**NUTRIENT ENTRY INTO THE PLANTS:**

**Soil:**

Soil is the heterogeneous mixture of three major components

1. Solid phase
2. Liquid phase
3. Gaseous phase

**Solid phase:**

It is main nutrient reservoir that contain both organic and inorganic cations & anions. The inorganic particles of solid phase provide a reservoir of K, Ca, Mg, and Fe whereas organic compounds containing N, P and S etc are also associated with this phase.

* **Inorganic solid phase**

1. Gravels (>2nm)
2. Coarse sand (2-0.2nm)
3. Fine sand (0.2-0.02nm)
4. Silt clay (0.02-0.002nm)
5. Clay (<0.002nm)

* **Organic solid phase**

**Humus:** It is partially decomposition of organic matter. It is stable component of organic matter. Soil particles both inorganic and organic have predominantly negative charges on thire surfaces. Cations are adsorbed on soil colloidal complex (very fine soil particles) more the organic matter more will be cations adsorbed. Mineral cations adsorbed on soil particles provide a nutrient reserve available to plant roots. There are certain mineral present in such as potassium (canal water contain rich amount of K+ which has been derived from hydrous mica. Adsorbed ions are readily available to plants.

**Liquid phase:**

It is required for movement and uptake of nutrients. It is a soil solution which contain dissolved mineral ions and served as medium for ion movement to root surface.

**Gaseous phase:**

It mediates gas exchange between living organisms and atmosphere. Roots exchange gases predominantly from the air gaps (soil pores) between soil particles.

**Cation adsorption:**

Superficial attachment of cations or negatively charged colloidal particles. These cations can be replaced by other cations. This replacement process is known as cation exchange.

**Cation exchange capacity:**

It is the measure of moles of positive charge per unit mass of dry soil and it is expressed as Cmolekg-. The degree to which a given quantity of soil can adsorb and exchange cations is called cation exchange capacity.

**Anion adsorption:**

There are certain minerals present in soil which have positive charge on their surface such as iron and aluminum oxides (acidic soil) these soils have anion adsorption.

**MOVEMENT OF NUTRIENTS FROM SOIL TO PLANTS:**

1. **Mass flow:**

Nutrients are combined by water moving through soil to roots. It depends upon the rate of flow of water towards the plant. Which in turn depends on transpiration rate and nutrients level in soil solution. When both the flow of water and concentration of nutrients in soil solutions are high bulk flow in the nutrients supply is dominant.

1. **Diffusion:**

Nutrient uptake by roots lowers the concentration of nutrients in rhizosphere generating concentration gradient in soil solution surroundings the root causing diffusion. It is most important for N, K, P.

1. **Root interception/exchange:**

When nutrient uptake by root is high and nutrient concentration in soil is low, mass flow cannot supply adequate nutrient and diffusion is also unable to supply nutrients in amount taken up by the plants. Thus a nutrient depletion zone is created adjacent to root surface which stimulates the roots to grow and reach the nutrients. This direct contact of roots to nutrients through root elongation into new unexplored soil is called root interception.

**NUTRIENT ENTRY INTO PLANTS:**

There are two active stages of entry.

1. **Soil solution to outer free space of cell**

**Cell wall:** Outer most wall of the cell, support to the cell, cemented material which prevent the cell from injury. From base to the tip, cell wall continuum present.

**Apoplast:** Cell wall of the plant cells are continues from root hairs (cells of epidermis grow like appendages called root hair= for the uptake of nutrients and water) to the top of the plant and it called apoplast. It also extends to the extra cellular spaces between cell walls. The movement of nutrients and water occur very rapidly depending upon the diffusion gradient through apoplastic pathway. There is no active transport only diffusion. First nutrients from soil solution enter into the extra cellular spaces through apoplast.

* **Water entry into free space (WFS)**

This entry of water of water along with nutrients with cat ions, anions and neutral can occur freely.

* **Nutrient entry from water free space to Dorman free space(DFS)**

A region around cell which contains indiffusable or fixed ions, e.g. protein, polymers of DNA and RNA along with their carboxyl and phosphate groups. These fixed ions are negatively charged so, can adsorbed cat ions from water free space(WFS) therefore it is said that roots have cat ion exchange capacity.

**Influx to the apparent free space**

Rhizodermal/ epidermal cell wall pore diameter 500-3000nm

Cortical cell wall 100-200nm

Potassium ion 0.66nm

Sucrose molecule 1nm

Calcium ion 0.82nm

Cat ion exchange capacity (CEC) of dicots is more than monocots.

1. **From outer free space of cell to the cell interior**

**Symplast:** This movement occurs through root hairs, water and nutrients move through plasmodesmata and this pathway is called symplast. It is a slow pathway and the movement from this pathway is occurs mostly active transport. All plant cells are symplastically in continues through plasmodesmata except guard cells. There are three main routes of nutrients uptake to the plant;

1. **Apoplast (**Cell wall and intercellular spaces**)**

This movement is block at casparian strips.

1. **Symplast**

Nutrients always cross the cell membrane and enter into symplast.

**Casparian strip** in endodermis a layer is develop around them made up of lignin and subrein and it is called casparian strips. Therefore, it blocks the apoplastic movement. This layer is impervious to water.

Theoretically all the ions of apoplast have to follow the symplast. Membranes are intact and block water and all nutrients. There are certain gates through which selection occur, only the selected wanted molecules and ions can enter through the cell membrane into the symplast.

1. **Trans-vacuolar**

In addition to symplast certain molecules and ions pass also through the vacuole by crossing tonoplast, this movement is called trans vacuolar or trans cellular.

**IV. Transpirational bypass flow**

There are certain leakages in the Kasparian strips, certain ion i.e. sodium ion can enter into xylem and it is called transpirational bypass flow. But this flow is only through apoplast beyond endodermis and enter the xylem to become the part of transpiration stream.

There are two types of proteins, first is structural protein and the second one is transport protein.