TRANSPIRATION

- Entry of water into plants, its movement in the plant body and its movement from the plant into the atmosphere ensure proper operation of SPAC in plants.
- Only **5%** of absorbed water is utilised by plant in its metabolic activities. Major part of remaining water is lost into the atmosphere in the form of transpiration.
- Loss of water in the form of vapour from aerial parts of the plant into the atmosphere is called as **Transpiration**. It mainly takes place through leaves.
- Wheat plants transpire **3000** litres of water for the production of **1 kg** of grains.
- Corn plants of one-hectare area transpire **40, 450** litres of water per day.
- Loss of water in the form of vapour from soil or water body into the atmosphere is called as evaporation.
- Transpiration has resemblance with evaporation but there is involvement of plant factor in transpiration. Hence transpiration is a **biological activity** in which the physical process **evaporation is** involved.
- It is driven by the difference in **water potential**. It can be demonstrated by **Bell-jar** experiment.

Types of transpiration

- It is of **3** types known as **Stomatal, Cuticular** and **Lenticular** transpirations.
- Transpiration through stomata present on leaves, young stems, flowers and fruits is called as **Stomatal transpiration**. It accounts for **80 – 95%** of total transpiration.
- **Cuticular transpiration** takes place through cuticle present on aerial parts of the plant body. It accounts for **5–10%** of total transpiration.
- Transpiration through lenticels of woody parts of plant is called as **Lenticular transpiration**. It accounts for **1 – 2%** of total transpiration.

Structure of Stomata

- The tiny pores present in the epidermis of aerial plant parts are called as stomata. These are abundantly present in the epidermis of leaf.
- Stomata account for **1 – 2%** of total leaf area.
- Each stoma is surrounded by two specialised smaller epidermal cells with chloroplasts known as **Guard cells**. These are **kidney** shaped in dicots and **dumb-bell** shaped in monocots. These have uneven thickened cell walls.
- The region of cell wall of dicot guard cell present nearer to the pore is more densely thickened and the region away from it is less densely thickened.
- In Monocot guard cell the ends are bulged and thin walled and the middle narrow region is thick walled.
- This uneven thickness of cell wall helps in opening and closing of stomata.
- The epidermal cells present around the guard cells are known as subsidiary cells. These have intermediate size.
- Guard cells, subsidiary cells and the stoma together called as Stomatal apparatus.

Mechanism of Stomatal Opening and Closing

- Stoma is turgor operated valve. Opening and closing of stomata is dependent on the size and shape of guard cells.
- In adequate water supply to leaf and not extreme leaf temperatures, light promotes stomatal opening and darkness stomatal closure.
- In *Photoactive* plants, stomata are opened during day time and closed during night time.
- In *scotoactive* plants like *Bryophyllum* (succulent xerophytes), stomata are opened during night and closed during day.
- **K^+ pump** hypothesis explains stomatal movement and solute levels.
- Stomata movements are closely associated with metabolic changes.

Opening of Stomata

- When plants are exposed to light, the ATP generated during photophosphorylation and Respiration of guard cells are utilised for the influx of K^+ ions and efflux of H^+ ions. Cl^- accompany the K^+ into the guard cells in response to electrical differential created by the K^+ intake.
- During daytime organic acids, particularly **malic acid** is produced from starch. It dissociates into **Malate ions** and **protons**. Protons are expelled into the subsidiary cells and malate ions help in balancing the **K^+** ions along with Cl^- ions.
- Presence of K^+, Cl^- and malate ions in the guard cell decreases the water potential. Hence the water present in the subsidiary cells enters into the guard cell. Turgor pressure of the guard cell is increased and becomes turgid.
- The distal wall of kidney shaped guard cell becomes more and more convex and draws the inner walls away from each other. This results in the opening of stomata.

- In monocots the ends of guard cells become more bulged and draw apart the middle thickened region of cells away from each other. It results in opening of stomata.

Closing of Stomata

- The proton pump is switched off during dark.
- The K^+, Cl^- and malate ions move passively into the subsidiary cells from guard cells. H^+ ions move into guard cells.
- Some amount malate remained in the guard cells is oxidised in respiration.
- This results in increase in water potential and exit of water of guard cell into the surrounding cells. Guard cells regain their normal condition and become flaccid. They loose turgor and stomata are closed.
- Stomata are opened at high pH and closed at low pH.

Factors affecting transpiration

- Transpiration is influenced by several environmental and plant factors.

A. Environmental Factors (external Factors)

1. Light

- The influence of light is three fold. Light controls stomatal movement, increases leaf temparature and permeability of cell membrane.
- With increase in light intensity, the rate of transpiration also increases.

2. Humidity of Air

- The actual amount of water vapour present in the atmosphere is called as **Absolute Humidity**.
- The rate of transpiration is dependent on the difference of vapour pressure between the atmosphere and vapour pressure in the leaf.
- High vapour pressure in the atmosphere decreases the rate of transpiration and low vapour pressure increases.

3. Temperature

- Up to certain physiological range, with increase in temperature, the transpiration rate also increases. This is due to more vapour pressure in the leaf than in the atmosphere.
- At very low and high temperatures, the stomata are closed.

4. Wind

- Its influence on transpiration is **complex.**
- In suddenly wind-exposed plant, initially the transpiration increases and then decreases.
- Wind removes the water vapour layer collected over leaf surface and it results in increase in transpiration.
- A gentle breeze increases transpiration. At high wind velocity, there is initial increase in transpiration and later followed by stomatal closure.

5. Atmospheric pressure

- With decrease in atmospheric pressure, the rate of transpiration increases.
- Reduction in atmospheric pressure shows low density of atmosphere and thus permits more rapid diffusion of water vapour.
- Trees growing at high altitudes show high rate of transpiration than plants growing in plains.

6. Availability of soil water

- With decrease in the amount of soil water the transpiration rate also decreases.
- This is due to flaccidity of guard cells.

B. Plant factors (Internal factors)

Root – Shoot ratio

- Transpiration rate increases with increase in root-shoot ratio. If more absorbing system is present, then there is availability of more water to the plant for transpiration.
- **Sorghum** shows more transpiration than **Maize** due to high shoot-root ratio.

Leaf area

- With increase in leaf area, the transpiration magnitude also increases. However there is no relationship between the leaf area and transpiration.
- In huge plants, the amount of transpiration per plant may be higher than small plants but the transpiration per unit area of leaf is less when compared to small plants.
- Number of stomata per unit area of leaf is called as **Stomatal frequency.**

Leaf structure

- Xerophytes show thick cuticle, thick walled epidermis, Sclerenchymatous hypodermis, hairy nature, reduction in leaf size, multiple hypodermis, well developed palisade and poorly developed spongy tissue and sunken stomata to minimise transpiration.

Antitranspirants

- Substances that promote stomatal closure to reduce transpiration are called as antitranspirants.
- **Colourless plastics, silicon oils, low viscosity waxes** bring about stomatal closure without affecting gaseous exchange.

Metabolic inhibitors:

- **CO_2** at high concentrations promotes stomatal closure.
- The fungicide, **Phenyl Mercuric Acetate** (PMA), is widely used as antitranspirant to minimise transpiration.
- ABA is natural antitranspirant. Whenever the plant experiences water stress, ABA is synthesised in the leaves and it promotes stomatal closure.
- In water stress conditions, ABA content of leaf increases and it promotes stomatal closure and then decreases transpiration.
- **ABA** is natural antitranspirant.
- **Asprin (**acetyl salicylic acid**)**

Film forming antipesirents:

- That forms a thin coating or film around the leaf
- They allow O_2 and CO_2 for photosynthesis and respiration but stops transpiration
- Eg: **Colourless plastics, silicon oils, low viscosity waxes**

Ideal antiperspirant's characteristics:

- Non-toxicity
- Non-permanent damage to stomata
- Specific effects on guard cells
- Low cost

Importance of Transpiration

Uses

- It helps in sending out excessively absorbed water by plants.
- It helps in absorption and distribution of water in plants.
- The force developed due to transpiration is called as transpiration pull. It helps in ascent of sap.
- It helps in absorption and transport of mineral salts in plants.
- It plays an indirect role in the translocation of organic solutes.
- It regulates the leaf as well as other parts temperature.

Disadvantages

- Most of the absorbed water is lost without being utilised.
- If transpiration rates exceed water absorption rates the leaf cells loose turgor and show wilting. Due to this the physiological processes of plants are impaired.
- Deciduous trees shed their leaves during dry spell to avoid transpiration to protect the plant. Xerophytes show modifications of their leaves and other parts to minimise transpiration.
- Since transpiration shows both advantages and disadvantages to plants, **Curtis** described transpiration as **necessary evil in plants.**