Well done 22/25 Accurate, well expressed. AO3 (not on spec) would have got an even higher mark.

Arran Horne

The Importance of Limiting Factors in Photosynthesis

~~-light~~ -mineral ~~ions~~ ions
~~-CO_2~~ - ~~temperature~~

Limiting factors are (environmental) variables that will decrease the rate of photosynthesis if they are too small. ~~The most productive area therefore will have all these factors~~ they can be internal eg chloroplast nos.

Concentration of carbon dioxide can be a limiting factor. Carbon dioxide is fixed during the light-independent reaction. The enzyme Rubisco adds carbon dioxide to ribulose biphosphate in a carboxylation reaction, which then splits into two ~~glycerate~~ glycerate-3-phosphate molecules. If carbon dioxide concentration becomes too low, it limits the rate of carboxylation, ~~and~~ thus slowing the rate of the overall light-independent reaction. This means that less triose phosphate is produced, meaning less organic molecules such as glucose are created. This is important in agriculture, especially in greenhouses, where the other conditions are controlled so they are the optimum level, meaning carbon dioxide is the limiting factor, which reduces the amount of organic compounds produced (i.e the biomass) reducing the yield + therefore profit. ✓✓

Mineral ions, ~~and other ions~~ can become a limiting factor. Magnesium ions are required by plants to create chlorophyll, where Mg^{2+} is the central metal ion surrounded by protein molecules. If a plant is deficient in magnesium ions, it cannot produce as many chlorophyll molecules, reducing the rate of photoionisation in a chloroplast + therefore the overall rate of photosynthesis. Nitrate ions also can be considered as a limiting factor. NO_3^- ions are used in ~~protein~~ amino acid synthesis, which are required to make proteins. Proteins are involved at every stage of ~~photo~~ photosynthesis, e.g as carrier proteins in the electron transport chains or enzymes such as Rubisco in the light independent reaction. Since proteins ✓✓

are so important to photosynthesis, when plants are defficient in nitrates the rate of photosynthesis may decrease. Mineral ions are so important for plant growth + photosynthesis that farmers often add fertilisers to fields in intensive farming, in order to increase production + therefore yield. The importance of mineral ions can be seen in eutrophication, where excess nitrates + other ions from run-off fertilisers cause algal blooms in still water, which shows a dramatic, unsustainable increase in productivity, to the expense of much of the fresh water organisms

Light is a limiting factor. Light on hitting chlorophyll molecules, causes the electrons to become excited in a process called photoionisation. This causes the high energy electrons to move into the electron transport chain. As they move down the chain, the electrons also move down energy levels, providing the energy for ATP synthesis via chemiosmosis of hydrogen ions. Light is also required for the photolysis of water, where water is split into hydrogen ions, which reduce the co-enzyme NADP, electrons which replace those lost in the chlorophyll, and oxygen as a waste product. Both NADPH and ATP are needed in the light independent reaction. Therefore if light intensity decreases too much, the rate of photoionisation + photolysis will also decrease, limiting the rate of reaction. Since respiration is constant, farmers can increase yields by supplying plants with a constant source of light e.g a lamp all day + night, which will increase the gross primary production + therefore net primary production + yield.

Temperature also has an effect on photosynthetic rates. As temperature increases, the kinetic energy of substrates (eg ribulose phosphate) increases, which means there are more collisions with enzymes, forming more enzyme-substrate complexes and therefore increasing rate. As the light independent reaction is enzyme controlled, increasing the temperature also increases the rate of photosynthesis. However if temperature gets too high, the enzymes (proteins) involved in photosynthesis begin to denature, changing the shape of the active site, meaning no more enzyme-substrate complexes can form, decreasing the rate of photosynthesis. It is therefore important to grow plants at the optimum temperature, where kinetic energy is high, but enzymes aren't denatured, in order to avoid