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Making Irrigation Decisions Using Tensiometers

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A tension meter, also known as a tensiometer, measures the direct physical forces that affect water processes in the soil, as opposed to indirect measures of an electrical property in other soil moisture meters. This tool is useful for any irrigated crop and is most beneficial to crops that have high water requirements and incur damage when there is any stress due to water shortages. Tensiometers are a user friendly, affordable tool that can aid farmers in making irrigation decisions.

A tensiometer is a water-filled plastic tube with a special porous tip at one end and a vacuum gauge at the other end. Some tensiometers have an electronic vacuum gauge, which can be reattached and transferred from a tensiometer to another easily.

Tensiometers are available in the market at various lengths (6 to 72 inches), which allows for installation and soil moisture monitoring at various depths based on plant root system depth (**Photo 1**). Using tensiometers also allow users to maintain a desired soil moisture content at a certain depth, such as crop root depth. The electronic gauge can be connected to a data logger to collect data continuously. If installed correctly, the tip of the tensiometer allows water to move freely in or out of the air-tight tube.

Photo 1. Examples of tensiometers at various lengths.

Similar to an artificial root, the tensiometer's ceramic tip interacts with the soil. The ceramic tip is placed in a wet soil, and as the soil dries, the soil will remove water from the tensiometer (**Photo 2**). As water is removed, a measurable tension is created between the ceramic tip and the soil. When there is enough water

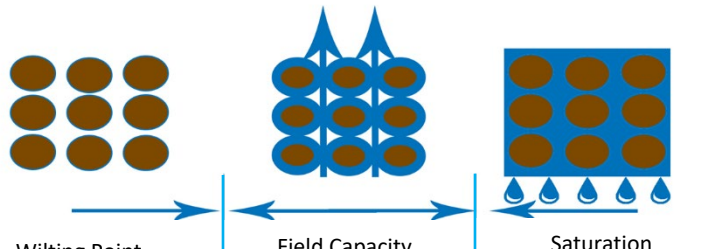

Photo 2. Tensiometers can measure soil tension and indicate when soil should be irrigated. Illustration by Sugano (modified from Rhode and Yonts, 1984).

in the soil, the water will flow back into the tensiometer causing the measured tension to decrease.

Measurable tension is a valuable field measurement in agriculture because the value can indicate how much and when irrigation is needed. Another reason why this is a valuable measurement tool is that it can indicate the difficulty for plants to uptake water from the soil (**Photo 3**).

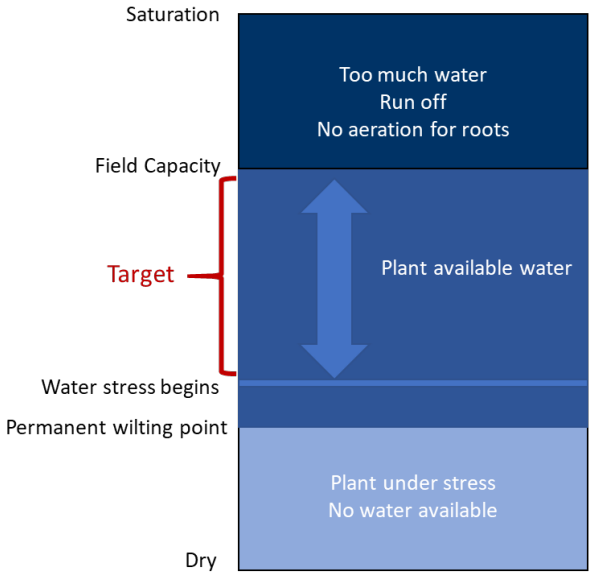

Photo 3. Tensiometers can aid farmers in maintaining desired soil moisture within the target range.

The units of measurement for research type tensiometers are in centibar or kilopascals (kPa), where 0 kPa represents a saturated, wet soil (i.e. low suction), and -100 kPa a dry soil (i.e. high suction). When using a tensiometer, the tools are accurate up to approximately -75 kPa. The measurement indicates how tightly water is held to the soil particles; not how much water is left in the soil.

Tensiometers on the commercial market, which are easily accessible to commercial farmers, convert the kPa into positive values (**Photo 4**). For example, if the soil is at 0 kPa, the soil is considered saturated and plants may suffer from a lack in oxygen; however, wetland plants like kalo, mangrove, etc. are a notable exception and can thrive in these types of conditions. Soil moisture at field capacity, ranges from 10 kPa to 30 kPa on commercially available tensiometers (**Photo 5**). Soil moisture should be kept within this range for optimal plant growth. If the tensiometer is reading above field capacity (e.g. between 30-70 kPa depending on crop type), the soil can be dry enough to cause stress to shallow-rooted crops and cause reduced yield and quality.

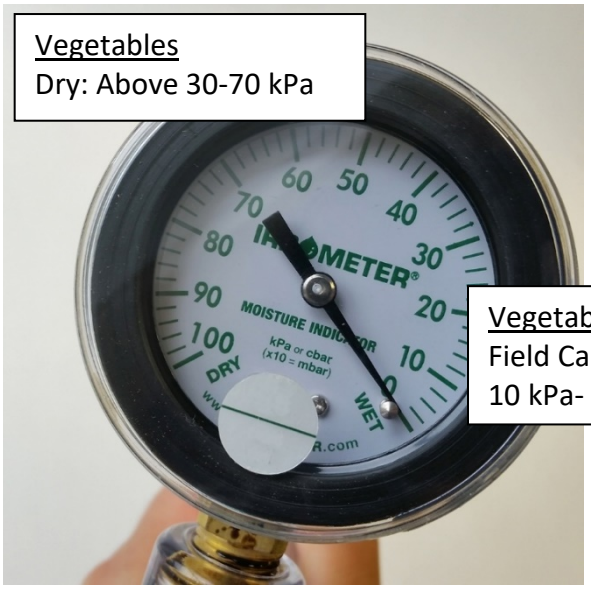

Photo 4. Commercially available tensiometers convert kPa values into positive values for ease of use. Photo credit: boutiquepro.ghlinc.com

Tensiometers like the one shown in **Photo 4** are most useful in vegetable and annual production systems. A tensiometer is less useful for fruit trees due to more negative soil tensions than a tensiometer can read. (Soil Water Basics, 2020). For example, 100 kPa (=1 bar) maybe considered “dry” for vegetable crops, but still considered “wet” for fruit orchard systems.

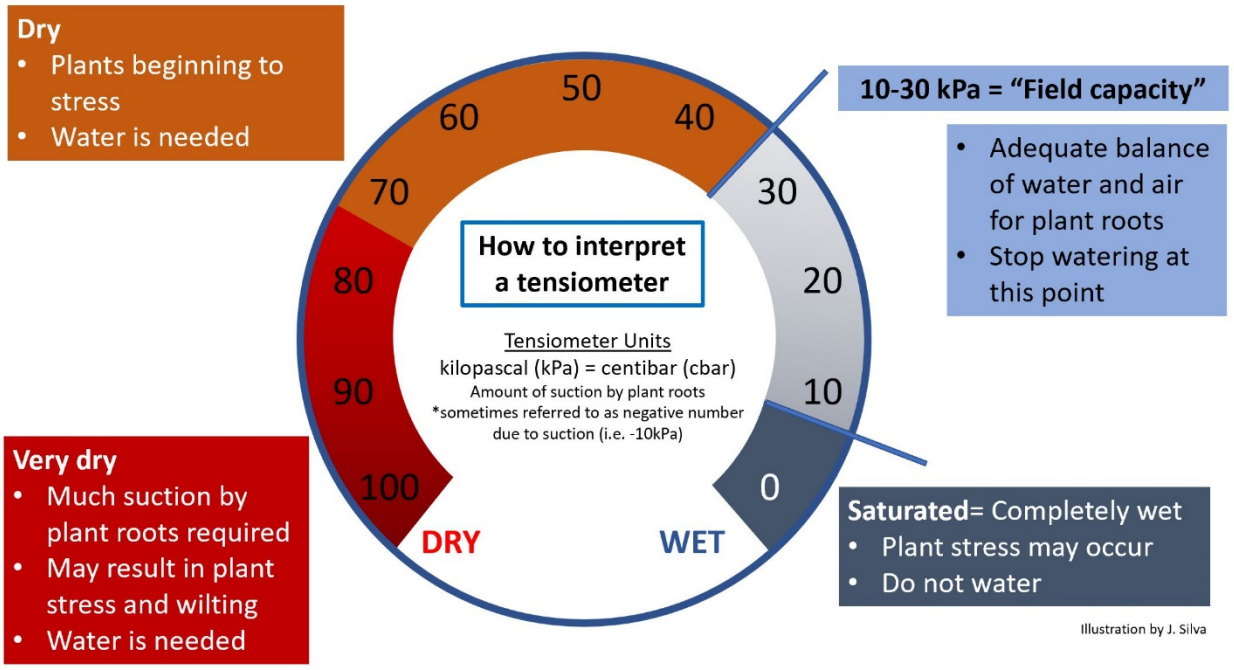

Photo 5. How to interpret a tensiometer

The set-up, maintenance, and care for tensiometers is essential for the accuracy of the measurements along with the long-term use of the meter. The crop type must be identified to establish a water threshold. When the threshold is reached in the root zone, irrigation should occur soon. Installing a tensiometer below the crop root zone is usually to measure water leaching or overwatering. (Victoria State Government, 2009).

Before installing, proper preparation of the tensiometer following manufacturer's instructions is important to ensure its accuracy and functioning. The tensiometer's ceramic tip should be submerged in water for a twenty-four-hour period prior to each use. The tube must be filled with water and have the sealing mechanism left off. Installation of tensiometers should be done at the crop root zone to measure plant water uptake and below the crop root zone to measure water losses. Tensiometers should be installed at the sunny side where there would be the greatest amount of water evaporation from the soil surface.

If the root systems are exceeding the available length of tensiometers, instruments should be installed at 25% of root zone depth and another at about 75% depth. If installation is too deep in a shallow rooted crop, the crop could be irrigated too late which could lead to plant water stress. If the tensiometer is too shallow in a deep-rooted crop, that could result in excessive irrigation and water accumulation at the deeper roots.

For proper installation, prepare a hole slightly wider than the tensiometer tip and about one inch deeper than the desired depth. Prepare a slurry using water and the surrounding soil, removing

any rocks. Place the slurry in the hole and snugly insert the tensiometer tip, allowing for good contact between the ceramic cup and soil slurry. Installation techniques vary depending on soil type. If the soil is very loose, shorter tensiometers can be pushed into the ground. After installation, the soil surface should be banked up around the plastic tube and packed to three or four inches in depth.

Photo 6. If air is permitted to flow down the plastic tube, false readings can occur.

If air is permitted to flow down the plastic tube, false readings can occur (**Photo 6**). The final task is to fill the tensiometer reservoir with the fluid for the device along with removing air that may have accumulated in the reservoir. (Victoria State Government, 2009).

Conclusion:

Use of tensiometers can assist growers in achieving irrigation efficiency by applying water in accordance with crop needs. Tensiometers can be used individually or in combination with other irrigation management tools such as the evapotranspiration calculator or the old fashion "look and feel" soil method.

Informed decision making can prevent irrigation triggered water quality issues such as run off, unnecessary plant stress, nitrogen leaching, etc.

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