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CENTER PIVOT SPRINKLER PACKAGE SURVEY RESULTS

Danny H. Rogers, Mahbub Alam, and L. K. Shaw
Extension Irrigation Engineers and MIL Project Coordinator
Kansas State University Research and Extension
Voice: 785-532-5813, or 620-275-9164
Email: drogers@ksu.edu, or malam@ksu.edu

Introduction

A road survey of center pivot irrigation systems was conducted in select counties across Kansas on two separate occasions. A county road map for the selected counties was divided into three transects north/south and three transects east/west. The survey was conducted in the fall of 2003 in Barton, Edwards, Pawnee, and Stafford counties. The counties surveyed in 2006 were Finney, Ford, Grant, Gray, Haskell, Scott, Stevens, and Thomas.

The purpose of the survey was to obtain useful information in order to characterize the types of center pivot nozzle packages currently being used and to gather baseline data for future surveys. The survey information consisted of observations on field location, degree of rotation, number of spans, nozzle type, pressure regulation, general nozzle type, nozzle height, number of spans and overhang, outlets on overhang, and end gun presence and type. Since the surveyor made observations from the road and not directly from the field, the exact type of nozzle packages could not always be determined. Therefore, they were generally characterized as impact sprinklers, fixed plate nozzles, or moving plate nozzles, which were recognizable configurations.

The results of the survey are presented in two groups: the south central survey and the western survey.

South Central Kansas Center Pivot Survey Results

The summary of observations from the south central region of Kansas is shown in Table 1 (a-f). Most of the 325 systems that were observed were typical quarter section center pivots and 95% of those systems could make a complete revolution, as shown in Table 1a. The most common type of nozzle package in the area was moving plate nozzles (rotator, I-wobbler, etc), as outlined in Table 1b, and each nozzle package was likely to be pressure-regulated, as shown in Table 1c.

Observations on the nozzle spacing and heights were divided into three height categories and five height locations. Table 1d reveals that the most common nozzle spacing was medium (8-12 feet) and Table 1e shows that the most common nozzle height was a mounting just below the center pivot truss.

The observations of primary interest for this region were the number of end guns used on the sprinkler systems. Table 1f reveals that over one-third (37.5 %) of the systems were equipped with a big gun or traditional end gun, which requires a booster pump. On the other hand, 48.9% of the systems were equipped with either double or single large impact sprinklers which are pressurized by using existing system pressure. Almost 13% of the systems did not have a different nozzle at the outer end as compared to the rest of the center pivot system.

Table 1 (a-f): Summary of Pivot Nozzle Package Survey for Barton, Edwards, Pawnee, and Stafford Counties surveyed in 2003.

Table 1a: Survey Results of Rotation Degree for Center Pivot Systems in South Central Kansas

Degree of Rotation	Number of observations	Percentage
Full Circle	309	95
Partial Circle	16	5
Total	325	100

Table 1b: Survey Results of Types of Sprinkler Nozzles on Center Pivot Systems in South Central Kansas

Nozzle Type	Number of observations	Percentage
Fixed Plate	19	5.8
Impact	22	6.8
Mixed	5	1.5
Moving Plate	244	75.1
Unknown	35	10.8

Table 1c: Survey Results of Pressure Regulators on Center Pivot Systems in South Central Kansas

Pressure Regulators	Number of observations	Percentage
Yes	90	27.7
No	91	28
Unknown	144	44.3
Total	325	100

Table 1d: Survey Results of Nozzle Spacing on Center Pivot Systems in South Central Kansas

Nozzle Spacing	Number of observations	Percentage
Close (< 8 ft)	64	19.7
Medium (8-12 ft)	187	57.5
Wide	66	20.3
Unknown	8	2.5

Table 1e: Survey Results of Nozzle Height on Center Pivot Systems in South Central Kansas

Nozzle Height	Number of observations	Percentage
< 4 ft above ground	25	7.7
> 4 ft above ground	42	12.9
Truss to 2 ft below truss	221	68.0
Within truss	1	0.3
Top of pivot	27	8.3
Unknown	8	2.5

Table 1f: Survey Results of End Gun Type on Center Pivot Systems in South Central Kansas

End Gun Type	Number of observations	Percentage
Big Gun	122	37.5
Double Large Impact	78	24.0
None	42	12.9
Single Large Impact	81	24.9
Unknown	2	0.6

Western Kansas Center Pivot Survey Results

The total number of systems observed in the western Kansas survey was 659. Center pivots larger than the typical quarter section system are more common in western Kansas, so the survey results of the number of spans ranged from 4 to 19, as shown in Table 2. Out of the total number of observations in western Kansas, 483 were either 7 or 8 spans in length, and only 10 systems were less than 6 spans in length. Seventy-six systems were either 9 or 10 spans in length,

and almost 15% of the observed systems were 15 spans or larger. Approximately 50% of the systems that were 11 spans or larger were operated as partial circles, as compared to about 7% for systems of 10 spans or smaller.

Table 2: Center Pivot Survey Results of Number of Spans and Degree of Rotation

Number of Spans	Number Observed	Number of Partial Circles	Percent
4	1	1	<1
5	2	0	0
6	10	2	<1
7	276	18	2.7
8	207	19	2.9
9	26	2	<1
10	50	1	<1
11	1	1	<1
12	2	1	<1
13	4	0	0
14	4	2	<1
15	6	4	<1
16	28	14	2.1
17	20	11	1.7
18	16	10	1.5
19	6	1	<1

As Table 3 shows, 78% of the observed systems were pressure regulated and 89% used a fixed plate nozzle package.

Table 3: Center Pivot Survey Results for Pressure Regulation Use and Nozzle Type

Pressure Regulation	Number	Percentage	Nozzle Type	Number	Percent
Yes	515	78.2	Fixed Plate	589	89.4
No	136	20.7	Moving Plate	62	13.6
Unknown	8	12.1	Impact	2	<1
			Mixed	1	<1
			Unknown	5	<1

End guns, defined either as traditional big guns or impact sprinklers, accounted for only slightly more then 15% of the systems, as shown in Table 4.

Table 4: Center Pivot Survey Results of Use of End Guns

End Gun Type	Number	Percent
Big gun	7	1.1
Single large impact sprinkler	22	3.3
Double large impact sprinkler	73	11.1
None (Last nozzle same type as system)	557	84.5

Observations were also made on the placement of the nozzle for both spacing and height, as shown in Table 5. The most common observation was a mixed spacing configuration, which means that the first several spans had wider spacing than the outer spans. Only three systems were observed to have wide spacing. The majority of the systems were shown to use drop nozzles located at less than a 4 foot height, followed by systems that had heights above 4 feet but more than 2 feet below the truss.

Table 5: Center Pivot Survey Results for Nozzle Spacing and Nozzle Height

Nozzle Spacing	Number	Percent	Nozzle Height	Number	Percent
Close (< 8 ft)	214	32.7	Less than 4 foot	385	58.4
Medium (8-12 ft)	197	29.9	Greater than 4 foot	212	32.2
Mixed	245	37.2	Truss to 2 foot below	55	8.3
Wide	3	<1	Within truss	4	<1
			Top of lateral	3	<1

Survey information was also collected on the ability of the center pivot to make a full revolution. Table 6 shows that 88 systems, or 13%, could only make partial revolutions.

Table 6: Center Pivot Survey Results for Rotations

Degree of Rotation	Number	Percent
Full (360 degrees)	571	88.6
Partial (Less then 360 degrees)	88	11.4

Additional analysis looked at various combinations of observations. Table 7 shows nozzle type versus nozzle spacing, Table 8 outlines nozzle height versus nozzle type, Table 9 compares nozzle height and nozzle spacing, and Table 10 shows the number of spans versus the degree of rotation.

Table 7: Center Pivot Survey Results for Nozzle Type and Nozzle Spacing

Nozzle Type	Nozzle Spacing	Observation	Percent
Fixed Plate	Close (< 8 ft)	196	33.3
	Medium (8-12 ft)	155	26.3
	Wide (> 12 ft)	1	<1
	Mixed	237	40.2
Fixed Plate	**Total**	589	
Impact	Close (< 8 ft)	0	-
	Medium (8-12 ft)	0	-
	Wide (> 12 ft)	2	100
Impact	**Total**	2	
Mixed	Medium (8-12 ft)	1	100
Mixed	**Total**	1	
Moving Plate	Close (< 8 ft)	18	29.0
	Medium (8-12 ft)	38	61.3
	Mixed	6	9.7
Moving Plate	**Total**	62	
Unknown	Medium (8-12 ft)	3	60
	Mixed	2	40
Unknown	**Total**	5	

Table 8: Center Pivot Survey Results for Nozzle Height and Nozzle Spacing

Nozzle Height	Nozzle Spacing	Number of Observation
< 4 ft	Close (< 8 ft)	131
	Medium (8-12 ft)	41
	Mixed	213
< 4 ft	**Total**	385
> 4 ft above ground	Close (< 8 ft)	64
	Medium (8-12 ft)	118
	Wide (> 12 ft)	29
	Mixed	1
> 4 ft above ground	**Total**	212
Truss to 2 ft below truss	Close (< 8 ft)	18
	Medium (8-12 ft)	35
	Mixed	2
Truss to 2 ft below truss	**Total**	55
Within truss	Close (< 8 ft)	1
	Medium (8-12 ft)	2
	Mixed	1
Within truss	**Total**	4
Top of Pivot	Medium (8-12 ft)	1
	Wide (> 12 ft)	2
Top of Pivot	**Total**	3

Table 9: Center Pivot Survey Results for Nozzle Height and Nozzle Type

Nozzle Height	Nozzle Type	Observation	Percent
< 4 ft	Fixed Plate	371	96.4
	Moving Plate	12	3.1
	Mixed	2	<1
< 4 ft	**Total**	385	
> 4 ft above ground	Fixed Plate	183	86.3
	Moving Plate	27	12.7
	Unknown	2	<1
> 4 ft above ground	**Total**	212	
Top of Pivot	Impact	2	67
	Fixed Plate	1	33
Top of Pivot	**Total**	3	
Truss to 2 ft below truss	Fixed Plate	41	74.5
	Moving Plate	13	23.6
	Mixed	1	1.9
Truss to 2 ft below truss	**Total**	55	
Within truss	Fixed Plate	4	100
Within truss	**Total**	4	

Table 10: Center Pivot Survey Results for the Number of Spans versus the Degree of Rotation

Number of Spans	Number Observed	Number with Full Rotation	Number with Partial Rotation	Percent Partial
4	1	0	1	<1
5	2	2	0	0
6	10	8	2	<1
7	276	258	18	2.7
8	207	188	19	2.8
9	26	24	2	<1
10	50	49	1	<1
11	1	0	1	<1
12	2	1	1	<1
13	4	4	0	0
14	4	2	2	<1
15	6	2	4	<1
16	28	12	14	2.1
17	20	9	11	1.7
18	16	6	10	1.5
19	6	5	1	<1

Ninety percent of the observed systems had nozzles which were placed in the two lower placement categories: "less than 4 feet" or "greater than 4 feet but less then 2 feet below truss." Sixty-three percent of all fixed plate nozzles were within 4 feet of the ground, while only 12% of moving plate nozzles fit that category. Sixty-two percent of the moving plate nozzles were observed in the "greater than 4 feet" category, as compared to 29% of the fixed plate nozzles.

Observation results revealed that moving plate nozzles tend to use higher and wider spacing configurations than the fixed plate nozzles. Approximately three-fourths of the fixed plate nozzles utilized a mixed spacing configuration. Sixty-one percent of the moving plate nozzles use medium spacing, and another 10% fit into the mixed spacing category.

The large center pivots, which have a greater number of spans, are more likely to be associated with partial rotations. For systems with 11 spans or less, only 7% did not have full rotation. For span numbers greater then 11, approximately half of the systems could do full circles. These results are expected, due to the likelihood of physical constraints in larger fields, water-right and land ownership constraints, and irrigation capacity issues for large systems.

A three-way observation of nozzle spacing, nozzle height, and nozzle type is shown in Table 11. Fixed plate nozzles are usually spaced closer and lower to the ground than moving plate nozzles, as is necessary because of the operational characteristics of the two nozzle types. Moving plate nozzles are most commonly used with medium spacing in the "greater than 4 feet" height category.

Table 11: Center Pivot Survey Results for Nozzle Spacing, Height, and Type.

Nozzle Spacing	Nozzle Height	Nozzle Type	Number	Percent
Close < 8 ft.	< 4 ft	Fixed Plate	126	98.5
		Moving Plate	5	1.5
	< 4 ft	**Total**	131	
	> 4 ft above ground	Fixed Plate	55	85.9
		Moving Plate	9	14.1
	> 4 ft	**Total**	64	
	Truss to 2 ft below truss	Fixed Plate	14	77.8
		Moving Plate	4	22.2
	Truss to 2 ft below truss		18	
	Within Truss	Fixed Plate	1	100
		Moving Plate	0	0
	Within Truss	**Total**	1	
Close <8 ft.		**Total**	214	
Medium (8-12 ft)	< 4 ft	Fixed Plate	36	87.8
	<4 ft	Moving Plate	5	12.2
	< 4 ft	**Total**	41	
	> 4 ft above ground	Fixed Plate	90	76.3
		Moving Plate	26	22.0
		Unknown	2	1.7
	> 4 ft above ground	**Total**	118	
	Truss to 2 ft below truss	Fixed Plate	26	74.2
		Moving Plate	7	20.0
		Mixed	1	2.9
		Unknown	1	2.9
	Truss to 2 ft below truss	**Total**	35	
	Within Truss	Fixed Plate	2	100
		Moving Plate	0	0
	Within Truss	**Total**	2	
	Top of Pivot	Fixed Plate	1	100
	Top of Pivot	**Total**	1	
Medium (8-12 ft)		**Total**	197	
Mixed	< 4 ft above ground	Fixed Plate	209	98.1
		Moving Plate	2	<1
		Unknown	2	<1
	< 4 ft above ground	**Total**	213	
	> 4 ft above ground	Fixed Plate	26	89.6
		Moving Plate	3	10.4
	> 4 ft above ground	**Total**	29	
	Truss to 2 ft below truss	Fixed Plate	1	50
		Moving Plate	1	50
		Mixed	0	
	Truss to 2 ft below truss	**Total**	2	
	Within Truss	Fixed Plate	1	100
		Moving Plate	0	0
	Truss to 2 ft below truss	**Total**	1	
Mixed Spacing		**Total**	245	
Wide (>12 ft)	> 4 ft above ground	Fixed Plate	1	33.3
	Top of Lateral	Impact	2	66.7
Wide (>12 ft)		**Total**	3	

Regional Survey Comparisons and Contrasts

The south central and western Kansas results were similar in that both regions predominately used systems with lengths of 7 or 8 spans. Approximately 21% of the systems in either region had span lengths of 8 or greater. However, in the south central region only two systems were greater then 10 spans in length, whereas 13% of the western systems were greater than the 10 spans. These results are expected since the terrain of the south central area requires systems that have a higher irrigation capacity for serving sandy soils. These systems are often problematic, though, because of friction losses and limitations of well capacities. In addition, more of the south central systems (95.1%) completed full circles than the western systems (86.6%), although this trend is likely related to the number of larger systems in the west.

The most common type of sprinkler package in the south central survey was a moving plate type nozzle as compared to the fixed plated nozzle in western Kansas. Higher capacity systems and sandy soils both make the use of moving plate nozzles and higher nozzle placement a preferred design selection for the general soils and slopes of south central Kansas.

End guns are commonly used on sprinkler systems in south central Kansas. Only approximately 13% of the systems in south central Kansas did not have some type of end nozzle. On the other hand, only 15% of western Kansas systems actually used an end gun on their sprinklers. Over one-third (37.5%) of the south central systems were equipped with a big gun (traditional end gun) and about half (48.9%) were equipped with either double or single large impact sprinklers.

Summary

The dominant center pivot nozzle package of western Kansas is a fixed plate nozzle positioned near to the ground using a drop tube as compared to a moving plate nozzle positioned near truss height in south central Kansas.

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