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Top and Bottom Photosynthetic Activity in Nerium oleander and Pandanus baptistii

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ABSTRACT

Photosynthesis can be performed on any part of a leaf, yet many plants orient their leaves in different ways and are composed of different leaf anatomies. In this experiment we attempted to discover if there is a significant difference between photosynthesis on the top and bottom of Nerium oleander, a dicot that orients its dorsal face towards the sun, and Pandanus baptistii, a monocot that does not orient its leaves specifically to the sun. To perform this experiment, we used both the LI-6400 and the LiCor Integrating Sphere. With the LI-6400, we measured the photosynthetic rate of the top and bottom faces of N. oleander and P. baptistii in-situ. Through the use of the LiCor Integrating Sphere, we were able to compare leaf absorbance, reflectance, and transmittance on the top and bottom faces of the two plant species. We hypothesized that N. oleander would have a statistically significant difference in the photosynthetic rate of its top and bottom leaves, and the P. baptistii would not have a statistically significant difference in the photosynthetic rate of its top and bottom leaves. The data gathered supported our hypothesis, illustrated in Figures 3 and 4. The results from our experiment suggested that there is a statistically significant difference between the photosynthetic rate of the top and bottom of dicot leaves, and lack of a statistically significant difference in monocots due to their orientation of leaves and their plant leaf anatomy.

INTRODUCTION

All plants undergo photosynthesis through their leaves. Many plant species orient their leaves different from one another and are constructed of varying internal anatomies. The purpose of our experiment was to discover if there was a relationship between the photosynthetic activity of the top and bottom faces of plant leaves and their orientation and internal anatomy. We observed that the Nerium oleander oriented the dorsal face of its leaves towards the sun, and, being a dicot, it has palisade parenchyma. The Pandanus baptistii was observed to have no specific orientation of its leaves, and, being a monocot, it has Kranz anatomy instead of palisade parenchyma. From these observations, we hypothesized that the N. oleander would have a statistically significant difference in the photosynthetic rate of the top and bottom of its leaves, whereas the P. baptistii would not have a statistically significant difference. In order to investigate our hypothesis, we used both the LI-6400 and the LiCor Integrating Sphere to measure the photosynthetic rate and leaf absorbance of the top and bottom of leaves.

METHODS

Fig. 1. (left) To measure gas exchange, we used an LI-6400 Portable Photosynthesis System. We set the parameters on the LI-6400 to CO2 = 400ppm, Light Level = 2000µmol/m²/s, and Temperature = 25°C. We placed the sensor head on a piece of one leaf in each plant and allowed the stomata to adjust for ten minutes. After recording the data for that side of the leaf, we flipped the leaf over to measure the opposite face (keeping the same section of the leaf under to use the active stomata), let the stomata adjust for five minutes, and recorded the photosynthetic rate again.

RESULTS

Fig. 2. (left) For our experiment, we found and tagged five Nerium oleander plants and five Pandanus baptistii on the Pepperdine University Malibu campus, all located less than twenty meters apart. To measure absorbance, we gathered five leaves from each plant and used the LiCor Integrating Sphere and set a standard to measure reflectance and transmittance using the three different setups. To calculate the absorbance, we used the formula: \( a = 1 - R - T \).

Fig. 3. Comparison of average Photosynthetic Rates for top and bottom of N. oleander and P. baptistii.

Fig. 4. Comparison of average Absorbance for top and bottom of N. oleander and P. baptistii.

Fig. 5. Comparison of average Stomatal Conductance for top and bottom of N. oleander and P. baptistii.

Fig. 6. Comparison of average Electron Transport Rates for top and bottom of N. oleander and P. baptistii.

Biological Science Division of Pepperdine University for their support.

CONCLUSION

1. There was a notable difference in function (shown by absorbance) between the top and bottom of Nerium oleander (dicot) leaves that orient their dorsal face towards the sun. This contrasted with Pandanus baptistii (monocot) leaves that do not orient either face specifically towards the sun which displayed a similar function when comparing the top and bottom faces.

2. There is a significant difference between the photosynthetic activity of the top and bottom faces of N. oleander leaves, whereas no significant difference exists between the top and bottom of P. baptistii leaves.

LITERATURE CITED


DISCUSSION

From our results, we were able to conclude that there was a statistical significance between the function of the top and bottom of Nerium oleander leaves and none between the top and bottom faces of Pandanus baptistii leaves. This relates to the fact that N. oleander designs its leaves to be most effective at photosynthesis on the face that contains palisade parenchyma and is oriented towards the sun. P. baptistii has an internal anatomy and orientation that does not give either side a specific photosynthetic advantage over the other, as either side might be facing the sun and undergoing photosynthesis at any time. A similar trend was observed with absorbance. There was a statistically significant difference between the absorbance of the top and bottom of N. oleander leaves whereas no statistically significant difference was observed between the top and bottom of P. baptistii leaves. This reinforces the purported effects of the differences between monocots and dicots. In measuring the P. baptistii leaves with the LI-6400, all photosynthetic values fell between 6.4 and 8 µmol/m²/s except for the final data point (measuring a negative conductance and photosynthetic rate). Instead of letting the stomata adjust for ten minutes, we waited for thirty minutes, and the photosynthetic rate eventually rose to 13.6 µmol/m²/s for the top and 13.3 µmol/m²/s for the bottom, significantly higher than the other five plants. The initial lack of photosynthesis and conductance may have been due to a mid-day shutoff of the stomata due poor water potential. P. baptistii may adjust to a shortage of water at mid-day by shutting down processes similar to maize, another monocot [1]. These processes may only have been reignited by the new conditions presented by the LI-6400's head.

The contrast between the two plants displays the fact that dicots and monocots have adapted differently in accomplishing the task of maximizing photosynthesis. While dicots like N. oleander amplify the photosynthetic ability on one face, monocots like P. baptistii distribute that same ability over both of its faces, not needing to specifically orient its leaves to maximize exposure on its most functional face (both sides function equally well). This trend that was observed in photosynthetic rate and absorbance, however, was not mirrored in conductance and ETR. For these processes, we were unable to confirm a statistical difference between the top and bottom faces of leaves in either of our plant species. This contrasts with other observations on N. oleander, possibly due to a lack of adaptive incentive for the plant to emphasize these functions on one specific face. Another explanation for this is our experiment simply not having enough observations (future experiments could repeat this with a higher number of individuals being observed). Our results support the idea that throughout time, different plants have undergone different evolutionary paths. In working towards the two adaptations observed in our two species, plants specialize themselves to thriving in specific environments or even specific niches within micro-environments. Dicots similar to N. oleander orient their leaves so that they grow to have one face; these plants might thrive living in a uniform line (such as on the hillside we observed them in), creating a sort of canopy layer covering one large face specifically in the direction with the most exposure to the sun. Monocots similar to P. baptistii, on the other hand, are more free to grow randomly in bunches, as the leaves can haphazardly jut out and absorb sun with any face that happens to be exposed to sunlight at any time of the day. Neither adaptation is specifically superior to the other; both their own role in specific niches or environments.

ACKNOWLEDGMENTS

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STUDY SITE

Samples of Nerium oleander and Pandanus baptistii were collected on the Pepperdine University Malibu campus in California.