for the experiment.