* The Effect of Carbon Dioxide Concentration on the Rate of Photosynthesis
* Abstract

As an important process for all organisms, photosynthesis can be affected by both internal and external factors that impact autotrophic and heterotrophic organisms. The objective of this experiment was to determine how varying concentrations of carbon dioxide affect the rate of photosynthesis by using the floating disk method. It was hypothesized that an increase in concentration of carbon dioxide would increase the rate of photosynthesis. However, this hypothesis was proven incorrect when the ET 50s increased from 8 minutes to 11 minutes as concentration increased from 0.5% to 3.0%, indicating that it took longer for half of the leaf disks to rise and that the rate was slowing down. Therefore, it was concluded that varying carbon dioxide concentrations did affect the rate of photosynthesis and that an increase in concentration slowed down the rate of photosynthesis.

* Introduction

Photosynthesis is the process by which autotrophic organisms synthesize organic molecules like sugars from carbon dioxide, water, and inorganic salts. Pigments found within the chloroplasts of most photosynthetic organisms harvest light energy from the sun to excite electrons, which drive photosynthesis through both light reactions and the Calvin cycle. Using the amount of substrate consumed or the amount of products and by-products produced, one can measure the rate of photosynthesis of an organism. The purpose of this experiment was to observe the effect of varying carbon dioxide levels on the rate of photosynthesis by using the floating disk method described in the AP Biology Investigative Labs textbook. The floating disk method uses the oxygen by-product of photosynthesis to make sunken disks of leaves to float. Thus, the rate can be determined as the amount of time needed for all disks to float. We hypothesized that as the concentration of carbon dioxide increased, the rate of photosynthesis would also increase until the rate is “saturated” by reaching a maximum carbon dioxide level because carbon dioxide is a crucial substance for photosynthesis to occur; therefore, with more carbon dioxide present, photosynthesis would occur at a greater rate.

* Experimental Details

Preparation of Carbon Dioxide Solutions

1. Four plastic cups were obtained and each labeled with 0%, 0.5%, 1.0%, and 3.0% CO2.

2. Four solutions were created by measuring and placing 100 mL of distilled water in the 0% cup, 100 mL of distilled water and 0.5 grams of bicarbonate in the 0.5% cup, 100 mL of distilled water and 1.0 grams of bicarbonate in the 1.0% cup, and 100 mL of distilled water and 3.0 grams of bicarbonate in the 3.0% cup.

-All solutions were mixed thoroughly before starting the experiment.

Floating Disk Method

3. The method detailed on pages 65-67 of the AP Biology Investigative Labs textbook was used to sink 10 leaf disks in each solution.

-A hole puncher and spinach leaves were used to obtain the disks.

-A syringe was used to create a vacuum in order to expel any extra air in the leaf disks.

-A drop of dish soap was placed in each cup before covering. The detergent acted as a surfactant or wetting agent to allow the solution to be drawn into the hydrophobic surface of the leaves.

4. Each cup was covered with aluminum foil before administering the light source and after the prepared leaves were sunk to prevent photosynthesis from occurring.

5. A light source in the form of a lamp was set up and each aluminum-covered cup was placed at an equal distance under the light source, ensuring that each cup received the same amount of light intensity.

6. The aluminum covers were removed off of each cup at the same time and a timer was started.

7. At each minute, the number of floating disks in each solution was recorded.

8. The timer was stopped after all of the disks in each cup were floating.

-Approximately 14 minutes

9. The collected data was then analyzed and a conclusion was formulated.

* Data and Calculations

Table 1.1

Number of Disks Floating at Various Times at Various Concentrations

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time (min) | 0% CO2 | 0.5% CO2 | 1.0% CO2 | 3.0% CO2 |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 1 | 0 |
| 4 | 0 | 1 | 3 | 0 |
| 5 | 0 | 3 | 3 | 1 |
| 6 | 0 | 4 | 3 | 1 |
| 7 | 0 | 4 | 3 | 4 |
| 8 | 0 | 5 | 5 | 4 |
| 9 | 0 | 8 | 6 | 4 |
| 10 | 0 | 8 | 6 | 4 |
| 11 | 0 | 9 | 9 | 5 |
| 12 | 0 | 10 | 9 | 6 |
| 13 | -- | -- | 9 | 6 |
| 14 | -- | -- | 10 | 10 |

Chart 1.1

Chart 1.2

Chart 1.3

Table 1.2

Time of ET 50 at Various Concentrations

|  |  |  |
| --- | --- | --- |
| Concentration | Time of ET 50 | 1/ET 50 (1/min) |
| 0% | -- | -- |
| 0.5% | 8 min | 0.125 |
| 1.0% | 8 min | 0.125 |
| 3.0% | 11 min | 0.091 |

Chart 1.4

* Discussion

Based on the data, our hypothesis that an increase in carbon dioxide concentration would increase the rate of photosynthesis was proven to be incorrect. Instead, a higher concentration of carbon dioxide slowed the rate of photosynthesis. Our control of 0% carbon dioxide showed that without any carbon dioxide, photosynthesis does not occur since no disks floated during the entire duration of the experiment as expected. The ET 50 for the 0.5% solution was deducted from Chart 1.1 to be at 8 minutes, in which half or 5 of the disks were floating. With the 1.0% solution, it was predicted that the ET 50 would occur at an earlier minute, indicating that photosynthesis was occurring at a faster pace than the rate of the 0.5% solution. However, as seen in Chart 1.2, the ET 50 for the 1.0% solution was 8 minutes again. This same ET 50 value showed that the increase in carbon dioxide concentration did not increase the rate of photosynthesis. With the 3.0% solution, the collected data was completely unexpected. Instead of having the lowest ET 50 time of all solutions, the 3.0% had an ET 50 of 11 minutes, as seen in Chart 1.3. The three minute increase from the ET 50s of the 0.5% and 1.0% solution reveals that the rate of photosynthesis for the 3.0% carbon dioxide concentration actually slowed down. The slower rates of photosynthesis that resulted from the increase in carbon dioxide concentration may be explained by the idea that the solution had already reached its saturated point somewhere below 0.5%. After this threshold, the extra carbon dioxide may have damaged or hindered photosynthesis, causing the higher ET 50 times as shown in Table 1.2.

Although the collected data contains an apparent, strong trend of slower rates due to increased carbon dioxide concentration, multiple errors could have occurred during the experiment to influence the results. For example, some of the disks were stuck in the groove of the plastic cup, which when lightly tapped, caused multiple disks to rise immediately. Therefore, our results may not have been entirely accurate as to the time taken when the disks began to float. This error is noticed in the 3.0% column in Table 1.1 between minutes 13 and 14. Method error as well as instrument error impacted the results. Method error resulted from not providing the same amount of light intensity for each cup variable and damaging the leaf disks when trying to sink them by preparing the floating disk setup. Instrument error may have occurred when weighing the necessary bicarbonate since the scale may not have been calibrated or zeroed correctly. All of these errors could have contributed the results seen in the data. In order to obtain accurate information, multiple trials should have been conducted.

* Conclusions

In conclusion, we achieved our purpose of discovering the effect of varying carbon dioxide concentrations on the rate of photosynthesis. Through the data, it was shown that an increase in carbon dioxide concentration caused a decrease in the rate of photosynthesis. At 0.5%, the lowest tested concentration, the ET 50 was 8 minutes; at 1.0%, the ET 50 was also at 8 minutes; at 3.0%, the ET 50 was an increased 11 minutes. The constant 8 minutes and then the three minute increase in the ET 50 shows that it took longer for the disks to rise as the concentration increased. As a result, the rate of photosynthesis decreased from 0.5% to 3.0%.

If we were to conduct this experiment again, we could test smaller increments in the concentration to see if there is a more accurate trend. Also, extra caution would need to be taken to ensure that each variable has the same light intensity, no damaged leaf disks, and correctly made solutions in order for a true result. Additionally, extra trials would need to be conducted to eliminate any outlier data. The rate of photosynthesis could also be affected by light color, light intensity, and pressure. These are all possible variables that could be tested.

* References

1. *AP Biology Investigative Labs: An Inquiry-Based Approach*. New York: The College Board, 2012. 62-69. Print.
2. Lab Partners: Haley Sechrist, Zach Scott, Kevin Kang, Maryam Petashuli
3. Lab Advisor: Mrs. Imler