

Chapter- Water relations physiology ,Bsc part III, paper VII, Total Page -10

content-i. Role of vacuoles in cell physiology

ii. Water absorption in higher plant

iii. Ascent of sap

IV. Transpiration

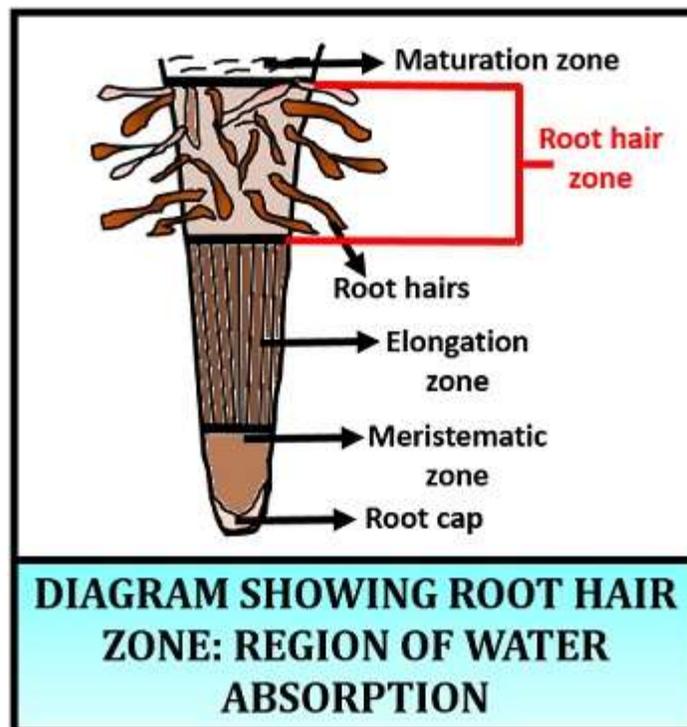
Role of Vacuoles in cell physiology

As cell development proceeds a small vesicles appear and coalesce to form a single vacuole that increase in volume as water is taken up by the cell. The vacuole membrane is composed of a single unit membrane as is the plasma membrane. Vacuoles contain dissolved solutes, such as inorganic ions, amino acids, organic acids, sugars, water soluble pigments (anthocyanins), and insoluble materials in the form of crystals and needles. In addition the vacuoles contain proteins with enzymatic activity as hydrolases, catalase, phosphatase, and so forth. vacuoles are not inert entities serving only as receptacles for waste metabolic products or secondary plant substances. Certainly vacuoles are maintaining plant form through turbidity of cells, tissue and organs. vacuoles are very important in development processes, however because they serve as storage compartments for metabolically active materials, such as sugars, amino acids, amides, organic acids, and inorganic ions. Depending on the specific stage of development of the cell, the vacuoles may contain high concentration of soluble sugars, or amides such as asparagine and glutamine. To mediate such metabolic activities vacuoles also contain an assay of enzymes. The vacuoles should be viewed as an important subcellular organell that particulate in a variety of metabolic processes.

Water absorption in higher plant

In lower plants as we know the absorption of the water take place through whole surface of thallus. But in Bryophytes, Pteridophytes and Gymnosperm there is advancement for absorption of water. There is a special organ develops and it is known as rhizoids. Rhizoids physiologically, morphologically performed the function of root but anatomically it is not

root. Anyway this rhizoids in gymnosperm develops as full fledged as root. In higher plant water is absorbed through root hair which are contact in soil water and form the root hair zone. Little behind root tip, root hairs are tubular hair like prolongation of cell of epidermal layer (when epidermis bears root hairs it is also known as piliferous layers) of the root. The walls of root hairs are permeable and consist of pectic substance and cellulose which are strongly hydrophilic in nature. Root hairs contain vacuole filled with cell sap.



Mechanism of water absorption:- Absorption of water is of two types

1. **Active absorption of water-** plant absorbs capillary and hygroscopic water. Chresard water means the amount of water available to the plant root for absorption. In his process root cells

play active role in the absorption of water and metabolic energy released through respiration is consumed. Active absorption is of two types-

1. Osmotic water absorption

2. Non Osmotic water absorption

Osmotic absorption means water is absorbed from into the xylem elements of the root according to osmotic gradient

Non osmotic absorption means water is absorbed in against of osmotic gradient

2. Passive water absorption- It is mainly due to transpiration. Root cells doesnot remain in active cell and remain passive

Osmotic water absorption-first step in the osmotic absorption of water is imbibitions of soil water by hydrophilic cell wall of root hairs. Osmotic pressure of cell sap is usually higher than osmotic pressure of soil water. Therefore DPD and suction pressure in root hairs become higher and water from the soil water enter into root hair through plasma membrane by osmotic diffusion. As a result OP, SP and DPD of root hairs become lower while TP is increased, now cortical cells adjacent to the root hairs have higher OP, SP, DPD in comparison to the root hairs. Therefore water is drawn into the adjacent cortical cells from the root hair by osmotic diffusion. In the same way the water by cell to cell osmotic diffusion gradually reaches the inner most cortical cell and endodermis. Osmotic diffusion of water into endodermis take place through special thin walled passage cells because the other endodermal cells have casparian stripes which are impervious to water from endodermal cells is draw into the cell of pericycle by osmotic diffusion which now turgid and their SP is decreased.

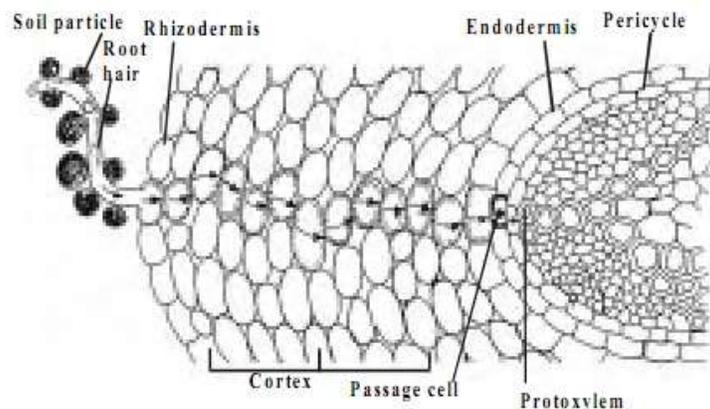


Figure: Path of water across the roo

In the last step water is drawn into the xylem from turgid pericycle cell. It is because of absence of turgor pressure and xylem vessels. The SP of xylem vessels becomes higher than the SP of the cell of pericycle. When water enters into xylem from pericycle a pressure is developed in the xylem of roots which can raise the water to a certain height. The pressure is called root pressure.

Non Osmotic absorption of water-sometimes it has been observed that absorption of water takes place even when the OP of soil water is higher than OP of cell sap of root hair. This type of absorption which is non osmotic and against the osmotic gradient, requires the expenditure of metabolic energy probably through the respiration. Recent views support this view by some evidences-

1. Factors which inhibit respiration also decrease water absorption .

2. poisons which retard metabolic activity of root cells also retard water absorption.

3. Auxin which increases metabolic activity of the cell stimulates absorption of water.

Passive water absorption

Passive absorption of water takes place when the rate of transpiration is usually high. Rapid evaporation of water from leaves during transpiration creates a tension in the xylem of leaves. This tension is transmitted to water in xylem of roots through xylem of stem and water rises upward to reach the transpiring surfaces. As a result soil water enters into cortical cells through the root hairs to reach the xylem of roots to maintain the supply of water. The force for this entry of water is created in leaves due to rapid transpiration and hence root cells remain passive during this process.

conclusion- In conclusion we find that plants absorb water passively due to environmental conditions but active absorption also takes place. Water absorption is generally passive absorption is ruled in higher plants

Ascent of Sap

upward movement of water is called Ascent of Sap. xylem is responsible for Ascent of sap. This can be explained through a ringing experiment so far mechanisms concerned for forces for upward movement of water. There are two important views responsible for this process. Vital theories think that ascent of sap is under direct control of vital activities in the stem i.e. cells must be living. The supporter of this theory like Godlewiskey, J.C. Bose, said that pulsatory activity of living cells pumping activity of xylem parenchyma is responsible for ascent of sap. Strasburger's criticism led the scientist not to believe in this theory.

The other school of physiologists says that physical forces like atmospheric pressure, imbibitional force theory, capillary force, root pressure theory, transpiration pull theory are responsible for ascent of sap. The most acceptable theory is transpiration pull theory which is innuited by Dixon and Jolly. This theory is based on following features-

1. Property of water molecules to form a continuous water column in xylem.
2. Transpiration pull is exerted on this water column
3. There are lacuna of this theory also has been seen by many workers but it is acceptable to all physiologists.

4. In my opinion it is a puzzling question and it is still unresolved.

Although hydrogen bond is very weak but when they are present in enormous no as in case of water very strong mutual force of attraction or cohesive force develops between water molecules and hence they remain in the form of continuous water column in xylem. The magnitude of this force is very high. Therefore continuous water column in xylem cannot be broken easily due to force of gravity or other obstruction offered by internal tissues in the upward movement of water.

The adhesive properties of water i.e. the attraction between water molecules and continuous walls further insure the continuity of water in xylem.

When transpiration takes place in leaf on the upper part of plant, water evaporates from the intercellular spaces of the leaf to the outer atmosphere through stomata. More water is released into the intercellular space from the mesophyll cells. In turn the mesophyll cells draw water from xylem of the leaf. This tension is transmitted to the downward in water xylem elements of root through xylem of petiole and stem water is pulled upward in the continuous unbroken column to reach the transpiring surfaces up to the top of plant.

According to some workers the main objection against this theory is that certain air bubbles present in the conducting channel will break the continuity of water column which will remain continuous through other elements of xylem.

Dixon's theory is most popular explanation today for ascent of sap in plants. This was supported by Davellin but in our opinion all the theories are responsible for ascent of sap in the plants. It is still a puzzling problem

Transpiration

It is quite obvious that transpiration is not of much importance to the plant, besides unnecessary wastage of energy in water absorption due to transpiration. It may be some times harmful to them in other respects. For eg-

1.very often when the rate of transpiration is very high and soil deficient in water ,and internal water deficiet is created in the plants which may affect other metabolic process.

2. Many xerophytes have to develop structural modifications and adaptation to check transpiration .

3.Deciduous trees have to shade their leaves during autumn to check the loss of waters.

But inspite of various disadvantage the plant cannot avoid transpiration due to their peculiar internal structure particularly those of leaves .Their internal structure although basically mant for gaseous exchange for respiration , photosynthesis etc is such that it cannot check the evaporation of water .Therefore many workers like Curtis 1926 have called transpiration is necessary evil.

Significance

Plant waste much of their energy in absorbing large amount of water .Most of which is ultimately to the lost through transpiration while some people think transpiration as advantageous to plant which infact is not true other regards it as a unavoidable process which is rather harmful.

1.Suppose advantages of transpiration –Although transpiration plays and important role in the uwpard movement of water ie Ascent of sap in plants ,it does not mean that translocation of water will be stopped without it.It has been observed that even in absence of transpiration water continue to rise upward to maintain turgidity of cell for various metabolic process.

2.Role in absorpion and translocation of mineral salts. Previously it was thought that more rapid rate of transpiration result in an increase in the rate of absorption of mineral salts through increased rate of water absorpion .But no is well established that absorpion of water and absorpion is entirely independent process. There fore transpiration is nothing to do it absorpion of mineral salts. However once minerl salts have been absorbed by the

plant.their further translocation or distribution may be facilitated by transpiration through translocation of water in xylem elements .

3.Role in regulation of temperature-some of the light energy is absorbed by leaves is utilized in photosynthesis. Rest is converted into heat energywhen raises the temperature .It has been argued by many physiologists that transpiration plays an important role in controlling the temperature of plants.rapid evaporations of water brings down their temperature and thus prevents them from excessive heatng..