TRANSLOCATION OF ORGANIC SOLUTES

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The movement of organic food material or solutes from one place to another in higher plants is called translocation of organic solutes. Translocation of organic solutes always takes place from the region of higher concentration called source to the region of lower concentration called the sink.

Direction of translocation

Downward ward translocation – Food matter is mostly prepared in green leaves of the plant and from there it is translocated downwards to different plant parts for storage and utilization in the metabolic process.

Upward translocation – It takes place mainly in germinating seeds, growing buds, developing leaves, opening flowers, and developing fruits.

Radial translocation – Radial translocation of organic solutes known to takes place through the cells of medullary rays.

PATH OF TRANSLOCATION

DOWNWARD TRANSLOCATION OF ORGANIC SOLUTES

Evidence of downward translocation of organic solutes through the phloem

1. **Elimination of tissues** – **Dixon (1924**) had established that **Ascent of sap** takes place through xylem so, The possibility of **organic solutes translocation** through it is very unlikely. The cells of ground tissue are structurally neither suitable nor they contain a transportable form of organic solutes. Thus **phloem** remains the only tissue that can carry on the organic solution.
2. **Structure and distribution of phloem** - The structure of the phloem strongly suggests that it is well adapted for conduction. The end to end arrangement of sieve tubes in phloem whose cross walls are perforated by **sieve pores**, well connected by **plasmodesmata** form a continuous system throughout the plant best suited for **translocation.**
3. **Effect of blocking of phloem** – The translocation process stopped when sieve tubes are blocked by callose.

4. **Chemical analysis of phloem sap** – A series of an experiment by **Mason** and **Maskell (1928-34)** showed that cells of phloem contain a large quantity of sugar in the soluble form.
5. **Isotopic study – Rabideau, and Barr (1945)** observed that when **carbon dioxide** labeled with **isotopic carbon** is supplied to a photosynthesizing plant translocation of carbohydrates labeled with **isotopic Carbon,** takes place through the stem. But when the stem segment including phloem was killed by hot wax, no movement of such isotopic substance was detected.
6. **Ringing Experiment** – This experiment was proved to be very conclusive. When a ring of bark including **phloem** removed from a dicot stem the downward translocation immediately stopped causing the accumulation of food material above the ring and it swelled while the lower parts of the plant below the ring dry up.

MECHANISM OF TRANSLOCATION THROUGH PHLOEM:

Many theories have been given to explain the mechanism of phloem conduction, among them **MUNCH (1930)** hypothesis was most convincing

MUNCH'S MASS FLOW OR PRESSURE FLOW HYPOTHESIS

Munch (1930) assumes that the protoplasm of the sieve tube is connected by **plasmodesmata** forming a continuous system, the **symplast**. According to this hypothesis when carbohydrate (sugar) is manufactured in the leaf by the process of photosynthesis, the **osmotic pressure** and **suction pressure** of the leaf mesophyll cells increased, that cause absorption of water from the xylem element of the leaf. Due to the absorption of water, the **turgor pressure** of the leaf cells increased that pressure force the cell solution down the sieve tubes. On the other hand, in the cells of root or the storage organ food is either consumed or converted into an insoluble form that decreased their osmotic pressure and turgor pressure. Hence the soluble organic solutes begin to flow **en mass** from highly **turgid mesophyll cells** down to the cells of stem and root through phloem under the gradient of **turgor pressure**. In the root cells, the **osmotic pressure** is low so the water **diffuses out** from the phloem into the xylem vessels and translocated again to leaf mesophyll cells.

This hypothesis was later elaborated by **Craft (1938 and 1961) and Esau {1966).**

The principle of mass flow hypothesis can be illustrated by an experiment conducted with the help of an **osmometer**. Two-chamber **A & B** having **semi-permeable** membrane walls are connected with a tube **C.** Chamber **A** contains a highly concentrated sugar solution represents the leaf (source), chamber **B** contains water represents the root (sink) and the tube **C** filled with water represents longitudinal sieve tube system. The system is dipped into a water tank. Due to the high osmotic pressure of sugar solution in chamber **A**, water enters into chamber **A** resulting in the development of high turgor pressure. The increase in turgor pressure results in **mass flow** of sugar solution from chamber **A** to chamber **B** through tube **C** till the concentration of sugar solution in both the chamber is equal. If sugar is continuously added to chamber **A** and removed from chamber **B,** a continuous **mass flow** of solution will take place from **A to B** through the tube **C.**

Demerits of Munch's hypothesis

1. Munch's hypothesis accounts for a unidirectional flow of organic solutions. Though there is evidence of both upward and downward translocation of solutes simultaneously.
2. There is doubt, that the magnitude of turgor pressure is sufficient enough to push the organic solution into the sieve tube.
3. Turgor pressure may not always be higher at the supply end.
4. This hypothesis completely ignores the involvement of any metabolic energy.

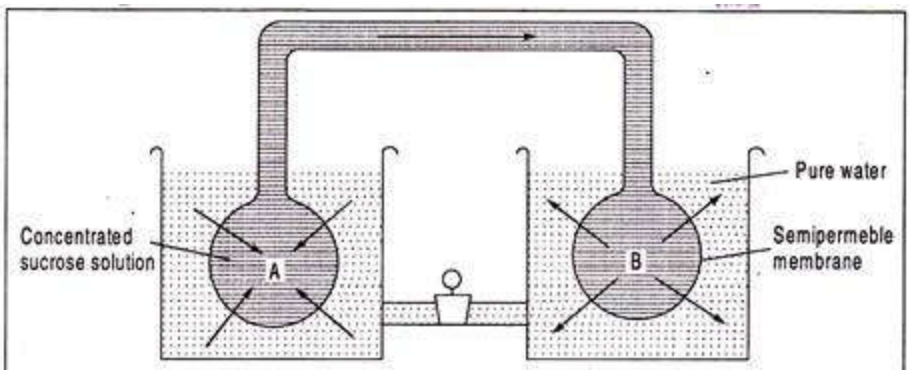

Fig. 6.12 : A diagrammatic representation of the pressure-flow model

OTHER THEORIES OF MECHANISM OF TRANSLOCATION

1. **Diffusion hypothesis** – Many believe that translocation of food from a place of a higher concentration, where food is manufactured (supply

end) to the place of lower concentration where food is consumed (consumption end) by the process of diffusion. This theory was discarded because the rate of translocation is very high in phloem and could not be achieved by simple diffusion.

2. Activated diffusion hypothesis – According to Mason and Phillis (1936) protoplasm of the sieve tubes accelerate the diffusion of an organic solution either by activating the diffusing molecules or by reducing the protoplasmic resistance for diffusion. ATP is involved in this process. But they fail to prove it.
3. Electro-osmotic theory – This hypothesis was proposed by Fenson (1957) and Spanner (1958). According to them, translocation of solutes through sieve tubes takes place due to electric potential created by an accumulation of K^+ ion across the sieve plate of phloem.
4. Interfacial flow hypothesis – According to the hypothesis proposed by Van Den Honert (1932), transported molecules might move along interfaces of membranes such as tonoplast. But this hypothesis also lacks experimental evidence.

LEARNING OUTCOME:

1. Understand the path of translocation of organic solutes
2. Understand different hypotheses given to explain the translocation of sugar through the phloem.
3. What is Munch's experiment?