Investigate one factor which will affect the rate of photosynthesis

Introduction

Photosynthesis is the process by which plants make their own food. For photosynthesis to occur the plants need sunlight energy, the energy is absorbed by a green pigment called chlorophyll which is found in the leaves of the plant. This energy then combines with water molecules from the soil, and carbon dioxide from the air. After this, a type of sugar called glucose is produced which can be used for the plants energy and oxygen is made as a byproduct.

The equation for photosynthesis is:

$6CO_2$ + $6H_2O$ -> $C_6H_{12}O_6$ + $6O_2$.

Carbon dioxide + Water -> Glucose + Oxygen

Any acceleration in the process of photosynthesis will naturally result in the production of more organic compounds and consequently more plant growth.

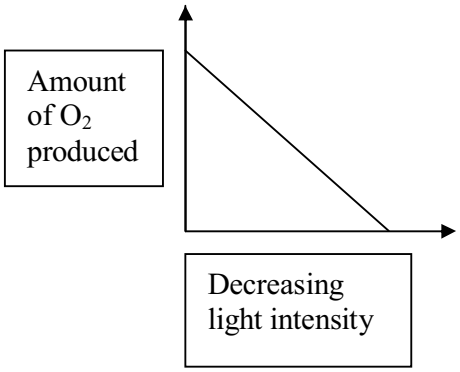
There are certain things that affect photosynthesis called limiting factors. These are: light intensity, temperature, amount of carbon dioxide available and the amount of water available. Light intensity speeds up photosynthesis because sunlight is needed for the chemical reaction to happen and if the concentration of light is greater, more of it can be used to make glucose and oxygen. The reason is similar for how carbon dioxide and heat affect photosynthesis. Heat speeds up photosynthesis because the enzymatic reactions require the enzymes to be at a warm temperature to work at their best, although not above 40 ^{o}c as this is when they are destroyed by the heat.

I am going to investigate light intensity in my experiment to find out how it affects the rate of photosynthesis. I will measure the rate of photosynthesis by calculating the amount of oxygen produced, as this is one of the products of photosynthesis. I will measure the amount of oxygen produced by using a piece of equipment called a micro burette. Using this piece of equipment I will measure what the volume the bubbles of oxygen given off are.

Prediction

I predict that by decreasing the light intensity the rate of photosynthesis will also decrease. I base this prediction on my background knowledge as well as previous experiments I have performed. In the spring and summer plants grow at a quicker rate than in winter and autumn. I believe that this is because light and heat are in a more plentiful supply. Farmers place their crops on an east-west axis to obtain maximum sunlight for salad crops in polytunnels. Also, horticulturalists use artificial 'daylight' bulbs in polytunnels to make their plants grow at a faster rate.

In a recent experiment I carried out observing how light affects photosynthesis I placed an 'S' shaped stencil over a leaf and left it overnight with plenty of light. The next day when I tested the leaf for it was only present within the 'S' shape when the iodine was added because it was exposed to the light. However the part that was not exposed to the light revealed no starch was present. This proves light is needed for photosynthesis to take place effectively. Using an I.T. program the results showed that the greater the light intensity the faster the rate of photosynthesis, and the more oxygen given off. I could see this from the graph that was produced:
(P.T.O for graph)

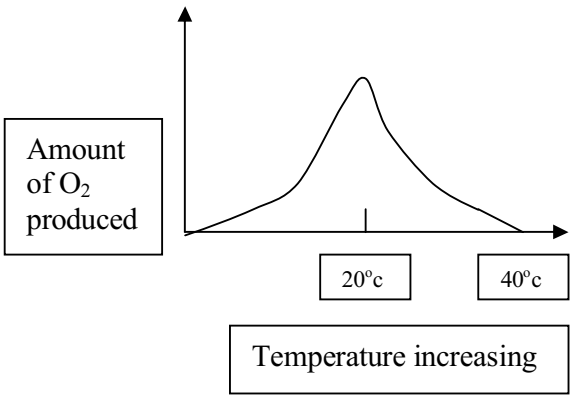


From the graph it is clear that the more the light intensity was decreased, the less O_2 was produced. However, I also know that if the light intensity was too great the chloroplasts would be damaged and therefore unable to perform photosynthesis.

Controlling other factors

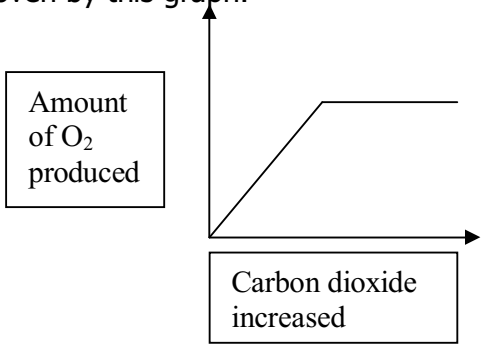
The amount of carbon dioxide, heat and water can also affect photosynthesis so these will need to be kept the same throughout the test to keep it fair and avoid anomalies and an inaccurate experiment and poor results. I know these factors affect photosynthesis from background knowledge and previous experiments.

Greenhouses and "hot houses" produce more plant growth than plants left outside a greenhouse because solar radiation is absorbed and magnified so therefore the temperature is warmer in the greenhouse. This means the rate of photosynthesis is quicker as the energy produced can be used for growing. The I.T. program I used showed that the optimum temperature for photosynthesis was 20.5 ^{o}c. Above or below this temperature resulted in a decrease in the amount of oxygen produced and therefore a decrease in the rate of reaction. This graph proves this (P.T.O. for graph)



This graph clearly shows an increase in oxygen until about 20.5 degrees when the amount of oxygen produced reduced and therefore the rate of photosynthesis also decreases until about 40 degrees when photosynthesis finishes. If it's too cold, the enzymes involved in photosynthesis won't work and if it's too hot, the enzymes are denatured. Different plants work best at different temperatures according to their environment.

The more carbon dioxide a plant has access to the faster the rate of photosynthesis. I know this because farmers add carbon dioxide to their "hot houses" to increase production so it must increase the rate of photosynthesis to increase the rate of growth. I also know carbon dioxide increases the rate of photosynthesis because I completed an experiment where a leaf was denied access to carbon dioxide and was given potassium hydroxide crystals to absorb the carbon dioxide. When tested for starch with iodine there was very little present so therefore only a small amount of photosynthesis took place. Also, using the I.T. program I found out that if the amount of carbon dioxide available to a plant increases, so does the rate of photosynthesis. However, this is only up to a certain point as the plant cannot take in carbon dioxide any faster and cannot photosynthesise any faster. The rate of photosynthesis will therefore stay at the same level when it reaches a certain point. This is all proven by this graph:



Planning

I am going to move the lamp 3 cm at a time away from the pondweed each time I move it. I will leave the pondweed for 2 minutes for it to photosynthesise and will then take 3 readings of the volume of oxygen given off. I hope to move the lamp 7 times so therefore get 21 readings - 3 for each distance. I want to do this many because then I think it will give me accurate and reliable results so therefore less chance of anomalies and incorrect results.

I am going to record the temperature each time I take a reading because as I explained earlier the temperature affects the rate of photosynthesis and so I need to make sure it is the light and not the temperature affecting my results. I will make sure of this by referring to my temperatures if they differ at the end to make sure they are not affecting my results. The amount of CO_2 will also be kept the same as it also affects the rate of reaction and the volume of water the pondweed is kept in will also be kept the same. I am going to change the intensity of light by moving the lamp away from the pondweed

and taking readings at different distances. The further the lamp is away from the pondweed the lower the density of light available to the pondweed.

It is likely that anomalies will occur in my experiment. However, the micro burette will help me avoid anomalies because it gives accurate readings. It will be clear when a result is an anomaly because it will not fit in with the pattern I hope to see. In this situation I will make a note of the anomaly but then delete it and repeat the experiment until the anomaly is overwritten.

Safety is an important factor in this experiment as the electricity from the lamp could potentially be dangerous being so close to the water. If water splashes onto the hot bulb it may explode and the electricity touching the water could result in electric shocks or fires. I will therefore be very careful when handling the lamp near water and be aware of the water to make sure it doesn't splash.

Obtaining Evidence

During my experiment I worked with accuracy and precision. Instead of merely counting the bubbles produced by the plant - which would be inaccurate because of the high chance of fluctuation in size of each of the bubbles- I decided to use the more accurate micro-burette to measure accurately the volume of oxygen produced. Before each reading I made sure I pushed out the excess oxygen to ensure a fresh new reading each time. To ensure that each time the plant had the same time in contact with the lamp I used a stop clock and timed for two minutes each time.

Analysing Evidence

My evidence shows that the greater the light intensity the greater the increase in the rate of photosynthesis. I can prove this because from the graph I can see that the shorter the distance the lamp was from the pondweed the higher the volume of oxygen produced in the strong negative correlation present. For example, when the lamp was at 0cm away from the lamp an average of 0.86 ml of oxygen was produced but at 18 cm a little amount of 0.03 ml of oxygen was produced. Each time the lamp was moved 1cm closer to the pondweed an average of an extra 0.14ml to 2dp of oxygen was produced.

Conclusion

My results clearly show that a high concentration of light enables a faster rate of photosynthesis because from the graph I can see that the shorter the distance the lamp was from the pondweed the higher the volume of oxygen produced in the strong negative correlation present.

I had predicted that that by decreasing the light intensity the rate of photosynthesis will also decrease. I had based this prediction on my background scientific knowledge as well as previous experiments I have performed. In the spring and summer plants grow at a quicker rate than in winter and autumn. I believe that this is because light and heat are in a more

plentiful supply. Also, farmers use light to make plants grow quickly and healthily so it must speed up photosynthesis to give the plant energy to grow.

In a recent experiment I carried out observing how light affects photosynthesis I placed an 'S' shaped stencil over a leaf, left it overnight with plenty of light. The next day when I tested the leaf for starch with the 'S' shape revealed it was present when the iodine was added because it was exposed to the light. However the part that was not exposed to the light revealed no starch was present. This proves light is needed for photosynthesis to take place effectively. Using an I.T. program the results showed that the greater the light intensity the faster the rate of photosynthesis, and the more oxygen given off. I could see this from the graph that was produced:
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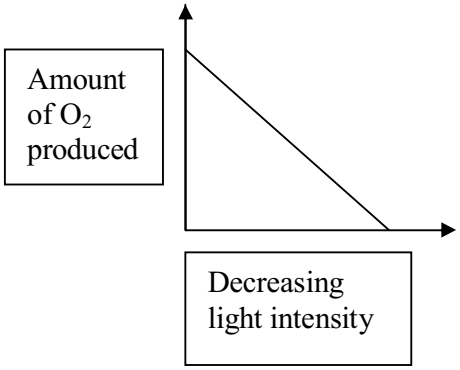

From the graph it is clear that the more the light intensity was increased, the less O_2 was produced. However, I also know that if the light intensity was too great the chloroplasts would be damaged and therefore unable to perform photosynthesis.

My results match and support this prediction so therefore it was correct.

Evaluating

I think my experiment went well. I got accurate results throughout the experiment that created a clear pattern in my results that supported my prediction. Nevertheless, I still got one anomaly during this experiment at 9cm away from the pondweed. I therefore used my intuition and recorded this anomalous result but overwrite it by repeating the experiment. I then got the result I expected which fitted in with the pattern.

This anomalous result could be due to many reasons. Throughout the experiment the temperature which I recorded did vary slightly and this rise and fall in heat may have increased or decreased the rate of reaction and so the amount of oxygen produced. Although I worked efficiently there is always a chance of human error and this may have been the case in this experiment. It is likely that in using the micro burette an inaccurate result may occur because it is easy to trap or lose a bubble. The weather during my

experiment was not helpful. It was a sunny day although cloud did cause a change in the amount of natural light present. I know from background knowledge that plants prefer natural light to artificial light given by the lamp so it is possible this may have affected the experiment. The carbon dioxide availability may have affected the experiment also as the plant might have run out of carbon dioxide too quickly and because there is no way to get it back because it was the only living thing in the beaker this would ha ve shortened the time the plant could photosynthesise in.

My evidence does support my conclusion because the amount of oxygen produced was greater (and therefore the rate of photosynthesis was greater) when the lamp was closer (and therefore the concent ration of light was higher). This can be seen in the graph with the strong negative correlation and the strong pattern in my table of results.

Improvements

Although I think my experiment went well there is always room for improvement and if I did the experiment again I would avoid any anomalies by repeating the experiment more times to give a wider range of results and therefore a more accurate set of results. I could exclude all other natural light by possibly completing the experiment in a dark room to avoid fluctuations in natural light and stopping the plant having access to natural light. Plants prefer different wavelengths of light and this may have affected my results, I could expand the experiment by testing the affects different wavelengths on the plant. To do this I could see the affects of different coloured lamps- which would produce different wavelengths of light - on the rate of photosynthesis. To avoid human errors I could use electronic technology e.g. an probe placed in the water linke d to a computer to record not only the amount of oxygen produced but also the other limiting factors like temperature, amount of carbon dioxide and the amount of natural and artificial light available to the plant.