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SOIL WATER RETENTION - pF CURVE

Growing insight

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Water is a precious natural resource. The application of a reasonable irrigation regime not only saves water but also has high efficiency in agricultural cultivation. To achieve this, we need to understand the soil moisture regime for plants.

Soil moisture and moisture regime

The soil moisture content only indicates the amount of water present in the soil, but cannot be an indicator to apply for a reasonable irrigation regime. The moisture regime of a soil is of storage and percolation properties and thus determines the quality of the soil as habitat for plants. The amount of water input into the soil from precipitation/irrigation partly moves by freely gravity downwards as percolating water; a certain proportion of it is retained as capillary and adsorbed water. The retention and movement of water in soils, water uptaken by plants and loss to the atmosphere are all energy-related phenomena. The energy relationships between free water and soil moisture are generally expressed in terms of soil-water potentials. These potentials are described in units of pressure hPa.

Because of the wide pressure ranges from very wet to very dry conditions, matric potential is often expressed as the log of the pressure in hPa and is called pF (ex. 100 hPa is equal to a pF of 2). The relationship between pF and the moisture content in volume (%) is called water retention curve or pF curve. It is often used to describe the influence of soil properties on the soil moisture regime. The water retention by soil is critical for plants and acts as the main source of moisture for it in almost all habitats.

Water potential is highly soil texture dependent. Clay particles have a larger surface area, produce micropores, and thus will have a higher affinity for water than that of silt and sandy that usually produce mesopores and macropores. Matric potential is very important for irrigation scheduling because it can represent the soil water that would be available to a crop.

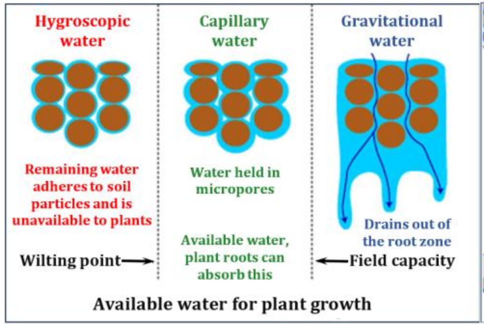
Soil Water Holding Capacity

One of the main functions of soil is to store moisture and supply it to plants between rainfalls or irrigations. Evaporation from the soil surface, transpiration by plants and deep percolation combine to reduce soil moisture status between water applications. If the water content becomes too low, plants become stressed. The plant available moisture storage capacity of a soil provides a buffer which determines a plant's capacity to withstand dry spells.

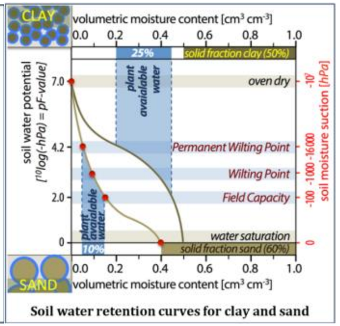
Water is held in soil in various ways and not all of it is available to plants. Chemical water is an integral part of the molecular structure of soil minerals. It can be held tightly by electrostatic forces to the surfaces of clay crystals and other minerals and is unavailable to plants. The rest of the water in the soil is held in pores, the spaces between the soil particles. The amount of moisture that a soil can store and can supply to plants are dependent on the number and size of its pore spaces. Gravitational water is held in large soil pores and rapidly drains out under the action of gravity within a day or so after rain/irrigation. Capillary water is held in pores that are small enough to hold water against gravity, but not so tightly that roots cannot absorb it. This water occurs as a film around soil particles and in the pores between them and is the main source of plant moisture. As this water is withdrawn, the larger pores drain first. The finer the pores, the more resistant they are to removal of water. As water is withdrawn, the film becomes thinner and harder to detach from the soil particles.

When soil is saturated, all the pores are full of water, but after a day, all gravitational water drains out, leaving the soil at **field capacity**. Plants then draw water out of the capillary pores, readily at first and then with greater difficulty, until no more can be withdrawn and the only water left is in the micro-pores. The soil is then at **wilting point** and without water additions, plants die.

The amount of soil water available to plants is governed within the root zone and the nature of the soil material. Because the total and available moisture storage capacities are linked to porosity, the particle sizes (texture) and the arrangement of particles (structure) are the critical factors. Organic matter and carbonate levels and stone content also affect moisture storage. Therefore, soil with poor structure, low organic matter, low carbonate content and presence of stones all reduce the moisture storage capacity of a soil.



Available water for plant growth



Soil water retention curves for clay and sand

Plant available water

This is the amount of soil water that can be extracted by roots and used for growth. Most plant available water is held in pores which range in size between 0.02mm and 0.005mm.

The amount of water available to plants is determined and calculated by the difference in moisture content between **field capacity** and **wilting point**. This is the total available water storage of the soil. Irrigators must have knowledge of the readily available moisture capacity so that water can be applied before plants have to expend excessive energy to extract moisture.

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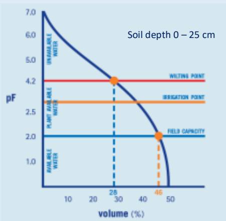
Irrigation regime adjusted by the pF curve

The pF-curve shows how much plant available water is at the very most, present and what the wilting point is. Eurofins AgroScience determines the pF values based on the physical soil properties such as clay, silt and sand and organic matter, in order to adjust irrigation regime and prevent leaching of nutrients due to too much irrigation. This might directly cause a loss of yield and quality of the crop. You can prevent this by not irrigating based on gut feeling, but using the pF-curve and, if you want even more accuracy, a moisture meter.

A typical example of calculating irrigation water according to the pF curve

Calculate the maximum irrigation for your crop



Step 1: Draw a vertical line at the point where the pF-curve and the wilting point line intersect (in this example 28% = 0,28).

Step 2: Also draw a vertical line at the point where the pF-curve and the field capacity intersect (in this example 46% = 0,46).

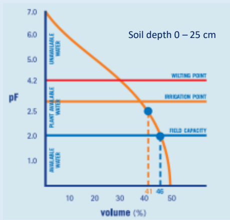
Step 3: Calculate the maximum supply (maximum quantity of plant available water) as follows: (% field capacity - % wilting point) x depth (rootable layer in mm). In this example: (0,46 - 0,28) x 250 mm = 45 mm

Step 4: If the crop roots deeper than 25 mm and the soil type below the sampled layer is not distinctly different, you can also adjust the maximum quantity to be irrigated, for example: (0,46 - 0,28) x 400 mm = 72 mm (for a rootable zone of 40 cm).

Step 5: Convert the amount of irrigation water (mm) to (Liter/ha). Example with the amount of irrigation water is 72 mm and applies for soil depth of 0 – 40 cm.

- 1 ha = 10.000 m²; soil depth of 0 – 40 cm is at 0,4 m. Thus, 1 ha with soil depth of 0 – 40 cm has: 10.000 m² x 0,4 m = 4.000 m³
- The amount of irrigation or rainfall for 1 ha is 72 mm = 0,072 m/ha.
- The amount of irrigation water needed for 1 ha to the soil depth of 40 cm is 0,072 m on 10.000 m². Thus, 0,072 m/ha x 10.000 m² = 720 m³/ha = 720.000 Liter of water/ha = 72 Liter of water/m²

Calculate the current required irrigation for your crop



Step 1: Use a moisture device to measure the moisture content of your plot. Draw a vertical line to the point where the moisture content measured by you and the pF-curve intersect (in this example 41% = 0,41).

Step 2: Draw a vertical line at the point where the pF-curve and the field capacity line intersect (in this example 46% = 0,46).

Step 3: Calculate the current supply as follows: (% field capacity - % current moisture content) x depth (rootable layer in mm). In this example: (0,46 - 0,41) x 250 mm = 13 mm

Step 4: If the crop roots deeper than 25 mm and the soil type below the sampled layer is not distinctly different, you can also adjust the maximum quantity to be irrigated, for example: (0,46 - 0,41) x 400 mm = 20 mm (for a rootable zone of 40 cm).

Step 5: Convert the amount of irrigation water (mm) to (Liter/ha). Example with the amount of irrigation water is 20 mm and applies for soil depth of 0 – 40 cm.

- 1 ha = 10.000 m²; soil depth of 0 – 40 cm is at 0,4 m. Thus, 1 ha with soil depth of 0 – 40 cm has: 10.000 m² x 0,4 m = 4.000 m³
- The amount of irrigation or rainfall for 1 ha is 20 mm = 0,02 m/ha.
- The amount of irrigation water needed for 1 ha to the soil depth of 40 cm is 0,02 m on 10.000 m². Thus, 0,02 m/ha x 10.000 m² = 200 m³/ha = 200.000 Liter of water/ha = 20 Liter of water/m²

Quick calculation experience: How many mm of water for irrigation is how many liters of water/m²

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