2.2.4

Human intervention to promote crop growth in greenhouses

Background Information Newsletter for teachers

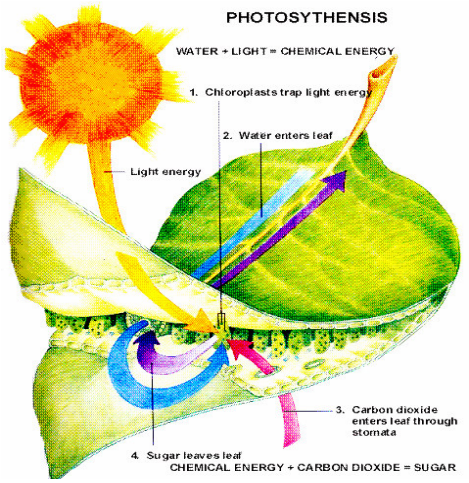
Syllabus requirement 2.2.4 P.18. Teacher Guidelines P.32
Human intervention: use of artificial light and carbon dioxide enrichment to promote crop growth in greenhouses

References:Michael Kent Advanced Biology
www.homeharvest .com
www.hortnet.co.nz
www.biologymad.com

Photosynthesis

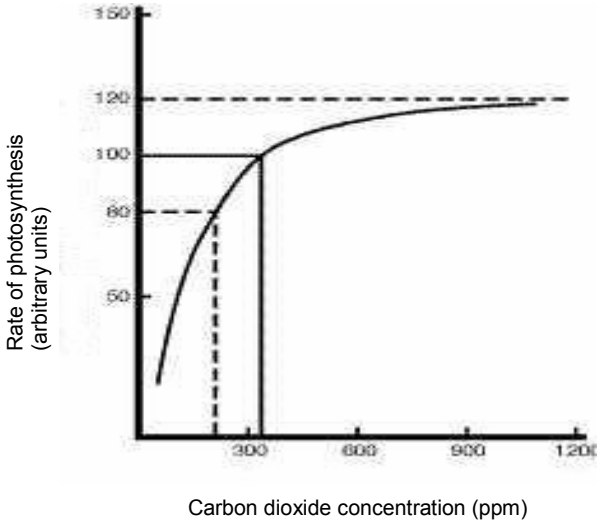
Plants absorb carbon dioxide from the surrounding air through the stomata in the leaves. Green plants use carbon dioxide and water in the presence of light to synthesise organic compounds . This process is known as Photosynthesis.

When the main growing conditions are satisfied plants will consume carbon dioxide at a high rate. Most plants receive far more water and energy in the form of sunshine than they can use. Increasing the carbon dioxide in the growing area will let the plant use the excess water and energy that is stored in the leaves . The result is a substantial increase in the growth rate of any plant that uses chlorophyll in the process of photosynthesis.



Effect of carbon dioxide on the rate of photosynthesis at different light intensities

The average carbon dioxide content of the atmosphere is about 0.034% (340ppm). Research has shown that photosynthesis is greatly increased when concentration of carbon dioxide in the surrounding air reaches 800 - 1000 ppm. When the supply of carbon dioxide is cut off, or reduced, the plant cannot utilise the suns energy fully and growth and development is curtailed. The better the light conditions, the more carbon dioxide will be absorbed by the plant. The more carbon dioxide is available, the more will be absorbed. This explains that photosynthesis and growth rate can be increased by supply of additional light and carbon dioxide to the greenhouse.



Greenhouses

One advantage of growing crops in greenhouses is that the environment inside the greenhouse can be controlled. Therefore successive generations of crops can be grown in the same environmental conditions that might not otherwise be feasible. Two of the primary variables that affect plant growth in greenhouses are carbon dioxide and light intensity.

When there is no additional carbon dioxide supplied and insufficient air refreshment in a greenhouse, the plants may consume more carbon dioxide than comes into the greenhouse. This makes the carbon dioxide level drop to below the normal outside level of 340 ppm. A crop in a tightly closed greenhouse will soon deplete the carbon dioxide concentration which reduces growth and production by slowing or stopping photosynthesis. Ventilation during the day can raise carbon dioxide levels but not sufficiently. Unless replaced, the carbon dioxide concentration will remain at the plants compensation point. This is the point at which the level of carbon dioxide produced from respiration equals the amount used for photosynthesis No growth occurs at this point.

Carbon Dioxide Enrichment

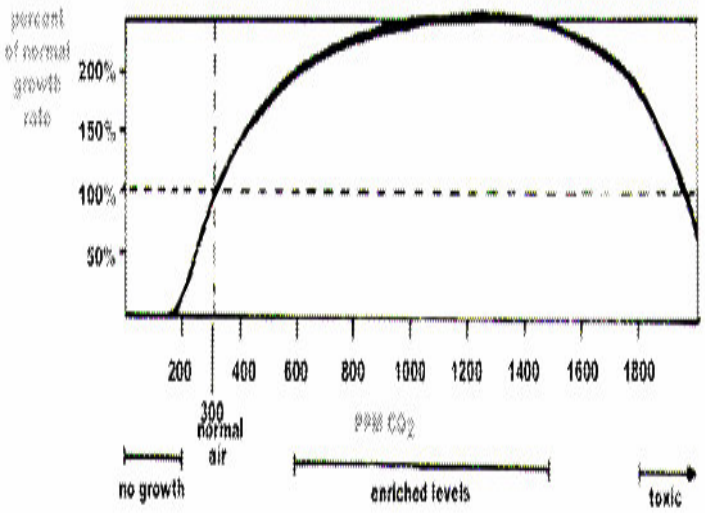
The level to which carbon dioxide should be raised depends on a number of factors. Enrichment should begin at sunrise and refrain during the hours of darkness.

For most crops saturation point will be reached between

1000 - 1400 ppm under ideal conditions.

Levels above this can cause growth to slow to below normal rates.

Tomatoe plants can benefit from the use of artificial light and carbon dioxide enrichment



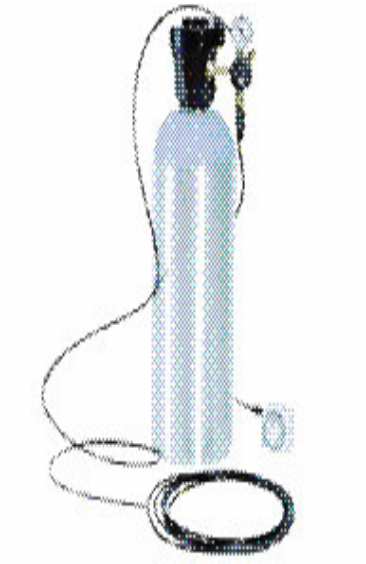
Carbon dioxide enrichment of 800 - 1000 ppm boosts the production of greenhouse crops. The following are some of the methods used for elevating the carbon dioxide concentration in greenhouses:

- Ventilation
- Using Carbon dioxide generators
- Inserting pure carbon dioxide gas
- Decomposition process generating carbon dioxide

Methods of Carbon Dioxide Enrichment

Ventilation can be used to maintain carbon dioxide concentrations at normal air levels. But even during ventilation, depletion may occur, because sometimes the plants consume more carbon dioxide than the ventilation brings in.

Carbon Dioxide Generators operate by burning carbonaceous fuels such as propane or natural gas. The gas can also be used to heat storage heaters which keeps the temperature up at night.



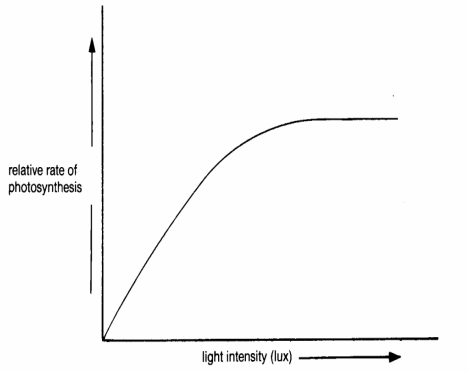
Pure Bottled Carbon Dioxide can be inserted from a pressurised cylinder. This is a more expensive but a safer option for plant enrichment. There are no toxic by products or additional heat produced.

Decomposition of organic matter by bacterial action releases carbon dioxide. This natural decay of dead plant and animal matter can be employed in greenhouses for little cost, but is odorous and unsanitary and so is not widely used.

Effect of light intensity on the rate of photosynthesis

The rate of photosynthesis is directly proportional to light intensity.

However beyond a certain light intensity the rate of photosynthesis levels off as the plant has become light saturated. Some other factor other than light e.g. carbon dioxide concentration is preventing further increase in the rate of photosynthesis.



Every plant has a light level where the rate of photosynthesis exactly equals the rate of respiration and no net exchange of gases takes place. This is known as the **Compensation Point** and is reached every day at dawn and dusk. During this time there is no net gain in sugars and so no growth.

Some plants (sun plants) have a high light value and others (shade plants) have a much lower value.

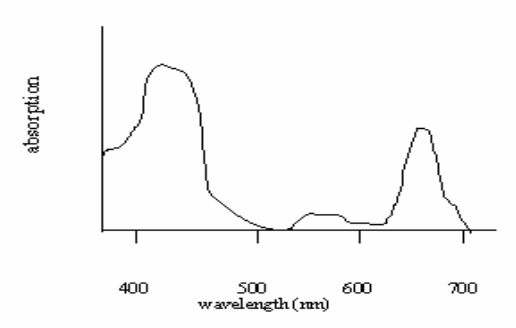
Light plays an important role in the production of plant material and the lack of light especially during the shorter and darker days of winter can be a major inhibiting factor in plant growth.

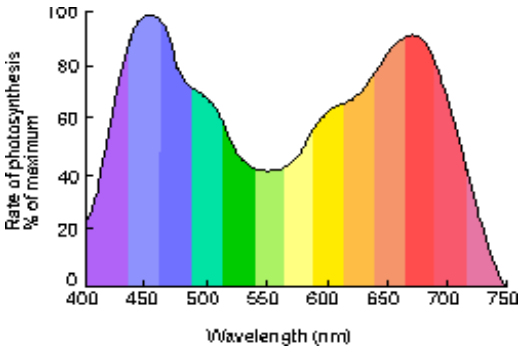
Use of artificial light to promote crop growth in greenhouses

Artificial light can be used in winter to boost natural daylight levels. Plants grow best when the days are about 16 - 18 hours long (summers in Ireland). In winter, with 8 hours or less of daylight, plants hardly grow at all. Plants generally do not like continuous light and need a 4 - 5 hour break from light. While the sun radiates the full spectrum (wavelength or colour of light) suitable for plant life, plants generally photosynthesise best at the blue and red ranges of the light spectrum.

An absorption spectrum is a graph (top right) showing the percentage absorption plotted against wavelength of light.

An action spectrum is a graph (bottom right) showing the rate of photosynthesis plotted against the wavelength of light. The similarity between the absorption spectrum and the action spectrum shows that red (650 - 700nm) and blue (400 - 450nm) wavelengths, which are absorbed most strongly, are also the wavelengths which stimulate photosynthesis





BRAIN TEASER

Suggest a reason why during the winter months, plants near the middle of the greenhouse beds generally do not grow as rapidly as plants at the edge?

Note:

Incadescent bulbs like those used in the home are not designed for plant growing as they do not supply a full enough spectrum to be adequate for most growing needs. A better alternative for beginners is to use fluorescent lights.

Types of artificial light

High Intensity Discharge Lights (HID)

HID lights flow electricity through vapourised gas under high pressure. These are expensive and are generally only used by commercial growers. There are two main types:

High Pressure Sodium lamps emit an orange red glow. This band of light triggers hormones in plants to increase flowering/budding . These are the best lights available for secondary or supplementary lighting used in conjunction with natural sunlight.

Metal Halide bulbs produce an abundance of light in the blue spectrum. This colour light promotes plant growth and is excellent for green leafy growth and can be used from seed germination to bloom. It is the best type of light to be used as a primary light source if there is little or no natural sunlight available.

Conclusion

Carbon dioxide and the use of artificial light have been shown to promote crop growth in greenhouses. However, enhancing environmental factors has cost implications. Some methods are more practical than others, some less expensive and maximum profit will be achieved when there is a balance between increasing essential raw materials and increased productivity.