Lesson 20

Title of the Experiment: Designing a simple micro-irrigation system
(Activity number of the GCE Advanced Level practical Guide - 33

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Introduction and Theory:

Micro-irrigation refers to low-pressure irrigation systems that spray, mist, sprinkle or drip. The water discharge patterns differ because emission devices are designed for specific applications due to agronomic or horticultural requirements. Micro-irrigation components include pipes, tubes, water emitting devices, flow control equipment, installation tools, fittings and accessories.

It is a challenge to select the right type of system and assemble the components suitable for irrigation needs. A description of various micro-irrigation systems, its many uses and limitations will help in this process.

Micro-irrigation

The term "micro-irrigation" describes a family of irrigation systems that apply water through small devices. These devices deliver water onto the soil surface very near the plant or below the soil surface directly into the plant root zone. Growers, producers and landscapers have adapted micro-irrigation systems to suit their needs for precision water application. Micro-irrigation systems are immensely popular not only in arid regions and urban settings but also in subhumid and humid zones where water supplies are limited or water is expensive. In irrigated agriculture, micro-irrigation is used extensively for row crops, mulched crops, orchards, gardens, greenhouses and nurseries. In urban landscapes, micro-irrigation is widely used with ornamental plantings.

Emission devices

The actual application of water in a micro- irrigation system is through an emitter. The emitter is a metering device made from plastic/brass or other material that delivers a small but precise discharge. The quantity of water delivered from these emitters is usually expressed in volume flow per time units (i.e. L/h, L/min, m^3/h etc.). These emitters dissipate water pressure through the use of long-paths, small orifices or diaphragms. Some emitters are pressure compensating meaning they discharge water at a constant rate over a range of pressures known as pressure compensating drippers.

Emission devices deliver water in three different modes: drip, bubbler and micro-sprinkler. In drip mode, water is applied as droplets or trickles. In bubbler mode, water `bubbles out' from the emitters. Water is sprinkled, sprayed, or misted in the micro-sprinkler mode. Emitters for each of these modes are available in several discharge increments. Some emitters are adapted to apply water to closely spaced crops planted in rows. Other emitters are used to irrigate several plants at once. There are emitters that can apply water to a single plant.

Drip irrigation

Depending on how the emitters are placed in the distribution line (mainly LDPE lines), the drip mode can be further delineated as a line source or a point source. The line source type emitters are placed internally in equally spaced holes or slits made along the line. Water applied from the close and equally spaced holes usually runs along the line and forms a continuous wetting pattern. This wetting pattern is suited for close row crops. The point source type emitters are attached external to the lateral pipe. The installer can select the desired location to suit the planting configuration or place them at equally spaced intervals. Water applied from the point source emitter usually forms a round deep wetting spot. The point source wetting pattern is suited for widely spaced plants in orchards, vineyards and for landscape trees or shrubs.

Types of Emitters

An emitter is a device which applies water to the soil from the distribution system. The two major categories of emitters are point source and line source. Both categories have been successfully used in various cropping situations. There are numerous attributes sought in an optimum emitter. It should be available in small increments of discharge that is, on the order of 1 L/h. The flow should be controlled within narrow limits as a function of operating pressure to able to properly balance applied water with crop water use. A large flow area will be more resistant to clogging by particles which pass through the screening and filtration system or bacterial slime than a small flow area. The emitter should resist degradation due to temperature fluctuations and solar radiation, both of which are expected in typical installations. The manufacturer should specify a useful life for the emitter during which it will operate according to design specifications. This will allow the designer to make more accurate cost projections for system operation and will be useful in development of a maintenance and replacement schedule.

Examples of different point and line source emitters are given in the following sections.

Line source emitter

Line source emitters are suitable for closely spaced row crops in fields and gardens. Line source emitters are available in two variations:

A thin walled drip line has internal emitters molded or glued together at set distances within a thin distribution line (Figure 1a). The drip line is available in a wide range of diameters, wall thickness, emitter spacing and flow rates. The emitter spacing is selected to closely fit plant spacing for most row crops. The flow rate is typically expressed in gallons per minute (L/h). Drip lines are either buried below the ground or laid on the surface (Figures 1b). Burial of the drip line is preferable to avoid degradation from heat and ultraviolet rays and displacement from strong winds. However, some specialized equipment to install and extract the thin drip distribution line is required.

The thick walled drip hose (Figure 2) is a robust variation of the thin walled drip line. The internal emitters are molded or glued to the drip hose. It is more durable because of its considerable thickness. The diameter of the drip hose is similar to that of the thin walled drip line. Unlike the thin wall drip line, the drip hose emitter spacing is wider and it operates at a higher pressure. The emitter discharges ranges from 0.75 to 7.5 L/h. Thick walled drip hose is typically laid on the ground and retrieved at the end of the cropping season.

Point source emitters

Point source emitters (Figure 3) are typically installed on the outside of the distribution line. Point source emitters dissipate water pressure through a long narrow path and a vortex chamber or a small orifice before discharging into the air. The emitters can take a predetermined water pressure at its inlet and reduce it to almost zero as the water exits. Some can be taken apart and manually cleaned. The typical flow rates range from 1 to 12 or more L/h.

Bubbler irrigation

Bubblers (Figure 4) typically apply water on a "per plant" basis. Bubblers are very similar to the point source external emitters in shape but differ in performance. Water from the bubbler head either runs down from the emission device or spreads a few inches in an umbrella pattern. The bubbler emitters dissipate water pressure through a variety of diaphragm materials and deflect water through small orifices. Most bubbler emitters are marketed as pressure compensating. The bubbler emission devices are equipped with single or multiple port outlets. Most bubbler heads are used in planter boxes, tree wells, or specialized landscape applications where deep localized watering is preferable. The typical flow rate from bubbler emitters is between 7 and 75 L/h.

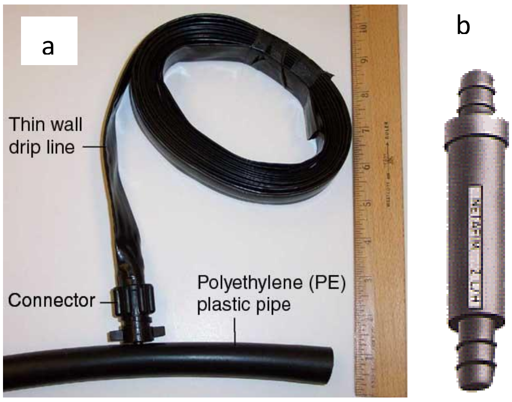

Figure 1:a. Thin wall drip line ("drip tape"),
b. An internal emitter

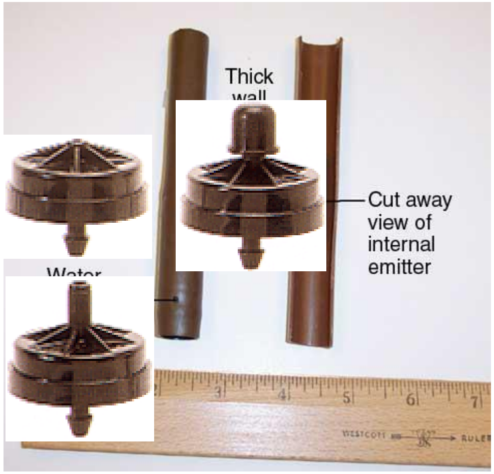

Figure 2: Thick wall drip hose with inline dripper

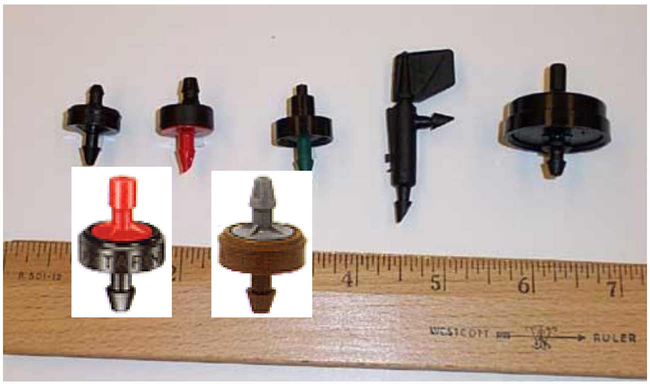

Figure 3: Point source emitters of different shapes and sizes.

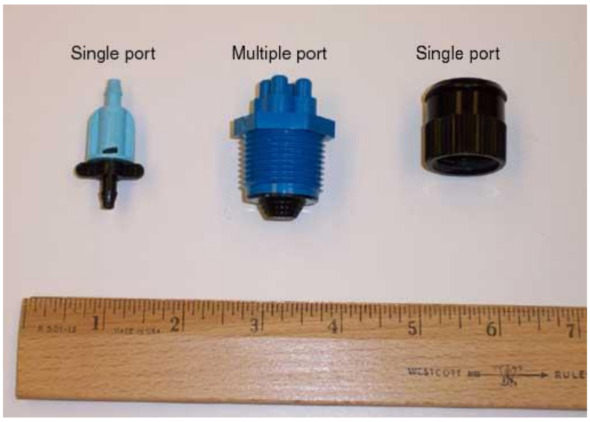

Figure 4: Bubbler emitters of different shapes with single and multiport exits.

Drip irrigation systems components

Irrigation pipeline systems are generally described as branching systems (Figure 5). Various branches are given names such as main, submain, and lateral. Choosing the right size main, submain, and lateral pipe to match the flow rates from the water source is important. Basic components can include a pump and power unit, a backflow prevention device if chemicals are used with water, a filter, a water distribution system, and some devices for controlling the volume of water and pressure in the system. If the water source is from a city/municipal/rural water supply, a direct connection is possible.

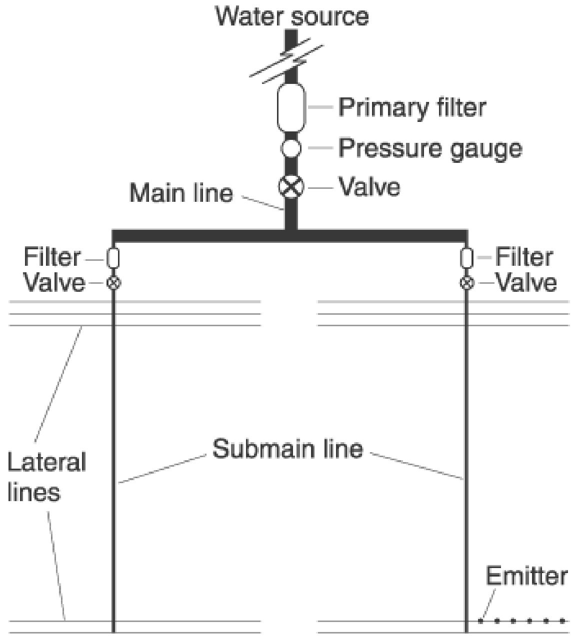

Figure 5: Typical water distribution line of a micro-irrigation system.

Pumps and power unit

Drip irrigation systems are typically designed to make the best use of the amount of water available. The type and size of pump selected will depend on the amount of water required, the desired pressure and the location of the pump relative to the distribution network. Electric power units or internal combustion engine driven pumps are equally adaptable. However, the electric power unit is preferred because it is easier to automate.

Filters

Filters remove sand and larger suspended particles before they enter the distribution network. However, the filters cannot remove dissolved minerals, bacteria and some algae. The three types generally used are screen, disk and sand filters.

Distribution lines

The water distribution system is a network of pipes and tubes that can range in size from 16 mm to 160 mm in diameter. Water from the pump may be carried to the edge of the field by a single large main. Smaller submains may then carry the water to laterals and ultimately to the emitters.

Control components

The control portion may include a combination of the following devices: pressure regulator, valve, vacuum relief valve and timing clock or controller. A flow meter should be used to measure the amount of water. Pressure gauges monitor the water pressure at the pump and other locations. Equipment to inject fertilizers into the water line is also frequently used. Backflow prevention devices are used to prevent contamination of the water source

Applications

Line source drip systems are generally used for row crops such as melons, tomatoes, onions and peppers. More durable subsurface drip lines and above ground retrievable hoses are now available. The availability of specialized equipment to install, retrieve, roll, and stack drip lines and hoses will reduce labor requirements. Most crops will respond favorably to some protective cover from cold and frost conditions. Covers are generally used in low and high tunnels, and as floating mulch. Crops and plants under cover usually require more irrigation water. The line source drip systems are adaptable to adequately water crops under cover.

Fruits and berries

Small fruits like strawberries, blueberries, blackberries, juneberries and raspberries respond well to micro-irrigation. Line source emitters are suited for closely spaced small strawberries. The point source mode is suited to wider-spaced plants such as fruit trees and in vineyards.

Home gardens

In home gardens the time-honored row planting may not always be preferable. Some growers prefer growing vegetables, edible greens and herbs in raised beds or under covers. There are others who may want to include flowers, container plants, fruit trees and shrubs. It is of practical necessity to consider many strategies for watering different plants. With careful watering strategies, the use of chemicals can be avoided, weeds minimized, and pests, fungus and mildew growth controlled. Different micro-irrigation modes can be used to match the different plant water needs in a garden.

Greenhouse and nursery

Plants under environmentally controlled conditions found in greenhouse and nursery systems generally require more water for growth. The widely used non-soil mixes quickly drain and require frequent watering. Manual watering is time consuming and may not be practical for large operations. It is good strategy to consider the use of point source emitters, bubblers and micro-sprinklers for different plant water needs. The use of a multi-port point source emitter with aboveground flowerpots in a greenhouse.

Sprinkler Irrigation

Sprinkle irrigation is the application of water in the form of a spray (as a rain) from the flow of water under pressure through small orifices (perforated pipes) or nozzles. The pressure is usually obtained by pumping, although it may be obtained by gravity if the water source is high enough above the area irrigated. Sprinkle irrigation systems can be categorized in many ways as given in following sections.

Sprinkle irrigation can be adapted to most climatic conditions where irrigated agriculture is feasible. The flexibility of present-day sprinkle equipment, and its efficient control of water application make the method's usefulness on most topographic conditions subject only to limitations imposed by land use capability and economics.

Types of Sprinkler Systems

Various sprinkler systems are have been developed in response to economic, labor, topographic conditions and special water application needs and availability of water and land resources.

Types based on arrangement of spraying water:

1) Rotating head system

   The main rotating head sprinkler is impact sprinkler which is shown in Figure 6. These nozzles are placed on riser pipes along laterals with uniform intervals.

2) Perforated pipe system

   Perforated pipe is a pipe with micro openings along the pipe which will spray water along its length.

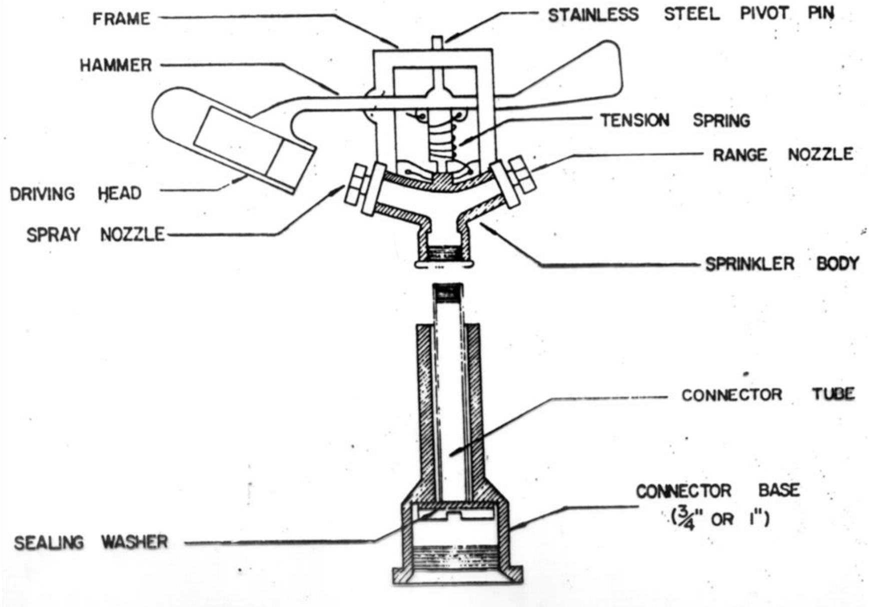

Figure 6: Main components of an impact sprinkler head

Sprinkler System Components

Components of a sprinkler system are given in Figure 7.

Pump

- Centrifugal or turbine pumps used (for deep tube wells)
- Water needs to be pressurized

  High pressure (830 – 1035 kPa) for big guns

  Moderate pressure (275 – 485 kPa) for impact sprinklers

  Low pressure (105 – 210 kPa) for rotating nozzles

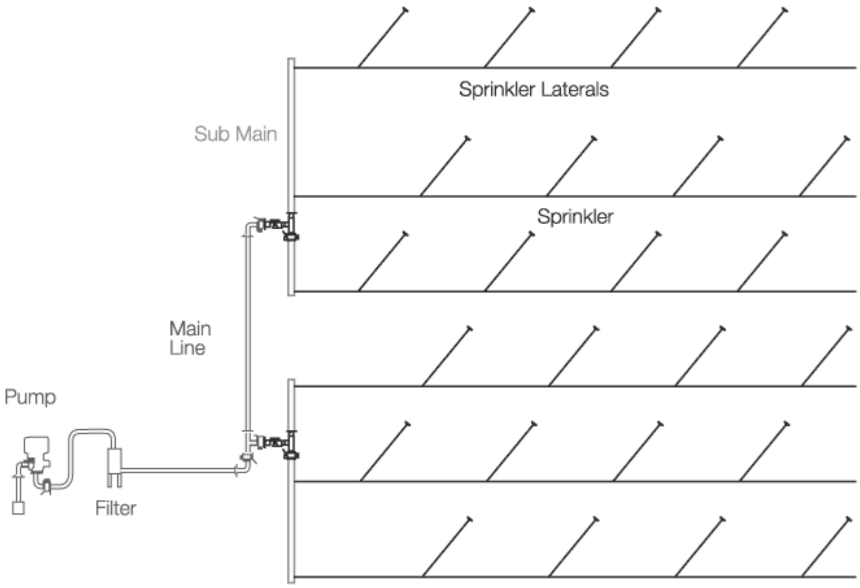

Figure 7: Components of a sprinkler irrigation system

Main line/laterals

- Buried or above ground
- Aluminum, PVC or LDPE

SPRINKLER HEADS

Suitability and efficiency of sprinkler heads depend on operating characteristics under optimum water pressure and climatic conditions (wind).

Other accessories

Filters, fertigation units

Learning outcomes:

At the end of this practical, the student will be able to

- Identify components of a drip and a sprinkler irrigation system
- Fix properly a drip and a sprinkler irrigation system
- Test the operation of a drip and a sprinkler irrigation system

Materials/Equipment:

LDPE pipes (32mm, 20 mm and 16 mm), connection accessories, in-line screen filter, ventury injector, in-line disk filter, blade sprinkler heads, on-line drippers, hole puncture

Methodology/Procedure:

- Identify the accessories and select suitable accessories for a drip and a sprinkler system separately.
- Layout the pipes and accessories in the field in order.
- Fix the accessories tightly.
- Connect the water source.
- Test the system for leakages and if leakages are there, rectify by fixing the accessories properly.
- Operate the system.

(Detailed Procedure has to be recorded by the student / teacher)

Readings/Observations: (If necessary, please include relevant tables with appropriate headings)

Observations after fixing the systems could be recorded.

Diagrams/Graphs: (If necessary, please attach blank graph papers/pages)

Sketch the system layouts.

Discussions:

Conclusions:

References:

Cuenca R.H. 1989. Irrigation System Design: An Engineering Approach, Prentice Hall