UNIT 6 IRRIGATION METHODS

Structure

6.1 INTRODUCTION

Proper amount of irrigation water at appropriate stages and intervals is very necessary for crop production. Irrigation requirement depends upon type of crop, season and weather factors, soil type and type of irrigation system used. Against the backdrop of the rapid decline in irrigation water potential and low water use efficiency in the conventional methods of irrigation, precision irrigation methods has recently been introduced in Indian agriculture. Besides saving a substantial amount of water, it also helps to increase the productivity of the crop. The research studies conducted in different institutes in India have indicated that water saving is about 40-80% and the yield increase is up to 100% for different crops by using micro irrigation. It has also been proved that drip irrigation, which a type of micro irrigation, is technically feasible and socially acceptable not only for large farms but also for small farms. Drip irrigation can be adopted to large areas irrigated from wells to save water. It is more suitable for widely spaced high value vegetable crops. Proper selection, installation, operation and maintenance are must for efficient and long lasting use of an irrigation system.

Objectives

After studying this unit, you should be able to

- understand various methods of irrigation and their relative advantages,
- learn selection of method of irrigation based on different related parameters,
- understand details about conventional method of irrigation like border, check basin and furrow irrigation methods,
- explain relative merits of precision irrigation methods like drip and sprinkler irrigation, and
- define and explain fertigation as an effective method of irrigation.

6.2 SELECTION OF IRRIGATION SYSTEM

Selection of irrigation system is first step in this endeavour and needs through knowledge of merits and demerits of different methods of irrigation. For proper selection of irrigation system it is necessary to give careful consideration to :

(a) The environment in which the irrigation system will operate, and

(b) The capabilities and limitations of all irrigation system alternatives which are economically feasible and technically sound potential.

The following outline presents a number of factors of physical social and economic environment, which will have a bearing on success of irrigation system alternates and will guide the selection of a particular system.

6.2.1 Physical Factors

Crops and cultural practices are of prime importance while selecting an irrigation system. There are certain crops like the transplanted vegetables, e.g. chilly is generally irrigated immediately after transplanting and thereafter at weekly intervals. The requirement of other crops may vary according to their water needs. Hence, proper knowledge of agronomic practices and irrigation intervals is necessary for proper use of irrigation water and to increase water use efficiency. This has been detailed out in Unit 2. At the same time, a number of crops cannot withstand water stagnation and excess moisture may prove dangerous to crop growth. If saturated condition exists for 24 hours, the plants will die. Also saturation condition inhibits plant growth leading to reduced yield. Effect of saturation condition and water logging on crop production will be discussed in Unit 7. Different critical stages of crops have also been discussed in Unit 2. Students are advised to first learn the requirements of different crops and differentiate between irrigation need of different crops under given agro ecological conditions. Like in vegetables the most critical stages of plant growth are initial establishment of transplanted seedling and just prior to flowering. So, moisture stress at blossoming stage leads to flower and fruit drop. Similarly long dry spell followed by heavy irrigation will also result in flower drop. The following physical factors need to be given due consideration.

Crop Parameters

Crop and the cultural practices in their production process are of utmost importance. Kindly refer to Unit 2 for requirements of different crops at different stages.

Soils Parameters

Important soil parameters with respect to irrigation are texture and structure; depth of root zone and uniformity; infiltration rate and erosion potential; salinity and internal drainage, bearing strength.

Field Topography

Field slope and surface irregularity play important role in irrigation. To improve irrigation efficiency, fields need to be levelled using precision leveller including laser leveller.

Climate and Weather Conditions

Climate and weather conditions of a region affect selection of irrigation system. For better management of agricultural production system, efficient planning of irrigation system and to curb environmental degradation, the country has been grouped into 20 agro-climatic regions and 60 agro-ecological sub-regions on the basis of soil, agro-ecological conditions and physiographic situations. This has helped a lot in planning irrigation in addition to other inputs.

Water Logging and Flood Hazard

The productivity of land in fact, gets affected when the root zone of the plants gets flooded with water, and thus become ill aerated. Inadequate aeration reduces crop yield.

The facts remains that quality water is a scarce commodity, it is imperative to make best use of available water by developing and adopting suitable technologies of proper and efficient water management. For this, it is important to have knowledge about irrigation water from its source to ultimate destination i.e. plant. India is a country with very diverse form of agriculture particularly due to varying soil, climate situations.

Water Supply

It is a key factor in selection of irrigation system. In fact, water supply may dictate selection of appropriate irrigation method, if there is scarcity of quality water for irrigation. The following parameters are important :

(a) Source and delivery schedule

(b) Water quantity available and its reliability

(c) Water quality

(d) Water table in case of ground water source.

Availability and Reliability of Electricity

Availability and reliability of energy for pumping of water is of much importance. In a country like ours where in many states limited and erratic supply of electricity is there, this factor needs much more attention while deciding irrigation method.

6.2.2 Economic Considerations

To give it a commercial shape to agricultural production and use of suitable agro inputs including irrigation, economic considerations are must. The following points need to be considered while selecting irrigation alternatives.

(a) Capital investment required and recurring cost.

(b) Credit availability and interest rate.

(c) Life of irrigation system, efficiency and cost economics.

6.2.3 Social Considerations

In the backdrop of popularity of advance irrigation system, the education and skill of common farmers and laboures available for handling the irrigation system is very important. Similarly, social understanding of handling of cooperative activities and sharing of water resources is also must get importance. The main social factors need to be considered while deciding the irrigation system for an area or individual farmer are legal and political considerations, local cooperation and support, availability and skill of labour and level of automatic control desired.

The above factors need to be considered as per the requirements of the location of the field. It is important to know the broad features, efficiency and economy of various irrigation systems to decide the merits and demerits of the potential alternates of irrigation system. The common types of irrigation methods, along with their capabilities and limitations are covered in the following sections.

Irrigation Methods

Irrigation water may be applied to crops by flooding the field surface, by applying it beneath the soil surface, by spraying it under pressure or by applying it drop by drops. Accordingly the following different methods are in vogue

Schematic Presentation of Irrigation Methods

The common methods of irrigation are indicated schematically as given below.

As described earlier, the water supply, the type of soil, the topography of the land and the crop to be irrigated determine the appropriate method of irrigation to be used. Irrespective of the method of irrigation, it is necessary to design the system for the most efficient use of water by the crop.

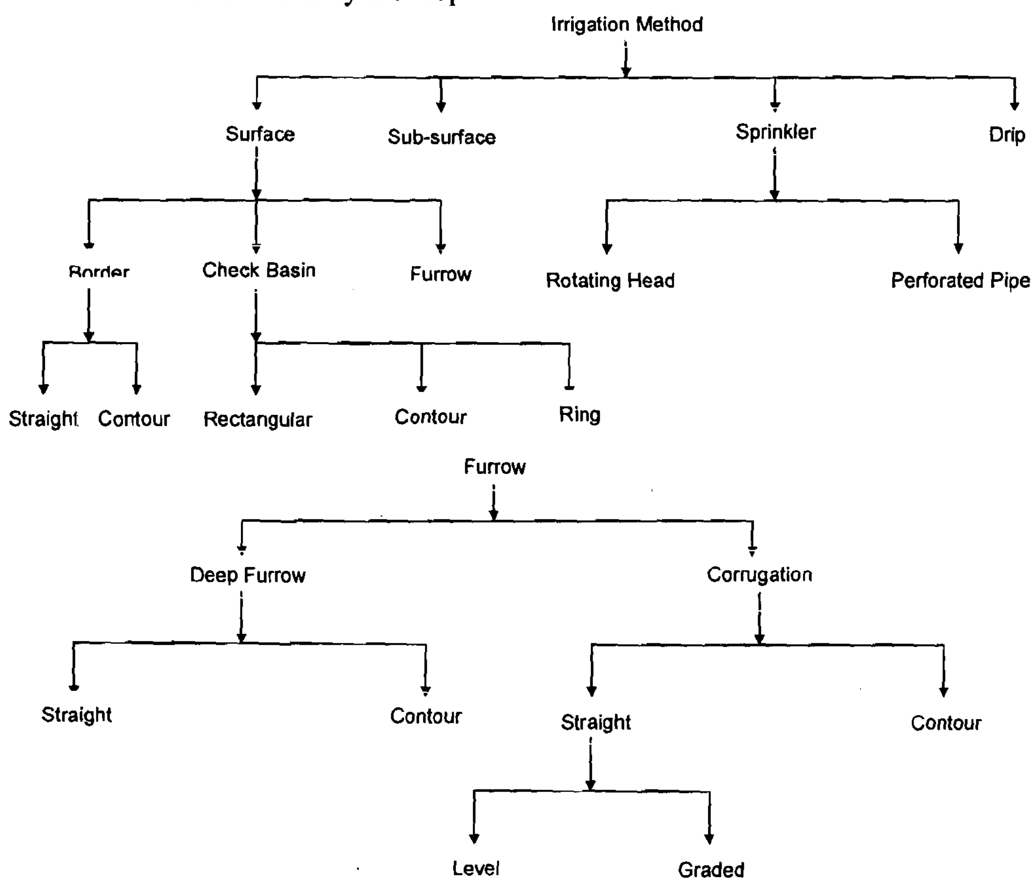

Figure 6.1 : Irrigation Method

6.3 SURFACE IRRIGATION METHODS

A brief about surface and subsurface irrigation method is given in Unit 1. Here, we will not detail out sub surface irrigation methods. In the surface methods of irrigation, water is applied directly to the soil surface from a channel located at the upper reach of the field. Water may be distributed to the crops in border strips, check basins or furrows. Thus, surface irrigation is further classified in three types- border irrigation, check basin irrigation and furrows irrigation as given in schematic diagram above. Two general requirements of prime importance to obtain high efficiency in surface methods of irrigation are properly constructed water distribution systems to provide adequate control of water to the fields and proper land preparation to permit uniform distribution of water over the field. In the following sections, we will be covering three widely used methods of surface irrigation, i.e. border strip, check basin and furrow irrigation.

6.4 BORDER IRRIGATION

In border strip irrigation, uses land formed into strips which are leveled across the narrow dimension, i.e. width but sloping along the long dimension, i.e. length, are formed. Ridges or borders bound these strips. A border strip can be formed as straight one or along the contour. Accordingly border strip irrigation may be classified as straight or contour. During irrigation, water is turned into the upper end of the border strip, and advances down the strip. After a time, the water is turned off, and a recession front where standing water has soaked into the soil, moves down the strip. These phases are termed as advance and recession phases. High irrigation efficiencies can be obtained with this method of irrigation, but are rarely realised in practice, due to the difficulty of balancing the advance and recession phases of water application. Border strip irrigation is one of the most complicated of all irrigation methods and its efficiency depends on the degree to which design specifications are adhered to. Normally at field level, design and operations are not managed properly due to different technical and social factors, the efficient water application is not realised. In fact, because of the large variations in field conditions that occur during the season, the operator or irrigator can have as great an effect on irrigation efficiency as the system designer. Border method is suitable to irrigate all close growing crops like wheat, barley, fodder crops and legumes but not suitable for crops like paddy where ponding of water is necessary during the life of the crop.

Types of Border Irrigation

Two types of borders are formed :

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 siope economically.

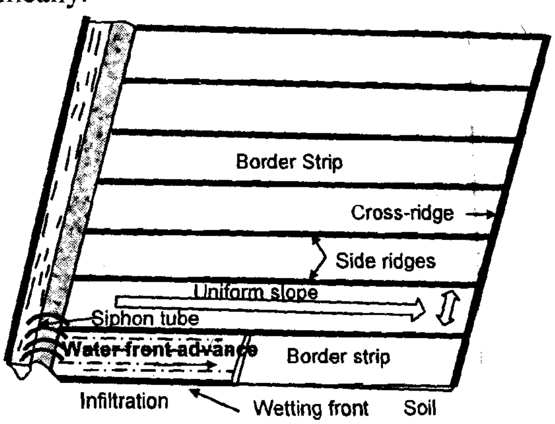

Figure 6.2 : Schematic Sketch Illustrating the Layout of an Impounding Type Border Irrigation System

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 not different.

6.4.1 Primary Design Factors

Successful operation of border method depends upon appropriateness of design and operation of the system. The primary design factors of a border irrigation system are :

(a) Border length and slope

(b) Stream size per unit width of border

(c) Soil moisture deficiency at the time of irrigation

(d) Soil intake rate

(e) Degree of flow retardance by the crop as the water flow down the strip.

Proper design requires careful consideration of hydraulic of flow in border along with accumulated infiltration- time relationship of the soil under existing soil conditions and vegetation and hydraulic resistance. Detail description of these is avoided here, however, some general suggestion on width length, slope of border and stream of irrigation system is described in the subsequent section.

6.4.2 Border Specifications and Stream Size

It would be prudent to present major specification for different soil and slope conditions to enable the irrigator and user to decide appropriate size of border strip. The major specifications are described below. Many of these specifications will depend on the size of the field also.

Width of Border Strip

The width of a border usually varies from 3 to 15 meters, depending on the size of the irrigation stream available and the degree of land levelling practicable. When the size of the irrigation stream available is small, the width is reduced.

Border Length

For moderate slopes and small to moderate size irrigation streams, the following border lengths are suggested :

Sandy and sandy loam soils	:	60 to 120 meters
Medium silt loam soils	:	100 to 180 meters
Clay loam and clay soils	:	150 to 300 meters

Border Slope

The border should have a uniform longitudinal gradient. Excessive slopes will make the water run to the lower end quickly, causing breach the bund at the downstream. The recommended slope for different texture soil is given below :

Table 6.1

Soil Texture	Recommended Slope
Sandy loam to sandy soils	0.25% to 60%
Medium silt loam soils	0.20% to 0.40%
Clay to clay loam soils	0.05% to 0.20%

The main factors that influence stream sizes of border irrigation are border length and slope infiltration rate, and soil type. Some typical values of stream sizes for different soil types and slopes are given in Table 6.2. The flow per meter width of border strip is highest for sandy soil with infiltration rate of 2.5 cm/hour.

Table 6.2 : Some Typical Values of Stream Sizes for Different Soil Types and Slopes

Soil type	Border Slope (%)	Flow Per Meter Width of Border Strip (lps)
Sandy soil, infiltration rate 2.5 cm per h	0.20-0.40	10-15
	0.40-0.65	7-10
Loamy sand, infiltration rate 1.8 to 2.5 cm per h	0.2-0.4	7-10
	0.40-0.60	5-8
Sandy loam, infiltration rate 1.2 to 1.8 cm per h	0.20-0.40	5-7
	0.40-0.60	4-6
Clay loam, infiltration rate 0.6 to 0.8 cm per h	0.15-0.30	3-4
	0.30-0.40	2-3
Clay, infiltration rate 0.2 to 0.6 cm per h	0.1-0.2	2-4

As in many cases, fields are not levelled it becomes disadvantageous to opt for border irrigation .At certain locations there may be impounding of water and some locations may be bereft of water supply. This may lead to uneven irrigation, which is bad for crop growth.

Advantages

(a) Construction of border ridges is easy as equipment like tractor drawn bund former or disc ridger can be used.

(b) Labour requirement is reduced in comparison to check basin irrigation.

(c) Uniform distribution and high use efficiency if properly planned and designed.

(d) Large irrigation stream can be advantageously used.

(e) Easy operation.

SAQ 1

(a) Discus the factors affecting the selection of irrigation system.

(b) Explain border strip method with a suitable example.

6.5 CHECK BASIN IRRIGATION

This is another important method of surface irrigation. In this irrigation system, water is applied to a completely level or dead-level area enclosed by dikes or borders. This requires perfectly level field which becomes a limitation in many cases at fielded level. This method of irrigation is used successfully for both field and row crops. The check basin irrigation may be classified as rectangular, contour and ring type. Thus, the basins need not be rectangular or straight sided, and the border dikes may or may not be permanent. The floor of the basin may be kept flat, ridged or shaped into beds, depending on crop and cultural practices. This irrigation technique is known by a variety of other names like check flooding; level borders; check irrigation; check-basin irrigation; dead-level irrigation; and level- basin irrigation. These different names are based on its characteristics and shape.

Design Considerations

(a) Basin size is main design parameter in check basin,

(b) available water stream size,

(c) topography,

(d) soil factors, and

(e) degree of leveling required.

There is wide variation in basin size. It may be quite small in certain cases and may be as large as 40 acres or so in situation depending upon field size and other factors mentioned above.

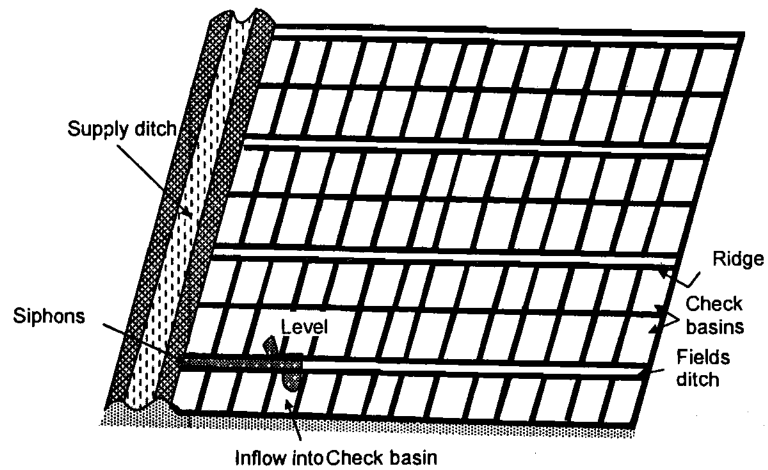

Figure 6.3 : Layout of Check Basin Method of Irrigation(Schematic Sketch)

Advantages

There are number of advantages of check basin irrigation. A few are listed below :

(a) Level basins improves water management, since the irrigator need only supply a specified volume of water to the field. If properly planned, it improves water use efficiency. With adequate stream size, the water will spread quickly over the field minimizing non-uniformities in inundation time.

(b) Basin irrigation is most effective on uniform soils, precisely leveled, when large stream sizes (relative to basin area) are available. High efficiencies can be obtained with low labor input.

(c) The distinguishing features of the uses of the check basin method of irrigation are that it involves the size and slope of the basins. Use will also be guided by the fact whether irrigation is accomplished by intermittent or continuous ponding of water in the basins.

Types of Check Basins, Based on Size and Shape

The size of check basins may vary from one meters 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. The vertical interval between contour ridges usually varies from 6 to 12 cm in case of upland irrigated crops like wheat and 15 to 30 cm in case of low land irrigated crops like rice.

Water Requirement of Check Basin Irrigation

The requirement of irrigation water is estimated by the following equation :

Total volume of water required = Area of basin × Net depth of irrigation

$$A\,(\text{m}^2) \times d\,(\text{m})$$

Example 6.1

An irrigation stream of 27 liters per second is diverted to a check basin of size 12 m × 10 m. The water holding capacity of the soil is 14 %. The average soil moisture in the crop root zone prior to applying water is 6.5 %. How long should the irrigation stream be applied to the basin to replenish the root zone moisture to its field capacity, assuming no loss to deep percolation. The average depth of crop root zone is 1.2 m. The apparent specific gravity of the root zone soil is 1.5.

Solution

The check basin is of rectangular shape. The stream basin capacity is 27 litre per second.

Net irrigation required = Field capacity – Available soil moisture content

$$= 14 - 6.5 = 7.5\ \%$$

$$= 1.5 \times 7.5 = 11.25\ \text{cm/m of soil depth}$$

The average depth of root zone = 1.2 m

$$= 11.25 \times 1.2 = 13.5\ \text{cm}$$

Total volume of water required in the check basin

= Area of basin × Net depth of irrigation

$$= 12 \times 10 \times \frac{13.5}{100} = 16.2\ \text{cu m} = 16{,}200\ \text{litres}$$

$$\text{Required duration of irrigation} = \frac{16200}{27} = 600\ \text{seconds} = 10\ \text{minutes}.$$

6.6 FURROW IRRIGATION

Furrow irrigation system is used in vegetables. It has advantage that water is not applied on the whole field rather water is applied in furrows. This saves water at the same time, plant is not in direct contact with water as some plant like that of vegetables are very sensitive to ponded water. Furrows are sloping channels formed in the soil. Infiltration occurs laterally and vertically through the wetted perimeter of the furrow. The plant gets water in its root zone, however, plant is not in direct touch with water.

Irrigation furrows may be classified into two general types based on their alignment. They are :

(a) straight furrows, and

(b) contour furrows.

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.

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.

Based on their size and spacing furrows may be classified as deep furrows and corrugations. In general, small plants need small furrows; like vegetables need furrows of 7.5 to 12.5 cm depth while some row crops like orchards much *deeper furrows*. A *corrugation irrigation* consists of running water in small furrows called corrugation which direct the flow down the slope. Corrugations are V-shaped or U-shaped channels about 6 to 10 cm deep, spaced 40 to 75 cm apart. It is commonly used for irrigating non-cultivated crops like small grains and pastures growing on steep slopes.

Design Considerations

Furrow irrigation systems may be designed with a variety of shapes and spacings. Optimal furrow lengths are primarily controlled by intake rates and stream size. The intake rates in furrows may be quite variable, even when soils are uniform, due to cultural practices. The intake rate of a new furrow will be greater than a furrow that has been irrigated, and wheel row furrows can have greatly reduced infiltration rates due to compaction. Because of the many design and management controllable parameters, furrow irrigation systems can be utilised in many situations, within the limits of soil uniformity and topography. With runoff return flow systems, furrow irrigation can be a highly uniform and efficient method of applying water. However, the uniformity and efficiency are highly dependent on proper management, so mismanagement can severely degrade system performance.

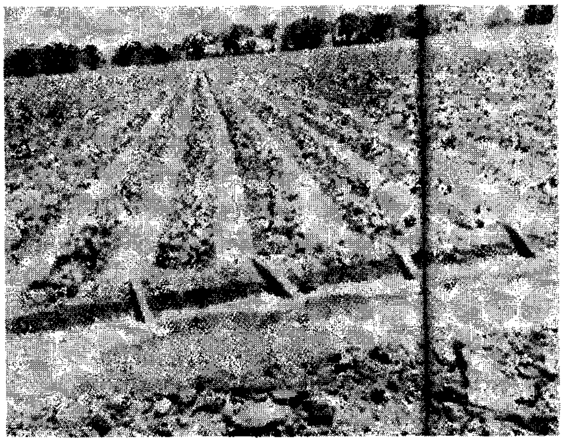

Fig 6.4 : Furrow Irrigation of a Vegetable Crop

Table 6.3 : Recommended Length of Furrows for Different Soil Types Furrow Length and Depth of Irrigation

Furrow Slope, %	Furrow Length, Meters						
	Slope Type						
	Clays		Loams		Sands		
	Net Depth of Water Application						
	7.5 cm	10 cm	5 cm	10 cm	5 cm	7.5 cm	10 cm
0.05	300	400	120	270	60	90	150
0.10	350	440	180	330	90	120	190
0.20	370	470	220	370	120	190	250
0.30	390	500	280	400	150	225	280
0.50	380	500	280	370	120	190	250
1.00	270	400	250	300	90	150	220

Estimation of Discharge Rate in Furrow Irrigation

The maximum non-erosive flow rate in furrows is estimated by the following empirical equation :

$$q_m = 0.60/s$$

where, q_m = Maximum non-erosive stream, liters/second, and

s = Slope of furrow, %.

The average depth of water applied during irrigation can be calculated from the following relationship :

$$d = \frac{q \times 360 \times t}{w \times L}$$

where, d = Average depth of water applied, cm,

q = Stream size, liter per second,

t = Duration of irrigation, hours,

w = Furrow spacing, meters, and

L = Furrow length, meters.

Example 6.2

Furrow 90 m long and spaced 75 cm apart are irrigated by an initial furrow of two liters per second. The initial furrow stream reached the lower end of the field in 50 minutes. The size of the stream was then reduced to 0.5 liters per second. The cut back stream continued for 1 hour. Estimate the average depth of irrigation.

Solution

Average depth of irrigation by the initial furrow stream,

$$d = \frac{q \times 360 \times t}{w \times L}$$

$$= \frac{2 \times 360 \times 50}{0.75 \times 90 \times 60} = 8.88 \text{ cm}$$

Average depth of irrigation by the cut back stream $= \dfrac{0.5 \times 360 \times 1}{0.75 \times 90} = 2.66$ cm

Net average depth of irrigation = 8.88 + 2.66 = 11.54 cm.

Suitability and Limitations of Surface Irrigation Methods

Some form of surface irrigation is adaptable to almost any vegetable crop. Basin and border strip irrigation have 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. Uniform, mild slopes are also be automated to some degree to reduce labor requirements. The complicated "art" of border irrigation (and to a lesser extent furrow irrigation) requires skilled irrigators to obtain high efficiencies. The labor skill needed for setting border or furrow flows can be decreased with higher cost equipment. The setting of siphons or slide openings to obtain the desired flow rate is a skilled job, but one that can be learned. With surface irrigation, little or no energy is required to distribute the water throughout the field, but some energy may be extended in bringing the water to the field, especially when water is pumped from groundwater. In some instances these energy costs can be substantial, particularly with low water use efficiencies. Some labor and energy will be necessary for land grading and preparation.

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 size of farm canals.

6.7 MICRO IRRIGATION METHOD

Micro irrigation methods are precision irrigation methods of irrigation with very high irrigation water efficiency. In many parts of the country there is decline of irrigation water and conventional methods are having low water use efficiency. To surmount the problem, micro irrigation methods has recently been introduced in Indian agriculture. These methods save a substantial amount of water and helps increasing crop productivity particularly valuable cash crops like vegetables. The research results have confirmed a substantial saving of water ranging between 40 to 80% and there are reports of two times yield increase for different crops crops by using micro irrigation. Two main micro irrigation systems are :

(a) Sprinkler Irrigation

(b) Drip Irrigation

6.7.1 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.

SAQ 2

(a) Discuss the design consideration of check basin irrigation and furrow irrigation.

(b) What are the advantages of micro irrigation?

6.8 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.

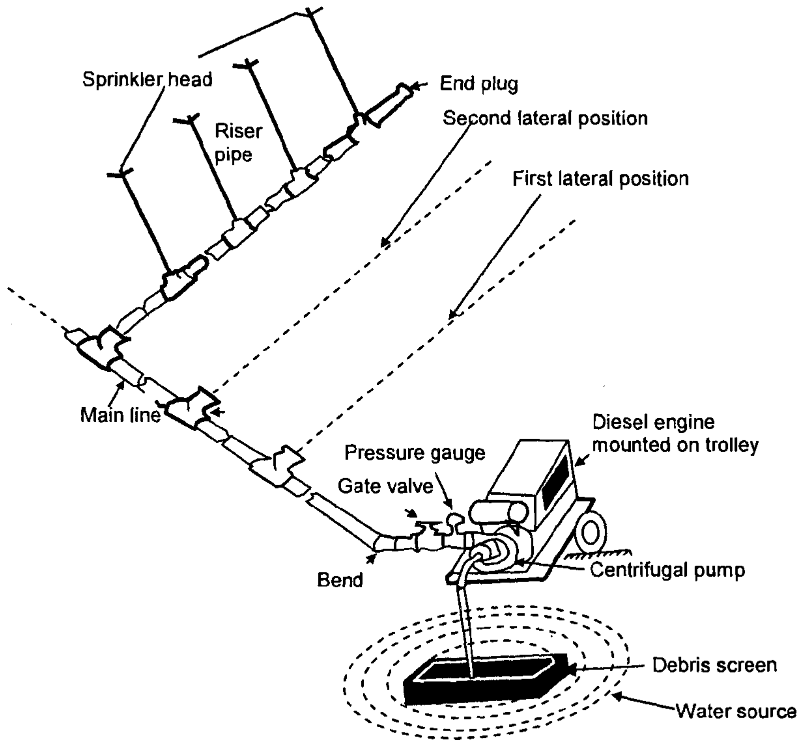

Figure 6.5 : Component of a Sprinkler Irrigation System

6.8.1 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.

6.8.2 Components of Sprinkler Irrigation System

The components of portable sprinkler system are shown through Figure 6.5. A 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. Most soils can be irrigated with the sprinkler method, although soils with an intake rate below 0.5 cm per hour may require special measures. Sprinklers are applicable to soils that are too shallow to permit surface shaping or too variable for efficient surface irrigation. In general, sprinklers can be used on any topography that can be formed. Land leveling is not normally required.

As for as water quantity and quality is concerned, leaching salts from the soil for reclamation can be done with sprinklers. Using much less water than is required by flooding methods (although a longer time is required to accomplish the reclamation). This can be particularly important in areas with a high water table. A disadvantage of sprinkler irrigation is that many crops (citrus, for example) are sensitive to foliar damage when sprinkled with saline waters.

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. At the other extreme, center pivot, linear move and LEPA systems require considerable skill in operation and maintenance, but the overall amount of labor needed is low. Energy consumption relates to operating pressure requirements, which vary considerably among sprinkler systems. At the extremes, the LEPA systems may require only 15 PSI or so, while the traveling gun system may require 100 PSI or more. Other systems may use 30 to 60 PSI, depending on design of the sprinklers and nozzles chosen.

Advantages of Sprinkler Irrigation

The simple portable sprinkler set in India costs around Rs. 15000 to 20000 per set by which the farmer can cover an area not less than 1 ha. The trials conducted in some of the state for various crops in the different agro climatic conditions has clearly indicated that, apart from water savings, there has been nominal increase in the net return on unit area basis ranging from nil to Rs. 760 per hectare in different crops. But, economics worked on the basis of the additional area that can be brought under irrigation with the saved water, showed that the net income could be increased substantially to as high as Rs. 32000.

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, %.

Example 6.3

Determine the system capacity for a sprinkler irrigation system to irrigate 16 hectares of maize crop. Design moisture use rate is 5 mm per day. Moisture replaced in soil at each irrigation is 6 cm. Irrigation efficiency is 70 %. Irrigation period is 10 days in a 12 day interval. The system is to be operated for 20 hours per day.

Solution

Given $A = 16, F = 10, h = 20, d = 6$

System capacity, $Q = 2780 \times \frac{16 \times 6}{10 \times 20 \times 70}$

$= 19$ liters/sec.

6.9 DRIP IRRIGATION

Drip irrigation, also known as *trickle irrigation* or *microirrigation* is an irrigation method 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 becoming 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. These are generally used on tree and vine crops with wider root zones. Subsurface drip irrigation (SDI) uses permanently or temporarily buried dripper line or drip tape located at or below the plant roots. Pump and valves may be manually or automatically operated by a controller. The modern technology of drip irrigation was invented in Israel.

Drip irrigation is the slow, frequent application of water to the soil though emitters placed along a water delivery line. The term drip irrigation is general, and includes several more specific methods. Drip irrigation applies the water through small emitters to the soil surface, usually at or near the plant to be irrigated. 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. Bubbler irrigation is the application of a small stream of water to the soil surface. The applicator discharge rate (up to 250 liters per hour) exceeds the soil's infiltration rate, so the water ponds on the soil surface. A small basin is used to control the distribution of water. Micro-spray irrigation applies water to the soil surface by a small spray or mist. Discharge rates are usually less than 120 liters per hour.

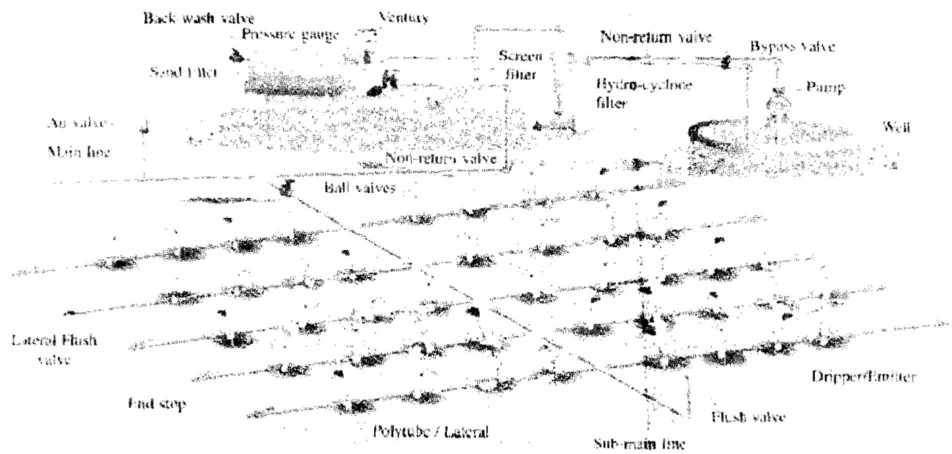

Figure 6.6 : Schematic Layout of a Typical Drip Irrigation System

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 Control 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).

Suitability and 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. The main limitation of drip irrigation system is the cost of the system, which can be quite high for closely-spaced crops. That is why, it is highly suitable for vegetable crops. Drip irrigation is suitable for most soils, with only the extremes causing any special concern. On very fine textured soils, drip application rates may cause ponding, with potential runoff, erosion and aeration problems. On very coarse textured soils, lateral movement of water under the applicators will be limited, so more emission outlets per plant may be required to wet the desired root area. With proper design, using pressure compensating emitters and pressure regulators if required, drip irrigation can be adapted to virtually any topography. In some areas, drip irrigation is successfully practiced on such steep slopes that cultivation becomes the limiting factor.

(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. Drip irrigation can be used successfully with waters of some salinity, although some special cautions are needed. Salts will tend to concentrate at the perimeter of the wetted soil volume. If too much time passes between irrigations, the movement of soil water may reverse itself, bringing salts back into the root zone. Salts concentrating on the surface around the edge of the surface wetted area can be a hazard should a light rain occur. Such a rain can move the salts down into the root zone, without applying enough water to leach the salts through and below the root zone. When rain falls after a period of salt accumulation, irrigation should continue as normal until about 50 mm of rain have fallen to prevent salt damage. In arid regions where annual rainfall is insufficient (less than 300 to 400 mm) to leach the salts, artificial leaching may be necessary from time to time, requiring the use of a supplemental sprinkler or surface irrigation system.

(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. The sensitivity of emitters to plugging varies with design, but virtually all emitters will require some degree of water treatment in agricultural situations. Cyclonic-separators and screen filters are used to remove inorganic particles from the irrigation water, and media filters are used to remove organic contaminants. Chemical treatment of the water may also be required to control biological activity in the water to adjust pH, or to prevent chemical precipitation which could plug emitters. Proper design and care of the water treatment system is vital to the successful use of drip irrigation.

(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%. With reasonable care and maintenance field efficiencies in the range of 80 to 90% may be expected. Where plugging is a problem, or emitter performance is highly variable field efficiencies may be as low as 60%.

(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, and are designed for long irrigation times. The systems are easily operated manually. But can also be fully automated. Thus, the major labor requirement is for system maintenance and inspection. The amount of maintenance labor required is related to the sensitivity of the emitters to plugging and the quality of the irrigation water. In a vineyard situation, one irrigator can inspect and maintain about 50 acres per day.

(f) Drip irrigation systems generally use less energy than other forms of pressurized irrigation systems. The emission devices usually operate at pressures ranging from 5 to 25 PSI. Additional pressure is required to compensate for pressure losses through the control head (filters and control valves) and the pipe network. System pressures range from about 30 PSI (small systems on flat terrain) to 60 PSI (larger systems on undulating terrain).

(g) Economic factors need special attention in case drip irrigation system as initial cost and operational cost is reasonably high. Drip systems costs can vary greatly. Depending on crop (plant. and therefore. emitter and hose spacings) and type of hose employed (permanent or "disposable" thin-walled tubing). Drip costs will be the lowest for widely-spaced orchard crops. Government of India has taken a number of initiatives including subsidy to popularise this method of irrigation methods. It is being used on large commercial scale now in different parts of the country particularly Western and Southern part and pockets of Northern India.

Advantages

The advantages of drip irrigation are :

(a) Minimised fertilizer/nutrient loss due to localized application and reduced leaching, allows safe use of recycled water.

(b) High water distribution efficiency. Moisture within the root zone can be maintained at field capacity.

(c) Leveling of the field not necessary. Soil type plays less important role in frequency of irrigation, minimised soil erosion.

(d) Highly uniform distribution of water, i.e. controlled by output of each nozzle.

(e) Lower labour cost.

(f) Early maturity and good harvest.

(g) Foliage remains dry thus reducing the risk of disease.

Table 6.4 : Comparative Performance of Conventional Irrigation with Drip Irrigation

Performance Indicator	Conventional Irrigation Methods	Drip Irrigation
Water saving	Waste lot of water. Losses occur due to percolation, runoff and evaporation	40-70% of water can be saved over conventional irrigation methods. Runoff and deep percolation losses are nil or negligible.
Water use efficiency	30-50%, because losses are very high	80-95%
Saving in labour	Labour engaged per irrigation is higher than drip	Labour required only for operation and periodic maintenance of the system
Weed infestation	Weed infestation is very high	Less wetting of soil, weed infestation is very less or almost nil.
Use of saline water	Concentration of salts increases and adversely affects the plant growth. Saline water cannot be used for irrigation	Frequent irrigation keeps the salt concentration within root zone below harmful level
Diseases and pest problems	High	Relatively less because of less atmospheric humidity
Suitability in different soil Type	Deep percolation is more in light soil and with limited soil depths. Runoff loss is more in heavy soils	Suitable for all soil types as flow rate can be controlled
Water control	Inadequate	Very precise and easy
Efficiency of fertilizer use	Efficiency is low because of heavy losses due to leaching and runoff	Very high due to reduced loss of nutrients through leaching and runoff water
Soil erosion	Soil erosion is high because of large stream sizes used for irrigation.	Partial wetting of soil surface and slow application rates eliminate any possibility of soil erosion
Increase in crop yield	Non-uniformity in available moisture reducing the crop yield	Frequent watering eliminates moisture stress and yield can be increased up to 15-150% as compared to conventional methods of irrigation

Table 6.5 : Extent of Water Saving and Increase in Yield with Drip Irrigation Systems

Crops	Water Saving (%)	Increase in Yield (%)
Sugarcane	50	99
Tomato	42	60
Watermelon	66	19
Cucumber	56	45
Chili	68	28
Cauliflower	68	70
Okra	37	33
Ground nut	40	152
Mulberry	22	23
Banana	45	52
Grapes	48	23
Sweet lime	61	50
Pomegranate	45	45

Source : INCID 1994 Drip irrigation in India, New Delhi.

NCPAH, 2001 Progress Report, Ministry of Agriculture Govt. of India, New Delhi.

6.10 FERTIGATION

Fertigation is the process of application of water soluble solid fertilizer or liquid fertilizers through drip irrigation system. Through fertigation nutrients are applied directly into the wetted volume of soil immediately below the emitter where root activity is concentrated. Fertigation is practiced only in drip irrigation system. However, fertilizer solution can be added with sprinkler irrigation system also. The method of adding fertilizer solution through the suction side of a centrifugal pump is shown in Figure 6.7.

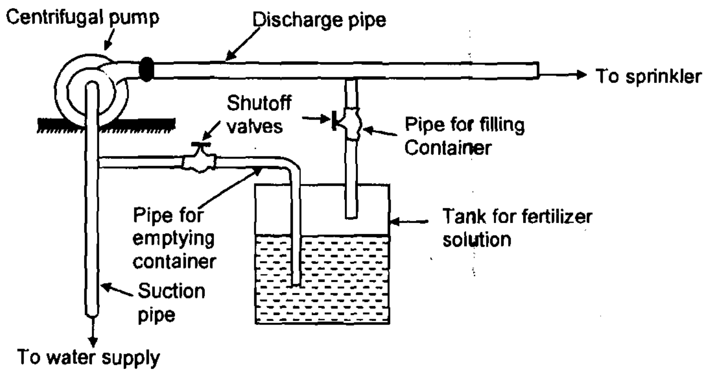

Figure 6.7 : Adding Fertilizer in Solution through the Suction Side of a Centrifugal Pump

Components of Fertigation

The main component of a fertigation is drip irrigation system. The main components are :

(a) Venturi pump (injector)

(b) Fertilizer tank with flow bypass

(c) Pressure bypass tank

(d) Injection pump.

The operation principle of venture is to create a pressure difference due to presence of constriction in the pipeline. The constriction creates high velocity of the solution, as an effect of continuity principle, due to that head loss is created in the constriction. This creates suction effect, which is used by the pump to suck the fertilizer solution into the main line. The injector operates over a wide range of pressure.

Computing Fertilizer Quantities

Fertilizer recommendations are given in many different ways, such as :

(a) Tables of fertilizers.

(b) Results of laboratory tests by extension service.

(c) Direct advice in the field by crop specialists.

The data may be expressed as: weight or volume of fertilizer; amount of fertilizer element; concentration in the irrigation water; fertilizer water ratio and others.

By Weight per Unit Area

The recommendation is expressed as kg/ha/day.

$$\text{Fertilizer required, kg/ha/day} = \frac{\text{Fertilizer element, kg/ha}}{\text{\% of element in the fertilizer}} \times 100$$

By Volume per Unit Area

When liquid fertilizer is used, it is easier, in preparation and control, to use the volume measured.

$$\text{Volume of fertilizer required, 1/ha} = \frac{\text{Weight of fertilizer, kg/ha}}{\text{Density of fertilizer, kg/1}} \times 100$$

Quantity per Irrigation Shift

It is used when the fertilizer is applied during a specific irrigation without reference to duration or diluation.

$$\text{Amount of fertilizer (kg or l)} = \text{Per hectare application} \times \text{Area}$$

Calibration of Fertilizer Tank in Bypass Flow

$$\text{Rate of delivery, l/min} = \frac{\text{Volume of water, l}}{\text{Duration of fertilizer ion, min}}$$

By Weight per Unit Area

$$\text{Weight, g/m}^3 = \frac{\text{Concentric on of element, ppm}}{\text{\% of element in the fertilizer}} \times 100$$

Advantages of Fertigation

(a) The fertilizer solution is distributed evenly in the irrigation network with the same uniformity as the irrigation water.

(b) The availability of nutrients including micro-nutrients is high, therefore the efficiency is very good.

(c) The fertilizer system can also be used for other activities such as incorporating acid to flush the drip system.

(d) It eliminates the work of spreading fertilizer. Manual spreading of fertilizer causes soil compaction and may damage the growing crop.

(e) Fertilizer placement is exactly to the root zone of plant and can be uniformly applied through drip irrigation system.

(f) All types of nutrients can be given simultaneously.

(g) Lower doses of fertilizer could be applied daily or weekly (i.e. a large number of split application) to avoid leaching and fixation in soil.

(h) Some liquid fertilizers are free of sodium and chloride salts, so these are not harmful to soil.

(i) Optimum production in light soil is possible.

(j) Spraying with liquid fertilizer is possible.

(k) Liquid fertilizers are immediately available to plants.

(l) Fertilizer use efficiency can be increased by 25 to 30% over the tradition method of fertilizer application.

(m) It decreases labour and energy cost.

(n) The quality and quantity of crop production can be improved.

Limitations

The fertigation system also has some limitations. The main one is the danger of poisoning people who drink the irrigation water particularly laborers those work on the farm. It is therefore necessary to warn the people in the field about drinking water separately and put up warning signs. The reverse flow of water mixed with fertilizer must be prevented.

Toxicity and Contamination

Care must be taken whenever fertilizer solution is introduced into a water supply system.

Fertilizer Suitability

Slowly water-soluble fertilizer such as super phosphate or calcium ammonium phosphate is not suitable. This method is suitable for liquid fertilizers or those that are readily soluble in water.

Corrosion

The metallic parts of the equipment are highly prone to corrosion. Sensitive parts of the equipment must be made out of corrosion resistant materials and extra care should be taken when filling the tanks.

Chemical Reaction in the Network

Certain fertilizer, e.g. phosphates may be subjected to precipitation within the pipeline depending on pH reaction. Criteria for applying fertilizers through drip system.

All the chemical fertilizers applied through drip irrigation systems must meet the following criteria :

(a) They must avoid corrosion, softening of plastic pipe and tubing or clogging of any component of the system.

(b) Fertilizers must be safe for field use.

(c) They must increase or at least not decrease crop yield.

(d) Fertilizers should be 100 per cent water soluble so as to leave no residue in the system.

(e) They should not react adversely with salts or other chemicals in the irrigation water.

In addition, the fertilizers must be distributed uniformly throughout the field. Distribution of fertilizers to a field depends on flow characteristics of water in the system and the uniformity of water application by emitters. A drip irrigation system should be designed with no more that 5% discharge variation and close to or above 94% emission uniformity. As the system clogs, discharge variation will increase, causing more variation in the fertilizer application.

SAQ 3

(a) What are the merits and demerits of sprinkler and drip irrigation system?

(b) Discuss fertigation.

6.11 SUMMARY

This unit discusses about the surface irrigation methods, such as, border irrigation, check basin irrigation, furrow irrigation, micro irrigation, drip irrigation and sprinkler irrigation. The advantages and disadvantages of each method is given in detail. Beside this, the fertigation which is the process of application of water soluble solid fertilizer of liquid fertilizers through drip irrigation system, is explained.

6.12 KEY WORDS

Border Irrigation : It uses land formed into strips which are located across the narrow dimension, but sloping along the long dimensions.

Check Basin Irrigation : In this irrigation system, water is applied to a completely level or dead level area enclosed by dikes or boarders.

Furrow Irrigation : Furrows are sloping channels formed in the soil. Infiltration occurs laterally and vertically through the wetted perimeter of the furrow and plants get water in its root zone.

Sprinkler Irrigation : In this system of irrigation, water is delivered through a pressurised pipe network to sprinklers nozzle or jets which spray water into the air.

Drip Irrigation : It minimises the use of water and fertilizer by allowing water to drip slowly to the roots of plants.

Fertigation : It is the process of application of water soluble solid fertilizer or liquid fertilizer through drip irrigation system.

6.13 ANSWERS TO SAQs

SAQ 1

(a) Refer Section 6.2.

(b) Refer Section 6.4.

SAQ 2

(a) Refer Sections 6.5 and 6.6

(b) Refer Section 6.7.

SAQ 3

(a) Refer Sections 6.8 and 6.9.

(b) Refer Section 6.10.