Subsurface Drip Irrigation
For Organic Baby Spinach Production

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UC ANR

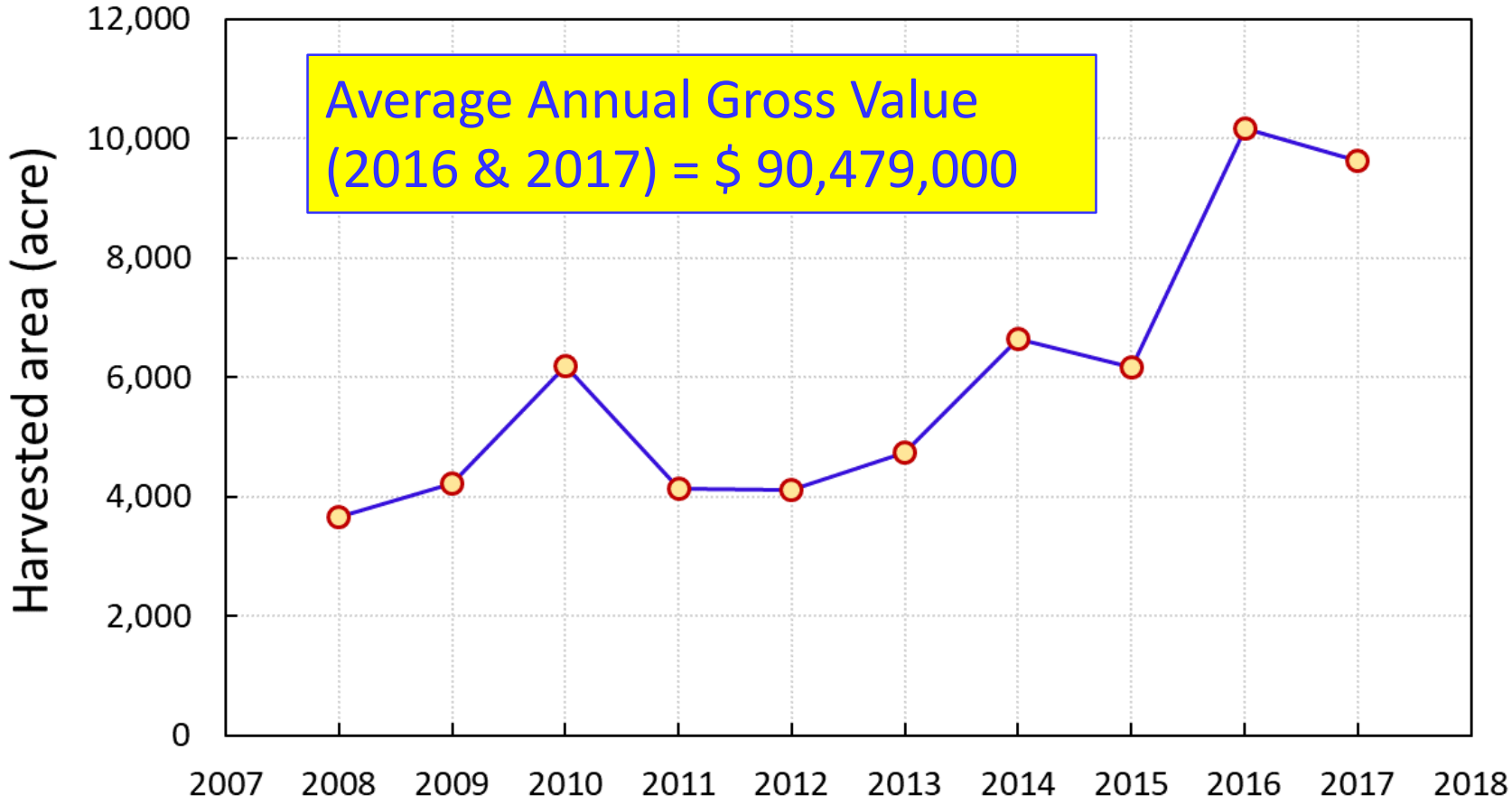
Why DRIP for organic spinach?

- Downy mildew on spinach as a widespread and very destructive disease (crop losses can be significant).
- In the low desert, spinach downy mildew typically occurs between mid-December and late-February.
- Fungicides are not available for organic production.
- Overhead irrigation may contribute to the severity of the disease.

"Peronospora effuse"



Trends of spinach production acreage in the Imperial Valley (2008-2017)



Spinach Production (Imperial Valley)

Solid-set Sprinkler
(80” bed)

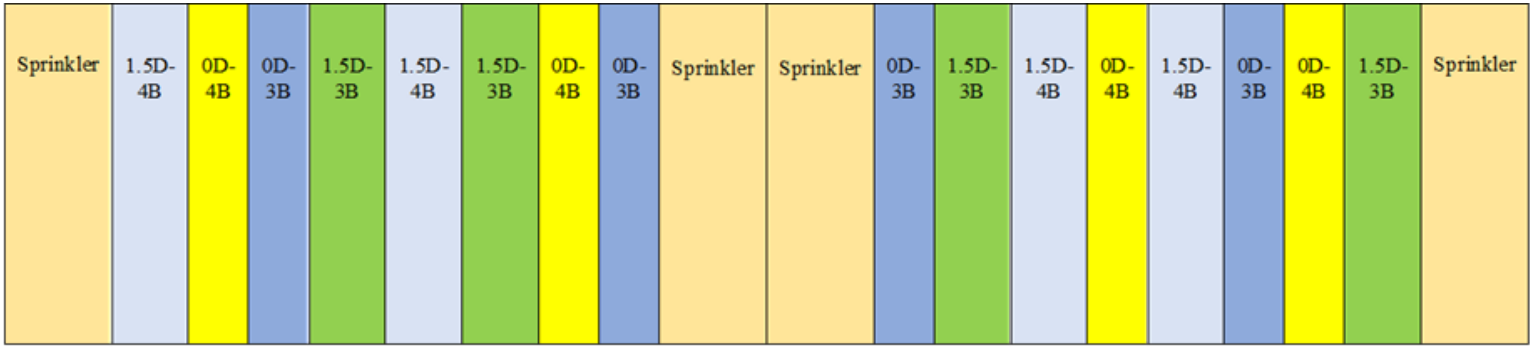
Linear Move Overhead
(No bed)

Field Experiment

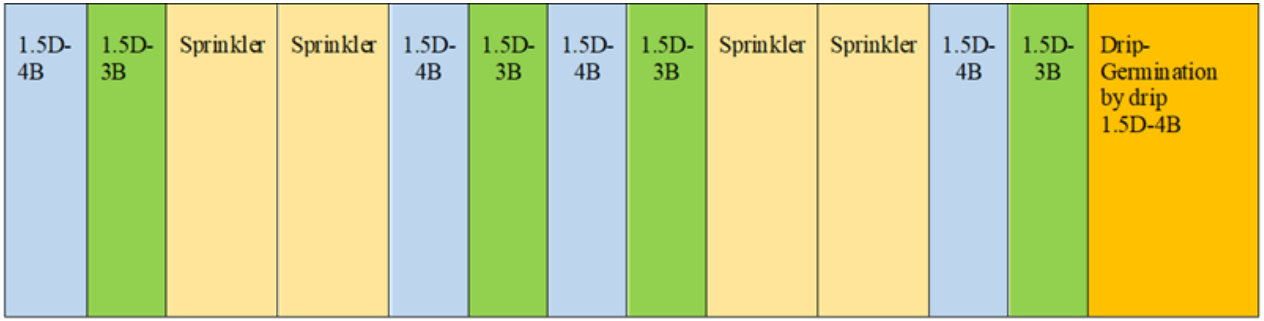
- UC Desert Research and Extension Center
- Silty Clay loam soil
- Untreated Viroflay spinach seeds
- Three crop seasons
  (Fall 2018/ Winter 2019/ Winter 2020)

- **Eight** (irrigation system/nitrogen) treatments:
  - ✓ Two drip depths: soil surface & 1.5-in depth
  - ✓ Two dripline spacings: three & four driplines **(80-in bed)**
  - ✓ Two nitrogen regimes: average rate applied by local growers & 20% more than average
  - ✓ Germination by drip: four driplines
  - ✓ Sprinkler irrigation

Plot Plans/Layouts



Fall 2018



Winter 2019

RCB Design

Winter 2020

Treatment	Code	Method for Germination	Method for Production	Nitrogen
1	S-N1	Sprinkler	Sprinkler	100%
2	3D-N1	Sprinkler	Drip (3 lines)	100%
3	4D-N1	Sprinkler	Drip (4 lines)	100%
4	3D-N2	Sprinkler	Drip (3 lines)	120%
5	4D-N2	Sprinkler	Drip (4 lines)	120%
6	4D-N1	Drip	Drip (4 lines)	100%

Special thanks to **Vessey Farms** for supporting this study with planting spinach seeds and sharing thoughts.

Fertilizer application

- **True 6-6-2** as pre-plant fertilizer
- **True 4-1-3** (liquid fertilizer) as complementary fertilizer through injection into irrigation systems

Measurements:

- Soil and Plant tissue N
- Irrigation applied water
- Yields
- Chlorophyll content (atLEAF)
- NDVI, actual crop ET, soil moisture, leaf wetness, weather data

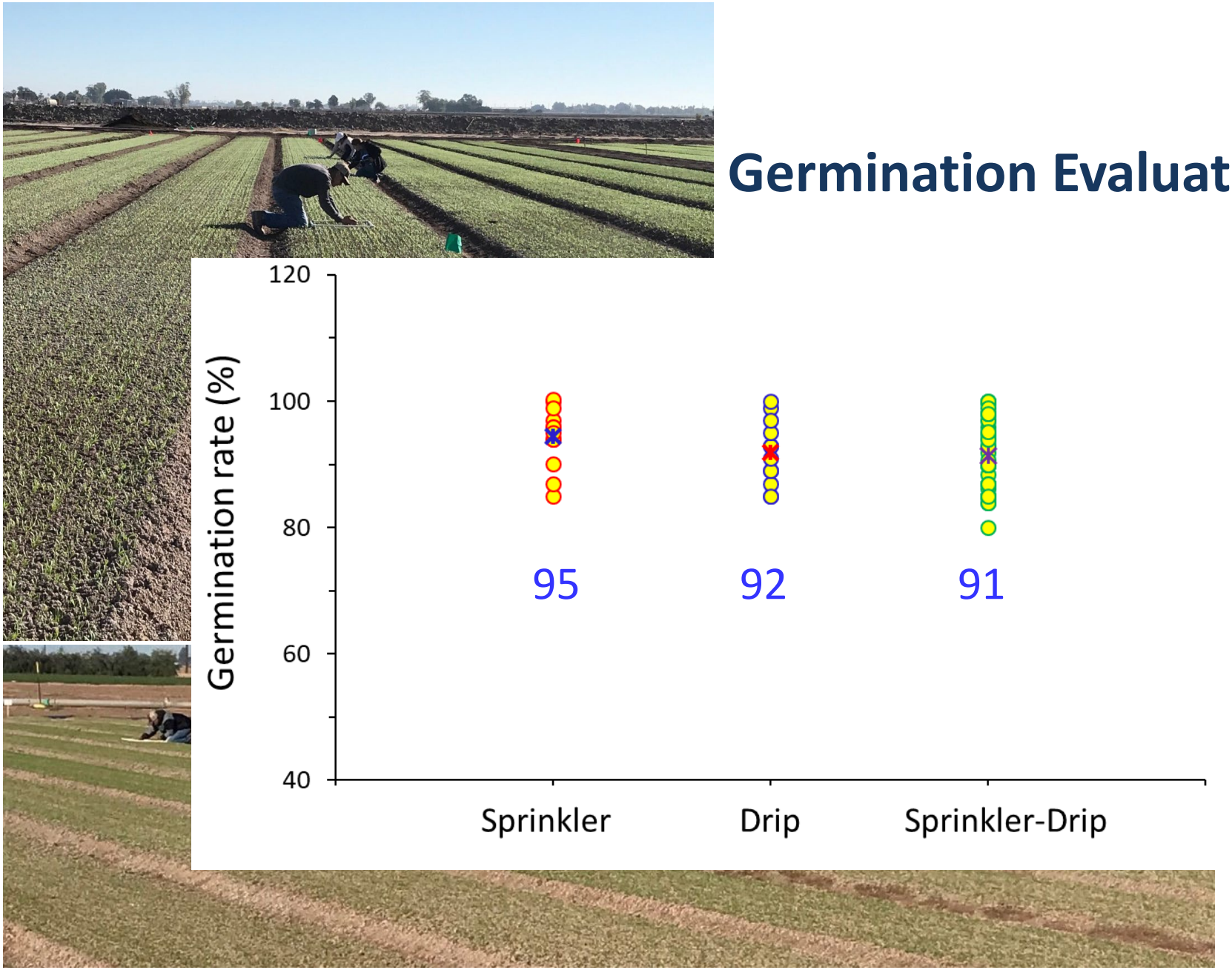
RESULTS

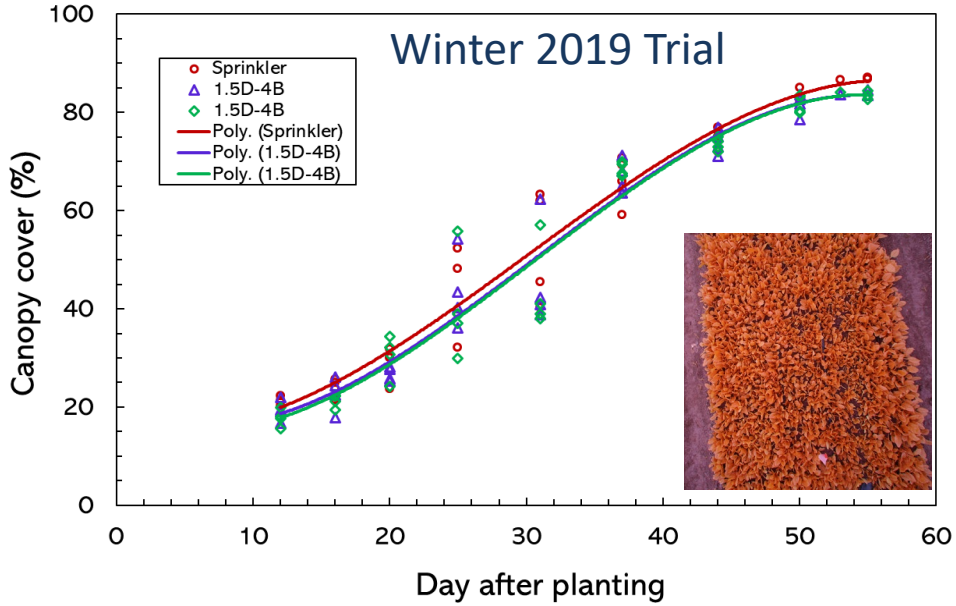
18 days after planting

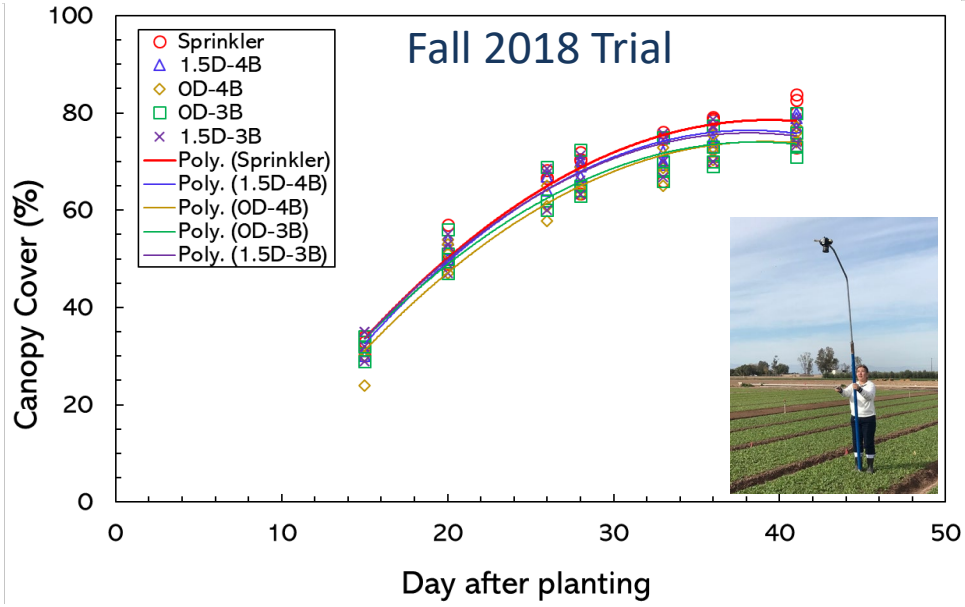
38 days after planting

Germination spinach seeds (drip vs. sprinkler)

Germination Evaluation



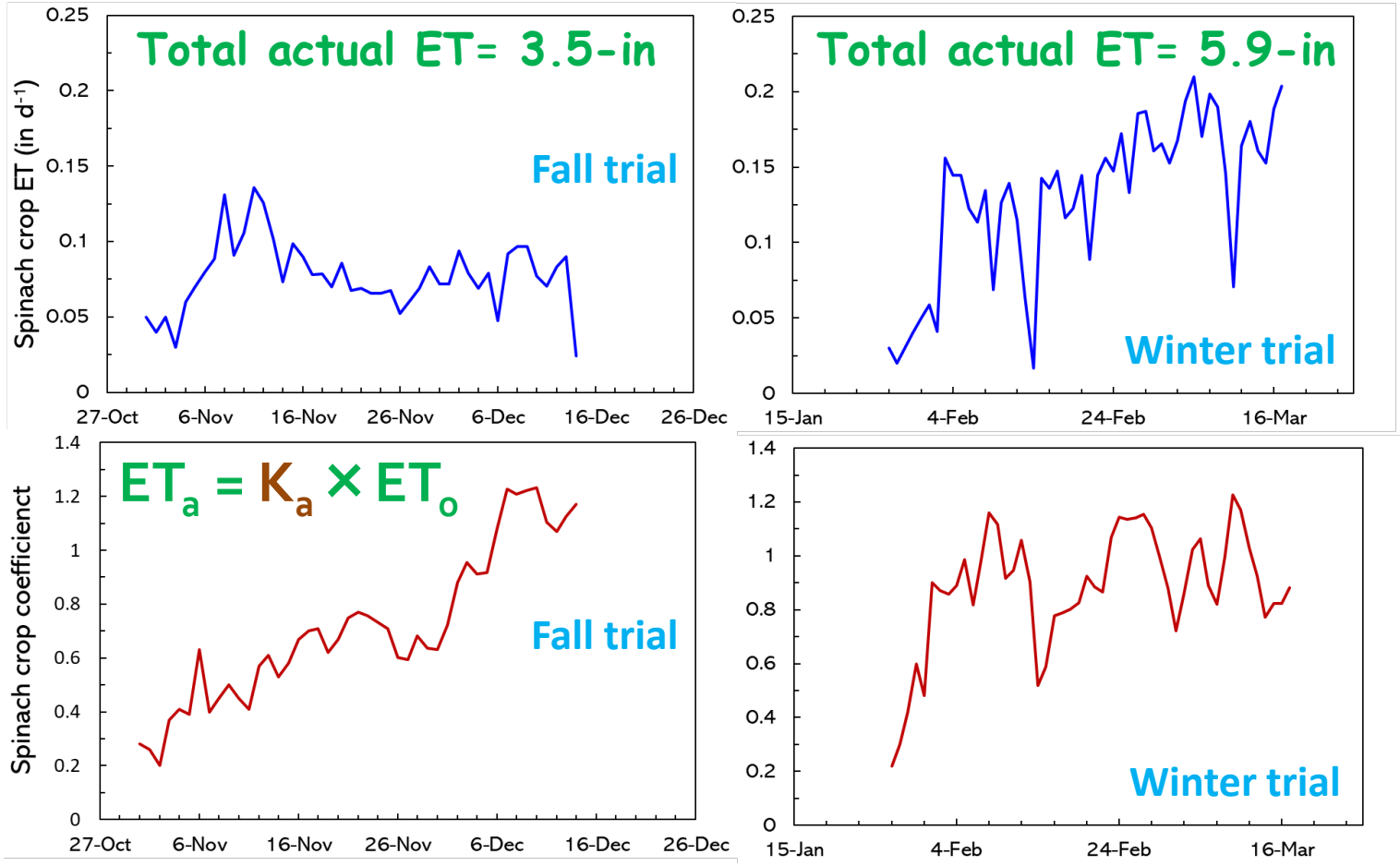


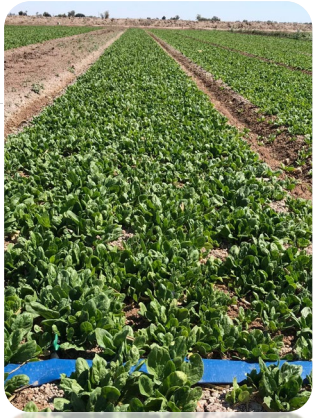


Crop canopy evaluation

The leaf density of drip irrigation treatments was slightly behind (**1-4 days** depending upon the irrigation treatment and crop season) that of sprinkler irrigation treatments in time.

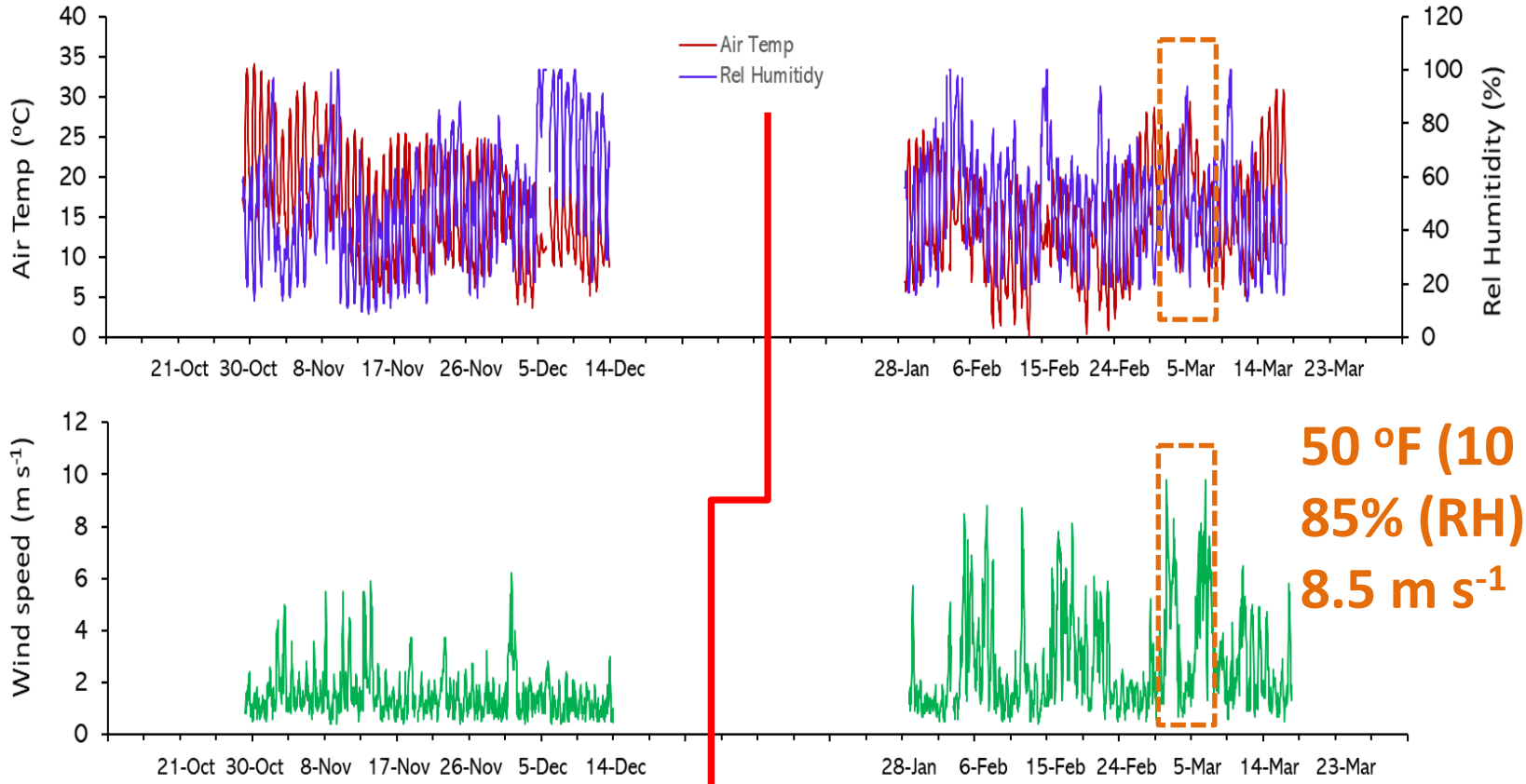
Crop water use information





- Crop coefficient values (K_a) varied from 0.2 to 1.2
- Aa average ET of 0.08 in d^{-1} for the fall trial and 0.13 in d^{-1} for the winter trial

Weather conditions over the crop seasons



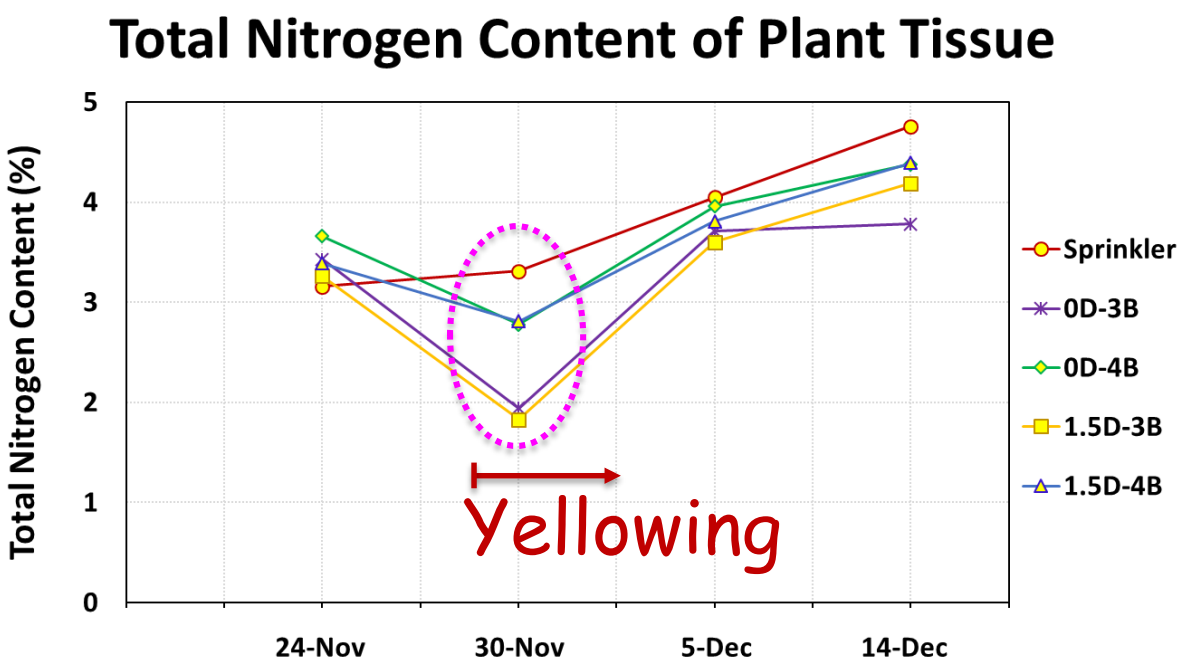
50 °F (10 °C)
85% (RH)
8.5 m s^{-1}

Fall 2018 trial

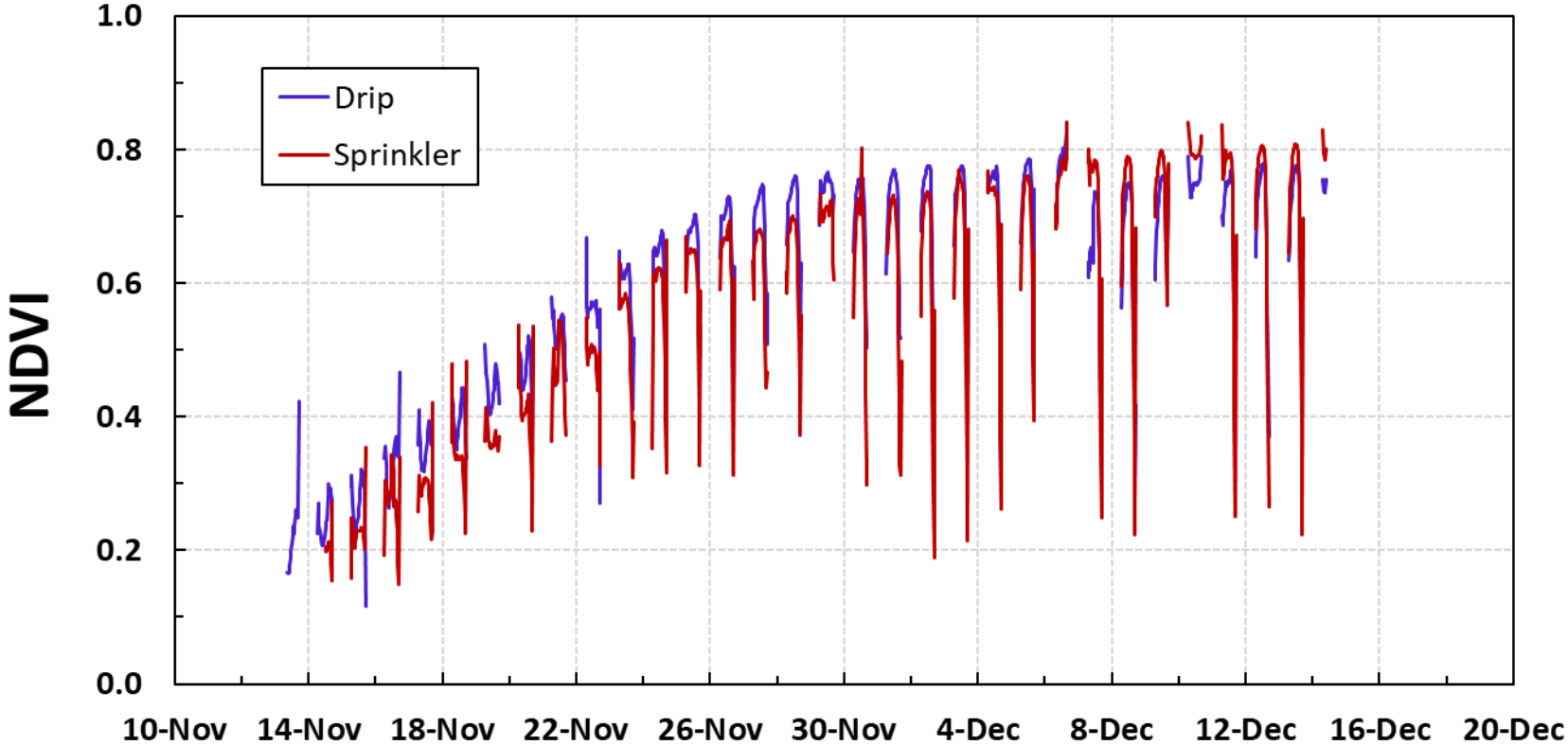
Winter 2019 trial

Yellowing issue in drip trials

Bed with 3- dripline

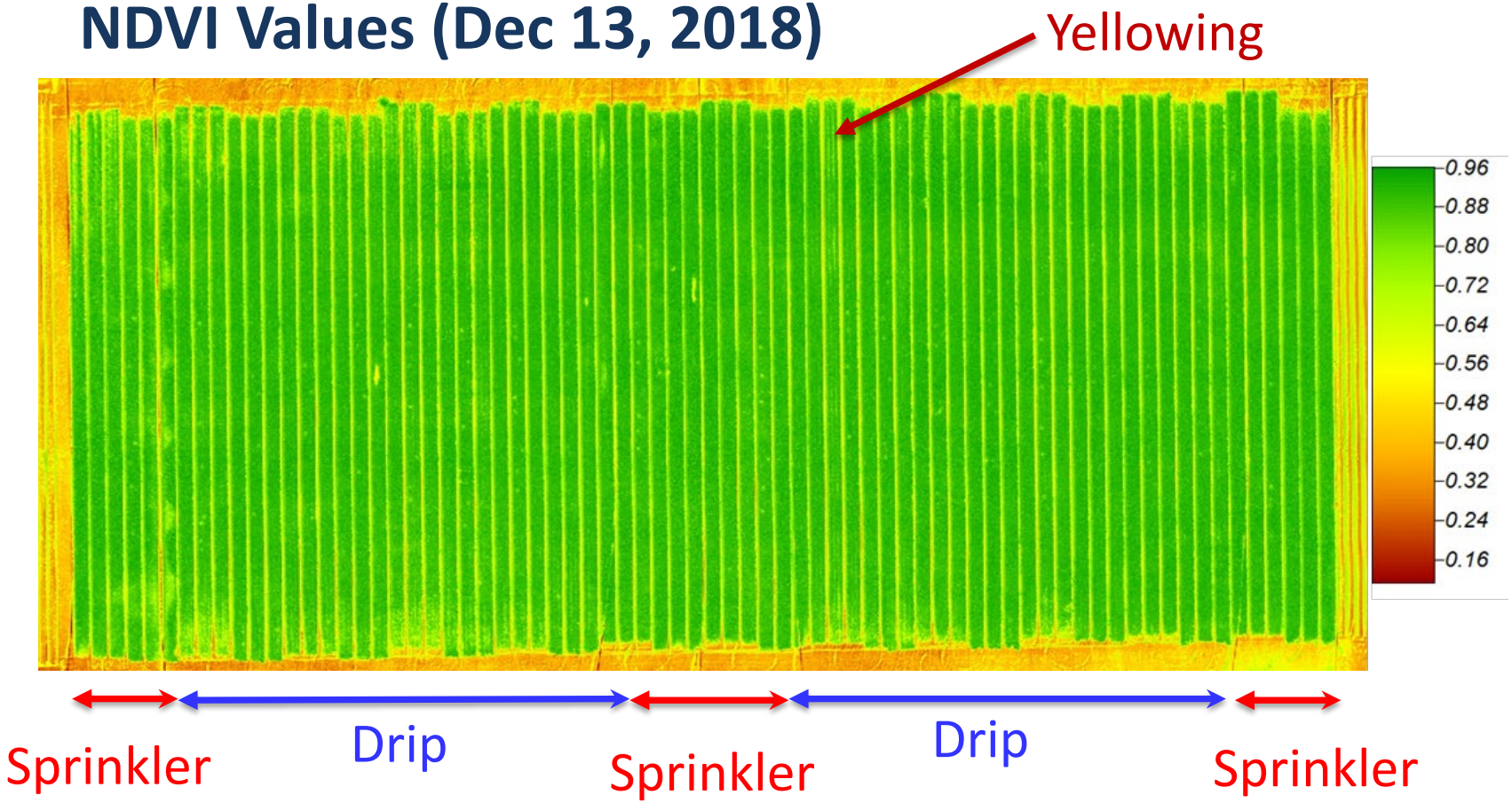


30-minute Daily NDVI (Drip vs. Sprinkler)



Spectral Reflectance Sensors

NDVI Values (Dec 13, 2018)

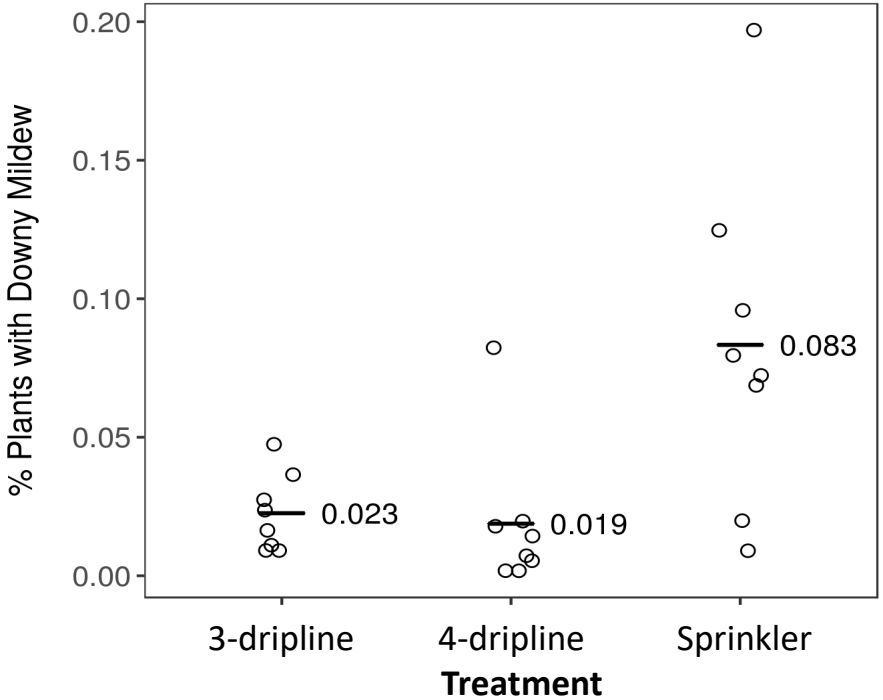


Surface drip is not practical.

- **T**he driplines moved around due to wind until the crop canopy is fully developed.
- **S**urface drip might be problematic for growers since the drip line would need to be removed before harvest and would pose a food safety risk.

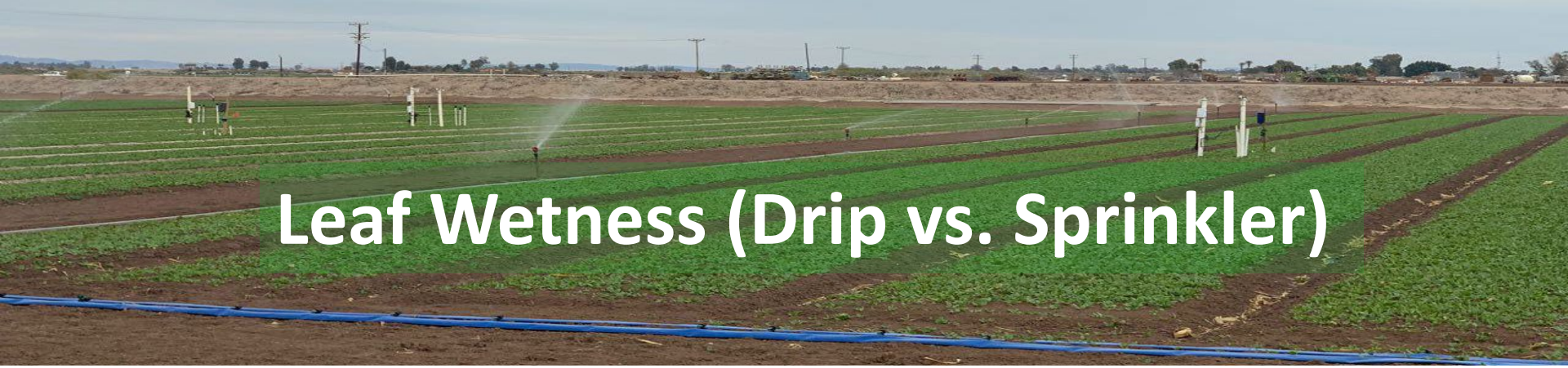
Downy mildew incidence

Downy mildew was not observed in the fall experiment but was first confirmed in the study area on March 5, 2019 (winter trial).

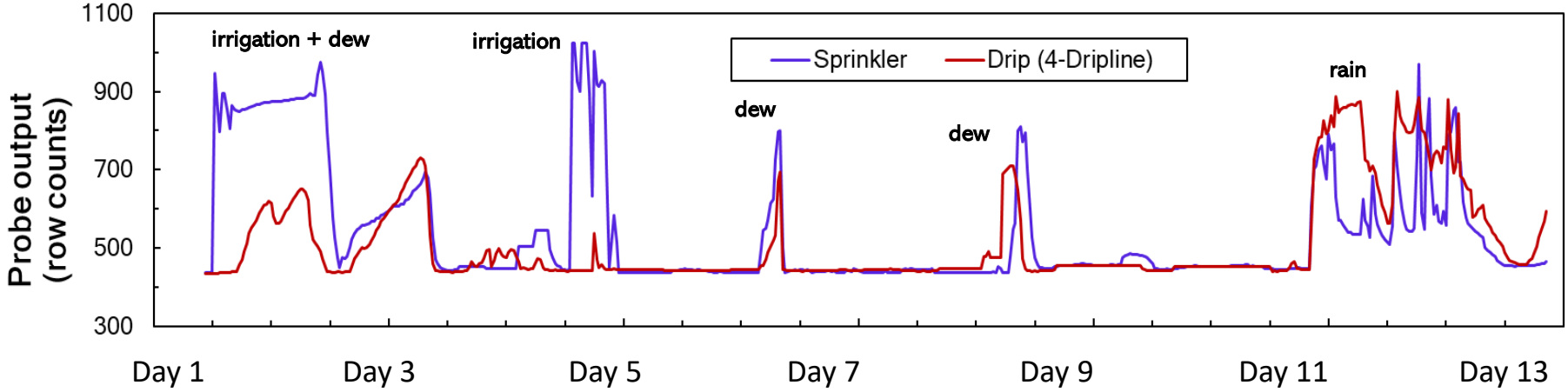


An overall effect of irrigation treatment on downy mildew:

<u>Downy Mildew incidence</u> was lower (4-5 times) in the plots irrigated by drip.

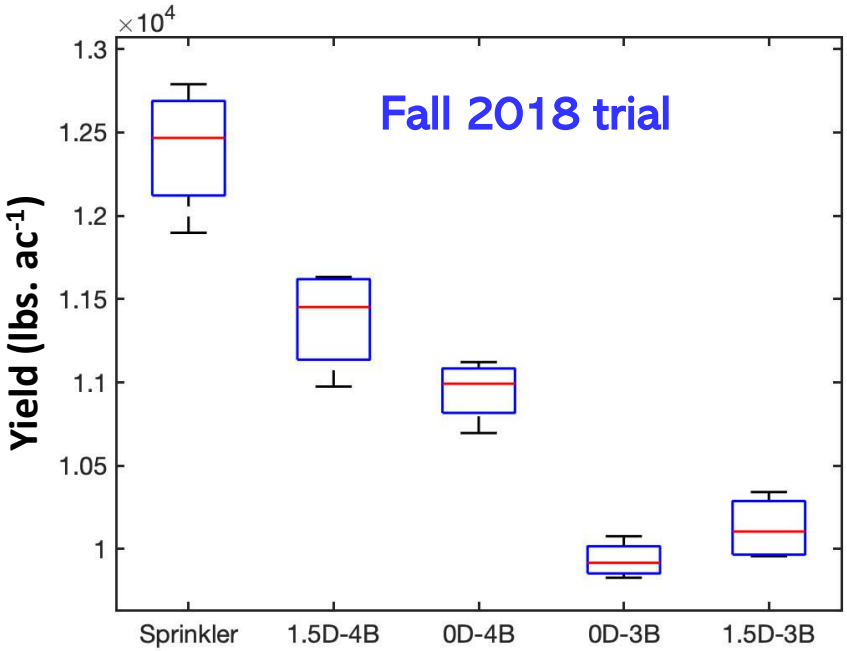


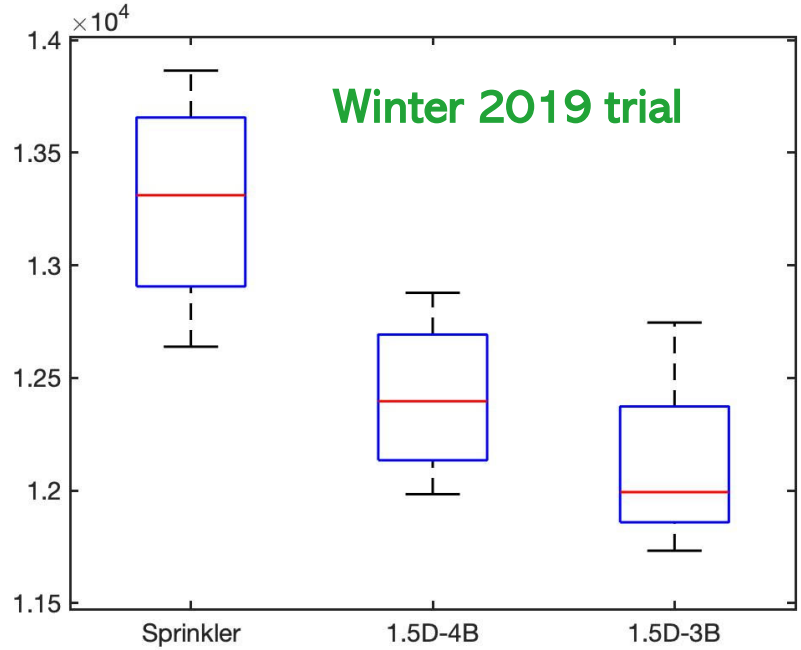
Leaf Wetness (Drip vs. Sprinkler)



Sprinkler irrigated crop canopies remained wet for 24.3 % more time than crop canopies under the drip treatment at the period.

Yield (shoot biomass) analysis





- **In the fall trial**, mean shoot biomass yield in the sprinkler treatment was **12,406 lbs. ac^{-1}**, approximately **9% more** than the drip treatment (4-dripline at 1.5-in depth). **In the winter trial**, the yield was **13,281 lbs. ac^{-1}** in the sprinkler treatment, about **7% more** than the drip treatment.

Mean spinach fresh yields

Fall 2018		Winter 2019	
Irrigation treatment	**Fresh yield (lb/ac)**	**Irrigation treatment**	**Fresh yield (lb/ac)**
Sprinkler	**12,406 a**	**Sprinkler**	**13,281 a**
1.5D-4B	**11,378 b**	**1.5D-4B**	**12,414 ab**
0D-4B	**10,950 b**	**1.5D-3B**	**12,116 b**
0D-3B	**9,935 c**	**-**	**-**
1.5D-3B	**10,127 c**	**-**	**-**

- **S**ignificant yield difference between the sprinkler irrigation and each of the drip irrigation treatments (fall trial)
- **N**o significant yield difference between surface drip and sub-surface drip with the same dripline number in bed, but very significant impact of the number of dripline in bed on spinach biomass (fall trial)
- **N**o significant yield difference between the sprinkler and the 4-dripline at 1.5-in depth drip treatment (winter trial)

Commercial Field

(Conventional Bunched Spinach)

3-Dripline
Loamy soil

Commercial Field

The grower reported these benefits for drip:

- Control down mildew disease
- No need to water treatments for food safety issue
- As the same yields as sprinkler fields
- Less fertilizer application

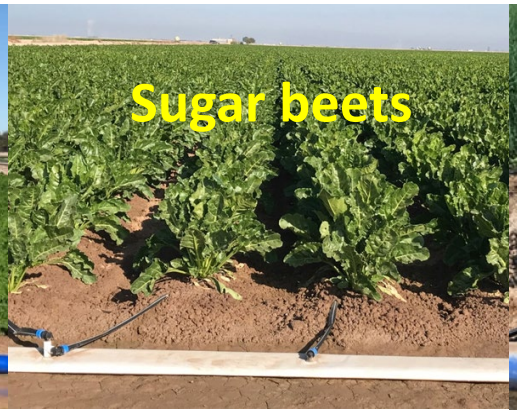
Drip vs. Sprinkler

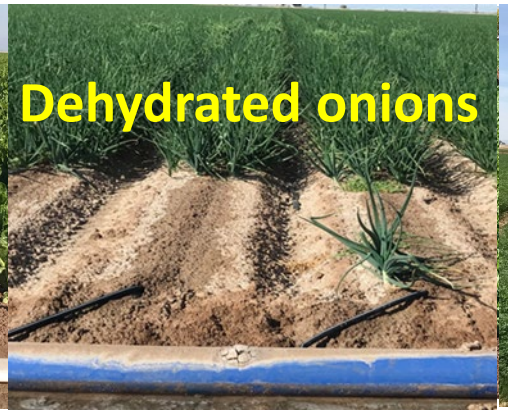
(sample costs at bunched spinach)

Item	Annualized costs ($/ac) (Drip – Sprinkler)
Drip tape (3-line/bed) - 1yr	+ 350
Insert/remove drip tape - 1yr	+ 450
Fertilizer	- 150
Irrigation management/labors	- 250
Water	0
Energy	- 200
Downy mildew control + water treatment for food safety	- 300
Yield production	0
Higher cost of producing spinach under sprinkler irrigation	**100**

Preliminarily Conclusions

- **D**rip irrigation demonstrated the potential to be used for producing spinach, conserve water, enhance the efficiency of water and nitrogen use, and reduce/manage downy mildew.
- **F**urther work is needed to evaluate the viability of utilizing drip (optimal system design, the impacts of I & N management practices, and strategies to maintain spinach productivity and economic viability) at spinach.





Future Experiments

- The project is planned to be conducted over a three-year period.
- Evaluate nitrogen levels in the drip-treatment.
- Evaluate drip irrigation for the whole crop season (germination and remainder of crop season).
- Assess the practice in commercial fields.
- Economic feasibility assessment.
- Develop recommendations.

Thank You (Q & A)

Special thanks to
California Leafy Greens Research Board

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