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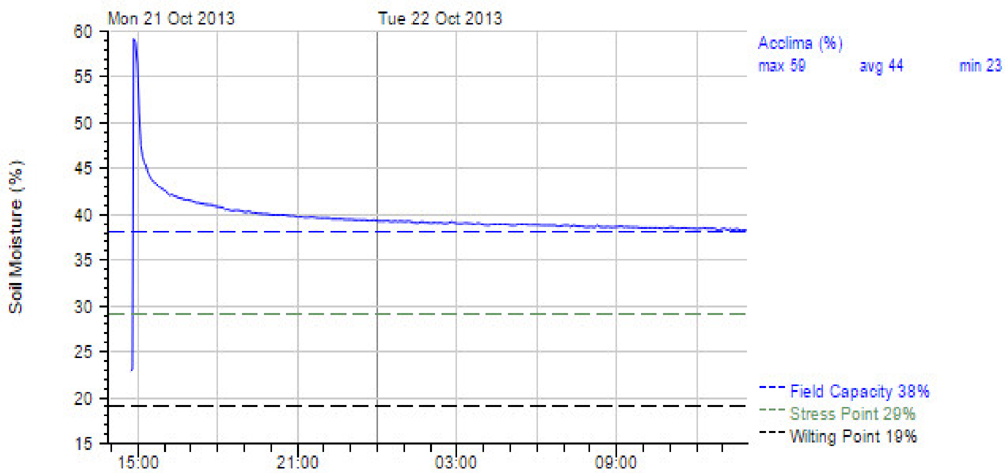
Soil Moisture Monitoring

Soil Moisture is the percentage of volumetric water content (VWC) in the soil. Soil acts much like a sponge. When you immerse a sponge in water and repeatedly squeeze it, it becomes saturated. If you remove it from the water it will drain rapidly then drip for a while. Gravitational forces act against capillary forces until equilibrium is reached and the sponge stops dripping. This equilibrium state is called **Field Capacity.**

Determining Field Capacity

Field Capacity can easily be determined by flooding the sensor installation area then waiting for the sensor readings to stabilize. The stabilized reading is Field Capacity. For heavier soils it may be best to flood the sensor in the evening, then take a moisture reading the next morning before transpiration starts (before the sun gets too high) and assuming there is no rain during the night. In the morning the soil will be at Field Capacity. When you determine the Field Capacity, Harvest can plot a dotted line or place shading on your graphs to show the Field Capacity, Refill Point and Wilting Point, as shown in the graph below.



Calculating Required Irrigation

Irrigation required to reach Field Capacity can be calculated using this formula:
(Field Capacity % – Current soil moisture %) x depth of probe in mm ÷ 100
E.g. if Field Capacity is 30% and current moisture level is 25%, the difference is 5% so you can apply 5mm for every 100mm of depth in the zone being measured. So if the sensor depth is 100mm (recommended for pasture) then this is in the center of a 200mm deep zone, so you can apply 10mm of water to achieve Field Capacity at a depth of 100mm. This is called the Soil Moisture Deficit. This assumes a uniform soil type from the surface down to 200mm. After irrigation it can take 2-8 hours or more for the reading to stabilize at 100mm depth depending on the soil type.

Irrigation
When soil is at Field Capacity and slightly below, conditions are excellent for plants. The addition of water above field capacity wastes water, causes leeching, and depletes the soil of valuable nutrients while also contaminating the groundwater with pesticides and fertilizers. It can also drive oxygen out of the soil and suffocate the roots. Irrigation above field capacity is also not cost effective due to money spent on electricity for irrigation pumping and fertilizers, which will end up in the water table, rather than benefiting your plant growth.

As soil dries out from field capacity, a point is reached where plants have difficulty drawing water out of the soil and begin to experience stress. This lower limit is called the Refill Point or the Stress Point. This is the percentage of the available water in the soil that can be removed by plants before irrigation is required. This is also the point where irrigation water must be applied to keep the plants from experiencing stress. If water is not applied the soil will eventually dry to the Permanent Wilting Point. This is the point at which the plant will eventually die.

The proper moisture zone for healthy plants is between Field Capacity and the Stress Point. The Acclima sensors measure absolute volumetric water content without calibration if they have been correctly installed. See the short Harvest training video in order to carry out correct installation at http://www.harvest.com/support/videos/

If you know the soil type then you can use the table below to more accurately determine the Permanent Wilting Point and the Stress Point.

Texture	FC (v%)	PWP (v%)
Sand	10	5
Loamy sand	12	5
Sandy loam	18	8
Sandy clay loam	27	17
Loam	28	14
Sandy clay	36	25
Silt loam	31	11
Silt	30	6
Clay loam	36	22
Silty clay loam	38	22
Silty clay	41	27
Clay	42	30

- Saxton and Rawls (2006)

Soil Temperature
Another important factor to consider when making irrigation decisions is the soil temperature, if the soil temperature is below 9-10°C, plant growth slows or comes to a stop. Therefore irrigating at this temperature will not increase production, rather it may decrease production by keeping the soil cold for longer as dry soil will warm up faster. 15-20°C is the optimum temperature for plant growth.

Soil Moisture Monitoring Applications

Monitoring Levels

In all applications soil moisture is commonly monitored at two levels. This gives an accurate representation of what is happening with soil moisture in the root zone of plant.

Typical levels are:
Pasture - 100mm & 300mm
Viticulture - 300mm & 600mm
Orchards - 300mm & 600mm

These levels may vary depending on the roots on your property.

These levels give a good indication of soil moisture in the root zone and to help with irrigation decisions. Having two levels of soil moisture monitoring means soil deficit can be calculated so you know how much you can irrigate before waterlogging the soil which is good for preventing run off and ponding. This is also helpful for preventing water running out below the root zone which saves water wastage, fertilizer wastage and pumping costs.

Sensor Placement

In grazed pasture we recommend that sensors are placed near to a fence line in your area of interest, this is so the pasture above the sensor is still grazed but also means the stock are less likely to trample the earth where the sensor is buried.

Sensing Methods

TDT (Time Domain Transmission)

Measures the amount of time it takes for a radio pulse to travel around the wire loop of the sensor. This is an accurate sensing method which does not require calibration as it is not sensitive to conductivity. However because the sensor is installed into disturbed soil there is typically 2-3 months before the soil returns to is original compaction, therefore the readings for the first 2-3 months will not be representative of the rest of the paddock which the sensor is installed in.

TDR (Time Domain Reflection)

Measures the time it takes for a radio pulse to travel to the tip of the sensor and bounce back again. It is not sensitive to conductivity changes in soil and is accurate as soon as it is installed as the soil around the sensor is not disturbed. The TDR probes are also easier to install correctly.

Practical Considerations

Accuracy, installation, cost and calibration needs to be taken into account when considering which soil moisture sensor to use. Both the TDT & TDR are accurate and do not require calibration, unlike the earlier capacitance sensors which do, due to conductivity changes in the soil. The TDR is a much easier sensor to install and doesn't have a 'stand down period' while waiting for soil compaction to return to its original state.

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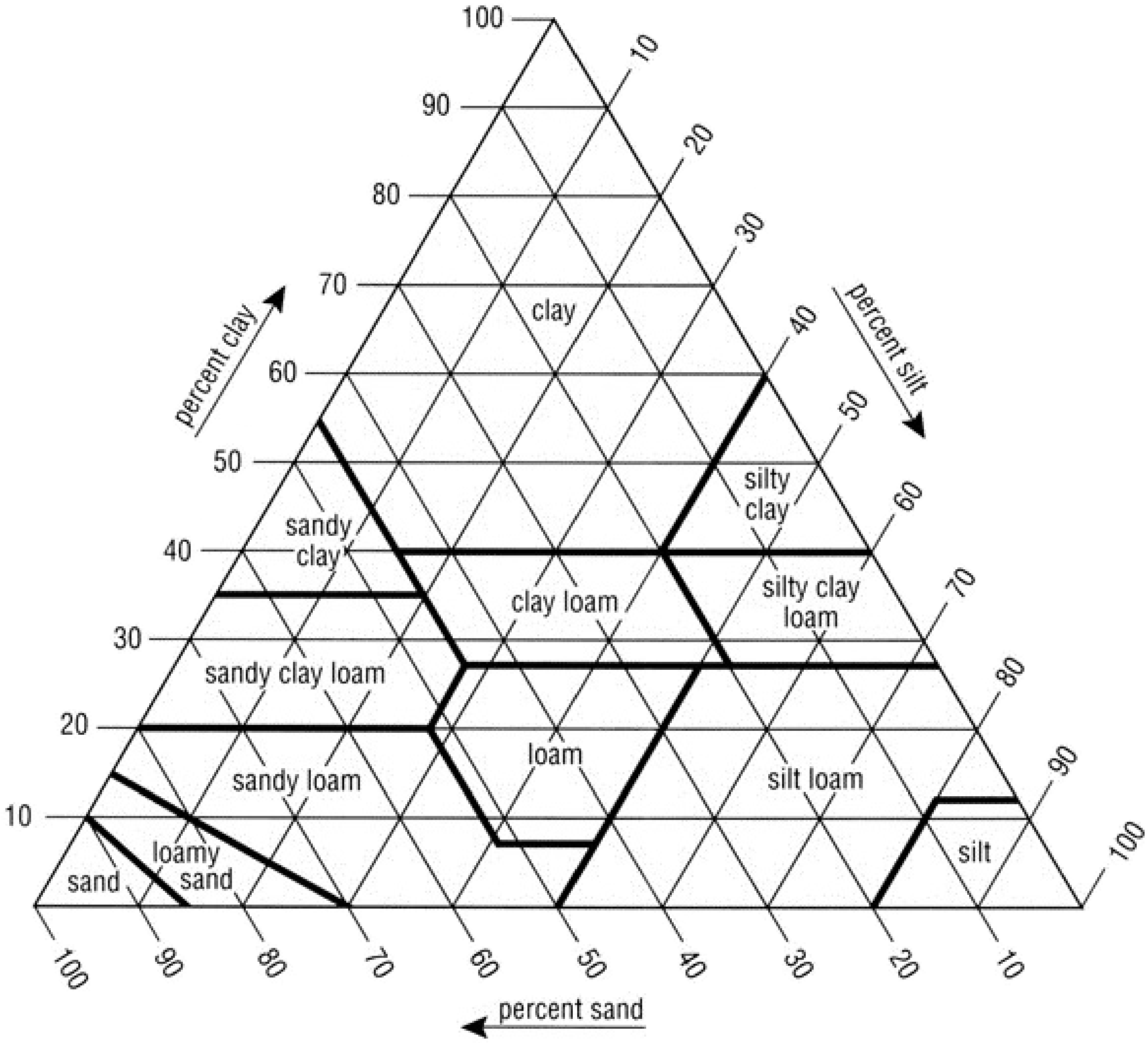
Using the Soil Moisture Triangle

Soil texture depends on its composition and the relative portions of clay, sand, and silt. In sedimentology, clay is defined as particles of earth between 1μm and 3.9μm in diameter (not to be confused with the chemical definition of clay, which is a mixture of hydrous aluminum phyllosilicate particles and water). Silt is defined as particles between 3.9μm and 62.5μm in diameter, while sand is particles between 62.5μm and 2mm in diameter.

The USDA classifies soil types according to a soil texture triangle chart which gives names to various combinations of clay, sand, and silt. The chart can be a little confusing at first glance, however, it makes sense after seeing a few examples.



First, look at the orientation of the percentages on the sides of the triangle. The numbers are arranged symmetrically around the perimeter. On the left the numbers correspond to the percentage of clay, and on the right the numbers correspond to the percentage of silt. At the bottom of the triangle chart are the percentages of sand.

To classify a soil sample, you find the intersection of the three lines that correspond the three proportions. On the chart, all of the percents will add up to 100%.

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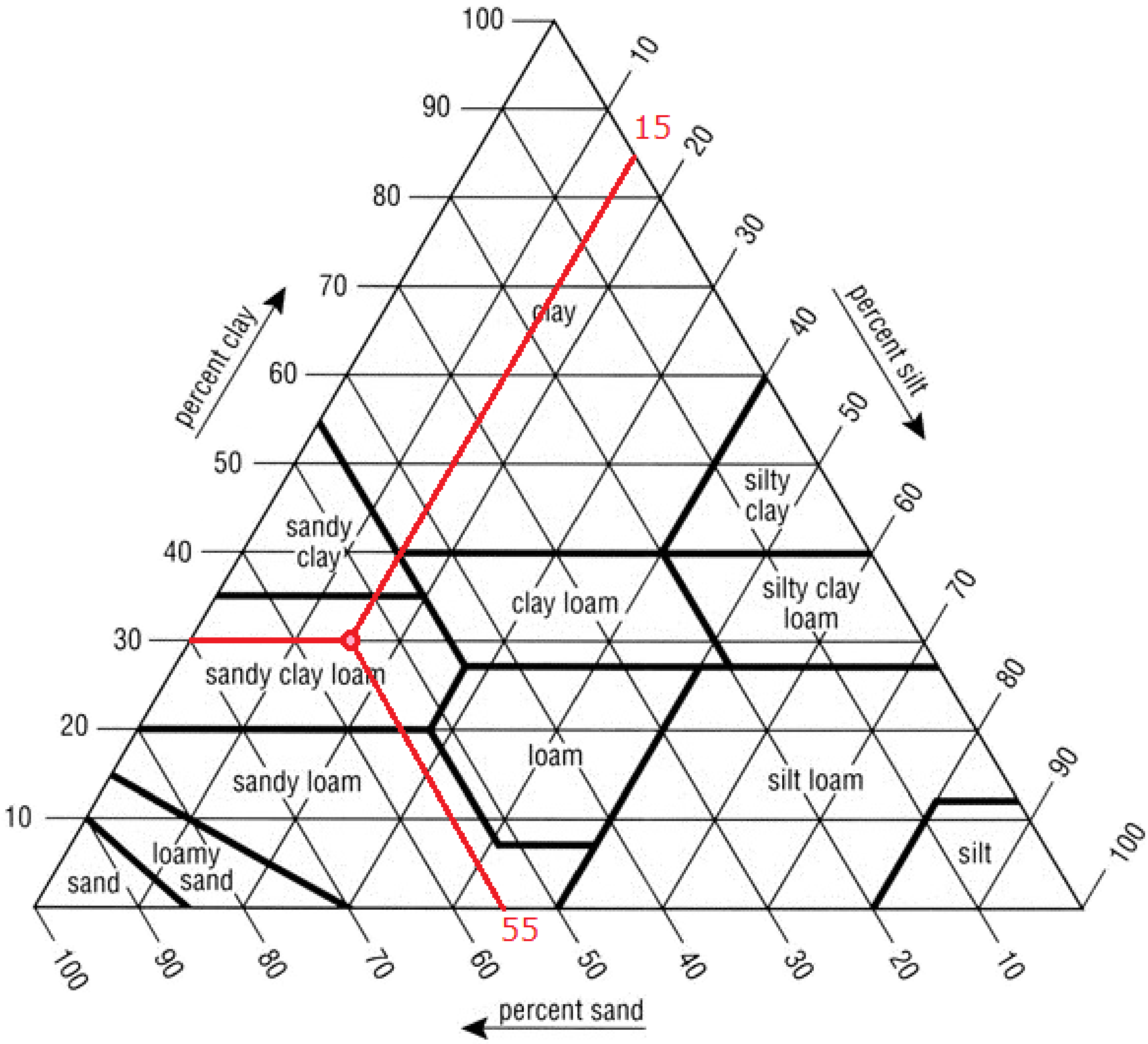
Example: Classify a soil sample that is 30% clay, 15% silt, and 55% sand. First, locate 30% on the clay axis, and draw a line horizontally from left to right. Next, locate 15% on the silt axis, and draw a line going down diagonally to the left. Finally, locate 55% on the sand axis, and draw a line going up diagonally to the left. The intersection is in a region called Sandy Clay Loam. See figure below. (Truthfully, you only need to make two lines.)



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Soil Texture Testing