Neutron Moisture Meters

Neutron soil moisture meters (neutron probe) use radioactive material for measuring soil moisture. They contain an electronic gauge, a connecting cable, and a source tube containing both nuclear source and detector tube (Fig. 1). An access tube is installed in the ground, and the source tube is lowered into the tube to the desired depths of measurement.

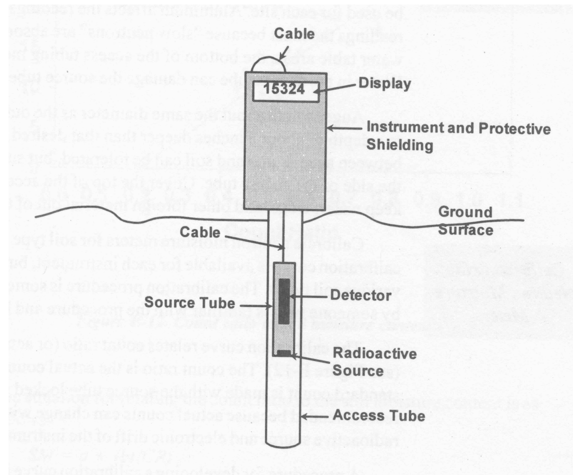

Fig. 1. Photo and schematic of a neutron probe.

An Americium 241/Beryllium pellet emits high-energy neutrons (typically with a radiation rating of 50 millicurries/m). Lowering the source tube down in soil causes high-speed neutrons to collide with hydrogen atoms in water and soil. Their energy is then lost and low-energy or "slow" neutrons are created. Some slow neutrons are reflected back to the source tube and counted by the neutron detector. These raw counts are transmitted to the gauge that contains a microprocessor with a calibration equation (supplied by the user or manufacturer) to give a reading of volumetric soil moisture content. Because soil moisture is the primary source of hydrogen atoms in the soil, neutron moisture meters indirectly measure soil moisture content.

An advantage of these meters is a volume of soil about the size of a volleyball is sampled. This better reflects soil moisture contents affecting plant growth compared with the small sampling volumes of other moisture sensors. Also, measurements at multiple depths can be made at a given site in a few minutes.

One disadvantage of this device is that reliable measurements at shallow depths (less than six inches) may not be possible because some neutrons escape from the soil surface into the air instead of being detected. The main disadvantage of this method, however, is its operator training, storage, and licensing and inspection requirements because the radioactive source.

Installing a Neutron Moisture Meter

Select a site that will not be disturbed by equipment. Install an access tube in the soil to a depth of about 6 inches deeper than the maximum measurement depth. A small gap between access tube and soil can be tolerated, but surface water should not flow down the side of the access tube. Cover the top of the access tube between measurements to keep water, frogs, and other foreign material out of the tube.

Two-inch diameter aluminum pipe, Class 125 PVC pipe, or electrical metal tubing (EMT) is commonly used for access tubes. Because meter readings are affected by access tubing material, the same material must be used for each site. Aluminum affects the readings the least, while PVC affects the readings the most because “slow neutrons” are absorbed by chlorine in PVC. In high water table areas, the bottom of the access tubing must be sealed to keep out water. Water in the access tube can damage the source tube and cause very high readings.

What do the Readings Mean?

Actual counts are not very useful. Actual counts must be related to volumetric soil moisture contents expressed in inches of water per foot of soil using an appropriate calibration curve. Then, measured soil moisture contents can be compared with soil moisture contents at field capacity, and soil moisture depletion determined. Actual depletion can be compared with allowable depletion to determine when to irrigate and how much to apply.

Multiple calibration curves can be stored in the memory of the electronics of the meter and can provide direct readouts of soil moisture content in a variety of terms, such as inches per foot and soil moisture percentage. Field readings can be stored for later retrieval or transfer to computers.

Placement of Monitoring Sites

At least two sites for each 40 acres are recommended. More sites may be necessary depending on soil variability. Additional sites may be needed for problem areas or for areas with different soil or management conditions.

The maximum depth of access tubes should be at least the depth of the root zone. However, measuring moisture contents at deep depths may be desirable for monitoring percolation below the root zone.

Maintenance

Neutron meters require little maintenance beyond checking to ensure proper operation. Access tubes should be checked for water or foreign materials in them. The most common failure is a broken or worn cable, which connects the source tube to the electronic readout device. A repaired instrument may also require recalibration. Operator recertification is required every two years.

Considerations in Using Neutron Moisture Meters

_ <u>Access Tubes:</u> Access tubing material can affect counting rates. Highest counting rates are achieved with aluminum, lowest in PVC. However, accurate calibration curves can be made with PVC, which is less expensive than aluminum and does not easily bend or become misshapen.

_ <u>Standard Counts</u>: A standard count is made periodically to monitor performance of the meter and to calculate count ratios (actual count divided by standard count). Standard counts should be taken with the detector/source tube locked in the polypropylene shielding positioned on top of the transport case. The instrument should be at least 2 feet from any material that can influence the count. At least five counts are recommended for calculating the average standard count to minimize errors in the count ratio.

_ Air Gaps: A slight air gap between access tube and soil will not greatly affect count rate. However, prevent water from flowing down the gap. Root density also might be affected by gaps. Random pockets of clay in an otherwise sandy loam root zone of an orchard will give artificially high readings of water content that do not reflect the average of the root zone. Avoid these areas.

_ Count Accuracy: Theoretically, one reading per depth is sufficient for an error of one percent or less if 5,000 or more slow neutrons are counted. Most neutron moisture meters base their standard count on a 16 second duration.

_ Count Duration: A 15 or 16-second count duration is a common count time for most soils. A longer count time may be needed in sandy soil. However, a 4-second count can also be used with reasonable accuracy when measurements are to be made at many sites and depths. The standard error of 0.1 inch of water/foot of soil was found for the 4-second count and 0.06 inch/ft for the 16-second count.

_ Interchanging Meters: Use caution in interchanging neutron moisture meters. Meters with similar standard counts and their calibration curves can be interchanged as long as count ratios are used to standardize the meter's performance. Meters with very different standard counts should not be interchanged unless calibration curves for each instrument are available. Using standard counts may not standardize performances of very different meters.

_ Depth of First Reading: Counts made at a six inch depth below the surface are affected by the soil-air interface, especially as the soil dries after irrigation, due to the large sampling volume of the meter. Thus, a separate calibration curve may be needed for accurate measurements made at that depth. In practice, however, making the first reading at 9 inches deep can minimize the effect of the soil-air interface.

References

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