I DRIP DESIGN

The steps to be followed for designing the drip irrigation system are given below:

1. Inventory of the resources and data collection.
2. Computation of peak crop water requirement
3. Deciding the appropriate layout of the drip irrigation system
4. Selection of emitters
5. Hydraulic design of the system in terms of lateral, sub main and main
6. Horse power requirement of pump

1.1 Inventory of the Resources and Data Collection

This step involves preparation of inventory of all the available resources and operating conditions. The resources involved include:

Water resources: Quantity (stream size, volume and duration for which the supply is available) and quality of water, the type of water resources i.e. bore/tube well; open dug well, reservoir/pond/tank or river and location of the water resource:

Land resources: The size and shape of the area to be irrigated, soil type for its texture and irrigation properties (field capacity, wilting point, bulk density, allowable depletion level) including infiltration rate, and topography of the land

Essential parameters	Orchard crops	Vegetables and other closely spaced crops
Stream size	1L s^{-1}/ha^{-1} for 4hday^{-1}	3Lp^{-1} ha^{-1} for 4 h day^{-1}
Storage capacity	15$m^3$$ha^{-1}$	45m^3 ha^{-1}
Power requirement	1hp ha^{-1}	3hp ha^{-1}

7. **Climate:** The climatic data required for the computation of crop water requirement.

8. **Crop:** Crop type, sowing/planting and harvesting period, crop coefficient, fertilser requirements, crop geometry.In general following guidelines can be used to ensure adequate quantity of available water for supply of irrigation water to the wide spaced (orchard) and close spaced (vegetable etc.) crops. However the area to be irrigated can be decided on the basis of the water availability and the crop water demand.
9. **Peak Crop Water Requirement**

The design of drip irrigation system needs the information on the peak water requirement, however while the system is in operation, the water requirement during the specified irrigation interval is required. This section describes the method to estimate the crop water requirement.Water requirement of crops is a function of plants, surface area covered by plant, evapotranspiration rate. Crop water requirement is calculated for each plant and the water requirement of the whole area is estimated based on the water requirement per plant and total number of plants. The crop water requirement which is maximum during any one of the three seasons is adopted for system design.

The daily water requirement for fully grown plants can be calculated as under:

$$V = ETr \times Kc \times A \times Wp \quad (44.1)$$

Net volume of water to be applied

$$Vn = V - \mathrm{Re} \times A \times Wp \quad (44.2)$$

Number of daily operating hours of the system

$$(T) = \frac{V_n}{Ne \times Np \times q} \quad (44.3)$$

where,

V =Volume of water required, L

ET_r= Reference crop evapotranspiration, mm day^{-1}

K_c = Crop coefficient

A = Area occupied by a plant (row to row spacing x plant to plant spacing), m^2

R_e = Effective rainfall, mm

W_p = Wetting fraction (varies from 0.2 for wide spaced crops and 1.0 for close spaced crops)

Ne = Number of emitters per plant

N_p = Number of plants

q = Emitter discharge, L h^{-1}

The crop coefficient (Kc) varies with crop growth stage and season. The crop coefficient (Kc) should be considered for the maturity stage of crop while designing micro irrigation system and for the specified growth while operation of the system.

Water requirement of few crops are given in Table 44.1, which can be used as guideline for design of irrigation system. However it should be noted that this is only guideline and actual water requirement needs to be computed on the basis of crop, climate etc.

Water requirements of few horticultural crops

Name of the Crop	Spacing (m)	Water requirement (l/plant/day)	
		Minimum	Maximum
Banana	2.0 × 2.0	4	18
Papaya	2.0 × 2.0	2	10
Guava	5.0 × 5.0	14	39
Mango	5.0 × 5.0	20	50
Pineapple	0.45 × 0.25	0.1	0.6
Cashew	7.5 × 7.5	25	60
Jujube	6.0 × 6.0	20	50
Sapheda	5.0 × 5.0	20	65
Pomegranate	5.0 × 5.0	15	40
Tomato	0.6 × 0.6	0.45	1.15

Pomegranate	5.0 × 5.0	15	40
Tomato	0.6 × 0.6	0.45	1.15
Cauliflower	0.6 × 0.45	0.7	1.4
Okra	0.3 × 0.3	0.6	1.8
Cabbage	0.6 × 0.45	0.7	1.6
Brinjal	0.9 × 0.6	0.8	3.3
Rose	0.75 × 0.75	0.5	2
Jasmine	1.5 × 1.5	1.5	5

1.2 SPRINKLER DESIGN

The general guide lines for set-move sprinkler system are stated below:

i) Mains should be laid up and downhill.

ii) Laterals should be laid across slope or nearly on the contour.

iii) For multiple lateral operations, lateral pipe sizes should be limited to not more than two diameters.

iv) If possible, water supply should be chosen nearest the center of area.

v) Layouts should facilitate minimal lateral movement during the season.

vi) Differences in number of sprinklers operating for various setups should be held to minimum.

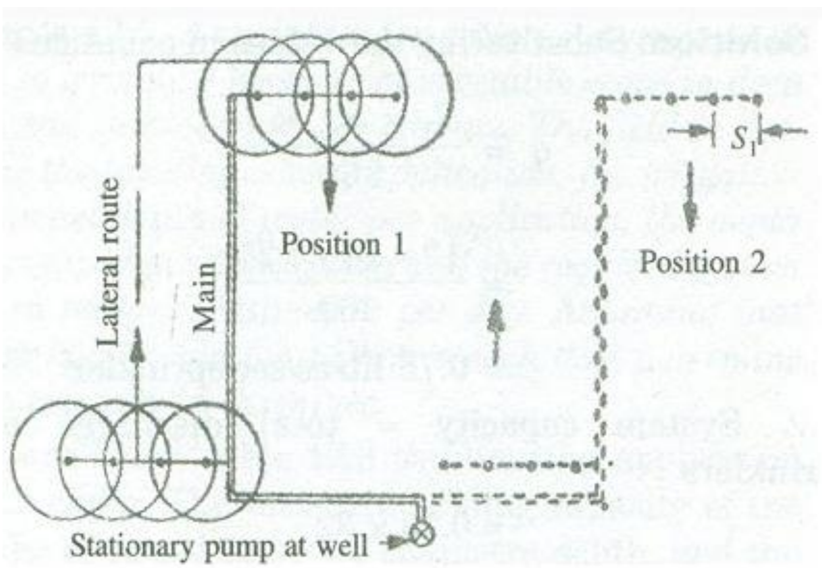
vii) Booster pumps should be considered where small portions of field would require high pressure at the pump.

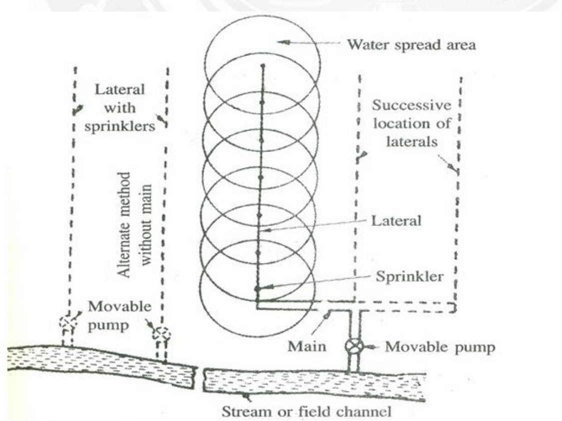
viii) Layout should be modified to apply different rates and amounts of water where soils are greatly different in the design area.

ix) Mainline and sub main layout is keyed to lateral layout.

x) When laterals run across prominent slopes, mainline or sub mains will normally run up and down the slopes.

xi) When it is necessary to run laterals up and down hill, mainlines or sub mains should be located on ridges to avoid laterals that run uphill.





Parameters for Design of Sprinkler Irrigation System

The basic objective of sprinkler irrigation system is to apply uniform depth of water at predetermined application rate. The sprinkler irrigation system should be designed properly to achieve high irrigation efficiency. The inventory of resources and climatic conditions of the field area are primarily required for the design of sprinkler irrigation system.

Inventory of resources and other parameters

Land: Land is often a major factor in irrigation system design as it influences the selection of sprinkler device, irrigation efficiency, costs of land development, labour requirements, range of possible crops, etc. The major factors of land which have a special bearing on sprinkler irrigation design are: slope, infiltration rate, effective soil depth, texture & structure of soil and size & shape of field.

Water: The source of water supply for sprinkler irrigation can be surface water (river, canal, pond etc.) or ground water (a tube well or open well). Adequate water availability & quality parameters play an important role in the design of sprinkler irrigation system.

Climate: Important climatic data required are solar radiation, temperature, relative humidity, evapotranspiration rate, precipitation or rainfall and wind speed. These climatic parameters are required to estimate peak consumptive use rate as well as total seasonal evapotranspiration of crop(s).

Source of power: Electricity, diesel, solar, wind and biofuels are used to pump water from the source. The selection of pump depends on type of power used to operate pump.

Soil water parameters

Net depth of water application

The depth of water application is the quantity of water, which should be applied during irrigation in order to replenish the water used by the crop during evapotranspiration. The difference between field capacity and permanent wilting point will give the available soil moisture (water holding capacity), which is the total amount of water that the crop can use. Depending on the crop sensitivity to stress, the soil moisture should be allowed to be depleted only partially. For most field crops, a depletion of 60 to 65% of the available moisture is acceptable. This is the moisture that will be easily available to the crop without causing undue stress. The maximum net depth to be applied per irrigation can be calculated, using Equation 14.1.

$$d_{net} = (\theta_{FC} - \theta_{WP}) \times D_{rz} \times P \qquad \text{---- (14.1)}$$

where,

d_{net} = readily available moisture or net depth of water application per irrigation for the selected crop, mm

θ_{FC} = soil moisture at field capacity, mm/m

θ_{WP} = soil moisture at the permanent wilting point, mm/m

D_{rz} = the depth of soil that the roots exploit effectively (m)

P = the allowable portion of available moisture permitted for depletion by the crop before the next irrigation

In order to express the depth of water in terms of the volume, the area proposed for irrigation is multiplied by depth.

$$\text{Volume of water to be applied } (m^3) = 10 \times A \times d \qquad \text{----(14.2)}$$

where,

A = area proposed for irrigation, ha

d = depth of water application, mm

Example 14.1

A twenty hectare area has medium texture loam soil grown with Wheat crop peak. Daily water use of wheat crop is 6.2 mm day^{-1}. The available soil moisture ($\theta_{FC} - \theta_{WP}$) is 120 mm m^{-1}. The allowable soil moisture depletion is 50%. The crop root zone depth (D_{RZ}) is 0.8 m. Soil infiltration rate is 6 mm h^{-1}. The other climatic data are: average wind speed 10 km h^{-1}. Determine the maximum net depth of water application.

Solution:

Using Equation 14.1, net depth of water application per irrigation for the selected crop is computed as

d_{net} = 120 x 0.8 x 0.5 = 48 mm

For an area of 20 ha, net application of 9600 m^3 (10 x 20 x 48) of water will be required for irrigation to bring the root zone depth of the soil from the 50% allowable depletion level to the field capacity (Equation 14.2).

Irrigation frequency

Irrigation frequency refers to the number of days between irrigations during periods without rainfall. Irrigation frequency depends on crop, soil and climate. After establishing the net depth of water application, the irrigation frequency at peak moisture rate of crop should be determined using the following equation 14.3.

$$\text{Irrigation frequency (F)} = d_{net} / wu \qquad \text{----(14.3)}$$

Where, F = irrigation frequency, days; d_{net} = net depth of water application, mm

wu = peak daily water use, mm day^{-1}.

Example 14.2

The peak demand for wheat was estimated as 6.2mm day^{-1}. Using the data available in Example 14.1, determine the irrigation frequency.

Solution:

Irrigation Frequency (F) =48 mm / 6.2 mm/day = 7.7 days

The irrigation system should be designed to provide 48 mm in every 7.7 days. For practical purposes, fractions of days are not used for irrigation frequency. Hence the irrigation frequency in this example is taken as 8 days. The corresponding net depth of d_{net} of water application

d_{net} = 6.2x 8 = 49.6 mm

The moisture depletion

= 49.6/(120 x 0.8) = 0.52

The question arises as to whether the irrigation system should apply the d_{net} in 8, 7, 6, right down to 1 day. This choice will depend on the flexibility the farmer would like to have and his/her willingness to pay the additional cost for different levels of flexibility. If irrigation is to be completed in 1 day, the system becomes idle for the remaining 7 days, and the cost of the system would be exorbitant, since larger sizes of irrigation equipment would be required. On the other hand, for all practical purposes and in order to accommodate the time for cultural practices (spraying etc), it is advisable that irrigation is completed in less than the irrigation frequency. In the case of our example, 7 days irrigation and 1 day without irrigation is considered adequate. The 7 days required to complete one irrigation in the area under consideration is called the irrigation cycle.

Gross depth of water application

The gross depth of water application (d_{gross}) equals the net depth of irrigation divided by the farm irrigation efficiency. It should be noted that farm irrigation efficiency includes possible losses of water from pipe due to leakage or from other sources.

$$d_{gross} = d_{net}/E \qquad \text{------(14.4)}$$

Where E = the farm (or unit) irrigation efficiency.

The farm irrigation efficiency of sprinkler systems varies from climate to climate.

Example 14.3

Assuming a moderate climate for the area under consideration and using application efficiency of 75% of sprinkler irrigation, determine the gross depth of irrigation.

d_{gross} =49.6/ 0.75= 66.13 mm

14.2.3 System capacity

The next step is to estimate the system capacity. The system capacity (Q), can be estimated using Equation 14.5 given below

$$Q = (10 \times A \times d_{gross}) / (I \times Ns \times T) \qquad \text{-----}(14.5)$$

Where Q = system capacity, $m^3 h^{-1}$; A = area, ha; d = gross depth of water application, mm; I = irrigation cycle, days; Ns = number of shifts per day; T = irrigation time per shift, h.

Example 14.4

The irrigation system operates for 11 hours per shift. Two shifts per day during peak demand is used in each irrigation cycle of 7 days to complete irrigation in 20 ha area. Determine the capacity of irrigation system.

Solution: A=20 ha, d_{gross}=66.13 mm, N_s=2, I = 7 days, T =11 h.

Substituting values in Equation 14.5, the system capacity is

$$Q = (10 \times 20 \times 66.13) / (7 \times 2 \times 11)$$

$$Q = 85.88\ m^3 h^{-1}$$

14.2.4 Sprinkler systems selection parameters

Sprinkler selection and spacing

Based on specifications furnished by the manufacturers of the equipment the sprinkler system components are selected. The important parameters include in selection are diameter of coverage, pressure available, sprinkler discharge, combination of sprinkler spacing and lateral moves, application rate suiting to soil and wind conditions. The required discharge of an individual sprinkler is a function of the water application rate and the two-way spacing of the sprinklers. The maximum application rate for different types of soils at different land slopes is given in Table 14.1.

Discharge from a sprinkler is computed by

$$q = \frac{s_1 \times s_m \times I}{3600} \quad \text{.... (14.6)}$$

where,

q = required discharge of individual sprinkle, Ls^{-1}

= spacing of sprinklers along the laterals, m

= spacing of laterals along the main, m

I = optimum application rate, mm h^{-1}

Example 14.5

A sprinkler system 18 m spacing along the main and 12 m along the laterals is used to irrigate crop grown on coarse sandy soil over more compact soil land slope of 3 per cent. Twenty sprinklers are used to irrigate field. Determine the total system capacity.

Solution:

Discharge from a single sprinkler $q = \frac{s_1 \times s_m \times I}{3600}$

=12 m, = 18 m, I =3.75 cm h^{-1}= 37.5 mm h^{-1}, q = 0.75 L s^{-1}

System capacity (q) = 20 × 0.75 =15 L s^{-1}

Height of sprinkler riser pipes

Sprinklers are located just above the crops to be irrigated and therefore, the height of the risers depends upon the maximum height of the crop. To avoid excessive turbulence in the riser pipes the minimum height of riser is 300 mm for 25 mm diameter and 150 mm for 15 mm to 20 mm diameter. In general, 900 mm long G.I. pipe of 25mm diameter is used.

Sprinkler spacing

The uniformity of water distribution from sprinklers depends on the pressure of water, wind velocity, rotation of sprinklers, spacing and nozzle diameter. The spacing of sprinklers in a lateral and the laterals spacing are adjusted considering all these parameters. Generally at satisfactory desired operating pressure the water distribution beneath sprinkler head accumulate more and depth decreases gradually with distance from the sprinklers.

Normally sprinklers are spaced at 50 per cent of the diameter of the coverage by an individual sprinkler. If there is a wind of considerable speed, the spacing between sprinklers is reduced. Table 2 is used to adopt sprinkler spacing under windy condition. This overlap is desired to achieve uniform application on water.

Table: 2 Spacing of sprinklers for different wind speed.

Sl.No.	Average wind speed	Spacing
1	No wind	65% of the water spread area of a sprinkler
2	0-6.5 km h^{-1}	60% of the water spread area of a sprinkler
3	6.5 to 13 km h^{-1}	50% of the water spread area of a sprinkler
4	Above 13 km h^{-1}	30% of the water spread area of a sprinkler

Source: Michael (2010)

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