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Evaluation of Collector Size for the Measurement of Irrigation Depths

E. Dogan, Former Graduate Student

Kansas State University, Dept. of Biol. & Agric. Engineering, Manhattan, KS.

G. A. Clark, Professor

Kansas State University, Dept. of Biol. & Agric. Engineering, Manhattan, KS.

D. H. Rogers, Professor

Kansas State University, Dept. of Biol. & Agric. Engineering, Manhattan, KS.

V. L. Martin, Associate Professor

Kansas State University, Sandyland Exp. Field, Dept. of Agronomy, St. John, KS.

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Abstract. *Results from three years and locations indicated that collectors with a 10-cm opening may not provide reliable irrigation depth data under fixed-plate (FP) sprinkler packages that produce distinct streams of water. Collectors with 15-cm diameter openings provided acceptable results under the FP sprinkler packages. The 10-cm opening collectors accurately measured both irrigation depth and uniformity under spinning plate (SP) and wobbling-plate (WP) sprinkler irrigation packages that produced smaller, more evenly distributed irrigation droplets with no distinct streams or jets.*

Keywords. Irrigation, Sprinklers, Irrigation Depth, Rain Gauge

Evaluation of Collector Size for the Measurement of Irrigation Depths[1]

E. Dogan, G. A. Clark, D. H. Rogers, and V. L. Martin[2]

Introduction

Sprinkler irrigation system uniformity is an important performance characteristic of sprinkler irrigation systems (William, 1963; Branscheid and Hart, 1968; Vories and von Bernuth, 1986; Heermann et al., 1992; Evans et al., 1995; and Li and Kawano, 1996), and should be evaluated based on expected conditions (field conditions) that will exist in the crop field (Volker and Hart, 1968). Since crop growth and yield are dependent on available water, substantially lower uniformity might result in reduced crop yields in the areas receiving less irrigation water.

Fixed-plate (FP), grooved-disk deflector sprinkler irrigation packages have distinct jet streams with large water droplets. Spinning-plate (SP) diffuser and wobbling-plate (WP) diffuser sprinkler irrigation packages produce smaller water droplets and usually evenly distribute irrigation water to the crop fields. In additionl, impact and rotating sprinkler designs also have more uniform applications due to the breakup in droplet size and patterns. However, sprayed water from those systems may be more susceptible to wind drift and evaporative losses than low drift nozzle (LDN) type sprinklers (James and Blair, 1983; Hanson and Orloff, 1996; Bilanski and Kidder, 1958).

Heermann et al. (1999) studied the effect of low-pressure sprinkler drop spacing on irrigation uniformity and concluded that the spacing of low-pressure sprinklers is more important than the pattern or shape of the low-pressure sprinkler package. To maintain a high coefficient of uniformity, the distance between irrigation drops should be no more than the throw radius of the irrigation package. Clark et al. (2003) reported that with some LDN packages, that the spacing should be no greater than 40% to 50% of the radius of throw in order to maintain CU values greater than 90. Field tests help with the assessment of these recommendations.

Kohl (1972) indicated that while various collectors had been used in research to measure applied irrigation amounts, little was known about the accuracy of those collectors. He conducted research to compare collected irrigation depth with one-quart (~1.0 L) oil cans, oil cans with paraffin and 7.62 cm diameter sharp edge rain gauges. He concluded that a good collector should have the following design criteria so that evaporation loss would be minimal: collectors should have a small inner surface where water drops adhere and evaporate; the device opening should be designed to minimize evaporation; collectors should be painted white so that sensible heat transfer to the inner surface would be minimized; and devices should be easy to carry around and be easy to read. Seginer and Kostrinsky (1975) indicated that evaporation, wind drift, and splash out from collectors can cause water loss between sprinkler heads and irrigation water collectors and needs to be considered during uniformity tests. Many other types and sizes of catch devices were used to measure irrigation application depths and included quart cans (Nir et al., 1980), plastic pans, fuel funnels (Clark and Finley, 1975),

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[2] E. Dogan is a former Graduate Student; G. A. Clark (contact author) and D. H. Rogers are Professors of Biological and Agricultural Engineering; and V. L. Martin is an Associate Professor of Agronmomy, Kansas State. G.A. Clark is located at the Department of Biological and Agricultural Engineering, Kansas State University, Manhattan, KS, 66506; and can be contacted at 785-532-2906 or gac@ksu.edu.

commonly used oil cans (Heermann and Kohl, 1980), and coffee cans on stakes (Vlotman and Fangmeier, 1983).

Marek et al. (1985) indicated that collectors should display characteristics such as sharp edges to separate water droplets, should prevent splash in and out, and should minimize evaporation losses of collected water as well as from droplets on the inner surface. They evaluated the measurement performance of three different collectors: oil cans with a 10.3 cm dia. and a 14.1 cm depth, glass separatory funnels with a 9.02 cm dia., and a fuel funnel with a 4.9 cm diameter. The sprinkler irrigation package had Rainbird model 30 W-TNT series impact sprinklers with a 0.52 cm inside diameter nozzle operated with 244 kPa pressure. Results from the three different collectors were significantly different. The separatory funnels were the most accurate devices, but were expensive. Oil cans-over estimated irrigation depth by 5%. They concluded that the fuel funnels were unacceptable collectors for uniformity measurements.

ASAE (2001) states that catch devices (collectors) used for uniformity measurements should be identical with a minimum height (h) of 12 cm, and with an opening of at least 6 cm in diameter. For data collection on center pivot systems, two or more sets of collectors parallel to one another should be used with a maximum collector spacing of 3 m between collectors for spray irrigation sprinkler packages. However, Evans et al. (1995) indicated that under field conditions, using two or more catch device rows is not practical during data collection. Further, there should be no obstructions (such as a crop canopy) between the irrigation nozzle or discharged water trajectory and the catch device. If the canopy is higher than the opening of the collection device, then a buffer distance equal to twice the distance between the opening of collector and the height of the obstruction should be cleared.

Clark et al. (2002) developed an inexpensive, non-evaporating in-field precipitation gauge (IrriGage) that might be used not only for rainfall and irrigation depth measurements, but also for evaluation of sprinkler irrigation system uniformities. The IrriGage (IG10) device is a 20 cm long, 10.2 cm dia. PVC pipe with a PVC cap glued to the bottom of the barrel. The gauge has a bottle attached to the bottom cap as a water reservoir. The authors concluded that these devices could be used to measure sprinkler irrigation depths with little or no evaporative loss, that they exceed the collector criteria specified in the ASAE center pivot performance test standard (ASAE, 2001), and that they are easy to make and set up in field tests. Because the IrriGages are non-evaporating, collected water amounts do not have to be read immediately following irrigation events.

Field measurements of center pivot irrigation system uniformity (data not currently reported) with 43 cm diameter pans and 10.2 cm diameter IrriGage's (IG10) raised some concerns about using IrriGage's on fixed-plate, grooved disk sprinkler packages. The distinct streams of water may or may not be caught by a gauge. Because the volume of water caught by the gauge is averaged over the surface area of the opening, small gauge openings may result in artificially high or low depths based upon the caught or missed streams. In addition, even with the larger catch devices, adjacently measured depths could vary from 10% to over 100%.

Therefore, the objectives of this study were:

1. To evaluate the catch accuracy of different irrigation water collectors from above-canopy, fixed-plate and rotating-plate sprinkler devices on a moving irrigation system.

2. To determine the appropriate number of catch devices to measure the average applied water depth from above-canopy, fixed-plate and rotating-plate sprinkler devices on a moving irrigation system.

MATERIALS AND METHODS

Catch Device Characteristics

This study evaluated the catch accuracy of the IrriGage 10.2 cm diameter (IG10) devices for both fixed-plate and rotating-plate sprinkler irrigation packages. Study sites included a linear-move sprinkler irrigation system at the Kansas State University (KSU) Sandyland Experiment Field, St. John, KS (1999 and 2000), a center-pivot system at the KSU Livestock Waste Management Learning Center in Manhattan, KS (2002A), and a linear move sprinkler system at the KSU North Central Experiment Field, Scandia, KS (2002B).

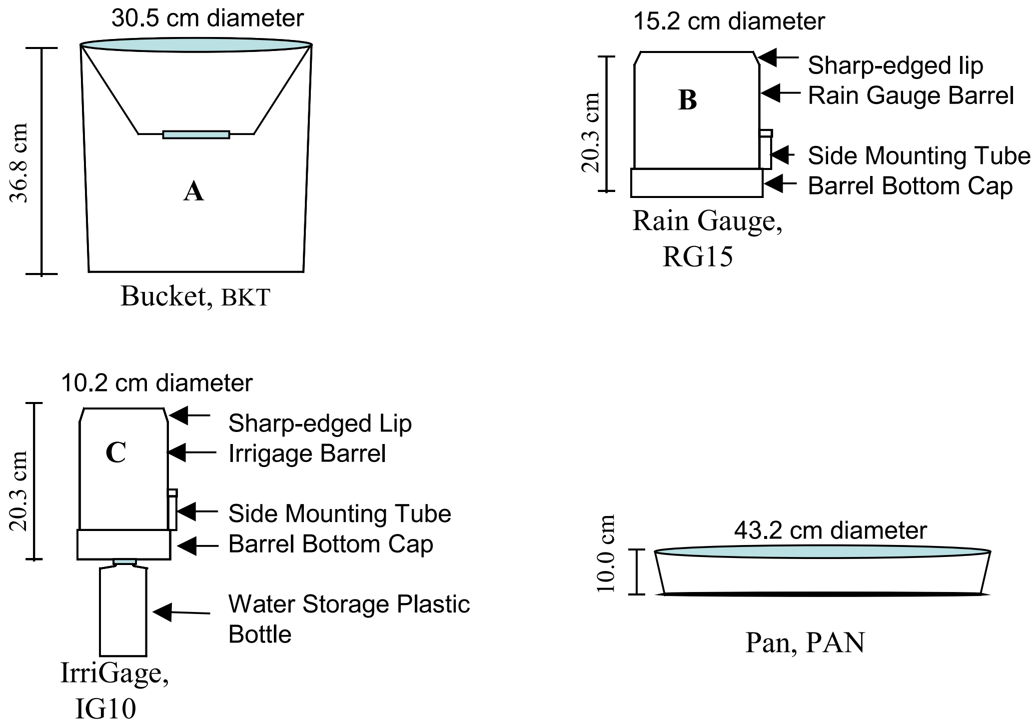
The primary objective of this work was to compare the catch accuracy of the IG10 collectors to a larger diameter catch device. The 1999 and 2000 studies compared IG10 collectors to large diameter (43.2 cm) pans (PAN). The 2002 study sites (2002A and 2002B) involved a comparison of the standard IrriGage devices (IG10) with a 15.2 cm diameter rain gauge (RG15) and a 30.5 cm diameter bucket (BKT) (Figure 1). The PAN gauges had the shallowest depths (10.2 cm), slightly less than ASAE criteria (12.0 cm) (ASAE, 2001). However, the large diameter (d) of the PAN's resulted in a much larger area (A) to circumference (C) ratio (A/C = d/4) than the smaller catch devices. The A/C ratio provides a relative indication of the potential boundary area that could result in splash in/out errors. Thus, it was believed that splash would not be a concern with the large diameter PAN's.

All three sprinkler systems in this study (1999, 2000, 2002A and 2002B) had sprinklers on drops just below the system trusses, and all drops were on a 3.0 m spacing. Discharge rates from the three middle sprinkler nozzles from each treatment zone of the linear sprinkler irrigation systems (1999, 2000, and 2002B) used in this study were measured once. A PVC pipe was positioned over the sprinkler nozzles and directed the discharge water into a 20 L bucket. Discharge volumes were measured for 30 seconds, collected water then was weighed, and data were converted to discharge rate units. The middle three nozzles and pressure regulators from both FP and SP sprinkler package test zones on the center pivot irrigation system (2002A) were taken to the Biological and Agricultural Engineering, Kansas State Univeristy hydraulic laboratory for discharge rate tests. A test pressure equal to the center pivot inline pressure was used and pressure-regulated nozzle discharge rates were tested three times for one minute. These tests were used to verify the nozzle consistency and the manufacturer reported nozzle discharge rates.

1999 and 2000 Field Evaluations

In 1999 and 2000, IG10 collectors were used to evaluate three irrigation pressure and nozzle sizes for irrigation uniformity under fixed plate, grooved-disk deflectors at the Kansas State University Sandyland Experiment Field, St. John, Kansas. A linear move sprinkler irrigation system was used with four 49-m long spans that each had 16 flexible hose drops with poly-weights to minimize swinging. Sprinklers were positioned at 2.2 m to 2.4 m above the soil surface. Characteristics of the irrigation package used in 1999 and 2000 are presented in Table 1. The three sprinkler nozzle size/pressure combinations provided the same nozzle discharge rate, but different distribution patterns.

In 1999, 12-IG10 collectors were placed within a corn canopy along corn rows that were 76 cm apart (Fig. 2.2). IG10 collectors were positioned 122 cm above the soil surface using steel support rods. Corn plants within 1.2 m of the IG10 collectors were removed to minimize any effect due to plant canopy. The corn canopy was approximately 2 m tall. Thus, at the corn tassle stage, the ratio of buffer distance to canopy height difference (from the collector opening) was 1.5 and not 2.0 as recommended by ASAE (2001). The IG10 collectors were left in the field during the entire growing season. Water amounts from irrigation events caught with IG10 collectors were measured with a volumetric cylinder and then converted to depth (mm) and used for graphical and statistical analysis.



Collector type	Diameter (cm)	Height (cm)	Color	Sharp edge
IrriGage (IG10)	10.2	20.3	White	Yes
Rain Gauge (RG15)	15.2	20.3	Green	Yes
Bucket (BKT)	30.5	36.8	White	No
Pan (PAN)	43.2	10.0	Black	No

Not to scale

Figure 1. Characteristics of the collectors evaluated in 1999, 2000, and 2002.

Table 1. Operating pressure, nozzle orifice size, and flow rates for the sprinkler packages used in this study. Flow rates are shown as manufacturer listed values, average field measured values, and average lab measured values.

Year	Sprinkler package	Pressure Regulation (kPa)	Orifice size (mm)	Flow rates (L/s)		
				Manufacturer	Field	Lab
		41.4	6.4	0.28	0.32	0.31
1999/2000	FP	103.0	5.2	0.28	0.31	0.33
		138.0	4.8	0.28	0.28	0.31
	FP	103.0	5.2	0.23	----	0.29
2002	SP	103.0	5.2	0.23	----	0.29
	WP	103.0	6.0	0.38	0.39	----

In addition, PAN's were placed in a grass buffer area 10.0 to 12.0 m from the IG10 collectors and about 6.0 m from the corn plants in line with the IG10 collectors (Figure 2). PAN's were positioned in the grass buffer just before irrigation events and measurements were taken immediately after the irrigation system passed over to minimize evaporative losses. Water collected by the PAN's was weighed with a balance and then converted to depth (mm) units. Those results were used as base values to compare with IG10 collector measurements. In 1999, IG10 collectors and PANs were evaluated 5 times during the growing season.

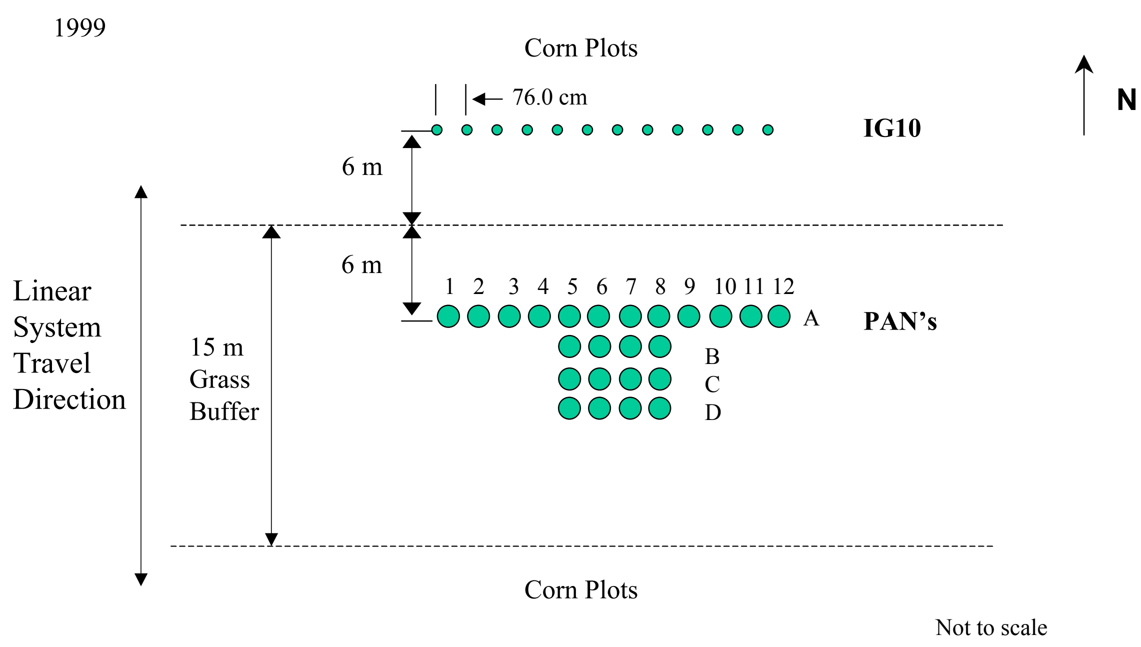


Figure 2. Set up of the collectors in 1999.

The IG10 collectors were also evaluated in 2000 using the same irrigation system as in 1999, but the IG10 collectors were moved to the same grass buffer strip area where the PANs were located (Figure 3). This time IG10 collectors were mounted 61-cm high using metal support rods, located 6 m from the corn plants, and about 1.0 m from the PANs. In addition to the single row with 12-IG10 collectors, two additional rows with 3-IG10 collectors were placed starting 60.0 cm away from the first row to test if placement had any effect on collected irrigation amounts (Figure 3). Five irrigation events were also measured in 2000.

2002 Field Evaluations

In 2002, IG10 collectors were compared to RG15 and BKT collectors (Fig. 2.4) on two experimental field sites (2002A and 2002B) under three different sprinkler irrigation packages. Since BKT collectors were 36.8 cm high, both IG10 and RG15 collectors were mounted on metal rods and kept at the same height.

In the 2002A study, IG10 collectors were evaluated at the KSU Livestock Waste Management Learning Center (WMLC), Manhattan, KS. The irrigation system was a new center pivot sprinkler irrigation system with seven, 55 m long spans. The last span of the center pivot irrigation system was used for the IG10, RG15, and BKT collector evaluations. The first nine drops of the last span were installed with a spinning plate (SP) sprinkler package. The remaining eight drops of that system had the FP sprinkler package. Both irrigation packages were operated at 103.0 kPa pressure. Sprinkler drops were about 1.4 m above the soil surface. Three sets of twelve IG10 collectors and one row each of RG15 and BKT collectors were set up under the sprinkler packages as shown in Figure 4. Collectors were tested using four irrigation events that were each set to apply 19 mm of water. Three IG10 collectors were set up as shown in Figure 4 (location C, D, and E) in order to determine the best number and arrangement of IG10 collectors to accurately measure sprinkler irrigation depths and application patterns.

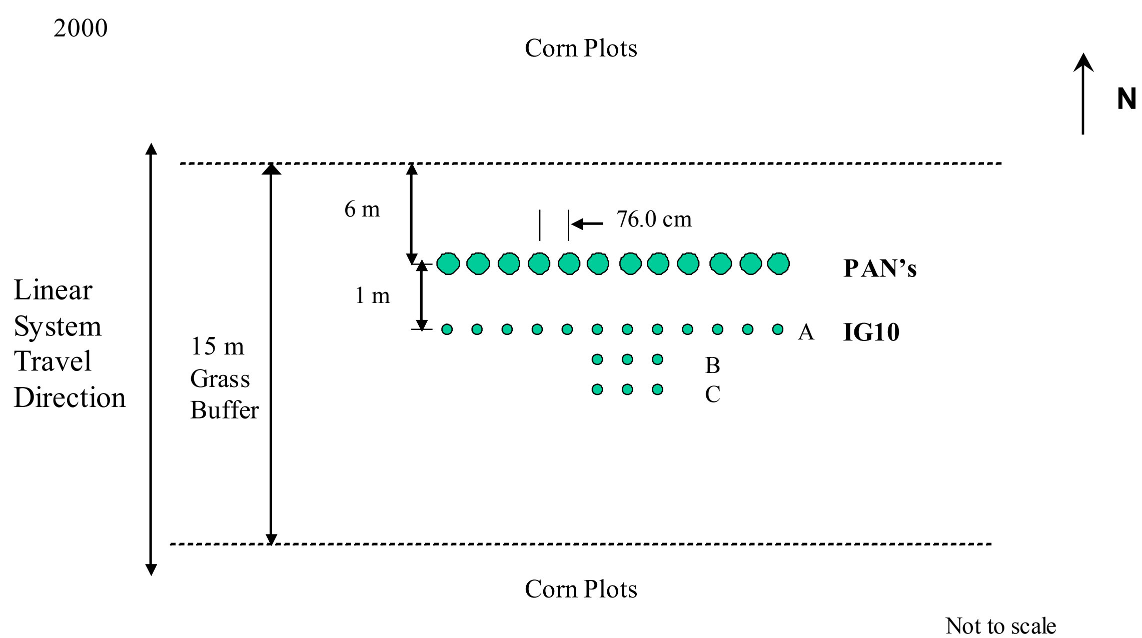


Figure 3. Set up of the catch devices in 2000.

In the 2002B study, IG10 collectors were evaluated at the KSU North Central Experiment Field, Scandia, KS. The irrigation system was a new linear move irrigation system with five, 55-m spans. The last two spans of the linear irrigation system were used for collector evaluations. Both spans had wobbling plate (WP) sprinklers (Senninger Wobblers[3]) operated at 103 kPa pressure. Irrigation drops were 2.0 to 2.3 m above the soil surface. The irrigation system was set to apply 19.0 mm of water and move with a speed of 24.7 m/h. In that field, only two catch devices, IG10 and RG15, were tested. Collector set up was similar to the 2002A study (Fig. 4) except without the buckets. All collectors were mounted on metal rods that were 61 cm high and the linear irrigation system was operated twice during the same day.

Irrigation depths measured with PAN, IG10, IG15, and BKT collectors were used to determine the best collector size and arrangements to measure sprinkler irrigation depths and application patterns under FP, SP, and WP irrigation packages. CU values were calculated using ASAE (2001) standard methods. Irrigation depths and CU values were analyzed using ANOVA statistical procedures and graphical analysis.

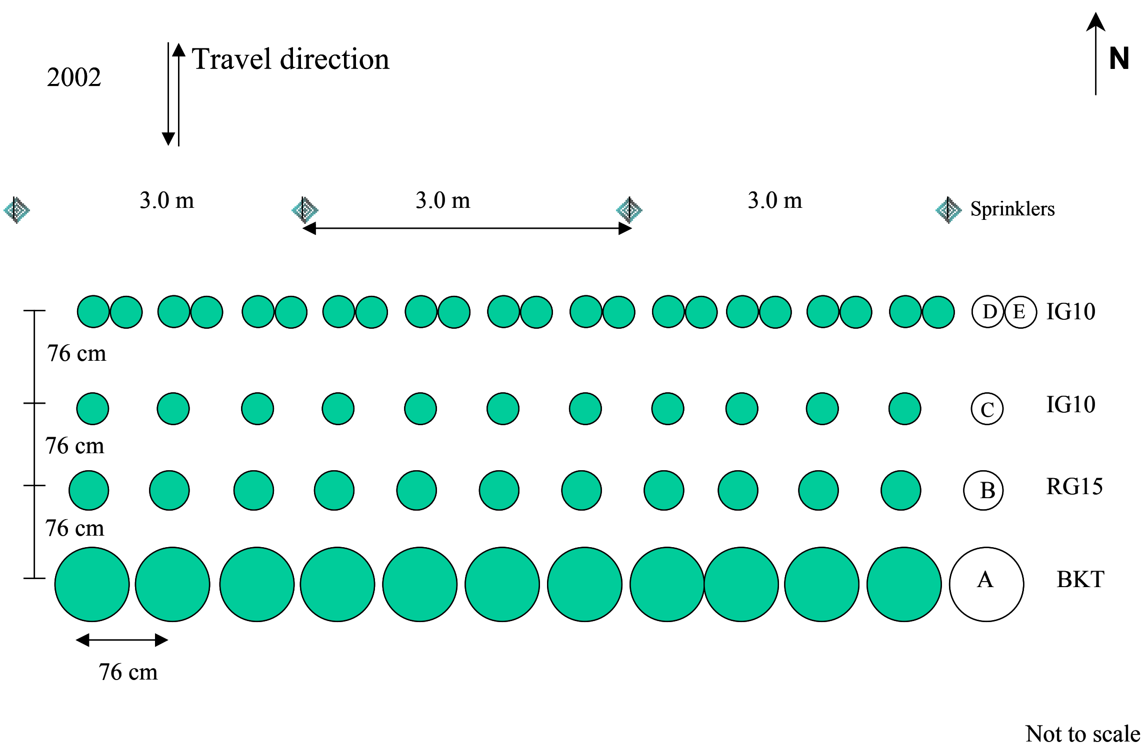


Figure 4. Set up of catch devices used in the 2002A and 2002B, KSU tests.

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[3] Mention of specific products or trade names does not imply endorsement by the authors or Kansas State University

Analysis of Number of Collectors

Data from the RG15 collectors under the FP package were grouped and analyzed to determine an appropriate number of collectors to measure the mean depth of application. Six of the twelve measured values were randomly selected to calculate a mean and coefficient of variation (cv). Next, the data were randomly paired using measured values from adjacent collectors. Again, six random pairs of data were selected to calculate a mean and cv. This process was repeated for groups of 3, then 4, then 5 and then 6 collectors. Similarly, this procedure was conducted using data from the IG10 collectors (position C) for both the SP and WP packages.

RESULTS AND DISCUSSION

Environmental conditions (air temperature, relative humidity, wind speed, and grass reference evapotranspiration) during catch device evaluations for all three years were generally typical (data not shown). However, climatic conditions during the second test in 2002 (July 21) were extreme (high evaporative conditions, high wind, hot and dry), and therefore, the data collected during that test were not included in the analysis.

1999 Results

In 1999, average irrigation depths and corresponding CU values from each set of twelve collectors for all 5-test events under the fixed plate sprinklers operated at 42 kPa (FP42), 103 kPa (FP103), and 138 kPa (FP138) measured with IG10 and PAN collectors are presented in Table 2. Irrigation depths collected with IG10 collectors under the FP42 sprinkler package averaged 8.3 mm, while FP103 and FP138 sprinklers had average irrigation depths of 10.3 and 10.0 mm, respectively. However, PAN's had significantly higher ($p < 0.05$) average irrigation depths of 13.7, 13.0, and 12.5 mm, respectively (Table 2). Because the diameter of the PAN collector opening (43.0 cm) was greater than the IG10 collectors (10.2 cm), irrigation depths from the PAN's were considered more accurate and representative of actual irrigation depths and patterns.

Table 2. Average irrigation depths and CU values for the IG10 and PAN collectors from the 1999 and 2000 sprinkler irrigation uniformity tests.

Sprinkler package		Average Depth (cm)			Coefficient of Uniformity (CU)		
		IG10	PAN	Signif.	IG10	PAN	Signif.
1999	FP42	8.3	13.7	*	42.3	77.5	*
	FP103	10.3	13.0	*	79.1	90.5	*
	FP138	10.0	12.5	*	80.4	92.5	*
2000	FP42	17.1	14.5	*	79.9	79.5	NS
	FP103	20.2	14.4	*	72.3	90.6	*
	FP138	16.9	13.8	*	77.1	91.3	*

Data were analyzed using ANOVA procedure. * Significantly different at 0.05 level. NS = Not significant.

Coefficients of uniformity (CU) from IG10 collectors for FP42, FP103, and FP138 sprinkler packages averaged 42.3, 79.1, and 80.4, respectively, while CU values from PAN's were significantly higher ($p < 0.05$) at 77.5, 90.5, and 92.5, respectively (Table 2). Under the

FP42 package, PAN's consistently indicated that rows 2, 6, and 10 received greater irrigation depths. However, IG10 collectors did not show the same pattern and had more variable data. Under the higher-pressure sprinkler packages, IG10 measured sprinkler irrigation patterns seemed to mimic PAN measured sprinkler irrigation patterns. Furthermore, standard errors from PAN's were smaller than from IG10 collectors. Differences in both irrigation depths and CU values in 1999 were attributed in part to the height of the collectors and possible corn canopy interference with the irrigation patterns.

In 1999, average irrigation depths (d) and coefficients of variation (cv) for rows 5, 6, 7, and 8 using the extra PAN collectors ranged from 12.4 to 15.3 mm (d) and 0.07 to 0.15 (cv), respectively under the FP42 sprinkler package (Table 3). Results were similar on the other two sprinkler packages (FP103 and FP138) except that cv-values on the FP138 package were lower and ranged from 0.03 to 0.06. On July 30, 1999, wind speed was high (6.7 km/h) and might have distorted the irrigation patterns under all sprinkler packages resulting in the higher cv values (Table 3). The effect of the high wind was more pronounced on FP42 and FP103 sprinkler packages as compared to FP138. Most of the cv values for the other dates (7/15 and 8/9) and locations (row 5, 6, 7, and 8) tended to be low (<0.10) indicating a consistency among measured depths along each row.

Table 3. Average irrigation depths (d, mm) and cv values collected along rows 5, 6, 7, and 8 using the extra PAN's in 1999 (Figure 2) under the FP42, FP103, and FP138 sprinkler packages.

Sprinkler Package	Row 5		Row 6		Row 7		Row 8	
	d (mm)	cv	d (mm)	cv	d (mm)	cv	d (mm)	cv
FP42	14.2	0.07	15.3	0.08	13.9	0.15	12.4	0.08
FP103	13.8	0.07	14.3	0.14	16.0	0.10	13.1	0.14
FP138	12.8	0.03	14.6	0.05	14.1	0.06	12.8	0.04

Table 4. Average irrigation depths (d, mm) and coefficient of variation (cv) values collected along rows 6, 7, and 8 using the extra IG10 collectors in 2000 (Figure 2.3) under the FP42, FP103, and FP138 sprinkler packages.

Sprinkler Package	ROW 6		ROW 7		ROW 8	
	d (mm)	cv	d (mm)	cv	d (mm)	cv
FP42	19.4	0.21	18.5	0.29	19.2	0.11
FP103	18.2	0.31	18.1	0.38	16.4	0.09
FP138	16.0	0.36	16.5	0.36	13.4	0.43

2000 Results

In 2000, irrigation depths from IG10 collectors averaged 17.1, 20.2, and 16.9 mm for the FP42, FP103, and FP138 sprinkler packages, respectively (Table 2). However, PAN measured irrigation depths for the same packages were all significantly lower ($p < 0.05$) at 14.5, 14.4, and 13.8 mm, respectively. These results are completely contrary to the 1999 results, where IG10 collector amounts were consistently higher. CU values from IG10 collectors for the FP42, FP103, and FP138 sprinkler packages were 79.9, 72.3, and 77.1, respectively, while PAN-based CU values were 79.5, 90.6, and 91.3 for the same sprinkler packages, respectively (Table 2). While the FP103 and FP138 CU values from the IG10 collectors were significantly lower ($p < 0.05$) than PAN-based data, associated CU values for the FP42 packages were not different. However, differences in irrigation amounts between devices were not consistent. Furthermore, irrigation depths from IG10 collectors were more variable in some rows than irrigation depths from PAN's (data not shown). Sprinkler irrigation application patterns from the two collectors did not show any similarity. In addition, PAN-based irrigation depths in 2000 under the FP42 sprinkler package also indicated that rows 2, 6, and 10 received higher irrigation amounts than other rows, as was the case in 1999. However, IG10 based irrigation depths did not show this pattern. These differences between the two collector types in both years were not expected, particularly since the IG10 collectors had a larger opening size (10.2 cm) than the current ASAE standard (ASAE, 2001) for uniformity measurements of center pivot sprinkler packages. Year to year (1999 vs. 2000) differences in irrigation depths from IG10 collectors were attributed to: collector opening size, collector height, and possible crop canopy effect on the discharged water trajectory patterns.

In 2000, average irrigation depths and corresponding cv values under all three sprinkler irrigation packages ranged from 13.4 to 19.4 mm (d) and from 0.09 to 0.43 (cv), respectively (Table 4). These results using the IG10 collectors are substantially more variable than those obtained in 1999 using PAN's.

2002 Manhattan Results

In 2002, WMLC (Manhattan) irrigation depths from all collectors and arrangements with corresponding CU values under the FP, SP, and WP sprinkler packages are presented in Tables 5 and 6. The BKT-based average irrigation depths were used as a reference to compare the results from the IG10 and RG15 collectors for the FP and SP tests. All IG10 data were compared with the RG15 data from the WP tests.

Average irrigation depths from the FP package using BKT, RG15, and IG10 collectors were 14.0, 14.3, and 16.9 mm, respectively (Table 5). Corresponding CU values for those collectors were 69.2, 66.7, and 63.2, respectively. Irrigation depths under the FP sprinkler package with BKT and RG15 collectors were not significantly different ($p > 0.05$). On the other hand, IG10 collector depths were significantly ($p < 0.05$) higher than BKT depths. The IG10 collectors consistently over-estimated irrigation depths as they did in 2000 under a similar sprinkler package. However, while CU values measured by all collector sizes were not significantly different for the FP sprinkler package, they were all low ranging from 63 to 69.

Measured irrigation depths from all collectors (BKT, RG15, and IG10) under the SP103 sprinkler package were not significantly different ($p > 0.05$) at 13.9, 13.6, and 14.7 mm, respectively (Table 5). Furthermore, resulting CU values for all three collectors (BKT, RG15, and IG10) were not statistically different ($p > 0.05$) at 93.0, 91.0, and 85.7, respectively. There was also strong agreement in irrigation depths and sprinkler irrigation patterns collected by BKT and RG15 collectors from the spinning plate irrigation package (data not shown).

Average irrigation depths from the BKT collectors (14.0 mm) were significantly lower than either of the two arrangements (C+D, 16.7 mm and D+E, 17.1 mm) of the IG10 collectors under the FP sprinkler package (Table 6). Therefore, using two IG10 collectors under the FP sprinkler irrigation package did not improve the accuracy of the depth measurements. Corresponding CU values were not different (Table 6) but were still low (63.8 to 69.2).

Table 5. Average irrigation depths and corresponding CU values for different collectors evaluated for all three experimental sites and sprinkler packages in 2002.

Sprinkler Package	Depth (mm)			CU		
	BKT	RG15	IG10	BKT	RG15	IG10
Manhattan						
FP	14.0a	14.3a	16.9b	69.2x	66.7x	63.2x
SP	13.9c	13.6c	14.7c	93.0y	91.0y	85.7y
Scandia						
WP	NA	18.8d	19.7d	NA	95.6z	91.3z

Average irrigation depths followed by the same letter (a, b, c, and d) and CU values followed by the same letter (x, y, and z) for a specific sprinkler irrigation package (FP, SP, or WP) were not significantly different at the p = 0.05 level. NA = not applicable

Table 6. Average irrigation depths and corresponding CU values for different collectors evaluated for sprinkler packages.

Sprinkler Package	Depth (mm)				CU			
	BKT	RG15	IG10 (C+D)	IG10 (D+E)	BKT	RG15	IG10 (C+D)	IG10 (D+E)
Manhattan								
FP	14.0a	NA	16.7b	17.1b	69.2x	NA	63.8x	64.4x
SP	13.9c	NA	14.6c	15.3c	93.0y	NA	88.0y	86.9y
Scandia								
WP	NA	18.8d	20.4d	19.8d	NA	95.6z	90.2z	92.5z

Average irrigation depths followed by the same letter (a, b, c, and d) and CU values followed by the same letter (x, y, and z) for a specific sprinkler irrigation package (FP, SP, and WP) were tested for catch devices using ANOVA and were not significantly different at the p = 0.05 level. NA = not applicable

Average irrigation depths measured by the BKT collectors (13.9 mm) and the two arrangements (C+D, 14.6 mm and D+E, 15.3 mm) of the IG10 collectors under the SP sprinkler package were not different (Table 6). Corresponding CU values were higher than with the FP package, ranging from 86.9 to 93.0 and were not different. Thus, using a single row of IG10 collectors under the SP sprinkler irrigation package seemed adequate to measure sprinkler irrigation depths and patterns. The addition of a second set of IG10 collectors either in the direction of travel or positioned laterally side-by-side (D+E) did not affect the accuracy of the measurements.

2002 Scandia Results

Measured irrigation depths under the WP irrigation package from the RG15 and IG10 collectors were not different and averaged 18.8 and 19.7 mm, respectively (Table 5). The corresponding CU values of 95.6 and 91.3 were also not different. There was a strong agreement in measured irrigation depths between RG15 collectors and IG10 collector positions C and E. However, IG10 collector position D had higher measured irrigation depths on certain rows (4, 6, and 7). Reasons for this are not understood.

Average depths under the WP sprinkler package from RG15 collectors (18.8 mm) and the two different arrangements (C+D, 20.4 mm and D+E, 19.8 mm) of IG10 collectors were not significantly different nor were the associated CU values (95.6, 90.2, and 92.5) (Table 6). Therefore, as with the SP sprinkler package, using two sets of IG10 collectors under the WP sprinkler package did not make any difference in measured irrigation depth or CU value compared to a single row of RG15 collectors.

Number of Collectors

Analysis of data combinations to determine the appropriate number of collectors indicated that up to six RG15 collectors might be needed to provide a reasonable measure (cv < 0.10) of the average depth from a fixed plate sprinkler package. However, only one or two collectors may be satisfactory on a wobbling-plate package while four collectors or more may be needed on a spinning-plate package (Figure 5).

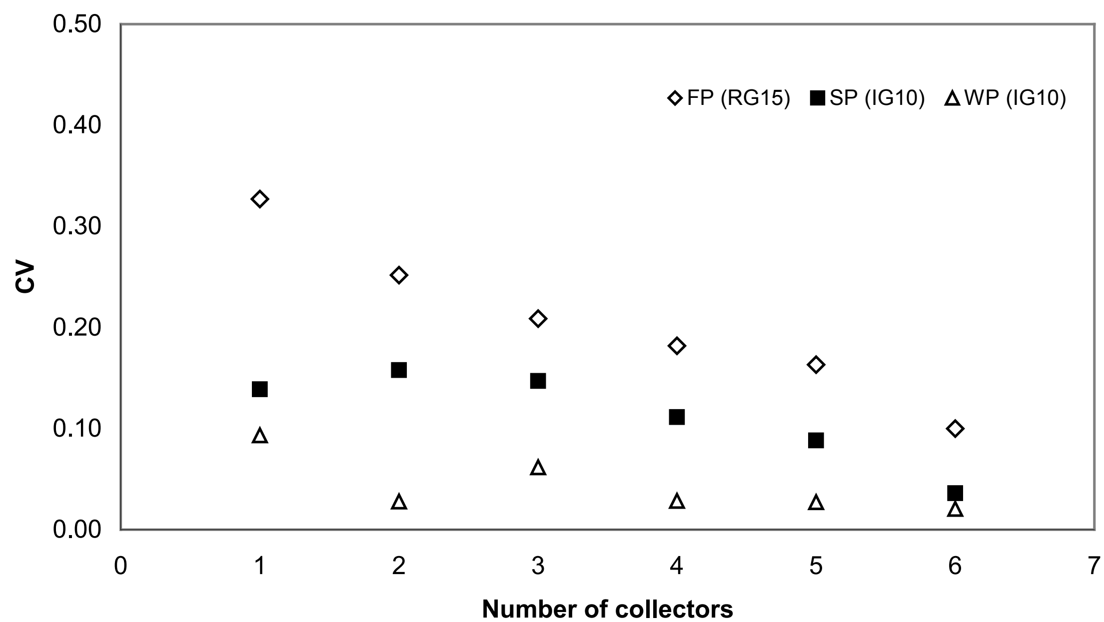

Figure 5. Effect of number of RG15 and IG10 collectors on coefficient of variability (cv) of irrigation depth under the FP, SP, and WP type irrigation packages.

Data from all 3 years indicated that for the FP sprinkler packages (FP42, FP103, and FP138), it is better to use a collector with a 15.2 cm or larger diameter opening to measure irrigation depths and application patterns. The IG10 collector results clearly showed that with smaller collector diameters, irrigation amounts tended to read higher (except in 1999) than the actual application depths. The variability in depths was greater in the IG10 collectors than larger devices, which resulted in higher cv values. Conversely, with other sprinkler irrigation packages such as spinning plates (SP) and wobbling plates (WP) collectors with an opening size of 10.2 cm diameter accurately measured and mimicked sprinkler irrigation depths and application patterns.

SUMMARY AND CONCLUSIONS

In 1999, 2000, and 2002, a study was conducted to evaluate the measurement effectiveness of a non-evaporating sprinkler irrigation catch device (IrriGage). Other catch devices that were evaluated included a 15 cm rain gauge (RG15), a 30.5 cm bucket (BKT) and 43 cm diameter pans (PAN). All collectors were tested to measure sprinkler irrigation system depths and uniformity under three different sprinkler irrigation packages. The standard IrriGage (IG10) has a 10.2 cm diameter opening, a 20.0 cm long collector barrel, and an attached storage bottle. Sprinkler irrigation packages tested included fixed-plate diffusers (FP) with a grooved-disk, spinning-plate diffusers (SP), and wobbling plate diffusers (WP) with different nozzle and pressure combinations. FP sprinkler packages had distinct water jet streams with larger water droplets, while SP and WP sprinklers had smaller water droplets that appeared to be evenly distributed.

In 1999, IG10 collectors positioned within a corn canopy failed to accurately measure the irrigation depths and sprinkler patterns. Even with higher irrigation pressures (103.0 to 138.0 kPa), IG10 collectors did not reasonably measure irrigation depths or patterns as compared to PAN collectors. In 2000, even though the IG10 collectors were lowered and repositioned to a grass buffer, measured irrigation depths and CU values were significantly ($p < 0.05$) higher than PAN's. In addition, irrigation application patterns from the IG10 collectors under the FP sprinkler package with different pressure combinations did not match the PAN results.

In 2002, IG10 collector evaluations under a fixed plate (FP) irrigation package indicated higher ($p < 0.05$) irrigation depths and lower CU values than BKT collectors, similar to 2000 results. Additionally, IG10 collector results did not accurately measure the FP irrigation patterns. However, RG15 collectors had similar ($p > 0.05$) irrigation depths and CU values compared to BKT collectors on that same (FP) package. Under the SP and WP irrigation packages, IG10 collector irrigation depths and CU values were not significantly ($p > 0.05$) different than the RG15 results.

Results from three years indicate that IG10 collectors should not be used to measure irrigation depths and uniformities on FP sprinkler packages. The results also indicate that RG15 collectors are acceptable devices to measure FP sprinkler package irrigation depths and uniformities. However, up to 6 collectors may be needed to accurately measure the irrigation depth. On the other hand, IG10 collectors under SP and WP sprinkler irrigation packages can accurately measure both irrigation depth and uniformity. IG10 collectors can be used under sprinkler packages that produce smaller irrigation droplets, but not those that have distinct streams or jets. Two to four RG15 collectors may be needed to accurately measure the average irrigation depth.

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