Performance of the Decagon Rain Gauge model ECRN

The purpose of this study was to identify the capabilities of Decagon Devices' rain gauge (hereafter know as DRG) under field circumstances. The focus of the study wasn't to discover the DRG's accuracy, it was to compare the DRG with other routinely used rain gauges. This angle was taken because of the difficulty in establishing the exact amount of water put down in a natural setting. Without knowledge of the exact amount of water, an accuracy value can't be assigned to the DRG because there isn't a standard that the rain gauges results can be compared with. The difficulty in establishing a standard is due to the many more variables that are present in the field as opposed to those present in the laboratory (wind, water distribution, water deflection, etc.). While these variables cause the problems in establishing a standard, they are also the reason tests were needed in the field to determine the DRG's performance.

Materials and Methods

Two simulation experiments were used in determining the DRG's capabilities. The first experiment was designed to test the DRG's performance under rain conditions of about an inch an hour. The second experiment was designed to test the DRG under the most extreme conditions that may result from high output irrigation systems, such as at the moment a high-pressure sprinkler passes over the gauge. Both simulation experiments used four rain collection devices, the DRG, Davis Instruments' 7852 Rain Collector, Texas Electronics' TR-525I, as well as a simple funnel suspended above a collection jar. The dimensions of the gauges can be seen in Table 1.

In the simulation experiments the devices were organized as the corners of a square with only a few inches separating them. It was done in this fashion so that all of the gauges were measuring close to the same area within the entire distribution area of water. All of the device's intakes were positioned at about the same height

Table 1 Rain Gauge Specifications

	Decagon Rain Gauge	Davis	Texas	Jar
Collection area (cm^2)	50	124	182.9	153.9
Tip. Volume (cm^3)	5	5.4	4.6	N/A
Precip./Tip. or Resolution (mm)	1	0.254	0.254	N/A

and as close to the ground as possible. The low height of the collection devices enabled a high trajectory to be achieved. In addition to the device's positional equality they were rotated along with the sources of water so that an equal and random distribution of water could be provided as closely as possible . The sources of water in the first experiment were two impact sprinklers positioned approximately 30 degrees apart from each other when viewed from the gauges and at a distance of about 27 feet. The sprinklers were directed so that a continuous supply of water could be applied. In the second experiment the source of water was a single hand held nozzle suspended six feet high and four feet away from the gauges.

In addition to the experiments described above, further testing was conducted to compare the results from the readings taken under actual irrigation with the results from the first two experiments. This third test was conducted under a center pivot irrigation system used over potatoes. In this experiment the jar wasn't included but the three other devises were used with the addition of a second DRG. The gauges were set up three feet above the ground and in a linear fashion so that they formed a line parallel with the irrigation circle's direction of movement. Readings were taken under both the low-pressure nozzles and the high-pressure impact sprinkler.

Results and Discussion

The purpose of the funnel and jar was to get a reading of the water being dispersed without having to deal with the error that could occur because of the tipping mechanisms of the rain gauges. From three examples collected as part of the first experiment it can bee seen that the Jar generally had a higher recorded amount of precipitation than the rain gauges (Table 2). It is possible that the error resulting from the tipping mechanisms brings about these lower readings. When the precipitation rate is at its highest this effect becomes most apparent.

Table 2 Exp. #1 – Jar Comparison

	Decagon Rain Gauge	Davis	Texas	Jar
Precip. (mm)	26.0	25.9	26.9	27.3
	26.0	23.9	27.4	27.0
	59.0	55.1	58.7	63.0

For the remainder of this discussion the highest recorded value by the three instruments will be considered the most accurate because it is the closest to the Jar's values (which is void of tipping error). With that in mind Figure 1 shows the amount of water recorded over time by the three gauges, and Table 3 shows the final results as well as the average deviation of the values recorded in the first experiment. The average deviation is the average distance each data entry is from the mean. The average deviation is given in millimeters and was calculated according to the five-minute interval at which data entries were made. According to the Texas Electronics rain gauge the rate of precipitation was 2.77 cm/hour or 1.09 in/hour.

Fig. 1 Exp. #1 – Precipitation over time

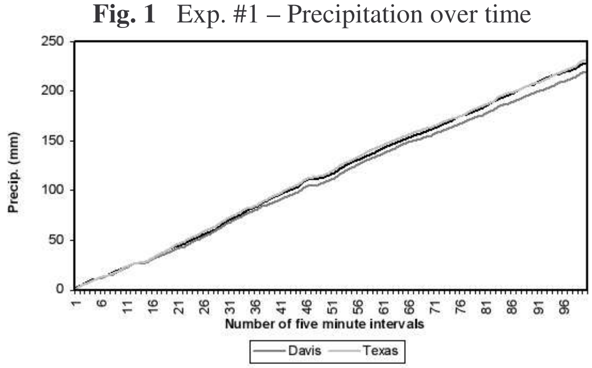


Table 3 Exp. #1 – Final results

	Decagon Rain Gauge	Davis	Gold
Precipitation (mm)	228.0	219.7	230.9
	0.58	0.44	0.46

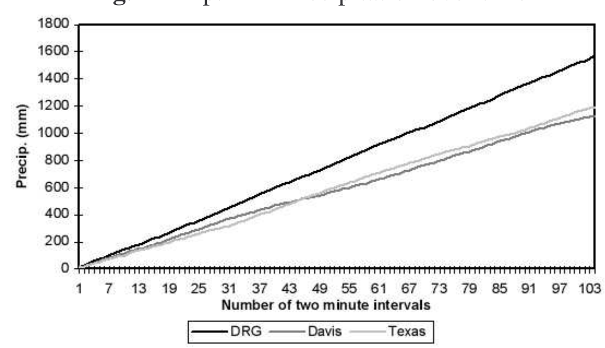
The data collected from the first experiment shows that the DRG produced nearly the same results as the Texas Electronics' gauge. The most notable problem with the DRG is its poor precision as seen by the average deviation. However, this lack of precision doesn't seem to create any significant problems with the DRG's accuracy when there is a prolonged precipitation period as there was in this experiment.

The second experiment involved the high precipitation rate. Once again higher values were recorded by the jar (Table 4). The water collected over time is represented in Figure 2 and the final results are in Table 5. In this case the average deviation was calculated according to the two-minute interval at which data was collected. The DRG recorded a rate of 90.4 cm/hr or 35.59 in/hr.

Table 4 Exp. #2 – Jar comparison

	Decagon Rain Gauge	Davis	Texas	Jar
Precip. (mm)	58.0	47.2	44.7	59.9
	57.0	47.0	38.6	57.6
	56.0	45.2	41.1	59.2

Fig. 2 Exp. #2 – Precipitation over time



From the data collected in this second experiment, the DRG showed the highest recorded precipitation as well as the lowest deviation. The other two rain gauges produced results comparable with each other's although the results were much lower than DRG's. At these high rain rates we assume that the tipping errors in the high-resolution gauges caused the under estimation of precipitation.

Most of the data that was presented in the first two experiments can also be shown and presented in the same way for the third experiment (Average Deviation isn't valid because of the difficulty in applying constant precipitation). Figure 3 and Table 6 respectively show the precipitation over time and the final results of the low-pressure data collection. Figure 4 and Table 7 show the results collected from the high-pressure impact sprinkler. According to the DRG #1 rain gauge the rate of precipitation was 6 cm/hr or 2.36 in/hr for the low-pressure nozzles and 7 cm/hr or 2.76 in/hr for the impact sprinkler. While the impact sprinkler produces only a slightly higher rate of precipitation it is important however, to note that the precipitation comes in bursts. Because the precipitation comes in bursts the only way to calculate the rate would be to divide the recorded precipitation by only the small amount of time the sprinkler is directed at the gauges. This couldn't be done and as a result the precipitation is divided by the entire measuring time. This causes the rate to appear much lower than it actually is. The impact sprinkler irrigation is much more closely related to a high rate model than it is to a low rate model.

Table 5 Exp. #2 – Final results

	DRG	Davis	Texas
Precip. (mm)	1567.0	1128.8	1191.8
Avg. Dev. (mm/interval)	0.74	1.27	1.33

Fig. 3 Exp. #3 – Final results

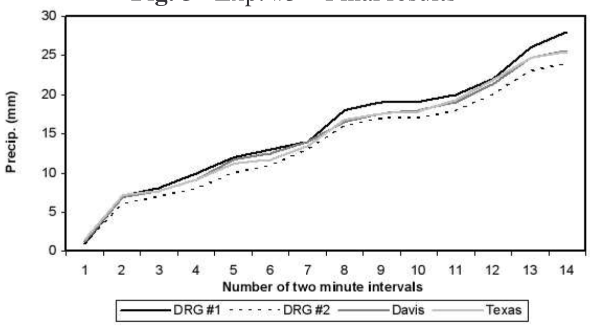


Table 6 Exp. #3 – Final results

	DRG 1	DRG 2	Davis	Texas
Precip. (mm)	28.00	24.00	25.65	25.40

Fig. 4 Exp. #3 – High-pressure precipitation over time

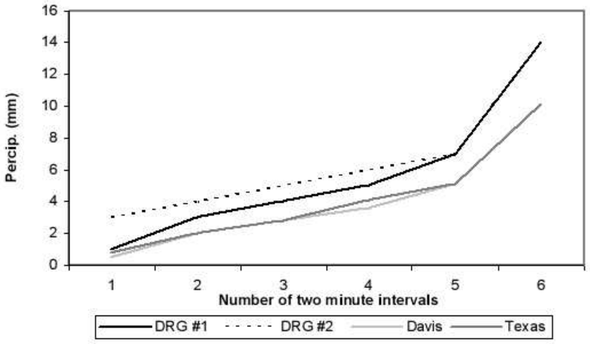


Table 7 Exp. #3 – Final results of high-pressure irrigation

	DRG 1	DRG 2	Davis	Texas
Precip. (mm)	14.00	14.00	10.16	10.16

The third experiment shows that the data collected in the first two experiments resembles the data that can be collected under an actual irrigation system. Under the low-pressure nozzles all of the recorded values are close together, just as they are in the first experiment. Under the high-pressure sprinkler the recorded values for the DRGs is significantly higher than the other two gauges, just as in the second experiment.

Conclusion

The dimensions of the rain gauges can explain everything the data shows us. Under the low precipitation rate (experiment one) the accuracy of the rain gauges decreases as the tipping volumes increase and the deviation increases as the rain collection area decreases. While the same dimensions that explain the data collected at a low precipitation rate are still factors when the precipitation rate is high (experiment two), those dimensions carry a different amount of importance. This is because dispersion becomes less variable at high levels and the tipping rate becomes more of a factor due to the increased number of tips. In general, at high levels, both the accuracy and deviation are improved when fewer tips are needed. As can be seen in Table 1, every tip of the DRG accounts for about four times as much water as the other gauges, resulting in a fourth the number of needed tips. While the DRG's performance is too standard at low rates of precipitation and improved at high rates, it is believed that it would be less accurate that the Davis and Texas gauges if precipitation was sparse enough to allow for significant evaporation to occur between tips. The overall picture shows that a low-resolution (high precipitation per tip) is desirable at high levels of precipitation and a high-resolution is desirable at low levels.

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