PHOTOSYNTHESIS IN HIGHER PLANTS
FACTORS AFFECTING PHOTOSYNTHESIS

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- **Sachs (1860)** proposed concept of cardinal point. According to this, factor affecting any physiological reaction has 3-main values-

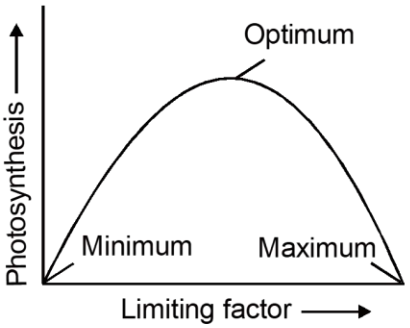
(a) **Minimum:** Physiological reaction does not occur if the value is below minimum.

(b) **Optimum:** At optimum value, the reaction can occur at the maximum speed for an indefinite period.

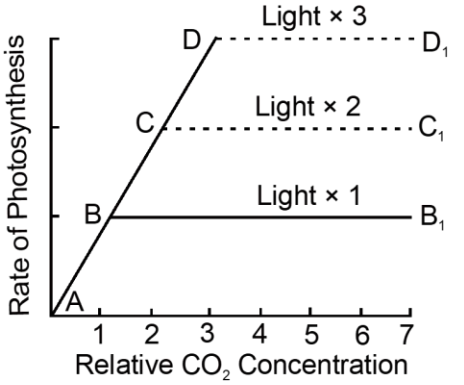
(c) **Maximum:** The value beyond maximum, the activity stops.

BLACKMAN'S LAW OF LIMITING FACTOR:

- **If a chemical process is affected by more than one factor, then its rate will be determined by the factor which is nearest to its minimal value: it is the factor which directly affects the process if its quantity is changed.**



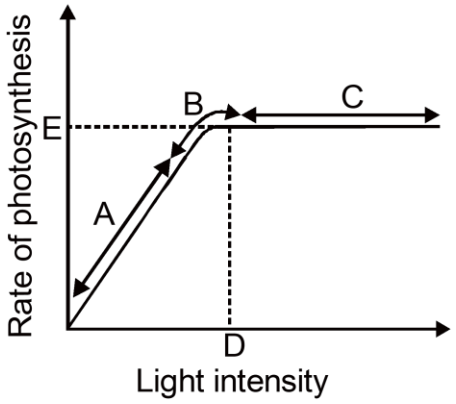
Concept of three Cardinal points



Representation of Blackman's Law of Limiting factor

EXTERNAL FACTORS:

1. Light:



- We need to distinguish between light quality, light intensity and the duration of exposure to light, while discussing light as a factor that affects photosynthesis.
- There is a linear relationship between incident light and CO_2 fixation rates at low light intensities.
- At higher light intensities, gradually the rate does not show further increase as other factors become limiting. What is interesting to note is that light saturation occurs at 10 per cent of the full sunlight.
- Hence, except for plants in shade or in dense forests, light is rarely a limiting factor in nature. Increase in incident light beyond a point causes the breakdown of chlorophyll and a decrease in photosynthesis.

2. CO_2:

- The normal concentration of CO_2 is **0.36% (360 ppm)** in atmosphere. If the CO_2 concentration increases the rate of photosynthesis also increases but in the presence of higher concentration of CO_2 it is declined.
- The C_3 and C_4 plants respond differently to CO_2 concentrations. At low light conditions neither group responds to high CO_2 conditions.
- At high light intensities, both C_3 and C_4 plants show increase in the rates of photosynthesis.

- What is important to note is that the C_4 plants show saturation at about 360 µlL-1 while C_3 responds to increased CO_2 concentration and saturation is seen only beyond 450 μlL^{-1}. Thus, current availability of CO_2 levels is limiting to the C_3 plants.
- The fact that C_3 plants respond to higher CO_2 concentration by showing increased rates of photosynthesis leading to higher productivity has been used for some greenhouse crops such as tomatoes and bell pepper. They are allowed to grow in carbon dioxide enriched atmosphere that leads to higher yields.
- **CO_2 compensation point:** It is a point at which amount of CO_2 consumption in photosynthesis is equal to the amount of CO_2 liberation in Respiration. It is **25–100 ppm for C_3-plants and 0-10 ppm for C_4 plants**.

3. Temperature:

- The dark reactions being enzymatic are temperature controlled. Though the light reactions are also temperature sensitive they are affected to a much lesser extent. The C_4 plants respond to higher temperatures and show higher rate of photosynthesis while C_3 plants have a much lower temperature optimum.
- The temperature optimum for photosynthesis of different plants also depends on the habitat that they are adapted to. Tropical plants have a higher temperature optimum than the plants adapted to temperate climates.

4. **O_2:** The rate of photosynthesis is declined in the presence of higher concentration of O_2 in C_3 plants due to photorespiration. It is called **Warburg effect.**

5. Water:

- Even though water is one of the reactants in the light reaction, the effect of water as a factor is more through its effect on the plant, rather than directly on photosynthesis.
- Water stress causes the stomata to close hence reducing the CO_2 availability. Besides, water stress also makes leaves wilt, thus, reducing the surface area of the leaves and their metabolic activity as well.

Internal factors:

1. Chlorophyll
2. Anatomy of leaf
3. Hydration of protoplasm
4. Accumulation of photosynthetic product
5. Age of the plant.