SNS COLLEGE OF TECHNOLOGY

SOIL MOISTURE MEASUREMENT

Soil moisture is estimated both by direct and indirect method. Direct methods involves the determination of moisture in the soil while indirect methods estimate amount of water through the properties of water I the soil. In direst methods moisture is estimated thermo- gravimetrically either through oven – drying or by volumetric method.

Oven drying method

Soil sample is collected in a moisture can and wet weight of the sample is recorded. The soil sample is dried in hot air oven at 105 ^{o}C until constant weight is obtained and dry weight of the sample is recorded.

$$\text{Moisture content (on weight basis)} = \frac{\text{Wet weight-Dry weight} \times 100}{\text{Dry weight}}$$

Volumetric method

Soil sample is taken with a core sample or with a tube auger whose volume is known. The amount of water present in the soil sample is estimated by drying in the oven. The volumetric moisture content can also be estimated from the moisture content estimated on dry weight basis.

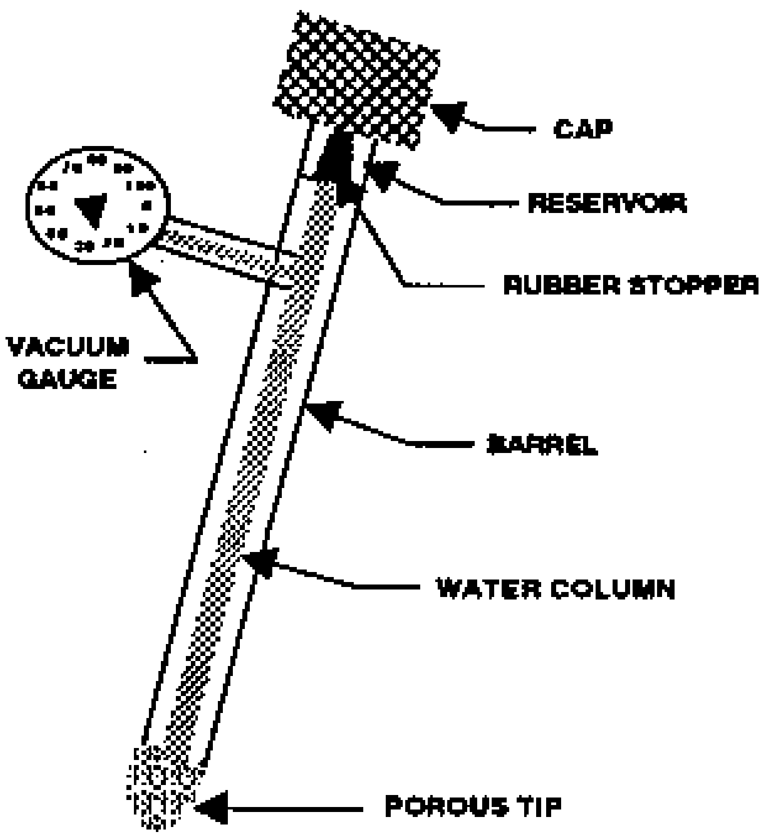
The most common instrument used for estimating soil moisture by indirect methods is; tensiometer, gypsum block, neutron probe, pressure plate and pressure membrane apparatus.

Tensiometer

Tensiometer is a sealed, airtight, water-filled tube (barrel) with a porous tip on one end and a vacuum gauge on the other, as shown in Figure 1. A tensiometer measures soil water suction (negative pressure), which is usually expressed as tension. This suction is equivalent to the force or energy that a plant must exert to extract water from the soil. The instru- ment must be installed.

properly so that the porous tip is in good contact with the soil, ensuring that the soil-water suction is in equilibrium with the water suction in the tip. The suction force in the porous tip is transmitted through the water column inside the tube and displayed as a tension reading on the vacuum gauge. Soil-water tension is commonly expressed in units of bars or centibars. One bar is equal to 100 centibars (cb).

The suction at the tip is transmitted to the vacuum gauge because of the cohesive forces between adjacent water molecules. As the suction approaches approximately 0.8 bar (80 cb), the cohesive forces are exceeded by the suction and the water molecules separate. When this occurs, air can enter the tube through the porus tip and the tensiometer no longer functions correctly. This condition is referred to as *breaking tension*. Tensiometers work in the range from 0 to 0.8 bar. The suction scale on the vacuum gauge of most commercial tensiometers reads from 0 to 100 cb.



Tensiometers are quite affordable for scheduling irrigation. The cost ranges from $25 to $50 each, depending on length of the barrel, which ranges from 6 to 72 inches. The only other equipment required is a small hand-held vacuum pump used for calibration and periodic servicing. Tensiometers are easy to use but may give faulty readings if they are not serviced regularly.

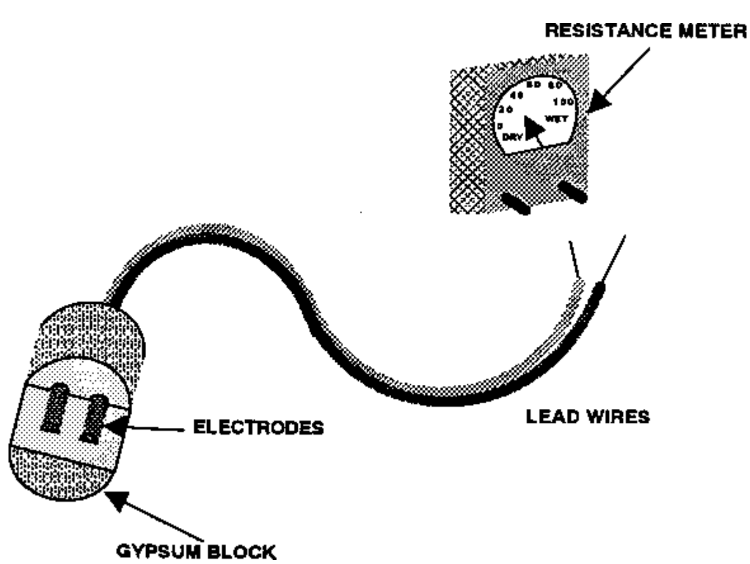
Tensiometers are best suited for use in soils that release most of their plant-available water (PAW) at soil-water suctions between 0 and 80 cb. Soil textures in this category are those that consist of sand, loamy sand, sandy loam, and the coarser-textured range of loam and sandy clay loam. Many clayey and silty soils still retain over 50 percent of their plant-available water at suctions greater than 80 cb, which is outside the working range of a tensiometer . Tensiometers are not recommended for clayey and silty soils unless irrigation is to be scheduled before 50 percent depletion of the plant-available water, which is the normal practice for some vegetable crops such as tomatoes.

Gypsum block or Electrical resistance blocks

Electrical resistance blocks consist of two electrodes enclosed in a block of porous material, as shown in Figure 2. The block is often made of gypsum, although fiberglass or nylon is sometimes used. Electrical resistance blocks are often referred to as *gypsum blocks* and sometimes just *moisture blocks*. The electrodes are connected to insulated lead wires that extend upward to the soil surface.

Resistance blocks work on the principle that water conducts electricity. When properly installed, the water suction of the porous block is in equilibrium with the soil-water suction of the surrounding soil. As the soil moisture changes, the water content of the porous block also changes. The electrical resistance between the two electrodes increases as the water content of the porous block decreases. The block's resistance can be related to the water content of the soil by a calibration curve.

To make a soil-water reading, the lead wires are connected to a resistance meter containing a voltage source. The meter normally reads from 0 to 100 or 0 to 200. High readings on the scale (corresponding to low

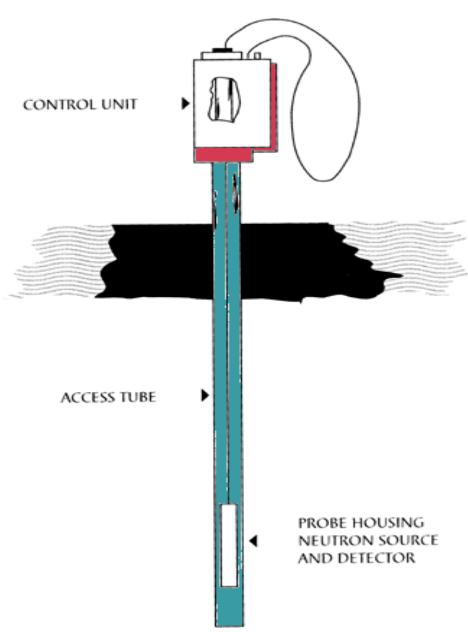


electrical resistance) indicate high levels of soil-water, whereas low meter readings indicate low levels.

Because of the pore size of the material used in most electrical resistance blocks, particularly those made of gypsum, the water content and thus the electrical resistance of the block does not change dramatically at suctions less than 0.5 bar (50 cb). Therefore, resistance blocks are best suited for use in fine-textured soils such as silts and clays that retain at least 50 percent of their plant-available water at suctions greater than 0.5 bar. Electrical resistance blocks are not reliable for determining when to irrigate sandy soils where over 50 percent of the plant-available water is usually depleted at suctions less than 0.5 bar.

Neutron moisture meter

Soil moisture can be estimated quickly and continuously with neutron moisture meter without disturbing the soil. Another advantage is that soil moisture can be estimated from large volume of soil. This meter scans the soil about 15 cm diameters around the neutron probe in wet soil and 50 cm in dry soil. It consists of a probe and a scalar or rate meter. This contains a fast neutron source which may be a mixture of radium and beryllium or americium and beryllium. Access tubes are aluminum tubes of 50-100 cm length and are placed in the field when the moisture has to be estimated. Neutron probe is lowered in to access tube to a desired depth. Fast neutrons are released from the probe which scatters in to soil. When the neutrons encounter nuclei of hydrogen atoms of water, their speed is reduced. The scalar or the rate meter counts of slow neutrons which are directly proportional to water molecule. Moisture content of the soil can be known from the calibration curve with count of slow neutrons.



Pressure membrane and pressure plate Apparatus

Pressure membrane and pressure plate apparatus is generally used to estimate field capacity, permanent wilting point and moisture content at different pressure. The apparatus consists of an air tight metallic chamber in which porous ceramic pressure plate is placed. The pressure plate and soil samples and saturated and are placed in the metallic chamber. The required pressure of 0.33 or 15 bar is applied through a compressor. The water from the outlet till equilibrium against applied pressure is achieved. After that, the soil samples are taken out and oven- dried for determining the moisture content.

Phene Cell

The Phene cell works on the principle that a soil conducts heat in relation to its water content. By measuring the heat conducted from a heat source and calibrating the conductance versus water content for a specific soil, the Phene cell can be used reliably to determine soil-water content. Because the Phene cell is placed at the desired soil depth, a separate cell is needed for each depth at each location to be monitored.For irrigating small acreages, the total cost of using the Phene cell is less than that of the neutron probe. For large acreages, the neutron probe may be more cost effective.

Time Domain Reflectometer

The time domain reflectometer (TDR) is a new device developed to measure soil-water content. Two parallel rods or stiff wires are inserted into the soil to the depth at which the average water content is desired. The rods are connected to an instrument that sends an electromagnetic pulse (or wave) of energy along the rods. The rate at which the wave of energy is conducted into the soil and reflected back to the soil surface is directly related to the average water content of the soil. One instrument can be used for hundreds of pairs of rods. This device, just becoming commercially available, is easy to use and reliable.

Selecting the Right Device

When cost, ease of use, and reliability are considered, tensiometers and electrical resistance blocks are usually the most practical devices for measuring soil-water in North Carolina. For best results, tensiometers and electrical resistance blocks must be properly installed, maintained, and calibrated for the primary soil types in each field. Installation Focedures for tensiometers and resistance blocks are described in the next section. The gravimetric method can be used to calibrate tensiometers and electrical resistance blocks on the farm.

Preparing and Installing Measuring Devices

Tensiometers

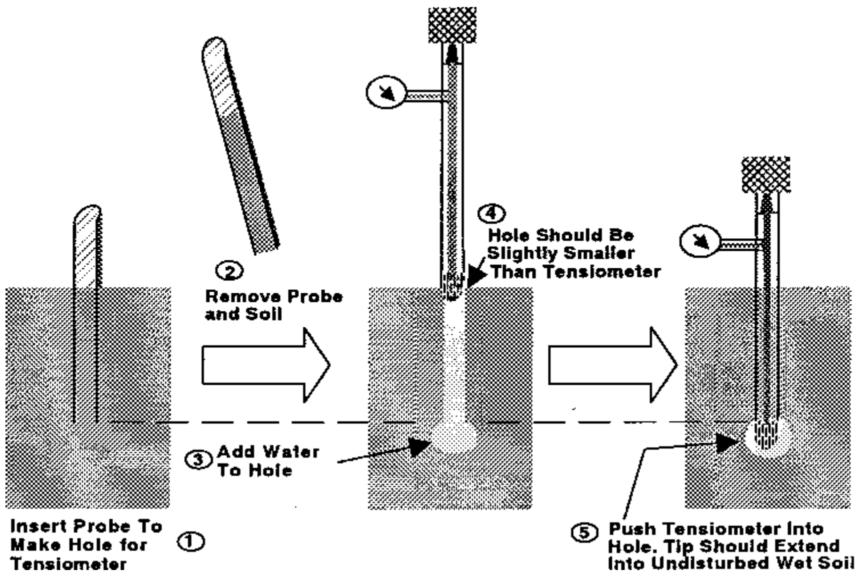
Before a tensiometer is installed, the porous tip should be soaked in water overnight. The tube should then be filled with boiled (air-free) water, and the gauge and tip should be tested using a small, hand-held vacuum pump (available from tensiometer manufacturers). The vacuum pump should also be equipped with a vacuum gauge. It is used to create a vacuum in the tensiometer.

After the porous tip of the tensiometer is saturated, attach the vacuum pump to the top of the tensiometer with the cap removed. Use the pump to evacuate air from the tensiometer barrel. The vacuum gauge reading on the pump and on the tensiometer should be the same. Furthermore, this reading should remain constant for several seconds, indicating that air is not leaking through the porous tip.

If tension cannot be maintained, the tip or barrel has probably been damaged or cracked. The most common cause of failure is a crack in the porous tip resulting from rough handling. A cracked tip allows air to enter the barrel so that tension forces in the soil are not correctly transmitted to the gauge. Tips, seals and gauges can be replaced by the tensiometer manufacturer.

After the vacuum pump test has been completed, the rubber seal in the cap should be tested. Fully assemble the tensiometer and place it on a table or surface so that the porous tip is exposed to the air. Water will begin evaporating from the tip. Within a few minutes, the tension reading on the gauge should begin to increase. If it does not, the rubber stopper in the cap is not providing a good seal and should be replaced. Otherwise, the tensiometer is ready for installation. It should be transported to the field with the tip submersed in a container of water or wrapped in a moist cloth so that tension is not broken before installation.

A probe slightly smaller than the diameter of the porous tip (for example, a steel rod, broom handle, or tube) is used to make a hole in the soil for the tensiometer. The depth of the hole should be about 1/4 to 1 inch less than the actual depth for the porous tip (Figure 3). Pour 1/4 cup of water into the hole to moisten the soil at the bottom. Insert the tensiometer and gently push it down to the desired depth, usually one-half the effective root zone depth. To ensure good contact between the soil and the porous tip, push the tip into the undisturbed soil just below the depth created by the probe. After the probe has been installed, the soil and porous tip usually reach equilibrium within 24 hours, and the instrument is then ready to use.



The tensiometer should be installed to one-half the effective root depth. The porous tip must be in good contact with the adjacent soil.

Field experiences with tensiometers have been mixed. When properly installed and maintained, tensiometers are reliable. Unsatisfactory results are usually caused by inadequate maintenance. Sandy soils, which are best suited for tensiometers, have low levels of plant-available water. In coarse, sandy soils the water content may decrease from field capacity to less than 20 percent of the plant-available water within three days. At this depletion rate, tension can exceed 80 cb within three days, breaking the water column (tension). The soil may then appear dry and the crop may show visible signs of stress. Because tension was broken and the tensiometer is no longer functioning correctly, however, the gauge shows a low tension (high soil moisture). Thus the irrigator concludes that the tensiometer is unreliable. Tensiometers should be read every day (sometimes twice a day in very sandy soils) until you obtain a feel for how fast the soil dries after rainfall or irrigation.

Whenever tension is broken, the tensiometer must be serviced. This includes refilling the instrument with boiled water and checking it with the vacuum pump. Adding a little food coloring to the boiled water makes it easier to see whether water is still present in the tensiometer. Air bubbles in the water column tend to collect at the top of the barrel and appear clear compared to the colored water. The water column should always be free of air bubbles, and water should always be stored in the reservoir. It may be necessary to add water to the reservoir during the season even if tension is not broken.

Electrical Resistance Blocks

Like tensiometers, electrical resistance blocks should be soaked overnight before they are installed in the field. A soil probe should be used to make a hole to the desired installation depth. The hole should be slightly larger than the moisture block so the block slips in easily. After placing the resistance block in the hole, backfill the hole with a thick soil slurry using soil from the installation depth. Since fine-textured soils do not dry as rapidly as sandy soils, resistance blocks do not need to be read as frequently as tensiometers. Normally, three to four readings per week are adequate.

The electrical resistance of soil-water is affected by substances dissolved in the water. The exchange of water between the soil and the block over the course of the irrigation season may gradually alter the electrical resistance of the block and eventually alter the calibration. This is not a serious problem in North Carolina soils unless highly saline water is used for irrigation. Since electrical resistance blocks are inexpensive, however, new calibrated blocks should be installed at the beginning of each growing season.

Positioning Soil-Water Measuring Devices

If tensiometers or electrical resistance blocks are used, at least one device should be located in each of the major soil types in the irrigated field. For most soils irrigated in North Carolina, the effective root depth is about 12 inches. The soil-water measuring device should therefore be installed to a depth of 6 inches. In soils with a dramatic textural change within 12 inches of the soil surface, such as a loamy sand surface texture overlying a sandy clay loam, one device should be installed in the center of the effective root zone portion of each layer.

Soil-water measuring devices should be installed in the plant row. Install them as soon as possible after planting so that roots will grow around them and water extraction will resemble natural field conditions. Flag each device so that it can be easily found in the growing crop. Mark the end of each row containing a device.

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