An Investigation To Show How Light Intensity Effects The Rate Of Photosynthesis

Aim

The aim of my investigation is to see how the light intensity will effect the rate of photosynthesis in a plant.

Introduction

Photosynthesis is a biochemical reaction that occurs in the presence of sunlight and takes place in the chloroplasts of green cells. In all biochemical reactions, energy is required to split the bonds between the reactants. In photosynthesis, this energy comes in the form of sunlight energy, which is absorbed by the chloroplast and is released to provide energy to combine the raw materials, carbon dioxide (from the air) and water to form simple sugars and oxygen (which is the by-product.) Photosynthesis can be defined as the production of simple sugars resulting from the reaction of when the raw materials (CO_2 and H_2O react together forming sugar and oxygen (by-product)) in the presence of sunlight and chlorophyll. The chemical equation for this is

It is a known fact that all plants require sunlight to photosynthesis and without it, the plants would die. I know this from my preliminary work and experiments that I did in year nine, where I took two plants and placed them in exactly the same conditions, except one was deprived of sunlight. At the end of my experiment, I discovered that the plant deprived of sunlight died, whilst the other survived. This shows the importance of light intensity to a plant.

I predict the as the intensity of light is increased, so will the rate of photosynthesis. This is because as light, which is the energy, falls on the chloroplast in a leaf, it is trapped by the chlorophyll, which then makes the energy available for chemical reactions in the plant. This is because 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 the chlorophyll pigment to the next. When enough light has been harnessed at the a reaction centre, ATP can be synthesised from ADP. During this reaction, oxygen is produced as a by-product and it is the oxygen bubbles that can be measured to give an indication of the rate of photosynthesis. Thus as the amount of sunlight, or in this case the light from the lamp, falls on the plant, more energy is absorbed, so more energy is available for the chemical reaction. As a result photosynthesis will occur at a faster rate in a given time which will be indicated through the amount of oxygen produced as the bi product of this reaction, in a given time. I also predict that increasing the light intensity will increase the rate of photosynthesis at a proportional rate. Therefore if the light intensity is doubled, the rate of photosynthesis will also be doubled. This is because, if the amount of sunlight, or in this case light from the lamp, is doubled the amount of energy available for the reaction will also be doubled; this means that the rate of the reaction will occur twice as fast. . Therefore the rate of photosynthesis will be directly proportional to the light intensity until a certain level is reached and then the rate of photosynthesis will not increase further. This is due to the law of limiting factor theory; which is that if a reaction (in this case the photosynthesis reaction) depends on a number of factors being favourable, then the rate is limited by the factors that is the closest to its minimum value. Thus, once the light intensity has reached a certain level that it is much higher than the other factors (e.g. carbon dioxide and water) will be limiting, and the rate of photosynthesis cannot increase unless the values for the other factors increase.

In addition to this I also predict that the distance between the light source and the Elodea will be inversely proportional to the rate of photosynthesis of that plant. This is because the light intensity falling on a given object from a constant source is inversely proportional to the square of the distance between them

Therefore if the light intensity is inversely proportional to the distance squared, and the rate of photosynthesis is directly proportional to the light intensity, then it is true that the rate of photosynthesis is also inversely proportional to the distance squared.

Preliminary Work

I have done many experiments, investigating the topic of photosynthesis in years nine and eleven. In year nine I did experiments to find out the factors that effect photosynthesis. For example how the concentration of oxygen effects this reaction, the colour of the light, the level of water and the necessity of chlorophyll. This has enabled me to identify what to control and the scientific reason for it.

I have previously conducted experiments to investigate the effects of light on the rate of photosynthesis. During these experiments I tried various methods to quantify the rate of photosynthesis using the oxygen bubbles as an indication. In this method I tries counting the number of bubbles produced in a given time, over a variety of distances (to find the rate of photosynthesis for each distance). However I found that this Was a very inaccurate method to quantifying the level of oxygen as some of the bubbles stuck to the funnel and therefore it was very difficult to obtain an accurate quantified of the bubbles produced in a given time. Therefore for this investigation, I have decided to remove the inverted funnel feature as it accounted for inaccuracies in my previous experiment and does not serve a significant purpose. Thus I will just use a test tube like shown in the diagram below.

In addition to this I also discovered that counting the number of oxygen bubbles is not an accurate reflection of oxygen production in the plant, as some bubbles were larger than others. Therefore it is not an accurate indication of the precise levels of oxygen produced. However my teacher gave us time to experiment quantifying the oxygen bubbles through other methods. From this I discovered that collecting the volume of oxygen, produced by the plant wen it is photosynthesising, in a syringe, was a far more accurate indication and a more scientific method. However this method takes a longer time to produce an adequate set of results (in the time that we were given) from which a conclusion can be drawn. For this reason I decided to use the oxygen bubble counting method as it was the only method that would give indication of the rate of photosynthesis in a given time. Therefore prior to the practical, I spent time perfecting this method and obtained accurate results in the preliminary work. When perfecting it I discovered that placing the plant upwards gives off more oxygen bubbles. Therefore I will place the plant upwards throughout the investigation as this will increase the oxygen bubble production and therefore produce an adequate set of results that will enable me to draw a firm conclusion and analyse. I also found that giving the Elodea a sharp, clean cut would a blade standardises the bubble production. Therefore doing this will cause the plant to produce very similar sizes of bubbles, and therefore an even more accurate indication of the oxygen production, hence accurate results. I also discovered that an adequate set of bubbles was produced in a time of over 5 minutes. Therefore I will be counting the bubbles in a given time; five minutes. Nevertheless, I will still use the method of counting the volume of oxygen productions a back up. As a longer time is required, I will do this over a period of 24hours per distance. The back up results makes my experiment more scientific, which will enable me to draw a firmer conclusion.

In order to conduct a fair experiment, the only factors I will change is the distance of the lamp, hence the light intensity.

Experimental variable- light intensity is the variable that is going to be explored in this investigation. Therefore I will vary it by increasing and decreasing the distance from the light source to the plant.

Carbon dioxide concentration- the concentration of carbon dioxide can effect the rate of photosynthesis because the greater the levels of carbon dioxide, the more CO2 diffuse into the plant. As a result the rate of photosynthesis will rise up to a certain point where the limiting factors theory comes in. this variable will be kept constant by adding a fixed amount of sodium hydrogen carbonate to the beaker and plant. This experiment should be completed within an hour, so the plant does not use up a significant percentage of the CO2.
Water- water is required on the photosynthesis reaction. When plants lack water, their stomata close to prevent further water loss. At the same time, closing the stomata cells does not allow CO2 to diffuse into the leaf. A lack of Water is therefore linked to the Co2 factor. Water needs to be kept constant by keeping the same amount of water in the beaker.
Temperature- enzymes are also used in photosynthesis and the respiration of plants. Therefore increasing the temperature will increase emyme reactions, to a certain point, which in turn will increase the rate of photosynthesis. However when the temperature reaches above 45 degrees, the enzyme will denature and reactions will stop. Therefore it is essential to keep the temperature at a constant level.

Safety

- Wear overalls
- Do not put any equipment into your mouth.
- Do not put your hands in your mouth without washing it, a previous experiments have shown that the plant contains small worms and the water used is dirty.
- do not run in the laboratory
- Make sure all bags are placed under the tables and are out of the way.
- Make sure that all glass equipment is looked after carefully.
- If there is any glass equipment broken inform a teacher and clear away.
- Be careful not to brake the thermometer as it contains mercury, which are poisons. If it does brake, inform a teacher immediately.

I want very accurate results so I am going to repeat each experiment three times and take an average each time I do the experiment, I am going to measure the oxygen production for f different distances, so that I can demonstrate a proportional relationship with my results. I will also measure and control the factors, which I hope to keep constant so I can prove they did not change and effect the experiment.
Therefore for a fair test and to obtain accurate results, I will-

- Do each experiment three times and find an average of the results.
- If any of the variables that I intend to keep constant change, then I will repeat that experiment after making that variable constant.
- Use the same size of the plant for each experiment.
- Use the same equipment for each experiment.
- Wash each equipment before each experiment.
- Leave at least three-minute interval between each experiment. This is because the plant could still be photosynthesising in one experiment, owing to the light exposed from the previous experiment. By leaving a three-minute interval, it gives the plant enough time t by leaving a three-minute interval; it gives the plant enough time to stop photosynthesising form the previous experiment.

- The position of the light bulb on the lamp should always be in the same place (although the actual distance of the lamp can be varied for each experiment), to ensure that its position did not effect the rate of photosynthesis.

Method

1. Set up apparatus like shown in the diagram above.
2. The level of water in the beaker should always be 25ocm3.
3. Take a piece of elodea and cut the edges with a blade so that it is exactly 5cm long. This clean cut will standardize the size of the oxygen bubble production.
4. Place it up right in the test-tube.
5. Place the test-tube into the beaker filled with water and hold the test tube with a clamp stand so that the bottom of the test-tube touches the end of the beaker.
6. Place a thermometer in the beaker to make sure that the temperature is constant.
7. Place the lamp 5cm away from the beaker (measure distance accurately with a meter rule)
8. The lamp should be placed so that its bulb is directly facing the part of the beaker where the elodea is.
9. Take a stopwatch and as soon as you switch on the stopwatch, switch on the lamplight as well.
10. Record the amount of oxygen bubbles in a clear table (by tallying) for exactly five minutes.
11. After five minutes, stop the experiment and wash all equipment.
12. Repeat this three times, leaving a three-minute interval between each experiment.
13. Repeat this entire procedure for the stated distances: 10cm, 15cm, 20cm, 25cm, 30cm, 35cm, 40cm, and 45cm.

Analysis

In this experiment the number of bubbles of oxygen produced in a given time is indicative of the rate of photosynthesis. The results displayed in figure 1 clearly show that as the distance between the Eldoea and the lamp increases, the number of oxygen bubbles produced decreases and hence the rate of photosynthesis decreases. For example when the distance of the lamp from the Elodea is 0cm, the number of bubbles of oxygen produced in 5 minutes is 19. In addition, when the distance was increased to 5cm, the number of bubbles produced was still 19. However when the distance was increased to 10cm, the number of bubbles of oxygen produced was 13, which is decrease. Figure one shows that the number of bubbles of oxygen continued to decrease like this as the distance increased, until the distance of 30cm was reached, in which the light source was too far to enable photosynthesis to take place, and hence the bubbles of oxygen production. These results clearly establish a simple relationship, being that as the distance increases, the number of bubbles produced decreases. Using this, It is also true to say that as the light intensity increases, the rate of oxygen bubble production will also increase. This is because I know that the distance is inversely proportional to the light intensity, so if you double the distance, the light intensity will be halved.

In addition to this, the results displayed in figures 1 and 2, show that the rate of photosynthesis is the highest when the distance is 0cm and 5cm, of which both produced 19 bubbles of oxygen. In the same way, both the graphs clearly show that the rate of photosynthesis was the lowest when the lamp was the furthest away; this being 30cm. Both graph 1 and 2 show that at this distance, there were no bubbles of oxygen produced. This proves that the rate of photosynthesis increases as the light intensity increase.
Figure 2 clearly shows a more smoother curve because I have used the inverse of the distance squared, which also gives a clear indication of the relation of the light intensity to the rate f photosynthesis. The inverse law states that the light intensity falling on a given object from a constant source is inversely proportional to the square o f the distance between them. The curve on figure 2 shows that there s a proportional relationship, i.e., when the light intensity increases the rate of photosynthesis increases.

The results on both figures 1 and 2 support my prediction, because I predicted that the rate of photosynthesis would increase if the light intensity increases, and this is what the result in figures 1 and 2 show. Thus I can form a conclusion, which supports my prediction that as the light intensity increases; the rate of photosynthesis will also increase. The reason for this, as stated in the prediction, is because, as light, which is the energy, falls on the chloroplast in a leaf, it is trapped by the chlorophyll, which then makes the energy available for chemical reactions in the plant. This is because 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 the chlorophyll pigment to the next. When enough light has been harnessed at the a reaction centre, ATP can be synthesised from ADP. During this reaction, oxygen is produced as a by-product and it is the oxygen bubbles that can be measured to give an indication of the rate of photosynthesis. Thus as the amount of sunlight, or in this case the light from the lamp, falls on the plant, more energy is absorbed, so more energy is available for the chemical reaction. As a result photosynthesis will occur at a faster rate in a given time which will be indicated through the amount of oxygen produced as the by-product of this reaction, in a given time.

Therefore the rate of photosynthesis will be directly proportional to the light intensity until a certain level is reached and then the rate of photosynthesis will not increase further. This is due to the law of limiting factor theory; which is that if a reaction (in this case the photosynthesis reaction) depends on a number of factors being favourable, then the rate is limited by the factors that is the closest to its minimum value.