SENSOTERRA

Wireless soil moisture sensors

Soil Sciences: Soil 101

SENSOTERRA

Introduction to soil

- Agriculture & current state of soil
- Production and yield
- Soil types (triangle)
- Water potential & water supply (wilting)
- Plant available moisture per texture types
- Trendwatching for soil moisture percentage
- Water use & predicting yield
- Defining ROI for soil data
- Glossary of Terms

Mega trends

80%

of the world's freshwater is consumed by agriculture; of that **60% is estimated to be used inefficiently** (wasted)

Water Resource Issues & Agriculture FAO

75%

of the world's **soil is degraded** due to excessive water & nutrient run-off from over-irrigation

IPBES 2018 report

$45B

Precision agriculture will reach **$45 billion by 2024**

Hexa Reports - Precision Agriculture Market Analysis

15%

of small farms will **leverage precision ag** technology in 2019

AgTech Trends in 2019

Less than 2% of agricultural land uses soil moisture data

Total Market Size

Agriculture & current state of soil

Data on soil

Currently 11% of global land surface is used for agriculture, around 1.5 billion ha.

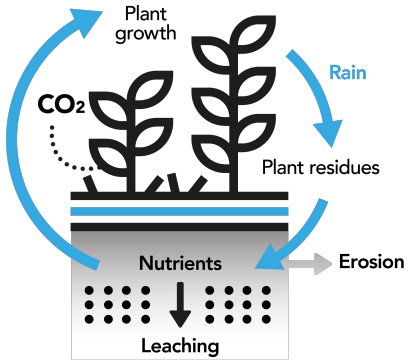
Soil degradation

However, one third of the global land used for agriculture has been affected by soil degradation. Mostly caused by water and wind erosions, due to intensive agricultural practices plus soil misuse.

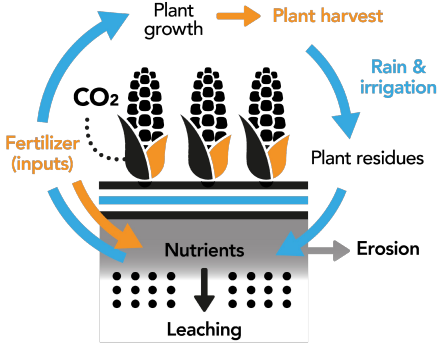
Role of water on soil & crops

Soil moisture is a key variable in controlling the exchange of water and heat energy between the land surface and the atmosphere, via evaporation and plant transpiration. As a result, soil moisture plays an important role in the development of weather patterns and the production of precipitation.

Natural Ecosystem



Agroecosystem



NPK & organic matter

Soil erosion affects soil structure, nutrient degradation and soil salinity; leading to crop deterioration. In addition, inputs leaching is a large contributor to ecosystems pollution.

Better irrigation means a **reduction of inputs** (and less leaching)

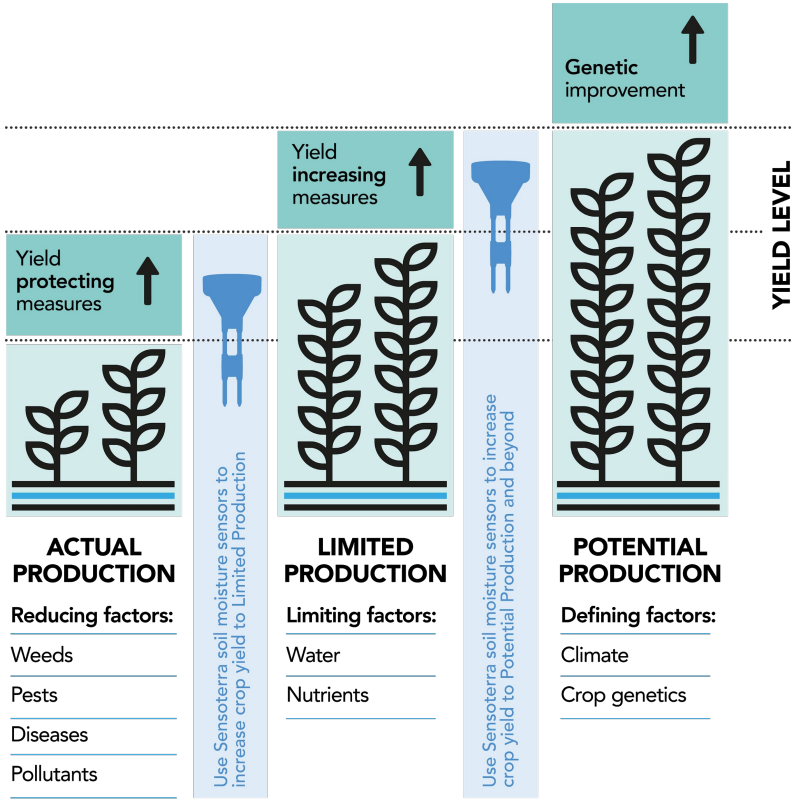
Production & Yield

Actual production: Actual yield is the amount of agricultural production harvested per unit of area (tons/ha or acres). It is possible to reduce the gap between actual and limited production with reduction of weeds, pests, diseases and pollutants (threats).

Limited production: Factors/resources e.g. water & nutrients availability can limit potential yield. With proper measures, improve limited production to potential production.

Potential Production: Potential yield is an ideal crop production without pests, diseases, nutrient and water stresses. Affected by climate and natural crop genetics, minimized by genetic improvement.

Yield gap: The difference between actual, limited, and potential yield levels.



Using Sensoterra soil moisture sensors can can **increase crop yield**

The benefits of optimized irrigation

Increase in crop yield

Deeper root systems

Less disease

Less pests

Increased resistance to threat

Reduction of water waste and costs

Reduction of **water** consumption, compliant with government legislation of water restriction

Reduction of **inputs** (fertilizers, pesticides, herbicides), compliant with government legislation on leaching (inputs leach into groundwater)

Reduction of **energy** (irrigation rounds, pumping, machinery) resulting in more efficient supply chain

Better forecasting

Minimize the **variability in forecasting** on harvest yield enabling farmers to find buyers in time

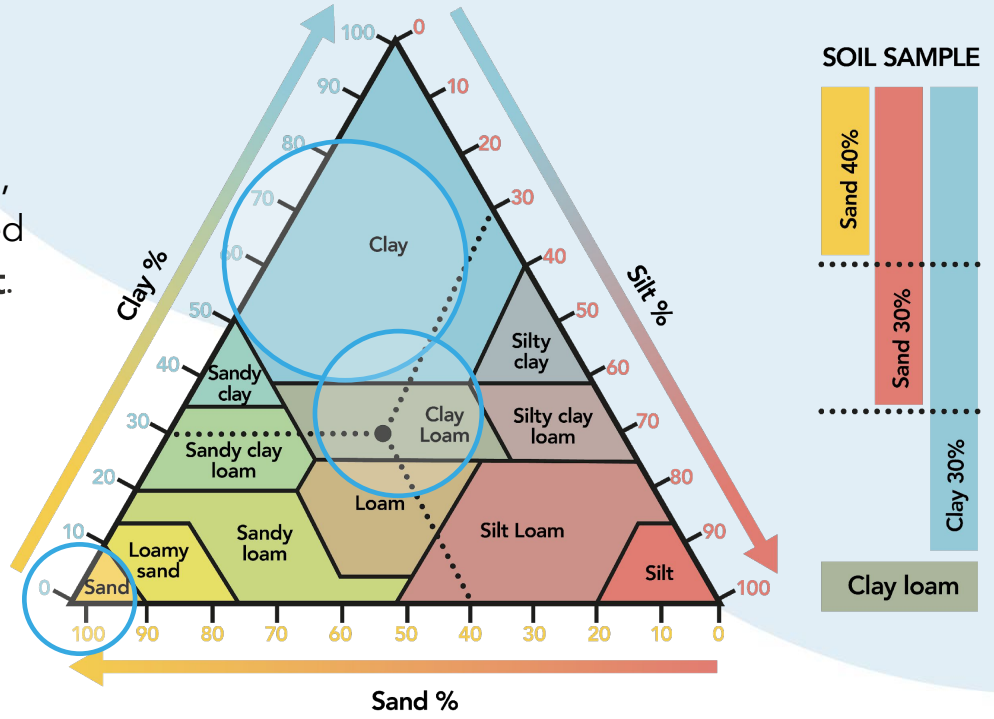
Less food and production waste post-harvest

Soil types

There are three main soil type categories: clay, silt, and sand. Sensoterra sensors are calibrated for: **sand, clay, saline clay, clay-loam, and peat**.

Saline clay is not on this diagram as it is a *condition* of the soil rather than a soil type. High salinity (the amount of salt in the soil) is due to inputs. Saline soil presents higher electric conductivity (EC), which impacts data readings.

Chemical and physical properties of soil are related to its texture. Particle size and distribution will affect soil's capacity for holding water and nutrients. Fine textured soils generally have a higher capacity for water retention, whereas, sandy soils contain large pore spaces that allow easier leaching and drainage.

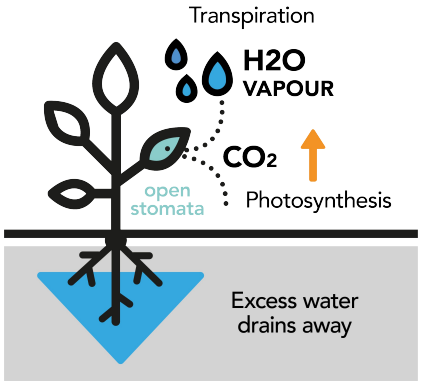


Soil particle distribution: texture triangle

The diagonal dotted lines in the diagram give you the intersection points from all three sides and represent the percentage of clay, silt, and sand.

Soil potential & water supply

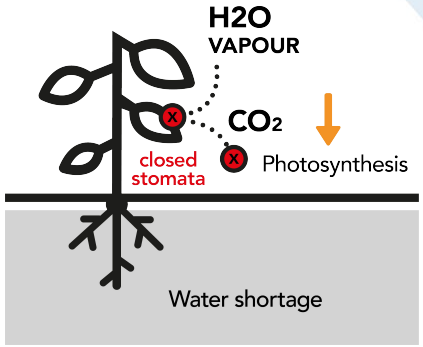
Healthy plant



When soil is wet (rain/irrigation) it will reach 'field capacity' meaning amount of soil moisture or water content held in soil after excess water has drained away. Usually 2-3 days after rain or irrigation. When field capacity is reached, stomata opens to release H20 & 02 gases & capture C02 (stomata are plant 'sweat glands') opening-closing pores in plant tissue to allow gas exchange with the environment).

Productive pF 2-2.5

Wilting plant



Wilted plant occurs when either too much water (pF0-2), or too little water available (pF2.5-3). Plant does not have enough energy to conduct photosynthesis, or transpiration, to conserve energy stomata close, and wilting occurs. **The frequency of wilting, results in a direct correlation with a decrease in yield.** Permanent wilting (pF4.2-7) occurs when wilting is prolonged, and the plant cannot recover with adjusted irrigation or additional inputs. Results in plant death.

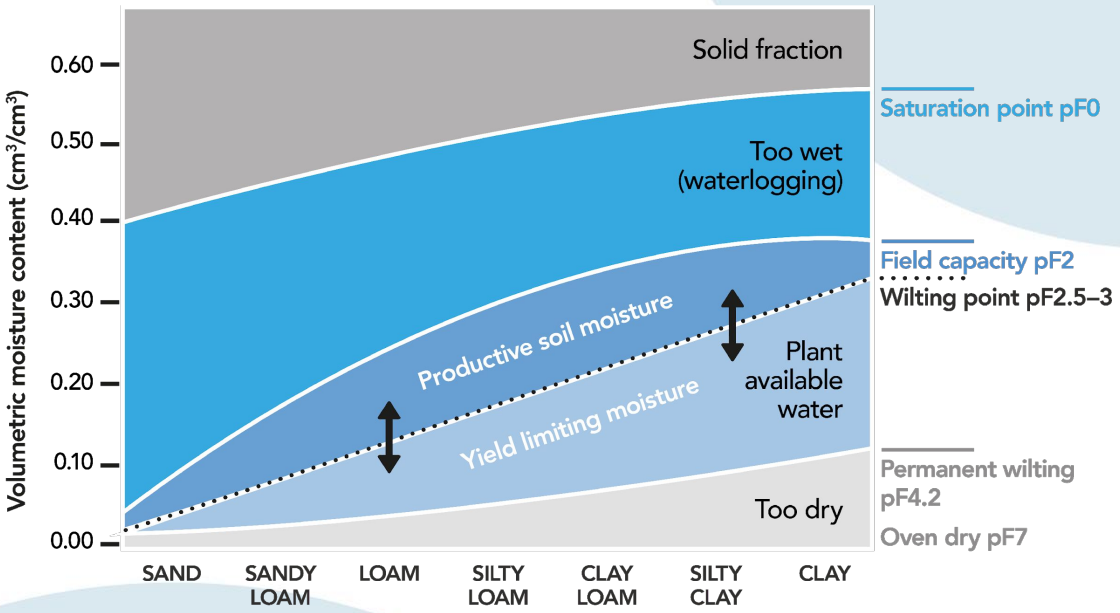
Plant available moisture by soil type

Sensoterra works out the range of plant available water from “yield limiting moisture” to “productive soil moisture”, for each soil type.

Estimated yield limiting and productive soil moisture levels, for each soil type. Available water for plants will be the mean between the two of them.

Saturation point	**pF 0**
Field capacity	**pF 2**
Wilting point	**pF 2.5-3**
Permanent wilting point	**pF 4.2**
Oven dry	**pF 7**

Soil texture and plant available moisture

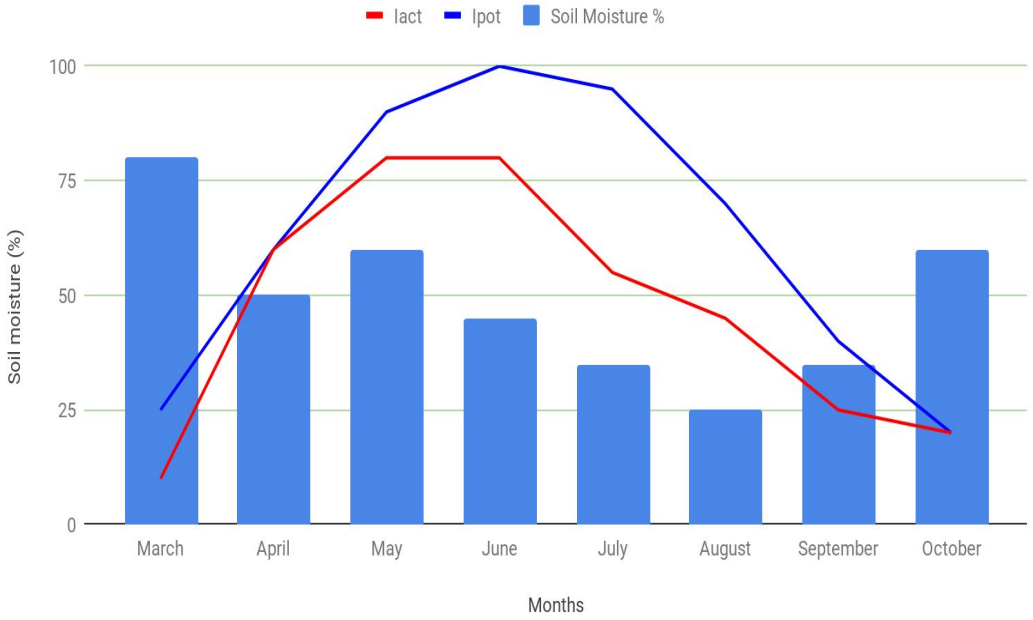


Optimized irrigation for max yield: example

Sensoterra gap closure between Ipot and Iact.

Blue line Potential Irrigation (Ipot)
Optimal irrigation conditions for maximum yield

Red line Actual Irrigation (Iact)
Irrigation with limitations (e.g. without irrigation management, over- or under irrigation), affecting crop yield



Sensoterra **closes the gap** between actual and optimized irrigation levels in order to **reach full potential yield**

Defining crop potential yield tons per ha

Crop type	Potential yield (tons * ha-1)	Active root depth (cm)
Potatoes	70	30
Maize	50	30
Carrots	70	40
Tomatoes	100	60
Sweet peppers	40	60
Beetroot	25	40
Onions	40	30
Wheat	10	90
Hops	3	60
Barley	7	90
Green beans	20	40

Broccoli	12	30
Brussel sprouts	15	30
Cabbage	90	50
Cauliflower	20	30
Chilli	15	20
Cucumber	30	50
Garlic	15	40
Lettuce	40	15
Parsley	8	20
Pumpkin	30	60
Sweet potato	40	60
Spinach	20	15
Strawberry	25	15

Glossary of terms

Inputs What is put in, taken in or operated by any agricultural system. E.g.fertilizers, pesticides, animal feed, manure, compost, etc.

Impedance Electrical impedance is the measure of the opposition that a circuit presents to a current when a voltage is applied. Measured in ohm.

Electric conductivity (EC) Electrical conductivity is the measure of the amount of electrical current a material can carry or it's ability to carry a current. Measured in Siemens/meter.

pF soil moisture retention in the soil. Relation between soil moisture suction and soil moisture content.

Soil particle size soils have different particle sizes, from the biggest to the smallest (sand>silt>clay). Their percentage will give the soil type. Each soil will have a different water capacity storage; interfering on how often it needs to be irrigated.

Soil water potential defined as the amount of energy that must be done by external forces to transfer reversible amounts of water from a standard state to the soil at the point under consideration (e.g. from top soil to active root zone).

Stomata Stomata are opening-closing pores in plant tissue that allow gas exchange with the environment. Stomata are typically found in plant leaves but can also be found in some stems.