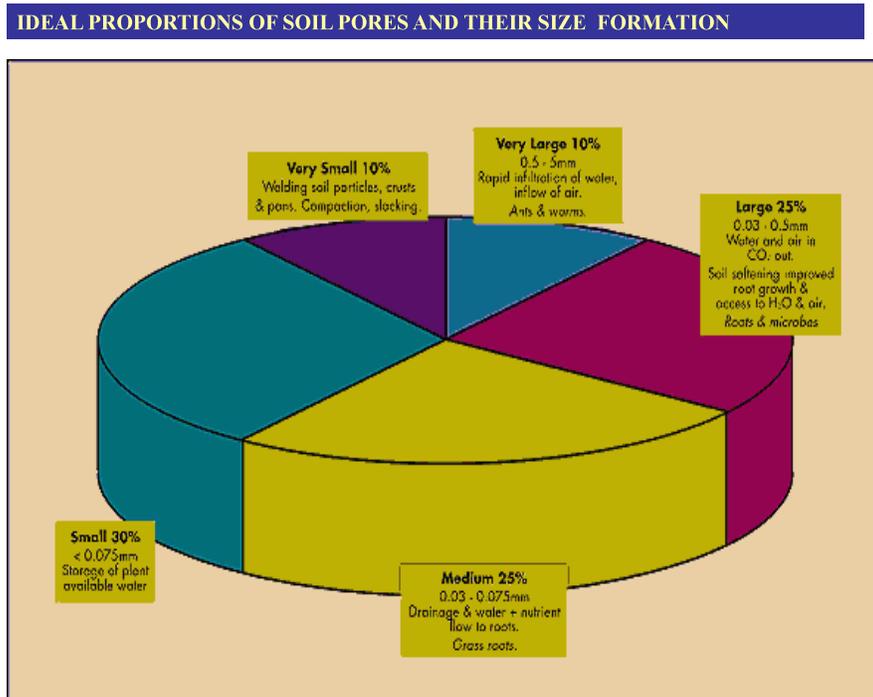# 03. Field capacity, Available soil water and permanent wilting point
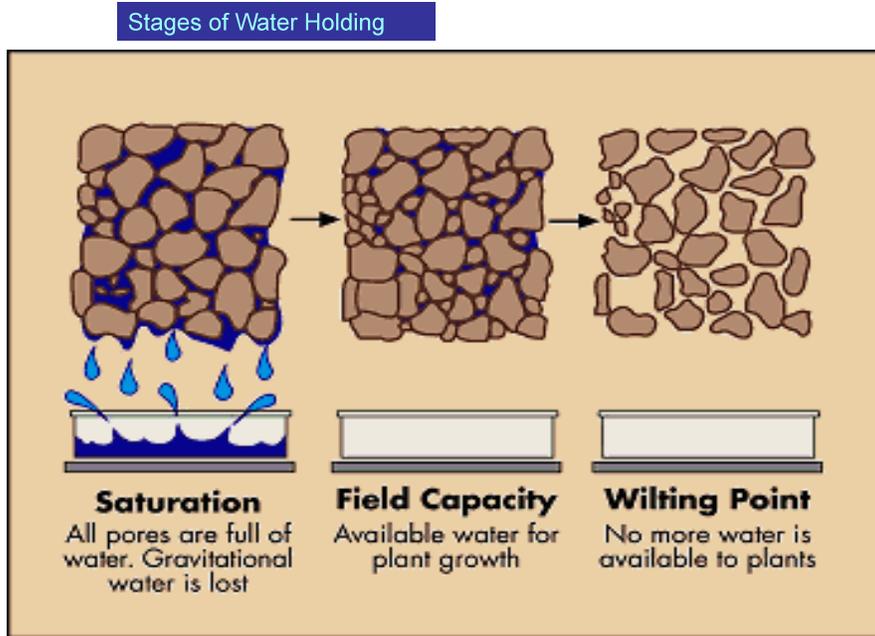
Field capacity or water holding capacity of the soil

After heavy rain fall or irrigation of the soil some water is drained off along the slopes while the rest percolates down in the soil. Out of this water, some amount of water gradually reaches the water table under the force of gravity (gravitational water) while the rest is retained by the soil. This amount of water retained by the soil is called as field capacity or water holding capacity of the soil.

IDEAL PROPORTIONS OF SOIL PORES AND THEIR SIZE FORMATION

Field capacity is affected by soil profiles soil structure and temperature. The effective depth of a soil, as determined by physical and chemical barriers, together with the clay content of the soil within that depth, determine the water holding capacity of the profile, and how much of the water is available to plants. Effective soil depth varies between plant species. Wheat is used as the benchmark plant in this assessment. Available water holding

capacity rankings are estimated from soil texture, structure and stone content within the potential root zone of a wheat plant.

Water-holding capacity is controlled primarily by soil texture and organic matter. Soils with smaller particles (silt and clay) have a larger surface area than those with larger sand particles, and a large surface area allows a soil to hold more water. In other words, a soil with a high percentage of silt and clay particles, which describes fine soil, has a higher water-holding capacity. The table illustrates water-holding-capacity differences as influenced by texture. Organic matter percentage also influences water-holding capacity. As the percentage increases, the water-holding capacity increases because of the affinity organic matter has for water.

It is the water content of the soil after downward drainage of gravitational water. It is the capillary capacity of a soil. It is the upper limit of soil water storage for the plant growth. At field capacity, the soil water potential is –0.1 to –0.3 bars.

Texture	Field Capacity	Wilting point	Available water
Coarse sand	0.6	0.2	**0.4**
Fine sand	1.0	0.4	0.6
Loamy sand	1.4	0.6	0.8
Sandy loam	2.0	0.8	1.2
Light sandy clay loam	2.3	1.0	1.3
Loam	2.7	1.2	1.5
Sandy clay loam	2.8	1.3	1.5
Clay loam	3.2	1.4	1.8
Clay	4.0	2.5	1.5
Self-mulching clay	4.5	2.5	2.0

Water potential

Every component of a system possesses free energy capable of doing work under constant temperature conditions.   For non-electrolytes, free energy / mole is known as chemical potential. With refuse to water, the chemical potential of water is called as water potential. The chemical potential is denoted by a Greek letter Psi (ψ).

For pure water, the water potential is Zero. The presence of solute particles will reduce the free energy of water or decrease the water potential. Therefore it is expressed in vegetative value.

It is therefore, water potential of solution is always less than zero so in negative value.

For solutions, water potential is determined by three internal factors i.e.

$\psi_w \quad = \psi_w + \psi_s + \psi_p$

$\psi_S \quad =$ is the solute potential or osmotic potential

$\psi_p \quad =$ pressure potential or turgor potential

ψ_w　　= is the matric potential. Matric potential can be measured for the water molecules adhering on the soil particles and cell wall.

In plant system, the matric potential is disregarded.

Therefore,

$$\psi_w = \psi_s + \psi_p$$

Osmotic pressure

Osmotic pressure is equivalent to osmotic potential but opposite in sign.Osmotic pressure in a solution results due to the presence of solutes and the solutes lower the water potential. Therefore osmotic pressure is a quantitative index of the lowering of water potential in a solution and using thermodynamic terminology is called as osmotic potential.

Osmotic pressure and osmotic potential are numerically equal but opposite in sign.

Osmotic pressure has positive sign

Osmotic potential has negative sign (ψ_s)

For eg.

I_A OP = 20 atm.

ψ_w　　= - 20 atm

Turgor pressure

In plant cell, the turgor pressure results due to the presence of water molecules is turgor pressure. The potential created by such pressures is called presure potential (ψ_p)

In a normal plant cell, the water potential

$\psi_w = \psi_s + \psi_p$ – partially turgid cell

(High)

ψ_w = Zero　　- Fully turgid cell

(Highest)

$\psi_w = \psi_s$　　- Flaccid cell or plasmolysed cell

(Lowest)

Water relation

Water forms the major constituent of living (cells) things and the cells originated in a highly aqueous medium and all the vital processes of the life are carried out in it. Besides, water predominately arts as a source of hydrogen to plants and is released by the photolysis of water during photosynthesis.

In living tissue, water is the medium for many biochemical reactions and extraction process. Inorganic nutrients, photosynthesis, bases and hormones are all transported in aqueous solution. Evaporation of water can control the temperature of leaf on canopy soil nutrients are available to plant roots only when dissolved in water. In short, water is essential for life and plays a unique role in virtually all biological process.

Example:

There are 2 cells A and B in contact with each other, cell A has a pressure potential (turgor pressure) of 4 bars and certain sap with an osmotic potential of -12 bars.

Cell B has presume potential of 2 bars and certain sap with osmotic potential of -5 bars.

Then,

$$\psi_w \text{ of cell A} = \psi_s + \psi_p$$
$$= -12 + (+4)$$
$$= -8 \text{ bars}$$
$$\psi_w \text{ of cell B} = -5 + (+2)$$
$$-3 \text{ bars}$$

Hence, water will move from cell B to cell A (i.e., towards lower or more negative water potential) with a form of (-8-(-3)) = -5 bars.

Diffusion Pressure Déficit (DPD) (Suction pressure)

Diffusion pressure of a solution is always lower than its pure solvent. The difference between the diffusion pressure of the solution and its solvent at a particular temperate and

atmosphere conditions is called as diffusion pressure deficit (D.P.D). If the solution is more concentrated D.P.D increases but it decreases with the dilution of the solution,

D.P.D of the cell sap or the cells is a measure of the ability of the cells to absorb water and hence is often called as the suction pressure (S.P). It is related with osmotic pressure (O.P) and turgor pressure (T.P) of cell sap and also the wall pressure (W.P) as follows.

D.P.D. (S.P) = O.P – W.P

But

(W.P) = T.P

D.P.D = O.P – T.P

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

O.P = T.P   = D.P.D = O

In fully plasmolysed cells: T.P = O

So   D.P.D = O.P

D.P.D. incase of plant cells is not directly proportional to their osmotic pressure or the concentration of the cell sap but depend both on O.P and T.P. Higher osmotic pressure of the cell sap is usually accompanied by lower turgor pressure so that its D.P.D is greater and water enters into it. But sometimes it is possible that two cells are in contact with each other one having higher O.P and also higher turgor pressure than the other cell and still its does not draw water. It is because of its lower D.P.D., no matter is O.P is higher.

Cell a   Cell b

O.P   = 25 atm. ———————▶   O.P   = 30 atm

T.P   = 15 atm.   T.P   =10 atm.   A

D.P.D = 10 atm.   D.P.D = 30 atm.

Cell a	Cell b
O.P = 35 atm. ⟵	O.P = 40 atm
T.P = 10 atm.	T.P = 20 atm. B
D.P.D = 25 atm.	D.P.D = 20 atm.

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