Photosynthesis: A study of CO_2 and O_2 changes with light

Technician and teacher sheet

Apparatus

CO_2 sensor

O_2 sensor

A large flat container with airtight lid, e.g. 2 litre capacity, 18cm diameter. 2 holes in lid for sensors

A number of freshly picked leaves.

Light source - broad spectrum, LED plant growth lamp.

Optional

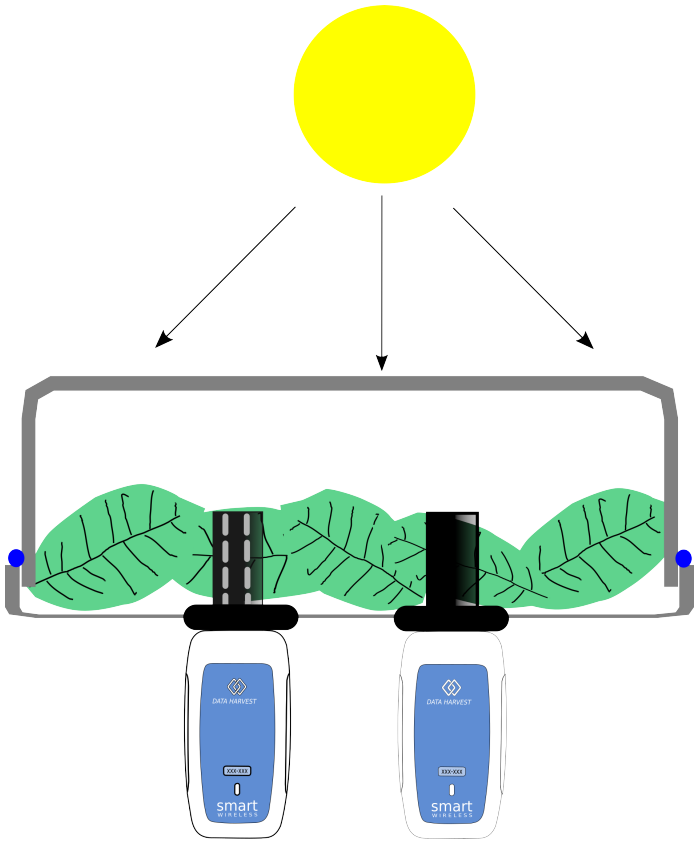
Light sensor

Data recording setup.

Length of recording will vary with set up, but a minimum of 5 minutes per light dark cycle

Intersample time 20 seconds.

Select Start to begin, stop after duration.



In the diagram the Data Harvest large environment chamber is being used. It has two holes designed to take the oxygen and carbon dioxide sensors. The holes have a rubber grommet fitted to ensure an airtight seal.

The whole apparatus is “upside down”. This allows the user to dribble a small amount of water between the lid and body of the chamber to make an effective air seal.

Making sure the apparatus is airtight did seem to be important in getting acceptable (obvious) data.

Oxygen is smaller molecule than carbon dioxide and is more difficult to control.

The leaves formed a single layer, with as little overlap as possible. Any leaves shaded will not photosynthesise and will add to the respiratory side of the equation.

The whole apparatus was mounted on a pair of Bunsen tripods with small wedges to level.

It can be an awkward practical to set up and get going, but the results are worth the effort. Once you have it working repeats are easier. Use fresh leaves.

Two key factors are;

1. The good seal around the lid and container and the seal around the sensors.
2. A good source of photosynthetic light. We found that a medium sized LED plant grow light gave good results. Beware of plants that give off heat and will damage the plant and bag.
3. The choice of plant material is also important, spinach leaves (from a supermarket) proved to be reliable as did basil leaves.

Practical notes

Use a mixture of leaf blade sizes to ensure the whole area of the base is covered. Avoid overlaps as much as possible.

Make sure the slots of the carbon dioxide sensor are below or within the sealing grommet, the oxygen sensor detects from the end only, push to give a good seal.

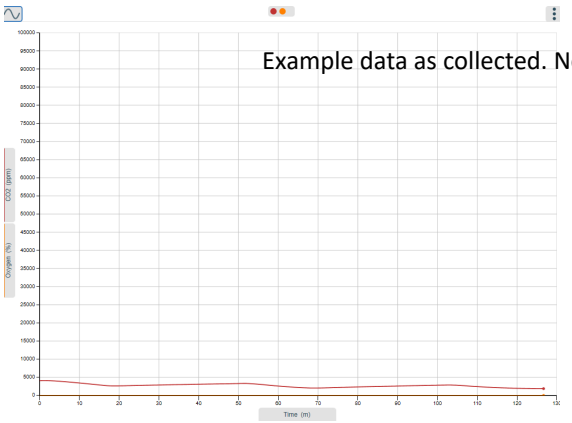
Use a good quality photosynthesis lamp. The internet is awash with lamp replacements and special panels, they are definitely worth the investment, especially if you have to work in a damp grey winter climate that demands teaching of plants in late November!!

SAPS (Schools and Plants in Science) offered the advice about the need to make a good seal and ensuring the leaves formed a single layer, it made a significant difference with the collected data.

Creating a seal around the apparatus was problematic, tape around the chamber seemed an obvious choice but made the apparatus unwieldy for changes etc. Placing the apparatus upside down and dribbling water into the space between the lid and base created a good seal. The other advantage of the apparatus being upside down was that the whole surface was available for illumination and the lamp could be place close to the apparatus to get maximal illumination.

The carbon dioxide measures in ppm and the oxygen in %. 1% = 10,000 ppm. The oxygen can resolve a 0.01% change this is the same as 100ppm change on the carbon dioxide. Consequentially the data from the oxygen sensor will have periods when it does not appear to change, its' data will appear stepped. Trends and changes will be clear to the observer and if t offends a rolling average can be applied to data to smooth it.

Use a longer intersample period to also give some smoothing to the data (you miss out collecting multiple same values).



Example data as collected. No scaling applied.

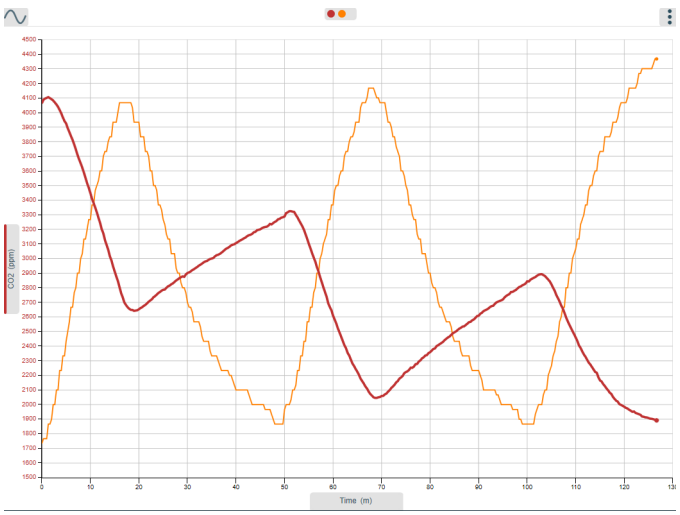
The same data after re-scaling)

The slightly steppy data is the change in oxygen.

The smoother data is the change in carbon dioxide.

The link between carbon dioxide changes and oxygen changes is clear to see. There are 3 periods of illumination. Data collection started from a period of darkness.

It is a very clear demonstration, the change is clear enough that a 5 minute collection could have been used.



Overall this is a practical worth the effort, but you need to be prepared (as with any living source material) for the unexpected.

Extension.

The apparatus once setup gives the potential for seeing what happens as you alter the light environment around the plant.

1. Change the light by placing a coloured filter between the light source and plant.
2. Compare different plants e.g. shade adapted and bright sun adapted.
3. Use a light sensor to measure light intensity and make sure the change in light was linear.

Software knowledge required.

1. Link sensor to software.
2. Set intersample period to 1 second from default - if recording for longer use a longer intersample.
3. Use min max to maximise the data for analysis.
4. Use independent axis for each sensor.
5. Use of values tool and or difference or gradient to quantify mass loss as a rate.
6. Use rolling average to smooth data.