2022 Processing Tomato Experiment
Final Report

Main Objective

The main objective of this field trial was to evaluate the effects of two spray application types on crop yield and water use efficiency of processing tomatoes. The two spray applications, known as 11HX and Solbere, are owned and manufactured by ORCAL, Inc. and CO_2 Solved, LLC, respectively.

Highlights

- Compared to the control plants, in the 100% irrigation treatment, Solbere and 11HX increased the tomato yield by 13% (6.9 tons/acre) and 16% (8.4 tons/acre), respectively. In the 85% irrigation treatment, both Solbere and 11HX increased the crop yield by 13% (6 tons/acre) compared to the control plants. The yield enhancement of the spray plots was about 5% in the 75% irrigation treatments. No differences were observed between the Brix levels of the control and spray treatments.

- The 85% irrigation treatments of treated plants (11HX and Solbere) had 3% more crop yield than the 100% irrigation of non-treated Control plants, indicating the spray treatments' yield-enhancing potential.

- Solbere increased the albedo of tomato plants noticeably by increasing the reflected shortwave radiation. An increased albedo would reduce the net radiation received at the canopy level, resulting in reduced crop water requirements.

- The reflected Photosynthetically Active Radiation (PAR) is comparatively small (less than 8%) in all crop treatments during the day. Solbere and 11HX had increased PAR reflection compared to the control plants. However, the increased yields in the Solbere and 11HX plots show that reflecting away some PAR radiation does not negatively affect plant productivity.

- Three field cameras recorded the canopy temperature every 30 minutes, 48 images daily. No differences were observed between the canopy temperature of control plants, Solbere, and 11HX during the 24 hours.

- A portable thermal camera measured the canopy temperatures of 36 subplots on selected days around solar noon under the clear sky. No significant differences were observed between Control, 11HX, and Solbere for 100%, 85%, and 75% irrigation treatments.

- Compared to the control plants, the increased albedo, combined with the lack of changes in the canopy temperatures, indicates the potential for water conservation at the canopy level.

- The combination of the increased crop yield and albedo, coupled with the lack of changes in evaporative cooling, show the water-use efficiency enhancement potential of the spray treatments.

- Irrigation treatments had significant effects on crop yield and canopy temperature. The 100% irrigation treatments in Control, Solbere, and 11HX, generally had higher tomato yield and cooler canopy temperatures than 85% and 75% irrigation treatments.

- The direct measurement experiment using loadcells and elevated boxes (mini lysimeters) was unsuccessful. The advection of sensible heat energy of elevated and isolated boxes appeared substantial. It dominated the driving force for evapotranspiration and did not allow observation of the effects of the expected spray treatments' reduced radiation load. Thus, no differences in evapotranspiration were observed between control and spray treatments.

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Recommendations

- The water conservation potential of Solbere and 11HX can be demonstrated by albedo modification and direct measurement.

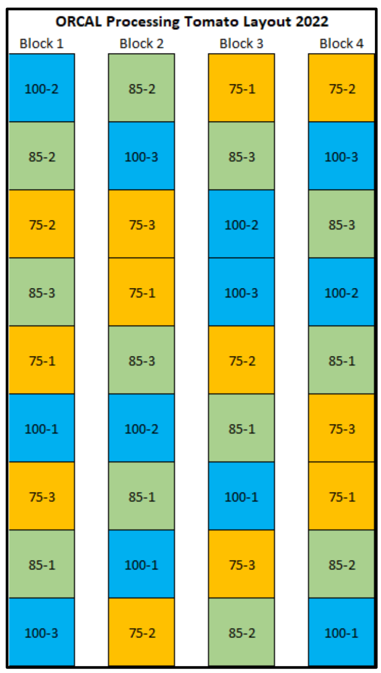
- Albedo is the most crucial variable in the net radiation balance. Higher albedo can reduce the absorption of solar radiation in plant canopies. Suggest measuring the albedo in large fields (minimum 200 x 200 feet) with a uniform canopy cover.

- Direct measurement using the loadcell and isolated raised box (mini lysimeter) is not recommended in a hot arid environment like Fresno. Advection, or the flow of sensible heat from the air to the crop surfaces, could be substantial in such conditions. The mini lysimeters should be buried with an adequate fetch to avoid excessive advection.

Field Experimental Design

The experiment was conducted in 2022 at a Center for Irrigation Technology (CIT) research plot located just east of the CIT office on Chestnut and Barstow Avenues, Fresno, California. Three crop treatments (Control, 11HX, and Solbere) and three irrigation treatments (100%, 85%, and 75%) were used. This field trial had two experimental plots: The main plot and the radiation plot. The main plot was used primarily for yield measurements, and the radiation plot was used for canopy temperature and radiation measurements.

The main plot was laid out in a randomized complete block design, with four blocks and nine random subplots (three crop treatments and three irrigation treatments) in each block. Each subplot had three 60-inch beds, 20 feet long. The radiation plot had three subplots for each crop treatment, with dimensions of 40 feet by 40 feet. The radiation plots had only 100% irrigation treatments. Figures 1a and 1b show the experimental plots. Photos of the field blocks and radiation plots are shown in Figures 1c and 1d.



1- Solbere
2- Control
3- 11HX

100 - 100% Irrigation
85 - 85% Irrigation
75 - 75% Irrigation

Figure 1a. Processing tomato experiment - Main plot

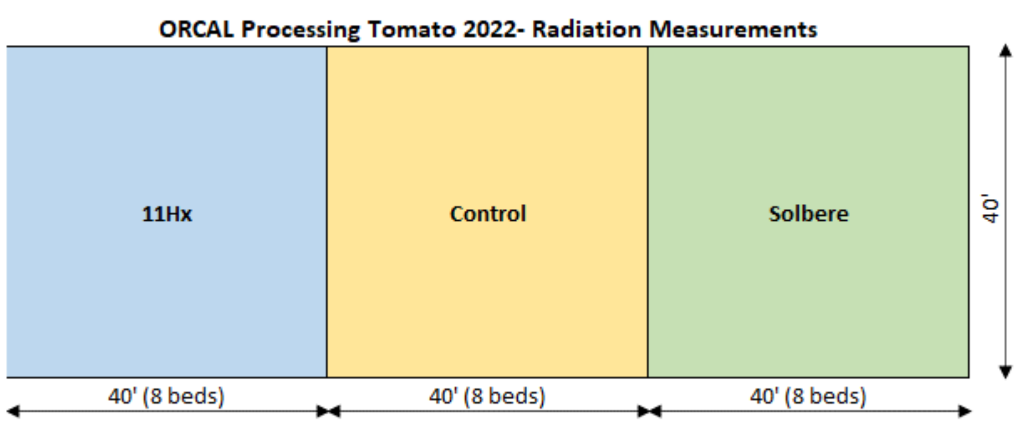


Figure 1b. Processing tomato experiment- Radiation plot

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Block 1

Block 2

Block 3

Block 4

Figure 1c. Main Plot with four blocks

Radiation Plot

Figure 1d. Radiation plots with stand for infrared cameras, solar radiation and PAR sensors

Cultural Practices

On March 25, 2022, transplants (SV 9032) were planted with 12-inch spacings in the middle of 60-inch beds. Plants with crop treatments were sprayed with 11HX and Solbere prior to transplanting. Fertilizer applications were scheduled per industry recommendations. The fertilizer applications included the weekly application of UAN-32 starting four weeks after transplanting. In addition to UAN-32, 25 gallons of Formation and five gallons of RootPhos were also applied. All the crop and irrigation treatments received identical amounts of fertilizers. Table 1 shows the fertilizer schedule.

Table 1. Fertilizer schedule for processing tomatoes

Date	Weekly N application, UAN-32 (pounds/acre)	Formation (gallons/acre)	RootPhos NS (gallons/acre)
Friday, March 25, 2022		5	
Friday, April 22, 2022	12.8	10	5
Friday, April 29, 2022	15.1	1	
Friday, May 6, 2022	17.4	1	
Friday, May 13, 2022	19.7	1	
Friday, May 20, 2022	22.5	1	
Friday, May 27, 2022	22.5	1	
Friday, June 3, 2022	22.5	1	
Friday, June 10, 2022	20.2	1	
Friday, June 17, 2022	17.9	1	
Friday, June 24, 2022	15.6	1	
Friday, July 1, 2022	13.3	1	
Total	**200**	**25**	**5**

Subsurface drip irrigation with 12-inch emitter spacing was used in this experiment. Each bed contained one drip tape in the center, buried 10 inches below the bed surface. Each irrigation treatment had a separate supply line, and each line was equipped with solenoid valves, pressure regulators, and flowmeters for control and monitoring purposes.

Spray applications in the treated plots were done on the following four dates:

First application: 4/29/2022
Second application: 5/23/2022
Third application: 6/14/2022
Fourth application: 6/28/2022

The 100% irrigation treatment was scheduled to receive adequate water to satisfy 100% of crop evapotranspiration (no stress). The crop evapotranspiration (ET) was estimated using the nearby California Irrigation Management Information System (CIMIS) weather station (Fresno State station #80) and local crop coefficients. The adequacy of the 100% irrigation treatment was monitored with a soil water profile sensor (SoilVUE, Campbell Scientific). The 100% irrigation was scheduled to ensure the soil water content in the rootzone remained in the management-allowed depletion range. To ensure good crop stand and establishment, all the irrigation treatments received full (100%) irrigation in the first five weeks until April 29, 2022. After this date, the 85% and 75% treatments received 85% and 75% of full (100%) irrigation in each water application.

Crop Yield Measurements

Tomatoes were harvested on 7/6/2022, and 10 plants from the middle bed of each subplot were cut at the soil surface. Green and red tomatoes were separated and weighed. The number of rotten tomatoes was minimal in all treatments and thus ignored. Table 2 shows the yield data.

Table 2. Processing tomato yield data (pounds), harvested on 7/6/2022

Block	Treatment	RED	GREEN	Total	Average RED	Average GREEN	Average Total	RED, % Change	GREEN, % Change	Total, % Change	Total, tons/acre
Block 1	100-Control	85.945	33.004	118.949	84.71	35.75	120.46				52.5
Block 2	100-Control	86.59	49.728	136.318							
Block 3	100-Control	90.64	40.92	131.56							
Block 4	100-Control	75.652	19.364	95.016							
Block 1	100-11HX	124.042	25.652	149.694	107.95	31.74	139.69	27%	-11%	16%	60.9
Block 2	100-11HX	102.104	45.568	147.672							
Block 3	100-11HX	111.632	22.726	134.358							
Block 4	100-11HX	94.038	33.012	127.05							
Block 1	100-Solbere	102.474	35.322	137.796	92.16	44.18	136.34	9%	24%	13%	59.4
Block 2	100-Solbere	83.068	68.63	151.698							
Block 3	100-Solbere	109.884	40.876	150.76							
Block 4	100-Solbere	73.199	31.9	105.099							
Block 1	75-Control	76.08	15.18	91.26	73.48	24.06	97.53				42.5
Block 2	75-Control	92.104	25.572	117.676							
Block 3	75-Control	70.404	30.364	100.768							
Block 4	75-Control	55.32	25.112	80.432							
Block 1	75-11HX	88.908	10.732	99.64	87.46	14.00	101.46	19%	-42%	4%	44.2
Block 2	75-11HX	97.828	23.958	121.786							
Block 3	75-11HX	98.748	11.058	109.806							
Block 4	75-11HX	64.366	10.258	74.624							
Block 1	75-Solbere	93.746	22.852	116.598	88.35	14.16	102.51	20%	-41%	5%	44.7
Block 2	75-Solbere	90.97	13.332	104.302							
Block 3	75-Solbere	76.754	7.964	84.718							
Block 4	75-Solbere	91.924	12.496	104.42							
Block 1	85-Control	101.41	30.48	131.89	84.01	25.76	109.78				47.8
Block 2	85-Control	43.502	44.262	87.764							
Block 3	85-Control	101.482	10.712	112.194							
Block 4	85-Control	89.66	17.594	107.254							
Block 1	85-11HX	104.49	24.032	128.522	96.45	27.22	123.67	15%	6%	13%	53.9
Block 2	85-11HX	87.65	42.318	129.968							
Block 3	85-11HX	100.778	23.048	123.826							
Block 4	85-11HX	92.89	19.482	112.372							
Block 1	85-Solbere	93.898	10.198	104.096	93.01	30.57	123.58	11%	19%	13%	53.8
Block 2	85-Solbere	87.196	57.19	144.386							
Block 3	85-Solbere	103.448	21.04	124.488							
Block 4	85-Solbere	87.48	33.866	121.346							

The crop yield results show that 11HX had 16%, and Solbere had 13% more yield than the control plots in the 100% irrigation treatment. In 85% irrigation, 11HX and Solbere had 13% more yield than control plots. Further, the 85% irrigation treatments of treated plants (11HX and Solbere) had 3% more crop yield than the 100% irrigation of non-treated (Control) plants. In 75% irrigation treatment, 11HX had 4%, and Solbere had 5% more yield than control plots. The 100% irrigation treatments had more crop yield than the 85% irrigation treatments, and the 85% irrigation had more crop yield than the 75% irrigation treatments.

Table 3 shows the yield enhancement of the spray and irrigation treatments. The yield enhancement in irrigation treatments was relatively uniform across all crop treatments as follows:

- 100% control had 10% more yield than 85% control, 100% Solbere had 10% more yield than 85% Solbere, and 100% 11HX had 13% more yield than 85% 11HX.
- 100% control had 24% more yield than 75% control, 100% Solbere had 33% more yield than 75% Solbere, and 100% 11HX had 38% more yield than 75% 11HX.

Table 3. Tomato crop yield enhancement due to spray and irrigation treatments

Yield enhancement of spray plots compared to control plots			
Spray Treatment	Irrigation Treatment		
	100%	85%	75%
Solbere	13%	13%	5%
11HX	16%	13%	4%

Yield enhancement of 100% irrigation compared to 85% and 75%			
Irrigation Treatment	Crop Treatment		
	Control	Solbere	11HX
85%	10%	10%	13%
75%	24%	33%	38%

Three red and ripe tomatoes were picked from all subplots for Brix measurements at harvest. Table 4 shows no differences were observed in Brix values of different crop treatments (Control, 11HX, Solbere).

Table 4. Processing tomato Brix data

No.	Sample ID	Tomato #1	Tomato #2	Tomato #3	Average Brix
Block 1	100-Control	5.6	6.8	4.8	5.7
Block 1	100-11HX	5.8	5.9	5.8	5.8
Block 1	100-Solbere	6.2	5.4	6.2	5.9
Block 1	75-Control	5.4	5.6	5.2	5.4
Block 1	75-11HX	6	6	5	5.7
Block 1	75-Solbere	6.4	6.4	6.4	6.4
Block 1	85-Control	5.6	5.1	5.2	5.3
Block 1	85-11HX	6.1	6.6	6	6.2
Block 1	85-Solbere	6.4	5.2	6.8	6.1
Block 2	100-Control	5.4	6.4	5.7	5.8
Block 2	100-11HX	5.6	5.8	5.4	5.6
Block 2	100-Solbere	5	5.1	6	5.4
Block 2	75-Control	6.2	5.9	6.2	6.1
Block 2	75-11HX	6.2	6.6	6.4	6.4
Block 2	75-Solbere	6	6.2	6.3	6.2
Block 2	85-Control	6.2	6.4	6.2	6.3
Block 2	85-11HX	6	5.6	6.2	5.9
Block 2	85-Solbere	5.8	5.9	5.9	5.9
Block 3	100-Control	5.2	5.6	5.8	5.5
Block 3	100-11HX	6	5.2	6	5.7
Block 3	100-Solbere	5	5.4	6.1	5.5
Block 4	75-Control	4.6	4.9	4.9	4.8
Block 3	75-11HX	6.2	6	6.6	6.3
Block 3	75-Solbere	6.6	5.8	6.2	6.2
Block 3	85-Control	5.6	6.2	6.8	6.2
Block 3	85-11HX	6	5.6	5.4	5.7
Block 3	85-Solbere	5.9	5.4	5.5	5.6
Block 4	100-Control	6.2	5.9	5	5.7
Block 4	100-11HX	5.2	6.6	6	5.9
Block 4	100-Solbere	5.8	5.4	5.2	5.5
Block 4	75-Control	5.2	6.2	5.8	5.7
Block 4	75-11HX	5.2	6.8	6.8	6.3
Block 4	75-Solbere	6.4	5.4	6.2	6.0
Block 4	85-Control	6.4	5.6	5.4	5.8
Block 4	85-11HX	5.8	5.4	6.4	5.9
Block 4	85-Solbere	5.4	6	5.4	5.6

Treatment	Average Brix
Control 100%	5.7
11HX 100%	5.8
Solbere 100%	5.6
Control 85%	5.9
11HX 85%	5.9
Solbere 85%	5.8
Control 75%	5.7
11HX 75%	6.2
Solbere 75%	6.2

Albedo Measurements

Albedo is a critical parameter in a crop's surface energy budget and water requirements. Albedo was measured in Control, 11HX, and Solbere treatments. Shortwave albedo is the ratio of upward (reflected) to downward (incoming) shortwave radiation. Solar radiation was measured with pyranometers, which measure global shortwave radiation. Two types of pyranometers (Apogee Instruments Inc.) were used to measure albedo: SP-510 to measure the incoming shortwave radiation and SP-610 to measure the reflected shortwave radiation from tomato canopies. Thus, this experiment used four pyranometers for albedo measurements: one SP-510 upward-facing pyranometer and three SP-610 downward-facing pyranometers. The downward-looking SP-610 sensors were installed about two feet above the plant canopies in the middle of the plots, as shown in Figure 2. A datalogger (Model CR1000x, Campbell Scientific) was used to collect the albedo data.

Figure 2. Camera stand with albedo and PAR sensors

As expected, the spray materials altered the tomato leaves' surface property, affecting the albedo. The fraction of solar radiation reflected off the crop surface depends on the characteristics of the crop surface, and the spray materials could alter such characteristics. Albedo was higher in the Solbere treatment compared to the control plot. The 11HX plants had slightly higher albedo than the control plants. Figure 3 shows the albedo of different crop treatments during the day. On average, the Solbere Plot had 20-30% higher albedo than the control plot.

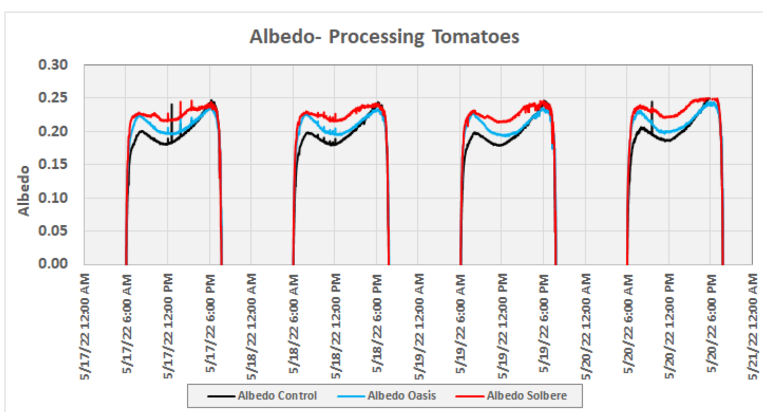

Figure 3. Typical Albedo of Control, 11HX, and Solbere plots

Figure 4 shows typical reflected solar radiation (Watts per square meter, Figure 4a) and spray materials' albedo enhancement (percent, Figure 4b).

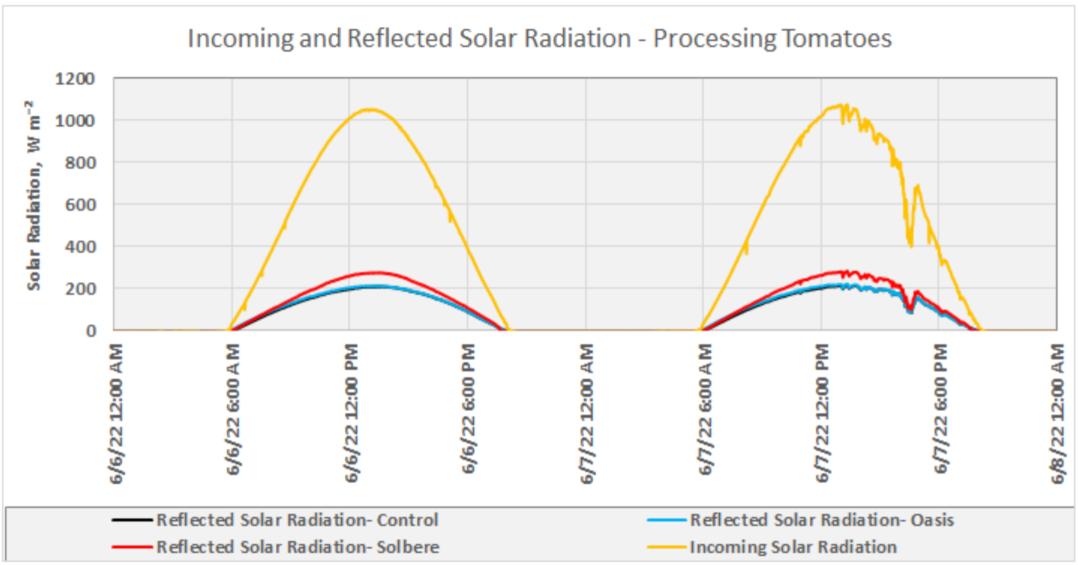

Figure 4a. Incoming and Reflected solar radiation

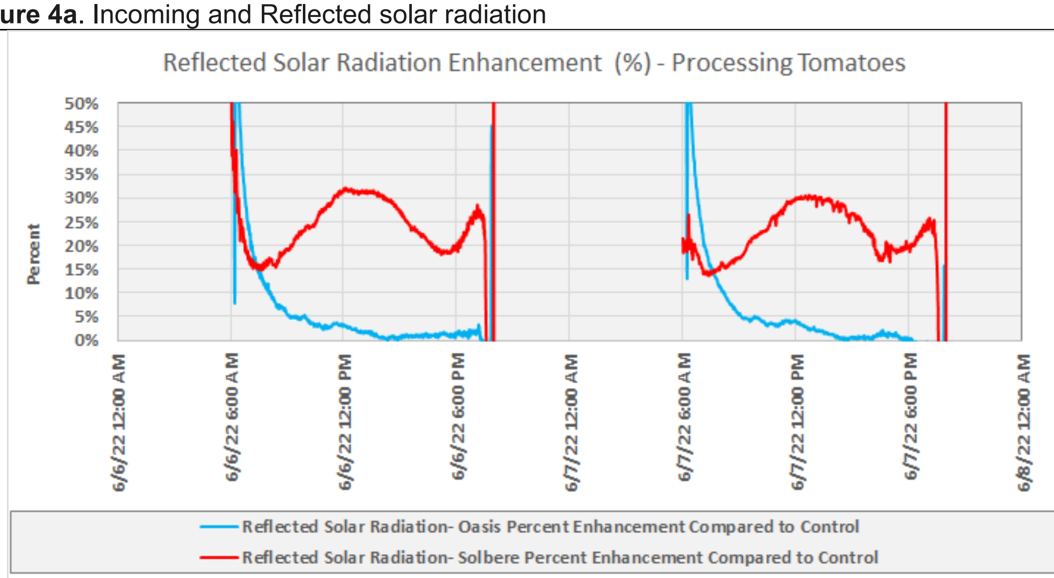

Figure 4b. Percent enhancement of reflected solar radiation of spray treatments compared to control plants

Towards the end of the experiment, many vines collapsed due to fruit sizing and high temperatures due to a heat wave. Consequently, the albedo sensors could see tomato fruits and branches. At this time, the reflected solar radiation of the Solbere Plot had a dip during the peak hours, one hour before and one hour after the solar noon, see Figure 5. The cause of such a midday depression is unclear.

Figure 5. Reflected solar radiation and percent enhancement of albedo compared to control plants with a midday depression in peak solar hours

Photosynthetically Active Radiation (PAR) Measurements

PAR (micromoles per square meter per second) was measured in Control, 11HX, and Solbere treatments using SQ-515 PAR sensors (Apogee Instruments Inc). The PAR data was collected using a datalogger (Model CR1000x, Campbell Scientific). Three PAR sensors were installed about two feet above the plant canopies in the middle of the plots next to the albedometers (Figure 1b and Figure 2). These sensors measured the reflected PAR in Control, Solbere, and 11HX, and another measured the incoming PAR. As expected, the Solbere and 11HX increased the reflected PAR.

The reflected PAR in this experiment was generally small, less than 8% of the incoming PAR during the day. Figure 6a and Figure 6b show the typical reflected PAR and the percent of incoming PAR reflected by the plant canopies. Even though Solbere and 11HX have higher PAR reflection than the control plants, such small changes are not expected to affect crop productivity.

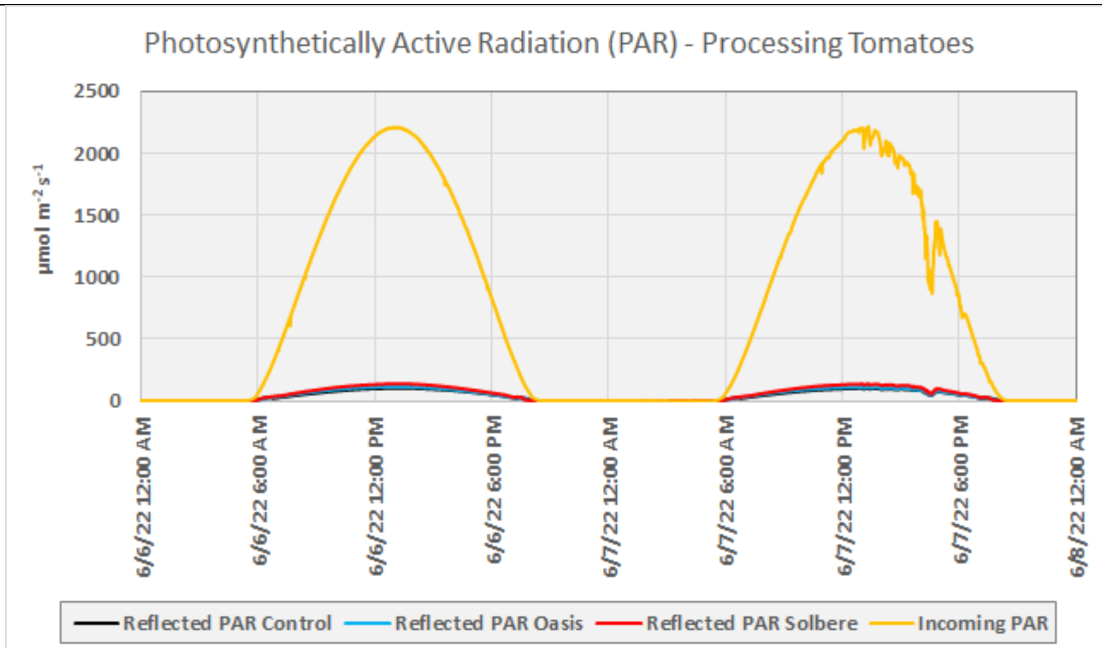

Figure 6a. Incoming and Reflected PAR

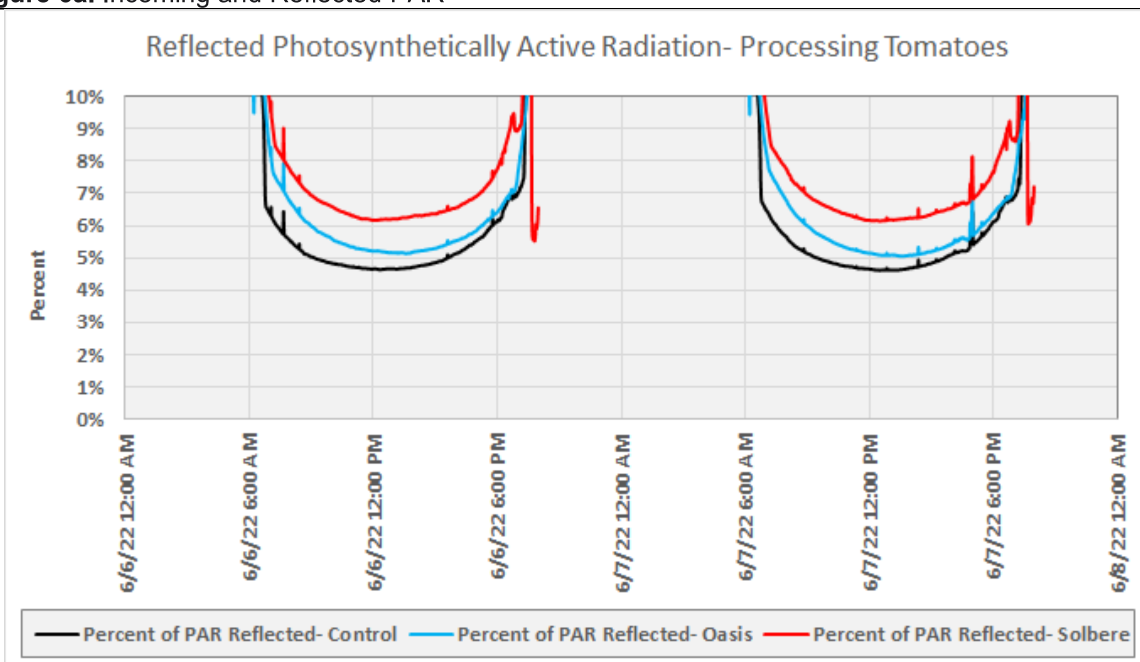

Figure 6b. Percent enhancement of reflected PAR of spray treatments compared to control plants

Canopy Temperature Measurements

Control, 11HX, and Solbere plots canopy temperature were measured with infrared cameras (Model AX8, FLIR Inc). Cameras were installed in the center of each Plot (40 x 40 feet, Figure 1b and Figure 2), about two feet above the crop canopies in the middle of the beds. The infrared cameras were programmed to take thermal images every 30 minutes, 48 images daily.

Additionally, the canopy temperatures of the main Plot (Figure 1a) were measured around solar noon with a more accurate thermal camera (Model SC660, FLIR Inc). This camera was installed on a tripod four feet above the bed (Figure 7), aiming at 20 degrees perpendicular to the bed direction. Attempts were made to measure the temperature of the green canopies only. The main plot had 36 subplots, as shown in Figure 1a. This camera measured all subplots nine times, and each time 36 images were taken in less than 45 minutes around solar noon. Overall, no significant differences were observed in canopy temperatures of different crop treatments (Control, 11HX, and Solbere). On the other hand, significant canopy temperature differences were observed between the irrigation treatments (100%, 85%, and 75%) in all crop treatments (Control, 11HX, Solbere).

Figure 7. FLIR (Model SC660) camera on the tripod

Diurnal changes in the canopy temperature of Control, 11HX, and Solbere plots are shown in Figures 8a, 8b, and 8c, along with the air temperature for June 2022. The air temperature was collected next to the radiation plot. No canopy temperature differences were observed between crop treatments (Control, 11HX, and Solbere). As expected, canopy temperatures followed the air temperature closely, and canopy temperatures generally remained below the air temperature during the peak afternoon hours.

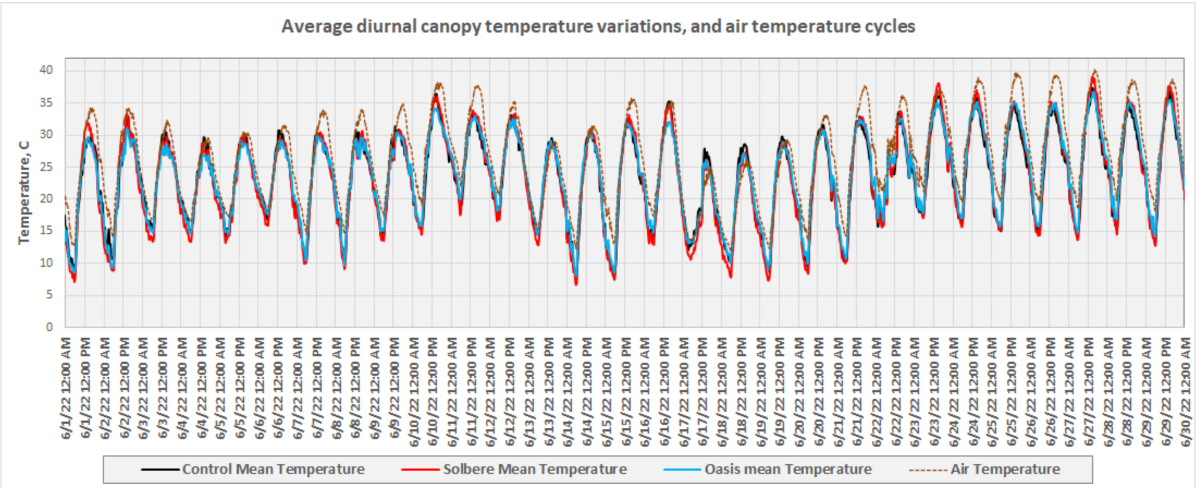

Figure 8a. Mean canopy temperature of Control, 11HX, and Solbere plots- June 2022

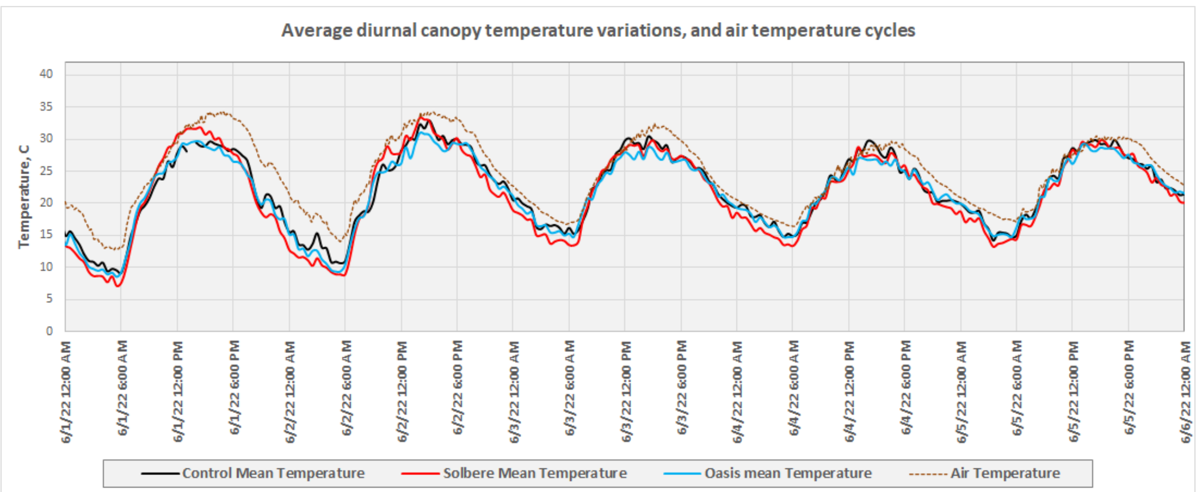

Figure 8b. Mean canopy temperature of Control, 11HX, and Solbere plots- June 1-5, 2022

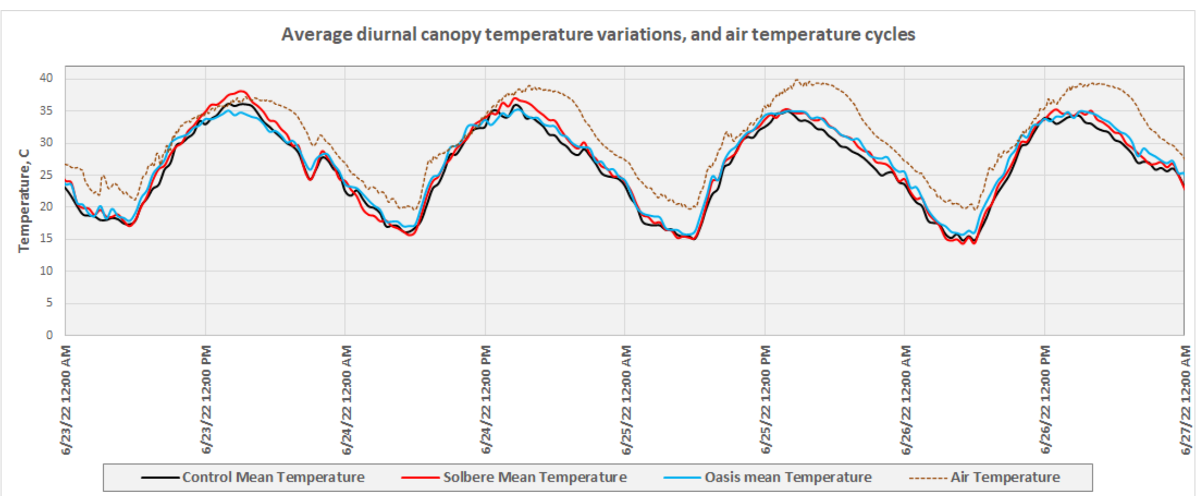

Figure 8c. Mean canopy temperature of Control, 11HX, and Solbere plots- June 23-27, 2022

Figures 9a and 9b show the diurnal changes in canopy temperature, air temperature, and solar radiation in the second half of May 2022. The solar radiation was measured next to the radiation plot along with the air temperature. As expected, all the canopy and air temperatures followed the solar radiation with a lag. Plant canopy and air temperatures increased with increasing solar radiation but peaked later in the afternoon.

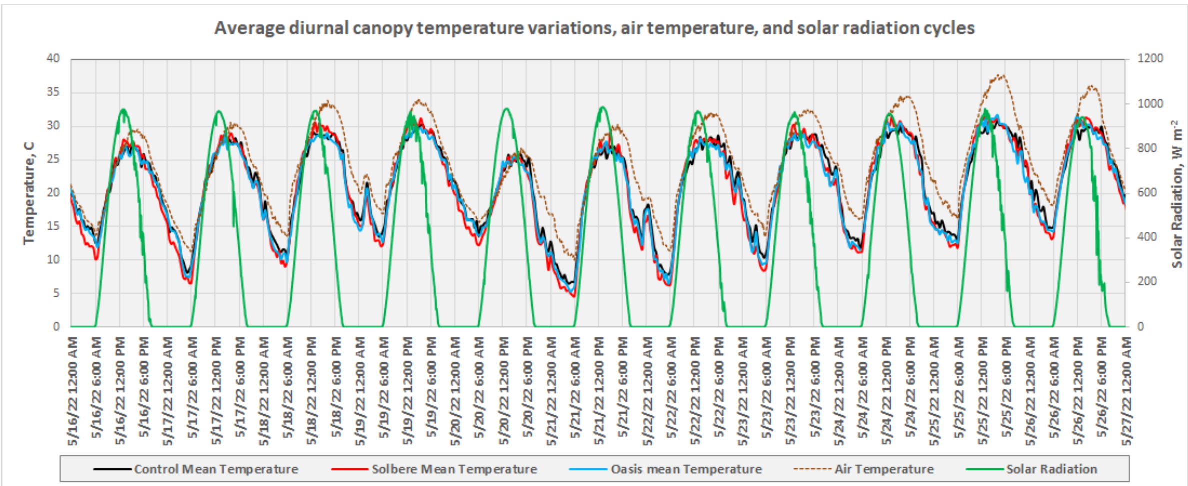

Figure 9a. Mean canopy temperature of Control, 11HX, and Solbere plots- May 2022

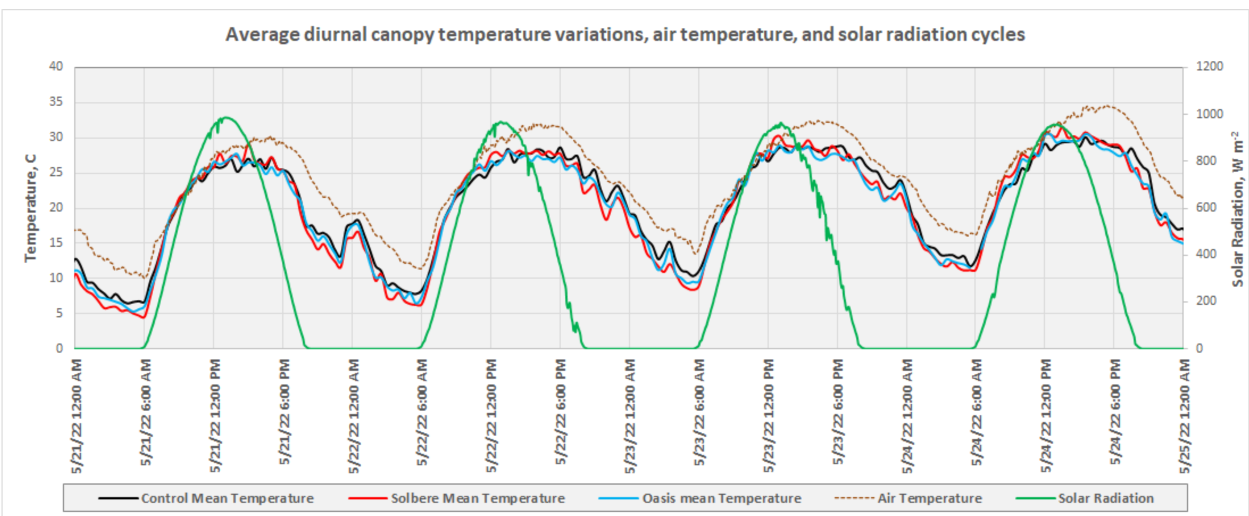

Figure 9b. Mean canopy temperature of Control, 11HX, and Solbere plots- May 21-24, 2022

As mentioned above, another camera (FLIR SC660) was used to measure the canopy temperature of 36 subplots in the early afternoon during the peak evapotranspiration periods. Canopy temperatures are compared in two categories: temperature differences due to spray applications (Control, 11HX, Solbere) and temperature differences due to irrigation applications (100%, 85%, 75%). Each subplot image contains 307,200 pixels (640 x 480). There are four subplots (replications) in each treatment. An average of four subplots for each treatment was calculated and shown in Figure 10 and Figure 11 for two measurement events. The standard deviation of the mean temperatures is also shown in these figures.

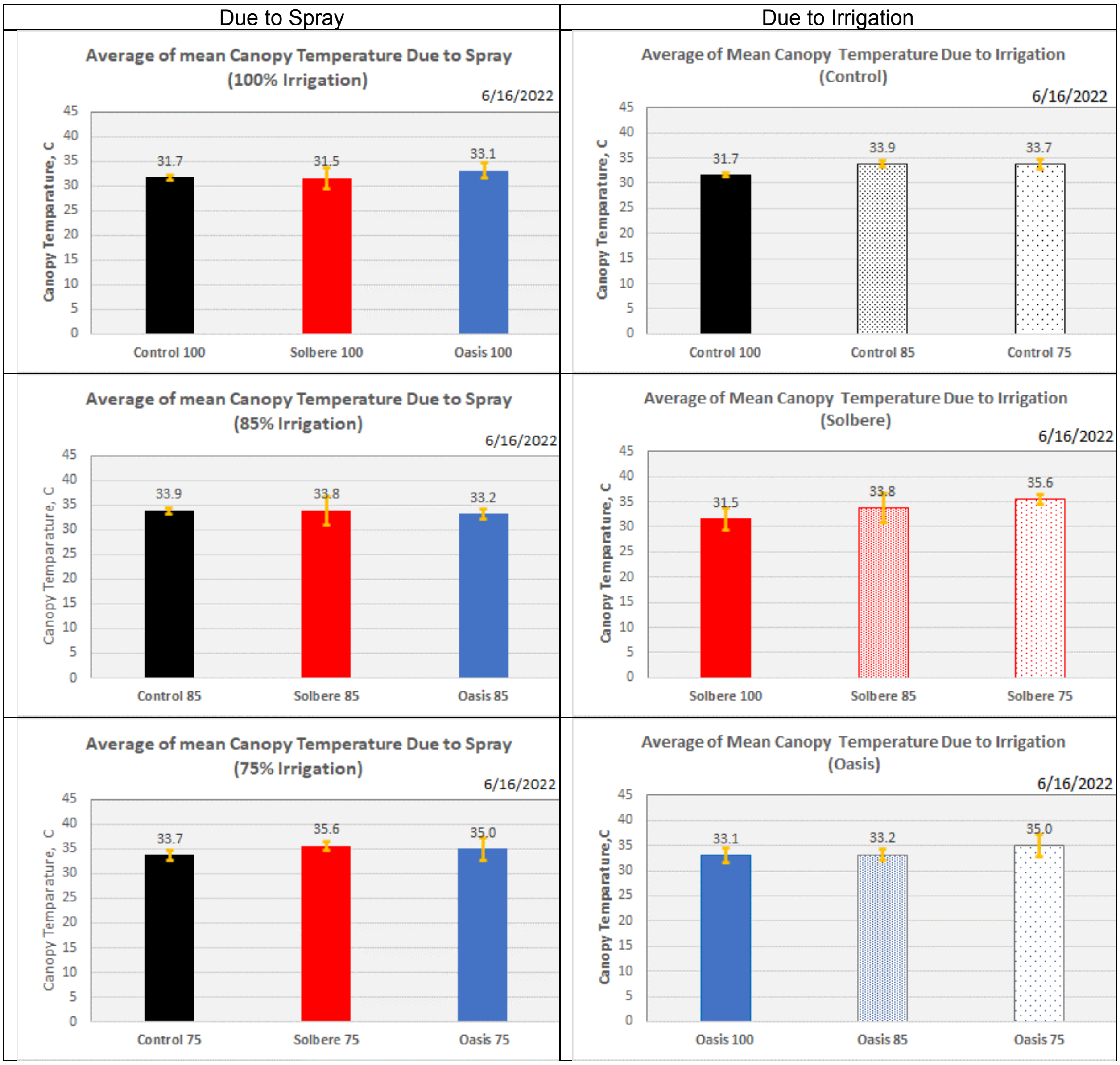

Figure 10. Canopy temperature difference due to spray applications and irrigation treatments 6/16/2022

Due to Spray	Due to Irrigation

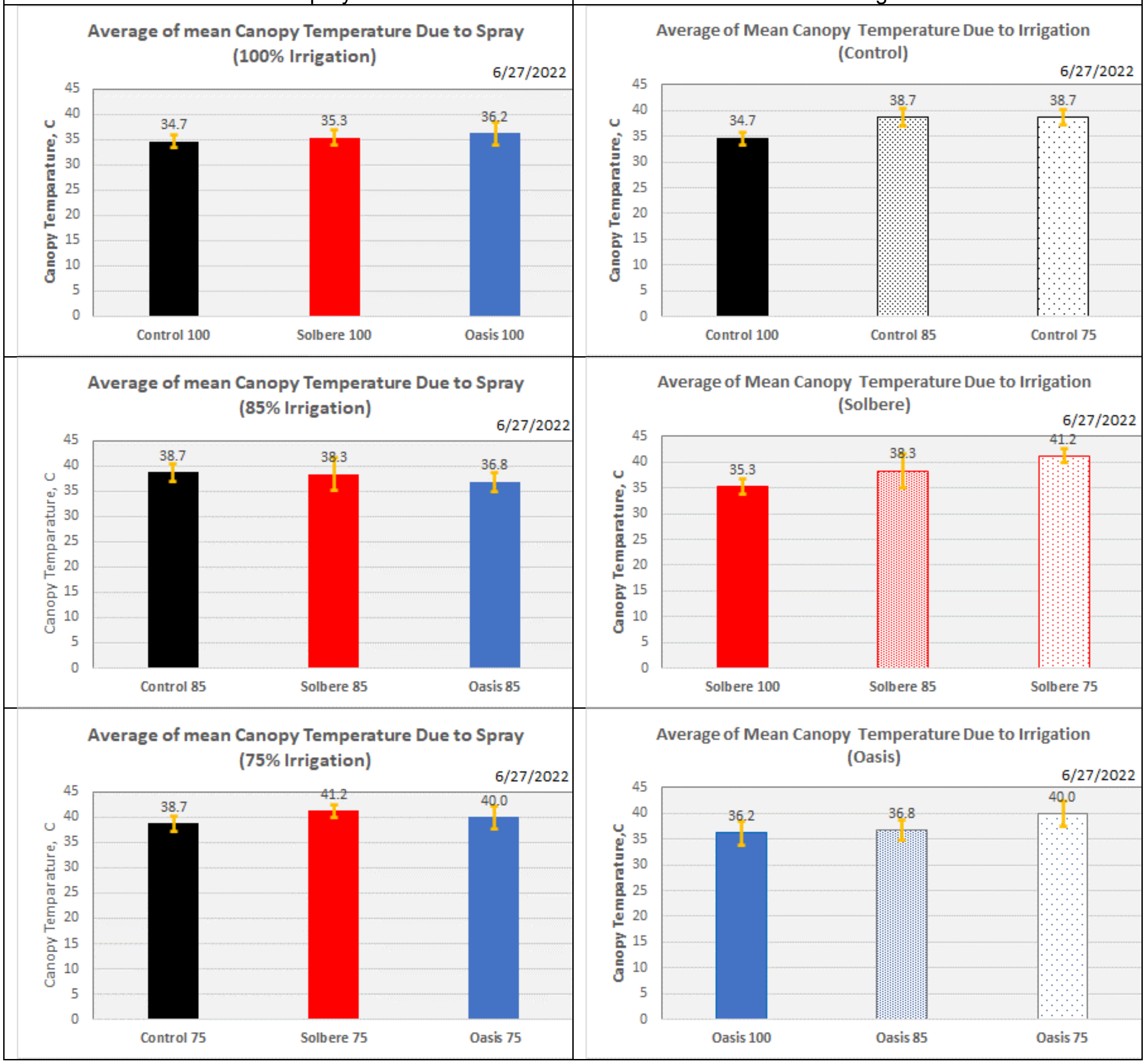

Figure 11. Canopy temperature difference due to spray applications and irrigation treatments 6/27/2022

The Statistical Package for the Social Sciences (SPSS, IBM) was used to analyze the canopy temperature data. No statistically significant differences (at 5% probability level) were observed between the canopy temperatures of Control, 11HX, and Solbere in any irrigation treatment. Canopy temperature differences due to spray are not large enough relative to the natural variation in the field. On the other hand, there are significant differences (at 5% probability level) between the canopy temperatures of irrigation treatments in all spray treatments (Control, 11HX, Solbere), except Control 85% vs. Control 75% and 11HX 100% vs. 11HX 85%. Results also indicate that control plants generally show a lower standard deviation than Solbere and 11HX, which could be attributed to the uniformity of spray applications. Table 5 shows the various treatments' average canopy temperatures and standard deviations (STDEV).

Table 5. Canopy temperatures due to spray and irrigation treatments

Spray Treatment	Irrigation Treatment					
	100%		85%		75%	
	Mean	STDEV	Mean	STDEV	Mean	STDEV
Control	32.1	2.0	34.3	3.0	34.2	3.1
Oasis	33.3	2.7	33.5	2.6	35.0	3.5
Solbere	32.4	2.5	34.2	3.6	35.9	3.5

Most published experiments report lower temperatures in antitranspirant spray applications (like kaolin-based particle film) than in non-sprayed control plants. Such low temperatures were not observed in this experiment. The spray application increased albedo and reduced the absorbed incident radiation compared to the control plants. The canopy temperatures of the sprayed plants were similar to the control plants, indicating that the transpiration of the spray plants was lower than the control plants. If the transpiration of sprayed and Control plants were similar, the sprayed plants should have exhibited lower canopy temperatures than the control plants due to the reduced radiation loads.

Direct Evapotranspiration Measurements

The direct measurements of evapotranspiration included 13 boxes (ice chests, 15.5" W x 38" L x 18" H). Like the field crop, there were three spray treatments (Control, 11HX, Solbere) and four replications for each treatment, 12 boxes total. Figure 12 shows photos of the boxes (mini lysimeter). Each box was filled with potting soil and had three tomatoes planted at the same time as the field crop. The box soil surface was covered with mulches to minimize soil evaporation. These boxes had individual supply lines with solenoid valves. Another box (#13) served as a Blank, with no soil or crop, just some weights. The purpose of the Blank box was to see the daily variations and seasonal deviations as the baseline for comparison purposes. Each box was placed on a load cell (Model 60410, ARTECH) through a metal frame. A datalogger (CR1000x), a multiplexer (AM16/32B), and a relay (SDM-CD16AC) from Campbell Scientific were used to program, Control, and monitor the loadcells and solenoid valves. The loadcells read the weights every two seconds and averaged the weights every minute. The boxes were weighed at midnight to get the daily water consumption and refilled with water to cover the water lost during the past 24 hours.

Figure 12. Mini Lysimeters (ice chests)

The treated plants were sprayed four times as follows:

First spray:	4/22/2022
Second spray:	5/3/2022
Third spray:	6/6/2022
Fourth spray:	6/14/2022

Tomatoes were planted on 3/25/2022, and the first spray was applied four weeks later on 4/22/2022. Two weeks after the first spray, plants in all the boxes showed root disease symptoms, such as yellowed and browned leaves on 5/6/2022. Several attempts were made to remedy the root problem, such as flushing the soil and chemical applications. However, tomato plants in all the boxes remained stunted and had poor growth and canopy cover during the experiment.

In addition to the disease problems, plants in all the boxes experienced heat stress. The crop ET (water consumption) values of all the boxes were much higher than the estimated field crop water requirements and higher than the CIMIS reference ET (measured at Fresno State station #80, less than half a mile from the project site). The crop ET should have been lower than CIMIS reference ET early in the growth stages due to the low crop coefficients. The extreme ET values from boxes could be attributed to the increased transfer of sensible heat from the air to the plant surfaces (advection) caused by the elevated and isolated boxes. Advection of sensible heat is common in hot and dry environments like Fresno, where sensible heat flow from the air to the plant surfaces could contribute substantial additional energy for transpiration.

Plants were harvested on 6/23/2022, and plants were cut at the soil surface and weighed with the attached tomatoes. Thus, the harvest data (Figure 13) represent above the soil biomass. There were significant yield variations (outliers) in the harvest data. Compared to the control plants, 11HX had 13% more yield, and Solbere had 4% less yield.

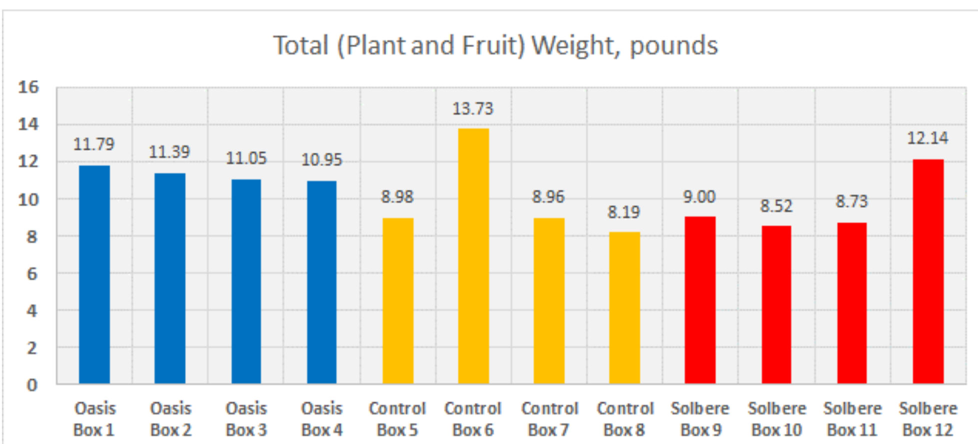

Figure 13. Harvest data for direct measurement experiment

The daily water consumption (ET) of all the boxes is shown in Figure 14. The reference ET from the CIMIS station (CIMIS #80, Fresno State) is also shown in Figure 14.

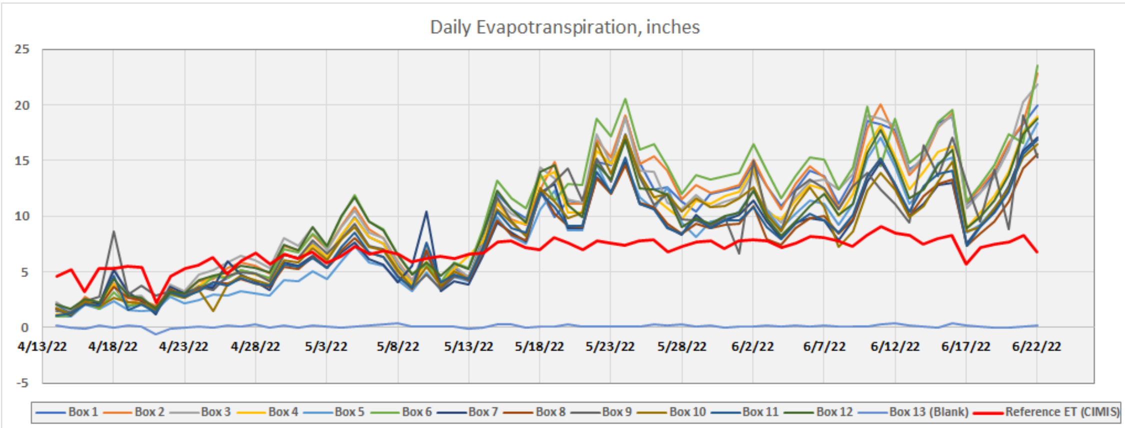

Figure 14. Daily evapotranspiration (inches) during the growing season for direct measurements

The tomato crop ET values were expected to be lower than the CIMIS reference ET values in the experimental period. The crop coefficient during this period should be less than 1.0 due to the crop growth period and size. Total seasonal ET is given in Figure 15. All the crop treatments (Control, 11HX, Solbere) had higher ET than the CIMIS reference ET. The control and Solbere plants had similar water consumption, and 11HX had 14% more ET than the control plants. The increased ET in 11HX could be attributed to the increased plant size, as 11HX had 13% more biomass than the control plants.

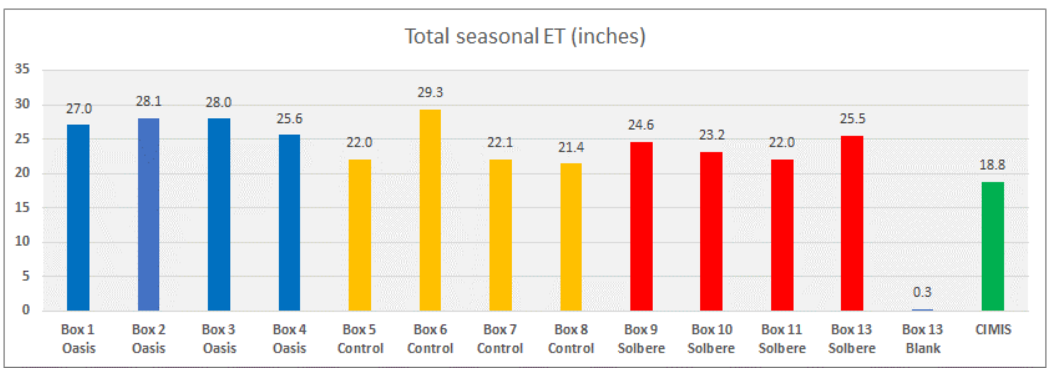

Figure 15. Total seasonal evapotranspiration and CIMIS reference evapotranspiration

This mini lysimeter experiment observed no differences in water use efficiency between control and spray treatments. With isolated and elevated boxes (see Figure 12), the advection of sensible heat energy appeared to be substantial. It seems that the relatively large component of the advection dominated the radiation load. Thus, it did not allow observation of the effects of the expected spray treatments' enhanced albedo (reduced radiation load).