Monitoring Soil Moisture

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Advanced Viticulture Short Course
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Texas A&M AgriLife Extension

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Soil Moisture Content

Types of Soil Moisture Sensors

Sensor Placement in the Vineyard

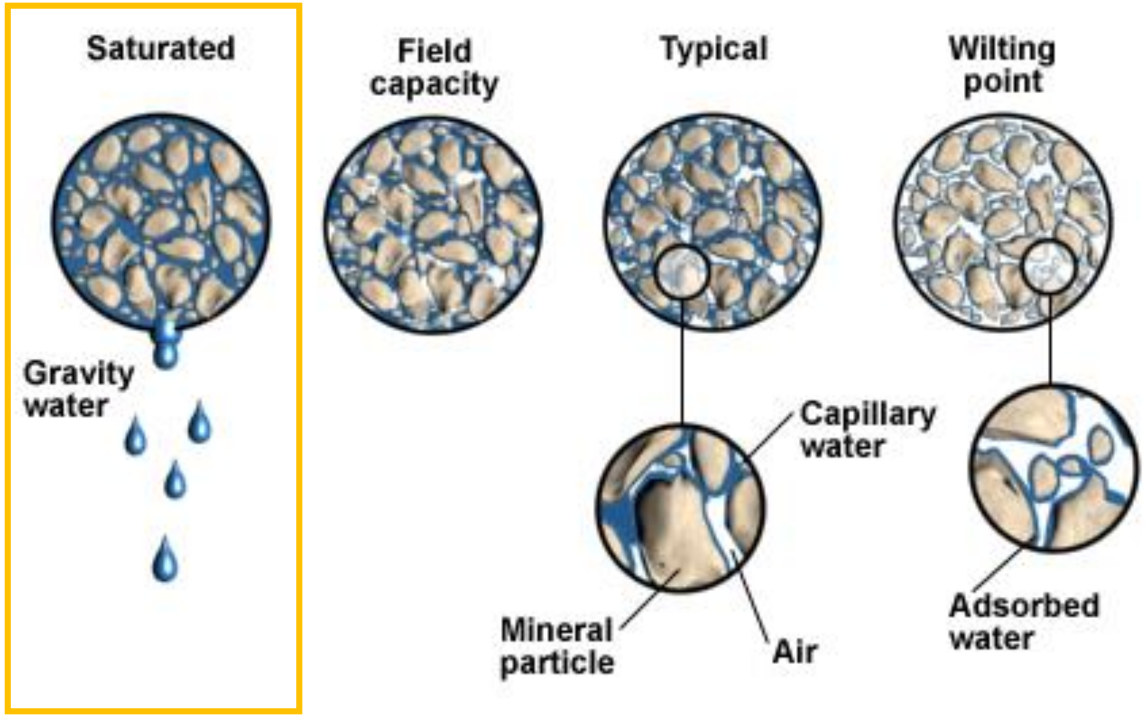
Depth of Sensor Placement

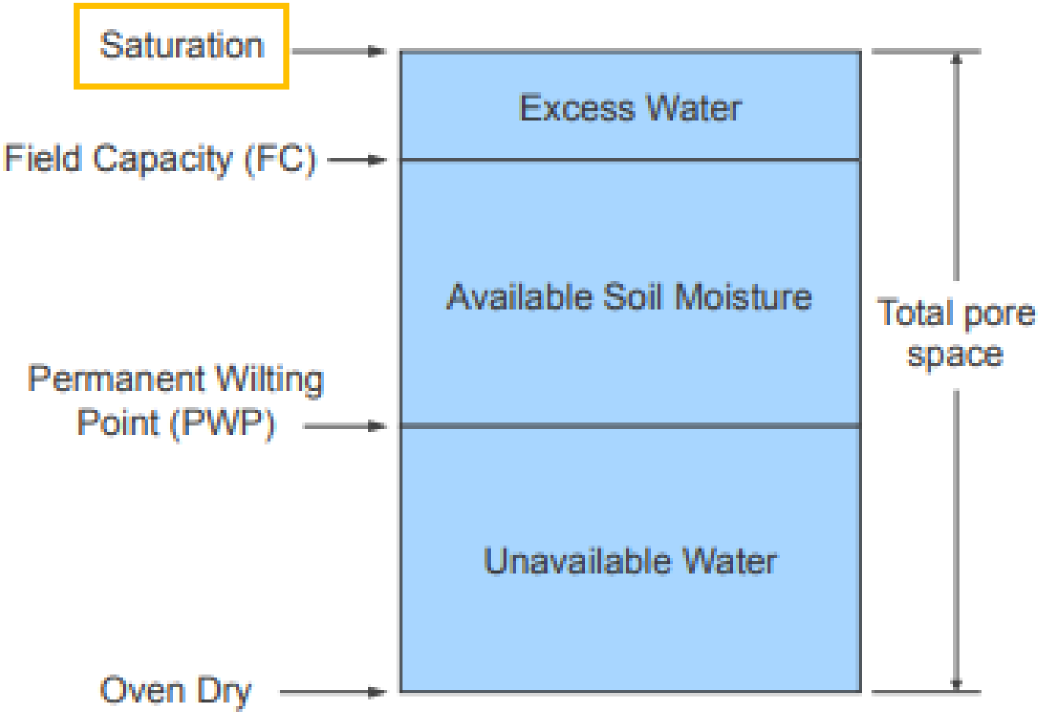
Sensor Placement Relative to Emitters and Vines

Sensor Installation

Soil Moisture Content

- Soil moisture content = Quantity of water within a unit of soil.
- Soil water is held in the pore space or empty spaces between soil particles.





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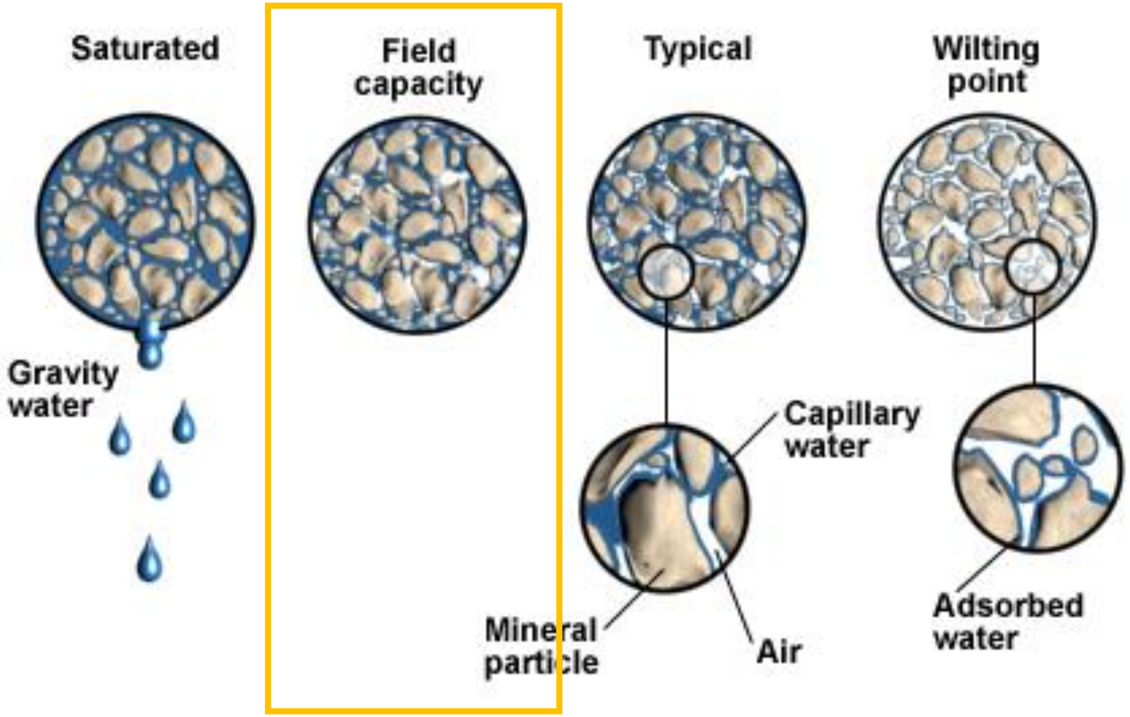

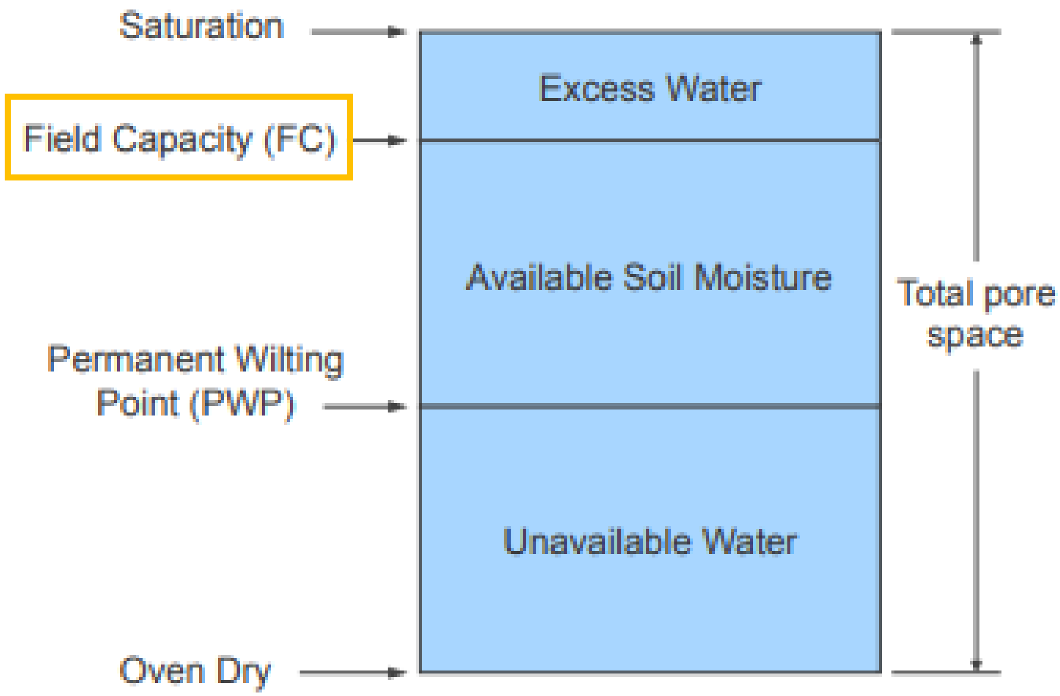

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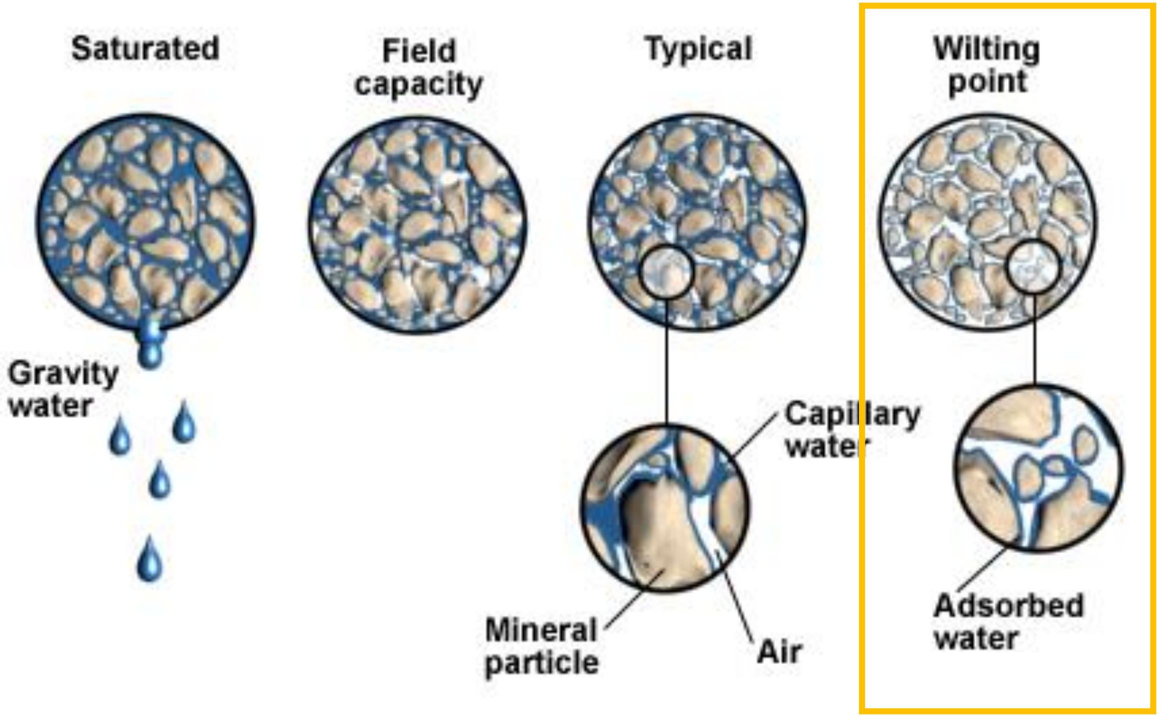

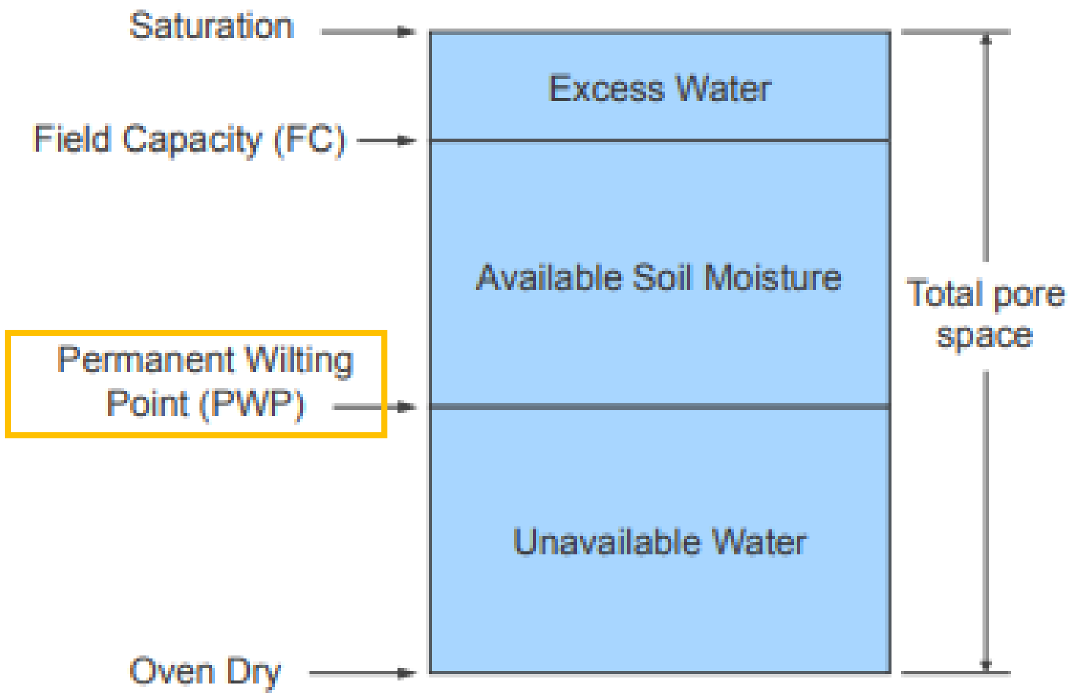

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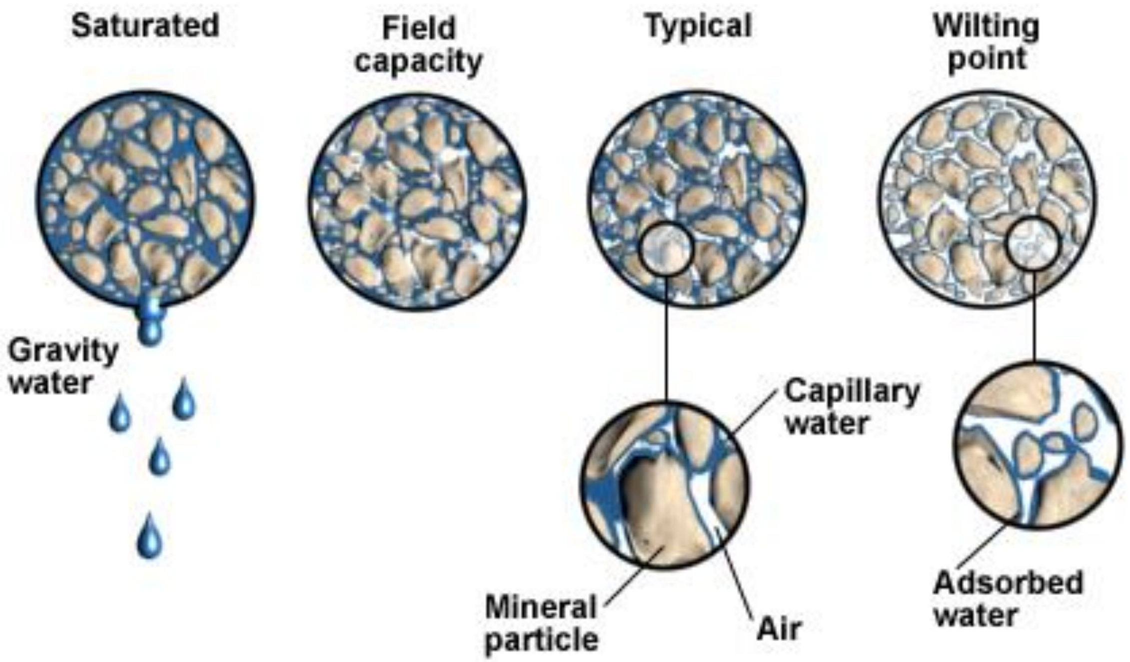
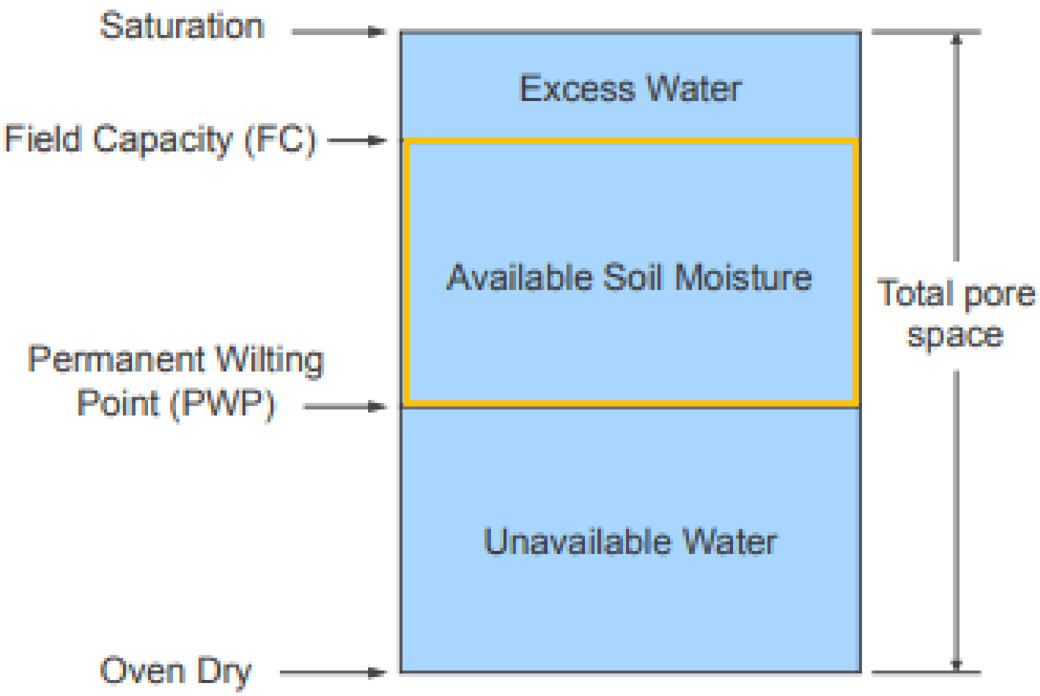
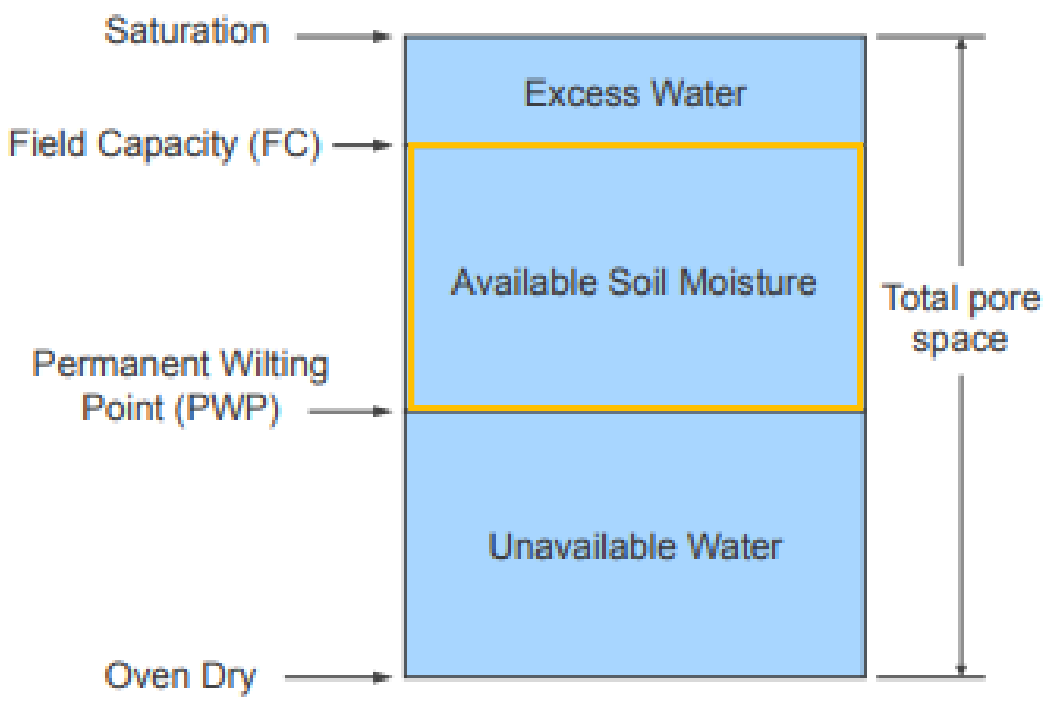




Soil Moisture Content

Different soils have different available water holding capacities.

Soil Texture	Available Water Capacity (AWC) in/ft
Coarse Sand	0.2–0.8
Fine Sand	0.7–1.0
Loamy Sand	0.8–1.3
Sandy Loam	1.1–1.6
Fine Sandy Loam	1.2–2.0
Silt Loam	1.8–2.5
Silty Clay Loam	1.6–1.9
Silty Clay	1.5–2.0
Clay	1.3–1.8
Peat Mucks	1.9–2.9



Soil Moisture Content

Soil moisture content is measured as a guide to determine:

- Irrigation timings - How often should the vineyard be watered?
- Amounts of water during irrigation - How much water should be applied per irrigation?
- Depth of irrigation - if rainfall or irrigation is reaching the rooting area.

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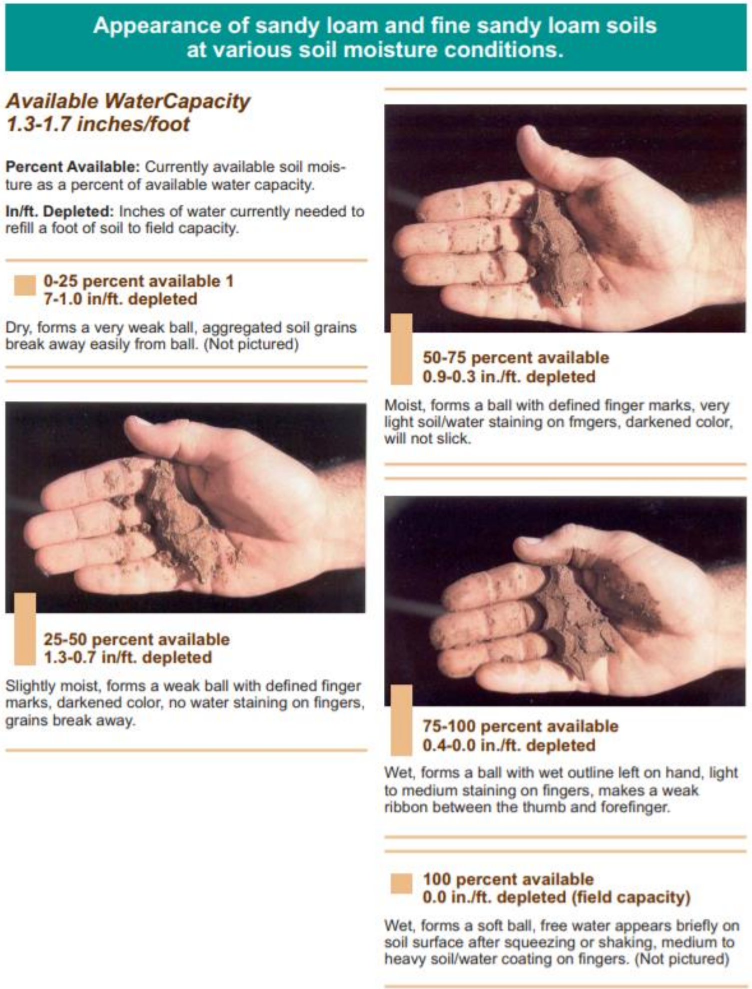
Soil Moisture Sensors

Feel and Appearance Method

It consists of viewing and feeling the soil.

The lack of staining or very light staining on the palm of hand indicates a need for water.

Advantages: Easy and cheap
Disadvantage: Only for topsoils and subjective



https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_051845.pdf

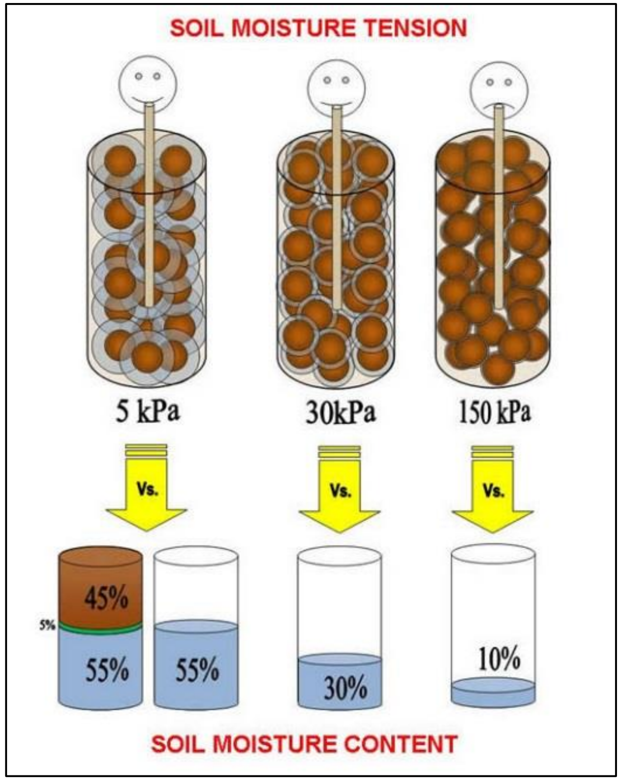
Soil Moisture Sensors

- Sensors that measure soil moisture content

How much water is present relative to the amount of soil.

- Sensors that measure soil moisture tension

Force by which water adheres to soil particles. It is very low in wet soils and increase in dry soils.



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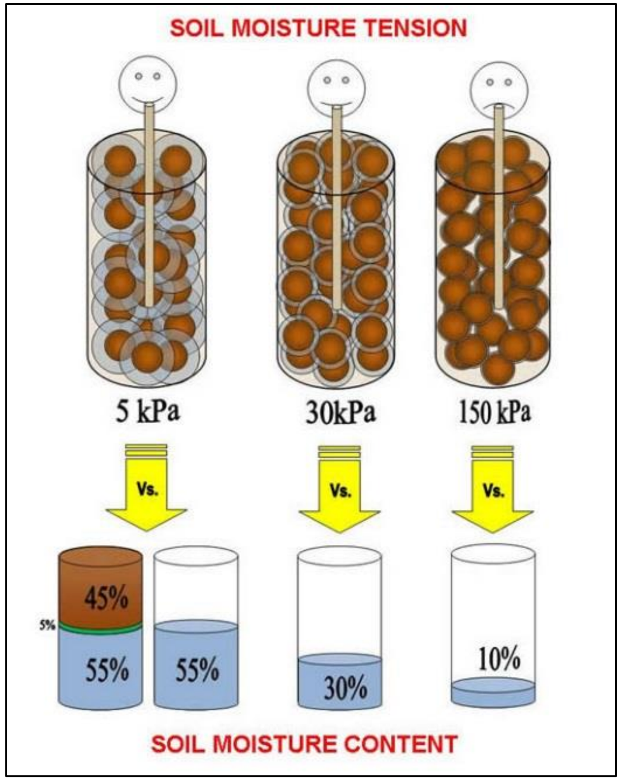
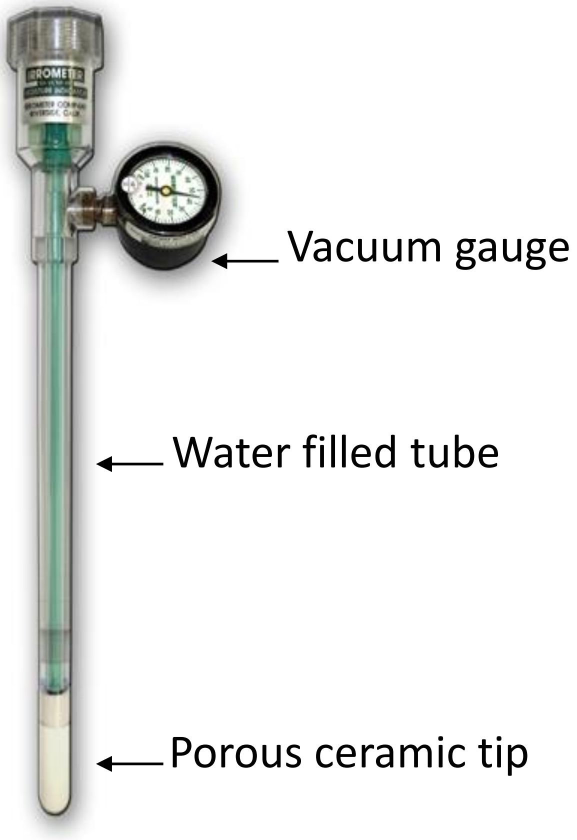


Tensiometer

It consists of a tube with a porous ceramic tip on the bottom, and a vacuum gauge near the top. When it is filled with water and inserted into the soil, water can move in and out of the tensiometer through the connecting pores in the tip.



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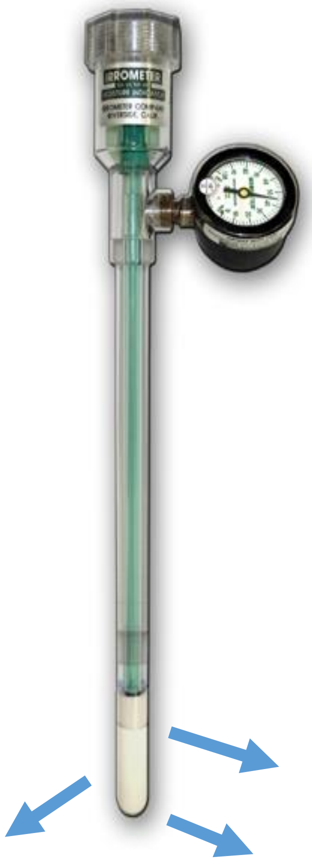
As the soil dries:



1. Water inside the tube is pulled out through the tip.

2. A vacuum is created and registered on the gauge.
The gauge reading is a direct measure of the force required to remove water from the soil.
The greater the reading, the drier the soil.

Tensiometer

Advantages
- Relatively inexpensive (~$100)
- Easy to install, read and maintain (periodically)
- Continuous reading at same location
- Not affected by salinity and temperature

Disadvantages
- Not useful in very dry conditions
- Need labor to collect data
- Risk of damage by equipment


http://hydropedologie.agrobiologie.cz

Electrical Resistance Blocks

It consists of 2 electrodes inserted in a block of porous material. As water moves in or out of the porous block, changes in the electrical resistance between the 2 electrodes occur.

As the soil dries:

1. Suction will pull water from inside the block.

2. Higher resistance occurs between the 2 electrodes measured by meter.

3. Resistance meter readings are converted to water tension.
The drier the soil, the higher the reading record.

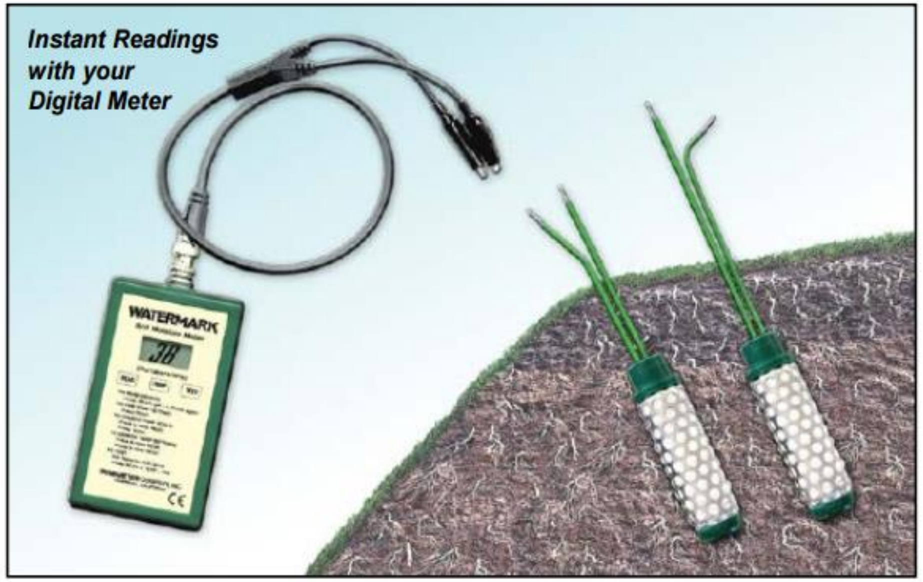
Electrical Resistance Blocks

Advantages

- Easy to install and read
- Inexpensive: Resistance blocks $6-20. Reading meter $200-400
- Operate over a wide range of soil moisture tension than do tensiometers
- Continuous measurements at same location
- Minimal damage by farming equipment and animals

Disadvantages

- Can be affected by soil salinity if high
- Slow response to moisture content
- Need labor to collect data



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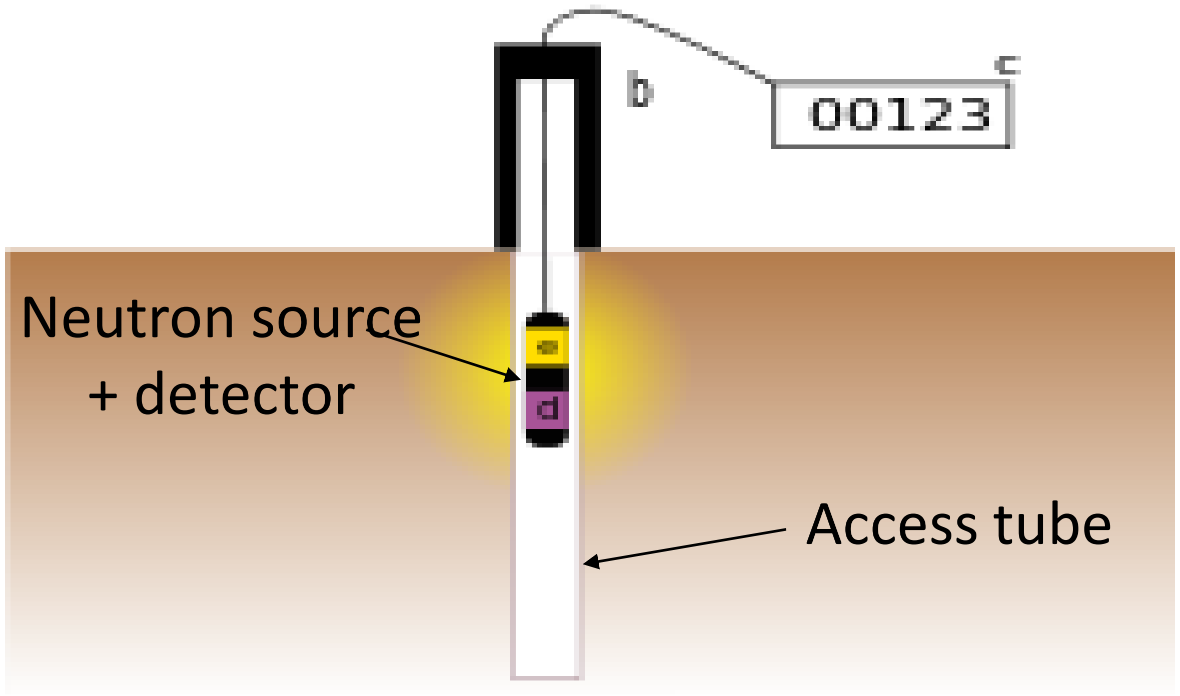
Neutron Probes

It consists of a nuclear unit which is both a neutron source and detector.



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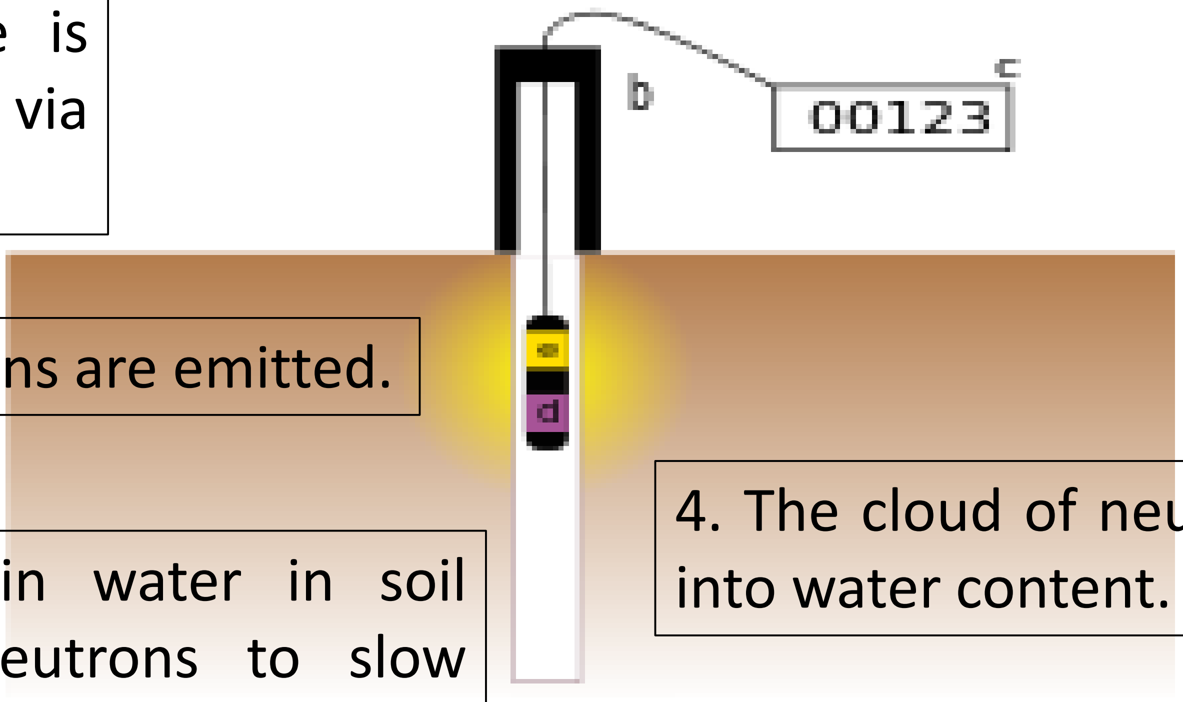

1. Radiation source is lowered into the soil via access tube.

2. Fast neutrons are emitted.

3. Hydrogen in water in soil causes the neutrons to slow down.
The probe becomes surrounded by a cloud of slow neutrons.

4. The cloud of neutrons is translated into water content.

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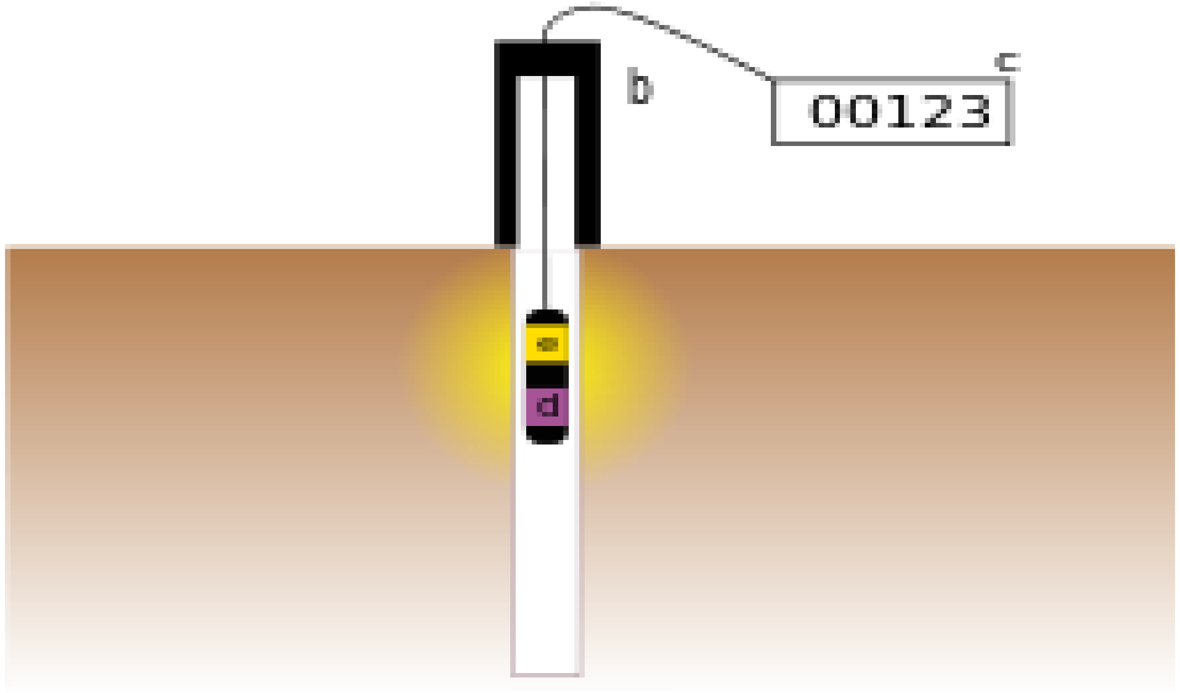


- If the soil is dry (less hydrogen → less slowing neutrons), the cloud of neutrons will be less dense.
- If the soil is wet, the neutron cloud will be more dense.

Neutron Probes

Advantages
- Rapid and easy
- A volume of soil about size of a volleyball is sampled at same depth: large measurement volume
- Excellent accuracy
- Salinity and temperature fluctuation not an issue
- Different site measure (if different access tubes exist)

Disadvantages
- Not reliable for shallow depths (~12'')
- Operator needs certificate due to the nuclear source
- Expensive: $5,000-$6,000
- No continuous record (can't leave nuclear source in vineyard)

Di-electric Moisture Sensors

Di-electric constant: ability of a substance to store charge/energy

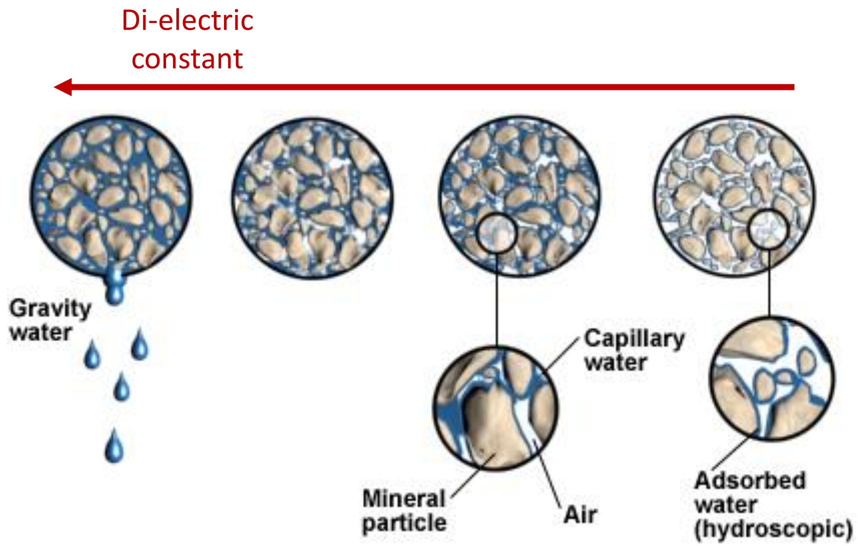
Soil = Organic matter + Minerals + Air + Water

The total di-electric of soil is made up of the di-electric of each individual constituent of soil

Measuring di-electric of soil → Measure of soil moisture

How measure di-electric?

- Time Domaine Reflectometer (TDR)
- Frequency Domain Reflectometer (FDR) or Capacitance

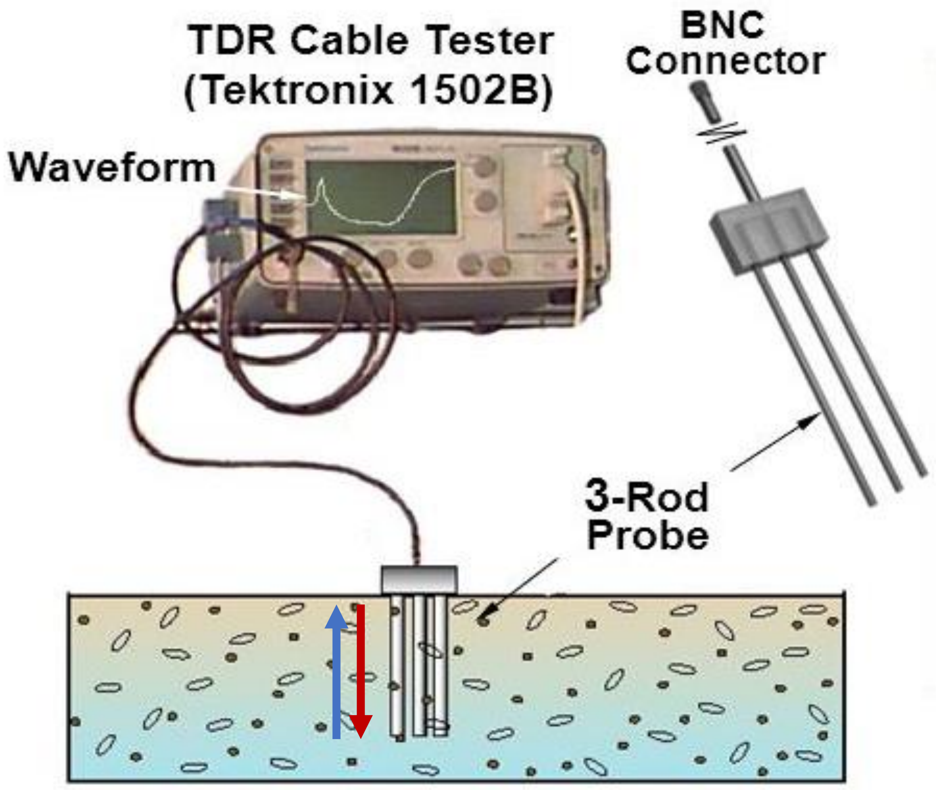


Time Domaine Reflectometers (TDR)

Measure the di-electric constant of a medium by finding the time taken for a pulse to reach the end of the probes and come back.

The travel time is related to energy storing of material around probes (di-electric constant).

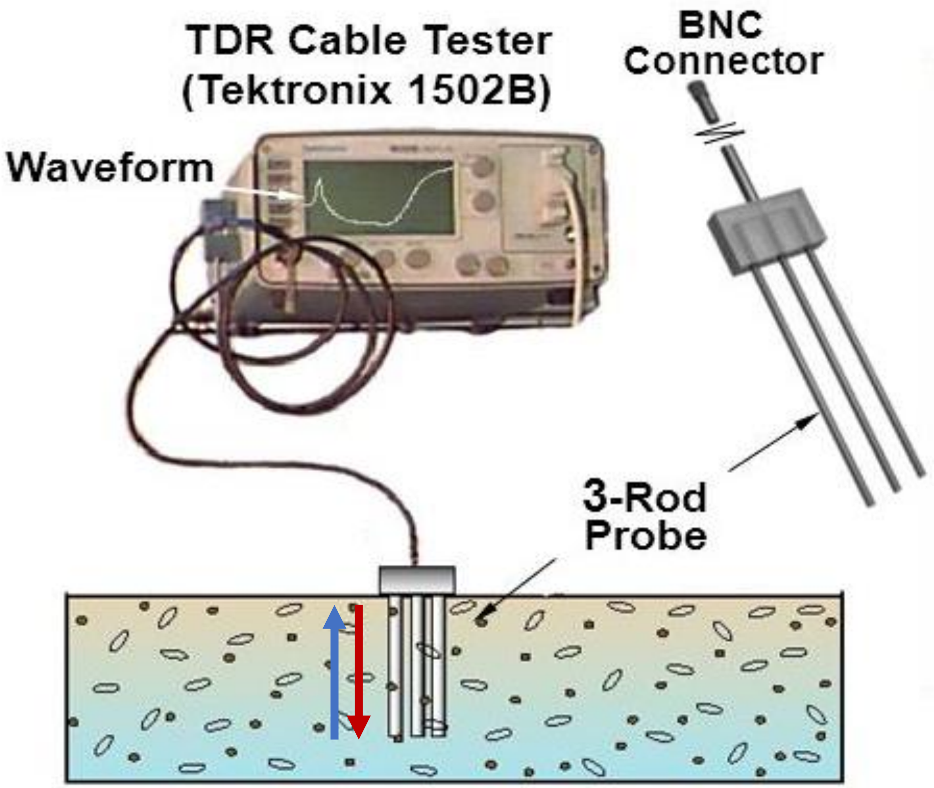
The longer the pulse travel time → the larger the dielectric constant → the higher soil moisture



Time Domaine Reflectometers (TDR)

Advantages
- Easy and rapid measurements
- Excellent accuracy
- Continuous record of data

Disadvantages
- Expensive: $500-600 to thousands of dollars
- Sensitive to air gaps, and salinity (if high)
- Complex system for setting-up and maintaining
- Need power (solar panel…) and specialized data reader

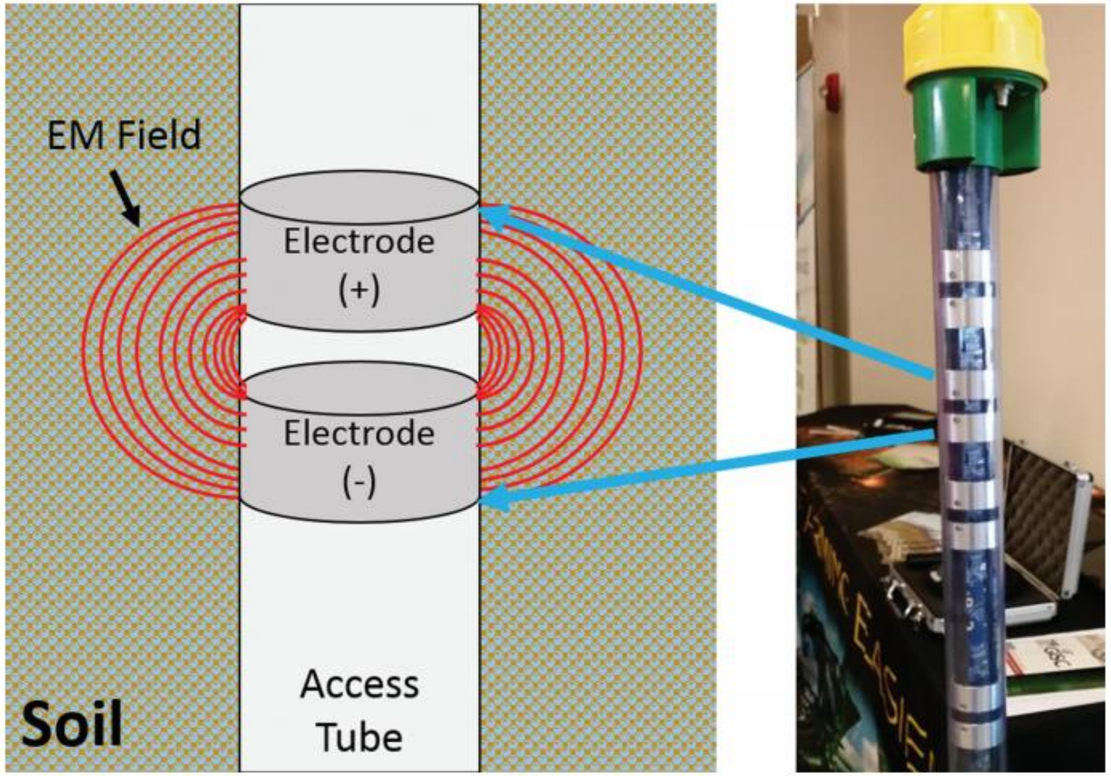


Frequency Domaine Reflectometers (FDR) or Capacitance

It consists of a capacitor that emits an electromagnetic field that extends into the soil.

The capacitance (storage of energy) is related to di-electric constant around the sensor and thus to soil water content.

Capacitance sensors can be purchased as individual sensors or built into a probe to measure soil moisture at multiple depths.

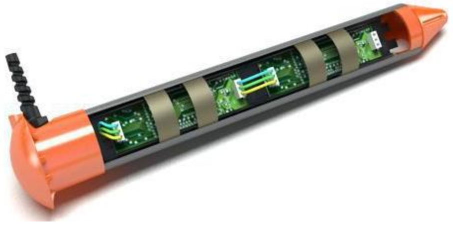


University of Nebraska EC3002

Frequency Domaine Reflectometers (FDR) or Capacitance

Advantages
- Remote access capability
- Fast response time
- Continuous record of data at same spot
- Lower cost but can be expensive: few hundred dollars to many thousands of dollars

Disadvantages
- Susceptible to salinity, temperature and soil texture
- Susceptible to air gaps (need proper installation)
- Small sample area



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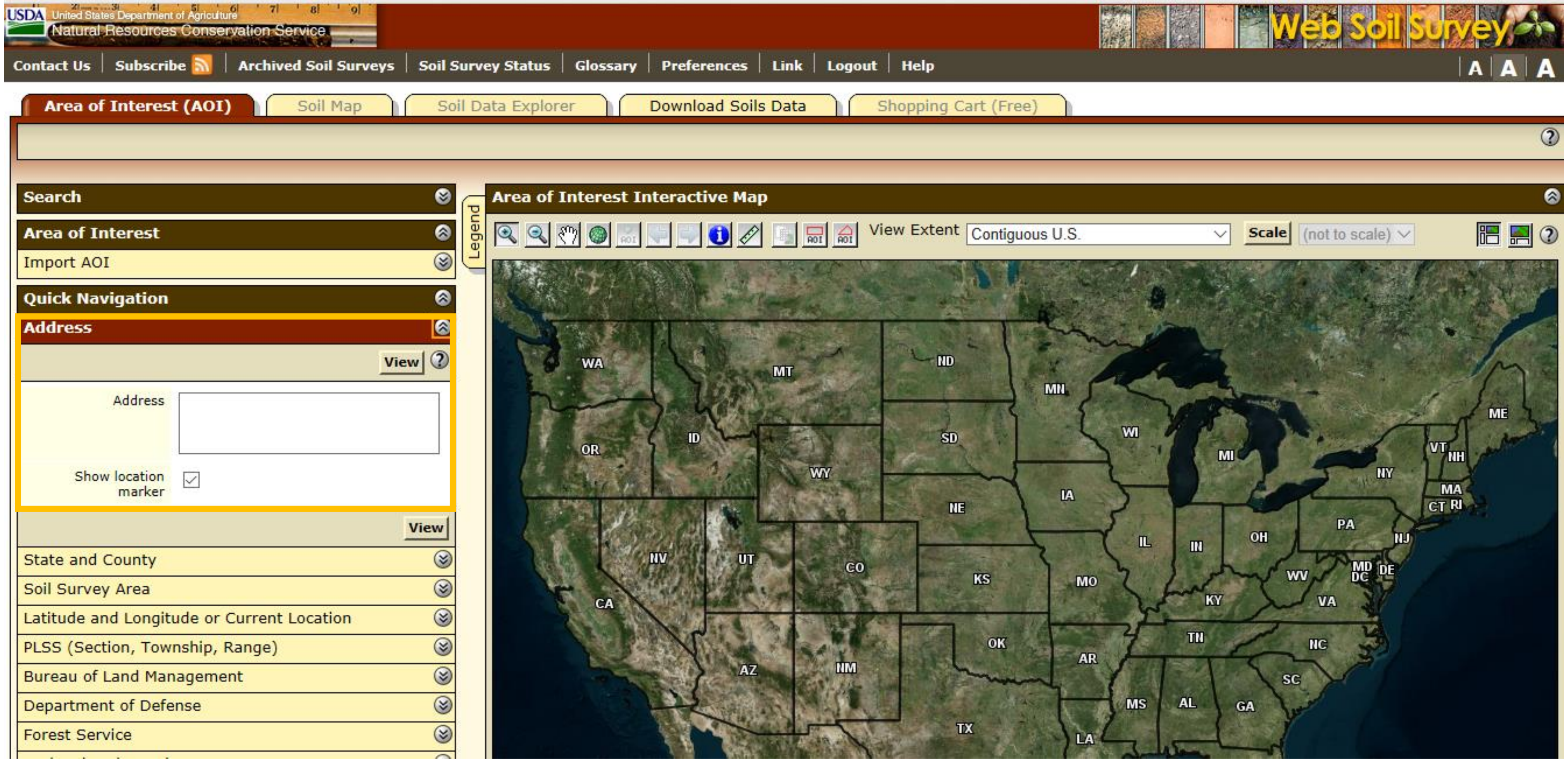
Sensors Placement in the Vineyard

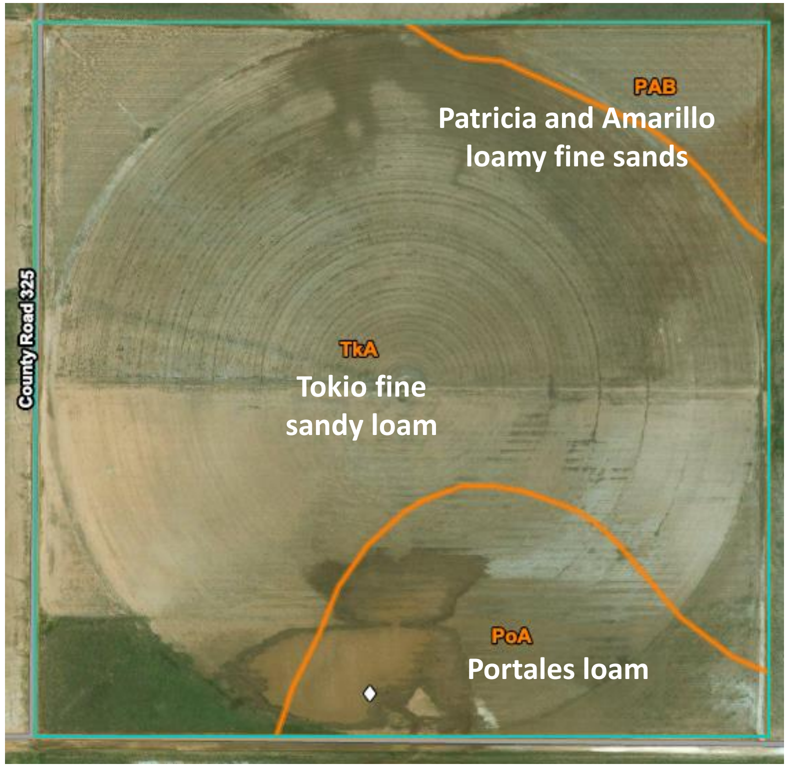
Vineyard soil can be mapped prior to planting and establishing irrigation blocks (http://websoilsurvey.sc.egov.usda.gov/).



Sensors Placement in the Vineyard

Vineyard soil can be mapped prior to planting and establishing irrigation blocks (http://websoilsurvey.sc.egov.usda.gov/).

These maps show the approximate boundaries of distinct soil series and can serve as a good starting point (general description of soil type).

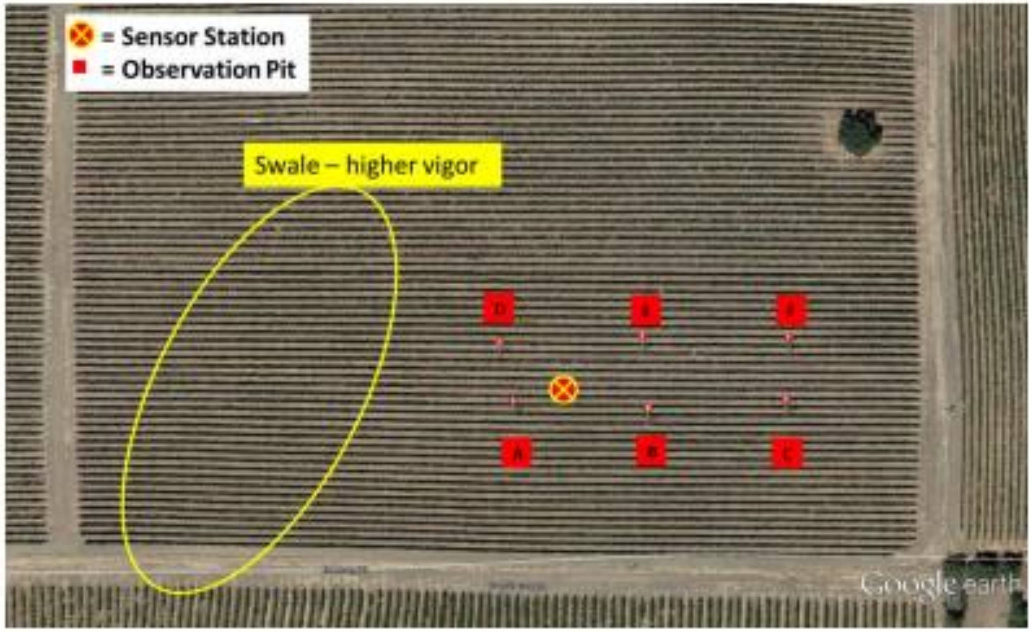


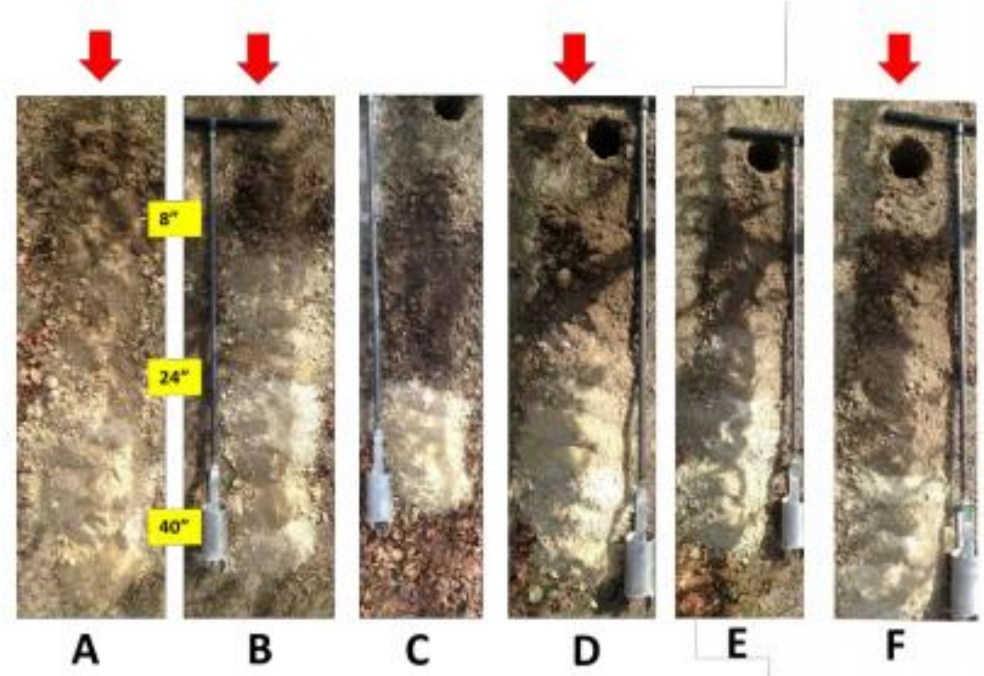
Sensors Placement in the Vineyard

On-site mapping (classic pits or use of auger) is recommended for detailed description (rooting depth, depth to bedrock, soil texture, and depth of distinct soil horizons).

Sensors Placement in the Vineyard

- After reviewing soil map, the location for soil sensor should be selected in an area that <u>represents</u> the most commonly observed soil profile across all sample sites.
- Where vines are healthy.
- Accessible site but not edge of vineyard.



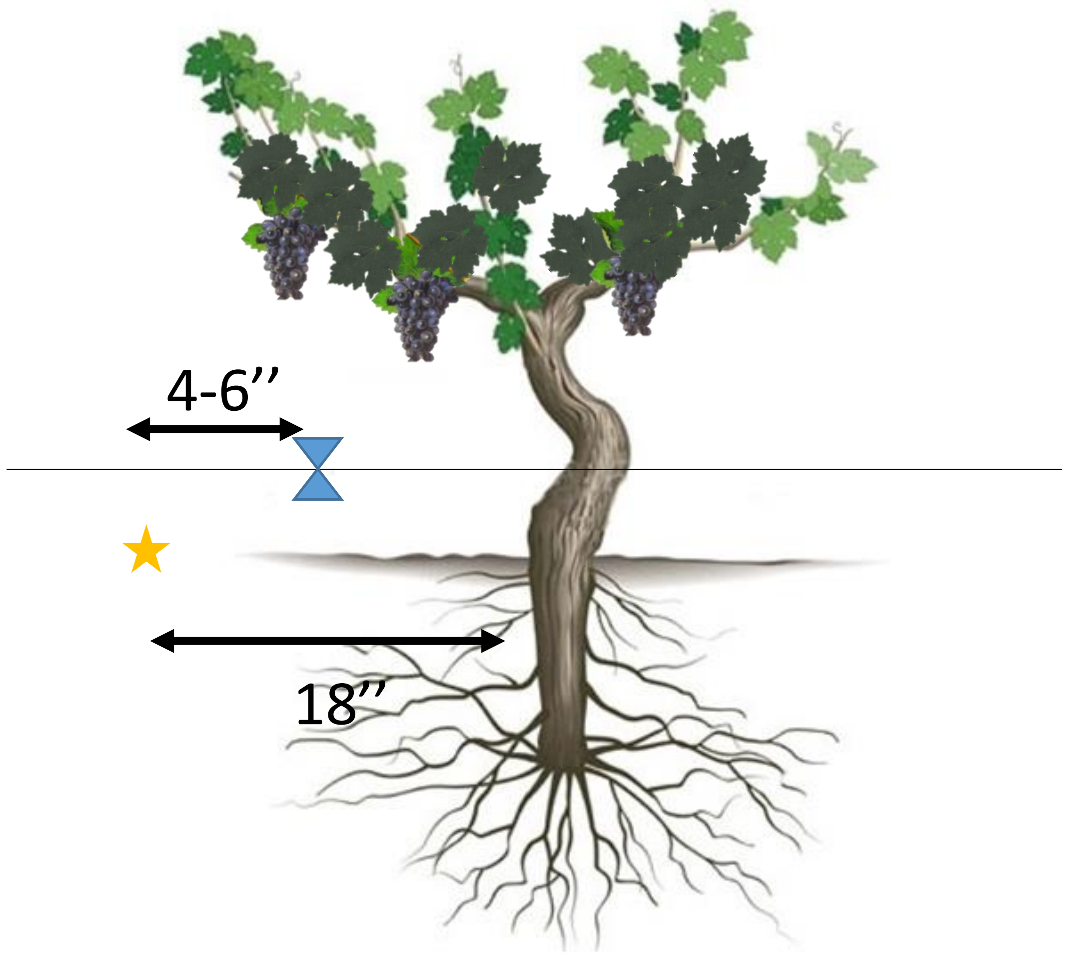


Using Soil Moisture Sensors for Vineyard Irrigation Management_VINEYARDTEAM.ORG

Depth of Sensor Placement

- Place sensors at increasing soil depths in order to capture the movement of water.
- Top sensor tells you when to water. A sensor near the bottom of the root zone allows to identify deep percolation.
- In general, the most shallow soil sensors should not be placed less than 8 inches from the soil surface due to the high fluctuation of water content.
- Depths:
    - (1) middle of root zone
    - (2) 1/3 – Middle, and 2/3 - bottom of root zone
    - (3) Top (8 inches), middle and bottom of root zone

Sensor placement relative to emitters and vines



If sensors are placed too far from active roots it can lead to underwatering: measure active uptake of water by roots.

Placement too far from the emitter can lead to excess watering of vines: sensor not within the desired wetting pattern of irrigation.

Sensor placement relative to emitters and vines

Wetting pattern

In a fine textured loamy to clay soil, the water will spread more laterally than in sandy soil.

Where to avoid placing sensors?

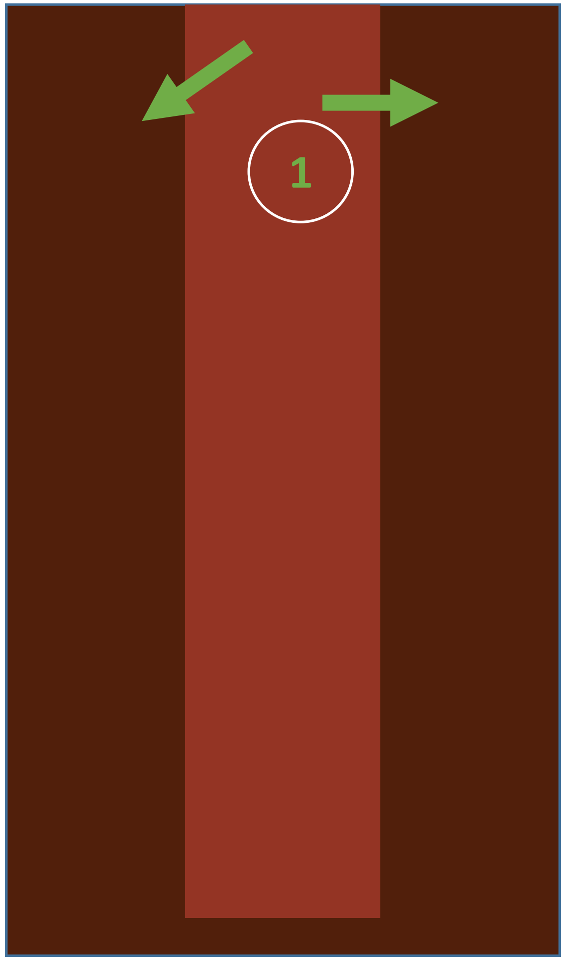
- Areas of excessively high or low vigor that do not represent the majority of the block (texture, vigor, depth, vines…).
- Areas that do not drain well or hold water longer than the majority of the block.
- Areas on the border of the vineyard or areas near competing vegetation.
- Areas where natural soil structure has been disturbed in the past (e.g., backhoe pits…).

Sensor Installation

Proper sensor installation is CRITICAL for obtaining data that will be useful to improve vineyard irrigation scheduling.

Sensor Installation

1) Side wall



Advantages

Visual and tactile confirmation of quality insertion

Undisturbed soil above the sensor

Disadvantages

Shallow depth

Sensor Installation

2) Down hole

Advantages

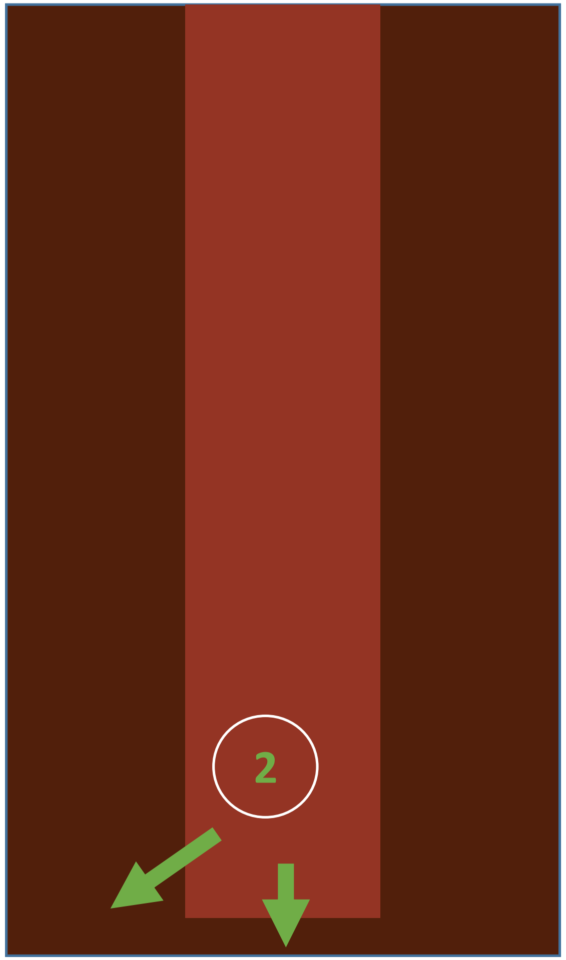
Deep installation

Disadvantages

Impossible to verify the quality of insertion

One hole per sensor: if several depth → several holes

Installation tools are required



Sensor Installation

- Pre-installation sensor testing:
  - Sensor output: play with sensors and data logger with soil (saturated soil, different soil type, air…)
  - Become familiar with type of data the sensor takes
- Sensor installation: sensors installed properly (the most important step)
  - Install in undisturbed soil (don’t move sensor after installation)
  - No air gaps between soil and sensor
  - Use “check” device (instantaneous sensor readings) to check readings to confirm a good installation
  - Label your sensors in field: type of sensor and depth
- Post-installation:
  - Sensors and logger are protected to maintain continuous data record: attention to cables and protect them (PVC pipes…) from rodents or other dangers
  - Check data very often to make sure that everything is working

Conclusion

- Choose a moisture sensor that fits your operation - Every technique has advantages and disadvantages.
- Know your site and characteristics of your sensor.
- Good installation is the most important component of good sensor data.
- It may take a year or two before you are good at interpreting your sensor readings - Don’t get discouraged if you can’t understand data.

THANK YOU

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