

# When and how much to irrigate.

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## Three approaches to estimate how much water is required

1. **Climate based** (temperature, sun shine, wind speed, humidity....)
2. **Soil based** ( soil texture and active root depth)
  - 2.1 Utilizing equipment for measuring soil moisture
  - 2.2 Utilizing equipment for measuring soil suction
  - 2.3 Utilizing experience and feeling by hand
3. **Plant based** (type of plant, growth stage, appearance)

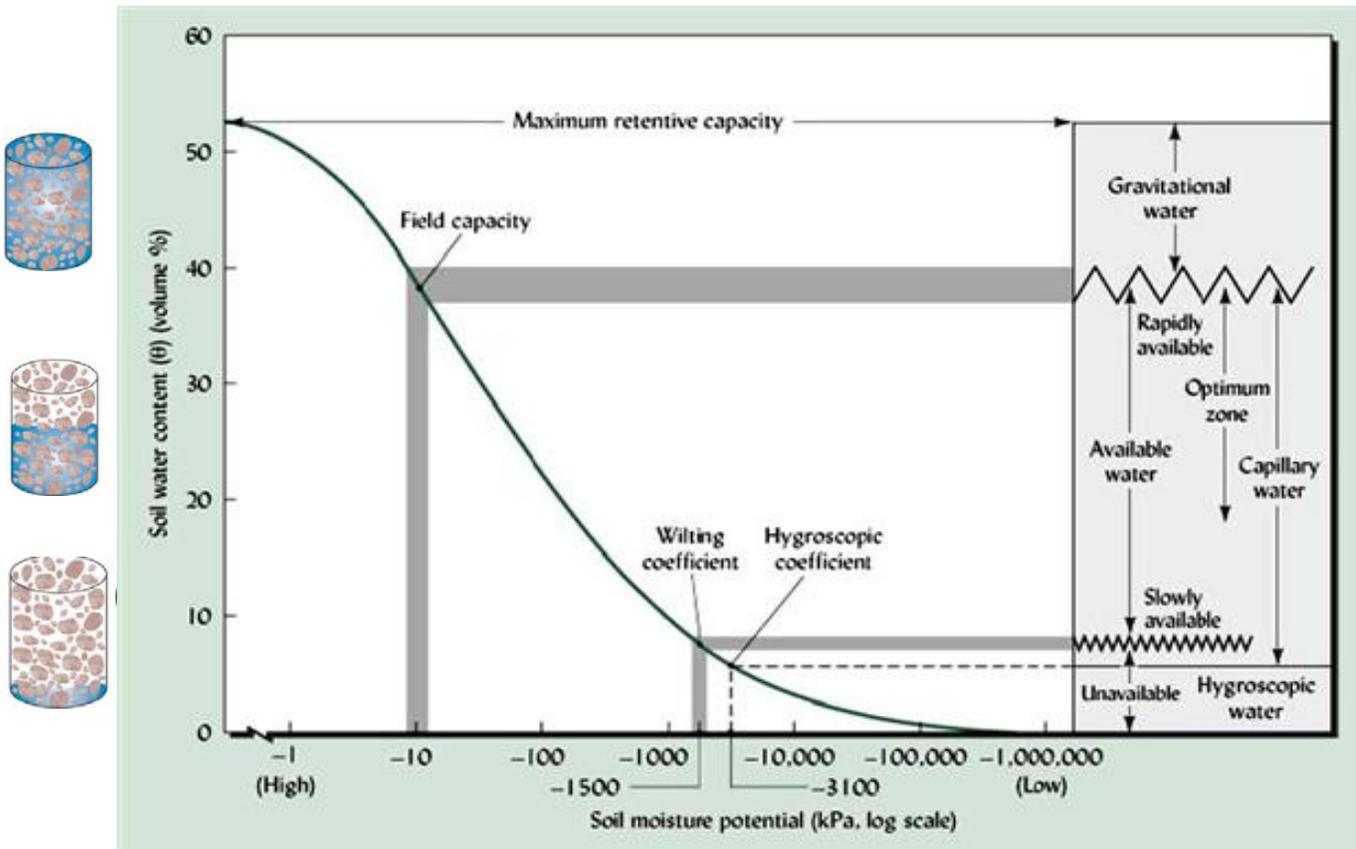
## 1. Soil based approach

- When the soil profile is full of water (immediately after an irrigation or heavy rainfall) it is said to be **saturated**
- Within 24 to 48hrs, the excess water (gravitational) **drains out**
- Once gravitational water has drained the water content is **at an optimum level and the soil water content at this stage is referred to as the upper limit of plant available water. The plant** is happy since it is easy to take up water. This stage is also known as **Field Capacity (FC)** (soil tension at FC is about -10 to -30 kPa)
- **Tension: measure of how tightly the soil particles hold on to the water**

## Relationship between soil water content and tension

- As water is used up by plants, or evaporated the tension in the soil increases and **less water is available**

Soil moisture retention curve shows the relation between soil water content and matric suction

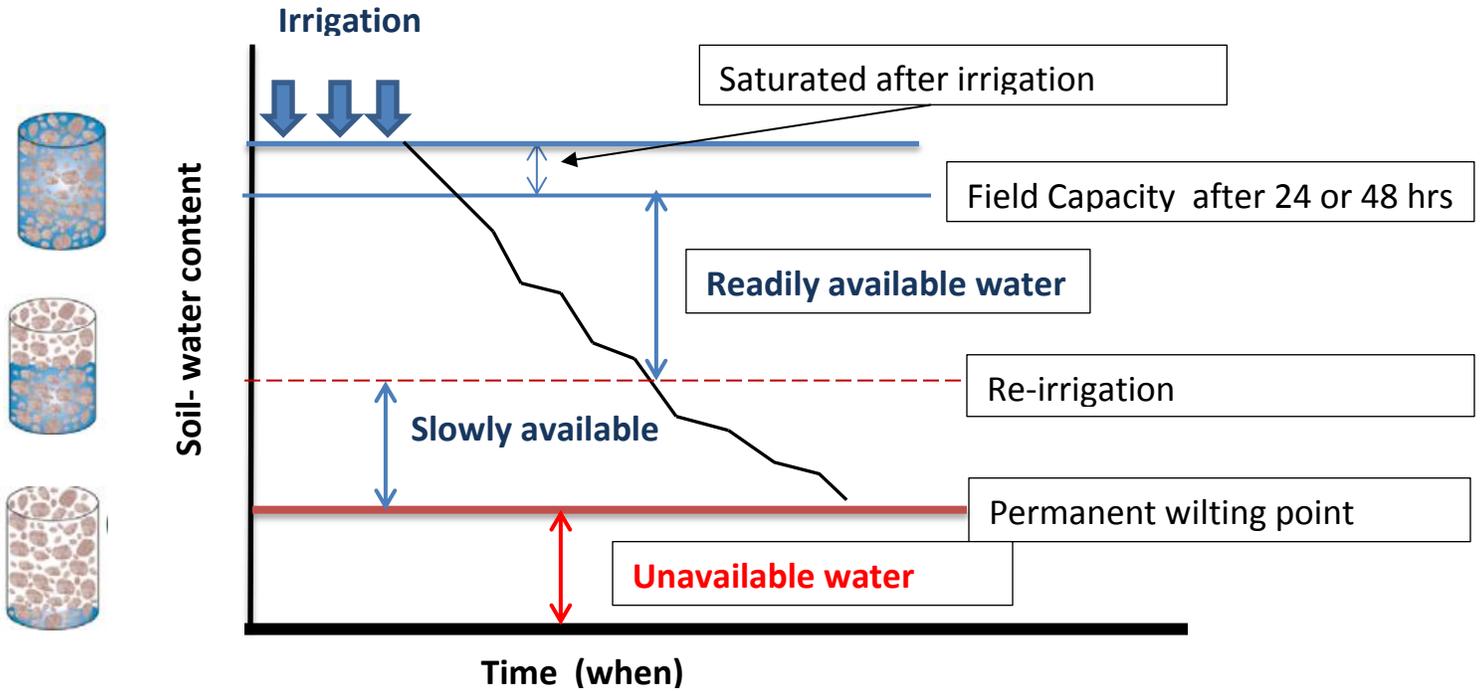


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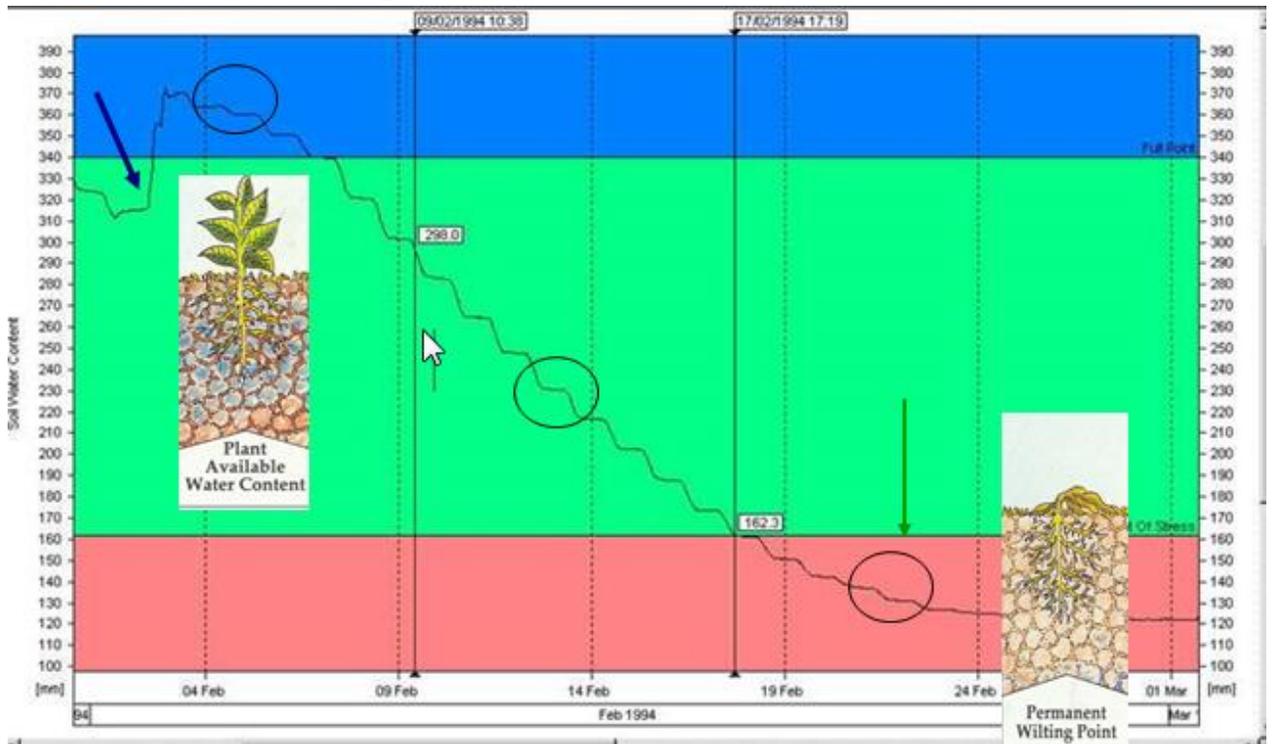
Plants use water until the soil water content drops to **Permanent Wilting Point (PWP)** which is also referred to as the **lower limit of Available water**. The moisture **below PWP** can't be used (soil tension at PWP is 15 bars or 1500 kPa)

- Difference between FC and PWP is known as **Plant Available Water (PAW)**

- **Readily Available Water (RAW)** is the portion of plant available water which is readily used by plant.



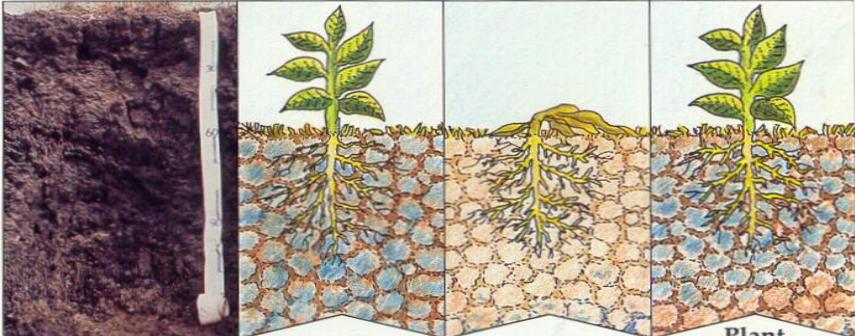
The schematic concept of different soil moisture level



## What amount of irrigation?

Irrig. depth to refill root zone  $I = (FC - PWP) \times P \times R$

- FC and PWP estimated from soil texture (see table below)
- R: Rooting depth determined by digging out the whole plant (see table)
- P: Depletion factor, is the fraction of total available water that can be depleted from the root zone **before moisture stress occurs** (0.4-0.5)

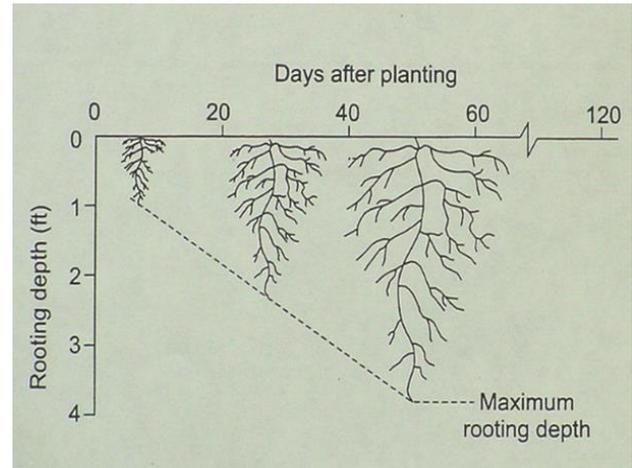


Soil texture	Field Capacity	Permanent Wilting Point	Plant Available Water Content
Well-structured clay	50	30	20
Clay	38	24	14
Loam	34	12	22
Sandy loam	23	9	14
Sand	9	2	7

Water storage ability of various soils (cm water in 1m depth).

## Irrigation based on soil moisture monitoring

**Step 1: Determine active root zone by digging or using soil moisture probe or from literature (Table below)**



**Step 2: Using a soil moisture monitoring device determine moisture content at the root zone**

**Step 3: Calculate the depleted water or water to refill**

Root depth and depletion factor of some selected vegetable crops (Allen et al., 1998)

Crop	Tomato	Onion	watermelon	Carrot	Lettuce	Broccoli	Cabbage
Root Depth (mm)	500-1500	300-600	800-1500	50-1000	300-500	400-600	500-800
Depletion Factor (p)	0.4-0.5	0.3-0.4	0.4-0.5	0.4-0.5	0.3-0.4	0.4-0.5	0.4-0.5

**Example:** Suppose my soil is sandy loam and current moisture is 10%. Calculate irrigation requirement to refill soil if the root zone is 50cm

**Irrigation depth  $I = (FC - SM) \times R$**

**$I = (0.23 - 0.10) \times 500 \text{ mm} = 65 \text{ mm}$**

- **I:** total required water to refill soil up to FC & SM is soil moisture

## Volume of required water

For **each plant**: multiply **I** by wetted area or canopy area

For **your block**: multiply **I** by the whole canopy area/wetted area



<https://www.google.com/search?q=whole+canopy+area>

## How long to irrigate? (Irrigation duration)

Once you estimated volume of required water you need to measure the flow rate of drippers/sprinklers in order to estimate irrigation duration

### Step 1: Check/measure your flow rate

A simple way: the time takes to fill a known volume bucket  
If it takes 100 seconds to fill 10 liter bucket

$$\text{Flow rate} = 10\text{L}/100\text{s} = 0.1 \text{ L/s or } 360 \text{ L/hr}$$

### Step 2: Divide volume of required water by flow rate

#### Example:

Irrigation depth  $I=40\text{mm}$  and your block size  $2000 \text{ m}^2$ .

if you are wetting 50% and you have 400 drippers with 8L/hr

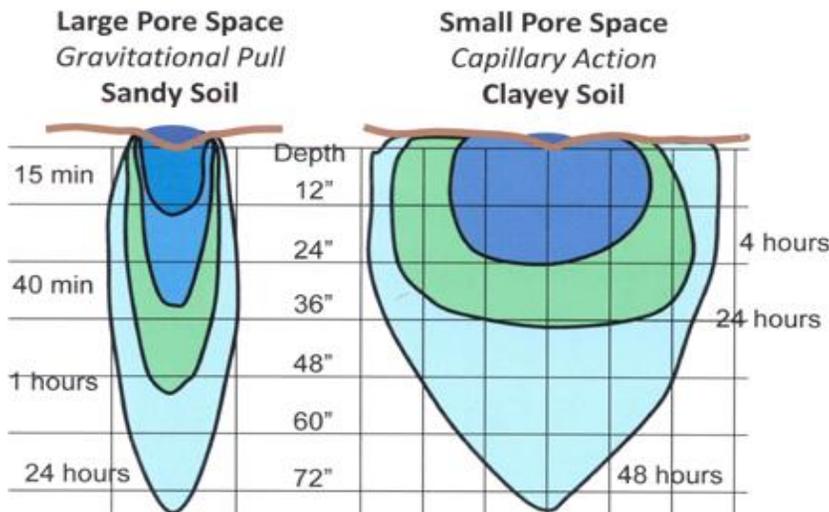


## Solution

Volume of water to refill soil=  $I \times A \times w = 40\text{mm} \times 1000 = 40,000\text{L}$

Irrigation duration=  $40000\text{L} \div (400 \times 8 \text{ L/hr}) = 12.5 \text{ hr}$

- Coarse soils (sands) have less storage while fine soils (clays) have larger storage  
 Water moves down faster in coarse soils than in fine soils



## Estimating available soil water capacity using soil texture assessment method

If you don't have access to a soil moisture probe device it is possible to dig a hole to the root zone occasionally to observe the moisture level by feel or re-irrigate when plant leaves start wilting

**1. Coarse Texture-** appearance of fine sand and loamy fine sand soils at various soil moisture conditions

*Available water capacity:* **50-98 mm / 1000 mm soil**

*Percent available :* **Currently available soil moisture as a percent of available water**

*mm/mm depleted:* **mm of water currently needed to refill a 1000 mm of soil to field capacity**



**0-25 percent available water**

**98-41 mm per 1000mm depleted**

**Dry, loose, will hold together if not disturbed**

**25-50 percent available water**

**74-25 mm per 1000mm depleted**

**Slightly moist, forms a very weak ball with well defined finger mark**



**50-75 percent available water**

**49-16 mm per 1000mm depleted**

**Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, will not ribbon**



**75-100 percent available water**

**25-0 mm per 1000mm depleted**

**Wet, forms a loose ball and aggregated sand grains remain on fingers, darkened color, will not make ribbon**

**2. Moderately Coarse Texture-** appearance of sandy loam and fine sandy loam soils at various soil moisture conditions

*Avialable Water Capacity:* **106-140 mm /1000 mm soil**

*Percent avialable :* **Currently avialable soil moisture as a perecent of avaiabel water**

**mm/mm depleted: mm of water currently needed to refill a 1000 mm of soil to field capacity**

**0-25 percent available water**

**140-82 mm per 1000mm depleted**

**Dry, forms a very weak ball, aggregated soil grains break away easily from ball**

**25-50 percent available water**



**106-57 mm per 1000mm depleted**

**Slightly moist, forms a weak ball with finger marks, darkened color, no water staining on fingers, grains break away**



**50-75 percent available water**

**74-25 mm per 1000mm depleted**

**Moist, forms a ball with defined finger marks, very light soil/water staining on fingers, darkened color, will not stick**



**75-100 percent available water**

**32-0 mm per 1000mm depleted**

**Wet, forms a ball with wet outlined on hands, light to medium staining marks on fingers, makes a week ribbon between thumb and forefinger**

**3. Medium Texture** appearance of sandy clay loam and silty loam soils at various soil moisture conditions

*Available Water Capacity:* 123-172 mm/ 1000 mm soil

*Percent available :* Currently available soil moisture as a percent of available water

*mm/mm depleted:* mm of water currently needed to refill a 1000 mm of soil to field capacity

**0-25 percent available water**

172-90 mm per 1000mm depleted

Dry, soil aggregation break away quickly, no staining on fingers, break away from balls, clods crumbles with applied pressure



**25-50 percent available water**

131-65 mm per 1000mm depleted

Slightly moist, forms a weak ball with rough surface, no water staining on fingers, few aggregated soil grains break away



**50-75 percent available water**

90-32 mm per 1000mm depleted

Moist, forms a ball, very light staining on fingers, darkened color, forms a weak ribbon between thumb and forefinger



**75-100 percent available water**

41-0 mm per 1000mm depleted

Wet, forms a ball with a well-defined finger marks, light to heavy soil/water coating on fingers, ribbons between thumb and forefinger

**4. Fine Texture** appearance of clay, clay loam and silty clay soils at various soil moisture conditions

*Available Water Capacity:* **131-197 mm / 1000 mm soil**

*Percent available :* **Currently available soil moisture as a percent of available water**  
**mm/mm depleted: mm of water currently needed to refill a 1000 mm of soil to field capacity**

**0-25 percent available water**

**197-98 mm per 1000mm depleted**

**Dry, soil aggregation separate easily, clods are hard to crumble with applied pressure**



**25-50 percent available water**

**147-65 mm per 1000mm depleted**

**Slightly moist, forms a weak ball, very few aggregation break away, no water stains, clods flatten with applied pressure**



**50-75 percent available water**

**98-32 mm per 1000mm depleted**

**Moist, forms a smooth ball with defined marks, light soil/water staining on fingers, forms ribbons between thumb and forefinger**



**75-100 percent available water**

**49-0 mm per 1000mm depleted**

**Wet, forms a ball, uneven medium to heavy soil/water coating on fingers, ribbons easily between thumb and forefinger**

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