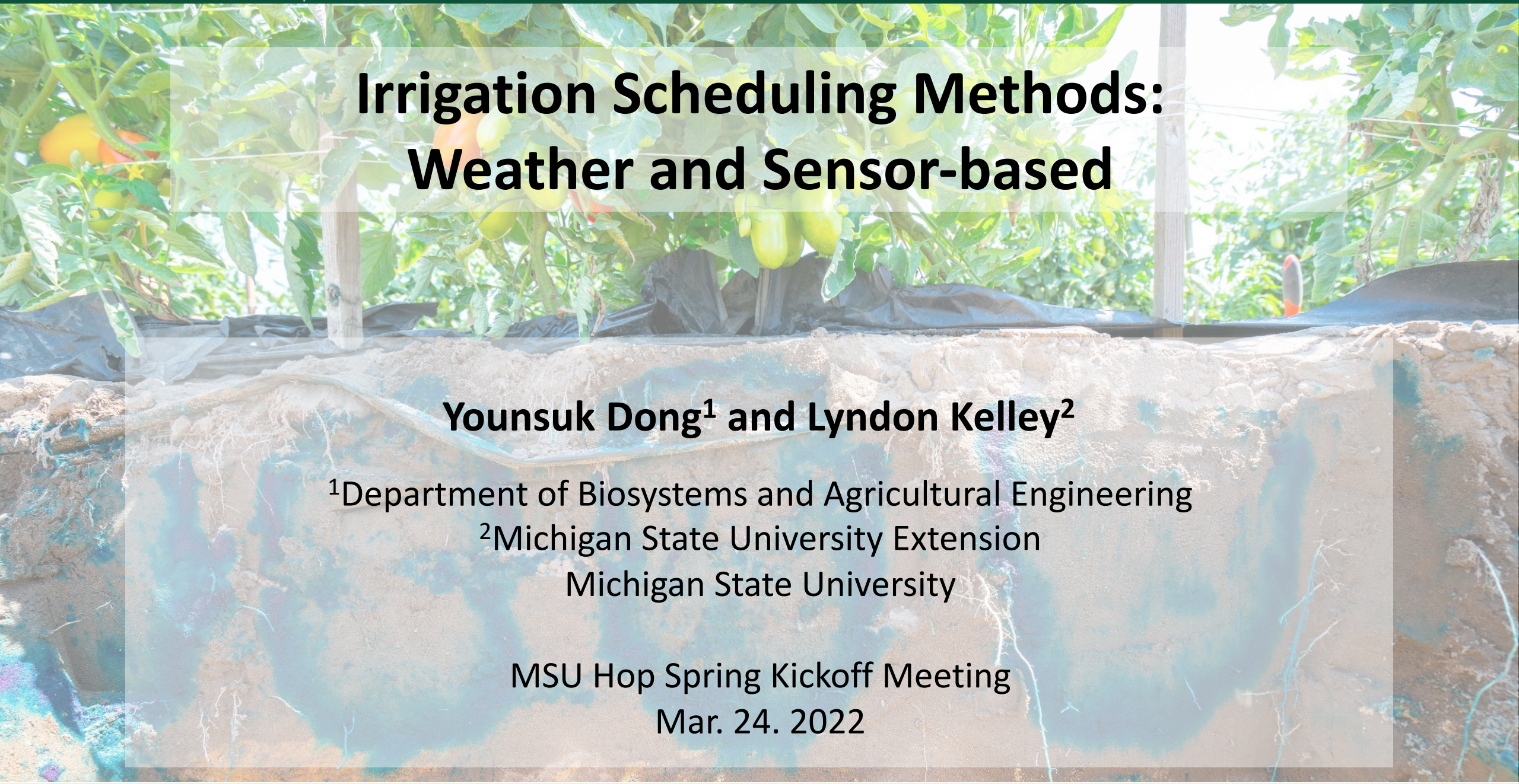

Irrigation Scheduling Methods: Weather and Sensor-based

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[1]Department of Biosystems and Agricultural Engineering
[2]Michigan State University Extension
Michigan State University

MSU Hop Spring Kickoff Meeting
Mar. 24. 2022

Why Scheduling?

- Improve water use efficiency.
- Protect the environment.
- Maximize yield and quality.

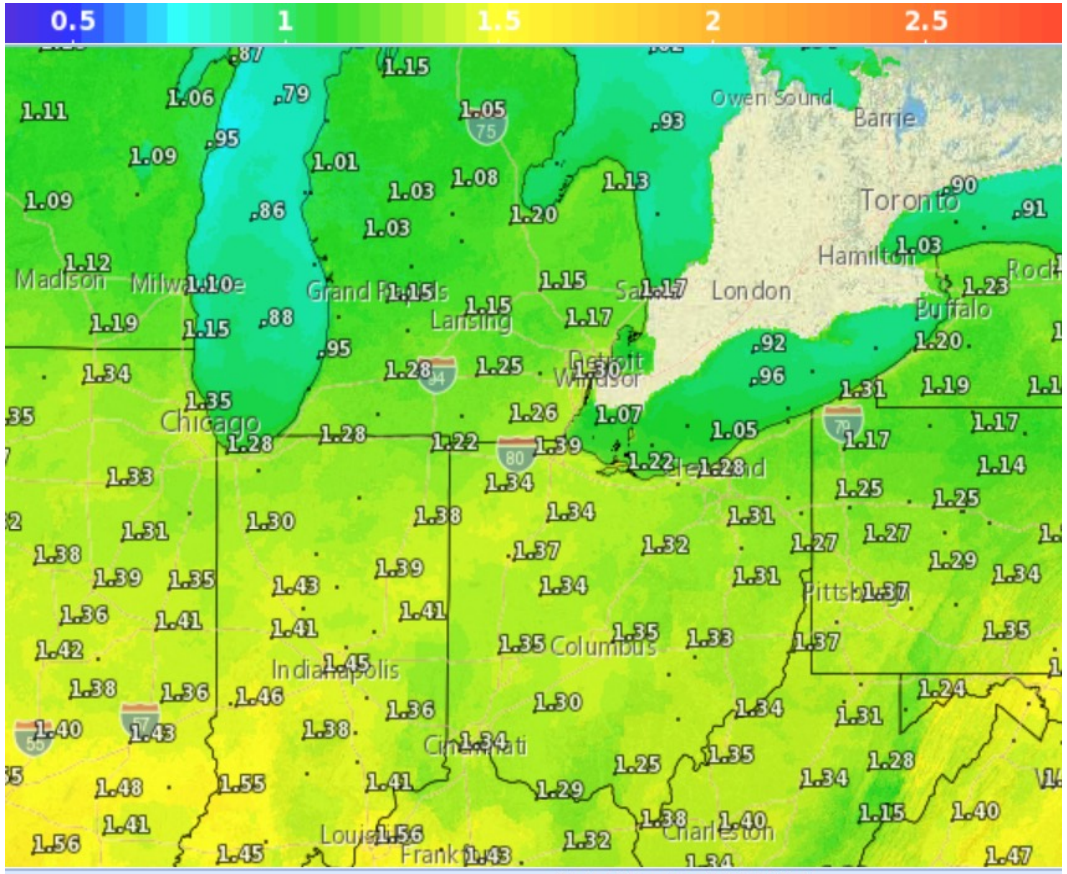
*"*To maximize yield, hops require supplemental irrigation. Michigan State University (MSU) Extension recommends ***at least 6 gallons per plant per day during June and July when the plants are growing rapidly***. *(*Sirrine*, 2014)."*

*"There was a **21 %** increase of yield on the average over the monitored years. The content of alpha bitter acids in the irrigated plants increased by **7 %** on the average in comparison with the non-irrigated group.*

(Svoboda et al. 2008)"

"Hop sensitively responds to supplementary irrigation, ***the application of which increases the yield by 20- 26 % in comparison with the non-irrigated plants*** (Slavík, Kopecký, 1997)."

Irrigation Scheduling



Weather-based Irrigation Scheduling

Sensor-based Irrigation Scheduling

Weather-based Irrigation Scheduling - Crop Evapotranspiration

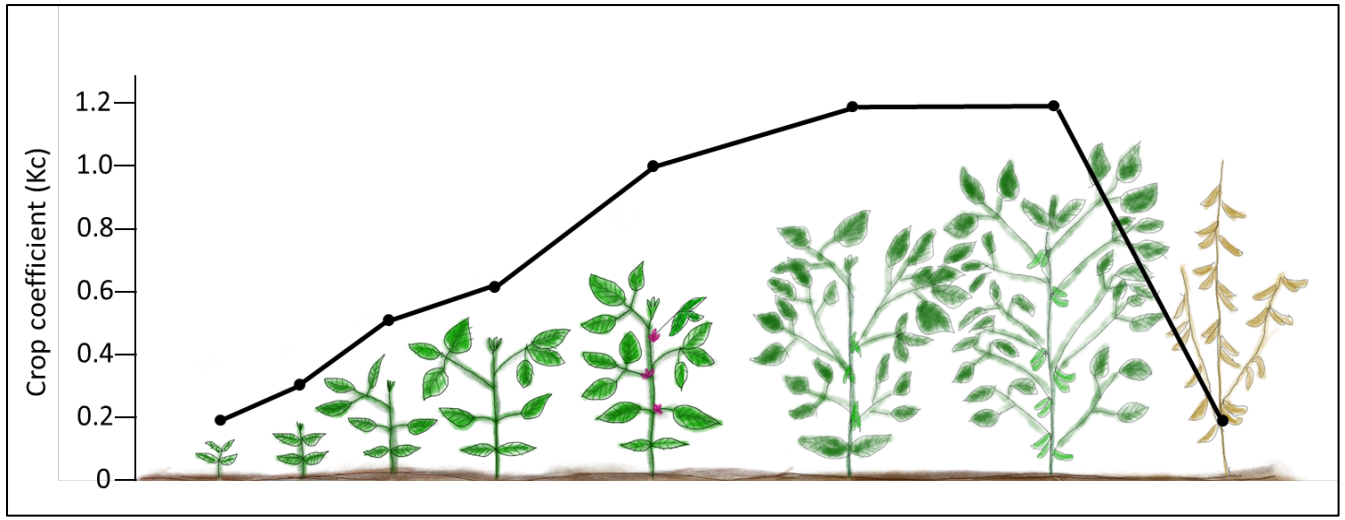
$$ET_C = K_C * rPET$$

Where,

ET_C = Actual Crop Evapotranspiration (in/day)

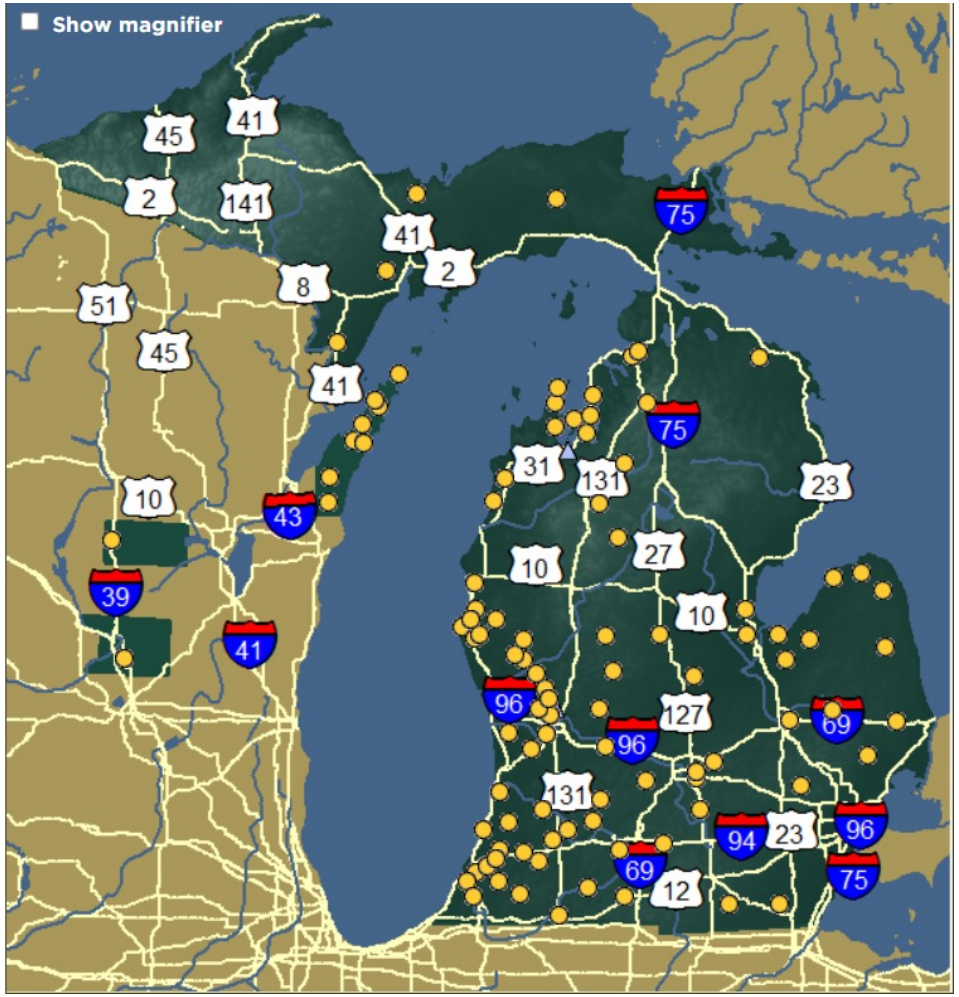
K_C = Crop Coefficient (unitless multiplier)

$rPET$ = Reference Potential Evapotranspiration (in/day)



Crop coefficient (Kc) changes as the soybean grows

MSU Enviroweather Program



https://enviroweather.msu.edu/

Example – Crop Evapotranspiration Calculation

$$ET_C = K_C * rPET$$

$$ET_C = 1.05 * 0.83\ in = 0.87\ in$$

Where,

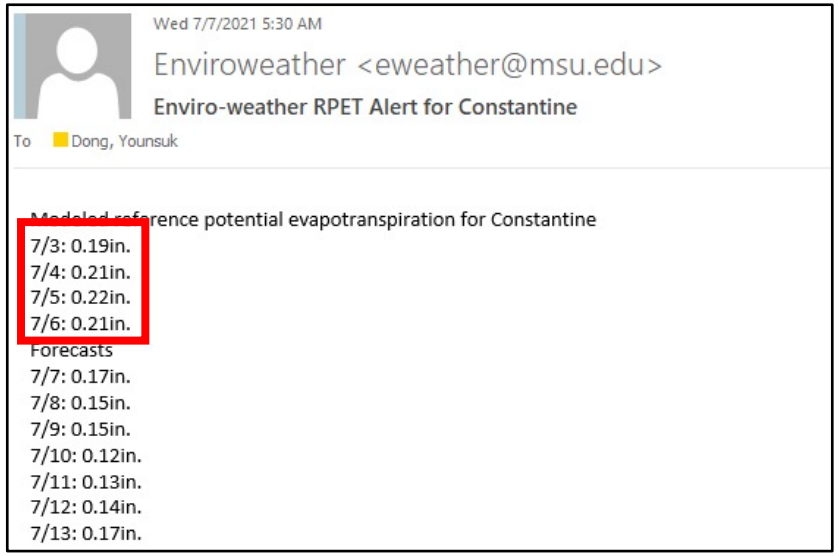
ET_C = Actual Crop Evapotranspiration (in/day)

K_C = Crop Coefficient (unitless multiplier)

$rPET$ = Reference Potential Evapotranspiration (in/day)

TABLE 12. Single (time-averaged) crop coefficients, K_c, and mean maximum plant heights for non stressed, well-managed crops in subhumid climates ($RH_{min} \approx 45\%$, $u_2 \approx 2$ m/s) for use with the FAO Penman-Monteith ET_o.

	Kc_ini	Kc_mid	Kc_end
Hops	**0.30**	**1.05**	**0.85**


Wed 7/7/2021 5:30 AM

Enviroweather <eweather@msu.edu>

Enviro-weather RPET Alert for Constantine

To Dong, Younsuk

Modeled reference potential evapotranspiration for Constantine

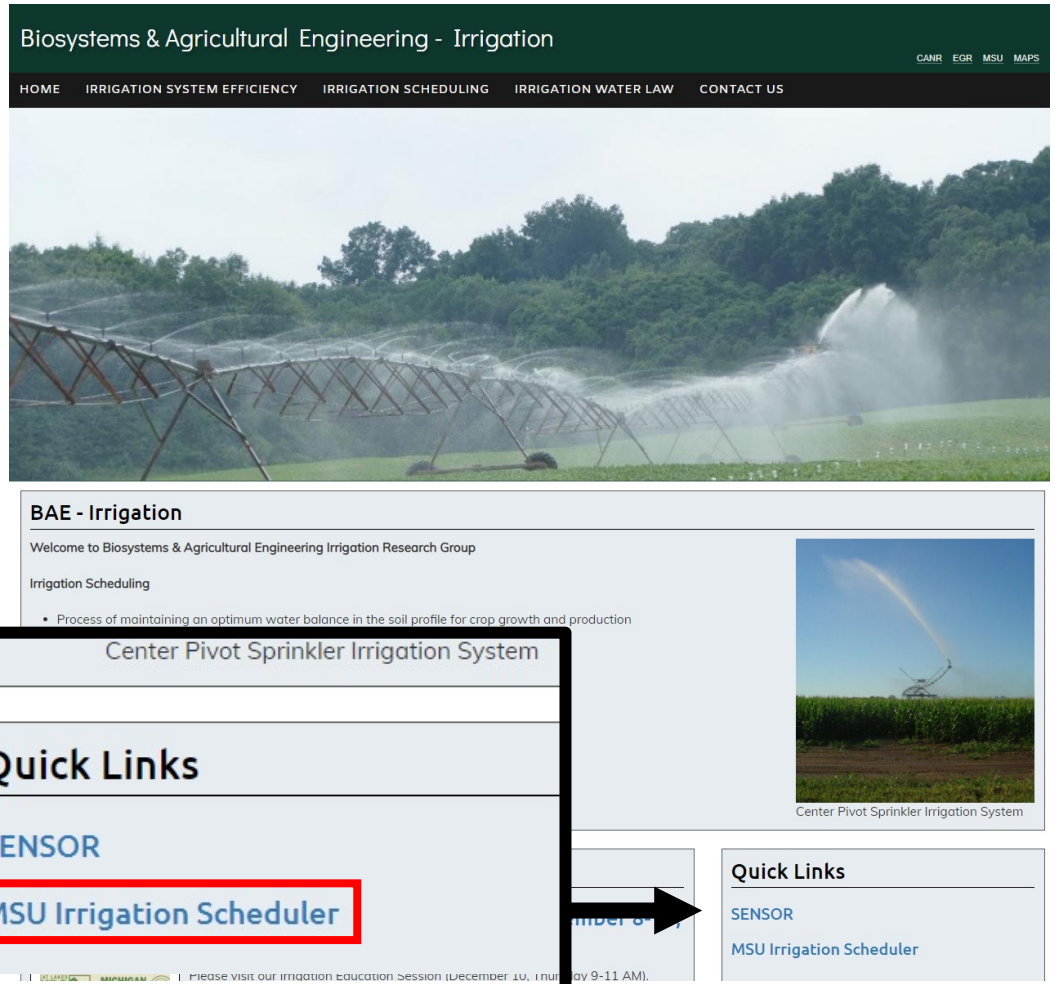
7/3: 0.19in.
7/4: 0.21in.
7/5: 0.22in.
7/6: 0.21in.

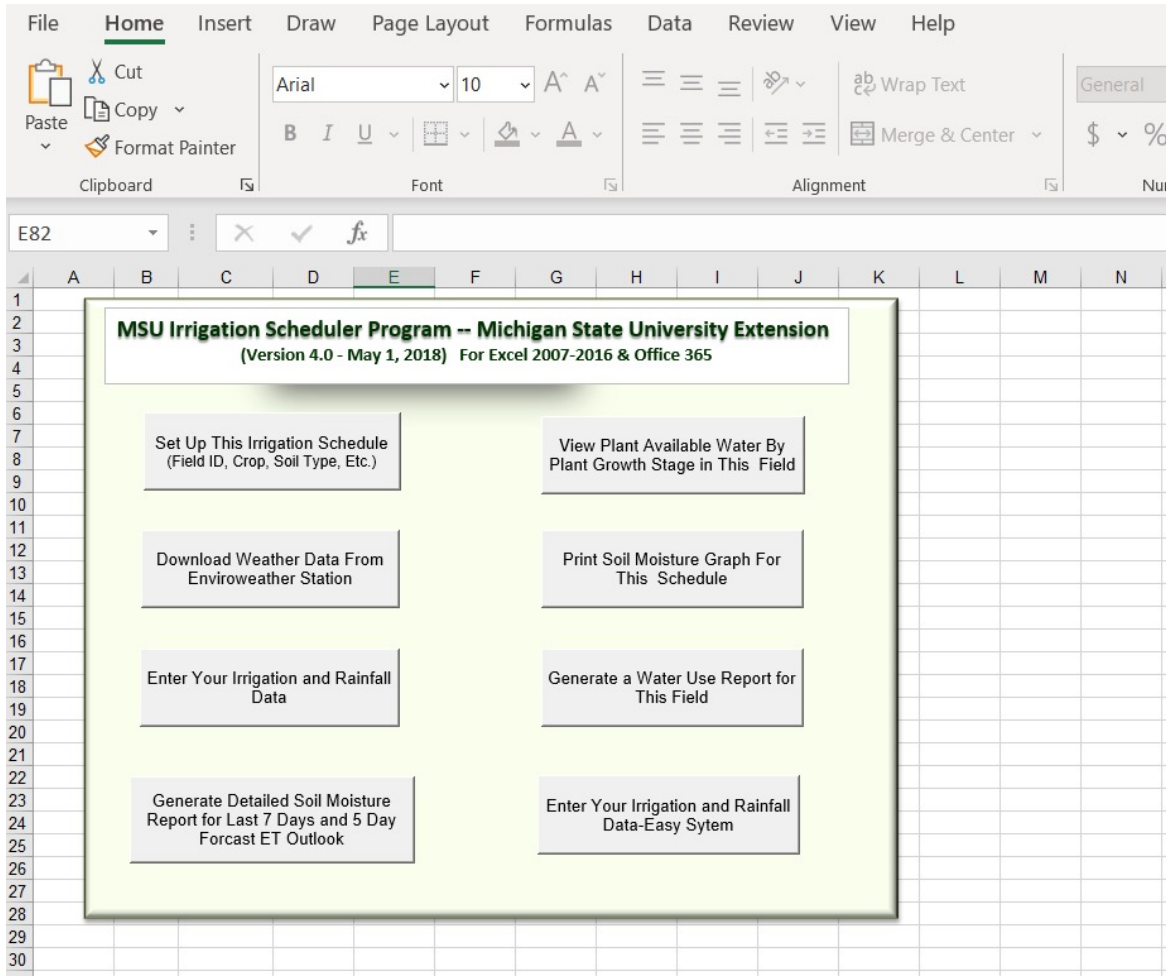
Forecasts

7/7: 0.17in.
7/8: 0.15in.
7/9: 0.15in.
7/10: 0.12in.
7/11: 0.13in.
7/12: 0.14in.
7/13: 0.17in.

https://www.egr.msu.edu/bae/water/irrigation/

MSU Irrigation Scheduler Program

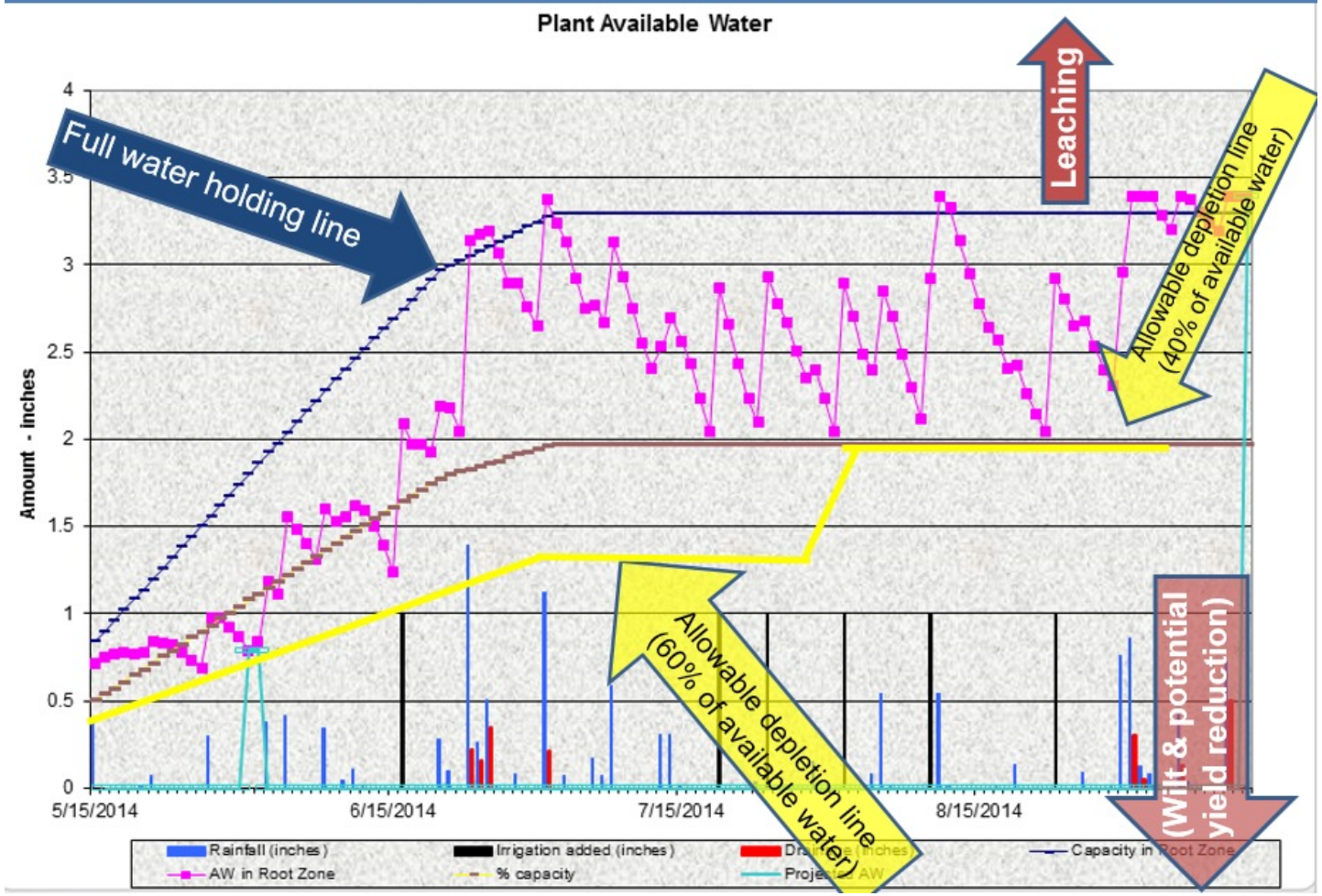




www.egr.msu.edu/bae/water/irrigation

MSU Irrigation Scheduler Program

MSU Excel Irrigation Schedule Checkbook Method - Mendon 2014



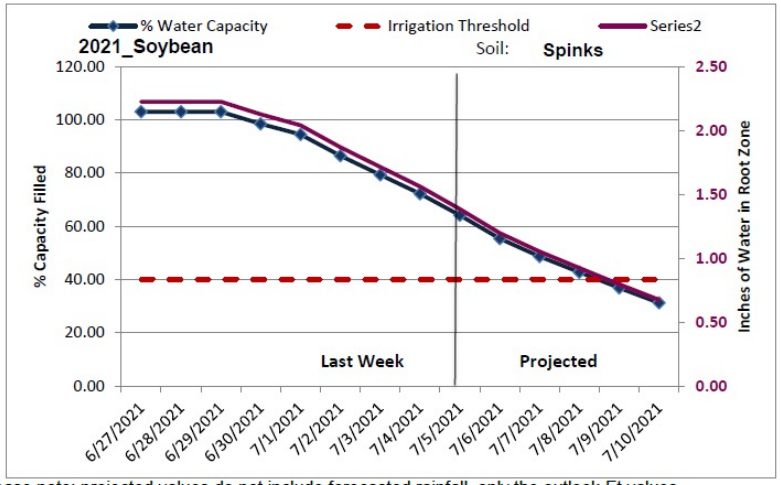
St. Joseph County Soil and Water Conservation District Irrigation Scheduling Service

Weekly Water Balance Report and Et Outlook for Next 5 Days

Generated: 07/06/21 MSU Irrigation Scheduler

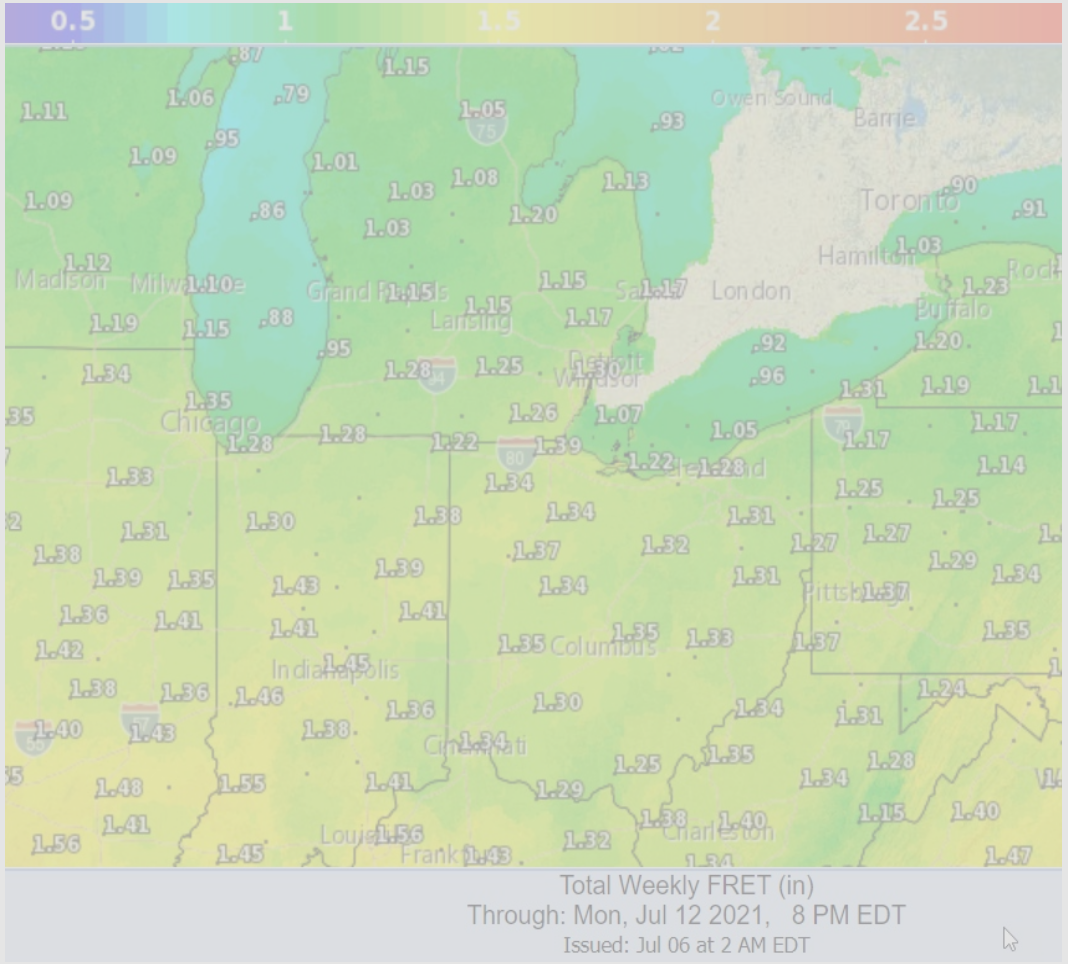
Field Name	2021_Soybean
Crop:	Soybeans24
Emergence Date:	5/16/2021

Date	Rainfall	Irrigation	Crop Et	Forecasted Et	Drainage	AW Above Threshold	Additional Capacity
6/27/2021	0.16		0.06		0.02	1.30	0.00
6/28/2021	0.32		0.11		0.21	1.30	0.00
6/29/2021	1.18		0.11		1.07	1.30	0.00
6/30/2021	0.02		0.12		0.00	1.26	0.03
7/1/2021	0		0.09		0.00	1.18	0.12
7/2/2021	0		0.17		0.00	1.00	0.29
7/3/2021	0		0.15		0.00	0.85	0.45
7/4/2021	0		0.15		0.00	0.70	0.60
7/5/2021	0		0.18		0.00	0.52	0.77
7/6/2021			0.1888		0.00	0.33	0.96
7/7/2021				0.15	0.00	0.19	1.11
7/8/2021				0.13	0.00	0.06	1.24
7/9/2021				0.13	0.00	-0.07	1.36
7/10/2021				0.12	0.00	-0.19	1.49
Totals	1.68	0	1.14	0.52	1.30		



Please note: projected values do not include forecasted rainfall, only the outlook Et values.
Irrigation Threshold: Dropping below this level may cause yield loss. To avoid, initiate irrigation.
Enviroweather Station Selected: Constantine

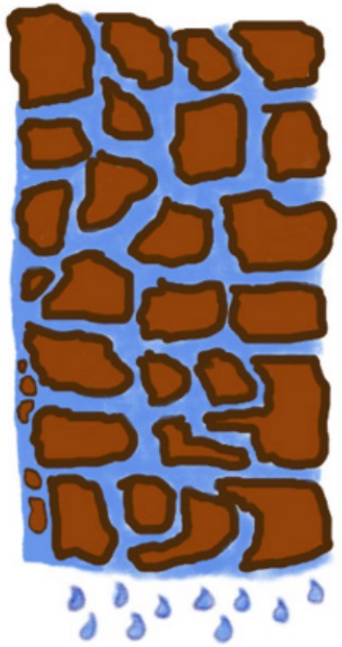
Irrigation Scheduling



Weather-based Irrigation Scheduling

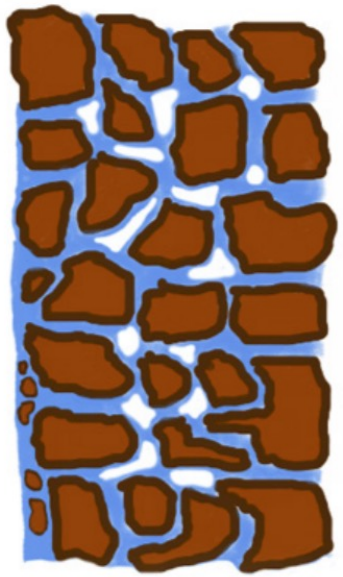
Sensor-based Irrigation Scheduling

Terminology for Irrigation Scheduling



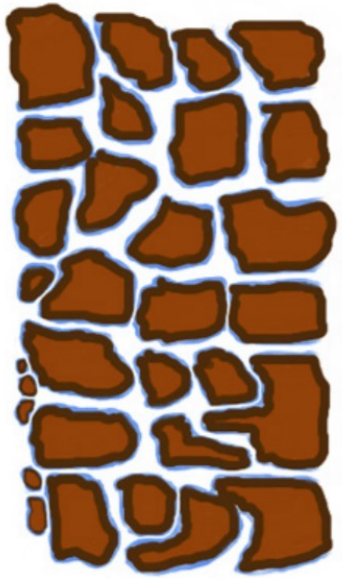
Saturation

All soil pore spaces are filled with water.



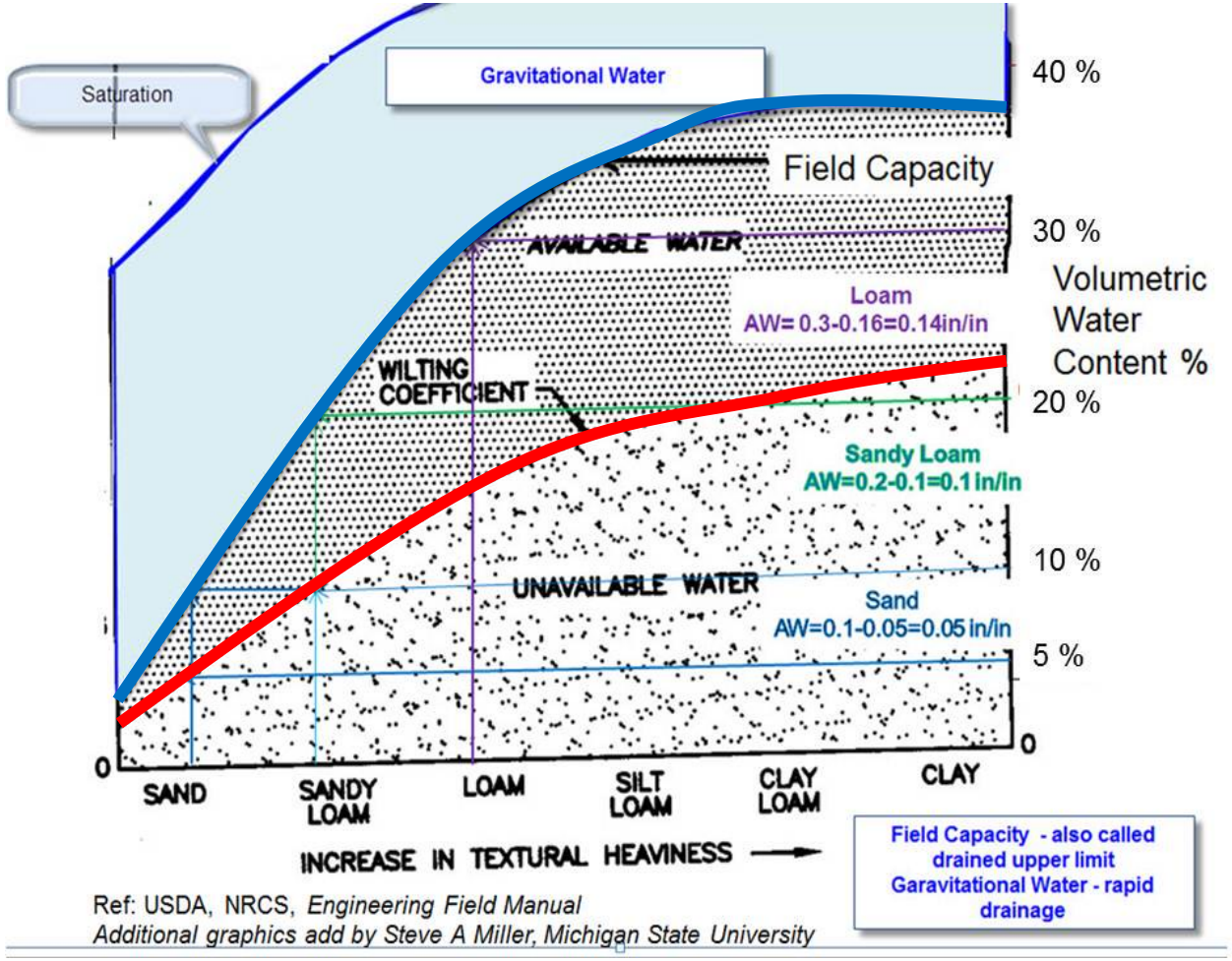
Field Capacity

Maximum amount of water that soil can hold after drainage.



Wilting Point

Soil moisture level where there is no available water for the crop.



Ref: USDA, NRCS, *Engineering Field Manual*
Additional graphics add by Steve A Miller, Michigan State University

Field Capacity, Wilting Point, and Available Water

Soil texture	FC (%)	WP (%)	AW (%)
Sand	9.4	5	4.4
Loamy sand	12	5.7	6.3
Sandy loam	17.9	8.1	9.8
Loam	31	14	17

Irmak, S., Payero, J. O., VanDeWalle, B., Rees, J., & Zoubek, G. (2014). Principles and operational characteristics of Watermark granular matrix sensor to measure soil water status and its practical applications for irrigation management in various soil textures.

Calculating Water Holding Capacity

Soil Name	Depth Inches	Available water holding capacity	Average Available water holding capacity	Ave. Available water holding capacity (24 in.)	Ave. Available water holding capacity (36 in.)
Oshtemo	0 - 14 14 – 35 35 - 60	0.10 – 0.15 0.12 – 0.19 0.06 – 0.10	0.125 0.155 0.08	14” x 0.125=1.75 10” x 0.155=1.55 ---------- = 3.3	14” x 0.125= 1.75 21” x 0.155= 3.26 1” x 0.08 = 0.08 ---------- = 5.09
Spinks	0 – 10 10 – 26 26 - 60	0.08 – 0.10 0.08 – 0.10 0.04 – 0.08	0.09 0.09 0.06	10” x 0.09= 0.9 14” x 0.09= 1.26 ---------- = 2.16	10” x 0.09= 0.9 16” x 0.09= 1.26 8” x 0.06= 0.48 ---------- = 2.64

Soil Moisture Sensors

EC-5

Soil Watch 10

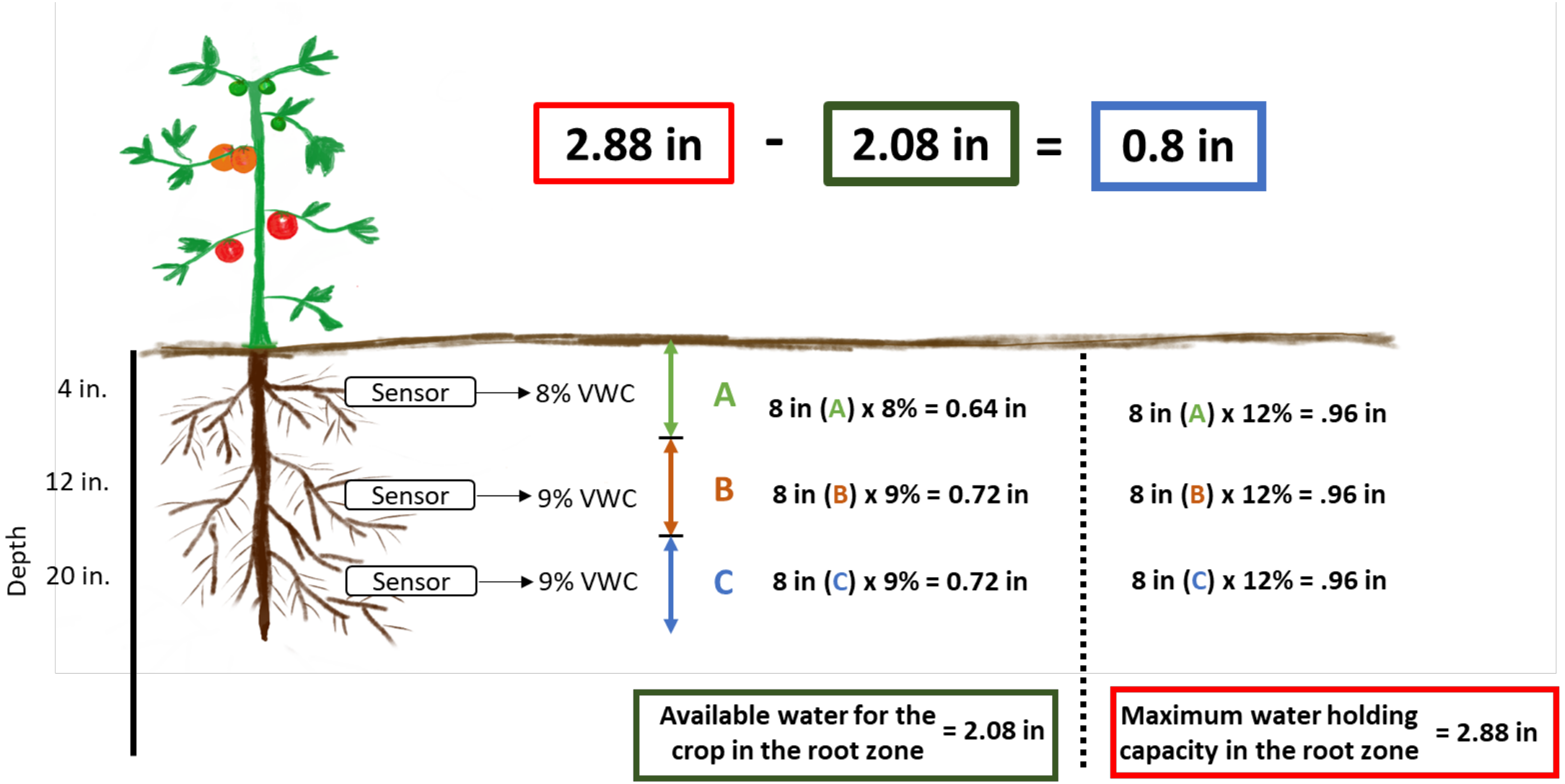
SoilVUE10

10HS

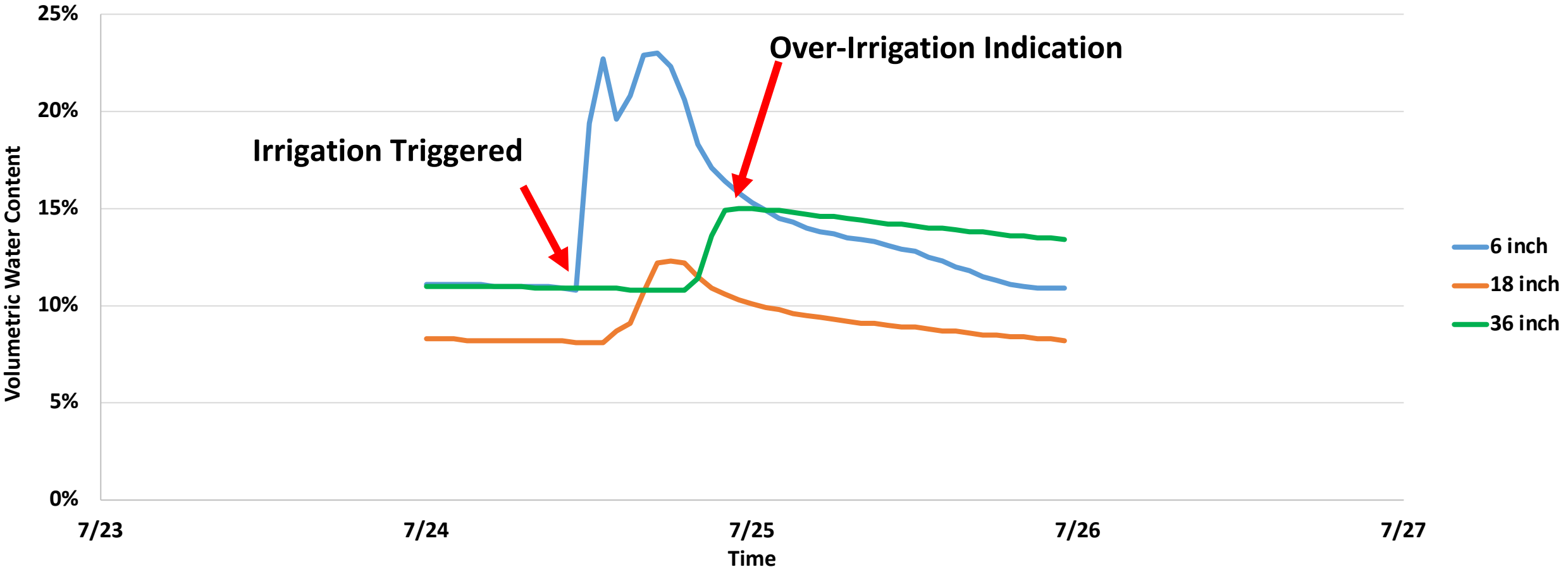
Teros 12

WATERMARK

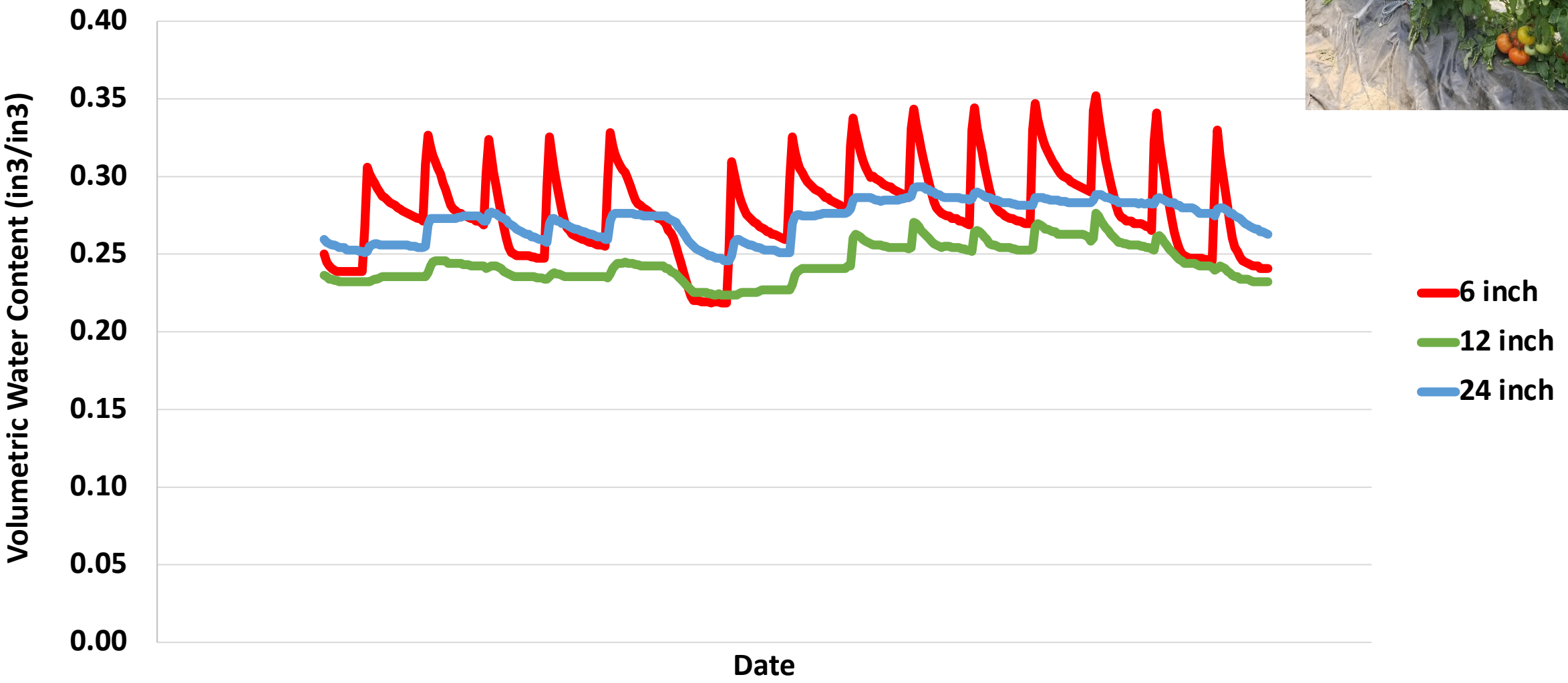
Example – Irrigation Amount



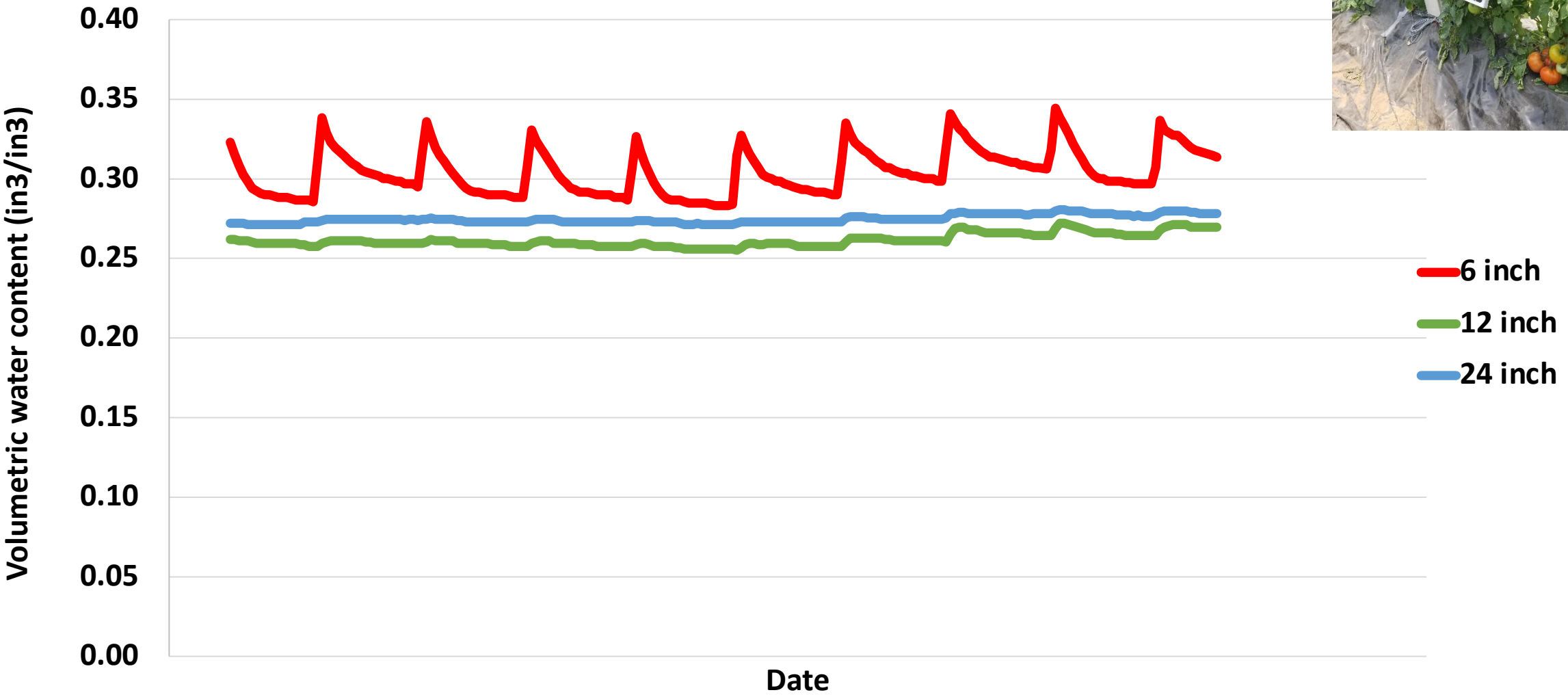
Example – Over Irrigation



Tomato – Drip Irrigation



Tomato – Drip Irrigation (After adjustment)



Sensor Installation Considerations

- Root depth.
- Wetting zone.
- No air gap.

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Biosystems and Agricultural Engineering – Irrigation

https://www.egr.msu.edu/bae/water/irrigation/

MSU Extension – Irrigation

https://www.canr.msu.edu/irrigation