Measuring Water Potential Among *Crassula ovata* and *Heteromeles arbutifolia*

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Abstract
Chaparral shrubs are known for their abilities to withstand dry environments. Both the California native C3 plant, Heteromeles arbutifolia, also known as Hollywood, and the CAM plant, Crassula ovata, also known as a Jade plant, have the ability to thrive under a Mediterranean-like climate region. However, during severe cases of drought one plant may better adapted than the other. The purpose of this experiment is to determine whether Heteromeles arbutifolia or Crassula ovata is better able to withstand drought by measuring the dehydration rate. We calculated the leaf-area to mass ratio and the change in water potential of each species by the use of a Scholander-Hammel Pressure Chamber and Leaf Area Meter. The Crassula ovata has a lower leaf area to mass ratio in comparison to Heteromeles arbutifolia, which demonstrates it can hold a greater volume of water. A Student paired T-test with a 95% confidence level was used to determine the significant difference between the dehydration rate of the Crassula ovata and Heteromeles arbutifolia. Based on our results, the dehydration rate per was higher for the Crassula ovata. This supports our initial hypothesis that the CAM plant is more drought tolerant than the C3 plant because the CAM plant had a lower change in water potential as a result of nocturnal stomata opening.

Introduction
Water use efficiency is one of the major determining survival factors among plants because, otherwise, plants are susceptible to mechanical stress, such as xylem cavitation and embolism. Xylem cavitation and embolism develops from air entering into the xylem tissues causing a formation of air cavities that can eventually burst and damage the plant (Jacobsen et al. 2005). According to the National Drought Mitigation Center, California has experienced the most drastic drought in the last year receiving only 30 percent of the average rainfall norm. As a result, maintaining the health of California native plants has become a major issue. For this reason, this experiment investigates the effects of drought stress upon two distinguishable plants: C3 plants and CAM plants. The photosynthesis of C3 plants results in fixing CO2 through the Calvin Cycle to form a 3-carbon molecule within the leaf mesophyll cells (Ehleringer et al. 2002). On the other hand, the CAM plant possesses a photosynthetic mechanism that allows it to conserve water and better photosynthesize under hot conditions. CAM plants undergo nocturnal CO2 fixation and stomatal opening when there is a higher concentration of air humidity allowing them to fix CO2 with low rates of water loss (Matiz et al. 2013). Research shows that CAM plants, do in fact, have a higher water use efficiency in comparison to C3 plants. The transpiration ratio of CAM plants varies from 50 to 125 kg H2O kg-1 CO2, which was found to be much higher than the transpiration ratio of C3 plants (Han et al. 1996). Using a Scholander-Hammel Pressure Chamber, the change in water potential of a plant can be measured. C3 plants are disadvantaged because of photorespiration while CAM plants find a way to prevent the process. Therefore, under drought stress, stomatal conductance declines much more dramatically in C3 plants, which causes a drought-induced reduction of photosynthetic performance (Taylor et al. 2011). Also, the leaf-area to mass ratio is found by the use of the Leaf Area Meter. This information helps our decision to test and support our hypothesis that Crassula ovata is more drought tolerant than Heteromeles arbutifolia.

Results

Discussion
There was a significant difference in water potential (ψ) both before and after a 6-hour drying period between the Heteromeles arbutifolia and the Crassula ovata and a significant difference in ψ values between the species themselves. Also, there was a significant difference between the Δψ over the drying period between the Crassula ovata and the Heteromeles arbutifolia. Therefore, under drought stress, CAM plants prevent photorespiration and sustain water use efficiency due to nocturnal stomatal opening. Thus, the photosynthetic process is less affected and water loss is decreased. The data suggests that the C3 plant lost a larger amount of water than the CAM plant during the drying period. The CAM plant had a lower leaf area to mass ratio in comparison to the C3 plant. An explanation for this finding would include the fact that the Crassula ovata is thicker than the Heteromeles arbutifolia, but shorter in length. For this reason, this enables the water within the Crassula ovata to remain compacted resulting in the CAM plant having a great volume of water. A greater volume of water in a small leaf area allows easier water movement from one area to another resulting. Although the data, does in fact, support our thesis the that Crassula ovata is more drought tolerant than the Heteromeles arbutifolia, some of the data slightly deviated from the mean for both of the plants. An explanation for this would include age and maturity; age and maturity effects the water potential of a leaf. The more mature the leaf was observed to be, the better was its’ water potential capacity. Our results were consistent with the research reported on comparing C3 and CAM plants under drought conditions because the CAM plant was shown to have more of an advantage in hot temperatures than the C3 plant.

Conclusion
We conclude the Crassula ovata is more drought tolerant than Heteromeles arbutifolia:
• CAM plant had a lower leaf area:mass ratio
• CAM plant had a lower Δψ over the 6-hour drying period
• CAM plant had a higher ψ

Literature Cited

Annexed: Table 1. Change in Water Potential (ψMPa) Before and After a 6-hour Drying Period for Heteromeles arbutifolia (Hollywood) and Crassula ovata (the Jade plant).

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Before Drying</th>
<th>After Drying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heteromeles arbutifolia (Hollywood)</td>
<td>3.27 MPa ± 0.45</td>
<td>0.32 MPa ± 0.25</td>
</tr>
<tr>
<td>Crassula ovata (the Jade plant)</td>
<td>3.40 MPa ± 0.45</td>
<td>0.25 MPa ± 0.25</td>
</tr>
</tbody>
</table>

Unpaired Student T-test for initial values of Heteromeles arbutifolia (Hollywood) and Crassula ovata (the Jade plant). Error Bars represent deviation from the mean.

Unpaired Student T-test P<0.05 obtained.  One way ANOVA following Fisher’s LSD to compare all water potential values p<0.05 obtained (ANOVA) and p<0.05 (Fisher’s LSD) between initial and final values of Crassula ovata.

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