Manejo de suelos bajo microriego en relación con su capacidad de retención de agua, distribución y conductividad hidráulica

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Mantenimiento y Manejo de Sistemas Agricolas Bajo Microriego en Puerto Rico

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Soil Water Relations

- Soil is a reservoir for water and chemicals and provides a medium for supporting plants
- Water is removed by evapotranspiration (ET = evaporation plus transpiration)
- The rate at which water is used determines
  - Plants to be grown
  - Plant spacing
  - Yield
  - General management criteria

Soil Water Relations

- **Knowledge of soil water relations and ET is essential for managing soil and water systems, particularly for irrigation systems.**
- **For irrigation, the water holding capacity and the rate of water removal by plants must be considered.**

The Soil Water Reservoir

- **Periodically filled by rainfall and/or irrigation**
- **Depleted slowly by ET**
- **Water applied in excess of the reservoir's capacity (soil water holding capacity) is wasted unless it is required for leaching.**

$$TAW = (\theta_{FC} - \theta_{WP})\, D_r/100$$

where

TAW = Total available water (mm)

θ_{FC} = Volumetric field capacity (%)

θ_{WP} = permanent wilting point (%)

D_r =depth of the root zone or depth of a layer of soil within the root zone.

Representative Physical Properties of Soils

TABLE 14.1 Representative Physical Properties of Soils

Soil Texture	*Saturated Hydraulic Conductivity,[a] k_s* (mm/h)	(in./h)	*Total Pore Space* (% by vol)	*Apparent Specific Gravity* (A_s)	*Field Capacity fc* (% by vol)	*Permanent Wilting pwp* (% by vol)	*Total Available Water* Percent by Volume (v)	(mm/cm)	(in./ft
Sandy	50	2	38	1.65	15	7	8	0.8	1.0
	(25–250)	(1–10)	(32–42)	(1.55–1.80)	(10–20)	(3–10)	(6–10)	(0.7–1.0)	(0.8–1.2
Sandy	25	1	43	1.50	21	9	12	1.2	1.4
Loam	(12–75)	(0.5–3)	(40–47)	(1.40–1.60)	(15–27)	(6–12)	(9–15)	0.9–1.5)	(1.1–1.8
Loam	12	0.5	47	1.40	31	14	17	1.7	2.0
	(8–20)	(0.3–0.8)	(43–49)	(1.35–1.50)	(25–36)	(11–17)	(14–20)	(1.4–1.9)	(1.7–2.3
Clay	8	0.3	49	1.35	36	18	18	1.9	2.3
Loam	(3–5)	(0.1–0.6)	(47–51)	(1.30–1.40)	(31–42)	(15–20)	(16–22)	(1.7–2.2)	(2.0–2.6
Silty	3	0.1	51	1.30	40	20	20	2.1	2.5
Clay	(0.25–5)	(0.01–0.2)	(49–53)	(1.25–1.35)	(35–46)	(17–22)	(18–23)	(1.8–2.3)	(2.2–2.8
Clay	5	0.2	53	1.25	44	21	23	2.3	2.7
	(1–10)	(0.05–0.4)	(51–55)	(1.20–1.30)	(39–49)	(19–24)	(20–25)	(2.0–2.5)	(2.4–3.0

Source: Hansen, V. E. et al. (1980). Reprinted with permission of John Wiley & Sons, Inc.

Note: Normal ranges are shown in parentheses.

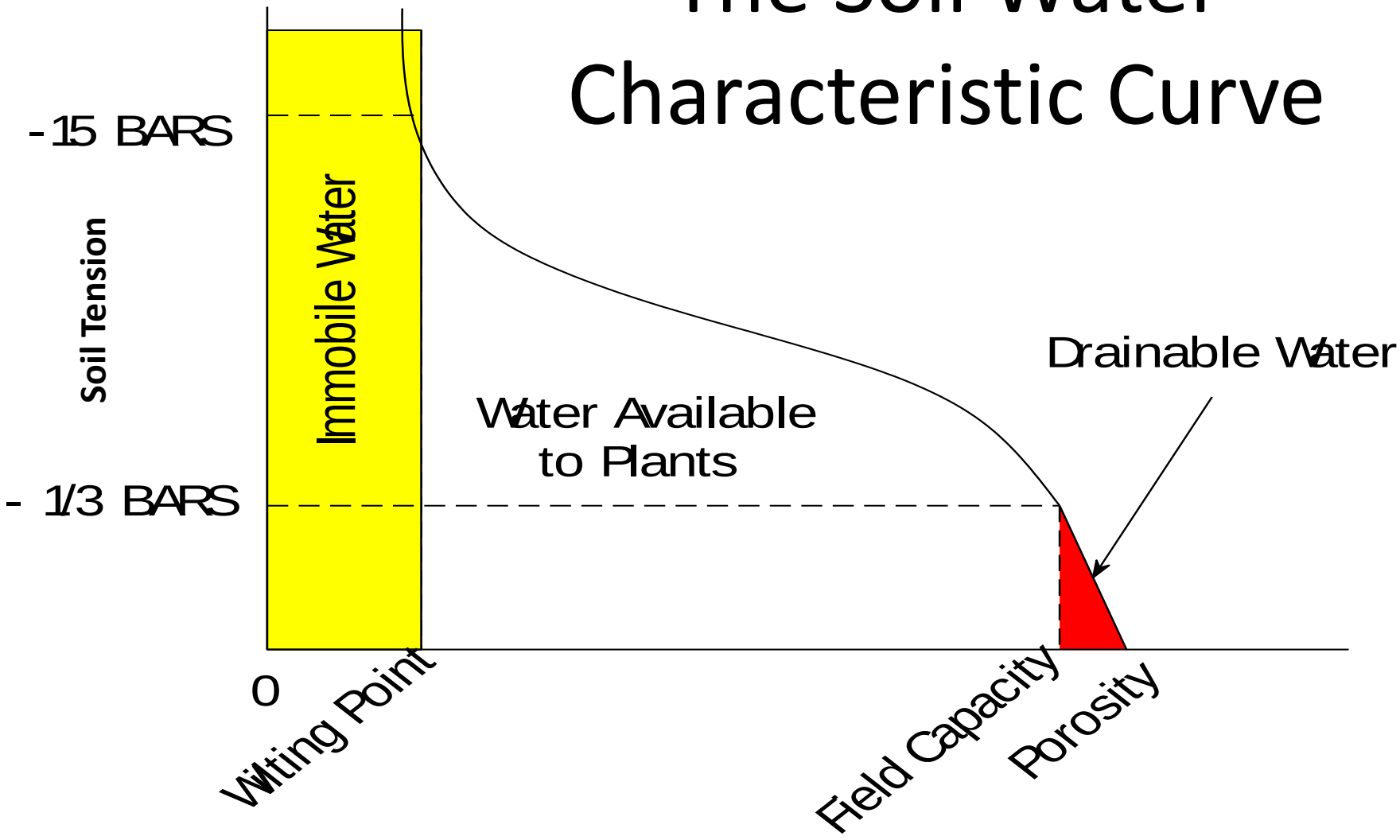
[a]Saturated hydraulic conductivities vary greatly with soil structure and structural stability, even beyond the normal ranges shown.

Management Allowed Deficit (MAD) and Rooting Depths of Various Crops

Crop	MAD	Rooting Depth	
		ft	*m*
Alfalfa	0.55	3–10	1.0–3.0
Banana	0.35	2–3	0.5–0.9
Barley	0.55	3–5	1.0–1.5
Beans	0.45	1–2	0.5–0.7
Beets	0.5	2–3	0.6–1.0
Cabbage	0.45	1–2	0.4–0.5
Sunflower	0.45	3–5	0.8–1.5
Sweet potatoes	0.65	3–5	1.0–1.5
Tomatoes	0.4	2–5	0.7–1.5
Vegetables	0.2	1–2	0.3–0.6
Wheat	0.55	3–5	1.0–1.5

Source: Doorenbos, J. and W. O. Pruitt (1977). Reprinted with permission from Food and Agriculture Organization of the United Nations.

The Soil Water Characteristic Curve

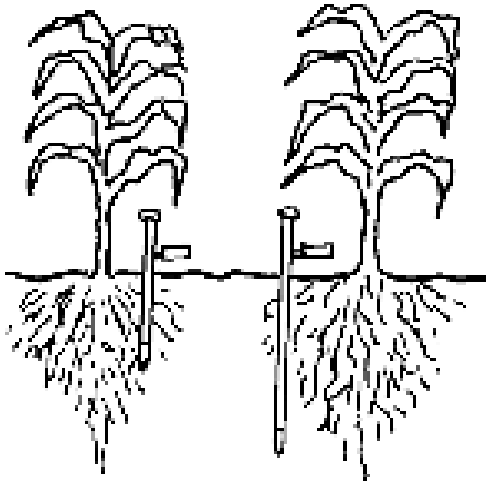


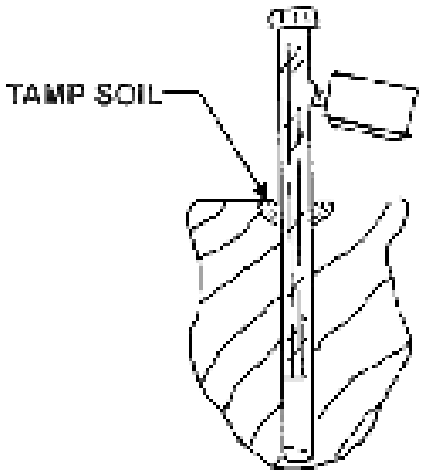
Volumetric Moisture Content

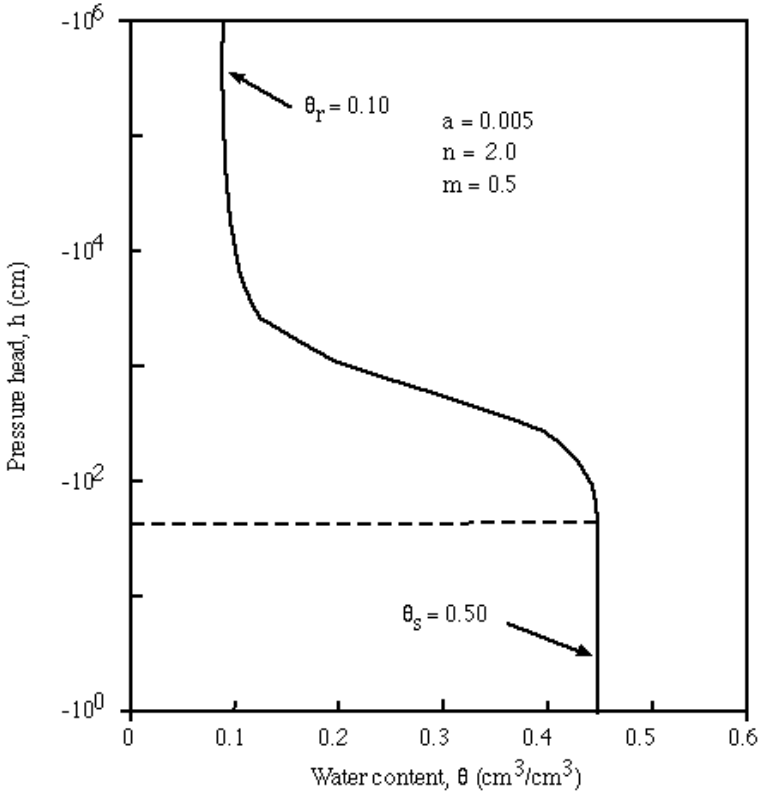
- Gravimetric Method (undisturbed core)
- Gravimetric Method (disturbed samples)
- Tensiometers
- Time Domain Reflectivity (TDR)
- Conductance
- Water balance method

Gravimetric Soil Sampling

Tensiometers







TDR

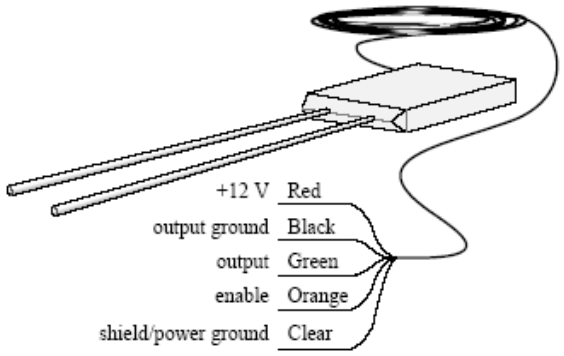
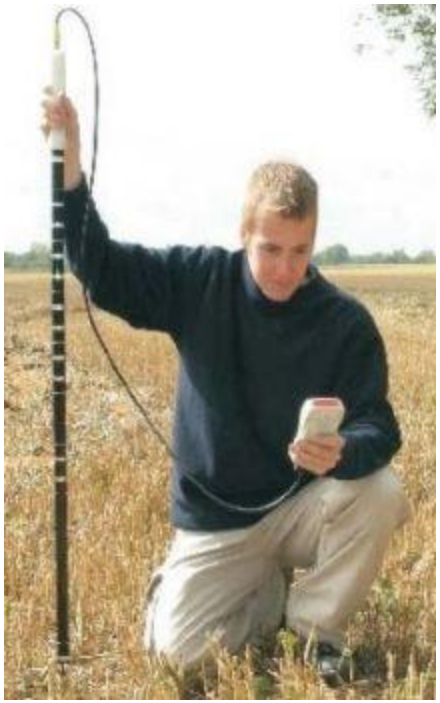


FIGURE 1. Water Content Reflectometer

Capacitance Method



Water Balance Method

$$\theta_{t2} = R + Irr - RO - ET_{c\ adj} - PERC + \theta_{t1}$$

θ_{t2} = volumetric moisture content at time 2

θ_{t1} = volumetric moisture content at time 1

R = effective rainfall

RO = runoff

PERC = water that percolates past the root zone

Crop Water Use (ET_{cadj})

- The rate of water use by the crops can be estimated as follows

$$ET_c = K_c\ ET_o$$

$$ET_{cadj} = K_s\ ET_c$$

Where

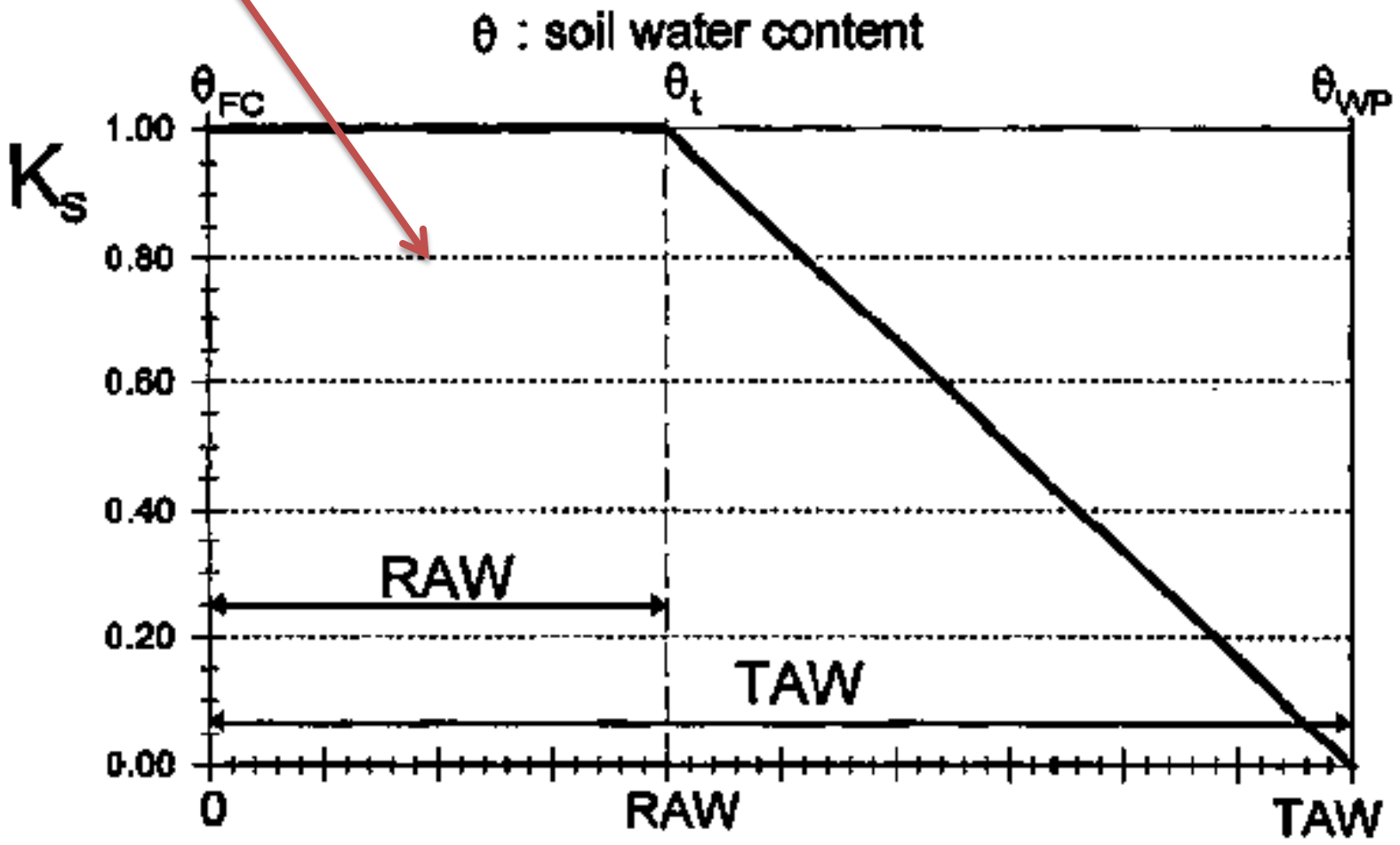
ET_o = Reference Evapotranspiration

K_c = Evapotranspiration Crop Coefficient

K_s = Crop Stress Factor

Crop Stress Factor

This is where Your soil should be



Readily Available Water

- Plants can only remove a portion of the available water before growth and yield are affected. This portion is the “readily available water” (RAW).
- For most crops RAW is between 40% to 65%
- RAW is estimated from the following formula:

$$RAW = (MAD)\ (TAW)$$

Management Allowed Deficit (MAD) and Rooting Depths of Various Crops

Crop	MAD	Rooting Depth	
		ft	*m*
Alfalfa	0.55	3–10	1.0–3.0
Banana	0.35	2–3	0.5–0.9
Barley	0.55	3–5	1.0–1.5
Beans	0.45	1–2	0.5–0.7
Beets	0.5	2–3	0.6–1.0
Cabbage	0.45	1–2	0.4–0.5
Sunflower	0.45	3–5	0.8–1.5
Sweet potatoes	0.65	3–5	1.0–1.5
Tomatoes	0.4	2–5	0.7–1.5
Vegetables	0.2	1–2	0.3–0.6
Wheat	0.55	3–5	1.0–1.5

Source: Doorenbos, J. and W. O. Pruitt (1977). Reprinted with permission from Food and Agriculture Organization of the United Nations.

Threshold Moisture Content, θ_t

- If the soil moisture content falls below θ_t , the crop will go into stress and you will loss crop yield!

$$\theta_t = \theta_{FC} - RAW$$

where

θ_t = threshold moisture content

θ_{FC} = field capacity moisture content

RAW = readily available water

Agricultural Water Management in Puerto Rico

Page last updated
March 4, 2008

Home Page

Contact Information

Research Activities

Links

Crop Water Use

Software and Books

Welcome to the University of Puerto Rico Agricultural Water Management Website.

University of Puerto Rico-Mayagüez

The goal of this site is to facilitate the dissemination of information related to sound water management practices in Puerto Rico. Information is included on:

Department of Agricultural Engineering
University of Puerto Rico-Mayagüez Campus
P.O. Box 9030
Mayagüez, PR 00681-9030

This website was developed through a grant from the
University of Puerto Rico
Experiment Station (Grant SP-347)

NEW

- **Download Soil Water Management Spreadsheet**
- **PR-ET Verion 1.03 is now available for download!!**
- PowerPoint presentation on Climate Change Impacts on Agriculture in Puerto Rico, presented at the Simposio de Ciencias 2007, UPR-Carolina
- Spanish language translation of FAO Irrigation and Drainage Paper no. 56 (Crop Evapotranspiration)!
- "Riego por Goteo" text book by Dr. Megh Goyal, download electronic version
- Links to climate change impacts on agriculture

Soil Water Management Spreadsheet

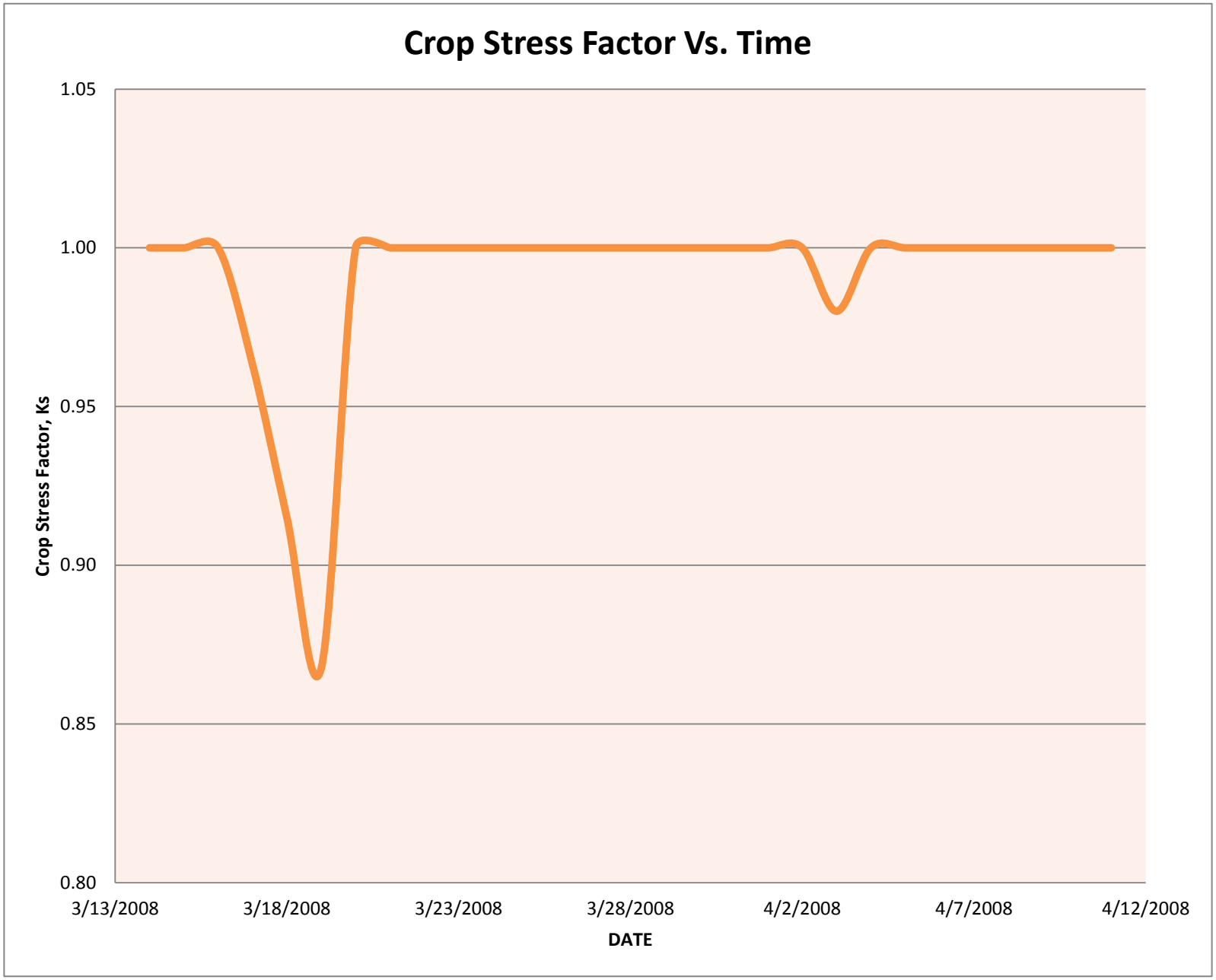
http://academic.uprm.edu/abe/PRAGWATER/

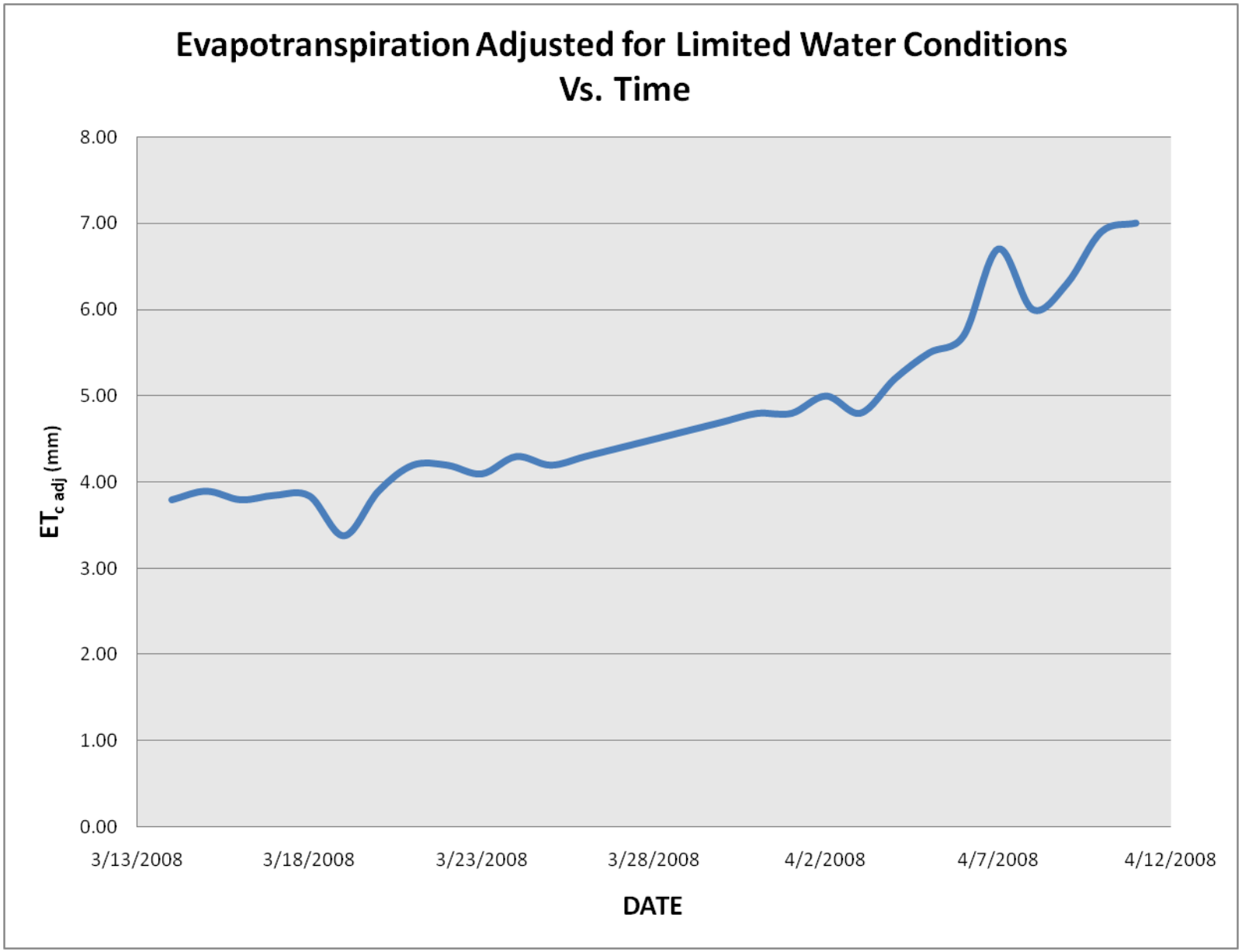
Date	Field Capacity	Wilting Point	Total Available Water	Root Depth	Management Allowed Deficit	Readily Available Moisture Content	Threshold Moisture Content	Moisture Content	Crop Stress Factor	Average Crop Evapotranspiration	Average Evapotranspiration Adjusted for Stress	Soil Water Deficit	Irrigation needed	Applied Irrigation or Rainfall	Did Stress Occur?
	FC	WP	TAW	RD	MAD	RAW	θ_t	θ	K_s	ET_c	$ET_{c\ adj}$				
	%	%	%	m	fraction	%	%	%		mm	mm	%	mm	mm	
3/14/2008	36	18	18	0.70	0.4	7.2	28.8	30.00	1.00	3.80	3.80	6.0	42	0	NO
3/15/2008	36	18	18	0.71	0.4	7.2	28.8	29.46	1.00	3.90	3.90	6.5	46	0	NO
3/16/2008	36	18	18	0.72	0.4	7.2	28.8	28.92	1.00	3.80	3.80	7.1	51	0	NO
3/17/2008	36	18	18	0.73	0.4	7.2	28.8	28.40	0.96	4.00	3.85	7.6	55	0	YES
3/18/2008	36	18	18	0.74	0.4	7.2	28.8	27.88	0.91	4.20	3.84	8.1	60	0	YES
3/19/2008	36	18	18	0.75	0.4	7.2	28.8	27.37	0.87	3.90	3.38	8.6	65	0	YES
3/20/2008	36	18	18	0.76	0.4	7.2	28.8	36.00	1.00	3.90	3.90	0.0	0	69	NO
3/21/2008	36	18	18	0.77	0.4	7.2	28.8	35.50	1.00	4.20	4.20	0.5	4	0	NO
3/22/2008	36	18	18	0.78	0.4	7.2	28.8	34.96	1.00	4.20	4.20	1.0	8	0	NO
3/23/2008	36	18	18	0.79	0.4	7.2	28.8	34.43	1.00	4.10	4.10	1.6	12	0	NO
3/24/2008	36	18	18	0.80	0.4	7.2	28.8	33.91	1.00	4.30	4.30	2.1	17	0	NO
3/25/2008	36	18	18	0.81	0.4	7.2	28.8	33.38	1.00	4.20	4.20	2.6	21	0	NO
3/26/2008	36	18	18	0.82	0.4	7.2	28.8	32.87	1.00	4.30	4.30	3.1	26	0	NO
3/27/2008	36	18	18	0.83	0.4	7.2	28.8	32.35	1.00	4.40	4.40	3.6	30	0	NO
3/28/2008	36	18	18	0.84	0.4	7.2	28.8	31.83	1.00	4.50	4.50	4.2	35	0	NO

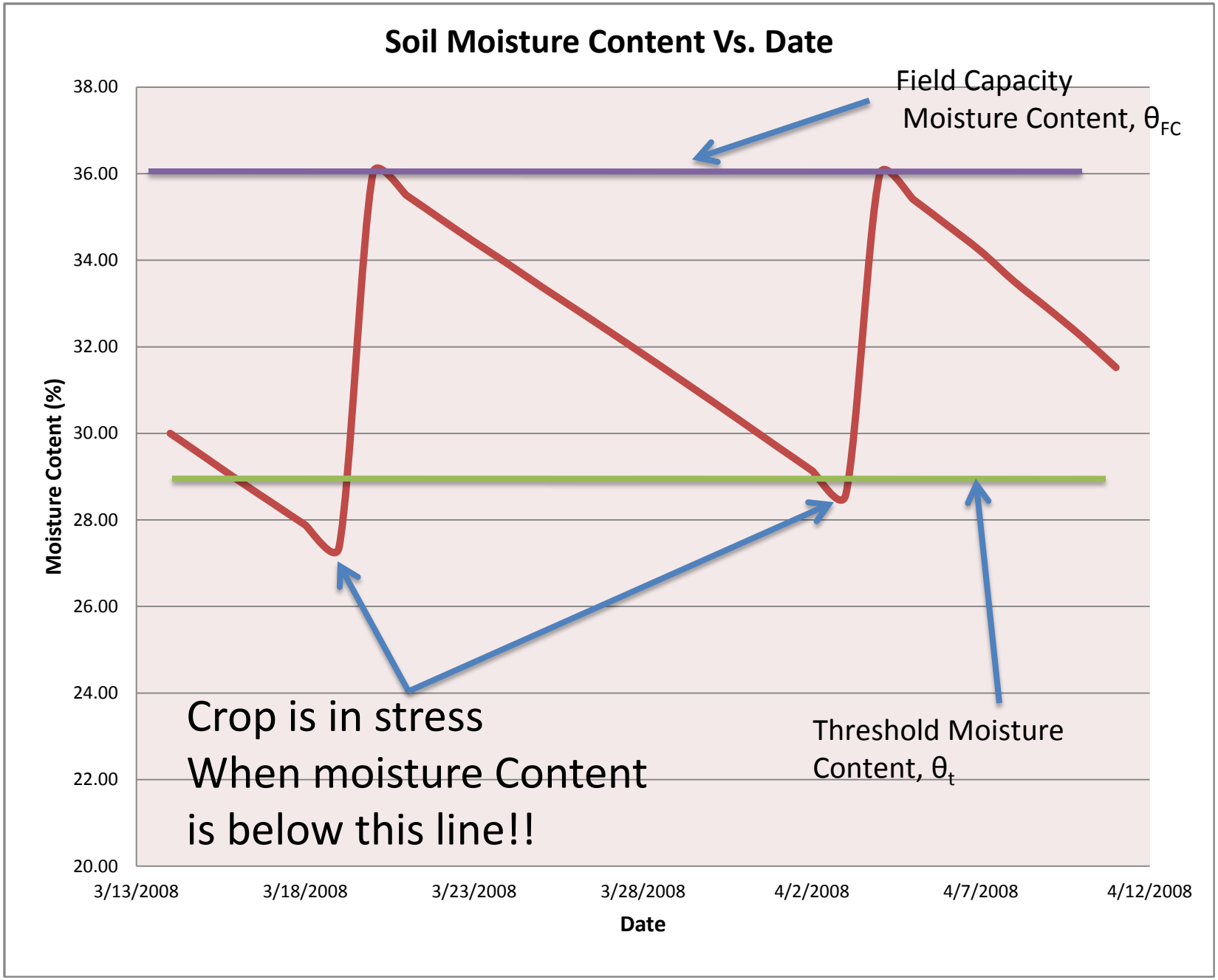
User must enter the yellow spreadsheet cells

Date	Field Capacity	Wilting Point	Total Available Water	Root Depth	Management Allowed Deficit	Readily Available Moisture Content
	FC	WP	TAW	RD	MAD	RAW
	%	%	%	m	fraction	%
3/14/2008	36	18	18	0.70	0.4	7.2
3/15/2008	36	18	18	0.71	0.4	7.2
3/16/2008	36	18	18	0.72	0.4	7.2
3/17/2008	36	18	18	0.73	0.4	7.2
3/18/2008	36	18	18	0.74	0.4	7.2
3/19/2008	36	18	18	0.75	0.4	7.2
3/20/2008	36	18	18	0.76	0.4	7.2
3/21/2008	36	18	18	0.77	0.4	7.2
3/22/2008	36	18	18	0.78	0.4	7.2
3/23/2008	36	18	18	0.79	0.4	7.2
3/24/2008	36	18	18	0.80	0.4	7.2
3/25/2008	36	18	18	0.81	0.4	7.2
3/26/2008	36	18	18	0.82	0.4	7.2
3/27/2008	36	18	18	0.83	0.4	7.2

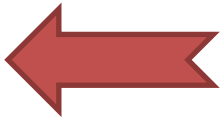
Threshold Moisture Content	Moisture Content	Crop Stress Factor	Average Crop Evapotranspiration	Average Evapotranspiration Adjusted for Stress
θ_t	θ	K_s	ET_c	$ET_{c\ adj}$
%	%		mm	mm
28.8	30.00	1.00	3.80	3.80
28.8	29.46	1.00	3.90	3.90
28.8	28.92	1.00	3.80	3.80
28.8	28.40	0.96	4.00	3.85
28.8	27.88	0.91	4.20	3.84
28.8	27.37	0.87	3.90	3.38
28.8	36.00	1.00	3.90	3.90
28.8	35.50	1.00	4.20	4.20
28.8	34.96	1.00	4.20	4.20
28.8	34.43	1.00	4.10	4.10
28.8	33.91	1.00	4.30	4.30
28.8	33.38	1.00	4.20	4.20
28.8	32.87	1.00	4.30	4.30
28.8	32.35	1.00	4.40	4.40


Crop Stress Factor Vs. Time
1.05
1.00
0.95
0.90
0.85
0.80
Crop Stress Factor, Ks
3/13/2008
3/18/2008
3/23/2008
3/28/2008
4/2/2008
4/7/2008
4/12/2008
DATE


Evapotranspiration Adjusted for Limited Water Conditions Vs. Time
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
ETc adj (mm)
3/13/2008
3/18/2008
3/23/2008
3/28/2008
4/2/2008
4/7/2008
4/12/2008
DATE


Soil Moisture Content Vs. Date
Field Capacity Moisture Content, θ_{FC}
Moisture Cotent (%)
38.00
36.00
34.00
32.00
30.00
28.00
26.00
24.00
22.00
20.00
3/13/2008
3/18/2008
3/23/2008
3/28/2008
4/2/2008
4/7/2008
4/12/2008
Date
Crop is in stress When moisture Content is below this line!!
Threshold Moisture Content, θ_t

Soil Water Deficit	Irrigation needed	Applied Irrigation or Rainfall	Did Stress Occur?
%	mm	mm	
6.0	42	0	NO
6.5	46	0	NO
7.1	51	0	NO
7.6	55	0	YES
8.1	60	0	YES
8.6	65	0	YES
0.0	0	69	NO
0.5	4	0	NO
1.0	8	0	NO
1.6	12	0	NO
2.1	17	0	NO
2.6	21	0	NO
3.1	26	0	NO
3.6	30	0	NO



Crop Stress!

Irrigation Application Rate and Timing

Irrigation Needed	Field Area	Percent Wetted Area	Irrigation Efficiency	Volume of Water to Apply	Pump Manifold Flow Rate	Time to Apply Irrigation
mm	Acres	%	%	gallons	Gallons per Minute	Hours
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0
69	5	50	90	204890	500	6.8
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0
0	5	50	90	0	500	0.0

Conclusion

Maintain soil water between θ_{FC} and θ_t