Efficient Irrigation Management in the Desert Cropping Systems

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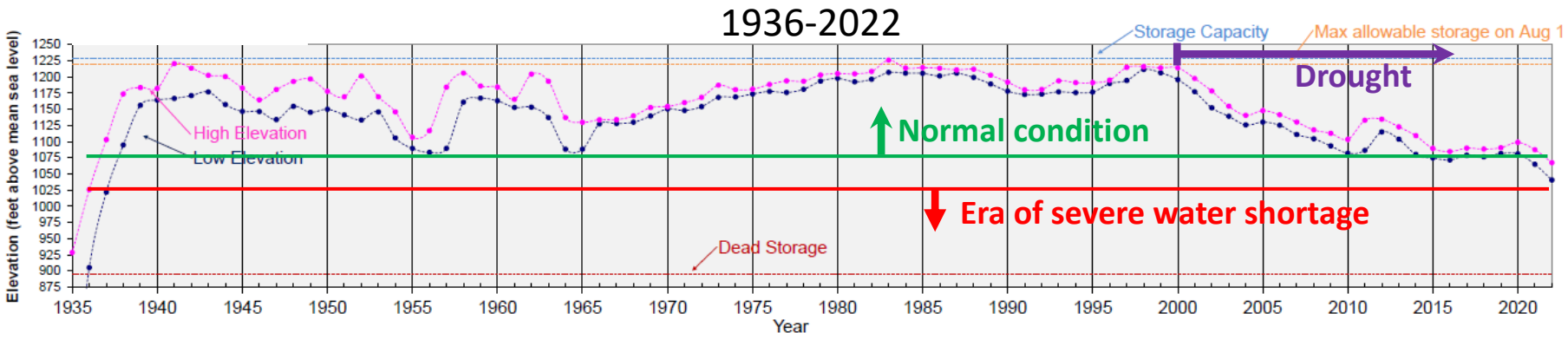
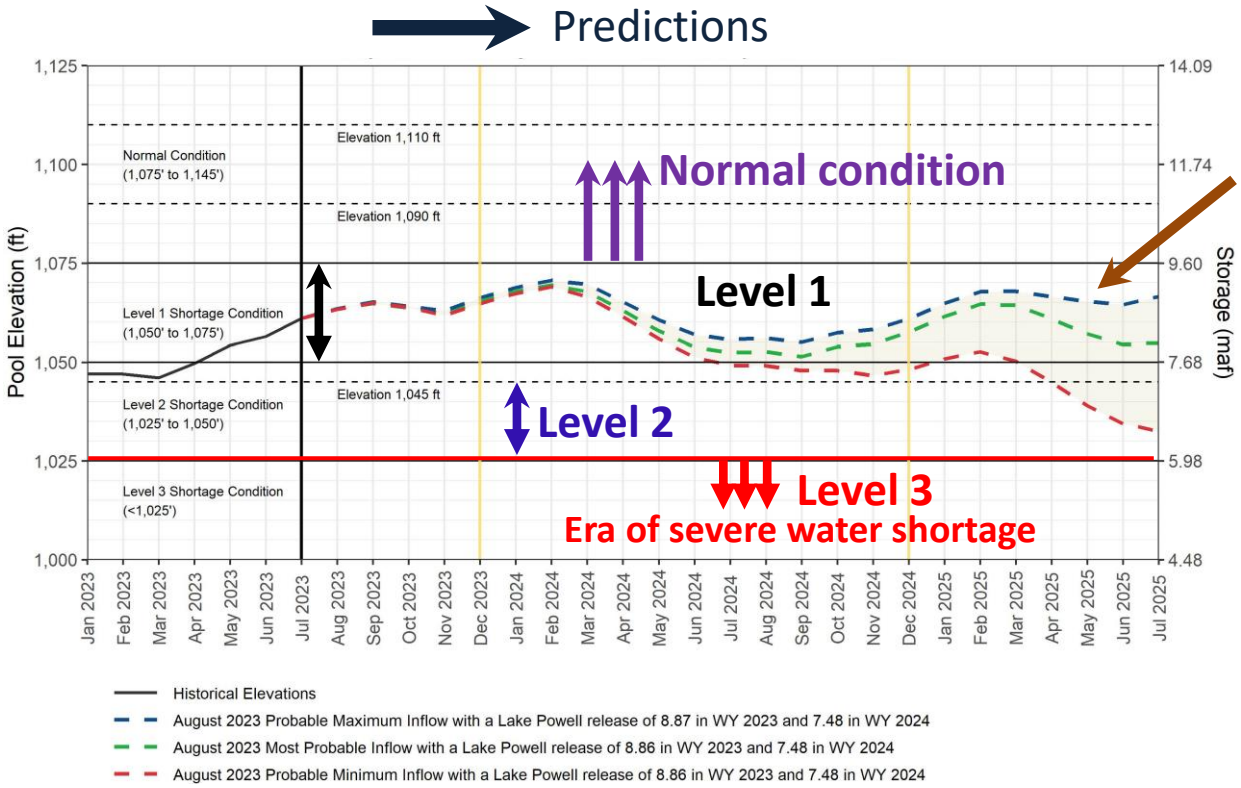
Lake Mead annual high and low elevations



Source: US Bureau of Reclamation (2022)

*Lake Mead is water storage for the Colorado River Lower Basin States.

Lake Mead end of month elevations (2023-2025)



Possible range of reservoir elevation/storage

Minimum power pool elevation=950 ft

Dead pool elevation= 895 ft

Source: US Bureau of Reclamation (August 2023)

Adapted water conservation practices in Imperial Valley

Results of recent survey (Montazar et al. 2020)

Water conservation practice	% of grower responders who adapted the practice
Surface Irrigation Optimization	87 (rank 1)
Sprinkler Irrigation	73 (rank 2)
Irrigation Scheduling Technology	65 (rank 3)
Drip/Micro Irrigation	43 (rank 4)
Portable Tailwater Recovery System	43 (rank 4)
Deficit Irrigation	43 (rank 4)
On-Farm Reservoir	34 (rank 5)
Permanent Tailwater Recovery System	26 (rank 6)
Automated Surface Irrigation	8 (rank 7)

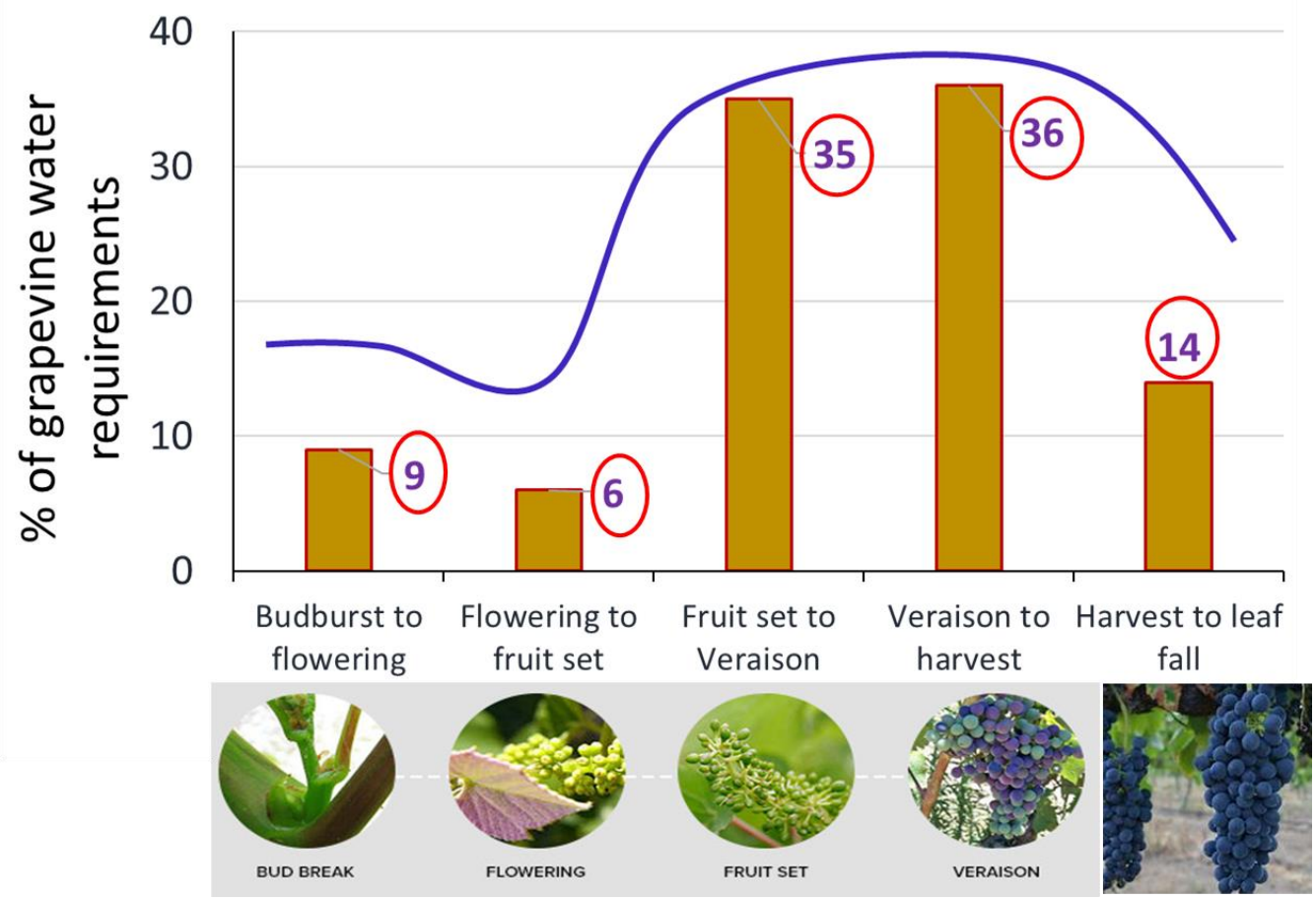
To effectively and efficiently irrigation fruit trees:

- Need good irrigation system design/ installation/maintenance
- Proper irrigation scheduling
- Applying adequate water

Match Water applied with Water demand

Knowledge of critical periods of irrigation:
Flowering, Fruit Set, Fruit Development

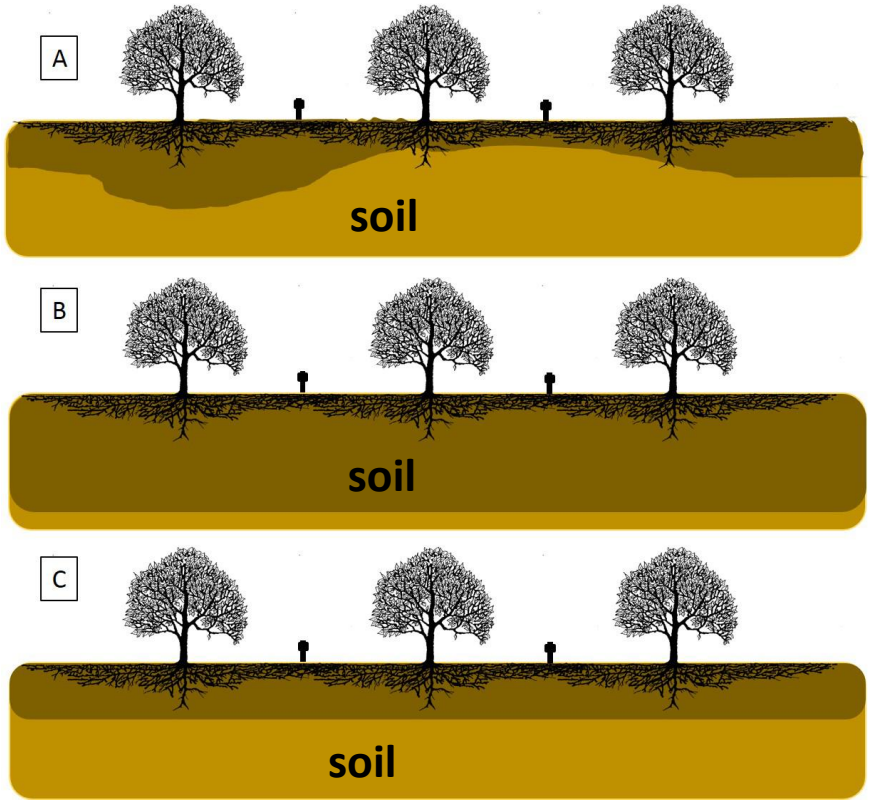
Approximate **grapevine** water demand by growth stage



Fruit set

Harvest

Darker brown soil indicates the wetted soil by the irrigation system, while **light brown** soil indicates dry soil.



Water was not applied uniformly nor efficiently.

Water was applied uniformly, but not efficiently.

Water was applied uniformly and efficiently.

What happens under different water distribution

Uniformities!

DU is water distribution uniformity

Target amount of applied water = 1”

DU	Application rate (in/hr)	Season long run time (hrs)	Actual applied water
90%	0.1	444	44.4”
70%	0.1	571	57.1”

Irrigation water needs = 40”

Plugged emitter

Hose screen plugged With organic matter

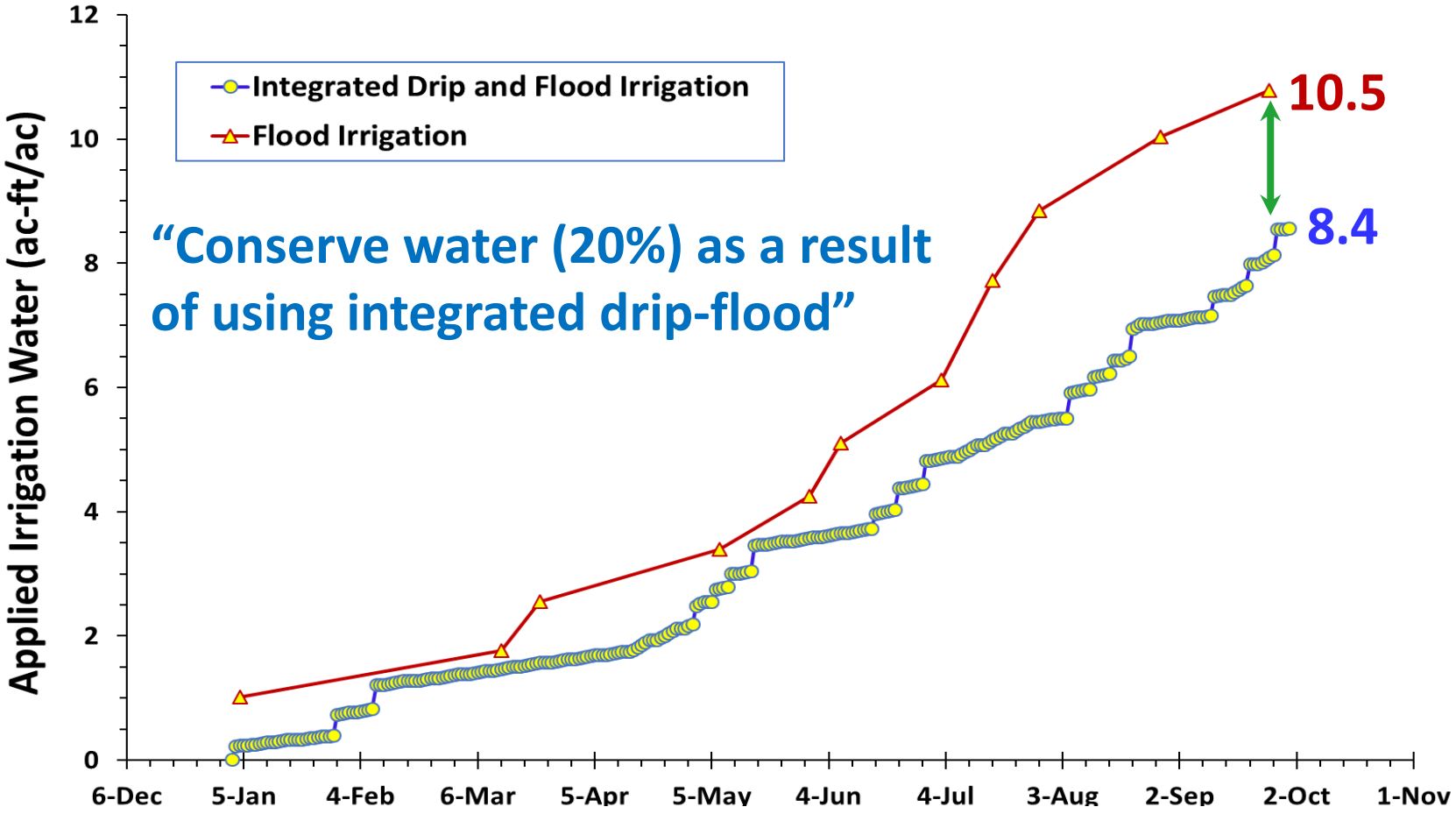
Plastic Shavings

Reach out to the Coachella Valley RCD for irrigation system efficiency test.

Date Palm Irrigation Management Survey

- Represents ≈ 2,000-acre date palms in CA
- **Irrigation:** 31% only flood, 19% only micro irrigation, 50% integrated drip and flood
- Micro irrigation: 88% drip & 12% micro-sprinkler

Impact of irrigation practice on applied water



Survey question:

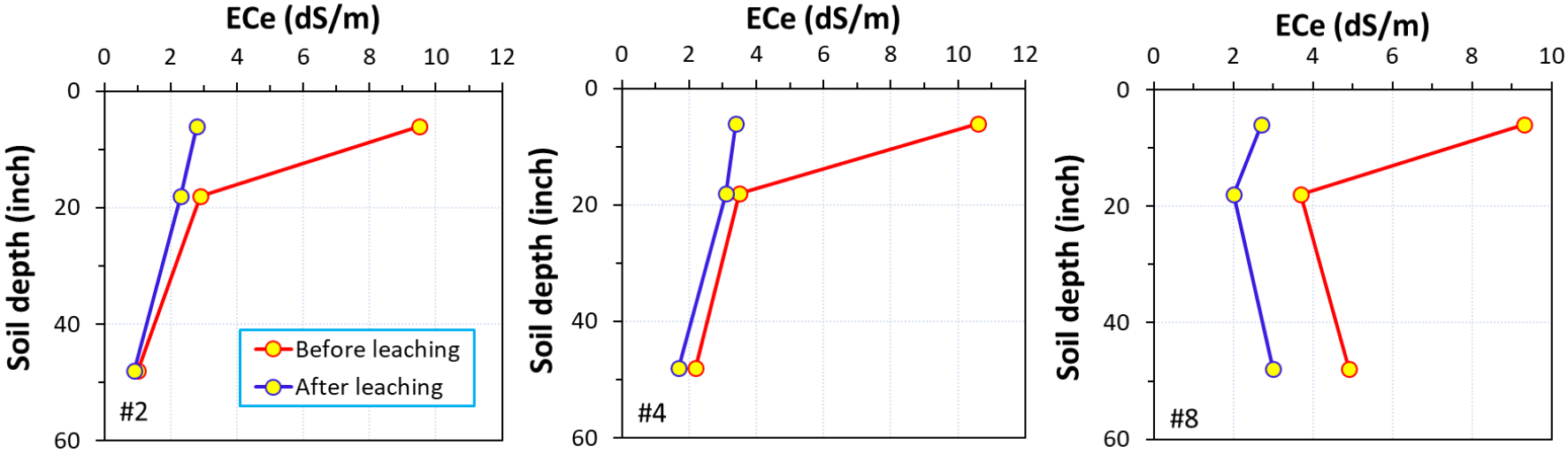
Are you aware of any soil conditions on your date palm/s that may affect production?

- **50% NO**
- **high water table, high salt and low potassium, soil needs amendments to improve soil permeability**

Date palm in the Salton Sea area

More salinity hazard than sodium hazard in the desert (The Colorado River water has high content of Calcium, Sodium, Magnesium, Chloride, Sulfate, and Bicarbonate).

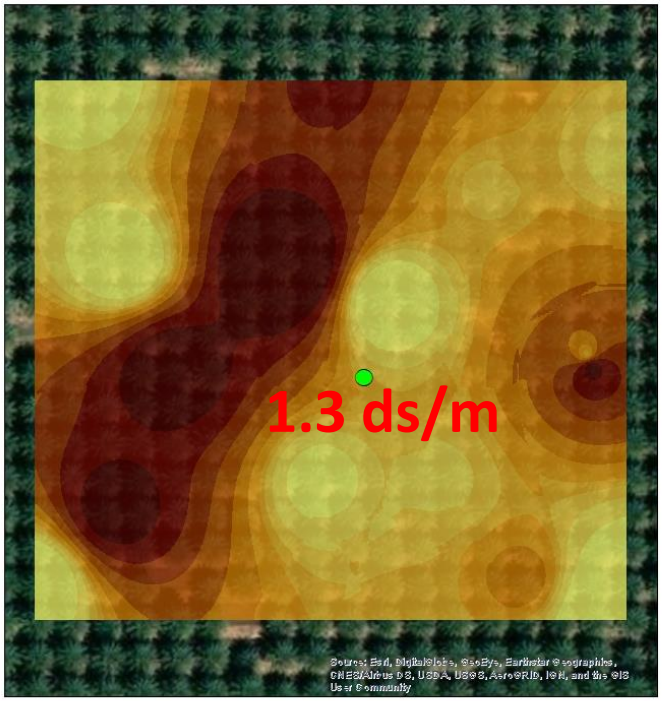
Effect of leaching in a field (Imperial Valley)



This field (onion drip irrigated) was effectively leached using flood irrigation on early-September.

Soil Salinity Issue in Date Palms

Date palm 3



ECe dS/m

0.64 - 1.09	1.26 - 1.3
1.1 - 1.15	1.31 - 1.38
1.16 - 1.18	1.39 - 1.45
1.19 - 1.2	1.46 - 1.56
1.21 - 1.25	1.57 - 2.04

Monitoring Station

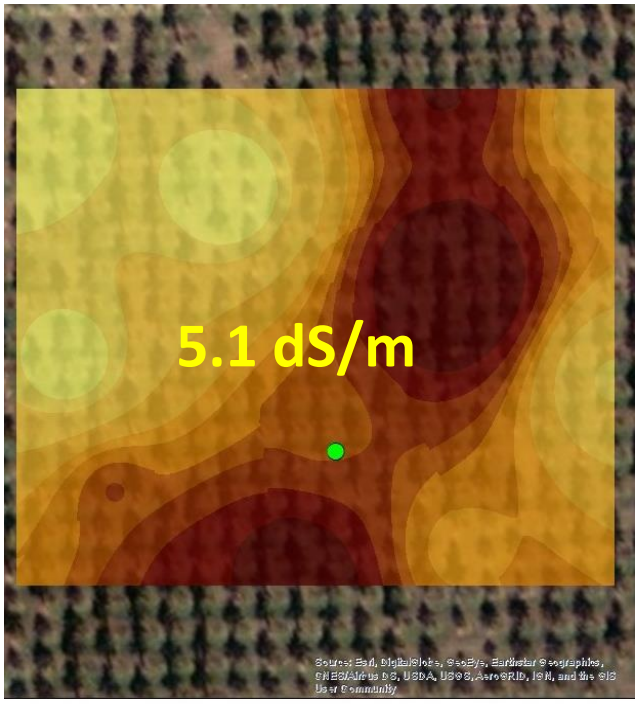
30-60 cm depth

N

0 10 20 40 60 80 Meters

0.64 – 2.04 dS/m

Date palm 6



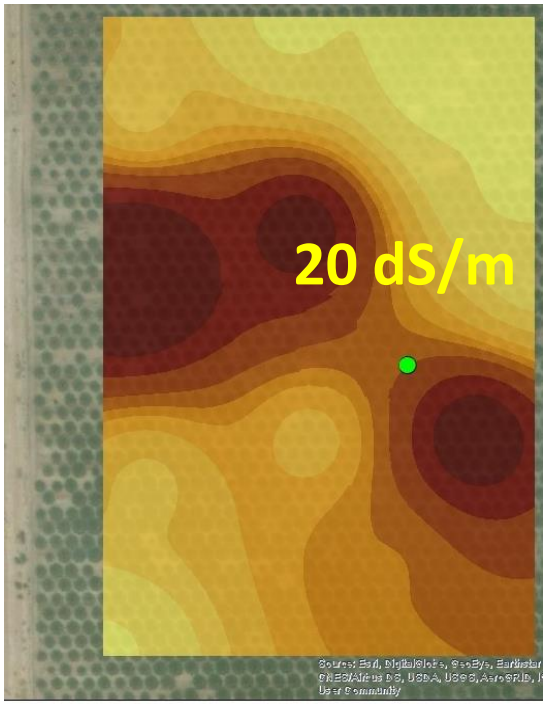
ECe dS/m

0.77 - 1.87	4.33 - 4.61
1.88 - 2.36	4.62 - 4.8
2.37 - 3.38	4.81 - 5.15
3.39 - 4.05	5.16 - 5.63
4.06 - 4.32	5.64 - 7.62

Monitoring Station

0.77 – 7.62 dS/m

Date palm 5



ECe dS/m

6.51 - 11.92	19.09 - 19.79
11.93 - 15.3	19.8 - 20.82
15.31 - 16.63	20.83 - 22.66
16.64 - 18.06	22.67 - 24.8
18.07 - 19.08	24.81 - 32.57

Monitoring Station

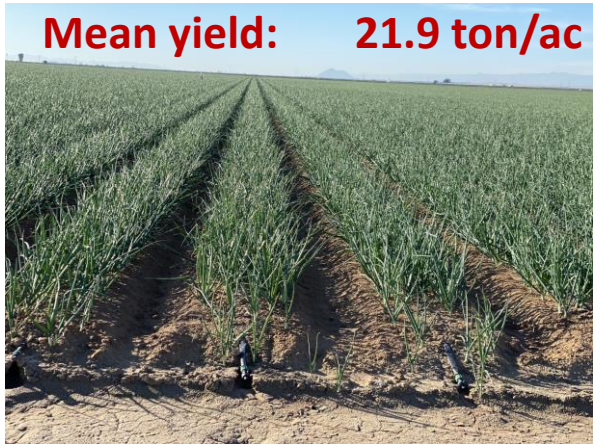
6.51 - 32.57 dS/m

Salinity and land productivity

"**Land productivity** is highly depending on the effectiveness of salinity management."

Salinity reduces actual crop water use and yields.

Processed onion field



vs.

Irrigation scheduling

Our survey shows that date growers in California use a combination of different methods to schedule irrigation:

- Calendar: 81%
- Plant observation: 75%
- Soil moisture sensor: 25%
- CIMIS (ET data): 12.5%

CIMIS: California Irrigation Management Information System

A wide range of irrigation management is currently followed by growers (3.5 - 9 ac.ft/ac).

Effective irrigation scheduling requires knowledge of:

- Soil water-holding capacity
- Irrigation and effective rainfall received

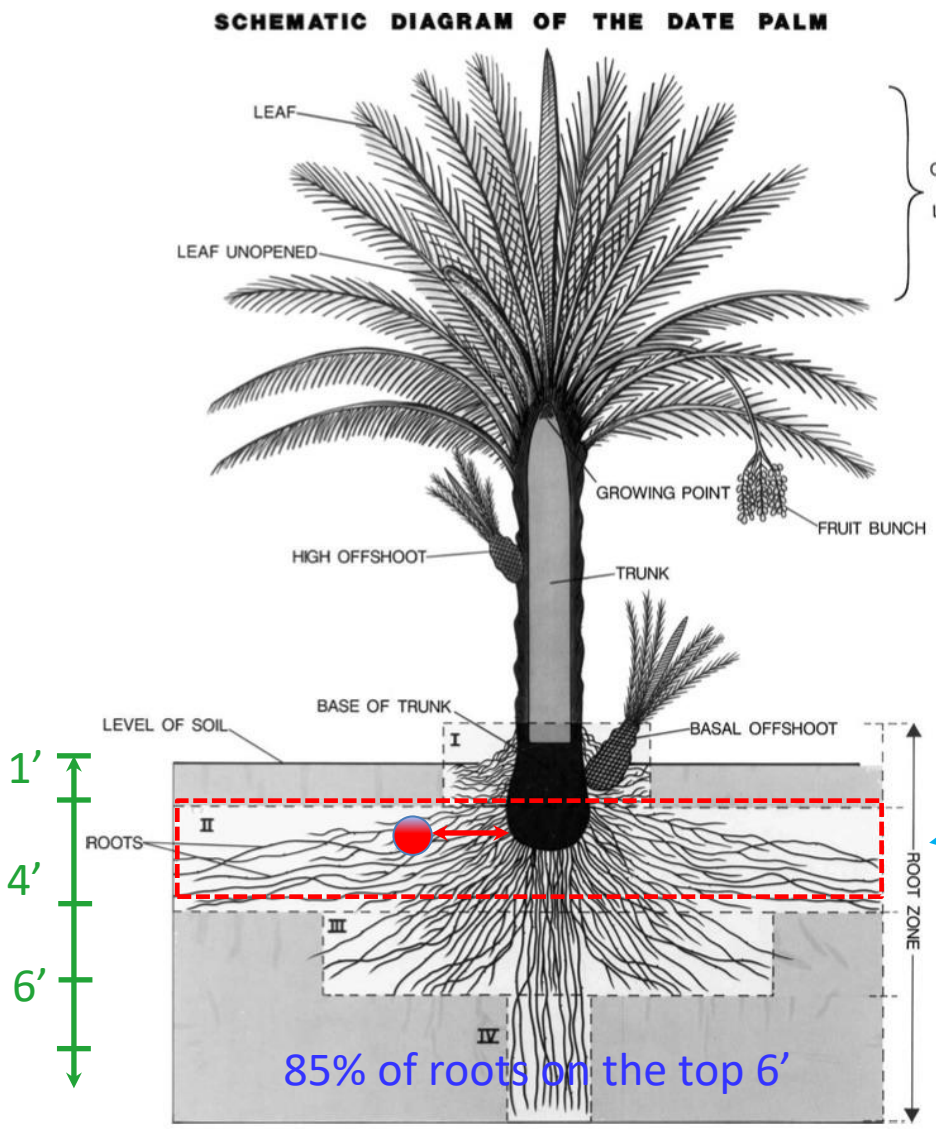
Soil type	Avail. Water (in/ft)	Ave. Allow. Depl. (in/ft)	Ave. Allow. Depl. 2 ft. zone (in)
Sandy loam	1.25-1.40	0.66	1.3
Silty clay loam	1.80-2.00	0.95	1.9

%46

- Available soil water content (soil water status)
- Crop water needs or evapotranspiration (**ET**)

Soil moisture sensors as useful tool may answer critical questions:

- How is water status of the soil early in the season?
- When is the right time for the first and subsequent irrigation events?
- Is the soil profile full after each irrigation event?
- What is the length of irrigation time?
- Should irrigation practice need to change?



Root distribution may change depending on ground water table, soil type and profile (number of stratified layers and thickness of each), and age of date trees.

Zone II: the highest proportion/density of primary and secondary roots.

Soil moisture sensing

2-2.5' away from tree trunk

4-6" away from emitter

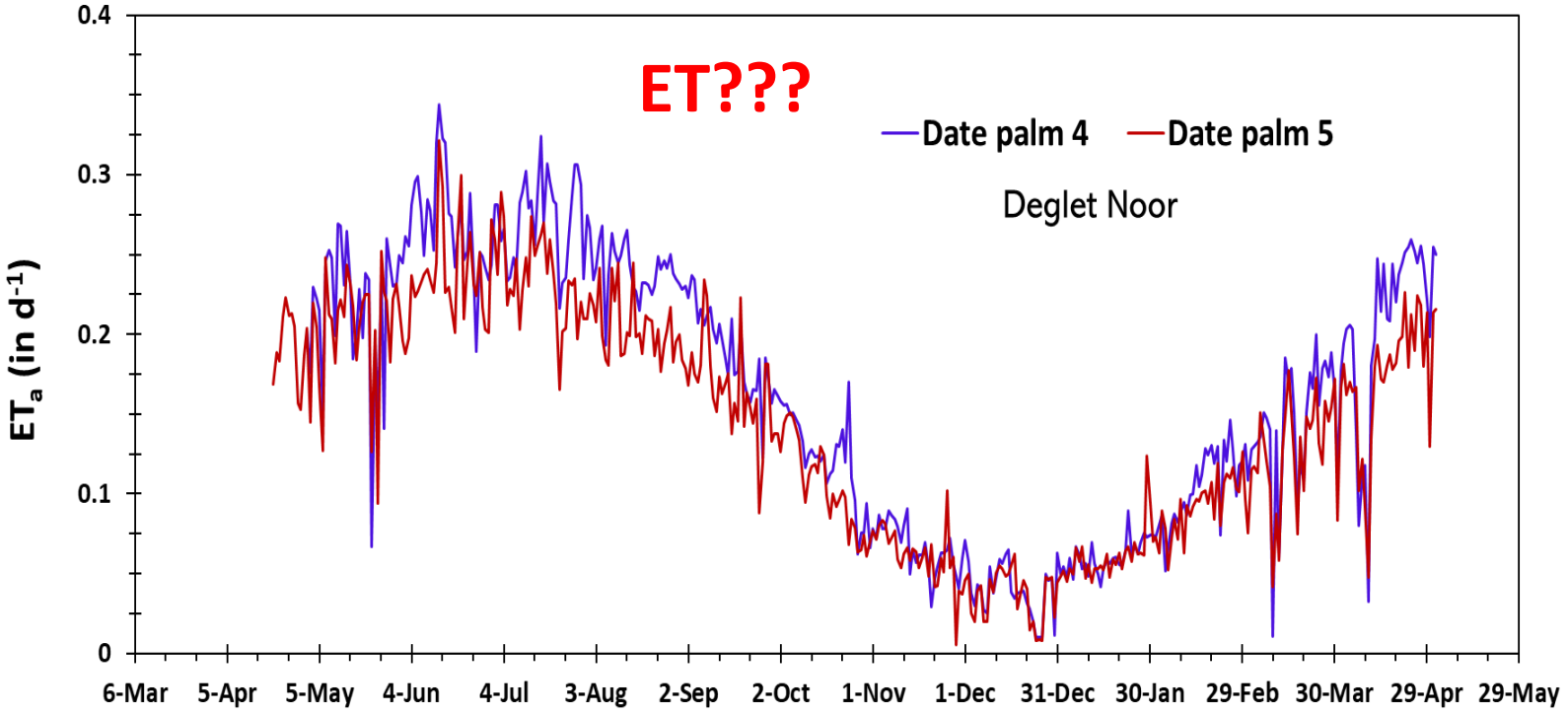
Recommendation

Refill the soil profile at early season and then maintain soil moisture at the depths of 1 – 4 ft.:

- ✓ **Lower than 40-centibar for a sandy loam soil**
- ✓ **Lower than 80-centibar for silty clay loam to silty loam soils**

If we have drip irrigation, soil moisture at the depth of 1-2 ft. will be a good indication for irrigation management (25-30 centibar for a sandy loam soil).

Daily crop water use (actual ET)



Date palms need variable amount of irrigation water depending on time of year, canopy cover percentage (light interception), and soil types and conditions.

52.2 - 59.1 in. (4.6 ac-ft/ac) in the study date palms.

Effective Irrigation Water Management

http://wwwcimis.water.ca.gov/

Following ET +

Soil Moisture monitoring

$$ET = K_c \times ET_o$$

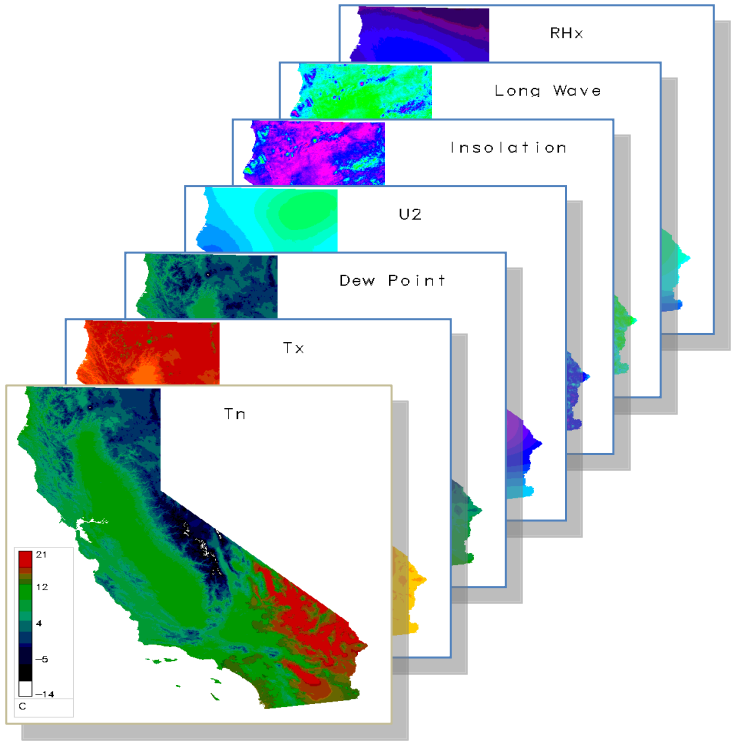
- ET: Crop ET
- K_c: Crop coefficient
- ET_o: Reference ET (grass) from CIMIS

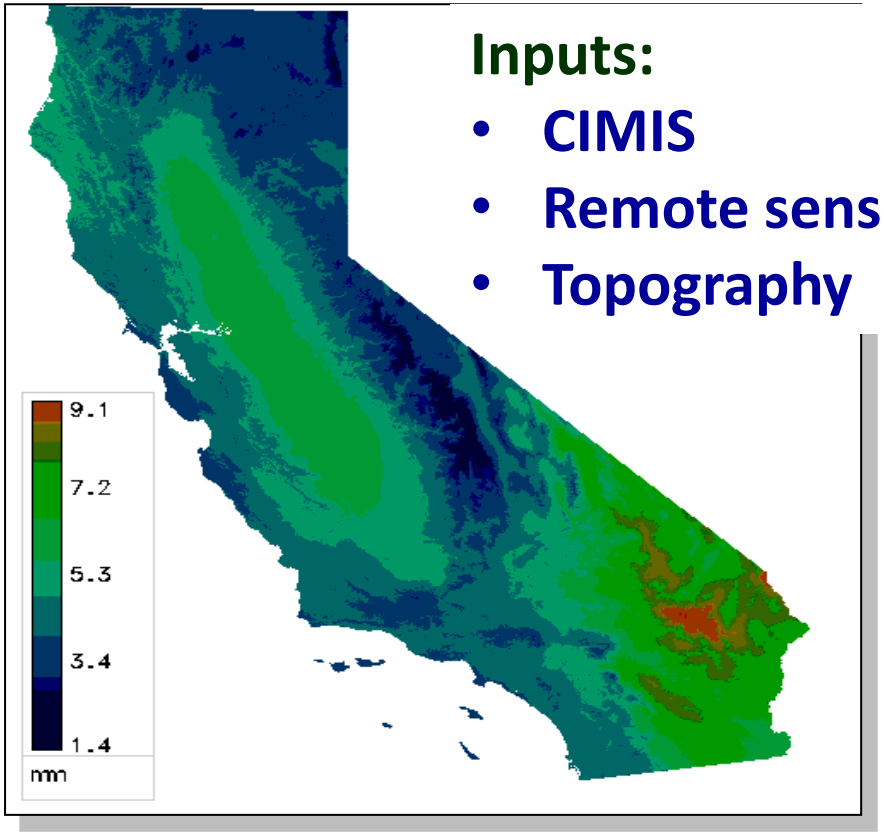
CIMIS ET_o & K_c Values

- light interception
- physiology
- age/ growth stage
- surface wetness
- soil type & condition
- ....

ETo: Spatial CIMIS

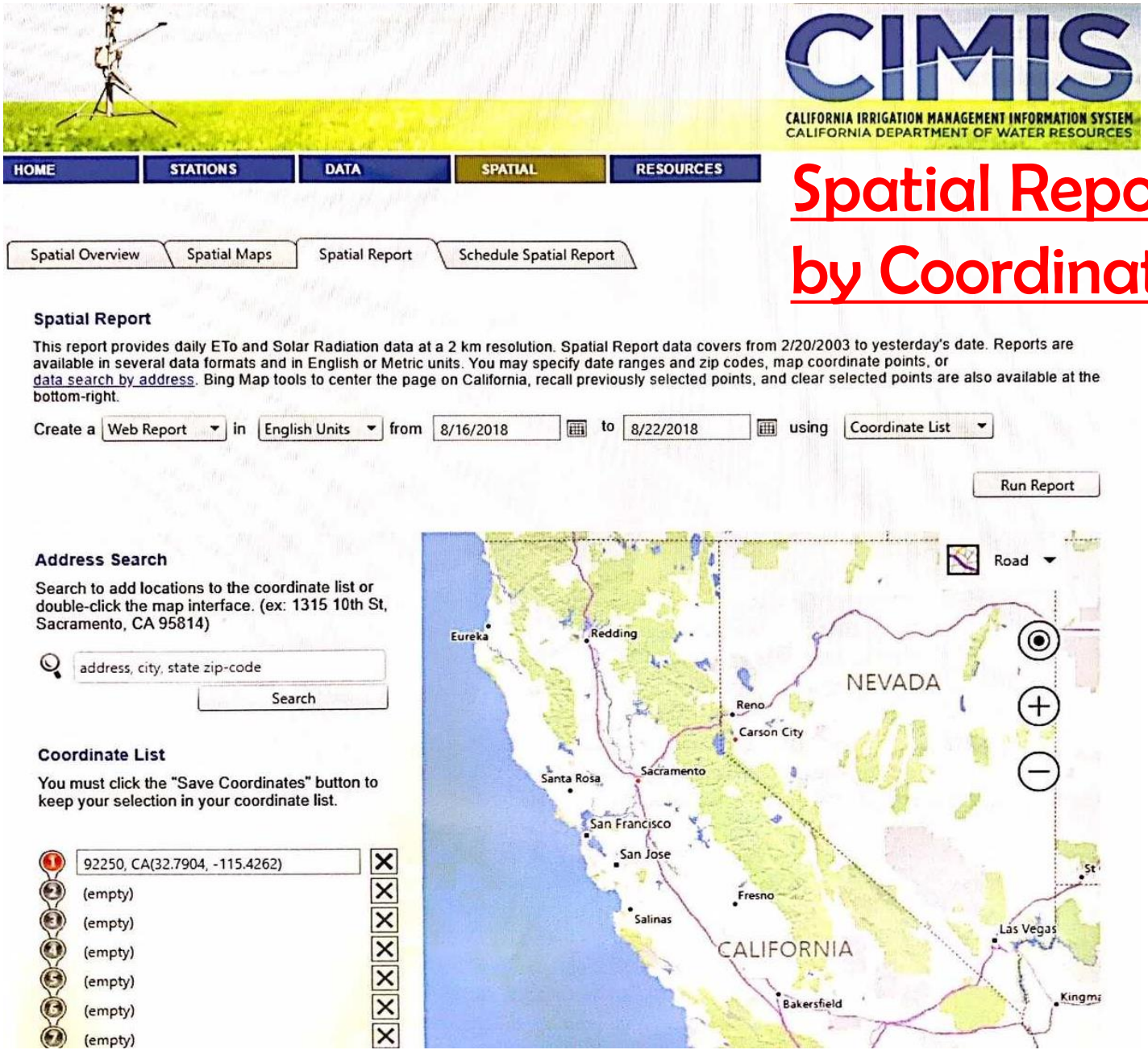
- Couples remotely sensed data from GOES satellite with point measurements from CIMIS stations to estimate ET_o.
- Provides daily maps of ET_o at 2-km grid.





Inputs:

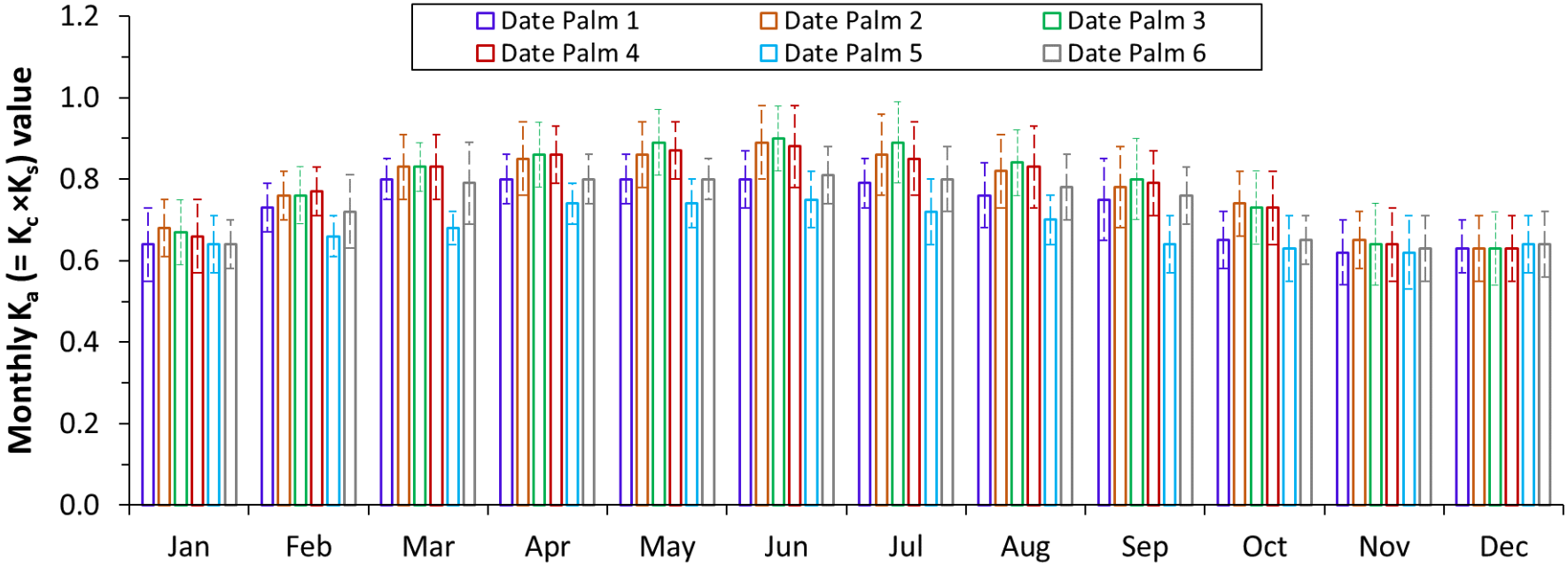
- **CIMIS**
- **Remote sensing**
- **Topography**



Spatial Report by Coordinate

Crop coefficients developed for Date Palms

(measurements in six date palms in the low desert)



Date palms have spatial and temporal crop coefficient values.

Recommendation

Integrated drip-flood irrigation is recommended for date palm.

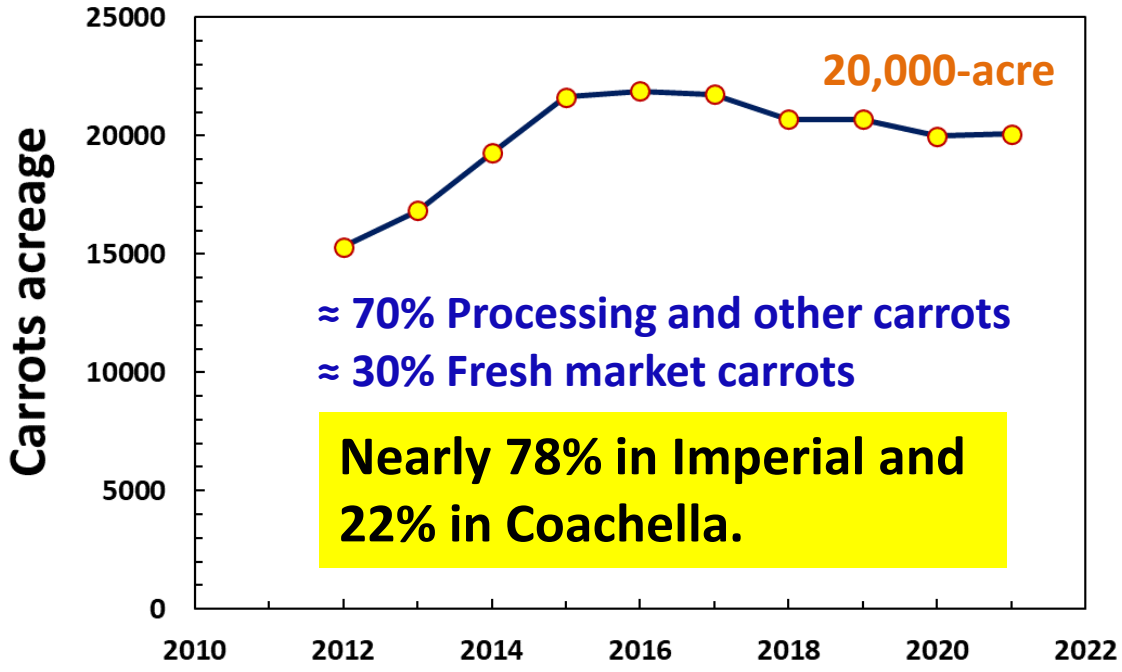
An easy approach

Assumption:

My drip system delivers an average of 10-gal/hr per tree.

Time of year	Drip run	Flood event
Mar	7-8 hours a day / 5-day a week	One
April - May	7-8 hours a day / 5-day a week	-
Jun - Sep	8-10 hours a day / 5-day a week	One
Oct	6-7 hour a day / 5-day a week	-
Nov - Feb	4-5 hours a day / 3-day a week	-

Carrots production in the desert region

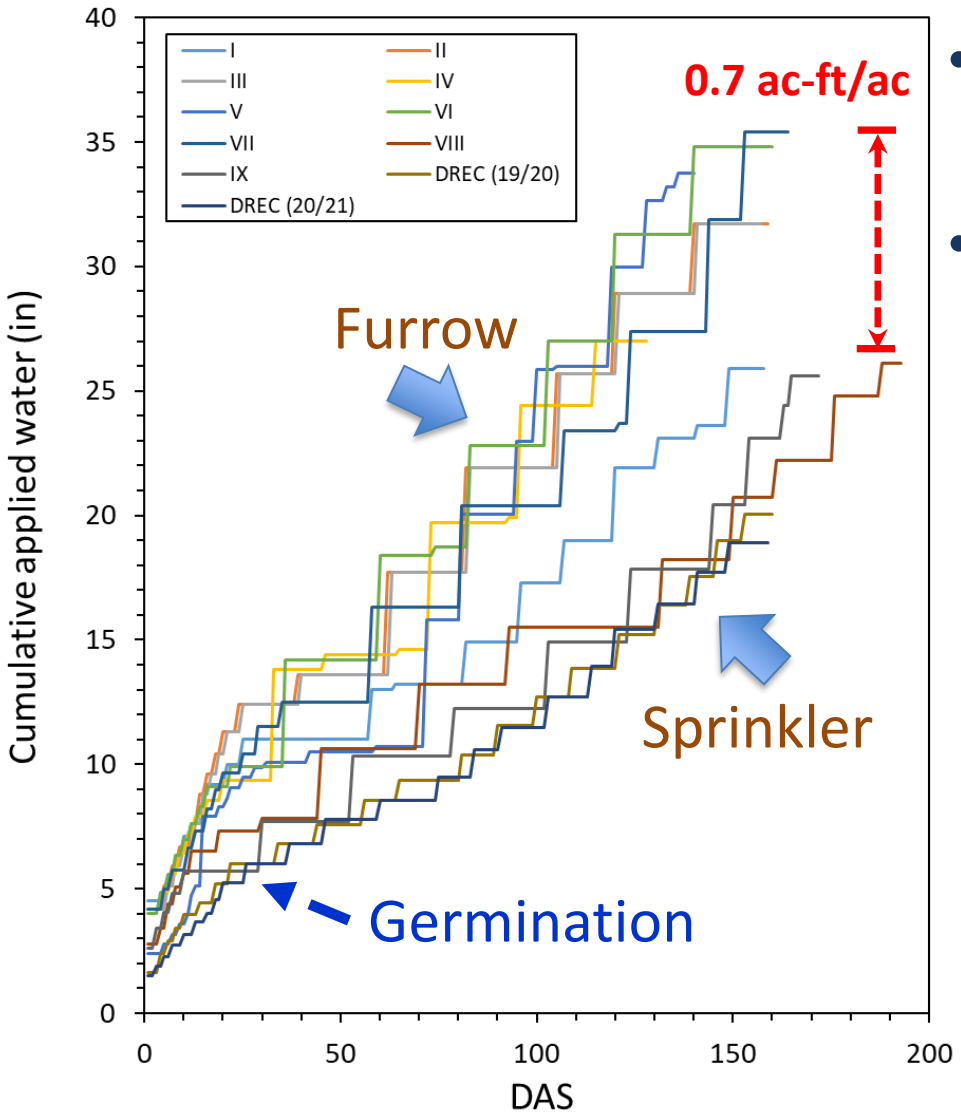


ONE of the California's top 10 valued commodities in 2021 ($1.11 billion).

Low desert accommodates nearly 1/3 of California carrots acreage.

Data sources
CDFA Agricultural Production Statistics & Imperial and Riverside Counties Agricultural Crop Reports

Applied water in carrot fields in the desert



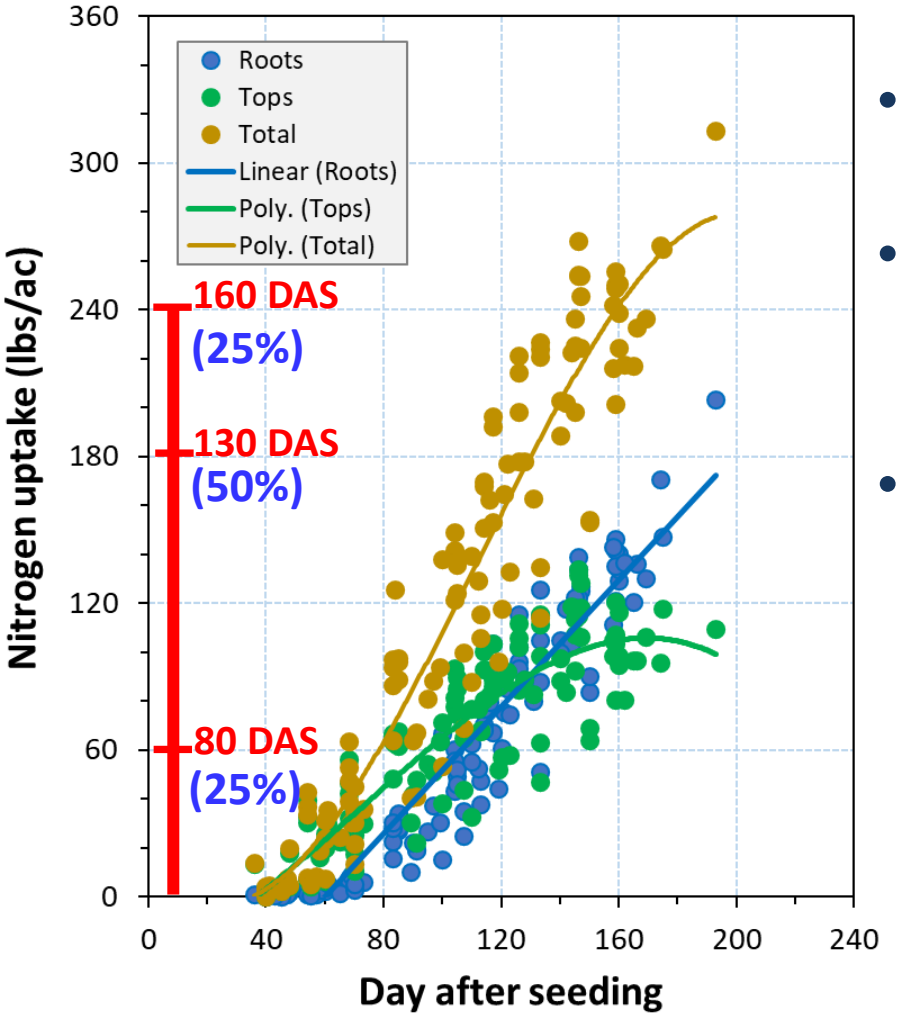
- **P**otential overirrigating during plant germination.
- **P**otential water conservation through irrigation practices (sprinkler vs. furrow).

In a typical 160-day season (October Planting):

“an average 16 inches as seasonal crop water use”

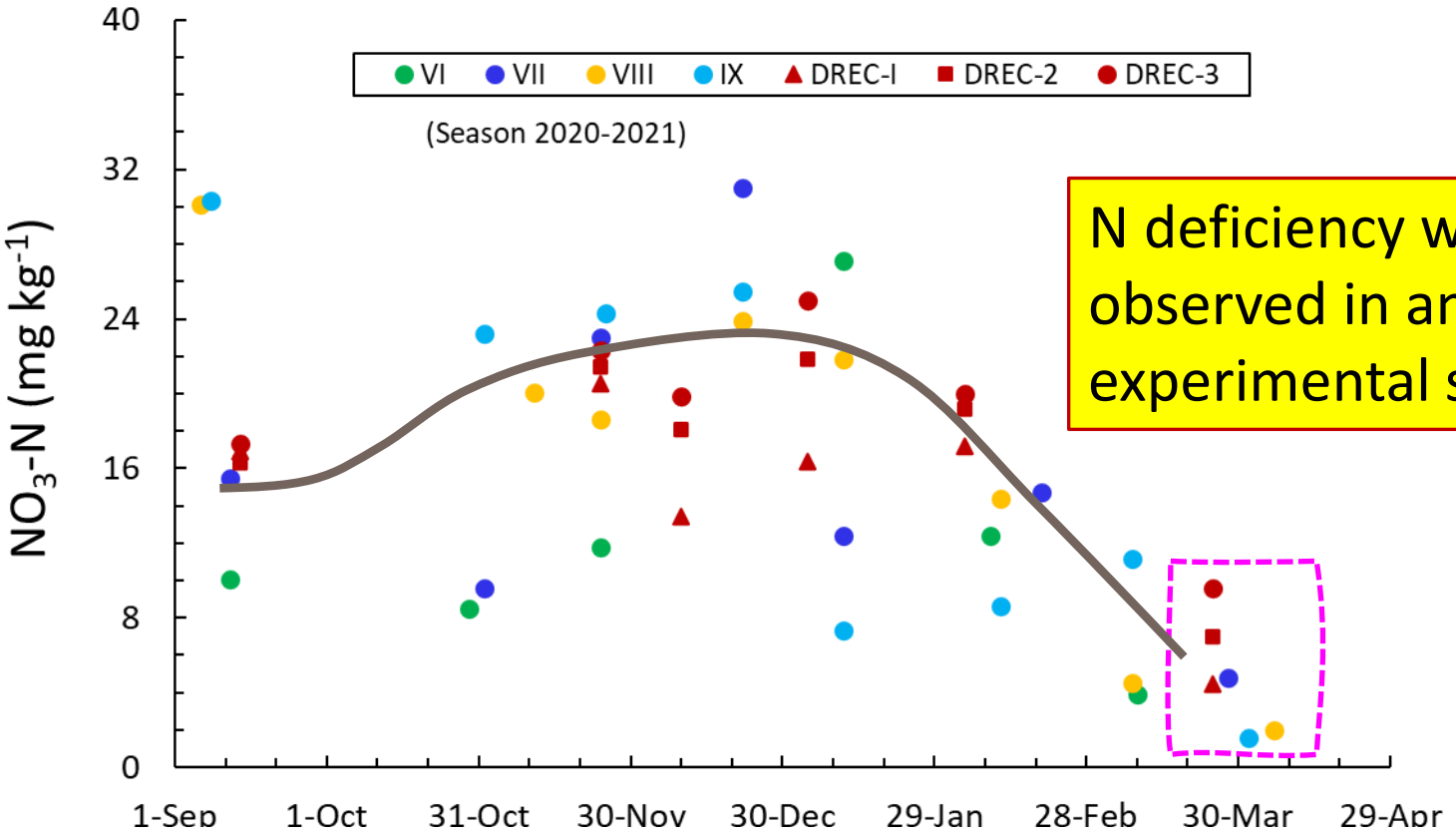
Approximately 50% of crop water needs occurred during the first 100 days after seeding and the other 50% during the last 60 days before harvest.

Nitrogen uptake curve in the desert



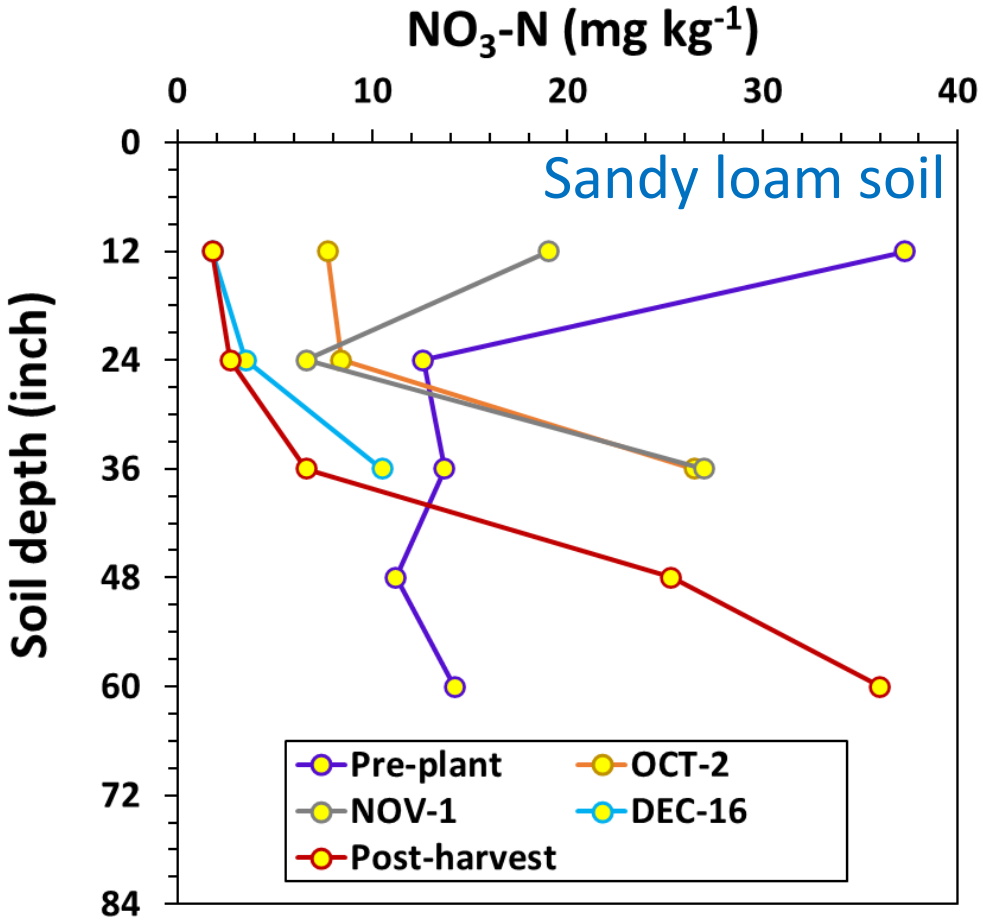
- **A** wide range of N accumulated in roots and tops at harvest.
- **A** linear regression model for N uptake in roots after 60 to 73 DAS.
- **N** uptake in tops increases gradually (quadratic regression), and levelled off or declines slightly late in the season (beyond 130 to 145 DAS)

Soil nitrate-N concentrations (top 1 foot)



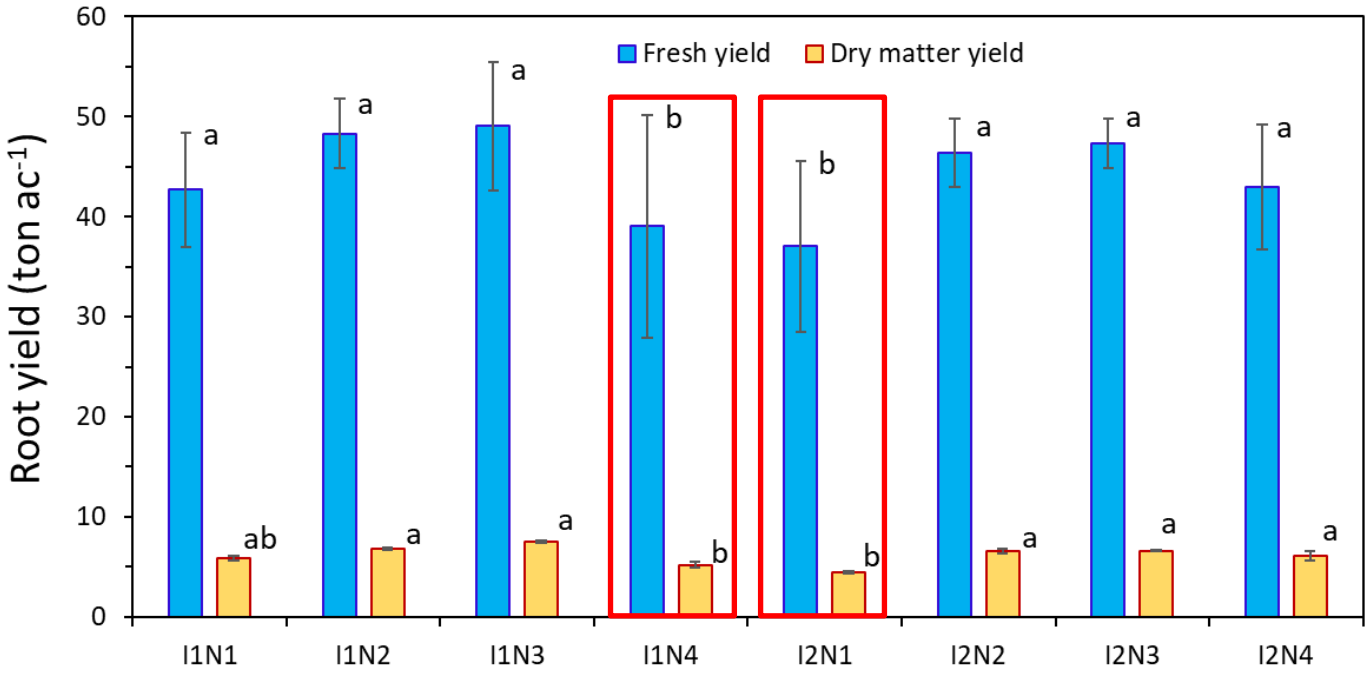
N deficiency wasn't observed in any of the experimental sites.

Soil nitrate-N variations within the soil profile



Sandy soils are at the high risk of nitrate leaching. Careful management of N in such soils is environmentally crucial.

Effect of irrigation regimes and N rates root yields



2021-2022

N1: 140 lbs.ac^{-1}

N2: 185

N3: 235

N4: 275

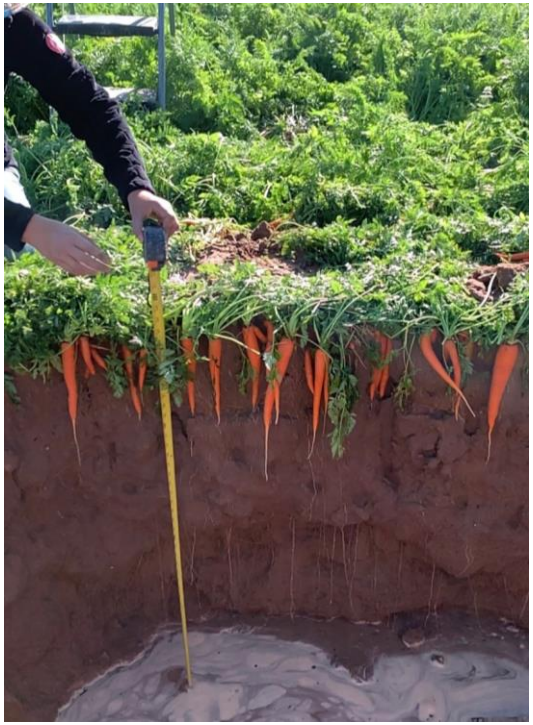
I1: 100%ET

I2: 125%ET

Fresh and dry matter root yields were significantly lower in I1N4 and I2N1 treatments ($p < 0.05$).

180 lbs/ac

In the desert, nitrogen application rates greater than 145 lbs/ac couldn't have a significant impact on root yield in a well-managed irrigated field. However, higher N rates are likely necessary in over irrigated carrot fields and/or sandy soils to maximize root yield.



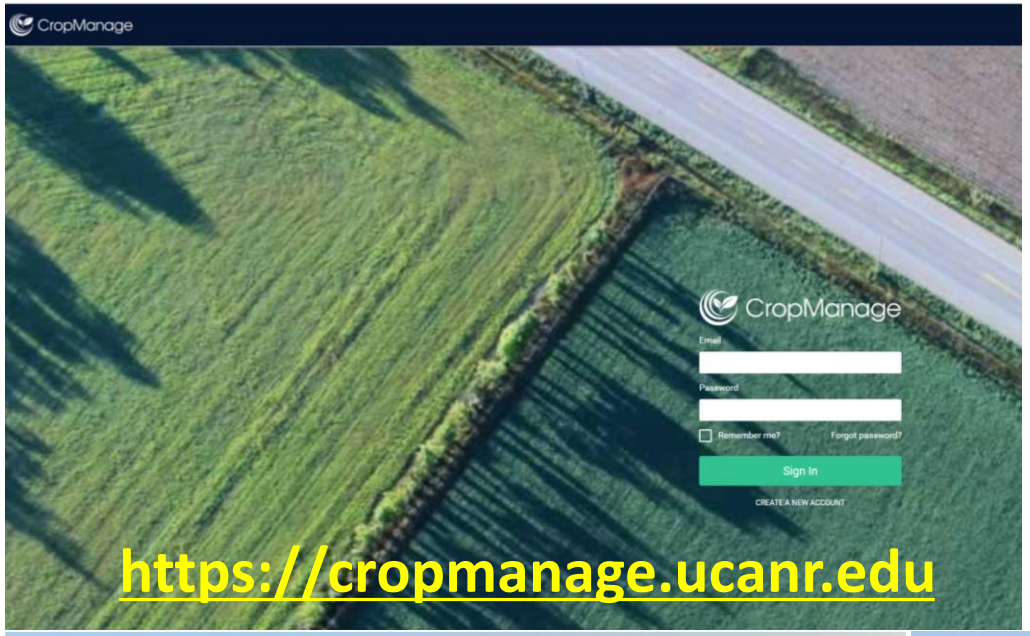
Fibrous roots at 5'
below the soil surface

Carrot field after harvest

Plant residues (Top) could contribute as a source of N for following season.

"38-42%
total N Uptake remained in the carrot foliage at harvest."

We developed **CropManage** carrot module.



CropManage is a free online decision tool for irrigation and fertilizer management (administrated by UC ANR).

Drip Irrigation Benefits in Desert Vegetables

40 in-bed vs. 80 in-bed!!!

Sweet corn

- 14 trial fields in the 2020 and 2021 seasons
- 7 furrow irrigated fields vs. 8 drip irrigated fields

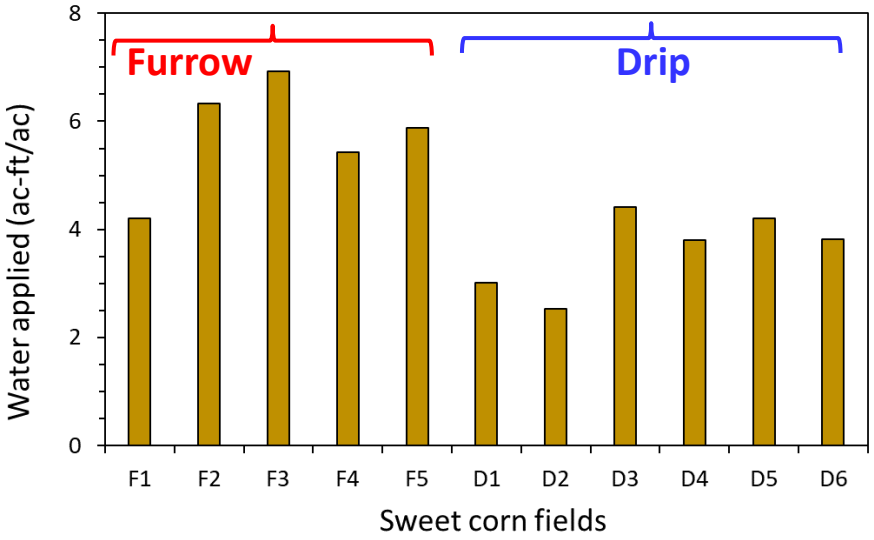
Nearly 450 acres furrow vs. 450 acres drip

- Monitor applied water, fertilizers, marketable yields and soil moisture

Dominant soil:
Sandy loam - Loamy fine sand

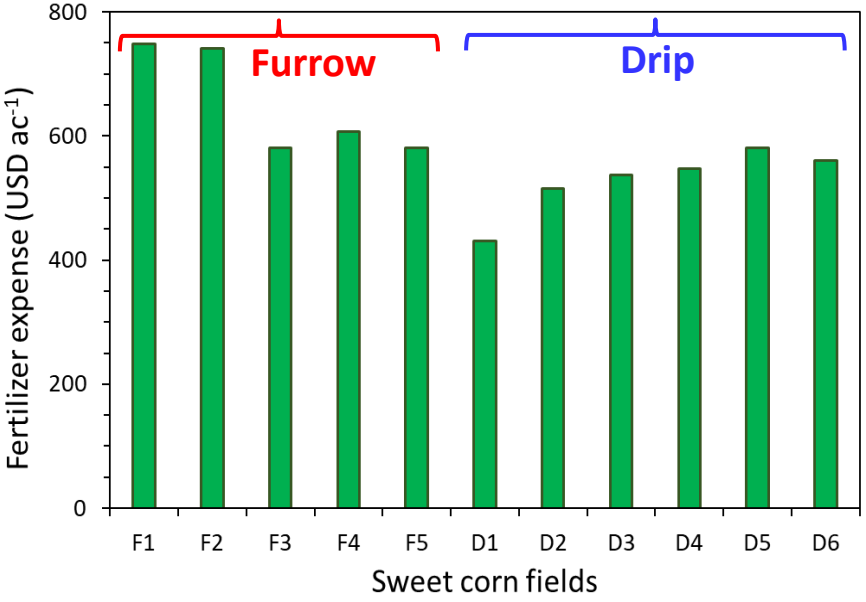
36-inch beds
One plant row per bed

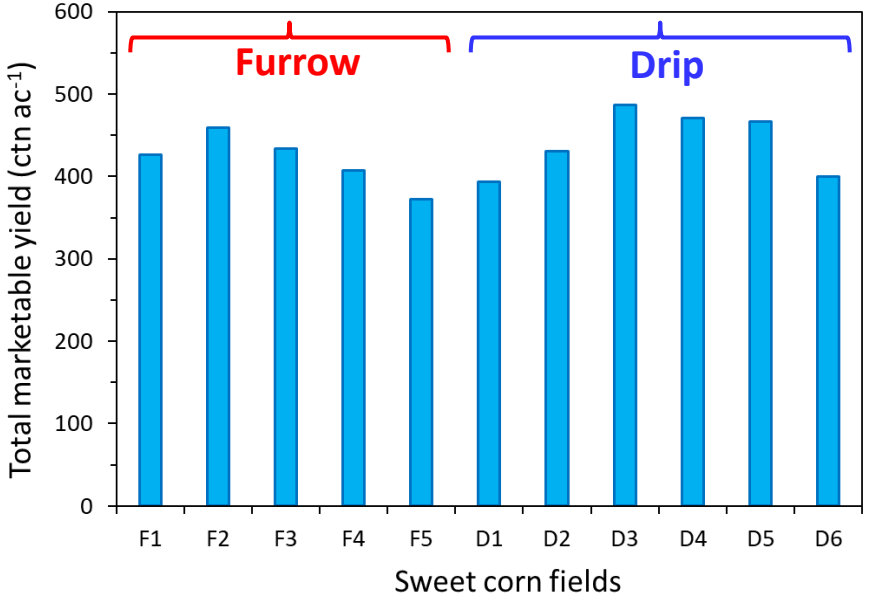
Dripline depth: 1.5-in



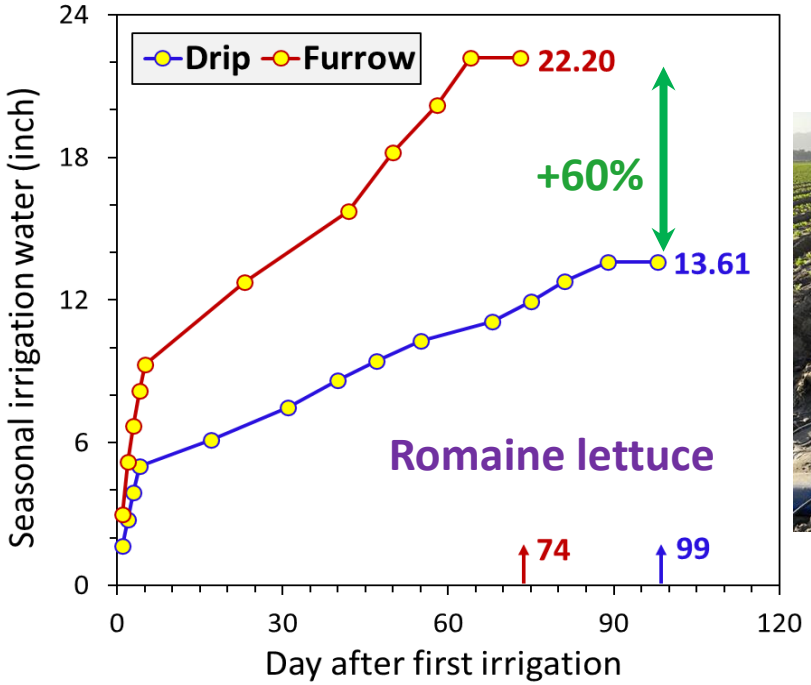
Results (2021)

- 37% water conserved in drip (2.2 ac-ft/ac)
- 26% fertilizer conserved in drip (146.0 $/ac)
- 5% yield increase in drip (21.0 ctn/ac)





Adapting drip irrigation in Lettuce

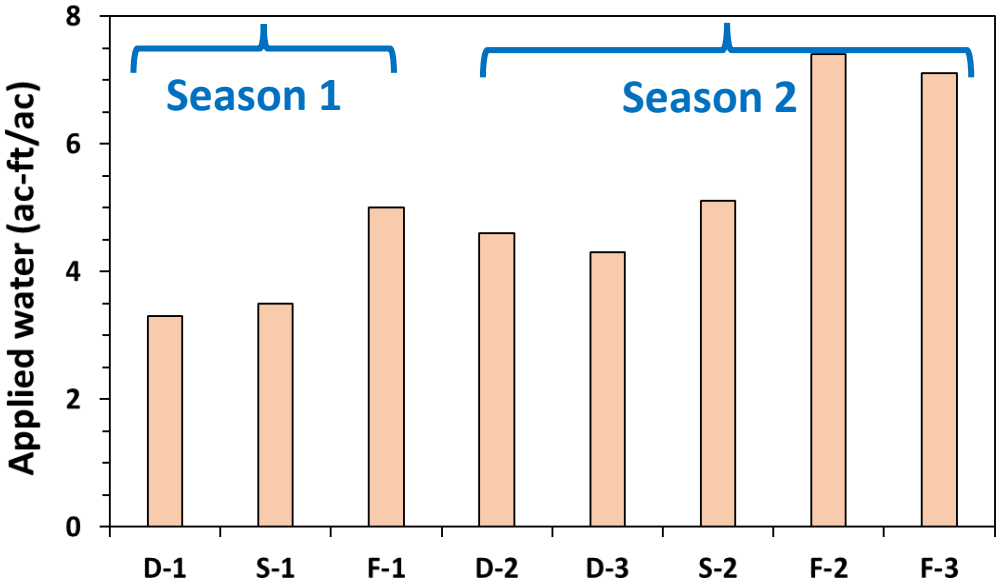


Drip vs. Furrow in desert lettuce

Preliminary data demonstrates that growers who adapted drip in lettuce conserved nearly 20% water (0.7 ac-ft/ac) and 15% N fertilizer.

Irrigation practices adopted in the desert onions

The current % of irrigation methods in the desert:
Furrow: ≈ 60-62%; Sprinkler: ≈ 35-37%; Drip: ≈ 3%

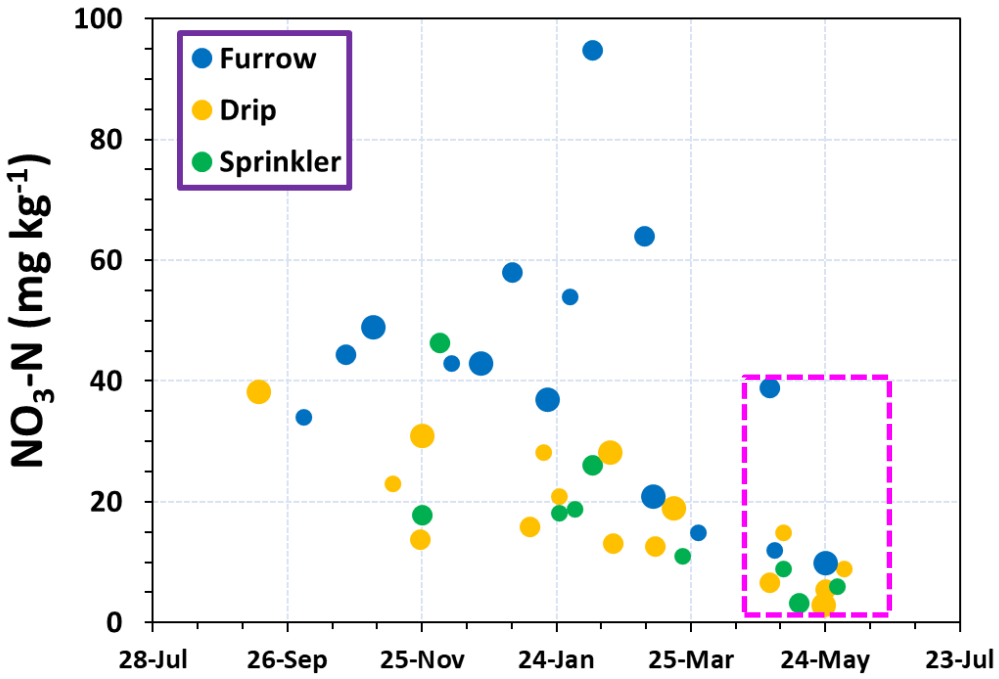


D: Drip
F: Furrow
S: Sprinkler

Average applied water (ac-ft/ac)

Drip: 3.9 Sprinkler: 4.3 Furrow: 6.5

Soil nitrate-N concentrations (top 1 foot)



Higher level of nitrate-N in furrow fields than sprinkler and drip.

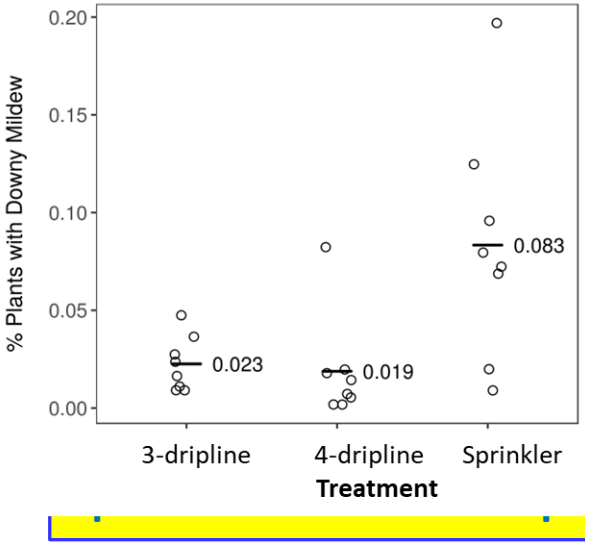
"Greater nitrogen-use efficiency at the drip irrigated field, nearly 40% and 8% more than furrow and sprinkler, respectively."

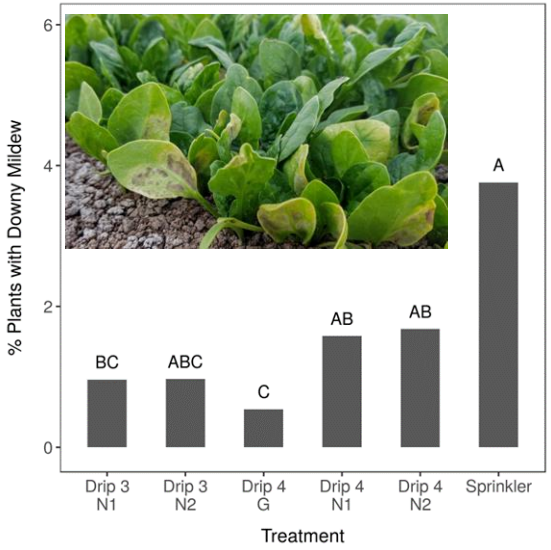
Encouragements to adopt drip in desert vegetables

Disease/water treatment and drip

Spinach: An overall effect of irrigation treatment on Downy Mildew incidence: It was lower (2-5 times) in the plots irrigated by drip. Growers reported $300 /ac less operational cost for water treatment (no food safety issue and downy mildew control).

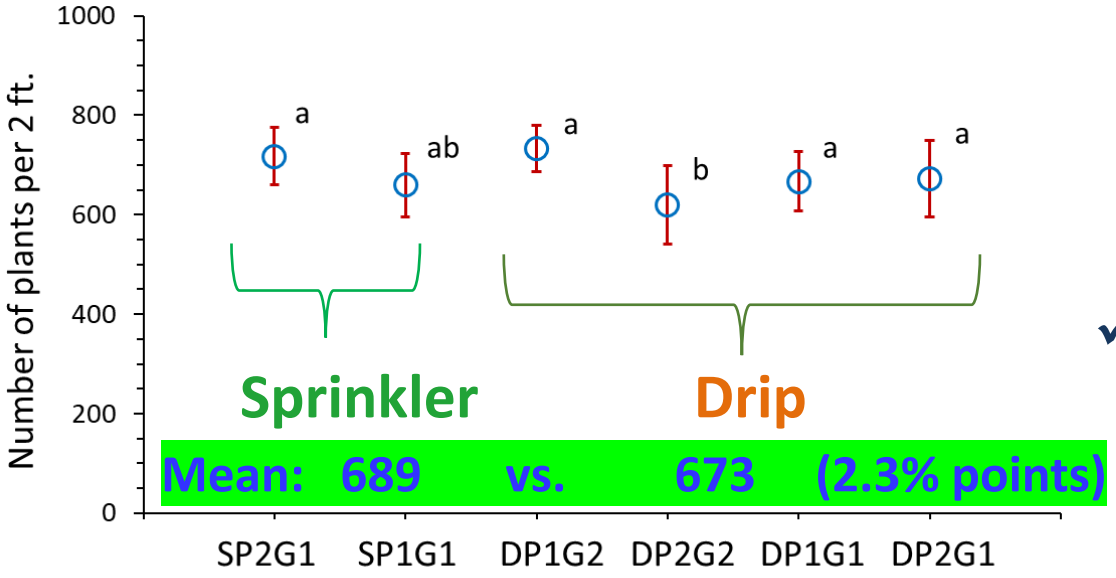
e in drip irrigated





"Sprinkler irrigated spinach canopies remained wet for 24-26 % more time than crop canopies under the drip treatment at a 20-day period."

Germination Evaluation

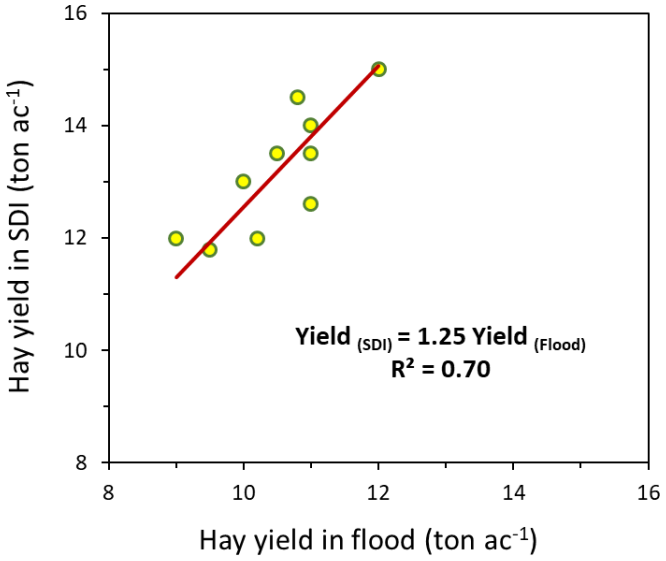


✓ **N**o significant difference between plant population of sprinkler and most drip germinated plots.

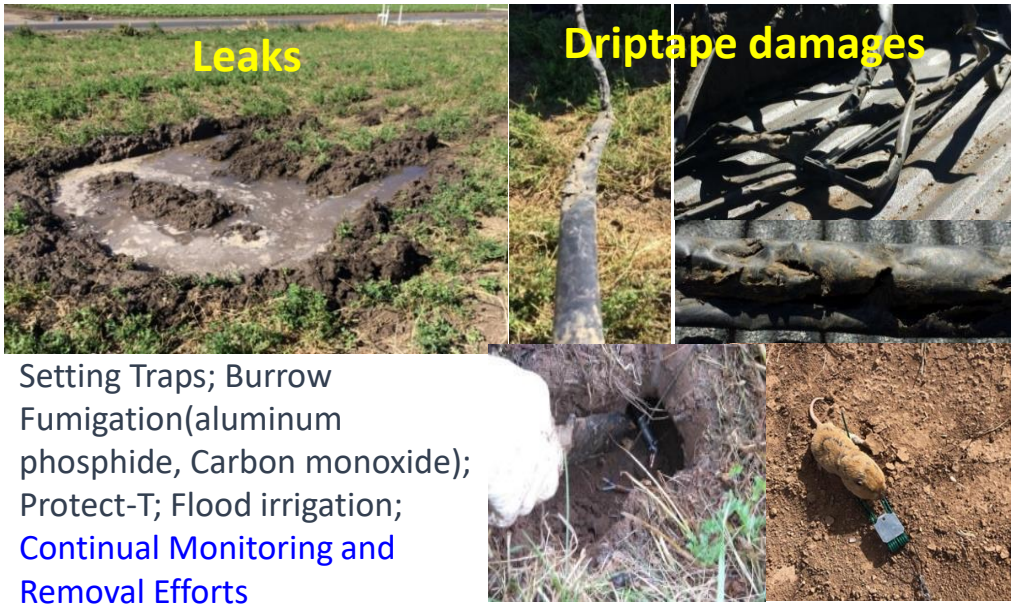
Germination by drip vs. sprinkler

Subsurface Drip Irrigation in agronomic crops - Alfalfa

Growers reported an average of 25% higher yield (2.4ton ac^{-1}) and nearly 1 ac-ft/ac less water applied in SDI.



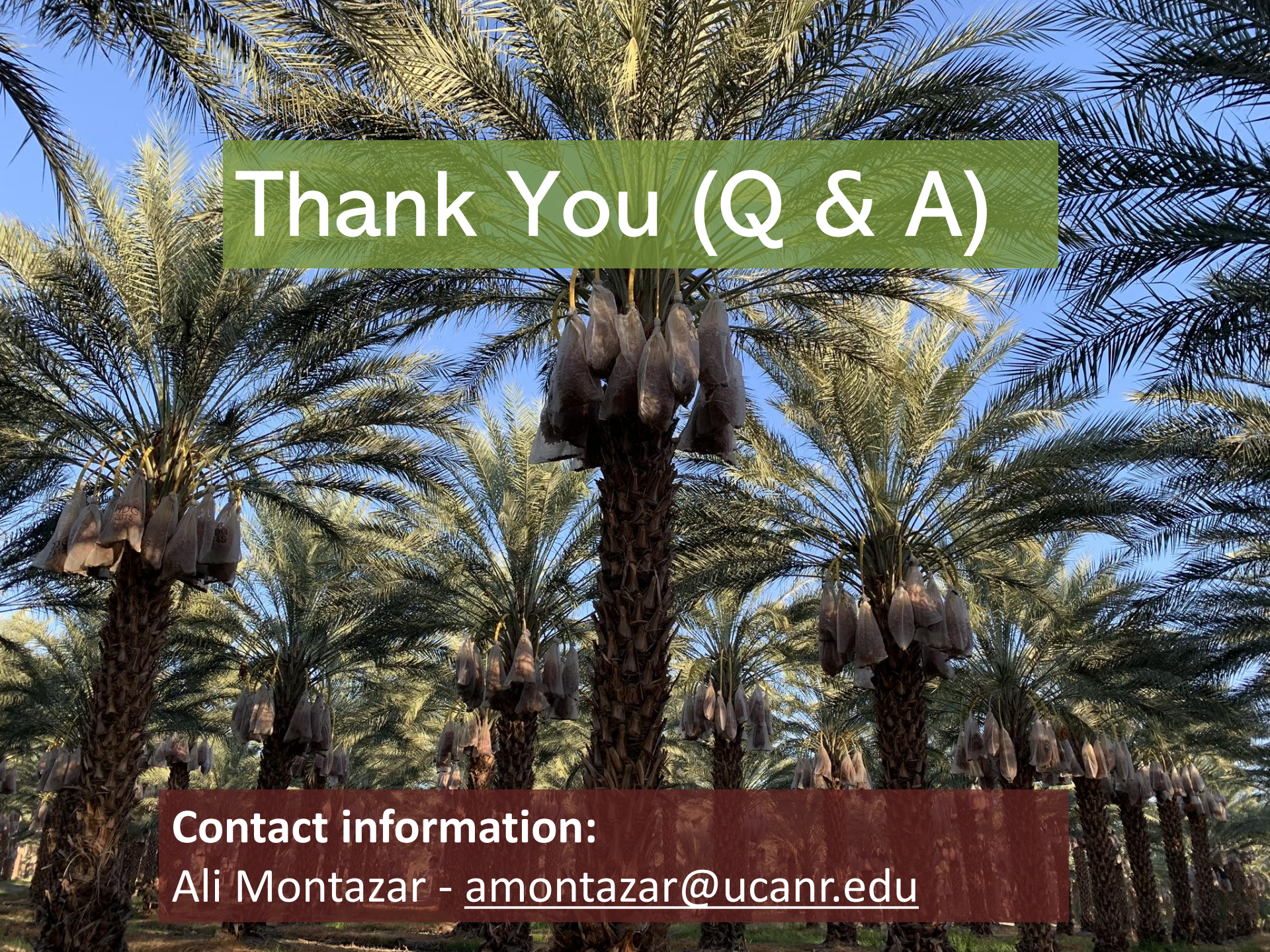
Maintenance and gopher strikes remains the major challenge. Salinity a challenge but manageable! Economically feasible!



Setting Traps; Burrow Fumigation(aluminum phosphide, Carbon monoxide); Protect-T; Flood irrigation; Continual Monitoring and Removal Efforts

Take-home Message

- **T**o enhance water-use efficiency, we need efficient irrigation system and effective irrigation scheduling.
- **C**IMIS data, appropriate crop coefficient, and soil moisture sensor are very useful tools for irrigation scheduling.
- **D**rip irrigation has promises/ enhancing resource-use efficiency.
- **C**onsider to use the developed crop coefficients, easy approach of irrigation management along with soil moisture recommendations for date palms.
- **I**n the desert, nitrogen application rates greater than 145 lbs/ac couldn't have a significant impact on root yield in a well-managed irrigated carrot field.



Thank You (Q & A)

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