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Biology 1107 Lab

15 April 2018

Photosynthesis Post Lab (Final Submission)

Introduction

Photosynthesis is a process in which carbon dioxide, water, and light are taken in to produce oxygen and water. There are two phases of photosynthesis: light reactions and dark reactions. In light reactions, light is absorbed by chlorophyll and converted to chemical energy in the form of ATP and NADP. Water is split and releases oxygen, hydrogen, and oxygen. In the dark reactions, the chemical energy formed in the light reactions is used to reduce carbon from carbon dioxide to sugar.

Since light is essential for photosynthesis to occur we decided to see how different colors/wavelength of light would affect the photosynthetic rate of a sunflower. The environmental variable that was tested was how red light affects the photosynthetic rate of a sunflower. We chose to test how red light affected the photosynthetic rate compared to white light because in other experiments, it was found that red light enhanced the photosynthesis process. Although the experiments weren't necessarily tested on sunflowers, we were curious to see if the effects were similar.

It was found that red light improved the efficiency of photosynthesis and increased the production of extracellular polysaccharides. In this experiment done on algae, red light seemed to enhance photosystem II relative to photosystem I (You et al., 2004). In another experiment, the red light was also tested and similar results were found. Red light emits a light spectrum that is

close to the maximum absorbance for chlorophyll. They found that red light is effective in inducing photomorphogenic responses (Goins et al., 1997). After finding these results in other experiments, we hypothesized that using red light would increase the photosynthetic rate in a sunflower. This is important to find out, because if a plant's photosynthetic rate can be increased, then there will be an increased yield in a shorter amount of time, and that could be beneficial.

Methods

To test the photosynthetic rate, we used an air-tight sensor connected to an oxygen and light sensor. This piece of equipment was connected to a computer to collect the data. To begin the process, we disconnected the tube from the gas bag and inflated it with our breath using a drinking straw. We then reconnected the tubing to the bag and closed the clamp.

We took a leaf from the sunflower plant and placed it just below the upper surface of the leaf chamber. We positioned the lower rim of the light fixture approximately 11 cm about the surface of the leaf chamber. We then sealed the leaf chamber. We began the program on the computer. The initial %O₂ should read around 20.9% O₂. We opened the clamp on the tubing attached to the gas bag and attached the free end of the tube to the inlet gas port. We squeezed the bag to flush the chamber with the breath. We detached the tubing from the inlet and promptly closed both the gas ports on the leaf chamber and closed the clamp on the tubing attached to the gas bag. We placed a beaker of water on the leaf chamber against the inlet gas port and O₂ sensor. We turned on the light after the %O₂ leveled off on the graph. When the O₂ concentration maintained a steady value for about 3 minutes, we stopped collecting data.

Then the leaf was measured. We placed an acetate grid on the chamber above the leaf and used the number of squares counted and converted to cm². We used the graph on the computer to measure three slopes: lag, photosynthetic, and plateau slopes. Using these slopes, we were able to calculate the photosynthetic rate for each phase (see calculation in the results section). We then repeated all of these steps, but instead of white light, we placed a red filter over the leaf chamber. We compared the results from each to make conclusions.

Results

White Light

Data Interval Selected	m (slope) (%O ₂ /min)	Photosynthetic Rate (μmolO ₂ /m ² /min)
Lag	0.667	4,622.81
Photosynthetic	1.51	10,452.02
Plateau	0.04	277.23

To find the slopes of each phase, we took the beginning and ending points on the graph and used the slope formula, $m = ((y_2 - y_1) / (x_2 - x_1))$. To find the photosynthetic rate for each phase we used specific equations. The first step would be to find y:

$$y = \frac{10,000 (m)}{[(273 + T) / 273]} \div 22.413$$

m = slope

Then, using the number found by the above equation, another equation is used.

$$\text{Photosynthetic rate} = \frac{0.047 (y)}{\text{leaf surface area (cm}^2\text{)}}$$

This is the final photosynthetic rate.

This process of using the slope and plugging into the equations is used for each interval/phase.

Red Light

Data Interval Selected	m (slope) (%O ₂ /min)	Photosynthetic Rate (μmolO ₂ /m ² /min)
Lag	0.923	6,889.9
Photosynthetic	0.431	3,214.7
Plateau	0.0660	492.2

The same process was used to find the slope and rate as explained above with the white light.

Discussion

To compare the photosynthetic rates of a sunflower exposed to white and red light, we used the rate of the photosynthetic interval. We decided to use this phase because this is where photosynthesis would be occurring and we believe that the best and clearest conclusion would come from comparing rates in this phase.

After comparing the two rates, we found that our results did not match our hypothesis. The photosynthetic rate for the white light was found to be 10,452.02 μmolO₂/m²/min. The photosynthetic rate for the red light was found to be 3,214.7 μmolO₂/m²/min. The photosynthetic rate for the sunflower exposed to the white light was significantly higher. These

results did not match with the research that was found and our hypothesis. This could be because the articles that were reviewed compared red light to other colors and we compared it to just white light. Perhaps compared to other colors, red light increased photosynthesis, but not compared to white light. Photosynthesis has to do with the absorption of light and different colors will be absorbed differently.

After thinking further into these results, we figured that since white light is a mixture of all the colors in the visible spectrum, it would absorb the most, resulting in a higher photosynthetic rate. In the thylakoids of plants, pigments absorb or reflect light. Chlorophyll a and b are two pigments. Chlorophyll a absorbs red light and chlorophyll b absorbs blue and yellow/green light. The sunflower under red light had chlorophyll a working but lacked nutrients from chlorophyll b. The plant under the white light had a greater photosynthetic rate, because it was receiving all of the photons from the visible spectrum benefitted from chlorophyll a, chlorophyll b, and other carotenoids.

References

- Goins, G. D., Yorio, N. C., Sanwo, M. M., & Brown, C. S. (1997). Photomorphogenesis, photosynthesis, and seed yield of wheat plants grown under red light-emitting diodes (LEDs) with and without supplemental blue lighting. *Journal of experimental botany*, 48(7), 1407-1413.
- You, T., & Barnett, S. M. (2004). Effect of light quality on production of extracellular polysaccharides and growth rate of *Porphyridium cruentum*. *Biochemical Engineering Journal*, 19(3), 251-258.

