Irrigation Training Toolbox
Irrigation System Design

Sprinkler Design Problem

National Employee Development Center
Natural Resources Conservation Service
Fort Worth, Texas
October 1996

Sprinkler Design Problem

A farmer wants to install a center pivot sprinkler system. You have been asked to help design the system. Determine the maximum sprinkler application rate and the minimum wetted diameter for the following conditions.

Grain sorghum with 1,500 pounds of residue at planting.
Keith Soils (0.5 intake family)
Design slopes estimated to be 2 percent
Net application depth = 1.5 inches
System discharge = 600 gpm
Distance to outer drive wheel = 1,200 feet
Maximum irrigated radius = 1,250 feet

First determine the maximum sprinkler application rate.

Next determine the minimum wetted diameter of the outer nozzle.

TABLE 5.2

MAXIMUM SPRINKLER APPLICATION RATE (Inches/Hour)

For 2000# Actual Residue at Planting

Irrig. Design Group	Design Slope Group	Net Irrigation Application (Inches)											
		0.5	0.75	1.0	1.25	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
1 & 2 (0.1)	0 – 1	4.8	3.0	1.0	0.6	0.4	0.3						
	1.1 – 3	4.8	0.8	0.5	0.4	0.3	0.2						
3 & 4 (0.3)	0 – 1	4.8	4.8	3.0	1.8	1.4	0.9	0.6	0.5	0.4	0.3	0.3	0.2
	1.1 – 3	4.8	2.4	1.5	1.2	1.0	0.6	0.5	0.4	0.3	0.2	0.2	0.2
	3.1 – 5	1.9	1.1	0.9	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2
	> 5	1.2	0.8	0.6	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.2
5 & 6 (0.5)	0 – 1	4.8	4.8	4.2	3.0	2.2	1.5	1.1	1.0	0.9	0.8	0.6	0.4
	1.1 – 3	4.8	3.6	2.5	2.0	1.6	1.1	1.0	0.9	0.8	0.7	0.6	0.4
	3.1 – 5	2.8	1.9	1.5	1.2	1.1	1.0	0.8	0.7	0.6	0.5	0.4	0.4
	> 5	1.8	1.4	1.1	1.0	1.0	0.8	0.7	0.6	0.6	0.4	0.4	0.3
7 & 8 (1.0)	0 – 1	4.8	4.8	4.8	4.8	4.2	3.0	2.5	2.1	1.9	1.6	1.4	1.2
	1.1 – 3	4.8	4.8	4.6	3.7	3.1	2.5	2.2	1.9	1.7	1.5	1.4	1.0
	3.1 – 5	4.8	3.2	3.2	2.8	2.5	2.0	1.8	1.5	1.4	1.4	1.1	1.0
	> 5	3.1	2.6	2.2	2.1	1.9	1.6	1.5	1.4	1.3	1.2	1.0	0.9
9,10,11 & 12	All Design Slopes	(No restrictions within practical design criteria)											

Gilley, J.R., Suitability of Reduced Pressure Center-Pivot. Journal of Irrigation and Drainage, Vol. 110, No. 1, March, 1984. ASAE. Pages 22-34, Table 5.

Allowable soil surface storage values for various slopes, (without artifical storage).
(Included in Table 5.2)

Slope (percent)	Allowable soil surface storage, (inches)
0 – 1	0.5
1.1 – 3	0.3
3.1 – 5	0.1
> 5	0.0

Dillon, et al, ASAE Transactions 1972, Pages 996 – 1001, Table 6.

Application rate adjustment for residue other than 2000#

with >4000# residue use 125% of above rate
with 4000# residue use 120% of above rate
with 3500# residue use 115% of above rate
with 3000# residue use 110% of above rate
with 2500# residue use 105% of above rate
with 1500# residue use 95% of above rate
with 1000# residue use 90% of above rate
with <1000# residue use 85% of above rate

12

Sprinkler Design Problem

A farmer wants to install a center pivot sprinkler system. You have been asked to help design the system. Determine the maximum sprinkler application rate and the minimum wetted diameter for the following conditions.

Grain sorghum with 1,500 pounds of residue at planting.
Keith Soils (0.5 intake family)
Design slopes estimated to be 2 percent
Net application depth = 1.5 inches
System discharge = 600 gpm
Distance to outer drive wheel = 1,200 feet
Maximum irrigated radius = 1,250 feet

First determine the maximum sprinkler application rate.

From the Kansas Irrigation Guide, Table 5.2, on page 5-3, for 2,000 pounds of actual residue at planting time, 0.5 intake family and 1.5 inches net application, the maximum sprinkler application rate is 1.6 inches/hour. The maximum sprinkler application rate for 1,500 pounds residue is:

1.6 inches/hour x 0.95 = 1.5 inches/hour

Next determine the minimum wetted diameter of the outer nozzle.

From the Kansas Irrigation Guide, page 5-35, step 14, the design application rate is calculated using the following equation:

$$I = \frac{192.6\ r\ Q}{R^2\ w}$$

Where:

I = design application rate
r = distance to outer drive wheel
Q = system flow rate
R = maximum irrigated radius
w = wetted diameter of the largest nozzle

This equation can be rewritten to solve for the minimum wetted diameter (w) as follows:

$$w = \frac{192.6\ r\ Q}{R^2\ I} = \frac{192.6\ (1{,}200\ \text{feet})(600\ \text{gpm})}{(1{,}250\ \text{feet})^2\ (1.5\ \text{in/hr})} = 59\ \text{feet}$$