CHAPTER (6)

SPRINKLER IRRIGATION

The Conditions Favoring the Adoption of this method

1- When the land topography is irregular, and hence unsuitable for surface irrigation.

2- When the land gradient is steeper.

3- When the soil is highly impermeable.

4- When the water table is high.

5- When the seasonal water requirement is low, such as near the coasts.

6- When the crops to be grown are having shallow roots.

7- When the water is available with difficulty.

Sprinkler System Layout

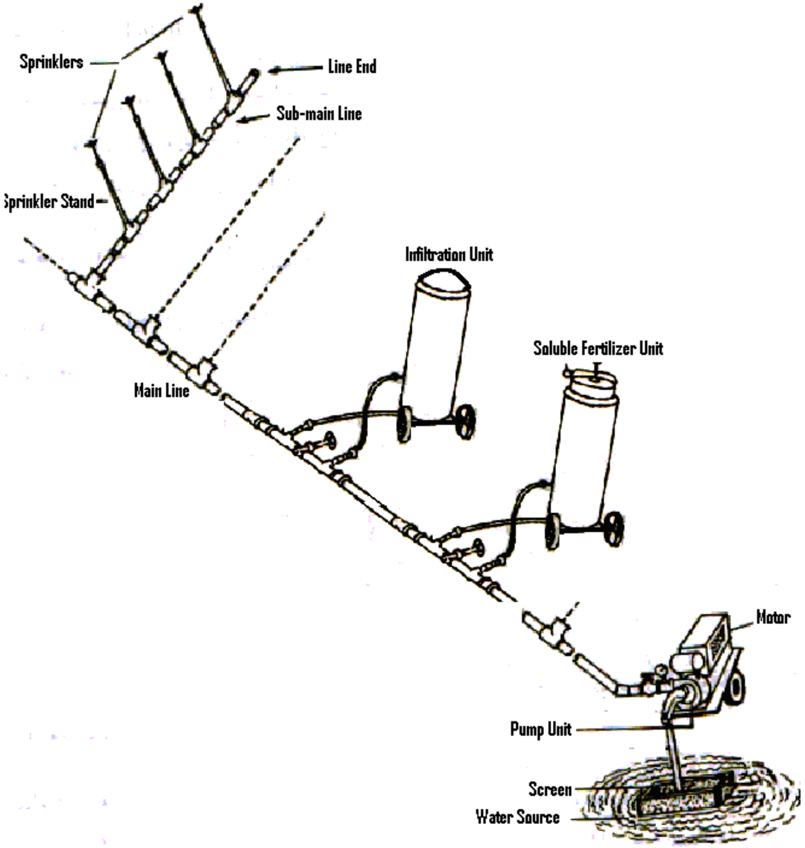
sprinkler irrigation system Components are:

1- Pump unit.

2- Main line and sub-main lines.

3- Laterals.

4- Sprinklers (impact type, defector-plate-type).



Types of Sprinkler systems

1) Permanent system

- Pipes are permanently buried.

2) Semi-permanent System

- The main lines are buried in the ground, while the laterals are portable.

3) Portable system

- The mains as well as laterals are portable.

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The Advantages of Sprinkler Irrigation

1-Seepage losses are completely eliminated. Moreover only optimum quantity of water is used in this method.

2- Land leveling is not required.

3- No cultivation area is lost for making ditches, as happens in surface irrigation methods. It, thus, results in increasing about 16% of the crop area.

4- In sprinkler system, the water is to be applied at a rat lesser than the infiltration capacity of the soil, and thus avoiding surface run off.

The Advantages of Sprinkler Irrigation

5- Fertilizers can be uniformly applied, because they are mixed with irrigation water itself.

6- This method leaches down salts and prevents water-logging or salinity.

7- It is less labor oriented and hence useful where labor is costly.

8- Up to 80% efficiency can be achieved, i.e. up to 80% of applied water can be stored in the root zone of plants.

The Limitations of Sprinkler Irrigation

1- High winds may distort sprinkling pattern, causing non-uniform spreading of water on the crops.

2- In areas of high temperature and high wind velocity, considerable evaporation losses of water may take place.

3- They are not suited to crops requiring frequent and larger depths of irrigation.

4- Initial cost of the system is very high, and the system requires a high technical skill.

5- Only sand and silt free water can be used.

6- It requires larger electrical power.

7- Heavy soil with poor intake cannot be irrigated efficiently.

8- A constant water supply is needed for commercial use of equipment.

Suitable Crops

Most row, field and tree crops. However, large sprinklers are not recommended for irrigation of delicate crops such as lettuce because the large water drops produced by the sprinklers may damage the crop.

Suitable Slopes

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

Suitable Soils

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

Suitable Irrigation Water

A good clean supply of water, free of suspended sediments, is required to avoid problems of sprinkler nozzle blockage.

Design of Sprinkler Irrigation Network

1- Selection of Sprinklers.

2- Design of the Laterals.

3- Design of the Sub-main Line.

4- Design of the Main Line.

5- Design of Pump.

1- Selection of Sprinklers

$$Q_s = C_d * a * (2 * g * h)^{0.5}$$

Where;

Q_s : Sprinkler Capacity (m^3/sec);

C_d : Discharge factor = 0.8 - 0.95;

a: Area of sprinkler (m^2);

g: Acceleration due to gravity = 9.81 m/sec^2;

h: Water pressure at sprinkler (m);

By using the tables (1,2) sprinkler discharge can be determined.

2- Design of the Laterals

a- Mean velocity ≤ 2.0 m/sec;

b- Diameter of laterals pipe ≥ 7.5 cm;

c- Length of lateral pipe 100m < L_l ≤ 300m;

d- Design discharge = No. of sprinklers * sprinkler discharge

e- Design pressure = sprinkler pressure + sprinkler height + the difference between the start of line and its end + 75% of friction losses.

f- Friction losses = Correction factor * friction factor* line length /100

g- Total losses in lateral / design pressure < 20%

3- Design of the Sub-main Line

a- Mean velocity ≤ 2.0 m/sec;

b- Design discharge = No. of laterals * lateral discharge;

c- Design pressure = design pressure of lateral + Total losses of sub-main line;

d- Total losses of sub-main line = friction losses (h) + connection losses (10% of friction losses);

3- Design of the Sub-main Line

$$h = 4 * f * (L / D) * (V2 / 2g)$$

Where; h: Friction losses (m);

f: Friction factor (= 0.005);

L: Total length of sub-main or main line (m);

D: Diameter of sub-main or main line (m);

g: Acceleration due to gravity = 9.81 m/sec^2;

V: Water velocity in the line (m/sec);

e- Total losses in sub-main line / design pressure < 20%

4- Design of the Main Line

a- Mean velocity ≤ 2.0 m/sec;

b- Design discharge = No. of sub-main lines * sub-main line discharge;

c- Design pressure = design pressure of sub-main line + Total losses of main line;

d- Total losses of main line = friction losses (h) + connection losses (10% of friction losses);

e- Total losses in main line / design pressure < 20%

5- Design of Pump

a- Total discharge =No. of main lines*main line discharge;

b- Total pressure = 1.1* design pressure of main line + pump pressure (3m assumed);

c- Pump capability (HP) and its electric energy (Pw) are determined from these equations:

5- Design of Pump

$$HP = (Q * H_{tot} * \gamma) / (75 * \eta_p)$$

$$P_w = (HP * 0.746) / (\eta_E)$$

Where; HP: Pump capability (horse);

Q: Discharge which is needed (m^3/sec);

H_{tot}: Total pressure (m); γ: Specific weight (kg/ m^3);

η_p: Actual efficiency of the pump (75 – 85%);

P_w: Electric energy (kilowatt/hr);

η_E: Actual efficiency of the motor (85 – 95%);

Example:

Design a half fixed sprinkler irrigation method for an area 885m*448m, if the main and sub-main lines are fixed and laterals and sprinklers are movable, where:

Diameter of effective circle = 40m;

Space between the sprinklers = 0.55 of effective circle diameter;

Sprinkler discharge = 4.3 m^3/hr;

Equivalent irrigation depth = 7.0 mm/hr;

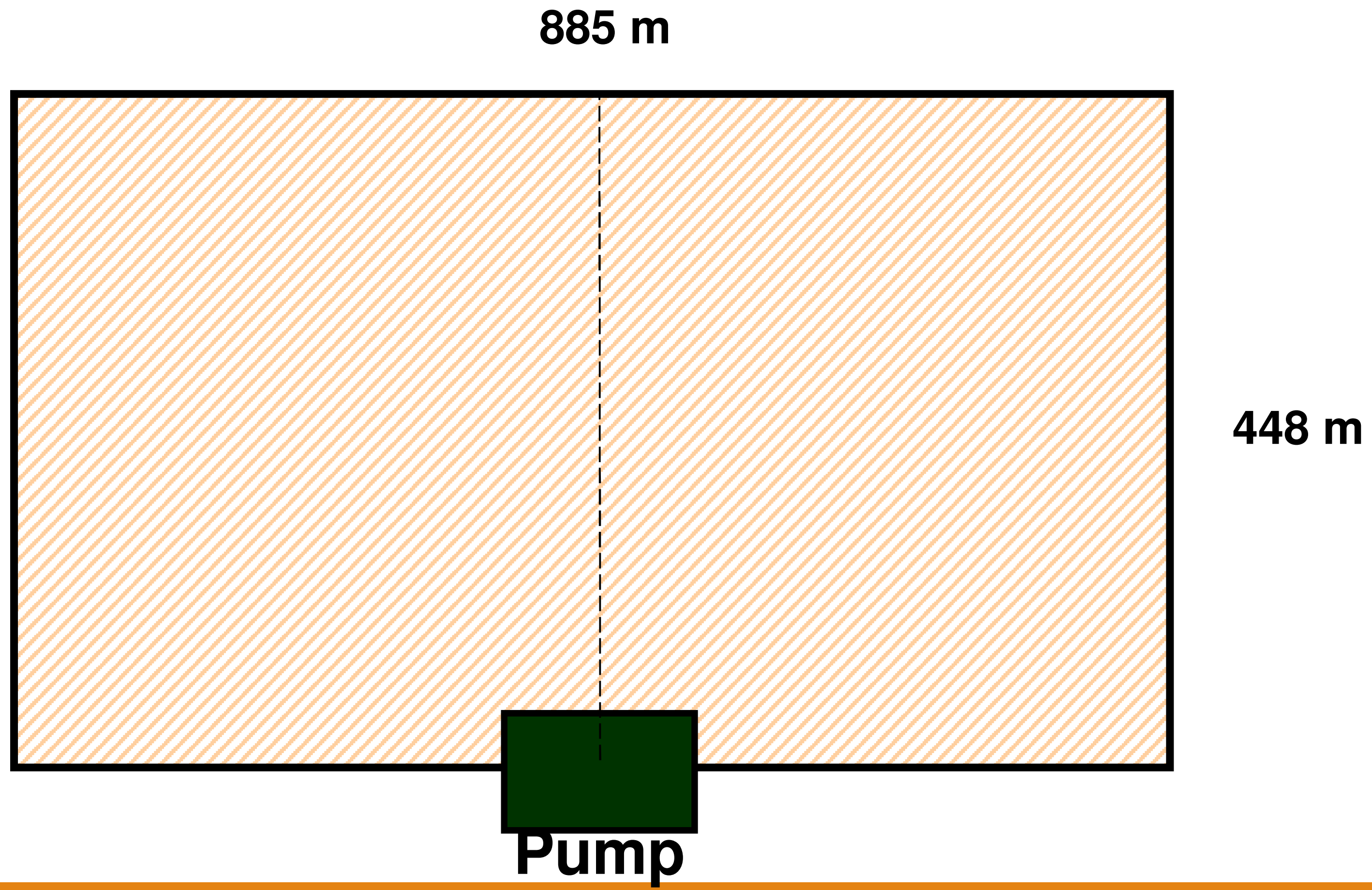
Total pressure of sprinkler =32m of water;

Required water depth = 30 mm/irrigation;

Irrigation period = 4 days/irrigation;

Irrigation efficiency = 75%;

Example:



Solution steps:

1- Space between sprinklers on lateral = 0.55 * 40 = 22m;

2- Actual irrigation depth = required water depth / irrigation efficiency

= 30 / 0.75 = 40 mm/irrigation;

3- Space between laterals = sprinkler discharge / (equivalent irrigation depth * Space between sprinklers) = 4.3 *1000 /(7*22) = 28m;

4- The lateral can make two movements in the day (space between laterals =28m, the total space = 28 * 2 * 4 = 224m in one irrigation (4days));

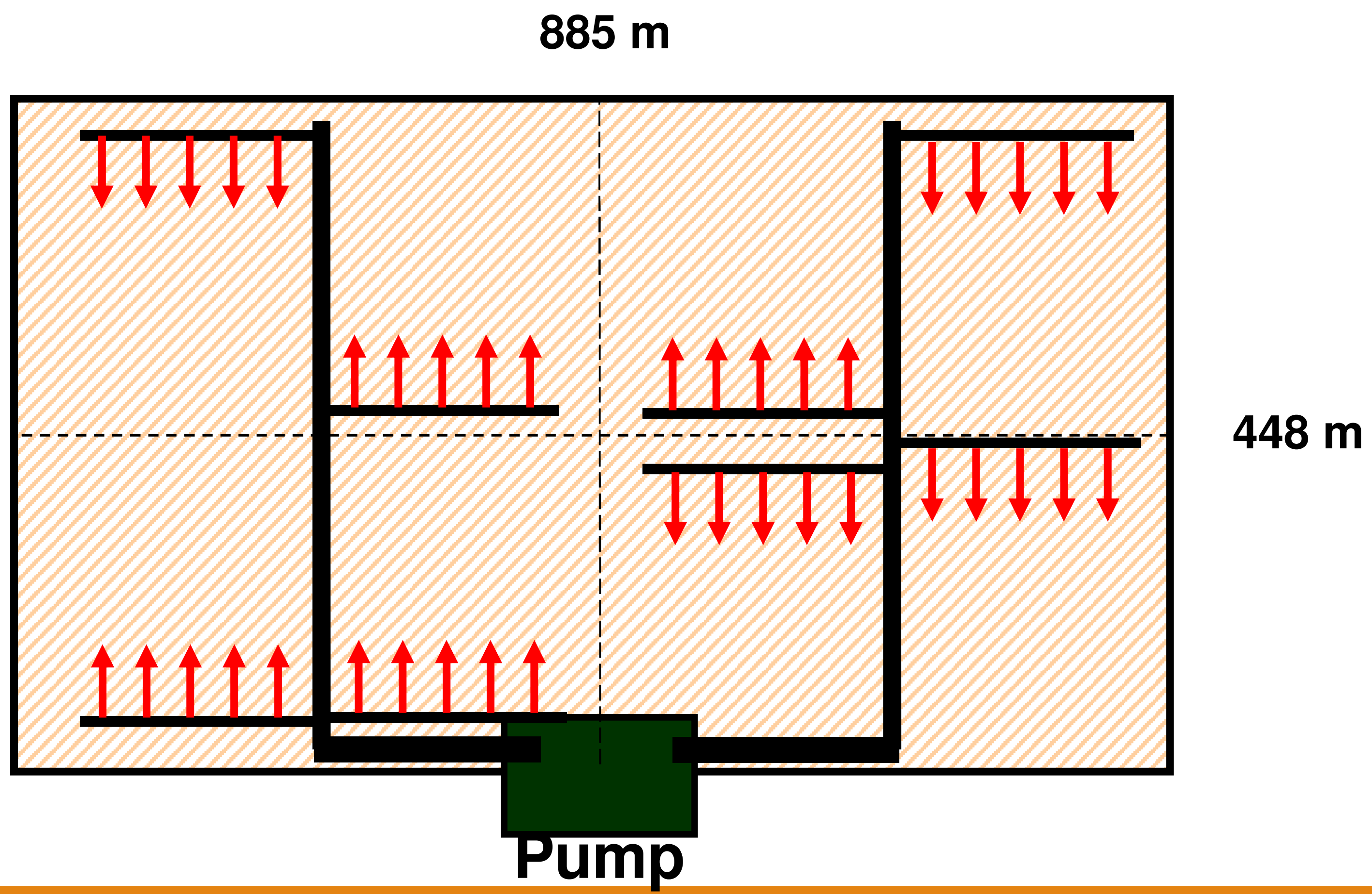
Solution steps:

5- Assume no. of sprinklers on the lateral = 10 sprinklers;

6- The lateral length = 9 *22 + 11 = 209m, and irrigate 220m;

7- No. of laterals = Total area / the area which irrigated by the lateral = (885*448)/(224*220) = 8, as shown in this figure:

Example:



8- Sprinkler design:

$$Q_s = C_d * a * (2 * g * h)^{0.5}$$

$4.3 / (60*60) = 0.95 * a\ (2*9.81*32)^{0.5}$

$a\ (\pi r^2) = 0.502\ cm^2$, r= 0.4 cm sprinkler opening diameter = 0.8 cm = 8 mm

4.3 m^3/hr = 1.19l/sec

From the table (1), we the largest open for the sprinkler with one opening is 0.714 cm, thus we must select the sprinkler with two openings.

From table (2), we select the sprinkler with two openings 7.14mm *3.2mm which gives discharge = 1.1673 l/sec, pressure =3.2 kg/cm^2 =32 m of water height.

9- Design of the laterals

The length of lateral = 209m;

The discharge of lateral = (4.3/60*60)*1000 * 10 sprinklers = 11.9 l/sec;

Select the lateral diameter = 10cm;

From tables (3), (4): the friction factor = 2.5 m for 100 m of lateral length, and correction factor = 0.396;

The total losses = 2.5 * 0.396 * 209 /100 = 2.07 m;

Design pressure = sprinkler pressure + sprinkler height + the difference between the start of line and its end + 75% of friction losses = 32 + 0.7 + 0 + 0.75 *2.07 = 34.25 m.

Total losses in lateral / design pressure = 2.07/34.25 = 0.06 < 20%

10- Design of the sub-main line

Sub-main line length = 448m

Design discharge = No. of laterals*lateral discharge =11.9* 4 =47.76 l/sec = 171.94 m^3/hr

The mean velocity = 1.5m/sec < 2.0 m/sec

From chart 1 Q=171.94, v=1.5m/sec D=8in=0.2m

Total losses of sub-main line= h + 10% *h = 4 * f * (L/D) * (V^2/2g) + 10%*h = 4*0.005*(448/0.2)*($(1.5)^2$/(2*9.81)) + 10%*h = 5.14 + 0.1*5.14 = 5.7 m

Design pressure = design pressure of lateral + Total losses of sub-main line = 34.25 + 5.7 = 40 m

Total losses in sub-main line / design pressure = 5.7 / 40 = 0.14 < 20 %

11- Design of the main line

Main line length = 220 m

Design discharge = discharge of one sub-main line = 47.76 l/sec=171.94 m^3/hr

Select diameter of main line = 8 in = 20 cm

From chart 1, the mean velocity = 1.5m/sec < 2.0 m/sec

Total losses of main line = h + 10% *h = 4 * f * (L/D) * (V^2/2g) + 10%*h = 4*0.005*(220/0.2)*($(1.5)^2$/(2*9.81)) + 10%*h = 2.52 + 0.1*2.52 = 2.77 m

Design pressure = design pressure of sub-main line + Total losses of main line = 40 + 2.77= 42.8 m

Total losses in sub-main line/design pressure = 2.77/42.8 = 0.06 < 20 %

12- Design of pump

$HP = (Q * H_{tot} * \gamma) / (75 * \eta_p)$

The pump pressure = 3.0m of water depth (assumed)

Total pressure = 1.1* design pressure of main line + pump pressure = 1.1 * 42.8 + 3 = 50 m

Total discharge = No. of main lines * main line discharge = 2 * 171.94 = 343.9 m^3/hr = 0.096 m^3/sec

Take efficiency of the pump75% and efficiency of the motor 85%

$HP = (Q * H_{tot} * \gamma) / (75 * \eta_p) = (0.096 * 50 * 1000) / (75 * 0.75) = 85.3$ horse

$Pw = (HP * 0.746) / (\eta_E) = (85.3 * 0.746) / (0.85) = 75$ kilowatt/hr

Thanks