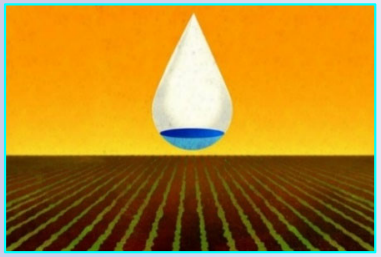

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Methods and Tools for Scheduling Irrigation in Avocado

Avocado Café – September 20, 2022

Understanding Irrigation – Part 4: Irrigation Scheduling

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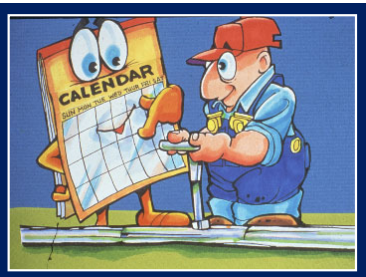
IRRIGATION SCHEDULING



It provides answers to three main questions:

1) When to irrigate our crops? → Before trees face water deficit (or at specific deficit/stress levels that are beneficial for fruit yield & quality)

2) How much water to apply? → The amount of water used by the trees for ET since the last irrigation or rainfall (or a portion of ETc max to maintain a target water stress level for fruit quality)

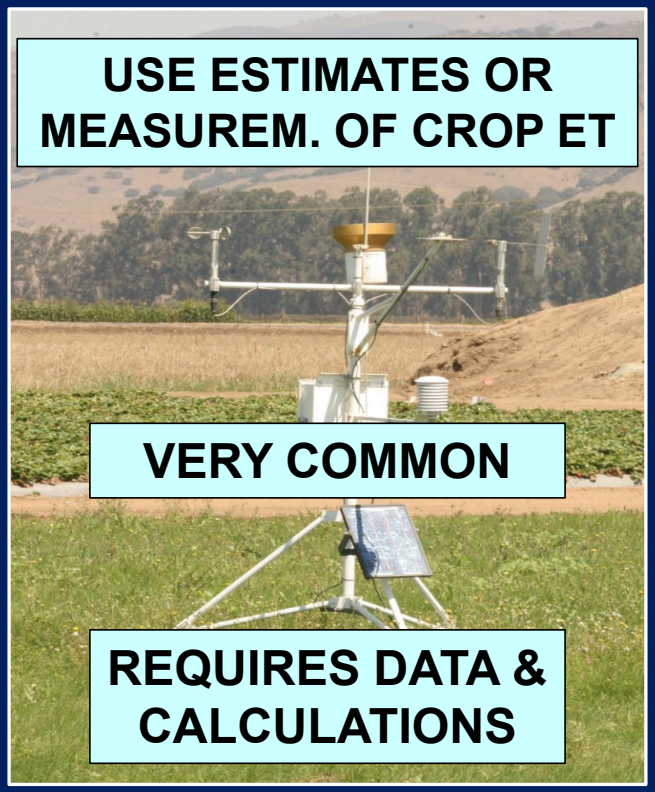
3) How to best apply the necessary amount of water? → Uniformly or Site-specifically

Frequent-light or Infrequent-deep irrigations?

Application rate and volume compatible with the soil infiltration and water holding capacity, **or with energy rates / time-of-use**

METHODS FOR IRRIGATION SCHEDULING

Weather-based



Soil-based

Plant-based

ALL IRRIGATION SCHEDULING METHODS REQUIRE SKILLED ON-FARM PERSONNEL & CAPACITY FOR EXECUTING SCHEDULES AND FOR FAST TROUBLE-SHOOTING

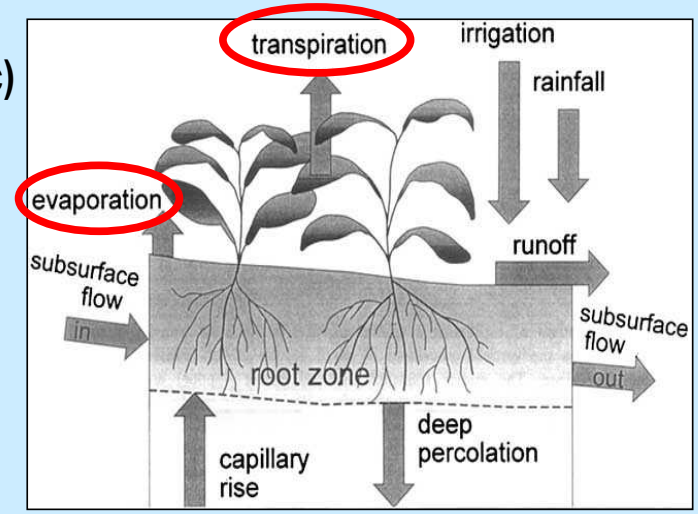
1 – WEATHER- OR ET-BASED SCHEDULING

Basic criterion:

replenish the root zone with the water amount lost by Soil Evaporation (E) and Crop Transpiration (T) => (E + T = ET_C) since the last irrigation/rainfall

Crop water use (ETc) = Reference evapotranspiration (ETo) x Crop coefficient (Kc)

$$ET_C = ET_O \times k_C$$



1) Use historical ET averages [(ET_O x Kc values), or ETc]
2) Use real-time ET_O x Kc values
3) Use ETo forecasts x Kc values

Having accurate Kc values is always crucial

Real-time ETo x Kc

ETc = ETo x Kc

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Forecast For Lat/Lon: 36.4180/-119.0920 (Elev. 472 ft)
Woodlake CA
Forecast Created at: 6pm PDT Aug 13, 2019

Custom Weather Forecast Table

	Tue Aug 13				Wed Aug 14				Thu Aug 15				Fri Aug 16				Sat Aug 17				Sun Aug 18			
Weather																								
Daily-Temp		High **-998** Low **--**				High **104** Low **68**				High **105** Low **70**				High **104** Low **71**				High **97** Low **68**				High **94** Low **63**		
Chance of Precip	--	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Precip		0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"	0.00"
12-hr Snow Total	--		0"		0"		0"		0"		0"		0"		0"		0"		0"		0"		0"	
FRET	-999"				0.24"				0.26"				0.25"				0.23"				0.21"			
Snow Ratio		2	2	2	2	2	1	1	1	2	1	1	1	1	0	0	0	0	0	0	1	1	1	1
6-Hour	5am	11am	5pm	11pm	5am	11am	5pm	11pm	5am	11am	5pm	11pm	5am	11am	5pm	11pm	5am	11am	5pm	11pm	5am	11am	5pm	11p
Temp		89	98	82	71	92	102	84	73	94	103	85	74	94	103	82	70	87	96	76	65	82	93	7
Cloudiness		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	2%	1%	39%	34
Dewpoint		56	50	52	52	53	50	52	52	53	49	52	52	52	49	52	53	54	52	56	55	57	54	5
Relative Humidity		33%	20%	35%	51%	27%	18%	33%	48%	25%	17%	32%	46%	24%	17%	35%	55%	32%	23%	50%	70%	43%	27%	47
Wind		SW 5	W 7	E 2	E 2	SW 5	NW 7	NE 3	E 2	SW 5	NW 8	NE 3	E 2	SW 5	W 7	E 3	E 1	SW 5	W 8	SE 2	S 1	SW 5	W 7	N

DRAWBACKS OF ET-BASED SCHEDULING

ETc estimated with generalized Kc values may be quite different from the actual ET in the site-specific conditions of your orchard (soil, wind, tree density & orientation, slope/aspect)

RISK OF OVER-IRRIGATION OR UNDER-IRRIGATION

Most of the available Kc information was developed in '80s - '90s:

- ✓ Infrequent irrigation methods, such as surface or sprinkler irrigation
- ✓ Well-drained soils, and level (flat) grounds
- ✓ Varieties, rootstocks, plant densities, and canopy management practices that were quite different from the current ones => **LOWER YIELDS** (normal vs. dense planting)

MICRO-IRRIGATION IS A GAME-CHANGER

(SPOON-FEEDS WATER AND NUTRIENTS TO TREES)

Looking only at ET may be limiting for High-value Fruit Production

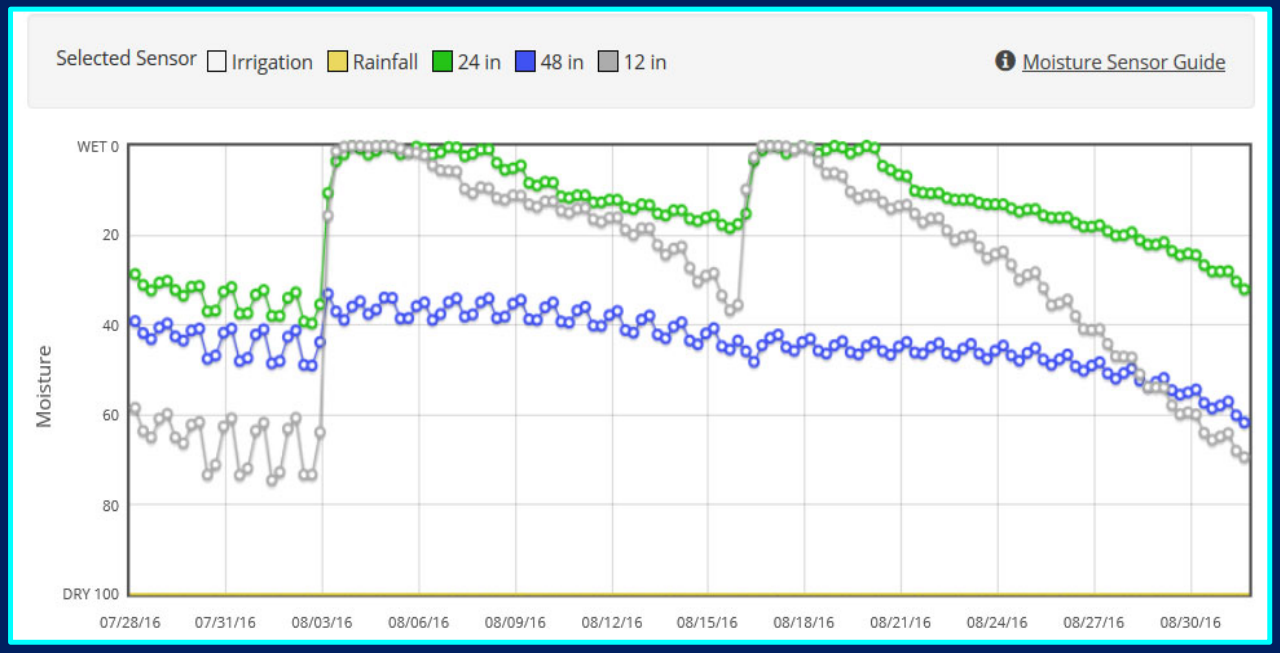
NEED TO LOOK ALSO AT THE SOIL AND TREE WATER STATUS

IRRIGATING BASED ON THE MEASURED ACTUAL CROP WATER USE (ETa)

SAFER AND TAILORED TO SITE-SPECIFIC & MANAGEMENT-SPECIFIC CONDITIONS

2 - SOIL MOISTURE-BASED IRRIGATION SCHEDULING

1. Observe soil moisture frequently or monitor it in continuous mode
2. Start irrigation at target level of soil moisture (management allowable depletion, or allowable negative tension)
3. Stop irrigation when soil moisture reaches target levels (field capacity)



HOW IS SOIL MOISTURE MEASURED?

SOIL MOISTURE CONTENT (%, in/ft, mm/m)

How much water is available per unit of soil?

% weight = (weight of water/weight of dry soil) x 100

% volume = (volume of water/volume of soil) x 100

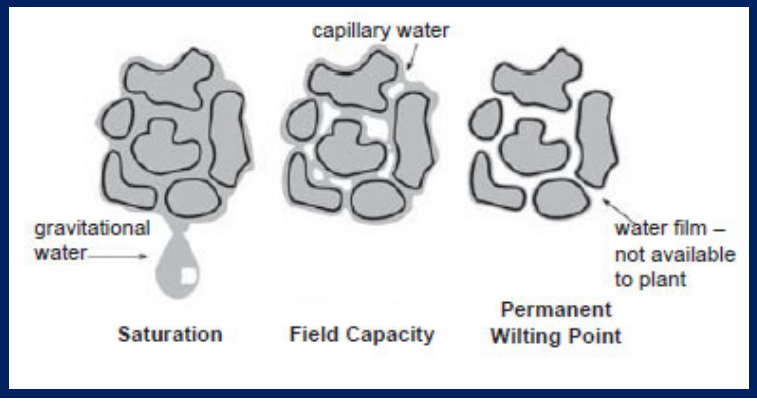
Depth = (inches of water/foot of soil)

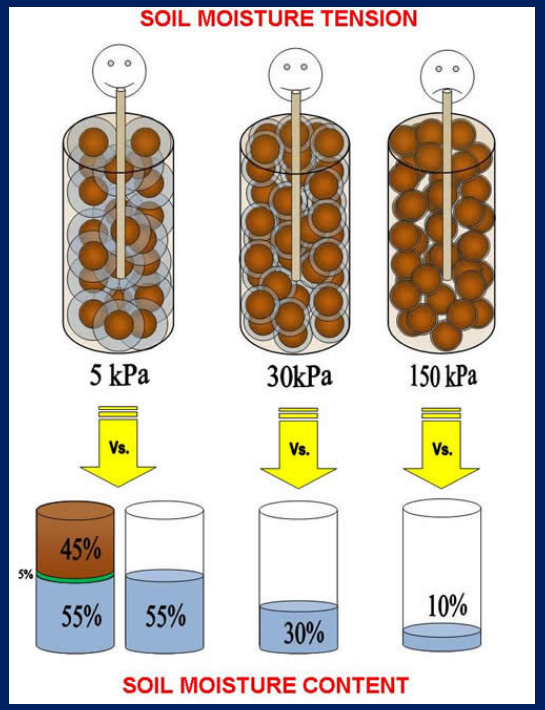
MOST COMMON AND PRACTICAL

SOIL MOISTURE TENSION (centibars, kPa)

How strongly water is held by soil particles

The higher the tension, the drier the soil and the more difficult is for trees to extract water





Challenges of Irrigating Avocado based on Soil Moisture

AVOCADO TREES ARE HEAVY WATER USERS

If properly irrigated, avocado orchards can uptake and use 40-50 ac-in/ac per year

80-90% OF THE FEEDER ROOTS ARE LOCATED IN THE TOP 8-10 INCHES OF SOIL

These fine roots are the primary absorbers of water and nutrients.

AVOCADO ROOTS ARE NOT VERY EFFICIENT IN UPTAKING WATER

Feeder roots have few or no hairs, so they are not able to search for and extract water that is tightly held by soil particles (lower levels of soil moisture). Below -25 kPa, avocado trees roots are unable to remove much water from the soil

AVOCADO HAS LOW TOLERANCE TO SALINITY & HYPOXIA

Extra water to leach salts must be periodically applied with irrigation. Low oxygen impairs root growth

MANY AVOCADO ORCHARDS ARE PLANTED ON STEEP HILLSIDE WITH LOOSE SOILS

Decomposed granite and sandy loam soils have high infiltration but do not store and retain water well.

MODERATE WATER STRESS CAN ONSET EASILY AND GREATLY REDUCE YIELD

Based on work done in South Africa, the current recommendation is that the soil water potential should not exceed -25-30 kPa in a sandy soil and -35 kPa in a clay soil (Kruger, 2011).

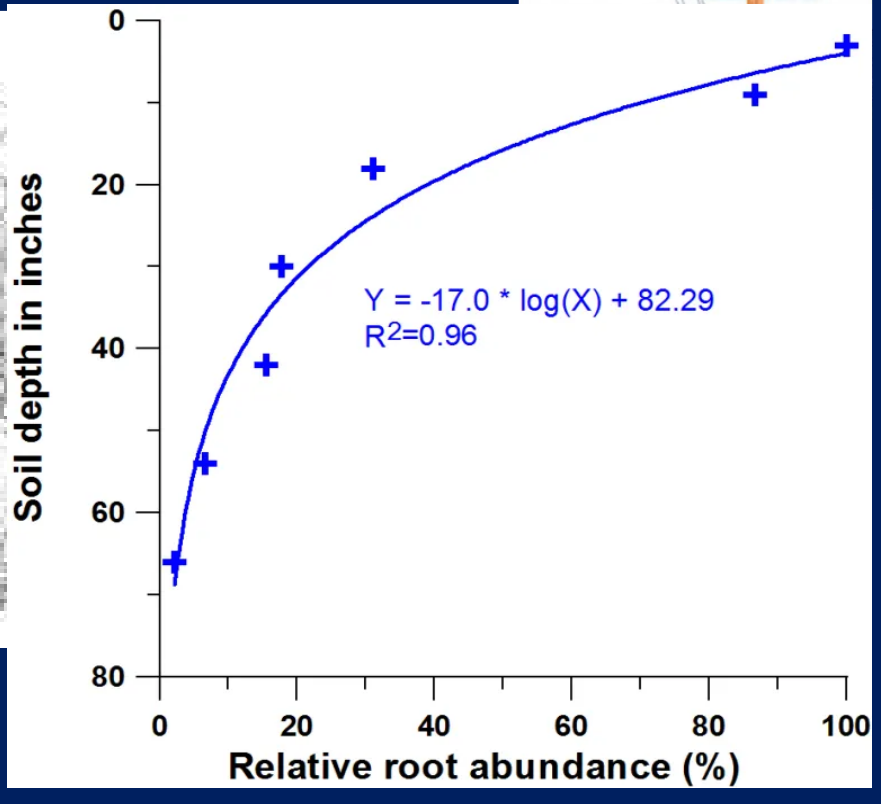
SOIL MOISTURE SENSOR TYPES AND INSTALLATION

Tensiometers and granular matrix sensors measure soil water potential (moisture tension).

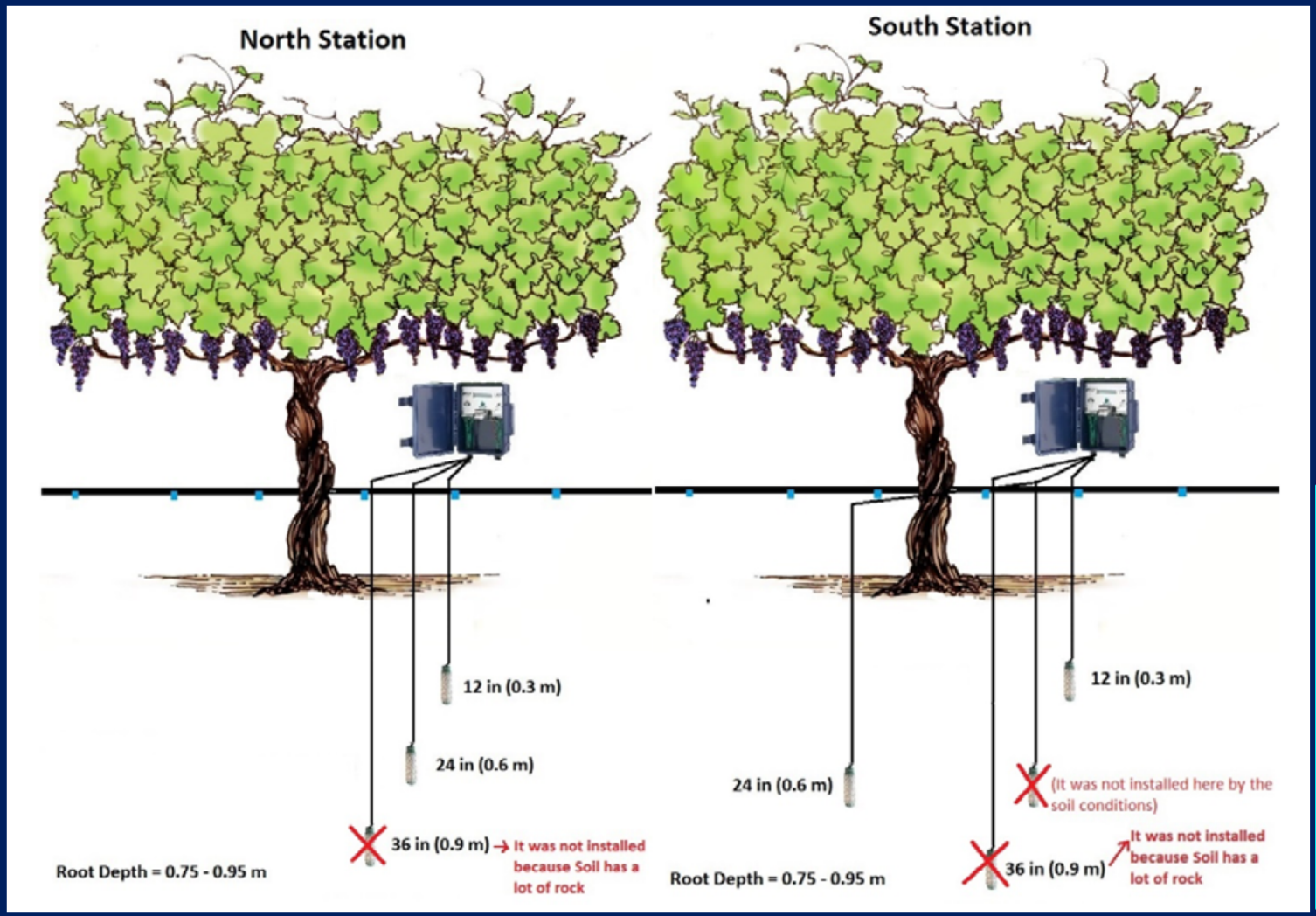
The other sensors “measure” the volumetric water content expressed as volume of liquid water per unit volume of soil

Soil water sensor type	Measured soil volume	Sensitivity to air gaps/loose soil	Sensitivit salinit
Tensiometer	large	high	low
Granular matrix	large	high	medium-l
Capacitance	medium	high	medium-l
TDT	large	medium-low	low
TDR	large	medium-low	low

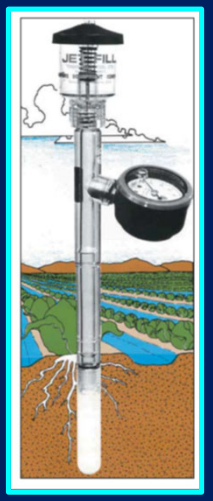
Source: UF - Citrus Research & Education Center



For micro-irrigated avocado, 2-3 sensors installed at adequate depths (8-10 in. & 18-20 in.) are sufficient


North Station
12 in (0.3 m)
24 in (0.6 m)
36 in (0.9 m)
It was not installed because Soil has a lot of rock
Root Depth = 0.75 - 0.95 m
South Station
12 in (0.3 m)
24 in (0.6 m)
(It was not installed here by the soil conditions)
36 in (0.9 m)
It was not installed because Soil has a lot of rock
Root Depth = 0.75 - 0.95 m


TRELLIS



Irrigation frequency is important for Avocado. In coarse-textured & well drained soils, daily light applications using drip or micro-sprinklers are appropriate. In heavier-textured soil that could suffer anaerobic conditions, irrigating every 2-3 days is desirable.

Research conducted in Chile showed that allowing 50-60% of soil water depletion between irrigations did not affect yield and fruit size relative to more frequent water applications. However, soil moisture depletion of 25-30% are adequate for most soils to maintain good water & oxygen supply.

Soil Texture	Soil Moisture Content (%)
Sand	7
Loamy Sand	12
Sandy Loam	15
Loam	20
Silt Loam	23
Silty Clay Loam	28
Clay Loam	27
Sandy Clay Loam	24
Sandy Clay	22
Silty Clay	30
Clay	31

Soil moisture content at which irrigation should occur (@ 50% of PAW depleted)

Recommended values of soil moisture tension at which irrigation should occur (50% of PAW)

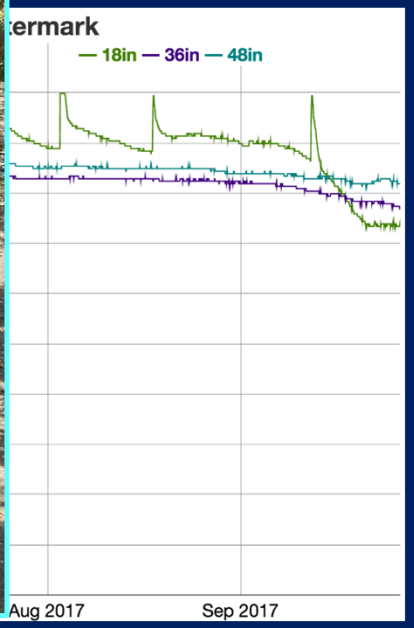
Soil Type	Soil Moisture Tension (centibars)
Sand or loamy sand	40-50
Sandy loam	50-70
Loam	60-90
Clay loam or clay	90-120

BENEFITS OF SCHEDULING IRRIGATION BASED ON SOIL MOISTURE

Suitable for irrigation of young trees and immature stands	→	Promote fast canopy development and onset of fruit production
Help achieve adequate/wider root growth	→	Buffer for heat waves and drought
Avoid excess irrigation (over-watering), hypoxia, nutrient leaching	→	Avoid favorable conditions to some pest and fungal diseases

DRAWBACKS OF SM-BASED SCHEDULING

Monitoring Soil Water Status only gives an indirect estimate of Plant Water Status



Plants may face water stress even under well-watered soil conditions (salinity/sodicity, hypoxia, hard pans/compaction layers)

Soil-water infiltration problems => top soil is somehow wet, but the deeper soil layers are dry

WITH MICRO-IRRIGATION THERE MAY BE SOME PREFERENTIAL WATER FLOW AND NON-HOMOGENEOUS SOIL MOISTURE

S.M. CAN BE USED AS FEEDBACK INFORMATION AFTER IRRIGATIONS

NEED TO LOOK ALSO AT THE TREE WATER STATUS IN ADDITION TO THE AVAILABLE SOIL MOISTURE

Methods to Monitor Tree Water Status (and Stress)

Leaf/Stem Water Potential

Sap Flow

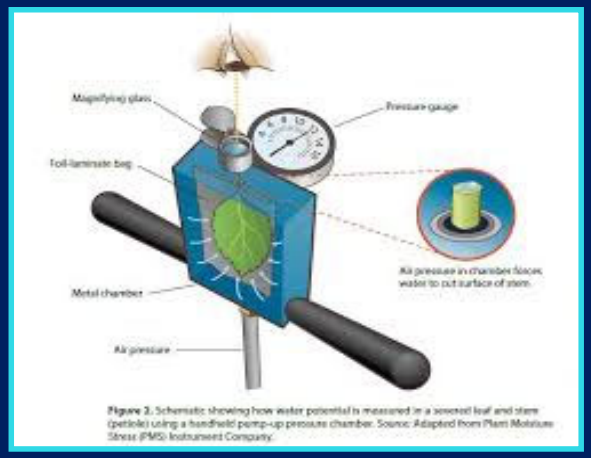
Canopy Temperature

Pressure Chamber to Measure Leaf/Stem Water Potential

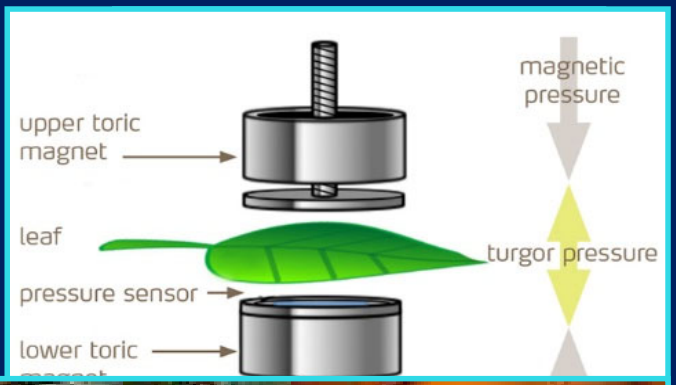
- ✓ Pressure bombs consist of a chamber that can be brought to different pressures using nitrogen gas or air.
- ✓ The petiole of a leaf protrudes from the chamber so that one can see when water bubbles from the end.
- ✓ By slowly stepping up the pressure in the chamber one can determine the water potential in the leaf.
- ✓ The higher pressure, the more the tree is water stressed.

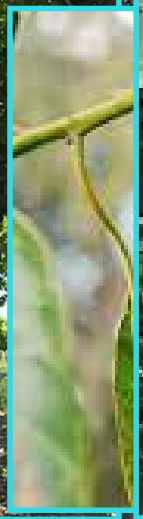
Stem Water Potential Threshold Values (FAO I&D Handbook No. 66, 2012)

- ✓ Midday SWP above **-0.3 : -0.5 MPa** indicate the absence of water stress during flowering and fruit-set of avocado
- ✓ Well watered trees have **-0.5 : - 0.6 MPa** on a typical summer day with **ETo ~ 0.25 - 0.30 in.**
- ✓ SWP values between **-0.6 and -1.0 MPa** are indicative of mild to moderate stress
- ✓ More severe water deficits are indicated by SWP below **-1.0 MPa**, reaching **-1.5 : -2.0 MPa**



Dendrometers and Other Plant Sensors





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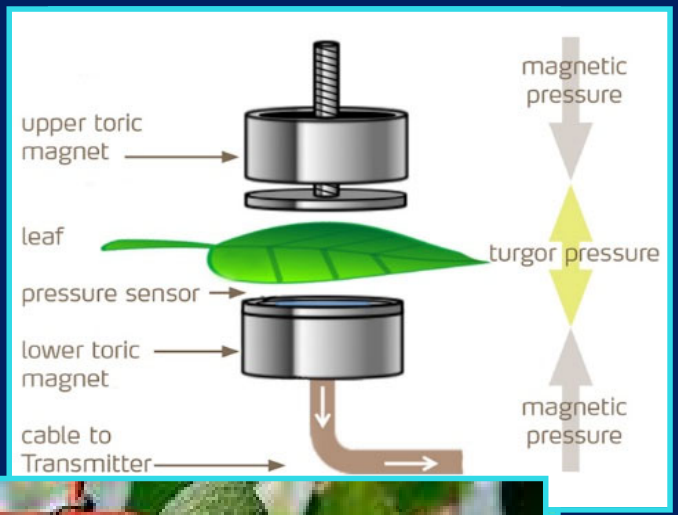

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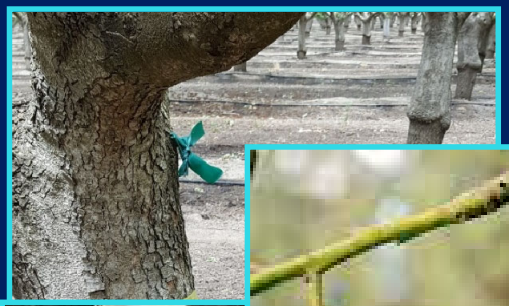
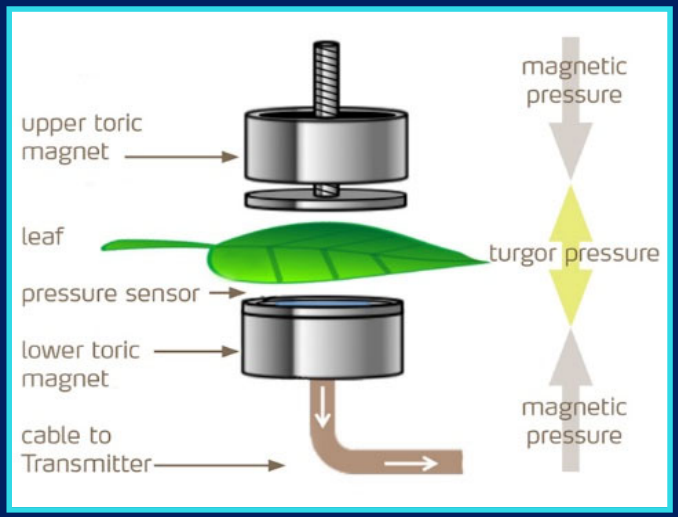
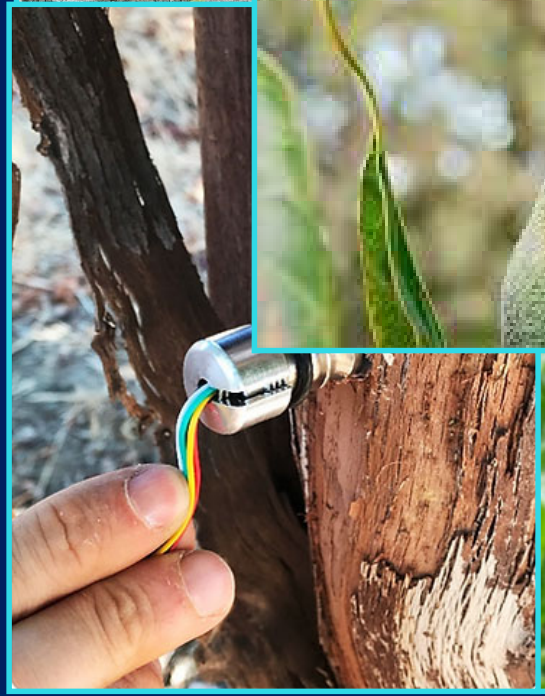






Deficit Irrigation Strategies in Avocado

All experimental evidence so far indicate that Regulated Deficit Irrigation (RDI) is not a recommendable practice for irrigation of Avocado, because of the high sensitivity of commercial yields to water deficits (and resulting salinity build up) during most of the irrigation season.

Alongside, excess irrigation is highly detrimental, given the sensitivity to waterlogging, hypoxia, and high risk of fungal disease infection.

The best irrigation practices for Avocado should be based on supplying ETc at optimal intervals to prevent both tree water deficits and supply adequate oxygen to the root system.

COMBINATIONS OF DIFFERENT APPROACHES

Plant-based
(Monitoring plant water status)

→ **Proper Irrigation Timing**

↓

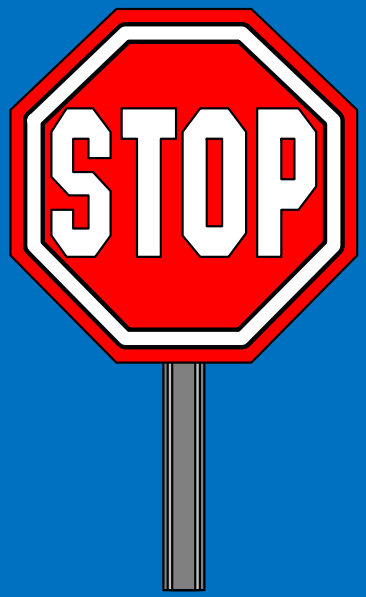
Weather-based
(Estimating the crop water use)

→ **Adequate Irrigation Amount**

↓

Soil-based
(Monitoring soil moisture)

→ **Check for Feedback**


STOP

S.M.M. HELPS ANSWERING THE FOLLOWING QUESTIONS

✓When to start irrigation, and when to stop it?

✓Has enough water infiltrated the root zone during an irrigation?

✓Are we applying enough, insufficient, or excessive water?

✓Is there any deep soil water reserve for crop water uptake during periods of no irrigation, or at start of vegetative growth, **during heat waves**, or during harvest under drought?