

STAT 509 Homework 9 Solution

Chong Ma

April 30, 2017

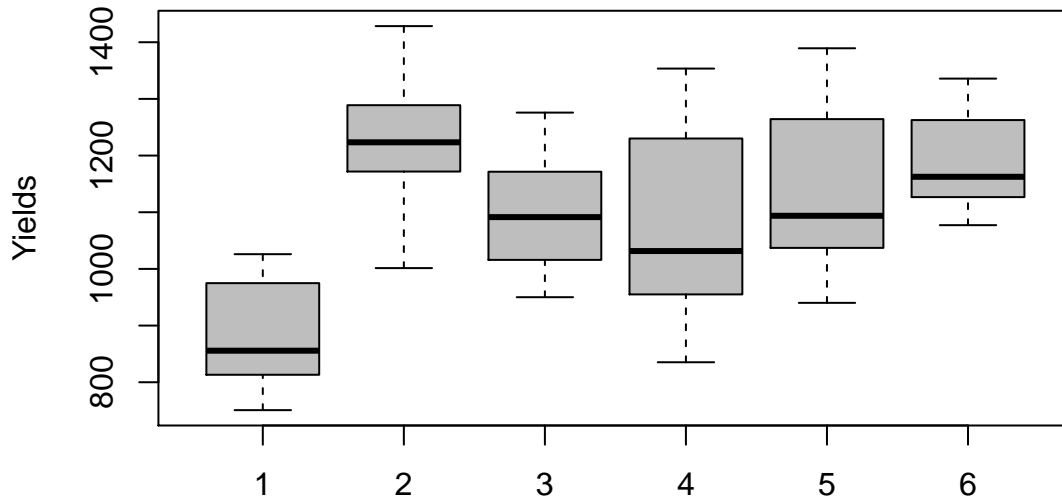
ANOVA for nitrogens

First of all, input the data in R.

```
nitrogen1=c(814.8,813.2,974.9,862.0,750.8,769.0,1026.0,849.4,946.3,997.9)
nitrogen2=c(1235.3,1185.9,1117.0,1171.8,1284.7,1211.5,1288.9,1001.4,1428.4,1373.6)
nitrogen3=c(1157.5,1236.1,1074.3,1171.5,1031.3,1015.9,950.1,1108.5,1275.8,999.4)
nitrogen4=c(955.0,1039.4,1318.6,926.9,1230.1,835.3,1013.8,1128.3,1023.7,1353.5)
nitrogen5=c(1070.0,1153.1,940.1,998.5,1264.3,1351.1,1117.5,1389.3,1037.1,1047.3)
nitrogen6=c(1077.2,1137.7,1187.4,1335.8,1262.6,1126.7,1081.6,1135.6,1272.0,1231.3)
```

Then, get the side-by-side boxplots to check if the variances all the six nitrogen sources are the same. The boxplots indicates that there does not seem significant difference among the variances of the sugar beet yields from the six nitrogen sources.

```
boxplot(nitrogen1,nitrogen2,nitrogen3,nitrogen4,nitrogen5,nitrogen6,
        xlab="",names=1:6,ylab="Yields",col="grey")
```



Next, we conduct the F-test/ANOVA to check if $H_0 : \mu_1 = \mu_2 = \dots = \mu_6$. Based on the ANOVA table, the p-value is $0.004 < 0.05$, we have sufficient evidence to conclude that there is of significant difference in terms of the population yields among the six sources of nitrogen.

```

yields=c(nitrogen1,nitrogen2,nitrogen3,nitrogen4,nitrogen5,nitrogen6)
nitrogen.type=rep(1:6,rep(10,6))
nitrogen=data.frame(type=nitrogen.type,yields=yields)
pander(anova(lm(yields~nitrogen.type)))

```

Table 1: Analysis of Variance Table

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
nitrogen.type	1	213731	213731	8.898	0.004171
Residuals	58	1393168	24020	NA	NA

At last, we conduct the follow-up analysis to further specifically study which pairs of nitrogens produce significant different yields. To control the family-wise error, we use Tukey's method. We can tell from the Tukey's method output for multiple comparisons such that all nitrogen sources, either organic or inorganic, produce more sugar beet yields than the non-nitrogen sources. However, neither of pairs of the nitrogen sources has significantly different influence on sugar beet yields. Since both of the lower and upper confidence interval for the difference between organic nitrogen source and the non-nitrogen source is higher than other inorganic nitrogen sources, the organic nitrogen source is recommended for highest yields.

```

TukeyHSD(aov(lm(yields~factor(nitrogen.type))),conf.level = 0.95)

```

```

## Tukey multiple comparisons of means
## 95% family-wise confidence level
##
## Fit: aov(formula = lm(yields ~ factor(nitrogen.type)))
##
## $`factor(nitrogen.type)`
##      diff      lwr      upr    p adj
## 2-1  349.42  181.90  516.94 0.0000
## 3-1  221.61   54.09  389.13 0.0034
## 4-1  202.03   34.51  369.55 0.0096
## 5-1  256.40   88.88  423.92 0.0005
## 6-1  304.36  136.84  471.88 0.0000
## 3-2 -127.81 -295.33   39.71 0.2309
## 4-2 -147.39 -314.91   20.13 0.1150
## 5-2  -93.02 -260.54   74.50 0.5760
## 6-2  -45.06 -212.58  122.46 0.9672
## 4-3  -19.58 -187.10  147.94 0.9993
## 5-3   34.79 -132.73  202.31 0.9896
## 6-3   82.75  -84.77  250.27 0.6909
## 5-4   54.37 -113.15  221.89 0.9288
## 6-4  102.33  -65.19  269.85 0.4714
## 6-5   47.96 -119.56  215.48 0.9573

```