Research Note

CONSTRUCTION AND USE OF TENSIOMETERS[1,2]

Tensiometers have been widely used as a tool in agronomic and soil water investigations over the years. In connection with recent soil water studies[3] on Oxisols and Ultisols of Puerto Rico, tensiometers were developed that can be easily and cheaply constructed.

Materials

The following materials are required for tensiometer construction:

(1) PVC plastic pipe, schedule 40, ½ in nominal pipe size, ½ in i.d., ⅞ in o.d.
(2) Nylaflow[4] pressure tubing, Type T, clear, ⅛ in o.d.[5]
(3) Acrylic plastic pipe, ⅝ in o.d.[6]
(4) Ceramic tensiometer cups, ½ in neck, ⅞ in o.d.[7]
(5) Miscellaneous: Rubber stoppers #0; epoxy cement.

In order to read soil water tensions, a manometer system requiring the following materials is necessary:

(1) Meter stick.
(2) Plastic vials (19 ml) for mercury well, 1⅛ in × 1$^{11}/_{16}$ in is suggested.
(3) Mercury (120 g/vial will serve 4 tensiometers).
(4) Mounts for meter stick and vial.

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[2] Contribution from the Department of Agronomy, Cornell University, Ithaca, N.Y. and the Agricultural Experiment Station, University of Puerto Rico, Rio Piedras, P.R. Present address of the author: CIDIAT, Box 219, Mérida, Venezuela. Appreciation is given to Drs. M. Drosdoff and R. Miller, Department of Agronomy, Cornell University, for their constructive criticism of this note. This study was part of the work supported by U.S. AID under research contract csd 2490 entitled "Soil Fertility Requirements to Attain Efficient Production of Food Crops on the Extensive, Deep, Well-drained by Relative Infertile Soils of Humid Tropics".

[3] Wolf, J. M., and Drosdoff, M., Soil-water studies on Oxisols and Ultisols of Puerto Rico: I, Water Movement, J. Agr. Univ. P.R., 60 (3): 375–85, 1976.

[4] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico or an endorsement over other equipment or materials not mentioned.

[5] Available in 500 ft rolls from Industrial Safety Supply Company, 574 New Park Avenue, West Hartford, Conn. 06110, (203) 233-9881.

[6] Almac Plastics Inc., 47-47 36th Street, Long Island City, New York 11101.

[7] R. & J. Ceramics, 1334 Silica Avenue, Sacramento, Calif. 95815, (916) 929-8741 or Soil Moisture Equipment Corporation, P.O. Box 30025, Santa Barbara, Calif. 93105; Cat. No. 2131; Description: 1 bar porous ceramic tensiometer cups.

Construction

(1) PVC should be cut to desired lengths. Cut to leave approximately 4 in of PVC above the ground. Using sandpaper and cloth insure that ends of PVC are free from burrs, and are clean.

(2) Using at $^{41}\!/_{64}$ in drill bit ream out one end of the PVC to a depth of 1½ in. This will accommodate the acrylic plastic sight glass. If a $^{41}\!/_{64}$ in bit is not available, place end of PVC pipe in boiling water for about 1 min. When softened in this manner, the acrylic plastic sight glass can be forced into the end of the pipe and subsequently glued in place.

(3) Cut acrylic plastic in 3 in pieces and remove burrs. Insert and glue into reamed end of PVC or softened end as described above. Use epoxy or PVC solvent. Let dry. The sight glass should protrude 1½ in from the PVC.

(4) Drill a hole for the Nylaflow pressure tubing at the upper end of the tensiometer. This should be located about ½ in from the top of the tensiometer and should go through one wall (only) of the PVC and the sight glass. Use a ⅛ in bit.

(5) Using epoxy, glue nylaflow tubing to the tensiometer. Let dry. The length of tubing will depend upon placement of the tensiometer in relation to the meter stick. Generally 10 in is sufficient.

(6) Glue the tensiometer cup to the PVC using epoxy. Let dry.

Figure 1 shows the construction and installation of the tensiometer.

Testing

Rather than having to remove a leaky tensiometer from the field it will pay to use care in construction, especially with regard to removing burrs and dirt, and in testing. The glued connections can cause problems and should be checked to insure that they are air tight. A simple test is to place the stoppered tensiometer under water and to blow air into the pressure tubing. This will reveal leaks should they be present. Tensiometers removed from the field should be tested prior to reuse.

Installation in Field

Bore to the desired depth using a 1 in auger. Dig out the hole to approximately 3 in beyond where the cup is to be placed. Pour a small amount of mud slurry into the hole and seat the tensiometer cup in the slurry. Backfill and tamp to a soil density approximating natural conditions. Run the Nylaflow tubing from the tensiometer to the top of the meter stick and down into the plastic vial containing mercury. Tubing may be enclosed in glass tubing for rigidity or may be taped to the meter stick. Fill the tensiometer with water. Using a squeeze bottle with conical cap, flush air from the system by pushing water through the sight glass and into the Nylaflow tubing and mercury well. Stopper the tensiometer. Bubbles are liable to cling to the sides of a newly filled tensiometer and should be eliminated. Air bubbles may accumulate in the sight glass and should be eliminated from time to time, otherwise response will be slow and readings will be doubtful.

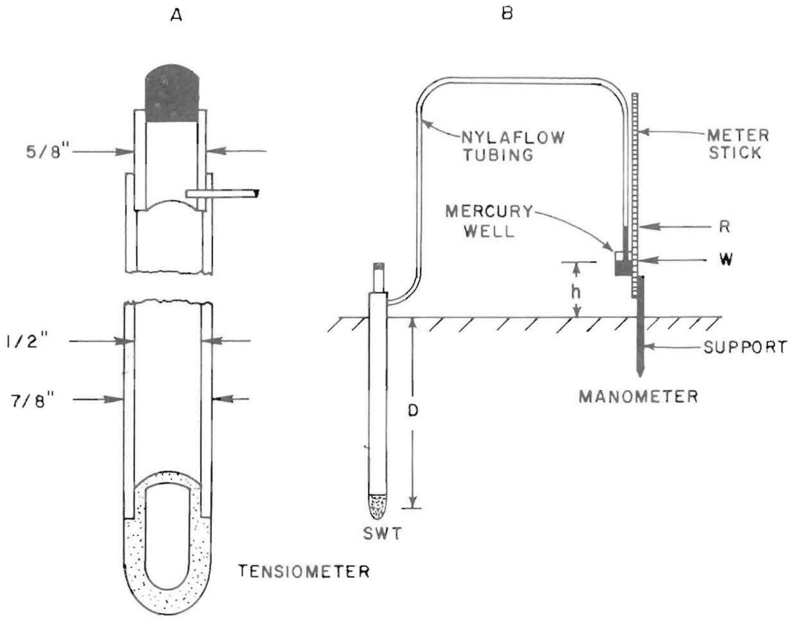

FIG. 1.—Schematic diagram of construction (A) and installation (B) of the tensiometer.

Reading Soil Water Tensions

Field data should be taken at the same time each day. Raw data must be converted to soil water tensions using the equation below:

$$SWT + D + h + (R - W) = (R - W)\,13.55 + C$$

$$SWT = 12.55\,(R - W) - D - h + C$$

where,

SWT = soil water tension (cm of water)
R = mercury reading on manometer (cm)
h = height of mercury well above ground (cm)
W = mercury reading in plastic vial (cm)
D = instrument depth (cm)
C = constant accounting for negative wetting of mercury in tubing. For Nylaflow, C = 7 cm.

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