

## Notes

**Programme: Bachelor of Science (Second Year – IV Semester)**

**Subject: Botany**

**Course Code: BOC 104**

**Course Title: Plant Physiology**

**Unit 1: Plant – Water relations**

**Module Name: Components of Water potential.**

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### **Components of water potential ( $\Psi_w$ )**

A typical plant cell consists of a cell wall, a large vacuole bounded by its membrane (tonoplast) and filled with an aqueous solution (cell sap) and a layer of cytoplasm between the vacuole and cell wall.

When such a cell is subjected to the movement of water then many factors begin to operate which ultimately determine the water potential of cell sap.

Three sets of internal factors contribute to water potential of cell sap -

- ✓ Matric potential ( $\Psi_m$ )
- ✓ Solute potential or osmotic potential ( $\Psi_s$ )
- ✓ Pressure potential ( $\Psi_p$ )

Water potential in a plant cell is equal to the algebraic sum of the Matric potential ( $\Psi_m$ ), Solute potential or osmotic potential ( $\Psi_s$ ) and Pressure potential ( $\Psi_p$ ).

$$\Psi_w = \Psi_s + \Psi_p + \Psi_m.$$

### **Matric potential ( $\Psi_m$ )**

Matrix is represented by the cell wall and cytoplasm which surrounds the vacuole. It expresses the adsorptive affinity of water to colloidal substances present in the protoplasm and cell wall materials. The values of matric potential are always negative. In non - vacuolated cells the matric potential is usually high. It is considerably high in dehydrated tissues also in which water is held mostly by adsorptive forces. E.g. dry seeds and in tissues of plants growing in deserts.

However, in mature and vacuolated cells of herbs and majority of plants, matric potential is negligible and is therefore often ignored.

Thus,  $\Psi_w = \Psi_s + \Psi_p$

### **Solute Potential ( $\Psi_s$ ):**

It is defined as the amount by which the water potential is reduced as a result of the presence of the solute particles. It is also called as osmotic potential. It becomes more negative with addition of solutes. It is expressed in bars with a negative sign.

Solute potential depends on the total number of solute molecules or solute ions in the solution. If a solution consists of several different solutes, the solute potential is the sum of individual solute potentials contributed by each solute.

In a pure solvent, the value of osmotic potential is zero.

### **Pressure Potential ( $\Psi_p$ ):**

When a cell absorbs water, the elastic cell wall exerts a pressure (wall pressure) on the cell contents. Due to this inwardly directed wall pressure, hydrostatic pressure is developed in the vacuole termed as turgor pressure or the pressure potential.

Sometimes turgor pressure in plant cells may arise due to pressures created by neighbouring cells.

Pressure potential is usually positive.

In leaf cells of herbaceous plants, during day time  $\Psi_p$  varies from +3 to +5 bars. At night, the same cells may have pressure potential of +15 bars. The

diurnal fluctuation in the pressure potential corresponds to the diurnal fluctuation in water content of the cells.

Pressure potential is zero in cells showing incipient plasmolysis.

### Fully turgid cell

$$\Psi_w = 0$$

$\Psi_p$  numerically equals  $\Psi_s$  but with opposite signs

### Incipient plasmolysis

$$\Psi_w = \Psi_s + \Psi_p$$

### Plasmolysed cells

$$\Psi_w = \Psi_s \quad (\Psi_p = 0)$$

Water potential is responsible for direction of the flow of water.

Suppose 2 cells A & B are in contact with each other.

Cell A	Cell B
$\Psi_s = -12$ bars	$\Psi_s = -5$ bars
$\Psi_p = 4$ bars	$\Psi_p = 2$ bars
$\Psi_w = \Psi_s + \Psi_p$ $= (-12) + 4$ $= -8$ bars	$\Psi_w = \Psi_s + \Psi_p$ $= (-5) + 2$ $= -3$ bars

Hence, water will move from cell B to cell A (i.e. towards lower or more negative water potential)

If two cells adjacent to one another are different in their water potential, water moves from cell with less negative water potential to cell with more negative water potential. It will happen until water potential of both the cells becomes equal.

### **Relationship of OP, TP and DPD**

Suppose Cell A and B are in contact with each other, where in Cell A (flaccid cell) with  $OP = 20$  and  $TP = 0$  and Cell B has pure water.

Then in Cell A,  $DPD (SP) = OP - TP$

$$DPD = OP = 20$$

Initial absorbing power or suction pressure of cell A is equal to its DPD.

When a cell is in flaccid condition, it has maximum diffusion pressure deficit.

After about 5 mins, let us assume that 5 ml water of enters cell A from cell B (due to higher water potential in Cell B). Then in cell A,

$$OP = 20, TP = 5$$

$$DPD (SP) = OP - TP$$

$$DPD = 20 - 5 = 15$$

If with time, more and more water enters cell A from cell B, Cell A becomes Turgid with  $OP = 20$ .  $TP$  &  $WP$  – increases till it equals  $OP$ .

$$DPD (SP) = OP - TP$$

$$DPD = 20 - 20 = 0$$

- ✓ In a fully turgid cell,  $WP$  completely inhibits diffusion of water from B to A and a state of dynamic equilibrium is attained.
- ✓  $DPD$  of cell A is completely wiped off.

1. Due to the entry of water, the osmotic pressure of the cell sap decreases while its turgor pressure is increased so much so that in a fully turgid cell, turgor pressure equals the osmotic pressure:

$$OP = TP \text{ (in fully turgid cell)}$$

$$\text{hence, } DPD \text{ (SP)} = 0$$

2. On the other hand, the removal of water from the cell sap (exosmosis) results in an increase in of its O.P. and decrease of the turgor pressure so much so that in fully plasmolysed cells, the value of turgor pressure becomes zero.

$$T.P. = 0 \text{ (in fully plasmolysed cell)}$$

$$\text{And hence, } S.P. = O.P.$$

3. In soil solution, water does not exist in its pure state because of dissolved salts. In such hypotonic solution (instead of pure water), the suction pressure / DPD of the cell will be:

$$DPD \text{ (SP)} = (O.P. - O.P.1) - T.P.$$

Where, O.P.1 is the osmotic pressure of the outer hypotonic solution.

- ✓ Higher osmotic pressure of the cell sap is usually accompanied by lower turgor pressure so that its D.P.D. or S.P. is greater and water enters into it.

Cell A	Cell B
✓ O.P. = 25 atm.	✓ O.P. = 30atm.
✓ T.P. = 15 atm.	✓ T.P. = 10 atm.
✓ S.P. = 10 atm.	✓ S.P. = 20 atm.

Movement of water will be from cell A to cell B.

Entry of water into the cell depends on D.P.D. or S.P. and not on O.P. only.

Cell A	Cell B
O.P. = 35 atm.	O.P. = 40 atm.
T.P. = 10 atm.	T.P. = 20 atm.
S.P. = 25 atm.	S.P. = 20 atm.

Movement of water will be from cell B to cell A because of its (Cell B) lower D.P.D. or S.P. even though its O.P. is higher.