

## 3.4

### Limiting factors

Qualities which impair photosynthetic performance

#### Limiting factors

When there are a number of factors which contribute towards a process and control its efficiency, the factor which is working at the least favourable level will be the **limiting factor** of the process. In photosynthesis, the limiting factor is the quality or condition of the environment which is least favourable and therefore acts as a constraint on the rate of photosynthesis. For example:

- on a warm night, the light intensity is the limiting factor (the temperature is sufficient but there is no light)
- on a cold, frosty morning, the temperature is the limiting factor (the temperature impairs the photosynthetic rate)
- on a normal, sunny day the carbon dioxide concentration in the atmosphere may be the limiting factor

The maxima tend to be around 30°C (temperature), 0.2% - 0.5% carbon dioxide concentration and bright sunlight during the day.

#### Effect of temperature on photosynthesis

Whilst the light-dependent stage of photosynthesis is not very much at all affected by the temperature of the surrounding environment, this is crucial during the Calvin cycle, where there is fundamental importance on enzyme action. As you well know, temperatures which fluctuate cause poor enzyme performance – and those which are too high will denature enzymes beyond repair.

The other problem, however, related with temperature, is that an increase in temperature will cause a plant to lose more water through the stomata. This leads to a stress response whereby the stomata close, which limits the availability of carbon dioxide as well as losing water.

#### Effect of carbon dioxide on photosynthesis

Generally speaking, an increase in carbon dioxide availability means an increase in the rate of photosynthesis. Our atmosphere has a CO<sub>2</sub> concentration of approximately 0.03% - 0.06% and the rate of photosynthesis will continue to increase with carbon dioxide concentration, but only up until a certain point. At around 0.5% concentrated, the rate stops increasing because it cannot physically increase any further as the other conditions (light and temperature) become limiting factors themselves.

Therefore, the limiting factor graph looks as shown.

#### Effect of light intensity on photosynthesis

When light intensity is the limiting factor on the rate of photosynthesis, the rate is directly proportional to an increase or decrease in light intensity. As the light increases, so does the rate of photosynthesis. This is because more light means:

- ✓ more stomata are opened, so more carbon dioxide can enter
- ✓ more light can be trapped by chlorophyll to excite electrons during the light-dependent stage
- ✓ more efficient photolysis of water during the light-dependent stage

