Does Irrigation Scheduling based on Evapotranspiration (ET) Work?

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Various Approaches to Irrigation Scheduling

Plant-based

Soil-based

Weather (ET)-based

Irrigation scheduling challenges in vegetables and berries

- Diversity of commodities
- Many fields to manage
- Shortage of labor

- High value crops
- Water often is a small fraction of growing costs

Some criticisms about irrigation management based on evapotranspiration (ET)

- ET is not accurate for vegetables and berries
- ET does not account for different soil types
- Scheduling based on ET is too complicated
- CIMIS weather stations are not close enough to my ranch
- CIMIS weather stations are not maintained
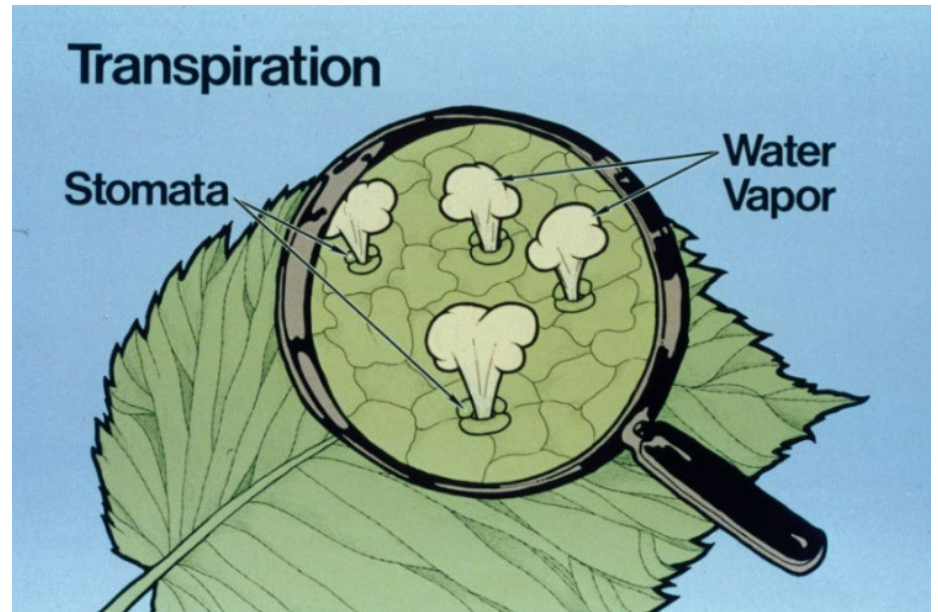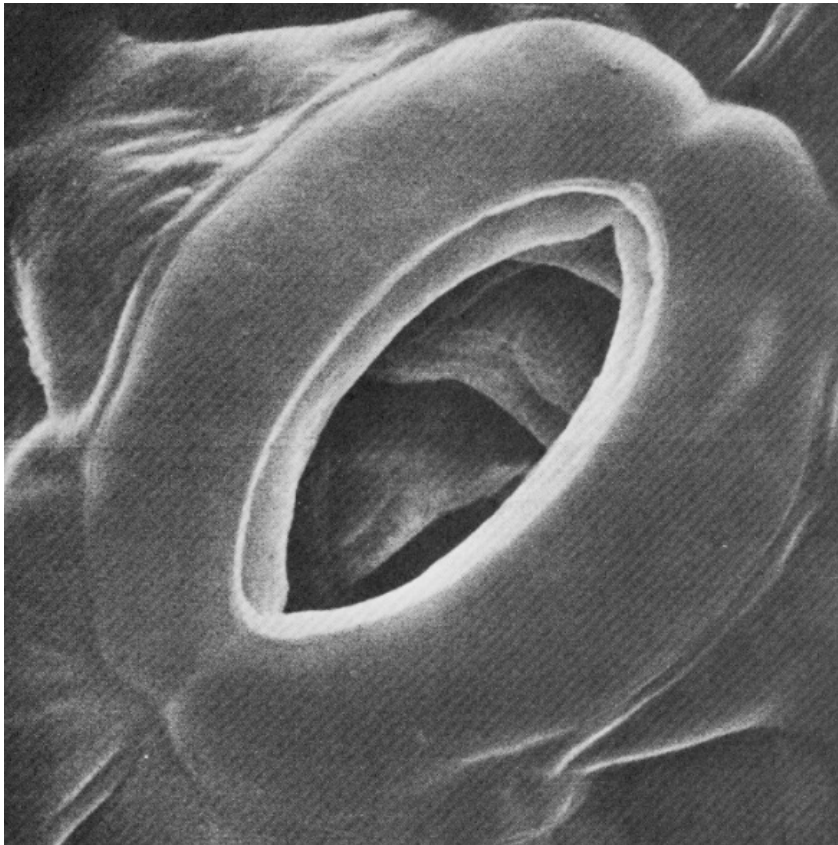
What is Evapotranspiration?
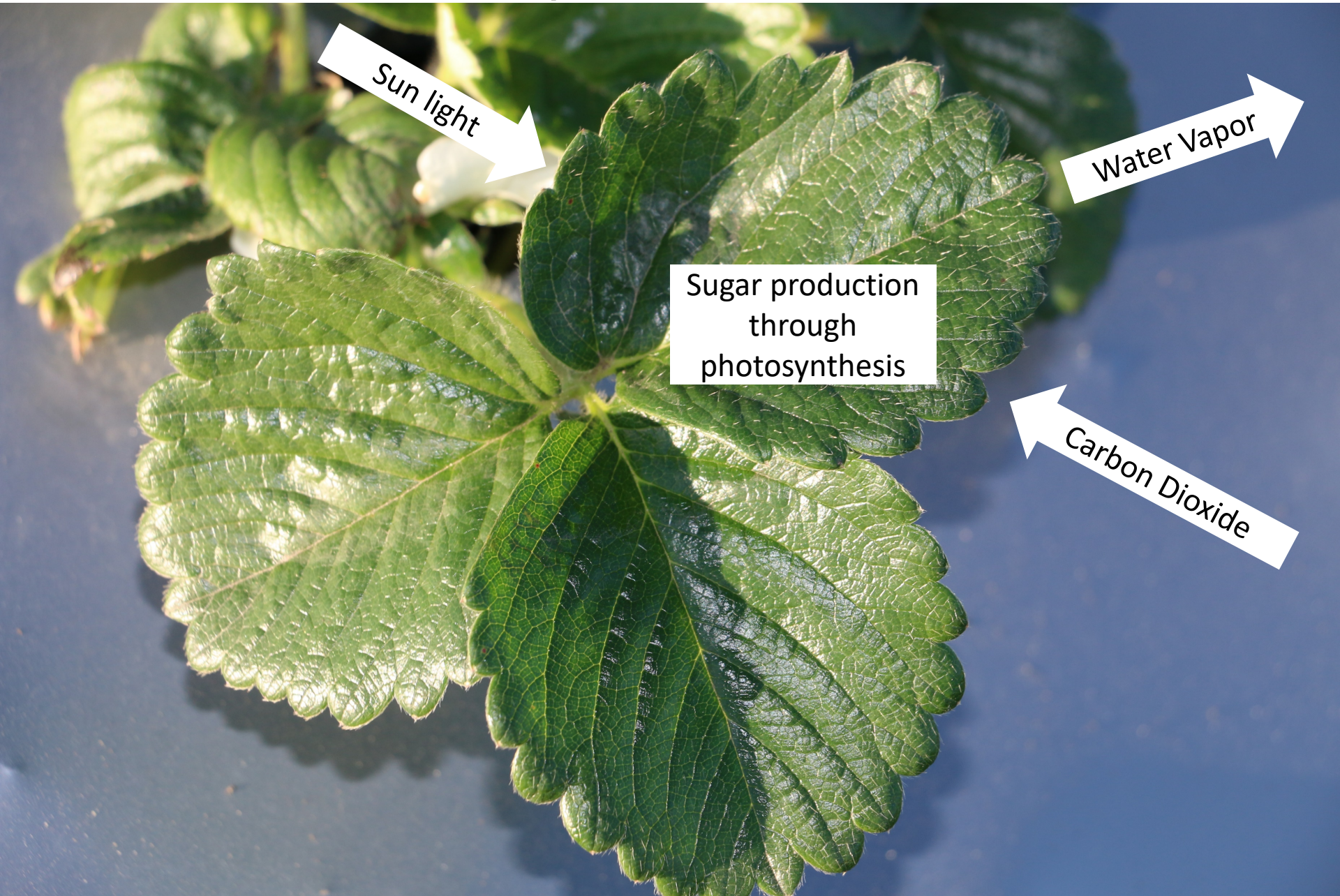
Evaporation   +   Transpiration

Transpiration occurs though the leaf stomata where water is lost as a vapor

Transpiration is needed for sugar and dry matter production

Energy is required for water to vaporize:
586 calories per gram (ml) of water

Dryer

Water cooling system

Evaporation from soil surface

Heat from soil

Heat from air

Main factors influencing evapotranspiration rate

Energy

- Solar (net) radiation
- Heat from the air
- Heat from the soil

Vapor Pressure (deficit)

- Relative humidity
- Air temperature
- Wind

Crop

- Plant species
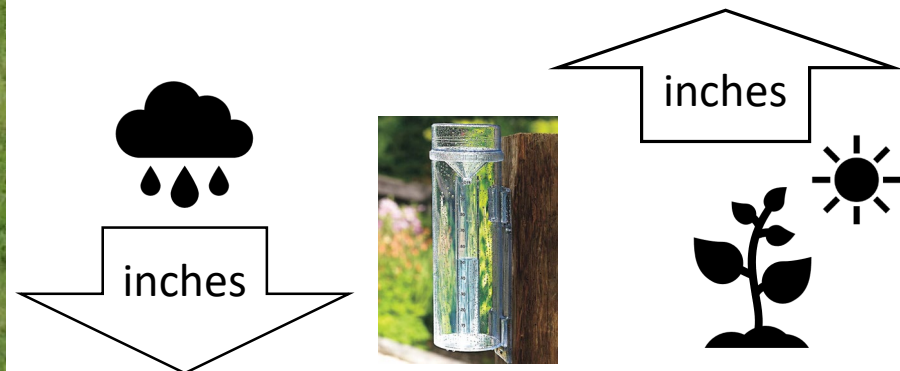- Stage of development
- Soil moisture

Estimating Evapotranspiration with Weather Stations

- **Solar radiation**
- **Wind speed**
- **Relative humidity**
- **Air temperature**

Penman and Monteith method for calculating reference ET (described in FAO bulletin 56)

Daily reference ET is calculated in units of inches/day or mm/day
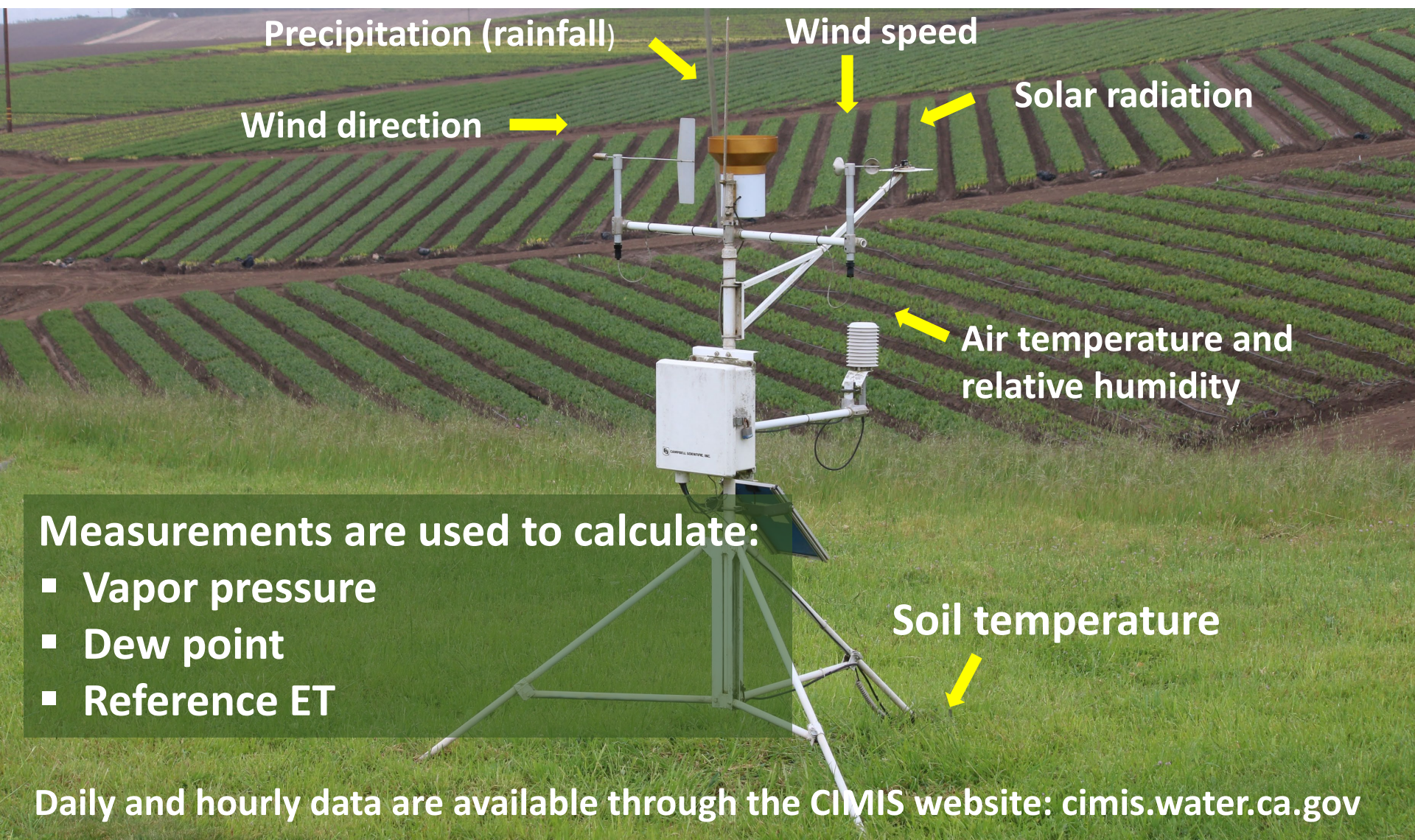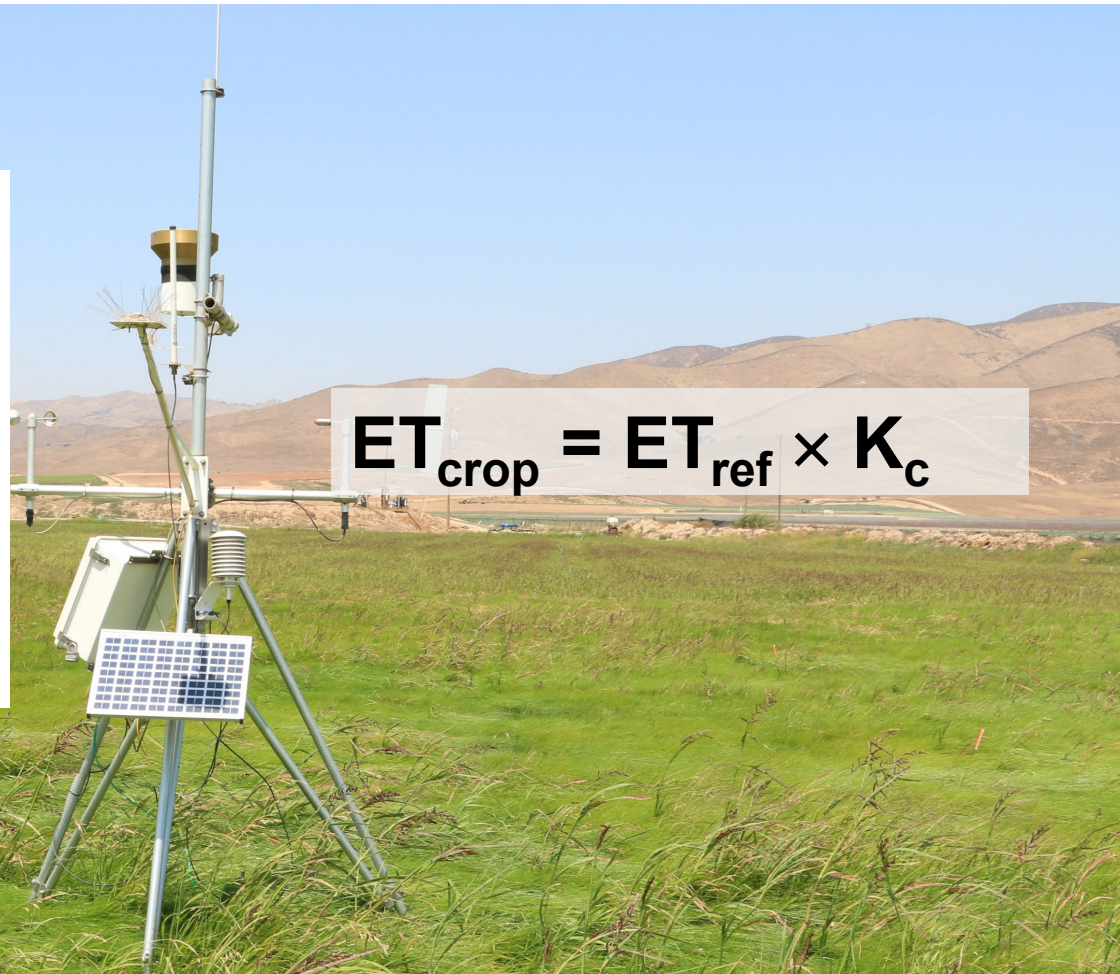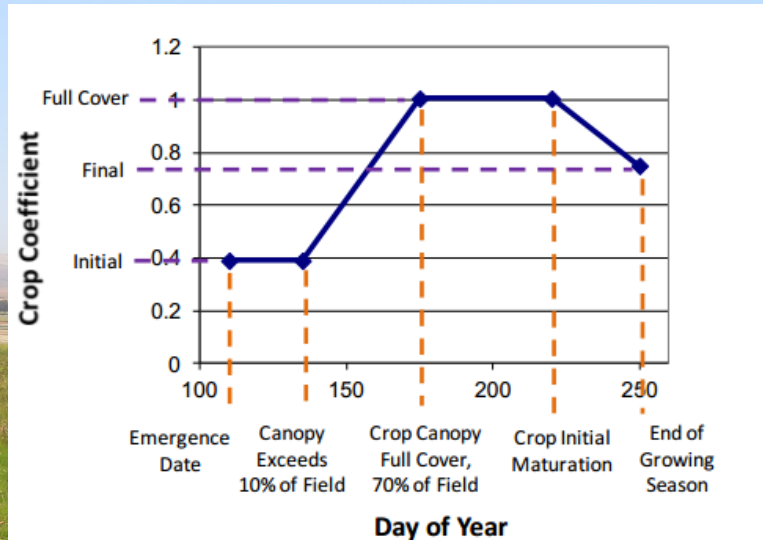
inches

inches

What is CIMIS?

- **California Irrigation Management and Information System**
- **Operated by the CA Department of Water Resources Agency**
- **Originated in 1982 as a joint project between DWR and UCD**
- **>145 active weather stations sited through out California**

What does a CIMIS weather station measure?

Precipitation (rainfall)

Wind speed

Solar radiation

Wind direction

Air temperature and relative humidity

Measurements are used to calculate:
- **Vapor pressure**
- **Dew point**
- **Reference ET**

Soil temperature

Daily and hourly data are available through the CIMIS website: cimis.water.ca.gov

ET stations are sited on a well-water reference crop


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

A crop coefficient (Kc) is used to estimate potential crop ET

"ET is not accurate for irrigation scheduling of vegetables and berries"

- Crop coefficients are unknown or inaccurate for vegetables and berries
- There are different varieties and production patterns
- Crop coefficients do not work during the germination and establishment phase
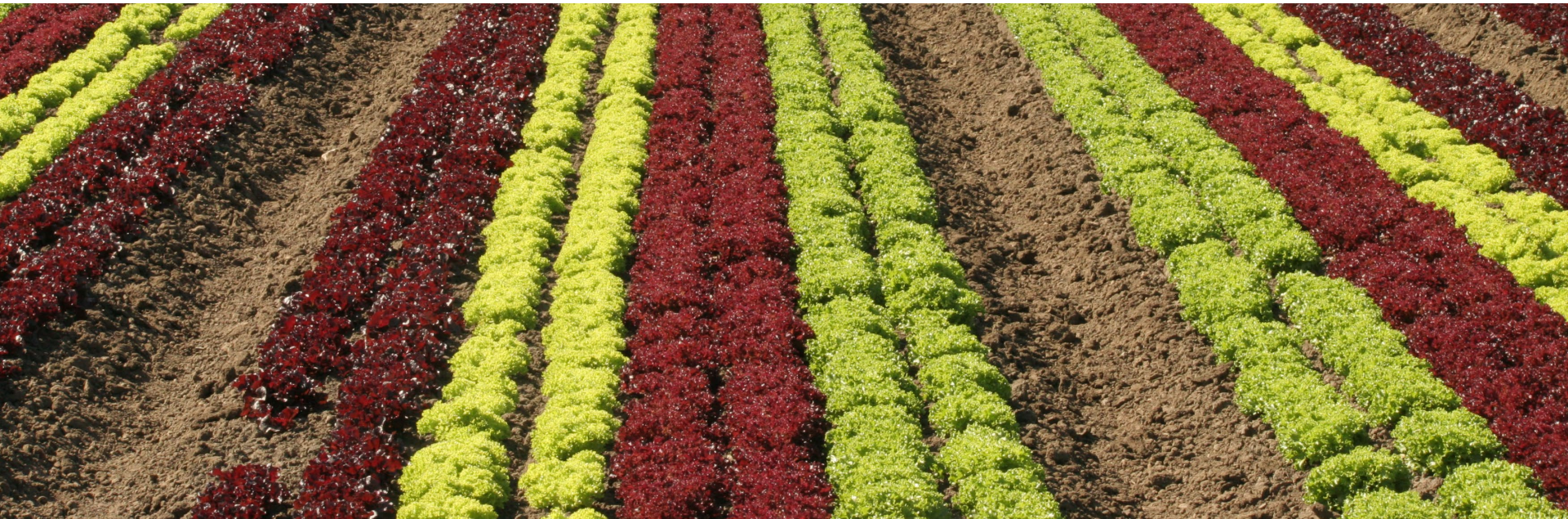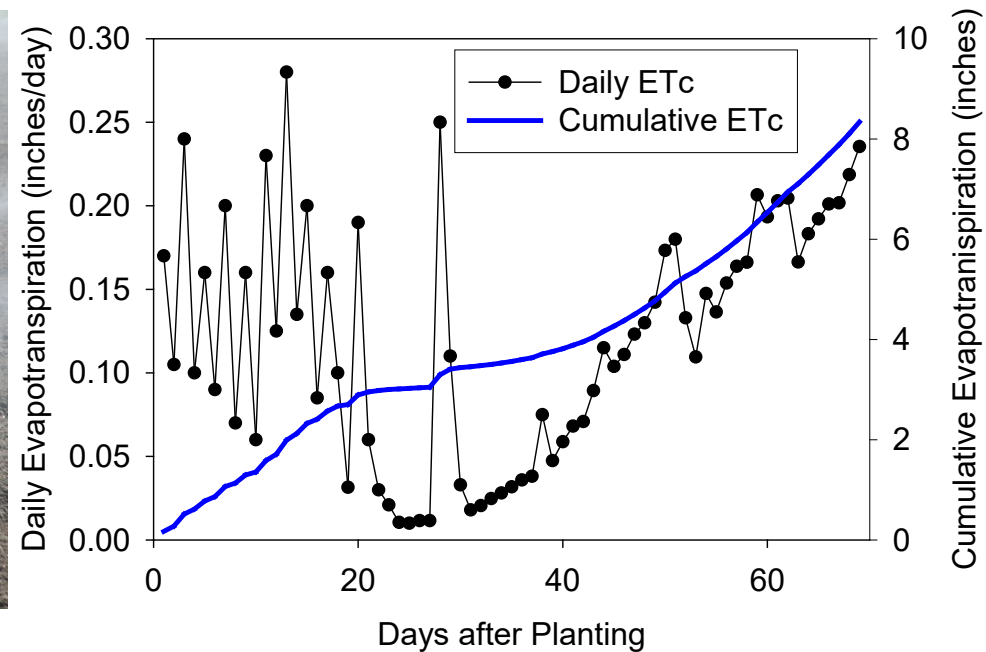
Using canopy cover to estimate Kc can address variance in development stage, variety, and plant population
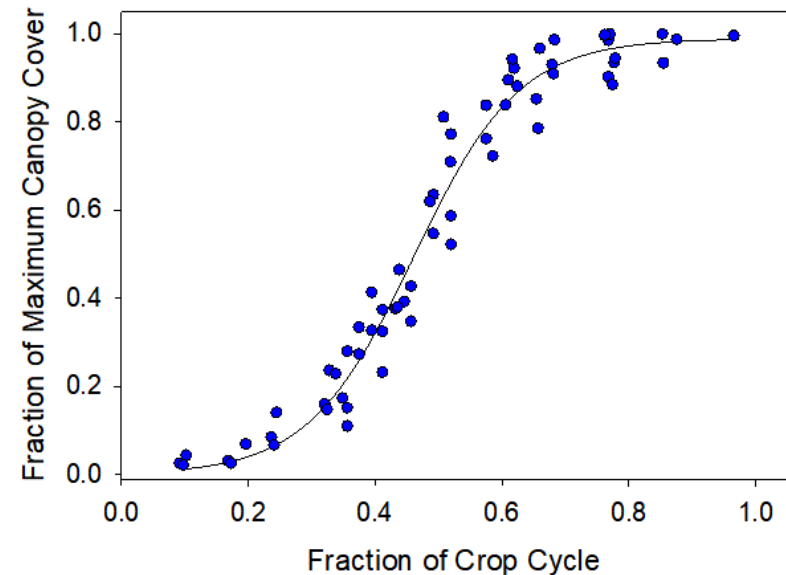
ET calculations can also estimate soil evaporation during germination and crop establishment

Crop ET of lettuce

- Irrigation date (frequency)
- Irrigation method
- Soil texture

"ET does not account for different soil types"

- Weather (ET) conditions will affect the water requirement of the crop; soil type will affect how often to irrigate.

- Maximum allow depletion (MAD) method can be used to estimate when to irrigate based on ET

- Estimate the maximum depth (volume) of water that a crop can deplete without becoming stressed based on water holding capacity of soil and rooting depth.
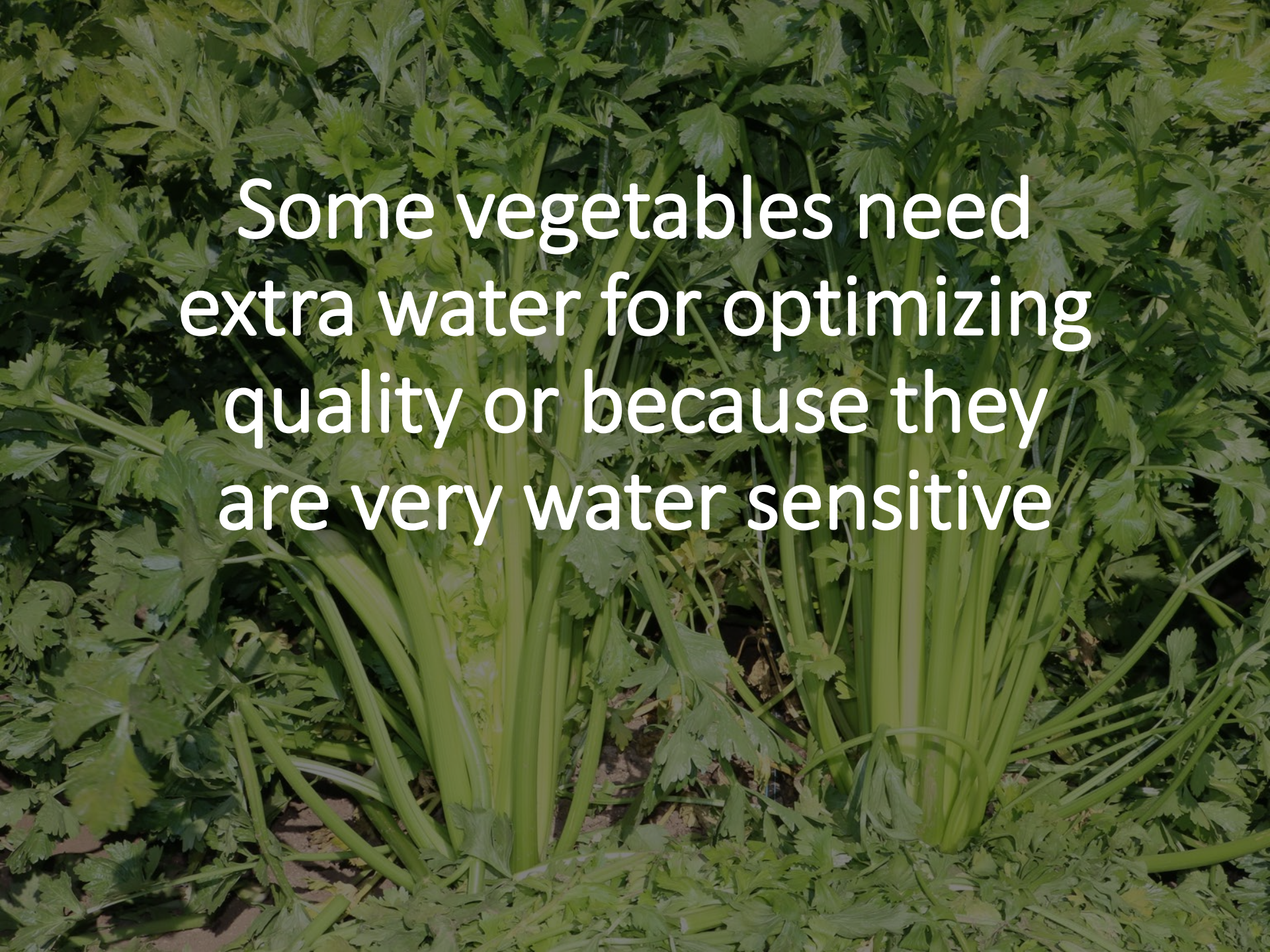
Example: Maximum allowable depletion = 0.40 inches
                    Average crop ET = .10 inches/day

Recommended irrigation interval = 0.40 inches ÷ 0.10 inches/day
                                                    = 4 days

"ET is not accurate for irrigation scheduling of vegetables and berries"

ET is not the amount of water to apply

- Adjust for distribution (application) uniformity of the irrigation system
- Adjust for leaching fraction if needed
- Consider the stage of development and sensitivity of the crop to water stress
- Adjust for irrigation frequency and soil water holding capacity
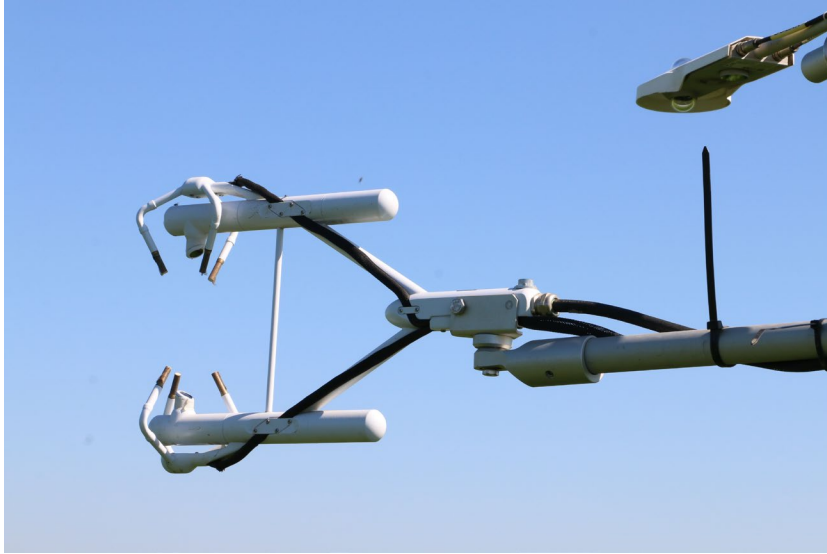
Some vegetables need extra water for optimizing quality or because they are very water sensitive

Evaluating if ET scheduling works

- **Field measurements of crop ET**
- **Replicated irrigation trials**
- **Grower trials**

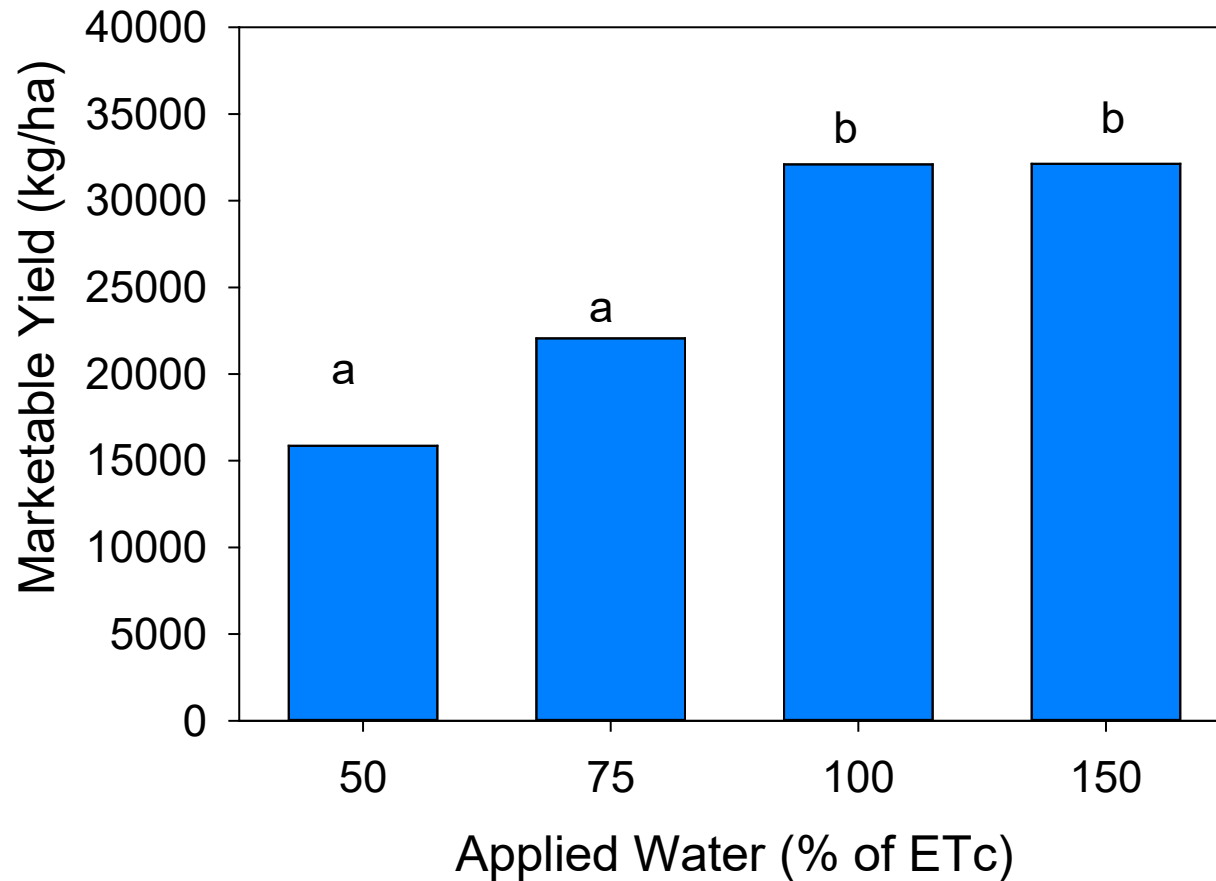# Infield monitoring of ET can be used to determine crop coefficients
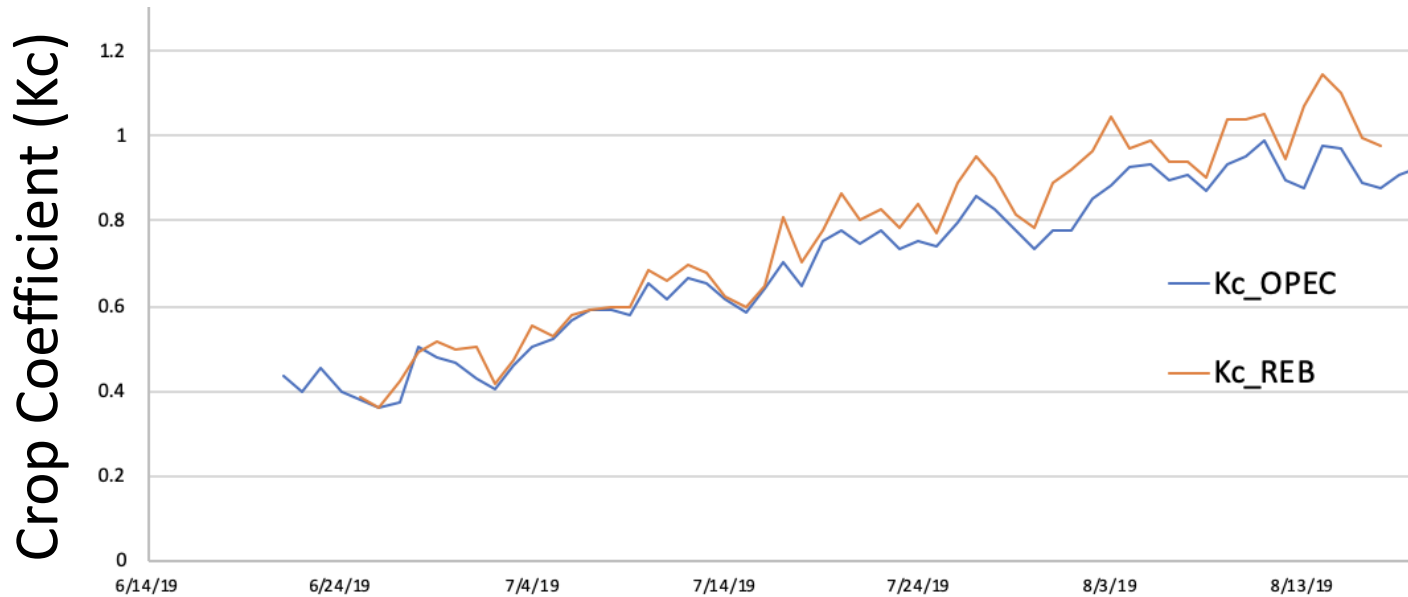
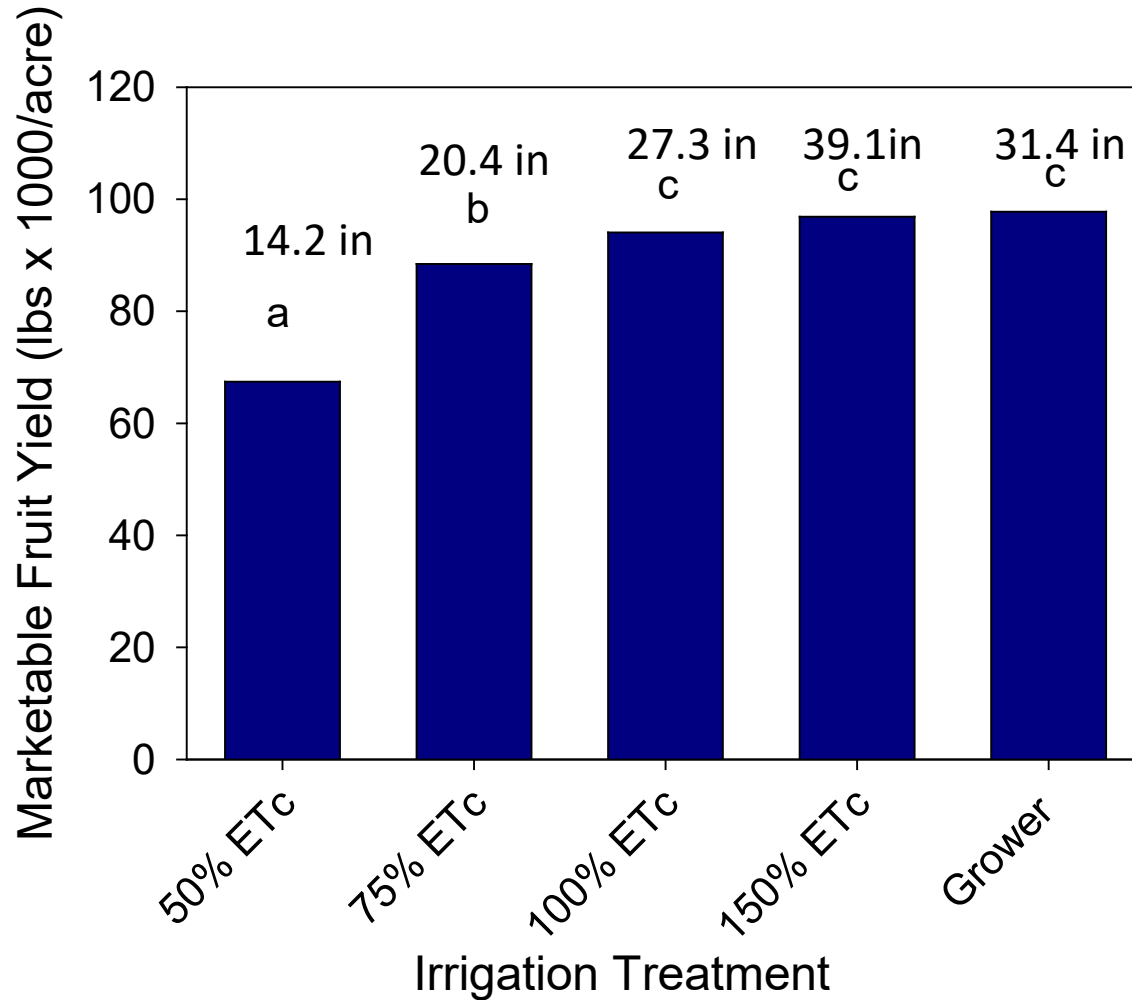# Replicated Irrigation Trial in Romaine Lettuce
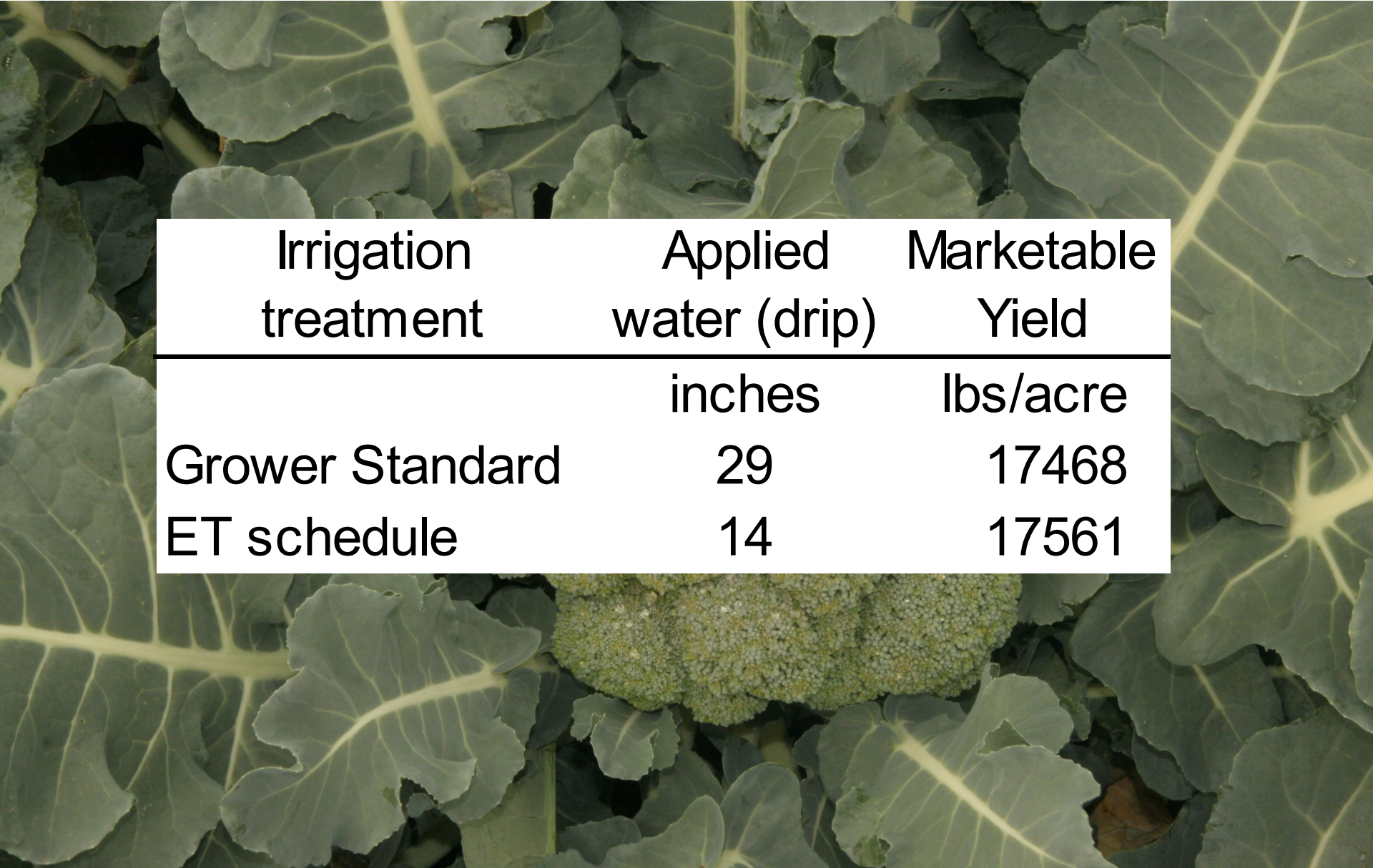
150% ETc

100% ETc

Irrigation scheduling based on crop ET in romaine lettuce maximized yield

Field trials show that irrigating by crop ET in strawberry maximizes fruit yield

Field trials in grower fields have demonstrated ET scheduling optimizes yield in broccoli

Irrigation treatment	Applied water (drip)	Marketable Yield
	inches	lbs/acre
Grower Standard	29	17468
ET schedule	14	17561

"Irrigation scheduling based on ET is too complicated"

CropManage:
Online Irrigation and Nitrogen Management Decision Support Tool

cropmanage.ucanr.edu

Add an irrigation event

Edit Watering Event

10/23/2019 📅

Irrigation Method

Drip ▾

Recommendations ⓘ

| inches | **hours** |

Maximum Irr. Interval ⓘ

29 Oct 2019
11 days since last irrigation

Manager Date ⓘ

23 Oct 2019
5 days since last irrigation

Recommended Amount ⓘ

5.60 hours

Manager Amount

hours

Recommendation Summary ⌄

Delete   Cancel   **Save**

Reveal Recommendation

Edit Watering Event ✕

Recommendation Summary ⌃

Average ET ⓘ	0.12 in./day
Average Crop Coefficient ⓘ	0.81
Distribution Uniformity ⓘ	85.00%
Days Since Last Irrigation ⓘ	5 Days
Leaching Requirement ⓘ	0% (0.0)
Total Precipitation ⓘ	0.00 in.

Base Amount = (Average ET x Average Crop Coefficient x Days Since Last Irrigation x 100) / Distribution Uniformity

0.58 = (0.12 inches x 0.81 x 5 x 100) / 85.00)

Recommended Irrigation Amount = Base Amount / (1 - Leaching Requirement) - Total Precipitation

0.58 = (0.58 in. / (1 - 0) - 0.00 in.)

| Date	ET	Source ⓘ	Last Modified
10/22/19	0.14	CIMIS Station: 214	10/23/19, 6:20 AM
10/21/19	0.13	CIMIS Station: 214	10/22/19, 6:03 AM
10/20/19	0.12	CIMIS Station: 214	10/21/19, 6:04 AM
10/19/19	0.11	CIMIS Station: 214	10/20/19, 6:22 AM

Delete   Cancel   **Save**

"CIMIS stations are not close enough to my ranch"

Station #	Name	Nearby City	County	Nearby road	ETo data
19	Castroville	Castroville	Monterey	Molera Rd	No
113	King City-Oasis Rd.	King City	Monterey	Oasis Rd	Yes
114	Arroyo Seco	Greenfield	Monterey	Los Coches Rd	Yes
116	Salinas North	Salinas	Monterey	San Jon Rd	No
129	Pajaro	Pajaro	Monterey	San Juan Rd.	Yes
210	Carmel	Carmel	Monterey	Carmel Valley Rd	Yes
214	Salinas South II	Salinas	Monterey	Old Stage Rd	Yes
252	Soledad II	Soledad	Monterey	Camphora Gloria Rd	Yes
126	San Benito	Hollister	San Benito	Fairview Rd	Yes
143	San Juan Valley	Hollister	San Benito	San Juan Oaks Rd	Yes
211	Gilroy	Gilroy	Santa Clara	Holsclaw Rd	Yes
209	West Watsonville II	Watsonville	Santa Cruz	San Andreas Rd	Yes

Choose a station most representative of your climate zone or use spatial CIMIS
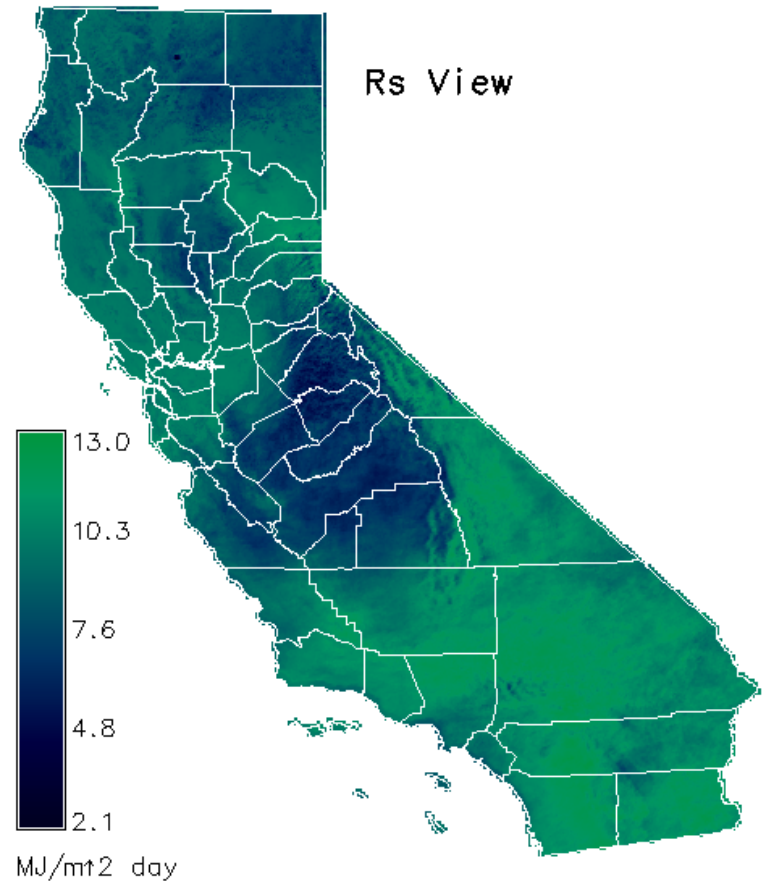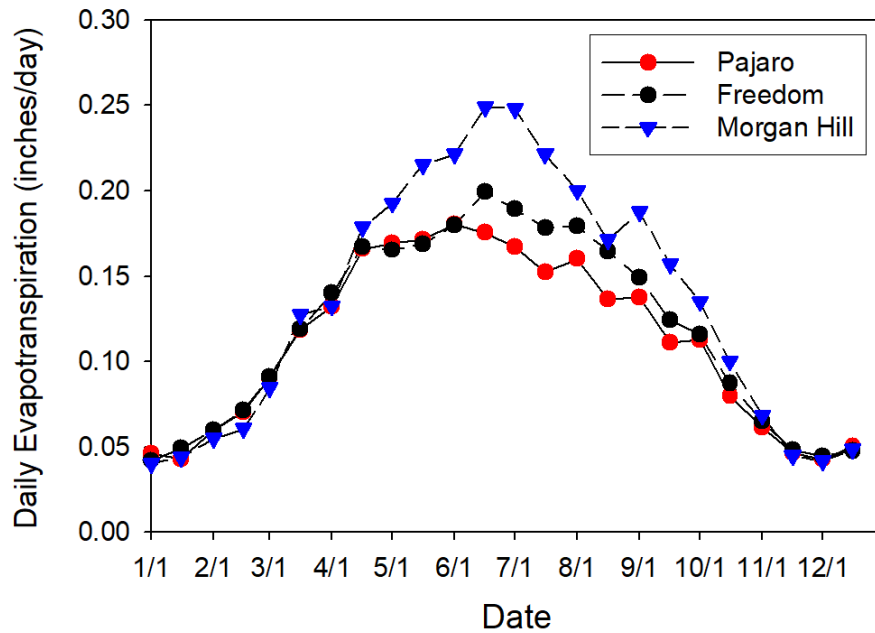
"CIMIS stations are not maintained"

- CIMIS is a partnership between the state and local agencies or private landowners
- Equipment is owned by either DWR or local agency
- Landowner sponsors and maintains site for CIMIS station
- DWR has staff that checks that instruments are accurate, and the site is maintained

Station #19

How to learn more about ET- based irrigation scheduling

- **Attend a CropManage Workshop**
- **Visit the CIMIS website**
- **Call the UCCE Irrigation hotline (831-759-7377)**