College of Agriculture Engineering Sciences

Soil and Water Department

3rd stage (Irrigation Systems)

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Design of Sprinkler Irrigation System

What is Sprinkler irrigation?

Sprinkler irrigation is a method of applying irrigation water that is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping.

It is then sprayed into the air through sprinklers so that it breaks into small water drops falling to the ground.

The pump supply system, sprinklers, and operating conditions must be designed to enable a uniform application of water.

When to Use Sprinkler Irrigation System

1. Suitable crops

Sprinkler irrigation is suited for the most row, field, and tree crops and water can be sprayed over or under the crop canopy.

2. Suitable slopes

Sprinkler irrigation is adaptable to any farmable slope, whether uniform or undulating.

3. Suitable soils

Sprinklers are best suited to sandy soils with high infiltration rates although they are adaptable to most soils.

4. Suitable irrigation water

A good clean supply of water, free of suspended sediments, is required to avoid problems of sprinkler nozzle blockage and spoiling the crop by coating it with sediment.

Design of Sprinkler Irrigation System

Before designing any sprinkler system we must get the information below

1. Crop data

a- Etc

b- Allowable depletion (RZD = Root Zone Depth (m))

2. Soil data

a- Available moisture (mm/m)

(mm/m) = 1000 (F.C – W.P)

b- Soil infiltration rate from double ring infiltrometer or from the table where measurement is not available.

c- Slope

3. Climate data

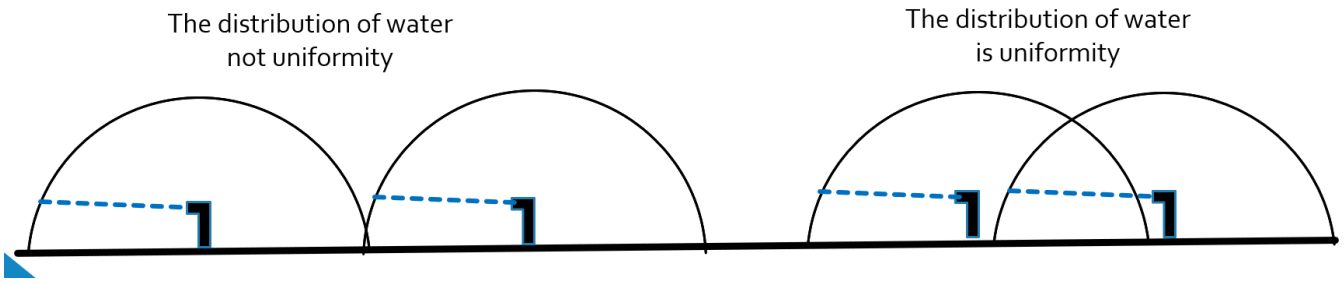
a- General climate to specify irrigation application efficiency from the table in lecture.

b- Wind speed to determine the percentage of overlap.

c- Metrological data for calculating Etc.

4. Other data such as field dimension area, sprinkler pattern price, energy cost, and available nozzles.

*The best design is to combine sprinkler selection with sprinkler spacing to *provide acceptable application uniformity, *acceptable pumping cost, and *acceptable cost hardware cost.



Steps for Design Sprinkler Irrigation System

1- Calculate d_{net}

d_{net} = (F.C – W.P) x RZD x P

d_{net} = net depth of water (mm), F.C = field capacity, W.P = wilting point, RZD= root zone depth (mm), and P= available water depletion

2- Calculate gross depth (dg)

dg = $\frac{d_{net}}{Ea}$

dg= gross depth of water, and Ea= Irrigation efficiency

3- calculate irrigation frequency (II)

II = $\frac{\mathrm{dg}}{ETc}$

ETc= Evapotranspiration of crop

4- Calculate system capacity

$$Q = \frac{A_{(hectar)} * dg * 10}{T * Ns * II}$$

Where:

Q = system capacity (m^3/hr)

A = area (ha)

dg = gross depth of water application (mm)

II = irrigation cycle (days)

Ns = number of shift per day

T = irrigation time per shift (hr)

Calculate system capacity soups that the irrigation area= is 10 hectares and irrigation time per shift = 5 hr and two shifts are used per day. If the dg=60mm.

Select Sprinkler

For example/ depending on the Information below, the rectangular design of 12X18m is suitable with our design?

Nozzle size = 4 mm

Operation pressure = 300 kPa

Wet dimeter = 26.6 m

Q = 1.08 m^3/hr

Slope = 5%

Soups that soil is clay loam texture

Wind speed = 8 km/hr

Quick Details

Type:	Sprinklers
Brand Name:	XF or OEM
Sprinkler Type:	Oscillating
Size:	3/4" Male
Flux:	32-73L/min
Shoot Distanc:	13-15m
Model:	Farm Land Big Rain Gun Sprinkler
Packing:	Carton
Place of Origin:	Zhejiang, China
Model Number:	XF1020-01A
Material:	POM
Working Pressure:	2-4bar
Nozzle Diameter:	7*3mm
Color:	black
Certificate:	ISO

Typical basic soil infiltration rates

Soil type	Basic infiltration (mm/hr)
Clay	1 - 7
Clay Loam	7 - 15
Silt Loam	15 - 25
Sandy Loam	25 - 40
Sand	>40

Maximum sprinkler spacing as related to wind velocity, rectangular pattern

Average Wind Speed (km/hr)	Spacing as Percent of Wetted Diameter (D)
Up to 10	40% between sprinklers 65% between laterals
10 - 15	40% between sprinkler 60% between laterals
above 15	30% between sprinklers 50% between laterals

TABLE 7
Maximum sprinkler spacing as related to wind velocity, square pattern

Average Wind Speed (km/hr)	Spacing as Percent of Wetted Diameter (D)
Up to 5	55%
6 - 11	50%
13 - 19	45%

Sprinkler Specifications				Sprinkler precipitation rate (mm/hr)						
				Sprinkler spacing (m x m)						
Nozzle Size (mm)	Pressure (kPa)	Q (m^3/hr)	Wetted Diam. (m)	9x12	9x15	12x12	12x15	12x18	15x15	18x18
3.0	250	0.57	25.00	5.28	4.22	3.96				
3.0	300	0.63	25.60	5.83	4.67	4.38				
3.0	350	0.68	26.20	6.30	5.04	4.72				
3.5	250	0.75	26.85	6.94	5.56	5.21	4.17			
3.5	300	0.82	27.60	7.59	6.07	5.69	4.56			
3.5	350	0.89	28.35	8.24	6.59	6.18	4.94			
4.0	300	1.08	26.60		8.00	7.50	6.00	5.00	4.60	
4.0	350	1.16	30.50		8.59	8.06	6.44	5.37	5.16	
4.5	300	1.32	30.95			9.17	7.33	6.11	5.87	
4.5	350	1.42	32.00			9.86	7.89	6.57	6.31	
4.5	400	1.52	33.05			10.56	8.44	7.04	7.56	
5.0	300	1.70	33.00				9.44	7.87	8.18	5.25
5.0	350	1.84	34.30				10.22	8.52	8.18	5.68
5.0	400	1.96	35.60				10.89	9.07	8.71	6.05

- *Nozzle size indicates the diameter of the orifice of the nozzle*
- *Pressure is the sprinkler operating pressure at the nozzle*
- *Discharge indicates the volume of water per unit time that the nozzle provides at a given pressure*
- *Wetted diameter shows the diameter of the circular area wetted by the sprinkler when operating at a given pressure and no wind*
- *The sprinkler spacing shows the pattern in which the sprinklers are laid onto the irrigated area. A 12 m x 18 m spacing means that sprinklers are spaced at 12 m along the sprinkler lateral line and 18 m between sprinkler lines*

Precipitation rates reduction on sloping ground

Slope	Percent Reduction
0 - 5%	0
6 - 8%	20
9 - 12%	40
13 - 20%	60
> 20%	75

Suggested maximum sprinkler application rates for average soil, slope, and tilth (Source Keller and Bliesner 1990)

	Slope			
	0-5%	5-8%	8-12%	12-16%
	Maximum application rate			
Soil texture and profile	mm/hr	mm/hr	mm/hr	mm/hr
Coarse sandy soil to 1.8 m	50	38	25	13
Coarse sand soils over more compact soils	38	25	19	10
Light sandy loams to 1.8 m	25	20	15	10
Light sandy loams over more compact soils	19	13	10	8
Silt loams to 1.8 m	13	10	8	5
Silt loams over more compact soils	8	6	4	2.5
Heavy textured clays or clay loams	4	2.5	2	1.5