Investigation into the effect of Light Intensity on Photosynthesis

by Dominic Mulley

Introduction

Photosynthesis is the process that produces 'food' in plants. The 'food' that it produces is called glucose. Photosynthesis takes place in the leaves of all green plants. Leaves are especially to make photosynthesis:

- Leaves are thin and flat to provide a large surface area to absorb as much sunlight as possible.
- The palisade cells are near the top of the leaf and are packed with chlorophyll.
- Guard cells control the movement of gases into and out of the leaf. They line the bottom of the leaf.

An equation can be demonstrated to show how a plant produces photosynthesis and what substances it uses:

Carbon Dioxide	+	Water	+	Sunlight Chlorophyll	Glucose + oxygen
$6CO_2$	+	$6H_2O$	+	Sunlight Chlorophyll	$C_6H_{12}O_6 + 6O_2$

The rate of photosynthesis depends on light intensity, carbon dioxide and temperature. Sometimes increasing these factors has little or no effect. This is because one of the other factors is so low that it limits the rate of photosynthesis. Scientists call this the limiting factor.

Chlorophyll in green leaves uses light energy to perform photosynthesis. It can only do it as fast as the light energy is arriving. Chlorophyll only actually absorbs the red and blue ends of the visible light spectrum, but not the green light in the middle, which is reflected back. This is why the plant looks green

CO_2 are the raw materials. There is hardly ever a shortage of supply of water in a plant but only 0.03% of the air around is CO_2 so it's actually pretty scarce as far as plants are concerned.

Chlorophyll is like an enzyme in that it works best when it's warm – about 25-37°C. But if it exceeds that limit the chlorophyll enzymes work slower and at 45°C they die off, photosynthesis can no longer take place.

Aim

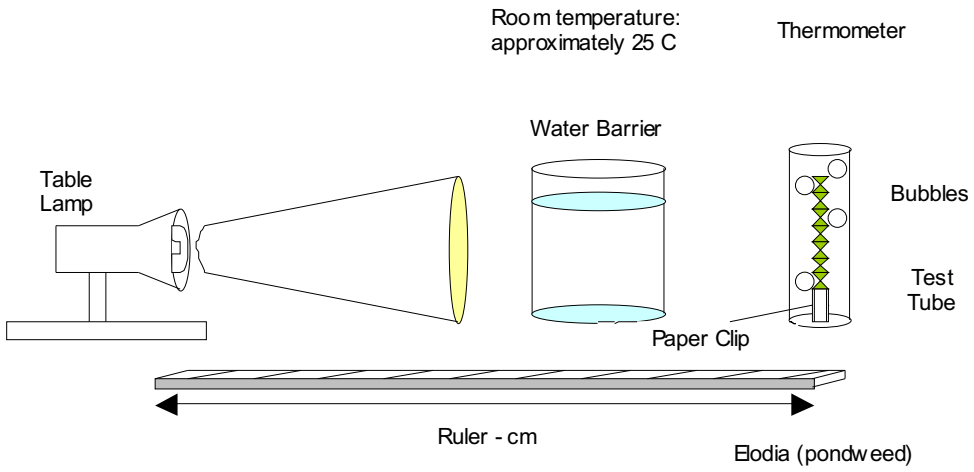
My aim is to prove that the rate of photosynthesis of the pondweed increases with a rise in light intensity.

Equipment List

- A test tube/boiling tube
- A 60watt lamp
- Pondweed – Elodea
- Hydro carbonate
- Water
- Water shield/heat shield
- A paper clip
- A ruler
- A spatula

Method

Firstly we set up the test tube, the water shield, and the lamp. The lamp should be pointing at the test tube with the water shield between the two to prevent the lights heat getting to the pondweed. In order to stop the pondweed from floating on the surface of the surface of the water and hydro carbonate, we must attach a paper clip to the bottom of it. And it is also important to cut the bottom of the pondweed at a 45° angle in order to maximize the surface area in which to absorb Carbon Dioxide. Vary the light intensity for photosynthesis by adjusting the distance of the lamp from the plant. Once the distance is set switch the lamp on activating a stopwatch at the same time. Measure the rate of photosynthesis by recording the number of bubbles given off in a set time. Depending on each group conducting the experiment, one can decide for how long to count the bubbles coming up from the plant for the duration of the experiment.



Accuracy

The test carried out must be done as accurately as possible, if not the graph will not show a positive correlation and as result nothing will be proven. Here are the ways to achieve the maximum accuracy in this experiment:

- The use of a water barrier efficiently in order to block out all heat.
- The same plant should be used throughout the investigation.
- The light intensity should be constant.
- Distances must be measured accurately.
- The table lamp is the only light source
- The carbon dioxide concentration in the water containing the plant should remain constant during the investigation.

Variables

The only variables throughout the investigation should be the light intensity by moving the lamp or changing the voltage supply.

Safety

There is no specific safety for this experiment except electrical hazards and no safety equipment is necessary.

Prediction

I predict that the rate of gas produced (O_2 in the form of bubbles) increases with an increase in light intensity and therefore more photosynthesis is being produced.

Results

For each distance three set-ups were made, this greatly increases the accuracy of the graph and makes it easier to find a positive correlation. The mean value of the 3-4 results are used for plotting graphs.

Distance of lamp from pond weed (cm)	Set – up			Relative light Intensity ($1/d^2$)	Rate of photosynthesis	
	1	2	3		1/time (s)	Mean
10						
20						
30						
40						
50						
60						
70						
80						

The results above are fairly accurate, however there are ways to improve the accuracy here:

Source Error	Remedy/Improvement
The room temperature may fluctuate.	Set up a control without the pondweed.
There are other light sources.	Shelter the set-up so that the pondweed only receives light from the table lamp.
The concentration of carbon dioxide in the water may be reduced during the experiment.	Use a dilute sodium hydrogen carbonate solution, which ensures a constant supply of carbon dioxide to the pondweed.
The rate of gas evolution is not consistent e.g. when measuring cylinder is knocked or vibrated or when it is moved to another place.	When changed to a new condition, the plant should be equilibrated for at least 10 minutes before taking a reading.

In order to prove my prediction I must, (using the table of results), plot a *B*ubble/Time curved graph, and a *B*ubble/*L*ight Intensity curved graph. These are the two essential graphs as they would be sufficient to prove my prediction, but to look at the investigation and explain it in different aspects I could also do *L*ight Intensity/*D*istance, and *B*ubbles/*D*istance curved graphs.

- *(Graphs are on graph paper at the end of the investigation)*

I*t is good to start with a high* l*ight intensity, e.g. at a distance of* 10-20 cm b*etween the plant and the* l*ight source, and then increase the distance* by 10-20 cm *each ti*me u*ntil the rate of photosynthesis* b*ecomes u*n*detect*able.

T*he source errors are very i*m*portant to* m*aintaining a high* accuracy. H*owever, the fluctuation in roo*m *temperature is not as i*m*portant as the other source errors as water is* mu*ch* l*ess expansive than air. T*h*erefore the syste*m *is very st*able *to s*mall *fluctuations in roo*m *temperature during the experi*m*ent.*

I *think that the source error that describes the* c*onsistency of the hydrogen* c*arbonate is the one that p*robably *affected* my *groups results the greatest.* W*e were fair*ly *careful with the other source errors* but *ideally we should have diluted the sodi*um *hydrogen* c*arbonate solution to roughly* 5% *to provide an* a*bundant supply of it.*

Other Investigations

The apparatus in the investigation can be used to study other factors on photosynthesis, such as:

1. Light Quality – by covering the table lamp with cellophane of different colours one can investigate which colours from the colour spectrum effect photosynthesis the most or least.

2. Carbon Dioxide Concentration – This can be varied by using sodium hydrogen carbonate solution of different concentrations (e.g. 0-5%.)

3. Temperature – by connecting the measuring cylinder to a pipette, the apparatus can be put into a water bath. The following temperature range can be studied: 20-50°C

Limiting Factors

The rate of photosynthesis is affected by three factors:

The Amount of Light (and the Wavelength)

The chlorophyll uses light energy to perform photosynthesis. It can only do it as fast as the light energy is arriving. Chlorophyll actually only absorbs the red and blue ends of the visible light spectrum, but not the green light in the middle, which is reflected back. This is why the plant looks green.

The Amount of Carbon Dioxide

CO_2 and water are the raw materials. Water is never really in short supply in a plant but only 0.003% of the air around is CO_2 so it's actually pretty scarce as far as plants are concerned.

The Temperature

Chlorophyll is like an enzyme in that it works best when it's warm but not too hot. The rate of photosynthesis depends on how active the chlorophyll enzymes are, (at 45°C the enzymes die and photosynthesis can no longer take place.)

At any given time one or the other of the above three factors will be the limiting factor which is keeping photosynthesis down at the rate it is.