Orchard Irrigation Principles

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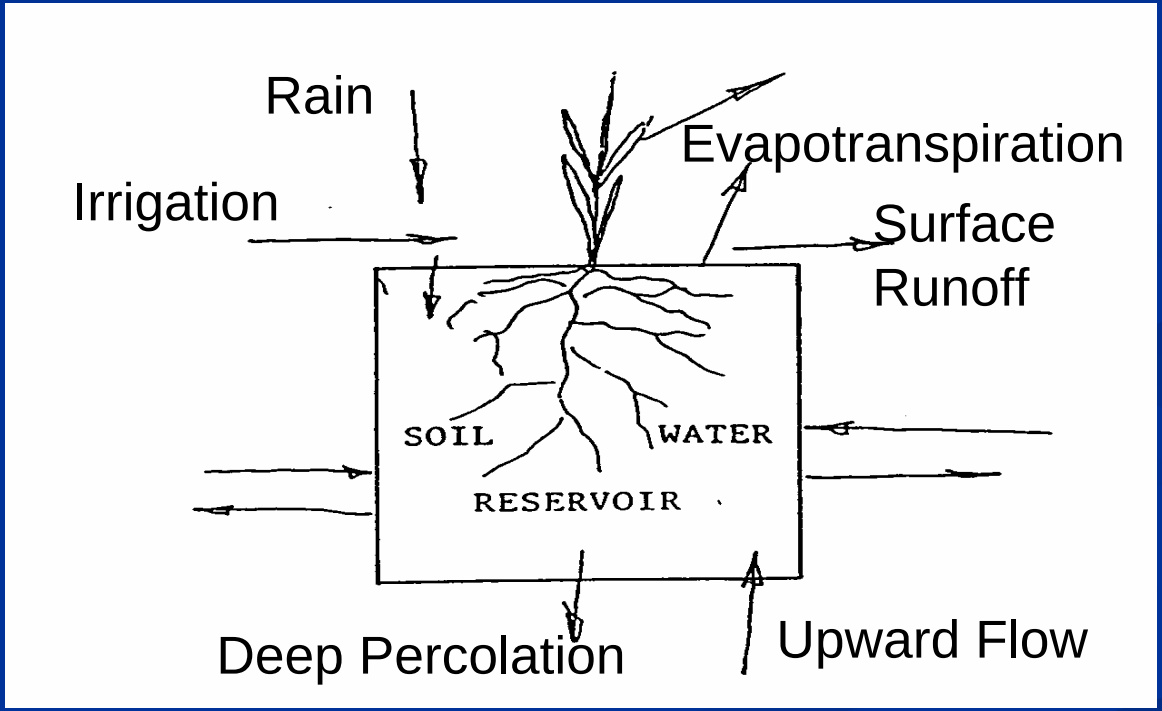
Introduction

- Proper orchard irrigation is critical to
  - Long-term plant survival and health
  - Efficient cropping
  - Maximizing fruit size and quality
- Over irrigation
  - Slows root development
  - Increases incidence of root and collar rots
  - Leaches soluble nutrients (N, S, B) out of the root zone
  - Reduces uptake of Ca and P
  - Induces excessive vegetative growth
- Under irrigation
  - Smaller fruit size
  - Less typy fruit
  - Bitter pit in apple
  - Shorter fruit storage life

The Budget Analogy

- Bank balance = Available soil water
- Income = Irrigation + Rainfall
- Expenses = Evaporation + Transpiration

Where is the water going?



The Budget Analogy

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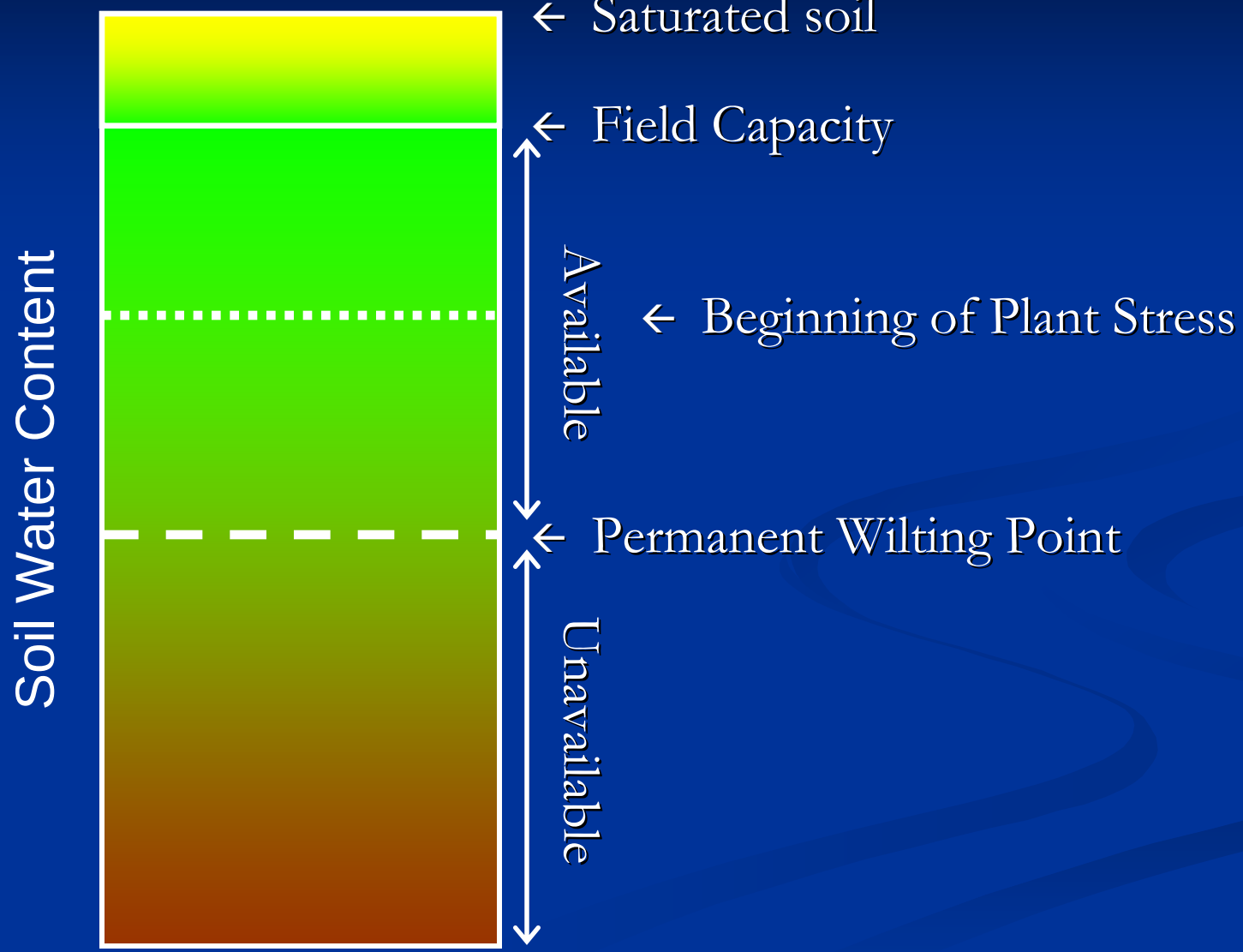
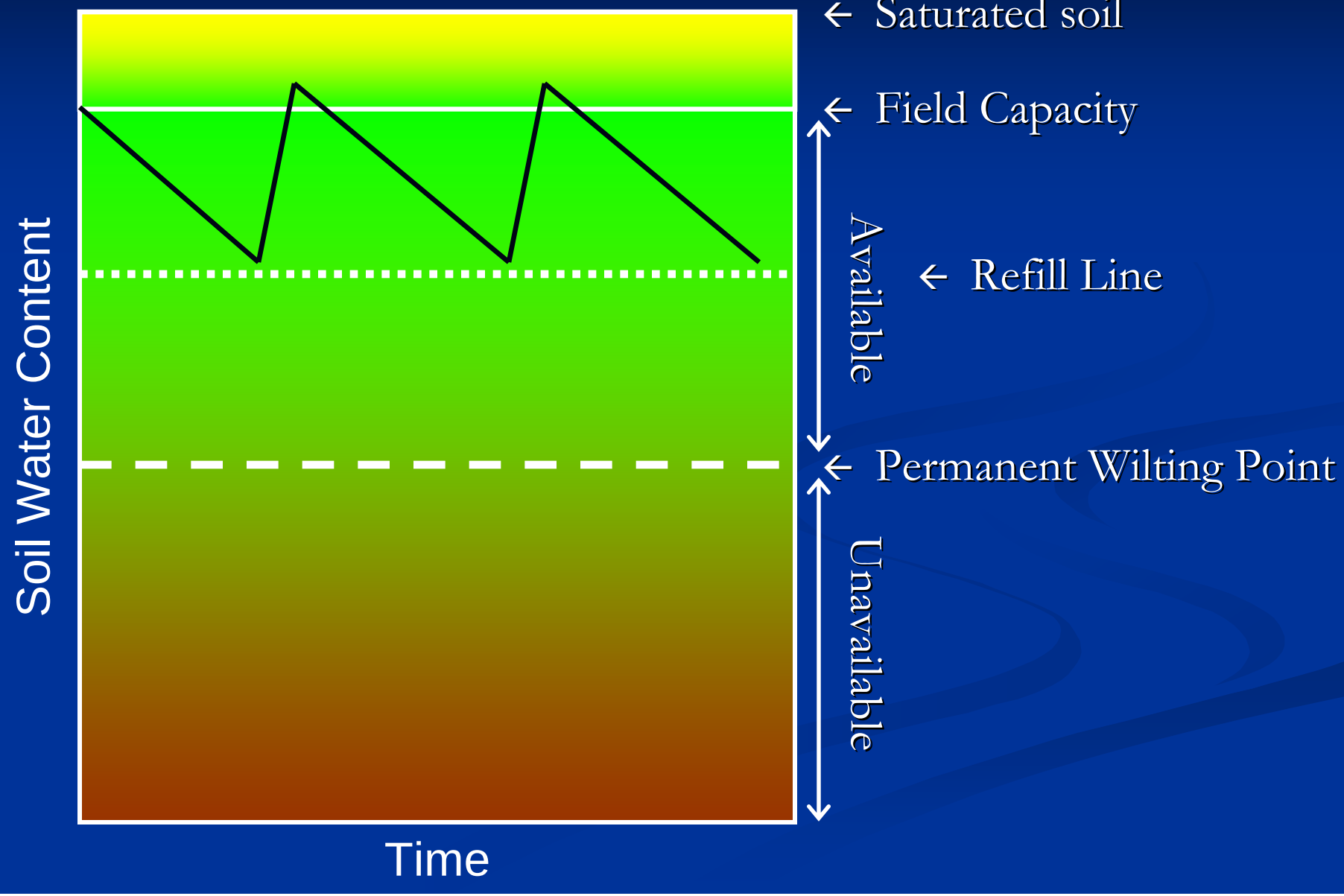
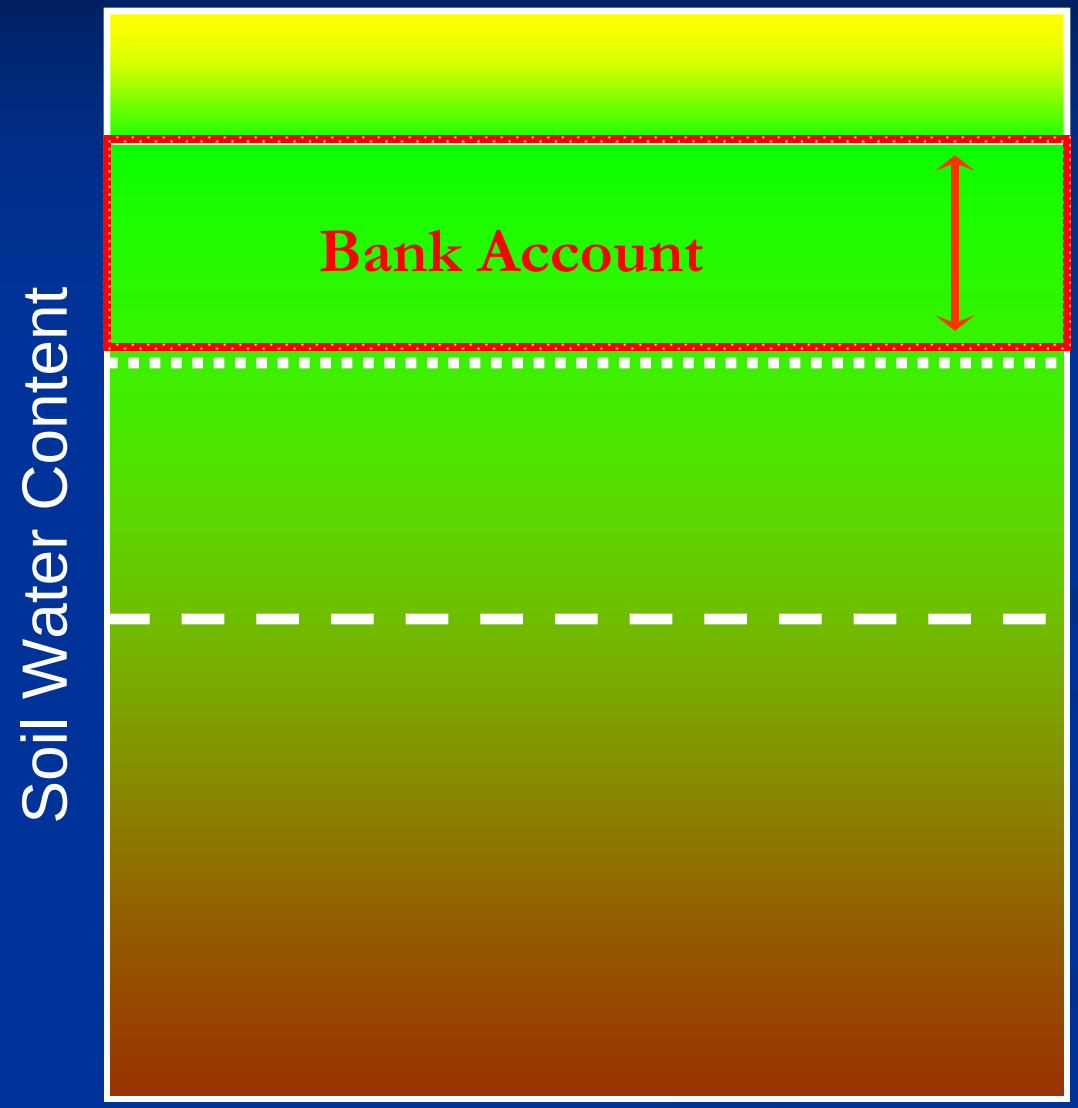
Soil Water Content



Soil Water Content



Soil Water Content



← Field Capacity

Available

← Refill line

Water holding capacity

- Rooting depth
- Soil type

Rooting depth

Orchard specific, depending on:

- Soil conditions
  - Soil type
  - Topsoil depth
  - Rocks
  - Hard pan
  - Clay layer
- Tree age
- Cultivar and rootstock
- Climate (soil temperature)

- For our climate and soils
  - 3 to 4 feet on vigorous rootstocks
  - 2.5 to 3 feet for dwarfing rootstocks.

Water holding capacity

	Available inch/foot
Sands and fine sands	0.5 - 0.75
V. fine sand, loamy sand	0.8 - 1.0
Sandy loam	1.2 - 1.5
Loam	1.9 - 2.0
Silt loam, silt	2.0
Silty clay loam	1.9 - 2.0
Sandy clay loam, clay loam	1.7 - 2.0

Water holding capacity

	Available	Readily available
	inch/foot	inch/foot
Sands and fine sands	0.5 - 0.75	0.25 - 0.38
V. fine sand, loamy sand	0.8 - 1.0	0.4 - 0.5
Sandy loam	1.2 - 1.5	0.6 - 0.75
Loam	1.9 - 2.0	0.9 - 1.0
Silt loam, silt	2.0	1.0
Silty clay loam	1.9 - 2.0	0.9 - 1.0
Sandy clay loam, clay loam	1.7 - 2.0	0.85 - 1.0

Water holding capacity

	Available	Readily available		
	inch/foot	inch/foot	2.5'	4'
Sands and fine sands	0.5 - 0.75	0.25 - 0.38	0.6 - 0.9	1.0 - 1.5
V. fine sand, loamy sand	0.8 - 1.0	0.4 - 0.5	1.0 - 1.25	1.6 - 2
Sandy loam	1.2 - 1.5	0.6 - 0.75	1.5 - 1.9	2.4 - 3.0
Loam	1.9 - 2.0	0.9 - 1.0	2.4 - 2.5	3.8 - 4.0
Silt loam, silt	2.0	1.0	2.5	4.0
Silty clay loam	1.9 - 2.0	0.9 - 1.0	2.4 - 2.5	3.8 - 4.0
Sandy clay loam, clay loam	1.7 - 2.0	0.85 - 1.0	2.1 - 2.5	3.4 - 4.0

Determining Soil Moisture: Where to measure?

- Monitoring depths
  - 10 – 12”
  - 2/3 of the rooting depth (typically 30”)

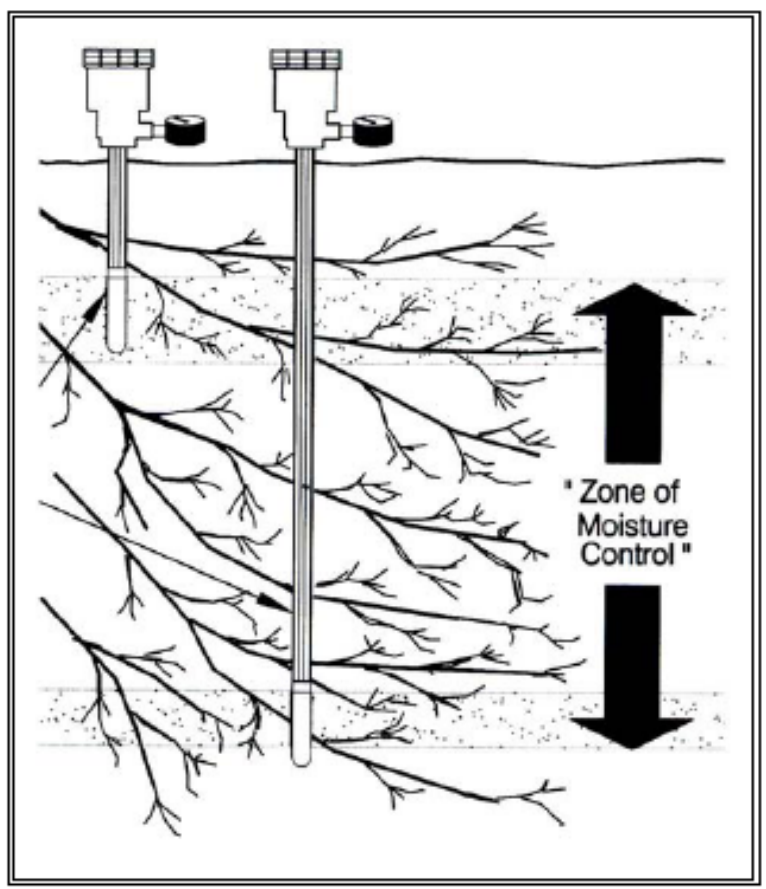


Figure 5 Soil Moisture Measuring

Determining Soil Moisture: How to measure?

- Hand feel
- Tensiometer
- Resistance block
- Capacitance probe
- Reflectance
- Neutron probe

Low tech – Low cost



High tech – High cost

Determining Soil Moisture: Hand Feel

Table 1	Soil Moisture, Appearance and Description Chart			
Available water *	**Feel or appearance of soil ▲**			
	Sand	**Sandy loam**	**Loam/Silt loam**	**Clay loam/Clay**
Above field capacity	Free water appears when soil is bounced in hand.	Free water is released with kneading.	Free water can be squeezed out.	Puddles; free water forms on surface.
100% (field capacity)	Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand. (1.0)	Appears very dark. Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand. Makes short ribbon. (1.5)	Appears very dark. Upon squeezing, free water appears on soil, but wet outline of ball is left on hand. Will ribbon about 1 inch. (2.0)	Appears very dark. Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand. Will ribbon about 2 inches. (2.5)
75-100%	Tends to stick together slightly, sometimes forms a weak ball with pressure. (0.8 to 1.0)	Quite dark. Forms weak ball, breaks easily. Will not slick. (1.2 to 1.5)	Dark color. Forms a ball, is very pliable, slicks readily if high in clay. (1.5 to 2.0)	Dark color. Easily ribbons out between fingers, has slick feeling. (1.9 to 2.5)
50-75%	Appears to be dry, will not form a ball with pressure. (0.5 to 0.8)	Fairly dark. Tends to ball with pressure but seldom holds together. (0.8 to 1.2)	Fairly dark. Forms a ball, somewhat plastic, will sometimes slick slightly with pressure. (1.0 to 1.5)	Fairly dark. Forms a ball, ribbons out between thumb and forefinger. (1.2 to 1.9)
25-50%	Appears to be dry, will not form a ball with pressure. (0.2 to 0.5)	Light colored. Appears to be dry, will not forma ball. (0.4 to 0.8)	Light colored. Somewhat crumbly, but holds together with pressure. (0.5 to 1.0)	Slightly dark. Somewhat pliable, will ball under pressure. (0.6 to 1.2)
0-25%	Dry, loose, single-grained, flows through fingers. (0 to 0.2)	Very slight color. Dry loose, flows through fingers. (0 to 0.4)	Slight color. Powdery, dry sometimes slightly crusted, but easily broken down into powdery condition. (0 to 0.5)	Slight color. Hard, baked, cracked, sometimes has loose crumbs on surface. (0 to 0.6)

Soil Water by Feel

Fine sand and loamy fine sand soils





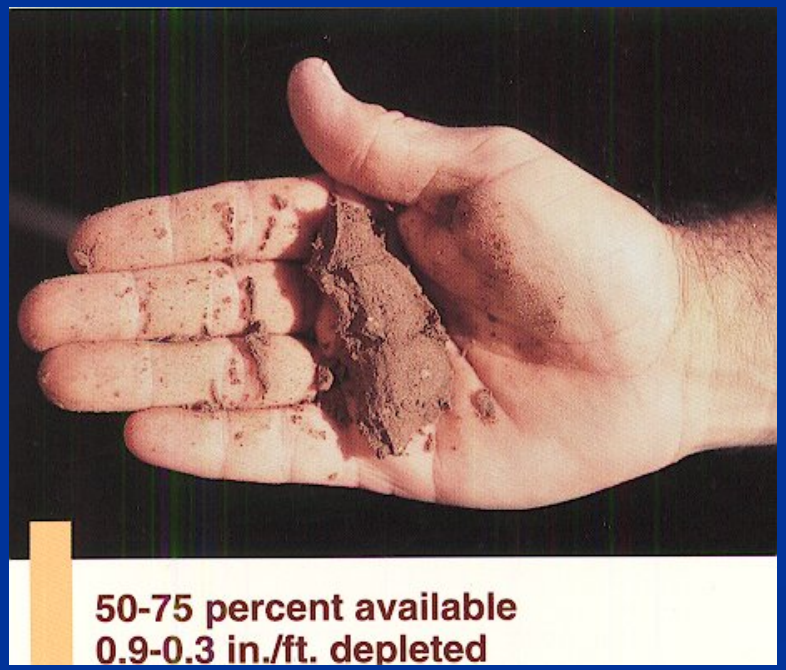


Soil Water by Feel

Sandy loam and Fine sandy loam soils



25-50 percent available
1.3-0.7 in./ft. depleted



50-75 percent available
0.9-0.3 in./ft. depleted



75-100 percent available
0.4-0.0 in./ft. depleted

Soil Water by Feel

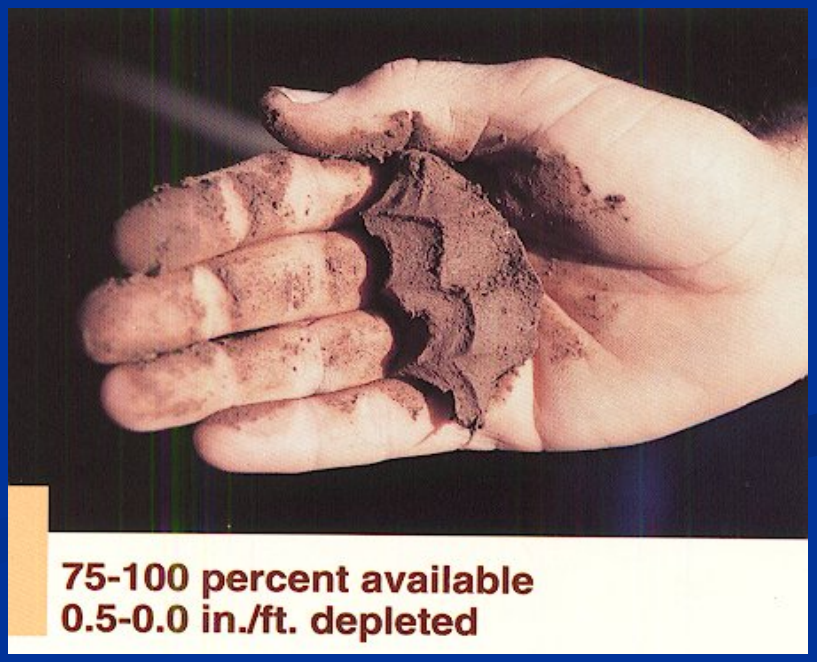
Sandy clay loam, loam, and Silt loam soils



25-50 percent available
1.6-0.8 in./ft. depleted



50-75 percent available
1.1-0.4 in./ft. depleted



75-100 percent available
0.5-0.0 in./ft. depleted

Soil Water by Feel

Clay,
Clay loam, and
Silty clay loam soils



25-50 percent available
1.8-0.8 in./ft. depleted



50-75 percent available
1.2-0.4 in./ft. depleted

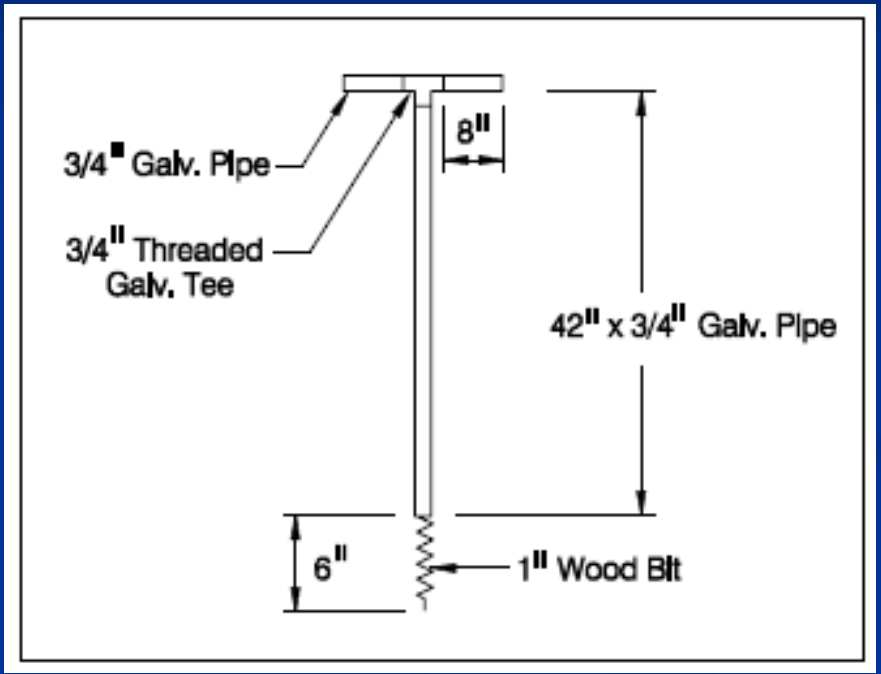


75-100 percent available
0.6-0.0 in./ft. depleted

Determining Soil Moisture: Hand Feel

- Monitoring to 30”?

- Advantages
  - Cost ($20 auger)
- Disadvantages
  - Time
  - Accuracy
  - Difficulty in rocky soils



Determining Soil Moisture: Systems

- Units
  - Soil Matric Potential (tension or suction)

    Low number = more water

    Indicates how hard a plant has to "pull" to get water
  - Volumetric Water Content

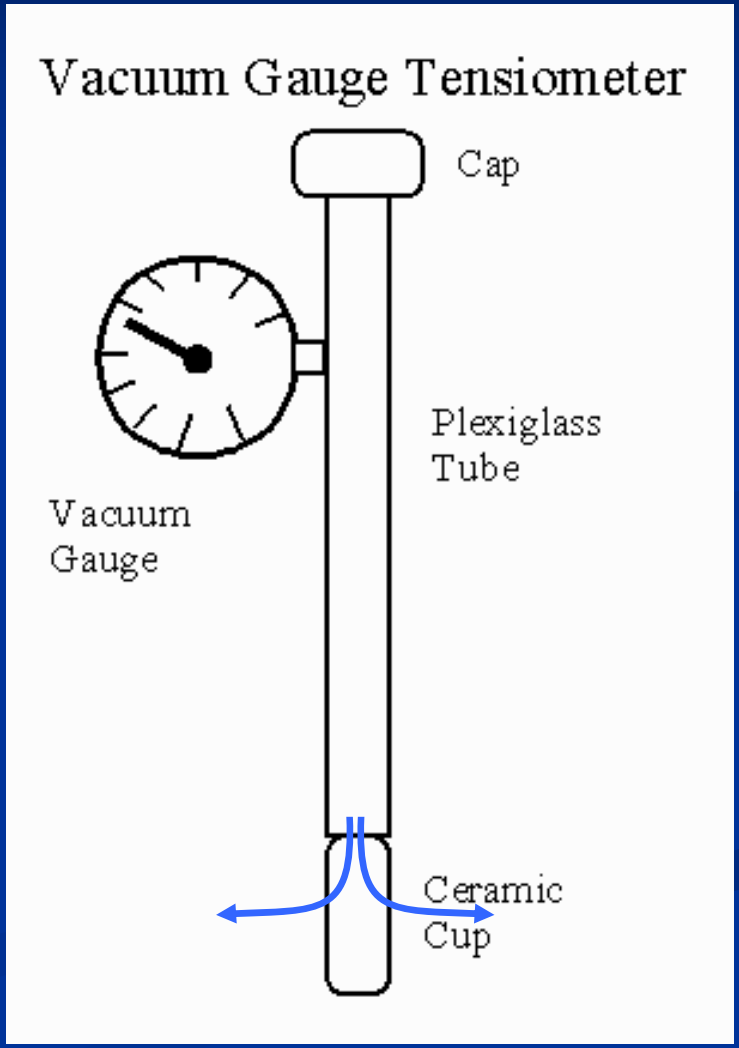
    Indicates the amount of water needed to recharge the soil
- Permanent installation vs. Access Tubes

Determining Soil Moisture: Tensiometer

- Soil matric potential

  (tension or suction)
- Units = Centibars
  - Range 0 to 75 centibars

  Low number = more water



Determining Soil Moisture: Tensiometer

Considerations

- Indicates what the plant roots are doing
- Cost
  - Analog pressure gauge - $65 to $80
  - Electronic pressure gauge $500 -$800
- Installation
  - No air bubbles
  - Needs good tip - soil contact
- Reinstall each year (can't be frozen)
- Interpretation and effectiveness vary with soil type

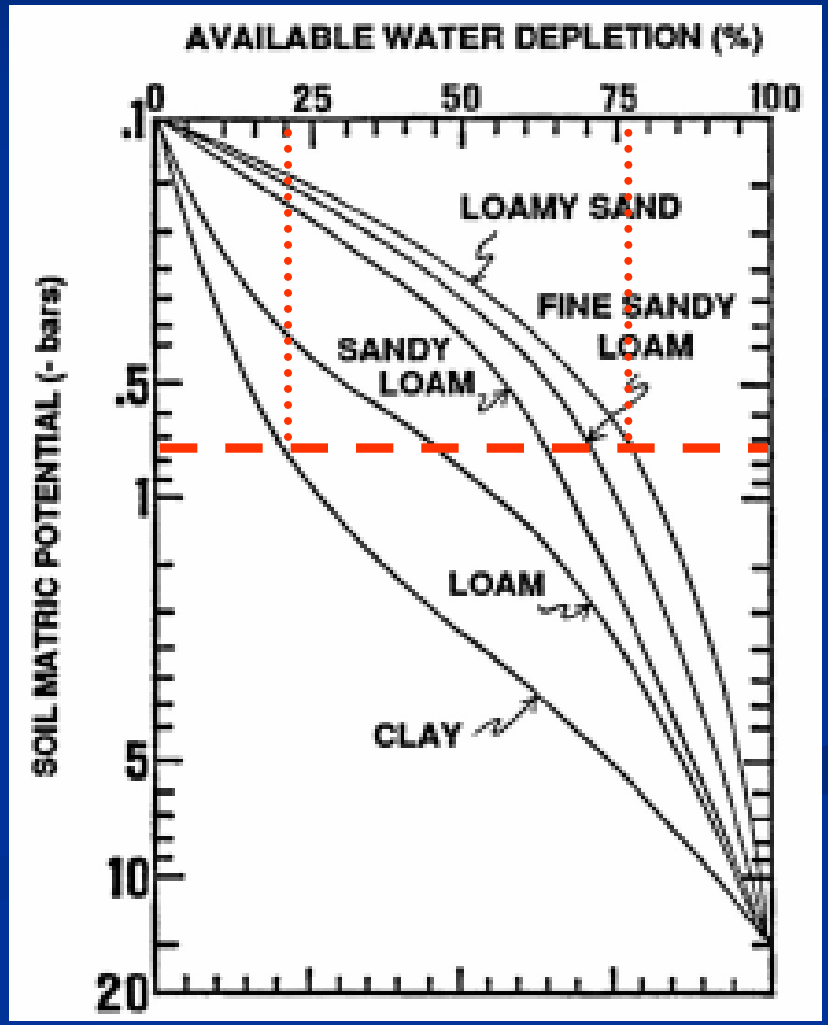




Determining Soil Moisture: Tensiometer

Tensiometer readings in different soils

- Field capacity
  - Course soils = 10
  - Fine soils = 30
- Maximum readings (75)
  - Fine soil 20% depleted
  - Course soil 75% depleted



Determining Soil Moisture: Electrical resistance blocks

- Electrical conductivity

  Low number (resistance) = more water
- Units = Centibars
  - Range 40 to 200 centibars
- Price:
  - Sensors: $30 to $35 each
  - Meter: $280
- Readings vary by soil type
  - Require good soil contact
  - Salinity artificially elevates readings

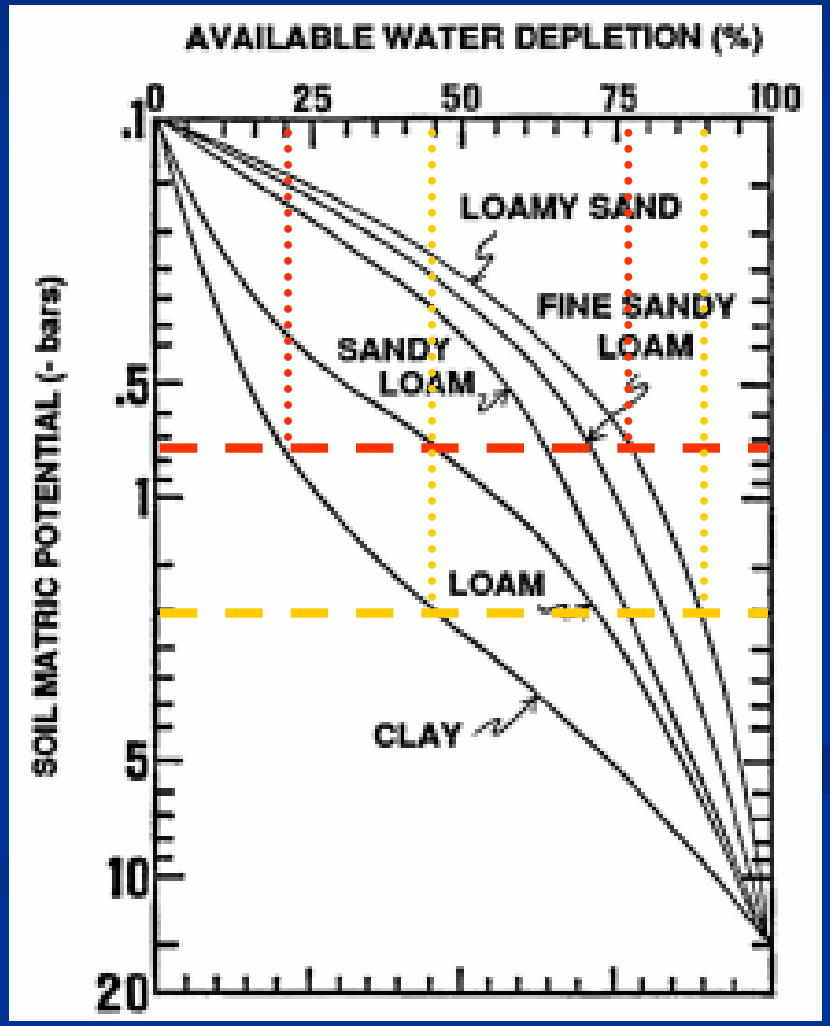




Determining Soil Moisture: Resistance Block

Resistance block readings in different soils

- Field capacity
  - Course soils = 10
  - Fine soils = 30
- Maximum readings (200)
  - Fine soil 45% depleted
  - Course soil 90% depleted



Determining Soil Moisture: Electrical resistance blocks

Considerations

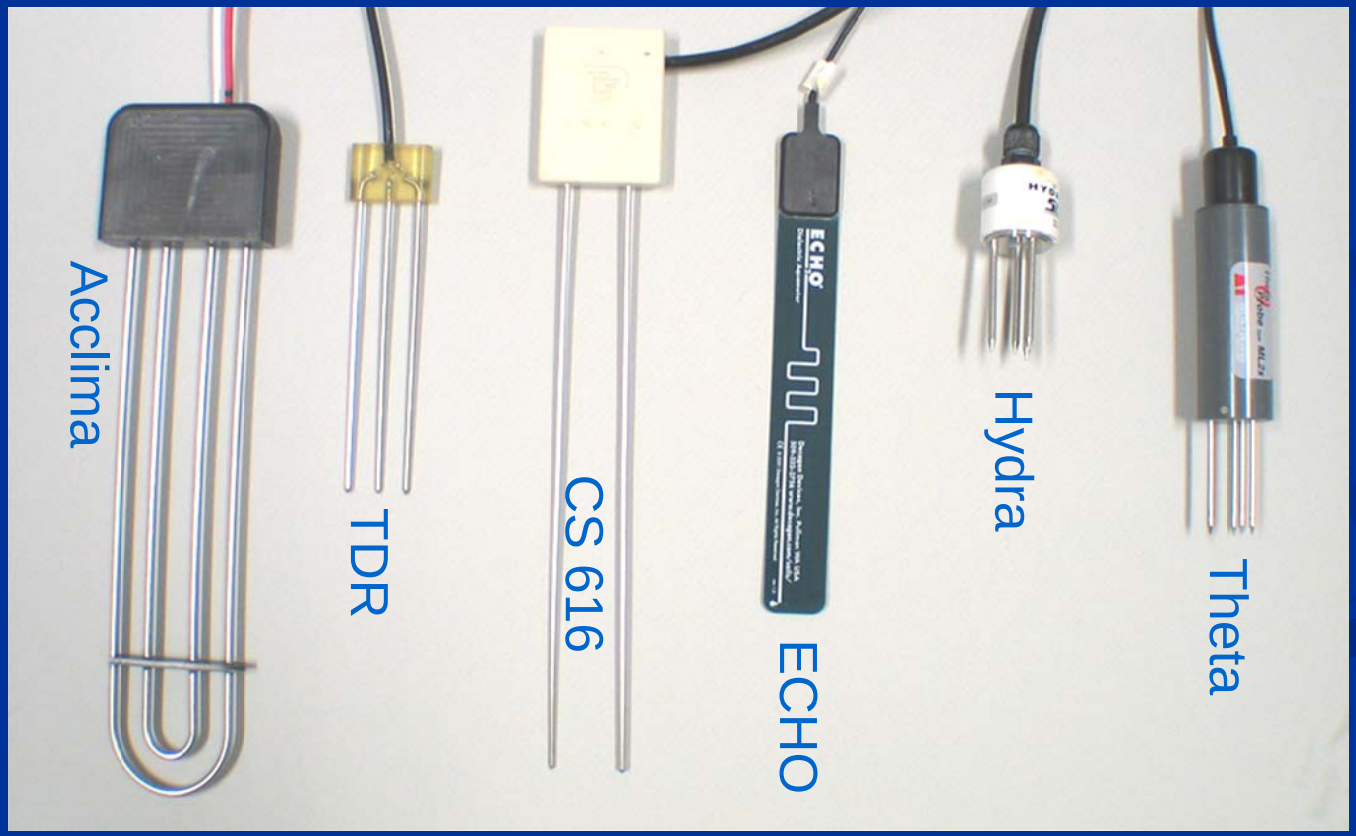
- Readings vary by soil type
  - Require good soil contact
  - Salinity artificially elevates readings
- Slow response time
  - Less reliable in very sandy soils
- Resists rewetting if excessively dry



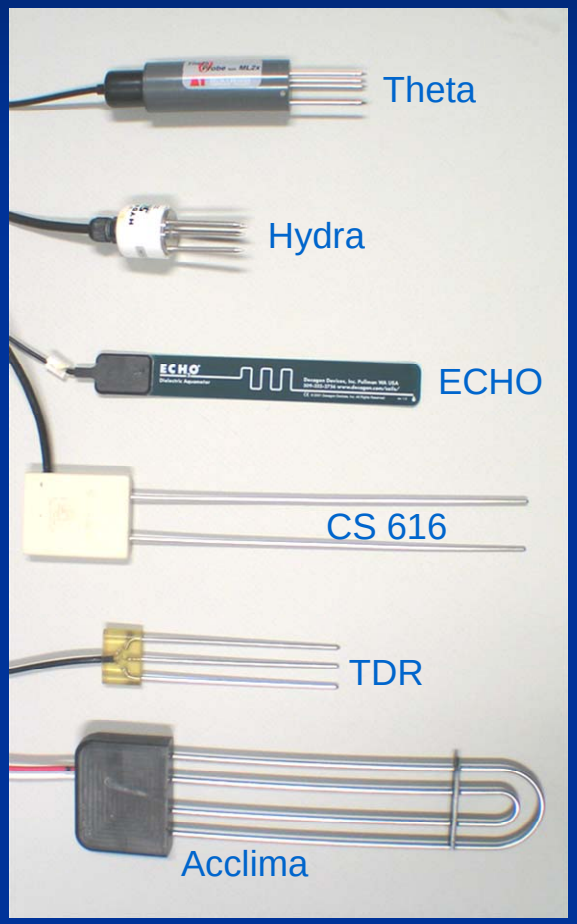


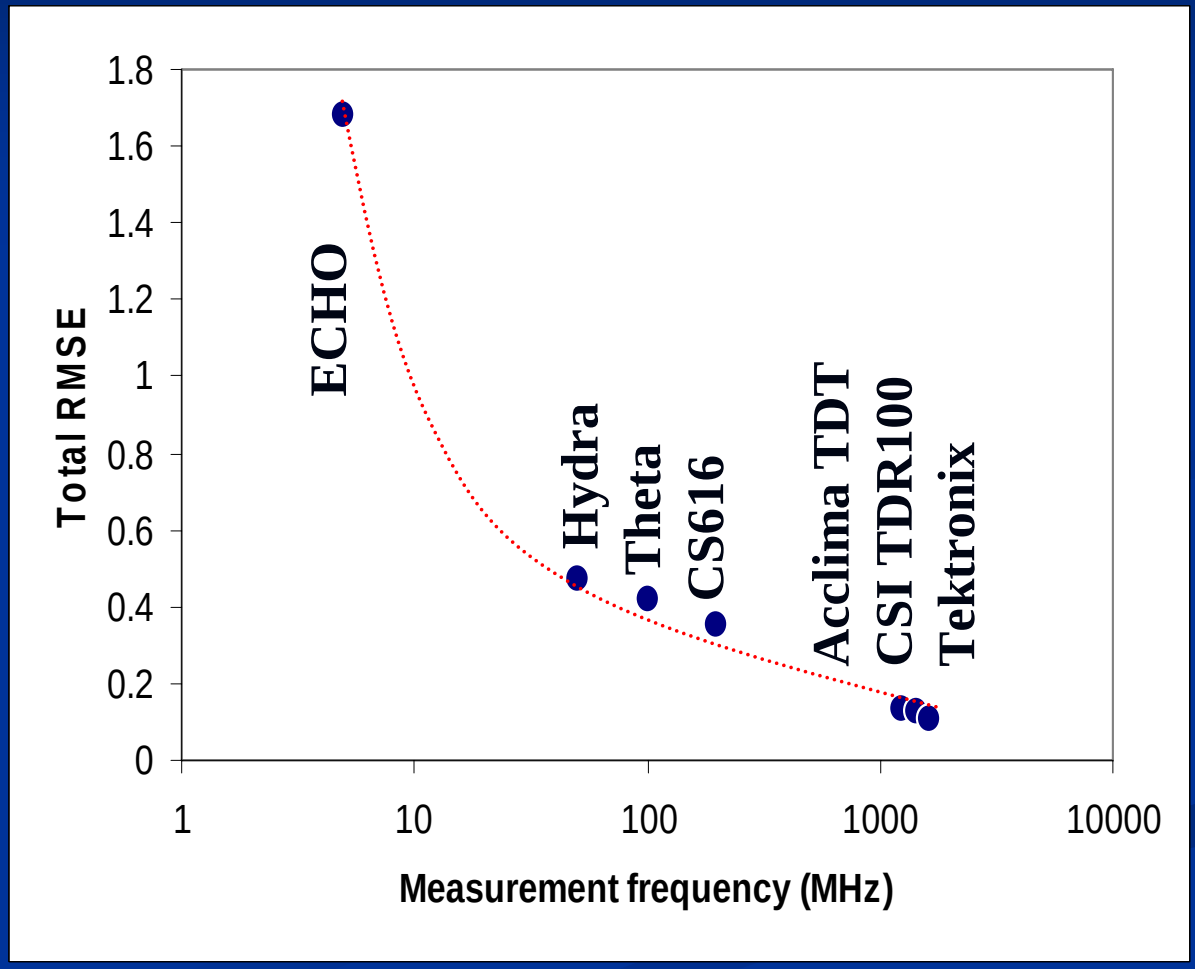
Determining Soil Moisture: Electromagnetic Probes

- Measure volumetric water content



Electromagnetic Sensors





Blonquist et al., 2005, VZJ

EM Sensor Cost Estimates

	Tektronix TDR	CSI TDR100	Acclima TDT	CS616	Hydra Probe	Theta Probe	ECH_2O Probe
ΣRMSE	0.1092	0.1290	0.1323	0.3526	0.4694	0.4192	1.681
Sensor Cost [$]	11,765	3,720	349	175	324	460	100
Logger Cost [$]	--	1,250	2,580	750	750	750	750
Total Cost [$]	11,765	4,970	2,929	925	1074	1210	850

Determining Soil Moisture: Volumetric water – Sentek

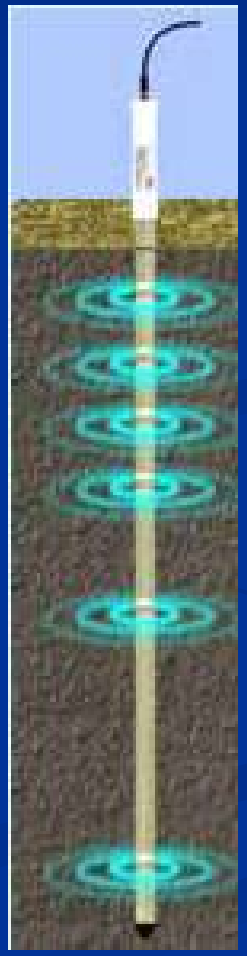
- Requires access tube
- Measures volumetric water
  - Capacitance of magnetic field
  - Measures very close to the tube
  - Tube installation is critical
  - Lengths of 3 and 4.5 feet
- Price:
  - Probe $2,600 - $2,700
  - Access tubes $54 - $59





Determining Soil Moisture: Volumetric water

- Requires access tube
- Measures volumetric water
  - Freq. domain response (FDR)
  - Measures very close to the tube
  - Tube installation is critical
  - Length of 3 feet
- Price:
  - Probe $1500-1700
  - Meter $700
  - Access tubes $55 - $65





Which is best?

- For cost and simplicity, most recommend the resistance block approach.



- We are also testing an electro magnetic system in conjunction with the orchard weather stations.



The Budget Analogy

- Bank balance = Available soil water
- Income = Irrigation + Rainfall
- Expenses = Evaporation + Transpiration

Irrigation inputs

- Need to apply enough to recharge the full rooting depth to field capacity
- Efficiency = How little water is lost in getting the driest spot in the field properly irrigated
  - Unequal coverage
  - Excess water percolating out of the root zone in over-watered areas
  - Evaporation
- Typical efficiencies
  - Flood/Furrow - 30 to 50%
  - Overhead sprinkler - 60 to 75%
  - Microsprinkler/Drip - 70 to 90%

Irrigation inputs

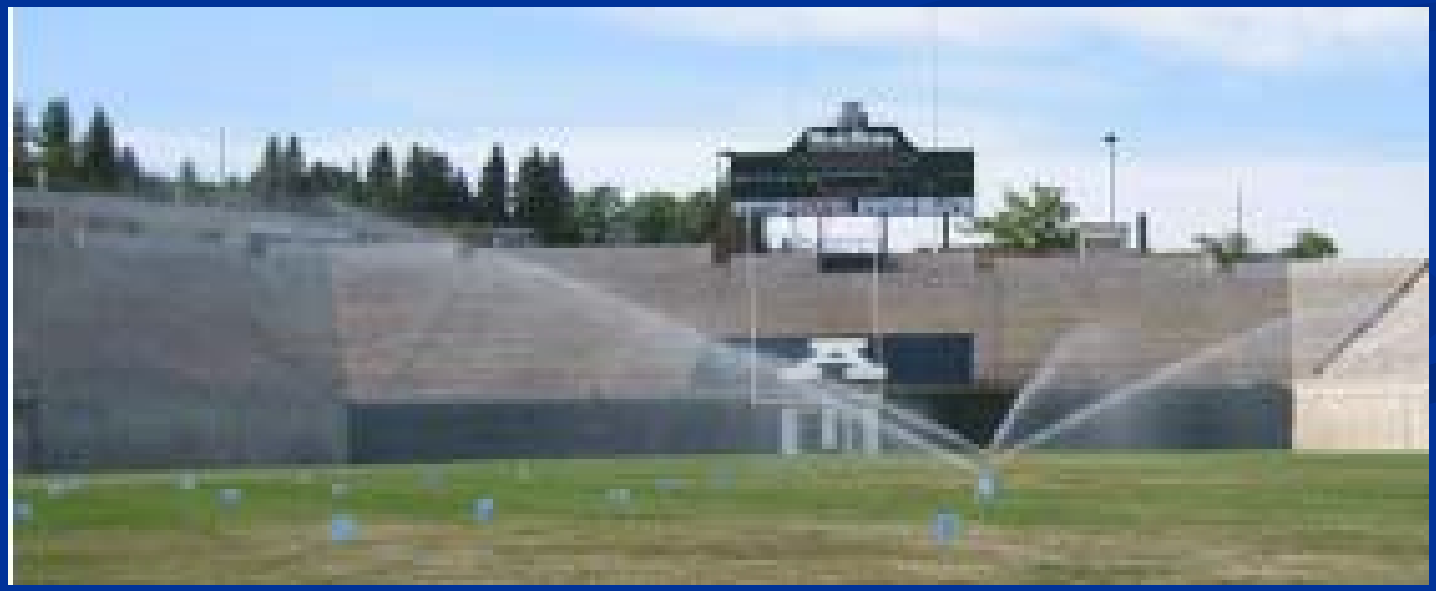
How efficient is my system?

- Calibration: Drip or microsprinklers
  - Measure the rate of water put out per nozzle or dripper
  - Measure nozzle output at different locations in the orchard
    - Highest and lowest elevation
    - Start and end of the line
- Sprinkler
  - Measure uniformity of distribution
  - Determine actual rate of accumulation

Irrigation inputs: Uniformity

- Collect 'precipitation' at multiple locations for a set period of time
- Variations from one spot to another will give an indication of efficiency
- Determine rate (amount/time)





The Budget Analogy

- Bank balance = Available soil water
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- Expenses = Evaporation + Transpiration

Expenses: Water lost

- Pathways
  - Evaporation: From the soil surface
  - Transpiration: Through the tree
    - In exchange for CO_2
    - Evaporative cooling of leaves
- Factors
  - Light intensity
  - Temperature
  - Humidity
  - Wind speed

Expenses: Water lost Estimating loss rates

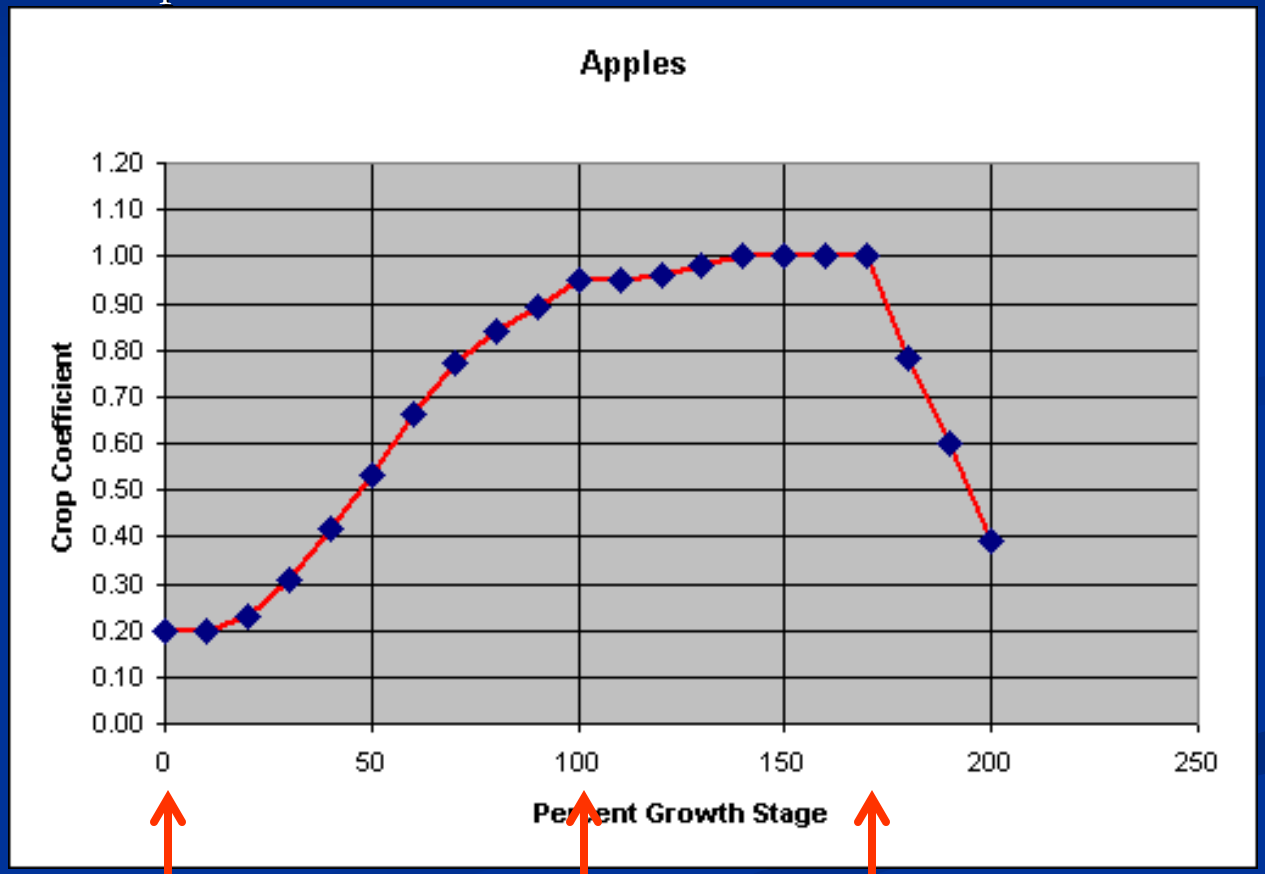
- Reference evapo-transpiration (ET)
  - Pan evaporation (ET_0)
  - Reference crop, usually alfalfa (ET_{ref})
  - $ET_{ref} = ET_0 \times 1.2$
  - Calculated based on temperature, humidity, wind speed
- $ET_{crop} = ET_{ref} \times K_{crop}$
  - K = depends on the specific crop and the stage of development



Expenses: Water lost
Crop coefficients (K) - Apple

$ET_{crop} = ET_{ref} \times K_{crop}$

Peak = 1.00



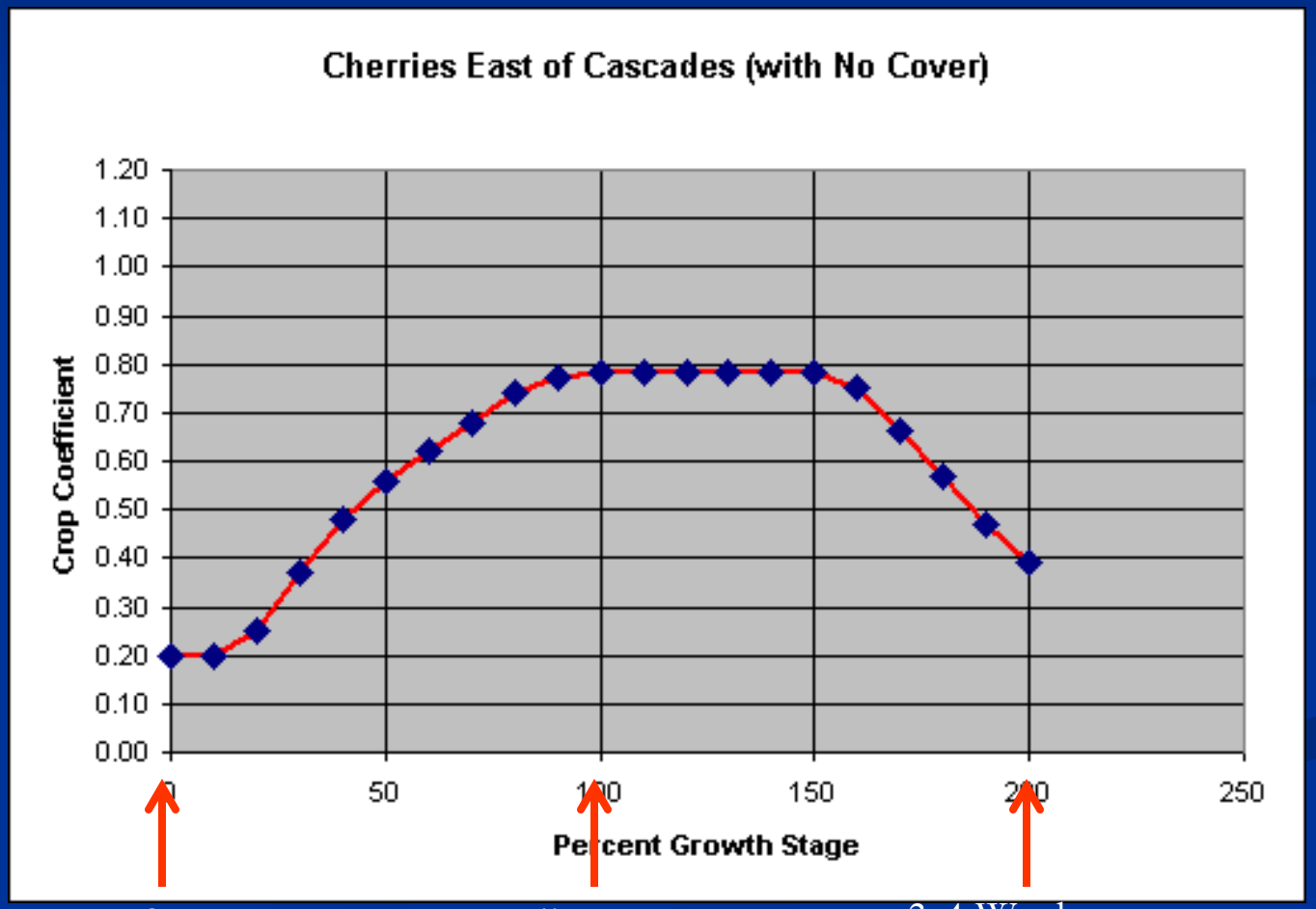
Full bloom

Full canopy

Harvest

Expenses: Water lost
Crop coefficients (K) - Cherry

Peak = 0.80



Leaf out

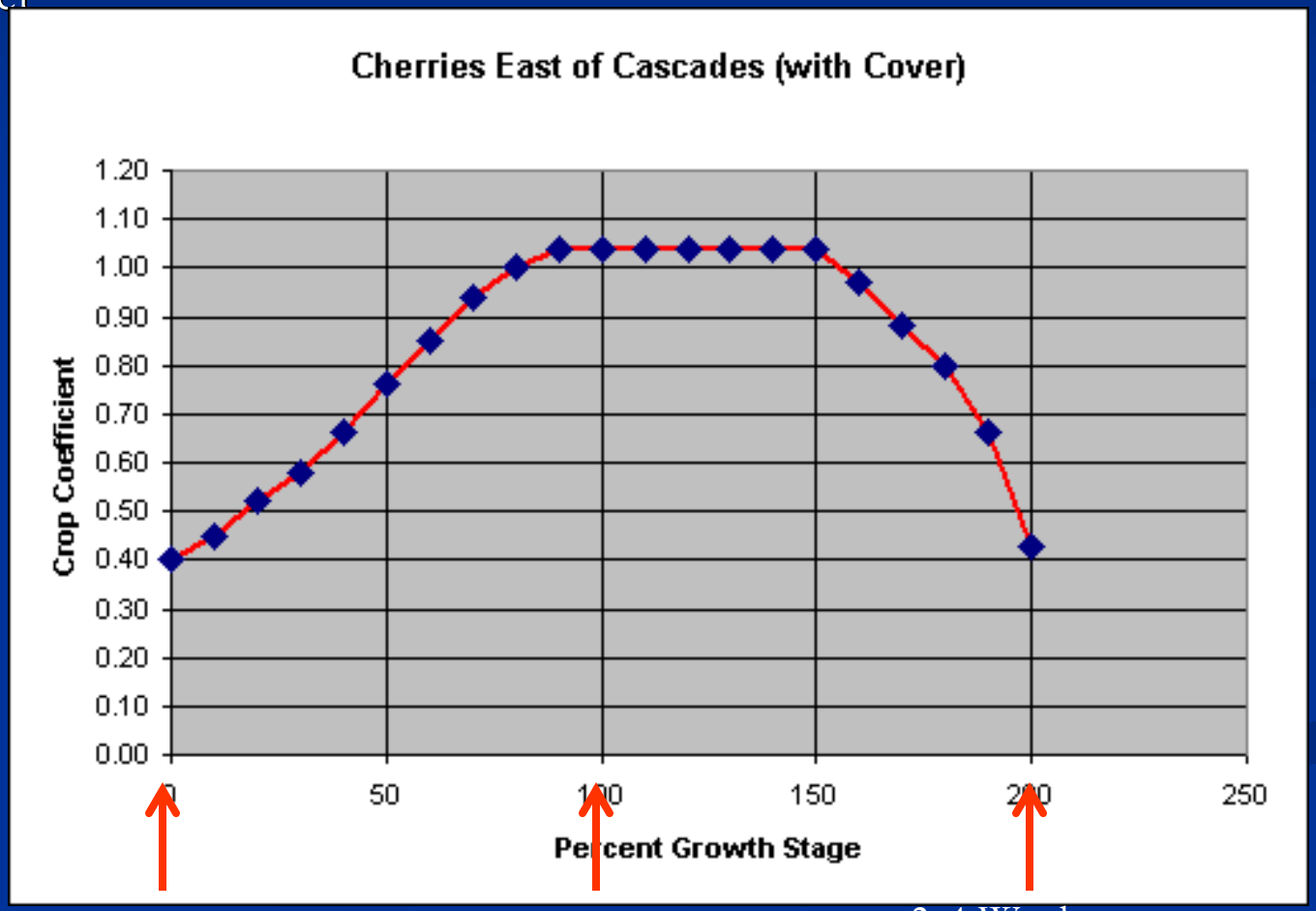
Full canopy

3-4 Weeks
After Harvest

Expenses: Water lost
Crop coefficients (K) - Cherry

$ET_{crop} = ET_{ref} \times K$

Peak = 1.04



Leaf out

Full canopy

3-4 Weeks
After Harvest

Expenses: Water lost
Obtaining ET data

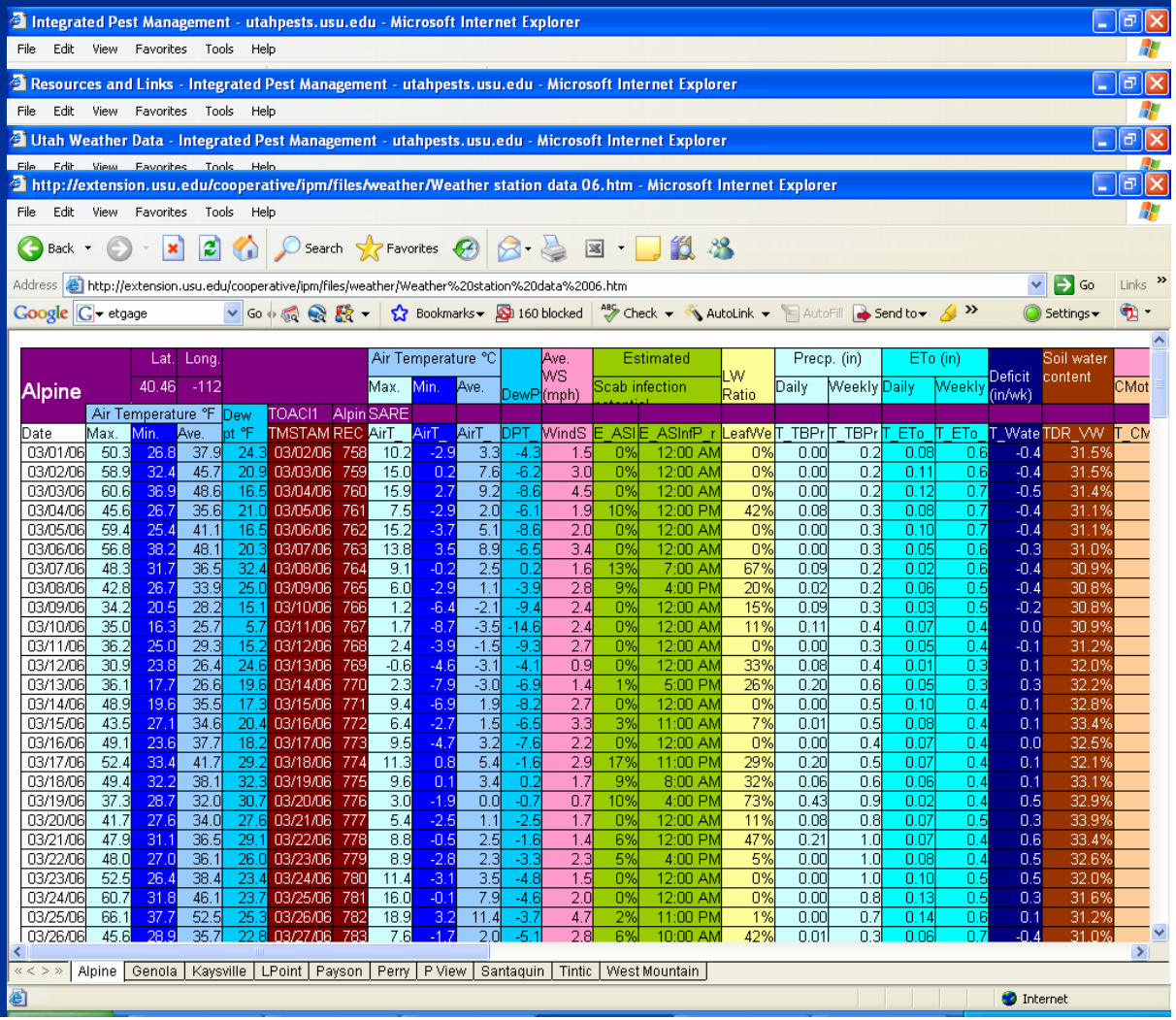
- Weather station data
  - Orchard stations

IPM website

Resources and links

Utah Weather

Select location



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Resources and Links - Integrated Pest Management - utahpests.usu.edu - Microsoft Internet Explorer

Utah Weather Data - Integrated Pest Management - utahpests.usu.edu - Microsoft Internet Explorer

http://extension.usu.edu/cooperative/ipm/files/weather/Weather station data 06.htm - Microsoft Internet Explorer

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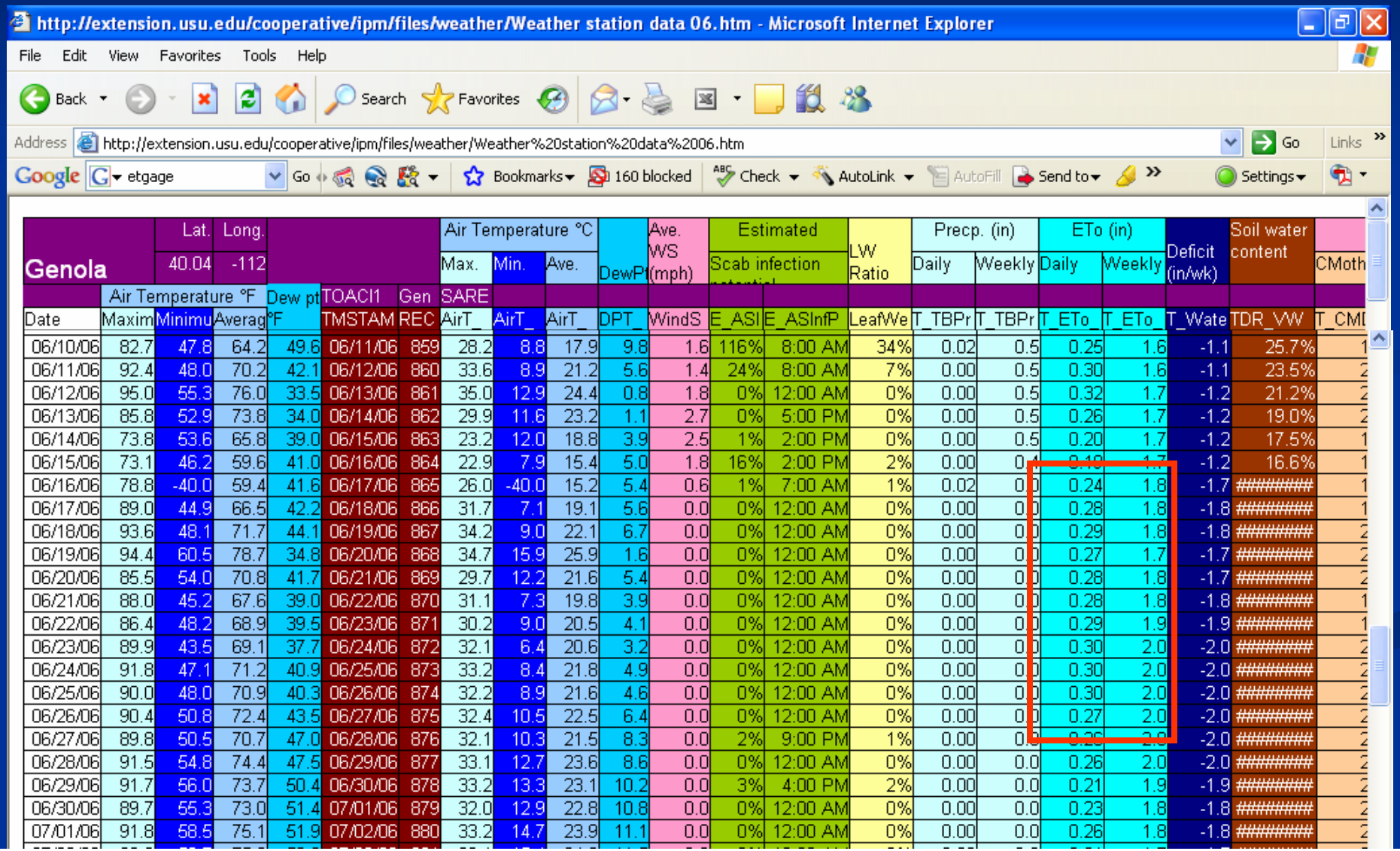
Alpine	Lat.	Long.					Air Temperature °C				Ave. WS (mph)	Estimated		LW Ratio	Precp. (in)		ETo (in)		Deficit (in/wk)	Soil water content	
	40.46	-112					Max.	Min.	Ave.	DewP		Scab infection			Daily	Weekly	Daily	Weekly			CMot
	Air Temperature °F			Dew	TOACI1	Alpin	SARE														
Date	Max.	Min.	Ave.	pt °F	TMSTAM	REC	AirT_	AirT_	AirT_	DPT_	WindS	E_ASI	E_ASInfP_r	LeafWe	T_TBPr	T_TBPr	T_ETo_	T_ETo_	T_Wate	TDR_VW	T_Clv
03/01/06	50.3	26.8	37.9	24.3	03/02/06	758	10.2	-2.9	3.3	-4.3	1.5	0%	12:00 AM	0%	0.00	0.2	0.08	0.6	-0.4	31.5%	
03/02/06	58.9	32.4	45.7	20.9	03/03/06	759	15.0	0.2	7.6	-6.2	3.0	0%	12:00 AM	0%	0.00	0.2	0.11	0.6	-0.4	31.5%	
03/03/06	60.6	36.9	48.6	16.5	03/04/06	760	15.9	2.7	9.2	-8.6	4.5	0%	12:00 AM	0%	0.00	0.2	0.12	0.7	-0.5	31.4%	
03/04/06	45.6	26.7	35.6	21.0	03/05/06	761	7.5	-2.9	2.0	-6.1	1.9	10%	12:00 PM	42%	0.08	0.3	0.08	0.7	-0.4	31.1%	
03/05/06	59.4	25.4	41.1	16.5	03/06/06	762	15.2	-3.7	5.1	-8.6	2.0	0%	12:00 AM	0%	0.00	0.3	0.10	0.7	-0.4	31.1%	
03/06/06	56.8	38.2	48.1	20.3	03/07/06	763	13.8	3.5	8.9	-6.5	3.4	0%	12:00 AM	0%	0.00	0.3	0.05	0.6	-0.3	31.0%	
03/07/06	48.3	31.7	36.5	32.4	03/08/06	764	9.1	-0.2	2.5	0.2	1.6	13%	7:00 AM	67%	0.09	0.2	0.02	0.6	-0.4	30.9%	
03/08/06	42.8	26.7	33.9	25.0	03/09/06	765	6.0	-2.9	1.1	-3.9	2.8	9%	4:00 PM	20%	0.02	0.2	0.06	0.5	-0.4	30.8%	
03/09/06	34.2	20.5	28.2	15.1	03/10/06	766	1.2	-6.4	-2.1	-9.4	2.4	0%	12:00 AM	15%	0.09	0.3	0.03	0.5	-0.2	30.8%	
03/10/06	35.0	16.3	25.7	5.7	03/11/06	767	1.7	-8.7	-3.5	-14.6	2.4	0%	12:00 AM	11%	0.11	0.4	0.07	0.4	0.0	30.9%	
03/11/06	36.2	25.0	29.3	15.2	03/12/06	768	2.4	-3.9	-1.5	-9.3	2.7	0%	12:00 AM	0%	0.00	0.3	0.05	0.4	-0.1	31.2%	
03/12/06	30.9	23.8	26.4	24.6	03/13/06	769	-0.6	-4.6	-3.1	-4.1	0.9	0%	12:00 AM	33%	0.08	0.4	0.01	0.3	0.1	32.0%	
03/13/06	36.1	17.7	26.6	19.6	03/14/06	770	2.3	-7.9	-3.0	-6.9	1.4	1%	5:00 PM	26%	0.20	0.6	0.05	0.3	0.3	32.2%	
03/14/06	48.9	19.6	35.5	17.3	03/15/06	771	9.4	-6.9	1.9	-8.2	2.7	0%	12:00 AM	0%	0.00	0.5	0.10	0.4	0.1	32.8%	
03/15/06	43.5	27.1	34.6	20.4	03/16/06	772	6.4	-2.7	1.5	-6.5	3.3	3%	11:00 AM	7%	0.01	0.5	0.08	0.4	0.1	33.4%	
03/16/06	49.1	23.6	37.7	18.2	03/17/06	773	9.5	-4.7	3.2	-7.6	2.2	0%	12:00 AM	0%	0.00	0.4	0.07	0.4	0.0	32.5%	
03/17/06	52.4	33.4	41.7	29.2	03/18/06	774	11.3	0.8	5.4	-1.6	2.9	17%	11:00 PM	29%	0.20	0.5	0.07	0.4	0.1	32.1%	
03/18/06	49.4	32.2	38.1	32.3	03/19/06	775	9.6	0.1	3.4	0.2	1.7	9%	8:00 AM	32%	0.06	0.6	0.06	0.4	0.1	33.1%	
03/19/06	37.3	28.7	32.0	30.7	03/20/06	776	3.0	-1.9	0.0	-0.7	0.7	10%	4:00 PM	73%	0.43	0.9	0.02	0.4	0.5	32.9%	
03/20/06	41.7	27.6	34.0	27.6	03/21/06	777	5.4	-2.5	1.1	-2.5	1.7	0%	12:00 AM	11%	0.08	0.8	0.07	0.5	0.3	33.9%	
03/21/06	47.9	31.1	36.5	29.1	03/22/06	778	8.8	-0.5	2.5	-1.6	1.4	6%	12:00 PM	47%	0.21	1.0	0.07	0.4	0.6	33.4%	
03/22/06	48.0	27.0	36.1	26.0	03/23/06	779	8.9	-2.8	2.3	-3.3	2.3	5%	4:00 PM	5%	0.00	1.0	0.08	0.4	0.5	32.6%	
03/23/06	52.5	26.4	38.4	23.4	03/24/06	780	11.4	-3.1	3.5	-4.8	1.5	0%	12:00 AM	0%	0.00	1.0	0.10	0.5	0.5	32.0%	
03/24/06	60.7	31.8	46.1	23.7	03/25/06	781	16.0	-0.1	7.9	-4.6	2.0	0%	12:00 AM	0%	0.00	0.8	0.13	0.5	0.3	31.6%	
03/25/06	66.1	37.7	52.5	25.3	03/26/06	782	18.9	3.2	11.4	-3.7	4.7	2%	11:00 PM	1%	0.00	0.7	0.14	0.6	0.1	31.2%	
03/26/06	45.6	28.9	35.7	22.8	03/27/06	783	7.6	-1.7	2.0	-5.1	2.8	6%	10:00 AM	42%	0.01	0.3	0.06	0.7	-0.4	31.0%	

« < > » Alpine | Genola | Kaysville | LPoint | Payson | Perry | P View | Santaquin | Tintic | West Mountain

Internet

Expenses: Water lost Obtaining ET data



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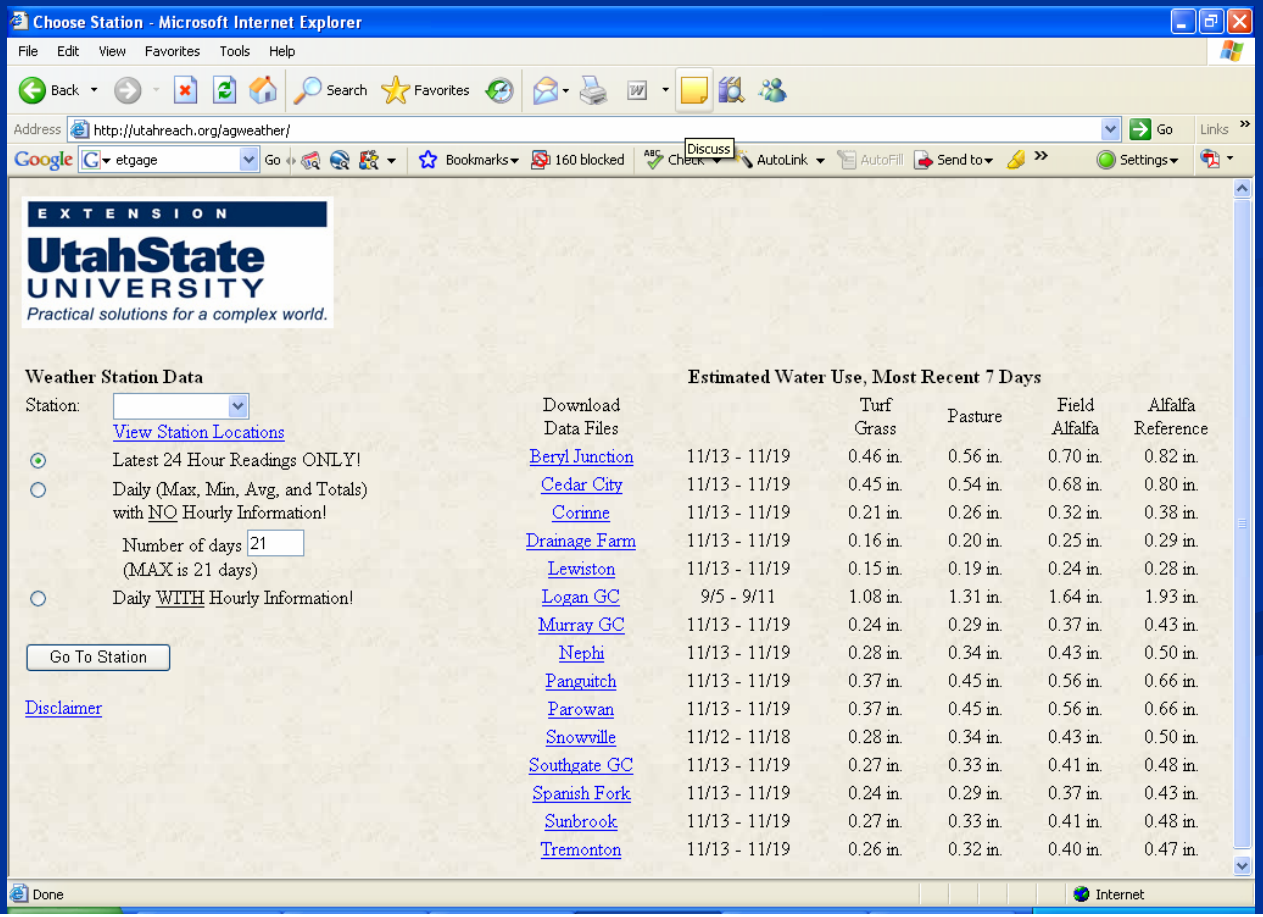
Genola	Lat. 40.04	Long. -112					Air Temperature °C Max.	Min.	Ave.	DewPt	Ave. WS (mph)	Estimated Scab infection		LW Ratio	Precp. (in) Daily	Weekly	ETo (in) Daily	Weekly	Deficit (in/wk)	Soil water content	CMoth
	Air Temperature °F			Dew pt	TOACI1	Gen	SARE														
Date	Maxim	Minimu	Averag	°F	TMSTAM	REC	AirT_	AirT_	AirT_	DPT_	WindS	E_ASI	E_ASInfP	LeafWe	T_TBPr	T_TBPr	T_ETo_	T_ETo_	T_Wate	TDR_VW	T_CMI
06/10/06	82.7	47.8	64.2	49.6	06/11/06	859	28.2	8.8	17.9	9.8	1.6	116%	8:00 AM	34%	0.02	0.5	0.25	1.6	-1.1	25.7%	1
06/11/06	92.4	48.0	70.2	42.1	06/12/06	860	33.6	8.9	21.2	5.6	1.4	24%	8:00 AM	7%	0.00	0.5	0.30	1.6	-1.1	23.5%	2
06/12/06	95.0	55.3	76.0	33.5	06/13/06	861	35.0	12.9	24.4	0.8	1.8	0%	12:00 AM	0%	0.00	0.5	0.32	1.7	-1.2	21.2%	2
06/13/06	85.8	52.9	73.8	34.0	06/14/06	862	29.9	11.6	23.2	1.1	2.7	0%	5:00 PM	0%	0.00	0.5	0.26	1.7	-1.2	19.0%	2
06/14/06	73.8	53.6	65.8	39.0	06/15/06	863	23.2	12.0	18.8	3.9	2.5	1%	2:00 PM	0%	0.00	0.5	0.20	1.7	-1.2	17.5%	1
06/15/06	73.1	46.2	59.6	41.0	06/16/06	864	22.9	7.9	15.4	5.0	1.8	16%	2:00 PM	2%	0.00	0.4	0.18	1.7	-1.2	16.6%	1
06/16/06	78.8	-40.0	59.4	41.6	06/17/06	865	26.0	-40.0	15.2	5.4	0.6	1%	7:00 AM	1%	0.02	0.0	0.24	1.8	-1.7	##########	1
06/17/06	89.0	44.9	66.5	42.2	06/18/06	866	31.7	7.1	19.1	5.6	0.0	0%	12:00 AM	0%	0.00	0.0	0.28	1.8	-1.8	##########	1
06/18/06	93.6	48.1	71.7	44.1	06/19/06	867	34.2	9.0	22.1	6.7	0.0	0%	12:00 AM	0%	0.00	0.0	0.29	1.8	-1.8	##########	2
06/19/06	94.4	60.5	78.7	34.8	06/20/06	868	34.7	15.9	25.9	1.6	0.0	0%	12:00 AM	0%	0.00	0.0	0.27	1.7	-1.7	##########	2
06/20/06	85.5	54.0	70.8	41.7	06/21/06	869	29.7	12.2	21.6	5.4	0.0	0%	12:00 AM	0%	0.00	0.0	0.28	1.8	-1.7	##########	2
06/21/06	88.0	45.2	67.6	39.0	06/22/06	870	31.1	7.3	19.8	3.9	0.0	0%	12:00 AM	0%	0.00	0.0	0.28	1.8	-1.8	##########	1
06/22/06	86.4	48.2	68.9	39.5	06/23/06	871	30.2	9.0	20.5	4.1	0.0	0%	12:00 AM	0%	0.00	0.0	0.29	1.9	-1.9	##########	1
06/23/06	89.9	43.5	69.1	37.7	06/24/06	872	32.1	6.4	20.6	3.2	0.0	0%	12:00 AM	0%	0.00	0.0	0.30	2.0	-2.0	##########	2
06/24/06	91.8	47.1	71.2	40.9	06/25/06	873	33.2	8.4	21.8	4.9	0.0	0%	12:00 AM	0%	0.00	0.0	0.30	2.0	-2.0	##########	2
06/25/06	90.0	48.0	70.9	40.3	06/26/06	874	32.2	8.9	21.6	4.6	0.0	0%	12:00 AM	0%	0.00	0.0	0.30	2.0	-2.0	##########	2
06/26/06	90.4	50.8	72.4	43.5	06/27/06	875	32.4	10.5	22.5	6.4	0.0	0%	12:00 AM	0%	0.00	0.0	0.27	2.0	-2.0	##########	2
06/27/06	89.8	50.5	70.7	47.0	06/28/06	876	32.1	10.3	21.5	8.3	0.0	2%	9:00 PM	1%	0.00	0.0	0.26	2.0	-2.0	##########	2
06/28/06	91.5	54.8	74.4	47.5	06/29/06	877	33.1	12.7	23.6	8.6	0.0	0%	12:00 AM	0%	0.00	0.0	0.26	2.0	-2.0	##########	2
06/29/06	91.7	56.0	73.7	50.4	06/30/06	878	33.2	13.3	23.1	10.2	0.0	3%	4:00 PM	2%	0.00	0.0	0.21	1.9	-1.9	##########	2
06/30/06	89.7	55.3	73.0	51.4	07/01/06	879	32.0	12.9	22.8	10.8	0.0	0%	12:00 AM	0%	0.00	0.0	0.23	1.8	-1.8	##########	2
07/01/06	91.8	58.5	75.1	51.9	07/02/06	880	33.2	14.7	23.9	11.1	0.0	0%	12:00 AM	0%	0.00	0.0	0.26	1.8	-1.8	##########	2

Expenses: Water lost
Obtaining ET data

- Weather station data –

http://utahreach.org/agweather



Expenses: Water lost Obtaining ET data

- Weather station data
- ET measurement device
  - Analog unit - $180
  - Electronic unit - $1,170
    - (ETgage Company)



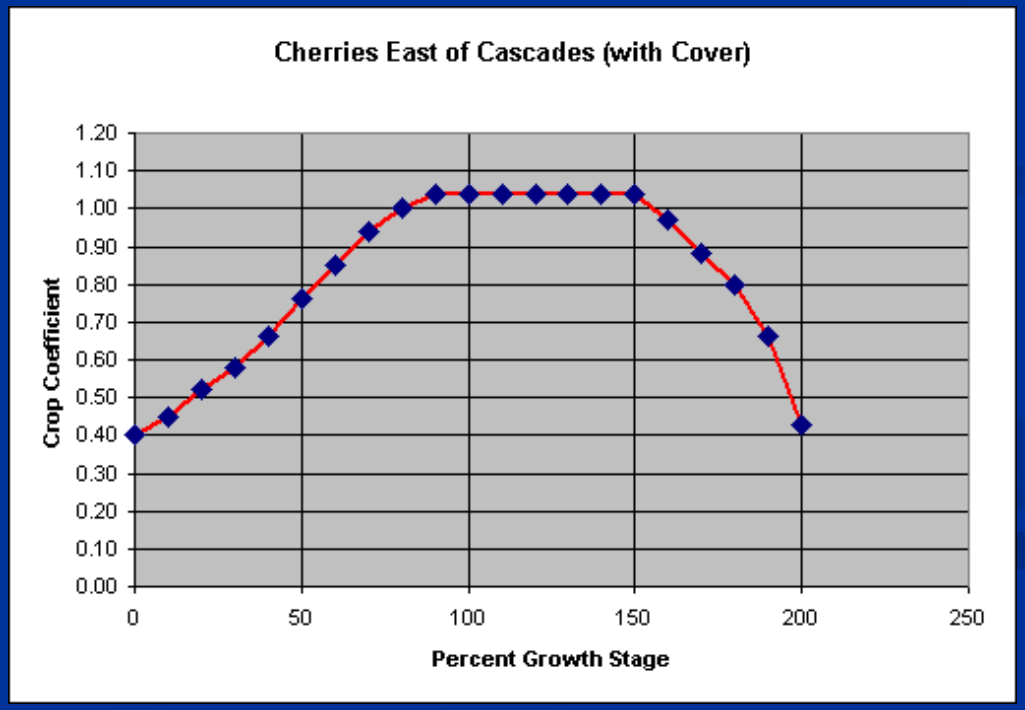
Case Study

- Mature tart cherry block on a deep sandy loam soil
  - Rooting depth = 4 feet
  - Size of bank account = 2.4 to 3.0 inches

	Available	Readily available		
	inch/foot	inch/foot	2.5'	4'
Sands and fine sands	0.5 - 0.75	0.25 - 0.38	0.6 - 0.9	1.0 - 1.5
V. fine sand, loamy sand	0.8 - 1.0	0.4 - 0.5	1.0 - 1.25	1.6 - 2
Sandy loam	1.2 - 1.5	0.6 - 0.75	1.5 - 1.9	2.4 - 3.0
Loam	1.9 - 2.0	0.9 - 1.0	2.4 - 2.5	3.8 - 4.0
Silt loam, silt	2.0	1.0	2.5	4.0
Silty clay loam	1.9 - 2.0	0.9 - 1.0	2.4 - 2.5	3.8 - 4.0
Sandy clay loam, clay loam	1.7 - 2.0	0.85 - 1.0	2.1 - 2.5	3.4 - 4.0

Case Study

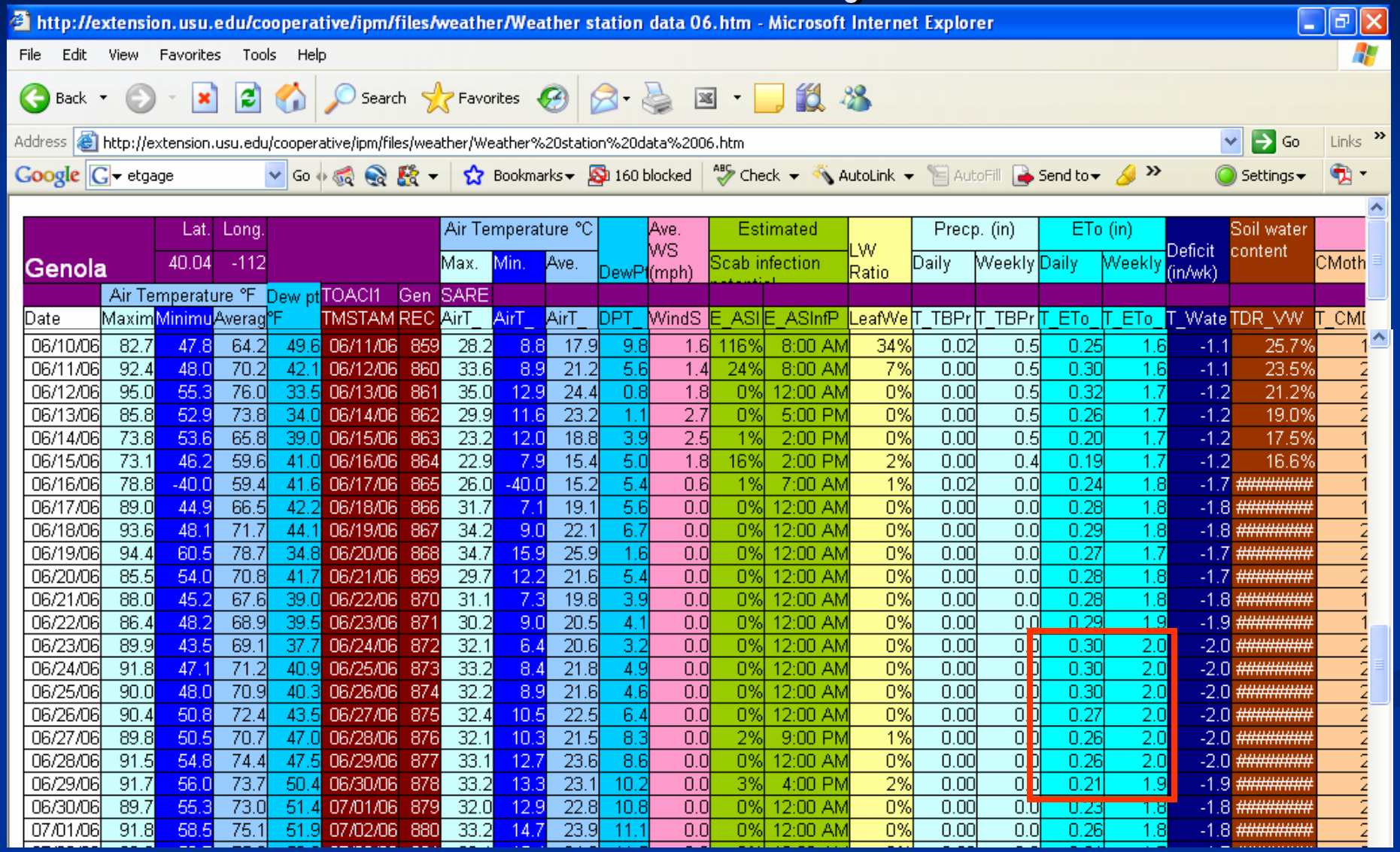
- Mature tart cherry block on a deep sandy loam soil
  - Storage of readily available water = 2.4 to 3.0 inches
- Canopy is at 100% of full, orchard has a cover crop
  - K_{crop} = 1.04



Case Study

- Mature tart cherry block on a deep sandy loam soil
  - Storage of readily available water = 2.4 to 3.0 inches
- Canopy is at 100% of full, orchard has a cover crop
  - K_{crop} = 1.04
- Reference ET

Case Study



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Genola	Lat.	Long.					Air Temperature °C				Ave.	Estimated			Precp. (in)		ETo (in)			Soil water	
	40.04	-112					Max.	Min.	Ave.	DewPt	WS (mph)	Scab infection		LW Ratio	Daily	Weekly	Daily	Weekly	Deficit (in/wk)	content	CMoth
	Air Temperature °F			Dew pt	TOACI1	Gen	SARE														
Date	Maxim	Minimu	Averag	°F	TMSTAM	REC	AirT_	AirT_	AirT_	DPT_	WindS	E_ASI	E_ASInfP	LeafWe	T_TBPr	T_TBPr	T_ETo_	T_ETo_	T_Wate	TDR_VW	T_CMI
06/10/06	82.7	47.8	64.2	49.6	06/11/06	859	28.2	8.8	17.9	9.8	1.6	116%	8:00 AM	34%	0.02	0.5	0.25	1.6	-1.1	25.7%	1
06/11/06	92.4	48.0	70.2	42.1	06/12/06	860	33.6	8.9	21.2	5.6	1.4	24%	8:00 AM	7%	0.00	0.5	0.30	1.6	-1.1	23.5%	2
06/12/06	95.0	55.3	76.0	33.5	06/13/06	861	35.0	12.9	24.4	0.8	1.8	0%	12:00 AM	0%	0.00	0.5	0.32	1.7	-1.2	21.2%	2
06/13/06	85.8	52.9	73.8	34.0	06/14/06	862	29.9	11.6	23.2	1.1	2.7	0%	5:00 PM	0%	0.00	0.5	0.26	1.7	-1.2	19.0%	2
06/14/06	73.8	53.6	65.8	39.0	06/15/06	863	23.2	12.0	18.8	3.9	2.5	1%	2:00 PM	0%	0.00	0.5	0.20	1.7	-1.2	17.5%	1
06/15/06	73.1	46.2	59.6	41.0	06/16/06	864	22.9	7.9	15.4	5.0	1.8	16%	2:00 PM	2%	0.00	0.4	0.19	1.7	-1.2	16.6%	1
06/16/06	78.8	-40.0	59.4	41.6	06/17/06	865	26.0	-40.0	15.2	5.4	0.6	1%	7:00 AM	1%	0.02	0.0	0.24	1.8	-1.7	########	1
06/17/06	89.0	44.9	66.5	42.2	06/18/06	866	31.7	7.1	19.1	5.6	0.0	0%	12:00 AM	0%	0.00	0.0	0.28	1.8	-1.8	########	1
06/18/06	93.6	48.1	71.7	44.1	06/19/06	867	34.2	9.0	22.1	6.7	0.0	0%	12:00 AM	0%	0.00	0.0	0.29	1.8	-1.8	########	2
06/19/06	94.4	60.5	78.7	34.8	06/20/06	868	34.7	15.9	25.9	1.6	0.0	0%	12:00 AM	0%	0.00	0.0	0.27	1.7	-1.7	########	2
06/20/06	85.5	54.0	70.8	41.7	06/21/06	869	29.7	12.2	21.6	5.4	0.0	0%	12:00 AM	0%	0.00	0.0	0.28	1.8	-1.7	########	2
06/21/06	88.0	45.2	67.6	39.0	06/22/06	870	31.1	7.3	19.8	3.9	0.0	0%	12:00 AM	0%	0.00	0.0	0.28	1.8	-1.8	########	1
06/22/06	86.4	48.2	68.9	39.5	06/23/06	871	30.2	9.0	20.5	4.1	0.0	0%	12:00 AM	0%	0.00	0.0	0.29	1.9	-1.9	########	1
06/23/06	89.9	43.5	69.1	37.7	06/24/06	872	32.1	6.4	20.6	3.2	0.0	0%	12:00 AM	0%	0.00	0.0	0.30	2.0	-2.0	########	2
06/24/06	91.8	47.1	71.2	40.9	06/25/06	873	33.2	8.4	21.8	4.9	0.0	0%	12:00 AM	0%	0.00	0.0	0.30	2.0	-2.0	########	2
06/25/06	90.0	48.0	70.9	40.3	06/26/06	874	32.2	8.9	21.6	4.6	0.0	0%	12:00 AM	0%	0.00	0.0	0.30	2.0	-2.0	########	2
06/26/06	90.4	50.8	72.4	43.5	06/27/06	875	32.4	10.5	22.5	6.4	0.0	0%	12:00 AM	0%	0.00	0.0	0.27	2.0	-2.0	########	2
06/27/06	89.8	50.5	70.7	47.0	06/28/06	876	32.1	10.3	21.5	8.3	0.0	2%	9:00 PM	1%	0.00	0.0	0.26	2.0	-2.0	########	2
06/28/06	91.5	54.8	74.4	47.5	06/29/06	877	33.1	12.7	23.6	8.6	0.0	0%	12:00 AM	0%	0.00	0.0	0.26	2.0	-2.0	########	2
06/29/06	91.7	56.0	73.7	50.4	06/30/06	878	33.2	13.3	23.1	10.2	0.0	3%	4:00 PM	2%	0.00	0.0	0.21	1.9	-1.9	########	2
06/30/06	89.7	55.3	73.0	51.4	07/01/06	879	32.0	12.9	22.8	10.8	0.0	0%	12:00 AM	0%	0.00	0.0	0.23	1.8	-1.8	########	2
07/01/06	91.8	58.5	75.1	51.9	07/02/06	880	33.2	14.7	23.9	11.1	0.0	0%	12:00 AM	0%	0.00	0.0	0.26	1.8	-1.8	########	2

Case Study

- Mature tart cherry block on a deep sandy loam soil
  - Storage of readily available water = 2.4 to 3.0 inches
- Canopy is at 100% of full, orchard has a cover crop
  - $K_{crop} = 1.04$
- Reference ET
  - $ET_0 = 2.0$ inches per week
  - $ET_{ref} = 1.2 \times ET_0 = 2.4$ inches per week
- $ET_{crop} = ET_{ref} \times K_{crop}$
- $ET_{crop} = 2.4$ inch/week $\times$ 1.04 = 2.5 inch/week
- All readily available water will be used in 7 days
  - (2.4 inch stored)
  - Will need to restore 2.4 inches of water at next irrigation

Summary

Good irrigation management requires:

- Understanding Soil-Plant-Water relationship
- Properly designed and maintained irrigation system
- Understanding the efficiency of your irrigation system
- Knowing proper timing based on
  - Soil water holding capacity
  - Weather
  - Crop growth stage
- A commitment to managing resources

Summary

- A commitment to managing resources
  - How much is going in
  - How much is going out
  - What is in the bank











