FACTORS AFFECTING PHOTOSYNTHESIS

The proficiency of photosynthesis, a paramount determinant of plant yield, is intricately orchestrated by an interplay of external and internal factors. Understanding this intricate dance requires an exploration of both realms, unraveling the profound influence of sunlight, temperature, carbon dioxide concentration, and water alongside the nuanced roles played by plant-specific factors.

Light

- **Light Intensity:** The relationship between incident light and CO_2 fixation manifests a linear correlation at lower intensities. However, at higher intensities, the rate plateaus, governed by other limiting factors. Light saturation occurs at 10 percent of total sunlight, and excessive light can lead to chlorophyll breakdown, diminishing photosynthesis.

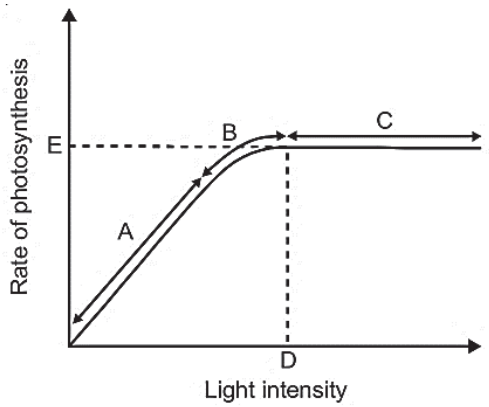

Fig. : Graph of light intensity on the rate of photosynthesis

- **Light Quality:** Photosynthetically active radiation (PAR), found between 400-700 nm wavelengths, dictates optimal photosynthesis. Red and blue light exhibit maximum efficiency, while green light triggers minimal photosynthesis.
- **Duration of Light:** While light duration doesn't impact photosynthesis rate directly, it does exert influence on overall photosynthesis.

Carbon Dioxide Concentration:

- A pivotal limiting factor, the concentration of atmospheric CO_2 (0.03-0.04 percent) falls below optimum levels for photosynthesis. Moderate increases up to 0.05 percent enhance photosynthesis, but excessive levels prove detrimental. C_3 and C_4 plants respond differently to CO_2 concentration, with C_3 showing saturation at about 360 μIL^{-1} and C_4 exhibiting saturation beyond 450 μIL^{-1}.

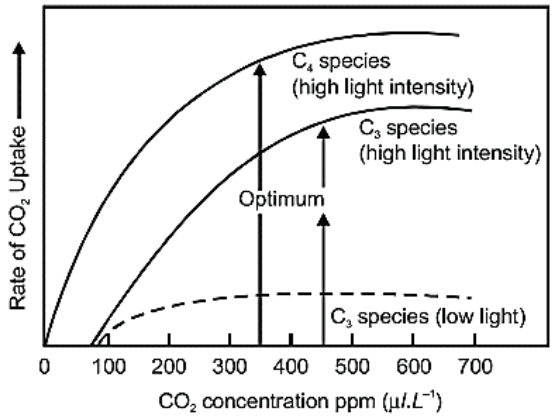

Fig. : Photosynthetic response of C_3 and C_4 plants to CO_2 concentration

Temperature

- Photosynthesis spans a broad temperature range, with light reactions being less temperature-sensitive compared to dark reactions. Temperature optima vary based on plant habitat, with tropical plants favoring higher temperatures. C_1 plants respond favorably to elevated temperatures, showcasing higher photosynthetic rates, while C_3 plants exhibit a lower temperature optimum (20-25°C).

Water

- Although photosynthesis utilizes less than 1% of absorbed water, water stress induces stomatal closure, reducing CO_2 availability. Wilting caused by water stress diminishes leaf surface area, impacting metabolic activity more indirectly than directly influencing photosynthesis.
- **Plant Factors Affecting Photosynthesis:** Plant-specific factors, including the number, size, age, and orientation of leaves, mesophyll cells, chloroplasts, internal CO_2 concentration, and chlorophyll amount, act as pivotal influencers. These factors, shaped by genetic predisposition and plant growth, collectively contribute to the orchestration of photosynthesis.
- **Blackman's Law of Limiting Factors:** Proposed by Blackman in 1905, this law emphasizes that when multiple factors influence a biochemical process, the rate is determined by the factor closest to its minimal value. Illustratively, if light intensity reaches a point where 5 mg of CO_2 is utilized per hour in photosynthesis, further CO_2 supply won't impact the rate, making light the limiting factor.

In the intricate symphony of photosynthesis, these factors intertwine, shaping the destiny of plant productivity and yield.

Internal Factors Influencing Photosynthesis

Photosynthesis undergoes intricate regulation by an array of internal (plant) factors, each contributing to the multifaceted symphony of this vital process. These internal factors include the numerical abundance, dimensions, maturity, and alignment of leaves, as well as the characteristics of mesophyll cells and chloroplasts. Additionally, internal CO_2 concentration and the chlorophyll content wield significant influence over the photosynthetic machinery. These plant-specific factors operate within the framework of genetic predisposition and the developmental trajectory of the plant.

- **Chlorophyll:** Among the internal factors, chlorophyll stands as the paramount player, as it exclusively captures light energy, making it indispensable for photosynthesis. The absence of chlorophyll results in a cessation of photosynthesis, elucidating why non-green sections in variegated leaves, such as those seen in Croton, lack starch. The photosynthetic or assimilation number quantifies the relationship

between chlorophyll and photosynthesis, representing the amount of carbon dioxide (in grams) assimilated by one gram of chlorophyll per hour. Emerson's (1929) observations underscore a direct correlation between chlorophyll content and the photosynthetic rate. When all other conducive factors align, an augmented chlorophyll presence translates into an elevation in photosynthesis.

- **Photosynthetic Products:** As photosynthetic end products accumulate within mesophyll cells, a counterintuitive trend emerges—there is a decline in their photosynthetic rate. This paradoxical effect arises due to the heightened concentration of these products within the cells, subsequently accelerating the rate of cellular respiration.
- Within the intricate dance of internal factors, chlorophyll emerges as the protagonist, orchestrating the capture of light energy and serving as a linchpin for the entire photosynthetic process. The nuanced interplay of these internal factors provides a deeper understanding of the dynamic regulation of photosynthesis.