Biology Coursework : Rate of Photosynthesis

Aim

To investigate a factor that affects the rate of photosynthesis.

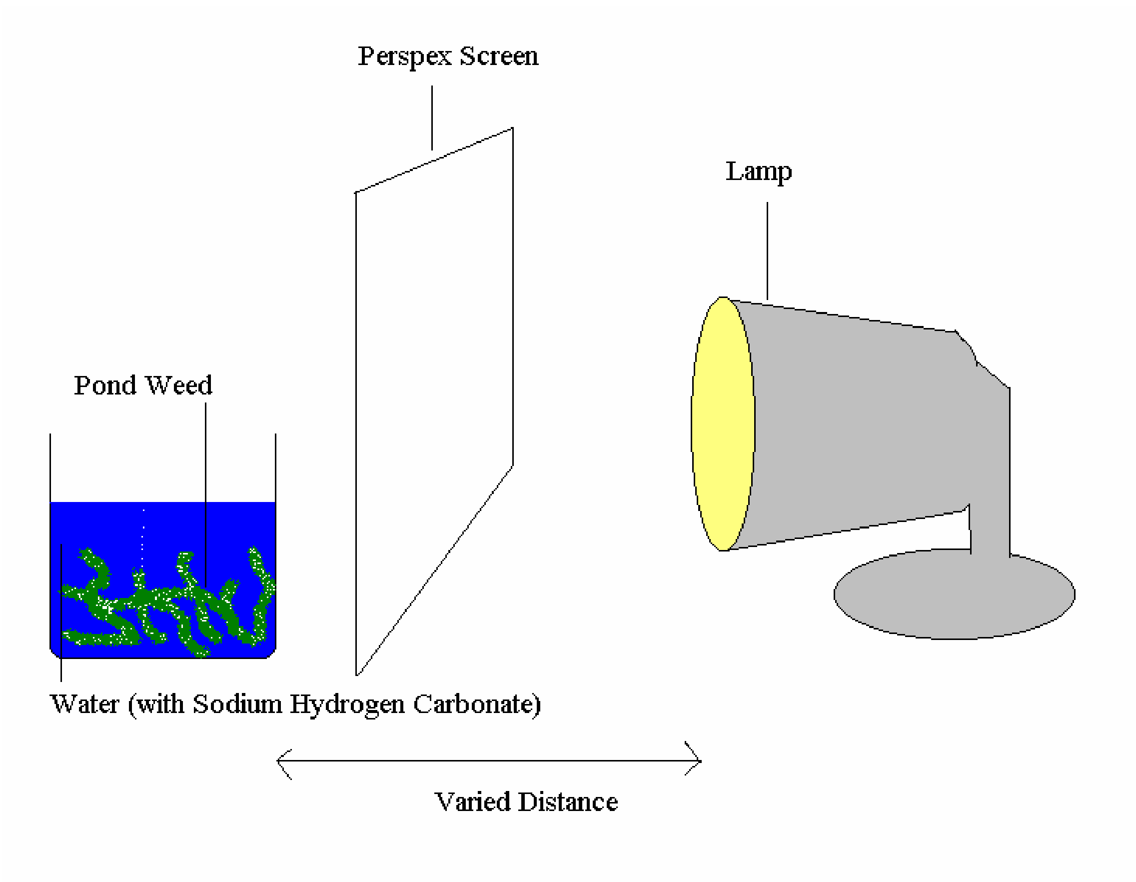
Outline

A piece of pond weed will be cut and placed into a beaker containing water and sodium hydrogen carbonate. A lamp will be shined on to the pond weed and the amount of bubbles released from the plant will be counted for 1 minute. The lamp will be adjusted to different distances from the plant to try and obtain different results.

Background

In Previous experiments leading up to this one, we have seen that plants are able to photosynthesis better when there is plenty of light. As long as there are no other limiting factors this should be true. When chlorophyll absorbs light energy, the light energy cannot be immediately used for energy conversion. Instead the light energy is transferred to a special protein environment where energy conversion occurs. This happens by using the energy of a photon to transfer electrons from a chlorophyll pigment to the next. When enough light energy has been harnessed at a reaction centre, ATP can be synthesized from ADP. During this reaction, oxygen is produced as a by-product and it is the oxygen bubbles that are being measured in the experiment. The greater the light intensity, the more light energy that can be transferred and harnessed to fuel reaction in photosynthesis.

Diagram



Photosynthesis Equation:

$6CO_2 + 6H_2O$ light energy & chlorophyll $C_6H_{12}O_6 + 6O_2$

Variables:
Experimental Variable- Light intensity is to be the variable explored in this investigation. Light intensity can be varied by increasing or decreasing the distance from the light source to the plant.

Fixed Variables

Light Wavelength (colour)- pigments in the leaf such as chlorophyll absorb Light energy. Chlorophyll easily absorbs blue light, in the 400-450 nm range, and also easily absorbs red light in the 650-700 nm range. Chlorophyll does not absorb green light or yellow light effectively but tends to reflect them, decreasing the amount of light absorbed and decreasing the rate of photosynthesis. Why the rate of photosynthesis increases or decreased from the amount of light energy absorbed is what is being investigated in this experiment. The light colour can be fixed by using the same lamp throughout the experiment.

Carbon Dioxide- CO_2 concentration can affect the rate of photosynthesis since the more CO_2 in the air, the more CO_2 that can diffuse into the leaf. This variable can be fixed by adding a fixed amount of sodium hydrogen carbonate to the beaker and plant. Ideally the experiment should also be completed in one session and under two hours so the plant does not use up a significant percentage of the CO_2.

Water- Water is required in the photosynthetic reaction. When plants lack water, their stomata close to prevent further water loss. At the same time, closing the stomata cells doesn't allow CO_2 to diffuse into the leaf. Water is also therefore, linked to the carbon dioxide factor. Water can be kept a constant by keeping the same amount of water in the beaker.

Temperature- Enzymes are used in photosynthesis and the respiration of the plant. Therefore, increasing the temperature will increase enzyme reaction and the photosynthetic rate until a certain point is reached when the enzymes denature. The temperature can be kept somewhat a constant by performing the experiment in one session, when the air temperature shouldn't change enough to affect water temperature. A transparent glass block will also be placed in front of the lamp to retain some of the heat from the lamp.

Limiting Factors- Light, carbon dioxide, temperature, and chlorophyll are all limiting factors. This means that even when there is surplus of every other variable, the rate of photosynthesis will be limited by the limiting factor until there is an optimal amount of the limiting factor to increase the rate of photosynthesis further. Otherwise, the rate of photosynthesis can no longer increase.

Prediction

I predict that increasing the light intensity will increase the rate of photosynthesis at a proportional rate where LI is inversely proportional to $1/d^2$ when LI= light intensity and d= distance (from light source to plant). We can justify this when we look at the background we know that the more light there is the more the weed will photosynthesis. This is true to a certain point until another factor is limiting the rate of photosynthesis.

Safety

With this experiment there are very few safety risks. Although we must be aware that we are using water and electricity, which can be hazardous if not take n seriously.

Method

1. Set up the apparatus as shown in the diagram above

2. Fill the beaker with 450 cm3 of water and 50 cm3 of $NaHCO_3$.

3. Select 1 or 2 pieces of pond weed each roughly 5 -10 cm long and cut off the stems.

4. Place the pond weed in the beaker and weigh it down using lead taping.

5. Put in the measured amount of Sodium Hydrogen Carbonate

6. Place the ruler so that the "0" measurement is aligned with the side of the beaker. (Distance measured from side of beaker to edge of light bulb)

7.) Take a control test with the lamp off. This means no light is present, and there should not be any bubbles.

8.) Place the lamp directly in front of the plant so that it is the desired distance away from the beaker.

9.) With the light shining on the plant, record the number of bubbles emitted in a 1 minute duration. Switch off the lamp and wait for another minute before taking another reading.

10.) Take 2 readings at the current distance and move the lamp 5 cm further away from the plant.

11.) Repeat steps 8 and 9 until 2 readings from at least 5 intervals of 5 cm have been taken.

12.) Proceed to the data analysis stage.

Results

Distance	Bubbles1	Bubbles2	Bubbles3
0			
5			
10			
15			
20			
25			
30			

Conclusion

From the results that I have gathered I can state that an increase in light intensity certainly does increase the rate of photosynthesis. As was also expected in my prediction, the relationship between light intensity and the rate of photosynthesis was non-linear. From both graphs there is a best-fit curved line. This means that the rate of photosynthesis increases at an exponential rate. However, my prediction that light intensity is inversely proportional to the distance squared did not fit into my results perfectly. The rule existed but there was often quite a large margin of error. When measuring light intensity in terms of distance, the greater the distance, the slower the rate of photosynthesis. While the rate of photosynthesis was decreasing, the rate at which it was decreasing at was also decelerating. This is where the line in my graph shallowed. This can be explained by the fact that light intensity is inversely proportional to the distance squared. This means that as distance increases the light intensity decreases at an exponential rate. If light intensity decreases exponentially, photosynthetic rates that depend on light intensity also decreases exponentially. The line in the graph would eventually reach "0" where photosynthesis stops as light intensity limits this rate.

Evaluation

Overall, I would state the experiment as a success since my predictions were supported by my results. This is important in reflecting success only if my prediction was sensible and logical. Just as important is where the experiment was not a success and why. This photosynthesis investigation was probably not performed as accurately as it could have been due to some controllable and uncontrollable conditions. Some mistakes can be corrected. While performing the experiment, the piece of pondweed did not photosynthesize at a steady rate, even when the distance from the plant to the light source was kept a constant. While the number of oxygen bubbles was being recorded, the rate at which the plant was photosynthesising was fluctuating. This may be due to the poor circulation of sodium hydrogen carbonate at the beginning of the experiment. Carbon dioxide may have initially limited the rate of photosynthesis. The readings at 0 cm and 5 cm were repeated many times until the rate of photosynthesis had begun to settle. From then on, there were no more similar problems during the experiment. The negative effects from this problem may be inaccurate data for some readings. These would show up on my graph. However, there seemed to be fewer anomalies than was expected when the experiment was being performed. Almost all readings were in correlation with each other and all of the anomalies were in the high photosynthetic rate end of the results. This was when the distance from plant to light source was 0 cm or only 5 cm. A large factor in determining data accuracy is the amount of human error during experiments. The rate at which oxygen bubbles were being produced by my plant was so high that I found it difficult to count the amount of bubbles. To improve the accuracy of the results, the readings would have to be taken several more times. The entire experiment could have been performed again, and the new results could be combined if the same plant is used. But the photosynthetic rate of the same piece of pondweed would eventually decrease over time anyway. Repetitions would, however, improve the overall reliability of the results. There are quite a few factors that could affect the results of my experiment. Some of these are variables that were mentioned earlier and could not be controlled, or they were variables that were not initially considered. While performing the experiment, some of the oxygen produced from photosynthesis may have dissolved into the water. Some oxygen may have even been used by micro-organisms living on the pond weed. The amount of oxygen dissolved or used by microbes is probably insignificant to my results since the degree of accuracy at which I measured was not high enough. Some oxygen is also used during the respiration of the plant. But since only bubbles were counted, the volume of bubbles was not as important. During the high intensities I had experienced counting difficulties of the bubbles being produced. There are also factors affecting accuracy at low light intensities. With low light intensity, the pond weed receives some light energy from background light such as sunlight seeping through curtains or the light from the lamp of another student's experiment. To eliminate most all background light, the experiment must be performed in a completely dark room. Even then, some of the light from the lamp in my experiment would reflect of the table and reach the plant though this amount of light is probably insignificant in affecting the rate of photosynthesis. Temperature was also another factor that was controlled by the lamp being used. Even though a perspex sheet was used in front of the lamp to prevent some heat from reaching the plant, not all the heat can be blocked. The method of the experiment could probably also be improved to obtain more reliable results. I had originally chosen to count the number of bubbles in one minute but this produced miscounts in the readings. If during a repeated experiment, counting bubbles is still used, there is a smaller chance for human error when counting within a smaller time frame. During high rates of photosynthesis, it would still be difficult and impractical to measure the volume of oxygen produced for a long duration.