The Plasticity of Illinois and Oklahoma *Quercus macrocarpa* Populations Allows for Them to Adapt in a Minnesota Climate

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Background

- Climate change has affected temperature and precipitation patterns causing species to experience different conditions in their environment[1,2]
- Temperate trees live for a long period of time due to the fact that they are able to tolerate a wide variety of environmental conditions, but it is unknown if they can adapt at the same pace as the climate is changing[3]
- Phenotypic plasticity is the capacity at which an organism can respond to changes in its environment by expressing a range of phenotypes[4]
- The *Quercus macrocarpa* (bur oak) is a temperate tree species that is able to thrive in different environmental conditions[5]

Question: Are *Q. macrocarpa* populations able to respond to different climates?

Hypothesis: Minnesota plants will have the highest Fv/Fm and ePS2 as they are being grown in their own environment and are more adapted to balancing their carbon intake and water loss, thus they are less likely to be stressed.

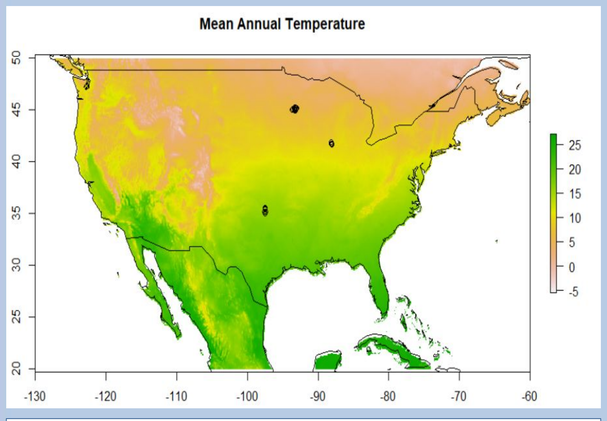

Figure 1: **Map of Mean Annual Temperature in the United States.** The points represent where the *Q. macrocarpa* originated from (Minnesota, Illinois, and Oklahoma).

Garden Information

- Acorns were collected from *Q.macrocarpa* trees in Minnesota, Illinois, and Oklahoma
- These acorns were separated by maternal family and then in grown in southern Indiana for one to two years (they were planted in 2018 and 2019)
- They were transplanted into the Minnesota garden at Cedar Creek Ecosystem Science Reserve in March of 2021
- The garden has six blocks each with 100 trees from the three populations randomly planted throughout each of the blocks

Methods and Materials

Dark acclimated measurements:[6]

- One leaf of each tree was covered with tin foil the night before the dark acclimated measurements were taken
- The next morning a Hansatech Fluorometer was used to measure Fo, Fm, and Fv/Fm
- For each measurement, a closed leaf clip was placed on the leaf underneath the foil and the foil was removed
- The fluorometer was then attached to the leaf clip, the window of the leaf clip was opened, and one flash of saturating light occurred to measure the Fo, Fm, and Fv/Fm
- Each value was recorded on a spreadsheet, and a sharpie was used to trace around the edges of the leaf clip

Light acclimated measurements:[6]

- During the middle of the day, the light acclimated measurements were taken using a Hansatech Fluorometer to measure Fs, Fm', and ePS2
- The leaf clip was attached in the same place where the dark acclimated measurements were taken
- With the fluorometer end placed over the leaf clip, ten seconds of low light followed by a flash of saturating light occurred to collect the light acclimated measurements
- The Fs, Fm', and ePS2 values were recorded on a spreadsheet for each tree

Results

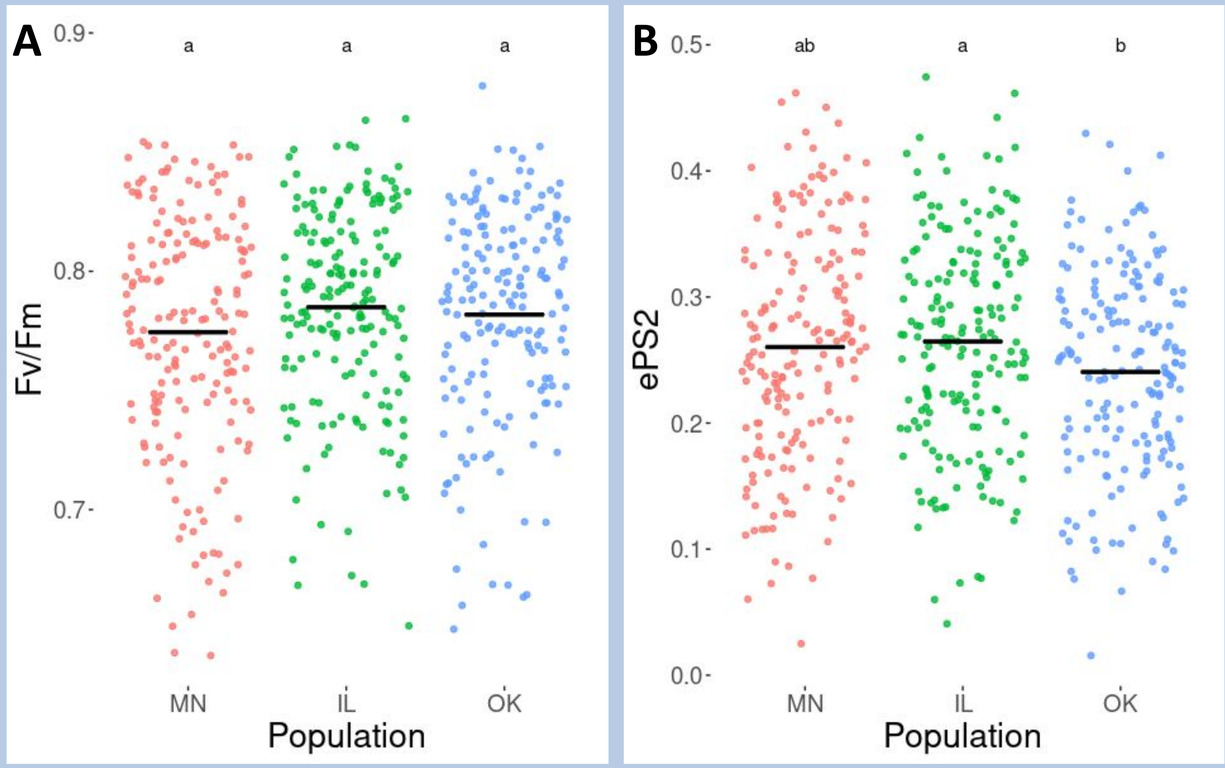

Figure 2: **Comparison of Fv/Fm and ePS2 Values Between Minnesota, Illinois, and Oklahoma Tree Populations.** When comparing the Fv/Fm between the three populations (A), there was no significant difference between the three populations (ANOVA: Fv/Fm~Population, p-value: 0.077). For the ePS2 measurements, there was a significant difference between the means of the Illinois and Oklahoma populations, but not between the other tree populations (ANOVA: ePS2~Population, p-value: 0.017; Tukey HSD: MN~IL p-value: 0.872, MN~OK p-value: 0.072, IL~OK p-value 0.019). The black line indicates the mean value for each plant population in both plots and the letters indicated whether the groups differed significantly.

References

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Data Analysis

Variables:

- The Fv/Fm variable indicates the maximum quantum efficiency of photosystem II in the dark, while the ePS2 indicates the quantum efficiency of photosystem II in the light

Dark acclimated measurements:

- Four Fv/Fm outliers were removed from the data using the Rosner outlier test
  - MN: 0.228, IL: 0.370, OK: 0.590 & 0.616
- There was not a significant difference between the Fv/Fm of each population
- The Illinois population had the highest mean Fv/Fm at 0.785, followed by Oklahoma at 0.782, and Minnesota population had the lowest at 0.774

Light acclimated measurements:

- There was a significant difference between the populations for the ePS2 values of the Illinois and Oklahoma tree populations
- The Illinois population had the highest ePS2 value at 0.265, followed by Minnesota at 0.260, and Oklahoma had the lowest value at 0.241

Conclusions

- Based on the Fv/Fm values, all of the populations appear to be somewhat stressed as their values are slightly lower than the optimal range
- For the dark acclimated measurements, the difference in location between the populations didn't seem to affect the amount of light stress
- The photosystem II efficiency (ePS2) indicates that the Illinois population was able to respond better to the environment change than the Oklahoma population
- Overall, the Illinois and Oklahoma populations seemed to respond plastically to the change in environment since the Fv/Fm and ePS2 values did not differ significantly from the local (Minnesota) population

Future Directions

- Continue to collect dark and light acclimated measurements on the *Q. macrocarpa* trees over the next few years to determine whether time plays a role in the plant's plasticity for the different populations
- Compare data from Minnesota, Illinois, and Oklahoma gardens to gain a better understanding of how well the *Q. macrocarpa* trees are able to respond in new environments

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