Fire Edge Effect on Water Potential and Stomatal Conductance in *Salvia leucophylla*

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Introduction

The edge effect is the effect of the transitions and interactions between two different adjoining ecosystems. In fire-prone communities, plants living on the edge of their ecosystem and in this intermediate zone are often spared from being fully burned by these fires. Salvia leucophylla, or purple sage, is known for being a hardy and drought-tolerant perennial herb. As a part of the widespread coastal sage scrub and chaparral communities, S. leucophylla is likely to be a species common in the edges of forest fire. A study on photosynthesis of desert plants in high temperatures had shown that "the temperature at which chlorophyll fluorescence begins to rise rapidly with increasing temperature coincides with the onset of damage to the capacity for photosynthetic CO₂ fixation by intact leaves." (Seemann et al., 1986) If CO₂ fixation is decreased with extreme heat then stomatal conductance may decrease to prevent excess gas exchange. It is possible that heat can also deplete water available, in which case photosynthetic activity would decrease because photosynthesis activity is directly correlated to stomatal conductance. We decided to test whether this statement by Seemann et al. applies to intact leaves on adjacent branches to heat-killed leaves. We looked at stomatal conductance, or the amount of carbon dioxide exiting the stomatal openings, and stem water potential, the negative pressure inside the stem of a plant.

Hypothesis

Heat damaged S. leucophylla will display a decrease in both stomatal conductance and water potential.

Conclusion

Our hypothesis did not correlate with the data that we collected. Water potential remained the same, but the stomatal conductance increased significantly. This may be because the amount of water available to the plant remained the same, but there were fewer leaves to uptake. The sudden decrease in leaf area may have led the living leaves to compensate for the lost plant leaves by increasing photosynthetic activity (gs ↑).

Results

Graph 1: Fluorescence (Fv/Fm) measurements of the control (0.728) and treated leaves (0.062). Measurements ranging from 0.7 to 0.8 show that the leaf is healthy, while those below 0.3 indicate that the leaf is dead.

Graph 2: Initial and final water potential for the control and heat-treated plants. There was no significant difference in water potential between the control and the treatment for both initial (before treatment) and final (1 week after treatment) measurements (paired t-test, P > 0.05).

Graph 3: Stomatal conductance (gs) comparison of control and heated plants. The final measurements of the treated plants show that stomatal conductance is statistically significant, being almost fourfold larger than the final control plants.

Discussion

Contrary to the expected decrease in both water potential and stomatal conductance, water potential of the treated group (-0.192 MPa) remained equivalent to that of the control (-0.193 MPa); stomatal conductance increased fourfold in leaves that survived the heat within the treated group (control: 21.7 mmol m⁻²s⁻¹; treatment: 95.5 mmol m⁻²s⁻¹; P < 0.05). This may be because the leaves that survived had more water available per leaf for photosynthesis. The treatment group lost a significant amount of leaves to heat, but water potential remained equivalent between the treatment and the control groups. In addition to the increase in water availability per leaf, the demand for energy production per leaf also increased. In order to meet this increased workload, each of the leaves that survived must increase their stomatal activity, resulting in the increased stomatal conductance measured. Such is the proposed recovery mechanism for plants found in the edges of wildfires.

A long-term study should reveal whether or not this maximized stomatal activity of the surviving leaves is beneficial by causing the heat damaged S. leucophylla to successfully recover and remain healthy. We suspect, that, despite the upward spike in stomatal activity, damage from heat would ultimately be detrimental to the individual plant. The demand for energy may outweigh the photosynthetic capacity of the surviving portions of the plant, which in addition to the effects of plant hormonal response may result in plant death. We believe that plant hormone regulation is what differentiates leaf area loss due to heat-induced damage from manual removal of the leaves. Due to the hazardous nature of wildfire simulation, we were limited to observing individual plant response to heat guns. We damaged the leaves of the plants we studied, and but we did not alter the plants in the surrounding area. Our results may have changed if we studied an area of fire damage, since there are many factors beyond heat-induced damage to the leaves that impact the ecosystem's ability to recover from wildfires. Although frequent fires would damage the plants and be detrimental to the ecosystem, we believe there are possible advantages from occasional wildfires: (1) the fire clears away weeds and revitalize the soil (2) certain types of seeds (i.e., Crotolaria megacarpa) germinate ideally under post-fire conditions (3) fire alleviates stress from high population density and promotes diversity among newly sprouting plants (4) occasional intermediate fires prevent fuel build up for bigger, lethal fires. Recent studies attribute the upward trend in fire potential and frequency to climate change (Liu et al., 2010). As scientists, we must further explore the effects of wildfires on the ecosystems around us to understand and prepare for the consequences of global warming.

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Work Cited