Irrigation Efficiency for outdoor container nurseries in California

Improving irrigation efficiency of containerized nursery ornamental production

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Introduction

Sprinkler efficiency and Irrigation Scheduling

Nurseries and greenhouses face challenges of limited water supply and increased scrutiny from water quality regulators. Improving irrigation efficiency thus minimizing irrigation runoff are the main strategies to save water and comply with regulations. Overhead sprinkler irrigation is common in nurseries, mostly due to high labor costs. Distribution Uniformity (DU) is one of the component of irrigation efficiency and is known to be affected by wind speed. Impact, gear drive, spray, stream and "wobbler" sprinkler heads are used with spacings 30 ft x 30 ft and 15 ft x 15 ft often in a square pattern. To minimize irrigation runoff and avoid irrigating roads, growers use sprinklers with adjustable arcs of 180° or 90° for edges and corners of irrigation blocks. Building on a previous project, we tested DU for Edge and Corner configurations in 15'x15' and 30'x30' spacings.

Irrigation efficiency is also determined by irrigation scheduling. Evapotranspiration-based (ET) methods that make use of the statewide network of weather stations maintained by CIMIS substantially improve efficiency. However, crop specific coefficients to calculate crop irrigation needs from weather data are not available in the nursery industry, particularly for large (15-gal and up) containers. In this project we measured water use and developed crop coefficient for 15-gal trees, one low water user (Olive, *Olea europaea*) and two high water users (Sycamore, *Platanus acerifolia* and *Ficus microcarpa*) with different canopy architectures.

Aim

Efficient sprinklers and weather-based irrigation scheduling

The objectives of this project were to:

1. Measure distribution uniformity of sprinkler heads with adjustable arcs in relation to wind speed. We tested impact (Rainbird 2045PJ), gear-drive rotors (Rainbird 5000) and wobbling sprinklers (Senninger Xcel and Mini-Wobblers), Multi Stream Multi Trajectory (MSMT) sprinklers (TORO PRN, Rainbird R-VAN, Hunter MP2000 and MP3000).
2. Measure water used by Sycamores, Olives and Ficus planted in 15-gal containers and calculate crop coefficients to inform weather-based irrigation scheduling.

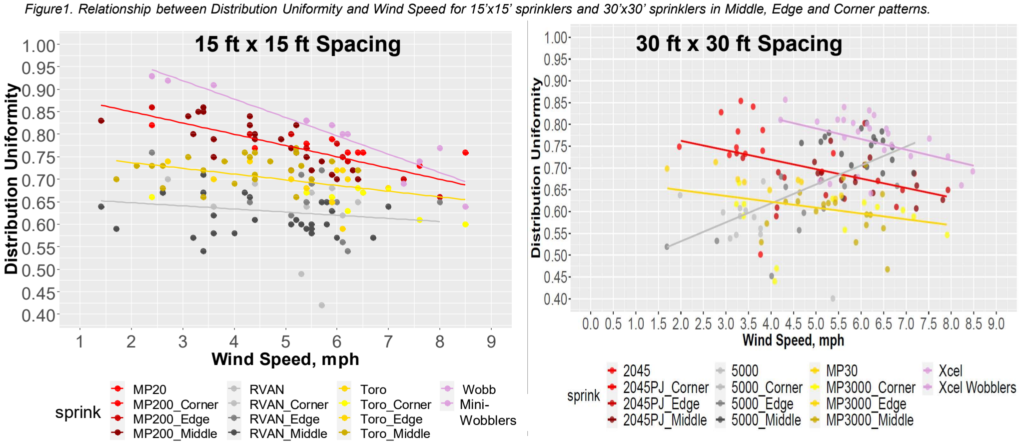
Methods

Catch-can and Load Cells

To calculate Distribution Uniformity (DU), we collected water with a catch-can experiment during 30-minute irrigation events, by setting up a grid of 6x6 1-gal buckets. We measured wind speed with a 3-cup anemometer.

Container weight was measured with load cells (a weighing device similar to a scale), with values logged every minute by a data logger. Daily water use was calculated as the difference in weight from after each irrigation to before the following one. Local CIMIS reference ET was used to calculate crop coefficients.

Figure1. Relationship between Distribution Uniformity and Wind Speed for 15'x15' sprinklers and 30'x30' sprinklers in Middle, Edge and Corner patterns.



Results

Clear differences in sprinkler efficiency and tree water use

There were clear differences in Distribution Uniformity (DU) among the tested sprinklers models, but no difference between Middle, Edge and Corner configuration for the same sprinkler model (Figure 1). Average DUs observed are reported in Table 1.

Table 1. Average Distribution Uniformity measured in different sprinkler models and configurations

	Hunter MP2000	Rainbird R-VAN	Toro PRN	Mini Wobblers	Rainbird 2045PJ	Rainbird 5000	Hunter MP3000	Xcel Wobblers
Middle	0.78	0.62	0.72	0.82	0.68	0.74	0.60	0.76
Edge	0.76	0.63	0.69	-	0.67	0.59	0.67	-
Corner	0.76	0.63	0.66	-	0.75	0.58	0.58	-

Tree water use yielded crop coefficients averaged 1.19 for Ficus; 0.57 for Olive and 1.21 in Sycamore during fall 2023 before defoliation started to occur for Sycamore in mid-October (Figure 3). Olive and Ficus defoliated through winter reaching the lowest crop coefficient in March 2024 when the coefficient was 0.42 for Ficus; 0.22 in Olive and 0.12 in Sycamore.

Discussion

Trade-offs in sprinkler efficiency

Senninger Wobblers presented the highest measured DU, over 0.9 for mini-Wobblers in calm conditions. These high DUs are observed in drip systems but are very high for sprinkler systems (Burt et al. 2011). A notable limitation of wobblers is that they have non-adjustable 360° arcs causing growers to waste water by irrigating roads around irrigation blocks. MP2000 and 2045PJ showed the second-best DU and have adjustable arcs, showing the trade-off between uniformly irrigating plants and roads, or irrigating only plants but with lower uniformity. Obviously, the first will be preferrable in nurseries with large irrigation blocks, but we don't know what block size determines the choice.

Crop coefficient were substantially lower than those presented by Burger et al., 1987. for similar woody ornamentals grown in 1-gal containers. The difference is that Burger's crop coefficients were calculated using the container surface area, while I used the (larger) block area divided by the number of containers. I reported Burger's method on the second axis of Figure 4. While less meaningful from a plant physiology point of view, a block-based crop coefficient is more useful for irrigation management and more similar to the crop coefficient calculation in field crops, vinegrapes and fruit trees.

Figure 2. Middle, Edge and Corner configurations for overhead sprinklers

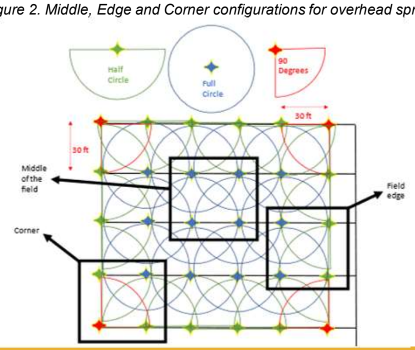


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Figure 3. Crop Coefficients for 15-gal Sycamore, Olive and Ficus

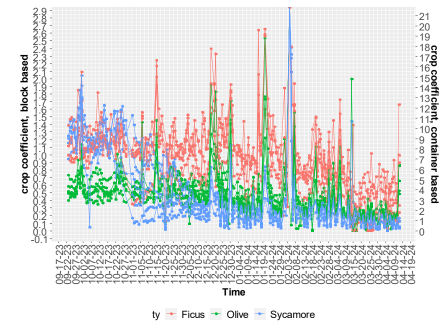

Figure 4. Load Cell measuring weight and daily water use of an Olive tree planted in a 15-gal container.

References

Burger D, Hartin J, Hodel D, Lukaszewski T, Tjosvold S, Wagner S. 1987. Water use in California's ornamental nurseries. Calif Agr 41(9):7-8.

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