Catch Can Placement, Height, and Nozzle Trajectory: Effects on Distribution Uniformity

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Abstract. *Catch can audits are a critical component of irrigation system evaluations. Recent experiences with catch can height and sprinkler nozzle trajectory showed that these variables were very important factors in distribution uniformity and should be considered in irrigation system performance metrics. Lower quarter distribution uniformity (DU_{lq}) was evaluated for nozzle trajectories ranging from 20^o to 27^o and catch can heights relative to nozzles. A small (30' x 15') indoor irrigation system was used to conduct the tests using Toro Precision Series Spray Nozzles (T- Spray, 27^o trajectory), Toro Precision Series Rotating Nozzles (T-RN, 20^o trajectory), and MP Rotators (MP-R, 25^o trajectory). Horizontal catch can placement relative to nozzles followed IA audit guidelines and was not varied based on pre-test evaluations. Twenty-eight Cal-Poly catch cans were uniformly distributed throughout the test system and leveled. Riser heights were varied to simulate catch can rims at ground level (CCRG) and catch can tips at ground level (CCTG). Distribution uniformities for T-RN ranged from 70% (CCRG) to 50% (CCTG); DU_{lq} ranges for MP-R at CCRG were 81% and CCTG, 79%; D_{lq} U ranges for T-Spray at CCRG and CCTR were 78% and 77%, resp. The results indicate that the true performance of the 20^o trajectory nozzle at soil level was not captured at normal catch can height and that alternate methods of performing irrigation audits on low trajectory nozzles should be explored.*

Keywords Distribution uniformity, sprinkler trajectory

Introduction

Sprinkler nozzles are designed for certain radius of throw, ranges of operating pressure, arc, and stream trajectory. The need for greater irrigation efficiency, uniformity, and better water conservation in landscape irrigation has led to many improvements in nozzle technology. One of the major improvements has been the MP Rotator nozzle, which has multiple rotating streams of water, matched precipitation rates, and typically high distribution uniformities (DU_{lq}).

Very low trajectory nozzles are useful in windy conditions or in turf areas where higher trajectory streams or spray could be blocked or adversely affect other vegetation. At Northern Water, an excellent area for a low trajectory, high uniformity nozzle is the turf under the weather station. This zone is circular and often has irrigation distribution problems. Because of

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the weather station, it is undesirable to have irrigation sprays or streams at trajectories that could directly affect instrumentation or be misted or blown into the instrumentation by wind.

However, initial experiences with a low trajectory nozzle (Toro Precision Series Rotating Nozzle, 20^{o} trajectory), showed that evaluation of these nozzles would be difficult under normal conditions in the field, as catch can rim heights are usually several inches above the ground.

This low trajectory nozzle sprayed the sides of the catch cans in our initial indoor observations regardless of the horizontal distances of the catch cans from the nozzles. A different approach was required to properly evaluate the low trajectory nozzle performance and its potential application at our weather station circle.

Methods

We evaluated the DU_{lq} of three sprinkler nozzles (Table 1) with different spray or stream trajectories (Toro Precision Series Spray Nozzles (The Toro Company, 2011a), Toro Precision Series Rotating Nozzles (The Toro Company, 2011b), and MP Rotators (Hunter Industries, 2011) using a small indoor irrigation system.

Table 1. Nozzles and part numbers.

	MP Rotator **(25 ^{o})**	Toro Precision Spray Nozzle **(27 ^{o})**	Toro Precision Rotating Nozzle **(20 ^{o})**
90 deg	MP-2000 Black	O-T-15-Q	PRN-TA
180 deg	MP-2000 Black	O-T-15-H	PRN-TA

The irrigation system was 30 feet by 15 feet, with a 90^{o} nozzle at each corner and a 180^{o} nozzle in the center of each 30' side (Fig. 1). The catch can stands were built to accommodate several types of catch cans, including Cal-Poly catch cans, which were used in these tests. The catch can stand heights and supports were designed to allow testing of typical sprinkler operational heights of 4" with catch can tips at the system's equivalent of ground level.

Twenty-eight Cal-Poly catch cans were uniformly distributed throughout the test system and leveled. Corner catch cans were placed two feet laterally from the corner sprinkler, then 2 feet into the lengthwise dimension (30' side) of the zone. Subsequent catch cans were spaced 4'4" apart in the lengthwise dimension, and 3'8" apart in the lateral (15') dimension.

It was logistically simpler to change the 6 riser heights than to raise and lower 28 catch can supports, so riser heights were varied to simulate catch can rims at ground level (CCRG) and catch can tips at ground level (CCTG)(Fig. 2). Cal-Poly catch can height is 5.75", so the sprinklers were raised by that amount to simulate catch can rims at ground level. (However, for simplicity, the paper will refer to the catch cans being raised and lowered, as that is the equivalence in a field setting.)

Figure 1. The indoor irrigation system set up for catch can rims at ground level. Each catch can support was shimmed so level was maintained from center to garage doors.

Figure 2. The sprinkler head set up for catch can tips at ground level.

Two runs for each nozzle at each height were conducted. All doors were kept closed during the tests, so wind was not a factor. Operating pressures for each nozzle were kept within manufacturer specifications by observing a pressure gauge installed before the valve and adjusting pressure with the pressure regulator. MP Rotators were operated at 40 psi. The Toro Precision Series Rotating Nozzles were operated at 30 psi and the Toro Precision Series Spray Nozzles were operated at 32 psi. Nozzles and heads were adjusted for proper arc and throw before each run. Runtimes were 30 minutes for MP Rotators and Toro Precision Series Rotating Nozzles. Toro Precision Series Spray Nozzles were run for 15 minutes. All runtimes exceeded Irrigation Association (Irrigation Association, 2010) guidelines for audits.

Results and Discussion

Table 2 shows the results of the 12 irrigation test runs.

Table 2. Distribution uniformity (DU_{lq}) and precipitation rate (PR) for each nozzle at CCRG and CCTG.

	MP Rotator MP 2000 (25^{o})		**Toro Precision Series Rotating Nozzle (20^{o})**		**Toro Precision Series Spray Nozzle (27^{o})**	
	Catch can tips at ground level					
	Run 1	**Run 2**	**Run 1**	**Run 2**	**Run 1**	**Run 2**
DU_{lq} (%)	79	80	49	50	75	77
PR (in/hr)	0.50	0.49	0.44	0.41	1.01	1.02
	Catch can rims at ground level					
	Run 1	**Run 2**	**Run 1**	**Run 2**	**Run 1**	**Run 2**
DU_{lq} (%)	81	81	70	69	78	78
PR (in/hr)	0.51	0.52	0.56	0.59	0.97	0.99

MP Rotators generally have high DU_{lq}; therefore inclusion in this test was an indication of what we could expect from this small indoor system. The MP Rotator performed very well at each catch can height, as did the Toro Precision Spray Nozzle. Trajectories of each were several degrees higher than the 20^{o} trajectory of the Toro Rotating Nozzle.

The change in catch can height from tip at ground level to rims at ground level increased the Toro Rotating Nozzle DU_{lq} from 49 and 50% to 70 and 69%, a substantial increase in performance metrics. When the riser heights simulated catch can tips at ground level, water streams continually hit the side of the catch can. Moving the catch can closer or further away did not alleviate this problem. Also, the precipitation rate was much higher when catch can rims at ground level was simulated, corroborating the visual observations.

It is possible that our indoor system at 15' wide was slightly small for the Toro Rotating Nozzle. At 30 psi, the quarter circle nozzles were specified to have a minimum 17.5' radius. The half-circle nozzles were specified to have radius of 17' at 30 psi. This irrigation system did not perform well at lower than 30 psi. Although the arc and radius were adjusted, the radius in particular was at the limits of its adjustment capabilities.

Precipitation rates of the MP rotator and the Toro Precision Spray Nozzle increased very slightly, but not substantially.

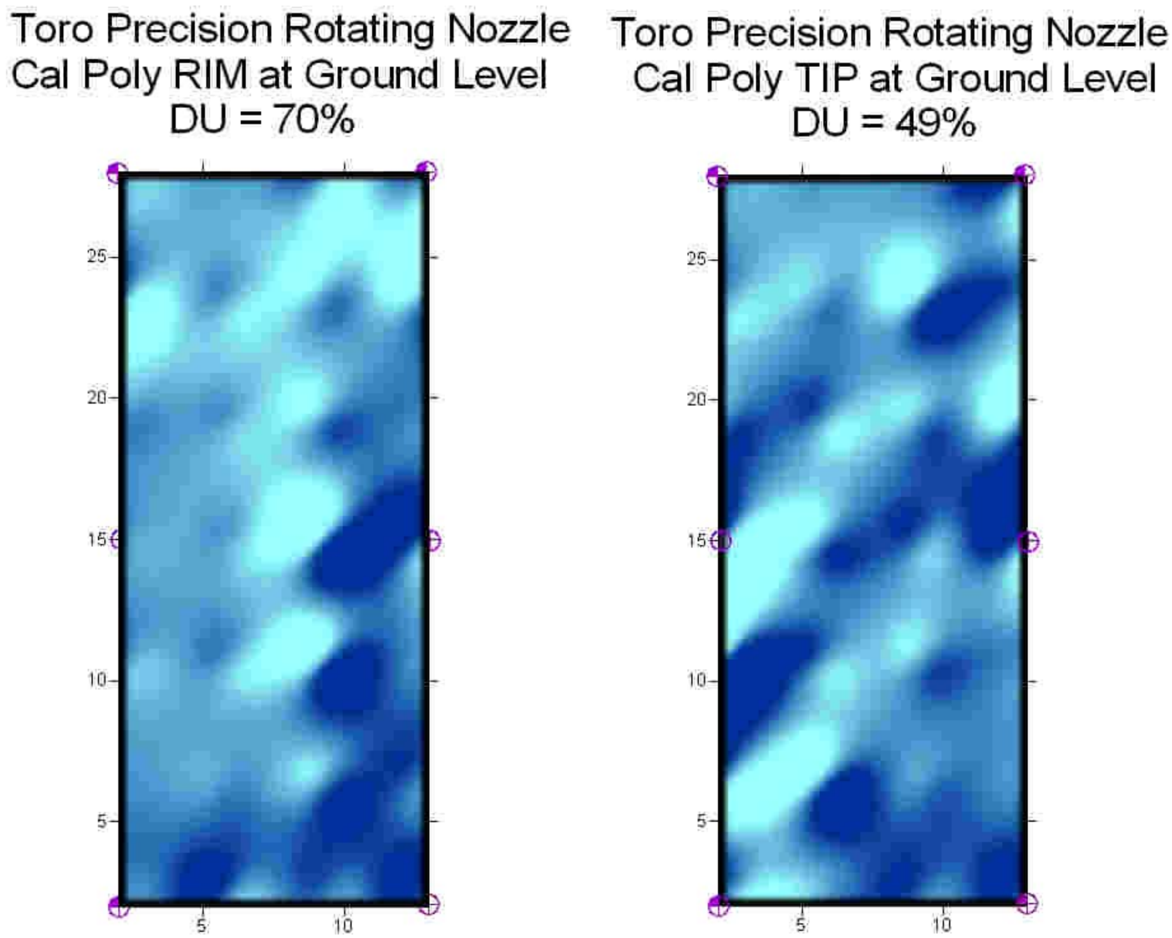

Figure 3. Shaded relief images of catch can volumes for CCRG and CCTG for the Toro Precision Rotating Nozzle.

The shaded relief images show how the Toro Precision rotating Nozzle irrigation was spatially distributed at the two catch can heights (Fig. 3). When the DU_{lq} was 70% and the catch can rim was at ground level, some areas in the lower right clearly received more water, but the rest of the area showed more uniform distribution. The catch can tip at ground level run had a much lower DU_{lq}, 49%, and the lack of uniformity was throughout the area.

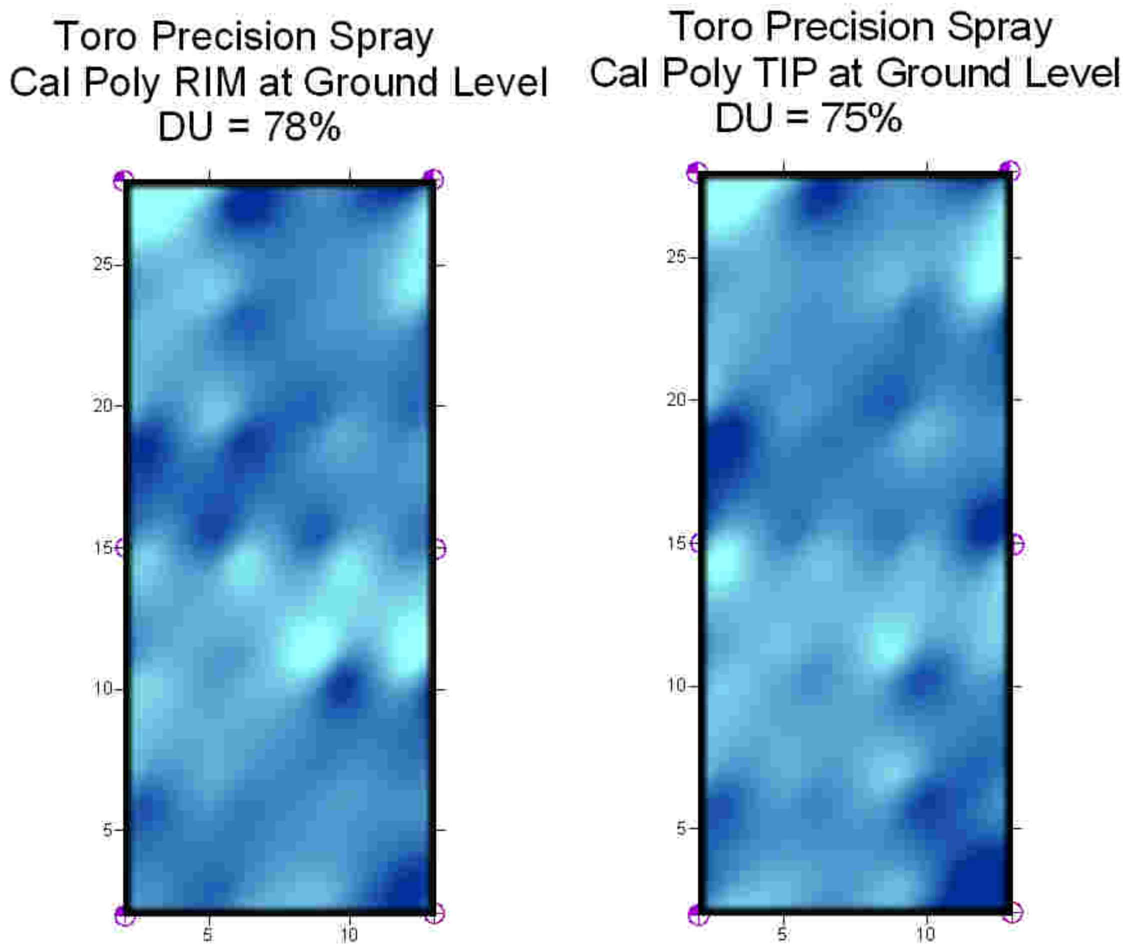

Figure 4. Shaded relief images of catch can volumes for CCRG and CCTG for the Toro Precision Spray.

The Toro Precision Spray Nozzles showed very similar spatial distributions (Fig. 4) across the irrigation zone at each catch can height. Some higher irrigation catches occurred directly in front of one or two of the heads, but otherwise did not show the wide variations that the Toro Precision Rotating Nozzle showed.

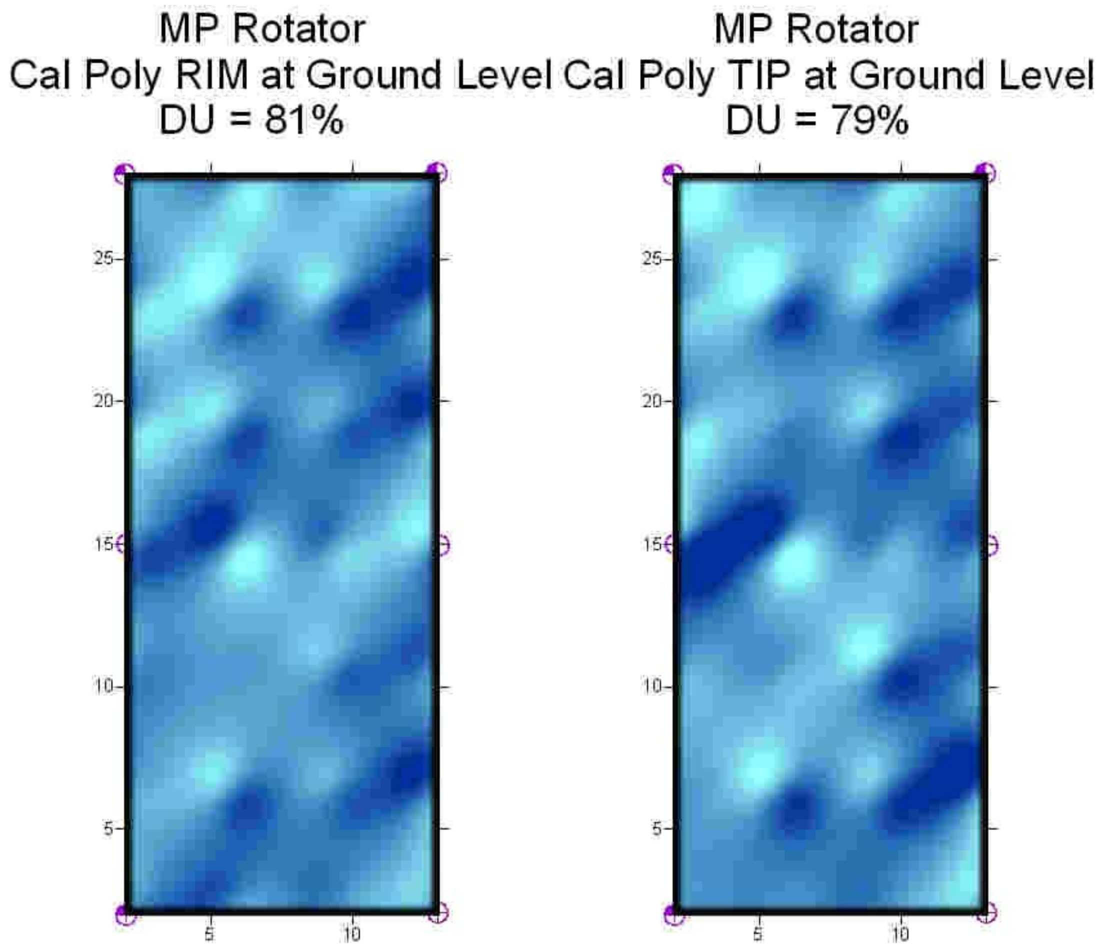

Figure 5. Shaded relief images of catch can volumes for CCRG and CCTG for the MP Rotator.

The MP 2000 DU_{lq} was high and similar for CCRG and CCTG (Fig. 5). One of the half circle heads had very high catch can amounts, but as with the Toro Precision Spray Nozzles, the rest of the area did not show the wide variations that the Toro Precision Rotating Nozzle showed.

If the 20^o trajectory nozzle was installed in a turf zone, an audit using standard guidelines would likely show results similar to the CCTG in our controlled study, or worse.

Possible solutions are 1) cut a hole in the turf that would allow the catch can rim to be at ground level. 2) Perform a soil moisture audit, if proper equipment is available. The ground level effect is really what counts operationally, so a soil moisture audit would take into account the droplet distribution at ground level and the soil's natural ability to laterally move soil moisture. Baum (2005) found that uniformities from soil moisture DU_{lq} were higher than those from traditional catch can audits, but raised a concern that the TDR soil moisture equipment used might not be sensitive enough to detect soil moisture redistribution.

A possible 3rd solution is to use a standard catch can such as the Cal-Poly and add sufficient height to the sprinkler head using a riser extension to simulate a CCRG condition. This would likely work for most situations.

A possible 4th solution is to design or find catch cans specifically for low trajectory nozzles. Flat, low-sided plastic bowls have successfully been at Northern Water to perform sprinkler irrigation audits. The chief drawback is that the bowls can be difficult to level in the turf; however, in a previous test using the indoor system described in this paper, the bowls performed comparably with Cal-Poly catch cans.

Conclusions

The low-trajectory nozzles are very desirable in windy irrigation zones or where high or fine spray could be detrimental to instrumentation. Practical problems exist, however, when testing performance even under controlled, indoor conditions. We tested DU_{lq} of three nozzles with different trajectories and rotating stream vs. spray output in an indoor, controlled setting. The results indicated that when catch can rims at ground level was simulated in the indoor irrigation system, DU_{lq} for a low-trajectory nozzle improved from 49% to 70%. The results of these tests indicate that a different approach to auditing low trajectory nozzles is required.

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