Agriculture Notes

How to use tensiometers

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What is a tensiometer?

A tensiometer measures soil moisture. It is an instrument designed to measure the tension or suction that plants' roots must exert to extract water from the soil. This tension is a direct measure of the availability of water to a plant.

Tensiometers may be used in any irrigated crop, however, it is with horticultural crops in particular that they provide an efficient method to schedule irrigations. Tensiometers are most useful when a crop's water requirements are high and when any stress due to water shortage is likely to damage crop potential.

A tensiometer consists of an air tight, water filled tube with a porous ceramic tip at the bottom and either a vacuum gauge at the top or a re-sealable rubber bung for a portable vacuum meter (Figure 1). During the irrigation season it is partly buried in the soil to a suitable depth and, when used properly, it will enable improved irrigation management by accurately determining when water should be applied to a crop to maintain optimum growth and how much water should be applied to avoid over-irrigating.

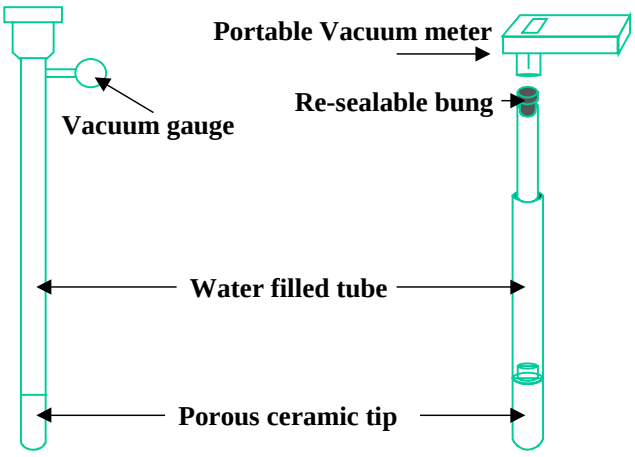

Figure 1. Components of two types of tensiometers. Tensiometer with a permanent vacuum gauge (left) and a portable electronic vacuum gauge (right) are shown.

How do they work?

When buried in the soil the ceramic tip of the tensiometer allows water to move freely in or out of the tube. As the soil dries out, water is sucked out through the porous ceramic tip, creating a partial vacuum inside the tensiometer which is read on the vacuum gauge. Soil tension increases as the soil dries out, the vacuum increases in the tensiometer and the gauge reading rises. When the soil is wetted by sufficient rainfall or irrigation, water flows back into the tensiometer, the vacuum decreased and the gauge reading is lowered.

Tensiometers measure how tightly water is held to the soil particles and not how much water is left in the soil. A sandy soil will reach a high tension sooner than a clay loam because sandy soils cannot supply as much water to the plant and it is used up more quickly.

Tensiometers do not operate in dry soil because the pores in the ceramic tip drain and air is sucked in through them breaking the vacuum seal between the soil and the gauge on top of the tensiometer.

What do the readings mean?

Vacuum gauges are normally calibrated in kilopascals (from 0 to 100 kPa). Tensiometers operate successfully up to about 75 kPa. A reading of 0 kPa indicates saturated soil in which plants will suffer from lack of oxygen. Optimum plant growth will occur when the soil is kept wetter than 30 to 40 kPa for coarse textured soils (sands) and 50 to 60 kPa for medium-textured and heavy-textured soils. Readings in excess of 70 kPa indicate that the soil is dry enough to reduce growth.

Placement of tensiometers

Tensiometers must be placed at about the midpoint of the main fibrous root system (where irrigation water is sure to wet the soil) and at the bottom of the root zone to avoid over-irrigation.

Correct placement is most important. Placement too deep in a shallow rooted crop will result in the crop being irrigated too late and suffering water stress. Shallow placement in a deep rooted crop may result in excessive irrigation and waterlogging of the deeper roots. As a safeguard against excessive irrigation, a tensiometer should be placed at the bottom of the root zone to check subsoil moisture and drainage.

In most situations two sites will be needed for each major species or variety and soil type in the orchard. Avoid high or low sites, zones of poor water infiltration, and areas that are lightly watered because of bad sprinkler distribution

patterns. All tensiometers must be marked clearly to avoid damage from traffic, workers and cultivation.

Installation

Tensiometers are generally installed in selected sites for the duration of the irrigation season. Before tensiometers are buried in the soil, the ceramic tip and tube must be placed in a container of water for 24 hours to ensure that the tip is fully wet. The tensiometer tube must be filled with water (fill to within 10 mm of the top if a rubber stopper is used to seal the instrument) and the tube sealing mechanism left off. Tensiometers must remain in the container of water until installed.

Tensiometers are fragile, especially at the point where the ceramic tip is fixed to the tube. During installation it is important to bore a straight hole to the desired depth in recently irrigated soil. As good soil contact is essential, the last 5 cm of the augered installation hole can be of slightly smaller diameter than the tip of the tensiometer. If the tensiometers are to be installed in a larger hole, back filling must be carried out in such a way as to provide good soil contact and also to prevent excess irrigation water running into the hole. Hilling up soil around the tensiometer will help prevent ponding around the tensiometer and preferential flow down the backfilled hole. Usually a tensiometer installed in moist soil can be measured 24 hours later.

Servicing and problems

Tensiometers need regular attention. Some air does enter through the ceramic tip and sometimes through joins, particularly at high tension. The amount of air entering depends on the quality of the ceramic tip. At each reading the water level in the tensiometer must be checked; when air occupies the top 20 - 40 mm of the tensiometer, water must be added. Ideally tensiometers are refilled after each measurement.

Tensiometers need skilful management and interpretation of readings. The most common problems in their use are the gauge reading remaining on zero, and the tensiometer not positioned within the crop's root zone and the irrigation wetting pattern.

Readings that remain on zero are caused by:

- continuously saturated conditions
- air leakage through the ceramic tip or around joints and seals
- bad soil contact with the tip
- a faulty gauge

Correct operation of the vacuum gauge and the condition of seals should be checked periodically. Readings that are higher than expected, especially after an irrigation, are generally not due to tensiometer failure but failure of the irrigation water to penetrate to the depth of the tensiometer tip. In this case, if application of additional irrigation water does not wet the tensiometer tip because of infiltration problems, then the tensiometer should be placed at a shallower depth within the wetted zone.

Irrigation timing with tensiometers

Tensiometers placed at about the mid-point of the main fibrous root system are used to determine when to irrigate. This is particularly important during the period when the water requirement of the tree (or crop) is highest and yields are most sensitive to water shortage. During this period tensiometers should be read daily. Tensiometer readings indicate how hard the tree is working to extract moisture. As a general guide, irrigation of crops with a 600 mm deep root zone should start when the tensiometer reading at 300 – 450 mm depth reaches 30 to 40 kPa on deep sands, or 50 kPa on silty loam or silty clay soils. Sufficient amount of water should be applied to re-wet the root zone. Following irrigation the reading on the tensiometer will be reduced. Daily readings should continue to determine when irrigation is required again.

When to irrigate will be determined largely by the amount of water applied and stored in the root zone at the last irrigation. If only a light irrigation was applied, or a small section of the root zone wetted, then the soil will dry faster and a high tensiometer reading reached sooner than if a heavy irrigation was applied and all of the root zone wetted. Climatic conditions and the leaf development of the crop will also affect the rate of soil drying.

Adjustments in how much irrigation to apply can be made by monitoring the bottom of the root zone. The deeper tensiometer at the bottom of the root zone allows you to determine if too much (never reads above 15 kPa) or too little water (continues to rise) is applied at each irrigation.

Tensiometers can also be used to determine the effectiveness of rainfall, the need for winter irrigation, and help in problem solving where run-off, waterlogging or poor water distribution occur. In areas where supplementary irrigation is used, tensiometer readings will assist to determine when and how much to irrigate, without wasting a precious storage.

Conclusion

The use of soil augering to hand feel the soil moisture and evaporation readings will increase the accuracy of tensiometer irrigation scheduling. Pan evaporation readings are particularly important as they are closely linked to the rate at which soil moisture will be used. The combination of evaporation and tensiometer readings gives the irrigator measurements of both climatic conditions and soil moisture, therefore enabling accurate determination of irrigating timing and amounts.

