Topic: Absorption of Water
B.Sc. Botany (Sub.) II
Group: C
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Absorption of Water

Water is the most important plant nutrient and constitutes the greater part of the plant weight. Plants have the potentiality to absorb water through their entire surface right from root, stem, leaves, flowers, etc. However, as water is available mostly in the soil, only the underground root system is specialized to absorb water. Roots are often extensive and grow rapidly in the soil.

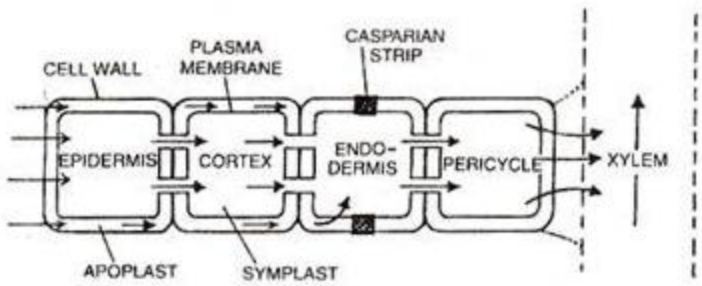
In roots, the most efficient region of water absorption is the root hair zone. Each root hair zone has thousands of root hairs. Root hairs are specialized for water absorption. They are tubular outgrowths of 50-1500 µm (0.05-1.5 mm) length and 10 nm in breadth.

Each root hair has a central vacuole filled with osmotically active cell sap and a peripheral cytoplasm. The wall is thin and permeable with pectic substances in the outer layer and cellulose on the inner layer. Root hairs pass into capillary micropores, get cemented to soil particles by pectic compounds and absorb capillary water.

Pathways of Water Movements in Roots

There are two pathways of water passage from root hairs to xylem inside the root-

i. Apoplast
ii. Symplast.



Pathways of water movement inside the root.

i. Apoplast Pathway

Water passes from root hair to xylem through the walls of intervening cells without crossing any membrane or cytoplasm. The pathway provides the least resistance to movement of water. However, it is interrupted by the presence of impermeable lignosuberin casparian strips in the walls of endodermal cells.

ii. Symplast Pathway

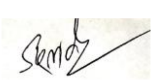
Water passes from cell to cell through their protoplasm. It does not enter cell vacuoles. The cytoplasms of the adjacent cells are connected through bridges called plasmodesmata. For entering into symplast, water has to pass through plasmalemma (cell membrane) at least at one place. It is also called transmembrane pathway. Symplastic movement is aided by cytoplasmic streaming of individual cells. It is, however, slower than apoplastic movements.

Both the pathways are involved in the movement across the root. Water flows via apoplast in the cortex. It enters the symplast pathway in the endodermis where walls are impervious to flow of water due to the presence of casparian strips.

Here, only plasmodesmata are helpful to allow passage of water into pericycle from where it enters the xylem. Mineral nutrients also have the same pathway as that of water. However, their absorption and passage into symplast mostly occurs through active absorption. Once inside the xylem, the movement is purely along the pressure gradient.

Mycorrhizal Water Absorption

In mycorrhiza a large number of fungal hyphae are associated with the young roots. The fungal hyphae extend to sufficient distance into the soil. They have a large surface area. The hyphae are specialised to absorb both water and minerals.



The two are handed over to the root which provides the fungus with both sugars and N-containing compounds. Mycorrhizal association between fungus and root is often obligate. Pinus and orchid seeds do not germinate and establish themselves into plants without mycorrhizal association.

Mechanism of Water Absorption

The absorption of water by plants is also known as water uptake. Terrestrial plants usually absorb water through the root hairs.

Water absorption is of two type’s passive and active (Renner, 1912, 1915).

1. Passive Water Absorption

The force for this type of water absorption originates in the aerial parts of the plant due to loss of water in transpiration. This creates a tension or low water potential of several atmospheres in the xylem channels. Creation of tension in the xylem channels of the plant is evident from:

(i) A negative pressure is commonly found in the xylem sap. It is because of it that water does not spill out if a cut is given to a shoot.

(ii) Water can be absorbed by a shoot even in the absence of the root system.

(iii) The rate of water absorption is approximately equal to the rate of transpiration.

Root hairs function as tiny osmotic systems. Each root hair has a thin permeable cell wall, a semipermeable cytoplasm and an osmotically active cell sap present in the central vacuole. Because of the latter a root hair cell has a water potential of -3 to -8 bars.

Water potential of the soil water is .1 to 3 bars. As a result water of the soil passes into the root hair cell. However, water does not pass into its vacuole. Instead it passes into apoplast and symplast of cortical, endodermal and pericycle cells and enter the xylem channels passively because of the very low water potential due to tension under which water is present in them, caused by transpiration in the aerial parts. A gradient of water potential exists between root hair

cell, cortical cell, endodermal, pericycle and xylem channels so that flow of water is not interrupted.

2. Active Water Absorption

It is the absorption of water due to forces present in the root. Living cells in active metabolic condition are essential for this. Auxins are known to enhance water absorption (even from hypertonic solution) while respiratory inhibitors reduce the same.

Therefore, energy (from respiration) is involved in active water absorption. Water absorption from soil and its inward movement may occur due to osmosis. Passage of water from living cells to the xylem channels can occur by:

(i) Accumulation of sugars or salts in the tracheary elements of xylem due to either secretion by the nearby living cells or left there during decay of their protoplasts.

(ii) Development of bioelectric potential favourable for movement of water into xylary channels.

(iii) Active pumping of water by the surrounding living cells into tracheary elements.

Environmental conditions influencing Absorption of Water-

i. Available Soil Water

Sufficient amount of water should be present in the soil in such form which can easily be absorbed by the plants. Usually the plants absorb capillary water i.e., water present in films in between soil particles. Other forms of water in the soil e.g., hygroscopic water, combined-water, gravitational water etc. are not easily available to plants. Increased amount of water in the soil beyond a certain limit results in poor aeration of the soil which retards metabolic activities of root cells like respiration and hence, the rate of water absorption is also retarded.

ii. Concentration of the Soil Solution

Increased concentration of soil solution (due to the presence of more salts in the soil) results in higher osmotic pressure. If the O.P. of soil solution will become higher than the O.P. of

cell sap in root cells, the water absorption particularly the osmotic absorption of water will be greatly suppressed. Therefore, absorption of water is poor in alkaline soils and marshes.

iii. Soil Air

Absorption of water is retarded in poorly aerated soils because in such soils deficiency of O_1 and consequently the accumulation of CO_2 will retard the metabolic activities of the roots like respiration. This also inhibits rapid growth and elongation of the roots so that they are deprived of the fresh supply of water in the soil. Water logged soils are poorly aerated and hence, are physiologically dry. They are not good for absorption of water.

iv. Soil Temperature

Increase in soil temperature up to about 30°C favors water absorption. At higher temperatures water absorption is decreased. At low temp, also water absorption decreases so much so that at about 0°C it is almost checked.

This is probably because at low temperature-

(i) The viscosity of water and protoplasm is increased,

(ii) Permeability of cell membranes is decreased,

(iii) Metabolic activities of root cells are decreased, and

(iv) Growth and elongation of roots are checked.

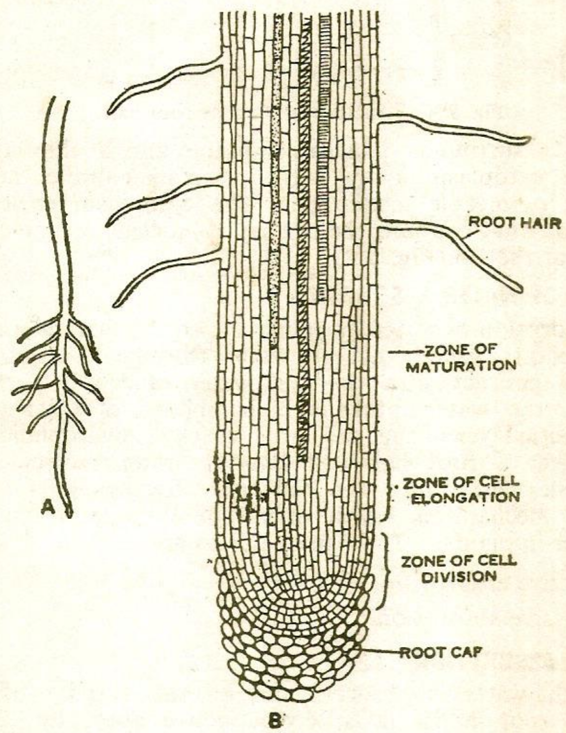


Fig. Root hairs ; A—a terminal portion of root showing root hair zone, B—longitudinal section of a young root showing the origin of root hairs just above the zone of maturation.

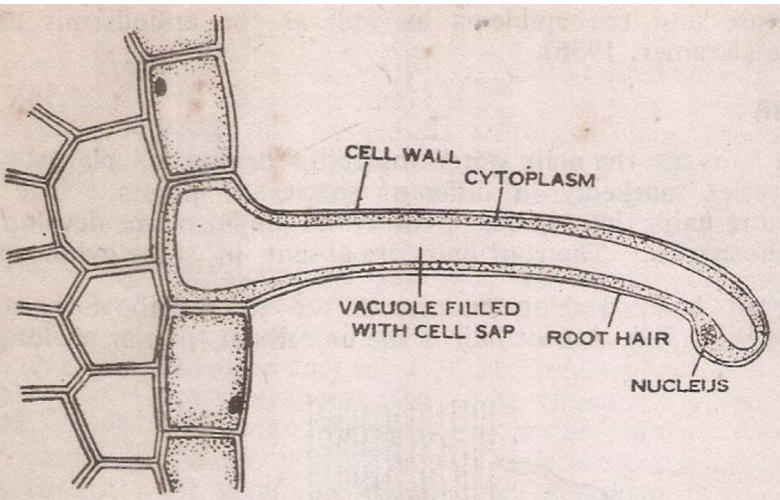


Fig. Structure of a single root hair.

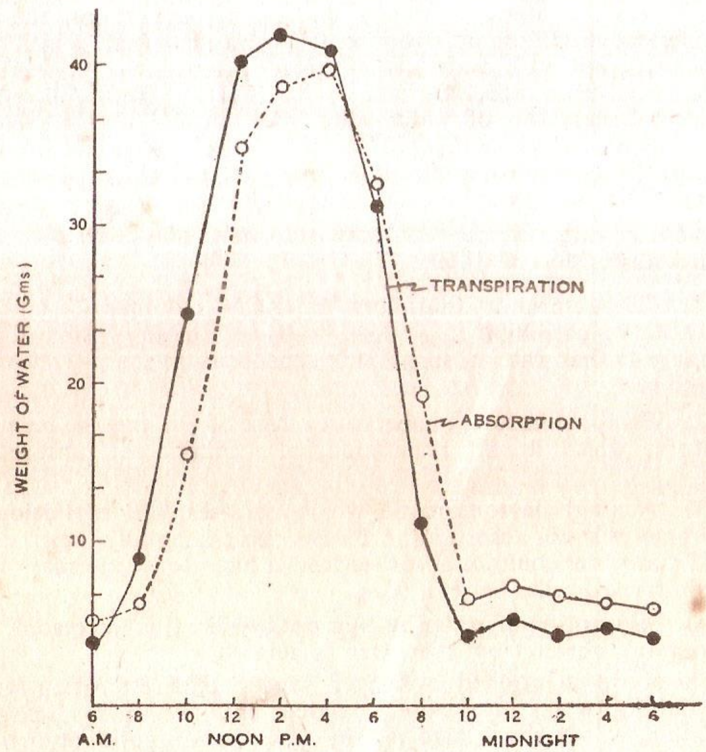


Fig. A graph showing parallel relationship between passive absorption of water and transpiration.