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Project Title: Year 2 of Developing Evapotranspiration Based Irrigation and Water Conservation Recommendations for multiple Groundcover species in inland Southern California

Progress report for year 1:

This proposal was only partially funded, which means we had to adjust the scope of work. In this report, we present the processes involved and results obtained from two adjacent groundcover irrigation research trials conducted at UCR Agricultural Experiment Station in 2021. The effect of irrigation frequency was evaluated on ten different landscape species that are commonly used or are alternative species that have the potential for urban settings in inland Southern California. The list of ten species is presented in Table 1.

Table 1. List of landscape groundcover species used in the irrigation study

Species number	Scientific name	Common name
1	*Eriogonum fasciculatum*	*Buckwheat*
2	*Lantana montevidensis*	*Lantana*
3	*Trachelospermum jasminoides*	*Jasmine*
4	*Lonicera japonica*	*Honeysuckle*
5	*Ruschia lineolata*	*Ice-plant*
6	*Rhagodia spinescens*	*Creeping Australian saltbush*
7	*Rosmarinus officinalis*	*Rosemary*
8	*Eremphila glabra*	*Gold Emu Bush*
9	*Baccharis x 'Starn' Thompson*	*Coyote bush*
10	*Oenothera stubbei*	*Saltillo evening*

Study design, Irrigation treatments, and field maintenance

The research plots were established in Riverside, CA, in 2019. Each landscape species was planted in a 10x10-ft area. The irrigation application was based on reference evapotranspiration (ET_{ref}). Four different irrigation treatments based on ET_{ref} were 80-, 60-, 40-, and 20-%. Each plot was irrigated using four quarter-circle pop-up heads (Toro Co., MN) controlled independently by a solenoid valve. Two ET-based Weathermatic Smart Irrigation controllers (Telsco Industries, Inc, TX) were used for autonomous irrigation scheduling. The study was replicated three times in a randomized complete block design. The aerial view of the research plot is presented in the figure-1.

Figure 1. Aerial view of the landscape irrigation project at UC Riverside.

Periodically fields were hand-weeded to keep them weed-free. Also, plant species were pruned from top and side to prevent them from growing higher than the sprinkler head (12 in) and ensuring the growth was always within the dimension of the plot (10x10-ft). This practice helps to confirm there is no interference in the irrigation application, and all plants are getting the amount of water we want to apply.

To accurately determine the amount of water being applied in the field, we did a flow test to collect the irrigation water from the sprinkler head into a bucket. Values obtained from here are useful to calibrate the flow meter for efficient and accurate irrigation applications. The amount of water applied to four irrigation treatments during the experiment period in 2021 is presented in the figure-2.

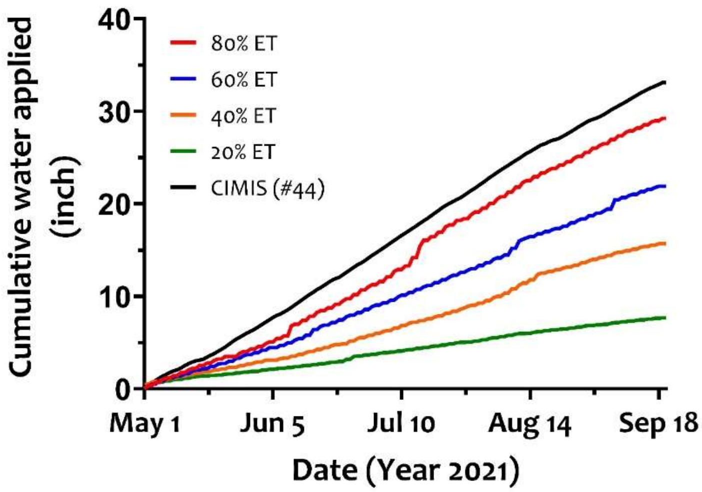

Figure 2. Amount of irrigation water applied for different irrigation treatments during the experimental period in 2021 compared to reference evapotranspiration data obtained from the nearby weather station of California Irrigation Management Information System (CIMIS, #44).

Monitoring plant growth and health

We continuously monitored the effect of irrigation on the growth and health of the plant species by measuring the NDVI values (Normalized Difference Vegetation Index, a measure of plant greenness and health) and canopy temperature (to determine the water stress in plants) for all the ten species. NDVI was measured using the handheld sensor (GreenSeeker, Trimble Inc., CA), and canopy temperature was measured using the handheld infrared temperature sensor.

Normalized Difference Vegetation Index (NDVI)

The effect of irrigation, species, and their interaction significantly ($p<0.001$) affected the quality and growth of the groundcover species as measured by the NDVI index (Table 2; Figure 3). For all four irrigation treatments, the species *Rhagodia spinescens* (Creeping Australian saltbush) showed acceptable visual growth and did not show the sign of water stress during the experimental period. *Eriogonum fasciculatum* 'Warriner Lytle' (Buckwheat) also was not affected by irrigation treatments; however, as we go into summer, the NDVI values decreased from around 0.7 (highest) to 0.4 (lowest). *Baccharis* x 'Starn' Thompson (Coyote bush) also maintained its acceptable quality for all irrigation treatments.

Table 2. Effect of irrigation, plant species, date of data collection, and their interaction on NDVI and canopy temperature collected using handheld sensors.

	df	NDVI	Canopy Temperature
		p-value	
Irrigation rates (I)	3	<.0001	<.0001
Groundcover species (S)	9	<.0001	<.0001
I x S	27	<.0001	<.0001
Date of data collection (D)	7	<.0001	<.0001
I x D	21	<.0001	<.0001
S x D	63	<.0001	<.0001
I x S x D	189	0.8311	0.6553

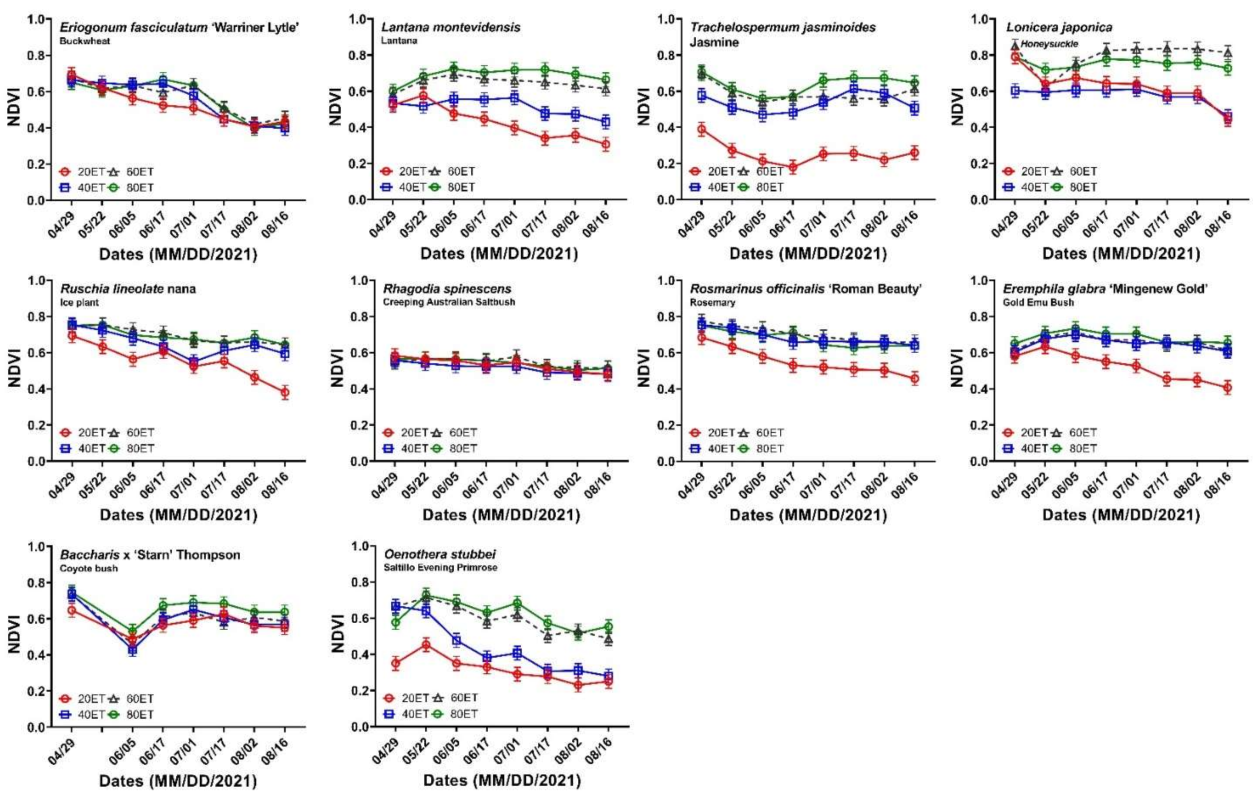

Figure 3. Effect of irrigation treatments on normalized difference vegetation index (NDVI) of different groundcovers during the experimental period in 2021

At the very deficit irrigation treatments (20% ET_{ref}), species including *Lantana montevidensis* (Lantana), *Trachelospermum jasminoides* (Jasmine), *Rosmarinun officinalis* 'Roman beauty' (Rosemary), *Eremphila glabra* 'Mingenew Gold' (Gold Emu Bush), and *Oenothera stubbei* (Saltillo Evening Primrose) showed a significant decrease in their growth and quality compared to 60- and 80-% irrigation treatments. At 60- and 80-% ET_{ref}, all groundcovers showed similar growth and development.

Canopy temperature of groundcovers

The effect of irrigation, groundcover species and their interaction was also found significant ($p<0.001$) on the canopy temperature of the groundcover. Figure-4 shows how different irrigation treatments affect the canopy temperature dynamics of the groundcover species. The difference in canopy temperature (ΔT) was calculated as the canopy temperature minus the air temperature. At any point, when the difference in canopy temperature and air temperature is close to or less than 0 °C then the plants are transpiring efficiently. Figure-4 suggests that species Rhagodia spinescens were transpiring efficiently even when irrigated at 20% ET_{ref}. Species including *Rhagodia spinescens*, *Baccharis* x 'Starn' Thompson, *Eremphila glabra* 'Mingenew gold', and *Rosmarinun officinalis* 'Roman beauty' were not water stressed and were transpiring efficiently when irrigated at 40% ET_{ref}. This suggests that these four species can withstand drought and do well while maintaining the acceptable quality even with deficit irrigation, based on the NDVI and canopy temperature data.

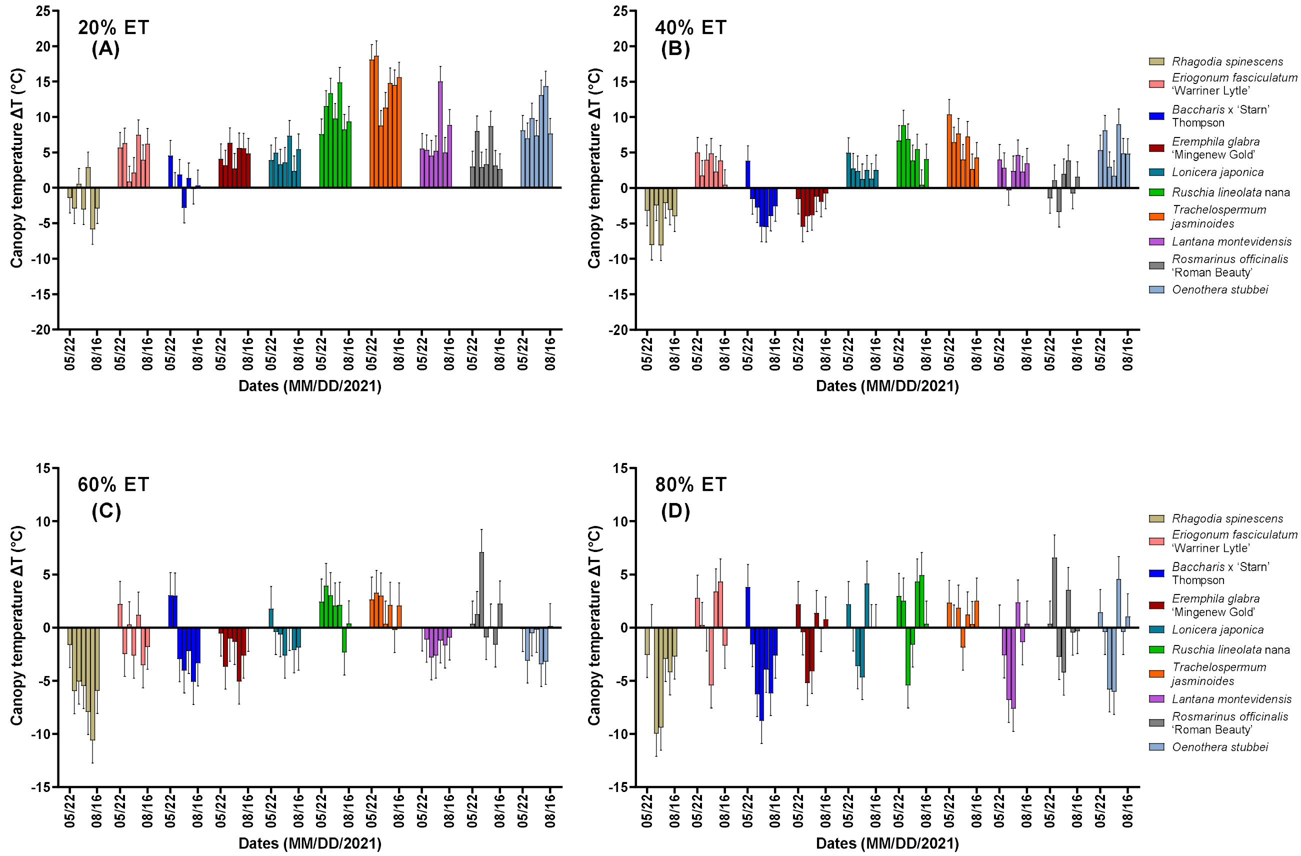

Figure 4. Effect of irrigation on the canopy temperature of different groundcover species at different irrigation treatments