Distribution uniformity of overhead sprinklers for outdoor container nurseries

Improving irrigation efficiency of containerized nursery ornamental production

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Introduction

Sprinkler irrigation in nurseries

Nurseries and greenhouses face challenges of limited water supply and increased scrutiny from water quality regulators. Improving irrigation efficiency and minimizing irrigation runoff are the main strategies to save water and comply with regulations. Overhead sprinkler irrigation is the preferred method for 5-gal nursery containers and smaller, mostly because of labor costs. Distribution Uniformity (DU) is one of the component of irrigation efficiency and it typically ranges from 0.6 to 0.8 for overhead sprinklers. Sprinkler Distribution Uniformity is known to be strongly affected by the wind. Nurseries are highly mechanized and diversified, with many plant species and varieties grown at the same site, so irrigation blocks are often small and surrounded by roads for machinery access. To minimize irrigation runoff and avoid irrigating roads, growers use sprinklers with adjustable arcs of 180° or 90° for edges and corners. Traditionally, brass impact sprinkler heads are used by the industry with spacings 30 ft x 30 ft in a square pattern. New rotatory and "wobbler" sprinkler are reported to deliver higher uniformities and the relatively new category of sprinkler heads called Multi Stream Multi Trajectory (MSMT) are reported to deliver high efficiency (Solomon et al, 2007) and offer the feature of adjustable arcs. These however have shorter throws and the sprinkler spacing must be 15 ft x 15 ft, leading to a larger number of sprinklers needed, more pipe, etc and ultimately larger capital investment costs.

Aim

What's the most efficient sprinkler?

The objectives of this project were to:

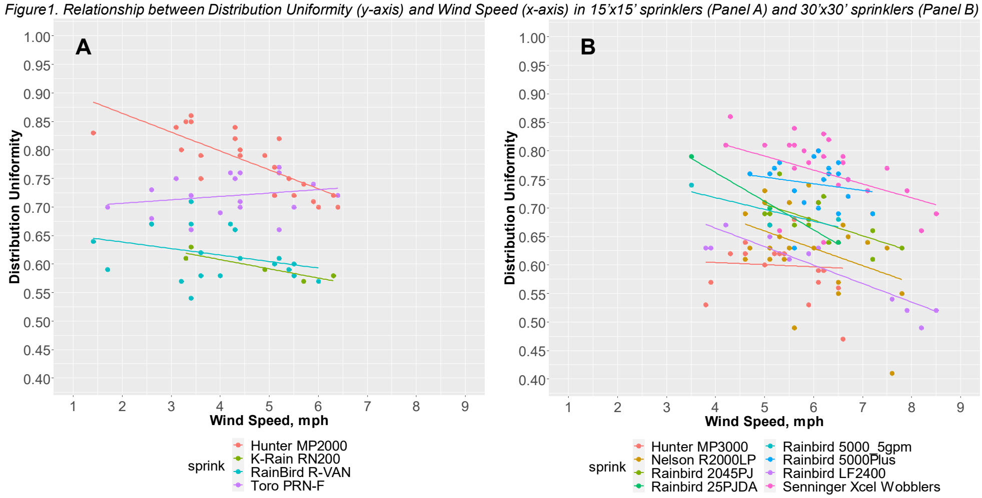
1. Measure distribution uniformity of impact and rotatory sprinkler heads with adjustable arcs in a 30 ft x 30 ft square spacing in relation to wind speed. We tested impact (Rainbird 2045PJ, 25PJDA and LF2400), geared rotors (Rainbird 5000 and Nelson R2000) and wobbling nozzles (Senninger Wobblers).
2. Measure distribution uniformity of Multi Stream Multi Trajectory (MSMT) sprinklers with adjustable arcs in a 15 ft x 15 ft square spacing in relation to wind speed. The MSMT sprinklers tested were TORO PRN, Rainbird R-VAN, K-Rain RN200 and Hunter MP2000.

Methods

A catch-can experiment

To calculate Distribution Uniformity (DU), we collected water with a catch-can experiment during 30-minute irrigation events, by setting up a grid of 6 x 6 1-gal buckets, with a diameter of 7 inches between four sprinkler heads. These size buckets were chosen because they most closely approximate a common 1-gal nursery container. The water volume collected in each bucket was measured with graduated cylinders. We measured wind speed with a 3-cup anemometer to evaluate wind effects on distribution uniformity. Mainline pressure was measured during the evaluations.

Figure1. Relationship between Distribution Uniformity (y-axis) and Wind Speed (x-axis) in 15'x15' sprinklers (Panel A) and 30'x30' sprinklers (Panel B)



Results

Two clear winners

There were clear differences in Distribution Uniformity (DU) between the tested sprinklers (Table 1). Among the 30'x30' sprinklers, Senninger Wobblers and Rainbird 5000 with 1.5 gpm nozzle had the highest average DU with 0.76 and 0.74, but the Wobblers do not have adjustable arc. However, Rainbird 5000 with 5 gpm nozzles showed a substantially lower DU (0.7). Among 15'x15' sprinklers, Hunter MP 2000 had average DU = 0.78. Generally, DU decreased with wind speed as expected, but the relationship was significant only for Rainbird 2045PJ, 25PJDA and LF2400, Senninger Wobblers, and Hunter MP2000 (Table 2). A significant correlation was found between app rate and mainline pressure for the Hunter MP2000s indicating that the Hunter pressure regulators are not performing as intended.

Discussion

Not all MSMT sprinklers were created equal

Solomon et al. (2007) and Baum-Haley (2014) reported an average DU = 0.7 and 0.59 for MSMT sprinklers, but do not report DU values for specific models. In this study we report an average DU = 0.7 but with substantial differences between manufacturers. The same studies reported that MSMT sprinklers have low application rates, however we measured 0.99 in/hr for the TORO PRN sprinklers. Tarjuelo et al. measured response of DU to wind speed for impact sprinklers similar to Rainbird 2045PJ and 25PJDA and report a response comparable to what observed in this study. In conclusion, MSMT sprinklers offer benefits including an adjustable arc, but high DU was observed also in "wobbler" and rotatory sprinklers.

Table 1. Average Distribution Uniformity and application rate for 30'x30' sprinklers (left) and 15'x15' MSMT sprinklers (below)

Sprinkler	DU	Application Rate, in/hr
Hunter MP3000	0.6	0.33
Nelson R2000LP	0.63	0.25
Rainbird 2045PJ	0.68	0.27
Rainbird 25PJDA	0.71	0.35
Rainbird 5000_5gpm	0.7	0.41
Rainbird 5000_1.5gpm	0.74	0.13
Rainbird LF2400	0.6	0.28
Senninger Xcel Wobblers	0.76	0.36

Sprinkler	DU	Application Rate, in/hr
Hunter MP2000	0.78	0.47
RainBird R-VAN	0.62	0.80
K-Rain RN200	0.60	0.66
Toro PRN-F	0.72	0.99

Table 2. Linear regression analyses between DU and wind speed

Sprinkler	Term	Estimate	Std.error	Statistic	p.value	Significance
Hunter MP3000	(Intercept)	0.62	0.09	7.21	2.08004E-06	
Hunter MP3000	wind	0.00	0.02	-0.24	0.810408896	NS
Nelson R2000LP	(Intercept)	0.81	0.09	9.21	3.54543E-09	
Nelson R2000LP	wind	-0.03	0.01	-2.07	0.050308371	NS
Rainbird 2045PJ	(Intercept)	0.84	0.06	14.52	5.62263E-09	
Rainbird 2045PJ	wind	-0.03	0.01	-2.86	0.014306437	*
Rainbird 25PJDA	(Intercept)	0.96	0.02	48.34	0.013168217	
Rainbird 25PJDA	wind	-0.05	0.00	-13.05	0.048694978	*
Rainbird 5000Plus	(Intercept)	0.81	0.10	8.42	1.81535E-07	
Rainbird 5000Plus	wind	-0.01	0.02	-0.73	0.47612101	NS
Rainbird 5000_5gpm	(Intercept)	0.80	0.08	10.58	0.060015805	
Rainbird 5000_5gpm	wind	-0.02	0.01	-1.41	0.393165133	NS
Rainbird LF2400	(Intercept)	0.79	0.04	22.19	1.74579E-10	
Rainbird LF2400	wind	-0.03	0.01	-5.60	0.00015925	***
Senninger Xcel Wobblers	(Intercept)	0.91	0.07	13.45	1.14155E-12	
Senninger Xcel Wobblers	wind	-0.02	0.01	-2.25	0.03390129	*

Sprinkler	Term	Estimate	Std.error	Statistic	p.value	Significance
Hunter MP2000	(Intercept)	0.91	0.03	29.49	4.86E-16	
Hunter MP2000	wind	-0.03	0.01	-4.55	0.000283897	***
RainBird R-VAN	(Intercept)	0.66	0.03	20.42	6.72189E-14	
RainBird R-VAN	wind	-0.01	0.01	-1.45	0.164739445	NS
Toro PRN-F	(Intercept)	0.69	0.03	24.07	1.42524E-14	
Toro PRN-F	wind	0.01	0.01	0.91	0.373365463	NS

Acknowledgements

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Figure 2. An outdoor container nursery where geranium is grown in 1-gal pots

References

Baum-Haley, M. 2014 Evaluation of Potential Best Management Practices - Rotating Nozzles

Solomon, K. H.; et al. 2007 Performance And Water Conservation Potential Of Multi-stream, Multi-trajectory Rotating Sprinklers For Landscape Irrigation

Tarjuelo, J. et al. 1999 Irrigation Uniformity With Medium Size Sprinklers Part II: Influence of Wind And Other Factors On Water Distribution

Wascher, J., Multi-Stream, Multi-Trajectory Nozzles: How They Save Water, Labor, And Installation Costs.