RAMA UNIVERSITY

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FACULTY OF MEDICAL SCIENCES

SOIL WATER

Soil serves as a regulated reservoir for water, as it receives precipitation and irrigation. Water is an excellent solvent of most of the plant nutrients and is a primary requisite for plant growth.

The water that fills part of the pore spaces established between the solid particles of soil is known as soil water. It is the liquid phase of the soil and is important as the other two phases of the soil system. It has profound influence on the life of the plant, at all the stages.

Source of water retention: All the water required by the plants come from the soil. Water supplied to the soil is first adsorbed and held by soil colloids until the adsorption capacity of the soil is satisfied. If more moisture is available then it moves downward l by gravity and drains off.

It is mainly clay or other colloidal particles that are responsible for adsorbing water. Silt and sand particles do not adsorb water or very little, if at all. The water so held on the surface of the clay particle is believed to be different from ordinary liq uid water. It is non-liquid, more dense and viscous compared to ordinary water.

The electrostatic forces exist on colloidal particles would attract water molecules. Water molecule by virtue of dipolar nature, gets attached to colloidal particle with it positively changed end, leaving its negative charge end outward. In this fashion water molecules will be oriented or arranged on the surface of clay particles. Now, another layer of water molecules will be attached to the negative end of water molecules, in a successive manner. This results in thickness of water layers around colloidal particles. As the water molecular layer gets thicker, the orientation becomes weaker, and at a certain distance from the particle surface, the water molecules cease to orie nt and liquid water or capillary water begins to appear.

Importance of soil water

- It dissolves and carries nutrients to the plant.
- It helps in soil formation
- It makes soil biological active by supporting flora and fauna.

- It carries dissolved oxygen in to the soil
- It keeps soil from getting too cold or too hot.

SOIL WATER POTENTIAL

Soil Water Energy Concept : Soil water like other bodies contains energy in different quantities and different forms. The retention of water, its movement, uptake and

tra nslocation in plants, its loss to the atmosphere are all related to the energy. Different kinds of energy are involved like potential, osmotic and electrical.

Kinetic Energy: This is the energy, which matter has by virtue of its motion and quantitatively i t is ½ mv^2 where 'm' is the mass and 'v' is the velocity. Since the movement of water is very slow its K.E. is also very less.

Potential Energy: This is the energy, which a body has by virtue of its position in a force field. Thus the potential energy is measured by the force required to move a body against the force field and is equal to the product of force and distance moved (i.e., F x d) . Work must be done when body is moving against the force field and the body will do work when it is moving with the field.

SOIL WATER POTENTIAL: The term potential may be defined as the amount of work done (or potential energy stored) per unit mass in bringing any mass 'm' from any distance to the point where potential is to be considered. The work need to be done on soil water to change it to
pure water at reference state against the force fields acting is called soil water potential.

Total Water Potential : The water in a system at rest , the sum of all potentials or the total potential at a point will be either constant or zero (This depends on the reference taken).

Total Potential (? T) = (? m)+ (? g)+ (? o)+ (? p) …..

$?_m$ - matric force ($?_g$) - Gravitational potential

($?_o$) - osmotic potential ($?_p$)- Pressure potential (? – psi)

If the total potential of water is constant through out the soil mass , then the water mass is said to be in 'static equilibrium' i.e., the net force acting on water to move is zero. If this is not zero, water movement occurs.

Gravitational Potential: The force of gravity acts on soil water, the attraction being towards the earth's center. The gravitational potential at any point in a gravitational fiel d is defined as the 'work done per unit mass in carrying any mass'm' infinity to that point.

Matric Potential: *Matric* potential is the result of two phenomena i.e., adhesion or adsorption and capillarity. The attraction of soil solids and their exchangeable ions for water and the loss of energy (heat of wetting) when the water is adsorbed are the processes involved in the phenomena. In addition to this attraction, surface tension of water also accounts for capillary force. The net effect of these two forces is to reduce the free energy of water. Matric potential is always negative, because of reduced free energy.

Osmotic Potential: The osmotic potential is attributed t o the presence of solutes in the soil. The solutes may be inorganic salts or organic compounds. They reduce the free energy of water. Osmotic potential is the result of hydration of ions in the soil solution. Due to dipolar nature of water molecules, the ions or compounds are attached on both sides reduces the free energy and the osmotic potential is the work to be done to detach these ions from water molecules. More the attachment, more the osmotic potential and less is the free energy. Unlike the matric potential , osmotic potential has little effect on the mass movement of water. But its effect is prominent in the uptake of water by plant roots. But in soils of high soluble salts osmotic potential may be greater than in plant roots. It is also negative

Pressure Potential: It is another component of soil water potential, which is due to the weight of water at a point under consideration or gas pressure exerted on water. With the change in elevation, the pressure potential in a soil with reference to water table may be either positive (below water table) or negative (above water table). The positive pressure potential is due to the weight of water column resting on any point below the water table and negative pressure potential is caused due to capillarity an d adsorptive forces. If the point is beneath the water

table, the potential is equal and opposite to the gravitational potential that is measured from the free water surface. This is otherwise known as 'Submergence potential' or 'Peizometric potential or 'Pneumatic Potential'. Pressure potential due to gas pressure may be measured with ordinary manometer. Pressure potential due to water weight may be measured with 'manometer' or 'Peizometer'.

pF Concept:

To express the soil moisture suction or tension **Schofield 1935** has suggested to use the logarithm of this tension with a symbol pF, an exponential funct ion of free energy difference. It is defined as the "logarithm to the base 10 of the numerical value of the negative pressure of the soil moisture expressed in centimeters".

$$pF = \log(-h)$$

Height of water column (cm)	pF
1	0
100	2
346	2.53 (field capacity)
15849	4.1 (wilting point)
31623	4.5 (Hygroscopic coefficient)

SOIL MOISTURE CONSTANTS

Knowledge about amount of water held by the soil at various tensions is required to calculate the amount of water ava ilable to plants, the amount of water retained by the soil before percolation starts and the amount of water that is favourable for irrigation.

Soil moisture constant	**Soil moisture potential**
Oven dry soil	-10,000 bars
Air dry soil	-1,000 bars
Hygroscopic coefficient	-31 bars
Wilting coefficient	-15 bars

Field capacity	-1/3 bars
Saturation	Almost "O"

- SATURATION :

Saturation water content is the amount of moisture present, when all the pores are filled with water. A soil whose pore spaces are completely filled with water is said to be saturated soil and the water is at zero tension. Such a condition is established only in coarse textured soils but not in fine textured soils as some fine capillary pores are filled with air. So the soil normally flooded with water will not be saturated as some air is blocked. Hence it is better to define a soil as saturated when the water is at zero tension and majority of its pores are filled with water.

AERATION– POROSITY LIMIT (Non-capillary porosity): Aeration porosity of a soil is defined as that part of the pore space volume that is free of water which can be established by creating a tension of water column of 50cms. This corresponds to a pF of

1.7 or 1/20 atmospheres tension. Aeration porosity is the volume of the pores whose diameter is more than 0.06 mm.

- FIELD CAPACITY:

After heavy rain or irrigation to the soil the water drains off rapidly for the first few hours and then starts to drain slowly. After two or three days, this rapid movement becomes slow and negligible later. The soil is said to be at field capacity. At this condition water moves out of macro pores and air occupies their places. The micro pores are still filled with water, which is available to plants. Moisture movement continues but very slowly. The moisture tension corresponds to pF of 2.53. But generally 1/3 bar tension is frequently used to describe field capacity. This constant can be measured with pressure plate apparatus. (At field capacity the moisture tension is about 1.0 atmosphere. But at one atmosphere tension water column breaks. Discontinuity of water column depends on texture of the soil. Discontinuity of water column depends on texture of the soil. For loam this occurs between 1/3 to one atmospheres).

BEST TILLAGE RANGE: Tillage practices play an important role in

the management of soil structure. Soil is tilled to improve its structure. If the soil is tilled , when it is wet , it will be puddled . If it is dry because of high cohesiveness of solid particles it breaks in to large clods and powder. In both cases soil structure will be disturbed. It should contain enough moisture content with which it can maintain small aggregates. The pF range 2.8 to 4.4 is considered optimal for tillage operations in medium textured soils.

WILTING POINT: (wilting coefficient or Permanent wilting percentage): It is the soil moisture content at which plants show wilting symptoms and can't recoup or recover even though it is kept in humid chamber. It occurs at pF value 4.18. The ease of release of water to the plant roots is just barely too small to counter balance the transpiration losses. Sometimes, plants exhibit wilting symptoms but recover with the addition of water or when placed in humid chamber. The water content at this condition is called the temporary wilting point. The water remains in small capillary pores and around the soil particles.

- HYGROSCOPIC COEFFICIENT:

Hygroscopicity is the ability of a body to adsorb moisture from the atmosphere. It largely depends on amount and type of clay, exchangeable cations and presence of free electrolytes. Soils high in expanding type of clay minerals and organic matter have a high hygroscopic coefficient. This water is not available to plants, but available to certain microbes.

Available water : Water held by soil at potential ranging between -15 bars to -1/3 bars, is considered as plant available water.