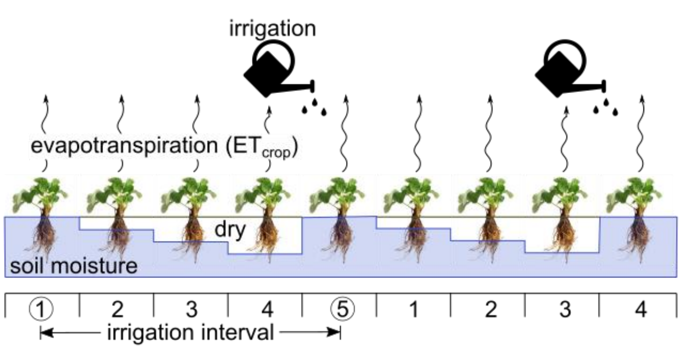
Introduction to Irrigation for Small-Scale Vegetable Farmers

WHY IRRIGATE?

- Soil water is necessary for optimal crop growth and yield
- Irrigation is used to supplement crop water needs not provided by rainfall
- Western Oregon's dry summers makes irrigation essential for many crops to be viable
- Optimal irrigation matches soil water to what is needed by the crop
  - Improves yields and crop quality
  - Conserves water and energy
  - Reduces leaching of nutrients and pesticides from the rootzone



WHY TO MEASURE SOIL MOISTURE?

- Knowing how much water is available in the soil versus how much is needed by the crop provides information on when and how much to irrigate
- Helps growers make informed irrigation scheduling decisions resulting in improved crop yield and quality while conserving water and reducing fertilizer, labor, and energy costs
- The soil moisture value is not enough for irrigation scheduling. The amount of that moisture available for crops depends on several factors

HOW MUCH WATER TO APPLY

- To provide enough water to meet the crop water needs, consider:
  - *Soils*: the amount of water a soil can hold depends on the soil texture and the amount of organic matter
  - *Crop*: water losses through evapotranspiration (ET) depend on temperature, solar radiation, crop growth stage, and depth of the roots
  - *Irrigation systems*: application rate and uniformity to avoid water losses (runoff, deep percolation and wind)

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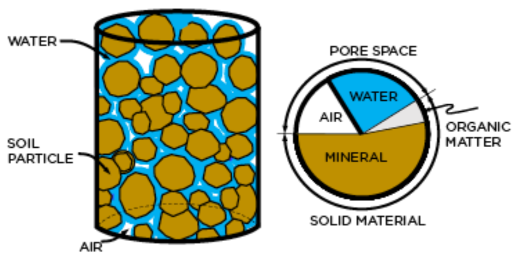
Understanding Your Soil and Crop Water Needs

UNDERSTAND YOUR SOIL

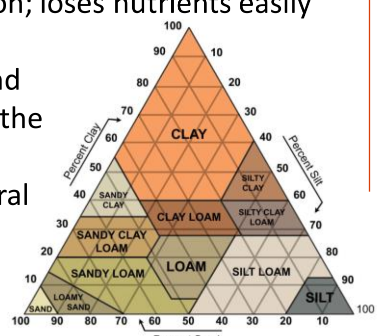
- Soil is composed of solid materials (soil particles and organic matter) and pore spaces (space between the solid material)
- These pore spaces are filled with varying percentages of air and water depending on the soil's moisture content



There are three types of soil particles:

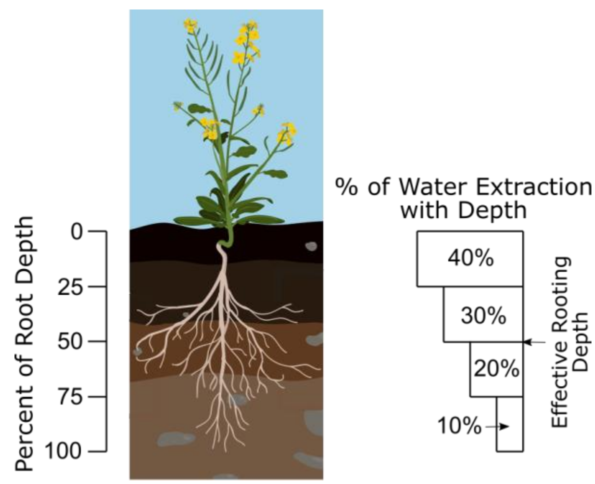
- Clay
  - Smallest diameter; forms "heavy" soil
  - Greatest percentage of pore space but with smallest diameter of individual pores
  - Pros: holds nutrients, pesticides, and water really well
  - Cons: poor infiltration rate and drainage; compacts easily; difficult for roots to penetrate
- Silt –
  - Particles larger than clay but smaller than sand
- Sand
  - Largest diameter; forms "light" soil
  - Largest diameter of individual pores
  - Pros: easy to work with; plants easily establish roots
  - Cons: drains quickly and requires more frequent irrigation; loses nutrients easily

The percent of sand, silt and clay in the soil determines the overall soil texture, shown using the USDAs Soil Textural Triangle

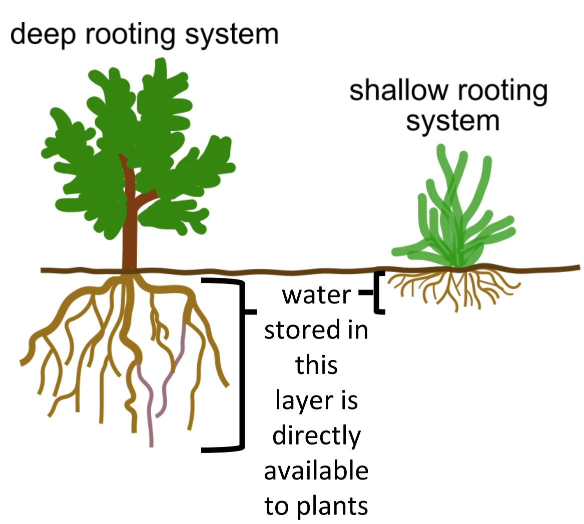


UNDERSTAND YOUR CROP NEEDS

- Each crop and each individual field will have different soil moisture requirements. This depends on:
  - Weather (radiation, temperature, wind…)
  - Soil (Available water capacity, water intake rate)
  - Crop characteristics (Crop growth stage, drought tolerance, rooting depth)
- Consider the effective root depth
  - Depth that plants get most of their water from
  - Estimated as half of the maximum root depth

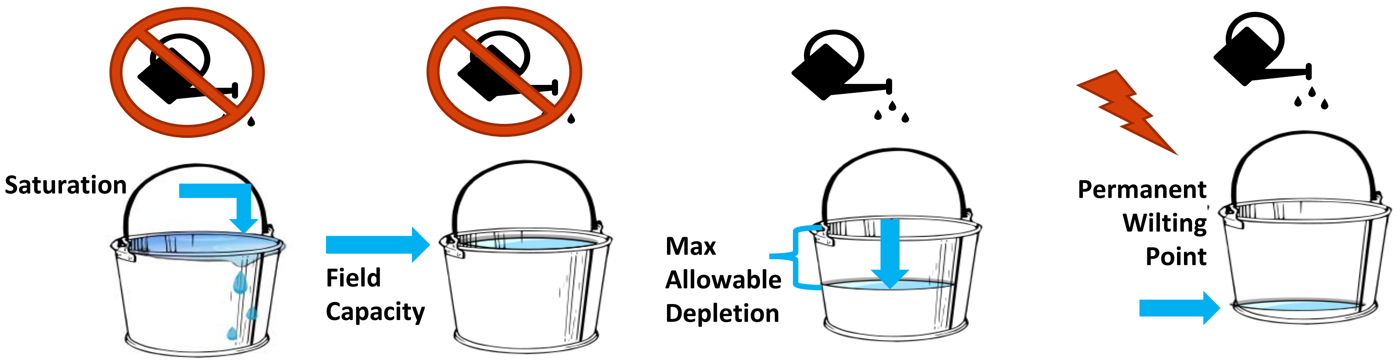


Just because there is water in the soil doesn't mean it's accessible for the plant



Understanding Soil Moisture

The soil is a reservoir for water. Approximately half of the bulk soil volume is pore space which may be filled with water and air. Let's imagine the soil like a bucket that can hold water. The water in the bucket represents the status of the plant-available water and the watering can represents when to irrigate.



Available water:
The amount of plant-available water that can be stored in a soil profile, typically defined as the range between field capacity and the wilting point.

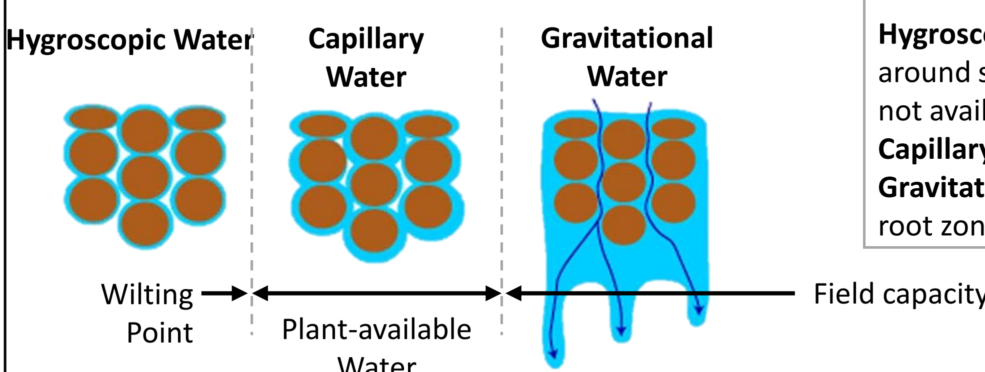
Saturation:
Soil pore spaces are filled with water. Excess water is lost through drainage from the root zone. Irrigating past this point is water lost.

Field capacity:
Excess water has drained and the rate of downward water movement has decreased. Typically ranges from 10 to 30 cb/kPa for sand and clay soils, respectively.

Maximum Allowable Depletion (MAD):
The percentage of available water that can be depleted before irrigation is required to prevent crop stress. This value depends on the crop's stress tolerance, growth stage, and water use.

Permanent wilting point:
No water left in the soil profile available to plants. Plants will wilt past this point. This is normally defined as 1500 cb/kPa.

<u>NOTE: Not all water in the soil profile is available to plants</u>



Hygroscopic water: water held as a film around soil particles through adhesion; not available to plants
Capillary water: water in soil pores
Gravitational water: Water drained out of root zone; not available to plants

Ways to Sense Soil Moisture

SOIL WATER TENSION SENSORS

- *What measures?* The soil water tension (usually reported in centibars [cb] or kilopasacals [kPa]) as an indicator of the effort of the roots to extract water from the soil (i.e., plant root force to pull water from soil)

- *How it works:* As the soil dries (i.e., increases tension) fluid is drown out of the instrument, reducing the fluid volume and creating a vacuum which is registered in the gauge

VOLUMETRIC WATER CONTENT (VWC) SENSORS

- *What measures?* Measures the amount of water in a soil by volume (expressed as a percentage) via the dielectric constant of the soil using capacitance technology
- Use to quantify changes in soil moisture

$$\text{VWC (\%)} = \frac{\text{volume of water}}{\text{volume of soil}}$$

Example: Decagon 10HS Moisture Sensor by ICT International

TWO TYPES OF SOIL WATER TENSION SENSORS

- Tensiometers
  - Acts like an artificial root
  - Only direct measurement
  - Most direct and accurate method
  - Periodic maintenance required
  - Automatic measurement can be achieved using data logging equipment

- Granular matrix sensor
  - Measures amount of moisture absorbed into the instrument's granular matrix
  - Calibrated to reflect the same values as read by
  - Maintenance free
  - Intended to be used as a permanent device and have an expected life of 5+ years
  - Automatic measurement can be achieved using data logging equipment

WHEN TO IRRIGATE?

- Reading a tensiometer gauge

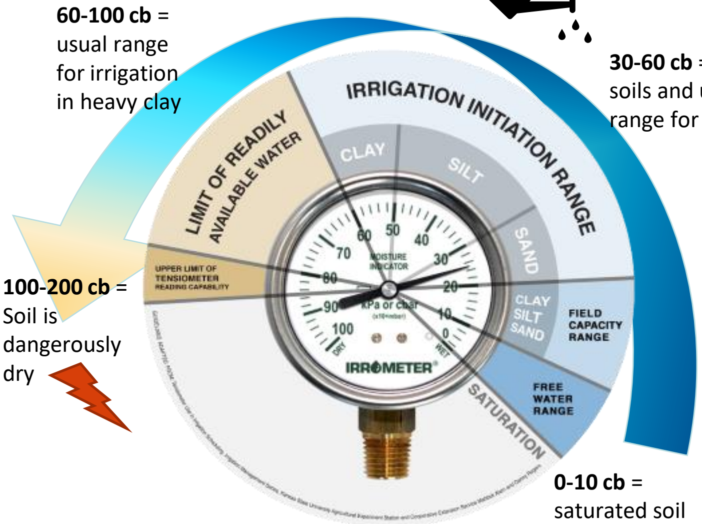
60-100 cb = usual range for irrigation in heavy clay

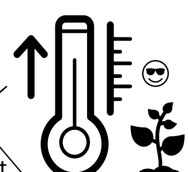
30-60 cb = moist soils and usual range for irrigation

100-200 cb = Soil is dangerously dry

10-30 cb = adequately wet soil (except for very sandy soils which will be too dry)

0-10 cb = saturated soil





Imagine soil water tension as the temperature at which plants will be "comfortable" to grow. Reducing plant water stress can help it grow and achieve higher yields

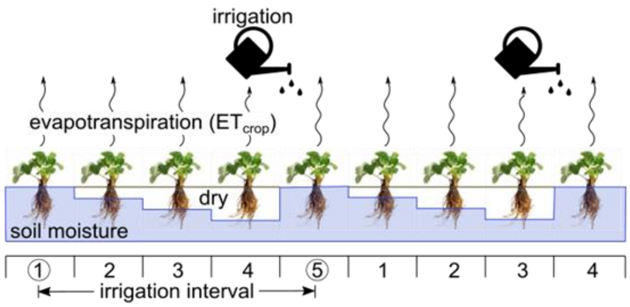
Crop	Optimum Range (kPa)
Strawberries	-20 to -30
Lettuce	-40 to -60
Potatoes	-30 to -50
Onions	
Early growth	-45 to -55
Bulbing time	-55 to -65
Carrots	-55 to -65
During seed year	-400 to -600
Small grains	
Vegetative period	-40 to -50
Ripening period	-800 to -1200

(Taylor, Sterling A. and Gaylen L. Ashcroft., 1072)

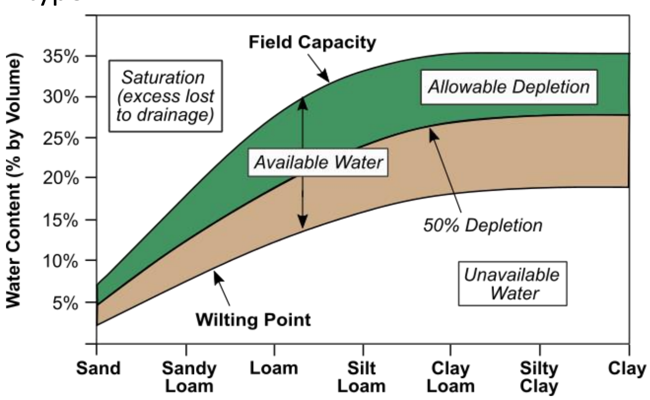
Using Soil Moisture Probes for Irrigation Scheduling

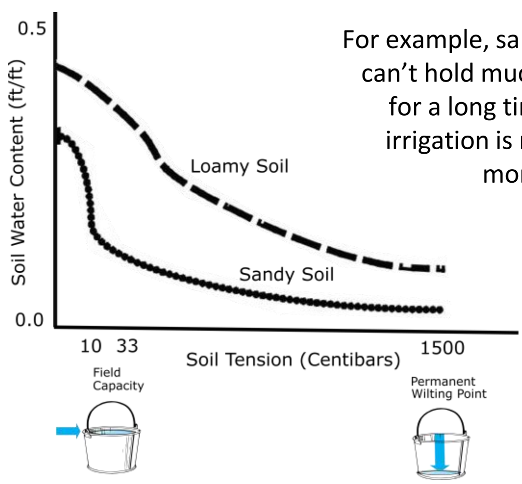
WHEN AND HOW MUCH TO IRRIGATE?

- Optimal irrigation would replace the amount of water lost through evapotranspiration (ET, water evaporated from the soil surface and the transpiration from the plants)



- Irrigation is managed differently based on your soil type.
- Using VWC, soil moisture should be kept between Field capacity (FC) and the Maximum Allowable Depletion (MAD); however, values for these parameters change based on your soil type

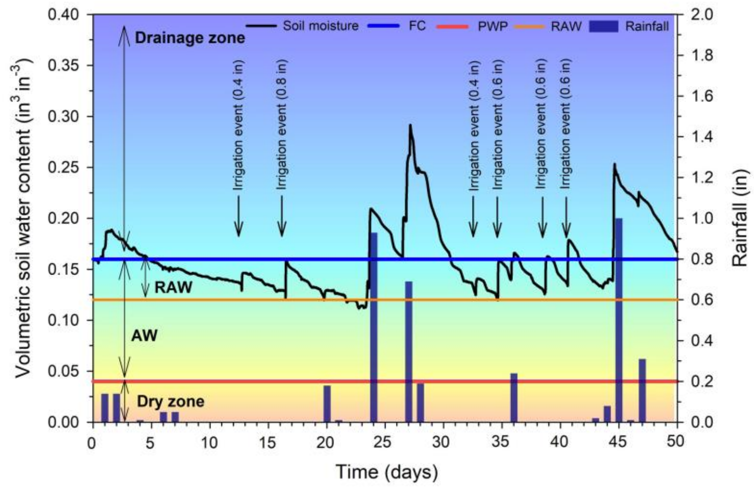




For example, sandy soils can't hold much water for a long time, thus irrigation is required more often.

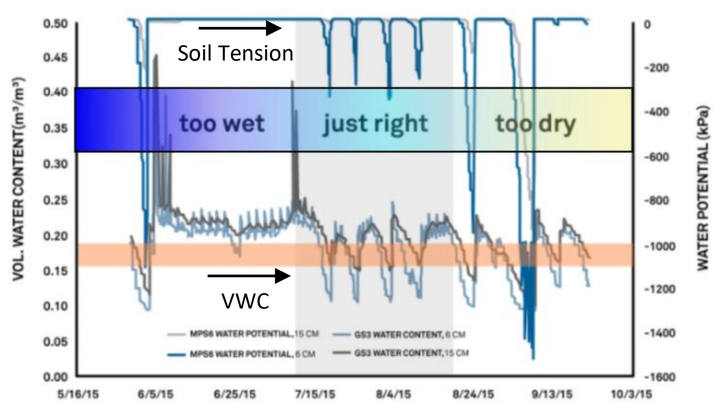
DATA EXAMPLES USING VWC AND TENSIOMETERS

- Example of irrigation using VWC in a sandy soil



(University of Georgia, 2015)

- Irrigation was applied to keep soil moisture between Field Capacity (FC, blue line) and readily available water (RAW, light orange line). Drainage zone and dry zones area avoided to avoid plant water stress due to over or under irrigation.
- Although VWC provides insights of the soil status, when combined with soil tension, insights of plant status can be inferred, and a holistic approach can be applied



(Meter Group, 2021)

- Ideally, VWC and soil tension should be monitored simultaneously to optimize irrigation applications and conserve water resources

Additional Resources

SOIL MOISTURE PROBES INFORMATION

- **Irrometer**
  https://www.irrometer.com/pdf/IRROMETERs/105-Model-SR.pdf
  https://www.irrometer.com/basics.html

- *Installation*
  https://edis.ifas.ufl.edu/publication/TR015
  https://www.youtube.com/watch?v=IvqmuUJRFEA

- **Watermark**
- https://www.irrometer.com/pdf/401-Watermark-family-brochure.pdf

- *Installation:*
- https://www.youtube.com/watch?v=vzIZCs3g6ac

- *Irrigation Calculator*
- https://www.irrometer.com/thresh.html

- **Pacific Northwest Irrigation resources**

THINGS TO CONSIDER FOR SENSOR INSTALLATION

- Should be installed at more than one location in a field
- In order to capture moisture variations in the soil profile, sensors need to be installed at different depths
- Recommended to place pairs of sensors at 1/3 and 2/3 the depth of the crop's total root depth zone
- It is recommended to install sensor pairs in soil types representative of the field and away from high points, depressions, and slopes
- For fields with both heavy and light soils, it is recommended to monitor and manage each soil type separately for irrigation
- For row crops, place the sensors between plants within a crop row at the desired depth
- Certain sensors are recommended for different soil types; make sure to check your soil and ensure the instrument is suitable for it

Use the Soil Web Survey to determine your field soil type
https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
Soil: The Dirty Secrets of a Living Landscape
https://catalog.extension.oregonstate.edu/em9304/html

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