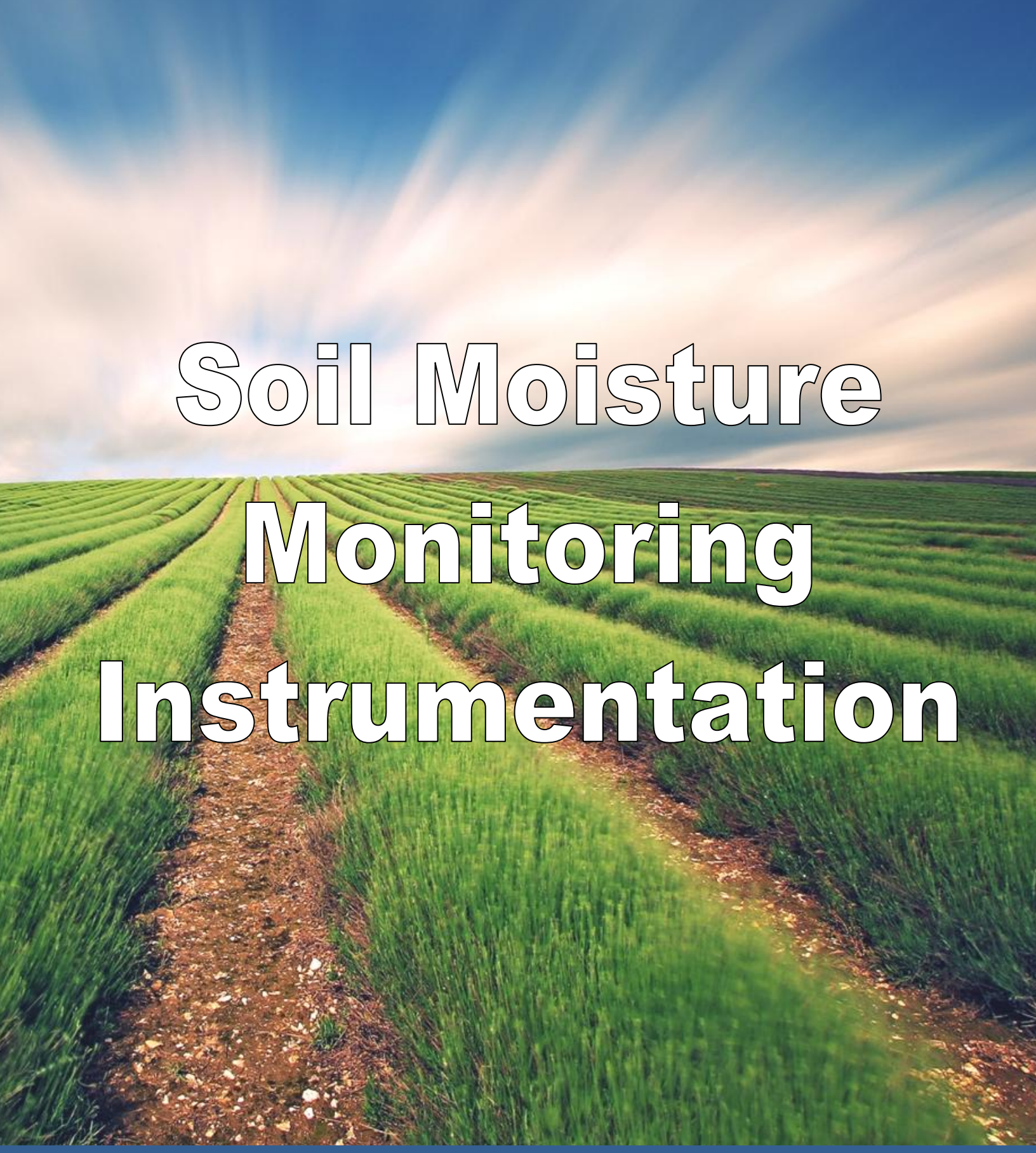


Soil Moisture Monitoring Instrumentation

IRRIGATION-MART
we SAVVY irrigation
800-SAY-RAIN | www.irrigation-mart.com

200 South Service Road East | Ruston, LA 71270-3442
P: 318-255-1832 | F: 318-255-7572 | info@irrigation-mart.com

13799 Airline Highway | Baton Rouge, LA 70817-5924
P: 225-755-3447 | F: 225-755-1240

Monitoring Soil Moisture to Schedule Irrigation

Irrigation is the application of water to supply or augment plant available soil moisture. A better concept may be: Irrigation is the application of water to LIMIT PLANT **STRESS**. When irrigation is **SCHEDULED** to limit plant stress:

> *IRRIGATION SCHEDULING*
> When to irrigate and how much water to apply

- Plants use a minimum amount of their own energy to obtain water from the soil
- Optimum conditions exist for the best possible plant health
- Production and quality are maximized
- Pests and disease are mitigated
- Nutrients, energy, water, and other resources are efficiently utilized and not wasted, and
- Pollution is minimized.

Loss in plant performance caused by water **STRESS** occurs when the water lost by **TRANSPIRATION** exceeds water **ABSORPTION** from the soil by the plant roots. Absorption normally lags behind transpiration, and some degree of water stress is normal – but, the amount of stress and loss in production is ***CONTROLLABLE*****.** Low water uptake rates by plants are caused be either too much soil water (poor drainage) or too little soil moisture (poor irrigation). For emphasis, plant stress is least when the amount of water in the soil is near a value called **FIELD CAPACITY**. The amount of soil moisture that is available to the plants at field capacity varies with the type of soil, as indicated by Table 1.

TABLE 1. Total Plant Available Water, inches of water per foot of soil depth	
Sand	0.6
Loamy Sand	0.8
Sandy Loam	1.6
Loam	1.7
Clay Loam	1.3
Clay	1.4
NOTE: Only a portion (maybe ¼) of this total plant available moisture is *readily* available to plants (without the plants having to use too much energy or effort to get the water and undergoing excessive stress).	

Good crop production can be obtained by basing irrigation scheduling on soil moisture content alone (as measured by science-based instruments rather than by simply feeling the soil and/or observing plants). Soil moisture monitoring should include data from both *in* and *below* the **ROOT- ZONE**. The *in* root-zone data is needed to determine how readily available the soil water is to the plants (how hard the plants must work can get the water) and when more water should be applied (when to irrigate). The *below* root- zone data reveals if too much water has been added, and lost/wasted (e.g., to deep percolation).

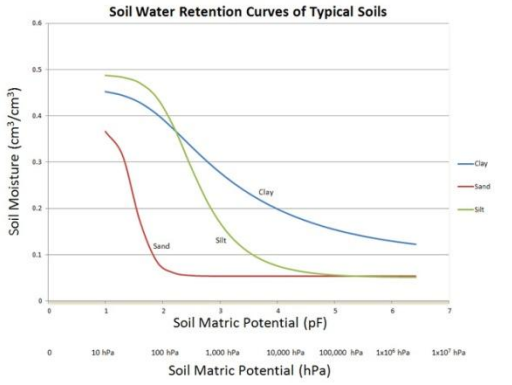
If both the amount and the availability of the soil moisture at all locations in the crop area are the same and if the irrigation scheduling scheme is the same for all zones, monitoring the soil moisture status at just one site is adequate. Otherwise multiple sampling sites should be established so that data is collected where soil moisture and/or irrigation schemes differ.

SOIL MOISTURE STATUS

- Soil Moisture Content (percent of water in the soil)
- Soil Moisture Tension (energy level of water in the soil, or the ease with which water can be removed)

Soil moisture status is expressed as soil moisture *content* or soil moisture *tension*, depending largely on how it is measured. The dryer the soil, the lower the soil moisture content and the higher the soil moisture tension; and the more the plants have to work (expend their energy) to get water. **Soil moisture *content* is the percent of water in (making-up) the soil**; this may be on a weight/mass basis (weight of water per weight of soil) or on a volume basis (volume of water in a given volume of soil). **Soil moisture *tension* expresses the energy level of water in the soil system**, or the ease with which water can be removed by plants. It is a pressure term and while any unit of pressure can be used, it is commonly measured and reported in centibars (cb). Another term expressing the same thing as soil water *tension* is soil water *potential*, just with the opposite sign (e.g., a soil water tension of 9 cb is a soil water potential of -9 cb). Soil moisture moves from places of low tension to where the tension is high, or from high to low potential.

A **soil water retention curve/graft** (also called a soil moisture characteristic curve) gives the relationship between soil water content and soil water tension. This curve is unique for each soil.



The standard/direct method of measuring soil water status involves collecting a physical sample of the soil, weighing it before any water is lost, and drying it in an oven before weighing it again. This is relatively inexpensive and easy to conduct, and requires very simple field and laboratory equipment. However, it is also both labor and time consuming, and leads to errors if the soil sample size is too small. Additionally, this sampling method is destructive, preventing repetitive measurements at the same location.

THREE RELIABLE INSTRUMENTS

- Tensiometers
- Electrical resistance-based granular matrix sensors
- Capacitance-based sensors

Therefore, only surrogate/indirect methods, using instruments, are routinely used for measuring the soil moisture status in crop production operations. This is mainly because instruments require less labor and give accurate readings; most give continuous readings and can be automated. Three reliable instruments are (1) tensiometers (e.g., Irrometer™), (2) electrical resistance-based granular matrix sensors (e.g., Watermark™), and (3) capacitance-based sensors (e.g., TriSCAN™).

Field Station continuously measuring and transmitting tensiometric soil moisture and other soil indices at various depths.

Both tensiometers and electrical resistance-based sensors measure soil moisture tension, continuously. They sense the ease/difficulty of removing water from soil, which is related to the amount of energy plants have to use to remove water from the soil. Thus, they can be thought of as "dummy roots". Data from these instruments can be read manually or collected automatically and transmitted electronically. Detailed information about these instruments, how they are used, and how to use the information they provide is readily available from many sources (e.g., **Irrigation-Mart** and **www.irrometer.com**). For example, irrigation events should be scheduled to keep the gauge readings on tensiometers between about 5 and 20 (i.e., 5 to 20 centibars tension, or negative pressure); begin irrigating before the crop has to use too much of its own energy to extract water (before the soil moisture tension exceeds 20 centibars) and stop before too much water has been added (before the tension will drop below 5 centibars); at and below 0 centibars the soil is saturated.

Capacitance-based sensors that provide convenient, reliable, and continuous measurements of volumetric water content (and salinity) at multiple depths in the soil profile are commercially available. Salinity data is useful in monitoring where the water (and fertilizers) ends-up in the soil profile. These sensors are usually combined with weather and other sensors to make Field Stations. In addition to soil moisture content and salinity, Field Stations usually sense both in and out of canopy weather (wind, solar radiation, humidity, and temperature), and irrigation line pressure (indicating when irrigation occurs). The data can be collected automatically and continuously, and may be transmitted electronically. They can be analyzed on-site or off-site.

Weather data helps predict how fast a crop can use water, and may give early indications of whether irrigation events are needed, or should be delayed or omitted. Augmenting soil moisture data with salinity and/or electrical conductivity readings reveals additional information on where the irrigation water (and fertilizers, etc.) ends-up in the soil profile, and how available it is to the plants.

Field Station continuously measuring and transmitting volumetric soil moisture and salinity (at various depths), weather (in and out of canopy), and irrigation system pressure (indicating when irrigation is occurring).

The instruments, sensors, and Field Stations mentioned herein may be purchased or leased from Irrigation-Mart. We provide hardware and software training, hardware installation, routine equipment maintenance and repair, monitoring and data analyzes, and periodic/daily recommendations for scheduling irrigation (and fertilization) via phone, email, and/or the internet. Irrigation-Mart is the full-service leader in providing growers with the "where-with-all" to make informed irrigation (and fertilization) decisions.