INTRODUCTION TO

IRRIGATION PRINCIPLES

A GUIDELINE MANUAL

To Undergraduate students for Agriculture College

Prepared by:

Dr. EZZAT FINDI

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Preface

The manual providing the reader with additional information on the various types of field Intakes, the measuring of the discharge of a siphon or spile, and the measuring of water by different types of method.

In addition, the manual describes in some detail the basin and border irrigation methods. Also, the furrow, sprinkler and drip irrigation methods are discussed.

On the other hand, the papers contain material that is intended to provide support for irrigation training courses and to facilitate their conduct.

Thus, taken together, they do not present a complete course in themselves, but I hope it helpful to use those papers or sections that are relevant to the specific irrigation conditions under discussion.

The material may also be useful to individual students who want to review a particular subject without a teacher.

E.FINDI
Julay, 2012, Duhok

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IRRIGATION-1

General introduction

An adequate water supply is important for plant growth. When rainfall is not sufficient, the plants must receive additional water from irrigation.

Various methods can be used to supply irrigation water to the plants. Importance of irrigation

Definition:

Irrigation means the action of applying water to land in order to supply crops and other plants with necessary water.

Objectives of irrigation

- To Supply Water Partially or Totally for Crop Need
- To Cool both the Soil and the Plant
- To Leach Excess Salts
- To improve Groundwater storage
- To Facilitate continuous cropping
- To Enhance Fertilizer Application- Fertigation

Purpose of irrigation

Irrigation is the process of supplying water, in addition to natural precipitation, to field crops, orchards, vineyards, or other cultivated plants. Irrigation water is applied to ensure that the water available in the soil is sufficient to meet crop water needs. The role of irrigation is to improve production and the effectiveness of other inputs.

Importance of Irrigation:

- In the next 35-45- years, world food production will need to double to meet the demands of increased population.
- 90% of this increased food production will have to come from existing lands.
- 70% of this increased food production will have to come from irrigated land.

Benefits of Irrigation:

1. Increase in Crop Yield
2. Protection from famine
3. Cultivation of superior crops
4. Elimination of mixed cropping
5. Economic development
6. Hydro power generation
7. Domestic and industrial water supply

Irrigation water

Water use for irrigation

Agriculture is by far the largest water use at global level. Irrigation of agricultural lands accounted for 70% of the water used worldwide. In several developing countries, irrigation represents up to 95% of all water uses, and plays a major role in food production and food security.

Future agricultural development strategies of most of these countries depend on the possibility to maintain, improve and expand irrigated agriculture

On the other hand, the increasing pressure on water resources by agriculture faces competition from other water use sectors and represents a threat to the environment.

Water is a resource that may create tensions among countries down and upstream. Irrigated agriculture is driving much of the competition since it accounts for 70-90% of water use in may of these regions.

Water resources for irrigation:

Water used for agriculture comes from natural or other alternative sources.

Natural sources include rainwater and surface water (lakes and rivers). These resources must be used in a sustainable way. Rainwater resources rely on the atmospheric conditions of the area. Surface water is a limited resource and normally requires the construction of dams and reservoirs with a significant environmental impact.

Alternative sources of irrigation water are the reuse of municipal wastewater and drainage water.

However, the use of recycled water for irrigation may have some adverse impacts on the public health and the environment. This will depend on the recycled water application, soil characteristics, climate conditions and agronomic practices.

Therefore, it is important that all these factors be taken into account in the management of recycled water.

Irrigation water quality:

The water quality used for irrigation is essential for the yield and quantity of crops, maintenance of soil productivity, and protection of the environment. For example, the physical and mechanical properties of the soil, ex. soil structure (stability of aggregates) and permeability are very sensitive to the type of exchangeable ions present in irrigation waters.

Irrigation water quality can best be determined by chemical laboratory analysis. The most important factors to determine the suitability of water use in agriculture are the following:

- *PH*
- *Salinity Hazard*
- *Sodium Hazard (Sodium Adsorption Ration or SAR)*
- *Carbonate and bicarbonates in relation with the Ca & Mg content*
- *Other trace elements*
- *Toxic anions*
- *Nutrients*
- *Free chlorine*

Salinity Hazard

Salt content in irrigation water

The excess of salts content is one of the major concerns with water used for irrigation. A high salt concentration present in the water and soil will negatively affect the crop yields, degrade the land and pollute groundwater.

The suitability of water reuse for irrigation with high salt content depends on the following factors:

- Salt tolerance of the type of crop.

- Characteristics of the soil under irrigation

- Climate conditions.

The quality of the irrigation water plays an essential role in arid areas affected by high evaporation rates and cause high concentrations of salt accumulating in the soil.

- Soil and water management practices.

In general, water reuse for irrigation purposes must have a low to medium salinity level (i.e. electrical conductivity of 0.6 to 1.7dS/m). (See table below).

Special account should be taken to coastal areas where the infiltration of seawater poses a high risk of salinity in the water that is then pump from wells to be used in irrigation.

Hazard	TDS (ppm or mg/L)	dS/m or mmhos/cm
None	<500	<0.75
Slight	500-1000	0.75-1.5
Moderate	**1000-2000**	**1.5-3.00**
Severe	**>2000**	**>3.0**

Salinity with moderate content of salts can be used if moderate leaching occurs.

Water with high saline (ECi>1.5) and sodium (SAR>6) should not be used for water irrigation. Nevertheless, in some places with water shortage, water with high salinity concentration is used as a supplement for other sources and therefore a good management, control is essential, and the salt tolerance of the plants must be considered.

If water with a very high salinity is used, the soil must be permeable, drainage must be adequate, water must be applied in excess to provide considerable leaching and salt-tolerance crops should be selected. Real hazard! A percentage of 21% of total irrigated land is estimated to be damaged by salt.

SAR hazard of irrigation

Sodium hazard of irrigation water

High sodium ions in water affects the permeability of soil and causes infiltration problems.

This is because sodium when present in the soil in exchangeable form replaces calcium and magnesium adsorbed on the soil clays and causes dispersion of soil particles (i.e. if calcium and magnesium are the predominant cations adsorbed on the soil exchange complex, the soil tends to be easily cultivated and has a permeable & granular structure).

This dispersion results in breakdown of soil aggregates. The soil becomes hard and compact when dry and reduces infiltration rates of water and air into the soil affecting its structure.

This problem is also related with several factors such as the salinity rate and type of soil. For example, sandy soils may not get damage as easy as other heavier soils when it is irrigated with high SAR water.

Sodium & crops

High sodium concentrations become a problem when the infiltration rate is reduced to such a rate that the crop does not have enough water available or when the hydraulic conductivity of the soil profile is too low to provide adequate drainage.

Other problems to the crop caused by an excess of Na is the formation of crusting seed beds, temporary saturation of the surface soil, high pH and the increased potential for diseases, weeds, soil erosion, lack of oxygen and inadequate nutrient availability.

Recycled water can be a source of excess Na in the soil compared with other cations (Ca, K, Mg) and therefore it should be appropriately controlled.

Tolerance	*SAR of irrigation water*	*Crop*
Very sensitive	2-8	Fruits, nuts, citrus, avocat
Sensitive	8-18	Beans
Moderately tolerant	18-46	Clover, oats, rice
Tolerant	46-102	Wheat, barley, tomatoes, beets, tall wheat grass, crested grass

Source: *Extracted from the Australian Water Quality Guidelines for Fresh & Marine Waters (ANZECC)*

What is SAR?

The index used is the Sodium Adsorption Ratio (SAR) that expresses the relative activity of sodium ions in the exchange reactions with the soil. This ration measures the relative concentration of sodium to calcium and Magnesium.

SAR is defined by the following equation:

$$SAR = \frac{Na}{\sqrt{ca + mg / 2}}$$

SAR: Sodium Adsorption Ratio (ion concentrations in meq/L)

Na: Sodium

Ca: Calcium

Mg: Magnesium

SAR Hazard of irrigation water		
	SAR	Notes
None	< 3.0	No restriction on the use of recycled water
Slight to moderate	3.0 - 9.0	From 3 to 6 care should be taken to sensitive crops. From 6 to 8 gypsum should be used. Not sensitive crops. Soils should be sampled and tested every 1 or 2 years to determine whether the water is causing a sodium increase
Acute	> 9.0	Severe damage. Unsuitable

Carbonates & bicarbonates hazard of irrigation water

Bicarbonate hazard of irrigation water: High carbonate ($CO_3^{=}$) and bicarbonate (HCO_3^-) increases SAR index (around >3-4mEq/L or >180-240mg/L). Let us explain why:

Bicarbonate and carbonate ions combined with calcium or magnesium will precipitate as calcium carbonate ($CaCO_3$) or magnesium carbonate ($MgCO_3$) when the soil solution concentrates in drying conditions.

The concentration of Ca and Mg decreases relative to sodium and the SAR index will be bigger. This will cause an alkalizing effect and increase the PH. Therefore, when a water analysis indicates high PH level, it may be a sign of a high content of carbonate and bicarbonates ions.

Residual Sodium Carbonate (RSC)

The RSC has the following equation:

$$RSC= (CO_3^{-}+HCO_3^{-})-(Ca^{2+}+Mg^{+2})$$

It is another alternative measure of the sodium content in relation with Mg and Ca. This value may appear in some water quality reports although it is not frequently used.

If the RSC < 1.25 the water is considered safe

If the RSC > 2.5 the water is not appropriate for irrigation.

Bicarbonate (HCO_3) hazard of irrigation water (meq/L)			
	None	Slight to Moderate	Severe
(meq/L)	<1.5	1.5-7.5	>7.5
RSC	<1.25	1.25 to 2.5	>2.5

Trace elements hazards of irrigation water

Trace elements:

Some elements in irrigation water may be directly toxic to crops. Establishing toxicity limits in water is complicated by reactions, which take place once the water is applied to the soil. When an element is added to the soil from irrigation, it may be inactivated by chemical reactions or it may build up in the soil until it reaches a toxic level.

An element at a given concentration in water may be immediately toxic to a crop because of foliar effects if sprinkler irrigation is used. If furrow irrigation is used, it may require a number of years for the element to accumulate to toxic levels, or it may be immobilized in the soil and never reach toxic levels.

Irrigation waters containing more than 1.0-ppm boron (B) may cause accumulation of toxic levels for sensitive crops.

Irrigation system and pumping station-2

The irrigation system consists of a (main) intake structure or (main) pumping station, a conveyance system, a distribution system, a field application system, and a drainage system (Fig.2.1)

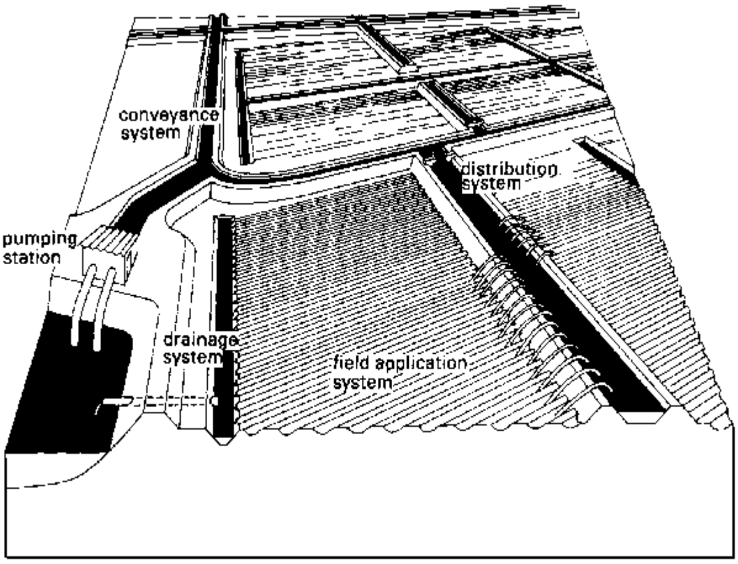


Fig.2.1 (irrigation system and pumping station)

The (main) intake structure, or (main) pumping station, directs water from the source of supply, such as a reservoir or a river, into the irrigation system.

The conveyance system assures the transport of water from the main intake structure or main pumping station up to the field ditches.

The distribution system assures the transport of water through field ditches to the irrigated fields.

The field application system assures the transport of water within the fields.

Main intake structure and pumping station.

The intake structure is built at the entry to the irrigation system (see Fig.2. 2) Its purpose is to direct water from the original source of supply (lake, river, reservoir etc.) into the irrigation system.

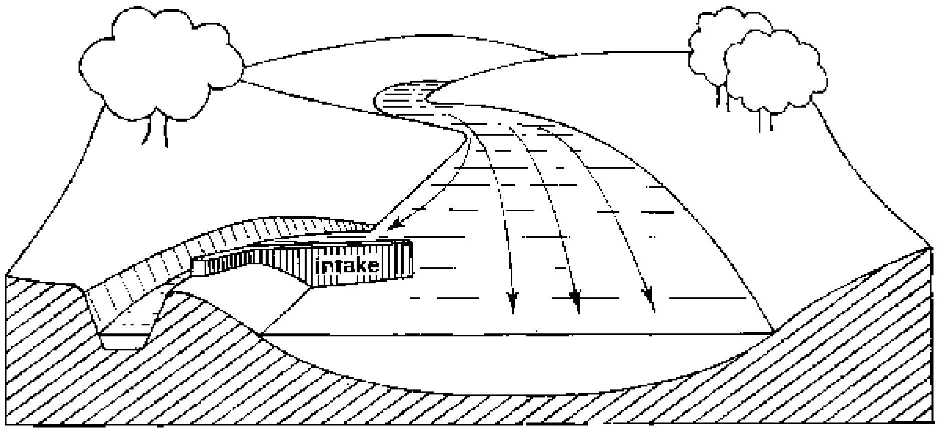


Fig.2.2 (main intake structure).

Pumping station

In some cases, the irrigation water source lies below the level of the irrigated fields. Then a pump must be used to supply water to the irrigation system. (See Fig. 2.3).

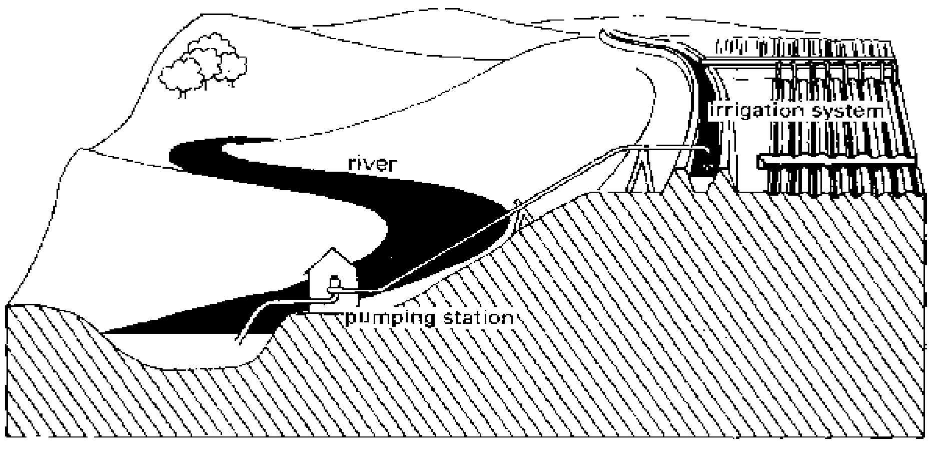
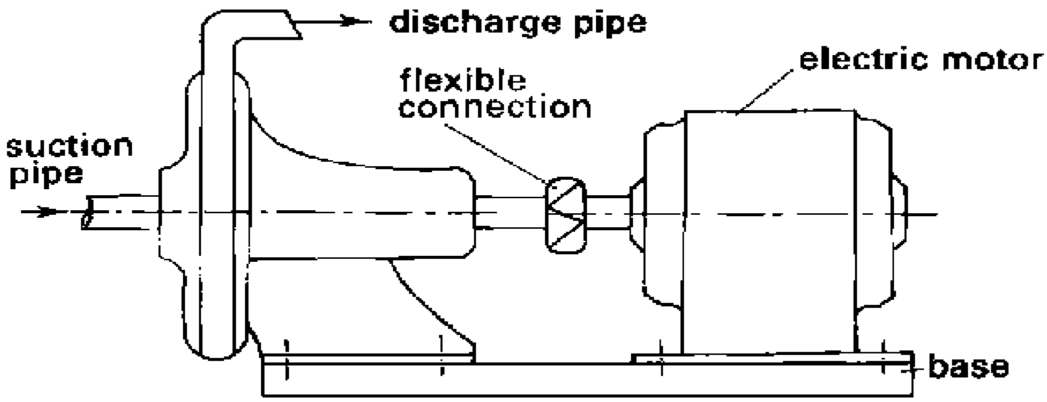


Fig.2.3 (pumping station).



(Diagram of a centrifugal pump

Pumping Lifts:

The vertical distance water is lifted for irrigation purposes vary widely. In some localities, water is lifted only a few feet, in others, it is raised several hundred feet (See Fig. 2.4).

The difference in elevation of the water surface in a pond, lake, or river from which pumped water is taken, and the water surface of the discharge canal into which water flows from a submerged discharge pipe is known as the "static head"

In pumping from ground-water sources, the static head is the difference in the well and the water surface of the discharge canal.

In addition to the static head that pumps must work against pipe frictional resistance, sharp curves in pipes, and other factors

-**Static Suction head**: Distance between the surfaces of water (Source) and pump.

-**Static discharge head**: Distance between the pump and discharge canal.

-**Total Static head**=static suction+static discharge.

-**Friction head**: Loss by the friction and (valve+elbow).

-**Total dynamic head**=Total static head+friction head.

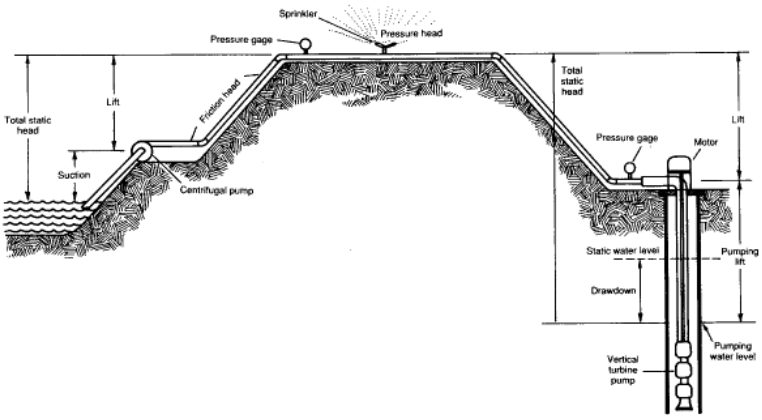


Fig.2.4 (Pumping Lifts)

Conveyance and distribution system:

The conveyance and distribution systems consist of canals transporting the water through the whole irrigation system. Canal structures are required for the control and measurement of the water flow.

Open canals

An open canal, channel, or ditch, is an open waterway whose purpose is to carry water from one place to another. Channels and canals refer to main waterways supplying water to one or more farms. Field ditches have smaller dimensions and convey water from the farm entrance to the irrigated fields

Canal characteristics:

According to the shape of their cross-section, canals are called rectangular (a), triangular (b), trapezoidal (c), circular (d), parabolic (e), and irregular or natural (f) (see Fig.2. 5).

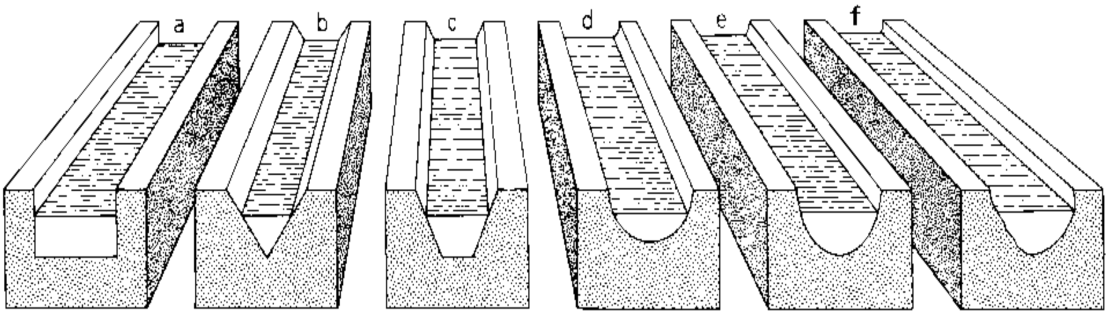


Fig2.5 (Type of cross-sectional for open canal)

The most commonly used canal cross-section in irrigation and drainage is the trapezoidal cross-section.

The typical cross-section of a trapezoidal canal is shown in (Fig.2. 6)

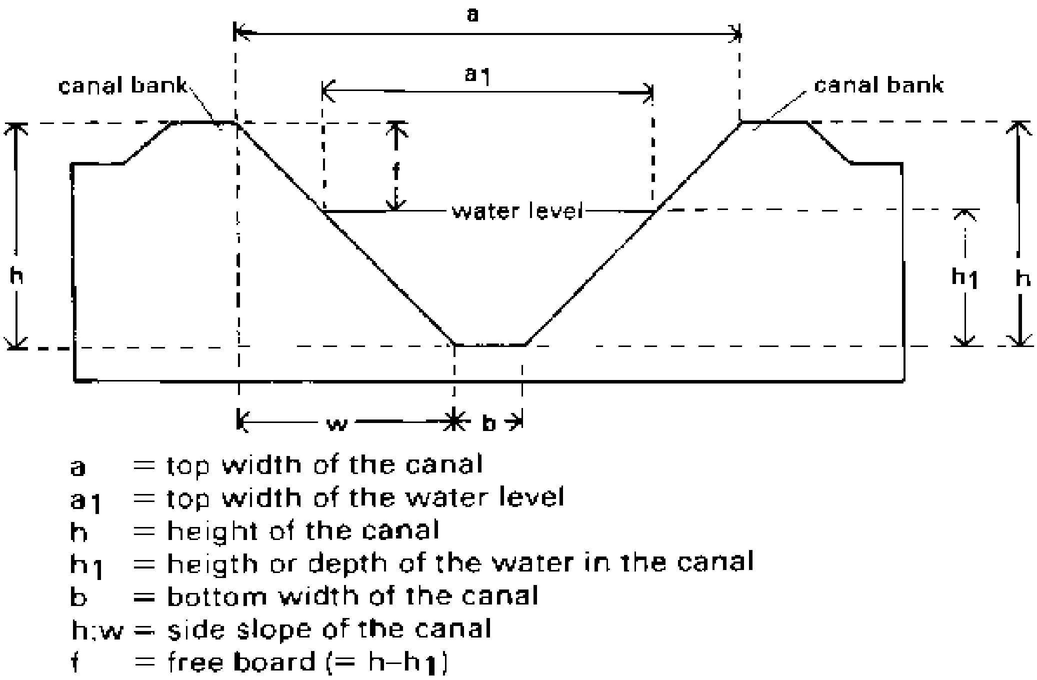


Fig.2.6 (typical cross-section of a trapezoidal canal)

The freeboard of the canal is the height of the bank above the highest water level anticipated. It is required to guard against overtopping by waves or unexpected rises in the water level.

The side slope of the canal is expressed as ratio, namely the vertical distance or height to the horizontal distance or width.

For example, if the side slope of the canal has a ratio of 1:2 (one to two), this means that the horizontal distance (w) is two times the vertical distance (h) (see Fig.2. 7)

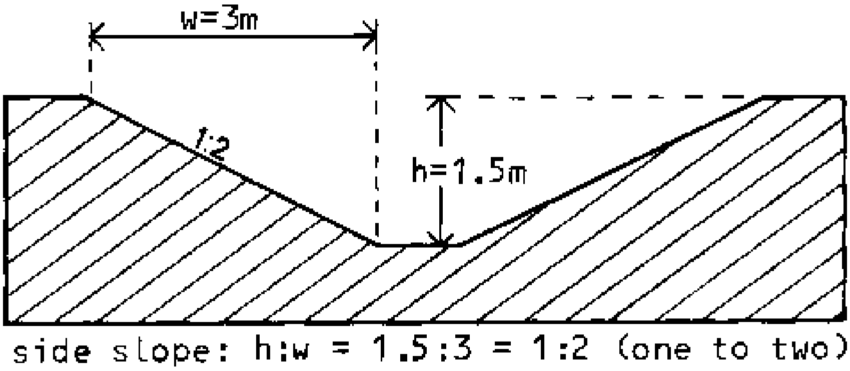


Fig.2.7 (side slope of canal)

The bottom slope of the canal does not appear on the drawing of the cross-section but on the longitudinal section (see Fig.2.8). It is commonly expressed in percent or per mil.

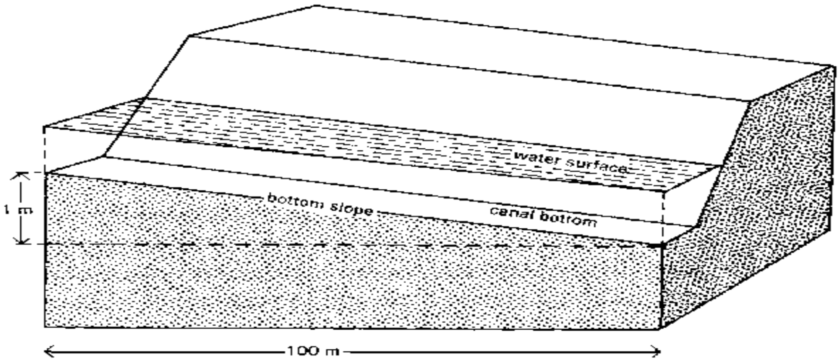


Fig.2.8 (bottom slope of the canal)

An example of the calculation of the bottom slope of a canal is given below (see Fig. 2.8).

$$\text{the bottom slope } (\%) = \frac{\text{height difference (metres)}}{\text{horizontal distance (metres)}} \times 100 = \frac{1\,\text{m}}{100\,\text{m}} \times 100 = 1\%$$

or

$$\text{the bottom slope } (‰) = \frac{\text{height difference (metres)}}{\text{horizontal distance (metres)}} \times 1000 = \frac{1\,\text{m}}{100\,\text{m}} \times 1000 = 10‰$$

Earthen Canals

Earthen canals are simply dug in the ground and the bank is made up from the removed earth, the disadvantages of earthen canals are the risk of the side slopes collapsing and the water loss due to seepage.

They also require continuous maintenance, in order to control weed growth and to repair damage done by livestock and rodents.

Lined Canals.

Earthen canals can be lined with impermeable materials to prevent excessive seepage and growth of weeds.

Construction of a canal lined with bricks

Lining canals is also an effective way to control canal bottom and bank erosion. The materials mostly used for canal lining are concrete, brick or rock masonry and asphalt concrete (a mixture of sand, gravel and asphalt). (See Fig. 2.9).

The construction cost is much higher than for earthen canals. Maintenance is reduced for lined canals, but skilled labor is required**.**

Fig.2.9 (canal construction)

Canal structures

The flow of irrigation water in the canals must always be under control. For this purpose, canal structures are required.

They help regulate the flow and deliver the correct amount of water to the different branches of the system and onward to the irrigated fields.

There are four main types of structures: erosion control structures, distribution control structures, crossing structures and water measurement structures.

i. Erosion control structures

a. Canal erosion

Canal bottom slope and water velocity are closely related, as the following example will show.

A cardboard sheet is lifted on one side 2 cm from the ground (see Fig.2.10a). A small ball is placed at the edge of the lifted side of the sheet. It starts rolling downward, following the slope direction.

The sheet edge is now lifted 5 cm from the ground (see Fig. 2.10b), creating a steeper slope. The same ball placed on the top edge of the sheet rolls downward, but this time much faster.

The steeper the slope, the higher the velocity of the ball.

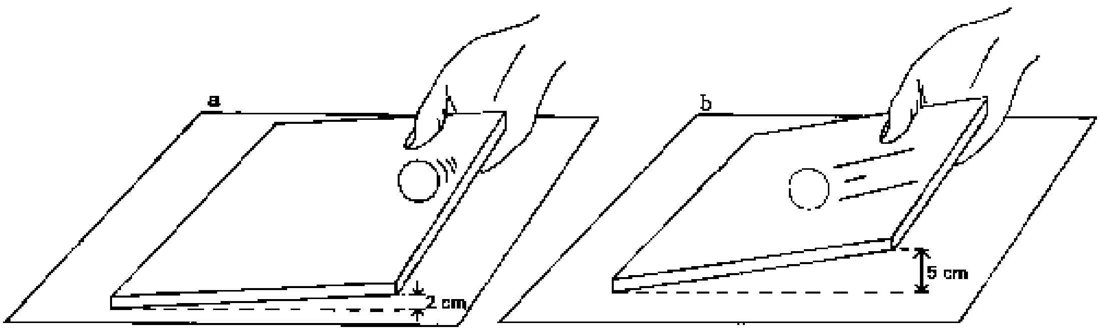


Fig.2.10 (the relationship between slope and velocity)

Water poured on the top edge of the sheet reacts the same as the ball. It flows downward and the steeper the slope, the higher the velocity of the flow.

Water flowing in steep canals can reach very high velocities. Soil particles along the bottom and banks of an earthen canal are then lifted, carried away by the water flow, and deposited downstream where they may block the canal and silt up structures.

The canal is said to be under erosion; the banks might eventually collapse.

b. <u>Drop structures and chutes</u>

Drop structures or chutes are required to reduce the bottom slope of canals lying on steeply sloping land in order to avoid high velocity of the flow and risk of erosion.

These structures permit the canal to be constructed as a series of relatively flat sections, each at a different elevation (see Fig.2.11).

Drop structures take the water abruptly from a higher section of the canal to a lower one.

In a chute, the water does not drop freely but is carried through a steep, lined canal section. Chutes are used where there are big differences in the elevation of the canal

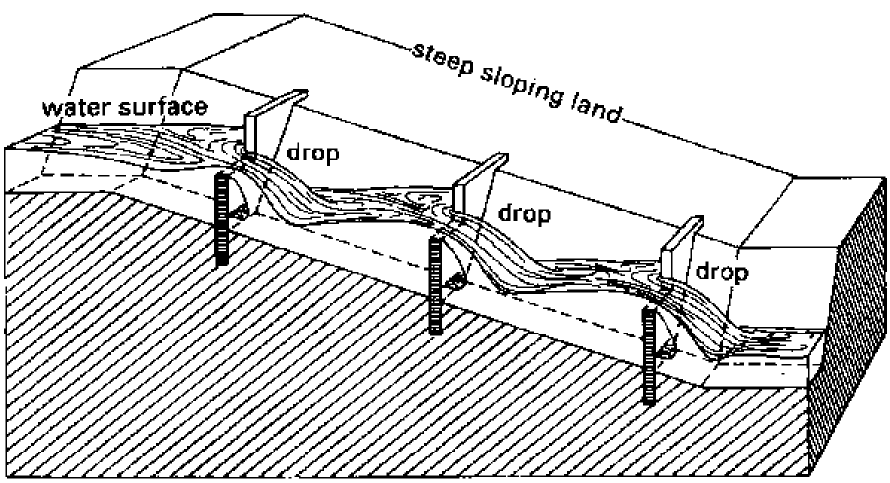


Fig.2.11 (Longitudinal section of a series of drop structures)

ii. Distribution control structures

Distribution control structures are required for easy and accurate water distribution within the irrigation system and on the farm.

a. Division boxes

Division boxes are used to divide or direct the flow of water between two or more canals or ditches.

Water enters the box through an opening on one side and flows out through openings on the other sides. These openings are equipped with gates (see Fig. 2.12).

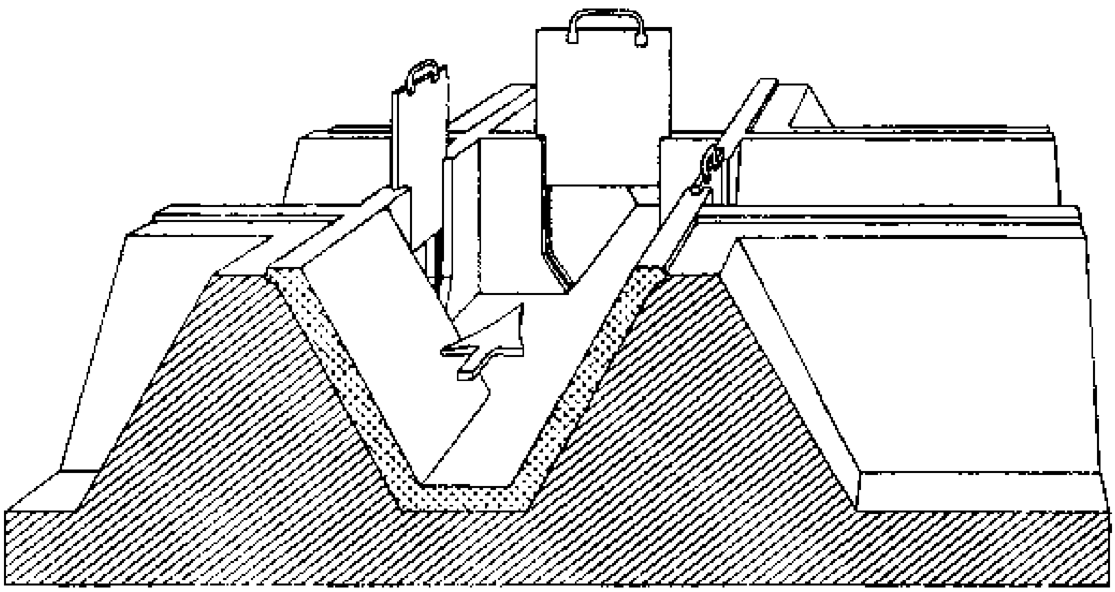


Fig2.12 (A division box with three gates)

b. <u>Turnouts</u>

Turnouts are constructed in the bank of a canal. They divert part of the water from the canal to a smaller one.

Turnouts can be concrete structures or pipe structures (Fig. 2.13).

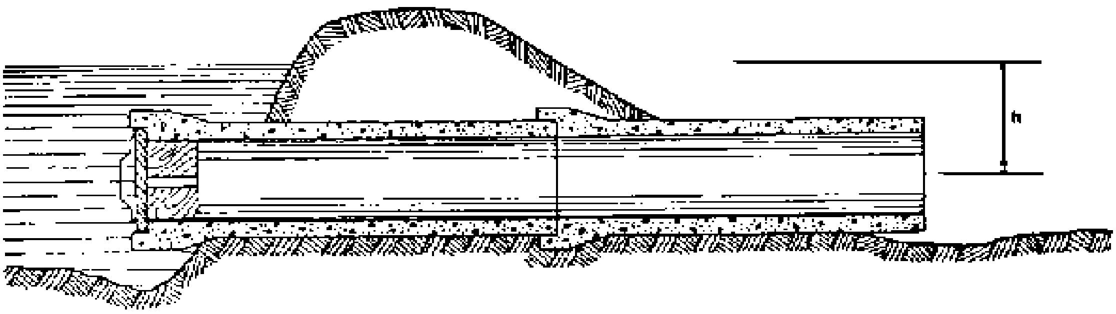


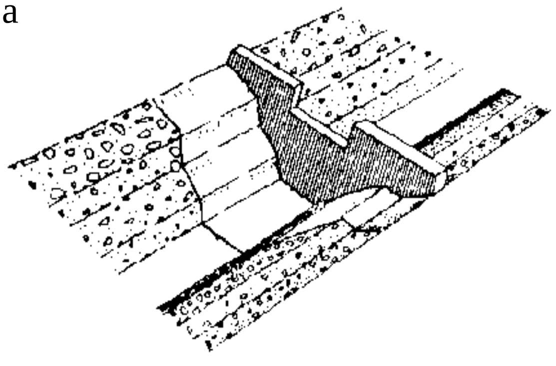
Fig. 2.13 (A pipe turnout)

c. <u>Checks</u>

To divert water from the field ditch to the field, it is often necessary to raise the water level in the ditch.

Checks are structures placed across the ditch to block it temporarily and to raise the upstream water level. Checks can be permanent structures (Fig. 2.14a) or portable (Fig. 2.14b).

a



b

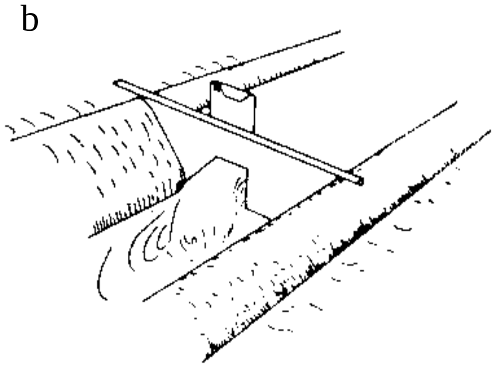


Fig.2.14a (A permanent structures) ***Fig.2.14b (A portable metal check)***

iii. <u>Crossing structures</u>

It is often necessary to carry irrigation water across roads, hillsides and natural depressions. Crossing structures, such as flumes, culverts and inverted siphons, are then required.

a. <u>Flumes</u>

Flumes are used to carry irrigation water across gullies, ravines or other natural depressions.

They are open canals made of wood (bamboo), metal or concrete, which often need to be supported by, pillars (Fig. 2.15a).

Fig.2.15a (A concrete flume)

b. Culverts

Culverts are used to carry the water across roads. The structure consists of masonry or concrete headwalls at the inlet and outlet connected by a buried pipeline (Fig. 2.15b).

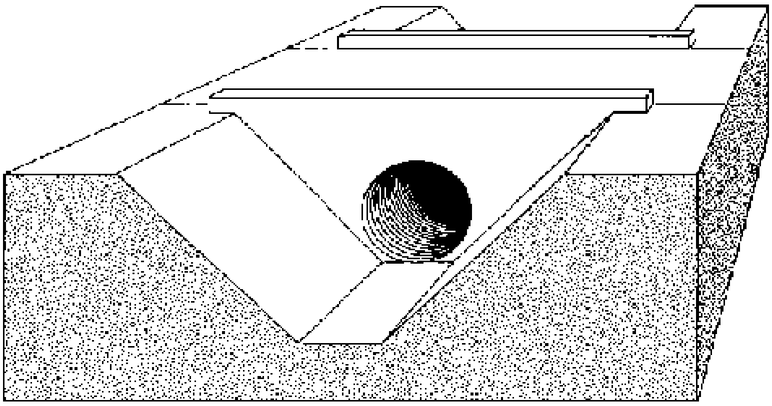


Fig.2.15b (A culvert)

c. Inverted siphons

When water has to be carried across a road which is at the same level as or below the canal bottom, an inverted siphon is used instead of a culvert. The structure consists of an inlet and outlet connected by a pipeline (Fig. 2.15c). Inverted siphons are also used to carry water across wide depressions.

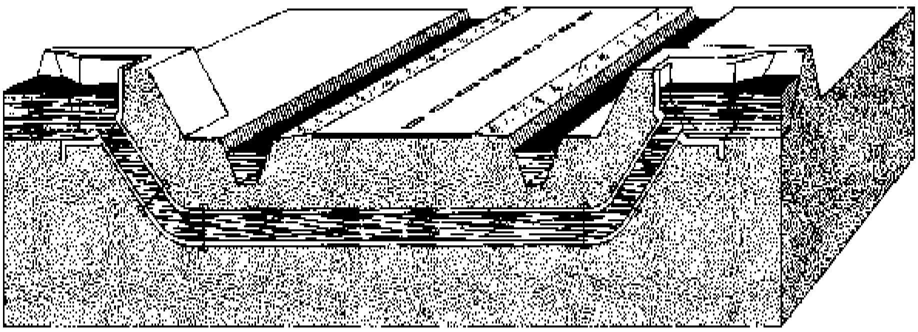


Fig.2.15c (An inverted siphon)

Irrigation Water measurement structures-3

The principal objective of measuring irrigation water is to permit efficient distribution and application. By measuring the flow of water, a farmer knows how much water is applied during each irrigation.

In irrigation schemes where water costs are charged to the farmer, water measurement provides a basis for estimating water charges.

The most commonly used water measuring structures are weirs and flumes. In these structures, the water depth is read on a scale, which is part of the structure.

Using this reading, the flow-rate is then computed from standard formulas or obtained from standard tables prepared specially for the structure

.

a. Weirs

In its simplest form, a weir consists of a wall of timber; metal or concrete with an opening with fixed dimensions cut in its edge (see Figs. 3.1a, b, c).

The opening, called a notch, may be rectangular, trapezoidal or triangular.

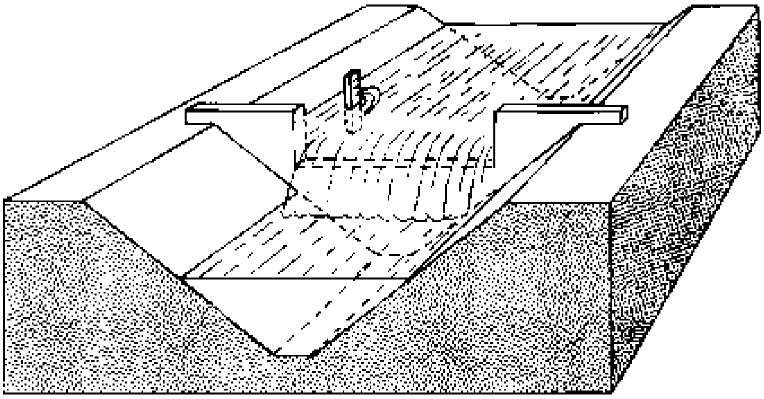


Fig.3.1a (A RECTANGULAR WEIR)

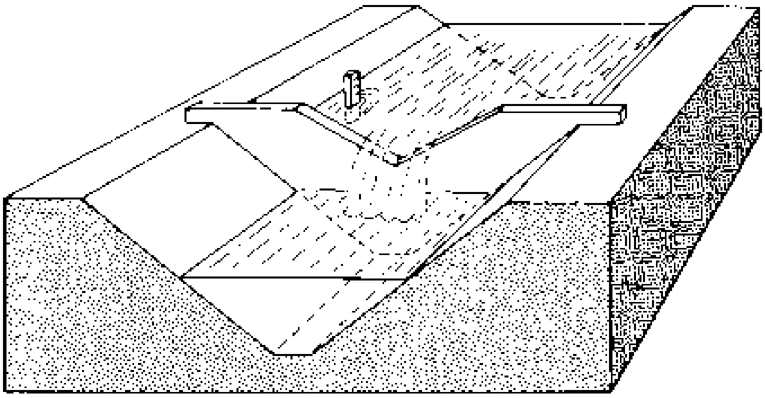


Fig.3.1b (A TRIANGULAR WEIR)

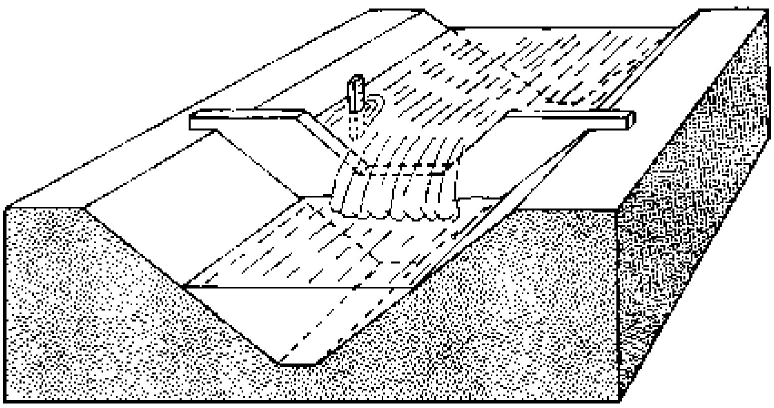


Fig.3.1c (A TRAPEZOIDAL WEIR)

b. Parshall flumes

The Parshall flume consists of a metal or concrete channel structure with three main sections: (1) a converging section at the upstream end, leading to (2) a constricted or throat section and (3) a diverging section at the downstream end (Fig. 3.2).

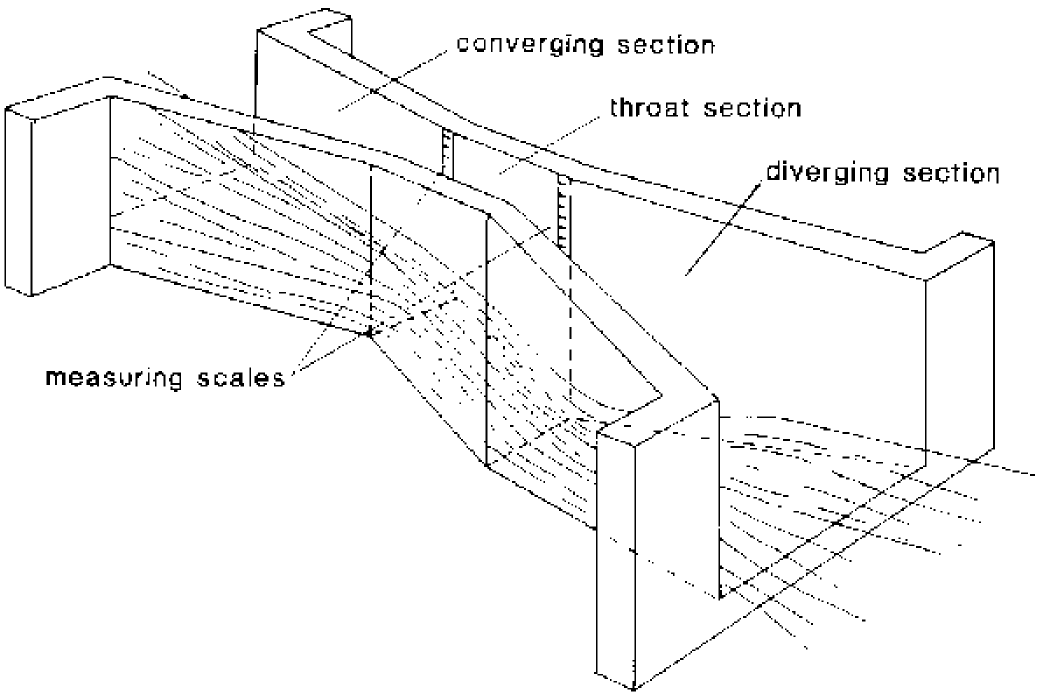


Fig. 3.2 (A Parshall flume)

Depending on the flow condition (free flow or submerged flow), the water depth readings are taken on one scale only (the upstream one) or on both scales simultaneously.

c. Cut-throat flume

The cut-throat flume is similar to the Parshall flume, but has no throat section, only converging and diverging sections (see Fig. 3.3).

Unlike the Parshall flume, the cut-throat flume has a flat bottom. Because it is easier to construct and install, the cut-throat flume is often preferred to the Parshall flume.

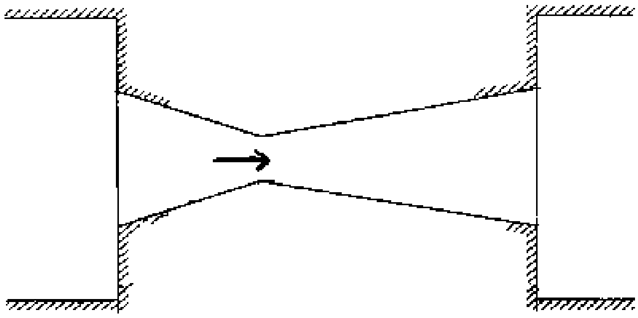


Fig. 3.3 (A cut-throat flume)

Methods of measuring irrigation water

1-Direct Measurement Methods

Measuring the period of time required to fill a container of a known volume can be used to measure small rates of flow such as from individual siphon tubes, sprinkler nozzles, or from individual outlets in gated pipe.

Ordinarily one gallon or five gallon containers will be adequate. Small wells can be measured by using a 55 gallon barrel as the container.

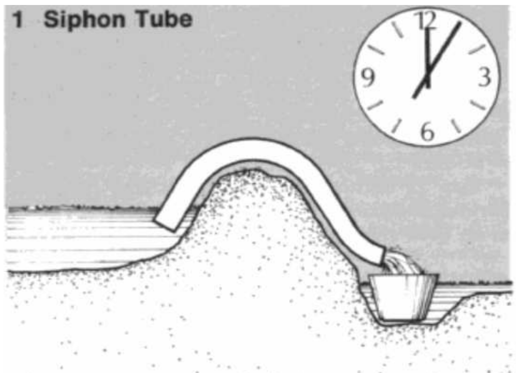


Fig.3.4 (Siphon Measurement)

2- Velocity-Area Methods

a- flow meters: Commercial flow meters are available for measuring the total volume of water flowing through a pipe.

b-

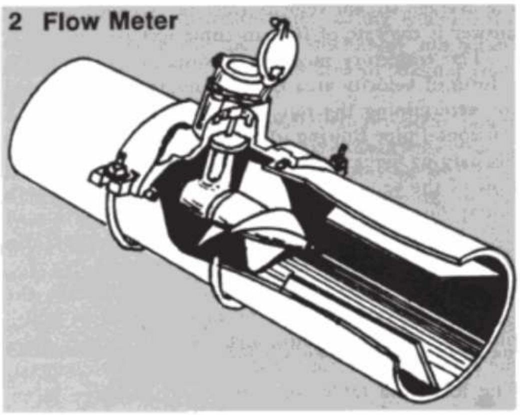
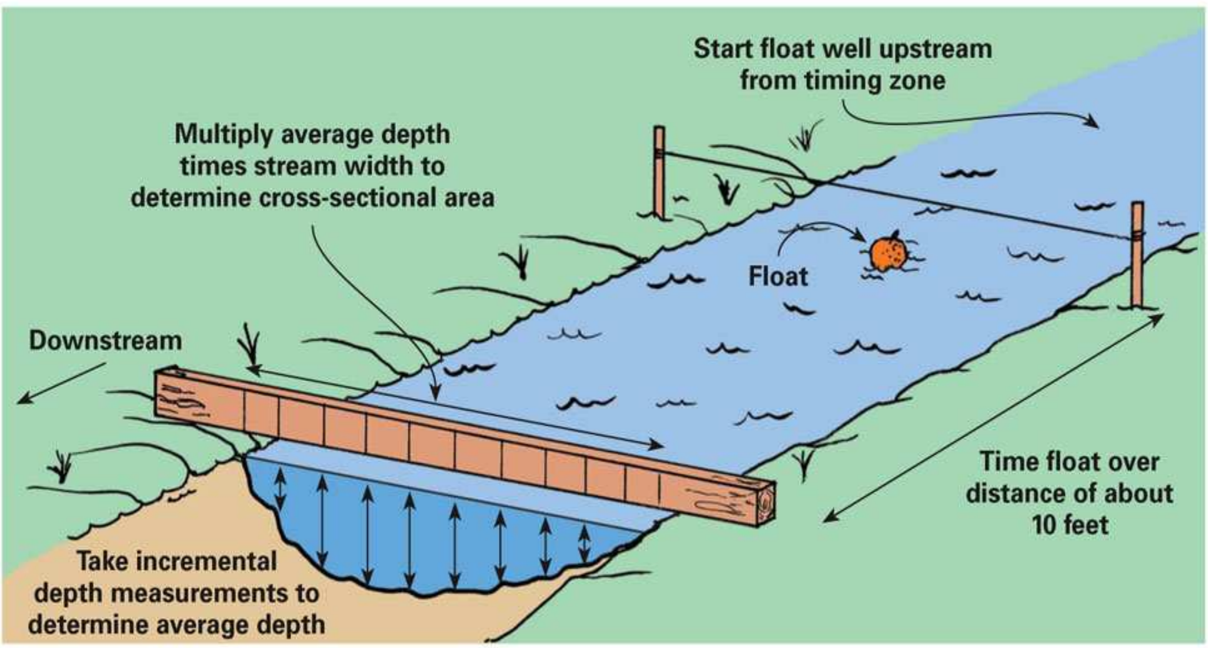


Fig. 3.5 (Flow meter)

The Float Method of Estimating Flow



b-Float method:

The float method can be used to obtain an approximate measure of the rate of flow occurring in an open ditch. It is especially useful where installations that are more expensive are not justified or high degree accuracy is not required.

Select a straight section of ditch from 50 to 100 feet long with uniform cross-sections. Make several measurements of the width and depth of the test cross-section to arrive at an average cross-sectional area.

Using a tape, measure the length of the test section of the ditch. Place a small floating object in the ditch a few feet above the starting point of the test section and time the number of seconds for this object to travel the length of the test section.

This time measurement should be made several times to arrive at a reliable average value. By dividing the length of the test section (feet) by the average time required (seconds), one can estimate velocity in feet per second.

Since the velocity of water at the surface is greater than the average velocity of the stream, multiply the estimated surface velocity by a correction factor (0.80 for smooth lined ditches, and 0.60 for rough ditches) to obtain the average stream velocity.

To obtain the rate of flow, multiply the average cross-sectional area of the ditch (square feet) times the average stream velocity (feet per second) and the answer is the rate of flow in cubic feet per second.

c-The trajectory method:

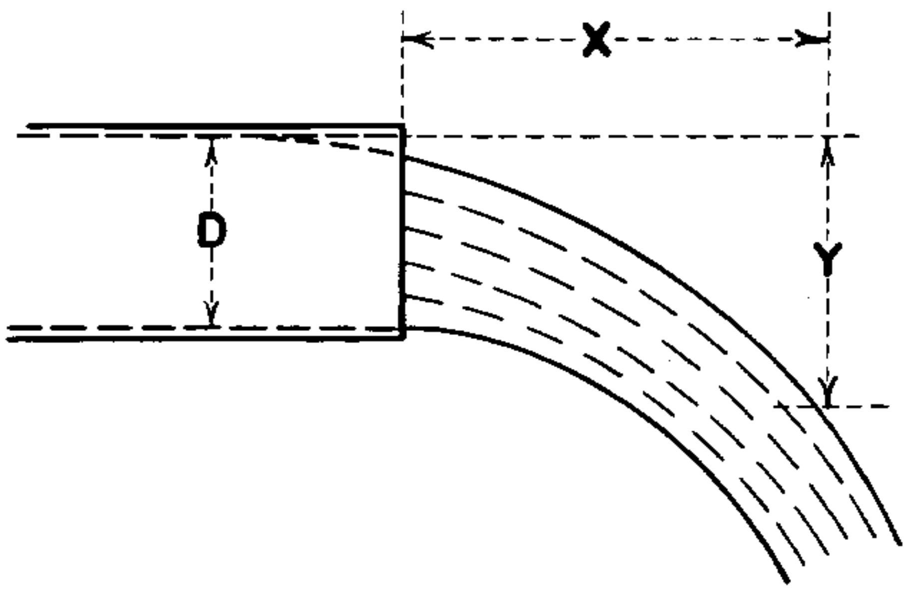
The trajectory method of water measurement is a form of velocity area calculations that can be used for determining the rate of flow discharging from a horizontal pipe flowing full.

Two measurements of the discharging jet are required to calculate the rate of flow of the water.

The first measurement is the horizontal distance, “X”, (parallel to the centerline of the pipe) required for the jet to drop a vertical distance “Y” which is the second measurement.

By using ”Y” equal to either 6 or 12 inches, the rate of flow for full pipes can be calculated by multiplying the horizontal distance “X” (in inches) times the appropriate factor for the nominal pipe diameter.

The following table contains water discharge factor where “Y” is measured from the outside of the pipe as indicated in the sketch above.



Nominal Pipe Diameter	Factor When Y=6	Factor When Y=12
2"	5.02	3.52
3"	11.13	7.77
4"	17.18	13.4
6"	43.7	30.6
8"	76.0	52.9
10"	120.0	83.5
12"	173.0	120.0

EXAMPLE:

A farmer has a well discharging a full 8" pipe. The horizontal distance (X) is 19" while the jet surface drops 12". What is the well yield?

Step 1: Enter the water discharge factor table at 8" nominal pipe diameter. Moving to the right and under the column headed Y = 12" we find the factor to be 52.9.

Step 2: Multiplying this factor 52.9, times the horizontal distance, 19" calculate the well yield to be 1,005 gpm.

Irrigation Methods-4

In general, there are many methods of applying water to the field. However, in irrigation practice there are three basic methods namely:

1-Surface irrigation.

2-Sprinkler irrigation. and

3-Drip irrigation.

Surface irrigation:	basin irrigation
	furrow irrigation
	border irrigation
Sprinkler irrigation	
Drip irrigation	

On the other hand, the following outline lists a number of factors of the environment, which will have a bearing on the evaluation of irrigation system alternates and the selection of a particular system.

A. Physical Considerations

1. Crops & Cultural Practices

2. Soils

a. Texture, Depth & Uniformity

b. Intake Rate & Erosion Potential

c. Salinity & Internal Drainage

B. Topography - Slope & Irregularity

C. Water Supply (Quantity and quality of Available water)

D. Climate

1. Flood Hazard

2. Water Table

E. Economic Considerations

a.Labour Costs & Inflation

b. Energy, Operation & Maintenance

1-Surface irrigation:

Surface irrigation uses gravity flow to spread water over a field. Surface systems are the least expensive to install, but have high labor requirements for operation compared to other irrigation methods.

Objectives:

1. Uniformity associated with surface irrigation.
2. Increase understanding of irrigation efficiency, losses, and distribution and application of best management practices to improve efficiency and uniformity of surface irrigation.

Application Rates

The correct amount of water to apply at each irrigation depends on the amount of soil water used by the plants between irrigations, the water-holding capacity of the soil, and the depth of the crop roots. The rate at which water goes into the soil varies from one irrigation to the next and from season to season.

1-Basin Irrigation

In basin irrigation, water is applied to a completely level (sometimes called "dead-level") area enclosed by dikes or borders. This method of irrigation is used successfully for both field and row crops. The floor of the basin may be flat, ridged or shaped into beds, depending on crop and cultural practices.

Basins need not be rectangular or straight sided, and the border dikes may or may not be permanent. This irrigation technique is also called by a variety of other names: check flooding; level borders; check irrigation; check-basin irrigation; dead-level irrigation; and level-basin irrigation.

Basin size is limited by available water stream size, topography, soil factors, and degree of leveling required. Basin may be quite small or as large as 40 acres or so.

Level basins simplify water management, since the irrigator need only supply a specified volume of water to the field. With adequate stream size, the water will spread quickly over the field, minimizing non-uniformities in inundation time.

Basin irrigation is most effective on uniform soils, precisely leveled, when large stream sizes (relative to basin area) are available. High efficiencies are possible with low labor requirements. The flatter the land surface, the easier it is to construct basins.

In addition the soils Which are suitable for basin irrigation depends on the crop grown, Also soils which form a hard crust when dry (capping) are not suitable.

Fig4.1 (Basin Irrigation)

BASINS SHOULD BE SMALL IF THE:

1. Slope of the land is steep
2. Soil is sandy
3. Stream size to the basin is small
4. Required depth of the irrigation application is small
5. Field preparation is done by hand or animal traction**.**

BASINS CAN BE LARGE IF THE:

1. Slope of the land is gentle or flat
2. Soil is clay
3. Stream size to the basin is large
4. Required depth of the irrigation application is large
5. Field preparation is mechanized.

2-Border Strip Irrigation

Border strip irrigation uses land formed into strips, level across the narrow dimension but sloping along the long dimension, and bounded by ridges or borders.

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.

High irrigation efficiencies are possible with this method of irrigation, but are rarely obtained 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.

The primary design factors are border length and slope, stream size per unit width of border, planned soil moisture deficiency at the time of irrigation, soil intake rate, and degree of flow retardance by the crop as the water flow down the strip.

However, because of the large variations in field conditions that occur during the season, the irrigator can have as great an effect on irrigation efficiency as the system designer. Borders can be up to 800 m or more in length and 3-30 m wide depending on a variety of factors.

Border slopes should be uniform, with a minimum slope of 0.05% to provide adequate drainage and a maximum slope of 2% to limit problems of soil erosion.

Deep homogenous loam or clay soils with medium infiltration rates are preferred. Heavy, clay soils can be difficult to irrigate with border irrigation because of the time needed to infiltrate sufficient water into the soil.

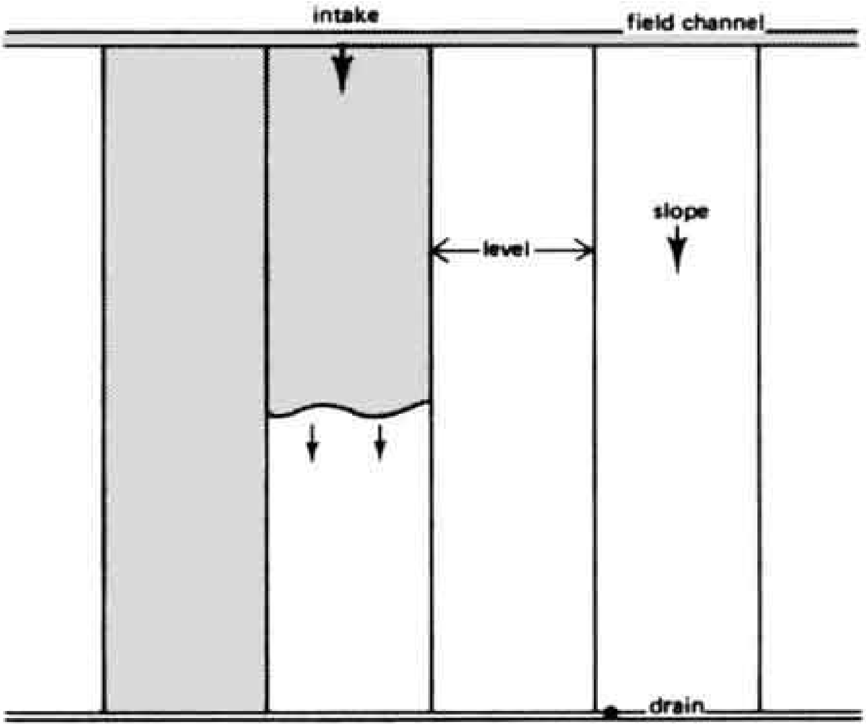


Fig.4.2a (Layout of Border Strip Irrigation)

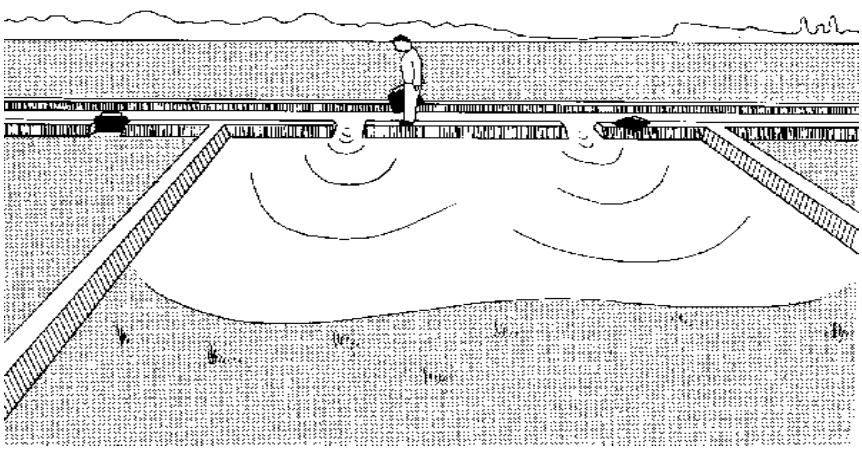


Fig.4.2b (Border Strip Irrigation)

3-Furrow Irrigation

Furrows are sloping channels formed in the soil. Infiltration occurs laterally and vertically through the wetted perimeter of the furrow. Systems may be designed with a variety of shapes and spacing's. 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 utilized in many situations, within the limits of soil uniformity and topography.

With runoff, return flow systems, furrow irrigation can be a 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.

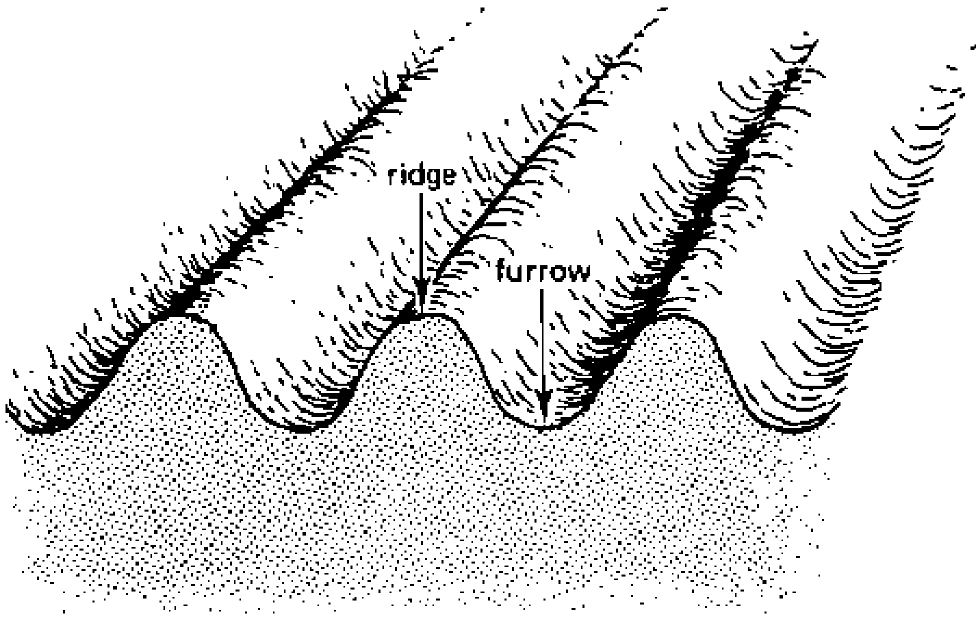


Fig.4.3a (Layout of Furrow Irrigation)

Fig.4.3b (Furrow Irrigation)

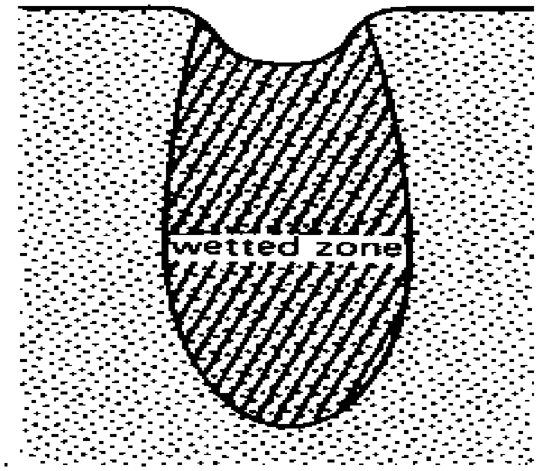
Wetting patterns:

Water is supplied to each furrow from the field canal, using siphons or spiels.

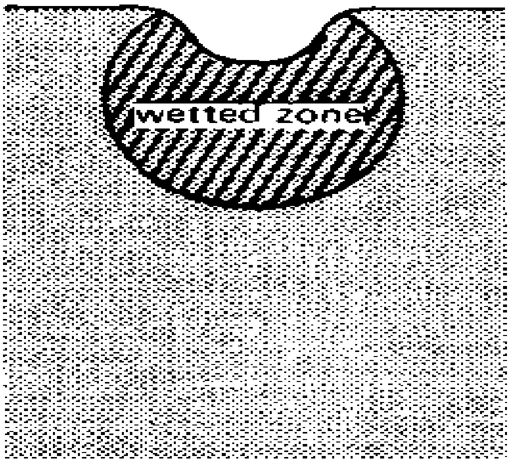
In order to obtain a uniformly wetted root zone, furrows should be properly spaced, have a uniform slope and the irrigation water should be applied rapidly.

As the root zone in the ridge must be wetted from the furrows, the downward movement of water in the soil is less important than the lateral (or sideways) water movement. Both lateral and downward movement of water depends on soil type as can be seen in Fig. A,B,C

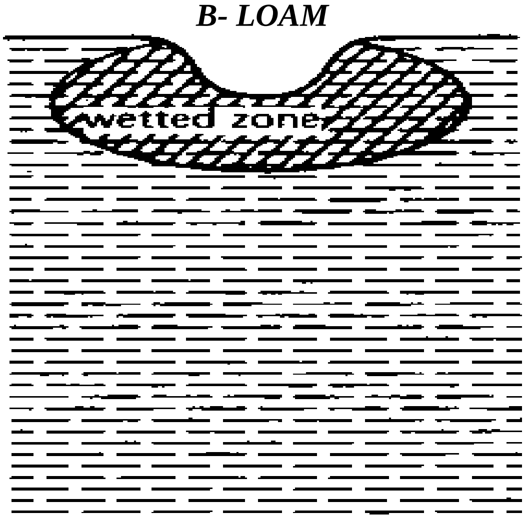
Different wetting patterns in furrows, depending on the soil type



A-SAND



B- LOAM



B- CLAY

Ideal wetting pattern:

In an ideal situation adjacent wetting patterns overlap each other, and there is an upward movement of water (capillary rise) that wets the entire ridge (see Fig.4.4), thus supplying the root zone with water.

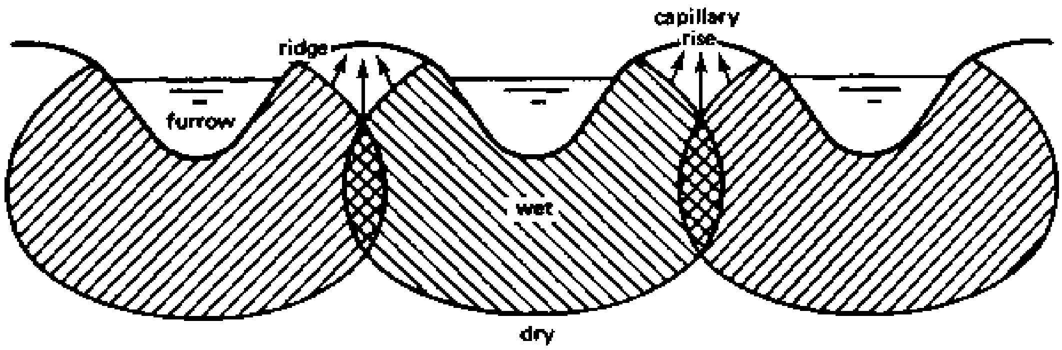


Fig.4.4 (Ideal wetting patterns)

To obtain a uniform water distribution along the furrow length, it is very important to have a uniform slope and a large enough stream size so that water advances rapidly down the furrow.

In this way, large percolation losses at the head of the furrow can be avoided. The quarter time rule is used to determine the time required for water to travel from the farm channel to the end of the furrow, in order to minimize percolation losses.

Poor wetting patterns:

Poor wetting patterns can be caused by:

- Unfavorable natural conditions, e.g. a compacted layer, different soil types, uneven slope:

- Poor layout, e.g. a furrow spacing too wide;

- Poor management: supplying a stream size that is too large or too small, stopping the Inflow too soon.

i. Unfavorable natural conditions

Compacted soil layers or different soil types have the same effect on furrow irrigation as they have on basin irrigation.

An uneven slope can result in uneven wetting along the furrow. Water flows fast down the steep slopes and slowly down the flatter slopes.

This affects the time available for infiltration and results in poor water distribution.

The problem can be overcome by regarding the land to a uniform slope.

ii. Poor layout

If the furrow spacing is too wide, (Fig.4.5) then the root zone will not be adequately wetted. The spacing of furrows needs careful selection to ensure adequate wetting of the entire root zone (Fig.4.5).

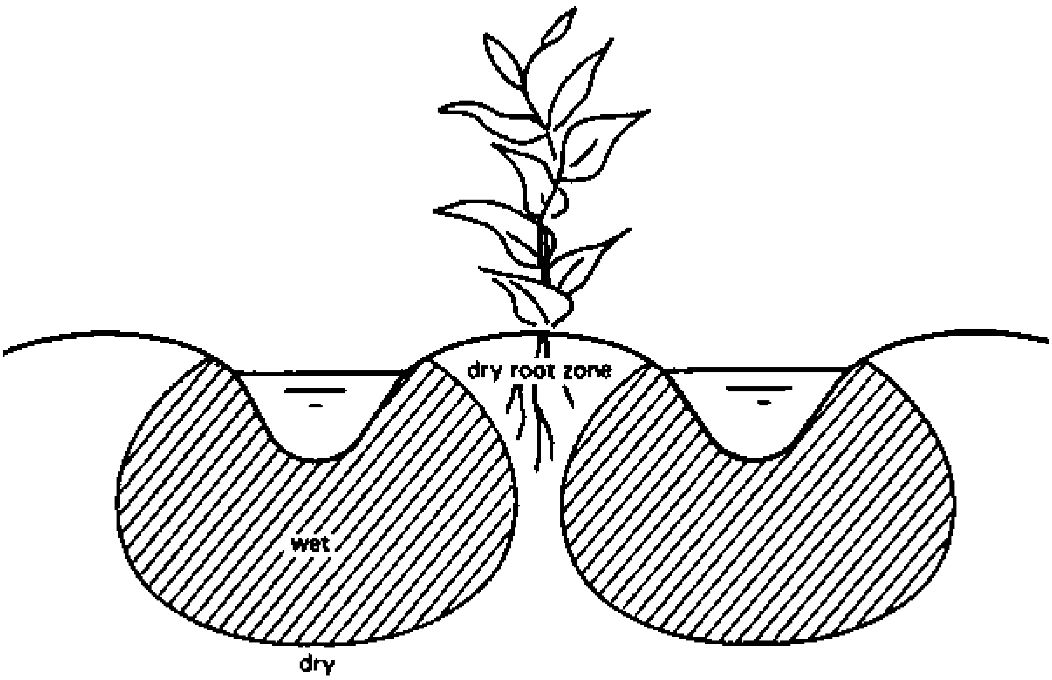


Fig.4.5 (The spacing between two adjacent furrows is too wide)

iii. <u>Poor management</u>

A stream size that is too small (Fig.4.6) will result in inadequate wetting of the ridges. Even if the plants are located at the sides of the ridge, not enough water will be available.

A small stream size will also result in poor water distribution along the length of the furrow. The advance will be slow and too much water will be lost through deep percolation at the head of the furrow.

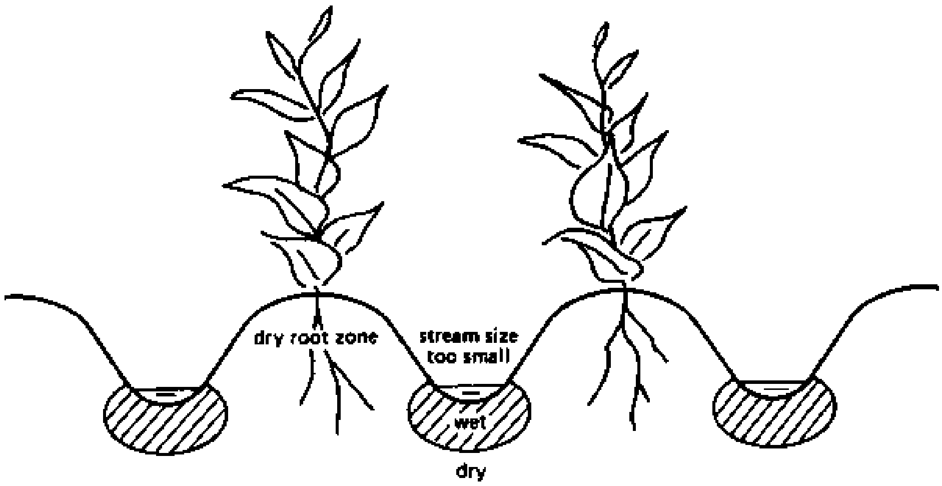


Fig.4.6 (Stream size is too small to wet the ridge)

If the stream size is too large on flat slopes, overtopping of the ridge may occur (Fig.4.7). On steeper slopes with too large a stream size, erosion of the bed and sides of the furrow may take place (Fig.4.7).

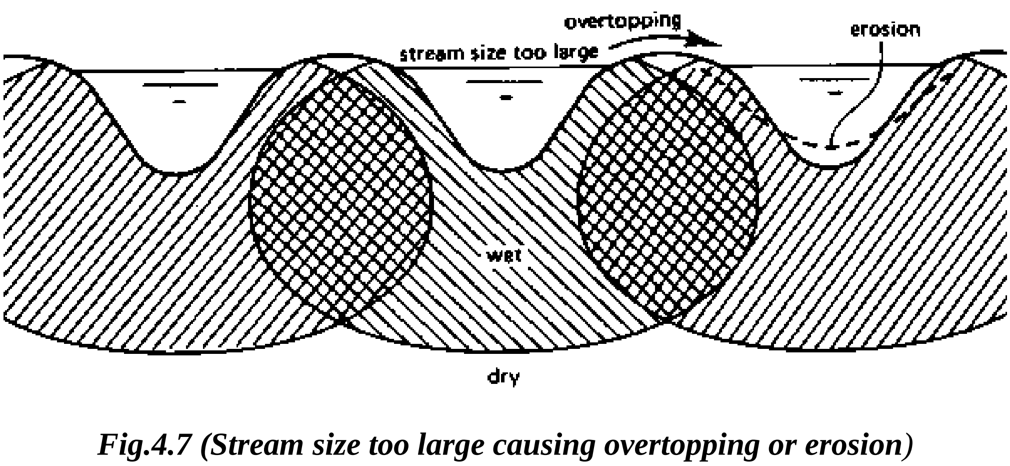


Fig.4.7 (Stream size too large causing overtopping or erosion)

A common management fault is to stop the inflow too soon. This is usually done to reduce runoff, but it results in a poor water distribution and the plants in particular at the end of the furrow do not get enough water.

If the Inflow of irrigation water is not stopped soon enough, the runoff is excessive and plants at the end of the furrow may drown when an adequate drainage system to evacuate excess water is not provided.

CAPABILITIES AND LIMITATIONS

Crop:

Some form of surface irrigation is adaptable to most any 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. 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.

Soils and Topography:

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 110 meter on very coarse textured soils, but may reach 440 meter 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 best adapted to surface irrigation.

Undulating topography and shallow soils do not respond well to grading to a plane. Steep slopes and irregular topography increase the cost of land leveling and reduce basin or border size.

Deep cuts may expose areas of nonproductive soils, requiring special fertility management. Erosion control measures may be required if large stream sizes are used. In areas of high intensity rainfall and low intake rate soils, surface drainage should be considered with basin irrigation, to reduce damage due to untimely inundation.

Water Quantity and Quality:

It is important that irrigation stream size be properly matched to basin or border size for uniform irrigation. Since intake, rates for border and furrow systems may vary during the season, it helpful if the water supply rate can be varied from one irrigation to the next. Border and furrow systems are not suitable for leaching of salts for soil reclamation, since the water cannot be held on the soil for any length of time.

The basin method, however, is ideal for this purpose. Under normal operating conditions, leaching fractions adequate for salinity control can be maintained with basin, border or furrow irrigation.

LABOR AND ENERGY CONSIDERATIONS:

Basin irrigation involves the least labor of the surface methods, particularly if the system is automated. Border and furrow systems may

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 required skill, 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.

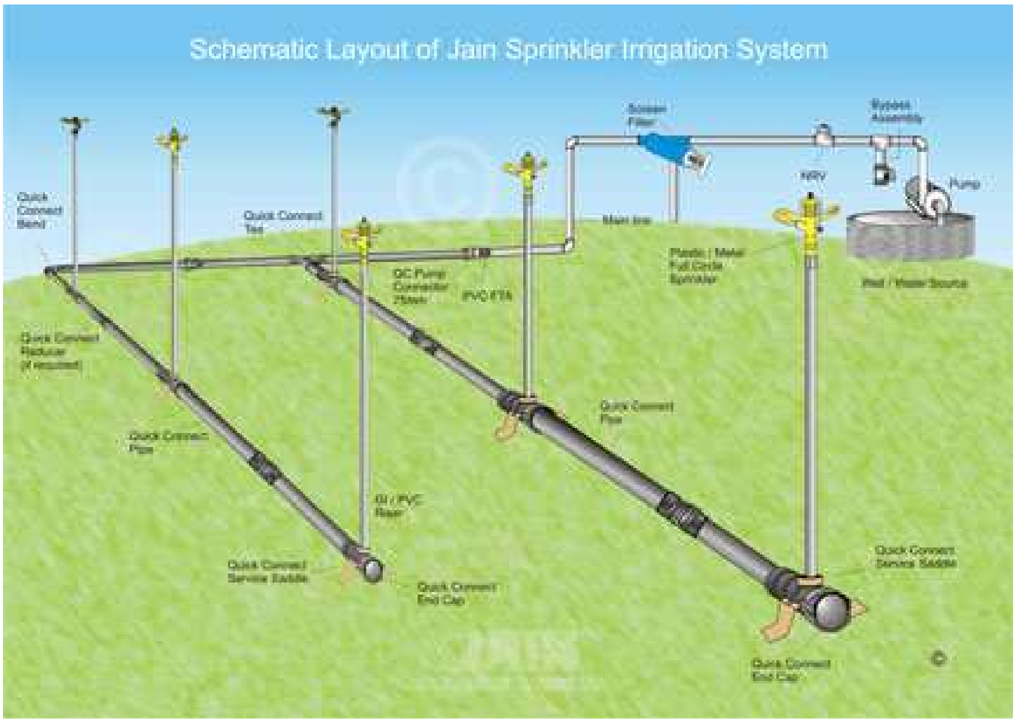
ECONOMIC FACTORS:

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.

Typical earth moving volumes are approximately 420 cubic yards per acre, but have on occasion exceeded 1300 cubic yards per acre. Volumes greater than 800 cubic yards per acre are generally considered excessive, suggesting a design review may be needed..

SPRINKLER IRRIGATION-5

In the sprinkler method of irrigation, water is sprayed into the air and allowed to fall on the ground surface somewhat resembling rainfall. The spray is developed by the flow of water under pressure through small orifices or nozzles.



sprinkler irrigation system

1-Elimination of the channels for conveyance, therefore no conveyance loss.

2- Suitable to all types of soil except heavy clay.

3- Suitable for irrigating crops where the plant population per unit area is very high.

4- Water saving.

5- May also be used for undulating area.

6- Areas located at a higher elevation than the source can be irrigated.

7- Possibility of using soluble fertilizers and chemicals.

8- Mobility of system.

9- Increase in yield.

10- Influences greater conducive microclimate.

Crop response to sprinkler system

The trials conducted in different parts of the country revealed water saving due to sprinkler system varies from 16 to 70 % over the traditional method with yield increase from 3 to 57 % in different crops. (Table 5.1)

Crops	Water Saving%	Yield Increase%
Barley	56	16
Cotton	36	50
Garlic	28	6
Potato	46	4
Wheat	35	24

General classification of different types of sprinkler systems

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

1. Rotating head or revolving sprinkler system.
2. Perforated pipe system.

1) Rotating head:

Small size nozzles are placed on riser pipes fixed at uniform intervals along the length of the lateral pipe and the lateral pipes are usually laid on the ground surface.

Fig .5.1 (rotating type sprinkler irrigation systems)

2) Perforated pipe system:

This method consists of drilled holes or nozzles along their length through which water is sprayed under pressure. This system is usually designed for relatively low pressure (1 kg/cm2). The application rate ranges from 1.25 to 5 cm per hour for various pressure and spacing. Based on the portability, sprinkler systems are classified into the following types.

(i) Portable system:

A portable system has portable main lines, laterals and Pumping plant.

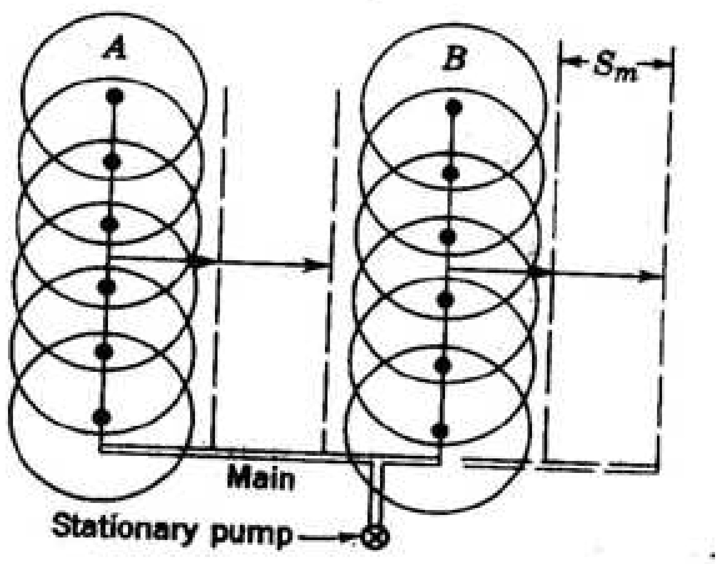


Fig .5.2(Fully portable sprinkler irrigation system)

(ii) **Semi portable system:**

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

(iii) **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.

(iv) Solid set system:

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

(v) Permanent system:

A fully permanent system consists of permanently laid mains, sub mains and laterals and a stationery water source and pumping plant.

Components of sprinkler irrigation system

The components of portable sprinkler system usually consist of the following parts.

(i) A pump unit

(ii) Tubings- main/submains and laterals

(iii) Couplers

(iv) Sprinkler head

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

(i) **Pumping Unit**:

Sprinkler irrigation systems distribute water by spraying it over the fields. The water is pumped under pressure to the fields. A high speed centrifugal or turbine pump can be used for operating sprinkler irrigation for individual fields.

(ii) **Tubings**:

Mains/submains and laterals: The tubing's consist of mainline, submanins and laterals. Main line conveys water from the source and distributes it to the submains. The submains convey water to the laterals, which in turn supply water to the sprinklers.

(iii) **Couplers**:

Couplers are used for connecting two pipes and uncoupling quickly and easily.

(iv) **Sprinkler Head**:

Sprinkler head distribute water uniformly over the field without runoff or excessive loss due to deep percolation. Different types of sprinklers are available. They are either rotating or fixed type. The rotating type 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 to 40 m head are considered the most practical for most farmers.

Fig5.3 (Sprinkler head)

General rules for sprinkler system design

1- Main should be laid up and down hill

• Lateral should be laid across the slope or nearly on the contour

• For multiple lateral operations, lateral pipe sizes should not be more than two diameters.

• Water supply source should be nearest to the center of the area

2- Layout should facilitate and minimize lateral movement during the season

• Booster pump should be considered where small portion of field would require high pressure at the pump

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

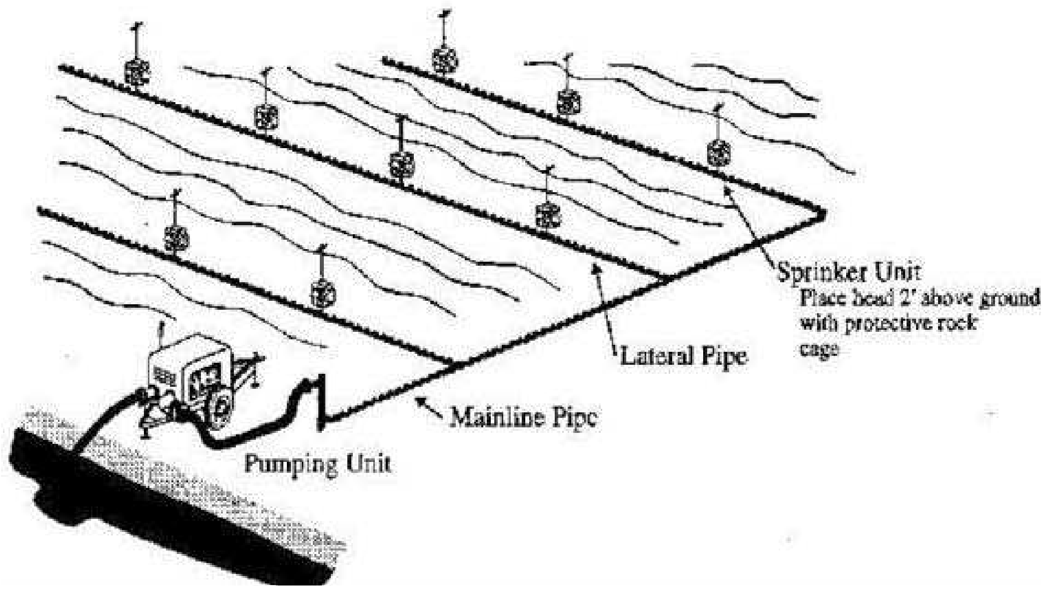


Fig.5.4 (Layout of sprinkler irrigation system Selecting the most appropriate sprinkler systems)

Selecting the most appropriate sprinkler systems

While selecting a sprinkler system, the most important physical parameters to be considered are:

1. The crop or crops to be cultivated.
2. The shape and size (acres) of the field.
3. The topography of the field.
4. The amount of time and labor required to operate the system.

Selecting sprinkler system capacity

A sprinkler system must be designed to apply water uniformly without runoff or erosion. The application rate of the sprinkler system must be matched to the infiltration rate of the most restrictive soil in the field. If the application rate exceeds the soil intake rate, the water will runoff the field or relocate within the field resulting in over and under watered areas.

The sprinkler system capacity is the flow rate needed to adequately irrigate an area and is expressed in liters per minute per acre. The system capacity depends upon on the: Peak crop water requirements during the growing season; effective crop rooting depth; texture and infiltration rate of the soil; the available water holding capacity of the soil; pumping capacity of the well or wells (if wells are the water source).

Constraints in application of sprinkler irrigation

(i) Uneven water distribution due to high winds.

(ii) Evaporation loss when operating under high temperatures.

(iii) Highly impermeable soils are not suitable.

(iv) Initial cost is high.

(v) Proper design.

(vi) Lack of Package of practices

(vii) Lack of awareness

(viii) Lack of social concern to save natural resources.

(ix) High water pressure required in sprinkler (>2.5kg/cm2).

(x) Difficulty in irrigation during wind in sprinkler.

Maintenance

General principles regarding the maintenance of the pipes and fittings and sprinkler heads are given below:

1. Pipes and fittings

The pipes and fittings require virtually no maintenance but attention must be given to the following procedures:

a) Occasionally clean any dirt or sand out of the groove in the coupler in which the rubber-sealing ring fits.

b) Keep all details tight.

c) Do not lay fertilizer sacks on the pipe.

2. Sprinkler heads

The sprinkler heads should be given the following attention:

a) When moving the sprinkler lines, make sure that the sprinklers are not damaged or pushed into the soil

b) Do not apply oil, grease or any lubricant to the sprinklers.

They are water lubricated and using oil, grease or any other lubricant may stop them from working.

c) After several season's operation the swing arm spring may need tightening.

This is done by pulling out the spring end at the top and rebinding it. This will increase the spring tension.

Storage:

The following points are to be observed while storing the sprinkler equipment during the off-season:

a) Remove the sprinklers and store in a cool, dry place.

b) Remove the rubber sealing rings from the couplers and fittings and store them in a cool, dark place.

c) The pipes can be stored outdoors in which case they should be placed in racks with one end higher than the other can. Do not store pipes along with fertilizer.

d) Disconnect the suction and delivery pipe-work from the pump and pour in a small quantity of medium grade oil. Rotate the pump for a few minutes. Blank the suction and delivery branches. This will prevent the pump from rusting. Grease the shaft.

e) Protect the electric motor from the ingress of dust, dampness and rodents.

Drip irrigation system-6

Definition:

Drip irrigation systems are those that apply water to plant material at a slow application rate**.**

A Brief History of micro irrigation

Drip irrigation, sometimes referred to as micro irrigation or trickle irrigation, has its roots in agriculture.

In many parts of the world with limited water supplies, drip irrigation was one of the few options available for irrigation.

Beginning in the late 1960's farmers discovered that by using drip irrigation they could increase yields while lowering water use.

Drip irrigation system is moreover one of the greatest channel of rainwater harvesting. It works through a very effortless process. It allows water to drip bit by bit through the roots of the plants with the help of instruments such as valve, pipes and emitters.

The recent method of drip irrigation work devices such as impact sprinklers, which help to decrease the wastage of water. Featuring in conventional irrigation, a lot of water is wasted, as the field is flooded with water.

Drip irrigation system.

When to Use Drip Irrigation:

Drip irrigation is most suitable for row crops (vegetables, soft fruit), tree and vine crops where one or more emitters can be provided for each plant and is adaptable to any farmable slope**.**

Drip irrigation is suitable for most soils. On clay soils, water must be applied slowly to avoid surface water ponding and runoff. On sandy soils, higher emitter discharge rates will be needed to ensure adequate lateral wetting of the soil.

Drip System Layout:

A typical drip irrigation system is shown in (Fig.6.1) and consists of the following components:

-Pump unit

-Control head

-Main and submain lines

-Laterals

-Emitters or drippers

The **pump unit** takes water from the source and provides the right pressure for delivery into the pipe system.

The **control head** consists of valves to control the discharge and pressure In the entire system. It may also have filters to clear the water.

Mainlines, submains and laterals supply water from the control head into the fields. They are usually made from PVC or polyethylene hose and should be buried below ground because they easily degrade when exposed to direct solar radiation. Lateral pipes are usually 13-32 mm diameter

Emitters or drippers are devices used to control the discharge of water from the lateral to the plants.

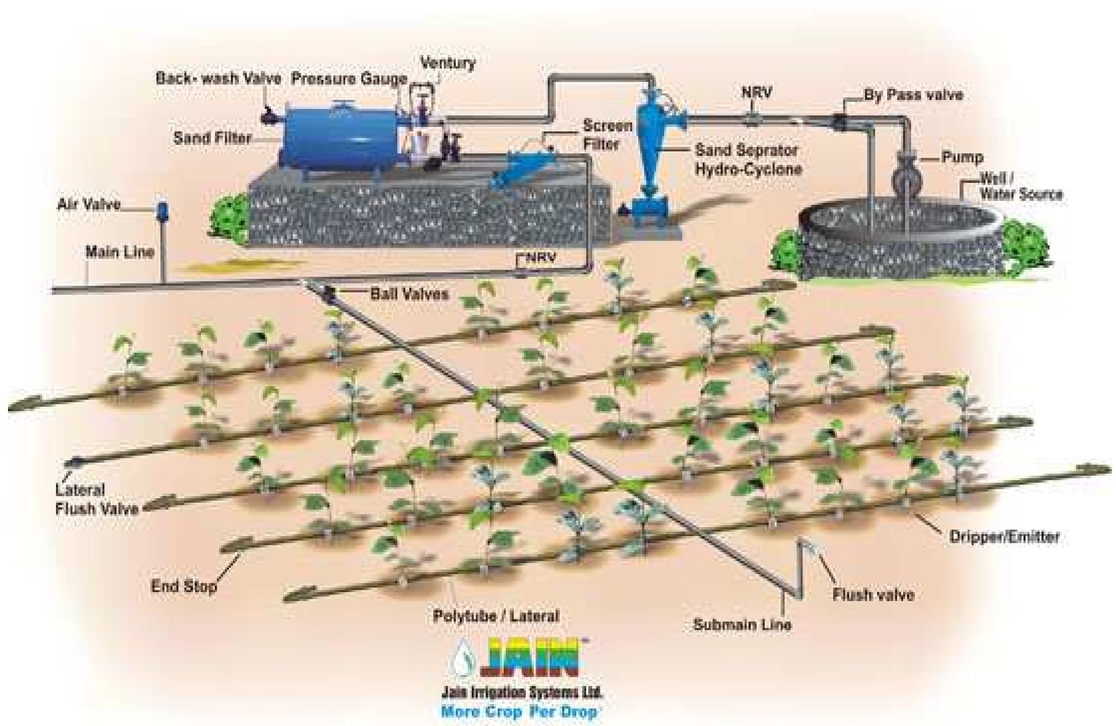


Fig.6.1 (Drip Irrigation Component)

Wetting patterns

Unlike surface and sprinkler irrigation, drip irrigation only wets part of the soil root zone. This may be as, low as 30% of the volume of soil wetted by the other methods.

The wetting patterns, which develop from dripping water onto the soil, depend on discharge and soil type. (Figs.6.2 and 6.3) shows the effect of changes in discharge on two different soil types, namely sand and clay.

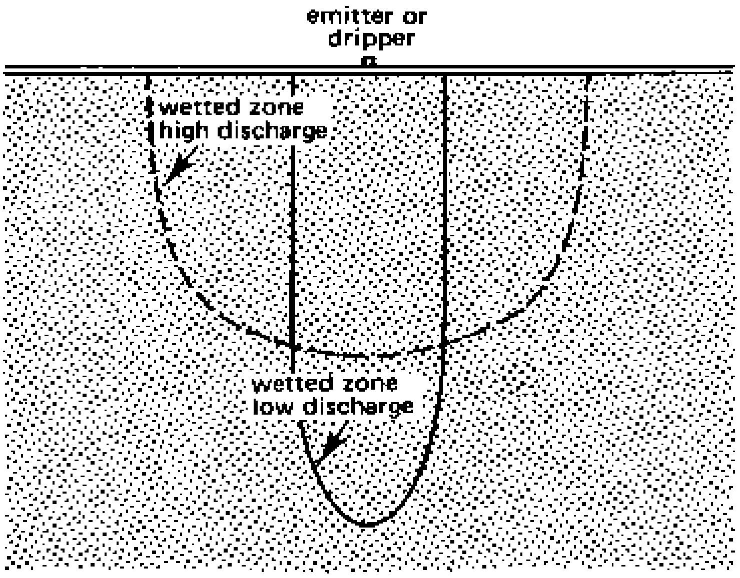


Fig.6.2 (Wetting patterns for sand and clay soils with high and low discharge rates (SAND)

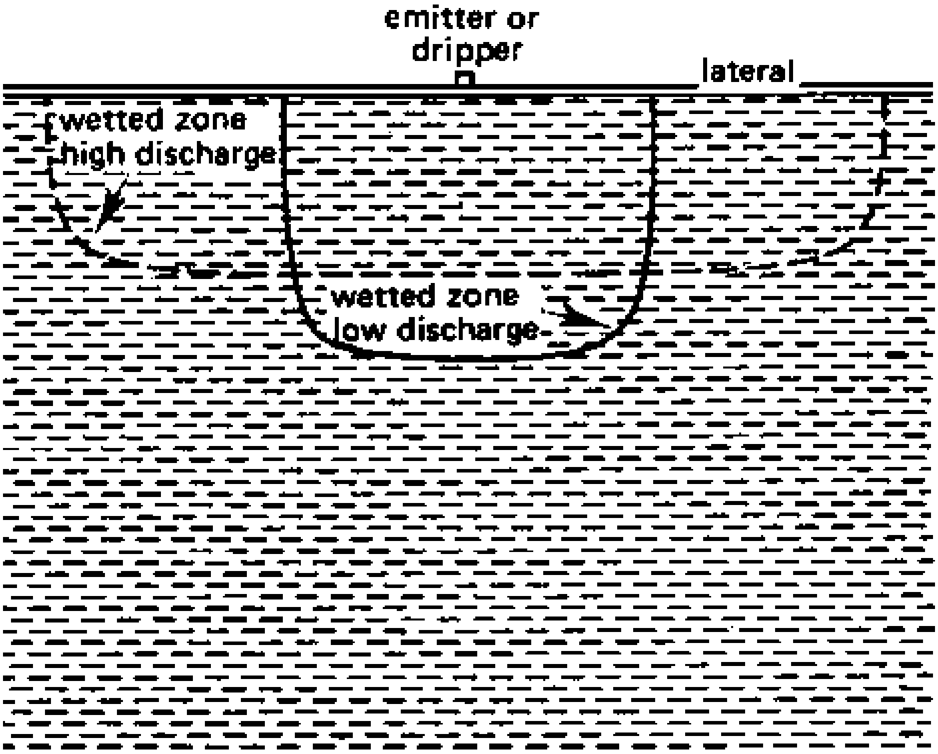


Fig.6.3 (Wetting patterns for sand and clay soils with high and low discharge rates (CLAY)

Although only part of the root zone is wetted, it is still important to meet the full water needs of the crop. It is sometimes thought that drip irrigation saves water by reducing the amount used by the crop. This is not true. Crop water use is not changed by the method of applying water. Crops just require the right amount for good growth.

The water savings that can be made using drip irrigation are the reductions in deep percolation, in surface runoff and in evaporation from the soil. These savings, it must be remembered, depend as much on the user of the equipment as on the equipment itself.

Drip irrigation is not a substitute for other proven methods of irrigation. It is just another way of applying water. It is best suited to areas where water quality is marginal, land is steeply sloping or undulating and of poor quality, where water or labour are expensive, or where high value crops require frequent water applications.

Advantages and Benefits of Drip Irrigation System

- **Water Efficiency:**

By applying water only, where and when it is needed, with less runoff and less evaporation from leaves and soil, the uniform application of water from drip irrigation systems can achieve high water savings.

- **Ease of Installation:**

The system can be installed without special tools or glue, and with limited knowledge, making the installation a very simple process.

- **Reduced Pest Problems and Weed Growth:**

Watering only the roots of your plants with drip irrigation cuts down on water-borne pests and fungal diseases that spread by water movement, as well as the germination of weeds in the area between your plants.

- **Versatility:**

Low volume irrigation systems are designed for placement in both new and existing landscape areas, and are ideal for installation on difficult terrain such as on slopes, in oddly shaped areas, and on windy sites.

- **Root Zone:**

One benefit of a drip irrigation system is the creation of a very new and more favorable root zone environment because of the maintenance of a relatively constant soil moisture level. This has important implications for plant water requirements, tolerance and control of disease.

- **Economy:**

Investing in a low volume irrigation system can save you money and significantly lower your water use.

Disadvantages of Drip Irrigation:

No serious introduction to drip irrigation would be complete without a look at the disadvantages associated with its use:

- The drip tubing can be susceptible to damage from rodents, and household pets.

- A filter is required to guard against potential clogging of the small water passages of the drip emitters and micro sprinklers.
- You cannot see a drip system working as you can see a conventional sprinkler system.
- Each drip emitter creates a wetted area around each plant, so watering is more critical in replacing the water used by the plant to avoid stress.

MAINTENANCE OF THE SYSTEM FILTERS

Both screen and sand media filters in a drip irrigation system should be checked during or after each operating period and cleaned if necessary.

A clogged screen or grooved-disk filter can be cleaned with a stiff bristle brush or by soaking in water.

A sand media filter should be back flushed when pressure gauges located at the inlet and outlet sides indicate a 5 psi difference. Check drip irrigation lines for excessive leaking and look for large wet patches in the planting area that indicate a leaking tube or defective emitter.

It is also a good practice to flush submains and laterals periodically to remove sediments that could clog emitters.

Systems can be designed with automatic back flushing devices and automatic end-line flushing devices, but they still require manual checks.

CHOOSING AN IRRIGATION METHOD-7

To choose an irrigation method, the farmer must know the advantages and disadvantages of the various methods. He or she must know which method suits the local conditions best. Unfortunately, in many cases there is no single best solution: all methods have their advantages and disadvantages.

This paper gives some very broad guidance and indicates several important criteria in the selection of a suitable irrigation method.

Surface, Sprinkler or Drip Irrigation:

The suitability of the various irrigation methods, i.e. surface, sprinkler or drip irrigation depends mainly on the following factors:

- Natural conditions
- type of crop
- type of technology
- previous experience with irrigation
- required labor inputs
- costs and benefits.

The natural conditions such as *soil type*, *slope*, *climate*, *water quality and availability*, have the following impact on the choice of an irrigation method

Soil type:

Sandy soils have a low water storage capacity and a high infiltration rate. They therefore need frequent but small irrigation applications, in particular when the sandy soil is also shallow. Under these circumstances, sprinkler or drip irrigation are more suitable than surface irrigation.

On loam or clay soils, all three irrigation methods can be used, but surface irrigation is more commonly found. Clay soils with low infiltration rates are ideally suited to surface irrigation.

When a variety of different soil types is found within one irrigation scheme, sprinkler or drip irrigation are recommended as they will ensure a more even water distribution

Slope:

Sprinkler or drip irrigation are preferred above surface irrigation on steeper or unevenly sloping lands as they require little or no land leveling. An exception is rice grown on terraces on sloping lands

Climate:

Strong wind can disturb the spraying of water from sprinklers. Under very windy conditions, drip or surface irrigation methods are preferred.

In areas of supplementary irrigation, sprinkler or drip irrigation may be more suitable than surface irrigation because of their flexibility and adaptability to varying irrigation demands on the farm.

Water availability:

Water application efficiency is generally higher with sprinkler and drip irrigation than surface irrigation and so these methods are preferred when water is in short supply.

However, it must be remembered that efficiency is just as much a function of the irrigator as the method used.

Water quality:

If the irrigation water contains dissolved salts, drip irrigation is particularly suitable, as less water is applied to the soil than with surface methods.

Sprinkler systems are more efficient that surface irrigation methods in leaching out salts

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دەسپێکەك بو

زانستێ ئاڤدانێ

ناميلكەكا رێ نيشاندەرە بو قوتابيێن خواندنا بەكالوريوسێ / يێن كۆليژێن چاندنێ

بەرهەڤکرن:

د. عزت فندی

پشکا زانستێن ئاخ وئاڤێ

فاکولتیا چاندن و دارستانێ / زانکۆیا دهۆک