Aylin Humzeli

April, 07 2011

Influencing the Rate of Photosynthesis with Light Intensity and Carbon Dioxide Concentration

Introduction

Background:

Photosynthesis is the process plants use to produce organic molecules, usually carbohydrates, from carbon dioxide and water by using sunlight or an alternative source of light. The light is used as energy which is absorbed by chlorophyll in the chloroplast of plants. Photosynthesis is comprised of two different reactions: the light-dependent reaction and the light-independent reaction. The light independent reaction is powered by light energy and produces ATP and NADPH, as well as oxygen as its waste product. The light independent reaction is powered by the NADPH produced in the light dependent reaction and produces sugars using carbon dioxide.

The general formula for photosynthesis is:

$6H_2O + 6CO_2 + \text{Energy} \rightarrow 6O_2 + 2\ C_3H_6O_3$

The rate of photosynthesis can be affected by 3 factors: light intensity, carbon dioxide concentration, and temperature. An increase in light intensity increases the energy absorbed by the chlorophyll, and hence increases the rate of photosynthesis to a point. Increase in the amount of carbon dioxide increases the amount of carbon dioxide available to the enzymes to catalyze. Carbon dioxide concentration

increases the rate of photosynthesis only to a point, specifically, when the enzymes are saturated. Since photosynthesis depends on enzymes, an increase in temperature increases the rate of photosynthesis to a point, for the enzymes have reached their optimum temperature. However, gradually temperature will decrease the rate of photosynthesis as the enzymes denature.

Purpose of my Process

Purpose: To determine the affect of light intensity and carbon dioxide concentration on the rate of photosynthesis.

Hypothesis: If the light intensity and amount of CO_2 increases, then more oxygen bubbles will be produce because the rate of photosynthesis has increased. The rate of photosynthesis will increase because increased light intensity increase the energy chlorophyll absorbs, which then produces more productions including oxygen. The carbon dioxide concentration increase allows the enzymes to be saturated which also increases the rate of photosynthesis.

Variables and Controls

Independent Variable: distance of light to change light intensity, amount of sodium bicarbonate to increase the carbon dioxide concentration

Dependent Variable: number of bubbles produced

Constant Variables:

- Temperature of water inside test tube (room temperature: 16-20 °C)
- Time used to count bubbles produce (5 minutes)
- Height of lamp

- Amount of Sodium bicarbonate (1 gram)
- Heat intensity

The distance of the lamp was changed, and the number of bubbles produced in the test tube was counted. Sodium bicarbonate was added to increase the carbon dioxide concentration and the bubbles produced were counted.

Materials and Methods:

Materials:

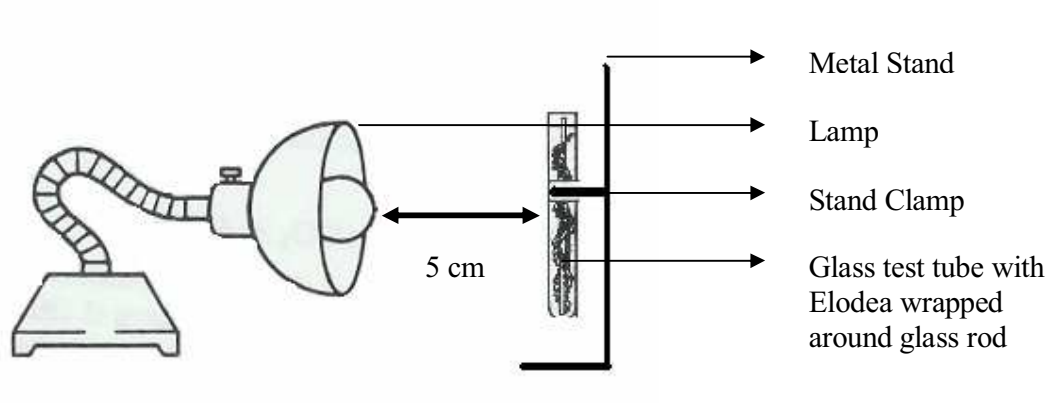
1 sprig of Elodea
1 test tube
15 ml of room temperature water
2 grams of Sodium Bicarbonate powder
Lamp with 40 watts
Sharp Scissors
Metric ruler (cm)
Metal Stand
Metal clamp for stand
Glass rod (17 cm long)
Digital Stop watch

Procedure:

The greenest sprigs of elodea were selected, since those are the freshest. Some leaves from the bottom of the plant were removed. Then the end was cut in an angle and crushed slightly using a hand. The elodea was wrapped around the glass rod, with the cut end on top, and put into the test tube which had been attached to the metal stand with a clamp. The test tube was then filled with room temperature water until the plant was completely immersed in it and the cut end was beneath the water's surface.

A 5 cm was measured for the distance between the plant and the lamp. For 5 minutes, recorded with a stop watch, the test tube was observed for bubbles which were counted. The data was recorded. This same procedure was done again for a second trial.

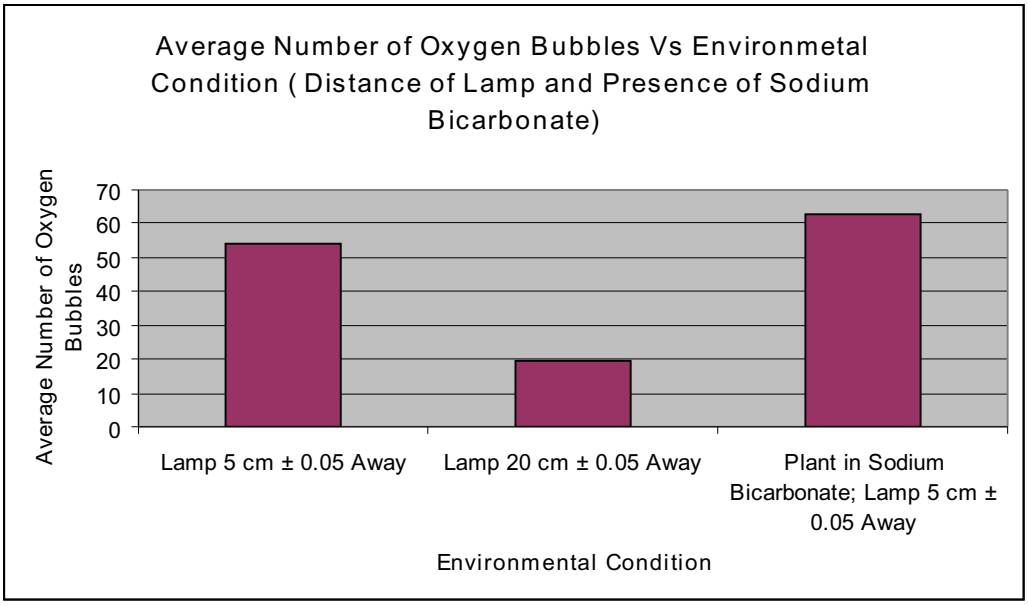
The same procedure of counting bubbles for 5 minutes was repeated with the same sprig, except the distance measured between the lamp and test tube was 20 cm. A similar procedure was using the same sprig was done by measuring 5 cms between the lamp and the test tube. Then 1 gram of sodium bicarbonate was measured and put into the test tube. Bubbles produce by the plant were counted and recorded for 5 minutes. The same procedure was done again in a second trial.



Results

Raw Data:

Set No.	Environmental Condition ±0.05	Number of Oxygen Bubbles		
		Trial 1	Trial 2	Average
1	Lamp 5cm from Plant	48	60	54
2	Lamp 20cm form Plant	21	18	20
3	Plant in Sodium bicarbonate; Lamp 5 cm away	71	55	63



Processed Data:

The average number of bubbles was calculated by adding the number of bubbles for trial 1 and 2 and dividing the sum by 2.

Uncertainties:

The distance between the lamp and the test tube was measured with a normal metric ruler. The ruler's smallest measurement was 0.1, half of this is 0.05 which is the ruler's uncertainty.

The uncertainty for time was 0.01 seconds which is the smallest unit measurable with a digital stop watch.

The uncertainty for the amount of sodium bicarbonate is 0.01 grams which is the smallest value measurable with a digital scale.

Results:

The data and graph show that when the distance of the lamp is 5 cm and sodium bicarbonate is added the average number of bubbles produced is the highest. The average number of bubbles produced is followed by the lamp at 5 cm without sodium bicarbonate. The condition with the lamp 20 cm away produced the smallest number of bubbles.

The second trial of the lamp at 5 cm away produced more bubbles. The second trial for the condition of 20 cm distance produced less bubbles than the first trial. The second trial with the lamp at 5 cm and with sodium bicarbonate produced a lower number of bubbles than the first trial.

Conclusion:

As the graph shows, the most bubbles were produced when the light intensity was closest, at 5 cms, and when sodium bicarbonate was added. The least amount of bubbles was produced when the light source was 20 cm away and with no sodium bicarbonate added. The large amount of oxygen bubbles produced when the light source is closer indicates that the rate of photosynthesis increases with increased light intensity. The rate of photosynthesis is also faster with the addition of sodium bicarbonate. These results support the hypothesis, for the increase in light intensity and amount of carbon dioxide (from sodium bicarbonate), evidently did produce more oxygen bubbles and therefore increased the rate of photosynthesis. An increase in light intensity increases the amount of energy absorbed by the chlorophyll

which will increase the amount of oxygen produced to a certain point. Since more oxygen is produced the rate of photosynthesis increases. Adding sodium bicarbonate also increases the rate of photosynthesis for it provides carbon dioxide which is the substrate essential for producing sugar and oxygen as a waste product. A higher concentration of carbon dioxide provides more substrate for the enzyme and hence produces more products. This also indicates the increase in rate of photosynthesis.

Evaluation:

Probably the biggest random error was that the light of the lamp released heat. The rate of photosynthesis is affected by increase in temperature because of the enzymes in photosynthesis. Since the enzymes are more effective with an increase in heat, this would have added to the production of products. In trial 2 for when the lamp is at 5 cm, the number of bubbles produced increased because the test tube was probably hotter than in trial 1. This would have affected the accuracy of the value for the average rate of photosynthesis. The temperature also seemed to affect trial 2 of the test tube with sodium bicarbonate, for it produced a much lower amount of bubbles. It was even lower than the amount of bubbles produced when the lamp was just 5 cm away which does not seem accurate. This might have occurred do to the denaturation of enzymes that occurred due to the temperature rise. Denatured enzymes would be less effective and would decrease the rate of photosynthesis.

Another source of random error was due to using the same piece of elodea for each condition and trial. The elodea's photosynthesis rate would decrease over time. So it would have

affected the accuracy of how many bubbles were produced as seen with the last trial for the sodium bicarbonate condition.

Some oxygen bubbles might have been used for respiration by the plant. Oxygen could also have been dissolved into the water. This would have affected the accuracy as well for some bubbles were unaccounted for.

Another random error was caused by the approximation error of the stop watch. If the stop watch was stopped a couple of seconds later, a couple of bubbles would still have been produced which affects the accuracy of the data.

Improvements:

To reduce the effect the heat from the light, a fluorescent or better yet, a LED light bulb could be used, since they produce the least amount of heat in bulbs. This would decrease the effect heat has on the elodea.

For more accurate average, more trials should be done. This would decrease the amount of deviation of the number of bubbles produced and would produce a better average value.

Unfortunately, the error which comes from using the same elodea cannot be reduced. For using a different plant for each experiment would also affect the data for the plant would vary in surface area and freshness. However, the data still did allow one to see the effect of each condition correctly.

Instead of counting the number of oxygen bubbles produced, the test tube would the elodea could be covered so that no gas escapes. The test tube could then be connected to a beaker which is

on scale or another instrument to measure mass. Then as the plant produces oxygen, the mass produced could be measured rather than having to count the bubbles which can be affected by human error.

Since the objective of the lab is to observe how factors influence the rate of photosynthesis. The experiment could be extended so that it also observes how temperature affects the rate of photosynthesis by submerging the plant in different temperature water. Also, instead of just using white light, different colored lights or transparent glossy paper to see the affect of different colored light on plants. Also, a wider number of distances would improve the experiment for it would provide better accuracy of how light intensity affects the rate of reaction.