Irrigation Scheduling of Pecan Orchards: Soil Moisture Monitoring

Guide H-640

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A number of cultural practices—from pruning to pest control—play important roles in successful pecan production, but in New Mexico, no cultural practice is more critical for maintaining top yields and quality from your pecan orchard than irrigation. Orchard water requirements depend on several variables, such as orchard age (or, more precisely, canopy coverage), soil type, and weather; thus, providing your trees with the right amount of water at the right time can be complicated and confusing. The goal of this publication is to introduce New Mexico pecan growers to available soil moisture monitoring techniques that can help with proper irrigation scheduling.

Your orchard's soil acts as the "bank" or "reservoir" from which your trees draw water. After you irrigate, when gravity no longer pulls water any deeper through the soil profile, your orchard's soil is said to be at *field capacity*. However, not all of the water in a soil at field capacity is *available water* for your pecan trees; as the trees' roots draw the soil water content down, the remaining water in the soil pores becomes progressively more tightly held by the soil and progressively more difficult for the roots to extract. Eventually, a drying soil reaches a *permanent wilting point* when all of the remaining water is so tightly held by the soil that the roots cannot extract any further water. Although pecan tree roots can extract water up to the permanent wilting point, **water stress (and the ensuing yield and quality losses) begins to occur when more than 45 to 50% of available water has been depleted.**

Several methods and devices are available to monitor soil moisture to determine when your pecan trees need to be irrigated. Assuming relatively consistent soil textures, you should monitor one site at the 1-, 2-, and 3-foot depths in each orchard block 20 acres or smaller in size. Larger orchard blocks and those having areas with considerably different soil characteristics require additional monitoring sites. In the case of orchards with drip or sprinkler irrigation systems, be sure to monitor within the orchard floor area wetted by the emitters/sprinklers. Regardless of the irrigation system, choose monitoring sites within the dripline of your trees that will not interfere with other orchard activities (harvesting, spraying, etc.).

Four common moisture monitoring approaches useful in New Mexico pecan orchards are described in the following sections.

THE "FEEL TEST"

This is an inexpensive, low-tech method that can be fairly accurate for experienced irrigators—the only required tool is a soil probe or shovel. In this test, a small sample of soil is felt by hand to determine moisture content. Table 1 describes how soil feel and appearance change as soil water is depleted. Printed guides that describe the "Feel Test" in more detail may also be available at your local Cooperative Extension Service or Natural Resources Conservation Service (NRCS) office.[2]

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[2]A helpful NRCS guide entitled *Estimating Soil Moisture by Feel and Appearance* is also available online at www.wsi.nrcs.usda.gov/products/W2Q/downloads/Irrigation/estimating-soil-moisture-by-feel-and-appearance.pdf

Table 1. Soil Moisture Indicators for the "Feel Test"

Level of Moisture	Available Water Remaining (%)	Soil Texture[a] Light	Moderate	Heavy
Low	0-50	Will not form a ball.	Powdery or crumbly; holds together only with pressure.	May be somewhat pliable; forms ball under pressure.
Good	50-75	Forms a ball under pressure but will not hold together.	Forms a pliable ball; feels slick.	Forms ribbon between fingers; feels slick.
Excellent	75-Field Capacity	May leave a wet outline on hand when squeezed; forms weak ball; does not feel slick.	Leaves wet outline on hand when squeezed; forms a very pliable ball; feels slick.	Leaves wet outline on hand when squeezed; forms ribbon between fingers; feels slick.

[a]Sandy and sandy loam soils are examples of light-textured soils. Medium-textured soils include loamy soils, while heavy-textured soils include silty clay loam and clay loam soils.

TENSIOMETERS

Tensiometers measure soil moisture tension (how much pull the soil is exerting on the water), which increases as a soil dries down. A tensiometer consists of simply a water-filled tube with a ceramic tip and a vacuum gauge (Figure 1). If the tensiometer's porous tip is in close contact with the soil, the soil's moisture and the water in the tensiometer tube reach equilibrium. Then, as soil moisture levels decrease, the tension on the column of water in the tensiometer tube increases. This tension is measured in pressure units (centibars or kilopascals) on the vacuum gauge.

To install a tensiometer, make a hole in the soil to the desired depth with a soil probe or auger. Push the tensiometer tip firmly into the soil. Pack additional soil around the tensiometer tip and tube to ensure good contact with the soil.

As a general rule of thumb, medium-textured soils (e.g., loamy soils) should be irrigated when the soil moisture tension reaches 40 to 50 centibars. The ideal soil moisture tension at which you should begin irrigation, however, depends on soil texture: in lighter soils (more sand) the soil tension threshold for irrigation should be lower than for loamy soils and, conversely, in heavier soils (more clay) it should be higher than for loamy soils. Even within relatively small and homogeneous areas, soil types always vary to some degree, both across an orchard block and through the soil profile, and you will therefore have to use your good judgment to pick the tension at which to irrigate that best represents the soils in your particular orchard block.

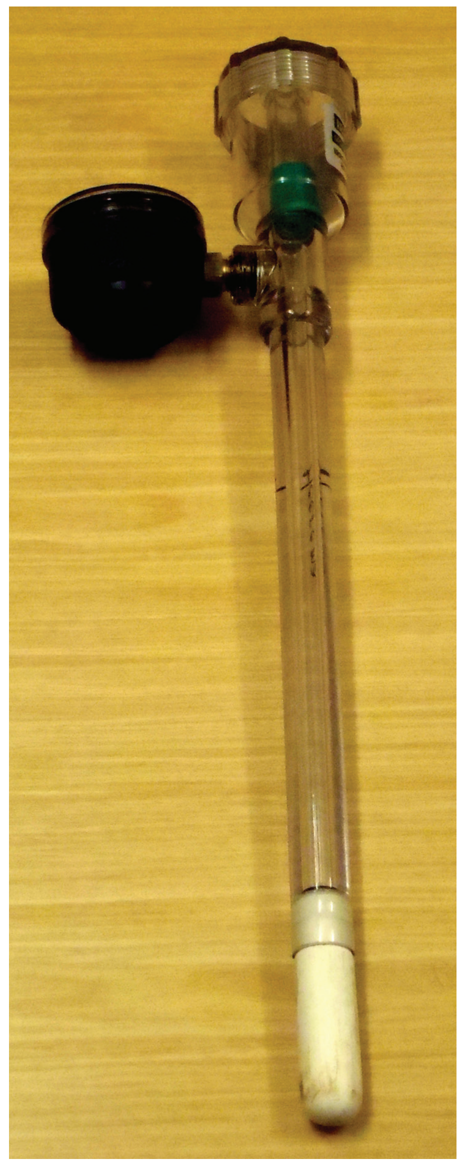

***Figure 1.* Tensiometer for measuring soil moisture tension.**

Tensiometers are reusable, simple to install, easy to read, and, at less than $100 per unit, relatively inexpensive. However, they have two main disadvantages: they must be periodically refilled to replace the water that slowly moves into the surrounding soil and, because the column of water in tensiometer tubes can break under high tension, they cannot be used in situations where the soil moisture tension is expected to approach 100 centibars.

Figure 2. **Granular matrix sensor and electric resistance meter.**

ELECTRICAL RESISTANCE BLOCKS

Soil electrical resistance increases as a soil dries. This can be measured for the purpose of soil moisture monitoring using porous blocks that enclose two electrodes with insulated wire leads and a specialized electrical resistance meter that converts the resistance reading to a soil water tension reading (readings from soil electrical resistance meters are given in the same units as tensiometers and may be interpreted in the same way). Sensors are installed in the soil at the desired depths at each monitoring site, with the wire leads protruding out of the soil surface. A single meter may be used to take readings from multiple sensors.

Currently, the price of electrical resistance sensors ranges from about $5 to $30 per sensor, and the price of meters is about $250. Two main sensor types, gypsum blocks and granular matrix sensors (i.e., Watermark sensors; Figure 2), are available. With gypsum blocks, the electrodes are encased in mineral gypsum (calcium sulfate) to lessen the effects that differences in soil salt concentration can have on resistance readings. In contrast, with granular matrix sensors, the electrodes and a gypsum plug are surrounded by quartz granules held together by a stainless steel mesh. Though less expensive than granular matrix sensors, gypsum blocks have fallen out of favor in recent years because, unlike granular matrix sensors, they degrade relatively quickly in the soil and must be replaced regularly.

DIELECTRIC DEVICES

Time domain reflectometry (TDR) relies on a known strong relationship between the volume of water held by a soil (not soil water tension as measured by tensiometers) and a readily measurable soil property called the bulk dielectric constant. TDR devices, and closely related dielectric technologies such as frequency domain reflectometry (FDR) devices, come in a wide array of designs, but often have two or three parallel metal rods that are inserted into the soil. Some designs are portable, allowing for quick spot measurements throughout the orchard, while others only allow for measurements at fixed locations in the orchard.

Dielectric devices are not a good option for small-scale growers because they are somewhat more complicated than other technologies to install and use, and are typically priced at over $2,500 per unit. But, since they are much more accurate than tensiometers or electrical resistance meters/sensors and have great potential to interface with computers, dielectric devices are now gaining popularity among larger-scale pecan growers wishing to more closely monitor soil moisture.

For more information about pecan production in New Mexico, call your county's NMSU Cooperative Extension Service office or go online to http://pecans.nmsu.edu. Also, University of Florida Extension publication *Field Devices for Monitoring Soil Water Content* (available online at http://edis.ifas.ufl.edu/AE266), which was a source for much of the information presented here, provides detailed descriptions of the soil moisture monitoring technologies explained here, as well as many others.

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