2024 Bi H2 Q9

Section: Sustainability and Interdependence

Topic: Food Supply

Question Summary

This question investigates how adding arsenic-reducing bacteria (ARB) to contaminated soil affects pigment content (chlorophyll and carotenoids) in crop plants. It requires reading a graph, expressing values as a ratio, and explaining the role of carotenoids and light absorption in photosynthesis and ATP production.

Worked Solution

- (a)(i) From the graph: carotenoid content (mg per g) is approximately 1.2 for soil with no arsenic, 0.4 for soil with arsenic, and 0.8 for soil with arsenic + ARB. The simplest whole number ratio is 1.2 : 0.4 : 0.8 -> 3 : 1 : 2.
- (a)(ii) The carotenoid and chlorophyll contents in soil with arsenic + ARB are still lower than in soil with no arsenic. This shows that some arsenic remains, reducing pigment content - not all arsenic has been broken down by ARB.
- (a)(iii) Carotenoids absorb light energy in wavelengths that chlorophyll cannot absorb efficiently. They transfer this energy to chlorophyll a, increasing the range of light used for photosynthesis and hence increasing the overall rate of photosynthesis.

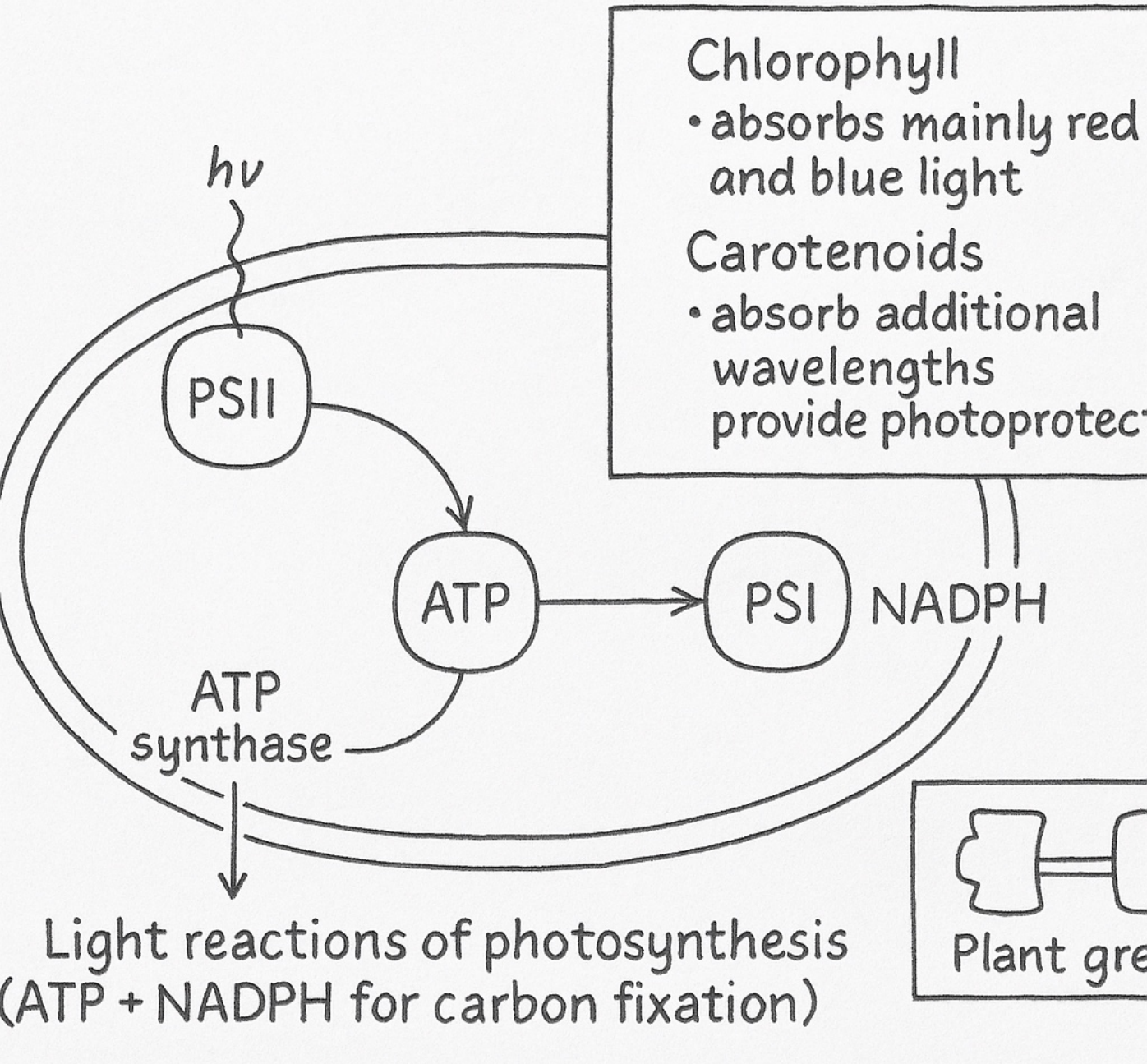
- (b) Absorbed light energy excites electrons in chlorophyll molecules within photosystems. The electrons are passed along an electron transport chain in the thylakoid membrane, releasing energy. This energy is used to pump hydrogen ions (H+) across the membrane into the thylakoid space. The resulting hydrogen ion gradient drives ATP synthase to produce ATP from ADP and inorganic phosphate. ATP is then used in the carbon fixation (Calvin) cycle to convert CO2 into carbohydrate.

Final Answer

-> (a)(i) 3 : 1 : 2
-> (a)(ii) Pigment levels still below control show not all arsenic broken down
-> (a)(iii) Carotenoids extend absorption range -> increase photosynthesis
-> (b) Light energy excites electrons -> ETC -> H+ gradient -> ATP synthase -> ATP for carbon fixation

Revision Tips

- Always quote values and calculate ratios directly from graphs.
- Carotenoids protect chlorophyll from photo-oxidation as well as widening absorption.
- Light reactions provide ATP and NADPH for the Calvin cycle.
- Pigment content directly influences photosynthetic rate and crop productivity.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• absorbs mainly red and blue light
Carotenoids
• absorb additional wavelengths provide photoprotec
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PSII
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Light reactions of photosynthesis
(ATP + NADPH for carbon fixation)
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