

Effect of calcium addition on Sugar Maple seedling growth

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Introduction

I am citing a paper (Juice et al. 2006). And another one Patykowski et al. (2018).

Methods

I got the data from (Juice and Fahey 2019).

```
clean.data <- read.csv("../02_outdata/hbr-maples_clean-dataset.csv")
```

We checked that the assumptions of a t-test were met.

1. Stem dry mass and leaf dry mass are both **continuous** variables.

```
head(clean.data$stem_dry_mass)
```

```
## [1] 0.0300 0.0338 0.0248 0.0194 0.0180 0.0246
```

```
head(clean.data$leaf_dry_mass)
```

```
## [1] 0.0453 0.0476 0.0423 0.0397 0.0204 0.0317
```

2. We assume that Juice and Fahey (2019) carried out **random sampling**.
3. The assumption of **homoscedasticity** is not respected, so we use a t-test with **unequal variance**

```
# Check equal variance for stem dry mass  
aggregate(stem_dry_mass~watershed, data=clean.data, var)
```

```
## watershed stem_dry_mass  
## 1 Reference 0.000593267  
## 2 W1 0.001062190
```

```
leveneTest(clean.data$stem_dry_mass, clean.data$watershed)
```

```
## Warning in leveneTest.default(clean.data$stem_dry_mass, clean.data$watershed):  
## clean.data$watershed coerced to factor.
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value    Pr(>F)
## group  1  9.2034 0.002593 **
##      357
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Check equal variance for leaf dry mass
```

```
aggregate(leaf_dry_mass~watershed, data=clean.data, var)
```

```
## watershed leaf_dry_mass
## 1 Reference 0.001092108
## 2 W1 0.001114441
```

```
leveneTest(clean.data$leaf_dry_mass, clean.data$watershed)
```

```
## Warning in leveneTest.default(clean.data$leaf_dry_mass, clean.data$watershed):
## clean.data$watershed coerced to factor.
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##      Df F value    Pr(>F)
## group  1  9.6759 0.002017 **
##      357
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

4. The data are not **normally distributed**, but because we're dealing with a fairly large sample size ($n = 359$), we will still conduct the t-test.

```
# Check normality of stem dry mass for reference samples
```

```
clean.data.ref <- clean.data %>%
  filter(watershed == "Reference")
```

```
shapiro.test(clean.data.ref$stem_dry_mass)
```

```
##
## Shapiro-Wilk normality test
##
## data: clean.data.ref$stem_dry_mass
## W = 0.81542, p-value = 8.84e-14
```

```
shapiro.test(clean.data.ref$leaf_dry_mass)
```

```
##
## Shapiro-Wilk normality test
##
## data: clean.data.ref$leaf_dry_mass
## W = 0.59272, p-value < 2.2e-16
```

```
clean.data.w1 <- clean.data %>%  
  filter(watershed == "W1")  
  
shapiro.test(clean.data.w1$stem_dry_mass)
```

```
##  
## Shapiro-Wilk normality test  
##  
## data: clean.data.w1$stem_dry_mass  
## W = 0.84849, p-value = 2.155e-12
```

```
shapiro.test(clean.data.w1$leaf_dry_mass)
```

```
##  
## Shapiro-Wilk normality test  
##  
## data: clean.data.w1$leaf_dry_mass  
## W = 0.94138, p-value = 1e-06
```

```
rm(clean.data.ref, clean.data.w1)
```

Results

A first look at the distribution of the data suggested there may be differences in stem and leaf dry mass between reference and calcium-treated seedlings.

```
# Histogram of stem dry mass  
ggplot(clean.data, aes(x = stem_dry_mass, fill = watershed)) +  
  geom_histogram(alpha = 0.6, position = "identity", bins = 30) +  
  labs(x = "Value", y = "Frequency") +  
  theme_classic()  
  
# Histogram of leaf dry mass  
ggplot(clean.data, aes(x = leaf_dry_mass, fill = watershed)) +  
  geom_histogram(alpha = 0.6, position = "identity", bins = 30) +  
  labs(x = "Value", y = "Frequency") +  
  theme_classic()
```

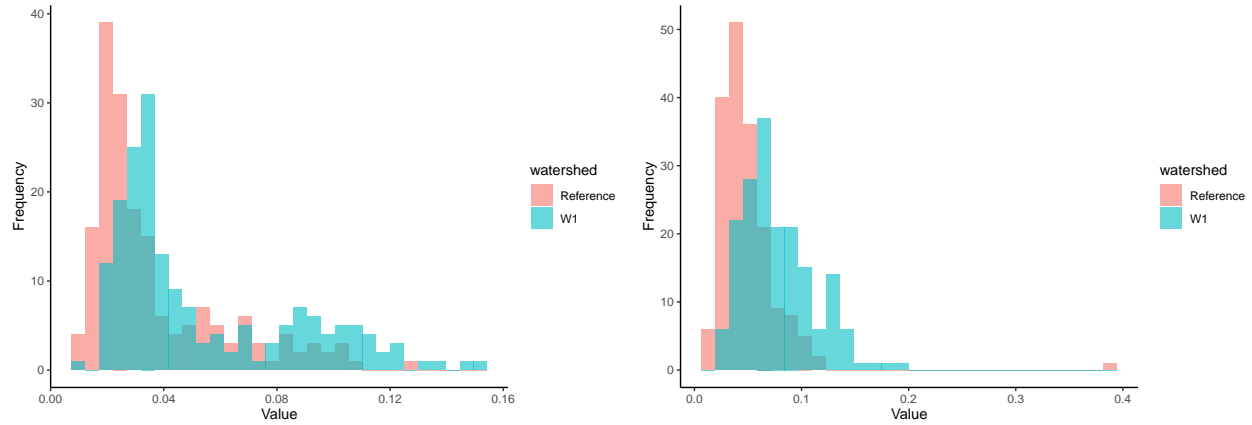


Figure 1: Distribution of stem dry mass (left) and leaf dry mass (right) of seedlings in reference (red) and calcium treated (blue) samples ($n = 359$).

We found that stem and leaf dry mass differed significantly between calcium treated and reference samples.

```
# Test for differences in stem dry mass
t.test(stem_dry_mass ~ watershed, data = clean.data, var.equal = FALSE) # Use Welch's Two Sample t-test

##
## Welch Two Sample t-test
##
## data: stem_dry_mass by watershed
## t = -5.4508, df = 331.41, p-value = 9.81e-08
## alternative hypothesis: true difference in means between group Reference and group W1 is not equal to 0
## 95 percent confidence interval:
## -0.02251850 -0.01057521
## sample estimates:
## mean in group Reference      mean in group W1
##           0.03676592           0.05331278

# Test for differences in leaf dry mass
t.test(leaf_dry_mass ~ watershed, data = clean.data, var.equal = FALSE) # Use Welch's Two Sample t-test

##
## Welch Two Sample t-test
##
## data: leaf_dry_mass by watershed
## t = -8.0462, df = 356.99, p-value = 1.278e-14
## alternative hypothesis: true difference in means between group Reference and group W1 is not equal to 0
## 95 percent confidence interval:
## -0.03510551 -0.02131523
## sample estimates:
## mean in group Reference      mean in group W1
##           0.04953296           0.07774333
```

Discussion

A citation for the discussion Kobe et al. (2002).

References

- Juice, S. M., T. J. Fahey, T. G. Siccama, C. T. Driscoll, E. G. Denny, C. Eagar, N. L. Cleavitt, R. Minocha, and A. D. Richardson. 2006. Response of Sugar Maple to Calcium Addition to Northern Hardwood Forest. *Ecology* 87:1267–1280.
- Juice, S., and T. Fahey. 2019. Health and mycorrhizal colonization response of sugar maple (*Acer saccharum*) seedlings to calcium addition in Watershed 1 at the Hubbard Brook Experimental Forest. Environmental Data Initiative.
- Kobe, R. K., G. E. Likens, and C. Eagar. 2002. Tree seedling growth and mortality responses to manipulations of calcium and aluminum in a northern hardwood forest. *Canadian Journal of Forest Research* 32:954–966.
- Patykowski, J., J. Kołodziejek, and M. Wala. 2018. Biochemical and growth responses of silver maple (*Acer saccharinum* L.) to sodium chloride and calcium chloride. *PeerJ* 6:e5958.