Investigating the Compensation Point of Algae

Introduction

Pupils studying Higher Biology often have difficulty in understanding the concept of plant compensation points (the light level at which the rates of photosynthesis and respiration are equal). The difficulty probably arises from the much neglected fact that plants respire. Teaching and learning about plants tends to focus on photosynthesis, with the process of respiration often being ignored altogether. The experiment described here provides a method for exploring the light conditions under which either respiration or photosynthesis dominates.

Figure 1: Effects of different concentrations of co_2 on the colour of hydrogencarbonate indicator

Preparing for the Activity

Most materials required for this experiment are available in the SAPS photosynthesis kit (see SSERC Bulletin 219 [1]).

The alga, *Scenedesmus quadricauda*, is firstly immobilised using sodium alginate/calcium chloride mixtures (a detailed procedure for making algal balls can be found in SSERC Bulletin 219). The balls are then illuminated under different light intensities while immersed in hydrogencarbonate indicator. This indicator is very sensitive to changes in carbon dioxide levels and so can be used to estimate the concentration of dissolved CO_2. The colours displayed by hydrogencarbonate indicator at different concentrations of CO_2 are shown in **Figure 1** (ranging from pH = 7.6 (yellow) to pH = 9.2 (purple) in increments of 0.2). The indicator is orange in colour at normal atmospheric CO_2 levels.

Under conditions where the rate of photosynthesis is greater than the rate of respiration, the hydrogencarbonate indicator turns from orange through red to purple (i.e. there is a net loss of CO_2 from the solution and hence a rise in pH). The hydrogencarbonate

Figure 2: Variation of light intensity using (from left) clear plastic, 71%, 50%, 25%, 12,5% ND filters and aluminium foil

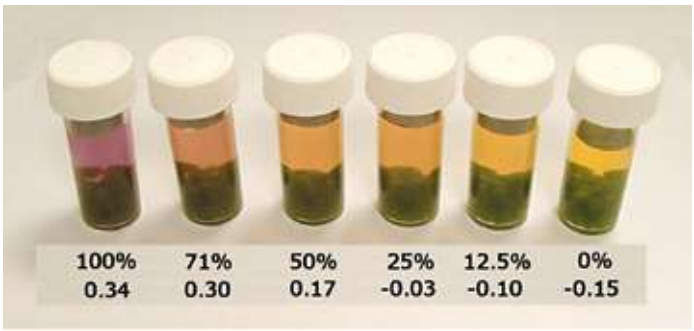

Figure 3: Appearance of hydrogencarbonate indicator after 50 minutes irradiation

indicator turns from orange to yellow under conditions where respiration dominates (i.e. there is a net increase of CO_2 in solution and hence a fall in pH).

Six Bijou bottles were set up each containing 50 algal balls and 4 cm^3 of hydrogencarbonate indicator maintained at atmospheric levels of CO_2 by aeration for one hour prior to the experiment. A further Bijou bottle containing only aerated hydrogencarbonate indicator was prepared and this bottle was designated as the blank.

Bijou cover	Clear plastic	ND=0.15	ND=0.30	ND=0.60	ND=0.90	Aluminium foil
Light transmitted through the ND filter (%)	100	71	50	25	12.5	0.0
Absorbance (550 nm) of sample after 50 minutes irradiation	0.34	0.30	0.17	-0.03	-0.10	-0.15

The intensity of light reaching the algal balls was varied by wrapping one layer of a different neutral density (ND) filter around four of the bottles. The neutral density filters allow a given proportion of light to pass through. One bottle was left uncovered to allow the maximum light intensity through. The final bottle was covered in aluminium foil to exclude all light (**Figure 2**). All bottles were then placed close to, and at the same distance from, a fluorescent tube. The heat given off by the fluorescent tube was negligible. After 50 minutes irradiation the absorbance of the six solutions was measured in a colorimeter[1] using a 550 nm filter. Results are shown in the table here and in **Figure 3**. The indicator solution used to zero the colorimeter was the blank described above.

Discussion

It can be seen that for three of the solutions the change in absorbance after 50 minutes irradiation was negative. This means that in these three solutions there had been a drop in pH and hence a net increase in CO_2 concentration. At these light intensities, respiration is therefore the dominant process. In the remaining three solutions the positive change in absorbance indicates that photosynthesis is the dominant process. The point at which there is no net change in the concentration of dissolved CO_2 is defined as the compensation point and can be estimated from plots such as **Figure 4**.

From the graph (**Figure 4**) the compensation point can be estimated as 29% of the maximum light intensity (see red arrow). At that light intensity the hydrogencarbonate indicator would not change colour as the processes of photosynthesis and respiration would be 'compensating' for one another i.e. the uptake of CO_2 by the plant through photosynthesis is exactly matched by its release through respiration. Therefore, at the compensation point there is no change in the concentration of dissolved CO_2, no change in pH, and therefore no change in indicator colour.

Further experimental details will appear on the SSERC website [2].

[1]The colorimeter used here was a WPACO75 which is capable of reading values below zero. We are aware that some older colorimeters in schools may not have this facility.

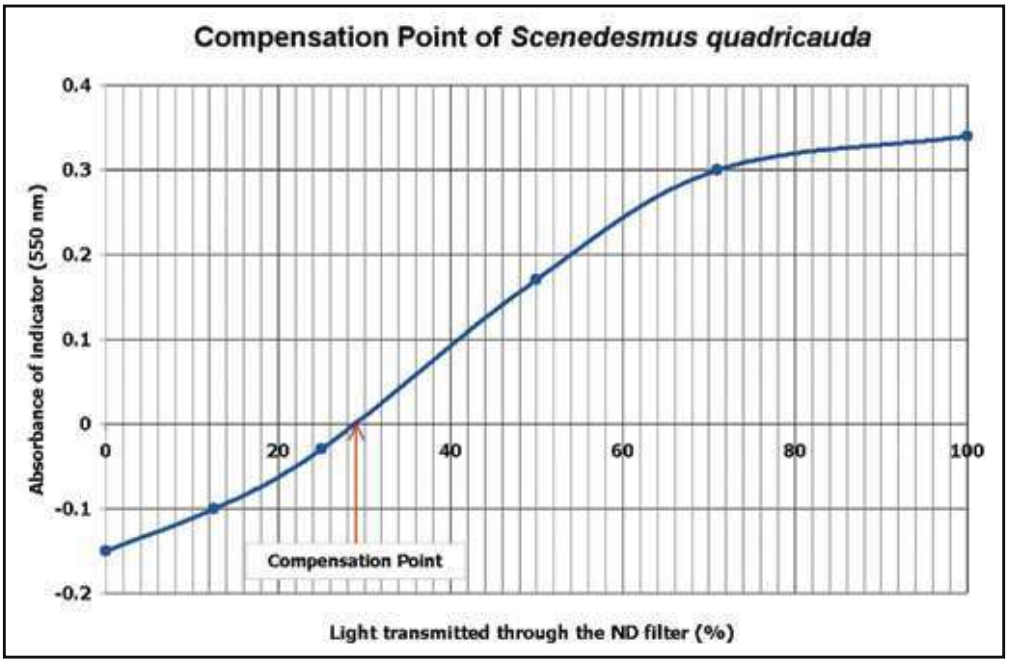

Figure 4: Effect of light intensity on the absorbance of hydrogencarbonate indicator solution

References

[1] - http://www.sserc.org.uk/members/SafetyNet/bulls/219/Biology.htm#The%20SAPS%20Photosynthesis%20Kit

[2] - http://www.sserc.org.uk/members/SafetyNet/bulls/225/Compensation_Point.htm