SUMMARY OF EVALUATIONS OF CENTER PIVOT UNIFORMITY

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SUMMARY

Center pivot irrigation systems are the most common system type in Kansas for a variety of factors – one of which is the ability to deliver a uniform depth of water application for a variety of crops and field conditions. Uniform applications are dependent on properly designed, installed and operated sprinkler nozzle packages. Uniformity evaluations were conducted as part of the Mobile Irrigation Lab (MIL) project to promote adoption of improved irrigation management practices with an emphasis on ET based irrigation scheduling. Since efficient and uniform water applications are critical to successful irrigation scheduling; MIL included evaluation of sprinkler package performance using a single line catch can test. Catch data was used to calculate the coefficient of uniformity and average application depth. The information was used in extension programs to illustrate the effect of various correctible sprinkler package deficiencies on performance and to encourage irrigation farmers to examine their nozzle packages and operating conditions. A summary of the evaluation results will be presented. This discussion is an expansion of the data was originally presented by Rogers and Aguilar, 2018.

INTRODUCTION

Center pivot irrigation systems are the dominant irrigation system type in use within Kansas (Rogers and Aguilar, 2017). This is also true for the CPIA states as nearly 85 percent of the irrigated area in Colorado, Kansas and Nebraska are watered using center pivot sprinkler irrigation systems (USDA NASS, 2012). Irrigation is also the dominant use of water supplies for Kansas, but in many areas of the state, water supplies are diminishing. However, irrigated agriculture makes significant contributions to the economy so improving irrigation water utility and conservation has long term benefits. Since center pivot irrigation systems serve the bulk of the irrigation acres in the region, it is important that these systems be properly designed, installed and managed to accomplish high irrigation efficiency and crop water productivity and these topics have been a reoccurring discussion in CPIC programs. For example, Terry Howell, retired director of the USDA-ARS Research Lab in Bushland, TX noted in a 1991 CPIC presentation that “Sprinkler irrigation methods can be efficient even in harsh environments, such as the Texas High Plains”, (Howell, et al., 1991). The late Dale Heermann and former director of the USDA-ARS

Research Lab in Fort Collins, CO began his 1992 sprinkler irrigation presentation at CPIc with these cautionary words, “We often assume that if a system is working for someone else, it will work for us too. Unless all the conditions are identical this myth may cause you troubles” (Heermann, 1992). Encouraging adoption of improved irrigation management practices is a major goal of the Kansas State Research and Extension (KSRE), including the irrigation scheduling. In the late 1980’s and early 1990’s, the development of information networks, communication systems and increasing availability of personal computers combined to make ET-based irrigation scheduling an option for irrigation managers to use but lack of familiarity of ET-based irrigation scheduling as well as lack of user friendly scheduling software and limited farmer skills with the operation of PC’s remained as barriers to adoption (Rogers et al., 2002).

In the early 1990’s, on-farm demonstration projects were established in south central and western Kansas to promote ET-based irrigation scheduling using KSU’s KanSched scheduling tool. These projects were the forerunners to the Mobile Irrigation Lab (MIL) project which was expanded to include performance evaluate center pivot nozzle packages for uniformity (Rogers et al., 2002, Rogers et al., 2006, Clark et al., 2002). One rationale for conducting center pivot nozzle package evaluations was that adoption of improved irrigation management techniques, such as ET-based irrigation scheduling, required a uniform application depth to assure all the crop had equal access to the available water and no areas of the field were either over- or under- watered which would reduce irrigation water productivity. The majority of the tests were conducted using a single line of catch cans of 4 –inch diameter, called Irrigages (Clark et al., 2003, 2004, 2006), spaced at no more than 80 percent of the sprinkler nozzle spacing.

Catch can evaluations require sufficient clearance of the nozzle above the top of the collector. In a center pivot survey (Rogers et al., 2009), most systems in south central Kansas could be tested using the irrigage catch can evaluation, since over 92 percent have nozzle heights of greater than 4 foot above ground surface. However, in western Kansas, almost 60 per cent of the nozzle packages are mounted at 4 foot or less above the ground surface which is insufficient clearance for an irrigage collector, especially since the top of the irrigage is about 16 inches above ground when installed.

PROCEDURES

The catch can generally used was a 4-inch irrigage which was constructed with a storage bottle attached to the bottom of the collection barrel to which the water drained after capture in the collection barrel. Once in the bottle, evaporation losses were minimal. This allowed data collection without concern for accuracy losses due to evaporation, improved time convenience for collection of data and minimized the on-site labor need for data collection.

The majority of the tests were conducted using a single line of catch cans, spaced at no more than 80 percent of the sprinkler nozzle spacing. The collector spacing was selected so a catch sample would be collected within each nozzle spacing interval but with gradual change in the collection location relative to the nozzle outlet. Although the overall coefficient of uniformity (CU) value could be calculated, another goal was to document the effect of various operational deficiencies on the performance of the sprinkler package. Many of performance issues could have been identified with a visual inspection of the nozzles and/or a comparison of the nozzle package as installed to the sprinkler design package.

The center pivot systems initially evaluated were a part of a demonstration project. Part of the selection criteria for the project field sites included the drive-by visibility of project signage and ease of access for education tours or programs. These systems also thought to be systems with well-maintained and operated at design specifications. Other systems evaluated were at the request of individuals, therefore, the evaluated systems were not randomly selected. The intent was to evaluate as many as systems as possible each year while the MIL program was funded. However many constraints limited the number of evaluations possible , such as winter evaluations were often precluded, spring cultural operations (where a wetted area within the field would not be desirable), scheduling limitations of the operators (we required them to start the systems), crop canopy height limitations, and even water right limitations.

RESULTS AND DISCUSSION

Fifty-three center pivot irrigation sprinkler package evaluations were conducted Kansas during the period of 1998 through 2011 using catch cans. These evaluations were conducted on unique systems, except for tests FI 01A – 99. In this instance, the system was tested in the two modes of operation; with the end gun on and with the end gun off. Both values are included. These results are shown in Table 1 which includes the general classification of the sprinkler type, collector spacing, the CU and slope of the average application depth, pressure regulation, collector diameter, and the measures region of the system.

The sprinkler types were classified as fixed plate, impact, and moving plate sprinklers. Fixed plate sprinklers are primarily spray nozzles with a splash plate that does not move when impacted by the water stream; while a moving plate sprinkler would have a splash plate that spins, oscillates or otherwise moves when impacted by the water stream. The number of each sprinkler type tested and the average CU of the systems are shown in Table 2. The averages of CU for the three sprinkler types were similar. Only four impact sprinkler packages were tested and all were operated by one producer. In the center pivot survey (Rogers et al., 2009), only about 2 per cent of the survey observations were impact sprinklers. In some instances, tested systems may have had either wider nozzle spacing on the first span and/or a different sprinkler type on the first span but the sprinkler type and later the sprinkler spacing reported reflects the package used on the bulk of the system. The measured range of the center pivots are included in Table 1 with the majority of the systems being quarter mile systems of approximately 1300 foot in length, although several are longer including one of one half mile in length and one with a corner system (tested with the corner extended). Note that some systems were tested only in the outer spans verses nearly to the pivot point. This range was reflection of whether the test was conducted with the evaluators staying on-site or being able to leave the site to return later for data collection. Graphs of the applied depths of systems often show higher application depths in inner span but including or excluding these values from the CU calculation, since the values are area weighted, have little impact on the overall CU value.

Early tests were conducted using 17-inch diameter pans before the development of the irrigages. The pans nested for easy transportation and storage and they were easy to install since they only needed to be placed on the ground surface. However, they also needed to be read quickly after an irrigation event to minimize pan evaporation losses. The weight of water collected was used as the measurement method. The pans had to be carried to a weigh station which was labor intensive and tedious. While the average CU value of the pan catches was higher than the irrigage catches, the difference was more likely do to the systems selected to tested by the pans rather than the collector size itself. Early systems were demonstration project fields thought to be well maintained and/or relatively new and selected to promote irrigation scheduling; verses later fields that were tested at the request of producers which were field that they suspected may have an issue.
Table 2 also includes the average CU values for pressure regulated (81.67) and non-pressure regulated systems (75.62). In the Kansas center survey (Rogers et al., 2009) about half of the center pivots in SC Kansas were pressure regulated and about 80 percent in western Kansas. In western Kansas, many of the spray systems are close to the ground and therefore not able to be tested with a catch can procedure.

The CU values for the various collector spacings are also summarized in Table 2. Initially, the tests were conducted at about 80 % of the nozzle spacing rounded to the nearest foot. Over time, the tests migrated to being conducted at either 4 foot or 8 foot spacing as a way to streamline the test procedure. There is a tendency for the closely spaced collectors to have higher CU but the data set, especially at wider spacing, is limited.
Figures 1a and 1b are the graph of the same system (FI 01A -99, Table 1) tested with the end gun on and end gun off, respectively. Figure 1a shows an area of good uniformity until the high catch at radius 945 feet. This high catch was due to a leaky tower boot. The next area of catch shows a gradual decrease in catch until radius 1241 when application depth increases dramatically. The area with gradually decreasing application was due to a reversal of the outer two spans nozzles, while the sudden increase was caused by over spray from the end gun onto a portion of the main lateral as the end gun was not ratcheting properly. The area of decreasing application depth due to improper nozzle installation is more visible in figure 1b (Rogers et al., 2008, Rogers, 2012).

The application depth distribution graph for test PR 5-27-99 is shown in figure 2. The CU value for this system is 84.3. The major problem associated with this system was at the outer edge where the application depth dropped to approximately half. This effect was due to an un-installed nozzle and under sizing of the orifices of the next two adjacent nozzles in both directions from the uninstalled nozzle location as compared to the design specifications. This under-watered area covered approximately 9.2 acres. So if the average water application was 12 inches, so this area received around 6 inches of irrigation. A conservative estimate of yield response would be 10 bu/in, resulting in an estimated annual field loss of over 500 bushels which could easily be repaired at minimal cost. Figure 3 shows the graph for center pivot test SN 7-18-02 which had the lowest CU value of the systems tested (CU = 53.2). The issue associated with this nozzle package was incrustation build-up within the system and on the fixed plate nozzles as shown in figure 4. A regular maintenance requirement for this system included unclogging nozzles at the start of irrigations and the removal of nozzles in the off-season for cleaning of incrustation. Incrustation on the splash plate would interfere with the development of the spokes of water typical for this type of nozzle and prevent proper overlap of the water streams. However, for this very level field, farmed with high residue practices, the applied water was adequately re-distributed on the ground surface as evidenced by the crop appearance (figure 5).

The ASABE standard (ASAE S436.1) describing the test procedure determining the uniformity of water distribution by center pivots has a maximum can spacing of 3 meters (9.84 ft.) for spray devices and 5 meters (16.4 ft.) for impact sprinklers. The MIL tests were conducted using a single line of cans verses two rows for the ASABE test. Never-the-less, the impact of can spacing on CU was examined by calculating the CU values for the base can spacing, then every other can (2 sets) and every third can (3 sets). The results are shown in Table 3, arranged by from lowest can spacing to largest spacing.

The first three systems (PR5-27-99, KI 6-09-99, ED 6-01-99) used a collector spacing of 4 ft. with CU values ranging from 84.3 to 89.9). Recalculating CU values for 2x or 3x spacing values resulted in less than 1.0 change in CU as compared to the base CU. The regression lines through the applied depth of catches were very flat and changed little with the increased spacing. In this case, the 2x catches would have been at a 8 ft. spacing which is still within the ASABE spacing recommendation but results varied little when going to a 12 ft. spacing, which slightly exceeds the ASABE recommendation.

The next two systems (RC-TZ-1998, ED 6-02-99) had CU values of 91.9 and 84 measured at 5 ft can spacing with a flat regression line for the applied depth of application for the first system, and a positive slope for the second, meaning increasingly more water was being applied with distance from the pivot point. The slope of the regression line was not greatly impacted by can spacing and also little impact on the average applied application depth. The CU for RC-TZ-1998 had a maximum CU change of 1.5 for both 2x and 3x spacing. The 2x spacing is 10 ft. or approximately the maximum recommended ASABE spacing, while 3x spacing would exceed the ASABE recommendation. The change in CU value for ED 6-02-99 was only 0.2 at 2x spacing but 5.1 for the 3x spacing.

System SN 7-18-02, which was discussed previously and shown in figure 3), had large change in CU calculation estimates with increased spacing, however with the base can spacing at 6 ft, both 2x and 3x catches would exceed the ASABE spacing recommendation. The estimate of applied application depth and the slope of the applied application depth regression line was also impacted by change in spacing.

The next four systems were tested at 8 ft. spacing and the last system at 10 ft., which would be within or near ASABE guidelines. Two systems (LN 4-21-03, BT 3-27-02) showed spacing had little impact on the CU value. The latter system had a strong slope to the application depth. This was thought to be from improper input operating conditions (The on-site values were accepted at the time since it was a new installation and not independently verified. Test crews returned to the site at later dates twice but a new catch was never successfully completed.). The maximum change in CU value for the other systems ranged from 7.6 to 8.6 with the largest CU change for the 2x spacing.

CONCLUSION

A series of center pivot uniformity evaluations were conducted over multiple years providing a snapshot of the performance of these systems at the time of the test. A single line test with a catch can spacing of less than the sprinkler spacing was used. The systems tested were not randomly selected. The average CU value of the tested systems was 78.65 with a range of from 91.9 to 53.2. Early tests tended to be on producer fields in a demonstration project and tended to have higher CU values, which indicates that high CU values are achievable. Latter tests, conducted at the request of producers, tended to be systems suspected of having an issue. Many of the sprinkler package deficiencies could have been identified and corrected with a visual inspection and/or a comparison to the sprinkler package design specifications. However, the catch test then documents the impact of a sprinkler package deficiency on the performance.

Information from these tests have been used in meetings and publications to encourage irrigation managers that high CU performance is possible with good package designs and proper operating conditions but also regular sprinkler package maintenance.

ACKNOWLEDGEMENTS

This project was supported in part by The Mobile Irrigation Lab Project GECG 601490 , funded by the Kansas Water Plan Fund administered by the Kansas Water Office, USDA Project GEGC 601448, the Ogallala Aquifer Project GEGC 600468 and the Center Pivot Technology Transfer Project.

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OTHER AVAILABLE INFORMATION

Additional irrigation-related websites are:

General Irrigation website: www.ksre.ksu.edu/irrigate

Mobile Irrigation Lab website: http://www.bae.ksu.edu/mobileirrigationlab/

Subsurface Drip Irrigation website: www.ksre.ksu.edu/sdi

Table 1: Coefficient of Uniformity (CU) and slope of linear regression line of catch depth and selected test information for various center pivot sprinkler packages of fixed plate, moving plate and impact sprinklers.

Test ID	Type of Nozzle	Can Space	CU	Regression Line Slope	Pressure Regulated	Can Dia.	Test Area
		Ft.	%		No or PSI	Ins.	Ft. from pivot point
ED 6-01-99	Fixed	4	86.6	-0.000006	No	17	628 - 1298
FI 01A -99 EG On	Fixed	4	74.8	0.00001	No	17	473 - 1365
FI 01A – 99 Off	Fixed	4	78.2	0.00002	No	17	473 - 1313
SV 5-27-99	Fixed	4	73.2	0.0001	No	17	1250 - 2598
FI 5-26-05	Fixed	4	72.8	-0.00005	6	4	266 - 1306
FI 4-17-06 a	Fixed	4	77.6	0.0004	6	4	12 - 1294
HS 8-05-09	Fixed	4	81.7	-0.0004	15	4	20 - 1324
BT 6-28-10	Fixed	4	76.3	-0.00003	No	4	295 - 1470
FI 8 - 12 - 11 a	Fixed	4	89.5	0.00002	10	4	8 - 1328
ED 6-02-99	Fixed	5	84.0	0.0001	No	17	660-1352
SN 7-18-02	Fixed	6	53.2	0.0001	No	4	750 - 1290
SV 5-12-05	Fixed	6	79.6	-0.00002	NR*	4	300 - 1296
FI 5-27-05	Fixed	6	87.0	-0.0001	10	4	532 - 1300
FI 7-02-08	Fixed	6	86.6	0.0002	10	4	24 - 1302
FI 7-17-08	Fixed	6	91.1	0.00009	10	4	168 - 1302
FI 3-28-08a	Fixed	6	92.1	0.00006	10	4	184 - 1296
FI 4-16-02	Fixed	8	81.9	0.00003	No	4	16 - 1288
FO 5-16-02	Fixed	8	58.2	-0.0005	No	4	210 - 1322
SN 6-02-02	Fixed	8	86.8	0.0002	10	4	537 - 1249
FI 7-19-05	Fixed	8	75.5	0.000001	No	4	50 - 1298
LN 4-21-03	Fixed	8	71.0	-0.00008	No	4	250 - 1282
RNU01	Fixed	8	68.6	0.0002	No	4	360-1528
FI 6-14-06a	Fixed	8	71.9	0.0003	10	4	24 - 1304
FO 5-27-09	Fixed	8	86.7	-7E-07	10	4	120 - 1392
FI 7-25-05 b	Fixed	8	71.8	-0.0005	10	4	134 - 1286
KI 6-09-99	Fixed	4	89.9	0.00001	No	17	526 - 1326
FO 3-13-06	Impact	8	82.4	-0.0001	No	4	264 - 1352
FO 3-09-06	Impact	8	72.1	-0.00008	No	4	48 - 1336
FO 4-04-07a	Impact	8	82.4	-0.0002	No	4	268 - 1352
FO 3-30-07a	Impact	8	73.5	-0.0003	No	4	270 -1344
PR 5-27-99	Moving	4	84.3	-0.00008	30	4	588 - 1300
RN 5-06-11a	Moving	4	90.9	-0.0002	20	4	8 - 847
MP GS-1998	Moving	5	91.8	-0.0002	No	17	770 - 1290
RC-TZ- 1998	Moving	5	91.9	-0.00003	NR	17	733 - 1213

SG 5-22-02	Moving	6	83.8	-0.0002	No	4	132 - 1212
SD 6-15-05	Moving	6	74.1	0.0002	Yes	4	480 - 1212
FI 7-15-09	Moving	6	90.9	-0.0002	12	4	30 - 1140
GY 4 -01-08 b	Moving	6	73.8	0.0003	10	4	102 - 1338
BT 3-27-02	Moving	8	81.7	0.0003	10	4	326 - 1254
KI 7-8-02	Moving	8	76.4	-0.0003	Yes	4	340 - 1308
MP 8-21-02	Moving	8	76.0	-0.0002	No	4	365 - 1277
MP1 8-21-02	Moving	8	67.0	-0.0003	No	4	486 - 1430
PN 4-01-03	Moving	8	83.1	-0.00007	10	4	350-1278
SW 5-15-03	Moving	8	76.3	-0.0007	10	4	350 - 1278
HV 10-05-11	Moving	8	79.1	-0.0001	20	4	176 - 1253
SG 3-14-03	Moving	8	65.9	0.0002	No	4	148 - 1284
FI 7-25-05	Moving	8	72.2	-0.0003	10	4	62 -1422
RN 6-05-00	Moving	10	74.5	0.0002	NR	4	630 - 1260
RN 7-01-00	Moving	10	88.8	0.0003	No	4	845 - 1335
RC 7-06-00	Moving	10	72.8	-0.0002	No	4	540 - 1230
SF 6-06-00	Moving	10	88	-0.0003	NR	4	624 - 1244
HV 4-10-03	Moving	10	62.6	-0.0002	No	4	383 - 1353
RN 6-08-02	Moving	12	65.3	-0.00005	NR	4	343 - 1311

*NR = not recorded

Table 2: Average CU values for center pivot performance evaluations

Test Summary of CU	CU	Number of Observations
Overall Average	78.65	53
Type of Sprinkler		
Fixed Plate Average	78.72	26
Impact Sprinkler Average	77.60	4
Moving Plate Average	78.75	23
Size of Catch Can		
4 inch Catch Can Average	77.73	45
17 inch Catch Can Average	83.80	8
Pressure Regulated System		
Pressure Regulated	81.67	23
Non-pressure Regulated	75.62	25
Not Recorded	79.86	5
Catch Can Spacing		
Average 4 ft	81.32	12
Average 5 ft	89.23	3
Average 6 ft	81.22	10
Average 8 ft	75.48	22
Average 10 ft	77.34	5
Average 12 ft	65.30	1

Table 3: Influence of can spacing on CU

Test ID	Type of Nozzle	Collector Spacing (Ft.)	CU %	Applied Depth Regression Line Slope	Applied Depth (Ins.)
PR 5-27-99	Moving	**4**	**84.3**	**-0.00008**	**0.3**
		Odd	**83.8**	**-0.00009**	**0.3**
		Even	**84.7**	**-0.00007**	**0.3**
		3.1	**83.3**	**-0.00007**	**0.3**
		3.2	**84.4**	**-0.00007**	**0.3**
		3.3	**85.2**	**-0.0001**	**0.3**
KI 6-09-99	Fixed	**4**	**89.9**	**0.00001**	**0.32**
		Odd	**89.7**	**0.00002**	**0.33**
		Even	**89.9**	**0.000008**	**0.32**
		3.1	**90.8**	**0.000004**	**0.32**
		3.2	**89.4**	**0.00002**	**0.32**
		3.3	**89.2**	**0.00001**	**0.32**
ED 6-01-99	Fixed	**4**	**86.6**	**-0.000006**	**0.54**
		Odd	**87.2**	**0.000008**	**0.54**
		Even	**86**	**-0.00002**	**0.54**
		3.1	**86.1**	**-0.00006**	**0.55**
		3.2	**86.4**	**0.00008**	**0.55**
		3.3	**87.4**	**-0.00004**	**0.53**
RC-TZ- 1998	Moving	**5**	**91.9**	**-0.00003**	**0.81**
		Odd	**91.2**	**0.00005**	**0.82**
		Even	**92.7**	**-0.0001**	**0.81**
		3.1	**91**	**0.0001**	**0.81**
		3.2	**92.5**	**-0.00007**	**0.83**
		3.3	**92.2**	**-0.0001**	**0.8**
ED 6-02-99	Fixed	**5**	**84**	**0.0001**	**0.44**
		Odd	**83.9**	**0.00009**	**0.45**
		Even	**84.1**	**0.0001**	**0.44**
		3.1	**87.2**	**0.0001**	**0.44**
		3.2	**82.1**	**0.00008**	**0.44**
		3.3	**83.1**	**0.0001**	**0.46**
SN 7-18-02	Fixed	**6**	**53.2**	**0.0001**	**0.67**
		Odd	**44.6**	**-0.0004**	**0.68**
		Even	**55.5**	**-0.0003**	**0.66**
		3.1	**44.7**	**-0.0005**	**0.62**
		3.2	**56.2**	**-0.0001**	**0.75**
		3.3	**50.7**	**-0.0004**	**0.64**
PN 4-01-03	Moving	**8**	**83.1**	**-0.00007**	**0.73**
		Odd	**77.9**	**0.0002**	**0.73**
		Even	**86.5**	**-0.0002**	**0.7**

		3.1	**81.3**	**0.000008**	**0.72**
		3.2	**79.2**	**-0.000003**	**0.74**
		3.3	**85.4**	**-0.00001**	**0.68**
LN 4-21-03	Fixed	**8**	**71**	**-0.00008**	**0.56**
		Odd	**70.6**	**0.00008**	**0.57**
		Even	**71.5**	**0.00008**	**0.56**
		3.1	**71.8**	**0.000006**	**0.52**
		3.2	**70**	**0.0002**	**0.61**
		3.3	**71.5**	**-0.000009**	**0.56**
MP 8-21-02	Moving	**8**	**76**	**-0.0002**	**0.69**
		Odd	**78.4**	**-0.0002**	**0.67**
		Even	**74.1**	**-0.0002**	**0.72**
		3.1	**80.5**	**0.00007**	**0.66**
		3.2	**72.2**	**-0.0003**	**0.71**
		3.3	**75.7**	**-0.0003**	**0.71**
BT 3-27-02	Moving	**8**	**81.7**	**0.0003**	**0.63**
		Odd	**82.6**	**0.0003**	**0.62**
		Even	**81**	**0.0003**	**0.65**
		3.1	**82**	**0.0003**	**0.61**
		3.2	**81.9**	**0.0003**	**0.63**
		3.3	**81.4**	**0.0004**	**0.64**
RC 7-06-00	Moving	**10**	**72.8**	**-0.0002**	**0.88**
		Odd	**72.4**	**-0.0001**	**0.89**
		Even	**73.1**	**-0.0003**	**0.88**
		3.1	**70.9**	**0.0001**	**0.85**
		3.2	**70.2**	**-0.0005**	**0.96**
		3.3	**77.8**	**-0.0003**	**0.84**

Figure 1a. Catch can uniformity analysis for Center Pivot FI 01A End Gun On

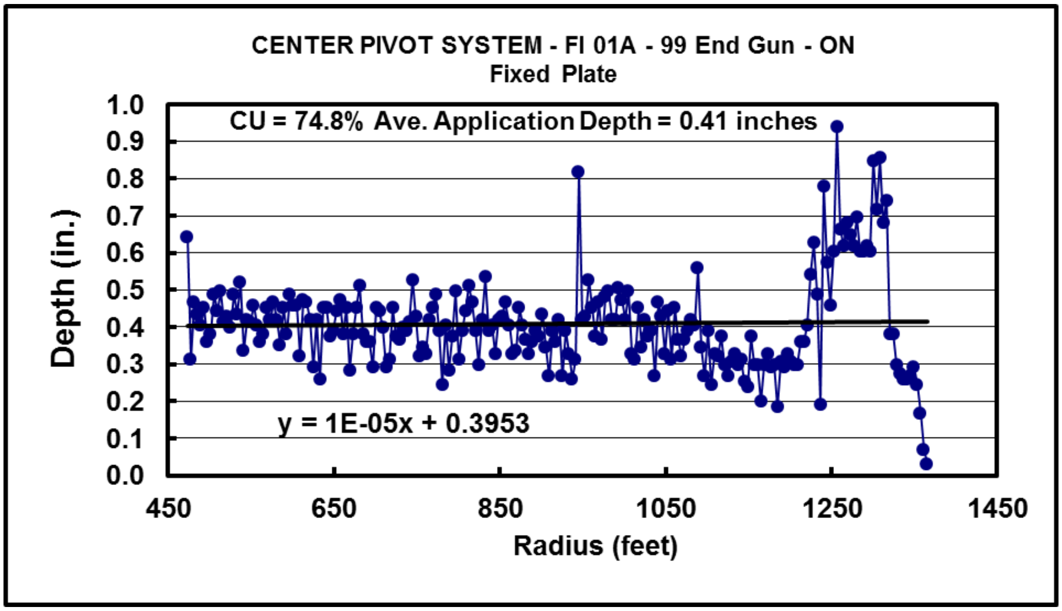

Figure 1b. Catch can uniformity analysis for Center Pivot FI 01A End Gun Off

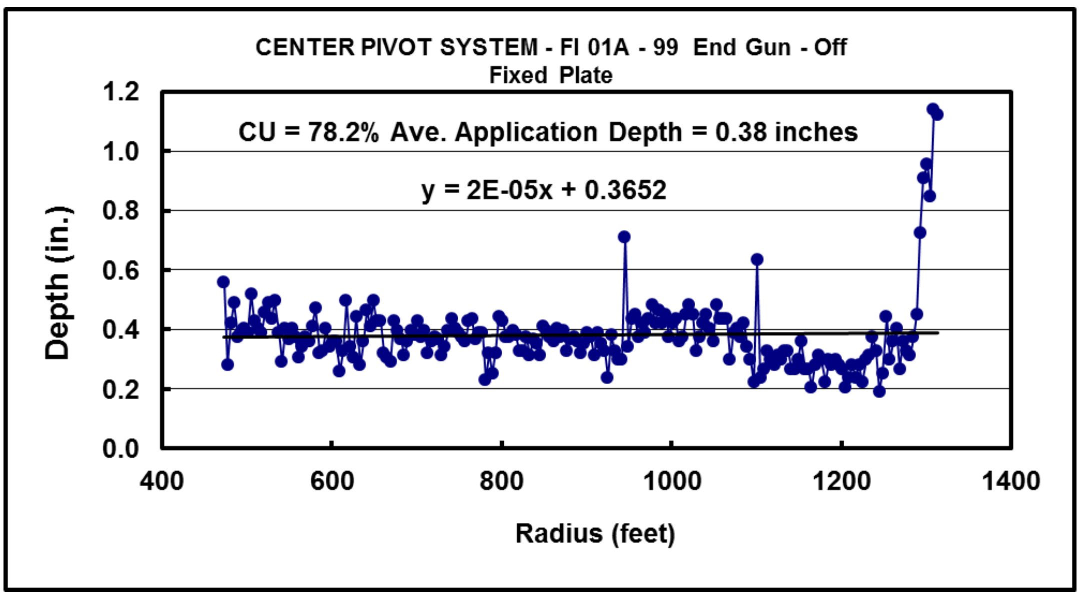

Figure 2: Catch can uniformity analysis for center pivot PR 5-27-99.

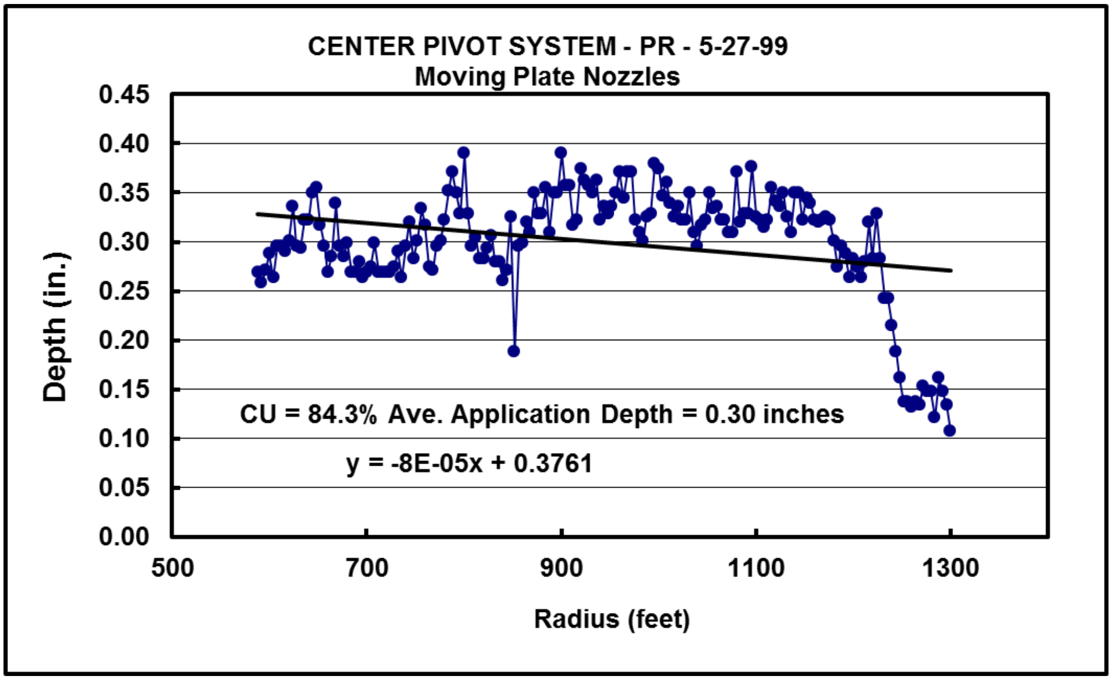

Figure 3: Catch can uniformity analysis for center pivot SN 7-18-02.

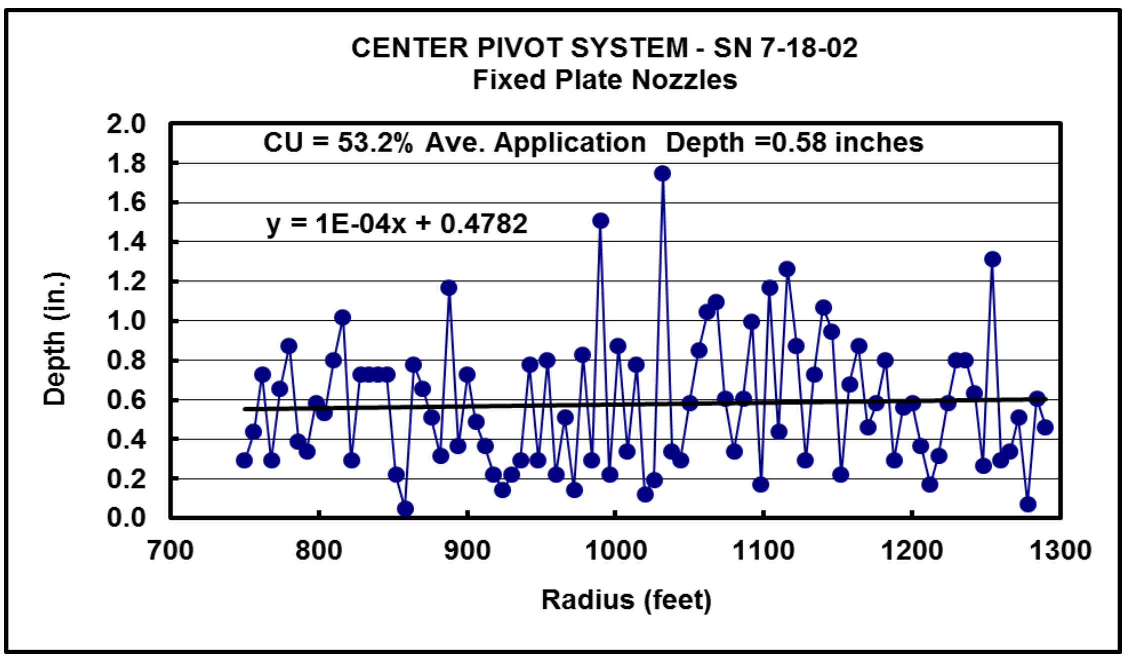

Figure 4: Nozzles incrustation for center pivot SN 7-18-02.

Figure 5: Crop appearance for center pivot SN 7-18-02.