IRRIGATION MANAGEMENT SERIES

Kansas Center Pivot Survey

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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 north/south transects and three east/west transects. 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 surveyed counties are highlighted in Figure 1.

The purpose of the survey was to obtain information to characterize the types of center pivot nozzle packages in use. 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 be determined. Therefore, they were generally characterized as impact sprinklers, fixed plate nozzles, or moving plate nozzles, which were recognizable configurations. Example nozzle package configurations are shown in Figures 2 through 5.

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 1a-g. Most of the 325 systems that were observed were typical quarter section center pivots (Table 1a), and 95 percent of those systems could make a complete revolution, as shown in Table 1b. The most common type of nozzle package in the area was moving plate nozzles (rotator, I-wobbler, etc), as outlined in Table 1c,

Tables 1a-g: Summary of Pivot Nozzle Package Survey for Barton, Edwards, Pawnee and Stafford counties in 2003

Table 1a: Survey Results on the Number of Spans for Center Pivot Systems in South Central Kansas

Number of Spans	4	5	6	7	8	9	10	11	18	Unknown
Number of Observations	1	3	11	106	133	12	28	1	1	1
Percentage	< 1	< 1	3.4	32.6	40.9	3.7	17.8	< 1	< 1	< 1

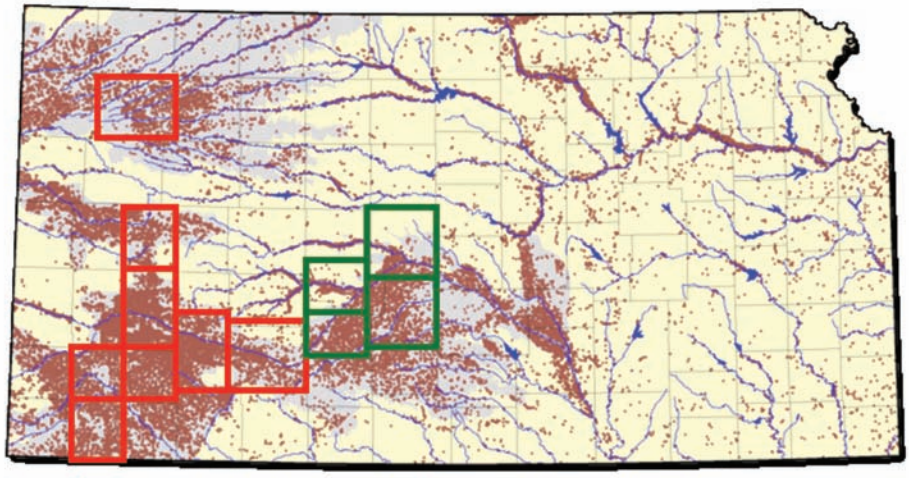

Figure 1. Kansas map showing the counties surveyed in south central Kansas in 2003 (green outlines) and western Kansas in 2006 (red outlines). The dots indicate irrigation points of diversion. *(Map courtesy of the KDA Division of Water Resources)*

and about half of the known systems were pressure regulated, as shown in Table 1d.

Observations on the nozzle spacing and heights were divided into three height categories and five height locations. Table 1e reveals that the most common nozzle spacing was medium (8-12 feet), and Table 1f 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 center pivot systems. Table 1g reveals that more than one-third (37.5 percent) of the systems were equipped with a big gun, or traditional end gun, which requires a booster pump. On the other hand, 48.9 percent of the systems were equipped with either double or single large impact sprinklers, which are pressurized by using existing system pressure. Almost 13 percent of the systems did not have a different nozzle at the outer end as compared to the rest of the center pivot system.

Figure 2: Center pivot equipped with impact sprinklers.
(Photo courtesy of Nelson Irrigation Corporation)

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

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

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

Nozzle Type	Number of observations	Percentage of all observations	Percentage of Known Observations
Fixed Plate	19	5.8	6.6
Impact	22	6.8	7.6
Mixed	5	1.5	1.7
Moving Plate	244	75.1	84.1
Unknown	35	10.8	Total known = 290

Table 1d: Survey Results on Pressure Regulators for Center Pivot Systems in South Central Kansas

Pressure Regulators	Number of observations	Percentage of all observations	Percentage of Known Observations
Yes	90	27.7	49.7
No	91	28	50.3
Unknown	144	44.3	-
Total	325	100	Total Known = 181

Table 1e: Survey Results of Nozzle Spacing for Center Pivot Systems in South Central Kansas

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

Table 1f: Survey Results of Nozzle Height for Center Pivot Systems in South Central Kansas

Nozzle Height	Number of observations	Percent of total
< 4 feet above ground	25	7.7
> 4 feet above ground	42	12.9
Truss to 2 feet below truss	221	68
Within truss	1	0.3
Top of pivot	27	8.3
Unknown	8	2.5

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

End Gun Type	Number of observations	Percent of total
Big Gun	122	37.5
Double Large Impact	78	24.0
None	42	12.9
Single Large Impact	81	24.9
Unknown	2	<1

Western Kansas Center Pivot Survey Results

The total number of systems observed in the western Kansas survey was 659. Center pivots larger then the typical quarter section system are more common in western Kansas, so the survey results of the number of spans ranged from four to 19, as shown in Table 2a. Out of the total number of observations in western Kansas, 483 were either seven or eight spans in length, and only 10 systems were less than 6 spans long. Seventy-six systems were either nine or 10 spans long, and almost 15 percent of the observed systems were 15 spans or larger. Table 2b shows information on the degree of rotation for the systems and is shown by span length. Approximately 50 percent of the systems that were 11 spans or larger were operated as partial circles, as compared to about 7 percent for systems of 10 spans or smaller.

Tables 2a-f: Summary of Pivot Nozzle Package Survey for Finney, Ford, Grant, Gray, Haskell, Scott, Stevens and Thomas counties in 2005 and 2006

Table 2a: Survey Results on the Number of Spans for Center Pivots in Western Kansas

Number of Spans	Number Observed	Percentage
4	1	<1
5	2	<1
6	10	1.5
7	276	41.9
8	207	31.4
9	26	3.9
10	50	7.6
11	1	<1
12	2	<1
13	4	<1
14	4	<1
15	6	<1
16	28	4.2
17	20	3.0
18	16	2.4
19	6	<1

Table 2c shows that 89 percent of the systems in western Kansas are equipped with a fixed plate nozzle package and 78 percent of the systems were pressure regulated (Table 2d). Observations were also made on the placement of the nozzle for both spacing and height, as shown in Tables 2e and 2f. The most common observation was a mixed spacing configuration, which means that the first several spans had wider spacing then 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 then a 4-foot height, followed by systems that had heights above 4 feet but more then 2 feet below the truss. End guns, defined either as traditional big guns or impact sprinklers, accounted for only slightly more then 15 percent of the systems, as shown in Table 2g.

Table 2c: Survey Results of the Types of Nozzles for Center Pivot Systems in Western Kansas

Nozzle Type	Number	Percentage
Fixed Plate	589	89.4
Moving Plate	62	9.4
Impact	2	<1
Mixed	1	<1
Unknown	5	<1

Table 2d: Survey Results of Pressure Regulation for Center Pivot Systems in Western Kansas

Pressure Regulation	Number	Percentage
Yes	515	78.1
No	136	20.6
Unknown	8	1.3

Table 2e: Survey Results of Nozzle Spacing for Center Pivot Systems in Western Kansas

Nozzle Spacing	Number	Percentage
Close (< 8 feet)	214	32.5
Medium (8-12 feet)	197	29.9
Mixed	245	37.2
Wide	3	<1

Table 2b: Survey Results on the Degree of Rotation for Center Pivots in Western Kansas by span length

Number of Spans	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total
Number Observed	1	2	10	276	207	26	50	1	2	4	4	6	28	20	16	6	659
Number of Partial Circles	1	0	2	18	19	2	1	1	1	0	2	4	14	11	10	1	87
Percentage Partial, by Number of Spans	100	0	20	6.5	9.2	7.7	2.0	100	50	0	50	66.7	50.0	55.0	62.5	16.7	13.2

Figure 3: Center pivot equipped with moving plate nozzles mounted near truss height.

the fixed plate nozzles. Approximately three-fourths of the fixed plate nozzles used a mixed spacing configuration. Sixty-one percent of the moving plate nozzles use medium spacing, and another 10 percent 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 percent 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.

Table 2f: Survey Results of Nozzle Height for Center Pivot Systems in Western Kansas

Nozzle Height	Number	Percentage
Less then 4 feet	385	58.4
Greater then 4 feet	212	32.2
Truss to 2 feet below	55	8.3
Within truss	4	<1
Top of lateral	3	<1

Table 2g: Survey Results of the Types of End Guns for Center Pivot Systems in Western Kansas.

End Gun Type	Number	Percentage
Big gun	7	1.0
Single large impact sprinkler	22	3.3
Double large impact sprinkler	73	11.1
None (Last nozzle same type as system)	557	84.6

Additional analysis looked at various combinations of observations. Table 3 shows nozzle type versus nozzle spacing. Table 4 outlines nozzle height versus nozzle type. Table 5 compares nozzle height and nozzle spacing. Ninety percent of the observed systems for western Kansas 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 percent 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 percent of the fixed plate nozzles.

Observation results revealed that moving plate nozzles tend to use higher and wider spacing configurations than

Table 3: Center Pivot Survey Results for Nozzle Type and Nozzle Spacing for Western Kansas

Nozzle Type	Nozzle Spacing	Total
Fixed plate	Close (< 8 feet)	196
	Medium (8-12 feet)	155
	Wide (> 12 feet)	1
	Mixed	237
Fixed plate total		**589**
Impact	Close (< 8 feet)	0
	Medium (8-12 feet)	0
	Wide (> 12 feet)	2
Impact total		**2**
Mixed	Medium (8-12 feet)	1
Mixed total		**1**
Moving plate	Close (< 8 feet)	18
	Medium (8-12 feet)	38
	Mixed	6
Moving plate total		**62**
Unknown	Medium (8-12 feet)	3
	Mixed	2
Unknown total		**5**

Table 4: Center Pivot Survey Results for Nozzle Height and Nozzle Spacing for Western Kansas

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

Table 5: Center Pivot Survey Results for Nozzle Height and Nozzle Type for Western Kansas

Nozzle Height	Nozzle Type	Total
< 4 feet	Fixed plate	371
	Moving plate	12
	Mixed	2
< 4 feet total		**385**
> 4 feet above ground	Fixed plate	183
	Moving plate	27
	Unknown	2
> 4 feet above ground total		**212**
Top of pivot	Impact	2
	Fixed plate	1
Top of pivot total		**3**
Truss to 2 feet below truss	Fixed plate	41
	Moving plate	13
	Mixed	1
Truss to 2 feet below truss total		**55**
Within truss	Fixed plate	4
Within truss total		**4**

Figure 4: Center pivot equipped with moving plate nozzles mounted near truss height and end gun.

Figure 5: Center pivot equipped with fixed plate nozzles with pressure regulators mounted on drop nozzles at a low height.

Table 6: Center Pivot Survey Results for Nozzle Spacing, Nozzle Height, and Nozzle Type

Nozzle Spacing	Nozzle Height	Nozzle Type	Total
Close (< 8 feet)	< 4 feet	Fixed plate	126
		Moving plate	5
		< 4 feet total	131
	> 4 feet above ground	Fixed plate	55
		Moving plate	9
		> 4 feet total	64
	Truss to 2 feet below truss	Fixed plate	14
		Moving plate	4
	Truss to 2 feet below truss total		18
	Within truss	Fixed plate	1
		Moving plate	0
		Within truss total	1
Close (< 8 feet) total			**214**
Medium (8-12 feet)	< 4 feet	Fixed plate	36
		Moving plate	5
		< 4 feet total	41
	> 4 feet above ground	Fixed plate	90
		Moving plate	26
		Unknown	2
	> 4 feet above ground total		118
	Truss to 2 feet below truss	Fixed plate	26
		Moving plate	7
		Mixed	1
		Unknown	1
	Truss to 2 feet below truss total		35
	Within Truss	Fixed plate	2
		Moving plate	0
		Within truss total	2
	Top of pivot	Fixed plate	1
		Top of pivot total	1
Medium (8-12 feet) total			**197**

Nozzle Spacing	Nozzle Height	Nozzle Type	Total
Mixed spacing	< 4 feet above ground	Fixed plate	209
		Moving plate	2
		Unknown	2
		< 4 feet total	213
	> 4 feet above ground	Fixed plate	26
		Moving plate	3
	> 4 feet above ground total		29
	Truss to 2 feet below truss	Fixed plate	1
		Moving plate	1
		Mixed	0
	Truss to 2 feet below truss total		2
	Within truss	Fixed plate	1
		Moving plate	0
	Truss to 2 feet below truss total		1
Mixed spacing total			**245**
Wide (>12 feet)	> 4 feet above ground	Fixed plate	1
	Top of lateral	Impact	2
Wide (>12 feet) total			**3**

A three-way observation of nozzle spacing, nozzle height, and nozzle type is shown in Table 6. Fixed plate nozzles are usually spaced closer and lower to the ground then 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.

Regional Survey Comparisons, Contrasts

The south central and western Kansas results were similar in that both regions predominately used systems with lengths of seven or eight spans. Approximately 21 percent of the systems in either region had span lengths of eight or greater. However, in the south central region only two systems were greater than 10 spans in length, whereas 13 percent of the western systems were greater than 10 spans. These results are expected since the sandy soils of the south central area require systems that have a higher irrigation capacity to achieve the same irrigation reliability as compared to western Kansas systems that serve soils with higher water holding capacity. High irrigation capacity for large systems is problematic because of friction losses in the main lateral and limitations of well capacity. In addition, more of the south central systems (95.1 percent) completed full circles than the western systems (86.6 percent), although this trend is likely related to the number of larger systems in the west.

The most common type of center pivot nozzle package in the south central survey was a moving plate type nozzle, as compared to the fixed plated nozzle package 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 center pivot systems in south central Kansas. Only about 13 percent of the systems in south central Kansas did not have some type of end gun nozzle. On the other hand, only 15 percent of western Kansas systems used some type of end gun. More than one-third (37.5 percent) of the south central systems were equipped with a big gun (traditional end gun), and about half (48.9 percent) were equipped with either a double or single large impact sprinkler configuration.

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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