TVET CERTIFICATE V in Crop production

SIMPLE METHODS OF IRRIGATION

CRPSMI501

Perform simple methods of irrigation

Competence

Learning hours: 70

Credits: 7

Sector: Agriculture and Food processing

Sub-sector: Crop Production

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Purpose statement

This module describes the skills and knowledge required to identify the site for irrigation, establish and maintain basic irrigation structures. By the end of this module the trainee will be able to apply manual methods of irrigation, establish simple sprinkler irrigation system, establish simple drip irrigation system and describe basic knowledge of drainage.

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Total Number of Pages: 44

LEARNING UNIT 1 – APPLY MANUAL METHODS OF IRRIGATION

LO 1.1 Select tools, materials basing on irrigation techniques

Content/Topic 1: Tools, materials used different types of manual irrigation

A. Irrigation related definitions

a) Irrigation means the action of applying water to land in order to supply crops and other plants with necessary water. Sometimes nutrients may be applied via irrigation as well.

b) Fertigation is the injection of fertilizers, used for soil amendments, water amendments and other water-soluble products into an irrigation system. Fertigation is related to chemigation, the injection of chemicals into an irrigation system.

c) Manual irrigation: is the action of applying water to land in order to supply crops and other plants with necessary water by means of manual tools like watering can, bucket, plate or other household water containers.

d) Surface irrigation is where water is applied and distributed over the soil surface by gravity. Surface irrigation comes in three major types; level basin, furrow and border strip.

e) Pressurized irrigation: In pressurized irrigation systems water is pressurized and precisely applied to the plants under pressure through a system of pipes. Pressurized irrigation systems, as opposed to the surface irrigation systems, are more effective in application of irrigation water to the crops**.** There are many variations of pressurized irrigation systems but the two major ones are: Drip irrigation systems and Sprinkler systems**.**

B. Types of irrigation water sources

Irrigation water can come from groundwater, through springs or wells, surface water, through rivers, lakes, or reservoirs, or even other sources, such as treated wastewater or desalinated water.

C. Tools used to supply water to the crops

- **Watering cans**

A watering can (or watering pot) is a portable container, usually with a handle and a spout, used to water plants by hand. It has been in use, from, at least the 17th century and has since seen many improvements in design. Apart from watering plants, it has varied uses, as it is a fairly versatile tool. The capacity of the container can be anywhere from 10 liters (for indoor household plants) to 10 liters (for general garden use).

Figure: Watering can

At the end of the spout, a "rose" (a device, like a cap, with small holes) can be placed to break up the stream of water into droplets, to avoid excessive water pressure on the soil or on delicate plants. It is very good garden equipment.

With watering cans, the field worker is able to irrigate very specific and only where it is necessary.

- **Clay pots**

A very basic subsurface method consists in placing porous clay jars (or pots) in shallow pits dug for this purpose. Soil is then packed around the necks of the jars so that their rims protrude a few centimeters above the ground surface. Water is poured into the jars either by hand or by means of a flexible hose connected to a water source. Since the walls of the pots are porous (make sure to use unglazed pots), the water can seep slowly out and reach the roots of the plants.

- **Pipes**

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. Inverted siphons are also used to carry water across wide depressions

D. Selection criteria of tools and materials used in manual irrigation method

- Costs considerations

All of the described systems are very cheap. Many of them can be made out and operated by easily available materials and tools (e.g. old buckets or bottles) or renewable resources (timber). This reduces the costs significantly. However, high labor inputs are required for operation and maintenance.

- Operation and maintenance

Tools are selected according to their skills of user and its complexity. The more the tools is complicated in its design, the more it is difficult to operate and maintain.

- Applicability

Manual irrigation methods are appropriate for small-scale farming or backyard gardening irrigation in dry and arid climates where water is scarce. In case it is applied on large scale, it will require a high cost to purchase more tools and pay labor force.

E. Advantages and disadvantages of manual irrigation methods

- Advantages

✓ Management is quite easy, you do not need any modern technology. If you have local traditional knowledge, you can do it
✓ You do not need high financial support. You can be beneficial with small lands too
✓ If you have short time water supplies, then this is the best process for you

- ✓ If your drainage system is far, then you just need longer tubes
- ✓ This is a nature-friendly system, you can utilize rainwater
- ✓ It also works effectively in a low filtration rate
- ✓ Low capital and no energy cost needed
- ✓ You can use this irrigation process in sloping lands and long fields

- Disadvantages

- ✓ Level lands require high accuracy, you cannot use it there
- ✓ Not applicable on soil with a high filtration rate
- ✓ Plants are always covered with water even when they do not need it
- ✓ Sometimes limited space gets more water than required

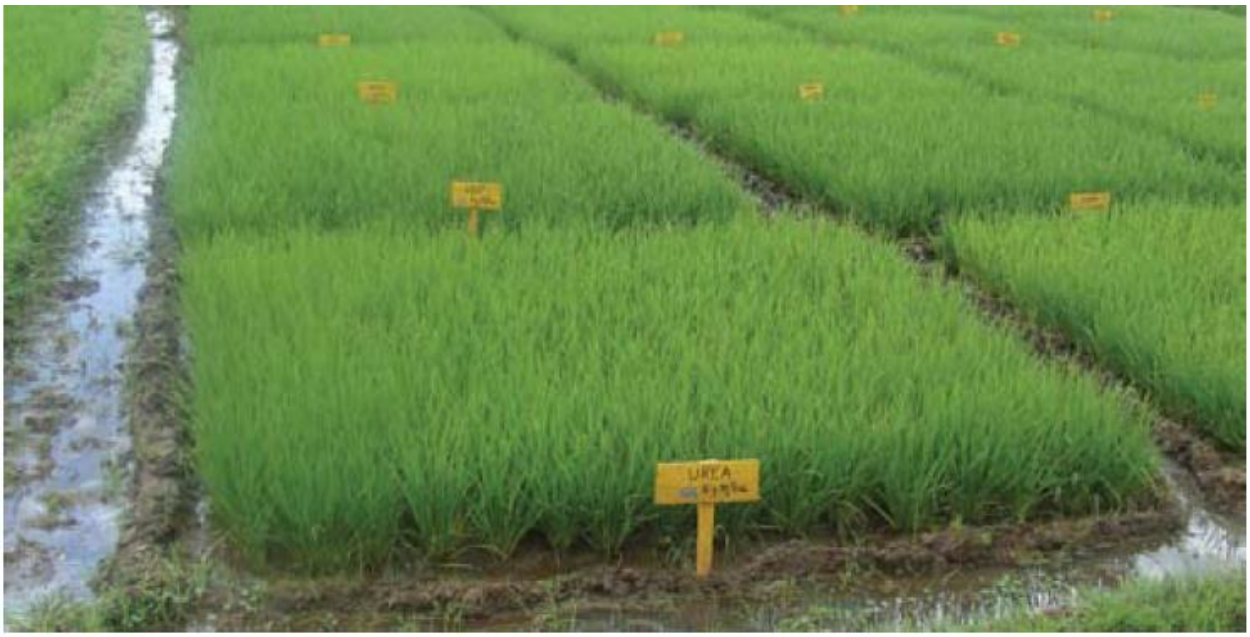
LO 1.2 – Install manual irrigation system according to irrigation techniques

- **Content/Topic 1: Methods of manual irrigation**

a) Manual or semi-manual basin irrigation

Level basin irrigation has historically been used in small areas having level surfaces that are surrounded by earth banks. The water is applied rapidly to the entire basin and is allowed to infiltrate. In traditional basins no water is permitted to drain from the field once it is irrigated.

Manual or semi-manual basin irrigation is common throughout Africa, and is widely used on a non-commercial basis throughout the world. Small basins of 20–30 m2 are constructed with soil walls, and the farmer delivers water directly to the basin in a controlled manner. This can be done by moving flexible hoses from a water source from basin to basin, by manually opening and closing furrows into the basin using one's foot or a spade, or by hand carrying water in sprinkler cans or buckets. Manual irrigation is an efficient system only in areas where manpower costs are very low.



b) Manual furrow irrigation

Furrow irrigation is a method of laying out the water channels in such a way where gravity plays the role of providing just enough water for suitable plants to grow. It is usually made by the planned placement of ridges and furrows. It is a kind of surface irrigation system.

Figure: Furrow irrigation system

c) Manual border strip irrigation

Border strip, otherwise known as border check or bay irrigation could be considered as a hybrid of level basin and furrow irrigation. The field is divided into a number of bays or strips, each border strip irrigation is separated by raised earth check banks (borders). The border strip irrigations are typically longer and narrower compared to basin irrigation and are orientated to align lengthwise with the slope of the field. Typical border strip irrigation dimensions are between 10-70m wide and 100-700m long. The water is applied to the top end of the bay, which is usually constructed to facilitate free-flowing conditions at the downstream end. One common use of this technique includes the irrigation of pasture for dairy production.

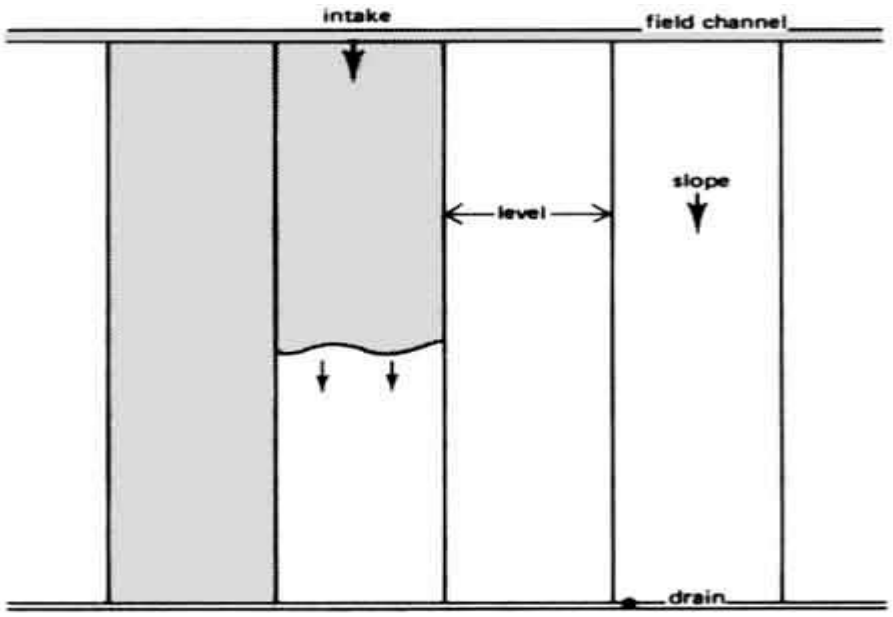


Figure: Furrow irrigation system

d) Traditional irrigation

These irrigation systems were used in earlier years. However, even today some small farms in rural areas adopt these. Although they are cheaper than modern methods, they are not as efficient. Because they need human or animal labor to function.

Figure 1: Traditional irrigation method using a Watering can

Figure 2: Traditional irrigation method using a bucket

LO 1.3 – Maintain manual/surface irrigation system according to irrigation techniques

- **Content/Topic 1:Components of manual/surface irrigation system**

It may be divided into the following four component systems: (1) water supply; (2) water conveyance or delivery; (3) water use; and (4) drainage. For the complete system to work well, each must work conjunctively toward the common goal of promoting maximum on-farm production.

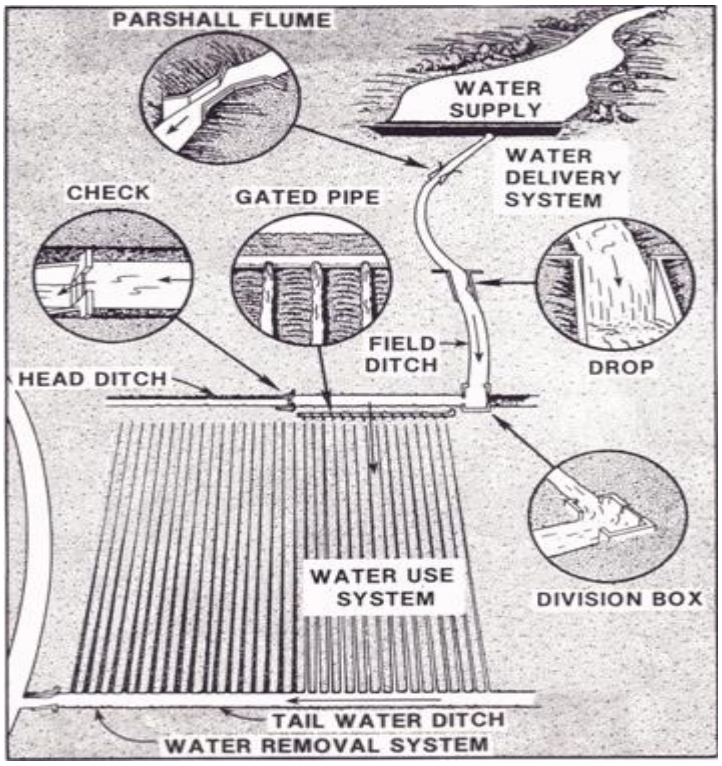


Figure: Surface/manual irrigation components

a) Water supply

After the water reaches the field ready to be irrigated, it is distributed onto the field by a variety of means, both simple and elaborately constructed. Most fields have a head ditch or pipeline running along the upper side of the field from which the flow is distributed onto the field. In a field irrigated from a head ditch, the spreading of water over the field depends somewhat on the method of surface irrigation.

b) Water conveyance

Conveying water to the field requires similar structures to those found in major canal networks. The conveyance itself can be an earthen ditch or lateral, a buried pipe, or a lined ditch. Lined sections can be elevated at surface level. Pipe materials are usually plastic, steel, concrete, clay, or asbestos cement, or they may be as simple as a wooden or bamboo construction.

c) Water use

After the water reaches the field ready to be irrigated, it is distributed onto the field by a variety of means, both simple and elaborately constructed. Most fields have a head ditch or pipeline running along the upper side of the field from which the flow is distributed onto the field.

d) Drainage

This section is comprising the channel which is used to drain excess water from the field. This channel is called drain.

- **Content/Topic 2: Operation and maintenance of manual/surface irrigation systems**
  - ✓ **Tips to operate and maintain surface irrigation system**

a) Clear the head ditch and conveyance canal of weeds and debris on a regular basis. Obstructions greatly influence the flow rate.
b) Check for washouts around the edges of all control structures along the conveyance system to the field.
c) Conduct micro-levelling in the border or basin: the need will become evident after the first couple of irrigations.
d) Regulate the flood gate or other means of turning in the water so that the water advances across the plot(s) as quickly as possible without creating erosion.
e) Make sure the operator knows how much water is being placed on the field.
f) Reform the ridges, levees, or furrows when necessary. Conduct land smoothing often.
g) Keep animals off of field.
h) Fill in or plug any rodent or ant holes.
i) If it is necessary to slow down velocity in canals, place heavy objects (e.g. rocks) in the canal to form a small check.
j) Pre-irrigate land before transplanting on to furrow beds.
k) Check field one to two days after irrigation with shovel or soil auger to assure uniform distribution of water.

✓ **Maintenance schedule**

The maintenance schedule is an allocation of activities in timelines. This schedule describes the types of maintenance such as periodic or daily maintenance to be performed.

- Components of maintenance schedule
    a. Activities
    b. timeline
    c. Responsible person to do the activity
    d. Observation
- Activities done to maintain surface irrigation system
    a. Cleaning
    b. Repairing
    c. Replacing
    d. Greasing

Learning Unit 2 – Establish sprinkler irrigation method

LO 2.1 – Characterize the site considering edaphic and climatic conditions

- **Content/Topic 2: Sprinkler irrigation system suitability**

Sprinkler irrigation system: It is the system where water is distributed by overhead high-pressure sprinklers or guns from a central location in the field or from sprinklers on moving platforms (center pivot). The water is applied on crops in form of rain.

✓ Suitable soils

Sprinklers are best suited to sandy soils with high infiltration rates although they are adaptable to most soils. The average application rate from the sprinklers (in mm/hour) is always chosen to be less than the basic infiltration rate of the soil so that surface ponding and runoff can be avoided.

Sprinklers are not suitable for soils which easily form a crust. If sprinkler irrigation is the only method available, then light fine sprays should be used. The larger sprinklers producing larger water droplets are to be avoided.

- ✓ **Suitable irrigation water**

A good clean supply of water, free of suspended sediments, is required to avoid problems of sprinkler nozzle blockage and spoiling the crop by coating it with sediment.

- ✓ **Suitable crops**

Sprinkler irrigation is suited for most row, field and tree crops and water can be sprayed over or under the crop canopy. However, large sprinklers are not recommended for irrigation of delicate crops such as lettuce because the large water drops produced by the sprinklers may damage the crop.

- ✓ **Suitable slopes**

Sprinkler irrigation is adaptable to any farmable slope, whether uniform or undulating. The lateral pipes supplying water to the sprinklers should always be laid out along the land contour whenever possible. This will minimize the pressure changes at the sprinklers and provide a uniform irrigation.

LO 2.2 – Select tools, materials and equipment according to the standards

- **Content/Topic 1:Components of a sprinkler irrigation system**

The components of a sprinkler irrigation system are:

- Water source/ tank
- A pump unit
- Tubing (mains, sub-mains and laterals)
- Couplers
- Sprinklers (sprinkler heads)
- Other accessories (valves, bends, plugs, risers, filters)

a) Pumping unit

Sprinkler irrigation systems distribute water by spraying it over the field. Water is pumped under pressure to the field.

The **pump unit** is usually a centrifugal or turbine pump which takes water from the source and provides adequate pressure for delivery into the pipe system.

Types of irrigation pumps

Irrigation pumps are put into categories based on their design. The following are the most common types of irrigation pumps:

Displacement Pumps These pumps move water by displacement. Examples are piston pumps, diaphragm pumps, roller-tubes, and rotary pumps. Piston Displacement Pumps are pumps you operate by moving a long level up and down. Usage for a displacement pump would be when you need to move very thick liquids, create very precise flow volumes, or create extremely high pressures. A fertilizer injector is the most common irrigation use for a displacement pump.

Centrifugal Pumps A vast majority of all irrigation pumps fall into this category. This particular pump uses an impeller (rotating part that transmits motion in a device) which spins the water rapidly in a casing, chamber, or housing. The spinning action is known as centrifugal force.

Submersible Pumps: Pumps that are completely installed under water. These are a single unit with a pump and electric motor. The main purpose is to be installed in a well but they can be installed on the bottom of a lake or stream if placed on their side or mounted to a pier. No need to prime these pumps due to them already being under water. If they aren't installed in a well they need to be placed into a special pump and this may be necessary when placed into a well.

Turbines and Jet Pumps - A centrifugal pump that is mounted underwater and attached by a shaft to a motor mounted above ground. The motor turns the shaft which causes the impeller to turn inside the pump. Jet Pumps are similar to the Turbines except they help lift the water by directing the down the intake. Turbine pumps are used a lot in irrigation because they are efficient and able to generate high water pressure.

Booster Pumps - are different from other pumps because they don't take water from a non-pressurized source and move it to another location instead they are used to increase the water pressure of water that is already on its way somewhere. These pumps are used to boost the water pressure.

Floating Pump - Submersible or Floating pump that is attached to the bottom of a float. The pump is underneath the float which is anchored to a river, pond, or lake.

These pumps are usually more energy efficient and easier to install than the other submersible pumps in a pond or lake.

Jet Pump - A jet pump is a self-contained unit. Most commonly used as a deep well pump, this pump is simply dropped into a well with just a power cord and a water line. Because this well is deep beneath the water it is almost silent.

b) Tubing

They consist of main lines, sub main lines and lateral lines.

Main lines convey water from the pump and distribute it to the sub main lines.

Sub-main lines convey water to the lateral lines.

The lateral pipe is located in the field until the irrigation is complete. The pump is then switched off and the lateral is disconnected from the mainline and moved to the next location. It is re-assembled and connected to the mainline and the irrigation begins again. The lateral can be moved one to four times a day. It is gradually moved around the field until the whole field is irrigated. This is the simplest of all systems. Some use more than one lateral to irrigate larger areas.

c)Couplers

They are used to connect two pipes and uncoupling quickly and easily. These couplers (fittings) are:

i. Quick couplers
ii. Elbow
iii. Tee-couplers
iv. Cross couplers

d) Sprinkler heads

They spread water uniformly over the field without runoff or excessive loss due to deep percolation.

Different types of sprinkler are:

- Rotating type
- Fixed type

Figure: Sprinkler irrigation system

You should also know what is considered to select the appropriate sprinkler to use;

Selection of the most appropriate sprinkler system.

The most important physical parameters to be considered are:

a) The crop to be grown / cultivated,
b) The shape and size of the field,
c) The amount of time and labor required to operate the system

Selection of sprinkler system basing their capacity.

a) Pick crop water requirements during the growing season,
b) Effective crop rooting depth,
c) Texture and infiltration rate of the soil,
d) The available water holding capacity of the soil,
e) Pumping capacity of the well for water source.

LO 2.3 – Install sprinkler irrigation system considering edaphic and climatic conditions

Content/Topic 2: Tools, materials and equipment used to install sprinkler irrigation system

- **Classification of tools, materials and equipment**

1. **Cutting tools**
   a. Tube/pipe cutters

In the context of machining, a cutting tool or cutter is any tool that is used to remove material from the work piece by means of shear deformation.

   b. Hacksaw

A fine-tooth saw with a blade under tension in a frame that is used for cutting hard materials (such as metal & plastics).

   c. Grinder machine

A grinding machine, often shortened to grinder, is one of power tools or machine tools used for grinding, it is a type of machine using an abrasive wheel as the cutting tool.

2. Holding tools

a. Bench vice

A vice is a tool used for holding an object for various tasks like filing, chipping, sawing, threading, tapping, bending, etc. The bench vice has two jaws, one of which is fixed and the other is movable.

b. Pipe vice

It is a tool used for holding a pipe for carrying out assembly, disassembly, threading, cutting, etc….

3. Measuring tools

a. Tape Measure

This is a simple equipment which all the plumbers have. A metallic measuring tape rolled inside a small, compact, plastic case is used to measure the dimensions of pipe system.

b. Vernier caliper

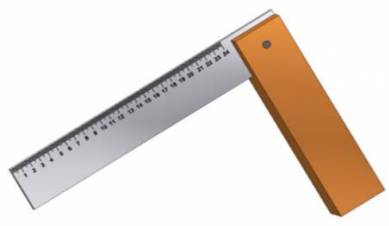
A Vernier caliper is an instrument that measures internal or external dimensions and distances. It allows you to take more precise measurements than you could with regular rulers.

c. Pressure gauge

It is a tool used to not only checking the pressure but also test the leakage.

d. Try square

The try square has a blade (straight edge) and a stock (beam) which are fixed together at exactly 90. The stock is much thicker than the blade. The edge of the blade and the stock are perfectly sharp and straight.



4. Marking tools

a. Scriber

The Scriber is a thin rod with very hard, fine pointed ends which is used to cut the lines in the surface of the work piece. Scribers are made from hardened and tempered high carbon or cast steel.

5. Fitting tools

a. Wrench

These are hand tools used for tightening and loosening the nuts and bolts. Wrenches hold slippery or small nuts and bolts for loosening or tightening them.

b. . Water pump pliers

It is a common plier used by irrigators for holding, tightening and loosening work during fixing process.

These are available in only one standard size of 250 mm length. The maximum width possible between the two jaws is 40 mm.

c. **Spanners**

This tool is used for tightening and loosening nuts and bolts of standard size. The standard spanners used are:

- Ring spanners

These spanners have full circular closed ring at both ends. It is difficult to slip and cause damage. It is made through forging process, with a burnished finish or a chrome-plating.

- Open-ended spanners

These types of spanners are open from both sides and are used for tightening and loosening nuts and bolts.

- Combination spanners

These spanners are open at one end and closed at the other

6. Hammering tools

A hammer is a tool consisting of a weighted "head" fixed to a long handle to deliver an impact to a small area of an object. This can be, for example, to drive nails into wood, to shape metal or pipe.

7. Drilling tools

a. Drilling machine

8. Sealing materials

- Teflon
- Glues

9. Threading tools

a. Electrical threading machine

A tool used to cut or form threads inside or outside a cylinder or pipe.

b. Diestock

- **Criteria for classifying different types of sprinkler system**

Sprinkler systems are classified into two major types:

- ✓ Based on the arrangement for spraying irrigation water:
  - **Rotating head or revolving sprinkler system**: 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. They may also be mounted on posts above the crop height and rotated through 90^0, to irrigate a rectangular strip.
  - **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
- ✓ Based on the portability:
  - **Portable system**: have portable main lines, sub main lines, laterals and pumping unit.
  - **Semi- portable system**: is similar to a portable system except that the location of water source and pumping plant is fixed.
  - **Semi- permanent system**: have portable lateral lines, permanent main lines and sub-main lines and a stationery water source and a pumping plant.

- **Solid set system**: have enough laterals to eliminate their movement. The laterals are positioned in the field early in the crop season and remain for the season
- **Permanent system:** consist of permanent laid mains, sub-mains and laterals and a stationery water source and a pumping unit.

- **Rules for sprinkler system installation**
  - ✓ Main should be laid up and down hill
  - ✓ Laterals should be laid across the slope or nearly on the contours
  - ✓ Water supply source should be nearest to the center of the area (field)
  - ✓ 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 amount of water where soils are greatly different in the design are
- **The factors affecting the Selection of sprinkler irrigation systems**

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

- ✓ The crop or crops to be cultivated
- ✓ The shape and size (acres) of the field
- ✓ The topography of the field
- ✓ Amount of time and labor required to operate the system

- **Importance of sprinkler irrigation**
  - ✓ Elimination of channels for conveyance, therefore no water loss
  - ✓ Suitable to all types of soil except heavy clay soils
  - ✓ Suitable for irrigating crops where the plant population per unit area is very high
  - ✓ It is a water saving system
  - ✓ It may also be used for undulating areas
  - ✓ Areas located at a higher elevation than the source can be irrigated
  - ✓ There is the possibility of using soluble fertilizers and chemicals

- ✓ The system is mobile
- ✓ It influences the increase of yield
- ✓ It influences the greater conducive (favorable) microclimate
- ✓ It saves land as no bunds are required
- ✓ Less problems of clogging of sprinkler nozzles due to sediment

- **Constraints in application of sprinkler irrigation**
  - ✓ Uneven water distribution due to high winds
  - ✓ Evaporation loss when operating under high temperatures
  - ✓ Highly impermeable soils are not suitable
  - ✓ Initial cost is high
  - ✓ Proper design
  - ✓ Lack of Package of practices
  - ✓ Lack of awareness
  - ✓ Lack of social concern to save natural resources
  - ✓ High water pressure required in sprinkler
  - ✓ Difficulty in irrigation during wind in sprinkler

LO 2.4 – Maintain sprinkler irrigation system

- **Content/Topic 1: Maintenance of a sprinkler irrigation system:**

✓ **Cleaning filter**

Water filtration is very important to almost any irrigation system. Appropriate filtration can help to extend the life and improve the maintenance of any irrigation system. For drip or micro sprinklers emitters, filtration is a basic need to avoid clogging.

Operating sprinkler system

The main objective of a sprinkler system is to apply water as uniformly as possible to fill the root zone of the crop with water.

Wetting patterns

The wetting patterns from a single rotary sprinkler are not very uniform. Normally the area wetted is circular. The heaviest wetting is close to the sprinkler.

For good uniformity several sprinklers must be operated close together so that their patterns overlap. For good uniformity the overlap should be at least 65% of wetted diameter. This determines the maximum spacing between sprinklers.

We have to remind that the uniform of sprinkler applications can be affected by wind and water pressure.

✓ **Check and repair damaged components**

The sections that do have irrigation may be temporary or permanent installations, usually in locations with high value landscaping. Wherever an irrigation system has been installed, you must maintain it in good working order. Repairs must start within 48 hours of detecting damage, or from the time of notification by the Engineer. Normal work shall be performed during daylight hours.

Application rate

This is the average rate at which water is sprayed onto the crops and is measured in mm/hr.

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:

- Occasionally clean any dirt or sand out of the groove in the coupler in which the rubber sealing ring fits. Any accumulation of dirt or sand will affect the performance of the rubber sealing ring
- Keep all nuts and bolts tight
- Do not lay pipes on new damp concrete or on piles of fertilizer. Do not lay fertilizer sacks on the pipe

2. **Sprinkler heads**

The sprinkler heads should be given the following attention:

- When moving the sprinkler lines, make sure that the sprinklers are not damaged or pushed into the soil
- 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
- Sprinklers usually have a sealed bearing and at the bottom of the bearing there are washers. Usually it is the washers that wear and not the more expensive metal parts. Check the washers for wear once a season or every six months which is especially important where water is sandy. Replace the washers if worn.
- 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 re-bending it. This will increase the spring tension.

In general, check all equipment at the end of the season and make any repairs and adjustments and order the spare parts immediately so that the equipment is in perfect condition to start in the next season.

Storage

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

- Remove the sprinklers and store in a cool, dry place.
- Remove the rubber sealing rings from the couplers and fittings and store them in a cool, dark place.
- The pipes can be stored outdoors in which case they should be placed in racks with one end higher than the other. Do not store pipes along with fertilizer.
- 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.
- Protect the electric motor from the ingress of dust, dampness and rodents.

Trouble shooting:

The following are the general guidelines to identify and remove the common troubles in the sprinkler systems:

1. Pump does not prime or develop pressure
    - Check that the suction lift is within the limits. If not, get the pump closer to the water.
    - Check the suction pipeline and all connections for air leaks. All connections and flanges should be air tight.
    - Check that the strainer on the foot valve is not blocked.
    - Check that the flap in the foot valve is free to open fully.
    - Check the pump gland (s) for air leaks. If air leaks are suspected tighten the gland (s) gently. If necessary repack the gland (s) using a thick grease to seal the gland satisfactorily.
    - Check that the gate valve on the delivery pipe is fully closed during priming and opens fully when the pump is running.
2. Sprinklers do not turn:
    - Check pressure
    - Check that the nozzle is not blocked. Preferably unscrew the nozzle or use a small soft piece of wood to clear the blockage. Do not use a piece of wire or metal as this may damage the nozzle
    - Check the condition of washers at the bottom of the bearing and replace them if worn or damaged
    - Check that the swing arm moves freely and that the spoon which moves into the water stream is not bent by comparing it with a sprinkler which is operating correctly.
    - Adjust the swing arm spring tension~ usually it should not be necessary to pull up the spring by more than about 6 mm
3. Leakage from coupler or fittings

The sealing rings in the couplers and fittings are usually designed to drain the water from the pipes when the pressure is turned off. This ensures that the pipes are automatically emptied and ready to be moved. With full pressure in the system the couplers and fittings will be effectively leak-free.

If, however, there is a leakage, check the following:

- There is no accumulation of dirt or sand in the groove in the coupler in which the sealing ring fits. Clean out any dirt or sand and refit the sealing ring
- The end of the pipe going inside the coupler is smooth, clean and not distorted
- In the case of fittings such as bends, tees and reducers ensure that the fitting has been properly connected into the coupler

➢ **Advantage and disadvantages of sprinkler irrigation system.**

<u>Advantages</u>:

✓ Suitable to wide range of crops,
✓ Low investment cost,
✓ Easy to operate and maintain,
✓ Unskilled team can manage it well,
✓ Wide range of emitters to meet soil crop requirements.

<u>Disadvantages</u>:

✓ Need high pressure,
✓ Influenced by pressure and wind,
✓ Water loss to field edges,
✓ Causes problems of leaf disease,
✓ Runoff,
✓ Interfering in cultivation and spraying

Adaptability of sprinkler irrigation system.

Sprinkler irrigation may be used for many crops on all types of soil on lands of widely different topography and slopes. However, it finds its best use to irrigate:

(a) Sandy soils and soils with high infiltration rates,
(b) Shallow soils that do not allow proper land leveling required for surface irrigation methods,
(c) Areas with steep slopes having erosion hazards,
(d) For growing high priced crops and
(e) Where water is scarce and costly.

The sprinkler system is designed according to necessity. It may be for main irrigations, supplemental irrigations or for protective irrigations. In arid regions, sprinklers may be used to apply the full quantity of water needed by crops grown as the irrigation water is scarce and the sprinkler irrigation ensures a high efficiency of water application.

Learning Unit 3 – Establish drip irrigation method

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

- Drip irrigation is a modified type of subsurface irrigation
- It uses a system of pipes that have tiny holes or nozzle at each plant station
- This enables water to drip or trickle through next to each plant

Drip irrigation is a type of micro-irrigation system that has the potential to save water and nutrients by allowing water to drop slowly to the roots of plants, either from above the soil surface or buried below the surface. The goal is to place water directly into the root zone and minimize evaporation.

Drip irrigation systems distribute water through a network of valves, pipes, tubing, and emitters. Depending on how well designed, installed maintained, and operated, it is a drip irrigation system that can be more efficient than other types of irrigation systems, such as surface irrigation or sprinkler irrigation.

LO 3.1 – Characterize the site considering edaphic and climatic conditions.

- **Content/Topic 1: Factors for selecting drip irrigation system:**

✓ **Natural conditions**

i) Soil physical properties

Suitable soils: 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.

ii) Slope

Suitable slopes: drip irrigation is adaptable to any farmable slope. Normally the crop would be planted along contour lines and the water supply pipes (laterals) would be laid along the contour also. This is done to minimize changes in emitter discharge as a result of land elevation changes.

✓ **Type of crop to be grown**

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. Generally only high value crops are considered because of the high capital costs of installing a drip system.

✓ **Suitable irrigation water**

One of the main problems with drip irrigation is blockage of the emitters. All emitters have very small waterways ranging from 0.2-2.0 mm in diameter and these can become blocked if the water is not clean. Thus it is essential for irrigation water to be free of sediments.

Blockage may also occur if the water contains algae, fertilizer deposits and dissolved chemicals which precipitate such as calcium and iron. Drip irrigation is particularly suitable for water of poor quality (saline water). Dripping water to individual plants also means that the method can be very efficient in water use. For this reason it is most suitable when water is scarce.

LO 3.2 – Adequate selection of tools, materials and equipment

Content/Topic 1: Components of a drip irrigation system:

- **Components of a drip irrigation system**

a. Water source / tank
b. Control head (valve)
c. Mains and sub-mains
d. Laterals
e. Emitters (Drippers)
f. Filters
g. End / Flush cap.

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

Mains, Sub-mains and Laterals supply water from the control head into the field. They are usually made from PVC pipes or polyethylene. Laterals are usually 12-32 mm diameter.

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

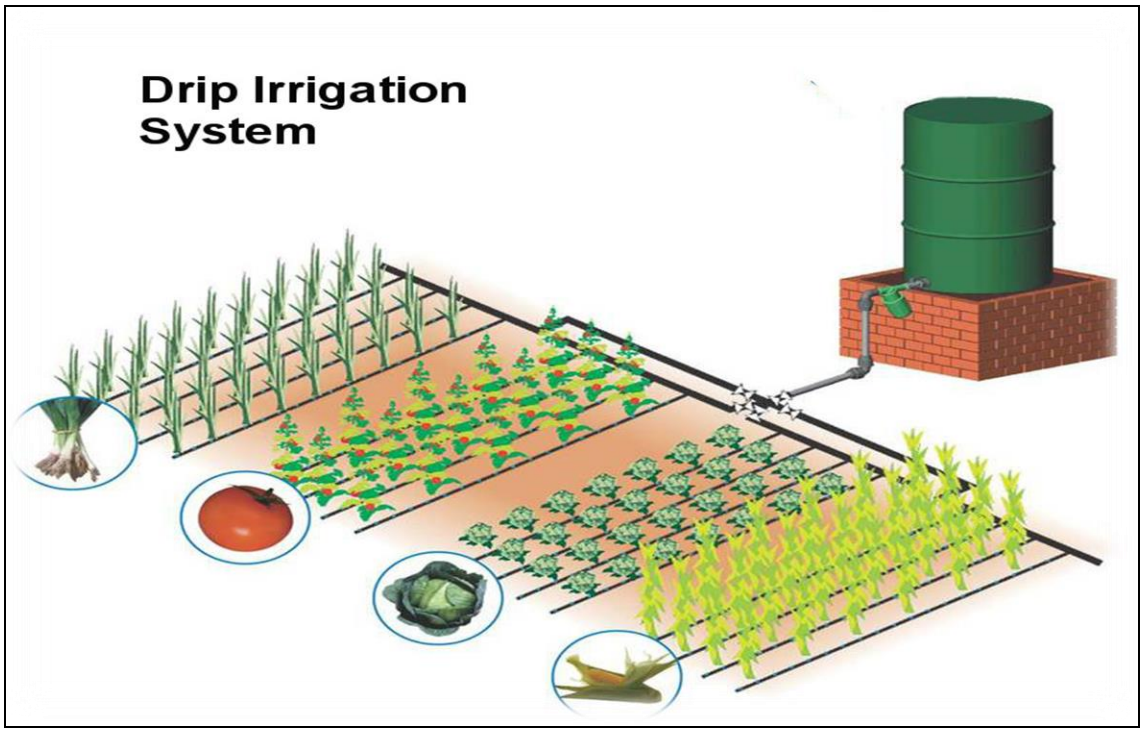


Figure: Components of drip irrigation

- **Technical specifications of materials used in installation of drip irrigation**

Most of the time the materials used in installation of drip irrigation are selected according to their technical specifications.

The technical specifications describe:

- ✓ Diameter of main lines
- ✓ Diameter of sub-main lines
- ✓ Diameter of lateral(drip lines)
- ✓ The size of water pump
- ✓ The material in which pipes and fittings are made (HDPE, LDPE, PVC, STEEL,etc…)
- ✓ Water source (tank) capacity
- ✓ Name of material

Example:

N°	Description of items	Specification	Illustration
1	Reservoir/ Plastic tank	10 m^3	
2	Tank outlet	HDPE pipe PN 10, 63 mm dia, M-M	
3	Elbow	63 mm dia. F-F with threads, HDPE	
4	Plastic Filter	63 mm dia, HDPE, M-M	
5	HDPE PN 10 pipe/Main line	63 mm dia, LDPE	

6	Plastic end caps	63 mm dia, HDPE	
7	Drip line pipe/Laterals	Soft PE (LDPE) pipes, 16 mm dia.	
8	Goof plug with drip line connector	16 mm dia.	
9	Grommet (rubber)	16 mm dia.	
10	Drip tape End caps	16 mm dia.	
11	Valves	F-F 63 mm dia, with body brass and internal threads	
12	Teflon tapes	-	
13	Plastic tee	63mm-dia,HDPE, equal	

14	Motor-pump	75mTDH,45m^3/hr, 20 HP,Inlet of 3 in (80mm) & outlet of 75mm with 10m suction pipe	
15	PVC or HDPE pipes	75mm dia,	
16	Drip union	16mm	

LO 3.3 – Proper installation of drip irrigation system

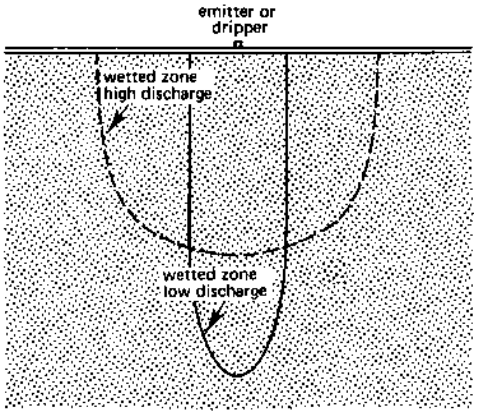
Content/Topic 1: Joining components of a drip irrigation system

The drip irrigation method is suitable for all types of soil.

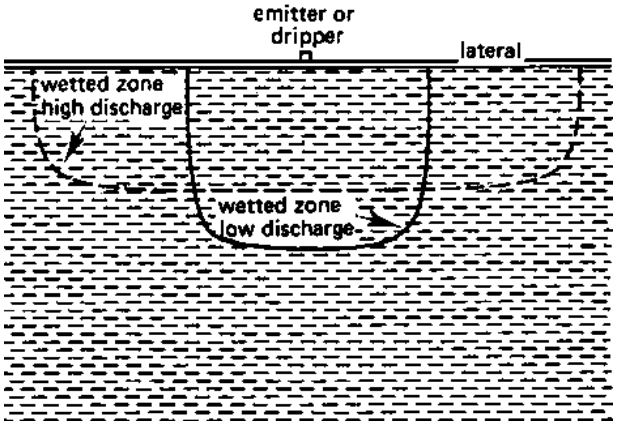
Wetting patterns

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.

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



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



- **The advantages of drip irrigation**

✓ Fertilizer and nutrient loss is minimized due to a localized application and reduced leaching
✓ Water application efficiency is high if managed correctly
✓ Field levelling is not necessary
✓ Fields with irregular shapes are easily accommodated
✓ Recycled non-potable water can be safely used
✓ Moisture within the root zone can be maintained at field capacity
✓ Soil type plays a less important role in the frequency of irrigation
✓ Soil erosion is lessened
✓ Weed growth is lessened
✓ Water distribution is highly uniform, controlled by the output of each nozzle
✓ Labor cost is less than other irrigation methods
✓ Variation in supply can be regulated by regulating the valves and drippers
✓ Fertigation can easily be included with minimal waste of fertilizers
✓ Foliage remains dry, reducing the risk of disease
✓ Usually operated at lower pressure than other types of pressurized irrigation, reducing energy costs

- **The disadvantages of drip irrigation are:**

✓ Initial cost can be more than overhead systems.
✓ The sun can affect the tubes used for drip irrigation, shortening their lifespan.

- ✓ The risks of degrading plastic affecting the soil content and food crops. With many types of plastic, when the sun degrades the plastic, causing it to become weak.
- ✓ If the water is not properly filtered and the equipment not properly maintained, it can result in clogging or bio-clogging.
- ✓ For subsurface drip the irrigator cannot see the water that is applied. This may lead to the farmer either applying too much water (low efficiency) or an insufficient amount of water; this is particularly common for those with less experience with drip irrigation.
- ✓ Drip irrigation might be unsatisfactory if herbicides or top dressed fertilizers need sprinkler irrigation for activation.
- ✓ Waste of water, time and harvest, if not installed properly. These systems require careful study of all the relevant factors like land topography, soil, water, crop and agro-climatic conditions, and suitability of drip irrigation system and its components.
- ✓ Most drip systems are designed for high efficiency, meaning little or no leaching fraction. Without sufficient leaching, salts applied with the irrigation water may build up in the root zone, usually at the edge of the wetting pattern.
- ✓ The PVC pipes often suffer from rodent damage, requiring replacement of the entire tube and increasing expenses.

LO 3.4 – Maintenance of drip irrigation system

Content/Topic 1: Maintenance of a drip irrigation system:

Maintenance consists of Preventive and Corrective maintenance

Maintenance consists of two categories:

i. **Preventive maintenance**: aimed at preventing clogging of the drippers, can be divided in three categories:
   - ✓ Cleaning the filters
   - ✓ Flushing the system
   - ✓ Chemical injection

- **Cleaning the filters**

Pre- season, thoroughly clean all filters. Do not overlook the body or housing of the filters. Filter housings can still be contaminated with scale or sludge when only the filter mesh is cleaned.

Sand filters will need to be back- flushed until completely clean and then runoff through the bypass until clean water is obtained. Carefully, inspect self- cleaning suction screens for any failure or holes in the mesh before placing them in the water supply.

Flushing the system

Once filters are cleaned and re- assembled, flush the system by turning on water and opening the ends of sub-mains. Sub-mains must be opened one at a time so that water velocity scours the pipe of any sediment that has settled in the pipe. Close off each sub-main when clean water flows and open the next sub-main.

After flushing all the sub-mains, start to flush the laterals following a similar procedure. More than one lateral can be opened at a time but make sure a decent skirt of water flows out the end of each lateral.

Chemical injection

The irrigation system is used also as a method for distributing products with the irrigation water. These products, such as fertilizers, insecticides, fungicides, herbicides, etc., must be totally soluble in the water and are injected into the system at a selected point, penetrating into the soil through the system.

Chemigation refers to the injection of chemicals (the addition of chlorine, hydrogen peroxide, acid or others) to prevent or reduce dripper clogging, and the injection of chemicals (herbicides, pesticides and others) for crop and soil concerns.

- ✓ **Chlorine treatment**

Before filling any tank with chlorine solution, it must be flushed thoroughly to remove any remaining fertilizer or other chemical products.

Avoid contact with the eyes. If chlorine comes in contact with the eyes, it can cause blindness. Avoid contact with the skin. If chlorine comes in contact with the skin, it can cause burns. Use protective clothing when working with chlorine: goggles, gloves, mask, long pants, long-sleeved shirts, and high closed shoes. Avoid swallowing or inhaling. Swallowing chlorine or inhaling its vapors could be fatal.

During treatment, a second operator must be present who can, if necessary, provide first aid. Stay in the location during the full duration of the treatment. Keep all unauthorized personnel away from the treatment area.

Chlorine injection into a drip irrigation system

Chlorine is a strong oxidant. It is very useful for the following purposes:

- To prevent and eliminate the growth of organic slime, ferrous slime and sulfurous slime.
- To oxidize elements such as iron, sulfur, manganese, etc.
- To clean organic sedimentation and bacterial slime from irrigation systems.
- To improve filtration efficiency, especially for gravel or sand filters

Note:

- Chlorine is effective only on organic matter.
- Chlorine is ineffective against inorganic materials, such as sand, silt, minerals, scale, etc
- Chlorine is available for commercial use in gaseous, liquid or solid state. Each type has its advantages and disadvantages. The suitability, availability and price of each material must be taken into account before deciding which to use.

  Commonly available forms usually include:
- Gaseous chlorine (Cl_2, 100% active chlorine).
- Solid chlorine (calcium hypochlorite, contains 60-85% active chlorine).If the water contains high alkaline levels, hardness and/or high pH, it is recommended not to use this form.
- Liquid chlorine (sodium hypochlorite, contains 7-13% active chlorine). Liquid chlorine is unstable and decomposes quickly in the storage tank, depending on time, temperature and solar radiation.

ii. Corrective maintenance: consists mainly of removal of obstructions already present in the drippers:

- ✓ Flushing the system
- ✓ Organic formation - treated with hydrogen peroxide (H_2O_2).
- ✓ Mineral sedimentation - treated with acids (or a combination of acid and hydrogen peroxide).

- ✓ Organic formation and mineral sedimentation - treated with a combination of acid and hydrogen peroxide.

Learning Unit 4 – Apply basic knowledge of drainage techniques

Drainage is the removal of excess water either from the ground surface or from the root zone by either natural or artificial means.

During rain or irrigation, the fields become wet. The water infiltrates into the soil and is stored in its 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.

Figure: Drain

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.

However, saturation may have lasted too long for the plants' health. Plant roots require air as well as water and most plants cannot withstand saturated soil for long periods (rice is an exception).

Besides damage to the crop, a very wet soil makes the use of machinery difficult, if not impossible.

The water flowing from the saturated soil downward to deeper layers, feeds the groundwater reservoir. As a result, the groundwater level (often called groundwater table or simply water table) rises. Following heavy rainfall or continuous over-irrigation, the groundwater table may even reach and saturate part of the root zone. Again, if this situation lasts too long, the plants may suffer. Measures to control the rise of the water table are thus necessary.

Soils that drain naturally allow any excess water from rain or irrigation to pass through them under the influence of gravity to replenish underground water resources. This action is called seepage.

Too much water in the soil keeps air out of the soil. When this condition continues for too long, the soil is said to be waterlogged.

Waterlogged land needs to be drained artificially if crops are to be grown on it successfully. On the other hand, much of our biodiversity depends on the existence of wetlands, which develop naturally on waterlogged soils. Thus, not all waterlogged soils should be drained or sustainability may be lost.

LO 4.1 – Different methods of drainage

- **Content/Topic 1 :Methods of drainage**

There are two drainage methods:

a) **Surface drainage**

b) **Sub- surface drainage**

- **Surface drainage**

Surface drainage 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 collector drains. In order to facilitate the flow of excess water toward the drains, the field is given an artificial slope by means of land grading.

- **Sub- surface drainage**

Subsurface drainage is the removal of water from the root zone. It is accomplished by deep open drains/ditches or buried/closed/ covered 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.

ii. **Pipe drains**

Pipe drains are buried pipes with openings through which the soil water can enter. The pipes convey the water to a collector drain.

Drain pipes are made of clay, concrete or plastic. They are usually placed in trenches. 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 (up to 200 m) and the water enters through perforations distributed over the entire length of the pipe.

Comparison between Deep open drains and pipe drains

Deep open drains	Pipe drains
1.Use land that otherwise could be used for crops	1. Cause no loss of cultivable land
2.They restrict the use of machines	2. The installation costs, however, of pipe drains may be higher due to the materials, the equipment and the skilled manpower involved.

3.They also require a large number of bridges and culverts for road crossings and access to the fields	3. Require no bridges and culverts for road crossings and access to the fields
4. Requires frequent maintenance (weed control, repairs, etc.)	4. Maintenance requirements are very limited

LO 4.2 – Inspection of an existing drainage system

Content/Topic 1: Inspection of drainage system

- **Pillars of an effective drainage system**

  - ✓ Quality material – including pipe, envelope/filter (if necessary), fittings, risers, etc.
  - ✓ Proper design – completed by a licensed drainage contractor or a professional engineer
  - ✓ Proper installation – completed by a licensed drainage contractor
  - ✓ Compatible land management practices
  - ✓ Regular inspection and maintenance

Properly designed and constructed drainage systems require minimal maintenance and repair after the first few years following installation. However, it is important that a new subsurface drainage system be carefully inspected and maintained for the first two or three years. Any weak spots that have developed in the lateral and main drains and any backfilled areas that have settled can be remedied and filled in. There is some ongoing maintenance to complete every year but this should be minimal for most systems.

- **The importance of the drainage plan**

A drainage plan indicates the location and layout of lateral and main drains, outfalls, surface water inlets and other structures in the field. It is a very important document to use for future maintenance. Keep this document with the property deed, so that even if the property ownership changes, the drainage information is kept with the farm. Some

municipalities require or allow for storage of the drainage plan at their office. This creates a permanent record, which helps locate the drains for future subsurface drainage repair or improvements.

A good drainage plan includes the following:

- ✓ date of construction
- ✓ Name of installer (i.e., contractor or landowner)
- ✓ Identification of any changes made during installation from the original plan
- ✓ Lateral spacing, size, depth, grade, footage and material
- ✓ Main location, material, size, depth, grade and capacity
- ✓ Details of any construction problems encountered during the installation
- ✓ Location of all outfalls, surface water inlets and other structures
- ✓ Location of utilities, sand pockets, springs, etc., that may affect future maintenance

The contractor should provide a copy of the plan of the drainage system to the landowner following the completion of the job. If a formal plan has not been provided by the contractor or if the landowner does the installation, a simple pencil sketch that provides the same information is acceptable. In the absence of a proper plan, obtain an aerial photograph of the work area, similar to that shown in Figure 1, to show the drainage system.

- **Health issues related to drainage water management**

Proper surface and subsurface drainage to remove excess water in a safe and timely manner plays an important role in controlling water related diseases. Careful control and appropriate reuse of drainage water can help protect the environment and optimize the use of water resources.

The health issues related to drainage water management can be grouped in three categories:

i. Water related vector-borne diseases;
ii. Fecal/orally transmitted diseases; and
iii. Chronic health issues related to exposure to residues of agrochemicals

✓ **Causes of drainage failure**

Some communities suffer from drainage problems not because they have no drains, but because the existing drainage system has collapsed, become blocked, or is otherwise in

need of repair and rehabilitation. Many more will find that the nearest convenient point of discharge for a new drainage system is an existing primary drainage pipe or canal that needs attention if it is to function properly.

Collapse and blockage are the principal types of drainage failure. Each of these can have several causes. Collapse of drains can occur through:

- ✓ Erosion of the bottom and sides of the drain (scouring);
- ✓ Excessive pressure of water in the ground beneath and beside the drain lining;
- ✓ Vehicles passing over or too close beside the drains; -root growth, especially from nearby trees;
- ✓ Crown corrosion in closed drains containing sewage

- **Initial inspection and maintenance of drainage system**

What happens during the initial period following the installation of the new subsurface drainage system is critical to ensuring it functions properly for years to come. The soil around and above the drains will still be loose and should be left alone to settle naturally with time and rain. Do not use equipment to pack down the soil over the drains, as any heavy pressure on the loose soil could damage or collapse the pipes. Minimize traffic on the field for as long as possible, and straddle the laterals and mains with equipment or work across (not parallel to) the drains when working the field in the first year after installation.

Using the drainage plan as a guide, locate, inspect and mark all outfalls and surface water inlets for reference when spreading nutrients on the property and for future maintenance. Use a durable, permanent marker that is highly visible above crops and tall grass. Ensure the workmanship of the system is good, as there will be limited time to access the warranty period provided by the contractor, typically one year following installation.

Confirm that all surface water inlets are fitted with a proper guard or grate to keep debris and trash out of the subsurface drainage system.
Ensure that a grate or rodent guard is installed on all outfall pipes to prevent unwanted entry by burrowing animals such as rodents, muskrats, rabbits and foxes. Check for

burrowing animal activity around the outfalls; if any signs exist, arrange to have the animals legally removed.

Figure: Outfall pipe with rodent guard installed

To minimize damage and sedimentation, locate the bottom of the outfall pipe(s) at least 300 mm above the normal water level in the receiving drainage channel. Otherwise, the outfall(s) may require additional ongoing maintenance. During the first year, sediment may appear in the outfall due to the soil settling. Under normal conditions, the outfall should flow free and clear from any sediment or debris.

Confirm that the contractor has installed a rigid, non-perforated end pipe. Standard corrugated plastic tubing is not satisfactory as it can be damaged. The pipe should be sufficiently durable to resist weather, animal damage, crushing, and ice or fire damage. It should extend into the ditch far enough that the flow will not erode the ditch bank.

The water that discharges from the outfall can cause erosion in the receiving drainage channel or natural watercourse. Check to see if the contractor has installed sufficient erosion protection to prevent this from happening.

Figure: Outfall pipe with erosion control located above the water level

Content /Topic2: Responsibilities of drainage supervisor

- **Ongoing inspection and maintenance**

✓ Remember to make records of any maintenance/repairs and changes to the system on the drainage plan. This will ensure that there is always an accurate plan of the system for future inspection and maintenance.

✓ Check for any signs of erosion of the drainpipe trench following rain events, especially in the first few years. Inspect the mains and laterals a couple of days after a heavy rainfall to look for any signs of ponding or excessive wet spots in your field. This may indicate that a blocked drain exists and will need to be repaired.

Uniformity of crop growth is another good indicator of a properly functioning drainage system. Ideally, the field should dry evenly and produce similar yields.

✓ Watch for changes in crop yield in different areas of the field annually to see if there is a slower developing problem in the drainage system that may need repair.

✓ Take periodic aerial photographs of the farm to get an overview of the drainage system and to identify potential drainage problems.

When drains get plugged, water rises to the surface at the point of the water stoppage.

✓ Dig up the drain at the wet spot and repair it.

- ✓ Mark any locations of concern and contact a licensed contractor to complete the repair as soon as reasonably possible. If the fields are wet, it may be better to wait for drier conditions to make the repairs to avoid damaging the soil structure. If drains carry water for a prolonged period during the growing season, they can become plugged by tree roots. A good design will route the drains (both laterals and mains) at least 30 m from water-loving trees such as willow, soft maple, elm and poplar and at least 15 m from all other types of trees.

Figure: Drain pipe plugged with tree roots

- ✓ Inspect all surface water inlets twice a year (spring and fall), and ensure that all of the markers are still in place and clearly visible. Re-mark if necessary. Remove any trash, debris or plant material that has accumulated around the inlet to make sure that it functions properly.
- ✓ Make thorough inspections of all outfalls in the spring, fall and after severe storm events when the soil is wet and the subsurface drains are running. Make sure that all of the markers are still in place and clearly visible. Re-mark any if necessary.
- ✓ Examine end pipes and any erosion control such as riprap aprons for scour and undermining and to confirm that water is not draining from under and/or around the end pipe.
- ✓ Check the end pipe for damage caused by ice. Remove any trash, debris or plant material that has accumulated around the end pipe to ensure that it continues to function properly.

- ✓ Make any repairs or replace the grate or rodent guard if necessary to prevent unwanted entry by burrowing animals. Check for any new animal activity around your outfalls. If signs exist, arrange to have the animals legally removed.
- ✓ Look for any signs of reddish-orange slime coming from the outfall. This may indicate the presence of iron ochre, which can plug the drainage system.

LO 4.3 – Maintenance of an existing drainage system

Content/Topic 1: Maintenance of drainage system

- **Cleaning open drains and pipes**

If the drainage system becomes blocked with tree roots:

- ✓ Reroute the drainage pipe away from the tree(s).
- ✓ Remove and replace the section of blocked drains and remove the tree(s) causing the problem.
- ✓ Replace the drain using continuous non-perforated pipe for a distance of 15 m on either side of the tree.

Some commercial crops have roots that grow into drain lines and clog them. Roots from annual crops such as alfalfa, brome grass, rye grass, canola and sugar beets will usually clear themselves when the crop is harvested. If a problem is encountered:

- ✓ Avoid growing the problem crops again
- ✓ Flush the roots from the drain pipe using low-pressure jet cleaning
- ✓ Remove and replace the blocked section with a larger diameter drain pipe

Silt boxes and catch basins are often installed at critical points in the system. Inspect and clean them out annually. Ensure their covers fit tightly and are free from structural damage. These structures should always remain locked to prevent unwanted access and tampering.

Check for any signs of wash-ins and blow-outs, which can indicate that there is a broken drain pipe, and surface water has entered the drain. At the first sign of the smallest surface

hole, repair the damage before too much sediment enters the subsurface drainage system and reduces its hydraulic capacity.

Figure: Drain pipe blowout

Figure: Drain pipe containing a significant amount of sediment

Consider these options if the drainage system is filled with sediment and is not functioning properly:

a) Renovate subsurface drains that have become filled or partly filled with sediment. This should only be completed when the cost of renovation does not exceed 70% of the cost of a new drain.
b) Dig up, clean and re-lay existing clay or concrete drain pipes. While it is too costly to dig up and salvage drain pipe 150 mm or less in diameter, it is cheaper to salvage larger sizes, if they are still structurally sound. Consider digging and re-laying only where the

drainage pipe is not damaged, carelessly laid with joints having wide gaps or not protected with a cover material to exclude sediment.

c) Clean lateral drains through the use of sewer-cleaning rods or flushing if the deposit is only for a short stretch of pipe. Thick deposits over the length of the pipe are difficult to remove.

- **Lining of drains**

Drain lining is generally done in order to reduce seepage losses and thus increase the irrigation efficiencies. It also substantially reduces drainage problems and canal maintenance as well as water ponding, thus reducing the occurrence of vector borne diseases. Also, smooth surface linings reduce frictional losses, thereby increasing the carrying capacity of the canals. Material used for lining:

- ✓ Clay
- ✓ Polyethylene plastic (PE)
- ✓ Concrete
- ✓ Sand-cement
- ✓ Brick

- **Planting grasses along the banks**

Evergreen and deciduous shrubs make effective plantings for stream buffers, either combined with trees or on their own. The red osier dogwood, winterberry, and ninebark are shrubs that will grow well in this environment, help provide a good habitat for wildlife, and look good all year.

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