Farm Irrigation & Drainage

Section A

* **Sources of Irrigation Water:-** There are regional differences in water characteristics, based mainly on geology and climate. There may also be great differences in the quality of water available on a local level depending on whether the source is from above ground (rivers and ponds) or from groundwater aquifers with varying geology, and whether the water has been chemically treated. Municipal system water and deep wells generally provide the best water source for greenhouse operations. Chemical treatment of water may be required when pollutants such as iron, sodium, dissolved calcium & Mg, or bicarbonates are present. Surface water such as ponds & streams may have more particulate matter such as suspended soil particles, leaves algae or weeds that needs to be filtered out.

The sources of water for irrigation can include surface water sources, groundwater sources, municipal water supplies, grey water sources, and other agricultural and industrial process wastewaters.

Surface water sources include 'flowing' water

• Drilled wells are a clean source of water for many greenhouse operations however, the water yield from drilled wells is usually limited.

supplies (i.e, creeks, streams, canals) and 'standing' or stored water supplies (i.e. ponds, reservoirs, lakes).

Surface water is subject to contamination from sources such as sediment, chemicals and plants growth. High levels of particles can reduce the life of pumps & clog irrigation systems and multiple filters may be required. It is also possible that surface waters can become contaminated with road salt, industrial, agri. chemicals, algae & plant pathogens.

Groundwater supplies may come from springs and wells, and although the quality is usually good, the avaliable quantity that can be pumped at any time may again limit the irrigation method.

Groundwater is found in aquifers that are located below the earth surface. As rainfall occurs, some of it evaporates, some of it is removed by plant transpiration and the remaining water filters down through the topsoil and flows into sand, gravel and fractured rock. It reaches a depth where all the pore spaces are filled. This saturated zone is call the aquifer.

The flow of water from a well depends on the permeability and size of the aquifer, its recharge area and the amount of rainfall. A well in one location may provide very low yield, while another area, may provide a high water yield. In most areas, well drillers keep an accurate record of the depth and yield of wells they drill. Groundwater quality varies due to the parent material. For e.g, in the Berkshires of Western Massachusetts groundwater is often drawn from limestone aquifers. Even for one site, the location and depth of the well can have an imp. effect on water quality. Elemental content and bicarbonate levels can also change with the seasons of the years and the amount of pumping from the wells.

Municipal water includes water supplied by city, country or municipality. Either, ground, rain and / or surface water may be used. The cost and quality are typically high since much of the water is for residential use and drinking water and is treated. Muncipal water may have fluoride ~~pd~~. and / or chlorine added at water which is not a problem for most crops. Occasionally, sodium compounds are added to treat hard water.

Drainage ponds are usually a combination of rainwater & run off. Drainage ponds commonly contain fertilizers or other agricultural chemicals. Because of the size and lack of aeration biological conditions such as algal growth may be concern.

Rainwater can be collected from greenhouses or building roofs without contacting the ground & held in a concrete cistern, fiberglass or polythene tank, water silo or other holding tank. Rainwater will be very low in elemental or chemical contamination unless there is industrial air pollution or fallout on the roofs. The pH of collected rain may be low (4.0-5.0) but is not buffered and changes readily. Rainwater is an excellent and

Once rainwater is collected, it can be distributed to the greenhouses through the normal irrigation system.

Grey-water is domestic wastewater, other than that containing human excreta, such as sink drainage, washing machine discharge or bath water.

The quality of agricultural or industrial process wastewaters often limits their use to surface or sprinkler irrigation methods, and in their suitability for fruit and vegetable crop irrigation.

* Methods of measurement of irrigation water:

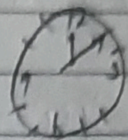
Irrigation water management begins with knowing how much water is avaliable for irrigation. Fact sheet 1501, discusses water measurement units & useful factors for converting from one measurement unit to another. The purpose of this fact sheet is to discuss a few basic methods of water measurement.

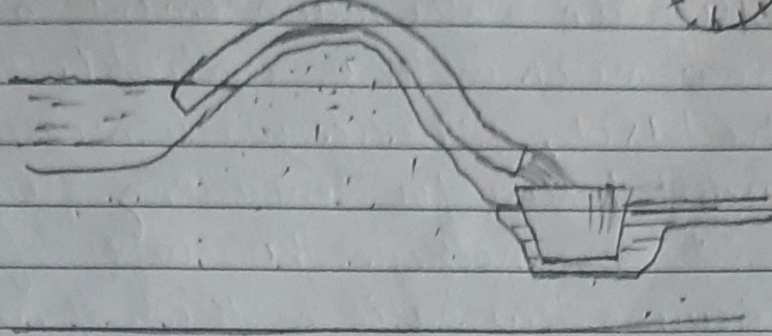
Methods of measuring irrigation water can be grouped into three basic categories - direct, velocity-area and constricted flow. Choice of method to use will be determined by the volume of water to be measured, the degree of accuracy desired, whether the installation is permanent or temporary, and the financial investment required.

1. (a) **Direct Measurement Methods:** Measuring the period of time required to fill a container of a known vol. 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 55 gallon barrel as the container. It is recommended that the measurement be repeated at least three & preferably five times to arrive at a reliable

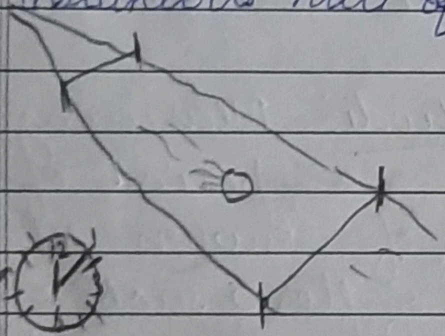
rate of flow per unit of time.

Siphon Tube



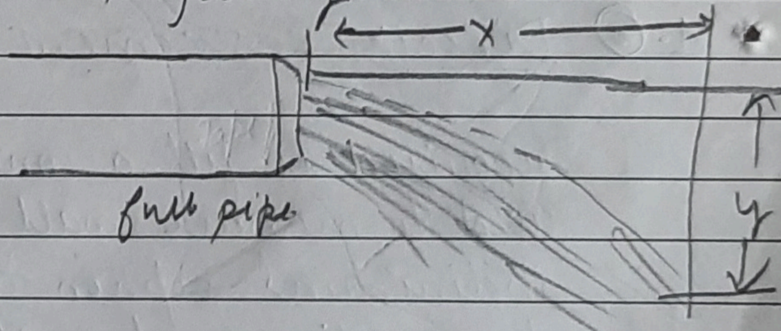


2. <u>Velocity-Area Methods</u> :- Commercial flow meters are available for measuring the total volume of water flowing through a pipe. These flow meters are relatively expensive, however, they have a good degree of accuracy if properly installed and maintained. Some meters can be purchased, which will indicate instaneous rate of flow.



Av. cross section

Trajectory Measurement



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

Select a straight section of ditch from 50 to 100 feet long with fairly uniform cross-sections. Make several measurements of the width and depth of the test cross-section so as 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 sections. 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 av. time required (seconds), one can estimate velocity of the stream, multiply the estimated surface velocity by a correction factor to obtain the av. stream velocity.

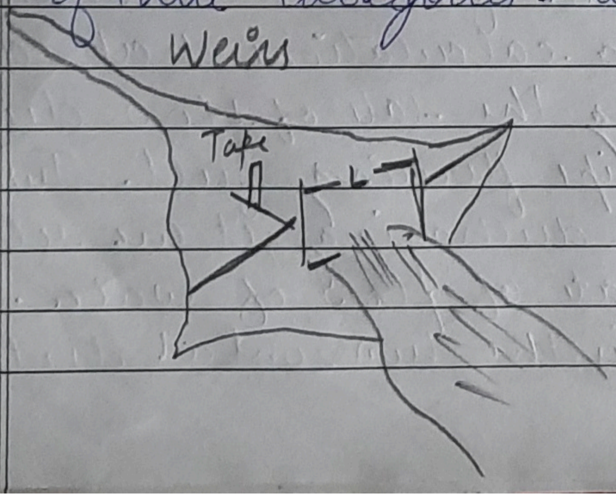
To obtain the rate of flow, multiply the av. cross sectional area of ditch times the av. stream velocity and the answer in the rate of flow in cubic feet per second.

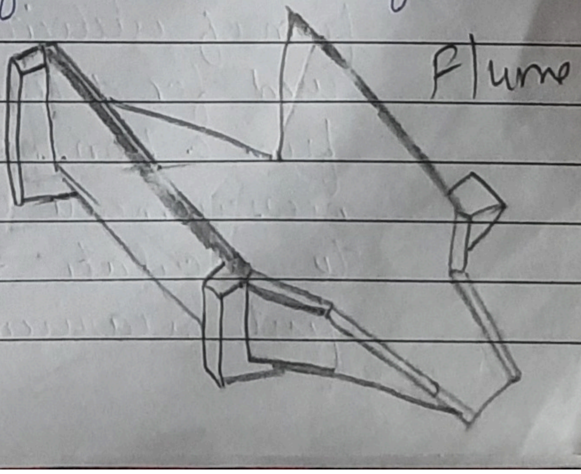
The trajectory method of water measurement is a form of velocity area calculations that can be used for determining the rate of flow discharging from a horizontal pipe flowing full. Two measurements of the discharing jet are required to calculate the rate of flow of water. The first measurement is the horizontal distance 'x'

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' 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.

Normal pipe dia	Factor when y=6	Factor when y=6
2"	5.02	3.52
3"	11.13	7.77
4"	17.18	13.4
6"	43.7	30.6

3. Constriction Flow Methods :- Methods employing a constriction of pre-determined dimensions are frequently used for measuring flow in irrigation canals & ditches. Constricting type measuring devices can generally be placed in one of three categories - weirs, flumes, and orifices.





[Submerged orifice
[Free flowing orifice   in phone pdf.
• Orifice plate – open pump discharge
• Orifice Plate construction

Generally, only one or two measurement are required where the dimensions of the constriction are known. Using these measurements, rate of flow is determined from either a table, a graph or by calculation.

Basically, a weir measures flow by causing the water to flow over a notch of pre-determined shape and dimensions. They are quite accurate when properly constructed, installed and maintained. Weirs do have some limitations. First, they require considerable drop b/w the upstream & downstream water surface which is often either not available in flat grade ditches or is undesirable. Second, it is frequently necessary to construct a pool or stilling area above the weir so the water looses its velocity.

A flume measures flow by causing the water to flow through a channel of pre-determined dimensions. Flumes usually can operate with less difference in elevation b/w upstream & downstream water surfaces than can weirs. Like weirs, when properly installed and maintained, flumes are quite accurate means of measuring water flow.

An orifice measures water flowing through an opening of pre-determined shape & size. For a given amount of head a specific quantity of water will flow through the opening. Orifices can be classified as "free flowing" where the flow from the orifice discharges entirely into a air or fully submerged" where the downstream water surface is above the top of the orifice & the flow discharges into water. Avoid orifices that do not flow free or are not completely submerged.

Orifice plates properly installed on open pump discharges can provide a relatively inexpensive and reasonably accurate mean of measuring well discharge. It is very imp. that the opening in the orifice plate be accurately machined to dimension. Slight variation from specified dimensions can cause wide variation from calculated rate of flow.

The eqn for calculating flow through an orifice is $Q = K\sqrt{H}$ where

Q = flow in gallons per min.

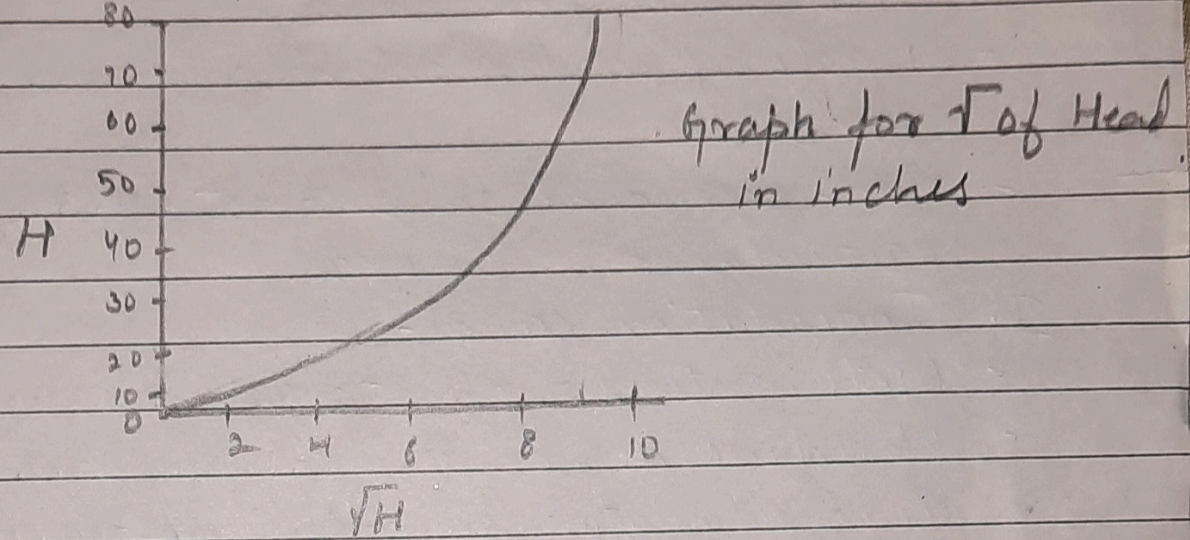
K = a constant dependent upon a combination of pipe size, orifice size & orifice shape, & discharge condn.

H = head in inches.

Value of K

Pipe size inches	Orifice size in inches: 3	4	5	6	7	8
4	42.3					
6	33.3	63.3	123.0			
8		58.0	97.3	155.0		
10				141.0	208.0	311.0

The following graph can be used for determining the "square root" of the head (H) in inches. Having measured the head H using the glass tube and a scale, enter the graph at the left side. Move horizontally to intercept the curve & move downward to determine the square root of H ($\sqrt{H}$).



Irrigation Channels and Underground Pipelines system :-

Defined as : Canal is a artificial channel, generally trapezoidal in section, constructed to carry water to fields from source / river / reservoir.

⑥ Classification of canals based on

1. Nature of source of supply
2. Financial output
3. Function of canal
4. Discharge and Relative importance of canal in network.
5. Canal Alignment

I. Nature of source of supply
(i) Permanent canal-
- Is fed from permanent source of water
- Aka perennial canal
- Made of well graded channel with permanent structures
- Non-perennial canals - get supply only during particular time of year.

II. Inundation canal-
- Gets water when stage in river is higher.
- Headworks for diversions are not provided.
- Head regulators are provided, generally 5-6 km d/s from offtake point.

2. Financial Output
(i) Productive - once fully developed yields enough revenue to recover initial investment.
(ii) Protective - after construction serves as relief work during famine and protect area against future famines, generates employment.

3. Function of canal
(i) Irrigation canal - carries water to the agricultural field
(ii) Carrier canal - along with irrigation, carries water for other canals.
(iii) Feeder canal - it feeds 2 or more canals.
iv. Navigational canal - used for navigational purposes
v. Power canal - carries water from reservoir to turbine houses, it is located on canal where fall is available.

Section B

* Methods of irrigation, selection and operation.

India has about 140 million hectares of net cultivated area, out of which merely 45% is irrigated. Currently, 9 million hectare is under micro-irrigation, in which drip irrigated area is 4 million hectare.

For the plant growth adequate supply of water is extremely important. Irrigation is the only way our farmers can continue to store and use water appropriately. Not only this, with proper irrigation facilities our farmers would be able to spend less time on the fields and more time in learning new skills, personal development and in on agricultural forums.

The primary points that need to be considered while planning for irrigation are:

1. Land suitability
2. Effective rainfall
3. Decide when to irrigate (this depends on the soil, crop and climatic condn)
4. How much water is required by the crop.
5. Select the most suitable method to irrigate
6. Quality of the irrigated water

Five highly effective methods of irrigation:-

1. Sprinkler irrigation
2. Drip irrigation
3. Surface irrigation
4. Basin irrigation
5. Furrow irrigation

- Micro (above)
- Subirrigation

1. Sprinkler irrigation :- It is similar to rainfall.
- In this type, water is pumped using a pipe system and then sprayed through sprinkler heads.
- With sprinkler irrigation field areas irrespective of their sizes can be covered efficiently.
- This irrigation method can be applied to all the types of soils since sprinklers with different discharge and outlet capacities are available on the market.

2. Drip irrigation: Drip irrigation can be defined as the method in which water drips slowly via a pipe system to the roots of the plants either from above or below the soil surface.
- It is also known as micro-irrigation by which both water and soil nutrients can be saved.
- A set up of valves, tubes, pipes, and emitters is used for drip irrigation.
- The best part about drip irrigation is that valves and pumps can be operated both manually and automatically with the help of a controller.

3. Surface Irrigation :- It has been practiced and followed for many years now.
- It can be defined as a group of techniques where water is distributed over the surface of the soil gravity.
- In this type of irrigation, either the field is flooded (this is known as Basin irrigation) or the water is fed into small channels (this is known as furrow irrigation).

4. Basin Irrigation :- Basin Irrigation method is primarily used for crops that stand in water for ~~some~~ more extended periods, flat lands where

is grown or in terraces on hillsides.

- In Basin irrigation flat areas of land are surrounded by low bunds. These bunds block the water and prevent it from entering the adjacent fields.
- Trees can also be grown using basin irrigation method.
- Basin irrigation is suitable pastures, citrus, banana and to some extent tobacco.
- This method cannot be used for crops that cannot stand waterlogged like potatoes, beetroot and carrots.
- The type of crop grown determines the soil suitable for basin irrigation.
- Basin Irrigation is suitable pastures, citrus.
- It can be constructed on a flat surface, the easier it is to build basins, sloping land.
- level basins, called terraces, can be constructed on steps of a staircase.

5. Furrow irrigation :- The application in which small channels carry water in between the crop rows and down the slope is known as Furrow irrigation.

- It is preferable to row crops and the ones that cannot thrive waterlogging.
- Only maize, sunflower, sugarcane, and soyabean can be irrigated via furrow irrigation.
- In this particular method of irrigation water flows from the field channel into the furrows by opening up the bank of the channel or by siphons or spiles
- While tomatoes, Potatoes, Beans, Citrus and Grapes would be damages if grown with furrow irrigation
- Furrows must determine the slope, type of soil,

size of the stream, irrigation depth, and field length.

- It should be done on flat or gentle slopes; if done on undualting land, furrow irrigation should follow the land contouring method.

⑥ Selection of irrigation methods: The different types of irrigation methods selected will depend on water supply conditions, climate soil, crops to be grown, cost of irrigation method and the ability of the farmer to manage the system. However, when using wastewater as the source of irrigation other factors, such as contamination of plants and harvested product, farm workers, and the environment and salinity and toxicity hazards, will need to be considered. There is a considerable scope for reducing the undesirable effects of waste water use in irrigation through selection of appropriate irrigation methods.

The choice of irrigation method in using waste water is governed by the following technical factors:-

- the choice of crops,
- the wetting of foliage, fruits and aerial parts,
- the distribution of water, salts and contaminants in the soil,
- the ease with which high soil water potential could be maintained,
- the efficiency of application, and
- the potential to contaminate farm workers and the env.

A border (and basin or any flood irrigation) systems involves complete coverage of the soil surface with treated effluent and is normally not an efficient method of irrigation. This system will also contaminate vegetable crops growing near the ground and root crops (growing near the ground) and will expose farm workers to the effluent more than any other method. Thus, from both the health and water conservation points of view, border irrigation with wastewater is not satisfactory.

Furrow irrigation, on the other hand, does not wet the entire soil surface. This method can reduce crop contamination of farm workers is potentially med. to high, depending on automation. If the effluent is transported through pipes and delivered into individual furrows by means of gated pipes, risk to irrigation workers will be minimum.

The efficiency of surface irrigation methods in general, borders, basins, and furrows is not greatly affected by water quality, although the health risk inherent in these systems is most certainly of concern. Some problems might arise if the effluent contains large quantities of suspended solids and these settle out and restrict flow in transporting channels, gates, pipes. The use of primary treated sewage will overcome many of such problems. To avoid surface ponding of stagnant effluent, land levelling should be carried out carefully and appropriate land gradients should be provided.

Sprinkler, or spray, irrigation methods are generally more efficient in terms of water use since greater uniformity of application can be achieved. However, these overhead irrigation methods may contaminate ground crops, fruit trees, and farm workers. In addition, pathogens contained in aerosolized effluent may be transported downwind and create a health risk to nearby residents. Rough land levelling is necessary for sprinkler systems, to prevent excessive head losses and achieve uniformity of wetting. Sprinkler systems are more affected by water quality than surface irrigation systems, primarily as a result of the clogging of orifices in sprinkler heads, potential leaf burns and phytotoxicity when water is saline and contains excessive toxic elements, & sediment accumulation in pipes, valves and distribution systems. Secondary wastewater treatment has generally been found to produce an effluent suitable for distribution through sprinklers, provided that the effluent is not too saline.

Localized irrigation, particularly when the soil surface is covered with plastic sheeting or other mulch, uses effluent more efficiently, can often produce higher crop yields and certainly provides the greatest degree of health protection for farm workers & consumers.

(c) Operation of irrigation System – It implies a package of organizational and economic and technical arrangements that ensure planned distribution and full use of water resources for heavy yield of agricultural crops of good quality under irrigation conditions.

i.e, during the operation of irrigation systems their state and the condition and use of irrigated lands as well as proper water use should taken into consideration.

Operational measures include the following:

- Implementation of scheduled water use practice to provide the irrigation regime required under specific meteorological conditions on certain land areas under efficient water use.
- Keeping irrigation, drain and other canals, pipelines and buildings in good working order by guarding supervision, maintenance & repair of irrigation systems.
- prevention of inflow of excess of water into irrigation system & diversion of excess water.
- Control of water losses in canals and improvement of system efficiency.
- Organization of irrigation water accounting.
- Control over proper water use and groundwater condn.

⊙ Objectives of irrigation system operation

Proper development of irrigated lands and streamlined function of irrigation system operating service are indispensable conditions for gaining heavy and sustainable crop yield.

Operation of irrigation system includes: implementation of scheduled water use in the system and in irrigated farms; keeping all system components in good working order; arrangement of their work in compliance with farm performance targets and depending on system operating conditions (climatic, hydrageological) etc; reconstruction of irrigation

2.

systems by adopting new techniques and technologies, control over efficient use of water and land resources, improvement of meliorative condⁿ of irrigated lands etc.

Irrigation systems are operated and maintained by special organizations: irrigation system administrations (ISA); canal management organizations; administration of hydroschemes; administration of reservoirs etc.

There are following operating services

- On farm operating service that maintains irrigation network and irrigation equipment in farms - water users
- Inter-farm operating service that is in charge of the inter-farm irrigation network.
- Basin operating service that distributes water from an irrigation water source among irrigation systems

On farm operation of irrigation system should be carried out in close cooperation with an agronomic service of farms.

On-farm operating service has the following duties: drawing up and implementation of water use schedules; control over water application process; cutting of temporary irrigation network; leveling of fields; preparation of irrigation equipment and irrigators, keeping of irrigation network and structures in serviceable condⁿ by their timely maintenance & repair, cleaning of canals from sediments and weediness; keeping of operational equipment in serviceable condⁿ; performance of tree-planting works; control of soil salinization and swamping, etc

Stages of irrigation system operation

1. Stages of irrigation system operation are broken down into stage of use and stage of maintenance

2. Stage of irrigation system use consists in the implementation of the full range of system features responsible for its capability to meet the need for optimum water regime of soils as effectively as possible.

3. Stage of irrigation system maintenance consists in material and technical support, implementation of measures for restoration of good condn of irrigated lands (soil conservation) and technical maintenance, routine maintenance and overhaul, which ensure continous system functioning and sustainable implementation of the full range of its feature.

4. At the operation stage, control of application and maintenance system is exercised.

Drainage Methods :-

Drainage is saturation of removal of excess water from the field to ensure a favourable salt balance in the soil and water table optimum for crop growth and development".

Drainage aims at maintenance of soil moisture within the range required for optimum crop growth.

Effects of poor drainage :- (a) causes relatively poor root growth.

(b) Reduction of soil strength.

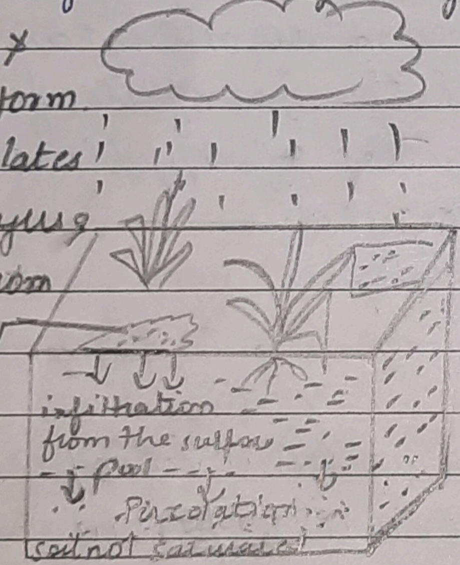
(c) change in the pH and natural stabilization.

(d) Reduced nutrient availability

e Accumulation of toxicants (H_2S, CH_4).

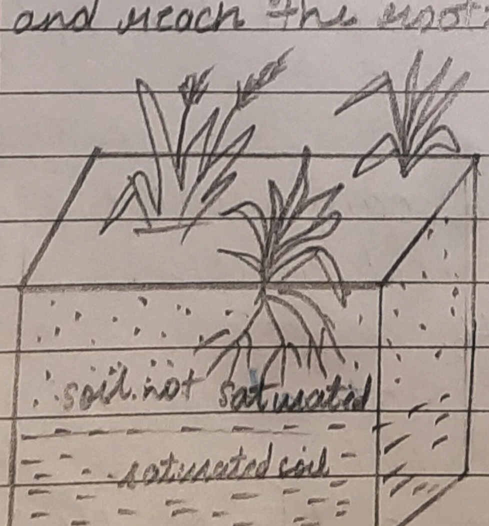
(f) Poor crop growth / nutritional disorders and yield reduction.

Need for drainage :- During rain or irrigation, the fields become wet. The water infiltrates into the soil and is stored in it's pores. When all the pores are filled with water, the soil is said to be saturated and no more water can be absorbed; when rain or irrigation continues, pools may form on the soil surface. During heavy rainfall the upper soil layer become saturated & pools may form. Water percolates to deeper layers, infiltrates from the pools

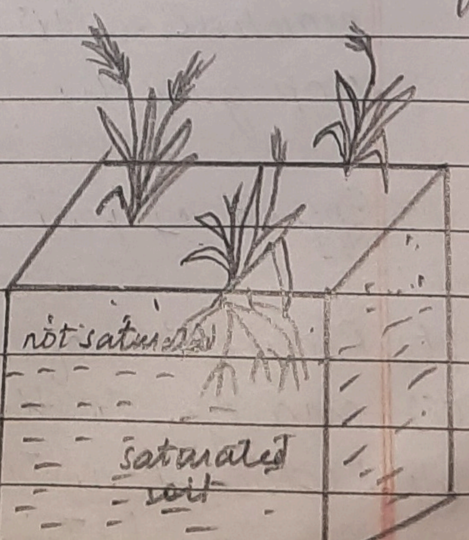


Part of the water present in the saturated upper soil layers flows downward into deeper layers and is replaced by water infiltrating from the surface pools. When there is no more water left on the soil surface, the downward flow continues for a while and air re-enters in the pores of the soil. This soil is not saturated anymore.

After heavy rainfall the groundwater table may rise and reach the rootzone.



Before heavy rainfall



After heavy rainfall

The removal of excess water either from the ground surface or from the root zone is called drainage. Excess water may be caused by rainfall or by using too much irrigation water, but may also have other origins such as canal seepage or flood.

Methods :- 1) Surface Drainage
2) Subsurface Drainage

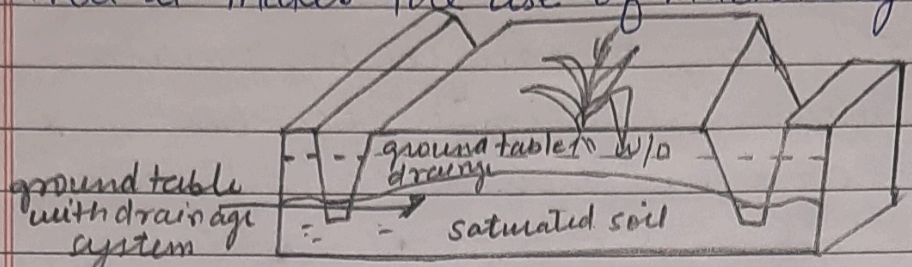
Drainage can be either natural or artificial. Many areas have some natural drainage; this means that excess water flows from the farmer's fields to swamps or to lakes and rivers. Natural drainage, however is often inadequate and artificial or man-made drainage is required.

2 types of artificial drainage :- Surface & Subsurface drainage.

Surface drainage :- It is the removal of excess water from the surface of the land. This is normally accomplished by shallow ditches, also called open drains. The shallow ditches discharge into larger and deeper ~~cool~~ collector drains. In order to facilitate the flow of excess water toward the drains, the field is given an artifical slope by means of land grading.

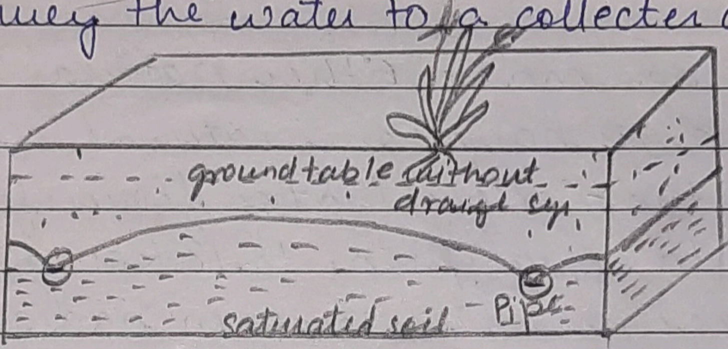
Subsurface drainage : It is the removal of water from the root zone. It is accomplished by deep open drains or buried pipe drains.

(i) Deep open drains : The excess water from the root zone flows into the open drains. The disadvantage of this type of subsurface drainage is that it makes the use of machinery difficult.



control of groundwater table by means of deep open drains

(ii) Pipe drains :- They are buried pipes with openings through which the soil water can enter. The pipes convey the water to a collecter drain.



Drain pipes are made of clay, concrete or plastic. They are usually placed in trenches by machines. In clay and concrete pipes (usually 30 cm long and 5-10 cm in diameter) drainage water enters the pipes through the joints. Flexible plastic drains are much longer and the water enters through perforations distributed over the entire length of the pipe.

(iii) Deep open drains versus pipe drains :- Open drains use land that otherwise could be used for crops. They restrict the use of machines. They also require a large number of bridges and culverts for road crossings and access to the fields. Open drains require frequent maintenance (weed control, repair, etc).

In contrast to open drains, buried pipes causes no loss of cultivable land and maintenance requirements are very limited. The installation costs, however, of pipe drains may be higher due to the materials, the equipment and the skilled manpower involved.

Components of Drainage system

Components of surface drainage :- It always has two components.

(1) land forming, which is bedding, land grading, or land planning.

(2) the construction of field and collector drains.

Land Forming

- Bedding :- Desgin considerations - To ensure good drainage in a bedding system, the beds should not be more than 10m wide. Further, the width of the beds is governed by the following:
- The kind of crops to be grown: Field crops require narrower beds than permanent pasture or hay crops do.
- Farming operations on beds: Ploughing, planting, and cultivating should fit the width of a bed. Bed width should be a multiple of the effective width of farm equipment.
- Soil characteristics: soils with low infiltration and low hydraulic conductivity require narrower beds than soils with better characteristics.

Construction :- It often take several years of ploughing to obtain an adequate bedding system. During the first ploughing. care should be taken to make beds of uniform width throughout the field and to have the field drains running in the direction of the greatest slope. Any obstructions or low points in the field drains should be eliminated because they will cause standing water and loss of crops. The collector drain should be laid out in the direction of the lesser field slope, and should be properly graded towards the main drainage system.

<u>Land grading and land planing</u>: When grading land for surface drainage, the slope does not need to be made uniform, as for irrigation; a non-uniform slope will suffice.

In addition, the types of crop and how they will be grown to be considered. Crops like maize, potatoes, and sugarcane are grown in rows with small furrows in between. For such crops, the length of the rows and the slopes of the field must be selected so as to avoid erosion and overtopping of the small furrows. To prevent erosion, it is recommended that the flow velocities in the furrows should not exceed 0.5 m/s. In highly erodible soils, the row length is limited to about 150m. The direction of the rows and furrows need not necessarily be at right angles to the slope, but can be selected in any way that meets the above recommendations.

Small grains and hay crops are grown by broad cast sowing or in rows, but on an even surface (i.e. no furrows). For such crops, surface drainage takes place by sheet flow. This flow is always in the direction of the maximum slope. With sheet flow, the flow resistance is much higher than in small furrows, and the flow velocity on the same land slope is less. Even after careful land grading and smoothing, however, sheet flow always has a tendency to concentrate in shallow depressions, and gullies are easily formed. With the transport duration for low flow velocities in mind, it is recommended that the field length in the flow direction to be limited to 200 m or less.

For wetland rice and other crops grown in basins, the surface is levelled by earthmoving machinery (large basins) or with simple farm implements. Levelled fields are surrounded by field bunds. Any excess water from basins is usually drained through an overflow in the field bunds that spills the water directly into a field drain.

Construction:- Land grading can be done by the farmers, although normal farm equipment, even if mechanized, can handle small-scale grading operations or the maintenance of already established grades. Large-scale land grading is done by contractors with conventional earthmoving equipment or with laser-guided motorized graders.

Grading operations involve a number of steps. The first step is to prepare the site. If the land has already been cleared, the work mainly involves removing or destroying vegetation and other obstacles, and levelling ridges or rows. This can normally be done with farm equipment. The surface should be dry, firm and well pulverized to enable the equipment to operate efficiently.

The second step is rough grading. This can be done with various types of equipment (e.g. dozer, motor graders, scrapers). The choice will depend on the soil conditions, the amount of earthwork needed, the time and equipment avaliable, the size of the fields to be graded as one unit, and local experience.

The third step is the finished grading. On small fields, drags, harrows, and floats can be used. These implements can be pulled by a farm tractor or by animal traction. On larger fields, a land plane pulled by a farm tractor is used. For the final smoothing, several passes are usually made at angles to one another.

When extensive grading is done with heavy equipment, it is likely to cause the soil to become compacted. This compaction should be relieved to eliminate differences in soil productivity. Various tillage tools can be used for this work (e.g. subsoilers, chisels and rippers.)

Field Drains

Design of surface drain: Field drains for a surface drainage system have a different shape from field drains for subsurface drainage. Those for surface drainage have to allow farm equp. to cross them and should be easy to maintain with manual labour or ordinary mowers. Surface runoff reaches the field drains by flow through row furrows or by sheet flow. In the transition zone between drain and field, flow velocities should not induce erosion.

Field drains are thus shallow and have flat side slopes. Simple field drains are V-shaped. Their dimensions are determined by the construction equp, maintenance needs, and their "crossability" by farm equipment. Side slopes should not be steeper than 6 to 1. Nevertheless, long field drains under condⁿ of high rainfall intensities, especially where field runoff from both sides accumulates in the drain, may require a transport capacity greater than that of a simple V-shaped channel.

A variation is the W-shaped field drain, which is applicable where a farm road has to run b/w the drains. These drains are generally farmed through and their upper slopes may well be planted. All fields drains should be graded towards the collector drain with grades b/w 0.1 and 0.3%.

Open collector drains collect water from field drains and transport it to the main drainage system. In contrast to the field drain, the cross-section of collector drains should be designed to meet the required discharge capacity. The hydraulic design is similar to the design of irrigation canals.

When designing the system, the maintenance requirements must be considered. For example, if the collector drains are to be maintained by mowing, side slopes should not be steeper than 3 to 1.

Attention must also be given to the transition b/w the field drains and the collector drain, because difference in depth might cause erosion at those places. For low discharges, pipes are a suitable means of protecting the transition. For higher discharges, open drop structures are recommended.

<u>Construction of surface drains</u>: Open surface drains can be constructed manually or mechanically. Care should be taken

that the spoil from the drains does not block the inflow of runoff, but is deposited on the correct side of the ditch or is spread evenly over the adjacent fields.

Collector drains are usually constructed with different machinery than that used for field drains. The soil is placed near the sides of the drain. Scrapers are needed when the excavated soil is to be transported some distance away.

Components of Subsurface drainage System:

Subsurface drainage aims at controlling the water table - a control that may be achieved by tubewell drainage, open drains, or subsurface drains (pipe drains or mole drains). Tubewell drainage and mole drainage are applied only in very specific condn. Moreover, mole drainage is mainly aimed at a rapid removal of excess surface water, indirectly controlling the rise of the water table.

- Open and pipe drains. The usual choice for subsurface drainage is :- between open drains and pipe drains. This choice has to be made at two levels: for field drains and for collectors.

Open drains have the adv. that they can receive overland flow directly, but the disadvantages often overweigh the adv. The main disadv. are the loss of land, interference with the irrigation system, the splitting up of the land into small parcels, which hampers mechanized farming operations and a maintenance burden.

- Tubewell drainage refers to the technique of controlling the water table and salinity in agricultural areas. It consists of pumping, from a series of wells, an amount of groundwater equal to the drainage requirement. The success of tubewell drainage depends on many factors, including the hydrological condn of the area, the physical properties of the aquifer to be pumped and those of the overlying fine-textured layers.
- Mole drainage. Heavy soils of low hydraulic conductivity (less than 0.01m/day) often require very closely spaced drainage systems for satisfactory water control. With conventional pipe drains, the cost of such systems is usually uneconomic and hence alternative techniques are required. Surface drainage is one possibility; the other is mole drainage.

Mole drains are unlined circular soil channels which function like pipe drains. Their main adv. is their low cost and hence they can be installed economically at very close spacings. Their disadvantage is their restricted life but, providing benefit/cost ratio are favourable, a short life may be acceptable.

The success of mole drainage system is dependent upon satisfactory water entry into the mole channel and upon the mole channel itself remaining stable and open for an acceptable period.

Moles drains are formed with a mole plough, which comprises a cylindrical foot attached to a narrow leg, followed by a slightly larger diameter cylindrical expander.

Design of subsurface drainage systems

Depth and spacing of field drains. The depth & spacing of field drains are usually calculated with the help of drainage equations. The data needed for these calculations include the agricultural requirements, the soil characteristics and hydraulic factors.

Calculated drain spacings normally show considerable variations due to the variations in input data. If so, the area should be divided into sub-areas or "blocks" of a convenient size. For each sub-area or block, a uniform and representative drain spacing can then be selected.

Pipes. The materials used in the manufacture of drain pipes are clay, concrete and/corrugated perforated plastics. Important criteria for pipe quality and for selecting the most suitable type of pipe are the availability of raw materials, the resistance to mechanical and chemical damage, longevity and costs. The costs are the total costs for purchase, transport, handling and installation.

Envelopes. Sometimes, pipe drains are installed with an envelope. An envelope is the material placed around the pipe to perform one or more of the following functions.

- Filter function: to prevent or restrict soil particles from entering the pipe where they may settle and eventually clog the pipe.

- Hydraulic function: to constitute a medium of good permeability around the pipe and thus reduce entrance resistance.
- Bedding function: to provide all-round support to the pipe in order to prevent damage due to the soil load. Note that large-diameter plastic pipes are embedded in gravel especially for this purpose.

A wide variety of materials are used as envelopes for drain pipes, ranging from organic and mineral materials, to synthetic materials and mineral fibres. Organic material is mostly fibrous, and includes peat, coconut fibre and various organic waste products like straw, chaff, heather and sawdust. Mineral materials are mostly used in a granular form: they may be gravel, slag of various kinds (industrial waste products), or fired clay granular form or in fibrous form. Glass fibre, glass wool and rock wool, which all are mineral fibres are also used.

There are various ways of applying envelope materials. They can be applied in bulk, as thin sheets, or as more voluminous "mats". Bulk application is common for gravel, peat litter, various slags, and granules.

It is recommended to place the pipe in such a way that it is completely surrounded by the envelope material.

Construction of Pipe drainage system

Construction methods. Pipe drainage systems are generally constructed by specialized contractors. They are selected after tenders have been called for, usually from a list of contractors drawn up by the authorities in a pre-qualification process. This type of construction work is beyond the scope of this manual. Only some matters directly related to the work at field level will be discussed.

The classical method of pipe installation consists of marking the alignments and levels, excavating the trenches by manual labour, placing the pipes and envelope material, and backfilling the trenches. ~~By~~ Nowadays, field drains are installed by drainage machines, either trenchers or trenchless machines.

Alignment and ~~labour~~ levels. To mark alignment & levels, stakes are placed in the soil at both ends of a drain line, with the top of the stakes at a fixed height above the future trench bed. The slope of the drain line is thereby indicated. A row of boning rods is then placed in line between the stakes, with an extension at a upstream end of the drain line, where the run of the drainage machine ends.

Nowadays, most drainage machines have grade control by laser. An emitter, placed on a tripod near the edge of the field, establishes an adjustable reference plane over the field by means of a rotating laser beam. A receiver, mounted on the digging part of the drainage machine, picks up the signal. The control system of the machine continously keeps a fixed mark in the laser plane

Machinery. The most common types of machines for installing field drains fall into two categories: trenchers and trenchless machines. Trenchers excavate a trench in which the pipe is laid, whereas trenchless machinery merely lift the soil while the pipe is being installed.

There are 2 types of trenchless drainage machines: the vertical plough and the V-plough. The vertical plough acts as a subsoiler: the soil is lifted and large fissures and cracks are formed. The V-plough lifts a triangular "beam" of soil while the drain pipe is being installed. Blackfilling is not needed, because no trench has been excavated.

② Types of Wells and Pumps.

Well:- It is a vertical structure dug in ground for purpose of bringing ground water to the earth's surface.

Types of wells:-

1. Drilled wells: Drilled wells are constructed by either cable tool or rotary drilling machines. Drilled wells that penetrate unconsolidated material require installation of sediment and collapse. They can be drilled more than 1,000 feet deep. The space around the casing must be sealed with grouting material of either neat cement or bentonite clay to to prevent contamination by water draining from the surface downward around the outside of the casing.
2. Driven wells: They are constructed by driving

a small diameter pipe into shallow water bearing sand or gravel. Usually a screened well point is attached to the bottom of the casing before driving. These wells are relatively simple and economical to construct, but they can tap only shallow water and are easily contaminated from nearby surface sources because they are not sealed with grouting material. Hand driven wells usually are only around 30 feet deep, machine driven wells can be 50 feet deep or more.

Dug Wells:- Historically, dug wells were excavated by hand shovel to below the water table until incoming water exceeded the diggers bailing rate. The well was lined with stones, bricks, tile or other material to prevent collapse, and was covered with a cap of wood, stone or concrete tile. Because of the type of construction, bored wells can go deeper beneath the water table than can hand-dug wells. Dug and bored wells have a large diameter and expose a large areas to the aquifer. These wells are able to obtain water from less-permeable materials such as very fine sand, silt or clay. Disadv. of this type well are that they are shallow and lack continous casing and grouting, making them sources, and they go dry during periods of drought if the water table drops below the well bottom.

tube wells.
[also read from pH. slideshare]

Types of pumps.
A Pump is a device which moves fluids by mechanical action, from one place to the other. It is essentially

the earliest form of machine, dating back to ancient Egypt.

The shaduf is the first device used for lifting water in several civilisations and thus the earliest form of pump.

Since pumps have been around for such a long time, it is no surprise that there are a seemingly endless variety of sizes and types used in multiple applications across industries

Pumps are divided into 2 major categories:

1. Dynamic and 2. Positive Displacement

In dynamic

- Centrifugal pumps
- Vertical centrifugal pumps
- Horizontal Centrifugal pumps
- Submersible pumps
- Fire hydrant systems

Positive Displacement

- Diaphragm pumps
- Gear pumps
- Peristaltic pumps
- Lobe pumps
- Piston pumps

Dynamic pumps

1. Centrifugal pumps. They are the most used pump type in the world, due to simple working principle and relatively inexpensive manufacturing cost.

How it works. An increase in the fluid pressure from the pump inlet to its outlet is created when the pump is in operation. This pressure difference drives the fluid through the system or plant.

Submersible pumps. (It also known as stormwater pumps, sewage pumps, septic pumps) can still operate when being fully submerged in water.

How it works.

Fire Hydrant systems. It (also known as fire pump, hydrant booster, fire water pump) is technically not a pump but as system by itself. The hydrant booster pump usually consists of 1 centrifugal pump and other components such as control pannel and coupled with either a diesel or electric driven motor.

* Positive Displacement pumps

Diaphragm pumps. There are 2 main types of diaphragm pumps: Air operated and Mechanical.

Air-operated diaphragm pumps are powered solely by air making them suitable for dangerous and tough environments. They are also used for chemical transfer, de-watering underground coal mines, food manufacturing or where the liquid being pumped has a high solids content or high viscosity.

Gear pumps. It transfer fluid by gears coming in and out of mesh to create a non-pulsating pumping action. They are able to pump at high pressures and excel at pumping high viscosity liquids efficiently.

How it works. Internal and external gear pumps are the 2 basic types of gear pumps. The main difference

b/w the two types of gear pumps are the placement of the gears and where the fluid is trapped.
Peristaltic pumps. It creates a steady flow for dosing and blending and is able to pump a variety of fluids, ranging from toothpaste to all sorts of chemicals. They are widely used in water treatment, chemical processing and food processing industries.
Lobe pumps. It offer superb sanitary qualities, high efficiency, reliability, corrosion resistance, and good clean-in-place and sterilise-in-place (CIP/SIP) characteristics. Thus they are very popular in F & B and pharmaceutical industries.
Piston pumps. A piston pump is a type of positive displacement pump where the high-pressure seal reciprocates with the piston. Piston pumps can be used in multiple applications and can be used to transfer paint, chocolate, pastry etc.

(2) Reinforced concrete pipes also read it.