Monitoring Equipment for Drought and Seedling Survival

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Historically the mild, moist climate in western Washington and Oregon, coupled with innovative growers, and research-based information has allowed growers in the PNW to lead the nation in the production of Christmas trees. Given that most Christmas trees in the PNW are not irrigated, seedling survival and the production of high-quality trees has been contingent on moderate temperatures and periodic precipitation during the growing season. Climate-induced stress is affecting all age classes of trees. The increasing frequency of extreme temperatures and extended drought during the growing season have increased the mortality of newly planted seedlings, resulted in direct heat damage to saplings and mature trees, and appears to be predisposing trees to attack by several root diseases that have resulted in the mortality of harvestable size trees.

In an effort to mitigate the risk of climate induced stress, growers in the PNW have begun to mulch newly planted seedlings to conserve soil moisture and reduce seedling mortality. An increasing number of growers are irrigating newly planted seedlings by hand and looking at other options such as drip irrigation to maintain soil moisture. However, they are faced with a number of knowledge gaps to optimize their irrigation practices. These include a limited understanding of critical soil moisture levels that result in seedling mortality and predispose trees to sunburn, the permanent wilting point of commonly grown Christmas tree species, and their drought tolerance. This information is necessary to optimize the effectiveness of irrigation practices.

In collaboration with Drs. Bert Cregg and Younsuk Dong at Michigan State University and growers who have installed Bluewise low-cost monitoring systems developed by Dr. Dong, we are monitoring changes to environmental conditions and soil moisture levels in a series of plots at WSU Puyallup and several grower sites to address the knowledge gaps above.

The following sections outline some key ideas about how soil texture influences water-holding capacity, along with examples showing how irrigation changes soil moisture levels.

Irrigation planning with soil moisture sensors

Water infiltration rate and water holding capacity vary with soil texture, therefore it is critical to have a basic understanding of the various soil types at your farm. Site history such

Definitions

- Field capacity (FC) – upper limit of water held by soil after drainage due to gravity
- Wilting point (WP) – lower limit of stored water at which plants cannot extract moisture from soil.
- Available water (AW) = FC-WP

as soil disturbance (plowing, rototilling, ripping), cover crops, and compaction from equipment also influences the movement of water in soils. Below are estimated values for the following different volumetric water content (VWC) values for different soil types.

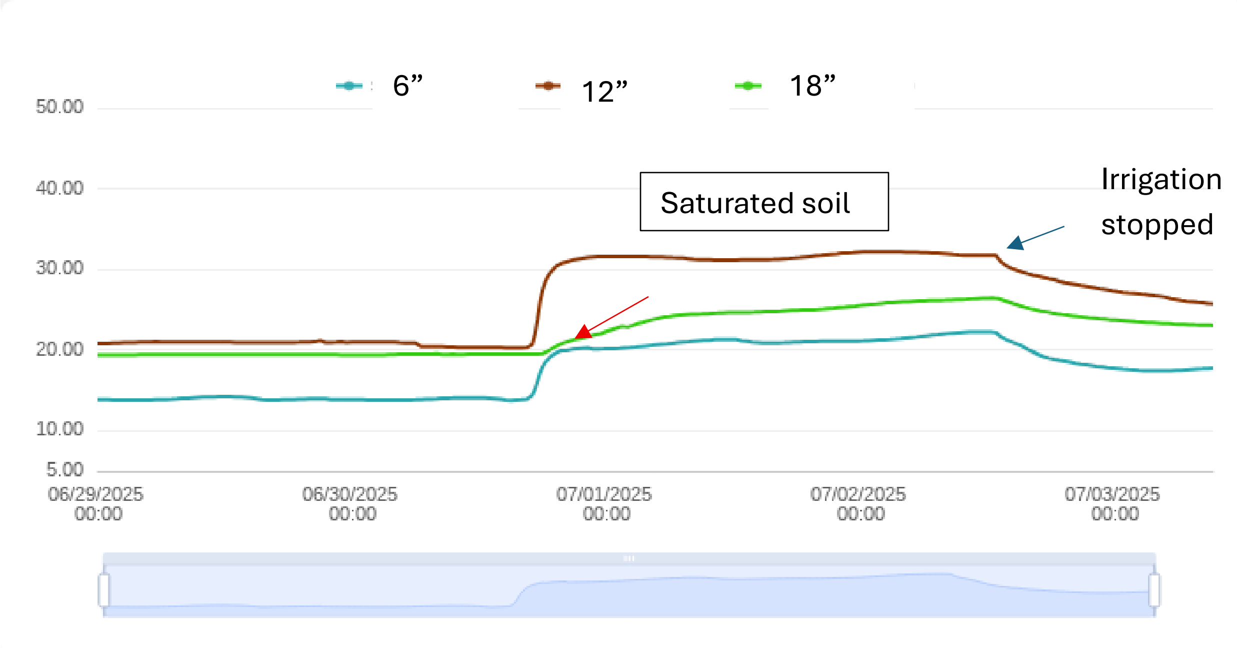
The amount of water in soil that is available to plants is known as the Water Capacity = ((AW-WP) / (FC-WP))*100. For most conifers, the exact soil moisture level that should trigger irrigation isn't known. However, for many other crops, irrigation is typically recommended when available water capacity drops to about 50%.

As indicated, there can be a great deal of variation within a soil type and within a field, so monitoring equipment should be placed in a representative area of the field.

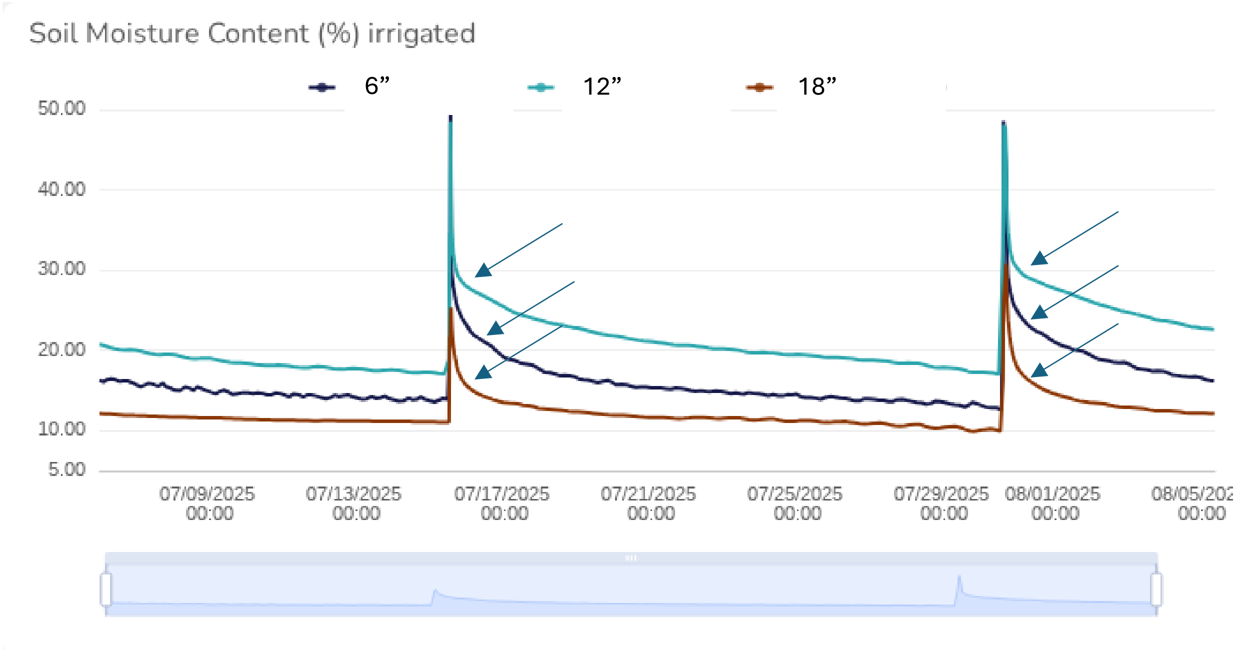
Soil texture	**FC (%)**	**WP (%)**	**AW (%)**
Sand	10	4	6
Loamy sand	16	7	9
Sandy loam	21	9	12
Loam	27	12	15
Silt loam	30	15	15
Sandy clay loam	36	16	20
Sandy clay	32	18	14
Clay loam	29	18	11
Silty clay loam	28	15	13
Silty clay	40	20	20
Clay	40	22	18

The weather station connects with the internet via cell service and is accessible from a website. Selected data shown in the screenshot above is from a plot at WSU Puyallup that has sandy loam soil.

The figure below is from a drip-irrigated plot at WSU Puyallup which contains noble, Fraser, and Nordmann fir seedlings that were planted in a sandy loam soil in 2025. To demonstrate soil saturation, this plot was over-irrigated for a period of 48 hours. The flattened moisture curves indicate that the soil at 6” and 12” was saturated within 3 hours of starting the irrigation. Given that the 18” sensor is located below the root zone, it would normally be recommended to stop irrigating when moisture content at this depth begins to increase (red arrow). When the irrigation is stopped (blue arrow), excess water drains out of the pore spaces in the soil until it reaches field capacity.



The figure below shows changes in the soil moisture content of a plot at Puyallup in sandy loam soil following 3-hour irrigation events on July 15 and 30. Field capacity is reached when the line starts to flatten after an irrigation event (blue arrows).



For more information

Dong, Y., Miller, S., and Kelley, L. 2020. Improving Irrigation Water Use Efficiency: Using Soil Moisture Sensors. Michigan State University Extension Publication E3445. https://www.egr.msu.edu/bae/water/irrigation/sites/default/files/content/E3445_Improving%20Irrigation%20Water%20Use.pdf

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Web soil survey https://websoilsurvey.nrcs.usda.gov/app/

USDA NRCS - Estimating soil moisture by feel and appearance Program Aid Number 1619. nrcs.usda.gov/sites/default/files/2023-01/Estimating-Soil-Moinsture-By-Feel-And-Appearance.pdf