Unit III

1. Methods of Irrigation

Irrigation is the artificial and controlled application of water to soil, plants, or agricultural fields in order to meet their water needs. It ensures optimal moisture levels for plant growth, increases crop yield and sustains agricultural activities in regions with inadequate or unpredictable rainfall. India has the world's largest irrigated land, with around 85 percent of total irrigation potential currently developed.

> *The artificial application of water to the soil or agricultural land which fulfills the demand for water is known as **Irrigation**.*

Irrigation systems are designed to aid in the growth of agricultural crops and plants by using the least amount of water possible, preventing soil consolidation, and so on. Irrigation frequency, rate, amount, and time differ for different crops, as well as soil types and seasons. Summer crops, for example, demand far more water than winter crops. However, overirrigation can lead to problems like waterlogging, salinization, and environmental degradation. Therefore, sustainable and efficient irrigation practices are essential to ensure long-term agricultural productivity and environmental balance.

Types of Irrigation

Irrigation can be done by different methods and on the basis of the pattern followed for the irrigation. Irrigation depends upon the climate, resources, crops, and surroundings. Irrigation is divided into different types:

1. Surface Irrigation
2. Micro-irrigation/Localized irrigation (Drip, Sprinkler, Centre Pivot)
3. Sub-surface irrigation
4. Manual irrigation

I. Surace Irrigation

In surface irrigation water is applied directly to the soil surface and allowed to flow over the field by gravity. This irrigation is done manually, with no involvement of any machine. It's one of the oldest and simplest methods of irrigation.

Types of surface irrigation

1. Flooding,

2. Bed or border method (Saras and flat beds)

3. Basin method (ring and basin) and

4. Furrow method (rides and furrows, broad ridges or raised beds)

1. Flooding

•It consists of opening a water channel in a plot or field so that water can flow freely in all directions and cover the surface of the land in a continuous sheet.

•It is the most inefficient method of irrigation as only about 20 percent of the water is actually used by plants. The rest being lost as a runoff, seepage and evaporation.

•Water distribution is very uneven and crop growth is not uniform. It is **suitable for uneven land where the cost of leveling is high** and where a cheap and abundant supply of water is available.

•It is unsuitable for crops that are sensitive to water logging the method suitable where broadcast crops, particularly pastures, alfalfa, peas and small grains are produced.

Adaptations:

- An abundant supply of water
- Close growing crops
- Soils that do not erode easily
- Soils that is permeable
- Irregular topography
- Areas where water is cheap.

Advantages

- Can be used on shallow soils
- Can be employed where expense of leveling is great
- Installation and operation costs are low

- System is not damaged by livestock and does not interfere with use of farm implements.

Disadvantages

- Excessive loss of water by run of and deep percolation
- Excessive soil erosion on step land.
- Fertilizer and FYM are eroded from the soil.

2. Bed or border method (Sara and Flat beds or check basin)

Border irrigation involves dividing a field into long, narrow strips called borders, which are then bordered by low ridges to contain water. Water is released at the higher end of the border, and it flows by gravity across the strip, irrigating the plants along its path

•In this method the field is leveled and divided into small beds surrounded by bunds of 15 to 30 cm high. Small irrigation channels are provided between two adjacent rows of beds.
•The length of the bed varies from 30 meters for loamy soils to 90 meters for clayey soils.
•The width is so adjusted as to permit the water to flow evenly and wet the land uniformly.
•For high value crops, the beds may be still smaller especially where water is costly and not very abundant.
•This method is adaptable to most soil textures except sandy soils and is suitable for high value crops. It requires leveled land.
•It is more efficient in the use of water and ensures its uniform application. It is suitable for crops plant in lines or sown by broadcast. Through the initial cost is high requires less labour and low maintenance cost.

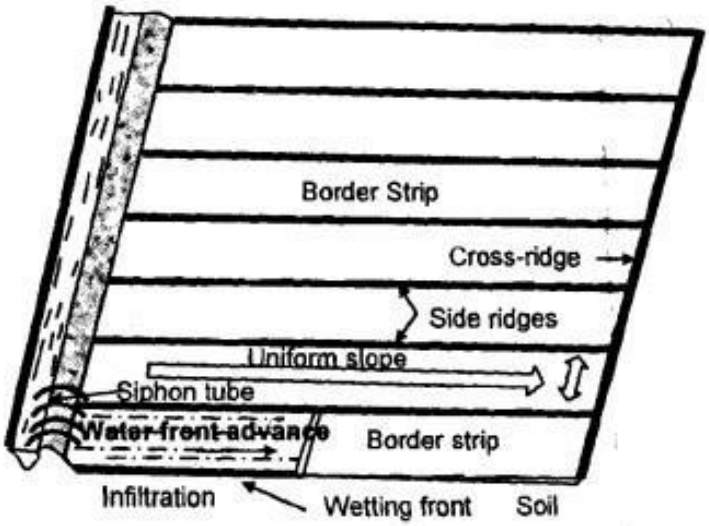
•This may also be **called a sort of sara method followed locally in Maharashtra** but the saras to be formed in this method are much longer than broader.

Types of Border Irrigation

Two types of borders are formed :

1. Straight Border: These border are formed along the general slope of the field. These are preferred when fields can be levelled or be given a gentle slope economically.
2. Contour Border:These are formed across the general slope of the field and are preferred when land slope exceeds the safe limits.

As fields are undulating and require a lot of earth work to level, economical levelling is not possible. Design criteria for both are different.



Adaptations:

- A large supply of water
- Most soil textures including sandy Loam, loams and clays
- Soil at least 90 cm deep
- Suitable for close growing crops.

Advantages:

1. Fairly large supply of water is needed.
2. Land must be leveled
3. Suited only to soils that do not readily disperse.
4. Drainage must be provided

3. Basin Irrigation

- It involves creating shallow depressions or basins around individual plants or groups of plants. Water is then applied directly into these basins, allowing it to gradually seep into the soil around the plants. Such types of irrigation are normally done in small layout fields.
- This method is suitable for orchids and other high value crops where the size of the plot to be irrigated is very small.
- The basin may be square, rectangular or circular shape. A variation in this method viz. ring and basin is commonly used for irrigating fruit trees.
- A small bund of 15 to 22 cm high is formed around the stump of the tree at a distance of about 30 to 60 cm to keep soil dry. The height of the outer bund varies depending upon the depth of water proposed to retain. Basin irrigation also requires leveled land and not suitable for all types of soil. It is also efficient in the use of water but its initial cost is high.
- There are many variations in its use, but all involve dividing the field into smaller unit areas.so that each has a nearly level surface. Bunds or ridges are constructed around the areas forming basins within which the irrigation water can be controlled. Check basin types may be rectangular, contour and ring basin.

Types of Check Basins

Based on Size and Shape

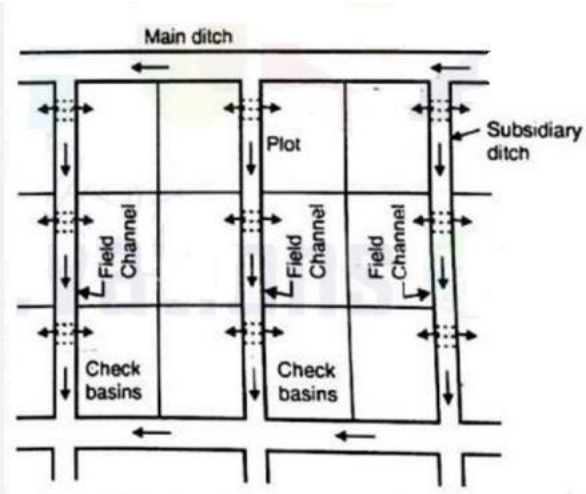
The size of check basins may vary from one meter square, used for growing vegetables and other intensive cultivation, to as large as one or two hectares or more, used for growing rice under wet land conditions. While the following points need to be considered :

Rectangular

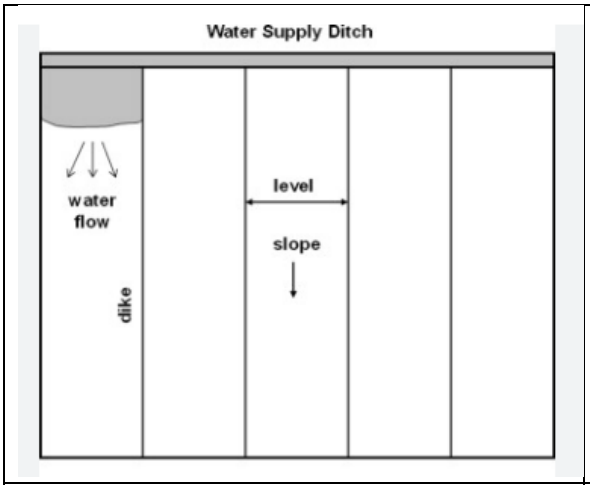
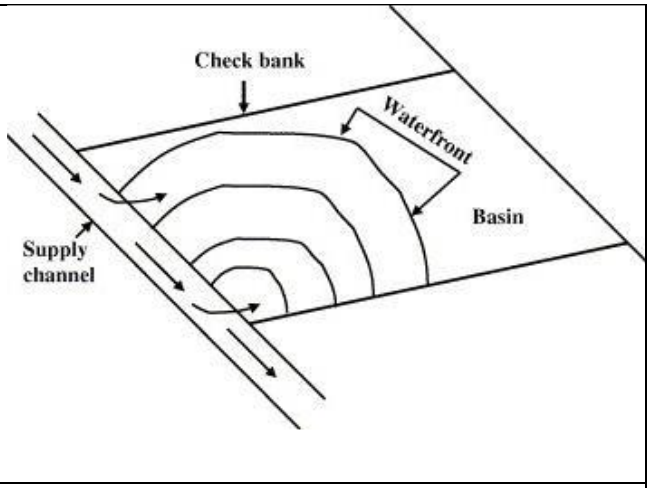
The basins are rectangular in shape when the land can be graded economically into nearly level fields.

Contour

•The ridges follow the contours of the land surface and the contour ridges are connected by cross ridges at intervals when there is rolling topography.



Check basin

	
Rectangular	**Contour**

4. **Furrow Irrigation:** It involves creating small channels or furrows along the field's contour, allowing water to flow down the furrows and infiltrate the soil around the plants' root zones. This method is suitable for row crops and orchards. If not done properly it can lead to uneven water distribution and potential soil erosion.

- In this method, narrow channels are dug at regular intervals. Water from the main supply is allowed to enter these small channels or furrows.
- Water from the furrows infiltrates into soil and spread laterally to saturate the root zone of the crops.
- It is suitable for row crops like potatoes, sugarcane, tobacco, maize, groundnut, cotton, jowar, etc.
- Row crops such as potatoes, cotton, sugarcane, vegetable etc. can be irrigated by furrow method. Water is allowed to flow in furrow opened in crop rows.
- It is suitable for sloppy lands where the furrows are made along contours.
- The length of furrow is determined mostly by soil permeability. It varies from 3 to 6 meters. In sandy and clay loams, the length is shorter than in clay and clay loams. Water does not come in contact with the plant stems.
- Economic water use.
- Some times, even in furrow irrigation the field is divided into beds having alternate rides and furrows. On slopes of 1 to 3 percent, furrow irrigation with straight furrows is quite successful.
- But on steeper slopes contour furrows, not only check erosion but ensure uniform water penetration. Irrigation furrows may be classified into two general types based on their alignment. They are :

(a) straight furrows, and

(b) contour furrows.

a) Straight Furrows

•They are best suited to sites where the land slope does not exceed 0.75 per cent. In areas of intense rainfall, however, the furrow grade should not exceed 0.5 per cent so as to minimise the erosion hazard.

•The range in furrow slopes for efficient irrigation in different soil types are the same as those recommended for borders.

b) Contour Furrows

- Contour furrows carry water across a slopping field rather than the slope. Contour furrows are curved to fit the topography of the land.
- Contour furrow method can be successfully used in nearly all irrigable soils. The limitations of straight furrow are overcome by contouring to include slopping lands.
- Light soils can be irrigated successfully across slopes up to 5 per cent.

Adaptations:

1. Medium and fine textured soils.

2. Variable water supply

3. Farms with only small amount of equipment.

Advantages:

1. High water efficiency

2. Can be used in any row crop

3. Relatively easy in stall

4. Not expensive to maintain

5. Adapted to most soils.

Disadvantages:

1. Requirement of skilled labour is more

2. A hazard to operation of machinery

3. Drainage must be provided. 5. Contour farming

•Contour farming involves ploughing, planting and weeding along the contour, i.e, across the slope rather than up and down.

•Contour lines are lines that run across a (hill) slope such that the line stays at the same height and does not run uphill or downhill.

•As contour lines travel across a hillside, they will be close together on the steeper parts of the hill and further apart on the gentle parts of the slope.

•Experiments show that contour farming alone can reduce soil erosion by as much as 50% on moderate slopes.

•However, for slopes steeper than 10%, other measures should be combined with contour farming to enhance its effectiveness.

Benefits:

1. Contouring can reduce soil erosion by as much as 50% from up and down hill farming

2. By reducing sediment and run off and increasing water infiltration

3. Contouring promotes better water quality

4. It gives 10-15% additional yield.

Criteria for Surface Irrigation Method Selection

The deciding factors for the suitability of any surface irrigation method are:

- Natural conditions (slope, soil type),
- type of crop,
- required depth of application,
- level of technology,
- previous experiences with irrigation, required labour input.

•Moreover, the irrigation system for a field must be compatible with the existing farming operations, such as land preparation, cultivation, and harvesting practices.

Factors influencing surface irrigation

Physical Factors :Crops and cultural practices are of prime importance while selecting an irrigation system. Hence, proper knowledge of agronomic practices and irrigation intervals is necessary for proper use of irrigation water and to increase water use efficiency. The following physical factors need to be given due consideration.

i) Crop Parameters

•Tolerance of the crop to soil salinity during development and maturation.

•Magnitude and temporal distribution of water necessary for maximum production.

•Economic value of crop.

ii) Soils Parameters

- Texture and structure
- Infiltration rate and erosion potential
- Salinity and internal drainage
- Bearing strength

- Crusting of soil and its effects on infiltration
- Reclamation and salt leaching- basin irrigation
- Spatial variability

Sandy soils have a low water storage capacity and a high infiltration rate. Under these circumstances, sprinkler or drip irrigation are more suitable than surface irrigation. Clay soils with low infiltration rates are ideally suited to surface irrigation. High intake characteristic require higher flow rate to achieve the same uniformity and efficiency.

iii) Field Topography

•Uniform, mild slopes facilitate surface irrigation.
•Location and relative elevation of water source – water diversion, pumping
•Acreage in each field
•Location of roads, natural gas lines, electricity lines, water lines and other obstructions.
•Shape of field – non rectangular shapes are more difficult to design for
•Field slope – steepness & regularity
•Furrow & borders 2-6% maximum

iv) Climate and Weather Conditions

•Under very windy conditions, drip or surface irrigation methods are preferred.
•**Scalding** (the disruption of oxygen-carbon dioxide exchange between the atmosphere and the root)& the effect of water temperature on the crop at different stages of growth -risk in basin irrigation.
•Irrigation with cold water early in the spring can delay growth, whereas in the hot periods of the summer, it can cool the environment— both of which can be beneficial or detrimental in some cases.

v)Water Supply

The following parameters are important:

1. Source and delivery schedule

2. Water quantity available and its reliability

3. Water quality

4. Water table in case of ground water source.

5. Availability and Reliability of Electricity 6. Availability and reliability of energy for pumping of water is of much importance.

vi) Economic Considerations

The following points need to be considered while selecting irrigation alternatives.
1. Capital investment required and recurring cost.
2. Credit availability and interest rate.
3. Life of irrigation system, efficiency and cost economics.

vii) Social Considerations

The education and skill of common farmers and labours available for handling the irrigation system
•Social understanding of handling of cooperative activities and sharing of water resources
•Legal and political considerations, local cooperation and support, availability and skill of labour and level of automatic control

Suitability and Limitations of Surface Irrigation Methods

•Some form of surface irrigation is adaptable to almost any vegetable crop. Basin and border strip irrigation has been successfully used on a wide variety of crops.
•Furrow irrigation is less well adapted to field crops if cultural practices require travel across the furrows. However, it is widely used in vegetables like potato.
•Basin and border strip irrigations flood the soil surface, and will cause some soils to form a crust, which may inhibit the sprouting of seeds.
•Surface irrigation systems perform better when soils are uniform, since the soil controls the intake of water. For basin irrigation, basin size should be appropriate for soil texture and infiltration rate.
•Basin lengths should be limited to 100 m on very coarse textured soils, but may reach 400 m on other soils. Furrow irrigation is possible with all types of soils, but extremely high or low intake rate soils require excessive labor or capital cost adjustments that are seldom economical.
•A major cost in surface irrigation is that of land grading or leveling. The cost is directly related to the volume of earth that must be moved, the area to be finished, and the length and related to the volume of earth that must be moved, the area to be finished, and the length and size of farm canals.

II. Micro-irrigation

Localized irrigation systems apply water directly to the root area of individual plants, reducing water loss from the soil through evaporation. It reduces water wastage, reduces evaporation, and weed growth. The network of pipes provides water evenly to the plants under low pressure. Drip irrigation, porous clay pots, porous pipes, and perforated plastic sleeves are examples of localized irrigation methods. It is a very efficient method because it provides the optimum amount of water to the plants or crops at regular intervals of time.

Two main micro irrigation systems are : a) Sprinkler b) Drip

Advantages of Micro Irrigation

(a) Water saving, possibility of using saline water.

(b) Efficient and economic use of fertilizers.

(c) Easy installation, flexibility in operation.

(d) Suitable to all types of land terrain also suitable to waste lands.

(e) Enhanced plant growth and yield and uniform and better quality of produce.

(f) Less weed growth.

(g) Labour saving.

(h) No soil erosion, saves land as no bunds, etc. are required.

(i) Minimum diseases and pest infestation.

SPRINKLER IRRIGATION

•In sprinkler irrigation, water is delivered through a pressurized pipe network to sprinklers nozzles or jets which spray the water into the air.
•To fall to the soil in an artificial "rain". The basic components of any sprinkler systems are : a water source. a pump to pressurize the water.
•A pipe network to distribute the water throughout the field. Sprinklers to spray the water over the ground, and valves to control the flow of water.
•The sprinklers when properly spaced give a relatively uniform application of water over the irrigated area.

Sprinkler systems are usually (there are some exceptions) designed to apply water at a lower rate than the soil infiltration rate so that the amount of water infiltrated **at any point depends upon the application rate and time of application but not the soil infiltration rate.**

General Classification of Sprinkler Systems

Sprinkler systems are classified into the following two major types on the basis of the arrangement for spraying irrigation water.

(a) Rotating head or revolving sprinkler system.

(b) Perforated pipe system.

Components of Sprinkler Irrigation System

Sprinkler system usually consists of the following components : (a) A pump unit

(b) Tubings-main/sub-mains and laterals

(c) Couplers

(d) Sprinker head

(e) Other accessories such as valves, bends, plugs and risers.

Suitability and Limitations

 With regards to crops, soils, and topography nearly all crops can be irrigated with some type of sprinkler system though the characteristics of the crop especially the height, must be considered in system selection.

 Sprinklers are sometimes used to germinate seed and establish ground cover for crops like lettuce alfalfa and sod.

 The light frequent applications that are desirable for this purpose are easily achieved with some sprinkler systems.

 Sprinklers are applicable to soils that are too shallow to permit surface shaping or too variable for efficient surface irrigation.

 With regards to labour and energy considerations, it has been observed that labour requirements vary depending on the degree of automation and mechanization of the equipment used.

 Hand-move systems require the least degree of skill, but the greatest amount of labor.

> *In general, sprinklers can be used on any topography that can be formed. Land leveling is not normally required.*

Advantages of Sprinkler Irrigation

The followings are the advantages of sprinkler irrigation:

(a) Elimination of the channels for conveyance, therefore no conveyance loss.

(b) Suitable to all types of soil except heavy clay, suitable for irrigating crops where the plant population per unit area is very high. It is most suitable for oil seeds and other cereal and vegetable crops.

(c) Water saving, closer control of water application convenient for giving light and frequent irrigation and higher water application efficiency.

(d) Increase in yield.

(e) Mobility of system.

(f) May also be used for undulating area, saves land as no bunds etc. are required, areas located at a higher elevation than the source can be irrigated.

(g) Influences greater conducive micro-climate.

(h) Possibility of using soluble fertilizers and chemicals.

(i) Less problem of clogging of sprinkler nozzles due to sediment laden water

Capacity of Sprinkler System

The capacity of the sprinkler system may be calculated by the formula :

$$Q = 2780 \times \frac{A \times d}{F \times H \times E}$$

Where,

Q = Discharge capacity of the pump, liter/second,

A = Area to be irrigated, hectares,

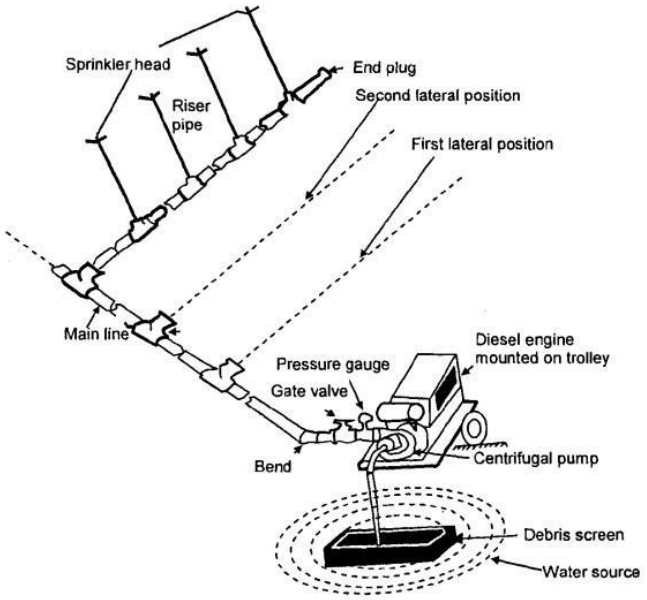
d = Net depth of water application, cm,

F = Number of days allowed for the completion of

one irrigation,

H = Number of actual operation hours per day, and

E = Water Application Efficiency in %



DRIP IRRIGATION

•Drip irrigation, also known as trickle irrigation or micro irrigation, which minimizes the use of water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters.

•It is popular for row crop irrigation. This system is used in place of water scarcity as it minimizes conventional losses such as deep percolation, evaporation and run-off or recycled water is used for irrigation.

•Small diameter plastic pipes fitted with emitters or drippers at selected spacing to deliver the required quantity of water are used. Drip irrigation may also use devices called micro-spray heads, which spray water in a small area, instead of dripping emitters.

•**Subsurface drip irrigation (SDI)** uses permanently or temporarily buried drip per line or drip tape located at or below the plant roots.

•Pump and valves may be manually or automatically operated by a controller

Drip irrigation applies the water through small emitters to the soil surface, usually at or near the plant to be irrigated.

Drip irrigation is the slow, frequent application of water to the soil though emitters placed along a water delivery line.

Subsurface irrigation is the application of water below the soil surface. Emitter discharge

rates for drip and subsurface irrigation are generally less than 12 liters per hour

Components of Drip Irrigation System (Listed in Order from Water Source)

(a) Pump or pressurised water source.

(b) Water Filter(s) - Filtration Systems : Sand Separator, Cyclone, Screen Filter, Media

Filters.

(c) Fertigation Systems (Venturi injector).

(d) Backwash Controller.

(e) Main Line (larger diameter Pipe and Pipe Fittings).

(f) Hand-operated, electronic, or hydraulic Contvl Valves and Safety Valves.

(g) Smaller diameter polytube (often referred to as "laterals").

(h) Poly fittings and Accessories (to make connections).

(i) Emitting Devices at plants (Example : Emitter or Drippers, micro spray heads, inline drippers, trickle rings).

Suitabi1ityand Limitation

(a) From stand point of crops, soil, and topography, drip irrigation is best suited for tree, vine, and row crops. A lot of research work has been conducted to establish the suitability of drip irrigation for different vegetable crops. Drip irrigation has been found suitable both for field vegetable crops and also under covered cultivation practices.

(b) With respect to water quantity and quality, drip irrigation uses a slower rate of water application over a longer period of time than other irrigation methods. The most economical design would have water flowing into the farm area throughout most of the day, every day, during peak use periods. If water is not available on a continuous basis, on-farm water storage may be necessary.

(c) Though a form of pressurized irrigation, drip is a low pressure, low flow rate method. These conditions require small flow channel openings in the emission devices, which are prone to plugging.

(d) High efficiencies are USP of drip irrigation system. Properly designed and maintained drip systems are capable of high efficiencies. Design efficiencies should be on the order of 90 to 95%.

(e) Labour and energy considerations are very important consideration in drip irrigation system. Due to their low flow characteristics, drip irrigation systems usually have few sub-units,.

Advantages

1. Water saving - losses due to deep percolation, surface runoff and transmission are

avoided. Evaporation losses occurring in sprinkler irrigation do not occur in drip

irrigation.

2. Uniform water distribution

3. Application rates can be adjusted by using different size of drippers

4. Suitable for wide spaced row crops, particularly coconut and other horticultural

tree crops

5. Soil erosion is reduced

6. Better weed control

7. Land saving

8. Less labour cost

Disadvantages

1. High initial cost

2. Drippers are susceptible to blockage

3. Interferes with farm operations and movement of implements and machineries

4. Frequent maintenance

5. Trees grown may develop shallow confined root zones resulting in poor

anchorage.

LAYOUT OF SPRINKLER IRRIGATION SYSTEM

- The sprinkler (overhead or pressure) irrigation system conveys water to the field

through pipes (aluminium or PVC) under pressure with a system of nozzles.

- This system is designed to distribute the required depth of water uniformly, which is not possible in surface irrigation.

Water is applied at a rate less than the infiltration rate of the soil hence the runoff from irrigation is avoided.

A sprinkler system usually consists of the following parts.

1. A pumping unit
2. Debris removal equipment
3. Pressure gauge / water-meter
4. Pipelines (mains – sub-mains and laterals)
5. Couplers
6. Raiser pipes
7. Sprinklers
8. Other accessories such as valves, bends, plugs, etc.

Pumping unit

A high speed centrifugal or turbine pump can be installed for operating the system for individual farm holdings. The pumping plants usually consist of a centrifugal or a turbine type pump, a driving unit, a suction line and a foot valve.

Pipe lines

Pipelines are generally of two types. They are main and lateral. Main pipelines carry water from the pumping plant to many parts of the field. In some cases sub main lines are provided to take water from the mains to laterals. The lateral pipelines carry the water from the main or sub main pipe to Sprinklers may rotate or remain fixed. The rotating sprinklers can be adapted for a wide range of application rates and spacing. They are effective with pressure of about 10 to 70 m head at the sprinkler. Pressures ranging from 16-40 m head are considered the most practical for most farms. Fixed head sprinklers are commonly used to irrigate small

lawns and gardens.

Other accessories / fittings

1. Water meters - It is used to measure the volume of water delivered.

2. Pressure gauge - It is necessary to know whether the sprinkler is working with the desired pressure in order to deliver the water uniformly.

3. Bends, tees, reducers, elbows, hydrants, butterfly valves, end plugs and risers

4. Debris removal equipment: This is needed when water is obtained from streams, ponds, canals or other surface supplies. It helps to keep the sprinkler system clear of sand, weed seeds, leaves, sticks, moss and other trash that may otherwise plug the sprinklers.

5. Fertilizer applicators. These are available in various sizes. They inject fertilizers in liquid form to the sprinkler system at a desired rate.

Types of sprinkler system

On the basis of arrangement for spraying irrigation water

1. Rotating head (or) revolving sprinkler system

2. Perforated pipe system

Based on the sprinklers. The pipelines may be either permanent, semi-permanent or portable.

Couplers: A coupler provides connection between two tubing and between tubing and fittings.

Based on the portability

1. Portable system: It has portable mainlines and laterals and a portable pumping unit

2. Semi portable system: A semi portable system is similar to a fully portable system except that the location of the water source and pumping plant are fixed.

3. Semi permanent system: A semi permanent system has portable lateral lines, permanent main lines and sub mains and a stationery water source and pumping plant The mainlines and sub-mains are usually buried, with risers for nozzles located at suitable intervals.

4. Solid set system: A solid set system has enough laterals to eliminate their movement. The laterals are placed in the field early in the crop season and remain for the season.

5. Permanent system: It consists of permanently laid mains, sub-mains and laterals and a stationary water source and pumping plant. Mains, sub-mains and laterals are usually buried below plough depth. Sprinklers are permanently located on each riser.

Advantages

1. Water saving to an extent of 35-40% compared to surface irrigation methods.
2. Saving in fertilizers - even distribution and avoids wastage.
3. Suitable for undulating topography (sloppy lands)
4. Reduces erosion
5. Suitable for coarse textured soils (sandy soils)
6. Frost control - protect crops against frost and high temperature
7. Drainage problems eliminated
8. Saving in land
9. Fertilisers and other chemicals can be applied through irrigation water

Disadvantages

1. High initial cost
2. Efficiency is affected by wind
3. Higher evaporation losses in spraying water
4. Not suitable for tall crops like sugarcane
5. Not suitable for heavy clay soils
6. Poor quality water can not be used (Sensitivity of crop to saline water and clogging of nozzles)

Steps to be taken for reducing the salt deposits on leaves and fruits during sprinkler irrigation

• Irrigate at night

• Increase the speed of the sprinkler rotation

• Decrease the frequency of irrigation