Western Kansas Center Pivot Survey

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Abstract

Center pivot sprinkler systems are the dominant irrigation system type in Kansas, representing over 85 percent of the irrigated land. The State of Kansas requires annual water use reports from all irrigators as part of the water appropriation process. The report includes information on system type, crops grow and the amount of water applied. This provides a broad brush view of irrigation in Kansas. However, the types of nozzles and the nozzle configurations are not well documented and this information is often requested. A center pivot road survey was conducted in several western Kansas counties. The results will be compared to a previous survey conducted in south central Kansas.

Introduction

A road survey of center pivot irrigation systems was conducted in eight western Kansas counties in 2005 and 2006. The purpose of the survey goal was to obtain information that would be useful in characterizing the types of center pivot nozzle packages in currently use in the area and potentially be used as a baseline data set for tracking trends should additional surveys be conducted. The counties surveyed were Finney, ford, Grant, Gray, Haskell, Scott, Stevens and Thomas. A county road map was divided into three north/south transects and three east/west transects. All observations on the center pivot systems were made from the road; the fields were not entered by the surveyor.

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, end gun presence and type, and the current or previous crop, if only stubble was present in the field.

Survey Results

The total number of systems observed in the survey was 659 with the number of observations in each county and the reported number of center pivot irrigated acres shown in Table 1. Center pivot irrigation is the dominant irrigation method in Kansas as reflected by the acreage report of the surveyed counties. The span length of the systems ranged from 4 to 19, (see Table 2). Most of the systems were probably typical standard quarter section sized systems (483 of 659 were either 7 or 8 spans in length). Only ten were six or fewer in span length. Seventy-six systems were either 9 or ten span length. Almost 15 percent of the observed systems were 15 spans or larger. There was a tendency for the larger span length systems to be operated as partial circles, as about 50 percent of the systems that were 11 spans or larger were partial circles as compared to about 7 per cent for systems 10 spans or smaller.

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The 78 per cent of the systems were pressure regulated and 89 per cent used a fixed plated nozzle package (Table 3). End guns are not widely used with only slightly more then 15 per cent of the systems with end guns. End guns were defined as either as traditional big guns or impact sprinklers if different from the nozzles on the bulk of the system. Only seven systems used big guns (Table 4).

Table 1: Counties surveyed, Center Pivot Systems, Reported Irrigated Acres, Reported Center Pivot Irrigated Acres (2005 Kansas Irrigation Water Use Report)

Counties	Systems Observed	Total Irrigated Acres	Center Pivot Acres[1]
Finney	143	228522	180555
Ford	69	87088	79996
Grant	54	107038	86448
Gray	107	180467	164268
Haskell	112	195999	112566
Scott	16	54483	31833
Stevens	93	169311	155335
Thomas	65	101947	99045

[1]Does not include center pivot acres from fields where multiple systems are used; for example, center pivot with flood irrigated corners.

Table 2: Center Pivot Survey information on number of spans and degree of rotation (full or part circle)

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

Table 3: Center pivot survey information on pressure regulation use and type of nozzle

Pressure Regulation	Number	Nozzle Type	Number
Yes	515	Fixed Plate	589
No	136	Moving Plate	62
Unknown	8	Impact	2
		Mixed	1
		Unknown	5

Table 4: Center pivot survey information on use of end guns

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

Observations were made on the placement of the nozzle for both spacing and height as shown in Table 5. The largest observation was a mixed spacing configuration, which generally meant the first several spans had wider spacing then the outer spans, although these numbers were not recorded. Only three systems were observed to have wide spacing. The majority of the systems were observed to use drop nozzles located at less then 4 foot height; followed by heights above 4 foot above ground but more then 2 foot below the truss.

Table 5: Center pivot survey information on nozzle spacing and nozzle height

Nozzle Spacing	Number	Nozzle Height	Number
Close (< 8 ft)	214	Less then 4 foot	385
Medium (8-12 ft)	197	Greater then 4 foot	212
Mixed	245	Truss to 2 foot below	55
Wide	3	Within truss	4
		Top of lateral	3

Survey information was also collected on whether the center pivot could make a full revolution. Table 6 shows that 88 systems or 13 per cent could only make partial revolutions.

Table 6: Center pivot survey information on full or partial rotation

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

Additional analysis looked at various combinations of observations. The selections shown are nozzle type verses nozzle spacing (table 7), nozzle height verses nozzle type (table 8), nozzle height verses nozzle spacing (table 9) and number of spans verses degree of rotation (table 10).

Ninety per cent of the systems had the nozzles placed in the two lower placement categories (< 4 ft or > 4 ft but less then 2 ft below truss) with the lowest placement representing about 58 per cent of the total. Sixty-three percent of all fixed plate nozzles were within 4 ft of the ground, while only 12 per cent of moving plate nozzles were that low. Sixty-two per cent of the moving plate nozzles were observed in the > 4 ft category as compared to 29 per cent of the fixed plate nozzle. As noted previously, the mixed spacing configuration was typically a wider spacing for the first several spans then a decrease in spacing for the remainder of the system. About three fourths of the fixed plate nozzles were observed in these spacing categories. Sixty-one percent of the moving plate nozzles used the medium spacing, with another 10 per cent in the mixed category with a wider spacing in the initial spans and wider in the outer. The trend, as would be expected is that moving plate nozzles tend to be used in higher and wider configurations as compared to fixed plate nozzles.

The larger sized center pivots (greater number of spans) are more likely to be associated with partial rotations. For number of spans 11 or less, about 7 per cent did not have full rotation. For span numbers greater then 11, approximately half could do full circles. This might be expected, due to the likelihood of more physical constraints in larger fields, water right and land ownership constraints for large systems and irrigation capacity issues for large systems.

Table 7: Center pivot survey information on nozzle type verses nozzle spacing

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

Table 8: Center pivot survey information on nozzle height verses nozzle spacing

Nozzle Height	Nozzle Spacing	Total
< 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 information on nozzle height verses nozzle type

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

Table 10: Center pivot survey information on number of spans verses degree of rotation

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

A three way sort of observations on nozzle spacing by nozzle height by nozzle type is shown in Table 11. The tendency is for fixed plate nozzles to be spaced more closely and lower to the ground then moving plate nozzles, as would be expected due to the operational characteristics of the two nozzle types. Moving plate nozzles were most commonly used with medium spacing in the > 4 ft height category.

Table 11: Center pivot survey information for nozzle spacing verses nozzle height verses nozzle type

Nozzle Spacing	Nozzle Height	Nozzle Type	Total
Close (< 8 ft)	< 4 ft	Fixed Plate	126
		Moving Plate	5
	< 4 ft Total		131
	> 4 ft above ground	Fixed Plate	55
		Moving Plate	9
	> 4 ft Total		64
	Truss to 2 ft below truss	Fixed Plate	14
		Moving Plate	4
	Truss to 2 ft below truss Total		18
	Within Truss	Fixed Plate	1
		Moving Plate	0
	Within Truss Total		1
Close (< 8 ft) Total			214
Medium (8-12 ft)	< 4 ft	Fixed Plate	36
		Moving Plate	5
	< 4 ft Total		41
	> 4 ft above ground	Fixed Plate	90
		Moving Plate	26
		Unknown	2
	> 4 ft above ground Total		118
	Truss to 2 ft below truss	Fixed Plate	26
		Moving Plate	7
		Mixed	1
		Unknown	1
	Truss to 2 ft 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 ft) Total			197
Mixed	< 4 ft above ground	Fixed Plate	209
		Moving Plate	2
		Unknown	2
	< 4 ft Total		213
	> 4 ft above ground	Fixed Plate	26
		Moving Plate	3
	> 4 ft above ground Total		29
	Truss to 2 ft below truss	Fixed Plate	1
		Moving Plate	1
		Mixed	0
	Truss to 2 ft below truss Total		2
	Within Truss	Fixed Plate	1
		Moving Plate	0
	Truss to 2 ft below truss Total		1
Mixed Spacing Total			245
Wide (>12 ft)	> 4 ft above ground	Fixed Plate	1
	Top of Lateral	Impact	2
Wide (>12 ft) Total			3

A similar survey was previously conducted in the south central region of Kansas (Rogers and Clark, 2004). This survey was conducted in the fall of 2003 in Barton, Edwards, Pawnee, and Stafford counties using the survey technique described previously. There would be a tendency for higher capacity irrigation systems in this region as compared to the western systems due to generally sandy soils in south central and generally non-declining water tables.

Seventy-three percent of the SC systems were of 7 or 8 span length which was essentially identical to western systems. About 21 per cent of the systems in either region were of greater then 8 span length, however, in SC only two systems were greater then 10 spans in length, whereas 13 per cent of the western systems were of greater then 10 span length. This might be expected since the terrain of the SC area may be less conducive to larger systems and the higher irrigation capacity requirements for systems serving sandy soils would be problematic with regards to friction losses and well capacities. More of the SC systems (95.1%) completed full circles as compared to 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 SC survey was a moving plate type nozzle (Table12) as compared to the fixed plated nozzle in western Kansas. The nozzle placement in the SC survey was higher then in the western survey, as might be expected due to the difference in the most common type of nozzle in use.

End guns (Table 13) are in common use in SC Kansas with only about 13 per cent of the systems not having some type of end nozzle as compared to only 15 per cent of western systems having an end gun. Over one-third (37.5%) of the SC systems were equipped with a big gun (traditional end gun). 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 fixed plate nozzle positioned near to the ground using a drop tube. This was different type and configuration observed in the south central region of Kansas, where moving plate nozzles positioned higher above ground were more common.

Acknowledgements

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References

Rogers, D.H. and G.A. Clark. 2004. Center Pivot End Gun Survey and Evaluation Report. Submitted to the Kansas Water Office, Topeka, KS in partial fulfillment of the Technical Assistance to Water Users: K-State Mobile Irrigation Lab, Contract No. 04-102. Final Quarterly Report -1/1/04 – 3/31/04.

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Table 12. Survey results of types and numbers of sprinkler nozzles on center pivot systems in south central Kansas – 2003.

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 13. Survey results of sprinkler vertical position for center pivot sprinkler systems in south central Kansas – 2003.

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

Table 14. Survey results of end gun type on center pivot sprinkler systems in south central Kansas – 2003.

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%