Soil Moisture Monitoring: Meeting Crop Need and Estimating Water Loss Out of the Root Zone

Michiana Irrigated Corn and Soybean Production Workshop

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MICHIGAN STATE UNIVERSITY | Extension

Objective

Compare the different types of volumetric water content sensors at multiple soil depth. Sensor include Campbell Scientific, Sentek, METER Group, and Watermark Blocks.

Irrometer

Is the least expensive option and a handheld reading tool can measure soil water tension in multiple sites, but not continuously.

- **Tensiometer** measures the actual soil water tension, which indicates the effort required by root system to extract water from the soil.
- **Watermark Soil Moisture Sensor** is a solid state electrical resistance sensing device, which is another method to measure soil water tension.
- **Watermark Monitor** is a data logger that automatically reads and records up to 8 sensors at a selected interval.

Tensiometer

Watermark

Watermark Monitor

Handheld reading tool

METER Group

Is slightly more expensive, but it is easy to set up (plug and play) and operate.

- **EC-5**
  - Low cost volumetric water content sensor, which is measured by dielectric constant of the media using capacitance/frequency domain technology.
  - Affordable and ideal for large sensor networks.
- **10HS**
  - Temperature
  - Large volume soil moisture sensor.
  - Similar to EC-5 but better at averaging varying soil moisture.
- **Teros 12**
  - Measures volumetric water content.
  - Robust steel needles for easy installation and better soil-sensor contact.
- **EM 60G**
  - Remote monitoring system.
  - Six sensor ports.
  - Built-in solar panel and rechargeable battery.

EC-5

10HS

Teros 12

EM 60G

Sentek

Measure volumetric water content at multiple depths, and is sensitive.

- Measures soil moisture every 4 inch up to 4 ft depth.
- Uses frequency domain reflectometry, which measures the soil dielectric by placing the soil between two electrical plates to form a capacitor.

Overview of system

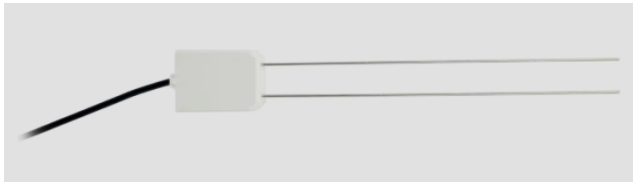
EnviroSCAN

Campbell Scientific

- **CS 616**
  - Measures volumetric water content from 0% to saturation.
  - Is high accuracy and high precision (±2.5% volumetric water content)
  - Uses time-domain reflectometry, which means the speed of an **electromagnetic signal** passing through a material varies with the dielectric of the material.
- **CR 1000 data logger** collects and stores data and is reliable for extreme environment. This can be converted to a remote monitoring system with cellular modem and solar panel.

Overview of system

CR 1000 data logger



CS 616

Cost comparison of soil moisture sensor systems

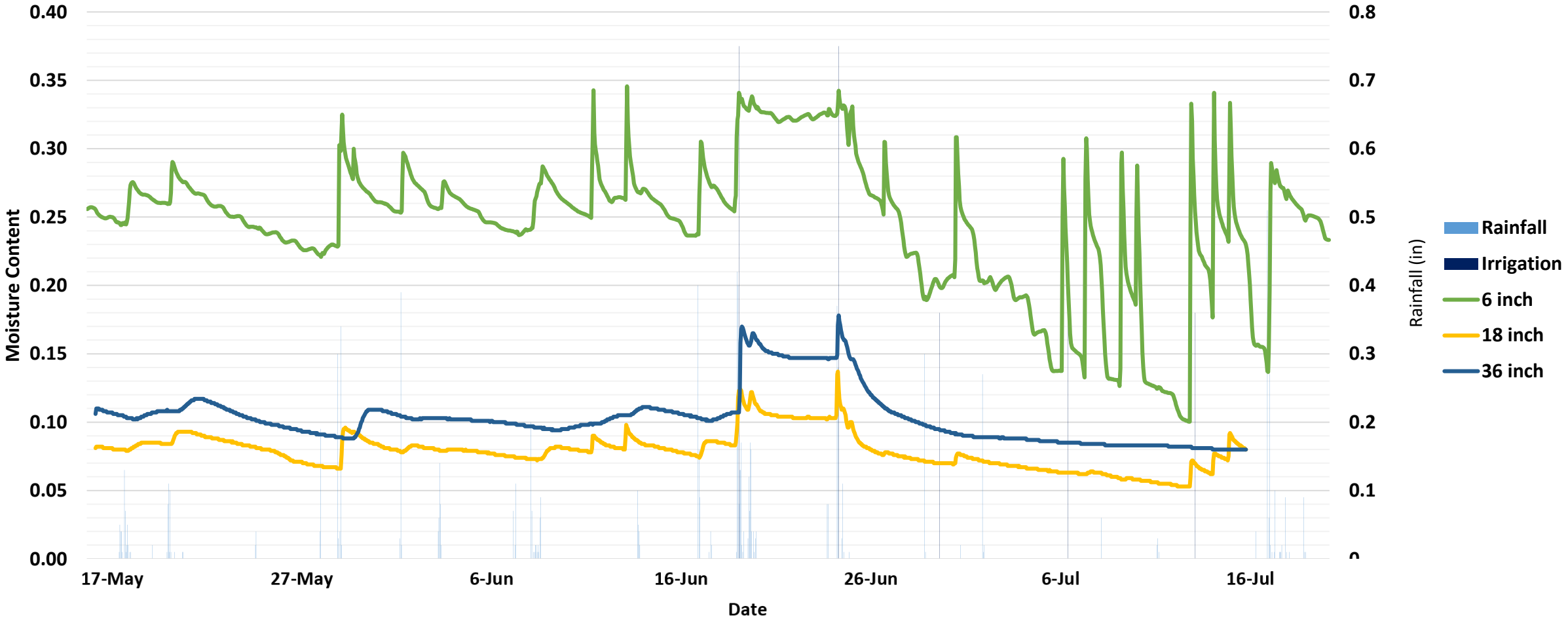
System	Single site with 5 sensors ($)	Advantages
IRROMETER handheld	$440	It can be taken to multiple sites
IRROMETER data logger	$933	Continuous data collection, Rain gauge capable
IRROMETER data logger cell	$2,528	Continuous data collection, Rain gauge capable, Remote data accessible
METER Group	$1,071 - 1,621	Continuous data collection, Rain gauge capable
METER Group cell	$1,890 - 2,440	Continuous data collection, Rain gauge capable, Remote data accessible
Campbell scientific	$2,990	Continuous data collection, Rain gauge capable
Campbell scientific cell	$3,783	Continuous data collection, Rain gauge capable, Remote data accessible
Sentek	$2,609	Continuous data collection, Rain gauge capable, Read every 4 inches
Sentek cell	$3,059	Continuous data collection, Rain gauge capable, Remote data accessible, Read every 4 inches

Southwest Michigan Research and Extension Center

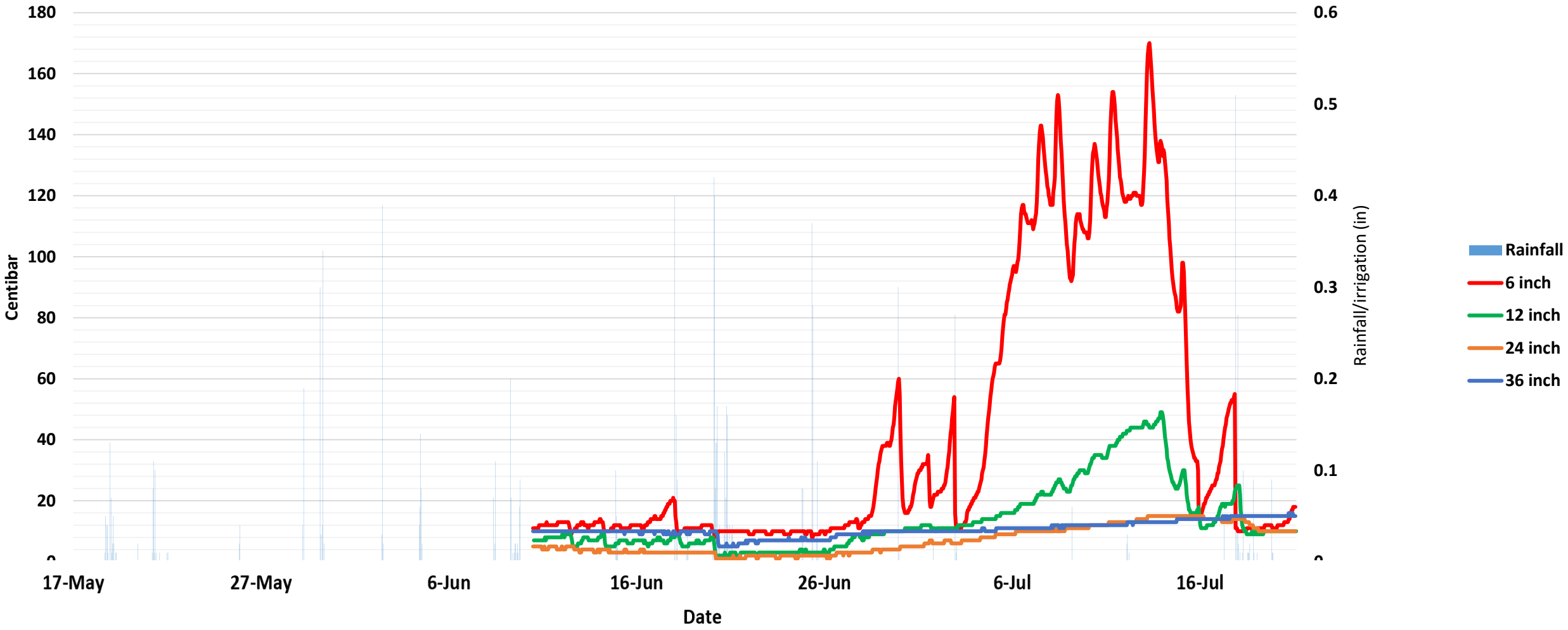
Soil type

Depth	Sweet Corn		Tomato
	Subsurface Drip Irrigation	Surface Drip Irrigation	Subsurface Drip Irrigation
6 inch	Loamy Sand	Loamy Sand	Loamy Sand
12 inch	Loamy Sand	Loamy Sand	Loamy Sand
18 inch	Sand	Sand	Loamy Sand
24 inch	Sand	Sand	Loamy Sand
36 inch	Sand	Sand	

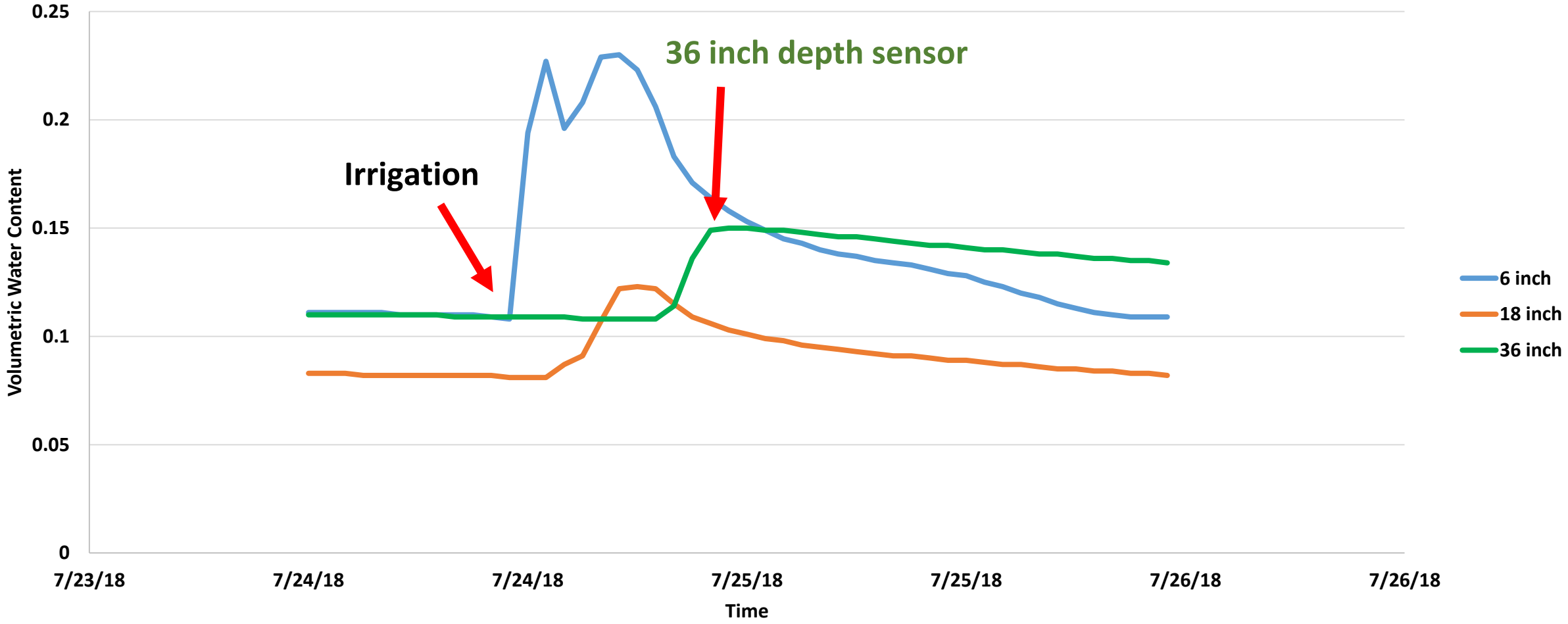
Sweet Corn – Campbell Scientific



Sweet Corn – Watermark

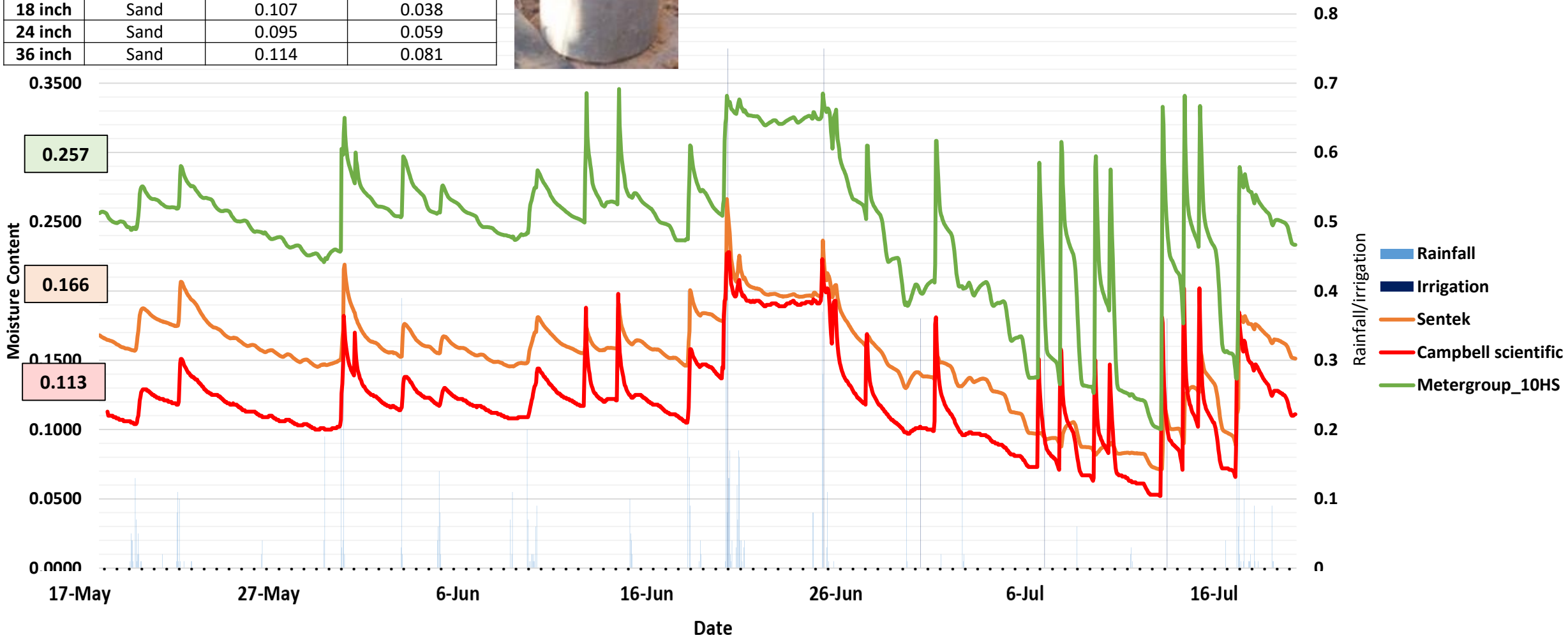


Example of data analysis



Sweet Corn – at 6 inch depth

Depth	Subsurface Corn		
	Texture	Initial VWC	VWC (7/17/18)
6 inch	Loamy Sand	0.138	0.167
12 inch	Loamy Sand	0.119	0.082
18 inch	Sand	0.107	0.038
24 inch	Sand	0.095	0.059
36 inch	Sand	0.114	0.081

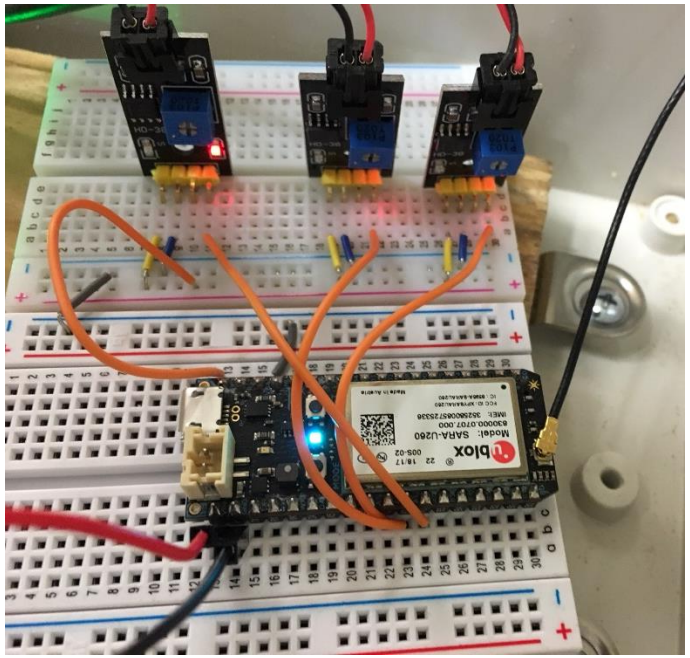


Conclusion

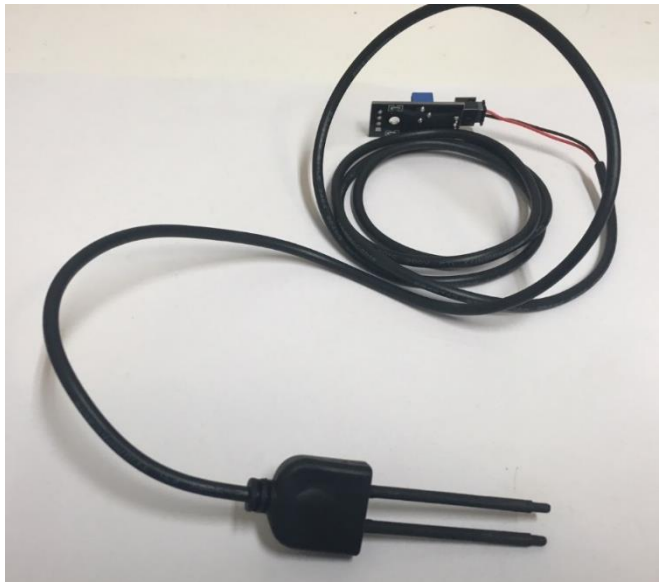
- Selection of sensor system should consider purpose, sensitivity, and economic.
- Sensor calibration for specific site condition is recommended.
- Metergroup 10HS and EC-5, Sentek, and Campbell Scientific sensors are sensitive to measure the moisture content of soil.
- Watermark sensor is not as sensitive as other sensors, but it provides a general idea of the soil's moisture condition.
- Sensor can help improve the water use efficiency.

Low-cost soil moisture sensor system

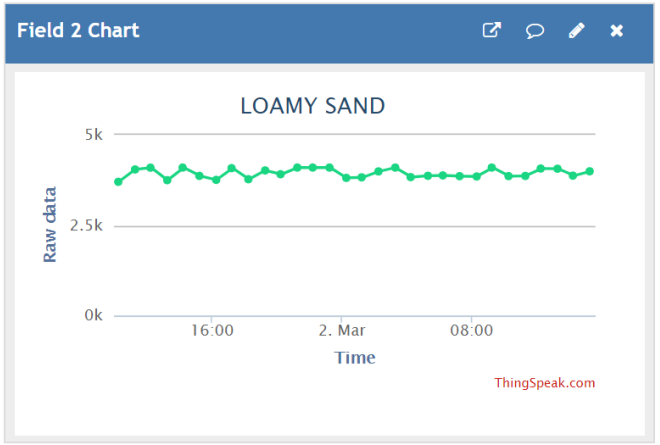
- Remote monitoring system.
- Development of the system in on-going.
- Cost of a system (5 sensors) is around $200.

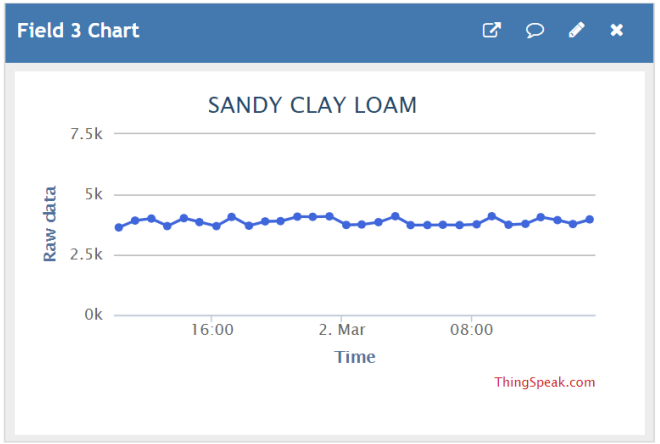


Particle Electron



Soil moisture sensor





Example of cloud system

Water Use Efficiency using AquaCrop

Main menu

Environment and Crop

Climate

Climate | (None) | Specify climatic data when Running AquaCrop

Crop

Growing cycle: Day 1 after sowing: 22 March - Maturity: 24 July

Crop | DEFAULT.CRO | a generic crop

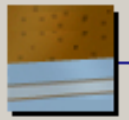
Calendar mode

Management

Irrigation | (None) | Rainfed cropping

Field | (None) | No specific field management

Soil



Soil profile | DEFAULT.SOL | deep loamy soil profile

Groundwater | (None) | no shallow groundwater table

Simulation

Simulation period | Simulation period: From: 22 March - To: 24 July

Initial conditions | (None) | Soil water profile at Field Capacity

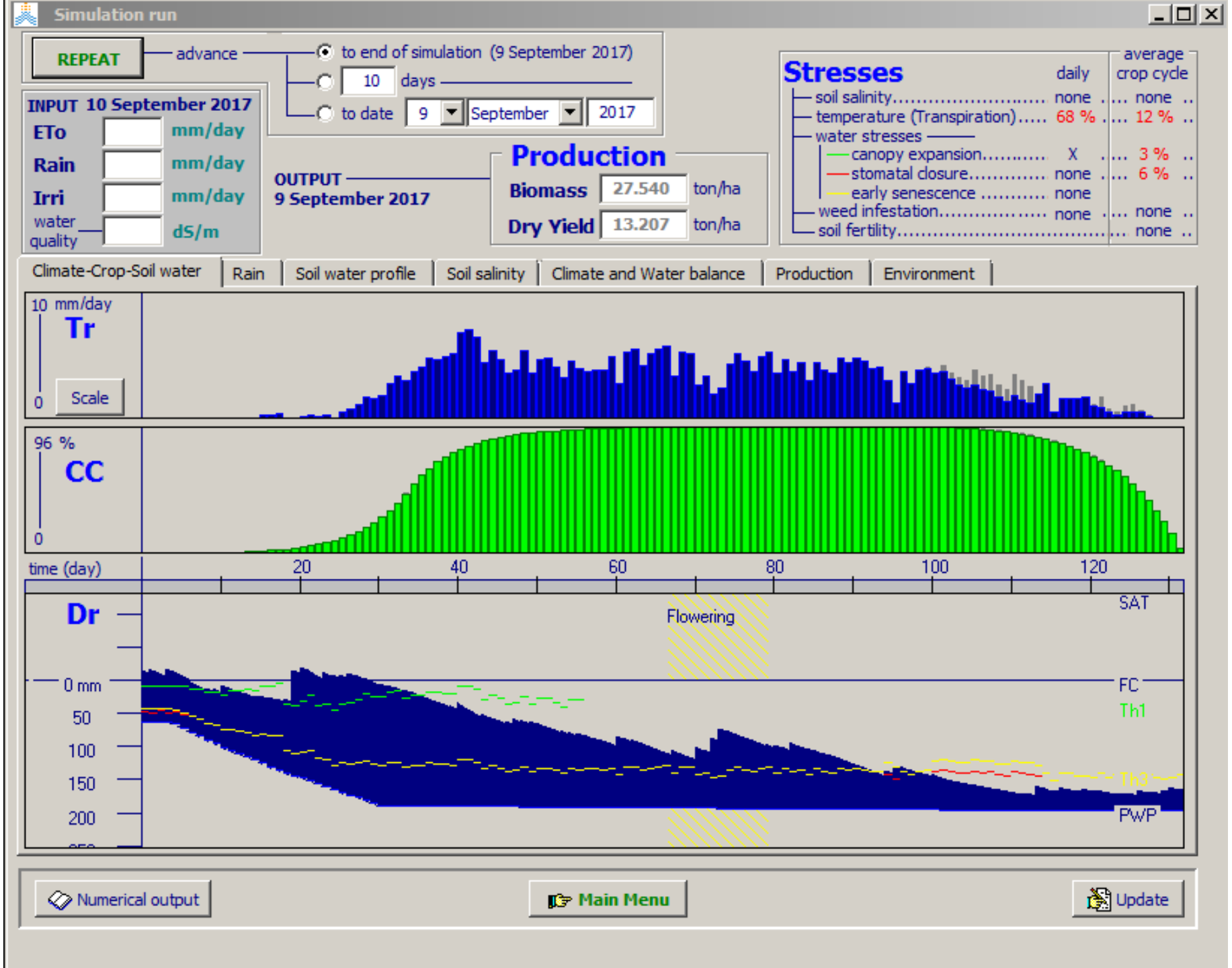
Off-season | Simulation period linked to cropping period

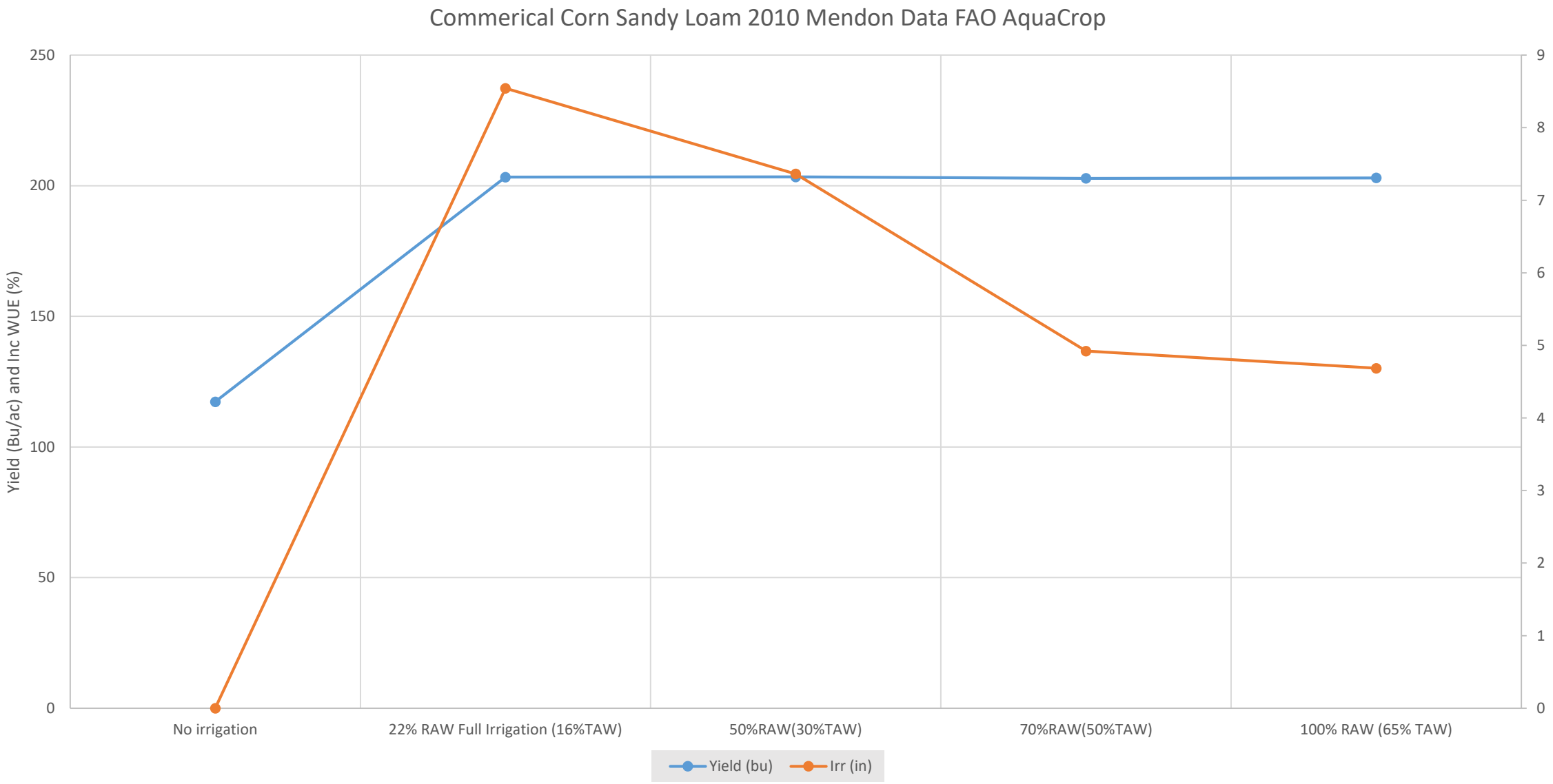
Project | (None) | No specific project

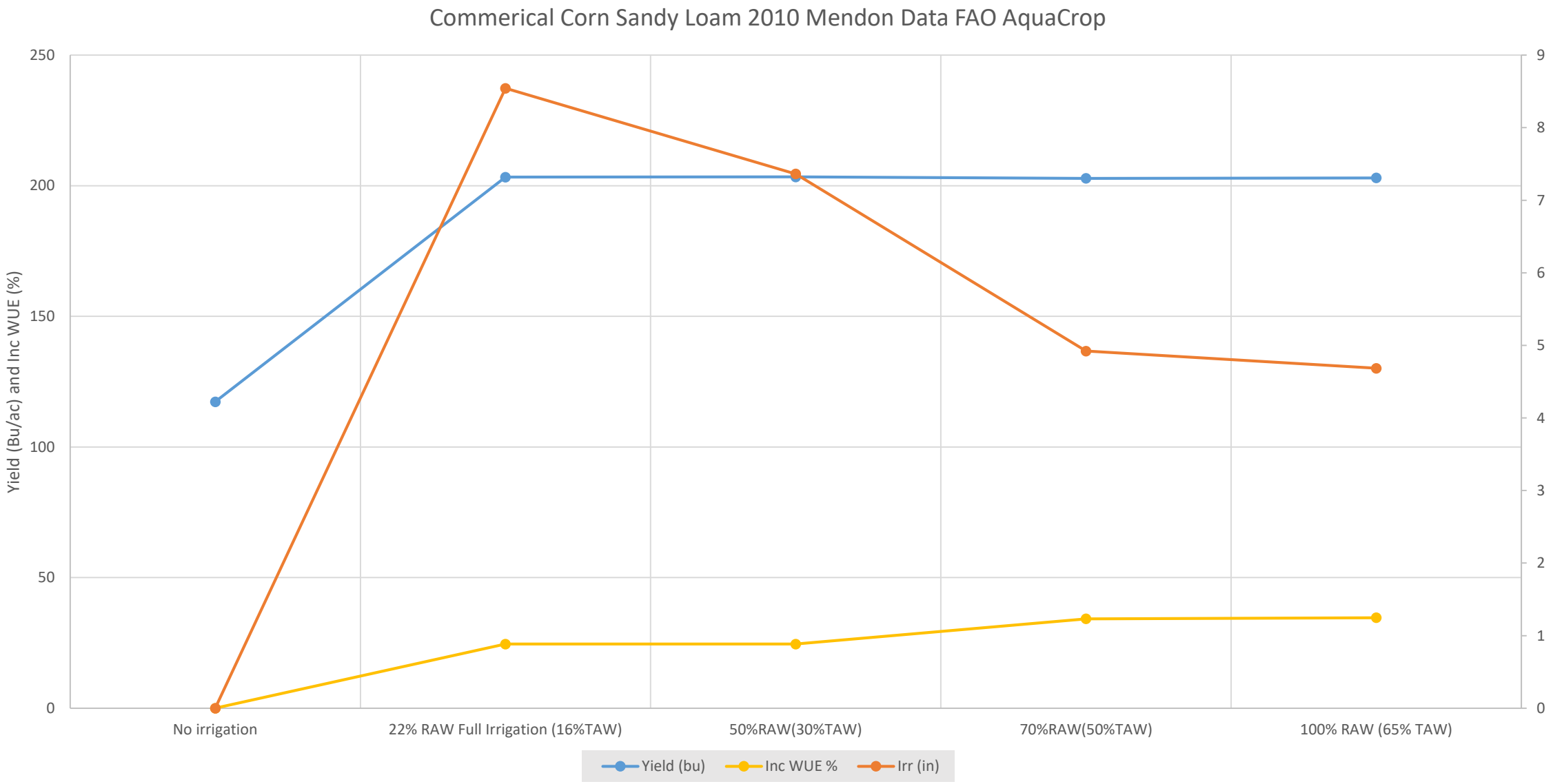
Field data | (None) | No field observations

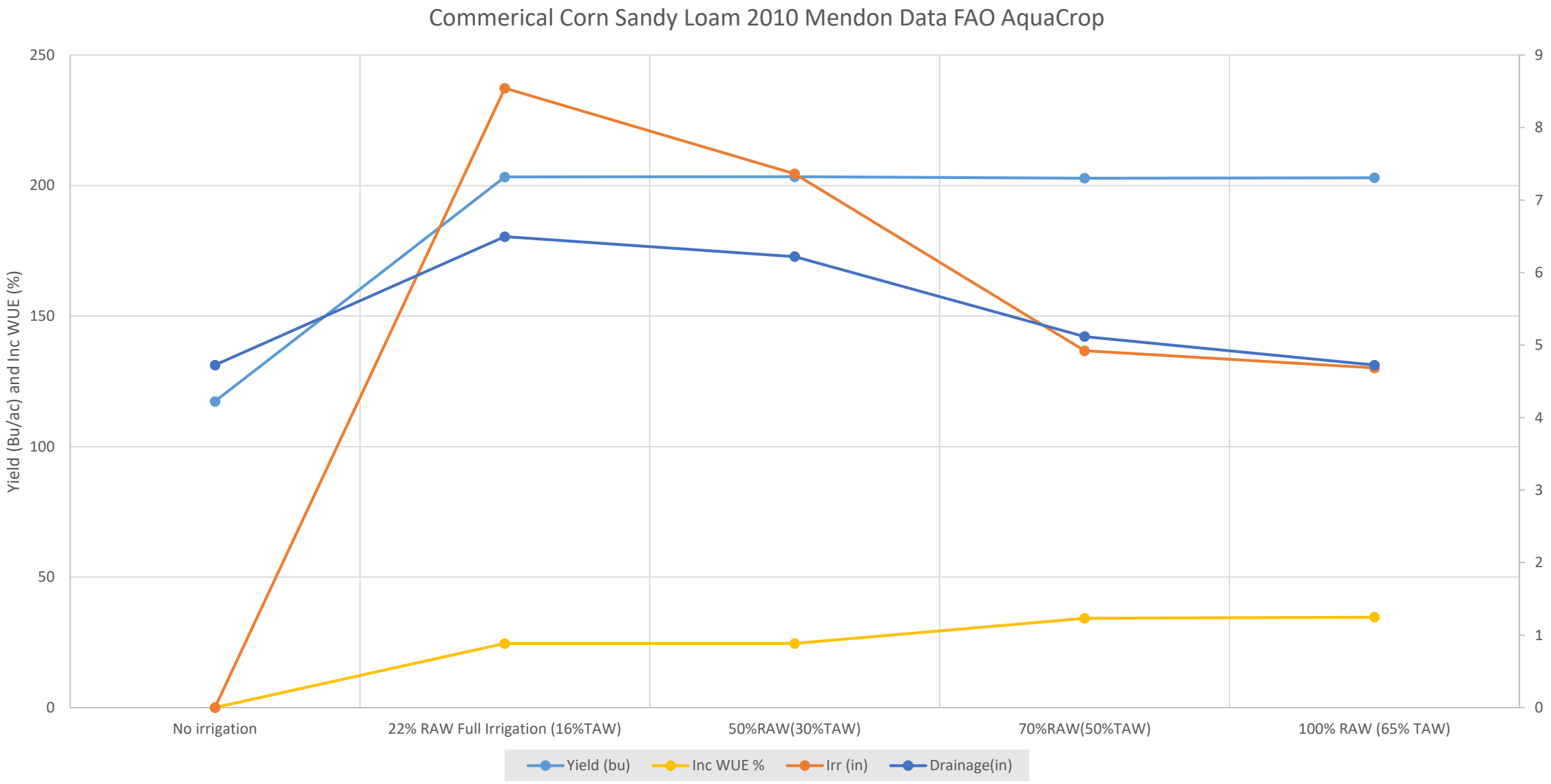
Run <<<

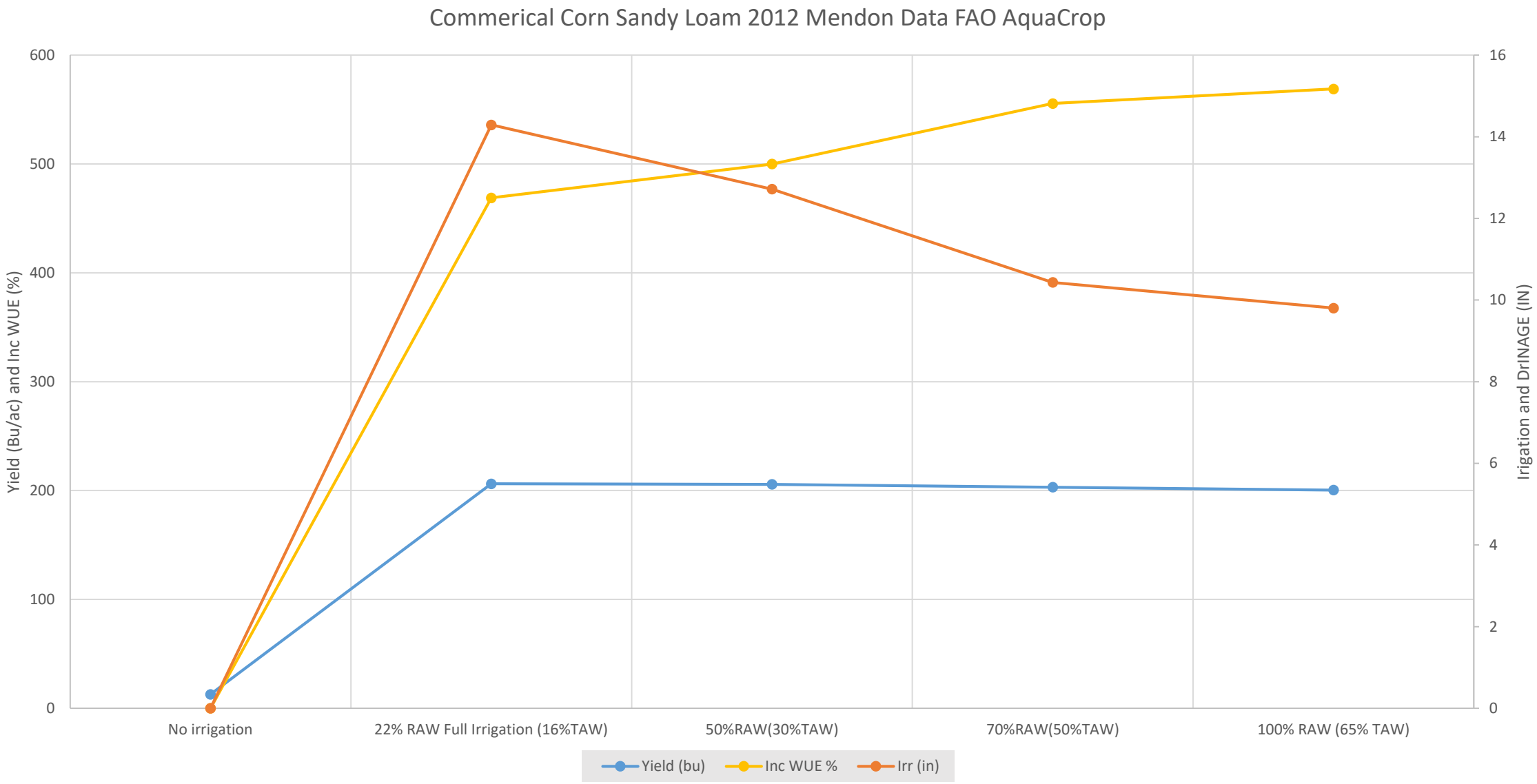
Exit Program

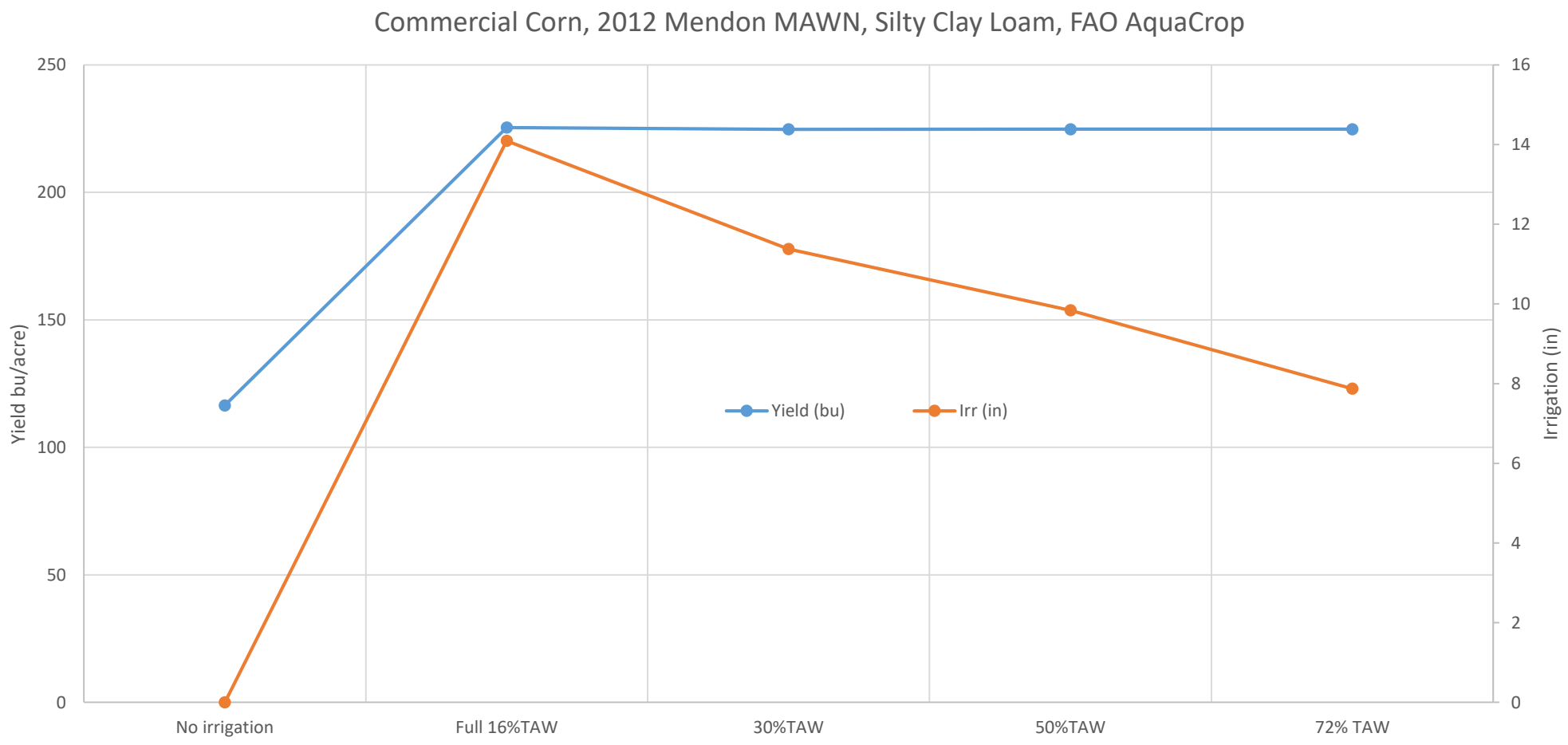

Simulation run
REPEAT
advance
to end of simulation (9 September 2017)
10 days
to date 9 September 2017
INPUT 10 September 2017
ETo mm/day
Rain mm/day
Irri mm/day
water quality dS/m
OUTPUT
9 September 2017
Production
Biomass 27.540 ton/ha
Dry Yield 13.207 ton/ha
Stresses
daily
average crop cycle
soil salinity none none
temperature (Transpiration) 68 % 12 %
water stresses
canopy expansion X 3 %
stomatal closure none 6 %
early senescence none
weed infestation none none
soil fertility none
Climate-Crop-Soil water
Rain
Soil water profile
Soil salinity
Climate and Water balance
Production
Environment
10 mm/day
Tr
0
Scale
96 %
CC
0
time (day)
20
40
60
80
100
120
Dr
Flowering
SAT
0 mm
50
100
150
200
FC
Th1
Th3
PWP
Numerical output
Main Menu
Update

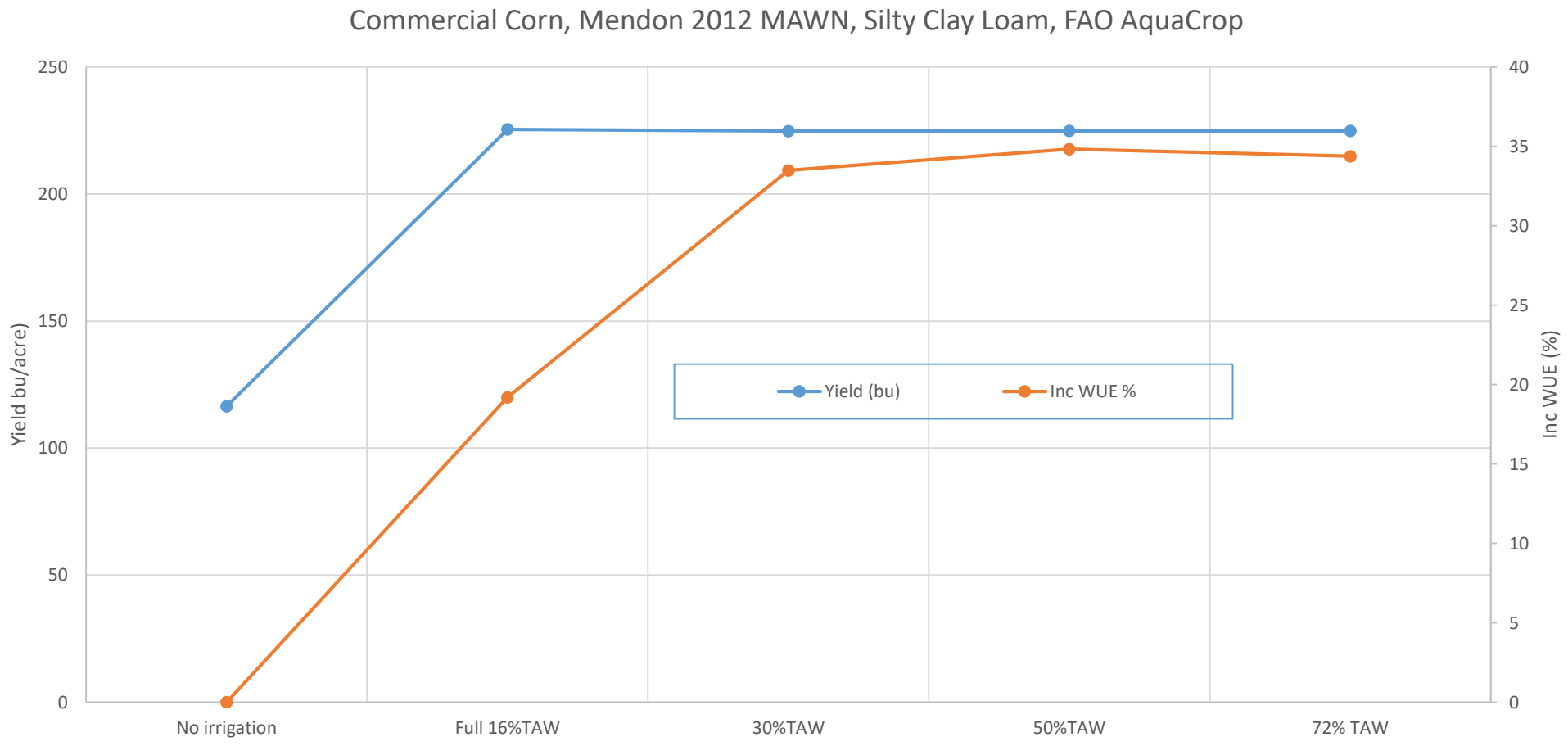

Commerical Corn Sandy Loam 2010 Mendon Data FAO AquaCrop
Yield (Bu/ac) and Inc WUE (%)
250
200
150
100
50
0
9
8
7
6
5
4
3
2
1
0
No irrigation
22% RAW Full Irrigation (16%TAW)
50%RAW(30%TAW)
70%RAW(50%TAW)
100% RAW (65% TAW)
Yield (bu)
Irr (in)

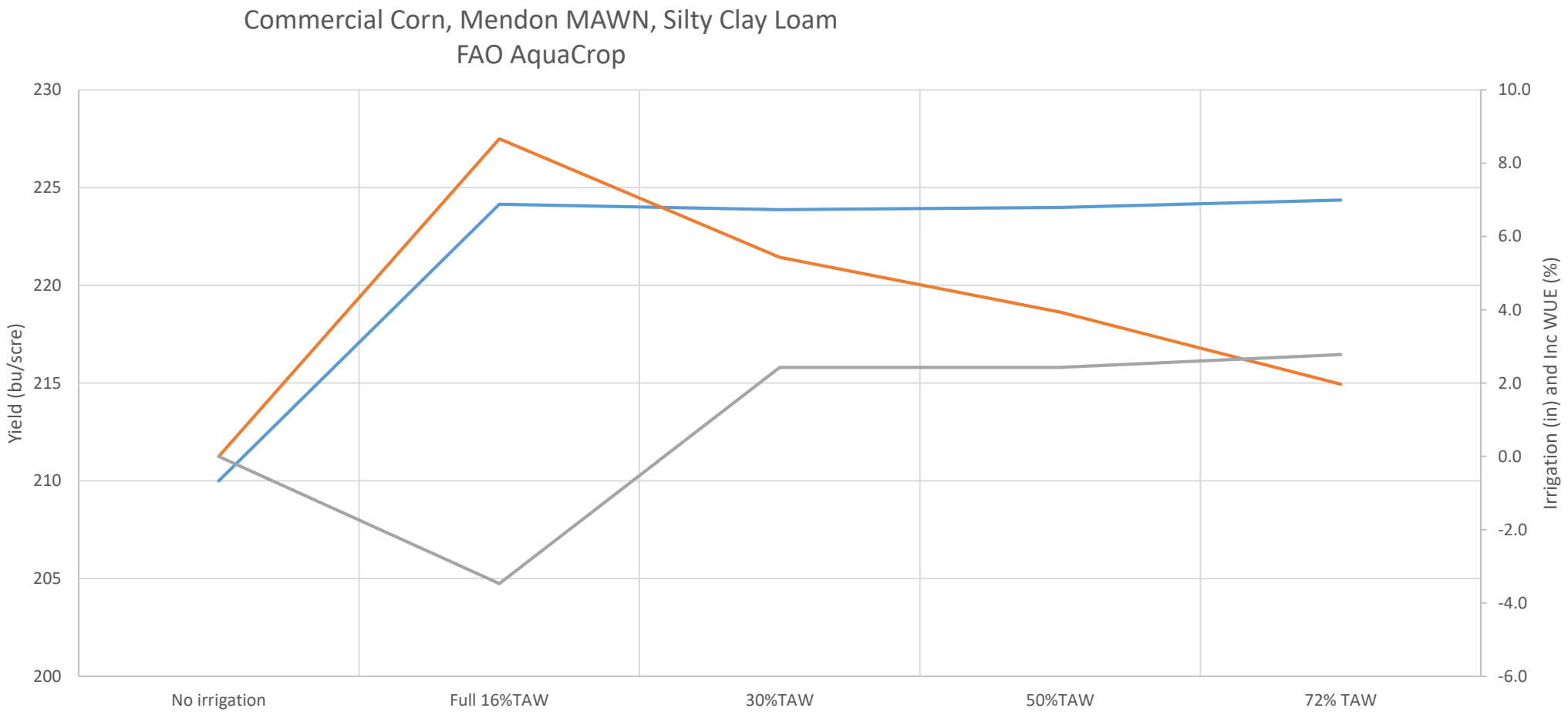

Commerical Corn Sandy Loam 2010 Mendon Data FAO AquaCrop
Yield (Bu/ac) and Inc WUE (%)
250
200
150
100
50
0
9
8
7
6
5
4
3
2
1
0
No irrigation
22% RAW Full Irrigation (16%TAW)
50%RAW(30%TAW)
70%RAW(50%TAW)
100% RAW (65% TAW)
Yield (bu)
Inc WUE %
Irr (in)


Commerical Corn Sandy Loam 2010 Mendon Data FAO AquaCrop
Yield (Bu/ac) and Inc WUE (%)
250
200
150
100
50
0
9
8
7
6
5
4
3
2
1
0
No irrigation
22% RAW Full Irrigation (16%TAW)
50%RAW(30%TAW)
70%RAW(50%TAW)
100% RAW (65% TAW)
Yield (bu)
Inc WUE %
Irr (in)
Drainage(in)


Commerical Corn Sandy Loam 2012 Mendon Data FAO AquaCrop
Yield (Bu/ac) and Inc WUE (%)
Irrigation and DrINAGE (IN)
600
500
400
300
200
100
0
16
14
12
10
8
6
4
2
0
No irrigation
22% RAW Full Irrigation (16%TAW)
50%RAW(30%TAW)
70%RAW(50%TAW)
100% RAW (65% TAW)
Yield (bu)
Inc WUE %
Irr (in)


Commercial Corn, 2012 Mendon MAWN, Silty Clay Loam, FAO AquaCrop
Yield bu/acre)
Irrigation (in)
250
200
150
100
50
0
16
14
12
10
8
6
4
2
0
Yield (bu)
Irr (in)
No irrigation
Full 16%TAW
30%TAW
50%TAW
72% TAW


Commercial Corn, Mendon 2012 MAWN, Silty Clay Loam, FAO AquaCrop
Yield bu/acre)
Inc WUE (%)
250
200
150
100
50
0
40
35
30
25
20
15
10
5
0
Yield (bu)
Inc WUE %
No irrigation
Full 16%TAW
30%TAW
50%TAW
72% TAW


Commercial Corn, Mendon MAWN, Silty Clay Loam
FAO AquaCrop
Yield (bu/scre)
Irrigation (in) and Inc WUE (%)
230
225
220
215
210
205
200
10.0
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
No irrigation
Full 16%TAW
30%TAW
50%TAW
72% TAW