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Soil Water, Soil Moisture Constants, Soil Moisture Characteristics Curve

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Introduction

Soil moisture is one of the most important ingredients of the soil. Water affects intensively many physical and chemical reactions of the soil as well as plant growth. The properties of water can be explained by the structure of its molecule. Two atoms of hydrogen and one atom of oxygen combine to form a molecule of water. The space occupied by an individual water molecule is largely determined by that of oxygen ion. Practically two hydrogen ions do not take space. Water molecule does not exist individually. The hydrogen in water serve as a connecting link from one molecule to other is known as hydrogen bonding.

Retention of water

Water that enters into the soil is retained by means of three forces, viz.

- Adhesion,
- Cohesion and
- Due to soil colloids like clay and humus.

1) **Adhesion {also called adsorption}:-** The water molecule get attached to the surface of the soil particles and that make a thin film of water which is tightly held around the soil particle is known as force of adhesion. Adhesion is operative only at the solid-liquid interface and hence film of water is established by it is very thin. By adhesion water film is held more tightly at the soil-water interface.
2) **Cohesion: -** Water sticks itself with great energy and this property is known as cohesion. Water molecules hold other water molecules by cohesive forces. This force makes thick water film due to attraction of water molecule to each other and it is operative at only liquid interface.
3) **Soil colloids (Clay or humus particles): -** The water is also retained in the soil colloids like clay or humus particles. These soil colloids absorb water and as result of it get swollen. The water thus retained in the soil is called imbibitional moisture.

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Soil water potential: -

The difference between the free energy of soil water and that of pure water in standard different state is termed as soil potential. Soil water potential is a due to the influence of force fields resulting from gravitational, metric, osmotic and pressure forces.

Gravitational potential: -

Gravitational potential is the potential attributable to the gravitational force and is dependent on the elevation. It is the amount of work that a unit quantity of water in an equilibrium soil-water or plant-water system at an arbitrary level is capable of doing when it moves to equilibrium identical in all respects except that it is at a reference level

Metric potential: -

The total water potential that is attributed to the soil colloidal matrix of the soil or plant is metric potential. Metric potential is negative potential which results from the capillary and adsorptive forces emanating from the soil matrix.

Osmotic or solute potential: -

Osmotic or solute potential is the portion of water potential that results from the solutes present in the soil. They reduce free energy of water as the salts ions or molecules attract water molecules. Osmotic potential is negative.

Pressure potential: -

Pressure potential is the result of hydrostatic pressure acting on soil water. An increase in pressure increase water potential and pressure potential is positive.

Kinds /Classification of soil water or different forms of soil moisture: -

A) Physical classification (based on relative degree of retention)

- Gravitational water
- Capillary water
- Hygroscopic water

Gravitational water: -

- Also known as its drainage water
- It is usually present in macro pores.
- It held by a negative tension of less than 0.3 atmosphere.
- Free water which drains out.
- It is not available to plants and detrimental to plants.

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- It dissolves plant nutrients and these nutrients leached away.

- **Capillary water**
  - It is present in micropores of soil.
  - Held between field capacity and hygroscopic co-efficient in micropores.
  - At tention of 0.3 to 31 atmospheres.
  - Function as soil solution.
  - It is available for plant growth.

Capillary water divided into inner capillary and outer capillary water:

1. **Inner capillary water:** It is that part of capillary water which is nearer to the hydroscopic water. It is in the form of thinner films, held more tightly and moves rather very slowly than outer capillary water.
2. **Outer capillary water:** It is that part of capillary water which is not very tightly held in the soil and therefore moves readily from place to place. It is the most useful water for the plants because of its very quick availability.
3. **Hygroscopic water: -**
   - This water is held very tightly as thin film around soil particles by adsorption forces and therefore plant cannot absorb it.
   - It held at hydroscopic coefficient.
   - Tension varies from 31 to 10000 atmosphere.
   - Moves in vapour form therefore biologically inactive.

B). Biological classification of soil (On the basis of available to plants):

There is a certain relationship between soil moisture retention and it's utilization by plants. On the basis of availability to plants, it is further categorized as:-

- Superfluous water,
- Available water and
- Unavailable water

1. Superfluous water (Free water or drainable water):

- It is excess of that held in soil at field capacity and has no use for higher plants.
- This water is held at tension between 0.1 to 0.3 atmosphere.
- It is also known as free or gravitational water.

2. Available water (Available soil moisture, ASM):

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- Soil moisture between field capacity and permanent wilting point is referred to as readily available moisture.
- It is the moisture available for plant use.
- Held between 0.3 to 15 atmospheres.

3. Unavailable water:

- It is held in the soil at the permanent wilting point (greater or equal to 15 atmosphere).
- Unavailable water includes hygroscopic water and that part of the capillary water held between 15 to 31 atmosphere which is utilized by plants too slowly to prevent wilting.

$$\text{Unavailable water (cm/depth)} = \frac{\text{PWP (\%)} \times \text{BD} \times \text{D}}{100}$$

Soil Moisture Constant: -

It is the study of water and its availability. Water available in the soil at standard crop growth stage is called as soil moisture constants. They are as follows:

- Maximum water holding capacity
- Moisture equivalent
- Field capacity
- Permanent wilting point
- Ultimate wilting point
- Available soil moisture
- Hygroscopic co-efficient

1) Maximum water holding capacity or saturation capacity: -

- When all the pores of the soil are filled with water, the soil is said to be under saturation capacity of maximum water holding capacity.
- The tension of water at saturation capacity is almost zero and it is equal to free water surface.

2) Moisture equivalent: -

- Moisture equivalent is defined as the amount of water retained by initially saturated soil after being subjected to a centrifugal force of 1000 times that of gravity for about half an hour.
- The moisture content when expressed as moisture percentage on oven dry basis, gives the value of the moisture equivalent.

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- In medium textured soils, the values of field capacity and moisture equivalent are nearly equal.
- In Sandy soils, the field capacity exceeds the moisture equivalent.
- In very clayey soil the field capacity generally lower than the moisture equivalent, it represents moisture content in the inner capillary or micro capillary pores.

3) Field capacity: -

- The moisture held by soil against gravitational force is called as field capacity.
- At field capacity, the large soil pores are filled with air, the micro pores are filled with water and any further drainage is slow.
- The field capacity is the upper limit of water availability to plants.
- The soil moisture tension between - 0.1 to - 0.33 atmospheres.
- It is determined with the help of pressure plate apparatus.
- The moisture content at the field capacity is taken as 100%.
- It comes after 48 to 72 hours after irrigation.

4) Permanent wilting point or wilting coefficient:-

- Permanent wilting point proposed by Briggs and Shantz (1912).
- The soil moisture content at which plants cannot longer obtain enough moisture to meet transpiration requirements; and remain wilted unless water is added to the soil.
- It is the lower limit of available soil moisture to plant.
- Soil moisture tension at permanent wilting point is about 15 atmosphere or -15 bars.
- Wilting point in most soil is in the region of 50% field capacity.
- Permanent wilting point is determined by growing dwarf sunflower plant.

5) Ultimate wilting point

- The moisture content at which wilting is complete and the plant die is called ultimate wilting point.
- At ultimate wilting point the soil moisture tension is as high as -60 bars.

6) Available soil moisture

- Moisture available for plant growth is the capillary water between field capacity and permanent point.
- It can be determined by ASM = FC – PWP
- (Available Soil Moisture = Field Capacity - Permanent Wilting Point)

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7) Hygroscopic coefficient

- Air dried soil at atmosphere contains tightly bound water with soil particles and water if macro and micro pores are completely replaced by air. The metric section of this stage is called hygroscopic coefficient.
- The clay soil contains more colloidal materials, contains more hydroscopic water than sandy soil.
- At this moisture constant, the metric potential of soil water is about 31 atmospheres. At this point water in the soil is adsorbed on the soil colloids so tightly that it can move only in vapour form.

Factors affecting available water soil moisture

- **Soil texture**: - Fine textured soil have more water holding and retention capacity, so more water availability.
- **Soil structure: -** Well aggregated soil have more retention of water, so have more available water.
- **Organic matter**: - Soil with higher organic matter have higher water holding, thus more water is available for plants.
- **Soil compaction**: - Less compact soils have higher number of total pore space which results in high water retention.
- **Soluble salt: -** Presence of high soluble salts in the soil increase osmotic potential results in low available water content.
- **Soil depth: -** High soil depth has high available water content.

Soil Moisture Characteristics Curve:

- A curve showing relationship between the energy status of water (tension) and amount of moisture in soil. As the energy status of soil decreases, soil water content also decreases.
- In other words, as the soil moisture content decreases, more energy has to be applied to extract moisture from the soil.
- Soil Moisture Characteristic Curve: -
  - For Sandy soil: L shaped
  - For Clay soil: I shaped (almost a straight line)